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Potential of Sentinel-1 C-band SAR data for a rapid detection of windthrows

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In recent years, extreme storm events have regularly hit central Europe and their frequency is expected to increase in future due to a changing climate. A rapid detection of the spatial distribution of the windthrown areas is crucial for forest managers to help them direct their limited resources.
In contrast to optical remote sensing data, Synthetic Aperture Radar (SAR) data is acquired largely independent of daylight or weather conditions. Thus, SAR sensors can produce temporally consistent and reliable data with a high revisit rate. In the present study [1], a straightforward approach was developed that uses Sentinel-1 (S-1) C-band VV and VH polarisation data for a rapid windthrow detection in mixed temperate forests for two study areas in Switzerland and Germany. First, several S-1 acquisitions of approximately 10 before and 30 days after the storm were radiometrically terrain corrected [2]. Second, based on these S-1 acquisitions, a SAR composite image of before and after the storm was generated. Then, after analysing the differences in backscatter between before and after the storm for windthrown and intact forest areas, a change detection method, based on two user-defined parameters, was developed to suggest potential locations of windthrown areas of an extent of 0.5 ha – as required by the forest management.
The results confirmed a successful detection of most windthrows, however always slightly underestimated in area. While results from the independent study area in Germany indicated that the method is very promising for detecting areal windthrow with a producer's accuracy of 0.88, its performance was less satisfactory in detecting single scattered windthrown trees. Moreover, windthrow in dense forest is expected to have a larger difference in backscatter than one in open forest.
Nevertheless, C-band backscatter data have great potential to rapidly detect the locations of windthrow in mixed temperate forests within approx. 2 weeks after a storm. We are currently applying our method to the entire region of north-east Italy, which was strongly hit by the last year's October storm Vaia. Preliminary results are also very promising for regions in alpine terrain.
Moreover, with the launch of the RADARSAT Constellation Mission (RCM) planned in 2019, an increased number of SAR C-band acquisitions will be potentially available soon. Combined with S-1 data, the time span could be substantially shorter to receive the number of required acquisitions for a windthrow detection of similar quality. This would make the approach using reliable SAR data worthy of consideration, even if its performance is worse than methods using more expensive ALS or optical data with longer latencies due to meteorological conditions. Forest managers would greatly benefit from an immediate first overview map of the windthrow locations, as it allows them to begin their planning of the clearing and reforestation of the windthrown areas as soon as possible.

[1] Rüetschi, M., Small, D., Waser, L.T., 2019. "Rapid Detection of Windthrows Using Sentinel-1 C-band SAR Data", accepted for Remote Sensing.
[2] Small, D., "Flattening Gamma: Radiometric Terrain Correction for SAR Imagery," IEEE Trans. Geosci. Remote Sens., 49(8), 3081–3093, Aug. 2011.