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Using Earth observation data of vegetation to improve global hydrological simulations

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Vegetation structure and activity are the crucial links between the water, carbon and energy cycles. However, their representation remains a major source of uncertainty in large-scale models. Hydrological models not only vary in the way they include vegetation and its interaction with water, but also become less tangible when their complexity increases. This poses a challenge in validating these models, as shown by several comparisons of dynamic vegetation models.

In this context, the increasing availability and quality of Earth observation-based data provides a new avenue and valuable information to improve model simulations and gain insights into the role of vegetation within the global water cycle. On the one hand, such observations can be used to calibrate model parameters. On the other hand, more vegetation related data allows new approaches to describe in-model vegetation characteristics beyond the values that are traditionally defined for plant functional types.

In this study, we use a simple and highly transparent global hydrological model and constrain its vegetation related parameters against diverse Earth observation-based data. We include GRACE terrestrial water storage anomalies, GlobSnow snow water equivalent, ESA CCI soil moisture as well as estimates of evapotranspiration from FLUXCOM and gridded runoff from GRUN in a multi-criteria calibration approach that considers the strengths and uncertainties of each data stream.

Further, we conduct several factorial experiments to test alternative approaches for representing vegetation characteristics that influence processes like infiltration, root water uptake and transpiration. The approaches range from the simple differentiation of vegetated and non-vegetated areas over applying plant functional type-specific parameters to defining vegetation characteristics as functions of Earth observation-based data such as EVI, tree cover and estimates of plant rooting depth.

For each of the experiments, the model is calibrated and the results are finally compared with each other and against observations to quantify the ability to reproduce observational patterns and to assess the effects of vegetation on simulated hydrological processes across spatio-

temporal scales.