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Developing the ability to predict the movement of water at regional scales with a spatial resolution from 1 to 5 km is one of grand challenges in land surface modelling. Coping with this grand challenge implies that land surface models (LSM) should be able to make reliable predictions across locations and/or scales other than those used for parameter estimation. Validating LSM only against integral basin response such as streamflow is a necessary but not a sufficient condition to warranty the appropriate partitioning of incoming precipitation and radiation into different water budget components. Extensive in-situ observations of state variables (e.g., soil moisture), on the contrary, are not feasible at regional scales. Remote sensing has been considered as the solution for this dilemma because they constitute a cost-effective source of information and provide a valuable insight about the spatio-temporal patterns of state variables. Their main disadvantage is their large uncertainty.

The mesoscale hydrologic model (mHM 5.0 http://www.ufz.de/index.php?en=31389) is used in this study to estimate uncalibrated water fluxes and states and then to investigate which are the effects of conditioning this model with freely available multiple-scale data sets. The main characteristic of mHM is the treatment of the sub-grid variability of input variables and model parameters which clearly distinguishes this model from existing precipitation-runoff models or land surface models. It uses a Multiscale Parameter Regionalization (MPR) to account for the sub-grid variability and to avoid systematic re-calibration. Another key characteristic of mHM is that it can simultaneously estimate fluxes in nested-scales and/or in multiple basins keeping its global parameters (i.e., regionalization coefficients) unaltered across scales and basins. These key characteristics of the model would allow to assimilate disparate sources of information such as satellite data, streamflow gauging stations, and eddy covariance data at their native resolutions.

To address these objectives, mHM was set up over more than 280 Pan-European river basins. This model was forced with the gridded EOBS data set (25x25 km^2) obtained from the European Climate Assessment & Dataset projec. The required morphological data was derived from the FAO soil map (1:5,000,000), the SRTM DEM (500 m) and three CORINE land cover scenes (500 m). MODIS LAI (NASA) was used to estimate a dynamic LAI model for every land cover class. mHM simulations were obtained at 25 km spatial resolution for the period 1950-2012. The multi-scale verification of simulated water fluxes was carried out using observation data sets such as: latent heat flux obtained from more than 150 eddy flux stations (FLUXNET), streamflow in more than 250 gauging stations (GRDC), and the remotely sensed Earth's gravity field anomalies retrieved by the Gravity Recovery and Climate Experiment (GRACE) release 05 (Landerer and Swenson, 2012, WRR). The former are used a proxy of the total water storage anomalies in mHM. In Germany, over 1000 weakly groundwater stage stations were used to evaluate and/or condition groundwater level anomalies. mHM water storage anomalies simulated over Europe from 2003 to 2012 at monthly time step were compared with those of GRACE. Results lead to the conclusion that mHM water fluxes are robust since less than 25% of river basins exhibit Nash-Sutcliffe efficiencies (NSE) of 0.5 or less. Likewise, the soil moisture and groundwater anomalies, specially in severe drought years such as 2003, exhibit a large spatial correlation with those obtained from remotely sensed products. Comparison against observed latent heat indicates that the dynamics and magnitude of the simulated values were well captured by the model at most locations. In general, deficient model performance (NSE$<$0.5 was attributed to either heavily regulated river basins or regions with a poor rainfall gauge network.