# Experimental seasonal monitoring and forecasting of total subsurface water storage over Germany

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The **Forschungszentrum Jülich (FZJ) experimental water resources bulletin (eWRB)** gives a **regular seasonal update** on the **current state and the upcoming potential evolution of terrestrial near-surface water resources**. The eWRB is an open access research data product for an expert environmental sciences and stakeholder audience as well as the interested public.

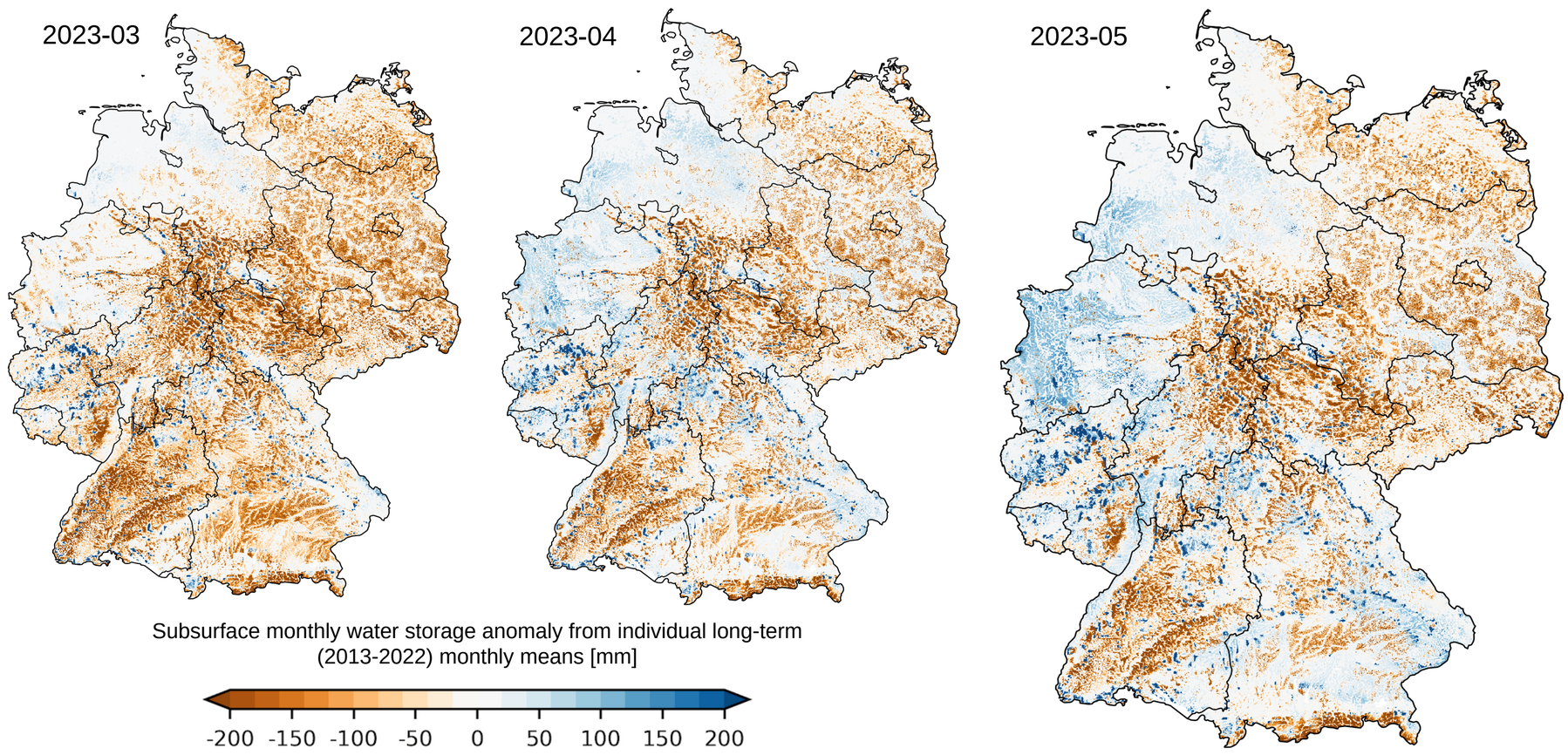


Fig. 1: **Monthly anomalies of total subsurface water storage for the past season** with respect to long-term monthly means from 2013-2022 in **mm water column** for the upper 60m of the subsurface. Data: Hindcasts from ParFlow/CLM simulations with ECMWF HRES atmospheric forcing.

**State and possible developments:** June has been very dry, along with sunshine, wind, and high temperatures. This caused a rapid decrease in the (partly recovered) subsurface water storage, known as flash drought. Negative anomalies of subsurface storage are expected for summer and autumn, based on a 50-member ensemble forecast initialized on 2023-06-01.

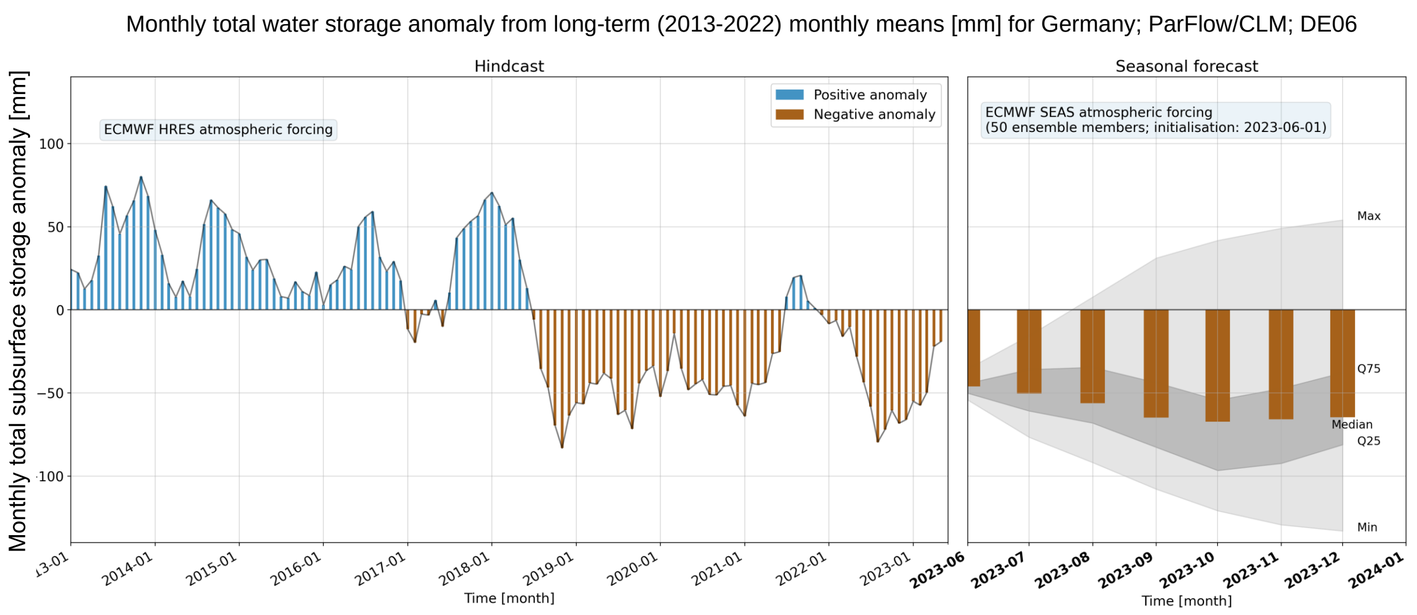


Fig. 2: **Past evolution of monthly total subsurface storage anomalies as spatial means for Germany** from 2013-Jan to 2023-May as simulated at 611m resolution with the ParFlow/CLM (www.parflow.org) integrated hydrological model based on daily forecasts driven by ECMWF HRES deterministic atmospheric forcing (“hindcast”), and 7-months forecast from 2023-Jun to 2023-Dec based on ECMWF SEAS 50-member ensemble (“seasonal forecast”).

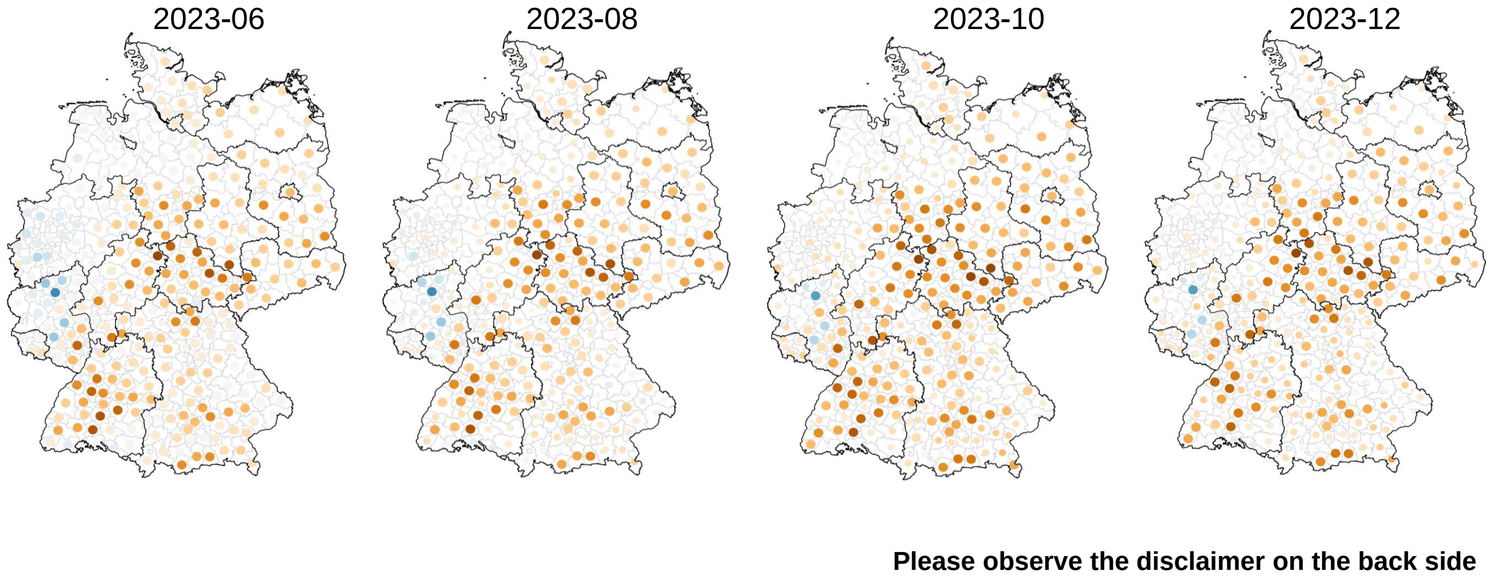


Fig. 3: **Seasonal forecasts (2023-Jun to 2023-Dec)**; mean of subsurface water storage anomalies from 50-member ParFlow/CLM ensemble (initialized on 2023-06-01), ECMWF SEAS seasonal ensemble prediction driven. Dots: NUTS-3 level administrative regions; dot size: proportional to how many members agree in their sign.

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### The FZJ eWRB at a glance

To provide easily accessible information on the current state, the past and the potential future evolution of relevant terrestrial water cycle quantities, the FZJ eWRB was created. It always follows a recurring content and structure. Currently, it features the monthly total subsurface climatological storage anomaly from the surface to 60m depth in mm water column, including the spatial distribution of the past meteorological season. Belleflamme et al. (2023) contains a complete description of the model setup.

Seasonal forecasts of all relevant quantities of the soil water balance are simulated every three months for seven months into the future at a resolution of 0.6km using the hydrological model ParFlow and its land surface module CLM (Common Land Model) on the JUWELS Booster (GPU) computer system at JSC. The atmospheric boundary conditions are taken from weather forecasts of the European Centre for Medium-Range Weather Forecasts (ECMWF).

### Benefits of the approach

- The strong memory effect of the subsurface water storage increases predictability.
- ParFlow is an integrated physics-based model that does not require any calibration. Belleflamme et al. (2023) have shown very good evaluation results.

### Current limitations

- For computational efficiency, overland flow is currently not simulated.
- The simulations do not include any human interventions with the terrestrial water cycle, e.g., groundwater pumping and, hydraulic infrastructures such as dams and man-made lakes.
- There is no interannual variation in land cover.

### Conclusions

The FZJ eWRB provides relevant information to various stakeholders across sectors (e.g., agriculture, water resources management and forestry) and can be used as an additional usable information for decision making.

**References**: Belleflamme, A., Goergen, K., Wagner, N., Kollet, S., Bathiany, S., El Zohbi, J., Rechid, D., Vanderborght, J., and Vereecken, H. (2023). Hydrological forecasting at impact scale: the integrated ParFlow hydrological model at 0.6 km for climate resilient water resource management over Germany. Frontiers in Water, 5, 1183642. doi:10.3389/frwa.2023.1183642

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