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Integration of MODIS LAI products into the hydrological model WGHM indicate the sensitivity of total water storage simulations to vegetation cover dynamics

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The vegetation cover has a profound effect on the long term and seasonal dynamics of all components of the water cycle in river catchments globally. In order to understand the effect Global Change has on the Earth system, it is essential to entangle the effects of changes in land cover and land use, biogeochemical cycles, climate and weather driven shifts in phenology and human water consumption. The WaterGAP Global Hydrology Model (WGHM) is one of the few global hydrological models, which integrates total water storage simulation with an estimation of anthropogenic water consumption from streams, surface water bodies as well as groundwater. The vegetation part in the actual version of the model is, however, a rather simplified parameterization. This simplification leads to a limited temperature and climatic water balance driven representation of phenology with a static land cover mask and no land use. These model assumptions limit its ability to reflect the above mentioned dynamic in time and space. In order to understand and quantify the effect of the current implementation, we substituted it with the MODIS LAI product. Running the model with daily European Centre for Medium-Range Weather Forecasts (ECMWF) temperature and Global Precipitation Climatology Centre (GPCC) precipitation data from 1997 to 2010, we analysed the effect on all components of the water cycle. The results show a clear effect on the long term and seasonal dynamics of the water balance with a pronounced spatial and temporal pattern. The primary effect is a change in evapotranspiration driven by the change in the simulated canopy storage which propagates through the water cycle affecting all subsequent fluxes like runoff, soil water storage and groundwater dynamics. The simplified phenology in the model leads to phase mismatch in the LAI development, which results in a periodicity in the divergence between model and MODIS observations. We conclude that a more realistic implementation of vegetation cover dynamic can lead to more realistic simulation of the water cycle for continental model applications, which is of high importance in combination with other large-scale observations assimilated into models, such as total water storages variations of the Gravity Recovery and Climate Experiment GRACE.