Plinius Conference Abstracts
Vol. 17, Plinius17-65, 2022, updated on 08 Oct 2022
https://doi.org/10.5194/egusphere-plinius17-65
17th Plinius Conference on Mediterranean Risks

Evaluation of the impact of calibration period for distributed modelling of the hydrological cycle during droughts

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Drought risk will increase in the next decades due to anthropogenic warming, especially in the Mediterranean region. Therefore, robust hydrological models during droughts are essential tools for disaster risk reduction and climate change adaptation strategies. Yet, many studies showed drops in model performance when simulating periods with different climatic conditions from those of the calibration period, which poses challenges in properly simulating discharge (Q) during droughts. Some works also revealed that these issues may be related to the simulation of evapotranspiration (ET) and changes in terrestrial water storage (TWS) in the catchment, which has been shown to be highly sensitive to the calibration period too. Here, we analyzed how the simulation of Q, ET, and TWS differs according to the selected calibration period and during droughts, thus expanding on previous work on this matter that has mostly focused on Q. We compared two parameterizations of the distributed hydrological model Continuum for the Po river basin over 2009 – 2019. The northern Italian study area is characterized by a transition from continental to Mediterranean climates and experienced two major drought events during the study period (2012 and 2017). The two model parameterizations result from an iterative semi-automated calibration against Q data during a wet period for the first model variant (2018-2019), and during a dry period for the second model variant (2016-2017). We then evaluated the modelling skills in simulating Q, ET, and TWS for the whole river basin and 43 subcatchments in terms of both temporal and spatial variability, using ground-based and satellite-derived data as benchmark. Calibrating during a dry period improved the simulation of Q during low-flow conditions, as expected, though at the expense of model internal consistency, ET, and TWS representation. We also detected a general deterioration of modelling skills in reproducing Q and ET temporal dynamics, as well as ET and TWS spatial patterns, during droughts for both the model variants. Results call for (i) comprehensive evaluation of the output and states of hydrological models across the whole water balance, rather than only Q, to verify their internal consistency and (ii) the development of alternative calibration procedures to improve the distributed modelling of Q, ET, and TWS during dry periods. This is highly needed to properly predict water availability in the different compartments of the hydrological cycle in a changing climate.