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Improving Operational SAR-based Flood Mapping in Arid Regions

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Synthetic Aperture Radar (SAR) based flood maps are rapidly becoming a vital part of flood monitoring applications, since they provide unobscured observations independent of illumination or weather conditions. As water surfaces are physically smoother than microwave wavelengths, they appear dark in SAR imagery due to specular reflection, enabling the automatic delineation of flooded areas. However, in arid regions using backscatter thresholds to identify inundation results in numerous false positives, since dry and smooth desert sand appears as dark as water in SAR images. Accordingly, a novel Sentinel-1 SAR-based flood mapping algorithm S1-L1 to discern flood inundation from water lookalike surfaces in arid regions. The swath is tiled to ensure comparable land-water pixel distributions and long-term water recurrence records from optical Landsat sensors is used to classify potentially water and definitely land (DL) areas. Smooth surfaces and radar shadow regions, which exhibit backscatter lower than the median value for >50% of the preceding year, are excluded from the DL pixels to avoid thin long tailed distributions. The first percentile value of the DL distribution is selected as the water threshold for each band (VV and VH), to include the maximum possible water pixels without letting in large volumes of land pixels. A Gaussian contextual smoother is used to combine the individual layers into the binary flood mask, with a weighted combination of the layers computed based on the underlying land-use. An empirical sensitivity analysis showed that different low backscatter frequency thresholds work better in different regions, and thus, a fuzzy flood plausibility layer (FPL) is proposed as a post-processor. The FPL improves upon the current state-of-the-art sand exclusion layers (SELs) by combining distance from drainage with seasonally dark surfaces and shadows identified through annual SAR backscatter time series analysis. Additionally, known agricultural land-use areas with low values of Sentinel-2 based Soil Adjusted Vegetation Index (SAVI) are used to identify harvested croplands. S1-L1 was evaluated using (1) expert classified Sentinel-1 SAR-based flood maps and (2) with Sentinel-2 clear view coincident optical maps for the 2020 flood events in Ghana (September) and Republic of the Congo (November). S1-L1 performance is compared to (a) Otsu thresholding (liberal and conservative) and (b) a deterministic SEL with >60% low backscatter frequency, to assess improvements over current best performing approaches for arid areas. First results demonstrated 50% false positive reductions over traditional Otsu approaches and consistent improvements of >20% in Critical Success Index values. Findings indicate that S1-L1 has the potential to efficiently differentiate between water and lookalike regions, and can facilitate more reliable SAR-based flood mapping in deserts.