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Coastal Sediments and Habitats in the German Wadden Sea Imaged by Polarimetric X-, C- and L-band SAR

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Microwave remote sensing using synthetic aperture radar (SAR) can be used to obtain geophysical parameters of intertidal surface independent of day time and cloud coverage. Polarimetric SAR imagery can provide more detailed information about surface features, moisture and roughness, which supports the classification of intertidal sediments and habitats. In this paper, the polarimetric characteristics of exposed intertidal flats are analyzed using spaceborne SAR imagery from TerraSAR-X (X-band), Radarsat-2 (C-band), and ALOS-2 (L-band) satellites. Four test sites in the German Wadden Sea coast were chosen, which represent typical surface compositions of different sediments, vegetation, and habitats, and of which a large amount of SAR imagery was used for our analyses. We studied the dominant scattering mechanisms of various surface types, including sediments (mud and sand flats) and bivalve (oyster and mussel) beds, using both fully and dual polarimetric multi-frequency and multi-temporal SAR imagery. The polarimetric characteristics of each surface type were then quantitatively compared using depolarization parameters derived from algebraic operations of the normalized Kennaugh elements. In addition, combining X-, C- and L-band SAR imagery, we not only provide Kennaugh elements for coastal sediments and bivalve beds, but also demonstrate the different scattering behavior of each surface type when observed at various wavelengths. Our results show that even-bounce scattering plays a key role in the radar backscattering from sand flats, while for bivalve beds odd-bounce scattering dominates the received signals. The Kennaugh elements, especially the real (K3) and imaginary (K7) parts of the inter-channel correlations, contain useful information about different sediments, vegetation, and habitats; and the combined K3 and K7 elements have great potential to discriminate bivalve beds from sand flats on exposed intertidal flats. Furthermore, we demonstrate that the polarimetric features in C- and X-band SAR imagery are similar, while L-band imagery owns unique characteristics, which complement those of shorter wavelengths. Our analyses contribute to a better understanding of the polarimetric characteristics of coastal sediments and habitats, and may therefore help improving existing classification schemes.