Optimal design of power-split HEVs based on total cost of ownership and CO2emission minimization

ClimRisk2020: Time for Action!

Raising the ambition of climate action in the age of global emergencies

Book of Abstracts

8th SISC Annual Conference, online, 21-23 Oct 2020

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About SISC Conference

"ClimRisk2020: Time for Action! Raising the ambition of climate action in the age of global emergencies" is the title of the SISC 8th Annual Conference, held on October 21st-23rd, 2020. Due to the COVID-19 virus, all sessions of ClimRisk2020 was held exclusively online.
The Conference aimed at connecting leading scientists, researchers, economists, practitioners, business leaders, and policy makers, whose activities are focused on different aspects of climate change, its impacts and related policies.
The Conference was an important interdisciplinary platform for the presentation of new advances and research results in the fields of science and management of climate change.

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About SISC

The Italian Society for Climate Sciences (Società Italiana per le Scienze del Clima - SISC) is a non-profit and non-advocacy association, which aims at contributing to scientific progress and the innovation of climatic sciences in Italy by promoting the convergence of disciplines and multidisciplinary research. SISC aims to be a reference point for all scholars dealing with climate-related sciences and their applications.

SISC was created to serve as a meeting point for scientists from different disciplines, who use climate information for their research: from climatologists to physicists and chemists, geographers to agronomists, economists to political scientists, and all scholars that deal with climate-related sciences and their applications.

The Italian Society for Climate Sciences aims at contributing to scientific progress and innovation of climatic sciences in Italy by promoting the convergence of disciplines and multidisciplinary research.

The institutional purposes of the SISC are:

a) to the world of research:

- to foster the exchange of ideas, the creativity and the development of new interdisciplinary research;
- to promote communication and cooperation between universities and research institutions in Italy, strengthening the presence of climatic sciences in both Italian universities as well as higher education systems;
- to attract young talents to build a new interdisciplinary scientific community and increase overall productivity;
- to stimulate and coordinate the Italian contributions to the International programs in the field of climate sciences;
- to become the reference point and the meeting place for Italian scientists living abroad.

b) to the society:

- to increase the impact of the studies and of the debate on climate issues, giving scientific rigour to the analysis of climate policies for mitigation and adaptation;
- to promote the dialogue among scientists, policy makers, businesses and citizens to support actions in the interests of the society and the environment;
- to provide research results to institutions, businesses and citizens

The SISC association is non-profit and non-advocacy, acts according to ethical principles and promotes policies for equal opportunities.

The aims of the Association are pursued in particular through the organization of conferences and debates addressed to the scientific and policy communities, the implementation of web-communications, the promotion of training courses for young graduates, and collaboration with multidisciplinary doctoral courses on climate science.

1 Plenary lectures

ORAL

Successful international cooperation: Lessons for climate change negotiations

Scott BARRETT

School of International and Public Affairs, Columbia University, USA

The abstract is not available.

ORAL

The role of carbo dioxide removal for CO2 neutrality

Sabine FUSS

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Reaching net-zero emissions by the middle of the century is a necessary condition for reaching the Paris climate goals according to the IPCC Special Report on 1.5°C Global Warming. Carbon Dioxide Removal (CDR) is an important component of all 1.5°C pathways with limited or no overshoot. While there is now more knowledge on the different technologies and practices for CO2 removal (CDR) and there is some flexibility to reduce the dependence on it through more ambitious emissions reductions via the demand side, it is clear that CDR will play a role (especially with further delays in increasing the emission reduction ambitions), though it cannot substitute for radical and swift emissions reductions. Which pathway is ultimately chosen – including the extent and type of carbon removal – will also be a societal choice. Still, few countries consider deliberation of CDR portfolios or policies for scaling up CDR in their current discussions on carbon neutrality. In this keynote I want to give an overview of the scenario space, options to withdraw CO2 from the atmosphere and illustrate the challenges of implementation using a country case.

ORAL

From niche construction to ecological traps: An evolutionary perspective on anthropogenic climate change

Andra MENEGANZIN

University of Padova, Italy

Climate change has historically been an evolutionary determinant for our species, affecting both hominin evolutionary innovations and extinction rates, and the early waves of migration and expansion outside Africa. Today Homo sapiens has turned itself into a major geological force, able to cause a biodiversity crisis comparable to previous mass extinction events, shaping the Earth surface and impacting biogeochemical cycles and the climate at a global level. We argue that anthropogenically driven climate change must be understood in terms of a monumental niche construction process, generating long-term ecological inheritance and eco-evolutionary feedbacks that are putting our health and well-being and those of future generations at risk. We then list five major sources of climate change counter-intuitiveness, highlighting how evolved cognitive biases and heuristics may stand in the way of providing effective responses within tight deadlines. Drawing on our framing of the climate breakdown, we finally call for an evolutionary perspective in approaching the adaptive challenge posed by climate change: we argue that putting the brakes on a genuine self-endangering evolutionary trap ultimately depends on our counteractive niche constructing abilities, played at the level of our institutional and innovation capacity.

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2 Explore, predict and project climate variations and extremes

ORAL

Atmospheric Fe supply has a negligible role in promoting marine productivity in the Glacial North Pacific Ocean

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Keywords: Ice core, iron, marine productivity, NEEM, Greenland

Iron is a key element in the Earth climate system as it can enhance the marine primary productivity in the High-Nutrient Low-Chlorophyll (HNLC) regions where, despite a high concentration of major nutrients, the chlorophyll production is low due to iron limitation. One of the main Fe sources to the ocean is aeolian dust. For this reason, ice cores provide a sensitive and continuous archive for reconstructing Fe fluxes over the last millennia. Here we show the first Northern Hemisphere Fe record retrieved from the NEEM ice core, which offers a unique opportunity to reconstruct the past Fe fluxes in the Arctic region over the last 108 kyr. Holocene Fe fluxes to the Arctic were three times lower than the average recorded over the last glacial period. They were greater during the Last Glacial Maximum (LGM) and the Marine Isotope Stage 4 (MIS 4). Comparing our data with palaeoceanographic records retrieved from the HNLC North Pacific, we demonstrated that during the coldest periods, characterized by the highest Fe fluxes, marine productivity in the subarctic Pacific

Ocean did not increase due to a greater sea-ice extent and the absence of upwelling nutrient supply. This supports the hypothesis that Fe-fertilization was more effective in other regions, such as the transition zone of the North Pacific, where a closer relationship between marine productivity and the aeolian Fe fluxes was observed.

ORAL

Regional Arctic sea ice response to abrupt climate changes: A focus on Dansgaard-Oeschger events

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Keywords: Sea-ice reconstruction, DO events, abrupt climate changes

Paleo-records such as marine sediments and ice cores are commonly used to extend our knowledge about past sea-ice cover during the period prior to instrumental observations.

Several studies have identified bromine in ice cores as a potential proxy for past sea ice conditions. During polar springtime, in fact, the photochemical recycling of bromine is extremely efficient over first year sea ice, resulting in enhanced concentrations of inorganic gas phase bromine (e.g. BrO) compared to the ocean surface, multi-year sea ice or snow-covered land. This process is known as "bromine explosion" and is detected by satellite sensors and in-situ observations from early March to late May. After emission, the BrO plume is carried by high-latitude cyclones in the lower troposphere until it reaches land and falls in the form of bromine enriched snow compared to seawater Br/Na ratio.

The bromine enrichment record from the NEEM ice core has been used to reconstruct sea ice conditions in the Canadian Arctic since the last interglacial. The sampling resolution, however, was unable to resolve the rapid climate fluctuations known as Dansgaard-Oeschger (D-O) events occurred at decadal scale.

Here, we present a new sub-decadal dataset resampled across the transitions of D-O 7, 8, 9 and 10. The increased resolution allows to better assess the magnitude and the timing of each transition while a robust statistical correlation with stable oxygen isotopes provides information about the causality between atmospheric warming and sea ice response.

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ORAL

200 years of equilibrium-line altitude variability across the European Alps (1901-2100)

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Keywords: Equilibrium-line altitude, European Alps, climate change, EURO-CORDEX, glaciers

Mountain glaciers are key indicators of climate change. Their response is revealed by the environmental equilibrium-line altitude (ELA), i.e. the regional altitude of zero mass balance averaged over a long period of time. We introduce a simple approach for distributed modelling of the environmental ELA over the entire European Alps based on the parameterization of ELA in terms of summer temperature and annual precipitation at a glacier. We use 200 years of climate records and forecasts to model environmental ELA from 1901 to 2100 at 5 arcmin grid cell resolution. Historical environmental ELAs are reconstructed based on precipitation from the Long-term Alpine Precipitation reconstruction (LAPrec) dataset and temperature from the Historical Instrumental climatological Surface Time series of the greater Alpine region (HISTALP). The simulations of future environmental ELAs are forced with high-resolution EURO-CORDEX regional climate model projections for the European domain using three different greenhouse gas emissions scenarios (Representative Concentration Pathways, RCP). We validated the environmental ELA patterns against the observed end-of-mass-balance-year ELAs from the WGMS 'Fluctuations of Glaciers' database for the period 1948-2017, as well as remote sensing ELAs derived from Landsat time series for the period 2006-2019. The environmental ELA time series pattern is in general well reproduced with WGMS and remote sensing ELAs, with an overestimation of ~75-150 m when averaged over a longer climate period, e.g. 15-30 years.

We find that the environmental ELA between the beginning (averaged over the period 1901-1930) and end of the 20th century (averaged over the period 1971-2000) rose by 114 m mainly due to an increase of 0.8°C in summer temperature, whereas the annual precipitation stayed largely unchanged. Our results suggest that projected summer warming of 1.6°C, 2.8°C and 5.4°C under mitigation (RCP2.6), stabilization (RCP4.5) and high greenhouse gas emission (RCP8.5) scenarios, respectively, will likely drive significant environmental ELA rises of about 194 m, 390 m and 786 m by the end of the 21st century (averaged over the period 2071-2100) for glaciers in the Alps compared with the period 1971-2000. A slight increase (~4%) in annual precipitation for all three emission scenarios, derived from a winter increase and a summer decrease, will only have a minor effect on the average environmental ELA over the entire Alps. However, local precipitation anomalies will drive different changes in environmental ELA over the various regions of the Alps, suggesting in general a faster environmental ELA rise in the west and south with respect to the east and north. These future projected levels of the environmental ELA will result in the unviability and possible subsequent disappearance of between 69% and 92% of all glacier in the Alps by the end of the 21st century. This will have a profound effect on river runoff, ecosystems, tourism and hydro-electric power generation.

ORAL

Paleoclimatological characterization of Grand Combin alpine site based on dust, organic fraction and heavy metals, in the framework of Ice Memory project

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Keywords: Glaciers, Grand Combin, Ice Memory project, ice cores, paleoenvironmental characterization

The inexorable worldwide shrinking of glaciers, occurred over the last few decades, is seriously alarming the international glaciological community. Indeed, at the current warming rate, the complete disappearance of glaciers is expected by the end of this century below 3500 m in the Alps, and 5400 m in the Andes [1,2]. Facing with this growing concern, Italian and French glaciologists decided to take action and launched the Ice Memory project in 2015, with the aim to preserve the memory of high-mountain threatened glaciers. The objectives of this international programme, patronaged by the UNESCO National Commissions, are to drill two or three deep ice cores from each of the selected mountain glaciers, and store part of them in Antarctica, as a heritage of raw material for future generations of scientists. Around twenty glaciers are planned to be drilled in the next two decades, and in this international framework Italy is committed to the conservation of climatic and

environmental signals from Alpine and Apennine sites. Among the others, Grand Combin (GC), on the border between Italy and Switzerland, has been pointed out as one of the most endangered Alpine sites that requires an immediate intervention. Indeed, since the end of the Little Ice Age (LIA) ~1850, and particularly from the 1980s, the north side of GC (Corbassiere glacier) has experienced a huge increase in melting speed, that led to the loss of around 32% of its area [3]. Therefore, in order to accurately prepare the official campaign of drilling, two pilot surveys were carried in 2016 and 2018 at the Corbassiere site, involving Italian and Swiss partners. Those surveys, conducted on a plateau at 4200 m s.l.m., led to the acquisition of a first georadar profile of the rocky substratum and the collection of two shallow ice cores (~10-12 m long) on which δ18O analysis have been subsequently performed. The δ18O values obtained from the preliminary analysis of both samples have been afterwards compared with the temperatures reconstructed at the drilling site, and they both revealed a good δ18O-T concordance for the recent period (2010-2018) observed. These results confirmed the suitability of the site for more in-depth paleoclimatic investigations. Indeed, the favorable exposure to the north of the Alps, and the high altitude ensure the conservation of climate records within the glacial layers and ward off the danger of percolation processes of the surface melt water.

In the next few months, a second Italian-Swiss mission is going to take place on Grand Combin glacier to drill three deep ice cores that will provide sufficient material either for immediate analysis and planned storage in Antarctica. We expect to obtain an in-depth climatological characterization of this peculiar Alpine site through the analysis of dust, heavy metals and organic fraction. Indeed, mineral dust trapped in ice cores represents a valuable archive for understanding the atmospheric circulation pathway, with important implications for the distribution of aridity, the dust loading and the direction of wind systems in the past [4]. Furthermore, heavy metals offer the chance to reconstruct past trends in the emission of the main anthropogenic pollutants [5], while organic fraction represents a powerful tool to trace back the sources of different biogenic compounds present in the atmosphere [6]. Thus, an on-line decontamination and continuous flow analysis (CFA) will be performed on one out the three drilled ice cores using a new melting device that is setting up at Ca' Foscari (Venice), with even possible further analysis on water stable isotopes. An accurate dataset of reference will then be available for future investigations.

From this perspective, the climatic and paleoenvironmental characterization of the Grand Combin Alpine site clearly represents a big challenge and undoubtedly requires an immediate action, given its high susceptibility to global warming. Furthermore, past climate changes need to be deeply investigated in order to put current and future environmental changes in the right perspective, and ice cores retrieved from midlatitude glaciers clearly represent one the most powerful archive of information due to their close proximity to urban areas compared to polar sites [7].

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ORAL

Alpine-wide trend assessment of total snow depth over recent decades from a harmonized database of validated in-situ observations

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Keywords: Total snow depth, Alps, trends, in-situ measurements

Snow is a key component of the Alpine environment playing an essential ecological role and representing a natural water storage for both mountains and valleys with influence on a wide range of sectors, such as agriculture, hydropower and winter tourism. Several studies investigated the past

changes in snow depth and snow cover from ground measurements over different portions of the Alps showing negative trends with more evident changes in spring and at low-elevation areas. However, no comprehensive studies over the whole of Alps have been carried out so far, partly because of the fragmentation of snow records into many national and sub-national archives.

The present contribution describes a new Alpine-wide database of daily in-situ observations of total snow depth (HS) encompassing the whole Alpine region and it discusses the HS trends over the recent past decades (1980-2018), when the data density is the highest, even though some series start late 19th century. The database, including around 3000 measurement sites, was set up thanks to a transnational cooperation of a large group of regional weather and research centers from Austria, France, Germany, Italy, Slovenia and Switzerland sharing snow records and scientific knowledge. All records were harmonized in a common format and underwent quality-check tests including spatial and temporal consistency and outlier detection. In addition, a daily gap-filling procedure was calibrated and applied in order to improve the data availability and the continuity of the HS series.

Based on the finalized database, a preliminary regionalization was performed by means of Empirical Orthogonal Function analysis which allowed to point out and characterize the main spatial components. The trend assessment was then performed at monthly and seasonal scales on long-term and shorter time windows by considering only the HS records with a sufficient data availability over the investigated period. The spatial distribution of detected trends over the Alpine region was analyzed together with the elevation-dependency over different months. Long-term trends of HS are mostly negative in all months for the largest part of the analyzed sites. Stronger declines, up to -5 cm per year over 1980-1999 period, were observed in January-March for stations within 1000-1500 m elevation range and in April-May for sites above 2000 m. However, a greater variability of monthly trend on shorter time windows and regional differences, especially between East-West and North-South, were depicted.

The presented study provides an insight of the recent changes in total snow depth in an Alpine-wide prospective and it represents a first transnational effort towards the creation of a common archive of validated snow records to support further research questions.

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ORAL

Degradation of the climate signal preserved in Svalbard ice archives

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Keywords: Svalbard, Arctic amplification, ice core, oxygen isotopic composition, degradation

The whole Arctic region is undergoing faster warming than the global average. The Svalbard archipelago is particularly sensitive to temperature increases due to the moderate altitude of the main ice fields and its geographical position (van Pelt et al., 2019). Though the greatest temperature increases have been observed during the winter (Maturilli et al., 2013), the rise in summer temperatures are enlarging the areas affected by melting. In 2012, 2015, 2017 and 2019 four shallow cores were recovered from the top of the Holthedalfonna ice field (1100 m a.s.l.) to study the response of specific geochemical parameters to the rapid warming in the higher North Atlantic (Spolaor et al., 2013). The four shallow cores cover the period 2005-2018 and have been analyzed for oxygen isotopic composition (δ18O), which is commonly used in ice core science to reconstruct the past atmospheric temperature. Through the comparison of the four shallow ice cores, we clearly show a deterioration of the signal of the Holthedalfonna ice field: the seasonal δ18O fluctuation was still clear in the first core collected in 2012, however the data from following cores suggest a progressive disappearance of the seasonal signal. The deterioration of the seasonal signal will result in a more uncertain annual layer identification, complicating the dating of cores. The disappearance of the seasonal signal suggests an increase of snowpack alteration most likely due to the increase of summer melting episodes even at this elevation. Although the δ18O signal still responds to temperature fluctuations, the ongoing temperature increase in this site might compromise the utilization of this proxy in a near future for climatic studies. These unique results underscore the impact of Arctic amplification in Holthedalfonna ice fields and on the climate signal this ice field has preserved so far. In addition, considering the similar altitude for the main Svalbard ice fields, these results suggest that a similar deterioration is ongoing in the glaciers and ice fields of the entire archipelago.

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ORAL

Scenes from a Monopoly: Renewable resources and quickest detection of regime shifts

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Keywords: Regime shift, quickest detection, renewable resource, monopoly

We study the stochastic dynamics of a renewable resource harvested by a monopolist facing a downward sloping demand curve. We introduce a framework where harvesting sequentially affects the resource's potential to regenerate, resulting in an endogenous ecological regime shift. The monopolist encounters two sources of uncertainty in the resources dynamics. The first takes the form of natural randomness of the environmental conditions (variance) and the other in the timing of this regime shift. In a multi-period setting, the firm's objective is to find the profit-maximizing harvesting policy while simultaneously detecting in the quickest time possible the change in regime. The resource dynamics are assumed to be monitored by the monopolist through sequential observations and we model the firm's detection process based on quickest detection methods. This captures the idea of environmental monitoring of the resource to detect for changes in the stock and its structure and the use of quickest detection method allows us to easily translate our framework to real-time detection. Solving analytically, we show that a negative regime shift induces an aggressive extraction behaviour due to a combination of faster detection, a sense of urgency, and higher markup in prices. Precautionary behaviour can result due to increasing resource rent. We study the probability of extinction and show the emergence of catastrophe risk which can be both reversible and irreversible.

ORAL

Analysis of the observations of temperature carried out at the meteorological station of the institute of physics

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Keywords: Climatology, meteorological station, temperature, data series, urban area

In the urban area of Turin, meteorological observations were recorded since more than a century, but in different places, and there is not a place in which data were available for the entire period (Di Napoli and Mercalli, 2008). The institute of Physics of the University was equipped with a meteorological station for some years between the two World Wars, but then this observing point was dismissed. Subsequently, in the 1991, the geopyisics group of the Institute of physics decided to start regular observations on the roof of the neighbor buillding edificated nearby the old building (Bonino et al., 1998). These observations are continuing nowadays, coordinated by the Atmospheric Physics and Meteorology group of the Department of Physics, and their database - even if some period of missing data are present - is close to celebrate its first 30-years period of observations. The station is constantly maintained by a dedicated staff of technicians and instruments were regularly calibrated. In occasion of the anniversary, the group has decided to analyze the series of data, starting from the temperature. Instantaneous raw data were then accurately managed and checked, and then daily, monthly and annual averages were calculated, as well as more refined statistical methods were applied to the data.

Since the institute of physics is located not far from the central area of Turin, the behavior of the data gathered at this station could be considered as representative of the urban area of Turin.

During this presentation, after a short description of the station and the instruments used, we would like to show the results of the analyses carried out on these data, with an eye to the climatological behavior.

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ORAL

Chinese lockdown as aerosol reduction experiment

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Keywords: Climate change, aerosols, China lockdown, 2020

The lockdown of large parts of chinese economy beginning in late January 2020 lead to significant regional changes of aerosol loads, which suggests a reduction of backscatter and consequently a regional warming in the following months. Using local data and a numerical experiment with a limited area model, we have examined how strong this response may have been. The observed (local and re-analysis) observations point to a warming of less than 1.0o, the simulations to a warming of about 0.5o. These numbers are uncertain, because of large-scale natural variability and an ad-hoc choice of aerosol optical depth anomaly in the simulation. Thus, the result was, in short, that there was actually a weak warming of a few tenth of degrees, while noteworthy changes in circulation or in precipitation were not detected.

More specifically, we found:

- At selected central China stations temperature were found to be higher than in previous 2 years. This warming goes with a marked diurnal signal, with a stronger warming, when cloudiness is low, and weaker warming, when cloudiness is high. Maximum warming in the early afternoon (06 UTC), weakest at night (18 UTC)
- This may be related to a general warming of large swaths of Asia (including Siberia, which is not related to local aerosol forcing. Indeed, also the stations outside the immediate strong lockdown are showing a albeit weaker warming. Thus, the difference 2020 minus 2919/2018 may overestimate the effect.
- The ad-hoc numerical experiment indicates that the change caused by the overall reduction of the atmospheric optical depth does not lead to phases of larger deviations of local time series in the simulations. Instead, the simulations with reduced aerosol load show more a mere locally increased temperature. This may indicate that the aerosol effect is mostly local thermodynamic.

ORAL

Interannual to decadal variability within and across the major Eastern Boundary Upwelling Systems

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Keywords: Upwelling, EBUS, trends, climate change

Climate variability and climate change in Eastern Boundary Upwelling Systems (EBUS) affect global marine ecosystems services. We use passive tracers in a global ocean model hindcast at eddy-permitting resolution to diagnose EBUS low-frequency variability over 1958-2015 period. The results highlight the uniqueness of each eBUS in terms of drivers and climate variability. the wind forcing and the thermocline depth, which are potentially competitive or complementary upwelling drivers under climate change, control EBUS low-frequency variability with different contributions. Moreover, Atlantic and Pacific upwelling systems are independent. In the Pacific, the only coherent variability between california and Humboldt Systems is associated with el nino Southern oscillation. the remaining low- frequency variance is partially explained by the North and South Pacific expressions of the Meridional Modes. In the Atlantic, coherent variability between Canary and Benguela Systems is associated with upwelling trends, which are not dynamically linked and represent different processes. In the Canary, a negative upwelling trend is connected to the Atlantic Multi-decadal Oscillation, while in the Benguela, a positive upwelling trend is forced by a global sea level pressure trend, which is consistent with the climate response to anthropogenic forcing. The residual variability is forced by localized offshore high sea level pressure variability.

ORAL

Northern hemisphere atmospheric blocking in future climate in CMIP3, CMIP5 and CMIP6 models

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Keywords: Blocking, GCM, climate model

A comprehensive analysis of the representation of winter and summer Northern Hemisphere atmospheric blocking in global climate simulations in both present and future climate is presented. Three generations of climate models are considered: CMIP-3 (2007), CMIP-5 (2012) and CMIP-6 (2019). All models show common and extended underestimation of blocking frequencies, but a reduction of the negative biases in successive model generations is observed. However, in some specific regions and seasons as the winter European sector, even CMIP-6 models are not yet able to achieve the observed blocking frequency.

For future decades the vast majority of models simulates a decrease of blocking frequency in both winter and summer, with the exception of summer blocking over the Ural and winter blocking over Western North America. Winter predicted decreases may be even larger than currently estimated considering that models with larger blocking frequencies - hence generally smaller errors - show larger reduction. Nonetheless trends computed over the historical period are weak and often contrast with observations: this is particularly worrisome for summer Greenland blocking where models and observations significantly disagree.

Finally, the intensity of global warming is related to blocking changes: wintertime European and North Pacific blocking are expected to decrease following larger global mean temperatures, while Ural summer blocking is expected to increase.

ORAL

Heavy daily precipitation events in the CMIP6 worst-case scenario: projected twenty-first-century changes

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Keywords: Extreme precipitation, climate scenarios, CMIP6

Heavy precipitation is often the trigger for flooding and landslides, leading to significant societal and economic impacts, ranging from fatalities to damage to the infrastructures to loss of crops and livestock. Therefore, it is critical that we have a better understanding of how it may be changing in the future. Based on model projections from the phase 3 and 5 of the Coupled Model Intercomparison Project (CMIP3 and CMIP5), future daily precipitation is likely to increase in intensity. The main goal of this study is to examine possible improvements in the representation of intense and extreme precipitation by a new set of climate models contributing to the phase 6 of the Coupled Model Intercomparison Project (CMIP6) effort, and to quantify its projected changes under the highest emissions scenario by the end of the current century (i.e., SSP5-8.5). Daily precipitation data from six CMIP6 models were analyzed that have a nominal horizontal grid spacing around 100 km and provide data for the highest emissions scenario SSP5-8.5. Two of the six CMIP6 models overestimate the extreme precipitation (defined as the 99th percentile of the precipitation distribution) in the tropics, leading to large biases in the right tail of the daily precipitation over the tropics. Consistent with the CMIP5 results, the CMIP6 models projected increased heavy daily precipitation and increased width of the right tail of the precipitation distribution associated with increased water vapor content.

ORAL

Local Atmospheric Response to Gulf Stream Sea Surface Temperature Front shifting: Impact of horizontal resolution in HighResMIP models

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Keywords: Air-sea interaction, atmospheric response to diabatic heating, Gulf Stream shifting

Western Boundary Currents (WBCs) occur in areas where air-sea interaction is particularly strong and also driven by intrinsic oceanic processes, especially on interannual and longer time-scales. Recent results suggest that general circulation models with sufficiently high horizontal resolution in the atmosphere feature an atmospheric response to the Sea Surface Temperature (SST) variability in WBC areas that is qualitatively different from its counterpart in the respective low-resolution models. However, these findings have been limited to idealised environments and to a single-model framework.

In this study we analyse the atmospheric response to the Gulf Stream SST front meridional shifting, using data from recent HighResMIP simulations, designed with the specific objective of investigating the impact of increasing the horizontal model resolution on the representation of the observed climate. Specifically, outputs of three Atmospheric General Circulation Models (AGCMs) have been analysed, each conducted with low-resolution (LR, about 1°) and high-resolution (HR, about 0.25°) model configurations. AGCMs have been forced with observed SSTs (HadISST2, with daily frequency on a 0.25° grid). The atmospheric response has been analysed using composites of "North" minus "South" phases of the GS SST front in wintertime.

Results show different atmospheric responses to the SST-induced diabatic heating anomalies associated with net poleward displacements of the Gulf Stream extension. In LR simulations a low-pressure anomaly is found downstream of the SST anomaly, while the diabatic heating anomaly is balanced by meridional advection of air coming from higher latitudes, as expected for an extra-tropical shallow heat source. In contrast, HR simulations generate a high-pressure anomaly downstream of the SST anomaly, thus driving positive temperature advection from lower latitudes (not balancing diabatic heating). Along the vertical, both in LR and HR simulation, the diabatic heating in the interior of the atmosphere is balanced by upward motion south of GS SST front and downward motion north and further south of the Gulf Stream. Growing evidence of aforementioned picture may foster a change of paradigm in way to look at extra-tropical oceanic forcing on the atmosphere, with possible consequences on predictability, especially on decadal time scales.

ORAL

Trend analysis of flood quantiles in the Italian Alps

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Keywords: Floods, global warming, alpine basins

Mountains are sensitive environments where global warming is strongly expected to affect the dynamics of snow deposition and melting, with highly likely changes foreseen in the runoff regimes. The increase in extreme rainfall and floods is one of the most debated possibility and its occurrence must be investigated and tested. In this regard, recent studies have highlighted non-uniform evidence for an increase of flood peaks in European cold regions, including high-elevation and high-latitude regions. Reasons for possible reduction of peaks against climate change are that anticipated melting can reduce the rain-on-snow phenomena in some areas. In the Alpine region, however, a closer look to the possible trends of flood peak is in order, as current knowledge indicates that dominant positive trends exist.

In the Italian Alpine area, 140 mountain basins with historical discharge data have been considered to study the temporal evolution of flood peak statistics. This dataset has been obtained after the selection of a subset of stations of a wider database, considering the following selection criteria: i) average basin elevation of at least 1000 m a.s.l.; ii) absence of significant natural or man-made lakes within the basin; iii) at least 10 years of observation available in the last century. Areas of the selected basins range from 10 to about 10000 km^2 and the average elevations reaches 3000 m a.s.l. The full range of observations available encompasses one century, as the oldest values dates 1911 and the most recent ones are recorded in the 2013.

The database is first analyzed as a whole with a station-by-stations trend analysis based on the classic Mann-Kendall test. The resulting high heterogeneity of results, including increasing and decreasing trends with different degrees of significance, suggests that the trend directions should be studied over smaller geographical domains. Different sub regions have been then further investigated through the quantile regression technique, to evaluate the evolution over time of the flood quantiles of a group of stations. This approach is particularly useful as it allows to efficiently treat time series with gaps and missing values. A further step in the analysis is the tentative of attribution through the application of the geomorphoclimatic model FloodAlp (Allamano et al., 2009) that is able to represent the portion of basin area contributing as direct runoff and the complementary part of basin where precipitation accumulates as snow.

Preliminary results of quantile regression on flood peaks suggest a general indication of positive trends. Results were positive for quantiles 0.5, 0.75 and 0.95 even reducing the analyzed time span to 1951-2007, where at least 60 contemporaneous active stations can be considered. The geomorphoclimatic model has been applied to the whole set of basin, without calibration, suggesting that this model-based attribution attempt can achieve interesting results, particularly considering the very low parameterization adopted.

ORAL

Assessment of seasonal forecasts skill over the Mediterranean area

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Keywords: Seasonal forecasts, skill scores, probabilistic forecasts, Mediterranean, temperature, precipitation

In general, the skill of Seasonal Forecasts (SFs) is determined, among other things, by processes taking place in the stratosphere and by specific initialization of soil moisture (Prodhomme et al., 2016) and sea-ice (Guemas et al., 2016) in models. Moreover, we know that SFs for precipitations over the Mediterranean region are influenced in winter by NAO (Athanasiadis et al., 2017) as well as by other teleconnections such as El Nino (Bell et al., 2009), but there is a general lack of knowledge in other sources of predictability.

The aim of this study is to assess of the skill of SFs of temperature and precipitation over the Euro-Mediterranean domain, evaluating different metrics, each of which is suitable for analyzing a different feature of the forecast ensemble. In fact, dealing with probabilistic forecasts, such as the ones considered in this study, strongly differs from the usual and more explicit way of dealing with deterministic forecasts. Because of their probabilistic nature, their evaluation is more difficult: there is not a single number which can be used alone for this purpose. Many statistics have been proposed, tested and used over the years (Brier, 1950; Hamill, 2002; Jolliffe & Stephenson, 2012; Murphy, 1973; Roulston & Smith, 2002; Wilks, 2011), but each of them answers to only one question, not being able to adequately summarize what is the overall skill (and then value) of a specific forecast. Weisheimer and Palmer (2014) tried to simplify the issue asking: "on a scale 1-5, where 5 is very good, how skillful are SFs today?". However, while this question is helpful to give a global indication on the state of the art and on the perspectives for the future, it does not analyze the different aspects or features characterizing different models.

The objective of this study is to assess the statistical properties of SF of precipitation and temperature issued by 5 different models and analyze their monthly skill at different lead-times, up to 6 months; an ensemble including all members available is also considered. Data are obtained by seasonal prediction systems of the Copernicus Climate Change Service (C3S) made available in the

frame of the MEDSCOPE project (https://httpmedscope-project.eu/) by 5 different European institutions: European Centre for Medium-Range Weather Forecasts, UK Meteorological Office, Deutscher Wetterdienst, Centro euro-Mediterraneo sui Cambiamenti Climatici, Meteo-France. Different forecast skill scores based on probabilistic and on categorical (divided into terciles) forecasts are computed: Brier Score, Relative Operating Characteristics curves, rank histograms, attribute diagrams, Continuous Ranked Probability Score, Ignorance Score; in addition, the Anomaly Correlation Coefficient, which is commonly used in forecast verification, is computed. Confidence intervals on the skill scores are assessed using a bootstrap method.

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ORAL

Seasonal prediction of ocean variables: towards user-relevant indicators

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Keywords: Seasonal forecasting, ocean predictions, ocean monitoring

Seasonal forecasting allows climate conditions to be predicted several months in advance. Early awareness of atmospheric conditions is beginning to serve a range of sectors, from energy providers to agricultural management. Seasonal forecasts of ocean conditions also have the potential to contribute to sustainable growth through predictions relevant to ecosystem management, aquaculture and tourism. Currently, however, the ability of seasonal forecast systems to predict conditions in the marine environment remains largely untested.

Here, we present a comprehensive assessment of a seasonal forecasting system's predictions of sea surface temperature and upper 300m heat content. This is one of the first assessments of oceanic variable forecasts performed on an operational, coupled atmosphere-ocean-land-cryosphere model: the Euro-Mediterranean Centre on Climate Change Seasonal Prediction System (CMCC SPS3). Six-month re-forecasts from 1993 onwards are compared to long-term climate products from the European Space Agency (ESA) and the Copernicus Marine Environment Monitoring System (CMEMS) global ocean reanalyses. A range of skill scores are used to identify the regions with predictive skill in the upper ocean.

Moreover, we highlight regional examples where forecasts can be used for effective ocean monitoring. We share our progress of working with potential users in aquaculture and marine protection as well as some challenges faced by seasonal forecasting systems in aiding sustainable use of the ocean.

ORAL

Predicting climate change over the multi-annual range

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Keywords: Decadal prediction, decadal predictability, climate change

Skilfully predicting the climate evolution beyond the seasonal time horizon is a major challenge for climate scientists, and a widely recognized potential benefit for decision-makers in several economic sectors.

After the early pioneering studies during the 2000s, and the first coordinated multi-model effort within the framework of the 5th Coupled Model Inter-comparison Project (CMIP5) in early 2010s, decadal predictions are now entering a more mature phase of their historical development. Also in recognition of their potentially high societal relevance, near-term prediction activities have been recently endorsed by the World Climate Research Programme (WCRP) as one of the Grand Challenges in climate science research, and a Lead Centre for Annual-to-Decadal Climate Prediction, collecting hindcasts and forecasts from several contributing centres worldwide has been established by the WMO.

Results from an ensemble of retrospective forecasts performed with the CMCC decadal prediction system (CMCC DPS) are presented. The decadal simulations are initialized every year with a realistic estimate of the Earth system using a combination of ocean-sea ice, land surface and atmospheric reanalyses, covering the 1960-2015 period, according to the CMIP6 DCPP-A protocol. The characteristics of the CMCC DPS are illustrated, and the predictive skill for global and regional key quantities (including surface temperature, precipitation and atmospheric circulation indices) is assessed and compared against a non-initialized standard climate projection, in order to verify the added value of initialization.

ORAL

Changing atmospheric predictability in a changing climate

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Keywords: Climate change, predictability, ensemble forecast, dynamical systems

Global warming projections outline wide-ranging future changes in the climate system. These include altered storm track activity, modified frequency and severity of extreme events, changes in the large-scale atmospheric overturning circulation cells and more. The question of how global warming may affect the atmosphere's predictability, and thus our ability to produce accurate weather forecasts, has however received very little attention.

Here, I will present two very different approaches to studying this question. The first is a theoretical approach grounded in dynamical systems theory; the second is a pragmatic approach based on a large set of simulations with a numerical ensemble forecasting system. Both approaches conclude that in a future, warmer world, mid-latitude atmospheric predictability will increase. The theoretical approach identifies this as the result of enhanced zonal atmospheric patterns, which are more predictable than meridional configurations. The pragmatic approach as resulting from a decrease in the meridional temperature gradient.

ORAL

Predictability of large scale drivers leading intense Mediterranean cyclones

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Keywords: Intense Mediterranean cyclones

Windstorms, extreme precipitations and instant floods seems to strike the Mediterranean area with increasing frequency. These events occur simultaneously during intense tropical-like Mediterranean cyclones. These intense Mediterranean cyclones are frequently associated with wind, heavy precipitation and changes in temperature, generating high risk situations such as flash floods and large-scale floods with significant impacts on human life and built environment. Although the dynamics of these phenomena is well understood, little is know about their climatology. It is therefore very difficult to make statements about the frequency of occurrence and its response to climate change. Thus, intense Mediterranean cyclones have many different physical aspects that can not be captured by a simple standard approach.

The first challenge of this work, within the framework of the EFIMERA project (Evaluation of Future Impacts of intense MEditerranean cyclones, Risk Associated), is to provide an extended catalogue and climatology of these phenomena by reconstructing a database of intense Mediterranean cyclones dating back up to 1969 using the satellite, the literature and reanalyses. Applying a method based on dynamical systems theory we analyse and attribute their future changes under different anthropogenic forcings by using future simulations within CMIP framework. Preliminary results show a decrease of the large-scale circulation patterns favoring intense Mediterranean cyclones in all the seasons except summer.

POSTER

A decadal time series of particle fluxes in the Kongsfjorden (Svalbard)

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Keywords: Particle fluxes, long time-series, glacial meltwater, subglacial particle transport, Kongsfjorden (Svalbard)

Since September 2010, the instrumented mooring MDI (mooring Dirigibile Italia) is anchored in the inner part of the Kongsfjorden at about 100 m depth with the aim to investigate the temporal variability of particle fluxes and their composition as well as the basic physical properties of the water column (D'Angelo et al., 2018).

On the basis of a 10-year time series, important information was acquired on the particle flux variability, sources and delivery mechanisms.

The majority of downward particle fluxes are restricted to a short period in the summer: in July-September, the mass flux accounts for one third to two thirds of the annual flux, depending on the collection year. Particles in summer are almost completely constituted by terrigenous sediments, both carbonate and silicoclastic.

The total mass fluxes (TMFs) peak in July-August, after the spring phytoplankton bloom triggered by the increased solar radiation, match air temperature peaks measured at the Amundsen-Nobile Climate Change Tower (http://mainnode.src.cnr.it/welcome/) and, to a minor extent, are associated with surface run-off by rainfalls. The highest values of water temperature are instead slightly delayed, occurring in August to September. It has been recently shown (Luckman et al., 2015) that ocean temperature strongly impacts the calving rates of tide-water glaciers in Kongsfjorden, where submarine melting is specifically forced by the Atlantic Water intrusions. However, the delay of maximum water temperature from the TMF peaks would suggest that submarine melting is a minor source of sediment for site MDI and can at best explain the slow declining trend of particle fluxes during some autumns.

Glaciers are the most probable source of clastic sediment for the mooring site. Air temperature strongly affects glacier thaw which, in summer, begins once there is sufficient surface melt to warm the glacier snowpack to the melting point, allowing water to make its way downward to the subglacial drainage network (Lydersen et al., 2014). As surface water enters this subglacial network, overpressure occurs, leading to lift-up and entrainment of basal sediments. As a result, the water coming out of the glacier tends to be sediment laden (Hodgkins et al., 1999). Conversely, when air temperature decreases below zero, during winter months, the processes of meltwater refreezing and water storage switch to a slow drainage system (Lydersen et al., 2014). This produces a pronounced

seasonality in freshwater (Jansson et al., 2003) and sediment discharge, and ultimately in downward particle fluxes in the inner fjord, as recorded by our sediment trap.

In order to test if meltwater run-off is the most important factor driving the suspended matter supply to the fjord, we used positive degree days (PDDs) as a proxy for meltwater availability. Following the method of Schild and Hamilton (2013), the daily average temperature after the onset of melt is defined as the PDD value for each day. To take into account lags in the hydraulic system introduced by finite transit time of meltwater through the glacier system and potential subglacial storage, we calculated a "lag index" using accumulated PDDs. This index is the cumulative sum of the PDDs in the 6 days prior to that day (Schild et al., 2017). We found a perfect synchronicity between TMF and accumulated PDD corroborating the hypothesis that glacial meltwater run-off, the subglacial transport of meltwater, is the main process able to supply clastic sediment to Kongsfjorden, and that the seasonal variability in air temperature, specifically the accumulated temperature above the melting point, ultimately modulates the timing of TMF at site MDI as well. Finally, a possible quantitative relationship between TMF and PDD was sought, useful in cases of missing TMF data.

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POSTER

Assessing tools for improving seasonal forecasting of climate services in Mediterranean areas

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Keywords: Seasonal forecasts, climate services, climate change, MEDSCOPE

Accurate climate predictions with several months in advance (i.e. seasonal forecasts) might greatly benefit land managers for best decision making in adaptation and planning. However, previous studies showed that the accuracy of seasonal predictions was limited over extra tropic regions such as Europe. Currently, the MEDSCOPE project is developing tools to improve the accuracy of seasonal predictions and thus the production of climate services over the Mediterranean area. This work aims to assess the performance of some post-processing tools produced in MEDSCOPE (R package CSTools) using agroclimatic indicators related with fire risk, vegetation thermal needs and water availability. Seasonal forecasts from the CMCC SPSv3 model were corrected using different techniques implemented on CSTools, named simple bias correction (SBC), calibration (CAL) and quantile mapping (QM), that differently correct the statistical properties of climate datasets. Correlations with up-scaled ERA5 reanalysis climate data showed that QM provides similar spatial patterns as raw data (no post-processing), whereas with CAL and SBC the extent of significant correlation decreased. The study suggests that results are highly influenced by the selected method and thus a cautious use is recommended.

POSTER

Changes in rainfall distribution patterns over Liguria Region

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Keywords: Rainfall distribution, Liguria Region, rainfall trends, rainfall distribution patterns, rainfall observations

We present an analysis of precipitation data recorded during a sixty-year period at four coastal and four in-land stations in Liguria (north-west Italy). The aim of the analysis is to identify possible

variations of the temporal and spatial distribution of cumulative rainfall in the region, and to attempt to relate such variations to the climate change foreseen for the Mediterranean area.

The dataset used for the analysis has been acquired from the Ligurian meteorological observational network (OMIRL). OMIRL is a network of about 200 automated meteorological stations measuring conventional meteorological parameters (wind speed and direction, rainfall, temperature, pressure, moisture) and other parameters such as river's water level and solar radiation. The network is designed and maintained according to WMO (World Meteorological Organization) standards and most of the data is transmitted via radio in near real-time to the monitoring facilities.

Climatic studies are usually influenced by the areas and timescales considered in the analysis due to the non-stationary and spatial inhomogeneity of climate phenomena. The analysis of rainfall patterns, however, is generally affected by an exceptional variability, which makes the identification of clear patterns more complex and uncertain when compared to the analysis of other climatic parameters which exhibit a clearer trend both on global and local scales (e.g. temperature, see: ISPRA "Gli indicatori del clima in Italia nel 2019", 94/2020). High variability of local scale precipitation often poses challenges to statistical analysis and therefore an identification of clear patterns is sometimes not possible because the synoptic, large-scale climatology heavily interacts with geography and local phenomena.

The first part of the study is a spatial analysis of the cumulative rainfall. The outcomes suggest that precipitations in the eastern part of the region are significantly higher than those in the western part. This result is generally true for both, the total cumulative precipitation and also the number of rainy days and daily cumulative rainfall. Furthermore, the number of consecutive dry days and consecutive rainy days is respectively lower and higher in the eastern province of the region. Similarly we observed an increase from the coast towards the in-land of the region which is linked to the orographic effects.

The second part of our work has been focused to identify possible variations in the inter-annual and seasonal distribution of the rainfall of the considered sixty-year data series (from 1961 to 2019). Precipitation has been aggregated for the two different periods of the year: a first interval comprising winter, spring and summer seasons (from January to August) and a second predominantly autumnal interval (from September to December).

Results show a discernible difference between the precipitation distribution in the first 30-year period (from 1961-1990) and the distribution occurred in the second half of the considered period (from 1991-2019). In particular, it was possible to observe a noticeable decrease in the cumulative precipitation recorded during winter, spring and summer seasons and a marked increase of rainfall during autumn interval. Conversely, the overall yearly cumulative precipitation presented a less pronounced change over the considered timescales.

The work, does not highlight a variation in the total annual precipitation in most of the Ligurian territory in agreement with other researches (ARPA FG report http://www.arpa.fvg.it/export/sites/default/istituzionale/consulta/Allegati/02_Cambiamenti_climatici.pdf) while it seems instead to highlight a seasonal redistribution of the rainfall, both in intensity and in frequency.

The observed tendency to a concentration of the rainfall during the autumnal seasons (and a nearly equal drop-off of precipitation occurred during the rest of the year) seems to confirm some of

the recent climatic modeling scenarios produced for the Italian territory (e.g. Piano Nazionale di Adattamento ai Cambiamenti Climatici PNACC, CMCC).

Knowledge of changes of the temporal and spatial rainfall variability could result in a useful tool for decision-makers, planners, economic sector and individuals in order to undertake proper planning and management of extreme rainfall events and landslides, to which the Ligurian territory is prone.

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POSTER

Estimation of probable maximum precipitation over Euro-Mediterranean under climate change

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Keywords: Probable maximum precipitation, heavy rainfall, euro-mediterranean, global circulation models, climate change

Probable Maximum Precipitation (PMP) is defined as the greatest depth of precipitation for a given duration meteorologically possible in a particular area. PMP estimation is necessary to calculate Probable Maximum Flood (PMF), whose outputs are indeed useful to consider planning at basin scale, including reservoir and water resources management for different critical Mediterranean sectors (Agriculture, Domestic, etc.).

In this study, we aim to estimate PMP values over Euro-Mediterranean area through a statistical approach, including Hershfield and Desa (revised Hershfield) methods. We compared results generated from observed daily rainfall (E-OBS gridded dataset, 0.25*0.25 degree resolution) against those generated from rainfall based on several Global Circulation Models (Hadgem, IPSL, MIROC5 and GFDL) downscaled (0.5*0.5 degree resolution) and bias-corrected and available through the ISI-MIP repository site.

E-OBS values showed the lowest dispersion comparing to the modeled rainfall projections. According to zonal statistics over 622 Euro-Mediterranean regions, we found GFDL modelling results could be the most significant representative of observed E-OBS values for yearly maximum rainfall 24h values. Observed maximum rainfall showed the highest coefficient of variation (40-150%) and standard deviation (15-36 mm) mostly over Southern Euro-Mediterranean, North of Africa and Eastern Mediterranean. K-means clustering illustrated some regions in central and southern Euro-Mediterranean will foresee the largest changes in mean annual maximum rainfall between historic (1950-2019) and future periods (2030-2099), respectively from 62.5 mm/day to 76 mm/day. Moreover, estimated PMP values aggregated into watersheds upstream the main Mediterranean dams demonstrate climate risks of heavy rainfall at present, mostly over some parts of Italy, Southern France, Spain, Switzerland, Slovakia, and Portugal. Moreover, for the future period, PMP spatial pattern will see the largest intensification in some watersheds, mostly over southern Spain and Sardinia Island as well.

POSTER

European precipitation extremes using high resolution model (WRF)

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Keywords: WRF precipiatation extremes high resolution

European wintertime rainfall is known to be skillfully estimated in reanalysis data and models' simulations since it is highly correlated with large scale, low frequency modes of variability, namely the North Atlantic Oscillation (NAO). As the NAO is mainly a wintertime mode of variability, the skill of estimating precipitation becomes significantly lower in the other seasons, most importantly in the summer, in which precipitation is mainly a result of mesoscale convection. In this study, we use the Weather Research and Forecast (WRF) model, to show the added value of using a high resolution convection-permitting model in estimating precipitation extremes. The results show that WRF succeeds to estimate precipitation extremes compared to observational data (EOBS), especially in summer and transition seasons, while ERA-Interim reanalysis performs well only in winter.

POSTER

Heat content trends of the Mediterranean Sea derived by Argo float data from 2000 to 2020

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Keywords: Heat content, Mediterranean Sea, Argo floats, heat fluxes, buoyancy fluxes, OHC trends

The Mediterranean Sea is reacting very sensitive to climatic changes and therefore has been identified as one of the hot-spots in future climate change projections (Giorgi, 2006).
In this study we use Argo float data to describe trends in Ocean Heat Content (OHC) of the Mediterranean Sea.
The amount of the OHC, spatially averaged in bins of 1°x1° over the period 2001-2019, increases moving from west to east in the Mediterranean Sea.
Time series of temperature from 2005 to 2019, estimated in the upper and intermediate layer (5-700 m), reveal warming trends in the Mediterranean Sea and for specified sub-basins. The upper 700 m of the Mediterranean Sea show a warming trend of 0.047 °Cyr-1, corresponding to a yearly increase in OHC of 4.25 Wm-2. The upper 700 m of the Western Mediterranean Sea are warming fastest with an increase in temperature at a rate of 0.079 °Cyr-1, corresponding to a yearly increase in OHC of 7.14 Wm-2.
The Mediterranean Sea acts as a strong buffer for climate change and mixing and convection events transport the temperature and OHC changes to deeper layers.
This study underlines previous results, contributes to a better understanding of climate change within the Mediterranean region and aims to act as another wake up call to policy makers and society.

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POSTER

Heat events in the Indian subcontinent under a warming climate scenario: Detection and its drivers

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Keywords: Climate, heatwaves, India, climate change, drivers, heat indices

Global temperatures have shown a warming trend over the last century, mainly as a result of anthropogenic activities. Rising temperatures are a potential cause for increase of extreme climate events, such as heat waves, both in severity and frequency. Under an increasing extreme event scenario, the world population of mid- and low-latitude countries is more vulnerable to heat related mortality and morbidity. In India, the events occurred in recent years have made this vulnerability clear, since the numbers of heat related deaths are on a rise. The heat stress and underlying anomalous conditions can exacerbate an increase in the number of deaths. Indian heat waves occur during the months of April to June and can impact various sectors including health, agriculture, ecosystems and the national economy. In May 2015, a severe heat wave due to the delayed onset of southwest monsoon affected parts of south-eastern India, which claimed more than 2500 lives. Heat wave and health impact research are needed in regions where this impact is expected to be most severe.

Our preliminary results show the prevalence of Heat events in seven different regions of India during the pre-monsoon (March, April, May) and transitional (May, June, July) months. We consider daily maximum temperatures and NOAA's Heat Index (HI), a combination of temperature and relative humidity (also known as apparent temperature) which gives an insight into the discomfort because of increment in humidity. It is important to take HI along with temperature anomalies, since humidity also plays a role in transitional period. We also look into various drivers behind the heat events in the seven different clusters namely, Pacific Decadal Oscillation (PDO), ENSO, Indian Ocean Dipole (IOD) and North Atlantic Regimes for better understanding.

POSTER

Orographic forcing and climate trends in Central Italy: Using a validated regional dataset over Umbria to compute climate indices

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Keywords: Orography, quality control

The peculiar position of the Umbria region within Central Italy, included between two mountain chains of the Apennines, in a continental position exposed to the effects of the Mediterranean cyclones, makes it an interesting field for assessing the effects of orographic forcing on the atmospheric parameters combined with the climate trends and their change in the last decades. The first step to make such a climate assessment is to collect, and then validate statistically the climate variables following the international standards [1].

Several actions have been undertaken with the support of the regional authorities and within EU founded projects (PSR 2014-2020; FEASR):

- A quality control and gap-filling methods following WMO standards [2], has been applied to timeseries of temperature, precipitation, humidity, pressure, radiation, and wind measurements.
- Then a spatial interpolation has been elaborated with different methods. During these elaborations, the need to compare both the timeseries, when spatial-temporal gaps were present, with other reliable climate datasets and the necessity of reducing the uncertainty on hourly data of the gridded variables, convinced the authors to use the ERA5 dataset [3] as a proxy to compare the high resolution data of the regional network with the global reanalysis to measure their distance in the parameters space.
- The climate trend has been computed using different indices derived from the validated dataset. The first results confirm the global trend of temperature warming within the region, but also the sensitivity of the local parameters to the global climate pattern as the El Nino. Other parameters with a chaotic, in a deterministic sense, behavior such as precipitation have trend that reminds of the change in the convection aggregation pattern and in the statistics of extreme events observed in the global climate.
- A measure of the orographic forcing has been attempted computing, within the validation process of the temperature variable, a vertical lapse rate starting from the surface measurements [4]: a comparison of the computed profiles at different time lags with the ERA5 profiles extracted with the same procedure from the grid points has been made. The comparison excludes the vertical points below and above the regional implementation of the ERA5 orography.

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POSTER

Spatio-temporal correlation of extreme climate indices and river flood discharges

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Keywords: Extreme events, river floods, climate indice

The occurrence of floods is strongly related to specific climatic conditions that favor extreme precipitation events. Although the impact of precipitation and temperature patterns on river flows is a well discussed topic in hydrology, few studies have focused on the rainfall and temperature extremes in their relation with peak discharges. This work presents a comparative analysis of Climate Change Indices (ETCCDI) annual time series, calculated using the NorthWestern Italy Optimal Interpolation (NWIOI) dataset, and annual maximum flows in the Piedmont Region. The Spearman's rank correlation was used to determine which indices are temporally correlated with peak discharges, allowing to hypothesize the main physical processes involved in the production of floods. The correlation hypothesis was verified with the Spearman's rank correlation test, considering a Student's t-distribution with a 5% significance level. Moreover, the influence of climate variability on the tendency of annual maximum discharges was examined by correlating trends of climate indices with trends of the discharge series. These were calculated using the Theil-Sen slope estimator and tested with the Mann-Kendall test at the 5% significance level. The results highlight that while extreme precipitation indices are highly correlated with extreme discharges at the annual timescale, the interannual changes of extreme discharges may be better explained by the interannual changes of the total annual precipitation. This suggests that projections of the annual precipitation may be used as covariates for non-stationary flood frequency analysis.

POSTER

Two centuries of temperature observations in the Alpine city of Trento (1816-2020)

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Keywords: Air temperature observations, Alps, trends

We present the reconstruction and analysis of the series of air temperature measurements taken in the city of Trento, starting from 1816. In two hundred years the location of the observatories and the observers have changed a considerable amount of times, and the collected metadata were fundamental to reconstruct the history of observations and finally merging the variety of short subseries. Inhomogeneities due to changes in location, observer, or procedures were first detected and related to metadata (when possible) and finally corrected through the application of homogenization techniques. For this purpose, different techniques were applied to monthly data and results compared. The corrected series was analyzed on both annual and seasonal basis. The analysis shows a significant increasing trend of annual mean temperatures, especially in the last 50 years, with Summer being the season with the most pronounced increase. Temperature fluctuations over subperiods obey mostly a normal distribution, displaying a shift towards higher mean values and broader standard deviations, especially in the recent period.

POSTER

Validation of the convection-permitting regional reanalysis SPHERA: Benefits of the high resolution in detecting severe weather events

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Keywords: Regional reanalysis, convection permitting, high resolution, severe weather, climate trends

In recent years the interest towards the development of regional atmospheric reanalysis datasets has been growing more and more. Limited-area reanalyses in fact, as a consequence of the smaller domain that they cover, provide a data distribution displaced on a much finer grid compared to a coarser global dataset.

This permits to resolve in a better way those patterns related to rapid and high-impact weather events, first and foremost convection. This study presents the first extensive validation of the novel regional reanalysis dataset currently still in development at ARPAE-SIMC: the High rEsolution ReAnalysis over Italy (SPHERA). SPHERA is a high-resolution convection-permitting reanalysis covering the Italian domain and the surrounding seas, which, when completed, will span for 25 years, from 1995 to 2020. SPHERA is based on the non-hydrostatic limited-area model COSMO, and produced by a dynamical downscaling of the global reanalysis ERA5 developed at ECMWF. A nudging data assimilation scheme is applied in order to steer the model outcomes, produced with hourly temporal frequency, towards observations.

From the validation of SPHERA against surface observations for the period 2003-2017, the added value of the convection-permitting dataset emerges. A clear advantage of SPHERA on its driver ERA5 is found for the detection of events characterized by moderate to intense daily total rainfall. Furthermore, it is shown how the performance of the reanalysis is influenced from the seasonality and the geographical location of these kind of high-impact events. These results point out that regional reanalysis is able to better resolve local extreme events, as a consequence of its higher spatio-temporal resolution. This feature indeed permits to explicitly solve deep convection, a key requirement to satisfy in order to represents small-scale atmospheric dynamics in the best way.

POSTER

Swiss stone pine (*Pinus cembra L.*) tree-ring data as a proxy for extending glacier mass-balance series in the Italian Rhaetian Alps

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Keywords: Climate change, glacier fluctuations, glacier mass balance, mass-balance reconstruction

The ongoing climate changes and global warming affect high elevation areas more than other environments. As a consequence, the glaciers as sensitive sentinels of climate changes, promptly modify their shape and extension to manage with the new climatic conditions. Thus, glacier mass-balance reconstruction represents a powerful proxy for documenting past climate changes at high elevation environments. The longer the extension of records back in time, the most significant are the information on glaciers' behavior, necessary to model their dynamics and to predict expected changes in the near future. However, series of annual mass-balance measurements longer than 60 years are very rare.

The sensitivity of the Swiss stone pine (*Pinus cembra L.*) to May-September mean temperature perfectly overlaps with the ablation season of the glaciers in the European Alps. The latewood density data (MXD) of this species was therefore used for the first time to reconstruct the summer mass balance of an Alpine glacier, back to the glaciological year 1811/12. Since the net mass-balance of a glacier is not only related to the ablation season temperature, but also to the snow accumulation that occurs during the winter, we used a synthetic gridded precipitation series interpolated at the study site as an independent proxy to infer the winter mass balance. The reconstructed MXD/precipitation-based net mass balance agrees well with field data of both Careser Glacier and other Alpine glaciers, elongating the existing series of about 150 years. Mass-balance reconstruction underlines periods of lowered and enhanced ablation during the last two centuries, which match also with geomorphological evidences and documentary knowledge.

Our results highlight the possibility to use Swiss stone pine MXD data for dendroglaciological purposes, because it represents a powerful tool to extend deeply in the past the data on summer and annual mass balance of the Alpine glaciers. Moreover, new promising dendrochronological findings aimed at reconstructing precipitation in the Alpine region promote the Swiss stone pine as a reliable and temporally stable proxy to perform accurate glaciological reconstructions.

3 Climate related impacts, risks and adaptation options

ORAL

5 kyr of fire history in the High North Atlantic Region: Natural variability and ancient human forcing

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Keywords: Ice cores, fire proxies, Greenland, Iceland, Vikings

Extensive wildfires have recently generated worldwide attention and raised concerns about the impacts of humans and climate change on fire regimes. However, little is known about trends and driving forces of past global fire activity, especially in the extreme latitudes of the High North Atlantic Region (HNAR).

Biomass burning is a key Earth system process that influences global atmospheric chemistry by releasing greenhouse gases and climate-forcing aerosols. Climate is the main driver of global biomass burning. Elevated surface air temperatures and sustained droughts can affect fuel flammability, leading to increased global fire activity over seasonal to centennial timescales. Climate conditions also determined forest expansion, with positive effects on fuel moisture and a dampening effect on biomass burning.

However, global climate alone may not be the only cause of the change in fire activity. Anthropogenic activities are suggested to have an impact on the fire regime, altering the temporal and spatial structure of fuel availability and timing and frequency of ignitions since the early Holocene.

Levoglucosan and black carbon in ice cores provide a signature of past fire activity on regional to hemispheric scales, with sub-annual to annual resolution (Rubino et al., 2015; Bharattai et al., 2019). We present a 5 kyr record of fire proxies levoglucosan and black carbon measured in the Renland ice core, retrieved from the eastern coast of Greenland. Levoglucosan flux shows high levels from 5 to 4.5 kyr with an abrupt decline followed by a relatively stable period from 4 to 1.1 kyr BP. The minimum in fire activities, suggested by weak flux levels for both black carbon and levoglucosan, is determined approximatively at 0.5 kyr BP.

Considering back trajectories analysis and available fire records, we suggest that Renland fire proxies are a signature of a local source, likely the eastern coast of Greenland and Iceland, rather than a hemispheric one.

We attribute the abrupt decline in levoglucosan flux at 4.5 kyr BP to a reduction in wildfire regime as a result of the monotonic decline in summer insolation in the Northern Hemisphere since 5 kyr BP that produced intense landscape changes and ice cap expansions in Iceland (Geirsdottir et al., 2013). The step change in levoglucosan and black carbon fluxes determined at 1.1 kyr BP, although following mainly the climate of the HNAR may also indicate a decline in wildfire regime in the Icelandic territory due to the extensive land clearing caused by Viking colonizers.

This study brings further evidence that human activities could have impacted the environment before the Great Acceleration and the study of fire proxies is useful to reconstruct past human footprint, distinguishing it from the changes in climatic conditions. In particular, we evidence that a human-derived change in the paleofire regime is also evident in the extreme latitudes of the HNAR.

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ORAL

Tipping oceans in a changing climate

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Keywords: Climate impacts, marine biota, regime shift, tipping points, global ocean

Ecosystems naturally continuously change, yet, in some cases, changes can be sudden, dramatic and persistent, involving the structure and function of an ecosystem and bringing it to a new state. These phenomena are called regime shifts (phase shifts in benthic ecology, abrupt shifts when feedback mechanisms are not identified, critical or catastrophic transitions). These abrupt alterations in the ecosystem structure often also impact ecosystem services (the benefits people obtain from ecosystems), and can disrupt economies and societies.

In the oceanic environment, abrupt ecological shifts have been identified in all marine basins and habitats where long time series exist. Recent studies suggest that they are more widespread than so far thought, and that their extent and intensity might increase as global temperature increases (Beaugrand et al 2019). In addition to the changes in individual ecosystems, lay the risk of entire climate subsystems tipping (Lenton et al 2019). Thus, early warnings at a global scale should be developed.

In this work, we present what we know at the present stage, a possible prediction tool, and some outlook on this rapidly developing field, especially as global warming continues.

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ORAL

Climate change impacts on the aquaculture sector for European islands

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Keywords: Aquaculture, climate change, impact chain, islands

According to the fifth Assessment Report of the Intergovernmental Panel on Climate Change, the warming of the climate system is unequivocal and continued emission of greenhouse gases will cause further warming and long-lasting changes in all components of the climate system. This increases the likelihood of severe and irreversible environmental impacts, which can induce large socio-economic damage. In order to create new policies on adaption, policy makers must have detailed and accurate information about likely impact chains and about the costs and benefits of possible resilience strategies corresponding to the potential decarbonisation pathways.

The SOCLIMPACT project aims at modelling and assessing downscaled Climate Change impacts and low carbon transition pathways in European islands and archipelagos for 2030-2100, complementing current available projections for Europe, and nourishing actual economic models with non-market assessment. The project is developing a thorough understanding on how Climate Change will impact the particularly vulnerable EU islands located in different regions and focuses on Blue Growth sectors. One of the fast-growing Blue Growth sectors is aquaculture. Aquaculture accounts for 20% of the fish production in Europe. Climate change impacts and risks for the marine aquaculture sector on the islands were identified based on climate hazards, exposure and vulnerability factors such as sensitivity and adaptive capacity.

The main risks for marine cage aquaculture identified are:

- Change in production due to changes in seawater temperature
- Increased fragility of the aquaculture activity due to extreme events

Impact chains for these risks have been developed and operationalised to identify the major risks and finally enable the comparison between different islands. These results facilitate the development of adaption strategies and support policy strategy and capacity building.

Acknowledgments

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ORAL

Multi-risk scenario analysis in the Apulia shoreline: A machine learning approach supporting coastal erosion risks assessment and management

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Keywords: Coastal erosion, water quality variation, Bayesian Network, GIS, future scenarios

Climate change is causing severe threats to natural and human systems worldwide, with relevant impacts on coastal areas where land-sea interaction occurs. According to the IPCC scenarios, they will be increasingly exposed to erosion as direct consequence of rising sea level and changing patterns of extreme events. Located at the land-sea interface, coastal areas are dynamic environments where natural and anthropogenic pressures interact at diverse spatio-temporal scales modifying their geomorphological, physical and biological features. Against this interplay, coastal managers are increasingly calling for new approaches supporting a multi-scenario evaluation of multiple risks arising from natural and anthropic stressors.

Moving beyond traditional approaches for coastal erosion risk and vulnerability appraisal, a GIS-based Bayesian Network (BN) approach was developed, exploiting functionalities of both methods to evaluate the probability and uncertainty of coastal erosion risks, and connected water quality variation, against multiple 'what-if' scenarios, including different management measures (i.e. nature-based solution) and climate conditions (e.g. higher coastal waves).

According to the spatial resolution of the available data for the case study of the municipality of Ugento (Apulia Region-Italy), the proposed BN-model was trained and validated by considering oceanographic and water quality parameters over the 2009-2018 timeframe, allowing to capture local-scale shoreline erosion dynamics and related driving forces.

The resulting output from the BN-based scenario analysis showed, even if in a minor extent, a nexus between oceanographic drivers, shoreline evolution and water quality parameters (i.e. suspended matter and diffuse attenuation), with increasing probability of high erosion/accretion along the coast and higher turbidity under potential rising maximum significant wave height.

Despite constraints posed by the spatial resolution of the available data for the investigated case, the outcomes of the performed assessment represent valuable information to support adaptive policy pathways in the context of Integrated Coastal Zone Management and Disaster Risk Reduction in the Ugento shoreline.

ORAL

C3S Demo Case Soil Erosion: Assessing climate change impacts on soil erosion over Italy

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Keywords: Copernicus climate change service, climate data store, soil erosion, soil loss, rainfall erosivity, climate projections, EURO-CORDEX

Water erosion process entails three main stages (Merritt et al., 2003): detachment, transport, and deposition. Detachment is due to raindrop impact or overland flow inducing local shear stresses exceeding soil strength (friction or cohesive mechanism). According to soil grain size and geomorphological features of the area, soil is then transported downstream up to reach the deposition area. Soil erosion can occur on different surfaces: open slopes (sheet erosion), preferential pathways (rill or gully according their geometric features), in-stream when it is induced by lateral erosion along the riverbanks. Soil erosion can generate significant on-site costs affecting farming land (loss of fertile land, nutrients) and off-site costs (siltation of reservoirs, sediment impacts on fisheries, the loss of wildlife habitat and biodiversity flooding, destruction of infrastructure). They can result in remarkable economic consequences; for example, over Europe, Panagos et al (2018) estimate annual productivity loss of about 1'260 MEuro and 12 MHa of agricultural area severely eroded.

In this respect, generally, the expected variations of precipitation regimes due to climate change could entail worsening conditions. Indeed, the greater atmospheric moisture retention capability could increase the frequency and severity of intense rainfall events, one of the biggest culprits of soil erosion, spaced out by longer dry periods acting as further predisposing factor for such dynamics.

For those reasons, precipitation datasets available in the Climate Data Store (CDS) of Copernicus Climate Change Service (C3S), and Toolbox for processing and returning them, could result a key support for decision-makers and practitioners. The C3S is part of the Copernicus Earth Observation Programme and is implemented by the European Centre for Medium-Range Weather Forecasts (ECMWF) on behalf of the European Commission. To explore C3S potentialities as support for soil erosion assessments, ECMWF contracted CMCC Foundation for a Demonstration Case developed as a Soil Erosion web-Application freely available through the C3S CDS. As test case, Italy was selected since, with its 33% of agricultural lands exposed, it suffers the highest impacts representing 42% of agricultural lands eroded and 24% of the related Gross Domestic Product loss of European Union (Panagos et al., 2018).

The released datasets include assessments concerning soil loss by rainfall-related rill and sheet (inter-rill) erosion and rainfall erosivity for recent decades and future horizons. To carry out such

evaluations, the Revised Universal Soil Loss Equation (RUSLE) was exploited, an empirical approach enabling spatially explicit estimates of soil loss at annual level. RUSLE was developed by Renard et al. (1997) as an improvement of the USLE by Wischmeier and Smith (1978); it is a combination of the erosivity factor detaching particles from their position within the soil, rainfall in this case (R-factor), and a number of soil susceptibility factors, i.e. those characteristics that make a soil highly or weakly prone to erosion, including here not only the intrinsic soil physical and biogeochemical properties (erodibility, K-factor) but also the topographic settings (slope length and steepness; LS-factor), as well as land cover and management (C-factor) and support practices to prevent/mitigate erosion (P-factor) largely based on human actions.

Concerning R-factor, the rigorous approach suggested by Wischmeier and Smith (1978) requiring data at very high temporal (at least, 30 minutes) and spatial resolution is usually hindered by the difficulties to retrieve such data over large areas and for extended periods. Nevertheless, several methodologies have been proposed in literature that relate R-factors to simpler indicators, usually representative of precipitation depths aggregated at a coarser temporal level (e.g. monthly, annual). Over Italy, Bazzoffi (2007) selected and tested a set of such approaches, widely known and exploited also by stakeholders (e.g. Italian Regional Authorities), and thus adopted in the Contract for the historical period and most recent decades using as input several datasets available in CDS: gridded observations (E-OBS, resolution ~12 km) and reanalysis (ERA5, ~31 km; ERA5-Land, ~9 km). Nevertheless, as side scientific activity, a deep evaluation of uncertainties introduced by the use of empirical models instead of the rigorous definition of the R-factor and by the use of gridded precipitation datasets instead of point-scale precipitation observations was carried out by collecting and processing, over 2002-2011, 173 rain gauges with resolute information about rainfall observations provided by the Regional Administrations and additional 68 rain gauges provided by the Joint Research Centre of the European Commission among those used in the REDES project (Panagos et al. 2015).

For two future time spans (2021-2050 and 2051-2080), the EURO-CORDEX simulations' ensemble (resolution ~12 km, daily time step) was considered under different Representative Concentration Pathways (RCPs; 12 for RCP4.5 and RCP8.5, 5 for RCP2.6). To deal with biases currently affecting climate models, climate simulations were bias-corrected recurring to a widely adopted approach [e.g. linear scaling, Quantile Delta Mapping by Cannon et al. (2015)]. On the other side, soil-related factors were assessed by adapting to updated datasets the consolidated approaches adopted in Panagos et al. (2015).

Moreover, gridded datasets about future expected variations in rainfall proxies assumed regulating water erosion are also made available using raw EURO-CORDEX climate simulations: annual precipitation amount, maximum precipitation at daily scale and aggregated over 5 days, wet days, maximum yearly number of consecutive wet days and number of days with rain exceeding 20 mm are computed.

The final Soil Erosion web Application (available since September) permits visualizing and retrieving trends and results for specific Areas Of Interest (AOI, e.g. NUTS) over Italy through maps and graphs in "Basic" Mode. Furthermore, more expert Users have the opportunity to access the Application also in "Advanced" Mode. According to it, for a selected AOI, the local conditions assigned to two soil susceptibility factors (C or P, strictly related to anthropic activities) can be modified. Such

"what-if" analysis acts as a sort of Decision Support Tool for different types of Users (e.g. planners, farmers) in order to have a preliminary assessment at large scale about the potential effects, over soil erosion, of land management practices.

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4 Climate policies and transition pathways in the context of sustainable development

ORAL

Pathways of transition and the characteristics of competing technologies: A taxonomy and a policy experiment

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Keywords: Technological transition, multi-level perspective, technologial knowledge, learning, climate policy, agent-based model

To accelerate the transition to low-carbon technologies, a profound understanding of technology transition processes is needed.

Empirically, pathways of transition differ across countries, industrial sectors, firms, and technologies. The purpose of this talk is to explain these differences based on a characterization of competing technologies and a macroeconomic simulation experiment. The macroeconomic understanding is crucial to cope with societal disruptions and to design effective policies.

Competing technologies can be characterized by their relative superiority in an exogenous socio-technical landscape, their relative maturity, and cross-technology interactions in the process of specialization. These characteristics are linked to the multi-layer perspective of transition theory and

build the conceptual basis for competing technologies in the macroeconomic agent-based model Eurace@unibi-eco. It is shown that the characteristics can be an explanation for heterogeneous pathways of transition. Policy may alter the external conditions of the technology race. In an experiment, it is shown how different market-based instruments can be used to speed up and stabilize a transition process. Taxes and subsidies perform differently conditional on the characteristics of competing technologies.

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ORAL

Drivers of Climate Policies: A Machine Learning Approach

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Keywords: Climate policies, climate change mitigation, machine learning, random forest

The goal of the Paris Agreement to limit the increase in global average temperature below 2°C requires considerable reductions in greenhouse gas emissions. National governments can facilitate these emission reductions by the implementation of stringent climate policies. While some countries are on track to meet their carbon-cutting goals, others have been less successful in adopting effective climate policies. Comparing climate policies across national governments, their implementation and stringency does not follow a straightforward pattern but instead seems to be driven by a complex combination of various politico-economic, institutional and socio-economic variables. This paper empirically analyzes the determinants of stringent climate policy implementation, thereby shedding light on the discrepancy of climate policy stringency between countries. The related literature that focuses on the influencing variables of climate policies relies solely on classical econometric methods. Regression analysis, however, requires predetermination of the underlying model and is limited to a relatively small set of variables. Since the implementation of climate policies is potentially driven by a plethora of determinants that vary in importance across countries, the results of previous econometric studies might be limited by the methods applied. For this reason, we provide a novel approach to identify the most important determinants for successful climate policy implementation among a large set of potential variables using machine learning-based methods. More precisely, our analysis starts with reviewing 19 different independent variables concerning a country's political economy, its institutions, and socio-economic characteristics. We then reduce the dimensionality of variables to using correlation analysis. Later, we develop a random forest ensemble based on data

from 95 countries to identify the most important variables among the remaining 9 independent variables. For the target variable, i.e. national climate policy stringency, we use the "Climate Laws, Institutions and Measures Index" (CLIMI) developed by Steves et al. (2011), which measures the quality and depth of national climate policies and measures. Our results suggest that GDP, democratic structures, public environmental awareness and European Union membership are the most important determinants of stringent climate policies. The level of democracy is measured by the democracy indicator of the Polity IV Project and ranges from -10 (full autocracy) to 10 (full democracy). The results show that democracy predicts substantially more stringent polices after its value hits 5. Environmental awareness as measured by results from a Gallup survey is scaled to range between 0 and 100. Similar to democracy, environmental awareness predicts higher scores for CLIMI especially after its value reaches 80. Based on our analysis, the GDP of a country positively affects its predicted value for CLIMI. The impact of GDP on predictions is more pronounced for countries with a GDP between 10 and 400 billion US-dollars. GDP per capita and fossil lobbying is deemed less important by our model for predicting stringent climate policies.

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ORAL

Energy taxes, public debt and endogenous growth engines in OECD countries

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Keywords: Energy taxes, economic growth, public debt, simultaneous equations model, multiple imputation

This paper explores the channels through which energy taxes may affect economic growth, using a simultaneous equations model for a balanced panel data of 31 OECD countries over the 1994-2013 period. The empirical results reveal a negative impact of energy taxes on physical investment in the short and long term. This impact is negatively sensitive to the existence and level of public debt. Additionally, the results show that energy taxes have an indirect effect on human capital through their impact on polluting emissions. The taxes on energy products are able to reduce both the flux and the stock of polluting emissions that have a negative impact on human capital skills in the short and long term. Finally, we found that energy taxes could encourage eco-innovation in the short and long term.

ORAL

A land-based approach for climate change mitigation in the livestock sector

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Keywords: Agriculture, climate change, mitigation, livestock, land-based sustainable management

Greenhouse gas (GHG) emissions from agriculture, forestry and other land uses (AFOLU sector) cover the 24% of global emissions, representing the second hot spot in the contribution to climate change after the energy sector. Thus, the land sector plays a crucial role in the context of climate change, being both a contributor to the problem and a part of its solution, particularly thanks to the capacity of soils and biomass to sequester atmospheric carbon. The challenge of this paper is to understand the extent to which the sustainable land management can be a valuable solution to increase the mitigation potential of the land sector, particularly at small-scale rural landscape level.

The paper presents and tests a land-based approach to be applied at small-scale rural landscape level, aiming at reducing and offsetting GHG emissions from the livestock activities, one of the main sources of GHG emissions of the whole agricultural sector. The proposed land-based approach builds on an ensemble of methodologies, including Geographic Information System (GIS) elaboration, Life Cycle Assessment (LCA) and methodologies from the Intergovernmental Panel on Cliamte Change (IPCC), that allow to estimate the livestock GHG emissions and the mitigation potential of sustainable land-use options applied in the same small-scale rural landscape.

Results from a case study in Italy show that land-based mitigation options applied at small-scale rural landscape level can reduce and completely offset the GHG livestock emissions of the same area, leading to carbon neutral livestock systems. Thus, this study confirms that the land sector can strongly contribute to climate change mitigation if sustainable land-use options are applied.

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ORAL

Measuring methane emissions from ruminants. Transposing lessons between different methods of greenhouse gas accounting for ambitious climate targets

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Keywords: GHG accounting, carbon accounting, carbon credits, methane, ruminant, mitigation projects

Greenhouse gas accounting reported in several different ways. Reported estimates appear to be considerable opportunity for exploring discrepancies and transposing methodological approaches and lessons between various fields. Greenhouse gas accounting methods have developed among others at the scientific level, national level, the project level. This research paper identifies three different approaches using data from a dairy farm in the UK which are used for UK National Inventory methodology, an in-vivo scientific dairy study, and a VCS carbon accounting methodology.

Globally livestock contributes to atmospheric methane (CH_4) made by enteric fermentation. This has increased interest among policymakers and animal scientists to develop and improve methods measuring CH_4 production in ruminants particularly cattle. Direct measurement technologies have been used to estimate CH_4 production by measuring gas concentration and flux by the animals. In vivo studies have shown that enteric methane emission can be reliably measured by the state-of-the-art monitoring technologies. The objective of the study was to compare CH_4 production measured by direct measurements with equations predicting CH_4 production. The evaluation was based on a dairy study in the UK, in which CH_4 production was measured using a handheld laser methane detector (LMD) from individual dairy cows. Data from the same farm are used to predict methane production from intake and nutrient composition parameters following the methods described in the UK National Inventory Report and in the VCS carbon accounting methodology for ruminants. The results from the three approaches indicated that on average, the estimated enteric methane emissions are similar and the numerical difference was relatively small considering yearly emission estimates. The focus of this paper is on the lessons that can be shared between different methods to provide a positive and supportive reporting environment. Reporting is critical to increase participation in mitigation activities and facilitate continuous learning and improvement while also facilitating the delivery of potential policy-relevant project estimates through consistent carbon accounting.

ORAL

Local climate change adaptation in the mountain region: An indicator-based decision support system methodology

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Keywords: Adaptation, climate change, sustainable development, mountain environmet, decision support system

Several studies show that mountains have special vulnerabilities and are subject to specific impacts of climate change. Geographical factors make mountain communities around the world particularly exposed to both direct and indirect effects of climate change (Terzi et al., 2019). As a consequence, a focused selection of adaptation actions can be assessed as particularly suitable to be applied in mountain regions (Beniston, 2003; 2005; Palomo, 2017). To deliver a consistent and effective selection of mountain-oriented actions, tailored policies are needed to regulate the adaptive response in these territories, possibly taking into account the interlinkages between adaptation and other domains of sustainability. Based on the experience with the drafting of guidelines for regional adaptation planning for Regione Autonoma Valle d'Aosta (Italy), we propose a methodological reference process for the elaboration of climate change adaptation strategies and plans, and for the selection of actions to be considered in the alpine context. Within this process, three primary aspects of the territory under investigation are analysed: i) climate change scenarios and sectoral climate impacts (direct and indirect ones); ii) tools, territorial policies and governance systems (responsible offices); iii) climate change vulnerability and monitoring indicators. Data on scenarios and impacts were collected and processed from recent national and regional studies (AdaPT Mont-Blanc, 2018) for Valle d'Aosta region and aligned to the Climate Change National Adaptation Plan (PNACC; MAATM, 2017), Guidelines for the Local Adaptation of the Alpine Convention (LGALCA; Ballarin-Denti et al., 2014) and the ongoing experience of their application in the project for the implementation of the Budoia Charter (Cetara et al., 2020). Subsequently, based on the identified regional climatic scenarios and sectorial impacts, policy and planning tools were selected among the ones impacting the regional territory. Through a qualitative analysis, their suitability to processing responses and accepting coherent measures was assessed. Institutional competences in the regional administration system were detected too, aiming at proposing a system of competences and responsibilities for the regional implementation and monitoring of adaptation policies. Finally, the ability of strategic and planning instruments to grasping alpine peculiarities and properly integrating them into adaptation strategies was considered. The evaluation of the distinctiveness of the traits characterizing alpine territories, a complex and vastly intersectoral issue, is fundamental for a correct creation and application of adaptation strategies and plans. Assessments can be brought on both, in terms of territorial vulnerability to impacts and in terms of setting and monitoring the achievement of

resilience objectives (Eriksen & Kelly, 2007), but a standardized appraisal using indicators defined a priori is difficult to apply. Literature provides many indicators that can be used in the field of adaptation, but this abundancy of options does not necessarily represent a simplification of the process of identifying specific indices. Rather, the large amount of measures available can be confusing and make it difficult to select the most appropriate indicators (Ebi et al., 2018). These difficulties can emerge especially in the selection of indices referring to a lower territorial level (e.g. sub-regional and local) or to a specific spatial area (e.g. mountain, urban). All this can further complicate the process of creating adaptation tools and therefore the identification of specific objectives and actions. Despite this, an indicator-based approach can support a mutually enabling and effective interplay between climate change adaptation governance and the implementation of SDGs in a mountain area (Blyth, 2002; Engle et al., 2014). Thus, the general objective of the study is to provide a methodological approach capable of establishing a closer link between strategies for implementing SDGs and local strategies and plans for climate adaptation through a coherence analysis of the indicators adopted at different territorial levels and selected on the basis of specific criteria. The case with the SDGs and their use in national and regional strategies for sustainable development (ISTAT, 2020), as well as in urban studies and applications to the urban environment (e.g. C40, 2018; 2019) suggests that there is space for developing: i) an analysis of the multiple functions that the same indicators can perform to transmit information for different purposes in a mountain environment (e.g. assessment of the vulnerability / effectiveness of responses to adaptation / compliance to the SDGs); ii) an extension of the set of indicators used in the analysis of climate change and impact by including dimensions traditionally owned by the social sciences. This objective will be illustrated within the methodological framework developed with the main purpose of providing an all-encompassing decision support system (DSS) to regional/local administrations committed to frame climate change adaptation strategies and plans by elaborating and selecting suitable measures for mountain areas. We also suggest a few dimensions to be better investigated collected from other studies and experiences addressing both the local level and mountain sites (Master ADAPT; Barbieri et al., 2019). A better understanding of this potential could help build integrated dashboards consistently addressing sustainable development and resilience to climate change at the local level and allow regional and sub-regional decision makers to assess the progress and conflicts of their policy choices.

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ORAL

Anchoring transition imperatives within municipal structures: Resilience as a new method for public action

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Keywords: Resilience, public action, public management, public policy, systemic, integrated, expertise

Environmental logics have highlighted the need for enhanced reflection around cross-cutting issues. The environmental and social transition within the municipal context is often presented through emblematic projects and achievements rather than a strategic challenge for public transformation. The starting point of this paper is an exhaustive analysis of the environmental policy coherence of the City of Paris during the 2014-2020 mandate.

Environmental policies have been condensed within municipal documents (i.e. plans, strategies or roadmaps) operating like an instrument of politics and policy. The City of Paris' efforts to adapt the capital to future challenges have resulted in 38 municipal documents that include 1623 projects and

actions. The detailed analysis of these documents revealed that while policies are often coherent at the level of objectives, their implementation is slow, ineffective, and a source of political and administrative conflict. Their establishment also lack procedural legibility and traceability, especially considering the rise in power of environmental subjects within the directorates. The current model has thus proved to be unable to overcome the sectorization of municipal policies, which has resulted in an additional workload for the administration. The existing system, based on ad hoc actions carried out by specific directorates, does not offer an appropriate response to future risks. Twelve years after the first Climate Plan in France, it is necessary to anchor the social and ecological imperatives within the structure of municipalities

Having an environmental reflection implies giving new dimensions to public action. Municipalities are responsible for modernizing their functioning to respond to the following specificities of environmental phenomenon: anticipating long-term effects; integrating uncertainties; defining degrees of prioritization; having a cross-border vision; and creating a close link between policy and expertise. Moreover, the environmental transition cannot be considered a policy amongst others. Each public policy and action must integrate the logical framework of resilience into its design: agility, reflexivity, robustness, integration, innovation, inclusion. In this article, resilience is presented as an innovative method for public action because it relies on an integrated and systemic approach.

The study assists in overcoming these gaps by proposing a radical evolution in environmental governance to strengthen the capacity of municipalities to respond in a coordinated and coherent manner. Two main propositions follow from the analysis: the creation of new politics-policy framework, and the positioning of scientific expertise within the highest administrative level.

The new conceptual framework aims at integrating the objectives defined for mandate but also for 2030 and 2050 into a single resilience strategy. The relevancy to public action would be ensured by a strategic committee chaired by the mayor, similar to a deliberative structure with various actors involved notably the civil society. The novelty of this framework lies in the conceptualization of “resilience doctrines” as a set of mandatory criteria based on the political objectives defined in the strategy. These doctrines would cover themes close to urban commons such as air, water, energy, data. Their aim is to ensure that all policies contribute to resilience and maximize co-benefits. In this way, the scientific doctrines would implement coherent and comprehensive policies because they would guarantee the response to these issues at all levels of internal processes and with the same coerciveness as budgetary imperatives.

The second transformation consists in better integrating scientific expertise into public policy and action. This paper argues that the presence of scientific and strategic experts within the highest level of the administration would enable a better articulation and capitalization of the existing thematic knowledge. On one hand, grouping strategic expertise would make it possible to cross knowledge in order to conceptualize interdependencies. This is necessary to impel an integrated management as it requires an understanding of the feedback loops that manifest at the local level. On the other hand, the high positioning of strategic expertise would participate in democratizing scientific practices and creating a debate with contrasting points of view. Ideas and concepts abound in the domain and it is crucial to update scientific knowledge on local issues while maintaining a critical distance in the face of novelty. The uncertainties that may emerge between the disciplines can engage social dialogue and be the entry point of the debate towards the plurality of political choices. Moreover, their

positioning would be close enough to politicians to create a bridge between the two spheres and trigger rapid reactions.

The paper details an organizational logic that responds to the specificities of social and environmental transition. The findings entail the creation of an administrative entity that includes a scientific pole for the time needed to institutionalize the doctrines. The entity is doomed to disappear once the systematic consideration of environmental criteria has been established in each of the administrative branches.

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ORAL

Mobilising finance for hydropower to achieve sustainable development and energy transition

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Keywords: Climate finance, energy transition, SDGs, financial networks, hydropower

Clean and affordable energy is crucial to achieve a sustainable future. Despite being controversial, hydropower remains the predominant low-cost and reliable source of energy at global level. It stabilizes the provision of electricity and it bares the power peaks without losing efficiency. However, it requires huge upfront investments and patient functional capital. Under the Paris Agreement, countries committed to direct financial capital flows towards a low-emission pathway in order to enable the transition. Furthermore, the private capital strongly engaged in the road to a climate-smart economy. The aim of this work is to study the investment system behind hydropower, investors' behavior and the optimal allocation of finance to favor the deployment of capital flows. We use Bloomberg Energy Finance database to track public-private investments over the past century (1903-2020). We obtain 3610 financial transactions reflecting 3047 unique projects. We use network science to build a bipartite equity-debt graph and to perform community detection. We find that financial investors are highly localized, with continental players mostly interacting with counterparts in the same area of the world. We acknowledge a powerful exception: international organisations and multilateral banks are clustered together but connected at global level. They also tend to support low-income and fragile countries, meeting their mandate of sustainable development champions. Finally, we compute the most powerful investors in the network by applying a collective influence algorithm. These actors maximise the capital allocated and prevent the network from collapsing. Our results offer a novel approach to finance for the energy transition: it challenges the idea of more capital invested, and calls for a more efficient allocation of the available resources.

POSTER

Sustainable fashion for climate change

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Keywords: Sustainable fashion, climate action, fashion industry charter for climate action, faction pact

Sustainable Development means development that "meets the needs of the present without compromising the ability of future generations to meet their own needs." This is the definition of the World Commission on Environment and Development (The 'Brundtland Report') Our Common Future. The current International and EU legal framework is aimed to avoid global warming and climate change which have resulted in momentum for green and white economy. The European Union's 2020 Climate and Energy Package set three crucial objectives for 2020: a 20% reduction in EU greenhouse gas emissions from 1990 levels, raising the share of EU energy consumption produced from renewable resources to 20%, and improve of 20% the EU's energy efficiency. The new package Clean Energy for all Europeans contains even more ambitious plans, following the Paris Agreement. Clean Energy for all Europeans is a package of new rules aimed at providing the necessary legal framework to facilitate the clean energy transition that the European Union wants to lead.

The aim of the Paris 2015 United Nations Climate Change Conference COP21 was to achieve a binding and universal agreement on climate from all the countries of the world. International Treaties cannot be under force without ratification consequently soft law, lobbies and political pressure have paramount importance in order to implement them.

The whole world now finds itself in historically challenging times because of Covid 19, despite this, the fight against climate change cannot be delayed due to this health crisis. The pandemic is giving a big boost to plastic because of the paramount importance of personal protective equipment, masks that are single-use, increased usage of disinfectant and flushable wipes. The fight against climate change and the Covid19 recovery plans must be closely linked. This is time for action, for raising the ambition of climate action in the age of global emergencies and the fashion industry has a pivotal role.

The world can move forward and turn this health emergency into a jump into future technologies, new sources, infrastructures and accountable behaviours. Since Europe has been hit very deeply by the Coronavirus pandemic, the European Green Deal is a central element for a resilient and sustainable recovery.

Sustainability affected many fields in the past and now even more. Environmental concerns entered into businesses. Fashion, one of the largest industries in the world, causes social and environmental issues.

The fashion industry is the second-largest polluting industry in the world, it is second just to the oil industry. Fashion world is responsible of the 10% greenhouse gas emissions. "Ethical" and

"sustainable" fashion industry (a collection from sustainable sources and ethically produced) is gaining momentum for the consumers/buyers. Fashion is going from greenwashing to green thinking The new product is not always the best product, it would be better to invest on quality and on sustainable sources. Sustainable fashion is moving from a linear to a circular business model. Indeed the economy must be circular, the recovery of waste by means of recycling, re-use or reclamation or any other process in order to extract secondary raw materials, or use waste as a new source is now a compulsory duty.

The new rule of accountable fashion is vintage, a "trip back in time". Second hand, swap and slow is a new meaning of sustainable fashion, recycling now is fashion.

Also the lockdown changed the fashion industry, elegance after the lockdown is very basic, minimalist, comfortable, functional, handmade, with less environmental impact and with a sensibility for products which have a long life, no waste anymore. Fashion and luxury are becoming digital, because of coronavirus pandemic also collections are basic and with online showrooms. Fashion is also discovery of local realities.

The 2030 Agenda for Sustainable Development, adopted by all United Nations Member States in 2015, provides a shared blueprint for peace and prosperity for the whole planet. The Sustainable Development Goals recognize strategies that improve health and education, reduce inequality, preserve the oceans and forests and spur economic growth, all while tackling climate change.

In 2018, fashion stakeholders, under the auspices of UN Climate Change, worked to identify ways in which the broader textile, clothing and fashion industry can move towards an holistic commitment to climate action. Indeed the Fashion Industry Charter for Climate Action was created for these purposes and launched at COP 24 in Katowice, Poland, in December 2018, containing the vision to move towards net-zero emissions by 2050. Fashion industry needs to embrace a deeper, more systematic change and scale low-carbon solutions. The fashion industry stakeholders have a role to play in reducing climate emissions resulting from their operations, the majority of climate impact within the industry lies in manufacturing of products and materials. The Fashion Industry Charter for Climate Action contains a series of principles addressing climate change.

Sustainable Fashion addresses the whole system. Multi-sectorial initiatives are important in order to minimize the environmental impact fashion and textiles have across oceans, climate and biodiversity. A Fashion Pact for this reason was adopted, it wants to commit to sustainability targets that are needed to bend the curve on climate. It is not legally binding and can be seen just as a guideline.

The Fashion Pact is a global coalition of companies in the fashion and textile industry (ready-to-wear, sport, lifestyle and luxury) including their suppliers and distributors, all committed to a common core of key environmental goals in three areas: stopping global warming, restoring biodiversity and protecting the oceans. The Fashion Pact was presented to Heads of State at the G7 Summit in Biarritz in 2019.

Thus many initiatives were taken recently in the fashion industry to address climate change, following the Paris Agreement. Another one is the Green Carpet Fashion Awards which is taking place in the last years in Milan, it is kind of Oscar Gala for Sustainable Fashion.

The global fashion industry is one of the largest and influential industries in the world and is one of the most impactful thus should have a pivotal role for climate action and can give an important message to support a sustainable world in an effective way.

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POSTER

Climate change adaptation plan

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Keywords: Climate change, climate change adaptation, energy and climate policies

Climate change is a phenomenon taking place at a global level, now scientifically proven, irreversible in the short term, whose effects have already caused huge social, economic and ecosystem losses. Climate change adaptation strategies aim to reduce the vulnerability of systems exposed to climate changes, making them more prepared to deal with extreme weather phenomena.

The study focused on the Municipality of Malalbergo in order to understand how climate change affects existing natural problems, human life and its activities and, subsequently, what actions can be put in place to limit the danger and potential damage. The temperature, precipitation and evapotranspiration (ETP) trends were studied both in the Emilia-Romagna region and in the Malalbergo territory, comparing the period 1961-1990 with 1991-2015, and evaluating the areas of the territory most vulnerable to extreme weather events.

For some years now the municipality of Malalbergo has joined the covenant of mayors (covenant of mayor) and after having approved the SEAP (Sustainable Energy Action Plan), it also wants to implement the climate change adaptation plan, from here the name of SECAP (Sustainable Energy and Climate Action Plan). It will then be the responsibility of the municipality to implement actions aimed at the resilience of its territory, taking into consideration the assessments set forth in the adaptation plan.

There are two strategies defined at international level to deal with climate threats: mitigation, or the set of prevention actions that act on the causes of climate change with the aim of reducing CO_2 emissions into the atmosphere; and adaptation, which acts on the effects of climate change, with the aim of reducing the vulnerability of environmental systems and socio-economic sectors to the negative effects of climate change, limiting the damage deriving from present and future impacts and seizing any opportunity. The two strategies are not alternative but complementary: the greater the commitment to mitigation, the less adaptation needs and viceversa.

The ultimate goal is therefore to create a resilient world, lived by equally resilient citizens capable of resisting climatic variations and equipped with instruments to safeguard their planet.

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5 Urban areas: assessing predicting and managing the current and future risk

ORAL

Co-production of urban climate services under the SPF UK climate resilience programme

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Keywords: Urban, climate services, co-production, urban heat, urban climate services

Climate services provide tailored climate information to assist decision making (Hewitt et al., 2012). City based climate services are needed for day-to-day operations in cities, emergency response and to inform urban design and development (Grimmond et al., 2015). Furthermore, cities are identified as a critical global system that can accelerate and upscale climate action (Revi et al., 2018). Supported by the UK Research and Innovation (UKRI) Strategic Priorities Fund UK Climate Resilience programme, the UK Met Office has been engaging with local authorities in UK cities to co-produce prototype urban climate services to enhance the resilience of urban environments to climate variability and change. This presentation will introduce two prototype urban climate services that are being developed for UK cities with a focus on co-production with users.

In partnership with Bristol City Council, a "City Pack" has been co-developed comprising three non-technical factsheets explaining how the climate of Bristol has changed and is projected to change in the 21st Century. With users identified as city officials, city planners and the general public, the City Pack includes climate change trends for key climate variables as well as a basic explanation of the science behind the climate projections to enable robust utilisation of the results. The City Pack has enabled Bristol City Council to build a collective understanding within the council of climate change in Bristol as well as informing the city's climate resilience strategy.

Recent extreme heat events are likely to become more frequent over the 21st Century and exacerbated in cities due to the urban heat island effect. (Oke, 1982; Arnfield, 2003; McCarthy et al., 2019). Due to high population densities and a concentration of assets, urban areas are more vulnerable to climatic extremes with impacts that traverse health, infrastructure, built environment and economic activity (Revi et al., 2014). An urban heat climate service is currently under development in partnership with Climate Ready Clyde for the city of Glasgow in Scotland. This prototype is based on a strong requirement from a number of UK cities to develop an evidence base and understanding of current and future hot spots vulnerable to extremes of heat within the city. This service aims to combine high resolution observation and climate projection data to understand current and future extreme heat events and their spatial distribution across the city. Combined with population and socio-economic data an assessment of heat vulnerability can be conducted identifying priority areas for action within the city.

This presentation will introduce the two prototype services and focus on the co-production process with Bristol City Council and Climate Ready Clyde and reflect on user engagement activities to determine user needs.

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ORAL

Climate adaptation strategy development in small and medium-sized municipalities

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Keywords: Urban planning, climate change adaptation, stakeholder participation, small and medium-sized municipalities

Climate change presents many risks, especially for urban areas where the population and economy are usually centred. The adaptation efforts are mostly visible in large cities, where most of the know-how and resources are concentrated. Nevertheless, small and medium-sized municipalities often lack knowledge on regional climate, risks at the local level, and personnel and financial capacities to adapt to the intensifying threats. Adaptation strategies based on vulnerability analyses are tools guiding municipalities in a structured and organized way of integration of climate change adaptation into decision-making. To support stakeholders in carrying out and directing adaptation activities, it is crucial to ensure their participation in the process and involve them actively in the shaping of adaptation strategy. An adaptation strategy therefore requires participation of key decision-makers from a given municipality, ensuring that strategy will reflect specific local needs and challenges. Meanwhile, it is important to familiarise stakeholders with current climate change impacts, possible risks and vulnerabilities that the municipality may face in the near future.

The process of adaptation strategy development is demonstrated in the example from the Northwest Region, Czech Republic, which is located further from the mainstream adaptation efforts and know-how of larger cities. Focusing on the stakeholders' involvement, the outcomes from a participatory workshop will be discussed in terms of stakeholders' input to the strategy These inputs concern mainly the identification and mapping of the most threatened localities and prioritisation of suitable adaptation measures. Finally, short-term scenarios (until 2030) are co-developed to identify possible adaptation actions in the municipality, which can then provide a basis for adaptation action plans. The participation of stakeholders and authorities in the process of adaptation strategy development enables to integrate insiders' look into the local problems and leads to a tailored adaptation to climate change.

ORAL

Integration of heterogenous data to high resolution temperature maps for urban planning and management in the ClimaMi project

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Keywords: Urban areas, air and land surface temperature, satellite, co-kriging

In the ClimaMi Project (Lavecchia et al, 2019, https://www.progettoclimami.it/) specific attention is paid to climatological applications for urban planning and climate change in and around Milano.
During the first year the ClimaMi Project released a database (DB) obtained using high-accuracy (Curci et al., 2017) in situ measurements in the Urban Canopy Layer (UCL) of various climate variables, mainly by the dedicated and homogeneous urban network owned and managed by FOMD since 2011 (Borghi et al., 2014). The database includes almost hundred climatological variables and derived indexes. The main purpose of the database is to act as a useful tool for officials and professionals in the different fields of urban management and planning.

The second year of the project aims at producing high resolution meteo-climatological thermal maps - both air (AT) and land surface temperature (LST) - of the Milano built environment and nearby rural area, merging surface and space measurements.

The FOMD measuring network is relatively dense, with more than 20 automatic weather station (AWS) in the greater Milano area (8 are downtown). However, given the high variability and complexity of the urban structure, the FOMD network lacks in accurately describing and resolving the UCL for a number of important applications: therefore, other 40 AWS from third parties have been included in the analysis after evaluation of sufficient availability and accuracy.

To fill the remaining gaps several approaches are possible. In particular, the use of remote sensing techniques from space represents a unique opportunity to retrieve information from the thermal infrared spectrum. Nevetheless, the availability of this kind of data is severely limited by various factors, mostly the need of (realtively seldom) clear-sky conditions and the orbital constraints.

Anyway, in the framework of ClimaMi a methodology is developed to integrate in-situ and remote sensing measurements, in order to produce and release high resolution meteo-climatological thermal maps for the Milano and the extended urban area.

The adopted methodology can be summarized in the following steps:
- Definition of a time interval sufficiently long to usefully represent the present urban "climate" but as homogeneous as possible in terms of data: considering the ClimaMi DB and the availability of satellite data this interval has been set starting from mid 2016 and ending in mid 2019, for more than 3 years and 4 full summers. For some applications it could be extended back to 2012.
- Definition and selection of typical climatological situations of specific interest for urban applications, in particular Heat Waves (HW) and Urban Heat Islands (UHI) heavier occurrences.
- Choice of measurements from space (other possibilities have been omitted at this stage):

a) Sentinel-3 Land Surface Temperature (LST): low resolution (1000 m) but several useful images available in the selected time interval (https://scihub.copernicus.eu/).

b) Landsat-8 optical and IR channels: high resolution (100 min the IR) but less useful data available in the same period (https://earthexplorer.usgs.gov).

- Implementation and testing of a Split Window Algorithm (SWA) (Rozenstein et al., 2014) to retrive LST from Landsat-8 raw data.
- Implementation of a co-kriging method, using the in-situ measurements of AT as the primary variable and, as secondary variable, the satellite LST data (Van der Meer, 1993).
- Construction, via the co-kriging algorithm, of mean AT maps at the best possible spatial resolution for the selected climatological situations.
- Evaluation of uncertainties of the computed AT.

The result consists of an AT and LST Climatic Atlas of the greater Milano area, at a resolution (100 m) useful for decisions in management and planning by urban authorities, professionals and practitioners. It will be accessible through the ClimaMi web-portal by the end of the year 2020, integrating the already available DB.

In this paper some details of the developed methodology are explained and first results presented and discussed.

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ORAL

Flood hazard mapping in urban areas: Modelling perspectives under climate change

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Keywords: Climate change, extreme rainfall, flood hazard, flood modelling, flood risk, hazard maps, urban flooding

Urban areas are one of the most challenging environments to analyse in the general context of weather-induced risks, because of the typically high exposures in terms of people, buildings and infrastructures which, on one hand, increase risk levels (also according to their intrinsic vulnerability), and on the other hand, complicate local modelling operations (Vacondio et al. 2016). Moreover, for the same reasons, the assessment of local weather-related hazards and their impacts on urban areas is a complex issue which is currently the subject of cutting-edge research, especially concerning the identification and quantification of possible effects of climate change. In this context, urban flooding is considered, along with heat waves, the main source of weather-induced hazard in urban areas, and one particularly affected by climate change.

According to the Fifth Assessment Report (2014) of the Intergovernmental Panel on Climate Change (IPCC), intensity of precipitation events could be greatly impacted by the expected climate changes primarily due to the increase in temperature, entailing an increase in the atmospheric moisture retention capability. However, the effect of climate change on the rainfall regime of local areas is not straightforward, but deeply depends on the particular local features such as latitude, topography, distance from the coast. In this regard, Mediterranean area is recognized as an hot-spot for climate change; due to the very complex geomorphological features of the area, the adoption of downscaling (statistical or dynamical) approaches is required to properly assess the atmospheric patterns and the associated variations under climate change (Bucchignani et al. 2016). Over Europe, an ensemble of simulations coming from the application of different dynamical downscaling models is freely available within the EURO-CORDEX initiative, which is the current standard for climate change analysis over EU countries. The availability of multiple climate projections coming from different Climate Simulation Chains (CSCs) allows to quantify the uncertainty in climate modelling, that should be accounted for in impact analyses. In turn, spatial resolution of EURO-CORDEX simulations (about 12km) is still too coarse to be directly used in local impact analyses; in this case, bias corrections are usually performed using local rainfall observations, to adjust climate simulation results to the local rainfall regime (Cannon et al. 2015). Under the same constraints, given that the temporal resolution of EURO-CORDEX simulations is 1 hour, such a horizontal resolution allows for reliably estimating climate dynamics up to the daily scale. This poses additional challenges in modelling the effect of climate change on short-duration rainfall events, which are addressed by

current research by means of different approaches and techniques, generally oriented to the update of Intensity-Duration-Frequency (IDF) curves. However, the effect of climate change on rainfall events with sub-hourly durations, particularly critical in limited and impervious catchments, such as in urban areas, is still difficult to analyse.

Nowadays, a large number of models, codes and software exist that can be of aid in the investigation of urban flooding, with different purposes such as timely prediction, hazard/risk mapping, design of adaptation measures (Hammond et al. 2015, Di Baldassarre et al. 2018, Macchione et al. 2019). Even in case the hazard level is known (e.g. by means of current or updated IDF curves accounting for climate change), several challenges are posed in modelling by the amount and detail of data required by the code, the detail and variety of outputs, temporal and spatial resolutions involved, general unavailability of suitable data for validation. In this perspective, complex and detailed models could be unsuitable for large areas or when a high number of simulations is needed, as happens for scenario analysis. In this case, multiple simulations are run by perturbing one or more parameters, such as the input rainfall, with the aim of understanding the response of urban areas to different inputs or physical configurations (Hammond et al. 2015). The choice of a particular code should be a direct consequence of the main goal of the analysis (or, in other words, of the outputs expected by the modelling), the availability of required input data, the availability of resources (time, computational requirements, etc.).

In the present work, an approach is proposed that aims to model urban flooding in a pilot area within the City of Naples (Italy) with the general purpose of understanding the resilience of the area with respect to any variation in rainfall intensity, such as those possibly caused by climate change, and with the technical purpose of obtaining hazard maps by means of a scenario analysis. The pilot area, 150-ha wide, is a critical area in the eastern part of Naples, with several strategic items such as an hospital and the main railroad of the City. The input data available are the Lidar-based Digital Elevation Model (DEM), with a resolution of 1 m, and the Regional Technical Map, providing land uses and delimiting land covers. Basing on standard literature values (Wang et al. 2018), reference surface roughness and infiltration rate values can be assigned to each homogeneous land unit.

As concerns climate change modelling, the research builds on a novel methodology to understand the effect of climate change at the local scale, with particular focus on the update of IDF curves and on the preservation of the uncertainties derived by the use of 19 climate models provided by the EURO-CORDEX initiative (Padulano et al. 2019). As concerns flood modelling, two different codes are adopted in order to investigate differences in applicability, potentialities, results in terms of flooded areas and/or runoff volumes. The first code is CADDIES CAflood (Ghimire et al. 2013, Gibson et al. 2016, Guidolin et al. 2016), which performs a 2D pluvial flood inundation simulation using cellular automata techniques instead of solving the classic shallow water equations, dramatically reducing the computational load in comparison to a physically based model. The second code is based on the fully dynamic shallow water equations on unstructured grid solved by a finite volume method (Costabile et al., 2019). This numerical model has been developed and tested in several critical situations from a numerical point of view, proving to be stable and accurate. The detailed description of the physical processes related to runoff propagation makes this model the reference approach for accurate, high-resolution estimation of inundation risk in urban areas. Finally, the OpenMP-MPI version of this code allows significant reductions of computational times.

Both codes return, as main outputs, inundation and velocity maps, that can be combined to obtain hazard maps. Hazard maps give useful information about local risks, and they can also be synthetically combined with vulnerability information to obtain technical guidelines (AIDR 2017, Costabile et al. 2020). Results show that both codes are generally consistent in the distribution of water depths over the pilot area, whereas some differences in the distribution of velocities are expected because of the different rules for surface runoff propagation used by the two codes. In turn, this can translate in significant differences in terms of hazard mapping. As main conceptual goal, results show insights about the expected accuracy in hazard mapping when using codes with different level of modelling detail.

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POSTER

Anchoring transition imperatives within municipal structures: Resilience as a new approach for public action

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Keywords: Resilience, public policy, public action, municipal administration, expertise

Environmental logics have highlighted the need for enhanced political reflection around cross-cutting issues. The environmental and social transition within the municipal context is often presented through emblematic projects and achievements rather than a strategic challenge for public transformation. Furthermore, environmental policies are often condensed within municipal documents (i.e. plans, strategies or roadmaps) operating like an instrument of politics and policy. The starting point of this paper is an exhaustive analysis on the environmental policy coherence of the City of Paris during the 2014-2020 mandate.

Having an environmental reflection implies giving new dimensions to public action. Municipalities are responsible for modernizing their functioning to respond to the following specificities of environmental phenomenon: anticipating long-term effects; integrating uncertainties; defining degrees of prioritization; having a cross-border vision; and creating a close link between policy and expertise. Moreover, environmental transition and adaptation cannot be considered a policy amongst others. The current health crisis has demonstrated that when the territory is confronted to a major event, all the areas of action are impacted. This implies that each public policy and action must integrate the logical framework of resilience into its design: agility, reflexivity, robustness, integration, innovation, inclusion. In this article, resilience is presented as an innovative methodology for public action, because it relies on an integrated and systemic approach that combines climate objectives with social and development causes.

The emergence of municipal documents has illustrated the need to strengthen cross-cutting and cross-directional efforts to address ecological and social transition issues. The City of Paris' efforts to adapt the capital have resulted in 38 municipal documents that include 1623 projects and actions. The detailed analysis of these documents revealed that while policies are often coherent at the level of objectives, their implementation is slow, ineffective, and a source of political and administrative conflict. Their establishment also lack procedural legibility and traceability, especially considering the rise in power of environmental subjects within the directorates. The current model has thus proved to be unable to overcome the sectorization of municipal policies, which has resulted in an additional workload for the administration. The existing system, based on ad hoc actions carried out by specific directorates, does not offer an appropriate response to future risks. Twelve years after the first Climate Plan in France, it is necessary to anchor the social and ecological imperatives within the structure of municipalities.

The study assists in overcoming these gaps by proposing a radical evolution in environmental governance to strengthen the capacity of municipalities to respond in a coordinated and coherent manner. Two main propositions follow from the analysis: the creation of new politics-policy framework, and the founding of an entity that includes a scientific hub within the highest level of the administration.

The new conceptual framework aims at integrating all the objectives, defined at the level of the mandate but also for 2030 and 2050, into a single resilience strategy. The relevancy to public action would be ensured by a strategic committee chaired by the mayor, similar to a deliberative structure with various actors involved like the civil society.

The strategy develops into two hierarchical components: programmes by the executive and roadmaps for each directorate. The programmes aim at creating a common directory between the elected officials and the administration guiding the development of municipal capabilities (e.g. housing, transport). They are then translated into roadmaps to be carried out by the directorates. The novelty of this framework lies in the conceptualization of resilience doctrines as a set of mandatory criteria based on the political objectives defined in the strategy. These doctrines would cover themes close to urban commons such as biodiversity, air, water, energy, data, soil. Their aim is to ensure that all policies contribute to resilience and maximize co-benefits. In this way, the scientific doctrines would implement coherent and comprehensive policies because they would guarantee the response to these issues at all levels of internal processes and with the same coerciveness as budgetary imperatives.

The second transformation consists in better integrating scientific expertise in public policy and action. This paper argues that the presence of scientific and strategic experts within the highest level of the administration would enable a better articulation and capitalization of the thematic knowledge. On one hand, grouping strategic expertise would make it possible to conceptualize interdependencies as it implies to cross expertise. This is necessary to impel integrated management as it requires an understanding of feedback loops that manifest at the local level. On the other hand, the high positioning of strategic expertise would participate in democratizing scientific practices and creating a debate with contrasting points of view. Ideas and concepts abound in the domain and it is crucial to update scientific knowledge on local issues while maintaining a critical distance in the face of novelty. The uncertainties that may emerge between the disciplines can engage social dialogue and be the entry point of the debate towards the plurality of political choices. The grouping of the experts would be close to the politicians to create a bridge between the two spheres and provoke rapid reactions.

The paper details an organizational logic that responds to the specificities of social and environmental transition. The findings entail the creation of an administrative entity that includes a scientific pole for the time needed to institutionalize the doctrines. In other words, the entity is doomed to disappear once the systematic consideration of environmental criteria has been established in each of the administrative branches. The new administrative model is the logical evolution of the importance given to environmental issues that frames the climate emergency as a global issue.

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POSTER

Ephemeral gardens, or spaces of necessary happiness

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Keywords: Nature, future, ephemeral, happiness, project

The implications of the *Sars-CoV-2* pandemic event on humanity also affect the perception and dimension of public space and the city, altering the play and well-being field to issues connected with health security for people and with healthiness of the built environments. For centuries, we have imagined the city as the most surprising result of our intelligence and built objects that exceed, in size and complexity, any human artifact. Each city was the material manifestation of the way in which we represented our thinking, until the unleashing of the pandemic event destabilized that predetermined and rigid system, based on functions, and made the logic of living vacillate towards other paradigms of livability. New space apparatuses have become part of the environments of our daily life, public hygiene equipment, signals, warnings are temporarily allocated pending the hoped-for return to so-called normality.

In this time of pandemic transition, the necessary adaptation to the provisional can change from a health emergency to another occasion to project future scenarios, sustainable and safe in the different present. How can we renovate the public space without forgetting the beauty of goods and sites? It is no longer enough to change the geometry, but it is the very idea of *urbs* that must re-imagine the social life of the *polis*. Experiences of ephemeral installations drawn from the Art of Gardens are proposed as design stratagems through which to investigate visions and dynamics of coexistence, empathy, inclusion in a bio-centric perspective (*commune conversationis officium*).

Apparent form that transcends into another form, the ephemeral is the mutant of the species that creates bonds, unites and at the same time alters geometries and geographies. It is the emblem of the present time that insinuates itself into the anthropological dynamics to overcome the concepts of separation and fragmentation in favor of interconnection, interdependence, reciprocity. *Ephemeral Gardens* by the author are investigated as unitary phenomena in which the artifice becomes a spectacle. Places of exception and innovation live in a room for a specific time, tune different languages, recompose singularities in a plurality of senses. They are privileged microcosms in which the interaction between arts, knowledge and people produces a common world and ways of coexistence that can be transferred to other scales and other environments. Case studies from Europe, North America and Asia explore major international events and festivals that produce temporary modifications of landscapes in the sign of art and sociability, declining unprecedented intentionality and happy figurations necessary for the construction of imaginaries and values for contemporary cities and nature.

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POSTER

Fuzzy logic modelling to assess high resolution spatial urban climatic risk impact in Valparaiso, Chile

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Keywords: Fuzzy modelling, climate risk, urban risk

Climate change in cities affect differentially depending of multiples combination of social, economic and environmental parameters, which are in turn dependant on the degree of exposition, sensibility and adaptation capacity of the urban territories. Generally, adaptation plans and actions are most effective when they are performed at the local level, with a keen understanding of how risks interact with different areas and populations within human settlements.

Multiparameter and criteria methodologies are used to combine parameters to create high resolution climate risks analyses, to be able to visualizing patterns and distributions of exposure, sensitivity and response capacity in the territory, were the risk overlap and the interaction of this parameters is a fundamental analytical challenge.

This study illustrates the application of a spatialized fuzzy-set methodology to map climate risks in the Vina del Mar-Valparaiso conurbation, a coastal city in central Chile. Previous studies have shown that fuzzy-set techniques are particularly useful for climate risk assessment because they are able to combine quantitative and qualitative indicators of heterogeneous nature, source and scale in a comprehensive narrative on risk, one which is more immediately understandable and accessible to decision-makers and practitioners in charge of urban adaptation planning. The conceptualization of risk follows the 5th Assessment Report from Working Group II of the IPCC. On this basis, it employs a variegate set of climate, geographical, socio-economic, demographic, infrastructural and administrative data to tackle climate risks associated to heat waves, drought, landslides, fires, flooding and extreme tidal phenomena on the population, their dwelling, and key urban services.

The results allow to identify the influence and impact of climate hazards or combination of hazards on the territory at a resolution unprecedented in the country, considering this amount of information. Large proportion of the analysed territories exhibit high levels of exposure to multiple hazards, while other areas only affected by one or two of them. The suburban perimeter, mostly built on hills and gorges, is found to be the most vulnerable part of the conurbation across all threats. This occurs due to a combination of geographical factors (the presence of high slopes, exposure of hillside, type of ground cover, and others), a reduced coverage of emergency services and overall response capacity, and the generally higher socio-economic and socio-demographic vulnerability of the

population residing in those zones -both because of socioeconomic inequalities and of spatial patterns related to informal settlements, access to infrastructure and urban services..

The microzonification of the climate risk in these two important Chilean cities provided by this study provides key information for climate change adaptation and a model for the next urban plans in the country. Final reflections are provided on the need of further work on the conceptualization and analysis of how different hazards interact and compound one another, a necessary step to advance toward an integrated assessment to climate risk.

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POSTER

Mapping supply and demand of urban ecosystem services

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Keywords: Ecosystem services, supply/demand mismatches, mapping, urban planning

Urban ecosystem services are vital for residents' wellbeing. Well-functioning ecosystems can reduce many climate-related risks such as the magnitude of floods and heatwaves or the amount of air pollution, besides others. The provisioning of ecosystem services has been, however, on the decline as a consequence of increasing demand. Ecosystems are thus, under the pressure from depletion due to impacts of climate change, urbanisation and land competition. Often there is only a small fraction of ecosystems in urban areas, controversially, urban ecosystem services are especially important as there is an increasing number of people to whom the benefits should be delivered.

Despite the known benefits ecosystems provide, the provisioning of ecosystem services has not been on the agenda of many policymakers. Mapping of ecosystem service supply and demand is vital for informing policy- and decisionmakers about the areas where the ecosystems are lacking so that the residents are provided with an appropriate supply of services, especially in areas of vulnerable groups. The poster presents a review of methods for mapping of urban ecosystem service supply and demand and assessing mismatches on spatial scale while introducing a database of articles with a categorisation of data entry and brief scientometrics. The information on the methods of mapping of urban ES is discussed in the context of urban development and can contribute to better land-use planning in terms of equal and equitable ecosystem service distribution.

POSTER

Participatory foresight methods as a tool for climate change adaptation planning, the case of the Czech Republic

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Keywords: Participatory scenario building, backcasting, urban adaptation planning

Currently, several cities in the Czech Republic adopted or are preparing an adaptation strategy to climate change. As long as the climate change adaptation planning is rather innovation than a fixed practice in the Czech context, it is essential to establish numerous processes allowing for efficient implementation of the adaptation strategies. One of the key elements of such processes is cooperation among a relatively wide range of stakeholders (from different bodies of municipal government to members of civil society as well as to the private sector) in order to include and satisfy the preferences of the policymakers as well as the general public. However, due to the novelty of the topic, this cooperation often has often not been developed yet and its absence may potentially hinder the adaptation efforts. In such circumstances, participatory processes represent a suitable tool for stakeholders' engagement and allow to deliver mutual co-development of shared knowledge and the ownership over the decisions made.

The purpose of this contribution is to discuss the use of participatory foresight methods for enhancement and improvement of urban adaptation planning to climate change and for engagement of different actors. Drawing on the case studies from Prague, Brno, and Ostrava, the contribution aims to present a methodology of participatory workshops carried out in each of the pilot cities during fall 2019. The workshop's methodology addressed the need of stakeholders' engagement in climate change adaptation planning through their active participation in exploratory and normative scenario building by using methods of envisioning and backcasting. Such approach enabled structural thinking over the needs, challenges and opportunities of climate change adaptation planning as well as it allowed to elaborate on possible strategic actions for the near future (the year 2050). Although participatory backcasting is rarely used for urban adaptation planning elsewhere, the experience from the Czech Republic shows that it can become a useful tool for sharing visions and pathways across a wide spectrum of stakeholders. Therefore, participatory foresight methods allow to establish processes essential for reaching the shared vision of future sustainable development which considers preferences of a wide audience.

6 Climate related impacts on natural and human system

ORAL

An estimate of solar resource and PV power production over Italy in a changing climate

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Keywords: Solar resource, PV power production, aerosol, climate change, RCM, reanalysis

Among the mitigation strategies aimed at handling climate change, renewable energies assume certainly a key role. However, most renewable resources are dependent on weather and climate and it's important to assess how this dependency could affect the feasibility of future energy supply systems in a low-carbon strategy.

Several studies examined how Coupled Model Intercomparison Project 5 (CMIP5) Global Climate Models (GCM) project potential changes in surface solar radiation over the coming decades, and how this may affect, in combination with the expected climate change, future photovoltaic (PV) power production. In these studies the RPC 8.5 scenario shows statistically significant decreases in PV power production in large parts of the world, with few notable exceptions including large parts of Europe that show instead a positive trend.

The aim of this study is to assess the impact of climate change on solar resource and on PV power production over Italy using Euro CORDEX Regional Climate Models (RCM). In this regard, several studies show ambiguous results. Less recent studies considering a first subset of Euro CORDEX models

show a slight decrease of PV power production over Europe, especially in the northern part, with an opposite signal with respect to the GCM drivers. More recent studies, considering a larger and more recent subset of Euro-CORDEX RCM, show instead a positive trend of solar resource over Europe for aerosol evolving RCM models with a climatic signal more coherent with the GCM drivers. A negative and opposite trend is instead expected considering fixed aerosol climatology simulations.

In this preliminary study we start from a subset of aerosol evolving Euro-CORDEX models in order to assess a more reliable estimation of solar resource and PV power production over the Italian peninsula. This first analysis shows an increase of solar resource over Italy according with the signal of GCM drivers and with an important variability related to the type of RCM considered.

Next step is the use of a simple and widely used PV power model to assess PV power production over Italy, considering solar irradiance and other atmospheric variables affecting panel efficiency, namely surface air temperature and surface wind speed. To this aim, a bias correction of the RCM solar radiation and of temperature and wind speed is developed using the Climate Monitoring Satellite Application Facility (CM-SAF) Surface Radiation Data Set - Heliosat (SARAH) and the Meteorological Reanalysis Italian DAtaset (MERIDA), respectively.

ORAL

Trends of phenological response to climate change and orography in Central Italy

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Keywords: Phenology, altitude

Plant's life cycle, meaning phenology, is strongly influenced by the climate and the weather in which they are developing (Menzel [2002]). In the context of climate change, the impact of the warming has been widely recognized and assessed in literature on regional (Tomasi et al. [2011], Pudas et al. [2008]) and global scales (Menzel and Sparks [2006], Gordo and Sanz [2010]). An equivalent statistical analysis is proposed for the Umbria region in central Italy for two willow species (Salix acutifolia and smithiana wild) growing in three phenological gardens of central Italy, included in the International phenological Gardens network (IPG), with different height and location. The study focuses primarily on the impact of climate change on the plants phenological phases of the leaves unfolding BBCH11, and leaves falling BBCH95. In the past, statistical phenological models have been proposed to relate regional and global changes in climate and phenology. This has been done through the use of different standard climate indexes (Copernicus) and measured phenological phases of different cultivar and/or species, for long time series (Fraga et al. [2016], Ruml et al. [2016]). The same attempt is made here, hence the phenological observations have been statistically related to the standard climate indices calculated with meteorological validated data of the Umbrian meteorological network

(Cerlini et al.[2020]). The main result is an early occurrence of the leaf unfolding and a late occurrence of the leaf falling with warming. Furthermore, thanks to the locations of the gardens, it has been possible to study the Umbrian orographic modulation impact over the seasonal change of the temperature distribution. This is done through the elevation modulation on plant phenology. This is a peculiar and fundamental aspect of the regional climate. Indeed, the analysis has brought up evidence of a shift, in terms of several days, in the life cycle of the same species due to their height location. There is evidence of later leaves unfolding and leaves falling at higher altitudes. This type of project, like the ones focusing on the impact of climate change on olive oil, wheat, and grapevine (Graca [2019]); is becoming more relevant when considering agricultural activity in general, as a fundamental aspect for our society and economy. Within these premises lays the importance of this study, as the basis to implement adaptation/mitigation strategies.

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ORAL

Sustainable sport in a warmer world

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Keywords: Sport, climate change, sustainability

Climate change presents a significant and growing challenge to the sport industry, especially related to outdoor and winter sports. Sport activities have remarkable positive effect on our societies. Sport is a priceless resource to promote social inclusion at any level as it is able to bring together people from different cultures. Professional and amateur sport activities positively affect the people health and their physical and mental wellbeing. In addition, considering that, for example, in Europe, sport related activities provide five million of employees, sports is also an economical resource that generates a significant and positive induced effect. Therefore, due to the growing global environmental crisis and the more recent climate projections that provide a mean global temperature increase of 1.5°C respect to the preindustrial level between 2030-2050, we shouldn't ignore that the sport of the future could assume a new socio-economical role. The negative impact of climate change on sport events have been already highlighted. A large number of examples involved marathons, football, tennis and biking and winter sports such as skiing. Recently, all around the world, heat waves, anomalous high humidity, extreme fire events and hurricanes have affected the carrying out of sport events. The consequence for sport organizations are both cultural and economic, including lowered revenues, damage and destruction of facilities, events delay and cancellations, and an overall decline in interest in a sport. However, the climatic perspective should not overshadow the global environmental crisis that, acting in conjunction with climate change, significantly affect the sporting world. International institutions such as UNESCO, CIO and SANDSI drawn the attention at the organizers of sporting events for a greater awareness of the potential negative impacts on the environment due to the event itself. Therefore the promotion of novel methodological tools to plan and manage the events is essential. For example, high valuable naturalistic ecosystems are increasingly selected as location for sport events, since they are able to attract more participants and generate increasing economic benefits, but the use of pristine and vulnerable environments places crucial questions about sport sustainability.

Sport activity and related events are not only threatened by climate change or come across as a threat for the environment. Indeed, they represents an opportunity. Sport for Climate Action, for example, is an initiative that aims to leverage the global popularity of sports to promote concentrate actions to counteract the climate change and minimize the environmental footprint of sporting

events through the maximization of the use of power from renewable sources. Moreover, the development of low-cost sensors for environmental monitoring represents a great opportunity to involve the athletes and the participants to actively contribute to the monitoring of the environmental quality as an example of citizen science.

In this talk, we will firstly present an overview of the main effects of future climate changes on outdoor sporting events during the last decade and discuss their economical, cultural and environmental impacts on future scenarios. We aim to favor the opening a discussion about the role of the sport in the future involving the citizens, the athletes, the scientific community as well as the decision makers and the world of the sport industry.

ORAL

A climate of war or peace? Forecasting the effect of drought on conflict dynamics

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Keywords: Climate variability, drought, conflict dynamics, escalation, forecasting

A recent wave of studies on the security implications of climate change suggests that climatic variability has already increased the likelihood of conflict in the past and is expected to have even a higher destabilizing impact in the future. Although a considerable research effort has targeted the mechanisms connecting climatic changes to the likelihood of conflict, the majority of quantitative studies so far has focused on either the onset or the incidence of violence, to the detriment of assessing the role of climate shocks in enduring conflict dynamics.

In the present study, I forecast how climate variability, proxied by drought, will affect the dynamics of fighting and identify a set of mechanisms that may link climatic shocks to conflict escalation or de-escalation. On the one hand, droughts may escalate ongoing conflicts by lowering the opportunity cost of fighting, exacerbating pre-existing grievances, and/or or triggering looting over increasingly scarce resources. On the other, the occurrence of a drought may contribute to de-escalate violence, to the extent that climate-induced livelihood deterioration and resource deprivation may incentivize collective solidarity and boost cooperation to efficiently manage scant resources and thereby increase the chances of survival.

To this end, I build on the on the framework of the Violence Early-Warning System (ViEWS [1]) and produce a climate variability model that forecasts violence escalation in Africa up to 36 months from the present.

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POSTER

A Machine learning-based approach for water quality assessment: Exploiting functionalities of artificial neural networks in the Venice lagoon case study

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Keywords: Machine learning, eutrophication, climate change, multilayer perceptron, Venice lagoon

Eutrophication is one of the main processes leading to water quality (WQ) deterioration (e.g. proliferation of algae) in environments characterized by stationary water, resulting in cascading effects on the environmental status of natural ecosystems and their capacity to flow services for human wellbeing. Understanding and modeling these processes can be beneficial for both integrated water resources management and sustainability, as required by the Agenda 2030, the relevant EU acquis (e.g. Water Framework and Marine Strategy Framework Directives) and the new ambitious EU targets set through the EU 2030 biodiversity strategy (as part of the Green New Deal).

With the increase in volume, variety, and velocity of spatio-temporal data for environmental applications, and the latest advances in hardware and computer science, Machine Learning methods have started to be widely applied for analyzing eutrophication-related issues, overcoming limitations posed by traditional in-situ measurements. Drawing on these advancements, an Artificial Neural Network-based model, integrating data from monitoring stations, was designed and implemented for the analysis of changes in the Chlorophyll-a (Chl-'a') values used as a proxy indicator of eutrophication processes in the Venice lagoon case study. According to the spatio-temporal resolution of the data available for the testing case, the proposed Multilayer perceptron (MLP) model was trained, validated and tested taking into account 575222 WQ parameters' observations (e.g. Chl-'a', dissolved oxygen, turbidity), monitored across ten stations located in the Venice lagoon, over the 2013-2018 timeframe.

The performance of the designed MLP model in estimating Chl-'a'variations against the input data increased during the learning process with a final ~76% of prediction accuracy during the testing phase, making it ready for the simulation of potential 'what-if' scenarios (e.g. climate scenarios with increasing water temperatures). Despite constraints posed by input data, the designed MLP model represents a useful tool to identify key drivers of deterioration of natural ecosystems, supporting decision makers in the achievement of environmental and sustainability targets.

POSTER

Agricultural total factor productivity growth, technical efficiency, and climate variability in Sub-Saharan Africa

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Keywords: Climate change, data envelopment analysis, maize, technical efficiency, total factor productivity, research and development

Despite continuous reforms and increased spending in the agricultural sector, Africa remains a net food importer. Previous research has argued that agricultural productivity is lower in Africa than in all other parts of the world due to challenging ecological conditions – soil fertility challenges and extreme climate. Increasing the region's food supply requires significant increases in agricultural productivity, which in turn depends on investment in research and development (R&D). This study examines how climate variability (proxied by rainfall variability) affects agricultural total factor productivity (TFP) of maize in 14 sub-Saharan African countries (SSA). Maize farming in Africa – due to its significance in regional food production, evident climate variability, and the need to significantly increase efficiency – is an ideal region of investigation for climate impacts on maize production. We apply a Data Envelopment Analysis (DEA) on the Malmquist Productivity Index (MPI) to decompose productivity growth into technical efficiency and technological progress. In addition, a single-stage maximum-likelihood estimation of a true fixed effect was used to investigate how climate variability affects maize productivity through technical efficiency. The results show that climate variability has a negative effect on technical efficiency in the agricultural production of maize. Furthermore, increased spending on R&D is required to enhance technical efficiency and productivity.

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POSTER

Climate change, armed conflicts and resilience

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Keywords: Resilience, armed conflicts, natural disasters, climate change

In recent years, there has been rapid development of the literature linking climate change and armed conflicts. Although no conclusionary evidence has been found of a direct link between climate change and armed conflicts, still climate change has been addressed as an important trigger, exacerbating underlying social, economic and institutional conditions and thus resulting in higher risk and magnitude of violent activities. In this context, while more research is needed to further disentangle how climatic changes combine with socio-economic and institutional elements to induce conflicts, an important pathway to be explored is the role that resilience investments can play in preventing and/or breaking the negative relationship between climate change and violent activity. In this context, resilience refers to the capacity of a system to come back to its original conditions after a shock and relies on the combination of socioeconomic, institutional and technological dimensions. In our paper we provide empirical evidence on the role played by resilience-building investments in attenuating the emergence of armed conflicts as a consequence of climate-related anomalies and natural disasters.

POSTER

Climate variability, migration and population in Kenya

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Keywords: Kenya, migration, population, Census data, climate variability

Over the past decades, East Africa has faced both repetitive climate extremes (mainly droughts and floods), and changes in precipitation and temperature trends (Herrero et al., 2010; Gebrechorkos et al. 201 Over the past decades, East Africa has faced repetitive climate extremes and changes in precipitation trends (Herrero et al., 2010; Gebrechorkos et al. 2018), driving significant modifications of demographic patterns. Both climate change and variability alter incentives to stay in affected areas and can lead to domestic or international migration (Marchiori and Maystadt, 2012; Beine and Parsons, 2016; Barrios et al.,2006; Cattaneo and Peri, 2016). This paper studies the effects of past climate variability on inter-district migration and intra-district population, at the level of the 3715 Kenyan sub-locations.

This study contributes to the micro-oriented literature on climate induced migration (Dallman and Millock, 2017; Joseph and Wodon, 2013; Long and Siu, 2018; Strobl and Valfort, 2015; Hornbeck 2012; Lynham et al., 2017; Defrance et al., 2020), by decompressing history, using long term, local, precise and representative data (information at individual and household levels). We match, over twenty years, population data at the sub-location level, from three exhaustive administrative censuses (1989, 1999 and 2009), with high spatial and temporal resolution precipitation data sets from the Climate Hazard Center (CHIRPS-ERA) (high accuracy data, validated over the region by Dinku et al., 2018).

It is also a methodological contribution, advocating for the use of relevant climatic indicators and local demographic effects in order to understand the impacts of climate variability on internal migration. Particular attention is devoted to the analysis of climate variability and changes in precipitation trends over the country. Several indices are compared, such as drought/flood frequency driven from the standardized precipitation evaporation index (SPEI) (Vicente-Serrano, 2010), cumulative rains, number of dry days, the consecutive wet/dry day index (CWD and CDD), during critical Kenyan seasons (Gebrechorkos et al., 2018). The study shows that the semi-arid and arid region (ASALS) have known a significant decrease in the length of the agricultural period, a concentration of intense rains and an increase in extreme events since 2000s. Five major shocks are identified, with national coverage (1983/2000) or regionally clustered (1993/2004/2007). This study exploits both the temporal and spatial variability of rain fluctuation during the 1983-2013 period.

At the district level, a yearly panel on bilateral migration is built thanks to retrospective questions, and permanent migrations are distinguished from return/seasonal movements thanks to micro level data (the literature pointing different magnitude of effects between temporary and permanent movements Gray and Mueller, 2012). In line with Dallman and Millock (2017), the results suggest that climate events act as push factors on inter-district migration, rather than pull factors. The main limitation of this first analysis is the spatial resolution, increasing the risk of concomitance between climatic and economic variables, and erasing an intra-district migration which should be important in the hypothesis of short distance movements.

Thus, a second analysis is made at a much finer scale. A decadal panel fixed effect model, at the sub-location level, is used in order to understand the incidence of climate variability on migration behaviors and sub-location's population changes and to tackle endogeneity issues. A demographic decomposition of the induced migration is built according to gender, economic activity, age brackets and education level. The results suggest that an additional dry rainy season over the decade implies a decrease of -2 percentage points (p.p) of the decadal population growth rate, and that the induced migration is about 48 % female (so 52 % male), 95 % of the working population with its own business (such as agricultural holdings, proxy for individuals involved in agricultural activity) and 92 % in working age (no effects on inactive population and infantile mortality). Climate migrants have attended at least primary education, while the population from the low end of the skill distribution significantly stay in affected areas. A Difference-in-Difference identifies the effect in West-Center of the country, and mainly borne by rural sub localities where pastoralism in the main sector of activity, in line with an agricultural channel of the migration. 8), driving significant modifications of human behaviors. Both climate change and variability alter incentives to stay in affected areas and can lead for instance to two different adaptive strategies, domestic or international migration (Marchiori and

Maystatdt, 2012; Beine and Parsons, 2016; Barrios et al.,2006; Cattaneo and Peri, 2016). This paper studies the effects of past climate variability on inter-district migration and intra-district population, at the level of the 3715 Kenyan sub-locations.

This study contributes to the micro-oriented literature on climate induced migration (Dallman and Millock, 2017; Joseph and Wodon, 2013; Long and Siu, 2018; Strobl and Valfort, 2015; Hornbeck, 2012; Lynham et al., 2017; Defrance et al., 2020),by decompressing history, using long term, local, precise and representative data (information at individual and household levels). If local and long term information of such impacts is necessary to understand adaptation measures and long-lasting impacts, the data are not easily available at the good spatial and temporal resolution. In this paper, we match, over twenty years, population data at the sub-location level, from three exhaustive administrative censuses (1989, 1999 and 2009), with high spatial and temporal resolution precipitation and temperature data sets from the Climate Hazard Center (CHIRPS/CHIRTS-ERA) (high accuracy data, validated over the region by Dinku et al., 2018).

It is also a methodological contribution, advocating for the use of relevant climatic indicators (and data) and local demographic effects in order to understand the impacts of climate variability on internal migration. A particular attention is devoted to the definition of climate variability. Several indices over different time periods are compared, such as drought/flood frequency driven from the standardized precipitation evaporation index (SPEI) (Vicente-Serrano, 2010), the consecutive wet/dry day index (CWD and CDD), during critical Kenyan seasons (Gebrechorkos et al., 2018), or an agricultural indicator (the moisture index).

At the district level, a yearly panel on bilateral migration is built thanks to retrospective questions, and permanent migrations are distinguished from return/seasonal movements thanks to micro level data (the literature pointing different magnitude of effects between temporary and permanent movements (in Bangladesh for instance, Gray and Mueller, 2012)). In line with Dallman and Millock (2017), the results suggest that climate events act as push factors on inter-district migration, rather than pull factors. The main limitation of this first analysis is the spatial resolution, increasing the risk of concomitance between climatic and economic variables, and erasing an intra-district migration which should be important in the hypothesis of short distance movements.

Thus, a second analysis is made at a much finer scale. A decadal panel fixed effect model,at the sub-location level, is used in order to understand the incidence of climate variability on migration behaviors and sub-location's population changes and to tackle endogeneity issues. In order to estimate the magnitudes, and demographic decomposition of the induced migration, a demographic record of migration, according to gender, economic activity, age brackets, education of the household head -and other characteristics- is built. A heterogeneity of the migration response according to the type, size, and density of the sub location is also investigated.The results suggest that droughts during the rainy season affect the demographic movements unevenly over a decade. Induced outflows are increased by dry events occurring during the first period of a 10-year period, rather than more recent events, pointing a delay in the migration. This result holds in the heterogeneity analysis. The demographic account estimates that the induced migration is about 42 %female (so 58 % male),73 % of working population with its own business (considered as farmers in rural sub-localities), and 57 % of people aged between 10-50 at the first year of the period (the rest suggesting infantile and old age mortality).

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POSTER

Decomposition of the temperature-driven output losses in India: Plant-level evidence for the climate change adaptation policy

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Keywords: Climate change, industrial output, productivity, manufacturing, India

Although the vulnerability of the agricultural sector to global warming has been the focus of many studies, the response of the industrial sector to climate change remains poorly understood. This paper combines a plant-level panel data from the manufacturing sector in India over 1998-2007 with a fine-scale weather dataset to estimate the effects of air temperature on industrial output and to understand the mechanisms underlying temperature-output relationship. Specifically, we decompose the temperature's impact to examine whether it propagates through productivity or factor inputs. We then explore heterogeneity in the effects of temperature on output across firms, industries, and regions. The paper concludes by the discussion of climate change adaptation and policy implications of our results.

POSTER

Droughts and exreme events in agriculture: A comparison of three November-June periods in Italy

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Keywords: Impacts of extremes in agriculture, ETCCDI indicators, ERA5, SPEI, heavy rain, agricultural drought

1. OBJECTIVES

The poster describes an agrometeorological analysis carried out in Italy referring to the behavior of drought and extreme events of temperature and rain during the water recharge period (November-March), a very important phase for agriculture, and the evolution at the beginning of the growing season (April-June). The main idea is to test the relationship between some indicators of exposure (as defined by IPCC, 2012) of agriculture to the extremes and the relative impacts. For these reasons, the November-June period of the current agricultural season 2019/2020, with serious concerns about winter drought, has been compared to the corresponding periods of 2002/2003 and

2016/2017, the last well-known conditions of high impacts in agriculture with official declared states of emergency both for drought and heavy rains (Parisse et al., 2020).

2. DATA AND METHODOLOGY

The data source chosen for the analysis is ERA5 hourly data on single levels from 1979 to present gridded dataset of climate reanalysis (doi: 10.24381/cds.adbb2d47; accessed on 6th July 2020). The elaborations have been carried out for each month involved in the analysis, starting from hourly data. The agrometeorological indicator selected for drought is the Standardized Evapotranspiration Precipitation Index (Vicente - Serrano et al., 2010), calculated at a step of 6 months (SPEI6). It derives from the climatic water balance (CWB) calculated as difference between total precipitation and potential evapotranspiration, estimated through the Penman-Montheit equation (Allen et al., 1998). The SPEI value is calculated for each month by comparing the CWB cumulated values of the previous n months with the corresponding values of the reference period. In this study, the reference period chosen is 1980-2019 and n = 6 (more suitable to describe the agricultural seasons). The classes of SPEI values are reported in table 1 (WMO and GWP, 2016).

With reference to extreme temperatures and precipitation, the indicators have been taken from the works of Expert Team on Climate Change Detection and Indices (http://etccdi.pacificclimate.org/list_27_indices.shtml). The indicators based on statistical distributions at a local scale (percentiles) have been preferred, as also recommended by WMO for the assessment of extremes (Klein Tank et al., 2009), except for the indicator for extreme rains. This choice is linked to the climatic and agricultural heterogeneity of Italy, where fixed thresholds seem unsuitable to adequately describe the different conditions. The indicators investigated here to represent the phenomena in agriculture (hereafter, mentioned by their acronyms) are:

- Percentage of days when minimum temperature > 90th percentile (TN90), calculated for each month;
- Percentage of days when maximum temperature > 90th percentile (TX90), calculated for each month.
- The 90th percentile of each analyzed day is calculated on the distribution of daily values, as defined by ETCCDI, adopting 1981-2010 period as reference.
- Monthly maximum 1-day precipitation in mm (rx1day), potentially causing damage to crops and runoff loss. This indicator has been chosen with the aim to start investigating very concentrated rains.
- Data processing has been performed using the opensource software R (R Core Team, 2019) and in particular the libraries "climdex.pcic" e "SPEI".

3. RESULTS

The results obtained highlight several critical situations due to extreme events. The SPEI6 as indicator of drought presents a differentiated situation in time and space, but with a behavior that leads to widespread drought conditions in all the 3 Spring periods (fig. 1; tab. 2). In the current season, the SPEI6 value started to fall in widespread drought conditions in May (between moderate and severe classes) with some improvements in June. The values have been more critical in 2017 and 2003 in May and June (extreme drought in several areas). The evolution in the current season is similar to that of 2016/2017, when the drought "appeared" in April. The situation in 2002/2003 is quite different, with normal or wet conditions until May, when drought conditions started, concentrated in the North.

The elaborations of the indicators on extreme events can highlight specific adverse situations. Starting from the phenomena of extreme temperatures, the current season shows almost constantly extreme values both for minimum and maximum temperatures (figg. 2, 3). At the national level, TN90 and TX90 values reached the highest values in November (concentrated in the North) and in June (more distributed all over the country) (tab. 3). A different evolution can be observed in 2016/2017, with highest values of TN90 recorded in April, widespread all over the country, with peaks reached in the South in February. In the same period, the highest TX90 values have been recorded in April at national level, with peaks in the North-West in November. Even in this case, the season 2002/2003 seems quite different, with more normal conditions until Spring: TN90 and TX90 highest values recorded in March, concentrated in the South, and in June, in the North.

Over the months, several extreme rains occurred in 2019/2020, potentially harmful to agriculture. The rx1day indicator values are often more than 10 mm, a threshold commonly used for the definition of heavy rain (Klein Tank et al., 2009). The results show that in the current year more relevant events occurred in November and April (peaks in the North-West) (fig. 4; tab. 3). In 2016/2017, the same kind of events has been recorded in November, but in the South, and other localized events occurred in February (peak in the North-West) and March (peak in the North-East). In 2002/2003 the highest values have been recorded in May and June (in the North-West). These results seem to suggest that heavy rains can occur during drought, supporting the generally accepted statement that this type of rains does not substantially affect the CWB values (IPCC, 2012).

Lastly, cross-reading these data with the impacts of the official declarations for disasters in agriculture (until 2019), there is a quite full correspondence between SPEI6 values and drought declared impacts (damages) (https://www.politicheagricole.it/flex/cm/pages/ServeBLOB.php/L/IT/IDPagina/4616).

A correspondence of almost 77% has been found between the rx1day values > 10 mm and the declared disasters due to heavy rains. In November 2019, the 100% of declared disasters are related to high rx1day values (at the NUTS3 level, up to 62 mm).

4. CONCLUSIONS

The results seem to confirm the contemporary occurrence of extreme events in time and space (Donat et al., 2013), causing direct damages to crops and structures. Different situations have been highlighted during the analyzed November-June periods. In particular, 2019/2020 and 2016/2017 drought and extreme temperatures seem to be in some way linked, especially in the winter periods. Moreover, localized extreme rains are always present before or during the drought, potentially more dangerous than useful for the water recharge: heavy rains directly strike crops, increase runoff and erosion, especially on dry soils, also making the planning of agricultural practices difficult. Despite the climatic characteristics of the different parts of Italy (Esposito et al., 2015), with the South and Islands more arid, Northern Italy has resulted to be the area most affected by the last droughts and the co-occurred heavy rains. The events-impacts correspondence caught by the rx1day indicator suggests that the threshold of 10 mm could be a reference level also in the Italian agricultural areas. A deeper analysis has been planned to test further indicators and time scales, in order to improve the assessment of the extreme conditions.

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POSTER

Impact of heatwaves on stroke and heart attacks Sofia

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Keywords: Heatwaves, cardiovascular, heart and stroke attacks

The prolonged heat load on the human body caused by heat waves (which frequency, intensity and duration increases during the last decades) has an extremely negative impact on people, regardless their personal health status. People suffering from cardiovascular diseases though are amongst those under highest risk in hot environment.

The research examines the impact of heat waves on the number of patients with heart attacks and cerebral stroke diagnosis admitted in Tokuda Hospital in Sofia. The average number of patients during heat waves for the period from 2007-2011 was compared with that over the rest of the warm half of the year (covering the months from May to September inclusive). Patients are studied according to their gender, age and type of disease (cardiac or cerebral).

As a result of the analysis, we can summarize that there is a decrease of about 6% in the number of hospitalized patients in Tokuda Hospital diagnosed with myocardial infarction in hot flashes; at the same time of the admitted patients with cerebral hemorrhage, cerebral infarction and stroke increased in such hot periods by 6.4%.

The observed most intense (with maximum air temperature Tmax, 39.8° C) and prolonged (16 days) heat wave for the period from 2007 to 2011 in Sofia showed a decrease of 10.1% in the number of hospitalized patients diagnosed with heart attacks, while admitted to the hospital with stroke, cerebral hemorrhage and cerebral infarction increased by approximately 10% compared to the period without hot days of the warm half of the year.

POSTER

Impacts of Eastern Mediterranean transient on marine biota: A review

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Keywords: Eastern Mediterranean Transient, marine biota

The Eastern Mediterranean Transient (EMT) lasted from the late-1980s to the mid-1990s and appears as the major climatic perturbation of circulation and water mass properties of the Mediterranean in the past hundred years. About 20% of the waters below 1200 m depth horizon were replaced in the eastern Mediterranean Sea by younger waters of Aegean origin with an average formation rate (1.2 Sv) four times faster than the rate calculated for the Adriatic source waters before the occurrence of EMT. The consequences of the EMT continue also today and have spread in the Western Mediterranean basin.

A variety of altered biological processes have been recorded in the pelagic realm of the Mediterranean Sea after the 'EMT' onset and this review discusses them critically and relates the triggering of these climatic phenomena in the future with the possible impacts on the marine biota.

POSTER

Impacts of global climate change on duration of logging season in siberian boreal forests

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Keywords: Forest economics, global climate change, logging season duration, ARIMA modeling, Mann–Kendall test, wood industry, Siberia, Russia

In Siberia, the most part of boreal forests is located in an area with relatively moist forest soils that makes logging activities available solely in frost period with a permanent snow cover and stable sub-zero temperatures so this period, therefore, can be identified as timber harvesting season. As the global climate experiences the tendency of warming, it is reasonable to suppose that duration of logging season in Siberia might get shorter over time. To test this hypothesis, we introduce a concept for calculating the duration of the logging season for the largest Siberian regions, taking into account the economic and climatic peculiarities of doing business in these territories. The climatic data from Roshydromet were used to calculate the duration of logging season for eight representative stations in Krasnoyarsk Krai (Yeniseysk, Boguchany, Achinsk, Minusinsk) and Irkutsk Oblast (Bratsk, Kirensk, Tulun, Yerbogachen) for the period 1966-2018. Using Mann-Kendall test we found out strong evidence of logging season duration shortening for almost all considered stations with an uneven effect on the start and end boundaries of the season.

The main conclusions of our analysis are:

1. There are strong evidences of logging season duration shortening during the retrospective period of 1966-2018 for almost all considered stations. Although the considered stations are located in similar natural conditions, the local climate varies significantly and affects the economic potential of logging activity.
2. The gradual reduction of logging season durations has an uneven effect on the start and end boundaries of the season. Climate warming has almost no effect on the start date of the season in winter, but it significantly shifts the boundaries of the season end in spring.
3. Despite some limitations of ARIMA modeling framework forecasting performance caused by the lack of prolonged time series of temperature and wind speed available for calculating the logging season durations, a set of ARIMA models of acceptable quality was elaborated. These forecasting models show that in the nearest future the trends of gradual shortening of logging season duration will hold for the most part of stations. The most pronounced effect is observed for Achinsk station, where, according to our calculations the logging season will decrease from 148.4 +- 17.3 days during the historical sample (1966-2018) to 136.2 +- 30 days in 2028.
4. In our opinion, the identified downward trends in the duration of the potential logging season in the largest Siberian logging regions are a direct consequence of the global climate change observed during the period on which the database used was based.

5. From an economic perspective, shorter duration of logging season means fewer wood stocks available for cutting that would make companies unable to comply with their logging plans and lead them to suffer losses in the future. In this regard, logging companies will have to adapt to these changes by redefining their economic strategies in terms of intensifying timber harvesting operations.
6. The approach we elaborated in this study might be applied to prediction of establishment and then loss of ice roads to access remote mines and communities in circumpolar areas.
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POSTER

Initial analysis of essential climate variables from ESA's Lake_CCI Satellite data package

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Keywords: Climate change, lakes, essential climate variables, remote sensing

Lakes are key indicators of local and regional watershed changes, making them useful for detecting Earth's response to climate change (Adrian et al., 2009). Specifically, variables such as lake surface temperature, water level and extent, ice cover and lake colour are recognized by the Global Climate Observing System (GCOS) as Essential Climate Variables (ECVs) because they contribute critically to the characterization of Earth's climate (Woolway et al., 2020).

Lakes are already responding rapidly to climate change. Some of the most pervasive and concerning physical consequences of climate change on lakes are the loss of ice cover (Sharma et al. 2019), changes in evaporation and water budgets (Rodell et al., 2018; Wang et al., 2018), warming surface water temperature (O'Reilly et al., 2015) and alterations in mixing regimes (Woolway and Merchant, 2019). Variations in temperature and precipitation can profoundly affect the hydrological functioning of the lake and its catchment. Together with changes in ice formation, lake level and hydrogeochemistry the effect on lake ecological functioning can be significant (Adger et al., 2007; Cisneros et al., 2014). The thermal structure of the lake can be strengthened by an increase in temperature leading to deoxygenation and an alteration of nutrient cycling that in some case exerts a stronger control than trophic status (Rogora et al., 2018).

Lakes are of significant interest to the scientific community, local to national governments, industries and the wider public. A range of scientific disciplines including hydrology, limnology, climatology, biogeochemistry and geodesy are interested in distribution and functioning of the millions of lakes (from small ponds to inland seas) from the local to the global scale.

Future efforts investigating lake responses to climate change need to be grounded in sustainable, systematic, multivariate observations for a consistent set of lakes. One effort in this direction is the ongoing European Space Agency Climate Change Initiative for Lakes (CCI Lakes), which coordinates a range of remote-sensing techniques to address the lake ECVs identified by the GCOS (Woolway et al., 2020). An important aspect of efforts such as CCI Lakes is that they focus on maximizing the benefit of legacy Earth observations made over the past decades, as well as developing better observational capabilities from current and prospective missions (Woolway et al., 2020).

The overarching objective of the Lakes_cci project is to produce and validate a consistent data set of the variables grouped under the Lakes ECV. This includes aiming for the longest period of combined

satellite observations by designing and operating processing chains, designed to be ultimately feature in a sustainable production system.

The Lakes_cci develops products for the following five thematic climate variables:

- Lake Water Level (LWL): a proxy fundamental to understand the balance between water inputs and water loss and their connection with regional and global climate changes.
- Lake Water Extent (LWE): a proxy for change in glacial regions (lake expansion) and drought in many arid environments, water extent relates to local climate for the cooling effect that water bodies provide.
- Lake Surface Water Temperature (LSWT): correlated with regional air temperatures and a proxy for mixing regimes, driving biogeochemical cycling and seasonality.
- Lake Ice Cover (LIC): freeze-up in autumn and advancing break-up in spring are proxies for gradually changing climate patterns and seasonality.
- Lake Water-Leaving Reflectance (LWLR): a direct indicator of biogeochemical processes and habitats in the visible part of the water column (e.g. seasonal phytoplankton biomass fluctuations), and an indicator of the frequency of extreme events (peak terrestrial run-off, changing mixing conditions).

In this context, Lakes_cci represents a unique framework to provide consistent and homogenous data to the multiple communities of lake scientists. The project actively engages with this community to assess the utility and future improvement of Lakes_cci products.

Actually, at the end of the first year of the project, a first version of the dataset is available on the full suite of parameters from 2002 to 2019, with some parameters extending further back to 1992, on an initial set of 250 lakes distributed globally. The validation of each individual thematic variables is based on direct comparison between remote sensing products and *in situ* data or other remoting sensing datasets. A following step is the analysis of the consistency between these variables through five use cases (Greenland lakes; large lakes; Danube river-lake-lagoon; Long Term Ecosystem Research (LTER) sites; brownification in Scandinavian lakes).

Data generated in the Lakes_cci project is derived from data from multiple sensors and multiple satellites. LWL estimation is based on altimeters data gathered from 7 satellites (e.g. Poseidon, ENVISAT, Sentinel-3). LWE estimation is based on 8 sensors both SAR an optical onboard on different satellites (e.g. Landsat, Sentinel, ERS 1). The same typologies were used for LIC detection (e.g. Terra/Aqua, Sentinel-1). LSWT retrieval is based on 5 satellite observations (e.g. Metop A/B, Terra). LWLR data for the retrieval of chlorophyll-a and turbidity is based on optical data measured by 5 satellites (e.g. ENVISAT, Aqua, Sentinel-3).

A consequence of this diversity of products is that temporal and spatial resolutions as well as data availably of each component are not currently the same. The same a first-order harmonization of the thematic variables is ensured in each NetCDF file which contains all information available for each product. The uncertainty and data quality level estimation for each product included in the Lakes_cci climate data records is available for the users. The Lakes_cci products are open public and easy to access so that it definitely presents an opportunity for lake scientists and climate modellers worldwide to perform studies for which the five lakes variables might present an important dataset. In this conference we will present the project overview and progress with a focus on the preliminary results of the 5 ECVs at global level and in particular regions.

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POSTER

Invasive alien species and climate change

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Keywords: non native species, biodiversity, questionnaire, European Union, protected areas

Invasive alien species (IAS) and climate change are considered two of the major threats to local biodiversity, impacting the economy and public health. IAS can act as vectors for new diseases, cause the extinction of native species, change ecosystem processes, and reduce the value of land and water for human activities. Some of these impacts have prompted the EU to develop risk assessment programs that aim to halt new invasions and further expansion of previously established IAS.

The effects of climate change, such as the increase in temperature and in the number of meteorological extreme events, lead to higher instability of ecosystems and, as a consequence, may affect the range, abundance and impact of IAS. Climatic stress potentially creates new opportunities for introduced species as they can establish and thrive in new ecosystems, while the fitness of native species is weakened.

In general, the geographic ranges of invasive species that originate from tropical regions are expected to shift poleward and upward in elevation as the climate warms, adding new species to those currently being managed.

However, not all ecosystems are prone to new colonisations to the same extent: in the management of IAS, it is important to identify which factors determine the vulnerability of ecosystems favouring the establishment of IAS in new regions. This approach, combined with the study of the effects of climate change, may improve the contrast of biological invasions.

New challenges to the management of invasive species foreseen in the near future can be dealt with by better scientific knowledge.

In this scenario, the 5-year INTERREG European project INVALIS (Protecting European Biodiversity from Invasive Alien Species, https://www.interregeurope.eu/invalis/) aims to improve regional policies against Invasive Alien Species (IAS). INVALIS brings together 7 European partners: National Center for Environment and Sustainable Development (Greece), Lombardy Foundation for the Environment (Italy), Regional Ministry for Environment and Rural, Agricultural policies and Territory - Regional Government of Extremadura (Spain), Corsican Agency of Environment (France), Bucharest-Ilfov Regional Development Agency (Romania), Institute of Sciences, Technologies and Agroenvironment of the University of Porto (Portugal) and Zemgale Planning Region (Latvia).

INVALIS will enable the participating territorial Authorities to address common challenges associated with biological invasions, such as a) knowledge gaps in ecosystem vulnerability to biological invasions; b) lack of awareness about IAS environmental and socioeconomic risks; c) low level of cooperation between public authorities and key stakeholders for the implementation of IAS management measures; d) conflicts of interest between concurrent economic activities.

The aim of INVALIS is to contribute towards tackling these issues proposing an action plan that improve the addressed policies on biodiversity and environmental protection, supporting policy measures for the prevention, early detection, control and eradication of invasive alien species financed by regional ERDF funds. This is achieved by comparing effective tools and encouraging interregional cooperation to implement new relevant projects for the protection of biodiversity in environmentally sensitive (touristic) areas (e.g. protected areas and NATURA 2000 sites).
Moreover, INVALIS will allow the involved public authorities to share practices for a) evaluating natural ecosystem vulnerability to biological invasions, b) managing/controlling IAS introduction, establishment and spread in their regions' natural environments and c) mitigating the associated environmental and socioeconomic risks.

Based on the lessons learnt during INVALIS, the management of alien species in the project partners' regions will be improved in the following ways: i) selecting funding priorities for projects based on the vulnerability of natural environments to IAS (e.g. allocating more funds to interventions contrasting biological invasions in fragile areas); ii) establishing collaboration schemes between research institutes, public authorities and the management bodies of protected areas to support the

reskilling of their workforce on IAS management; iii) developing indicators for monitoring the effectiveness/efficiency of the IAS-related projects that have been implemented; iv) increasing the knowledge and the awareness of local Authorities, NGOs and citizen organizations on the risk posed by IAS.

The main role of the Lombardy Foundation for the Environment as a partner of the INTERREG project was to prepare a methodology in order to enable partners to collect information from their stakeholders: a common questionnaire was circulated to identify the factors that determine regional natural ecosystem vulnerability to the introduction and establishment of IAS.

We elicited the perceptions of 106 experts working in 56 protected areas (e.g. Natura 2000, Ramsar, Biosphere reserves) located in six EU countries to gather insights on the determinants of ecosystem vulnerability to IAS. The online questionnaire implemented by FLA helped us to understand: i) the expectations and perceived drivers of the future dynamics of IAS in protected areas; ii) the most common policy frameworks and management options used; and iii) the main challenges encountered when managing or preventing biological invasions.

The respondents represented expertise related to ecosystem vulnerability to IAS in 6 European countries/regions participating in INVALIS: Portugal, Extremadura (Spain), Corsica (France), Greece, Lombardy (Italy) and Latvia. Most respondents worked either as a director/manager or technical operator of the assessment areas.

Specifically, we asked experts to report their expectations for the risk of IAS introduction into assessment areas, considering the predicted future climate conditions, and the available options followed a Likert scale: "high", "medium" and "low", and "I don't know". Thus, we used experts' responses to this question as a response variable in a regression analysis to understand the drivers behind experts' expectations for the future introduction of IAS in assessment areas.

Most of the respondents indicated that the risk of IAS entry related to climate change into their regions is considered high (43.8%) or medium (37.1%); we also found that regions with increased expectations for future introductions of IAS (Portugal, Spain and Corsica) are insular or peninsular, rich in endemisms, and knowingly vulnerable to climate change and biological invasions.

Areas where the entry of IAS is expected to increase comprise: i) low to average anthropogenic disturbance; ii) average biodiversity richness, with endemic/threatened/protected species; iii) current presence of IAS; and iv) anthropogenic activities in surrounding regions.
Respondents expecting increased entrance of IAS in protected areas also consider corridors as the main pathway promoting their entry, whereas those expecting IAS entrance to decrease believe IAS enter protected areas mainly through intentional introductions.

Our results underline the complexity of IAS management, often hampered by the lack of clear policies, shortage of economic resources and specialised staff, and poor awareness of biological invasions, especially in regions with agreements on free trade and movement, such as the EU.
Future research should further strive to understand which ecosystems are more vulnerable to IAS, explicitly taking into account the effects of climate change.

Meanwhile, ecosystem vulnerability to IAS can be minimized through a stricter management of both protected areas and surrounding anthropogenic activities, and by raising manager and citizen awareness of the ecological and economic problems caused by IAS.

POSTER

Time of emergence of extreme climate-induced impacts

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Keywords: Climate change, time of emergence of climate impacts, climate risk factors

We introduce a concept of time of emergence of economic impacts (ToEI), which identifies the moment when the climate change impact signal exceeds a previously defined threshold of past economic output shocks in a given geographic area. We compute the ToEI using probabilistic climate change projections in three integrated assessment models of climate change: DICE, RICE and CLIMRISK. Our results demonstrate that, in terms of the business-as-usual carbon emissions scenario, the global economy could reach its ToEI by 2095. Regional results highlight areas that are likely to reach the ToEI sooner, namely Western Europe by 2075, India by 2083, and Africa by 2085. We also explore local-scale variations in the ToEI demonstrating that, for example, Paris already reached the ToEI around 2020, while Shanghai will reach it around 2080.

We conclude that ToEI methodology can be applied to impact models of varying scales when sufficient historical impact data are available. Moreover, unprecedented impacts of climate change in the 21st century may be experienced even in economically developed regions in the US and Europe. Finally, moderate to stringent climate mitigation policies could delay the extreme economic impacts of climate change by three decades in Latin America, the Middle East, and Japan, by two decades in India, Western Europe, and the US, and by one decade in Africa. Our results can be used by policymakers interested in implementing timely climate policies to prevent potentially large economic shocks due to climate change.

POSTER

The inter-twinned crises: COVID-19 and climate crises on the vision of the One-Health concept

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Keywords: COVID-19, one health, climate, crises

One Health is an approach that recognizes that the health of people is closely connected to the health of animals and our shared environment [1].

The "One Health" concept was introduced at the beginning of the 2000s. to summarize the idea that that human health and animal health are interdependent and bound to the health of the ecosystems in which they exist.

The One-Health concept fosters a collaborative, multisectoral, and trans-disciplinary approach - working at local, regional, national, and global levels - to achieve optimal health and well-being outcomes recognizing the interconnections between people, animals, plants and their shared environment [2].

At its core, One Health is rooted in the deep interdependence of human and natural systems.
Sometimes the concept of One Health is also coupled with the vision of Planetary Health.
Planetary health is a concept launched in 2015 by Rockefeller Foundation and The Lancet [2] that refers to "the health of human civilization and the state of the natural systems on which it depends". There is significant overlap between planetary health and traditional environmental health; both examine the relationship between human health and conditions and exposures originating outside the body, be they extreme temperatures, chemicals and biological agents, vector-borne diseases, or any number of other potential factors.
Before COVID-19 in recent years we have witnessed the spread of other viruses such as Zika, Sars, Mers, COVID-1 and H1N1. Each of them has a common denominator with the recent COVID-19: they have been transmitted from animals to men[3]. In fact, 70% of EID (Emerging Infectious Diseases - derives from a more or less direct interaction between wild animals that infect domesticated animals which in turn infect men.

The spread of viruses that in recent years has increased by 70% compared to the pre-industrial era is due to the exploitation of natural habitats, the illegal trade in wild species, deforestation and anthropic activities that cause an extreme exploitation of resources.

The concept of Planetary Health has properly derived by the assumptions that even if we can hardly assume that in the last thirty years the exploitation of the environment has contributed to human health, we finally reached a tipping point in which the exploitation of the environment began to have a negative impact on human health[1].

COVID-19 has given us a frightening proof of such assumption, in the form of the zoonosis phenomena.
Zoonosis is another name for a zoonotic disease. This type of disease passes from an animal or insect to a human.Standing to WWF Report [5] the distruction of ecosystem particullarly the forests can cause the diffusion of pandemic standing to the phenomenon of "spillover" [6] . Zoonoses become easier if there are less intermediate species to come to man, furthermore the illegal commerce of wild animals and parts of them is a way to increase the probability of the phenomenon. These assumption put the COVID-19 pandemic nearly close the framework of Planetary health, that by definition, explicitly accounts for the importance of natural systems in terms of averted cases of disease and the potential harm that comes from human-caused perturbations of these systems.

Being suppose to be an health crises indeed COVID-19 pandemic is very close to be also an environmental crises more on the vision of the One-Health concept interlinkages.
COVID-19 health crisis and the climate and environmental crisis have different interconnections, for different reasons and different aspects. The most near and immediate stands by the fact that the spillover phenomena that's worsen by the loss of biodiversity. Once erupted, the spread of the pandemic is also facilitated by the presence of large urban hyperanthropized centres and by

uncontrolled and hyperkinetic travels. Secondly, the global pandemic unveiled the strong effect that the biosphere can have on anthroposphere. Never before a biotic component (virus) has influenced and determined the state of the economic system so much. COVID-19 has also creating an education crisis. Most governments around the world have temporarily shut schools in an effort to enforce social distancing and slow viral transmission. [7].

From a physical and ecological point of view, this pandemic can be considered as a sort of self-regulation of the biosphere on the hard pressure of anthroposphere above a stable, and sustainable state. Such a self-regulatory mechanism can be thinly guessed by observing the effects of lockdown and COVID-19 widespread on air quality.

Studies on the Po' basin[8] has demonstrate that lockdown affected direct emissions of NOx and principal precursors (NH3,VOC,SOx and properly NOx) in relation to several sector (transport, agriculture, heating and industry). Total reduction has been estimated on being 40% for PM10 and 20% for NOx on the whole northern italian region. Same results has been obtained in China, region with a reduction of 20% of PM2.5 and PM10 in Wuhan during the first phase of the emergency [9]. Furthermore it is still on study the inverse relationship among COVID-19 mortality and morbidity due to air quality [10].

Thirdly, the clinical response to contain COVID-19 pandemic had to be conceptually ecological, science driven and community based. Health systems and decision makers had to face such emergency by applying measures like social distancing and lockdown. The shift in the the intervention stands in the fact the "cure", was not relied by the disease itself, like with a drug or a patient focused treatment, rather than to the systemic response of the community. The response was base in either technological, behavioural and proximity measures. Furthermore, due to the pandemic scale, governments needed to launch measures that were useless if citizenship would not cooperate and also, if al the governments of the world would not coordinate in the global response. The similarity to the climate change crisis and related response are quite impressive. Some authors defined COVID-19 as a test of what we would encounter if we do not address properly the climate crisis.

The last WHO estimates[11] says that COVID-19 reached 14.971.036 confirmed cases, 618.017 deaths in 208 countries worldwide since the start of the outbreak

Such a great human cost is the one that somehow can be associate to the action of biosphere on anthroposphere to rely on community resilience. These feature of human communities would be in the future a key point of healthy communities inside the One-Health Conception. The work will go into deep in such kind of relationship,focusing on air quality issues to drive societal and political suggestion for a resilient post COVID-19 reprise [12].

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POSTER

The effect of weather & farm management on cereal Yields in Ethiopia: A panel data analysis

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Keywords: Weather, climate, farm management, maize, wheat, agriculture, Ethiopia

The biophysical and socio-economic impacts of climate change are sought to be immediate and adverse in low-income countries in the tropics [1] with the projected impacts on the agricultural activities standing out [2,3]. Ethiopia is a case in point where not only temperature is projected to continue to rise and rainfall to become erratic as early as 2020s [4], and about 95 % of total agricultural output comes from virtually rain-fed smallholder agriculture [5]. The food security and poverty implications of the projected climate change are detrimental seen against the fact that about 60 % of the total grain production is consumed by rural households [5]. Considering this, the relevance of assessing the linkage between weather and agricultural yields is paramount to inform the current and the future of agricultural growth in the country.

Assessing the historical association between weather and agricultural yields, among others, will underpin the proactive adaptation planning in agriculture. This in turn will inform maintaining (or improving) agricultural yields in the face of climate change [6]. Both process-based crop models and statistical methods are widely used to investigate the historical association between crop yields and weather factors. Statistical methods include econometric techniques using cross-sectional [3], time-series [7], and panel [6] datasets. Likewise, previous impact studies for Ethiopia have shown the nexus between weather using both process-based crop models [8] and econometric methods [9] using plot and household level of information. On the one hand, usually plot-level data is not easily available. On the other hand, proactive adaptation planning by government agencies is indispensable in the Ethiopian context as farmers' adaptive capacity to undertake autonomous adaptation is very limited.

In such cases, studies based on information at subnational administrative units may be more informative than farm-plot or national-level studies.

This study aims to contributes its part to fill this gap. It combines spatially explicit historical weather data with agricultural data at district levels. The temperature (CHIRTS) and precipitation (CHIRPS) data are extracted from Climate Hazards Group University of California Santa Barbara. The original weather data (at 0.25° x 0.25° grid resolution) are aggregated to each district using raster package [10] in R programming language [11]. The district-wise crop yields and farm inputs data (2003-2016) are extracted from annual agricultural sample surveys by the Central Statistical Agency (CSA) of Ethiopia. The paper particularly focuses on maize and wheat crops. It employs a fixed-effects regression model. The models could explain nearly about 40 % of the yield variations (R2 = 0.4). The results show that the proportion of fertilizer applied area, farm size, and crop growing season mean temperature to positively and significantly affect both wheat and maize yields. Both precipitation and mean temperature influence maize yields positively and significantly (at 1% level of significance) while the influence of mean temperature are significant in the case of wheat (at 5% level of significance). The results for maize particularly remain robust across model specifications. The study results imply region-and crop-specific adaptation measures will be important.

The study adds to the existing literature which usually focus either on a specific country, region, or locality (for time series regression methods) or cross-country and household level studies (for cross-sectional methods).

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7 Risk and adaptation options in a warmer world

ORAL

Risks and options for action: a common equation for investigating analogies and differences between Covid-19 and climate crises

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Keywords: Risks, climate change, Covid-19, actions

The urgency of action to contrast climate change and its impacts is not properly understood by the population, not being grounded on a sound perception of the phenomenon. On the contrary, the urgency to act against Covid-19 epidemic has been promptly caught by common people and, often, also by policy makers around the world.

Why this difference? After all, from a scientific point of view it is possible to show that the two phenomena have similar dynamics and inertia. In fact, the natural evolution law of an epidemic is exponential if we do not act with social distancing or even "lockdown" measures; similarly, the increase in global temperature will be nonlinear if we do not strongly reduce our greenhouse gases emissions. Furthermore, in both cases there is an inertia, which leads to a delay between the date in which we act and the results of these actions: for Covid-19 this delay is about 15 days (the incubation

period for this virus), for the climate systems is several tenths of years (decades), because of the inertia due to the long persistence time of CO_2 in the system and to the slow response time of the oceans.

Of course, the incorrect perception of a phenomenon, which leads to a lack of urgency in actions, is also a sociological problem with many aspects: insufficient scientific culture, economics interests, ideological polarization, etc. Thus, we do not deal with it in this context. Here, instead, we would like to focus on the concrete possibility of actions to contrast climatic impacts, by performing a comparison between coronavirus pandemic risks and climate change ones in a common framework. For us, such a common framework is given by the so called "risk equation":

$$R = H \times V \times E,$$

where H = Hazard, V = Vulnerability and E = Exposure. As well known, this equation is frequently adopted in any risk assessment of natural hazards on territories and population. In this somewhat "conceptual paper" we limit ourselves to qualitative reasoning which, however, can shed light to analogies and differences between the two phenomena of interest and the various chances of action.

This equation "splits off" the risk in its main factors and, when applied to different fields, obviously the meaning of the single factors is not unique.

If we consider the risk coming from meteo-climatic extreme events - as in Pasini (2020) -, Hazard H measures the probability of occurrence of a phenomenon characterized by certain frequency and intensity. Today, owing to climate change, some phenomena, such as heat waves, are changing these characteristic features in many places of the world and their future behaviour is projected to increase in frequency and intensity, with a high level of confidence (IPCC, 2013). As for other phenomena, such as heavy storms, floods, tropical cyclones and even tornadoes, our confidence in a significant change is lower (especially as for their frequency, which critically depends on atmospheric circulation), but thermodynamic fundamental laws and numerical modelling experiments let us think of an increase in their future intensity as anthropogenic forcings will increase (Lebeaupin et al., 2006; Miglietta et al., 2017). Vulnerability V of territories crucially depends on the use of soils by humans. For instance, waterproofing by asphalt or concrete tremendously modifies rainfall absorption capacity of terrains, so that intense precipitation can cause violent floods and disasters. Anthropogenic land consumption is increasing vulnerability of terrains to extreme events and could keep doing it in the future if the unbalanced exploitation will continue. Exposure E depends on the presence of buildings, infrastructures and people. Anthropic activities tend to extend the presence of humans and their structures over lands, even vulnerable ones. If we will not follow strict rules and regulations, E will increase its value in the future.

With reference to a virus epidemic, instead, through Hazard H we estimate the "strength" of the virus itself and the frequency of appearance in our territory. In the case of Covid-19, we are sure that it is more dangerous than a typical winter flu virus and it is also more contagious than Ebola or SARS viruses, even if less lethal (Rajgor et al., 2020). Concerning its appearance, this seems quite random. However, some human actions, such as heavy deforestation in tropical countries for setting up monocultures and intensive livestock or expanding towns inside a forest, increase the probability of spillover from wild animals to humans (Allen et al., 2017; Rohr et al., 2019). Vulnerability V estimates

the vulnerability of the human body of a person in presence of Covid-19. One can be young or old, healthy or affected by previous diseases, maybe concerning respiratory system. In these different cases, the consequences of the infections can be more or less serious. In any case, the only direct way to reduce the factor V is to vaccinate population, but at present a specific vaccine (or therapy) for Covid-19 does not exist. Exposure E estimates the exposure to contacts with infected persons. As far as we currently know, the only way to reduce E is defusing physical connections by means of social distancing and isolating infected people. Actually, the principal measures adopted to contain the pandemic around the world were applied at this level, something that occurred in a traumatic and emergency way.

Even if the risk equation is quite simple and the hypotheses of its application are not always satisfied, e.g. the independence of probabilities, it can represent a useful tool for comparing Covid-19 and climatic crises.

In this framework, it is quite clear that, in order to reduce the urgent risk coming from Covid-19, our possible actions are very limited: at present, due to the rapid evolution of the pandemic, we have more chances to influence the factor E than the others, by regulating our contacts and social life. In a longer range we could stop our activities of deforestation and proximity with wild animals and, hopefully, develop a vaccine.

What's about the risk by climate impacts on territories? In this case, the previous analysis of the risk equation shows that we can act now on all factors, because each factor's value partly depends on our actions. Even if the inertia of the system (some decades) suggests us to act rapidly, however we can plan these actions until we are not in emergency, acting in many synergic ways.

In short, a unified scientific framework can help to achieve a correct perception of these two very impacting phenomena and shows that, even if climate change and its impacts are probably more critical and long-lasting than the contingent Covid-19 crisis, we have more instruments of action for reducing its risks.

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ORAL

Identification of adaptation measures to cope with sea level rise in coastal areas

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Keywords: Adapting policies climate change flood risk mitigation uncertainties sea level rise

In recent decades, extreme weather-related events have caused devastating damage worldwide, as happened in the United States (2005, 2008, 2012, 2017), in the Philippines (2012 and 2013) and in Great Britain (2014), showing how vulnerable coastal areas are (Aerts et al., 2014). The negative impacts of these events could worsen in the coming decades due to the rapid anthropic development of coastal areas, the population density in coastal areas is expected to increase by 25% by 2050, and to the rise in average sea level due, in part, to the melting of polar ice caps (Church et al., 2013; Lin & Shullman, 2017). In fact, future climate projections indicate that coastal regions will be faced with a general increase in the average sea level, as well as, an intensification of extreme meteorological phenomena that can increase the frequency and/or intensity of large-scale flooding (Giorgi et al., 2019; IPCC, 2013). Flood protection policies must be able to adapt to the non-stationarity of hydrological series (Milly et al., 2008). We therefore need to develop methodologies that help decision makers identify the optimal policies for adapting to the growing risk to the population and economy of most vulnerable areas (Doss-Gollin et al., 2019). In April 2013, the European Union formally adopted the Adaptation to Climate Change Strategy, in which the principles, guidelines and objectives of the Community policy on adaptation to climate change were defined. However, methodologies for long-term planning of adaptation policies are very challenging since they should be able, in uncertain future scenarios, to identify the best adaptation solutions to adopt and the right timing. However, future climate projections are affected by considerable uncertainty due to multiple factors: a) multiple future CO_2 emission scenarios; b) Structural and parametric and initial condition uncertainties climate modelling; c) discount factor changes due to market fluctuations. Different possible Representative Concentration Pathways were hypothesized in CMIP5 by IPCC, RCP 8.5, 6, 4.5, 2.6 corresponding at different climate scenarios (van Vuuren et al., 2011) that necessarily have to be considered equally probable. Within a given climate scenario a second source of uncertainty is inherent to the different characteristics of Global Climate Models (GCMs) and related simulations. Structural, initial conditions, parametric uncertainties affect the GCM simulations which represent climate evolution paths that can significantly differ even for the same emission scenario (Parker, 2010). To overcome that problem, ensemble of models is thus employed to go beyond a simple best-guess projection, in order to offer a probabilistic representation of climate projections. A further issue is due to the need, in order to explore possible adaptation policies at local or regional scale, to project values of the hydrological variables as temperature, rainfall or sea level rise at a finer spatial

resolution than that provides by GCMs. Due to the coarse spatial resolution in GCMs, such hydrological variables result usually biased. For instance, in CMIP5 GCMS, oceanographic processes are simulated with a horizontal resolution of 1 degree. This resolution is not sufficient to represent bathymetry variation affecting local processes like coastal currents (Holt et al., 2009), or small-scale processes like eddies (Penduff et al., 2011). Furthermore, structural errors in models of the sea level components are probable, as well as, systematic bias caused by missing process and/or feedback. Coupled atmosphere-ocean models have problems in simulating sub-surface ocean temperatures in the circum-Antarctic (Little & Urban, 2016), therefore corrections have to be applied to ocean temperatures at 400m depth to compensate model bias. Bias correction methods are also usually adopted to correct rainfall amount projections by GCMs, as well as, downscaling methods but both methods add further uncertainties (F. Cioffi et al., 2019; Orton et al., 2017; Orton et al., 2018). Finally, a further issue in the development of methods to identify the timing of flood defense works is the superimposition of natural variability cycles of hydrological variables to that due to climate trends. Natural variability that modulates on decennial or twenty years, could shadow the climate trends and make very difficult the identification of adaptation policies timing (F. A number of methodologies for the identification and the assessment of adaptive actions and works to cope hydraulic risks in coastal areas under climate change have been proposed in the past (Balica et al., 2012; Muis et al., 2015; Ramieri et al., 2011). Among the approaches which explicitly take into account the elements of uncertainty due to climate change we have the predictive top-down approach, most used, and the resilience bottom-up approach (Carter et al., 2007; Dessai & van Der Sluijs, 2007). Top-down methods take climate projections into consideration while bottom-up approaches are more independent of climate projections and could be used even without them. The predominant critique concerns the high expenditure of time to perform an assessment and the complexity of the system is too high for a proper comparison of all the drivers.

Furthermore, mentioned methods do not provide indications on the most appropriate planning time horizons within which to activate adaptation actions or to build flood defense infrastructures. In order to address those issues, i.e. the need to identify design and timing of defense constructions taking into account the uncertainties in climate projections, we propose a methodology that integrates, hydraulic modelling with multi-objective optimization approach. The multi-objective optimization problem is formalized defining two optimality criteria consisting in: minimizing both the cost of the flood defense infrastructure system and the flooding hydraulic risk based on the definition of Expected Annual Damage (EAD). The latter accounts the joint probability density functions referred to extreme rainfall, storm surge and sea level rise, as well as, the damages, which are related to a given defense system state, identified by water depth - damage curve related to the land use (CORINE Land Cover). The uncertainties in future projections above mentioned - uncertainties due to different emission scenarios and the ensemble of GCMs- are treated by time varying pdf's that are included in the definition of EAD. The decision variables of the multi - objective optimization problem are the size of defense constructions and their timing schedule. The input variables are the coupled heavy rainfall and storm-surge events as well as the average sea level rise as deduced by climatic projections. A hydraulic model for the assessment of damage is integrated within the multi - objective optimization algorithm (non-dominated sorting genetic algorithm 2, NSGA2, Deb et al., 2002). A set of optimal policies to mitigate the risk of flooding to aid decision makers are thus identify with

reference to a case study which is focused on Pontina Plain (Lazio Italy), a coastal region, originally a swamp reclaimed about a hundred years ago, today rich in urban centers and farms.

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ORAL

Coping with changing climate extremes in large regulated river basin

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Keywords: Water resources systems, multi-sectoral impact, robustness

In a changing climate and society, water systems operation can play a key role for securing water, energy, and food, and rebalancing their cross-dependencies across a range of time scales. Traditional management strategies are designed assuming that the statistical characteristics of future inflows and water demands will be similar to those of the historical record. This assumption is no longer valid due to the large degree of uncertainty about the future conditions, potentially causing declines in water resource system performance or even complete system failure. This is especially true for river basins with high intra-annual and inter-annual variability, such as monsoonal systems, that need to buffer against seasonal droughts and protect against extreme floods by timely adapting to changing timing, intensity, duration, and frequency of hydrologic extremes.

This study contributes an innovative method for exploring how possible modifications of the monsoonal cycle, induced by the changing climate, impact the robustness of reservoir operating policies designed assuming stationary hydrologic and socioeconomic conditions. We illustrate this analysis on the Red River basin in Vietnam, where reservoirs and dams serve as important sources of hydropower production, multisectoral water supply, and flood protection for the capital city of Hanoi. Building on recent bottom-up approaches based on exploratory modeling techniques, we first synthetically generate climate exposures for a range of plausible changes that extend beyond the

bounds projected by General Circulation Models (GCMs), and assess the associated system response along with the existence of critical thresholds for system failure. Then, we evaluate the plausibility of the generated inflow scenarios by driving a hydrological model with bias-corrected climate projections from 34 GCMs in the CMIP5 multimodel ensemble, each run with multiple initial conditions across all four representative concentration pathways.

Our results show that reservoir operations designed assuming stationarity provide robust hydropower performance in the Red River basin. However, increased mean streamflow, amplification of the within-year monsoonal cycle, and increased interannual variability all threaten their ability to manage flood risk and meet multisectoral water demands, exacerbating multisector trade-offs.

ORAL

Socioeconomic vulnerability to climate change. Poland case study

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Keywords: Climate change, socioeconomic vulnerability, Poland

From the point of view of origin, there are three types of risk associated with non-geophysical natural disasters:
- Meteorological - different type of storms, and tornadoes,
- Hydrological - floods and landslides,
- Climate - extreme temperatures, drought, and forest fires.

They often occur together and are associated with weather extremes. It is estimated that about 3/4 of natural disasters are associated with hydro-meteorological phenomena. Threats concern both health and life of people, as well as the condition of infrastructure and property of various economic entities and the possibilities of investing. It is estimated that since the 1980s, the amount of compensation paid for disasters caused by weather events has doubled every decade (indexed to inflation). The average increase in air temperature in Poland in the 20th century was 0,9°C (Kozuchowski, 2011) and further growth is expected. A number of days with a maximum daily air temperature exceeding 30°C will increase several times, and temperatures above 35°C may occur almost every summer. Weather extremes will cause a number of adverse changes in the Polish environment. An increase in temperature in spring and autumn will extend the growing season. However, biomass production by plants will be reduced, mainly due to the insufficient amount of water and the high temperature. Water scarcity will also contribute to the weakening of trees and increase their susceptibility to the development of fungal diseases and pest attacks (Kundzewicz, 2013). Warm, snowless winters interrupted by rapid temperature drops, without snow cover providing protection for plants, will cause considerable losses in agriculture and gardening. Similarly, an earlier beginning of the vegetation season will involve a higher probability of damage caused by spring frost. In addition, changing temperature extremes in Central and Eastern Europe can reduce

the amount of rainfall in the summer, increase the risk of forest fires, the occurrence of strong winds, and the development of pathogens (Srodowisko Europy 2015). Hot waves (less frequently cold), pose a serious threat to the health and life of the population, rather than to the material infrastructure (Heatwaves and Health, 2015). Despite that global warming will also entail certain limited economic benefits for Poland, e.g. lower expenditure on heating, the possibility to grow new plants or a longer vegetation period. However, the threats seem stronger than potential benefits (The Changing Wealth of Nations 2018).

The aim of the study is to determine the socioeconomic vulnerability of voivodships in Poland to the risk associated with climate change.

Extreme meteorological, hydrological, and climate phenomena observed in recent years, such as tornadoes, severe droughts, hailstorms, floods, including flash floods, landslides, confirm that climate change also affects Polish society and the economy. For example, a total of 24,000 families suffered during the 2010 flood, and the estimated losses amounted to more than PLN 12 billion. The same flood demonstrated the scale of the problem of landslides in the Carpathians. Approximately 1,300 landslides occurred at that time in Malopolskie voivodeship where 81 privet residential and farm buildings, two road bridges, school building, and 250 m of a county road were damaged. Estimated direct property losses amounted to PLN 25,9 million. Currently, it is estimated that the number of landslides in the Carpathians can be in the range of 50,000-60,000. "Landslide indicator" expressing the size of the area covered and threatened by landslides in relation to the total area is estimated in the Carpathians at 30-40% (https://www.gov.pl/web/klimat/gdzie-wystepuja-osuwiska-w-polsce).

Due to frost and hail in 2017 harvest volume in Polish orchards was 30% lower than average and PLN 45 million were paid by insurers to farmers. It is worth to underline, that only a small part of the affected area was insured (Climate of risk, 2019).

According to data from the Ministry of Agriculture and Rural Development at the end of September 2018, direct losses in agriculture caused by the 2018 drought amounted to PLN 3.6 billion and additionally PLN 1 billion of losses as the impact on other sectors (Climate of risk, 2019).

The example of flood 2010 has demonstrated the scale of lack of social awareness about the effects of natural disasters. From the total losses amounted to more than PLN 12 billion, only less than 13% of these losses had insurance coverage. Although Poles have twice as few assets as residents of the euro area a significant increase in earnings and capital accumulated in recent years was observed. The average household has 57.1 thousand euros in assets when the average per family from the euro area is 104.1 thousand euros. The development of infrastructure and the enrichment of society mean that the value of assets at risk, both private as well as state and municipal, is increasing. Poles remain one of the poorest nations in the EU, which can explain why the scope of private insurance is still low and the people expect help from the state (Climate of risk, 2019). It may come as a surprise that Poles ensure only 60% of their private real estate.

Research Method

The risk exposure of people, companies, assets, and socioeconomic vulnerability is highly spatially diversified. The synthetic measure of socioeconomic vulnerability (SMV) was applied to assess the exposure of particular voivodeships for the risks caused by climate change. The statistical data published by Statistics Poland were used (https://stat.gov.pl/en/). SMV is applied for the linear ordering of objects characterized by several diagnostic variables, which are later replaced by one

diagnostic value. The following diagnostic features (indicators) were applied: (1) percentage of the population aged 0-14 and over 70 as particularly vulnerable to risk, (2) population density (number of people per km^2), (3) population density in built-up and urbanized areas (number of people per km^2), (4) average gross salary, (5) percentage of employment in agriculture, (6) number of working doctors per 10,000 inhabitants, (7) number of inhabitants per bed in a general hospital, (8) confirmed landslide threat, (9) average expenditure on the regulation of rivers and mountain streams in 2014-2018 and (10) recurring significant floods in the 21st century. The variables were divided into stimulants (x1, x2, x3, x5, x7, x8, x9, x10) and destimulants (x4, x6). For indicators comparability, the normalization of diagnostic features was carried out using a zero-unitarization procedure. As a result of unitarization, the values of characteristics take the range . Then the destimulants were converted to stimulants by multiplying the data standardized by -1. The standardized sum method was further used. Higher values indicate a higher level of a complex phenomenon, in this case, a higher socioeconomic sensitivity to threats related to climate change.

Findings

As a result of the analyzes, the socioeconomic vulnerability of Polish voivodships to climate change was found. The greatest threats concern the Malopolskie, Podkarpackie and Swietokrzyskie voivodships, where adverse environmental and economic factors are intertwined.

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POSTER

Assessing the effects of urban morphology on air temperature in the Euro-Mediterranean context

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Keywords: Microclimate, urban morphology, air temperature, urban parameterization, housing blocks

Urban environment characteristics are affecting and in turn are affected by local microclimate, often resulting in negative consequences on human health and comfort. Land use change, high-density and multi-faceted buildings, and high concentration of people and activities in urban environments are indeed affecting the outdoor microclimate, resulting in a worsening of pedestrian thermal comfort and building environmental performance. For these reasons, urban features play a pivotal role in the city sustainable development as they directly affect its ecological footprint, metabolism and flow of resources (EEA, 2015; Musango et al., 2017). Investigating urban morphology can support the systematic understanding of urban features to characterize size, shape and structure of a city with all its constituent elements. In this sense, the presence of an evolving urban environment requires a quantitative approach to correlate variations in urban morphology to variations in microclimate conditions, providing an effective tool for steering future adaptation policies and design processes. This represents one of the leading principles inspiring the URBAN-PRO Strategic Project by REMHI Division.

The study of these interactions is largely supported by scientific literature, but there is a general lack concerning influence of urban forms on outdoor thermal comfort in Euro-Mediterranean cities. Recent studies adopt a morphometric approach to investigate mainly streets canyons (Andreou, 2013; Erell & Kalman, 2015) and vegetation types (Shashua-Bar & Hoffmann, 2000; Georgi & Zafiriadis, 2006; Shashua-Bar et al., 2010; Vartholomaios, 2015; Goncalves et al., 2019). Other works evaluate the impacts of building form archetypes or density features on cooling and heating loads, shading and daylight distribution in residential and office buildings. Despite the wide investigation on the relationship between urban geometry and microclimate conditions in open spaces, the contribution of geometrical characteristics of different urban block types is only introduced in works evaluating solar access and energy consumption in buildings. Works concerning the influence of urban blocks on outdoor thermal comfort in Mediterranean climate are even more limited and the typologies considered are not representative of the variety of urban forms that characterize Euro-Mediterranean cities (Shashua-Bar et al., 2006; Berkovic et al., 2012; Perini & Magliocco, 2014; Salvati et al., 2016; 2019).

Recently, Apreda et al. (doi: 10.1016/j.enbuild.2020.110171) have published the results of a deep research activity aimed at investigating performance and characteristics of typical Euro-Mediterranean housing blocks to highlight their effects on microclimate. Seven typologies (detached, attached, linear, U-shaped, block with courtyard, block with multiple courtyards, tower) are modelled

by adopting a parametric approach based on urban morphometric descriptors (density, land-use, canyon geometry descriptors) commonly used in urban and environmental planning. The modelling is performed with the Computational Fluid Dynamic (CFD) ENVI-met v4.4 model, considering three configurations of surface cover (0%, 20% and 60% pervious) and three wind direction (W, SW, S). For each combination, air temperature at pedestrian level (TA,1.6m) and descriptors are compared to highlight the microclimate performance of urban forms.

The study adopt the following methodology, consisting in a three-step process:

- Selection of the most recurrent housing block types in Euro-Mediterranean cities;
- Parametric modelling of the selected housing blocks and setup of the microclimatic numerical experiments;
- Microclimate analysis, with the comparison between housing blocks and correlation between TA,1.6m and urban morphometric descriptors.

The microclimate analysis is aimed at highlighting two thermal effects: 1) "built form effect", resulting from the comparison between impervious housing blocks, neglecting the effects of green areas; 2) "green cooling effect", resulting from the comparison between housing blocks with the same green configuration (20% and 60% pervious) and the impervious ones (0% pervious).

The main findings of such a parametric investigation highlight a close relationship between density, geometry and air temperature distribution, recognizing the perimeter type (which includes three block types: U-shaped, block with courtyard, block with multiple courtyards) as the optimal configuration. Furthermore, in some cases is clear the added value due to a reduced vegetation amount in limiting air temperature values, with economic benefits as cost reductions for implementation, management and maintenance.

Such a methodology could be integrated with further block typologies according to site conditions also outside of the Euro-Mediterranean zone. In this perspective, it is important to distinguish between strategies unlikely to be adopted for existing city, and strategies representing best practices to follow for the development of new urban centres or for recovery of underused areas. Such a differentiation should properly account for specific constraints. The analysis of key factors affecting the urban thermal environment represents a grounded theoretical basis for the improvement of design measures by integrating quantitative climate data in urban planning, architecture and environmental design, supporting both local authorities and practitioners to build resilient cities in a changing climate context.

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POSTER

Climate and ecological crisis: A systemic response to risks and vulnerabilities by strengthening sustainability, resilience and preparedness in Italy

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Istat

Keywords: Climate ecological crisis risk response systemic vulnerabilities resilience preparedness

The global crisis facing humanity today involves all areas of society, the way of life and the relationship between humanity and the environment. Climate change and the progressive decline of the natural environment is due to an unlimited and persistent exploitation, depletion and pollution of natural resources caused by human activities, which has reached unsustainable limits and is irreparably altering natural cycles, vital balances, ecosystems, the regenerative capacity and the quality of natural resources, facilitating the conditions that have allowed zoonotic diseases. The planet is a network of interconnected systems and the intertwining of natural and anthropic phenomena are multiple and

extremely complex. Drivers of climate change, environmental degradation, safety and health risks, converge in a system of multiple causes. Greenhouse gas emissions, deforestation, loss of biodiversity, soil consumption, pollutants, degradation are the main drivers of disruption and alteration of ecosystems. The resulting consequences have an impact on the capacity to ensure sustenance, health, safety and well-being for present and future populations, with repercussions that involve and intertwine social, economic and geopolitical spheres, causing negative chain reactions. This crisis is borderless and involves all territories, between and within countries, in the urgently needed and necessary transition to a new model of sustainable development that call for a transformation towards green, safe, faire and inclusive systems. Human health and environmental health are inextricably linked. Strengthening the resilience of populations, communities, territories and infrastructures to these threats and shocks is a priority at global and local level. 2015 was the year of the signing of three important international agreements that outlined the guidelines and strategies to be undertaken urgently to face the challenges of the future of the planet: the Sendai Framework for Disaster Risk Reduction, the Paris Agreement on Climate Change and the Agenda 2030 on Sustainable Development. These accords set out the path - that Europe is seizing with the Green Deal - to urgently tackle the global crisis with a coherent and coordinated systemic response to avert future risks. Disaster Risk Reduction models are useful in the context of the global crisis that include natural, biological, technological risks, providing the necessary tools to manage multi-risk systems at the different stages: impact/shock, response, recovery, risk assessment, prevention and mitigation, preparedness. To break the chain of the events it is necessary to strengthen the resilience of the entire system by intervening on risk determinants: hazards, vulnerability, exposure, capacity. Understanding risk is the priority of the Sendai Framework and the dissemination of awareness at all levels, avoiding misinformation (infodemic). The pandemic has highlighted the fragility of the entire system and unveiled how deep social and economic inequalities are, between and within countries; it has underlined how strong and complex are interconnection between the economic, social and environmental spheres and the need for a holistic recovery strategy, a One-Health systemic approach, Nature Based Solutions and Green Adaptation, to stop the destructive cycle, trigger positive chains and restore balance to protect the population and the planet. To address this challenge it is necessary to build taxonomies, cause-effect relations, maps of the network of interconnections between all the dimensions that constitute the infrastructure of life on earth in the different domains. This work aims at analyse risks and vulnerabilities in Italy, the improvements towards a more resilient and sustainable society, the progress fighting climate change, citizen's awareness and risk perception, the development in the areas that can contribute and that are relevant for a energy and ecological transition: decarbonisation, energy efficiency and saving, renewable energies, land use and soil regeneration, sustainable agriculture, circular economy, production and consumption chains, urban regeneration, combating pollution, investment in infrastructure, modernisation, innovation, social responsibility, vulnerabilities and resilience of social and health care systems, inequalities.

POSTER

Integrated application of ecosystem-based model and Bayesian Network on freshwater to explore the trade-offs among potential impacts and adaptation options changing world

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Keywords: Climate change, human activities, ecosystem services, water yield, nutrient retention

FreshWater Ecosystem Services (FWES) provides a wide range of services such as provisioning, regulating, and cultural services. Nevertheless, climate, land-use change, and human interventions are negatively affecting FWES on both supply and demand side. There is an urgent need to map and assess these services and their alterations, deriving from the abovementioned drivers, in an integrated manner, across domains of biophysical, socio-cultural, and economic methods. This information could help to protect the ecosystems and their services to maintain their essential contribution to human wellbeing and economic prosperity, especially in a rapid and unpredictable global change context. In this work, we developed a robust, consistent, transparent tool to map, quantify the absolute values and the changes of different ecosystem services, namely water yield, nitrogen, and phosphorus retention, under different scenarios until 2050. First, ecosystem services (InVEST) was calibrated and validated with climate (COSMO-CLM) and land-use data (LUISA) to map and quantify selected services. Second, outputs of the ES model were integrated into the Bayesian Network (BNs) model to investigate the changes induced by different learning techniques and input settings. After the calibration and validation of the BNs, thousands of different scenarios were simulated with multiple input variables configurations, thus allowing to describe the uncertainty of climate conditions, land-use change, and water demand. Two types of inferences were conducted, namely, diagnostic (bottom-up) and prognostic (top-down) inference. The former attempted to seek the best combination of the key drivers (i.e., precipitation, land-use, and water demand) so that ESs are maximized while the latter concentrated on the quantification of ESs under different scenarios. Finally, the values of selected services, deriving from different inference in BNs, were plotted in the space of ES to identify the pattern and trade-offs among services and among scenarios. This approach was applied and validated in the Taro River basin in Italy. The results showed that the values of water yield would decline in the medium-term period due to the changes in evapotranspiration demand and rainfall patterns. Regarding water quality services, total nitrogen retention would decrease while total phosphorus retention would increase in the future as the changes in land use patterns leading to the variation in nutrient sources. Moreover, the rate of change would be different over time, with the most pronounced differences between 2020-2030 and slower variations afterward. When exploiting the ES's space, the results of the BNs inferences demonstrated that there would be a limit

of space to improve selected ESs values, especially for nutrient retention services. The obtained results provide valuable support to identify and prioritize the best management practices for sustainable water use, balancing the trade-offs among services. This analysis allows decision-makers to build adaptation plans with a specific configuration of land-use and water demand to optimize relevant ESs within their basin.

POSTER

Resilience assessment for coastal systems to natural disasters: the case study of the Metropolitan City of Venice

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Keywords: Resilience analysis, disasters, climate change, risk assessment, risk management measures prioritization

Climate change represents one of the most challenging topics that humanity is facing nowadays. The significant increases in magnitude and frequency of climate-related disasters are placing considerable environmental, economic, logistical and, at times, social impacts upon coastal systems and communities. In light of this, there is the need to develop measures and strategies to increase the overall resilience to such events. The Metropolitan City of Venice and its Lagoon are closely interlinked and represent a fragile coastal-urban ecosystem, facing multiple challenges related to socio-economic dynamics (e.g. depopulation, transportation, industry, trade and over-tourism) and global change phenomena (e.g. sea level rise, increasing water temperature, heavy precipitations). For its particular position and structure, this case study is vulnerable to various types of risks occurring at different spatial (e.g. localized pluvial floods and windstorms, larger scale inundations) and temporal scales (e.g. frequent and sudden high tides, slower coastal erosion and subsidence processes). In this context, a scenario-informed multicriteria methodology was applied to the Metropolitan City of Venice to integrate qualitative (i.e. local stakeholders' preferences) and quantitative information (i.e. climate change projections) in a unique framework supporting the enhancement of coastal systems and communities' resilience to climate related extreme events. Different groups of local stakeholders (e.g. local authorities, civil protection agencies, SMEs, NGOs) were involved to identify critical functions (i.e. coastal systems and processes that are likely to be affected by extreme events) and propose strategic risk management measures to enhance overall system resilience under future climate scenarios. Most representative scenarios describing main climatic threats (e.g. storm surges, floods, heatwaves, drought) that could affect coastal areas of

interests were selected and represented based on projections of Regional Climate Models for medium term period (e.g. 2021-2050). Finally, a set of these measures proposed by local stakeholders were assessed and compared through Multicriteria Decision Analysis (MCDA) allowing to i) understand crucial interdependencies between critical infrastructures, cultural heritage, the environment and the society affecting community resilience to coastal disasters; ii) prioritize and ranking measures in term of their capacity of enhance coastal resilience across different climate change scenarios. In a first ranking of measures, based solely on local stakeholders' perspectives, priority measures belong both to the physical, cognitive and information domains. However, the introduction of climate change scenarios describing the occurrence of particular climate related extremes (i.e. storm surge, drought, heatwaves, pluvial flood) are likely to change stakeholders' priorities and rankings. Measures belonging to the physical domain are generally less stable even if they are within the top positions and thus their position can be strongly influenced by climate change scenarios, while cognitive and informative measures resulted quite stable across different scenarios. Results suggest that, in a condition of high uncertainty and climate variability, the optimal set of risk management measures should rely on a mix of cognitive and physical measures (i.e. updating ad implementation of plans and regulations (P3), Adaptation of hydraulic defence structures (P5), Civil Protection machine planning (P10)) in order to guarantee that the system is able to cope and adapt to the different typologies of extreme events which will potentially occur in the near future. Overall results provide first and quick screening on impacts of climate-change related extremes across multiple domains, supporting cognitive decision making during different life cycle stages of disaster occurrence. Such outputs can be particularly useful to address disaster risk reduction and climate change adaptation at the local scale permitting to plan for resources allocation in a way that economic losses are minimized.

POSTER

The impact of drought on the domestic water security of the Chilean population, in the context of climate change: A fuzzy-logic approach

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Keywords: Climate change, water security, risk, fuzzy logic, impact, drought

Climate change has brought a significant reduction in both surface and underground water resources in different regions of the world, in addition to increases in the frequency and intensity of droughts (IPCC, 2014). Chile displays among the harshest conditions of water stress at the Latin American level (WRI, 2015), currently intensified by an ongoing mega-drought scenario with rainfall deficits ranging from 25 to 45% in the central part of the country (Garreaud et al., 2017). Official figures indicate a

sustained decrease in the availability of water resources in of up to 20% in the southern macrozone and 50% in the north-central areas, expected to last in the next 30 years (DGA, 2018; DGA, 2019).

The limited and declining supply of the resource combines with a continuously increasing demand to respond to a variety of agricultural, industrial, domestic and cultural uses, resulting in a pending threat to the water security of the Chilean population. These hazards, in turn, are not experienced equally, but depend on the varying climates reigning throughout the territory and on pre-existing socio-economic, cultural and environmental inequalities, often deepened by the market-based model of water management. This situation, moreover, is made bleaker considering the projected increase in climate change and the current health crisis.

Considering this scenario, this research aims at assessing the consequences of drought on the water security of urban and rural populations throughout the country, generating maps of hazard, exposure, sensitivity and risk for each of the 345 municipal subdivisions of the country. This work was part of the Climate Risk Atlas (ARClim) project, carried out by the Center for Climate and Resilience Research (CR2) and the Center for Global Change UC, upon a mandate ofby the Chilean Ministry of the Environment (MMA) , with funding from the German Society for International Cooperation (GIZ).

In conceptual terms, the research embraces an understanding of risk as a multidimensional, complex and controversial problem, resulting from socio-environmental interactions (and thus, at least partially socially constructed) and subject to multiple and sometimes conflicting framings. Consistent with this, the study applies the methodology proposed by the IPCC (2014) and GIZ (2017) for the risk assessment consisting in the co-construction of an impact chain together with relevant experts, decision-makers and stakeholders, and providing an integrative view on the different factors driving vulnerability, exposure and threat, as well as those contributing to the resilience of different territories and the populations residing in them.

In methodological terms, the approach acknowledges the challenge of dealing with heterogeneous information (qualitative and quantitative, from multiple sources and with different degrees of spatio-temporal granularity), and the difficulty of aggregating and model such information across different territories. To face this challenge, the research proposes the use of a spatialized fuzzy logic approach, which offers a flexible standardization of variables of different types and values, favoring the construction of composite and comparable indicators and of coherent narratives more immediately intelligible to stakeholders.

Climate data were supplied by the ARClim project, based on modelling of a multiplicity of variables on temperature, precipitation, humidity and wind, among others, for the 1980-2010 period. Projections for the 2035-2065 period were also provided, by combining multiple models under assumptions consistent with the RCP8.5 scenario. The analysis combines this data (referring to the 'hazard' dimension of risk) with a fuzzy-set processing of a plurality of secondary data allowing to characterize the exposure and sensitivity of different territories in the face of these hazards.

The results show that drought concentrates in areas of the north and center of the country, being slight towards the south. In urban sectors, the sensitivity encompasses factors associated with the characteristics of the sanitation companies that are responsible for the collection, treatment and distribution of drinking water in households, together with the territorial conditions of vulnerability to droughts, such as water stress and on the granting of water rights, and aspects associated to the conditions of the households, e.g. the proportion of urban households that are outside the coverage

areas of the sanitation companies, which manifests the precarious urban planning of the cities in the face of the increase population and demand for services. Other sensitivities aspects considered in the study relate to socioeconomic, gender, ethnic and migrant conditions that, although not necessarily directly related to the threat, generally influence the vulnerability of the population. The northern and central areas of the country present the highest sensitivity figures, which decrease in the South.

In rural sectors, the main difference concerning sensitivity is due to the importance of the way in which the resource is managed and distributed to different users, often relying on self-organized Committees and Cooperatives, in turn inserted in a water market, which defines the right of use in an often unequal way. Considering the distribution of drought discussed above, risk rates are the highest in the central part of the country, between the regions of Tarapaca and O'Higgins region, with rural settlements in the Coquimbo and Valparaiso Region being especially affected. Consistent with the low level of relative hazard, southern Chile, although it has a significant rural population, displays lower levels of risk compared to the north of the country.

In a future scenario projected for the years (2035-2065), the high rates of water insecurity of urban households extend further to the south, reaching the Bio Bio region. As for rural households, we can observe the same trend, presenting an increase in the risk indexes of the central south zone, reaching high rates up to the Araucania region.

The absence of information or precarious levels of its digitization, limited the possibility of strengthening the investigation with indicators of over-exploitation of water rights or of the materiality of construction of water infrastructure, among others. However, the information that could be included in the study provides a first comparative picture on the distribution of water security risk in the country, providing indications for multi-scale public policies that can contribute to the reduction of said risk. Final reflections are advanced on the importance to explore the links between water security and other threats simultaneously affecting the same territories and populations.

POSTER

Climate change adaptation: Water reuse practices identified by AQUARES Interreg

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Keywords: Climate change, adaptation, water reuse, water reclamation technologies, water reuse practices

The threat to water security is one of the consequences of climate change [1]. It can negatively impact freshwater ecosystems by changing streamflow and water quality. There is high agreement that it can reduce renewable surface water and groundwater resources significantly and cause great variations in the availability of water in all the regions [2].

Europe's freshwater resources are under increasing stress, with a mismatch between demand for and availability of resources, across both temporal and spatial scales. Nowadays, water scarcity is affecting at least 11% of the European population and 17% of the EU territory [3].

In the face of vulnerability, there is a dire need for adaptation and for increasing resilience [1]. There existsa valuable portfolio of solutions for it; adaptive measures forthe management of freshwater resources include institutional interventions (for example, updating the legal frameworkand developing financial instruments) and operational interventions (for example, introducing water reuse, rainwater harvesting and desalination) which can be shaped for different economic and environmental frames [1].

While water reuse is an accepted practice in several EU countries, currently, just 2.4% of the treated urban wastewater effluents and less than 0.5% of annual freshwater withdrawals are reused annually. The EU potential is estimated to be much higher, almost six times the current volumes[4]. However, the increase in water reuse at the EU level is dependent on many local specificities and, additionally, exploiting this potential often requires toovercome economic barriers, information failures and unfavourable policy settings [5].

EU water policies indicate the reuse of treated wastewater as an alternative source of water [6] but, at date, the only legal instruments for Europe as a whole are the Regulation (EU) 2020/741 of the european parliament and of the council of 25 May 2020 onminimum requirements for water reuseand the Council Directive 91/271/EEC of 21 May 1991 concerning urban waste-water treatment under which Member States are allowed not only to collect wastewater from big scale agglomerations but they are also not prevented from the application of local scale schemes [7]. Indeed, a diversification strategy targeting both approaches, is extremely important because beyond the advantages of dominant uses of reclaimed water at large scale, the growing local competition would benefit from it [5].

Among the efforts of the EU, which is constantly updating water reuse knowledge, there is AQUARES. The project is part of the program Interreg Europe; it has started in June 2018 and, after approval, it

will proceed in its second phase until May 2023. It brings together 10 partners from 9 countries[1], to join forces and exchange local scale experiences so that to identify viable water reuse strategies, secure the protection of water bodies and promote public dialogue to address conflictinginterests in the water reuse sector [8]. These objectives will be achieved through a series of activities, financially supported from European Regional Development Fund, which will be included in 9 regional Action Plans [9, 10].

During the current first phase, partners have collected examples on water reuse technologies that are being applied or being proposed in the EU, by creating a guide targeted to public authorities. The practices have also been evaluated to identify which would better work for each region and sector, as water reclamation entails various treatment processes, suitable for different purposes [11, 12].
Italy has more than one distinctive example of wastewater treatment plants (WWTPs). The most recognised is the Nosedo municipal WWTP. It purifies about 50% of Milan total urban sewage, then conveyed back into the existing hydrographical system [13].Follows, the Milano San Rocco municipal WWTP, which cleans water for agricultural irrigation, making a significant contribution to water resource conservation [14]. The examples in the above paragraphs allows for excellent results of water reclamation, mainly in agriculture. Not surprisingly, the Regulation (EU) 2020/741 sets out harmonised minimum water quality requirementsfor the safe reuse of treated urban wastewaters in agricultural irrigation. This policy background promotes but also clarifies a set of roles on this specific water reuse instrument paving the way for its application.

In addition to the most applied methods for water reuse, is worth noticing how less widespread local technologies play an important role in reducing communities' dependence on water. All partners in the project have indeed expanded the inventoryof water reuse practicesby reporting and promoting local scale schemes with agricultural, industrial, leisure and domestic applications. Examples from them are sewer-mining decentralized wastewater reuse technologies whose output can be used for local non-potable uses, on-site technologies enabling the recovery of treated wastewater in textile factories or ultrafiltration membrane treatment systems that enables the release of bathing quality water into resorts natural environment and the irrigation of golf courses [11].

Lombardy Foundation for theEnvironment, with the aim of highlighting this potential has brought attention on Italian local water reuse practices. In Apulia region an agro-food industry is achieving a reduction in its water withdrawals. It reuses part of the wastewater produced during processing and packaging operations to irrigate its own fields through a full-scale tertiary treatment [15].
Another scheme applied in an alpine hut in Veneto region allows to mix black water with grinded kitchen wastes and yellow water, in order toproduce biogas for kitchen and heating uses, through he separation of wastewaters at the origin and on a decentralized and flexible treatment system [16].
A condominium in Milan, has installed a greywater and whitewater recovery system obtaining a 50% reduction in drinking water consumption. Through different levels of filtration and sterilization, water is returned to a state suitable for subsequent reuse, for example for garden irrigation or toilet flushing [8].

These, and other examples that could be added, show that at such smaller scales, an increased rate of water reuse could significantly contribute to reduce water scarcity, as demonstrated in the regions that already use this alternative supply solution [5]. It is even more important considering these opportunities in a country where the territorial pattern is mainly organized on small scale, as

Italy is. The contribution of water reuse to address water stressneeds to be analysed at a national, regional and river basin scale to take account of geographical characteristics (for example, the distance between offer and demand) [5]. In the view of climate change effect on water availability, the implementation of different adaptation strategy, would be more beneficial and these different approaches, would be more and more effective if favourable regulations will let them flourish. This is what AQUARES is working on, increasing awareness and consensus on water reuse among local stakeholders and encouraging the adoption of policies fostering the efficiency in the use of water.

Note:

[1]Partnership: Regional Government of Murcia, Ministry of Water, Agriculture, Livestock and Fisheries, General Direction of Water (Lead Partner-Spain); Ministry of Environment and Energy, Special Secretariat for Water (Greece); Lodzkie Region (Poland); The Regional Development Agency of the Pardubice Region (Czech Republic); Energy and Water Agency (Malta); Lombardy Foundation for the Environment (Italy) which participates with the support of Region Lombardy; Water Board of Oldenburg and East Frisia (Germany); Euro-mediterranean Water Institute Foundation (FIEA) (Spain); Association "Baltic Coasts" (Latvia); The Municipality of Trebnje (Slovenia)

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8 Climate action: societal transformations and behaviours

ORAL

Facing the hard truth: Evidence from Climate Change Ignorance

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Keywords: Climate change, climate beliefs, mass layoffs, coal

Public ignorance around climate change remains high in many countries, including the United States, where in 2019 only 67% of adults reported to believe that global warming is happening. In this paper we show that information avoidance aimed at protecting identity contributes at explaining climate ignorance. Exploiting mass-layoffs of coal miners in the US and a difference-in-differences design we find that climate ignorance shrinks less in counties affected by the layoffs as compared to other coal-mining counties. An instrumental variable strategy that uses geographic variation in gas prices to predict mine closures strongly suggests that the layoffs causally impact beliefs about climate change. We also employ a triple difference-in-differences strategy that compares layoffs from coal and metal mines to understand the underlying causes of persistent climate change ignorance in communities experiencing layoffs. Our triple difference results confirm that information avoidance is specific to coal-mining communities suggesting that protecting identity plays an important role.

ORAL

Climate regime shift and mental health adjusment

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Keywords: Climate change, tipping point, climate regime shift, mental health, adaptation and adjusment

A climate change can be regardedas a critical shift challenging both complex civilized and developing societies, with paramount effects, such as social disruption and political collapse. The assessment of possible future ecologically critical climate conditions requires the study of current and past climate changes and a view of a the adaptation characteristics of our species .

Human mind is a highly integrated, coherent, sentient, and proactive information system. It provides an evolutionary advantage in complex and sometimes rapidly shifting environments. This adaptive plasticity and coping ability may function differently or be altered when a drastic environmental change occurs,as if a climate tipping point were reached. Our work has a proposal of an extensive review concerning mental adaptation and maladaptation to climate changes, also focusing on the current and future consequences that the climate may provoke on mental health worldwide.

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ORAL

Managing climate change risk: The case of the Italian churches

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Keywords: Climate change, climate events, cultural heritage, churches, insurance

In a world of increasing and reinforcing climate events, there is an urgent need to adapt to climate change in an opportunity to make Cultural Heritage more resilient. Given the relevant threat represented by climate-related events, this paper aims to analyze the role of insurance and the importance it covers in safeguarding Cultural Heritage from natural disasters. In particular, the focus is on Italian Churches seen as a particular case of study. With the aim of providing all the characteristics of the adopted strategy, a Value-Belief-Norm approach is adopted to identify and define an efficient governance scheme. It is mainly based on an insurance private contract developed on a double track, local and national, that has achieved to reach an important goal: the full coverage of all churches. Thanks to the sensitivity and the openness to change shown by the Italian ecclesiastic world, it has been possible to define an optimal risk management approach that may be adopted in several other contexts. In this sense, Cultural Heritage can drive climate action and the originality of the Italian strategy can represent a benchmark in this field.

ORAL

The Scientists for Future South Tyrol initiative

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Keywords: Societal change, climate action

Many researchers across the globe are reacting to the unprecedented climate-, biodiversity- and sustainability-crises, which currently face our planet and humanity. In 2019, a group of scientists working in South Tyrol has been started to organize to strengthen the voice of science as it contributes to objective political discussion and promotes constructive dialogue. For this reason, it has been founded the first "Italian regional group" of SCIENTISTS FOR FUTURE (S4F South Tyrol), inspired by the group S4F Germany.

The central concern of the S4F in general is to actively introduce the current state of science in a well-founded and understandable form into the social debate on sustainability and future security. In this way, scientists support the political decision-making process and contribute to improving the future orientation of socio-political decisions.

S4F South Tyrol wants to support society to assess current developments based on scientific findings, to point out the consequences of insufficient action and to call attention to options for action. First activities have been oriented toward a scientific support for the local Friday for Future movement and toward the development of a "Pact of Future", where a strategy for a sustainable and climate-neutral development for the South Tyrol region will be designed together with the civil society.

Scientists for Future is an open network, and we would like to involve scientists from all disciplines and other regions to support this initiative, as well to get in touch with other similar local initiatives for a (worldwide) sustainable and fair future.

In this contribution, we would like to present the S4F South Tyrol and open a discussion on how to strengthen the voice of science to actively contribute to the societal change.

Reference

More information on how to join to the initiative could be found at: https://www.scientistsforfuture.bz/

ORAL

Sustainable energy, water and food security Solutions for Arctic Regions, Small Island Developing States ("SIDS") and WANA (Western Asia and North Africa) Considering COVID-19

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Keywords: WANA, SIDS, UN SDGs, UN-GSTC, COVID-19, sustainable development, sustainable tourism

Access to safe energy, water and food are common issues across all Arctic regions,Small Island Developing States ("SIDS") and WANA (Western Asia and North Africa) regions. Relevant solutions and lessons are cross-cutting as well. This includes changes to energy, water and food systems and technologies; changes to economic, political and social systems and policies; community, public and

private sector initiatives and participation in sustainable development and sustainable tourism; cooperation and governance; and analytics, data and technology innovations.

Significant disruptions of humanitarian aid to millions of refugees and internally displaced people are being experienced across the WANA region, and accentuated by the COVID-19 pandemic. Women, children, older persons and persons with disabilities, migrants, refugees and internally displaced person are likely to bear the brunt of further violence and increased pandemic health risks.

Considering the impacts of the COVID-19 pandemic on sustainable development for WANA countries, recommendations on recovery actions and policy options are being formulated to help countries recover from the pandemic and to move toward the UN SDGs. Within the WANA region, analysis is intended strengthen the knowledge and skills of national stakeholders, private parties and local communities engaged in UN SDG implementation to apply systematic thinking to ensure integrated recovery planning, decision-making and policy coherence.

For SIDS, there is discussion of capacity building support to Caribbean and Pacific SIDS islands in the implementation of the 2030 Agenda and SDGs in the context of the COVID-19 pandemic. The pandemic poses an unprecedented health and economic crisis for small island economies. The number of deaths is higher in SIDS countries compared to other developing country groups and regions, including least developed countries (LDCs) and landlocked developing countries (LLDCs). The development of more sustainable economy and sustainable tourism approaches will be considered.

The economic consequences of COVID-19 pandemic for small island economies will be extensive and far-reaching. They include health effects, absent or decreased tourism revenues, high and growing debt servicing costs, dependence on food imports, and high unemployment.

COVID-19 and environment issues will be discussed for the impacts of the pandemic on sustainable development in SIDS, LDCs, and other islands and coasts, and will be used to assist countries, public and private parties, and stakeholders in formulating recommendations on development actions and recovery policy options. Select islands and islands groups in the Caribbean Sea will be discussed and the Hawaiian Islands and the Galapagos Islands will be discussed for the Pacific Ocean.

Tourism is changing globally during and in the aftermath of the COVID-19 pandemic, and the potential impact and benefits of sustainable tourism for these islands in these recovery efforts and achievement of the SDGs will be explored. The UN-Global Sustainable Tourism Council (GSTC) Destination Criteria and Industry Criteria and UN-GSTC-Recognized Standards such as Green Destinations will be considered in this analysis.

There is a strong relationship between the UN-GSTC Criteria, the UN-GSTC-Recognized Standards and the UN SDGs. Economic, environmental and societal dimensions are all addressed by the criteria and standards. By incorporating these criteria and standards, SIDS and other islands can move towards meeting the UN SDGs.

Therefore, the linkages between these sustainable tourism standards and movement towards achievement the UN SDGs in light of the COVID-19 pandemic for islands and coasts is examined, as well as how standards, financing and access to vaccines can assist these regions in achieving the UN SDGs.

Finally, the circum-Arctic islands, coasts and its communities and peoples are considered in light of the strong historic connections between this region and the SIDS. The Arctic and SIDS communities and peoples share characteristics of vulnerability and resilience for climate, COVID-19 and other

environmental and health changes. This continues and is especially true for the COVID-19 pandemic, sustainable tourism and implementatio of the UN SDGs. Cross-cutting solutions applicable for the Arctic coasts and islands and the SIDS are raised and explored.

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ORAL

Fostering transformation in individuals toward climate change by playing with challenges: an empirical study with secondary school students

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Keywords: Climate change education, societal transformation, action, secondary school students

Climate change is one of the main issues of our time and the Intergovernmental Panel on Climate Change (IPCC) has called for urgent mitigation action and highlighted the need to undertake a rapid and far reaching transition to limit warming to 1.5°C, listing the different possible outcomes and stating it is necessary to tackle the issue in order to avoid long lasting or irreversible consequences (IPCC, 2018). In 2015, in the Paris Agreement, it was agreed by 195 countries to limit the global temperature increase to well below 2°C while pursuing efforts to limit the increase to 1.5°C - a threshold that has been indicated as having fewer consequences to which humanity is more likely to be able to adapt, and that also represents the best scenario. The IPCC stated that in order to limit global warming to 1.5°C, global net anthropogenic CO_2 emissions should decline and reach net zero by 2050. The latter requirement poses profound challenges and requires a deep collective

transformation of human behaviour. We are witnessing a multiplicity of reactions, with much divergence among them. On the one hand, youth movements have emerged all around the world over the last four years. Disappointed with inaction by world leaders, they have expressed their frustration in the streets, while creating a more empowering narrative about climate change and a sustainable vision for their future. On the other hand, a recent EU report reveals that even if 93% of Europeans see climate change as a serious problem, the issue is not recognized as being so urgent by individuals or as something that can be tackled through individual actions (EC, 2019). In the face of the vast complexity of the phenomenon, the individual feels impotent. They attribute to governments and industries the main responsibility for implementing effective actions. Such misalignment between the impact and humans' (re)actions was studied in recent decades from many different angles and in many fields of research, among which has been science education. For instance, it was shown that providing information on the consequences of climate change is not enough to induce an effective change in behaviour (Norgaard, 2006) since people encounter difficulties in understanding how the actions they undertake individually - as well as their individual support for certain policies - can have an impact on a phenomenon that is global with effects that reach far into the future. A successful shift from concern to effective action is influenced by the understanding of the causal mechanisms governing the behaviour of climate as a complex system (Barelli et al., 2018). Previous studies have demonstrated that it is possible to positively influence the willingness of people to adopt pro-environmental behaviour through the provision of scientific knowledge focused on clarifying climate dynamics. They can help people understand the existence of the complex interaction between human behaviour and nature through modelling climate phenomena like the greenhouse effect and global warming, and recognizing the role of individual as a causal agent in such a complex dynamic system. In a previous study we argued that the willingness to adopt pro-environmental behaviour presupposes a kind of knowledge (causal knowledge) where individual causality is clear and explicit, and that acquiring some practical knowledge about the impact of daily actions on the environment allows people to help mitigate the effects of climate change (Tasquier & Pongiglione, 2017).

In this work we address the issue of how it is possible to foster a deep transformation in individuals toward climate change by playing with challenges. In particular, we try to answer the following question: How can we equip secondary school students with the knowledge, experience and supportive structures they need to contribute as individuals, citizens and active participants in society to enable the transformation required to address climate challenges?

The study we are presenting concerns the design and implementation of a teaching module on climate change, organised within the Piano Nazionale Lauree Scientifiche (National Plan of Scientific Degrees - PLS) at the Department of Physics and Astronomy of the University of Bologna. The module is a consolidated research outcome created in 2012 in the context of a PhD thesis on climate change education, that was refined in subsequent years and whose nature and aims have evolved over time (Tasquier et al., 2016; Tasquier & Pongiglione, 2017; Levrini et al., 2019). The last version of the module was re-designed within the context of the Horizon 2020 project titled "Science Education for Action and Engagement towards Sustainability (SEAS - 2019-2022; https://www.seas.uio.no) coordinated by the Department of Teacher Education and School Research at University of Oslo,

whose aim is to develop tools and methods that facilitate collaboration between schools and local communities facing sustainability challenges.

In order to re-think the module by introducing this transformative dimension, two tools were integrated: 1) the cCHALLENGE platform, implemented within SEAS project by the cChange research center in Oslo (Norway) (O'Brien & Sygna, 2013; https://www.cchallenge.no); and 2) the role-playing activity World Climate: A Role-Play Simulation of Global Climate Negotiations developed by Climate Iteractive at MIT Sloan in Cambridge, Massachusetts (US) (Sterman et al., 2015; https://www.climateinteractive.org).

Those tools were embedded in the re-design of the teaching module and were tested with a class of 20 voluntary students (11 males and 9 females; 17-18 years old) who, for six afternoons, attended the climate change course. Through this teaching and practical experience we collected data about the interaction and outcomes of the sessions. In the poster we will describe the teaching experience in order to investigate the impact of those two tools on transformative aspects and present the preliminary results.

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POSTER

The necessary spaces: The reuse of road. Case study on the Nebrodi Mountains in Sicily around Floresta

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Keywords: Agricultural culture, landscape, floresta, reconnection, road

Contemporary cities and territories are facing increasingly demanding challenges on new natural emergencies due to the impacts of climate change, ecological crises, geopolitical unrest. In addition, the *Sars-CoV-2* pandemic condition triggers new and unpredictable variables on societies, economies and the way we relate to nature. All this requires management skills different from the traditional one. Today's communities need different prefigurations to foster a peaceful transition to urban alternatives and geographic horizons in which one can "imagine and build a sustainable, inclusive and beautiful future for the heart and mind" (New European Bauhaus).

An original research on the highest municipality in Sicily (Floresta), one of 54% of the Italian territory, offers food for thought on new ways of understanding and interpreting the inherited mountain heritage. It is a vision that abandons the idea of the mountain as a bucolic place, far from everyday life or part of a distant past, to re-imagine the charm at high altitude that the city cannot give and project an alternative growth scenario. The study on Floresta reconsiders the role of the locality in the Nebrodi Park, for a long time considered marginal or weakly profitable by the economic, cultural and social circuits between the Etna Volcano, the Ionian Sea and the Tyrrhenian Sea, presenting the unpublished results of a mapping on the geographical maps used from the Travelers of the *Grand Tour* from 1745 to 1784 who provide new interpretations on the meaning of living in the mountains. The geography and agricultural culture that determined the fundamental transformative processes of Floresta's landscape become the indicators of a renewed romanticism on which to project different growth scenarios for the mountain municipality between two seas. The research project, therefore, develops the idea of a regeneration of the Floresta territory, about 31 sq km on the Nebrodi Mountains at an altitude of 1.275 m, identifying elements of strength and strategies of the mountain landscape that reconsider Floresta as a district in transition whose minor routes (the direction of San Fratello - Agira and the ancient routes of transhumance) are those geographical assets and trans-communal means found for a necessary connection with the near future of nature and community. It is an interdisciplinary study on agricultural culture, history of the territory and public-private integration processes to revive the minor mountain routes as skilled interconnection systems in the landscape and renewed places of cultural migration between the mountain area and the metropolitan sea.

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9 Climate services and their potential to support adaptation and risk management

ORAL

Seasonal forecasts of mountain snow depth: An application in the Alps

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Keywords: Seasonal forecasts, snow, mountain, Alps, downscaling, climate services

The development of seasonal forecasts of the state of snow resources in the Alps is of particular interest for the management of water resources, hydropower energy production and tourism. In the frame of the MEDSCOPE project (https://www.medscope-project.eu/) we set up a modeling chain based on the seasonal forecasts of meteorological variables produced by seasonal prediction systems of the Copernicus Climate Change Service (C3S), with the objective to derive snow depth forecasts at the local scale.

Seasonal forecasts of precipitation, near-surface air temperature, radiative fluxes, wind and humidity are eventually bias-corrected with a quantile mapping technique (Gudmundsson et al., 2012) and then downscaled at three selected instrumented sites, close to five Alpine glaciers, in the North-Western Italian Alps. A stochastic downscaling procedure (D'Onofrio et al., 2014; Terzago et al., 2018; Perez-Zanon et al., 2020) is used for precipitation data in order to allow an estimate of uncertainties linked to the small-scale variability in the forcing. The long-term mean of air temperature forecasts is corrected to match the observed climatology at the three stations, while the other variables are simply interpolated to the station site. Downscaled seasonal forecast data are finally used as input for a physically-based multi-layer snowpack model (SNOWPACK; Bartelt and Lehning, 2002).

The chain is tested considering seasonal forecast starting dates of November 1st, which are relevant for snow processes, over the hindcast period 1995-2018. We compare ensemble snow depth forecasts obtained with ECMWFS5 and MFS6 forcings to observations using both deterministic and probabilistic metrics. The former include temporal correlation, average bias, RMSE with respect to observations. Concerning the latter, we evaluate tercile-based forecasts (i.e. the forecast probabilities for the three categories: snow depth below normal, near normal and above normal), and the corresponding ROC curves. We finally estimate the uncertainties affecting the skills of the modeling chain in predicting the evolution of the winter snowpack and we discuss the sensitivity of the snow model to the accuracy of the input variables.

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ORAL

Climate Services for the Energy Sector: current state and future development

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Keywords: Climate services, energy, seasonal forecast, extreme events

In recent years, local stakeholders, political administrators and industrial actors have become increasingly interested in climate variability and its prediction at the seasonal scale. This interest is adding pressure to the need to present climate data and predictions in a trustworthy way, and as certified and credible information which can be understood and managed not only by the scientific community, but also by a broader audience such as institutional players and private companies.

Several European research projects and the Copernicus initiative is providing strong support to develop the so-called climate services, in which the process of transforming the climate data in an operative information is provided and designed with the final users' needs as a target. In these climate service projects, the involvement of the final user is strong and they work with the scientific community to build a reliable and tailored climate service.

The Energy sector was, from the very beginning, interested in climate services and several public and private institutions are nowadays starting to employ the results of climate services research in their decision-making procedures.

Here, we present the activities carried out by ENEA related to the H2020 European projects SECLI-FIRM (http://www.secli-firm.eu/) and S2S4E (https://s2s4e.eu/) on the use of seasonal forecast to provide relevant information on the energy production, management and assessment.

Both projects aim at developing tailored and innovative seasonal climate forecast products. These are co-designed with a wide range of industrial partners. The added value of seasonal forecasts and the derived products are demonstrated through a series of case studies which illustrate how the use of climate forecasts, out to several months, can minimize the operational costs and risks of European industries sensitive to climate variability, particularly for the energy industry.

In this work, we analyse the skill and the accuracy of the current operational seasonal forecasts provided by Copernicus C3S, focusing on the most relevant essential climate variables for the energy sector: temperature, surface solar radiation and precipitation. We further explore the potential of a multi-model approach and the most effective strategies to optimize model selection and combination. Moreover, we analyse the ability of the seasonal forecast to reproduce extreme events at global and European level.

ORAL

MED-GOLD Living Lab 2020: the story of an online training event

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Keywords: Climate services, tranining event, H2020 project

In the framework of the H2020 MED-GOLD project a training event was originally planned as a Summer School, and was to be held in Cagliari, Italy from the 25 May to 29 May 2020.

Owing to travel restrictions resulting from the coronavirus pandemic, during spring 2020 the summer school was converted into an online training event called the MED-GOLD Living Lab "Turning climate information into value for traditional Mediterranean agri-food systems".

The Living Lab was held over five weeks, from May 25 to June 25, with weekly interactive webinars by speakers across different disciplines and on-line working groups with multidisciplinary teams, supported by scientists from MED-GOLD as mentors.

This work describes the main features of the MED-GOLD Living Lab 2020, including also the necessary steps and the strategy adopted to turn the physical summer school into an online event.

Taking into account the circumstances of the COVID-19 emergency and based on the feedback by the participants, it could be considered like a quite successful experiment, that could be also replicated (and further ameliorated) for the second training event, planned for late spring 2021.

ORAL

Can artificial intelligence improve seasonal forecasts and inform reservoir operations?

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Keywords: Seasonal forecast, water management, climate teleconnections, artificial intelligence

Increasingly variable hydrologic regimes combined with more frequent and intense extreme events are challenging water systems management worldwide. These trends emphasize the need of accurate medium- to long-term predictions to timely prompt anticipatory operations.

In this work, we introduce the Climate State Intelligence framework that relies in Artificial Intelligence tools to capture the concurrent state of multiple global climate signals, such as El Nino Southern Oscillation (ENSO) and the North Atlantic Oscillation (NAO), and improve seasonal forecasts. The use of multiple climate signals ensures the portability of this framework to different geographic locations, including regions where traditional teleconnections are weak. Adopting a data-driven modeling approach, we use these teleconnections and other observed preseason sea surface temperature anomalies to forecast local meteorological variables on a seasonal time scale. The resulting forecasts are subsequently transformed using a dynamic hydrologic model into streamflow predictions, which are used as additional inputs for informing water systems operations. Finally, we quantify the operational value of the hydrologic forecasts as the corresponding gain in system performance with respect to a baseline solution that does not use any forecast information. We apply the framework to the Lake Como basin, a regulated lake in northern Italy which is mainly operated for flood control and irrigation supply.

Numerical results show the existence of notable teleconnection patterns dependent on both ENSO and NAO over the Alpine region, which contribute in generating skillful seasonal precipitation and hydrologic forecasts. The use of this information for conditioning the lake operations produces an average 44% improvement in system performance with respect to a baseline solution not informed by any forecast, with this gain that further increases during extreme drought episodes.

ORAL

Considerations on the use of third party data in spatial interpolation for climatological applications

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Keywords: Gridded datasets, third-party data, citizen observations, Bayesian inference

MET Norway is using amateur weather observations and remote sensing data to post-process numerical model output to deliver better automatic forecasts for temperature and precipitation on Yr.no. The temperature post-processing has been operational since March 2018. The precipitation post-processed datasets are currently shared with hydropower companies, which are assessing their potential for hydrological applications. MET Norway has demonstrated that third party (or non-conventional) data can be used to improve the weather forecasts.

Our contribution begins describing the lessons learned so far in the use of a massive amount of non-conventional observations for monitoring the weather. Depending on the geographical area considered, the number of amateur observations can be up to two orders of magnitude larger than the number of conventional observations. New challenges must be addressed to effectively take advantage of non-conventional data. In particular, we will discuss the issues related to: data archiving; quality control and spatial interpolation.

Public institutions have no control at all on third party data, as a consequence this data often lacks proper metadata. Furthermore, non-conventional stations can be easily relocated from one place to another. This poses a challenge on the data model used to store observations in climatological archives. We will present a possible solution, which is currently under development at MET Norway.

Quality control is a key-component of any system that aims at making use of observations. For non-conventional data, the expected frequency of gross measurement errors is much larger than for observational networks managed by national MET services. Non-ideal sensor placements may cause significant representativity issues in the observation errors. On the other hand, the redundancy of non-conventional data allows the quality control to be extremely reliable in data-dense regions. MET Norway is developing a software for data quality control tailored to the use of non-conventional data in spatial interpolation.

Observational networks are characterized by an inhomogeneous spatial distribution of stations. Third party data enhances dramatically the differences in station coverage between urban and remote regions. State-of-the-art spatial interpolation methods often use a fixed spatial structure function to describe the correlation between observation errors over the domain. In this context, a fixed structure function must be optimized so to achieve reasonable results even for data sparse regions. The optimization would penalize the fine-scale representation of meteorological fields in data dense regions. We will present a possible way to adapt the spatial structure function to the local station density so as to exploit the potential of the observational network.

POSTER

Integrating forest fire simulators for fire risk assessment in Apulia region

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Keywords: Flammap, wildfire analyst, forest fire

Spatial distribution of fire risk is of main importance to best allocate resources for fire management, including prevention and suppression. In this context, fire spread and growth models have been increasingly used in fire risk assessment. In general, the application of fire simulators is based on recurrent fire weather conditions and historical fire locations. However, outputs across simulators, albeit built upon the same algorithm, can change due to a number of elements thus affecting the potential risk indices that could be calculated and used by forest managers. Here, we integrate outputs from the traditionally used simulator FlamMap (Finney 1995) with the ultimate software WildFire Analyst (https://www.wildfireanalyst.com/) in order to assess fire risk in Apulia region (southern Italy) under recurrent fire weather conditions. Historical fire data (>100ha) from 2007-2017 and climate reanalysis at 9 km resolution (ERA5-Land) were used to identify historical fire weather scenarios and calculate burn probabilities (BP), fire potential index (FPI), flame length (FL), rate of spread (ROS), fire intensity (FI), fire size (FS) and Campbell analysis (CA). Five recurrent fire weather scenarios with different historical frequencies were identified using a cluster method that account for circular variables (i.e. wind direction). Only in one scenario (Maestrale) wind speed was close to 30 km h-1 but the number of historical fires under this scenario was the lowest. Instead, historical fires occur mostly in scenarios with relative humidity below 30% (Libeccio and Grecale). Forest fire simulators showed potential greater impacts might under Maestrale, Levante and Lebeccio weather conditions. After weighting weather scenarios results suggest higher risks on northern and southern areas. The results of this study can be used for fire and fuel management planning with the aim to reduce the risks posed by wildfires and can be replicated in other regions and countries.

10 Mitigation technologies for ambitious climate targets

ORAL

Fossil and renewable energy sources for a negative emission technology based on ocean alkalinity enhancement and hydrogen production: Comparison through a life cycle assessment

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Keywords: Negative emission, ocean alkalinity enhancement, life cycle assessment, CO_2, renewable energy

The growing CO_2 concentration is warming the atmosphere and causing ocean acidification, because seawater is taking up about 25% of worldwide CO_2 emissions (IPCC, 2018; Friedlingstein et al., 2019). In addition to ambitious actions for cutting emissions, a wide portfolio of Negative Emissions Technologies (NETs) is required for removing at least 5 gigatonnes (Gt) of CO_2 per year by 2050, in

order to limit the global average temperature increase to 1.5°C (Nemet et al., 2018; Rockstrom et al., 2017). In this context of urgent and ambitious climate action, researches on diverse NETs are needed and not only on the current frontrunners such as bioenergy with carbon capture and storage (BECCS) (Rau, 2019).

Among the Negative Emissions Technologies (NETs), Ocean Alkalinity Enhancement (OAE) based on spreading slaked lime in the ocean addresses global warming through the increase of ocean CO_2 uptake and the simultaneous counteracting of ocean acidification (Lenton et al., 2018; Renforth et al., 2013). Many studies have evaluated different aspects of this technology, e.g. Renforth and Henderson (2017) assessed the carbon sequestration process, Renforth et al. (2013) evaluated the technological and economic issues, Bach et al. (2019) investigated the potential co-benefits and risks, Lenton et al. (2018) simulated the potential CO_2 removal given by the spreading of 10 Gt y^{-1} in the period 2020-2100.

The design of an OAE process should take into account the unavoidable CO_2 emission released during the calcination of limestone to produce quicklime, that will form slaked lime thanks to the mixing with water. Caserini et al. (2019) proposed a process which produces slaked lime for OAE through woody biomass gasification and prevents the CO_2 emission from gasification and calcination through carbon capture and storage (CCS). The potential environmental impacts of the process have been evaluated by Campo et al. (2020) through a Life Cycle Assessment showing that the process gives a potential benefit to the climate change impact category, while the wood supply negatively affects the land-use impact category.

Here, in addition to the process configuration based on biomass, two other configurations are assessed and compared with the LCA methodology. A fossil configuration, where coal is used instead of woody biomass, and a renewable option, where calcination is fuelled by electricity generated from renewable energy sources (a mix of solar, wind, and hydro).

From the carbon balance of the process, it results that the woody biomass configuration is the most effective for removing CO_2 from the atmosphere since in addition to OAE the process removes CO_2 through storing biogenic CO_2 emission caused by wood gasification as BECCS. Furthermore, the biomass configuration indirectly avoids further CO_2 emission if the avoided impacts for the production of the hydrogen, which is the by-product of the process, are considered. Contrarily to the biomass configuration, the CO_2 released during coal gasification is fossil and does not add further CO_2 removal, but also in this case the avoided emissions thanks to the production of hydrogen can be accounted for; the renewable electric configuration does not produce any by-product, then the benefit generated by the process referred to 1 kg of produced slaked lime is the lowest. However, in all three configurations the system removes CO_2 from the atmosphere.

The implemented LCA methodology is based on the ISO standards (ISO, 2006; ISO, 2018); the Functional Unit (FU) of the system is 1 kg of slaked lime produced by limestone calcination and discharged into the ocean.

The sources of the Life Cycle Inventory (LCI) data are mainly from the preliminary design of the process and from the scientific literature, as well as the ecoinvent database (version 3.5). Sixteen impact categories representing different impacts on the environment and human well-being are evaluated, with a particular focus on Climate change and Land use. The system is modeled with the SimaPro (version 9.0) software and the impacts are assessed with the Environmental Footprint method (version 1.0) for all categories.

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ORAL

Alkalinization strategies to remove atmospheric CO2 and mitigate acidification in the Mediterranean Sea

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Keywords: Climate change, mitigation, ocean alkalinisation, Mediterranean Sea

It is now widely recognised that reducing the global carbon emissions alone won't be sufficient to reach the Paris agreement target of limiting global warming well below 2°C above pre-industrial levels. In recent years many types of research have addressed active Carbon Dioxide Removal (CDR) strategies, but only few have assessed the mitigation capacity of ocean-based Negative Emission Technologies (NET) and the feasibility of their implementation.

This work investigates the case of ocean alkalinization that has the additional potential of contrasting the acidification resulting from increased uptake of atmospheric CO_2 by the sea. In particular, we analyse the potential of alkalinization applied to the Mediterranean Sea that exhibits clear trends of warming and acidification across virtually the entire basin, but the strength of these trends is conditioned by the basin-wide heterogeneity of physical and biogeochemical processes.

A set of numerical simulations was carried out to quantify the effectiveness of alkalinization intervention over existing shipping routes by using a coupled physical-biogeochemical model (NEMO-BFM) for the Mediterranean Sea at 1/16 degree horizontal resolution (~6 Km) under RCP4.5 emissions scenario over the next decades. With respect to the baseline scenario, simulations suggest the potential of increasing the carbon dioxide uptake of the Mediterranean Sea up to nearly 40 Mt C y-1 over the next 30 years. Moreover, the surface pH exhibited different increase tendencies depending on the intensity of alkalinisation interventions, ranging from a preservation of the current conditions up to the restoration of pH values recorded at the beginning of this century.

ORAL

Cost analysis of carbon capture and storage: A review

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Keywords: CCS, carbon capture and storage, cost

The main goal of the Paris Agreement, signed in 2015, is to limit the increase in global temperature to 2°C, with strong efforts for a maximum of 1.5°C (UNFCCC, 2015). For this, a striking reduction (about 90% compared to 2020) in carbon dioxide (CO_2) emissions should be realized in the following three decades (Rockstrom et al., 2018), and it is widely recognized that a portfolio of option should be used to reach this goal.

Carbon Capture and Storage (CCS), the separation of CO_2 from the emission source and subsequent storage, has been proposed and extensively studied, in particular in the past two decades. CO2 is mainly captured from the post-combustion stream by chemical absorption, using aqueous amine solutions. Before the storage the CO_2 is transported from source to sink, and this is made through pipelines, both on-shore and off-shore, or ships.

The different technologies developed for the capture, transport, storage of CO_2, have different Technology Readiness levels (TRL). CO_2 capture technologies are in high stages of development, transport technologies are on the commercial level, fully operational, whereas the geological storage of CO_2 is currently at the demonstration stage, with about 40 projects in operation or under construction around the world (GCCSI 2019). CCS has the potential to provide relevant emissions cuts, acting as a transitional technology to buy time in which to improve the delivery of long-term low-carbon renewable generation.

Cost is currently often one of the main limiting factors of CCS. So, understanding the cost and its underlying uncertainties can be determining for the success of the technology. This work aims to provide an overview of the main uncertainty relative to CCS costs through a literature review.
The study has been carried out by identifying existing scientific publications on cost studies for CCS. The Web of Science engine was used with the research query: ALL (ccs AND cost) AND (LIMIT-TO (PUBYEAR, 2019) OR LIMIT-TO (PUBYEAR, 2020)). Only the years 2019 and 2020 were selected to state the art on where the scientific community is when it comes to this topic. Two hundred ninety-seven results came up. From those, there was the application of a filter from the categories available, and only one hundred eighty-five came out. When analyzing them better, only sixty-four made sense to the purpose of this study.

One way to deal with uncertainty is by "not dealing with it," leaving it out of the scope. The lack of uncertainty analysis is the majority in the articles assessed (thirty-five out of sixty-four). It is hard to deal with uncertainty and to put a value on it. What Garcia and Berghout (2019) did that is valuable is to point out the gap in the information and how this increases uncertainty.

The most common quantitative method regarding uncertainty is sensitivity analysis. This analysis consists of changing one variable inside a fixed range and evaluating the target variable's changes. In Ugwuishiwu (2019), the goal is to analyze CCS costs for the retrofit of gas-fired plants in Nigeria. Regarding the uncertainty, a sensitivity analysis is conducted to understand how a specific parameter affects the "total revenue required or Levelized cost of electricity". In this paper, the parameters adopted were the number of turbines, natural gas cost, CO_2 storage system, plant capacity factor, and fuel property. The other thirty-one works perform a similar type of analysis.

Regarding the sensitivity analysis, the work of Guo et al. (2020) focuses on three performance evaluation indexes: the time to the accumulated capacity of the installed CCS to peak, the allocation difference, and total revenue. The categories considered are investment cost and learning rate, depreciation rate, and oil price. When discussing investment cost and learning rate, three parameters are used: investment cost, operating cost coefficient, and technology learning rate. There is a difference from the previous manner, in any case. It is an investigation of the effects of the changes on the target variable of the three of them combined.

From van der Speck et al. (2019), the uncertainty is thoroughly evaluated. First, there is a broad and profound discussion about quantitative methods for cost uncertainty analysis. "Preparing a cost estimate is the first step in understanding the costs of a process. Subsequent, essential elements of costing studies include an uncertainty analysis and (where possible) a comparative analysis with other studies and/or industry results of the same or similar technologies to understand the causes of any significant differences." (van der Speck et al., 2019).

Differing from the eighty-nine others, the study from van der Speck et al. (2019) proposes that quantitative methods alone are not enough when dealing with policy and decision making. There can be uncertainties of different natures such as: epistemic, contextual, or methodological. Dealing with it requires another form of evaluation: the pedigree analysis, which assesses the strength of models and their knowledge base. The combination of both methods is interesting because it is possible to see the "weak spots" of the model.

There are quite different ways of dealing with uncertainty. Either just pointing out the gaps of knowledge and the subsequent uncertainties, or performing a sophisticated analysis using quantitative and qualitative methods. From the sixty-four, there were also some not mentioned manners of performing an uncertainty analysis. These are some ways to deal with uncertainty to a more realistic result regarding the cost of the CCS.

In conclusion, precise information is essential, but may not always be available. Transparency is crucial for understanding the limitations and uncertainties of the adopted methods and information. Moreover, if possible, a sensitivity analysis can be of great assistance. Nevertheless, it needs to be done in a way to be able to communicate with the target audience.

The final message would be to understand the analysis stage, for whom the analysis is being done, and what needs to be analyzed. The cost of CCS is complex and should be thought about critically before being just a number.

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ORAL

Enhanced pressurized weathering of limestone as an option to store CO2: Technological aspects, advantages, limitations and research needed

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Keywords: Mitigation, CCS, CO_2 Storage, Limestone, Slaked lime

Enhanced Weathering of Limestone (EWL) has been previously proposed (Rau & Caldeira, 1999; Rau, 2011) to store CO_2 in the marine environment in the form of bicarbonate The method consists of the reaction between CO_2 captured from an effluent gas stream (i.e. a fossil-fuel power plant), seawater and carbonate minerals ($CaCO_3$, either as calcite or aragonite), and the subsequent discharge of Ca_2+ and HCO_3- into the ocean, where it is diluted by additional seawater. In this way, a CO2 emission could be effectively stored in the oceans, largely in the form of HCO_3-, with the buffering effect of carbonate minerals preventing a further decrease of pH of seawater to level dangerous for the marine biota, like in the case of direct injection of CO_2. A limitation of this method is the high request of water, about 3800 tonnes of seawater for tonne of CO2 captured. Studies on the existing biggest EWL plant (Kirchner et al., 2020a, 2020b) found how EWL-derived water impacts the carbonate chemistry of the southern North Sea and concluded that although EWL could be used for a safe and long-term storage of CO_2 at locations with high availability of limestone and water, the discharge in shallow water could reduce the efficiency of the storage down to 50% since the acidic effluent from the EWL reactor it is likely to degas the excess CO_2 into the atmosphere once released into the sea along with the possible abiotic precipitation of calcium carbonate near the effluent release point due to high values of Ω_{cal} .

To overcome this limitation, a new technology called Enhanced Pressurized Weathering of Limestone (EPWL) has been proposed and is here presented. In EPWL, the reaction between a stream of pure CO_2, seawater and calcium carbonate happens inside a pipe, in a condition of progressively increased pressure. This pipe is located between the coast and the deep sea, so the apparatus is

suitable for generating an increasing pressure taking advantage of the sea's hydrostatic pressure that enhances the solubility of limestone and increases the partial pressure of CO_2, in this way promoting the production of bicarbonates at the depth of the discharge point. The CO_2 can be taken form a CO_2 rich-flue gas by scrubbing it with seawater, using the same technology proposed by Rau & Caldeira (1999), or can be a stream of pure CO_2. The amount of water needed depends on the amount of residual $CaCO_3$ and on the pH that can be accepted at the discharge point, and has been assessed with the software PHREEQC developed by US-EPA, considering the solution at the equilibrium before the discharge point. The acceptable residual $CaCO_3$ and pH depend on the possibility that $CaCO_3$ after the discharge could be dissolved to continue is effect of buffering the input of acidic water.

Two different scenarios have been considered: the discharge of the effluent below the CCD (carbon compensation depth, typically located at approximately 5.000m) and above the CCD.
When the discharge pipe goes deeper than the CCD, the depth in the oceans below which the rate of supply of calcite lags behind the rate of solvation, no calcite is preserved in seawater after the discharge, since it is dissolved by the corrosive seawater. The amount of water in the pipe could be low and is dependent on the desired pH of the effluent at the discharge point, because the complete dissolution of $CaCO_3$ before the discharge from the pipe is not needed, since the $CaCO_3$ that will not react with the CO_2 inside the pipe will anyway dissolve into the seawater, buffering the residual CO_2 inside the plume.

The deep discharge of the effluent will minimize the risk of $CaCO_3$ precipitation and CO_2 degassing because of the high pressure, thus all the remaining CO_2 will react in the plume with the carbonates to form bicarbonates.
In places with lower sea depth, like the Mediterranean Sea, where the CCD cannot be reached, the EPWL method cannot be economically applied, since the eventual residual carbonate in the effluent could not be dissolved by seawater once discharged and a huge amount of water is required to dissolve all the carbonate before the end of the pipe, making this solution not sustainable from an engineering and economic point of view. A new configuration is thus proposed, called pHA-EPWL (pH Adjusted -Enhanced Pressurized Weathering of Limestone), which adds to the EPWL a floating reactor where a final pH adjustment is obtained by means of a natural flow of seawater mixed with calcium hydroxide $Ca(OH)_2$, that buffers the remaining CO_2 in order to increase the pH of the discharge to 8 and guarantee a complete CO_2 storage efficiency.

Since the production of $Ca(OH)_2$ leads to CO_2 emission, the overall storage efficiency of this configuration is lower (about 90%), but it allows to minimize the amount of water used in the pipeline solving the low overall CO_2 storage efficiency in shallow waters or the residual acidification of the seawater in deep waters of the EWL technology .

After the presentation of the three technological options (EWL, EPWL, pHA-EPWL), the paper will compare the advantages, limitations, and the need for further R&D for their full-scale deployment.

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ORAL

How does the interaction between environmental policy and intellectual property rights affect environmental innovation? A study of 7 OECD countries

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Keywords: Environmental innovation, natural language processing, environmental policy, intellectual property rights

The main goal of this paper is to analyze the effect of the interaction of environmental and intellectual property (IP) policy on environmental innovation. Our theoretical approach combines the porter hypothesis with the concept of externalities and public goods. Considering that environmental innovation is a unique case where innovation is effected by two very different policy apparatuses (environmental and IP policy). We examine the changes in environmental innovation (measured by environmental patents) filed in 7 OECD countries on firm and industry level in conjunction with the changes in environmental and IP policy in the respective countries. We find that the interaction between environmental and IP policy is significant in pushing environmental innovation. To identify environmental innovation we pioneer a patent identification technique using Natural Language Processing's Topic Modeling technique, and show improvements our technique makes to current patent classification systems.

11 Special session: Economic modelling under climate change- case studies from Asia

ORAL

Why climate resilient economic development matters

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Keywords: Climate change adaptation, economic sector analysis, science-based adaptation policy support, perfect foresight, weather extremes

Economic development plans of nations are increasingly forced to consider climate related risks (e.g. increase in extreme weather events). This pertains mainly medium and long-term strategies (5-30y) when impacts of climate change are expected to intensify and poses new challenges for policy making. One challenge is that development planning and climate risk assessments continue to be dealt with in separate institutions, caused by limited awareness and capacity of public actors mandated with development planning (e.g. Ministries of Economy and/or Planning) to consider

climatic effects. An integration of development planning and climate action is "The only way forward" (OECD 2019). In response to these challenges the German Development Organization (GIZ) is implementing an IKI funded project Policy Advice for Climate-Resilient Economic Development (CRED). The approaches and tools developed in this project will serve to assess expected climate risks (via scenario analysis) and subsequently plan climate-resilient economic development. The economic models are expected to provide insights on two levels. First, what are sector specific damages and efficient adaptation measures at sectoral level? Second, what intersectoral dynamics exist when adaptation to climate change and what are the effects of the structural transformation of the economy on avoided future damages? That is, the economic models are expected to be country specific and reliable and support the eco-nomic decision makers regarding assessment damages and efficient adaptation measures, as well as intersectoral dynamics and thus enable economic decision makers to understand the effects of structural transformation on avoided future damages.

ORAL

Modeling frameworks for different levels of expertise

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Keywords: Climate change adaptation, economic sector analysis, science-based adaptation policy support, perfect foresight, weather extremes

One major goal of the CRED project is to provide capacity building on economic modeling with respect to climate change and adaptation policies to experts from the partner countries. For Georgia and Kazakhstan, an Excel-based model building framework will be used. The framework simplifies the model building process by providing a self-contained solution (historic data, model runtime, model code and projected data) that is easier to handle for both model builders as well as model users who are familiar with the basic usage of this spreadsheet program. The software package is accompanied by hands-on training sessions covering all steps of the model build-ing process from data collection to scenario analysis. The participants will be entitled to independently update, maintain, and improve the models. The framework and the country-specific models will be further evaluated and may serve as a template for other countries for which the economic impacts of climate change need to be addressed.

ORAL

Economics of climate change adaptation in a small country in transition: The case of Georgia

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Keywords: Climate change adaptation, economic sector analysis, science-based adaptation policy support, perfect foresight, weather extremes

Georgia's geographical location and natural conditions (e.g. complex mountainous landscape, black sea coastal zone) contribute to a substantial vulnerability to climate change. There are several observable signs of climate change in Georgia during recent decades, e.g. increasing mean, and extreme air temperatures, increased average annual precipitation and changing rainfall patterns, increased frequency of droughts and hailstorms and so forth (see USAID 2016). A scenario analysis is performed to examine the macroeconomic effects of implementing adaptation measures to climate change. The observable effects can be clearly assigned to the respective adaptation measures since the socio-economic parameters (for example population development) in the scenarios are identical in each case. Overall, the macroeconomic effects of the adaptation measures in Georgia are expected to be positive. In particular, a transformation in the effects on gross domestic product (GDP) can be observed: In fact, a positive GDP effect in the years of damage (without adaptation) can be measured due to additional repairing, reconstruction and increased consumption; however, this positive effect is due to the fact that damage has previously been caused by storms, heavy rains or heatwaves ("bad" GDP effect). Adaptation to climate change ensures that, e.g. additional annual construction activity will also generate a positive GDP effect and, at the same time, damage in extreme weather events will be lower ("good" GDP effect).

ORAL

Economics of climate change adaptation in a resource-based economy: The case of Kazakhstan

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Keywords: Climate change adaptation, economic sector analysis, science-based adaptation policy support, perfect foresight, weather extremes

Economic growth and the wealth of Kazakhstan is dependent on resources which are at risk. The country exports fossil fuels (52% of total nominal exports in 2017) especially to the European market

as well as agricultural products. While the agricultural sector is highly vulnerable to climate change, oil and gas demand is more affected by mitigation strategies of EU countries and their aim to be climate-neutral in 2050. Climate change is an issue of growing importance in Kazakhstan and affects especially the agricultural, energy and the water sector. In climate projections, increased temperatures, droughts, and heat waves are expected as well as more incidences of heavy precipitation events by 2050. Based on experiences in previous projects, macro-econometric Input-Output models are considered appropriate tools to consider and analyze the impacts of climate change and adaptation on a yearly basis. Scenario analysis is used to implement economic implications from climate change (e.g. damages caused by flooding) and adaptation strategies (e.g. investments in infrastructure) into the economic model. For the model to consider the future impacts of climate change, climate projections need to be linked to economic damages and losses which have been observed in the past. In other words: Physical effects need to be translated into monetary values to calculate the economic effects. Comparing both scenarios - a scenario including climate change effects but no adaptation measures and a scenario including adaptation measures - shows the impacts (such as adaptation costs and avoided damages) of adaptation activities.

ORAL

Economics of climate change adaptation in a highly vulnerable economy: The case of Vietnam

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Keywords: Climate change adaptation, economic sector analysis, science-based adaptation policy support, perfect foresight, weather extremes

Vietnam is a Southeast Asian developing economy and highly vulnerable to climate change. The country needs to adapt to a very likely rise in sea level, a very likely increase in the number of heat waves and cyclones. There-fore, policymakers need to consider adaptation measures to ensure a more climate resilient economic development.

We develop a small open economy spatial dynamic general equilibrium model to simulate different climate change and adaptation scenarios. Our approach explicitly models the link between sectoral and regional pro-duction in Vietnam and climate change variables. We calibrate and estimate structural parameters of the model to match economic characteristics of the Vietnamese economy and their development over time. Our main goal is to conduct a cost-benefit analysis to evaluate different adaptation measures to climate change. Therefore, we run counterfactual scenarios with and without specific adaptation measures to evaluate their impact on the economic development of Vietnam. To this end, we first define regional and sector specific damage functions that capture the negative effects of climate change on output. We include the sectors that are severely affected by climate change: agriculture, tourism, transportation, and the construction sector. In a second step,

we identify potential adaptation measures to reduce the potential damage by climate change on the economy and compare the resulting benefits with the costs of the respective policy measures.

Presenters

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