Monitoring and forecasting the regional water cycle with the Terrestrial Systems Modelling Platform (TSMP): Overview and first evaluation results

Maksim Iakunin[1,2], N. Wagner[1,2], A. Graf[1], K. Goergen[1,2], S. Kollet[1,2]

[1]FZJ/IBG-3, [2]Centre for High-Performance Scientific Computing in Terrestrial Systems (HPSC TerrSys), Jülich, Germany

Terrestrial System Modelling Platform (TSMP)

Components

- A scale-consistent highly modular fully integrated soil-vegetation-atmosphere numerical modelling system using COSMO, Community Land Model and ParFlow;

- physically-based representation of transport processes of mass, energy and momentum across scales down to sub-km resolutions, explicit feedbacks between compartments;

- to exchange fluxes and states across the individual component models of TSMP and close the terrestial water and energy cycle, the Ocean-Atmospheric-Sea-Ice-Soil coupler interfaces with the Model Coupling Toolkit (OASIS-MCT) is used;

- towards a regional Earth system model; used primarily for water cycle research.

-> https://github.com/HPSCTerrSys/TSMP <-

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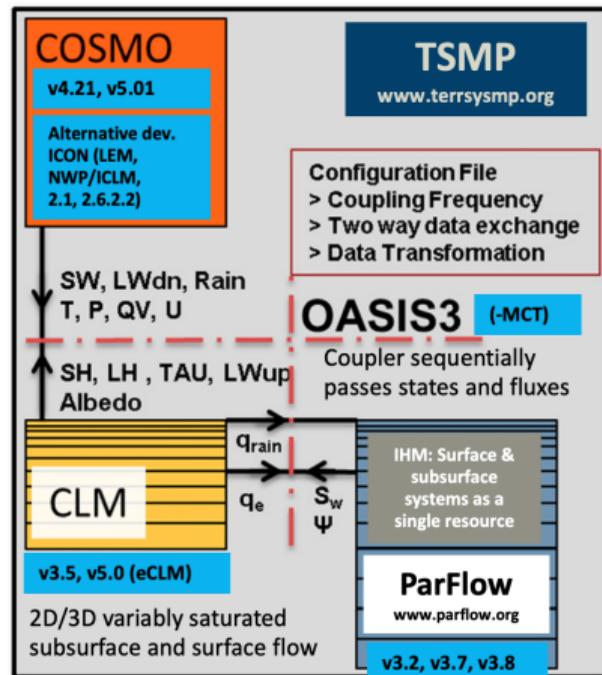
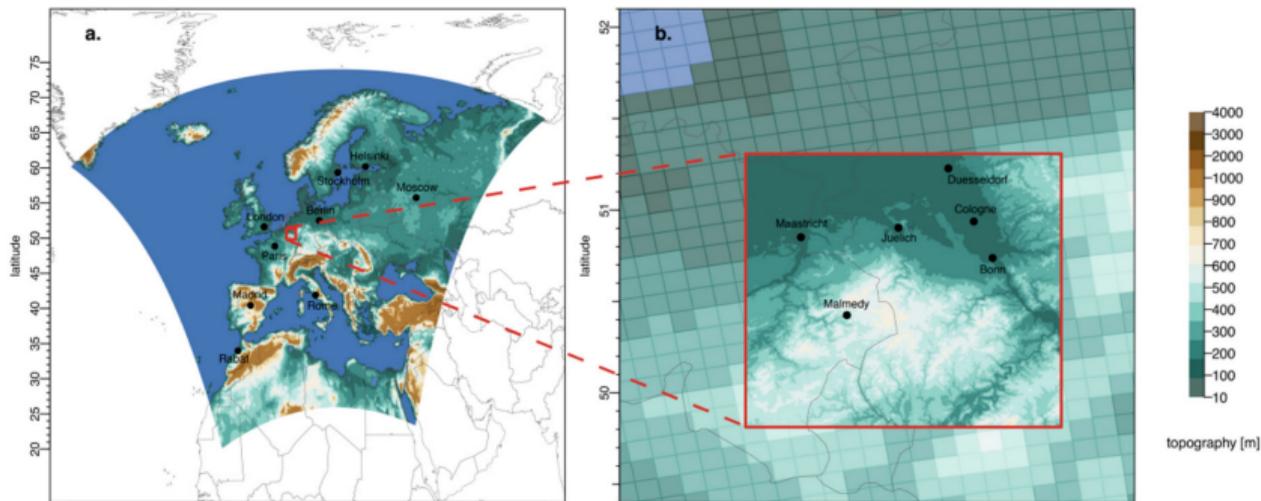# Water cycle, coupled European model domains

Simulated water table depth (ParFlow), spinup runs

River networks start to evolve, redistribution of surface and groundwater in continuum approach
Surface runoff and subsurface hydrodynamics are linked

Tunnel valleys Sweden

Upper Rhine river

J. Keune (Meteorological Institute, University of Bonn)
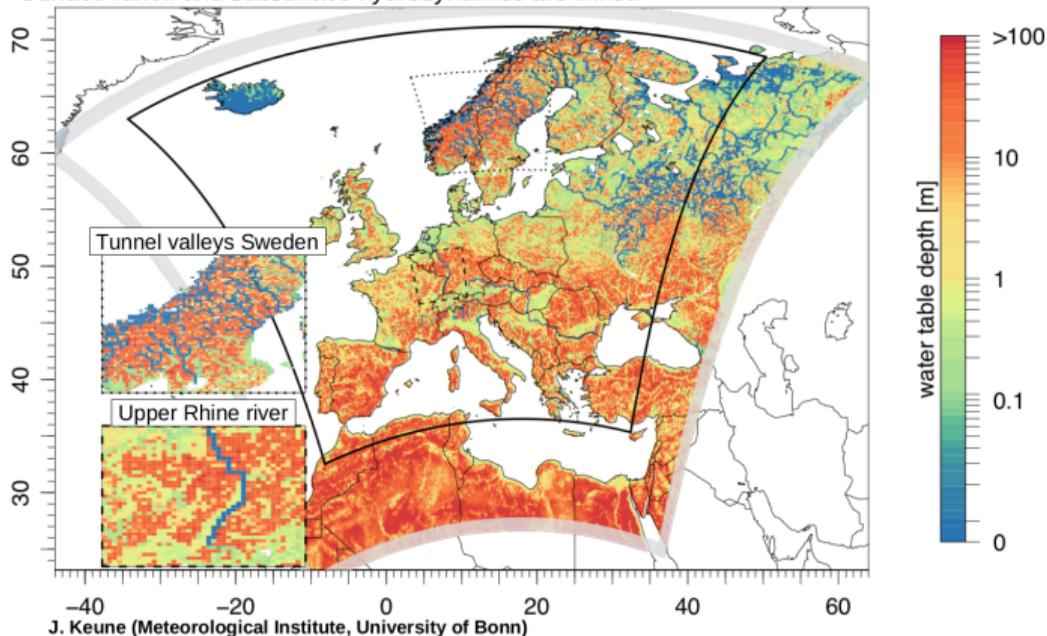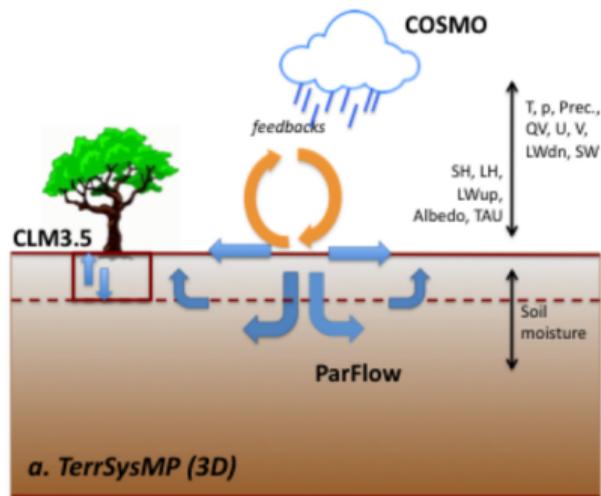
TSMP-M — a system for monitoring and forecasting
Domains

- **Domain a.:** CORDEX EUR-11, $dx = dy = 12.5km$; $nx = 436$ $ny = 424$ driven by ECMWF HRES deterministic forecasts.
- **Domain b.:** NRW, $dx = dy = 0.5$ km; $nx = ny = 300$. Is a nesting to the EUR domain.

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TSMP-M

Implementation

Daily 00UTC forecast simulation at the Jülich Supercomputer Center (JSC) on JURECA-DC CPU module (TOP500 June2021 rank **43**, Green500 June2021 rank **8**).

JURECA-DC (480 compute nodes) is:
- 2x AMD EPYC 7742, 2x 64 cores, 2.25 GHz
- 512 (16x 32) GB DDR4, 3200 MHz
- InfiniBand HDR100 (NVIDIA Mellanox Connect-X6)

TSMP-M

Forecasting workflow

1. 10-days European forecast driven by ECMWF-forecast;

2. RADOLAN DWD (German Meteorological Service) precipitation radar data used for a short 24 hours TSMP simulation that is aimed on updating soil moisture data in the model ("correction" simulation);

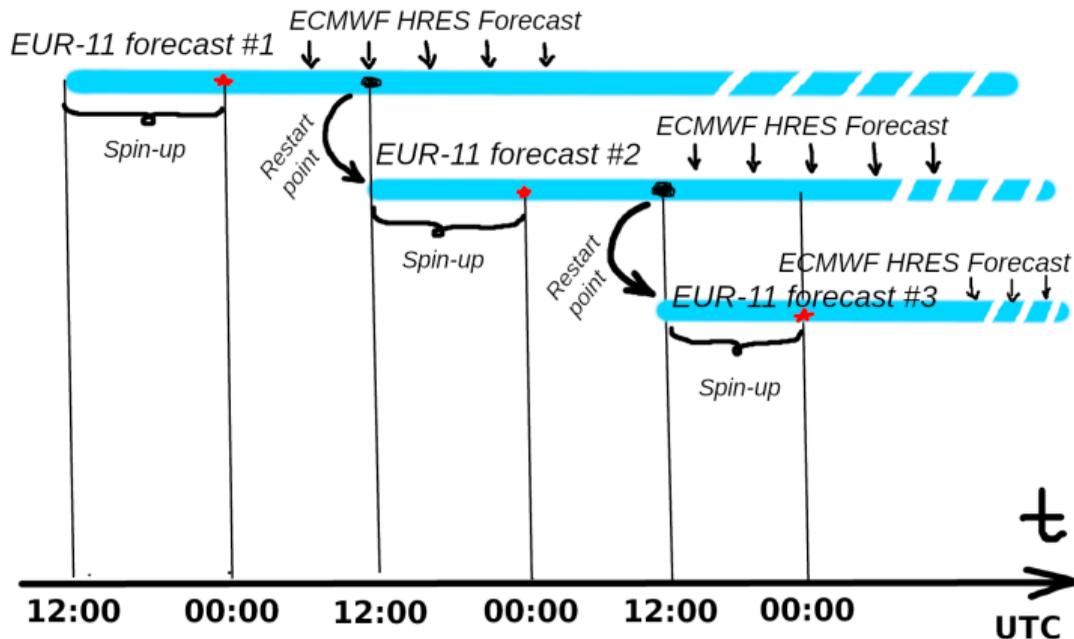3. 10-days forecast over NRW domain based on EU-forecast and correction simulation.

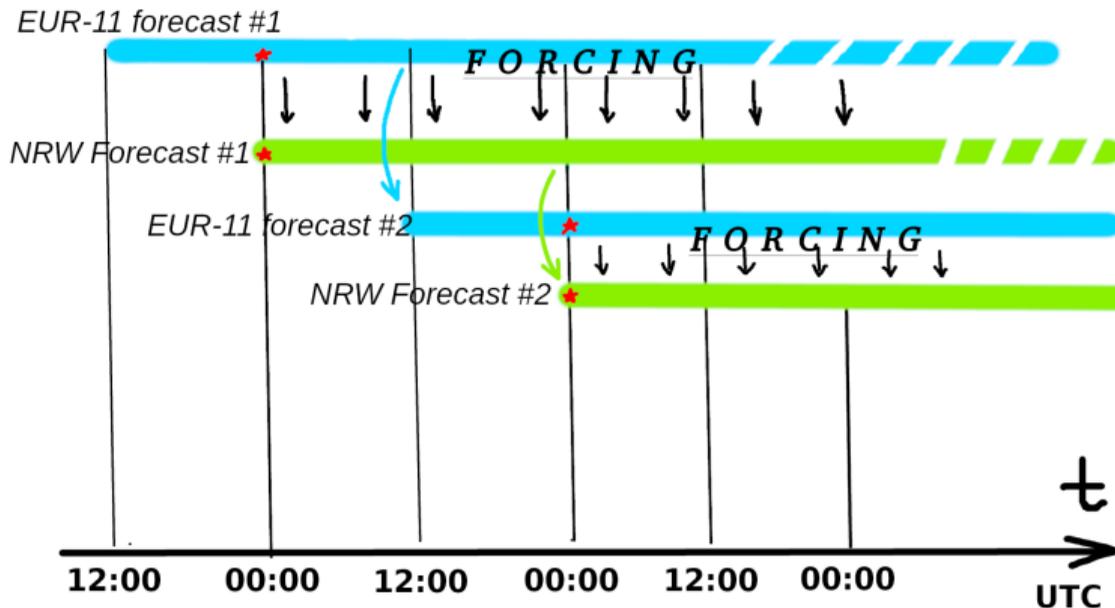Visualisations are available at:
www.terrsysmp.org/forecast/index.html
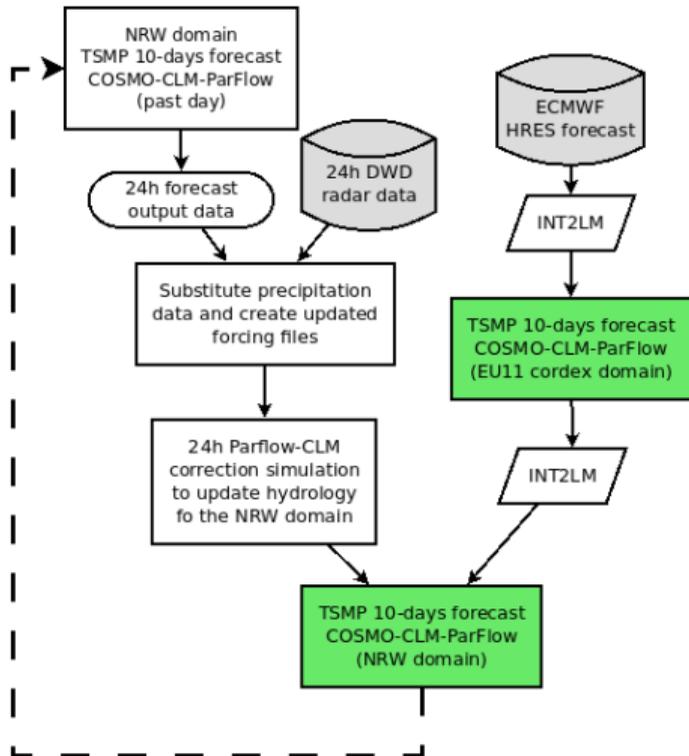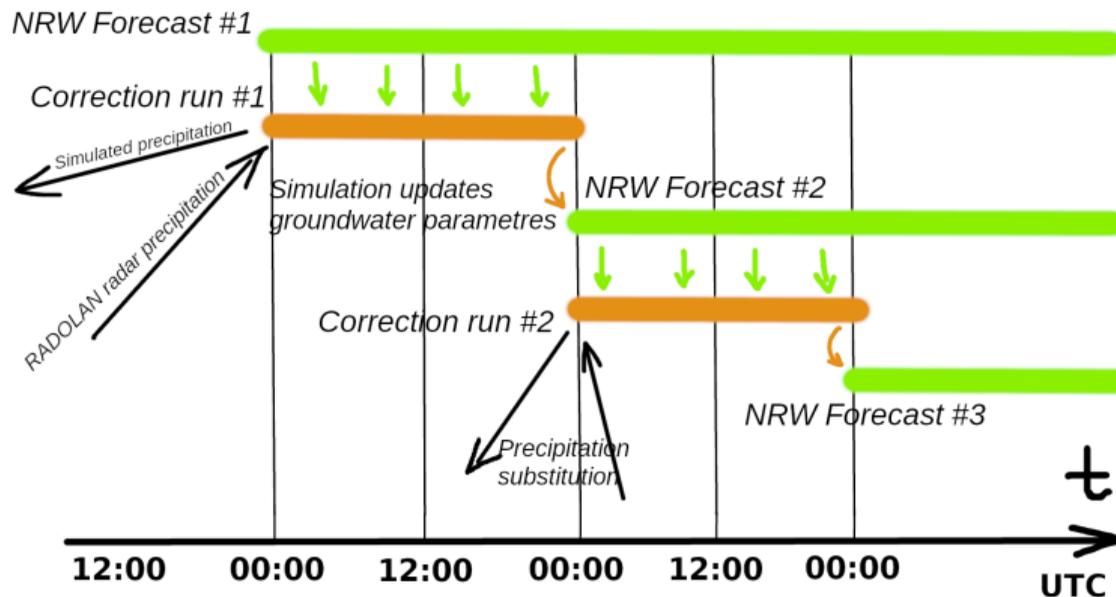
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Forecasting workflow: time schemes. EUR-11

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Forecasting workflow: time schemes. NRW

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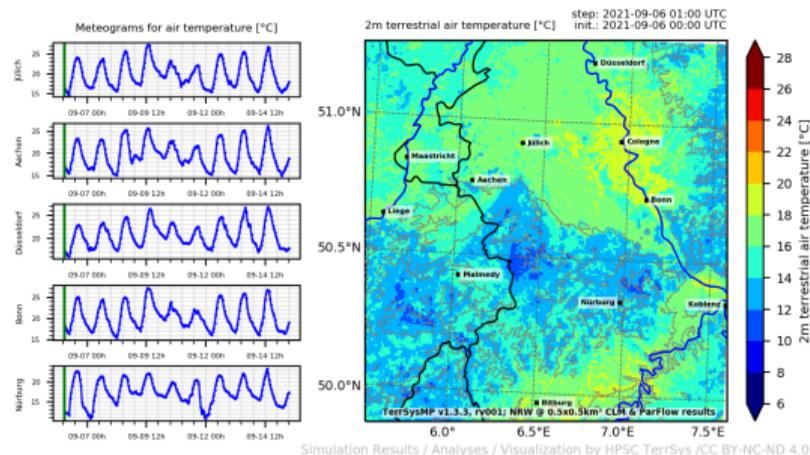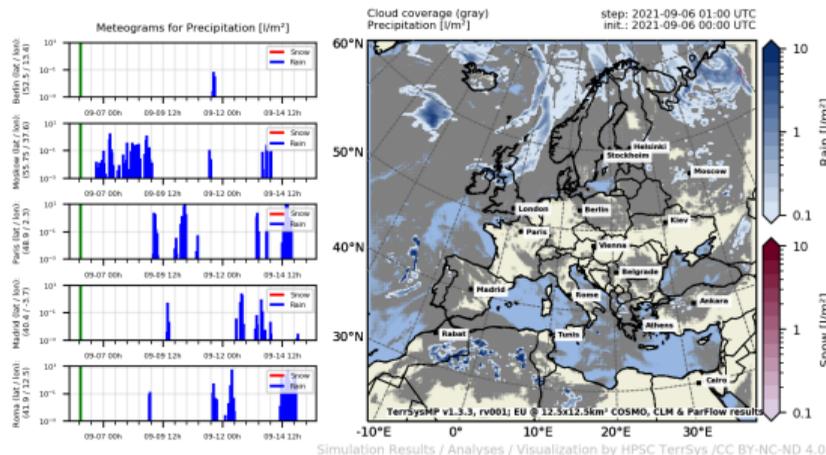## Forecasting workflow: time schemes. NRW radar correction
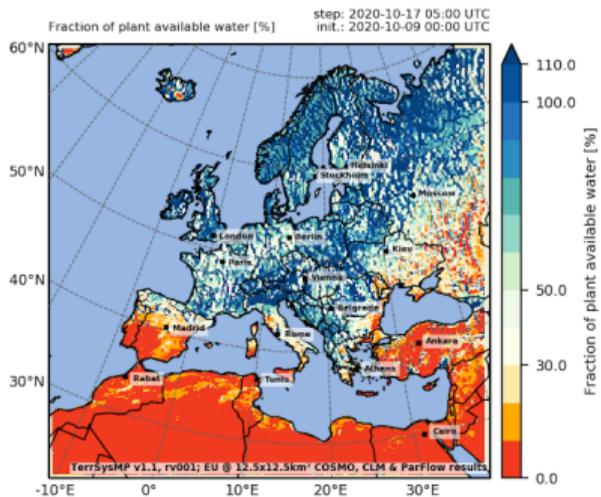
TSMP-M website

Daily forecasts available at
`www.terrsysmp.org/forecast/index.html`

The system is set up in 2016. Since July 2019 forecasts for both domains are produced on a daily basis.
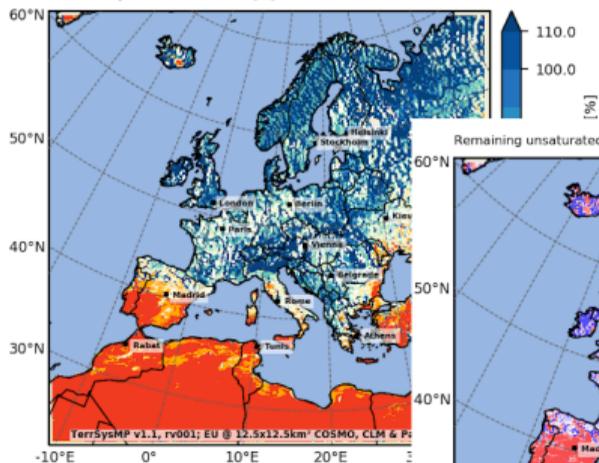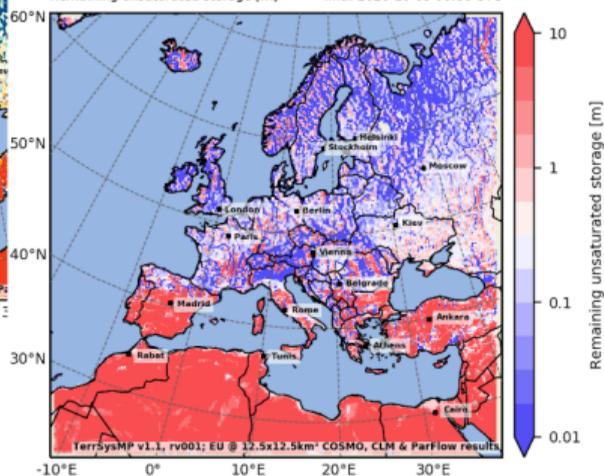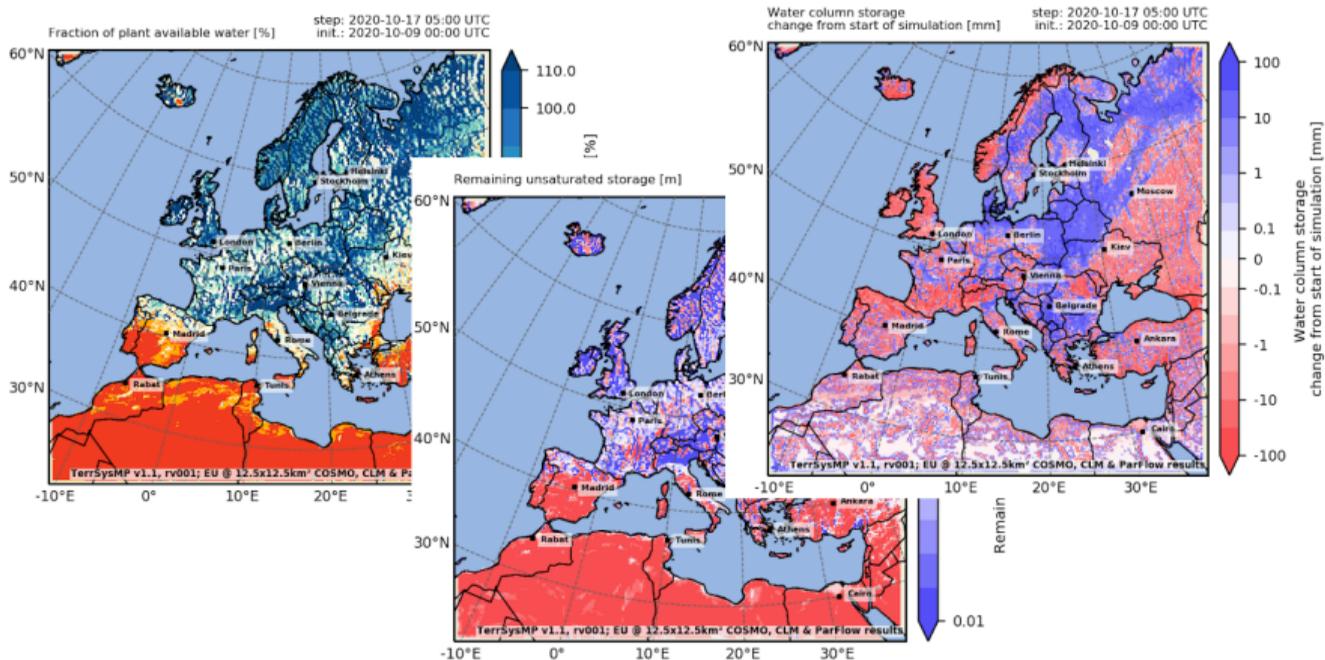
TSMP-M products

TSMP-M products

TSMP-M products
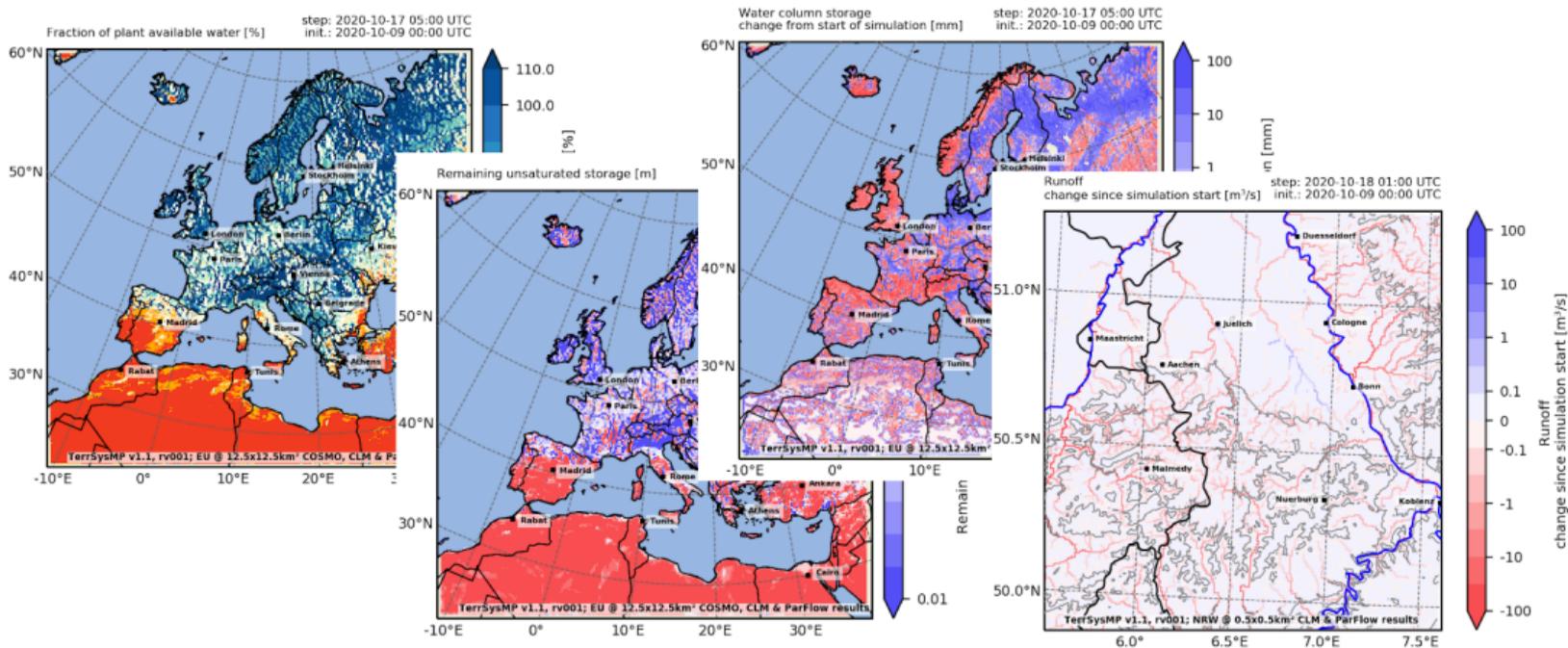
TSMP-M products

TSMP-M products

*Hartick, C., Furusho-Percot, C., Goergen, K., Kollet, S. (2021). **An Interannual Probabilistic Assessment of Subsurface Water Storage Over Europe Using a Fully Coupled Terrestrial Model**, *Water Resources Research*, 57, e2020WR027828, *doi.org/10.1029/2020WR027828*
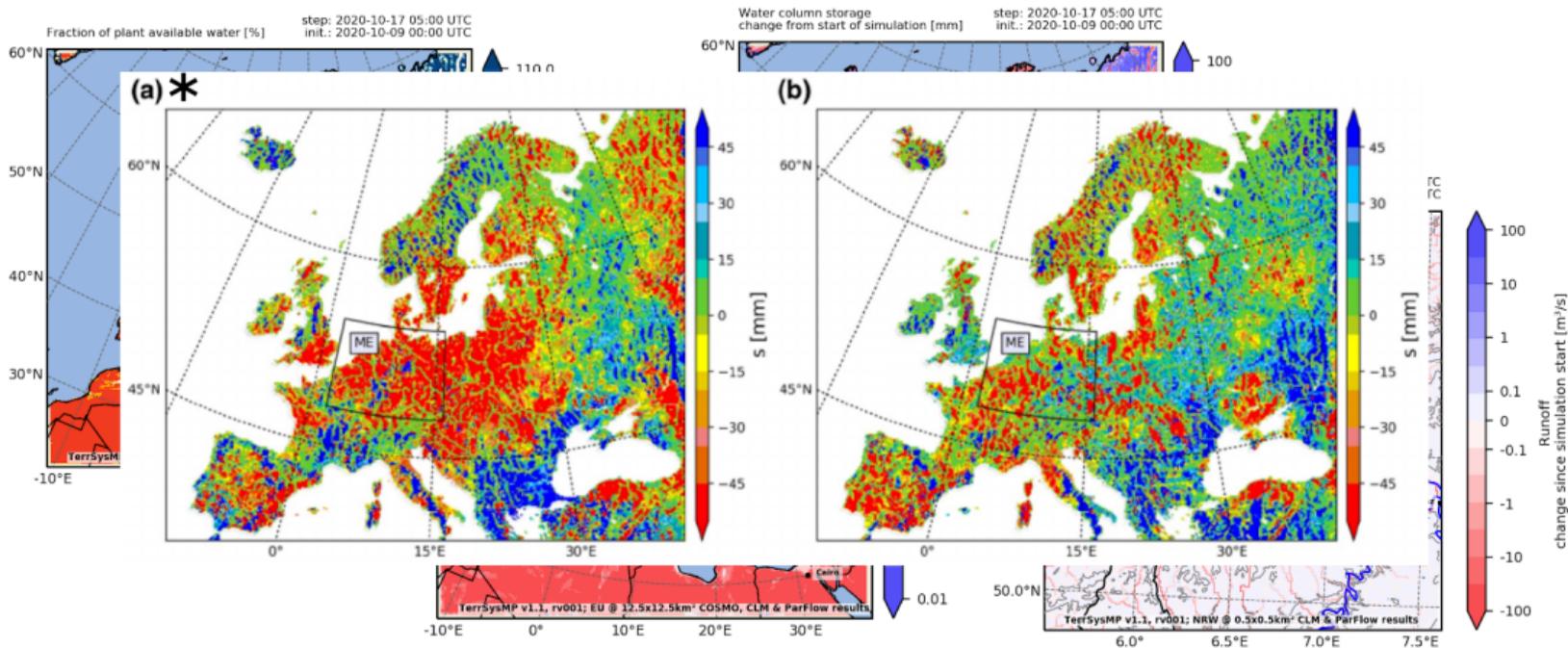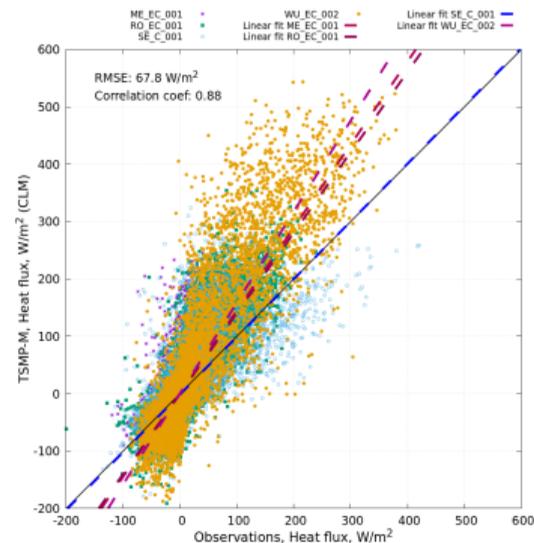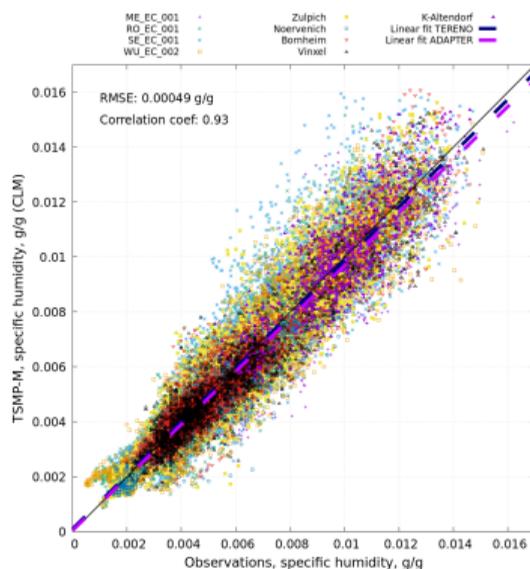
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TSMP-M evaluation

TERENO stations

First steps into evaluation of TSMP-M in NRW domain.

- TERENO — Terrestrial Environmental Observatories;
- Climate and Eddycovariance stations, cosmic-ray neutron soil moisture stations, streamflow observations, weather radars;
- https://www.tereno.net
- ADAPTER/DG-RR stations https://adapter-projekt.de/
- 2 years timespan: July 2019 – July 2021;

TSMP-M NRW evaluation
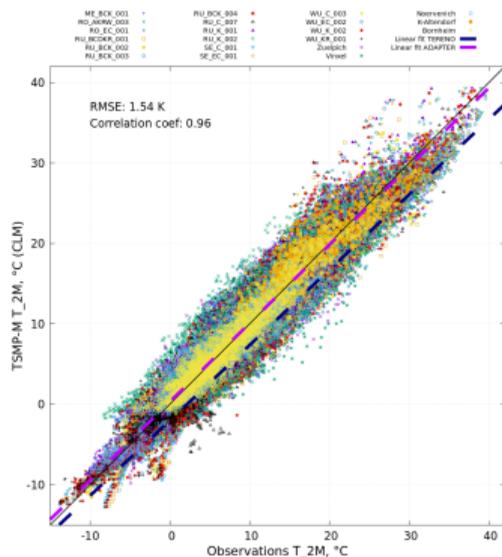
Attention: work in progress!
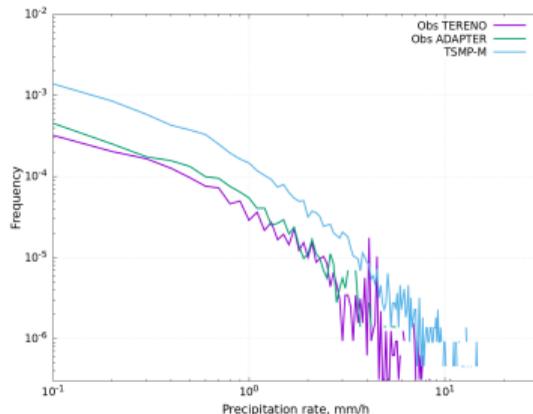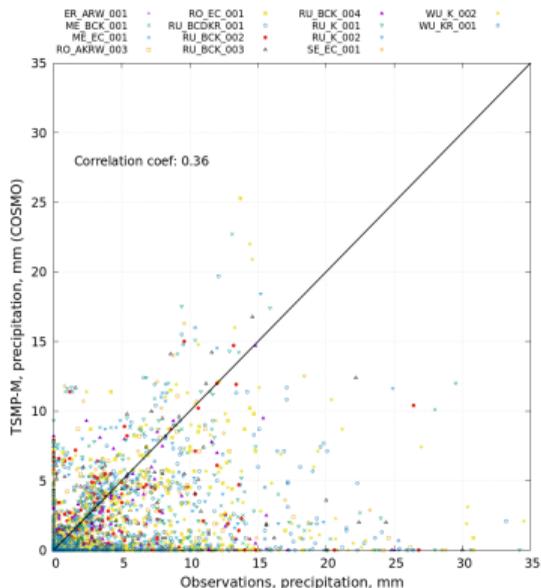
Evaluation results

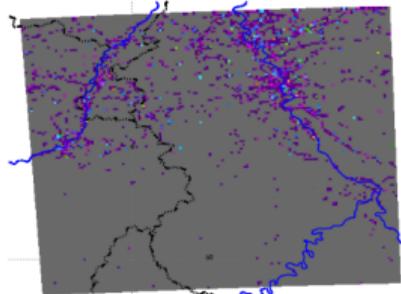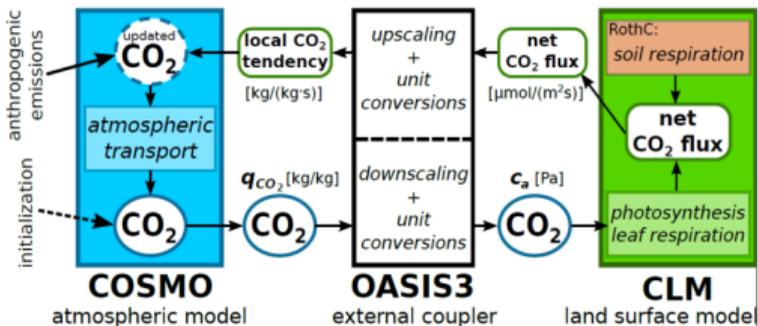**Precipitation (COSMO)**

- Daily accumulated precipitation in the scatter plot (0.36 correlation coefficient);
- model values (from COSMO) were picked as the best fit from 9 neighbouring pixels;
- frequency distribution of instantaneous hourly precipitation (>0.1 mm/h) shows an overestimation of the precipitation by the model;
- yet to be compared spatially with radar data.

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Future plans

Inclusion of CO2 coupling in TerrSysMP

Implementation of parallel data assimilation framework

Anthropogenic CO2 emissions as source Terms for COSMO

Typical diurnal cycle

NRW model domain 1 km resolution
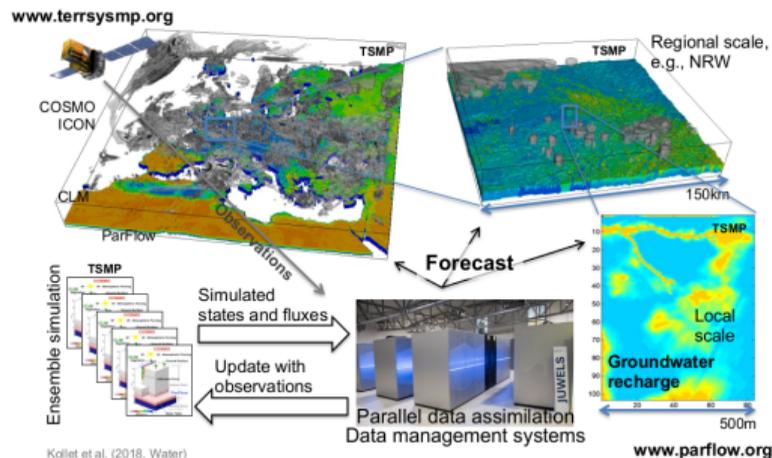
Selected publications

1. Furusho-Percot, C., Goergen, K., Hartick, C., et al. (2019). **Pan-European groundwater to atmosphere terrestrial systems climatology from a physically consistent simulation**. *Scientific Data*, 6, 320. doi:10.1038/s41597-019-0328-7.

2. Keune, J., Sulis, M., Kollet, S., Siebert, S., and Wada, Y. (2018). **Human Water Use Impacts on the Strength of the Continental Sink for Atmospheric Water**. *Geophysical Research Letters*, 45(9), 4068-4076. doi:10.1029/2018GL077621.

3. Kollet, S., Gasper, F., Brdar, S., et al. (2018). **Introduction of an Experimental Terrestrial Forecasting/Monitoring System at Regional to Continental Scales Based on the Terrestrial Systems Modeling Platform (v1.1.0)**. *Water*, 10(11), 1697. doi:10.3390/w10111697.

4. Shrestha, P., Sulis, M., Masbou, M., Kollet, S., and Simmer, C. (2014). **A Scale-Consistent Terrestrial Systems Modeling Platform Based on COSMO, CLM, and ParFlow**. *Monthly Weather Review*, 142(9), 3466-3483. doi:10.1175/MWR-D-14-00029.1.

5. Hartick, C., Furusho-Percot, C., Goergen, K., & Kollet, S. (2021). **An interannual probabilistic assessment of subsurface water storage over Europe, using a fully coupled terrestrial model**. *Water Resources Research*, 57, e2020WR027828. doi.org/10.1029/2020WR027828

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