AI Improving CMORPH2 Orographic Precipitation Estimates

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Abstract

Monitoring extreme rainfall in mountainous regions remains a significant challenge for satellite-based precipitation estimates. The second-generation Climate Prediction Center Morphing technique (CMORPH2) is a Level-3 product that merges Level-2 passive microwave (PMW) retrievals from multiple low-Earth-orbit satellites. While CMORPH2 performs well at the global scale, it often underestimates orographic rainfall. Some of this bias can be traced back to limitations in the input Level-2 retrievals, including insufficient information for accurately detecting and quantifying precipitation intensity over complex terrain.

In this study, we develop a physically informed AI framework to improve CMORPH2 rainfall estimates in mountainous regions. The framework combines satellite-based CMORPH2 rainfall estimates, high-resolution terrain information derived from a Digital Elevation Model (DEM), and environmental fields from numerical model simulations. Rather than applying a black-box AI correction, we focus on the physical processes that drive orographic rainfall. We use interpretability tools, such as Permutation Importance, to evaluate how different predictors contribute to bias correction.

We started our development work with a diagnostic study to identify atmospheric processes important to the formation of heavy orographic rainfall. The results showed that moisture flux is the dominant factor controlling the onset and intensity of the orographic rainfall enhancement. At the same time, current operational global models (e.g. NOAA Climate Forecast System Reanalysis CFSR) often struggle to accurately quantify the local surface wind over complex terrain, limiting their ability to capture terrain-induced lifting. Our results suggest that improving the quantification of near-surface wind fields is a key element for enhancing satellite-based precipitation estimates in mountainous areas.

The framework is first tested at a single station (e.g., PAKT, Alaska) and then extended to regional applications. Results show that incorporating physically interpretable AI techniques can substantially improve the quantification of extreme rainfall estimates in mountainous regions, helping to narrow the gap between satellite-based estimates and ground observations. Detailed results and case studies will be presented at the IPWG workshop.