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MODIS SCA assimilation with the particle filter for improving discharge simulation

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LISFLOOD is a distributed, semi-physical rainfall-runoff model designed for the simulation of hydrological processes in medium to large scale river basins. This model is used at the European Commission Joint Research Centre for studying floods, global hydrological changes and droughts. LISFLOOD is the basis of the European Flood Alert System (EFAS), which is a real-time probabilistic flood prediction system with a lead-time of up to 10 days.

The aim of this study is to evaluate the feasibility of assimilation of satellite snow data into LISFLOOD. Furthermore, the impact of the assimilation on the snow simulation as well as on discharge will be assessed. For this purpose, MODIS Snow Cover Area (SCA) has been used here. Since cloud coverage limits the availability of MODIS data, we implemented methods for improving the data set, such as
- combination of the data from the two MODIS satellites
- merging data from previous days
- extrapolate data from neighboring pixels
- extrapolate data from pixels with similar altitudes.

The data provided by the MODIS satellites is SCA, i.e. presence or not of snow, whereas the LISFLOOD model simulates Snow Water Equivalent (SWE). For the conversion from SWE to SCA we employed a snow depletion curve.
The assimilation method used is the particle filter. This method is based on multiple perturbed simulations of the model, which at each assimilation time step are either kept or removed based on the similarity between the modeled SCA and the observed SCA (i.e. MODIS data). One major advantage of the particle filter as applied here is, that model states are not modified directly and hence the model conserves the mass balance throughout the assimilation.
Tests have been performed on synthetic data (normal LISFLOOD SCA used as observations) on a small basin (1-dimensional problem) and on a larger basin (7-dimensional problem), both located in the Czech Morava River basin. These experiments showed the positive performance of the assimilation for improving SCA and model discharges. The impact of the observation error used has been assessed, as well as the impact of the frequency of assimilation (from 1 to 7 days).
Finally, tests of assimilation of actual MODIS SCA data have been performed on the small and on the large basin (including the same tests on frequency of assimilation and on observations error). We showed that SCA was improved for all cases, but that discharges were not necessarily improved for high assimilation frequencies or significantly large observation errors. Increasing the dimension of the problem (from 1 to 7) deteriorates the performance of the assimilation system.