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A change detection approach to flood detection in urban areas using TerraSAR-X

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Due to the specular backscattering characteristics of active radar pulses on open water surfaces and the resulting low signal return, the use of Synthetic Aperture Radar (SAR) data for high-resolution flood mapping is relatively straightforward. Algorithms that enable an automatic delineation of flooded areas are an essential first component of any remote sensing-based flood monitoring and prediction service but are to date virtually non-existent. Moreover, it is important to focus on urban areas, where flood risk is highest and flood observations are needed most urgently. Here a new concept for an efficient SAR-based monitoring of floods, in particular inside urban settlements, is described. A hybrid methodology, which combines radiometric thresholding and region growing as an approach enabling the automatic, objective and reliable flood extent extraction from SAR images, is proposed. The method relies on the calibration of a statistical distribution of 'open water' backscatter values inferred from SAR images of floods. Water pixels exhibit characteristically low backscatter values and can be detected through thresholding, providing the seed region for a subsequent region growin
g process. Pre- or post-flood SAR reference images with the same parameters as the flood image may help to enhance the flood map obtained. Change detection is therefore included as an additional step that limits over-detection of inundated areas and helps identifying flooded areas that are not visible for the sensor (i.e. regions affected by 'layover' and 'shadow' in built-up areas).
The objective of this study is to describe the potential of the automatic algorithm to detect flooded areas within urban settlements through high resolution SAR imagery and with minimum data requirements.
The potential of the algorithm to detect flooded areas in urban settlements is shown through the case study of the July 2007 flood of the Severn River (UK) observed by a high-resolution SAR sensor on board of TerraSAR-X. In order to highlight advantages and limitations of the proposed method, the map computed by the automated flood delineation algorithm is validated against the flood extent derived from a high-resolution aerial photograph of the event, contemporaneous to the satellite acquisition.
A significant result is that the reference pre-flood image helped to substantially improve the performance of the automated flood extraction procedure within urban settlements (city of Tewkesbury). Parts of the urban areas where image distortions are caused by geometric structures could be identified via change detection and masked out from the flood delineation process. In addition, the specular reflection on smooth surfaces, erroneously considered as open water reflection by the algorithm, could be corrected with the pre-flood reference image. In this study some progress has been made with respect to the flood detection in urban areas. The fully automated SAR-based flood mapping technique that is introduced in this paper overcomes some limitations of state-of-the-art methods normally used. Our study further highlights the potential of high resolution SAR data as an alternative to aerial photography for flood delineation in built-up environments.