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Flood mapping under vegetation using single SAR acquisitions

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Routine flood inundation mapping is important for flood management and response. The 24-hour all-weather capability of Synthetic Aperture Radar (SAR) technology makes it a perfect choice for this application, except the backscattered microwave pulses at oblique angles can be difficult to interpret. Radar backscatter is mainly a function of surface roughness and thus smooth water surfaces and rough water-free areas generally have different responses. Nevertheless, a number of event-related and catchment-related factors can alter the backscatter characteristics and hinder accurate SAR image interpretations, particularly when the inundated areas have vegetation above the water. The electromagnetic interaction phenomena between microwaves, horizontal and vertical surfaces are highly complex and detection of flooded vegetation has been identified as one of the biggest challenges for accurate flood mapping. In this context, image interpretation algorithms usually make use of detailed field data and reference image(s) to implement electromagnetic models or change detection techniques. However, field data are rare, and, despite the increasing availability of SAR acquisitions, adequate reference image(s) might not be readily available, especially for fine resolution images. To bypass this problem, this study presents an algorithm for automatic flood mapping in vegetated areas which makes use of single SAR acquisitions and commonly available ancillary data.

First, probability binning was used for statistical analysis of the backscatter response of wet and dry vegetation for different land cover types. This analysis was then complemented with information on land use, morphology and contextual information within a fuzzy logic approach. The algorithm was applied to three fine resolution images (one ALOS-PALSAR and two COSMOSkyMed) acquired during the January 2011 flood in the Condamine-Balonne catchment in Queensland, Australia. The results were validated using flood extent layers derived from optical images.

In these case studies, state-of-the-art operational interpretation algorithms focusing solely on open water areas led to large omission errors with the Producer's Accuracy (PA) for the class water as low as 10.1%, 33.3% and 16.5% and the Overall Accuracy (OA) of 77%, 65%, and 75%, respectively. Notwithstanding the difficulty to fully discriminate between dry vegetation backscatter heterogeneity and backscatter variation due to flooding using a single SAR image, the use of probability binning allowed the omission errors to be reduced and the PA for the class water to have an increase of +75.2%, +62.2%, and +115.1%, respectively. Incorporation of land use, contextual, and morphological information allowed further refinement of the classification thus achieving a final OA of 83.7%, 81.5%, and 85.7%, respectively.

The main benefit of the proposed algorithm is its ability to automatically detect flooded vegetation using one single SAR acquisition and commonly available ancillary data (ie. land cover, land use, and digital elevation models). This approach can support both real time flood monitoring and the analysis of historical acquisitions within proof of concept studies investigating the use of SAR data to improve flood modelling skill. Finally, to disclose the potential of current and upcoming SAR satellite missions, future work will feature the inclusion of time-series and multi-polarization SAR data analysis in the proposed algorithm.