Towards improved high-resolution hydrologic simulations over Europe using HPC based TerrSysMP–PDAF

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Introduction

- Soil moisture is an important driver for water and energy exchange at the land surface. A correct prediction of soil moisture (e.g., with hydrological or earth system models) plays a crucial role in water management, food production, flood forecasting, or climate projections.
- Data assimilation techniques, like the ensemble Kalman filter (Evensen, 1994) can be used to integrate those soil moisture observations into the corresponding hydrological model applications at different scales.
- Assimilating observational soil moisture data can improve not only soil moisture but other important simulated fields such as discharge.
- In this poster, we provide an examples for the assimilation of soil moisture observations at continental scale into earth system model TerrSysMP (Shrestha et al., 2014) using the Parallel Data Assimilation Framework (Nerger & Hiller, 2013, Kurtz et al., 2016)

Terrestrial System Modeling Platform (TerrSysMP-PDAF)

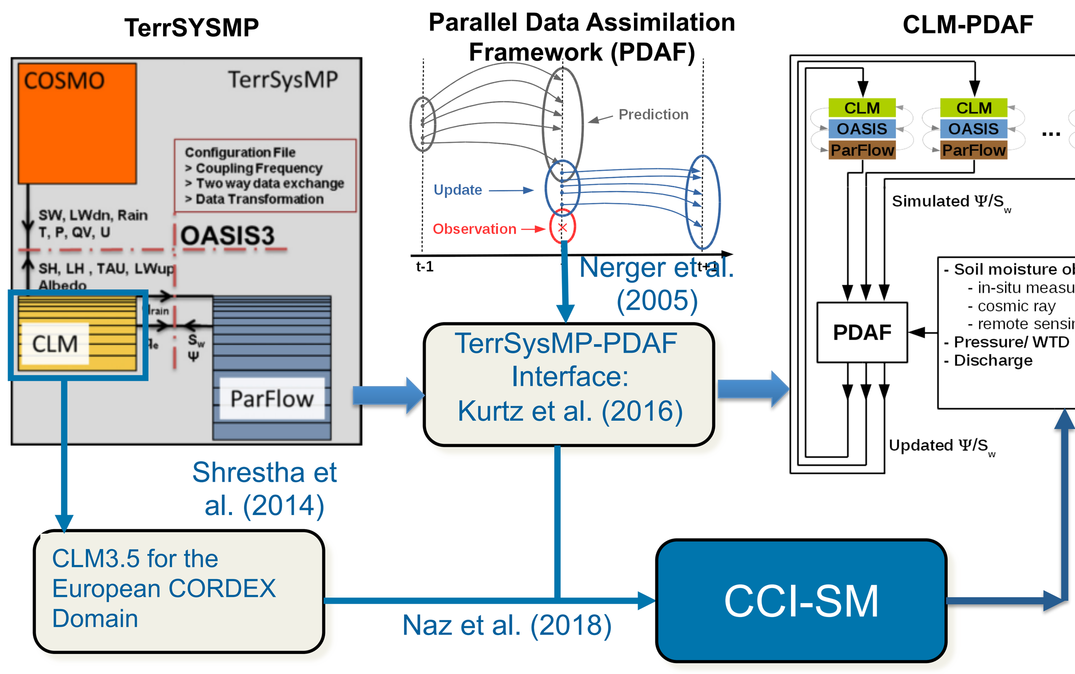


Figure 1: Data flow for the data assimilation with TerrSysMP and the Parallel Data Assimilation framework PDAF.

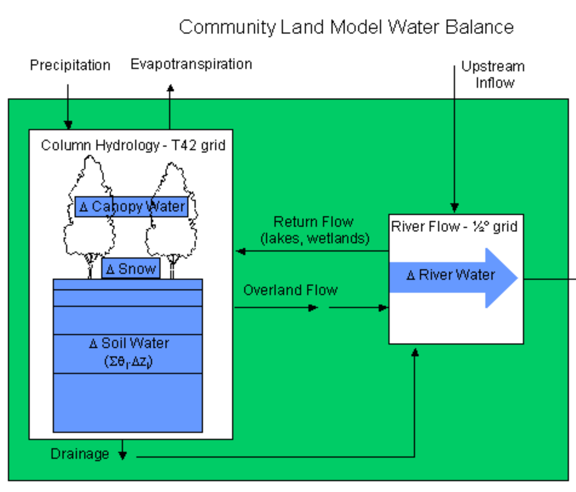


Figure 2:Diamgram of CLM terrestrial hydrological processes such as interception of precipitation by the vegetation canopy, throughfall, infiltration, surface and subsurface runoff, snow and soil moisture evolution, evaporation from soil and vegetation and transpiration (Oleson et al., 2008). In CLM, the land surface is represented by 5 primary sub-grid land cover types (glacier, lake, wetland, urban, vegetated) in each grid cell.

Model: PDAF-CLM

Domain Extent and resolution:
EU-CORDEX at 0.0275° (~3km) x 0.0275°(~ 3km)

Satellite Observations:
ESACCI soil moisture observation from satellite (2000 – 2006) at 0.25° resolution. For data assimilation 100 grid cell were randomly selected where the data is available for each day.

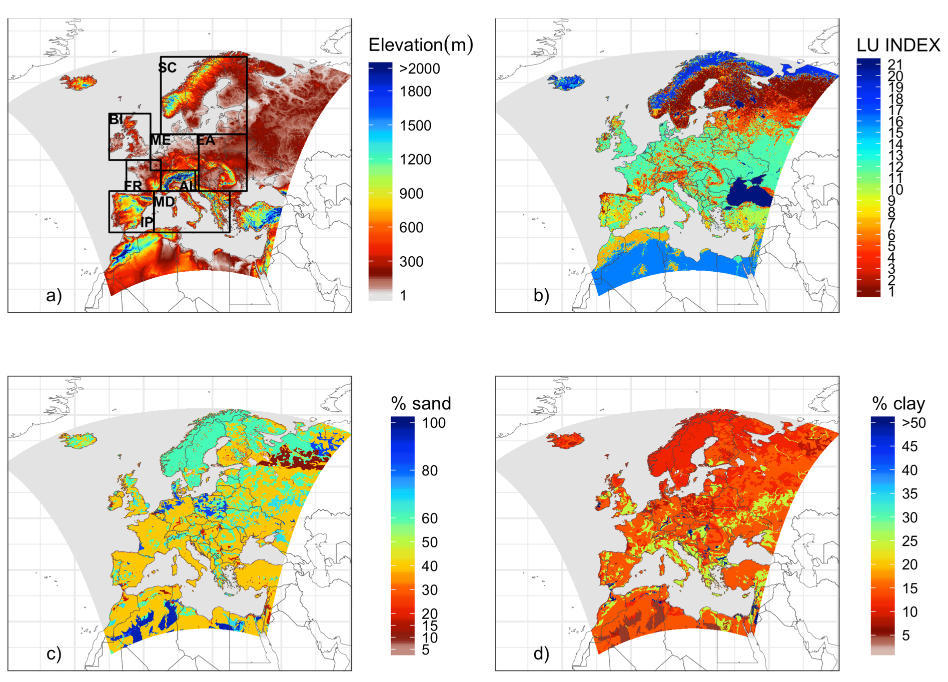
Ensemble generation:
12 realization of perturbed precipitation and soil texture.

Simulation period: 1 January 2000 – 31 December 2006

Simulation Scenarios:
- Open-loop (no data assimilation)
- State update (soil moisture)

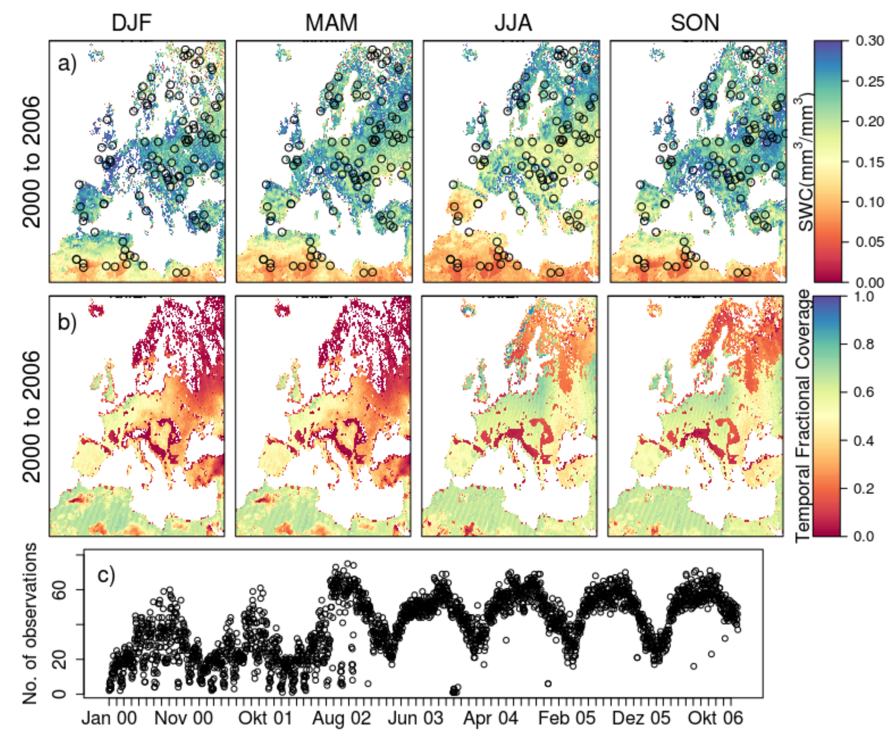
Study area and observations

Organize various key hydrologic model inputs at 1/36 degree (~3 km) grid for the EU-CORDEX domain:
- Topography (GMTED2000 elevation)
- Soil characteristics (FAO global dataset)
- Vegetation LAI (MODIS LAI)
- Land surface classification (MODIS)
- Meteorological forcing (6km COSMO-REA6 reanalysis)



ESACCI satellite soil moisture observation (2000 – 2006) at 0.25° resolution.
- For data assimilation 100 grid cells were randomly selected where daily data are available.
- More data gaps exist in the winter and in the earlier time period.
- Data coverage of observation is low in northern Europe than southern areas.

Model Validation:
- Long term E-RUN v1 gridded monthly runoff for 1950 - 2015 (Gudmundsson et al., 2016)



Continental scale soil moisture and runoff simulations

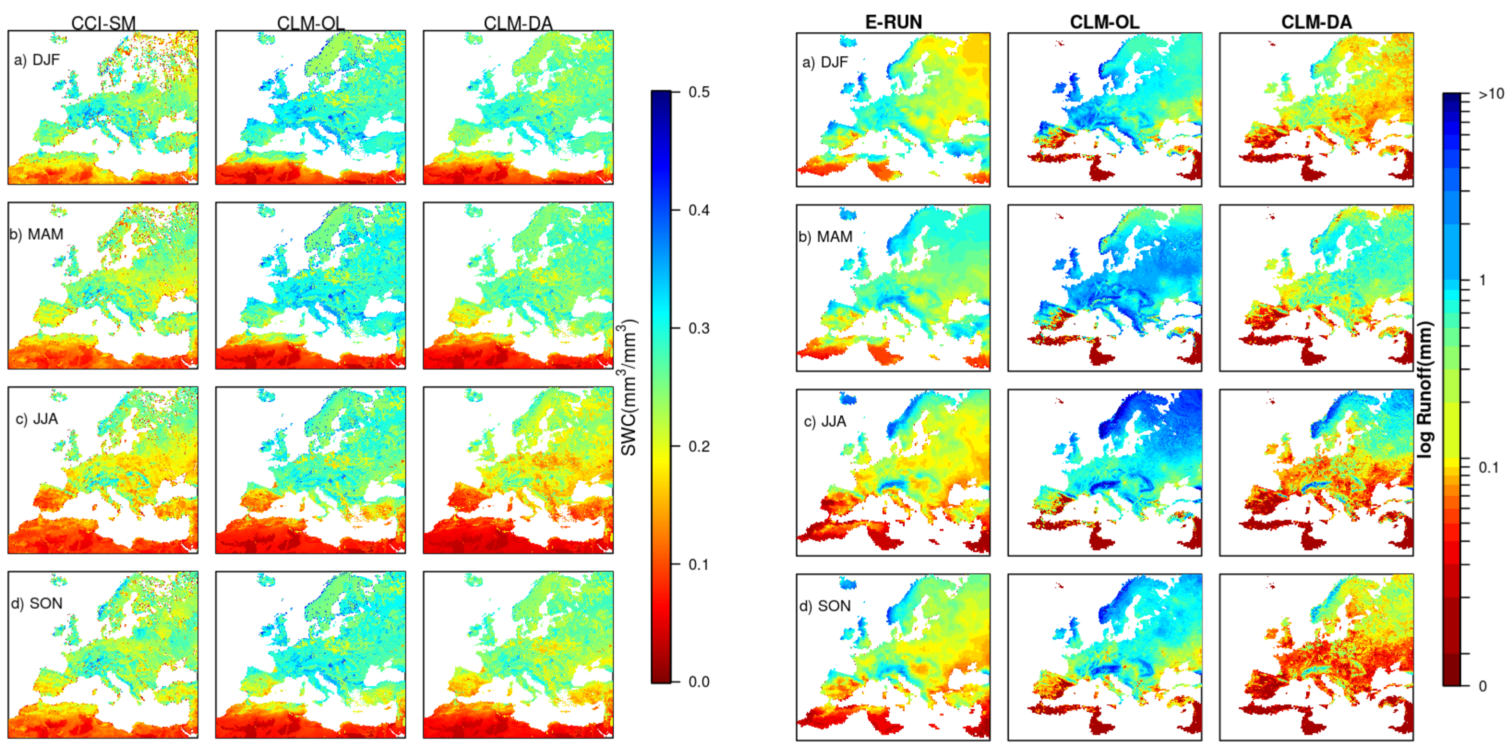
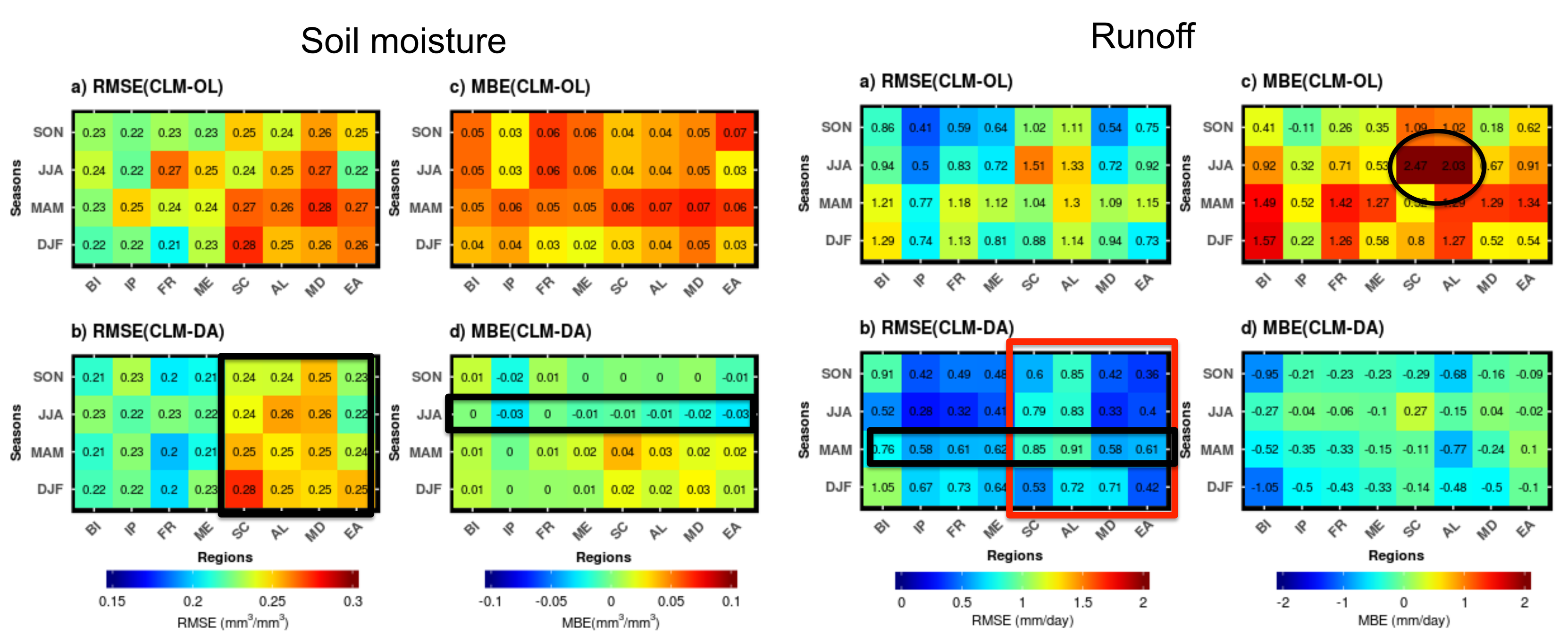


Figure 3: Comparison of seasonal mean soil moisture (cm³/cm³) and runoff simulated by CLM (CLM-OL) and data assimilation (CLM-DA) for the year 2000 – 2006 with CCI-SM satellite data, for a) DJF,(b) MAM, c) JJA and d) SON.

Improvements in soil moisture and runoff



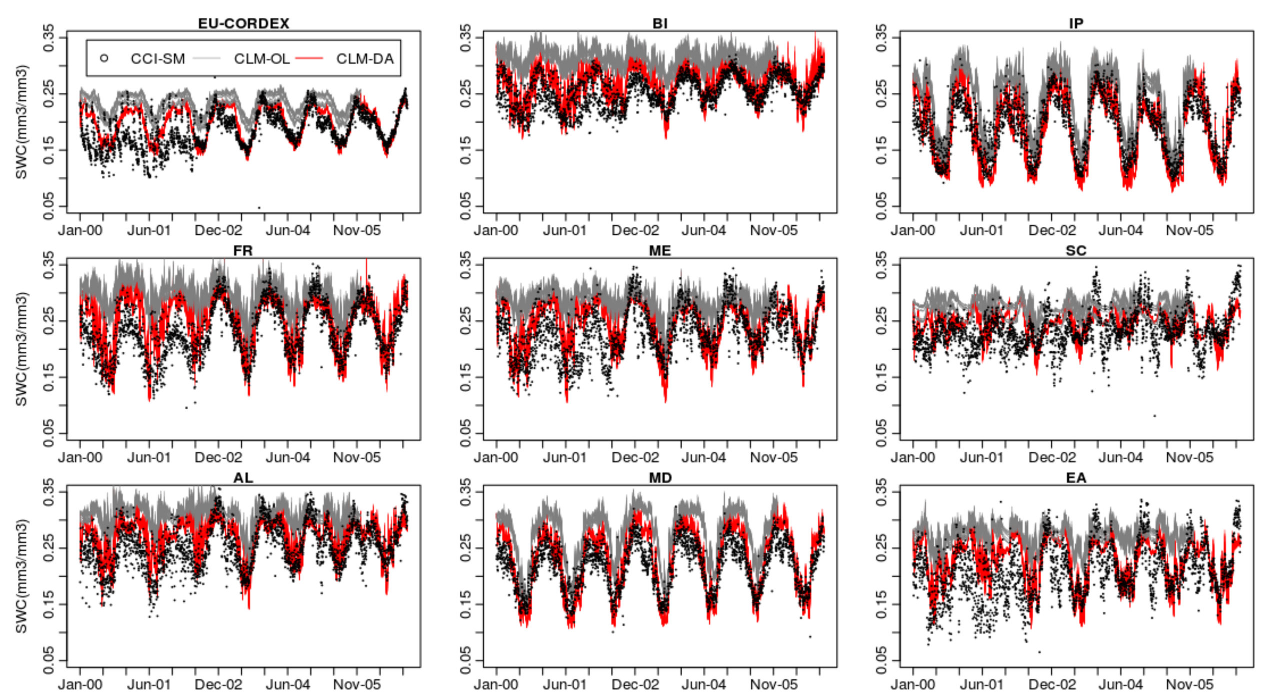


Figure 4: Comparison of Spatially aggregated daily average of soil moisture derived from CCI-SM data, CLM-DA and CLM-OL runs for time period of 2000 – 2006 in Prudence regions.

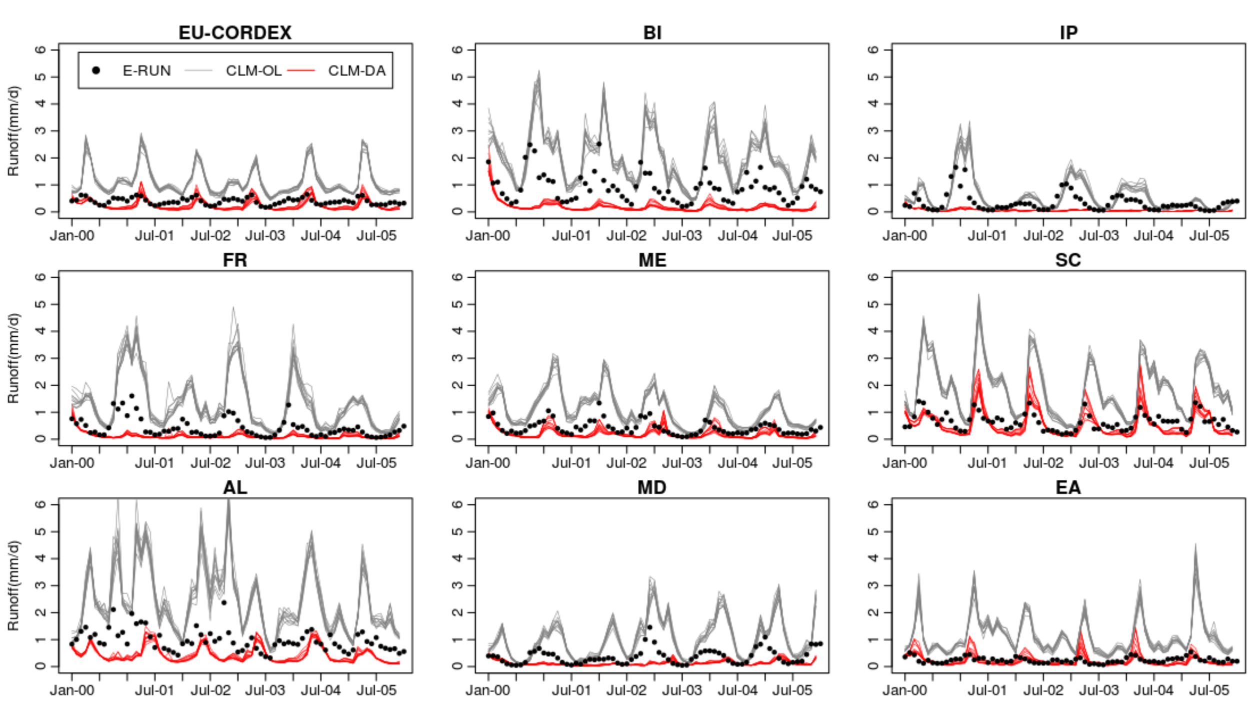


Figure 5: Comparison of Spatially aggregated monthly average of runoff derived from E-RUN data, CLM-DA and CLM-OL runs for time period of 2000 – 2006 in Prudence regions.

Summary and Outlook

- Assimilating monthly ESA CCI data **improves** the RMSE of CLM3.5 soil moisture and runoff outputs.
- Improvements in terms of RMSE are more pronounced in the SC, AL, MD and EA regions.
- CLM-DA underestimated runoff in the summer and autumn seasons particularly in the mid and south Europe
- Include ParFlow and COSMO
- DA in coupled model
- More recent CLM version (imporved runoff generation and routing)
- Joint update of model parameters
- Validation of the assimilated model using independent data sets

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