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COMBINING SAR IMAGERY AND TOPOGRAPHY FOR THE AUTOMATIC RETRIEVAL OF FLOODWATER DEPTH MAPS

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ABSTRACT

This paper proposes and evaluate an innovative method for automatically retrieving floodwater depth maps by combining SAR-derived flood extent maps and topography data. The proposed algorithm can integrate as topography data either Digital Elevation Models (DEMs) or the Height Above Nearest Drainage (HAND) derived from these DEMs. The algorithm is applied using SAR images, DEMs and HAND maps of various spatial resolutions. We use as a test case the flood event that hit River Severn in the UK in July 2007. The maps obtained using our algorithms are evaluated using the results of shallow-water model simulations and aerial photographs. The results show that high level of accuracies (Root Mean Squared Deviations of Water Depth equal 0.52 cm) can be obtained if DEMs and SAR images of high resolution are used.

Index Terms— SAR imagery, Digital Elevation Model, Height Above Nearest Drainage, Floodwater depth, Floodwater extent.

1. INTRODUCTION

As a result of climate change, intensified and more frequent natural events are expected to occur in the coming years and decades. Among these events, floods are every year causing huge damages in many areas around the world. It is therefore necessary to put in place rapid and cost-effective flood monitoring technics in order to obtain accurate information for flood risk assessment. Over the last decades, several automatic flood mapping approaches [e.g., 1] based on remote sensing data have been proposed, with various level of accuracy. However, although floodwater levels and depths represent very relevant information for flood risk assessment, most of these methods are only focused on flood extent

mapping and do not provide information on water depth [2,3]. To circumvent such a limitation, we propose to develop and evaluate a new automated and unsupervised method for estimating floodwater depths based on satellite Earth Observation (EO) and topography data.

2. METHODS

In this study we propose to evaluate the respective advantages and limitation of exploiting either a Digital Elevation Model (DEM) or the Height Above Nearest Drainage (HAND) derived therefrom. To do so, three variants of the proposed algorithm are tested, namely HAND global, HAND local and DEM local. They all rely on the following generic processing steps (Figure 1): i) thresholding topographic data (HAND or DEM) either globally or locally to produce topography-derived flood extent (FE) maps [1], ii) optimizing the thresholds by maximizing the fit between the topography-derived and SAR derived FE maps, and iii) generating water depth (WD) and water surface elevation (WSE) maps along with improved flood extent maps based on the optimal thresholds. In our study, we compare the flood extent and water depth maps estimated using the three variants of the algorithm to assess their advantages and limitations. This evaluation is carried out using FE and WD maps derived from hydraulic model simulations and aerial photography.

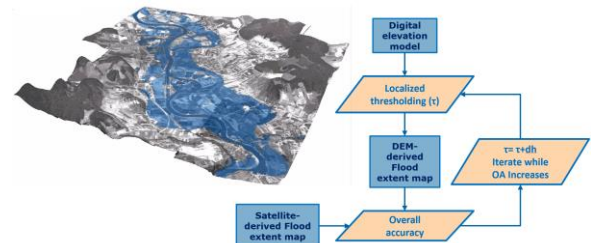


Figure 1: algorithm generic workflow

3. RESULTS AN CONCLUSIONS

For the algorithm variants' evaluation, we use the 2007 flood event of River Severn in the UK as a test case. We use SAR images of various spatial resolutions (Envisat at 150m and TerraSAR-X at 3m) and DEM and associated HAND maps at various resolutions (i.e., Copernicus DEM at 10m, SRTM at 30m and a Lidar DEM at 10 m)

Our results show that the improved FE maps derived from the different variants of our algorithms are accurate with overall accuracy reaching 94.5%. Moreover, depending on the variant and the input data used, Root Mean Squared Deviation of WD values varies between 0.52 m and 1.7m. The best performances are obtained using the highest resolution inputs (i.e., Lidar DEM and TerraSAR-X image) and the DEM local variant. For lower resolution inputs, the best performances are obtained using the Hand Global methods.

4. CONCLUSIONS

This study showed that the proposed automated algorithm is capable of providing accurate flood depth and water level maps with satisfying level of accuracy, along with improved (compared to SAR-derived flood extent maps) flood extent maps. Considering that the data (SAR images and DEMs) used as input to the algorithms are globally available (except Lidar DEMs), the proposed method is easily applicable anywhere in the world and is well-adapted for estimating WD and FE in data-scarce areas.

5. REFERENCES

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