Uncertainties and reference stations in measurements of physical variables for climatology and meteorology

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In the context of global warming, there is an increasing demand for having high-quality climatological data. Hence, the principal goals of this thesis are enhancing the comparability of climate data in space and time, by establishing metrological traceability, researching the environmental effects, and delving the analysis of the uncertainty budget for the ground-based meteorological stations. INRiM, the Italian National Research Institute in Metrology, is significantly involved in supporting climate and meteorological measurements by delivering metrological techniques and knowledge. Recently, new laboratories have been established, and INRiM has been nominated lead center on "Traceability and Field Metrology" by the World Meteorological Organization, WMO. This work was carried on in the laboratories and field sites of this novel infrastructure, and is based on three studies under the common topic of thermodynamic metrology for the environment.

The first study involves an on-site calibration of thermometers from the Meteorological Observatory of Moncalieri, a centennial station in Italy. The study shows the main contributions to the expanded uncertainty and points out the advantage of this procedure. Involving the same system (dataloggers, cables and sensors) in the same environmental conditions, the calculated calibration curve represents more convincingly the real measurement conditions. A comparison analysis with previous calibrations is also included, demonstrating the drift effect and the importance of having an active calibration program to reduce it.

The second study aims to understand the environmental effects on air temperature measurements, analysing the differences in temperature readings, ΔT, among six identical thermometers installed in an open field at INRiM. Relative humidity and wind speed are also measured and considered as quantities of influence. The expanded uncertainty of ΔT is calculated according to different ranges of relative humidity and wind speed, and assumed as the temperature uncertainty due to the environmental conditions. From these ranges, physical effects like condensation and solar heating can be inferred, associating values of uncertainty with specific environmental effects.

The third study researches the relationship between air and rock temperature and investigates the heat transfer into the rock. The rock temperature measurements at different depths and exposures in the Bessanese glacier basin are analysed. The analysis shows the significant role of the radiative component in modulating the rock temperature. However, the heat transfer into the depths is not linear and depends on thermal conduction. This study proposes considering the vertical temperature gradient on the rock as a measure of thermal stress, and therefore, a possible indicator of rockfall.

This work has a metrological approach, where technical and experimental knowledge of climate and environment is applied to guarantee the reliability of the results. Considering that air temperature is an indicator of climate change and rockfall is a consequence of climate warming and permafrost degradation, the results of this thesis will improve the accuracy of climate measurements for a better understanding of global warming and risk prediction.