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Assimilation of ASCAT-derived soil wetness indices into hydrological models

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Over the last decade, many studies demonstrated that spatial information on the distributed physiogeographical characteristics and hydrological responses of rivers basins can be gained from remote sensing observations. Moreover, the onset of new Earth Observation (EO) constellations and technologies enables the supply and processing of multi-mission satellite data at a temporal frequency that starts to become compatible with operational water resources management requirements. Nonetheless, a time continuity that is crucial in both monitoring and forecasting applications cannot be obtained by the sole use of remote sensing observations. The information that may be extracted from discrete EO data thus needs to be used as time-varying state or flux data in hydrological models.

This paper focuses on the sequential assimilation of remote sensing-derived soil wetness indices (SWI) into a lumped conceptual hydrological model and investigates the reliability and usefulness of a systematic remote sensing of soil wetness for operational forecasting applications. Since soil moisture patterns tend to persist in time, SWI obtained via scatterometers operating at coarse resolution can be used to periodically verify and eventually update the water budget that is computed by hydrological models. Our study is based on bi-daily coarse resolution soil moisture estimates retrieved from the ASCAT instrument on board the METOP-A satellite.

The overall objective is the evaluation of the potential of Particle Filter-based data assimilation schemes for increasing the accuracy and reliability of flood predictions at subsequent time steps. The proposed methodology consists in adjusting the soil reservoirs simulated by a hydrologic model, by comparing an ensemble of modeled soil wetness indices with those that are derived from remote sensing observations. We advocate the use of a Particle Filter as part of the proposed assimilation scheme because it provides flexibility regarding the form of the probability densities of both model simulations and remote sensing observations. By selecting the most likely model runs, the Particle Filter, unlike the more commonly used Ensemble Kalman Filter, closes the overall water balance. It thus allows inferring input data (i.e. whole-catchment precipitation) and model parameters that gave the most likely simulations given the observations. The approach may be viewed as a way to diagnose the functioning of hydrologic systems.

In this paper we illustrate the potential of the proposed methodology in a case study of the Bibeschbach experimental catchment (Grand Duchy of Luxembourg).