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SAR-based flood mapping: an assessment of established approaches

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In our changing world, floods are a threat of increasing concern causing major fatalities and economic losses. Within this perspective, flood extent mapping is an important tool for both damage assessment and improving flood forecasts. While flood mapping through optical imagery is often hampered by the presence of clouds, Synthetic Aperture Radar (SAR) sensors are capable of sensing in all weather conditions during both day and night. Consequently, a broad range of SAR-based flood mapping algorithms has been developed during the past years. Main flood mapping approaches include thresholding, change detection, region growing, active contour modelling and probabilistic approaches. However, most of the developed algorithms were presented based on their performance on a single test case. Moreover, comparisons between methods are rare.

This study presents an in-depth assessment and comparison of both accuracy and robustness of a selection of flood mapping algorithms. Accuracy is assessed by means of binary measures, including the Critical Success Index (CSI) and the bias, while robustness is evaluated by investigating the influence of both image size and parameter values on the accuracy. The selection of flood mapping methods includes global, tiled and Height Above Neirest Drainage (HAND) masked thresholding, active contour modelling, change detection based thresholding and the Hierarchical Split-Based Approach (HSBA) developed by Chini, Hostache, Giustarini, and Matgen (2017). These methods were applied on six SAR images of different flood events that occurred in the United Kingdom and Ireland (the 2000 River Trent flood, the 2006-2007 River Dee flood, the 2007 River Severn flood and the 2015-2016 Ireland floods) as well as a SAR image of Loch Tay, Scotland. The images used were acquired by the ESA ERS-2, ENVISAT and Sentinel-1 sensors.

The results of this study indicate that the most suited method depends on both the area of interest and the intended use of the observation product. Whereas global thresholding performs good on small image subsets which have a clear bimodality, tiled thresholding is significantly more robust and performs good on both small and large image subsets. Change detection methods are both robust and accurate but are constrained by the availability of a good reference image. Active contour models result in even higher accuracies and are only slightly affected by changing image sizes. However, they require long computation times that increase strongly for increasing image sizes. Thus, active contour models would be appropriate for accurate flood mapping in smaller areas of interest and a subsequent assimilation in flood forecasting models, while tiled thresholding is suited for automated, near-real time flood detection and monitoring on full images.

Chini, M., Hostache, R., Giustarini, L., & Matgen, P. (2017). A Hierarchical Split-Based Approach for Parametric Thresholding of SAR Images: Flood Inundation as a Test Case. IEEE Transactions on Geoscience and Remote Sensing, 55(12), 6975-6988.