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How well do operational Numerical Weather Prediction configurations represent hydrology?

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Land surface models (LSMs) have traditionally been designed to focus on providing lower boundary conditions to the atmosphere with less focus on hydrological processes. State of the art application of LSMs include land data assimilation system (LDAS) which incorporates available land surface observations to provide an improved realism of initial surface conditions. While improved representations of the surface variables (such as soil moisture and snow depth) make LDAS an essential component of any Numerical Weather Prediction (NWP) system, the related increments remove or add water, potentially having a negative impact on the simulated hydrological cycle by opening the water budget.

This work focuses on evaluating how well NWP configurations are able to support hydrological applications, such as the Global Flood Awareness System, in addition to the traditional weather forecasting. River discharge simulations from two climatological reanalyses, based on ECMWF's new ERA5 dataset, were compared: one 'online' set which includes land-atmosphere coupling and LDAS with an open water budget, and also an 'offline' set with a closed water budget and no LDAS. From these two datasets, a range of hydrological and atmospheric variables were analysed globally.

It was found that while the online version of the model with land-atmosphere coupling and LDAS largely improves temperature and snow depth conditions, it causes significant discharge biases in certain areas and poorer representation of peak river flow, particularly in snowmelt-dominated areas in the high latitudes. For example, the systematic negative increments in snow covered areas seem to correct for a significant weakness of the current ECMWF LSM snow scheme, which melts the snow too slowly. Without addressing such issues there will never be confidence in using LSMs for hydrological forecasting applications across the globe. This type of analysis should be used to diagnose where improvements need to be made; considering the whole Earth System in the data assimilation and coupling developments is critical for moving towards the goal of holistic Earth System approaches.