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Improving the TanDEM-X DEM for flood modelling using flood extents from Synthetic Aperture Radar images.

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Many floodplains in the developed world have now been imaged with high resolution airborne LiDAR or InSAR, giving accurate DEMs that facilitate accurate flood inundation modelling. This is not always the case for remote rivers in developing countries. However, the accuracy of DEMs produced for modelling studies on such rivers should be enhanced in the near future by the high resolution TanDEM-X World DEM.

In a parallel development, increasing use is now being made of flood extents derived from high resolution SAR images for calibrating, validating and assimilating observations into flood inundation models in order to improve these. The paper discusses an additional use of SAR flood extents to improve the accuracy of the TanDEM-X DEM in the floodplain covered by the flood extents, thereby permanently improving the DEM for future flood modelling studies in this area.

The method is based on the fact that for larger rivers the water elevation changes only slowly along a reach, so that the boundary of the flood extent (the waterline) can be regarded locally as a quasi-contour. As a result, heights of adjacent pixels along a small section of waterline can be regarded as a sample of heights with a common population mean. The height of the central pixel in the section can be replaced with the average of these heights, leading to a more accurate height estimate.

While this will result in a reduction in the height errors along a waterline, the waterline is a linear feature in a two-dimensional space. However, improvements to the DEM heights between adjacent pairs of waterlines can also be made, because DEM heights enclosed by the higher waterline of a pair must be at least no higher than the refined heights along the higher waterline, whereas DEM heights not enclosed by the lower waterline must be no lower than the refined heights along the lower waterline. In addition, DEM heights between the higher and lower waterlines can also be assigned smaller errors because of the reduced errors on the refined waterline heights.

The method was tested on a section of the TanDEM-X Intermediate DEM (IDEM) covering an 11km reach of the Warwickshire Avon, England. Flood extents from four COSMO-SKyMed images were available at various stages of a flood in November 2012. Waterlines were detected automatically using the method described in [1]. The 12.5m resolution IDEM was re-sampled to the 2.5m resolution of the CSK images using nearest neighbour interpolation. Improvements to the IDEM were attempted only in regions of low slope and low vegetation, so that the DEM could be regarded as the DTM. The height of a pixel on a waterline was replaced by the average of the waterline pixel heights in an 11 x 11 IDEM pixel window centred on the current CSK pixel (but selecting only one waterline height per IDEM pixel to reduce correlations).

Original and refined IDEM heights were compared to corresponding airborne LiDAR heights. Along the waterlines, it was found that the original IDEM heights had a standard deviation of 1.1m and a bias of 0.2m, while the refined heights had a standard deviation of only 0.6m and a similar bias.

Between two adjacent waterlines, on average approximately 25% of IDEM heights were above the higher waterline, and 20% below the lower waterline. When compared to LiDAR, the original higher heights had a mean difference from the LiDAR height of 2.4m with standard deviation 3.0m, while after correction the mean difference was 0.5m with standard deviation 1.0m. The corrected heights below the lower waterline were similarly improved. The height errors of a further 40% of IDEM heights between the higher and lower waterlines were also reduced, because of the reduced errors on the refined waterline heights.

1. Mason DC, Davenport IJ, Neal JC, Schumann GJ-P and Bates PD (2012). Near real-time flood detection in urban and rural areas using high resolution Synthetic Aperture Radar images. IEEE. Trans. Geoscience Rem. Sens., 50(8), 3041-3052.