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Classification and monitoring of reed belts using dual-polarimetric TerraSAR-X time series

Iris Heine (1), Thomas Jagdhuber (2), and Sibylle Itzerott (1)

(1) German Research Center for Geoscience GFZ, 1.4 Remote Sensing, Potsdam, Germany, (2) German Aerospace Center (DLR), Microwaves and Radar Institute, Wessling, Germany

The shorelines of lakes in northeastern Germany are often covered by reed. These reed belts fulfill an important function as erosion protection, biotope for animals, carbon storage, and as cleaning filter for lake water. However, despite their importance for the limnic ecosystem, reed vegetation in northeastern Germany is not regularly monitored.
In this research study we investigate the potential of synthetic aperture radar polarimetry (PolSAR) for seasonal monitoring of reed vegetation. SAR imagery enables sunlight- and (almost) weather-independent monitoring. Polarimetric decomposition techniques allow the physical characterization of the scattering scenario and the involved scatterers. Our study is based on 19 dual-polarimetric (HH/VV) TerraSAR-X images acquired between August 2014 and May 2015. We calculated different polarimetric indices comprising the HH and VV intensities, the dual-polarimetric coherency matrix with dominant and mean alpha scattering angles, entropy and anisotropy (normalized eigen-value difference) as well as combinations of entropy and anisotropy for the analysis of the scattering scenarios. The reed areas in the TerraSAR-X images were classified using a random forest algorithm and validated with high-resolution digital orthophotos.
The time series analysis of the reed belts revealed significant seasonal changes in the double bounce sensitive parameters (intensity ratio HH/VV and intensity difference HH-VV, the co-polarimetric coherence phase and the dominant and mean alpha scattering angles). Additionally, the dual-polarimetric coherence (amplitude), anisotropy, entropy, and anisotropy-entropy-combinations showed seasonal changes of reed. In summer, the reed areas are characterized within the X-band SAR data by volume scattering, whereas in winter double-bounce scattering dominates. The volume scattering in summer is caused predominantly by reed leaves. In autumn, the leaves start to wither and fall off, so that in winter predominately double-bounce scattering occurs between the remaining reed stems and the water surface. In spring, the growth of new leaves enhances again the amount of volume scattering gradually. Our analysis indicates that dual polarimetric (HH/VV) TerraSAR-X images are a valuable tool for phenological monitoring and classification of reed belts. The analysis indicates that winter scenes were generally better suited, because of a more distinct difference in scattering mechanisms between reed and other vegetation, such as meadows and deciduous or coniferous forests.