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Assessment of Sentinel-1 C-band SAR data for rapid damage mapping in urban environments

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The emergence of the Sentinel-1A and 1B satellites now offers freely available and widely accessible synthetic aperture radar (SAR) data for global application. The near-global coverage and rapid repeat time (1-2 weeks) gives Sentinel-1 data the potential to be a widely used tool for damage mapping following catastrophic natural hazard events. Coherence loss associated with natural hazard events, such as the 7.8Mw 2015 Nepal earthquake, has been shown to be a valuable damage proxy using longer wavelength L-band SAR systems. While L-band SAR has the advantage of being less sensitive to land cover perturbation, it is often prohibitively expensive to acquire and not widely accessible, and therefore not well-suited to rapid deployment following a disaster. While more widely available, the C-band SAR provided by Sentinel-1 is more sensitive to changes in land cover, such as vegetation, that can cause low or noisy coherence. Applying C-band SAR data to damage proxy mapping without taking this into account can result in an inability to differentiate signal from noise when creating reliable damage proxy maps.

To address this, we present an assessment of the applicability of Sentinel-1 C-band coherence loss to damage mapping following severe natural hazard events in markedly different environments: (1) Fatal mudslides in tropical and densely vegetated Mocoa, Colombia (1 April 2017) and Freetown, Sierra Leone (14 August 2017). (2) Damage caused by Cyclone Xavier in the temperate, densely urban region around Berlin, Germany (5 October 2017). (3) Damage caused by the catastrophic 7.3Mw earthquake on the Iran-Iraq border (12 November 2017). For each event, we construct a damage proxy map following established methods, based on coherence loss from a pre-event reference SAR pair, and a syn-event SAR pair. In theory, a loss in coherence between these two pairs should correspond to event-related damage. To assess whether and where such coherence loss can be considered meaningful in inherently noisy environments, we use a timeseries of Sentinel-1 coherence, predating the event, to determine which areas have a consistently high coherence with minimal noise. Additionally, timeseries analysis allows us to determine, for a given pixel or region, what magnitude of coherence loss can be considered significant. The resulting map provides an estimate of where damage proxy mapping is applicable with C-band data, and of values that need to be exceeded to constitute likely damage. Using this approach, Sentinel-1 data can be applied to aid in disaster response and mapping even in moderately to highly vegetated urban areas. While calculating such maps requires some computational time, they can be generated and maintained pre-emptively for high-risk areas so they are available to apply to rapid damage mapping following a catastrophic event.