

# Improving the Reconstruction of the Hydrological Cycle through Satellite Observations: The Case Study of the Po River Basin

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Climate change is having a detrimental impact on the availability of water resources, and the effects are found to be particularly pronounced in regions where human activity is more concentrated. Across the world, the rising frequency of meteorological, agricultural, and hydrological droughts highlight the urgency of understanding how human activities contribute to their occurrence, which is crucial for effective water management. Specifically, estimating water storage in groundwater, reservoirs, and snowpack is essential for determining overall water availability and, in turn, assessing the amount of water that can be sustainably allocated for irrigation purposes.

In this context, the INTERROGATION project, funded by the Italian Ministry of Universities and Research, examines the interactions between climatic and anthropogenic factors in the development and recovery of major hydrological droughts that have affected the Po river basin in northern Italy in recent decades (1990-2023). The purpose is to gain insights for developing an integrated approach for managing water resources during future droughts that may occur in the Po basin. In particular, the aim of the INTERROGATION project is to demonstrate how the combination of accurate input data, a robust hydrological model and a tool capable of assessing the uncertainty in the model prediction are fundamental elements for the development of a reliable decision support system for water resources management.

For the purpose, three different precipitation datasets, namely long-term (2000-2023) daily in situ, high-resolution (4km) reanalysis and high-resolution (1km) satellite precipitation data are used as input data in a flexible conceptual hydrological model, MISDc (Modello Idrologico Semistribuito in Continuo, Camici et al, 2018). The model is able to mimic both natural processes and anthropogenic activities, such as irrigation and the water stored in the reservoirs. To assess the uncertainty of modelled river discharge, the Bluecat tool (Montanari et al., 2022), is applied.

Once calibrated, the framework is employed to simulate three sets (one for each precipitation dataset) of the principal variables of the hydrological cycle, namely soil moisture, evaporation, snow accumulation, irrigation and river discharge. A comprehensive validation of the corresponding modelled hydrological variables is performed using high-resolution satellite-derived observations of soil moisture, evaporation, groundwater, irrigation and snow accumulation, which are developed within the framework of the European Space Agency Digital Twin Earth (DTE) Hydrology Next project.

The results of this work demonstrates the significance of employing a suitable hydrological model in conjunction with accurate satellite information for capturing the evolution of the hydrological cycle, in both space and time, within highly anthropized basins. These results will be the base for developing a decision support system that will guide stakeholders towards an integrated management of water resources during drought events.