EGU21-7122
https://doi.org/10.5194/egusphere-egu21-7122
EGU General Assembly 2021

Analyzing the propagation of drought through water storages using global scale GRACE-based data assimilation

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The frequency and severity of drought increase in many regions of the world, which emphasizes the need for sufficient research to better monitor and trigger management plans. An important role hereby plays hydrological drought, because it affects water supply and crop yields that are necessary to ensure food security. Typically, hydrological drought detection is based on in-situ observations of fluxes or storages at the surface. However, this neglects the fact that drought might occur in multiple storages with different timing and severity. The use of subsurface storage, e.g. groundwater, is rare because the available in-situ well level monitoring is irregularly distributed in space and time and access might be restricted, for example due to national security reasons or problems in converting them to storage estimates.

The satellite mission Gravity Recovery and Climate Experiment (GRACE) and its successor GRACE-FO offer a great possibility to observe the total water storage, i.e. the sum of surface and subsurface storages, on a global scale from space. However, GRACE is restricted to monthly data on a spatial resolution of about 300 km and the vertical sum of the storages. Hydrological models present another possibility to derive global storage information with a finer spatial (~50km), temporal and vertical resolution than GRACE but they do not perfectly represent the reality because they are underlying assumptions and are affected by uncertainty of forcing data. Therefore, to enable downscaling of GRACE while improving the models realism, the GRACE measurements are assimilated into a hydrological model.

In previous works we used a framework that assimilates GRACE into the WaterGAP Global Hydrological Model (WGHM) regionally or basin-wise. In this work we present a new framework that globally assimilates GRACE on a 4 degree grid with full uncertainty information from 2003 to 2018. The framework enables to assimilate about 95% of the global WGHM land surface except Greenland. With regard to vertical and spatial resolution the performance of model, observation and assimilation is compared. Global GRACE based drought indicators are applied and its development in the different compartments of surface water, soil and groundwater is analyzed to identify new insights into the propagation of drought. We expect that by including GRACE we derive new information especially for groundwater droughts, which might reveal time lags and a

different severity as compared to surface water droughts for some regions.