The benefits of using remotely sensed soil moisture in parameter identification of large-scale hydrological models

Niko Wanders[1], Marc F.P. Bierkens[1,2], Steven M. de Jong[1], Ad de Roo[1,3] and Derek Karssenberg[1]
1)Department of Physical Geography, Utrecht University, The Netherlands 2) Deltares, Utrecht, The Netherlands 3) Joint Research Centre, Water Recourses Unit, Ispra, Italy

Objectives

- Is it possible to use remotely sensed soil moisture data for calibration of hydrological models and the identication of parameters related to land-surface processes?
- Does the calibration of a large scale hydrological model with multi-sensor soil moisture retrievals improve discharge simulations?
- Is the simulation of soil moisture by a large scale hydrological model improved by using remotely sensed soil moisture for model calibration and which parameters can be identified?

The hydrological model

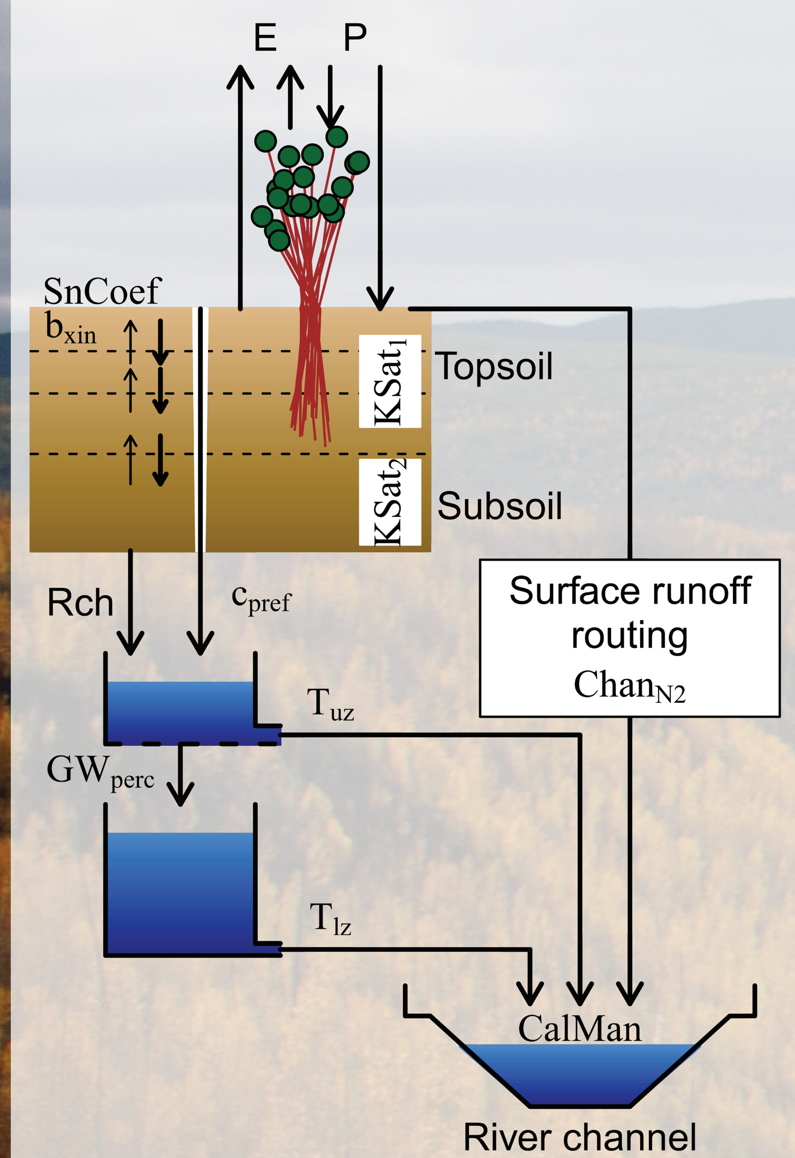

Figure 1: LISFLOOD model set-up

In this study the hydrological model LISFLOOD (Van Der Knijff et al. 2010) was calibrated and validation on soil moisture and discharge observations. LISFLOOD is a hydrological rainfall-runoff-routing model in the PCRaster modelling environment. LISFLOOD is used in the operational European Flood Alert System of the European Commission for medium range flood forecasting a large river basins in Europe.

The Upper Danube Catchment

In this study the Upper Danube area up to Bratislava (Figure 2) is used for the calibration. The total catchment size is 135x10^3 km^2 of which the Southern border is formed by the Alps. Elevations range from 150 - 3150m above sea level. In the catchment, daily discharge observations for 23 locations are available for the years 2000-2011.

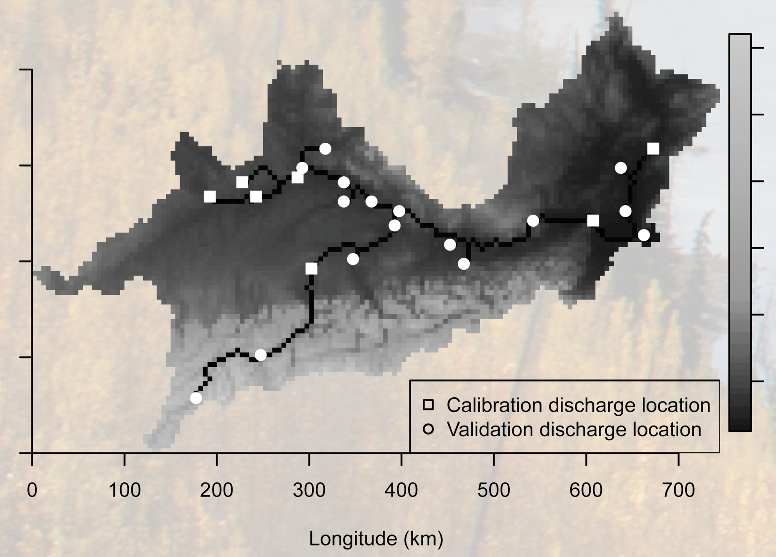

Figure 2: Upper Danube Catchment

Scenarios

Observations of three microwave satellites (ASCAT, AMSR and SMOS) and 7 discharge timeseries are used to estimated the parameters of the LISFLOOD model for the Upper Danube area using the Ensemble Kalman Filter. The scenarios used in this study are, calibration with:
- One satellite soil moisture product, ASCAT, AMSR-E or SMOS
- Discharge observations, either one or seven locations
- Discharge observations and one satellite soil moisture product
- Discharge observations (one or seven locations) and all satellite products

The performance of the soil moisture simulations was evaluated against timeseries of AMSR-E (2002-2009) and discharge observation (2000-2011).

Discharge simulation

In Figure 3 timeseries for the validation of the discharge at the outlet of the Upper Danube are shown. For the simulation of discharge at the catchment outlet the calibration on only one station in the main channel is superior to other calibrations.

Calibration with remote sensed soil moisture improves discharge in the upstream catchments (Figure 4). Calibrations with seven discharge location and either ASCAT, AMSR-E, SMOS or a combination of satellites is compared to a scenario with only calibration on seven discharge locations. From the spatial evalution it is concluded that discharge simulations are better for upstream areas when soil moisture is added to the calibration. The RMSE for the entire catchment is only reduced when no discharge data is used (Figure 5). Including discharge observations will reduce the overall catchment RMSE.

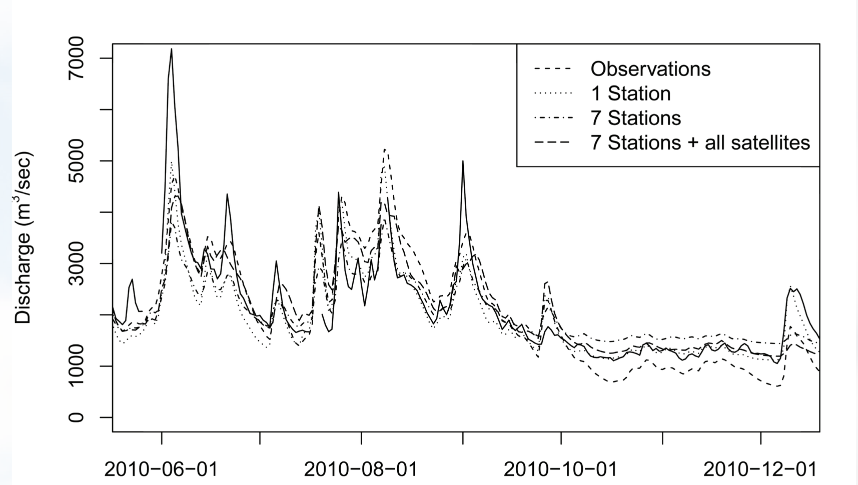

Figure 3: Discharge simulation after calibration

Soil Moisture simulation

On average no significant difference is observed between soil moisture simulations in the different scenarios. However, if the scenarios are compared spatially some distinct patterns are found. The improvements for calibration with ASCAT and AMSR-E are mainly found in the higher areas as can be seen in Figure 4.

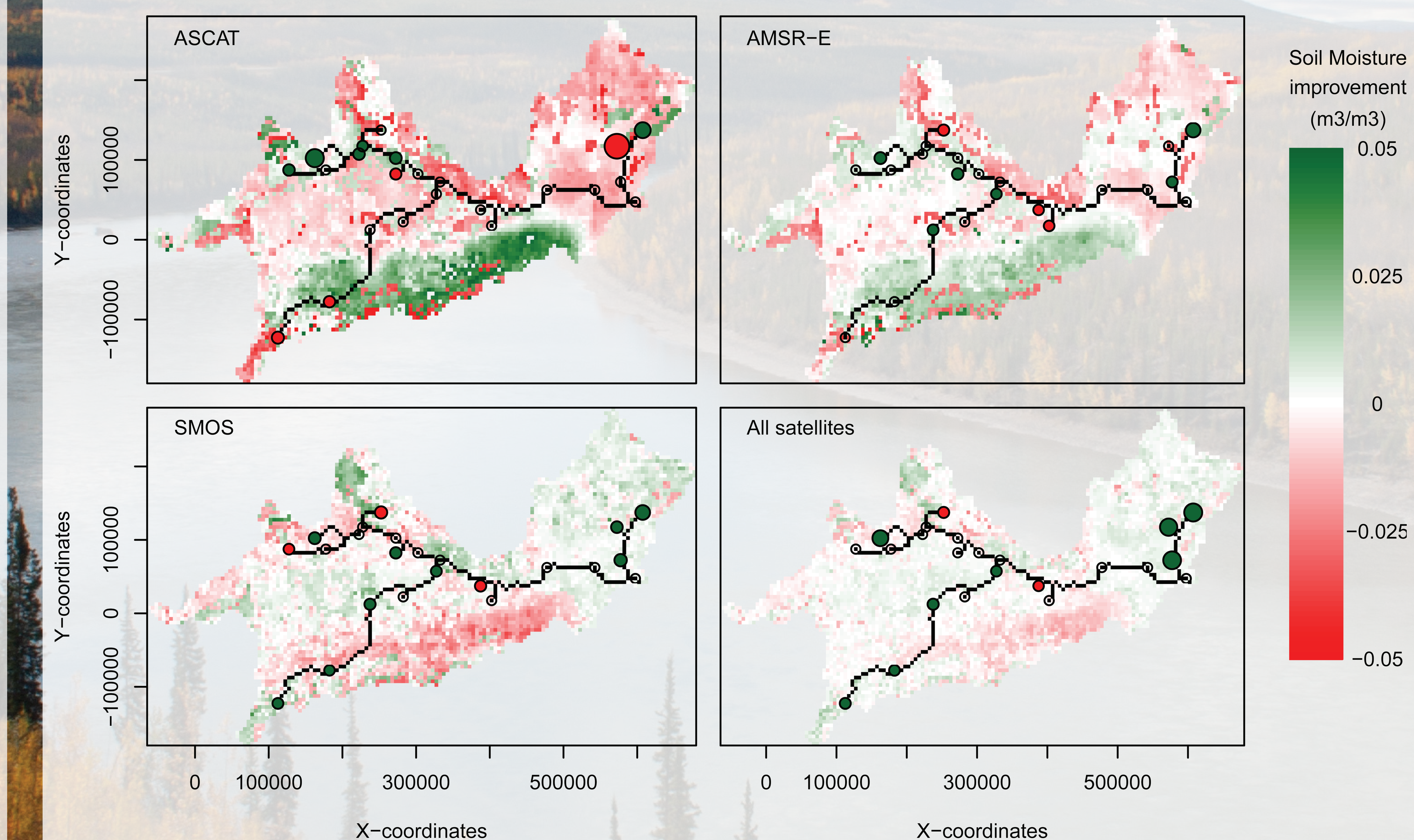

Figure 4: Comparison of soil moisture and discharge simulations between calibration with only discharge observation and discharge observations and different satellite datasets. Size of circle indicates relative improvement in discharge simulations compared to calibration with only discharge observations, where white circles are not significant, green circles indicate and improvement and red circles a deterioration of the discharge simulations.

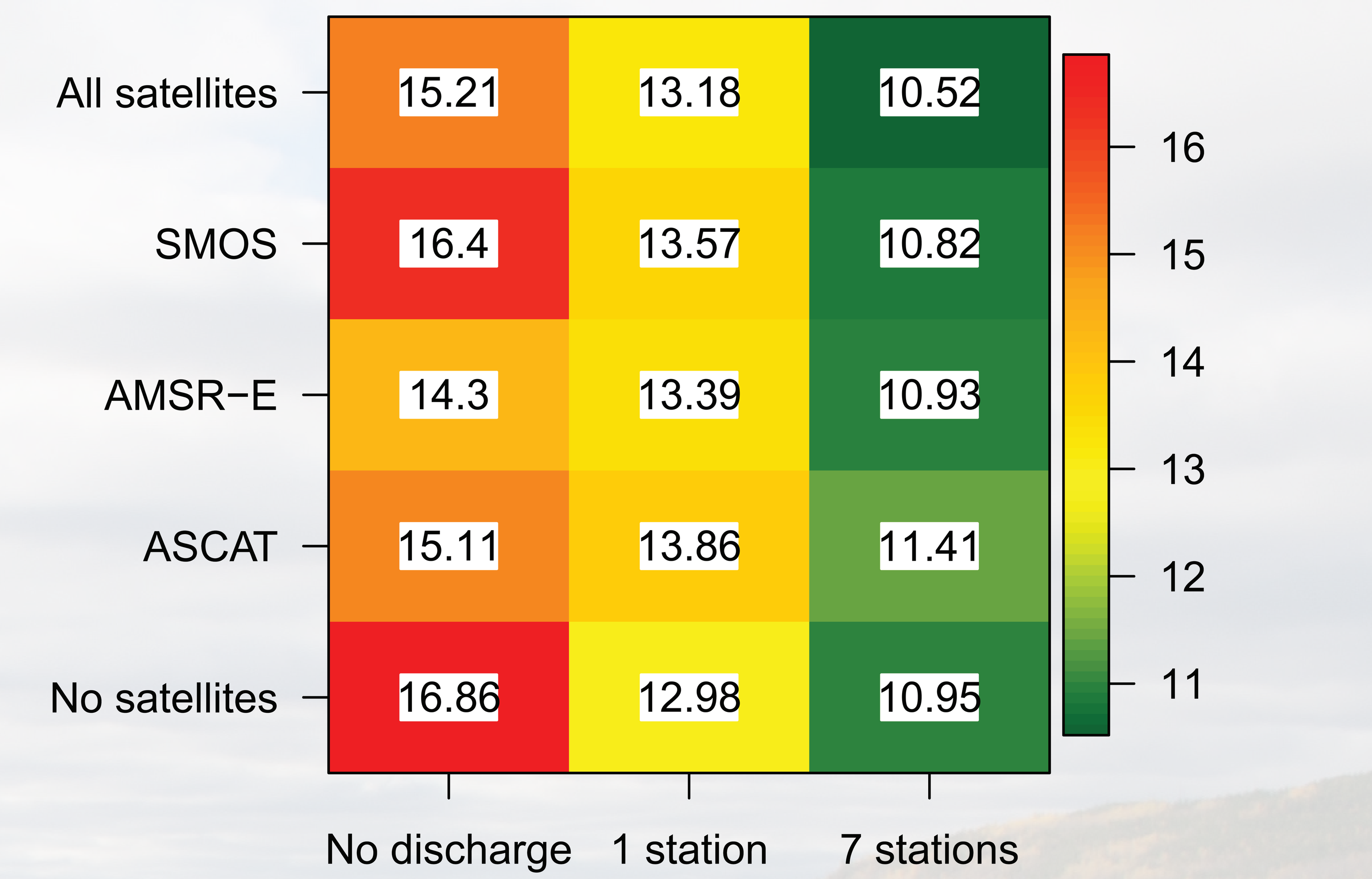

Figure 5: Total Root Mean Square Error of discharge simulations at the validation locations over the Upper Danube Catchment for three different calibration scenarios

Parameter estimations

Parameters related to land-surface process can be identified with less uncertainty when satellite data is used for calibration (Figure 6). The more observations and smaller the satellite error the better the estimation of land-surface process parameters.

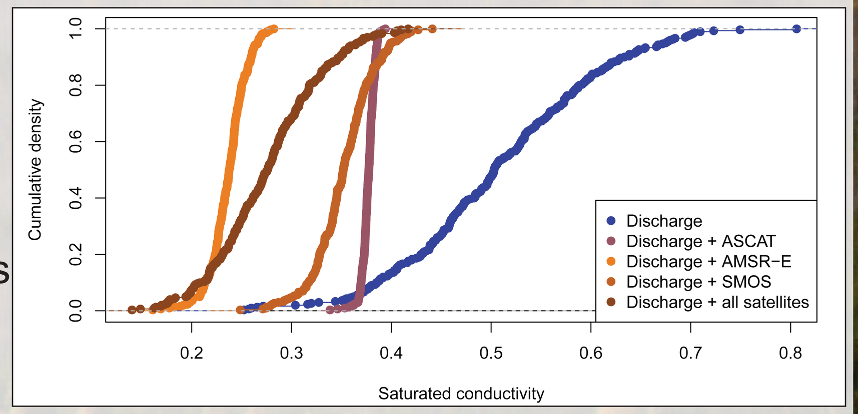

Figure 6: Calibrated saturated conductivity for 5 different scenario's.

Conclusion

- Adding soil moisture data improves upstream discharge simulation for the Upperdanube when discharge observation are not available
- Soil moisture simulations are on average not significantly improved. Locally improvements are found
- Land-surface parameters can be better identified and with less uncertainty when remotely sensed soil moisture is used

Refernces:
Van Der Knijf et al. (2010) : Lisflood: a gis based distributed model for river basin scale water balance and flood simulation, international journal of Geographical information science, 24(2), 189-212

Niko Wanders
e-mail: n.wanders@uu.nl