Operational data assimilation of Earth observation hydrological data across contrasted river basins: insights from the SEED-FD project

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Operational hydrological forecasting systems at the global scale still suffer from uneven performance across regions, particularly in data-scarce environments where uncertainties in model states and parameters propagate rapidly and limit short- to medium-range forecast skill. While data assimilation has been widely explored in regional hydrological models, its design and stability within **global operational forecasting systems** remain largely unexplored.

Within the SEED-FD (Strengthening Extreme Events Detection for Floods and Droughts) project, we investigate how multi-source data assimilation strategies can be configured to improve the propagation of observational information into short- to medium-range hydrological forecasts under operational constraints. We implement and evaluate Ensemble Kalman Filter (EnKF) workflows within the GloFAS modelling framework used in the Copernicus Emergency Management Service (CEMS) Hydrological Forecast Modelling Chain.

Multiple observation types are assimilated, including in-situ river discharge, satellite-derived discharge, and water level observations from Earth Observation (EO) missions. To mitigate spurious correlations associated with limited ensemble sizes, localization strategies based on hydrological distance are implemented and tested, including both fixed-radius and adaptive localization approaches. Assimilation experiments are conducted across several contrasted river basins representative of diverse hydro-climatic and socio-environmental conditions, including the Niger, Paraná, and Juba–Shebelle basins.

The analysis focuses on short- to medium-range streamflow forecasts and examines how different assimilation configurations influence the persistence and propagation of corrections beyond the assimilation window. In particular, we compare state-only approaches with exploratory joint state–parameter estimation experiments, while assessing the role of localization in maintaining physically consistent corrections.

This work provides one of the first systematic investigations of data assimilation strategies within a **global operational hydrological forecasting system**, and highlights key design choices required to maximise the impact of Earth observation data in large-scale flood and drought forecasting frameworks.