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Improved large-scale crop water requirement estimation through new high-resolution reanalysis dataset

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Estimation of crop water needs is essential to understand the role of agriculture in the water balance modeling at various scales. In turn, this is relevant for water management purposes and for the fulfilling of water-related environmental regulations. In this study, a comprehensive assessment of crop water requirement at large scale is presented, both in terms of rainfall (green water) and irrigation (blue water).

A water-balance model is built to provide estimates of actual evapotranspiration and accompanying soil moisture by using high space-time resolution data. The new ERA5 reanalysis dataset, published by the ECMWF within the Copernicus monitoring system and obtained from satellite data and ground measurements, provides the precipitation and temperature input variables to the model. Data available at the hourly time scale are all aggregated on a daily scale and used in the water balance model over a grid of cultivated areas from the MIRCA2000 dataset. Cultivated areas are available for 26 crops for year 2000 at a spatial resolution of 5 arcmin (about 9 km at the Equator). Data from MIRCA2000 are separated between rainfed areas and areas equipped for irrigation and are characterized by specific monthly calendars of the crop growing seasons.

The model performs the daily soil water balance throughout the whole year, considering all crops at their growth stage and assuming as initial condition at each crop sowing date a monthly average soil moisture. Results quantify the volumes of green and blue water necessary for crop growth and describe the spatial variability of the water requirements of each individual crop. The high spatial and temporal resolution of Copernicus ERA5 data enables a great improvement in the characterization of hydro-climatic forcings with respect to previous assessments and a greater accuracy in the crop water requirement estimates.

Finally, the knowledge of water requirements is an important step to quantify the irrigation volumes used in agriculture, on which there is a high uncertainty and little spatially distributed information. The model proposed enables the investigation of spatio-temporal variability associated to varying meteorological forcings and of the effects of different irrigation techniques, enabling an improved management of water resources.