Earth Observation data for Advancing Flood Forecasting: EO4FLOOD project

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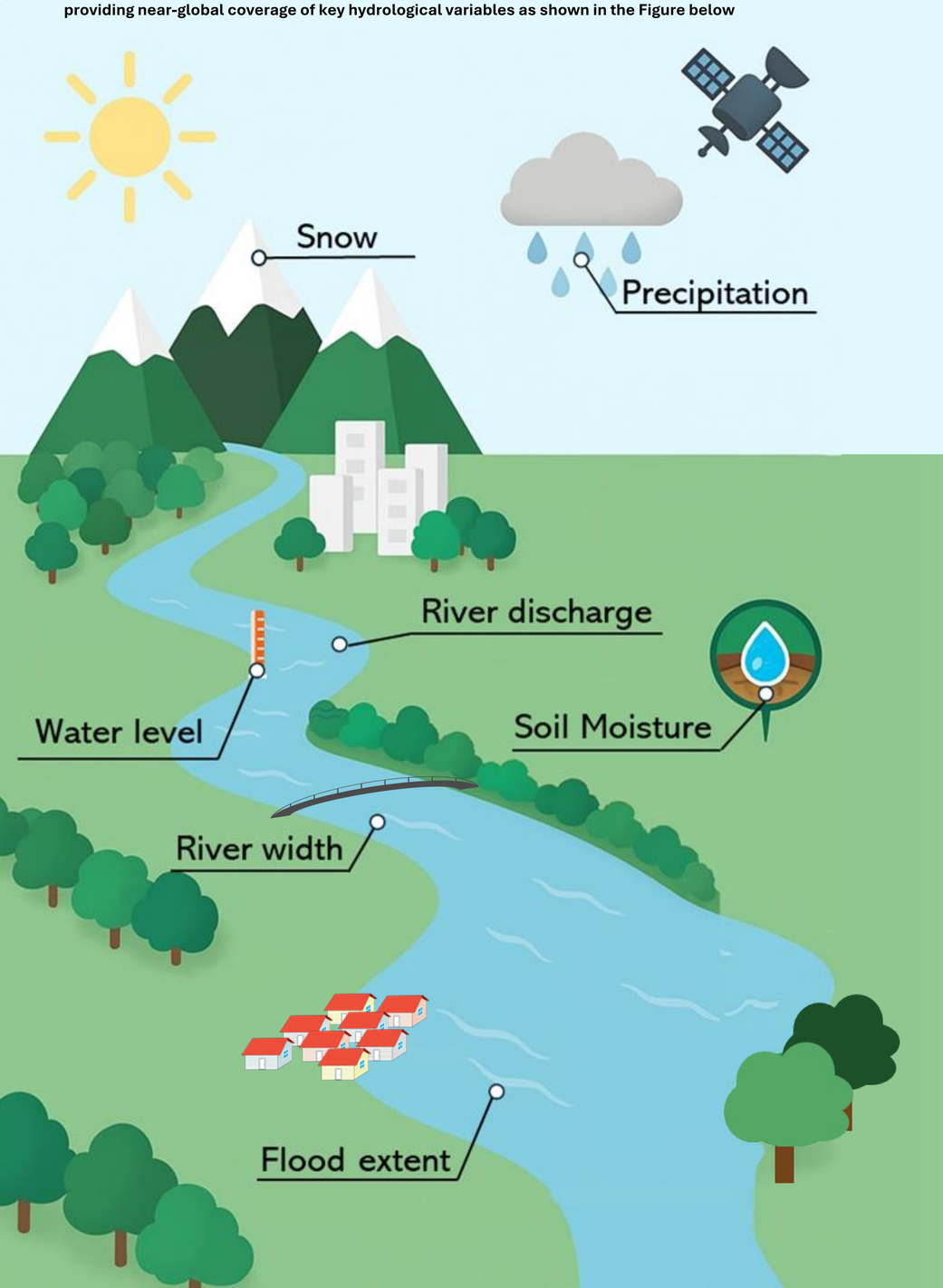
EO4FLOOD

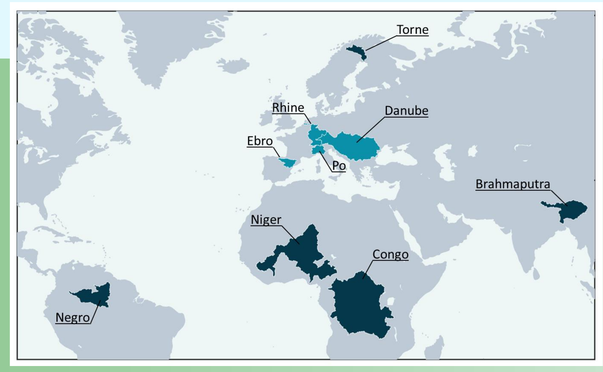
The last two decades have seen a proliferation of available satellite remote sensing data providing near-global coverage of key hydrological variables as shown in the Figure below



IMPACT OF FLOODS

In the period 2000-2024, **floods caused the most internal displacements** (EM-DAT, https://public.emdat.be/data):

- **1.8 billion people**
- **180 countries**
- **135'000 deaths**
- **338'000 injured**
- **973 billion US$ losses**



RATIONALE

The numbers of displacements highlight the **collective inability** to adequately anticipate flood events, reduce vulnerability, and mitigate their impacts, underscoring the need for more effective strategies to reduce flood risk.

Real-time flood forecasting is critical for reducing immediate impacts and enhancing emergency response. **Traditional flood forecasting** relies on ground-based hydrological networks, but these systems often **suffer from data gaps**, particularly in vulnerable and data-scarce regions. **Satellite-based Earth Observation (EO) data emerges as a promising solution**. Offering broad spatial and temporal coverage, EO technologies can bridge critical gaps in monitoring and improve the accuracy and reliability of flood forecasting systems. Despite their vast potential, the integration of satellite data into operational flood forecasting remains limited.

OBJECTIVES

EO4FLOOD is a project funded by ESA demonstrating the potential of advanced satellite data in enhancing the accuracy and timeliness of flood forecasting systems. For this purpose, **it aims to develop a new generation of flood forecasting systems that synergistically integrate cutting-edge EO data, advanced hydrological models and AI tools.**

EO4FLOOD is structured around three main objectives:

Development of an Advanced EO Dataset that integrates high-resolution satellite products from ESA and non-ESA missions, providing global coverage of critical variables such as precipitation, soil moisture, snow, flood extent, water level and river discharge.

Integration into Flood Forecasting Models: By combining these datasets with machine learning-enhanced hydrological and hydraulic models, the project achieves more accurate flood predictions while quantifying uncertainty.

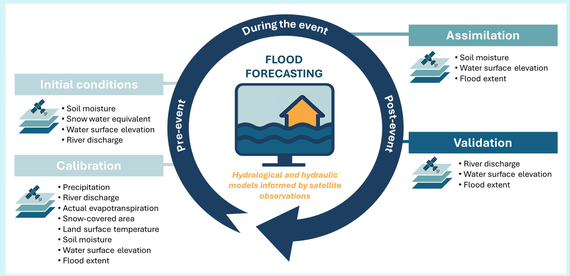
Demonstration for Science and Society: EO4FLOOD showcases the application of these tools in flood risk management and explores the influence of human activities, such as land-use changes and dam construction, on flood dynamics.

TESTING BASINS

The testing modelling framework will be implemented over selected areas within five specific basins (**Torne**, **Negro**, **Congo**, **Niger** and **Brahmaputra**) . The dataset of EO will be provided also in the bigger European basins like **Po**, **Danube**, **Rhine** and **Ebro**.

EO4FLOOD APPROACH

EO4FLOOD will test the impact of EO through calibration, forcing data, initial condition and data assimilation in three rainfall-runoff models (Hype, GHM, MGB) and one AI model. To optimize the use of the available tools for flood forecasting, we will develop a hybrid approach that integrates the strengths of a physics-based approach and advanced AI techniques.



KEY PROPOSED INNOVATIONS

- ❑ Retrieval of multi-mission water level data, combining nadir, SAR, and SWOT altimeters;
- ❑ Utilization of multiple sensors for river discharge estimation, incorporating various water variables like level, width, reflectance indices and slope;
- ❑ Regionalization of parameters also for space-based river discharge estimation;
- ❑ Hybrid approach merging physical-based hydrological models with AI methods for robust flood forecasting;
- ❑ Integration of satellite data into established flood forecasting systems to evaluate their potential impact and benefits;
- ❑ Extensive model comparison to optimize application fields based on data and environmental factors;
- ❑ Provision of probabilistic flood forecasting results to simulate real-world conditions for stakeholders during early warning phases.

ACKNOWLEDGEMENT

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