Assimilation of Remotely-Sensed Soil Moisture Data into an Integrated Hydrological Model: A Probabilistic Validation of Soil Moisture and Real-time Flood Forecasting

Samira Sadat Soltani, Stefan Kollet
Institute of Bio- and Geosciences, Agrosphere (IBG-3), Forschungszentrum Jülich GmbH, Jülich 52425, Germany
Contact: s.soltani@fz-juelich.de

Introduction

- The July 2021 flooding event (Figure 1) has cast doubt on the ability of current models to forecast previously unseen events due to factors such as limited observations, uncertainties in simulations, and calibration.
- One promising approach is the assimilation of satellite-derived soil moisture estimates into prognostic hydrological models, which has the potential to reduce uncertainty in soil moisture and streamflow simulations.

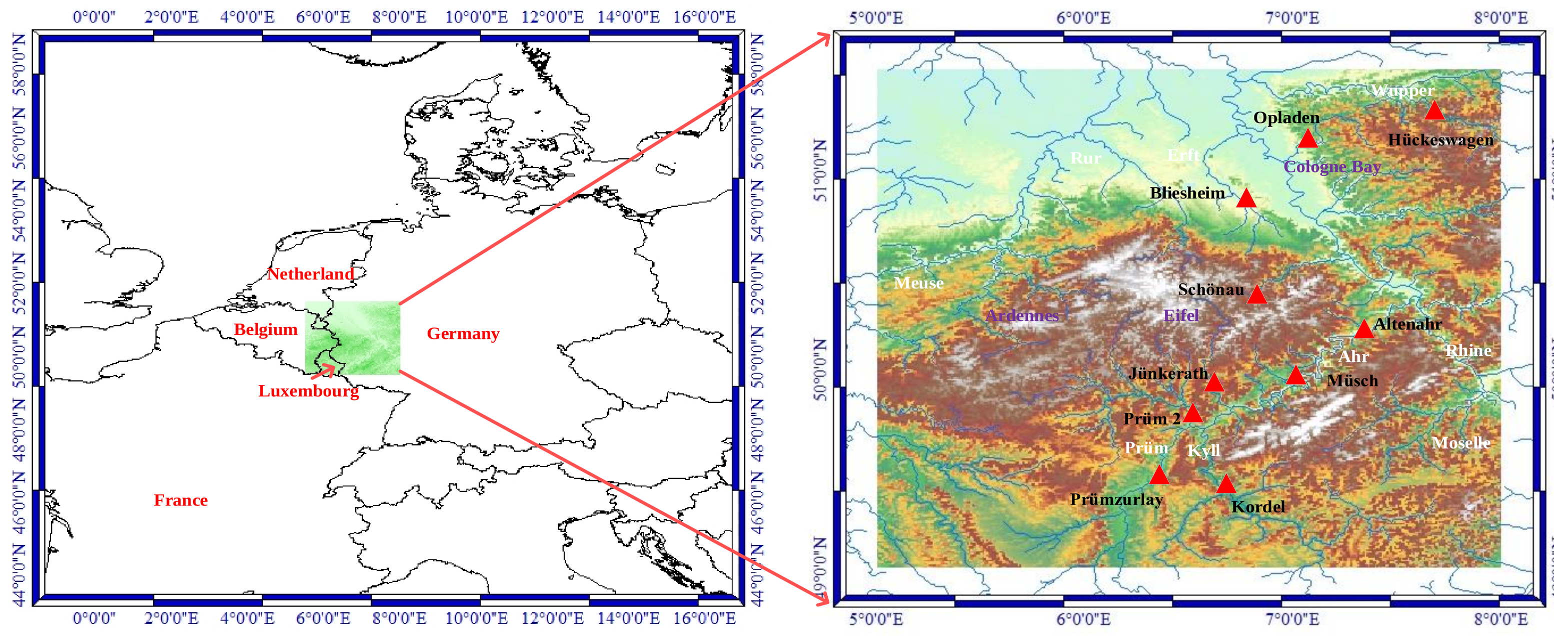


Figure 1. Overview map of the study area with European context. Digital Elevation Model (DEM) overlaid by the main rivers (blue) and river gauges (red).

Objectives

- Testing initial, antecedent moisture state of the catchment effect, particularly soil wetness on flood occurrence and magnitude.
- Testing **EnKF** capabilities in improvement of soil moisture and real-time flood forecasting.
- Proposing and implementing a novel application of the First Order Reliability Method (FORM) to validate the reliability of the DA performance in a **probabilistic** framework.

Model: ParFlow-CLM

- CLM represents **land surface processes**, surface energy balance, vegetation dynamics, biogeochemistry, and snow accumulation and melt.
- ParFlow effectively captures the complex dynamics of **unsaturated and groundwater flow**, as well as surface flow, within a comprehensive continuum framework .
- This integration enables a coupled representation of water, energy, and momentum exchanges between the **surface** and the **subsurface.**

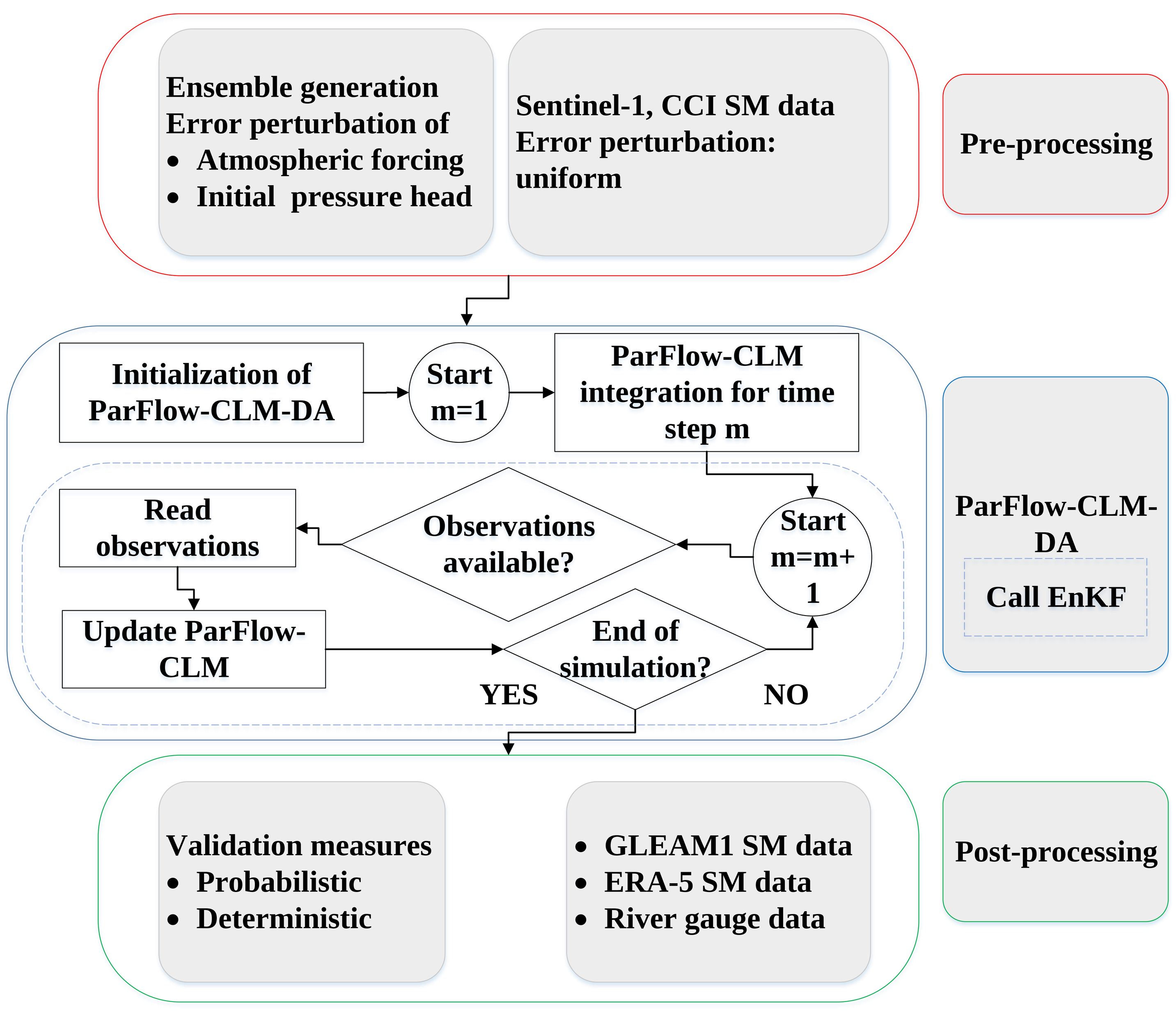


Figure 2. DA framework.

Results

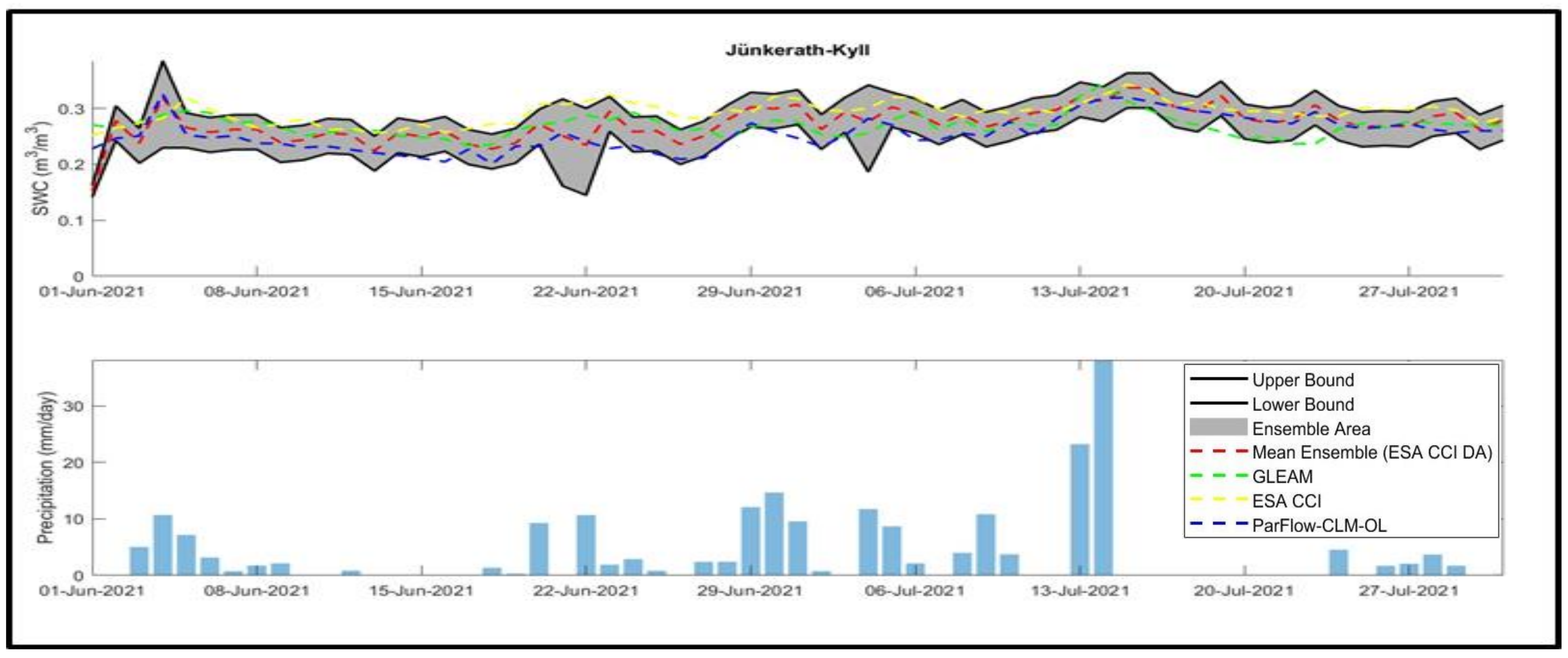
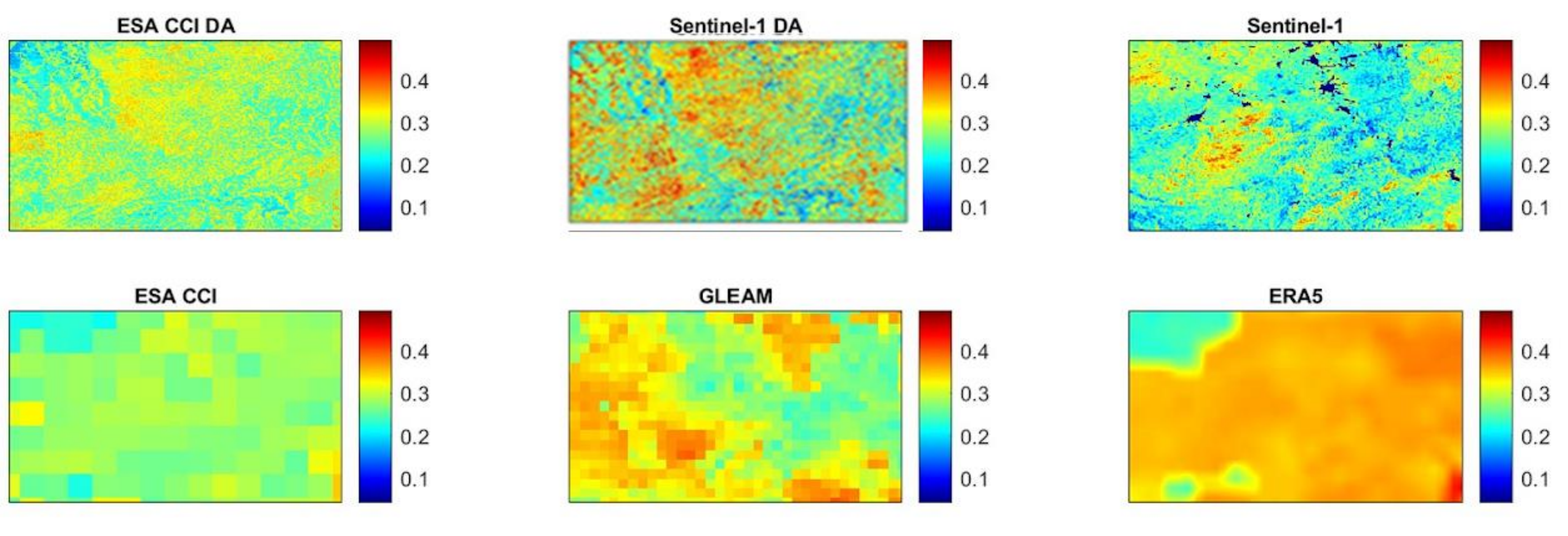
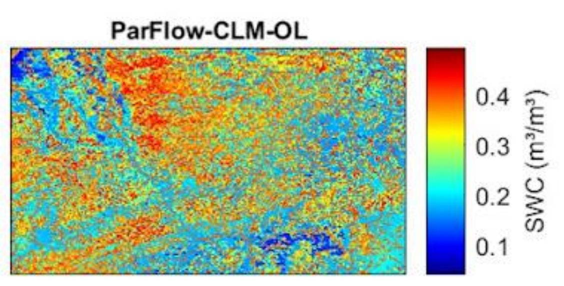


Figure 3. Simulated and observed SWC (m^3/m^3) .





- CCI DA proves to be a robust approach for representing soil moisture dynamics (good agreement with GLEAM).

Figure 4. Temporally averaged SWC (m^3/m^3) over flood period.

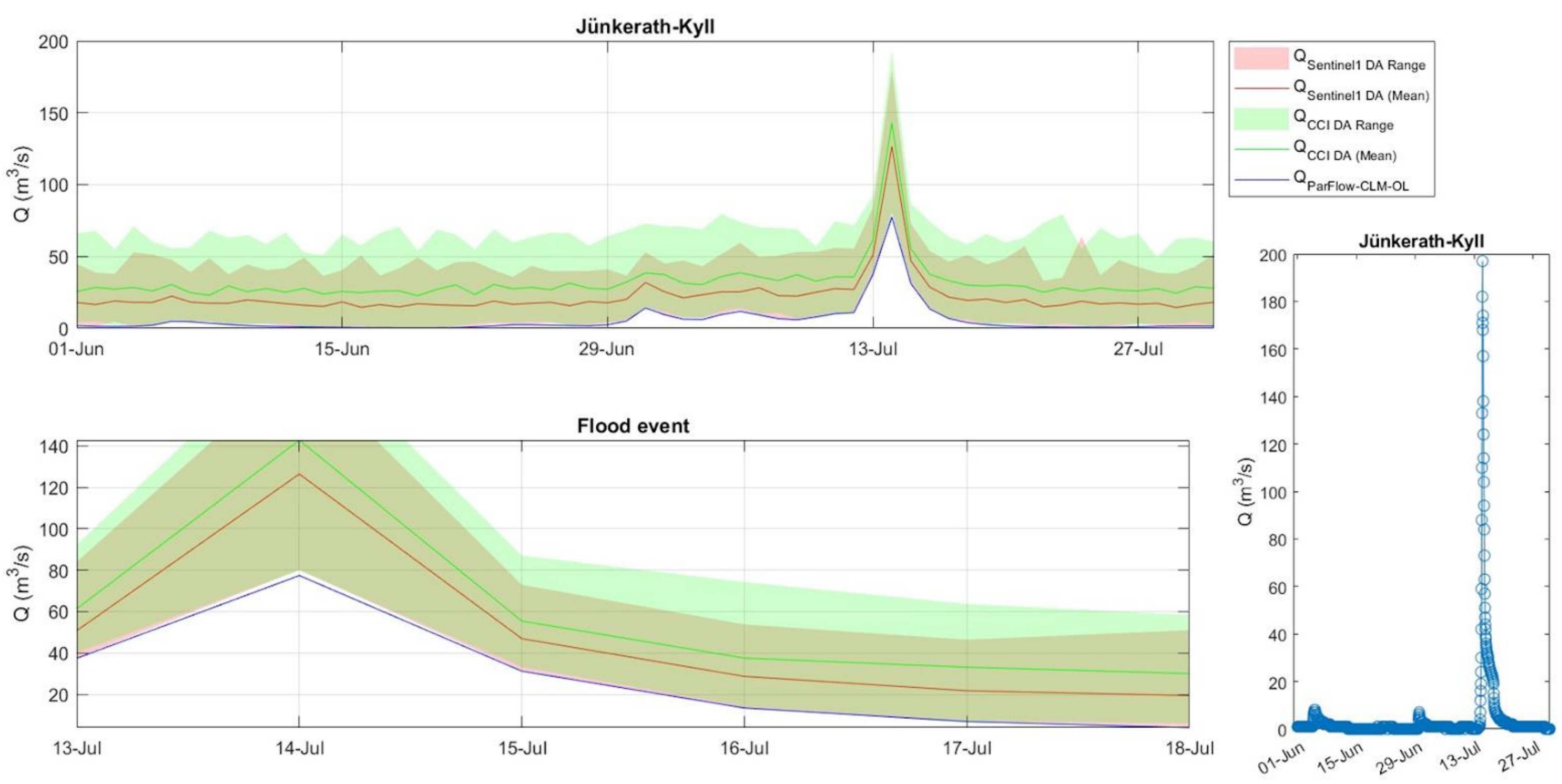


Figure 5. Simulated (left panels) and observed daily discharge (right panels).

Table 1. The probability of failure calculated using the FORM.

	P_f					
	RE > 0.35		CE < 0.75		DDA > 0.2	
	GLEAM	ERA5	GLEAM	ERA5	GLEAM	ERA5
ESA CCI-DA	12 %	15 %	11 %	14 %	7 %	11 %
CCI-DA	9 %	12 %	10 %	10 %	8 %	9 %
Open-loop	14 %	17 %	15 %	16 %	12 %	14 %

- ESA CCI-SM DA shows the lowest probability of failure across all locations, indicating superior performance in reducing failure risk.