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Estimating discharge from ASAR imagery

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Remote sensing from space-borne platforms is often seen as an appealing method of monitoring components of the hydrological cycle, including river discharge, due to its spatial coverage. However, data from these platforms is often less than ideal because the geophysical properties of interest are rarely measured directly and the measurements that are taken can be subject to significant errors. This study assimilated water level information derived from a fused satellite synthetic aperture radar image and digital terrain model with simulations from a coupled hydrological and hydrodynamic model to estimate discharge in an un-gauged basin scenario. An Ensemble Kalman Filter was used to assimilate spot heights derived from the fused imagery and digital elevation model with the hydrodynamic model simulations of water level. Discharge was estimated from the ensemble of simulations using state augmentation and then compared with gauge data. Assimilating water level measurements led to a 79% reduction in ensemble discharge uncertainty and an improvement in water level accuracy given field measurements compared to the coupled hydrological hydrodynamic model alone. Measurement bias was evident, but the method still provided a means of improving estimates of discharge for high flows where gauge data are unavailable. Quality control prior to assimilation, where measurements were rejected for being in areas of high topographic slope or close to tall vegetation and trees, was found to be essential. The study demonstrates the potential, but also the significant limitations of currently available SAR imagery to reduce discharge uncertainty in un-gauged basins when combined with model simulations in a data assimilation framework. The consideration of measurement uncertainty (although assumed normal by the filter analysis) allowed "what if" scenarios to be investigated, given expected errors in alternative data sources and the ensemble of simulations generated here. From these it was demonstrated that the SAR measurements should not be viewed as an alternative to ground gauges, although the spatial point-in-time information provided by the SAR imagery could only be replicated with accurate (<10 cm standard deviation) ground measurement every 3 km (note this conclusion depends strongly on the ensemble generation). The study used a LiDAR DEM and Envisat ASAR imagery, thus, the data was of higher resolution and accuracy than that which would usually be expected in an un-gauged basin. Therefore, the typical performance of the method given the wide range of data sources which may be available is the subject of ongoing research. The work is timely because in the near future the launch of satellite radar missions will lead to a significant increase in the volume of data available for space-borne discharge estimation.