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AI-based Accuracy Improvement of Precipitation Mapping for the Korean Peninsula

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Abstract:

The Korean Peninsula, located on the eastern edge of the Asian continent, exhibits distinct geographical characteristics despite its relatively small area of approximately 220,000 km². Over 70% of its landmass consists of mountainous terrain, and it is surrounded by the sea on three sides, placing it in a humid climatic region. These geographical and climatic features result in marked seasonal variations in precipitation and significant interannual variability. This makes the region particularly vulnerable to extreme weather events such as droughts and floods. Furthermore, recent climate change has intensified the irregularity of precipitation patterns, underscoring the need for accurate and high-resolution precipitation maps that reflect the spatial and temporal variability of rainfall.

The Automated Surface Observing System (ASOS) data provided by the Korea Meteorological Administration (KMA) offers highly reliable ground-based observations from approximately 105 stations across South Korea. However, as the data are collected as point measurements, they are limited in their ability to fully represent precipitation distribution. To address this limitation, this study integrates ASOS data with additional datasets to generate high-resolution, continuous precipitation maps that reflect seasonal variations for the entire Korean Peninsula.

The integrated datasets include high-resolution radar-derived precipitation data collected from 10 operational radar stations managed by the KMA, the Global Precipitation Measurement (GPM) Integrated Multi-Satellite Retrievals (IMERG) data jointly developed by NASA and JAXA, the Local Data Assimilation and Prediction System (LDAPS) developed by KMA, and the Shuttle Radar Topography Mission (SRTM) digital elevation model (DEM) data. Additionally, MODIS MCD12Q1 land cover data were utilized, with MODIS data and aspect data used as categorical variables. All data were resampled to a 1km grid for consistency in analysis, and all datasets were integrated using the WGS84 coordinate system.

To reflect the geographical characteristics and seasonal patterns of Korea, monthly variables were transformed into cyclical cosine and sine functions and added to the model. This significantly improved model performance, particularly reducing the RMSE (Root Mean Square Error) during winter months. The Empirical Cumulative Distribution Function (ECDF) was also adjusted monthly to reduce precipitation bias for each month.

The performance of this high-resolution integrated precipitation map reflecting Korea's annual variations was validated using independent 2024 data not used in model development, resulting in a high correlation coefficient (CC) of 0.93. This confirms the effectiveness of the methodology developed in this study in capturing the unique precipitation characteristics of the Korean Peninsula and demonstrates the potential for improving precipitation mapping by integrating diverse datasets and machine learning techniques. This is expected to contribute to applications in various fields such as meteorology, hydrology, and policy planning.

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