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Enhancing flash flood simulations through appropriate assimilation of remotely sensed soil moisture

Yan Liu[1], Yong Chang[2], Ingo Haag[3], Julia Krumm[3], Visakh Sivaprasad[1], Dirk Aigner[3], Harry Vereecken[1], and Harrie-Jan Hendricks Franssen[1]

[1]Agrosphere (IBG 3), Forschungszentrum Jülich, Jülich, Germany
[2]School of Earth Sciences and Engineering, Hohai University, Nanjing, China
[3]HYDRON GmbH, Environmental and Hydrological Consulting, Karlsruhe, Germany

The precondition of a catchment, especially soil wetness that can affect remaining soil water storage capacity and infiltration rate, is crucial for flash flood generations. Remotely sensed (RS) soil moisture (SM) can provide valuable information on soil wetness, but typically for the top 5 cm soil. Many flash flood hydrological models only have few or even a single soil layer. How to appropriately represent wetness of the entire soil by RS SM becomes crucial for enhancing flash flood simulations with data assimilation (DA). In this study, we propose a new approach to use a certain amount of historical RS SM to derive total soil water storage such that we can assimilate it into flash flood simulations. We applied this approach for the Körsch and Adenauer catchments in Germany, where we assimilated RS SM from the Soil Moisture Active Passive (SMAP) Mission into the Large Area Runoff Simulation Model (LARSIM). Our results show that we can build a good relationship between RS SM considering different antecedent and present data and soil storage using random forest regression compared to linear, polynomial and long short-term memory (LSTM) regressions, resulting in R^2 of 0.85 and 0.94 for Körsch and Adenauer, respectively. Using our approach to assimilate RS-derived soil storage into flash flood simulations, performance of flash flood event simulations was improved by an increase of ~0.19 in KGE (Kling-Gupta efficiency) for our study sites. Errors in flash flood peak can be reduced up to 15% compared to simulations without assimilating RS SM. The uncertainty of soil wetness over space was reduced as expected. We examined the possibility of transferring our approach to other RS SM products. We also noticed that despite of the enhancement by assimilating RS SM, the simulation of flash flood is still primarily affected by precipitation uncertainty. In general, we provided a feasible way to use RS SM for hydrological models only with a single soil layer. Future studies applying it to more catchments and events can help to better verify the general validity of our proposed approach.