EGU21-4058
https://doi.org/10.5194/egusphere-egu21-4058
EGU General Assembly 2021

The importance of ecosystem adaptation on hydrological model predictions in response to climate change

Laurène Bouaziz[1,2], Emma Aalbers[3,4], Albrecht Weerts[2,5], Mark Hegnauer[2], Hendrik Buiteveld[6], Rita Lammersen[6], Jasper Stam[6], Eric Sprokkereef[6], Hubert Savenije[1], and Markus Hrachowitz[1]
[1]Department of Water Management, Faculty of Civil Engineering and Geosciences, Delft University of Technology, P.O. Box 5048, NL-2600 GA Delft, The Netherlands (laurene.bouaziz@deltares.nl)
[2]Department Catchment and Urban Hydrology, Deltares, Boussinesqweg 1, 2629 HV Delft, The Netherlands
[3]Royal Netherlands Meteorological Institute (KNMI), P.O. Box 201, 3730 AE De Bilt, the Netherlands
[4]Institute for Environmental Studies (IVM), Vrije Universiteit, Amsterdam, 1081 HV, the Netherlands
[5]Hydrology and Quantitative Water Management Group, Wageningen University and Research, P.O. Box 47, 6700 AA Wageningen, The Netherlands
[6]Ministry of Infrastructure and Water Management, Zuiderwagenplein 2, 8224 AD Lelystad, The Netherlands

Models calibrated on the past are often used to predict future hydrological behavior in a changing world, disregarding that hydrological systems, hence model parameters, will change as well. Even if we are aware of the non-stationarity of hydrological systems, we are impeded by our limited knowledge on how to meaningfully implement this in hydrological models. Yet, ecosystems are likely to adapt in response to climate change and other species might become dominant, both under natural and anthropogenic influence. The root-zone storage capacity of ecosystems is an important hydrological parameter, which ecosystems can adjust in response to climatic change. In this study, we propose a top-down approach, which directly uses projected climate data to estimate how vegetation adapts its root-zone storage capacity at the catchment-scale, in response to changes in magnitude and seasonality of hydro-climatic variables. In order to make reliable estimates of hydrological behavior of future ecosystems, we exchange space-for-time, whereby the Budyko characteristics of different dominant ecosystems in sub-catchments are used to simulate the behavior of potential future land-use change. We hypothesize that predicted changes of the hydrological response as a result of global warming are more pronounced when explicitly considering changes in the sub-surface system properties induced by vegetation adaptation to changing environmental conditions. We test our hypothesis in the Meuse basin in four scenarios designed to predict the hydrological response to +2°C global warming in comparison to current-day reference conditions using a process-based hydrological model with (1) a stationary system, i.e. no changes in the root-zone storage capacity of vegetation and historical land use, (2) an adapted root-zone storage capacity in response to a changing climate but with historical land use, and (3,4) an adapted root-zone storage capacity considering two hypothetical changes in land use from coniferous plantations/agriculture towards broadleaved forest and vice-versa. We found that the larger root-zone storage capacities (+33%) in response to a more pronounced seasonality with drier summers under +2°C global warming strongly alter seasonal patterns of the hydrological

response, with an overall increase in mean annual evaporation (+4%), and a decrease in recharge (-6%) and streamflow (-7%), compared to predictions with a stationary system. Through the integration of a time-dynamic representation of changing vegetation properties in hydrological models, we address the 19th Unsolved Problem in Hydrology (Blöschl et al., 2019) and move towards more reliable hydrological predictions under change.

Blöschl, G., Bierkens, M. F. P., Chambel, A., Cudennec, C., Destouni, G., Fiori, A., et al. (2019). Twenty-three unsolved problems in hydrology (UPH) – a community perspective. *Hydrological Sciences Journal*, 64(10), 1141–1158. https://doi.org/10.1080/02626667.2019.1620507