Bridging Data Gaps: AI and Satellite Insights for Moroccan Hydrology

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Hydrological modeling in Morocco is constrained by sparse and uneven hydroclimatic observations, particularly for precipitation and air temperature, which are critical inputs under increasing climate variability and extremes. This study proposes a unified, data-driven framework that integrates satellite remote sensing, reanalysis datasets, bias correction, and machine learning to improve hydroclimatic inputs and enhance hydrological simulations.

Satellite and reanalysis precipitation products were evaluated against observations from approximately twenty weather stations covering mountainous, semi-arid, and arid environments. The assessment was conducted at daily, monthly, and annual time scales and extended to floods and droughts using volumetric, categorical, and extreme-event metrics. Results show strong spatial and scale-dependent variability among products, highlighting the need for basin-specific evaluation. Among the tested datasets, PERSIANN-CDR, GPM-IMERG, ERA5, and MSWEP exhibited the best overall performance. Bias correction using cumulative distribution function mapping significantly improved precipitation magnitude, variability, and extreme event representation.

To address the lack of reliable high-resolution air temperature data, a new product, TEMLI (Temperature Estimation with Machine Learning and Land Inputs), was developed at 1 km resolution. TEMLI integrates satellite land surface temperature with environmental variables and outperforms reanalysis datasets, especially in complex terrain and during temperature extremes. The improved precipitation and temperature datasets were hydrologically validated using the GR4J model across sixteen Moroccan basins. A machine learning approach was finally developed to identify optimal precipitation–temperature combinations for both gauged and ungauged basins, leading to improved hydrological performance.