Geophysical Research Abstracts
Vol. 19, EGU2017-4504, 2017
EGU General Assembly 2017

Assimilating high resolution remotely sensed soil moisture into a distributed hydrologic model to improve runoff prediction: a case study.

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The susceptibility of a catchment to flooding during an extreme rainfall event is affected by its soil moisture condition prior to the event. This paper describes a study attempting to improve a distributed hydrological model by assimilating remotely sensed soil moisture in order to keep the model flow rate predictions on track in readiness for an intense rainfall event. The work is being funded within the SINATRA project of the UK NERC Flooding from Intense Rainfall (FFIR) programme.

The recent launch of Sentinel-1 has stimulated interest in measuring soil moisture at high resolution suitable for hydrological studies using active SARs. One advantage of high resolution data may be that, when used in conjunction with land cover data, soil moisture values may be obtained over pixels of low vegetation cover (e.g. grassland). This may reduce the component of the backscattered signal due to vegetation, which for dense vegetation types may be a significant proportion of the whole. Additionally, backscatter contamination problems caused by mixed pixels containing unknown amounts of more than one land cover type within their coverage can be avoided. Sentinel-1 has been launched only recently, and has yet to build up a substantive sequence of flood event data suitable for analysis. As a result, ASAR WS data were used for this study. ASAR is C-band like Sentinel-1, and has a long data record.

The hydrologic model HSPF was made fully spatially distributed to make it able to properly ingest the high resolution satellite surface soil moisture information, and to conduct assimilation analyses. A 1 km grid cell size was used. The study area covered the catchments of the Severn, Avon and Teme rivers (plus a further 4 sub-catchments) in the South West UK. The results of assimilating ASAR soil moisture readings over this area were compared with those of assimilating low resolution ASCAT readings.

For the ASAR data, in each 1 km model grid cell, the 75 m surface soil moisture values coinciding with grassland were averaged. The resulting surface soil moistures were converted to profile soil water index (SWI) values prior to assimilation. The 25 km ASCAT data were downscaled to 1 km resolution to match that of the hydrologic model. Triple colocation of the model open loop, the ASAR and the ASCAT SWI values was used to estimate the SWI variances of the datasets, for use in the assimilation. The method of assimilation employed was a local Ensemble Kalman Filter, using an ensemble of 150 samples. Global parameters in the hydrologic model were estimated by calibration.

Preliminary results for ASAR for 2006-8 indicated that, for a number of the assimilations, the resulting changes in flow were significant fractions of the modelled flow. In almost all cases the assimilation adjusted the modelled flow to be closer to the observed flow as required. There was a strong positive correlation between change in flow and change in the model's upper zone storage at assimilation. Assimilation of ASAR SWI values generally improved the modelled flows and kept the model on track, while ASCAT data were less effective.