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Validation of the Precipitation Nowcasting for selected cases in Greece, using weather radar data assimilation

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Abstract

Floods driven by short-duration intense rainfall, remain among the most damaging natural hazards in the Mediterranean and set major challenges for early warning systems. Accurate nowcasting (short-term forecasting) of convective rainfall is essential for hydrological response modelling and risk management. However, numerical weather prediction often struggles to capture storm initiation and localization in complex terrain.

This study investigates the assimilation of XPOL polarimetric radar data into the Weather Research and Forecasting (WRF) model using a 4DVAR data assimilation approach, to improve rainfall prediction for flood-relevant time scales. Selected high-impact precipitation events from 2024–2025 over Greece are simulated, including cases associated with flash flooding. Radar reflectivity and radial wind observations are assimilated through 4DVAR cycling, and simulations were performed at 2-km resolution with a 3-hour forecast horizon, representative of nowcasting. In addition, humidity, vertical velocity and horizontal wind divergence profiles estimated from lightning data, are also assimilated with a three-dimensional variation (3D-Var) method. Verification, using primarily the estimated rainfall from the weather radar, supplemented by satellite products where needed, shows that radar assimilation significantly enhances convective initiation, storm structure, and peak rainfall placement during the first forecast hours. These results demonstrate that radar-based 4DVAR assimilation can strengthen operational flood early-warning capabilities by providing more reliable rainfall forcing for hydrological and decision-support models. Ongoing work explores integration within multi-sensor workflows, coupling with meteorological forecasting chains, toward operational implementation in Greece.

Key Words: extreme rainfall, WRF, data assimilation, weather radar