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Creating a water depth map from Earth Observation-derived flood extent and topography data

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Enhanced methods for monitoring temporal and spatial variations of water depth in rivers and floodplains are very important in operational water management. Currently, variations of water elevation can be estimated indirectly at the land-water interface using sequences of satellite EO imagery in combination with topographic data. In recent years high-resolution digital elevation models (DEM) and satellite EO data have become more readily available at global scale. This study introduces an approach for efficiently converting remote sensing-derived flood extent maps into water depth maps using a floodplain's topography information. For this we make the assumption of uniform flow, that is the depth of flow with respect to the drainage network is considered to be the same at every section of the floodplain. In other words, the depth of water above the nearest drainage is expected to be constant for a given river reach. To determine this value we first need the Height Above Nearest Drainage (HAND) raster obtained by using the area of interest's DEM as source topography and a shapefile of the river network. The HAND model normalizes the topography with respect to the drainage network. Next, the HAND raster is thresholded in order to generate a binary mask that optimally fits, over the entire region of study, the flood extent map obtained from SAR or any other remote sensing product, including aerial photographs. The optimal threshold value corresponds to the height of the water line above the nearest drainage, termed HANDWATER, and is considered constant for a given subreach. Once the HANDWATER has been optimized, a water depth map can be generated by subtracting the value of the HAND raster at the each location from this parameter value. These developments enable large scale and near real-time applications and only require readily available EO data, a DEM and the river network as input data. The approach is based on a hierarchical split-based approach that subdivides a drainage network into segments of variable length with evidence of uniform flow. The method has been tested with remote sensing data and DEM data that differ in terms of spatial resolution and accuracy. A comprehensive evaluation of the obtained water depth maps with hydrodynamic modelling results and in situ measured water level recordings was carried out on a reach of the river Severn located in the United Kingdom. First results show that the obtained root mean squared difference is 10 cm when using high resolution high precision data sets (i.e. aerial photographs of flood extent and a LiDAR-derived DEM) and amount to 50 cm when using as inputs moderate resolution SAR imagery from ENVISAT and a SRTM-derived DEM.