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Automatic selection of flood water levels from high resolution Synthetic Aperture Radar images for assimilation into hydraulic models

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Flood extents caused by fluvial floods in urban and rural areas may be predicted by hydraulic models. Assimilation may be used to correct the model state and improve the estimates of the model parameters or external forcing. One common observation assimilated is the water level at various points along the modelled reach. Distributed water levels may be estimated indirectly along the flood extents in SAR images by intersecting the extents with the floodplain DEM. It is necessary to select a subset of levels because adjacent levels along the flood extent will be strongly correlated and add little new information, while a large number of levels will increase the computational cost of the assimilation unnecessarily. The subset of points selected should be at positions at which the water level can be accurately determined, with the points distributed uniformly over the flood extent sufficiently sparsely that adjacent water levels are spatially uncorrelated. Although models run in hindcasting mode can provide useful information for predicting the effects of future floods, the ultimate goal must be to use SAR water levels in a forecasting model, which means that they have to be estimated in near real-time.

A method for selecting such a subset automatically and in near real-time is described. The input to the method is a flood extent in both urban and rural areas extracted from a high resolution SAR image using an automatic near real-time algorithm based on object segmentation and classification, which takes into account, for example, object heights as well as their SAR backscatter, and the presence of radar shadow and layover in urban areas. The method of subset selection uses this flood extent to first select candidate waterline points in flooded rural areas having low slope, so that levels may be calculated accurately. The waterline levels and positions are corrected for the effects of double reflections between the water surface and emergent vegetation at the flood edge. Waterline points are also selected in flooded urban areas away from radar shadow and layover caused by buildings, with levels similar to those in adjacent rural areas. The resulting points are thinned to reduce spatial autocorrelation using an adaptive top-down clustering approach. The method was applied to a TerraSAR-X image containing urban and rural flooding, using a LiDAR DEM of the floodplain. The waterline points extracted proved to be spatially uncorrelated, with levels reasonably similar to those determined manually from contemporaneous aerial photographs, and in good agreement with the readings of nearby gauges. In the test areas considered, only 23 points in urban and rural areas were selected from a SAR flood extent containing 253,288 waterline pixels, a data reduction of 11,000:1.