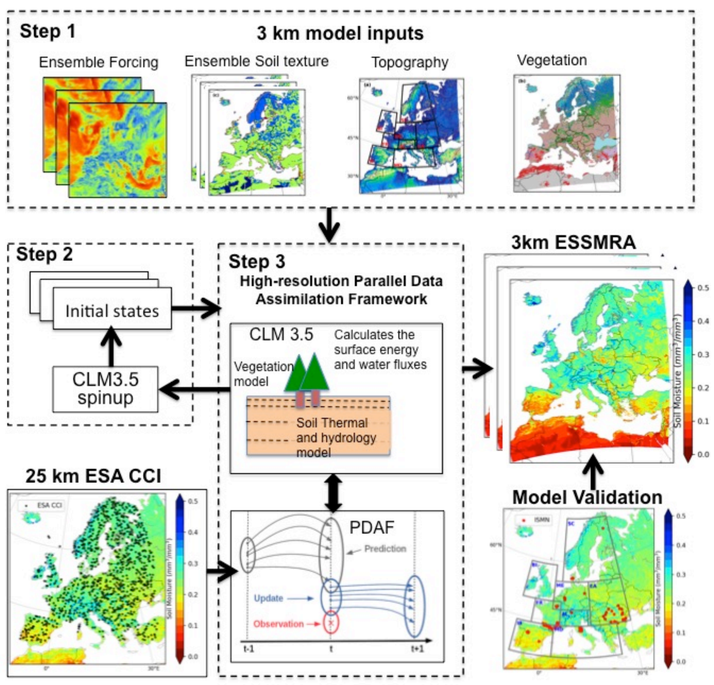
Development of pan-European daily high-resolution soil moisture reanalysis dataset using parallel data assimilation system

Bibi S. Naz[1,2], Stefan Kollet[1,2], Harrie-Jan Hendricks Franssen[1,2] and Wolfgang Kurtz[3]

(1)Agrosphere (IBG-3), Forschungszentrum Jülich; (2) Centre for High-Performance Scientific Computing in Terrestrial Systems, Geoverbund ABC/J,
(3) Leibniz Supercomputing Centre, Environmental Computing Group, Boltzmannstr. 1, 85748 Garching, Germany

Introduction

- Soil moisture (SM) 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.
- The land surface data assimilation system TSMP-PDAF consisting of the Terrestrial System Modeling Platform (Shrestha et al., 2014) and the Parallel Data Assimilation Framework (Nerger & Hiller, 2013, Kurtz et al., 2016) was used to generate SM reanalysis dataset.



- Satellite-derived soil moisture data are assimilated into the land surface model using an ensemble Kalman filter data assimilation scheme, producing a 3 km daily soil moisture reanalysis dataset over Europe.
- In this poster, pan-European 16 years (2000–2015) high-resolution (3 km) soil moisture reanalysis dataset (ESSMRA) is presented.

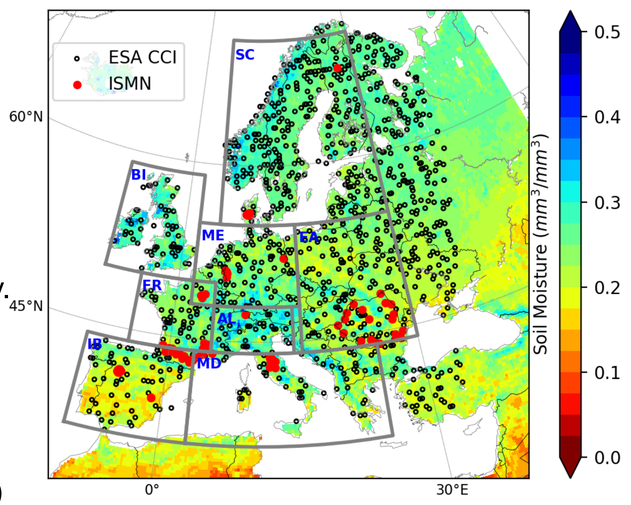
TSMP-PDAF modeling setup

Data assimilation

- Domain extent and resolution: EU-CORDEX at 0.027° x 0.027°(~ 3km)
- ESA CCI satellite-based surface soil moisture products (2000 – 2015) at 0.25° resolution.
- For data assimilation 1000 grid cells were randomly selected (black points).
- Soil moisture updates was set to 1 day.

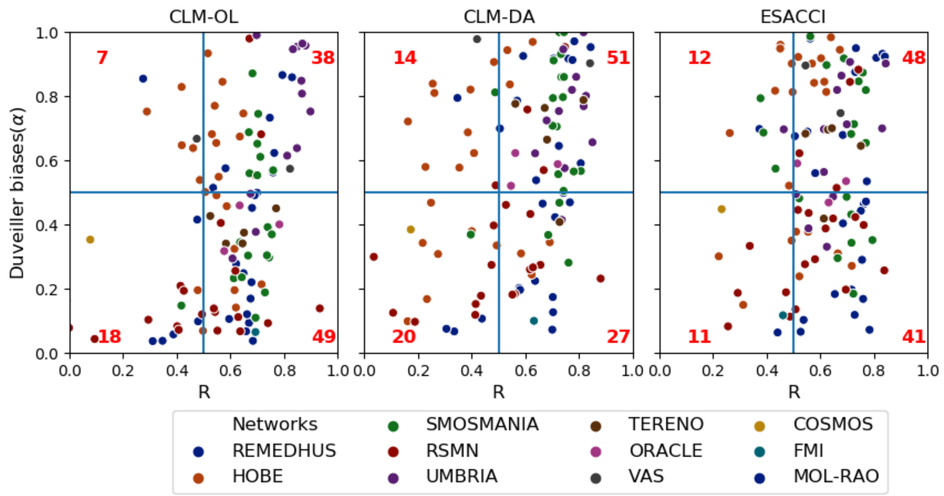
Model Validation:

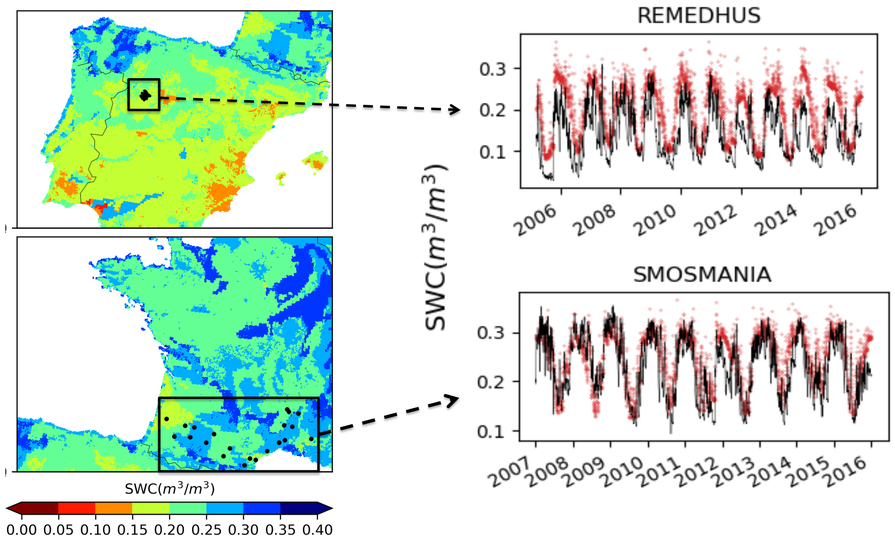
- *In-situ* soil moisture from ISMN (red points)
- ESA CCI and existing SM reanalysis products (GLDAS, ERA5 and GLEAM) over PRUDENCE regions



Surface soil moisture validation with in-situ observations

- Surface soil moisture data between 2000–2015 at 112 ISMN stations for top 5 cm surface layer were collected and compared with the top two CLM soil layers (about 3 cm).
- CLM-DA is in good agreement with observations over half of the stations.

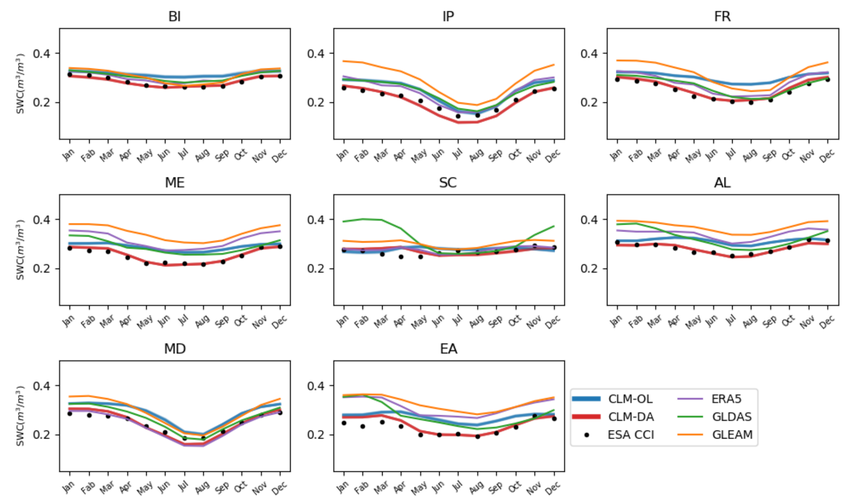




Comparison of daily time series of volumetric water content (m^3/m^3) from CLM-DA and in-situ observations for REMEDHUS and SMOSMANIA networks. The average of the in-situ observations of all stations within ISMN network was first calculated and then compared with the averaged soil moisture of all grids within the same ISMN network.

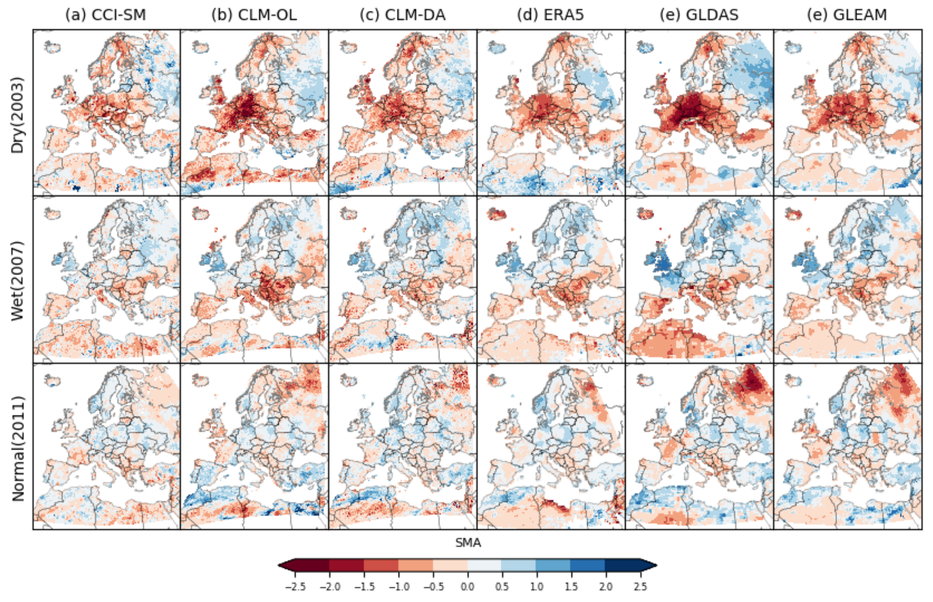
Regional scale validation

- ESSMRA followed the seasonal variations fairly well, indicating that the timing and magnitude of SM at monthly and annual scales is reasonably accurate.
- In the dryer regions such as IP and MD, the soil moisture estimates by ESSMRA is lower than the other products particularly in summer.



Summer soil moisture variability

The summer SM anomaly (relative to 2000-2015) from CLM-DA for the dry, wet and normal years (2003, 2007, 2011) has better match with ESA CCI, where CLM-OL shows much stronger negative anomaly.



Summary

- Comparison of CLM-DA simulated soil moisture with ISMN network shows a good agreement with observations over half of the stations.
- Assimilating daily satellite SM improved the RMSE of CLM 3.5 near-surface soil moisture simulations up to 45% relative to open-loop simulations over PRUDENCE regions.
- CLM-DA simulated soil moisture anomalies are consistent with other reanalysis products.
- In future fully coupled TSMP assimilation of other RS SM products (e.g. SMAP) and joint assimilation of SM and GRACE data will be explored.

Acknowledgements

The authors gratefully acknowledge the computing time granted by the John von Neumann Institute for Computing (NIC) and provided on the supercomputer JURECA at Jülich Supercomputing Centre (JSC). This work was supported by funded the Energy oriented Centre of Excellence2 (EoCoE2), grant agreement number 824158, funded within the Horizon2020 framework of the European Union.

References

Kurtz, W., He, G., Kollet, S.J., Maxwell, R.M., Vereecken, H., Hendricks Franssen, H.-J. (2016). TerrSysMP-PDAF (version1.0): a modular high-performance data assimilation framework for an integrated land surface-subsurface model, Geosci. Model Dev., 9, 1341-1360.

Naz, B. S., Kurtz, W., Montzka, C., Sharples, W., Goergen, K., Keune, J., Gao, H., Springer, A., Hendricks Franssen, H.-J., and Kollet, S.: Improving soil moisture and runoff simulations at 3 km over Europe using land surface data assimilation, Hydrol. Earth Syst. Sci., 23, 277–301, https://doi.org/10.5194/hess-23-277-2019, 2019.

Nerger, L., Hiller, W. (2013). Software for ensemble-based data assimilation systems – implementation strategies and scalability, Comput. Geosci., 55, 110-118.

Shrestha, P., Sulis, M., Masbou, M., Kollet, S.J., Simmer, C. (2014). A scale-consistent terrestrial systems modeling platform based on COSMO, CLM, and ParFlow, Mon. Wea. Rev., 142, 3466-3483.

Contact

Bibi S . Naz
b.naz@fz-juelich.de

Agrosphere (IBG-3)
Institute of Bio- and Geosciences
Jülich Research Centre (FZJ)
Jülich, Germany

Centre for High-Performance Scientific, Computing in Terrestrial Systems (HPSC TerrSys)
Geoverbund ABC/J (Germany)

Follow us on Twitter @HPSCTerrSys

HPSC TerrSys YouTube Channel