On the Use of Multi-Frequency SAR Data to Improve the Monitoring of Intertidal Flats on the German North Sea Coast

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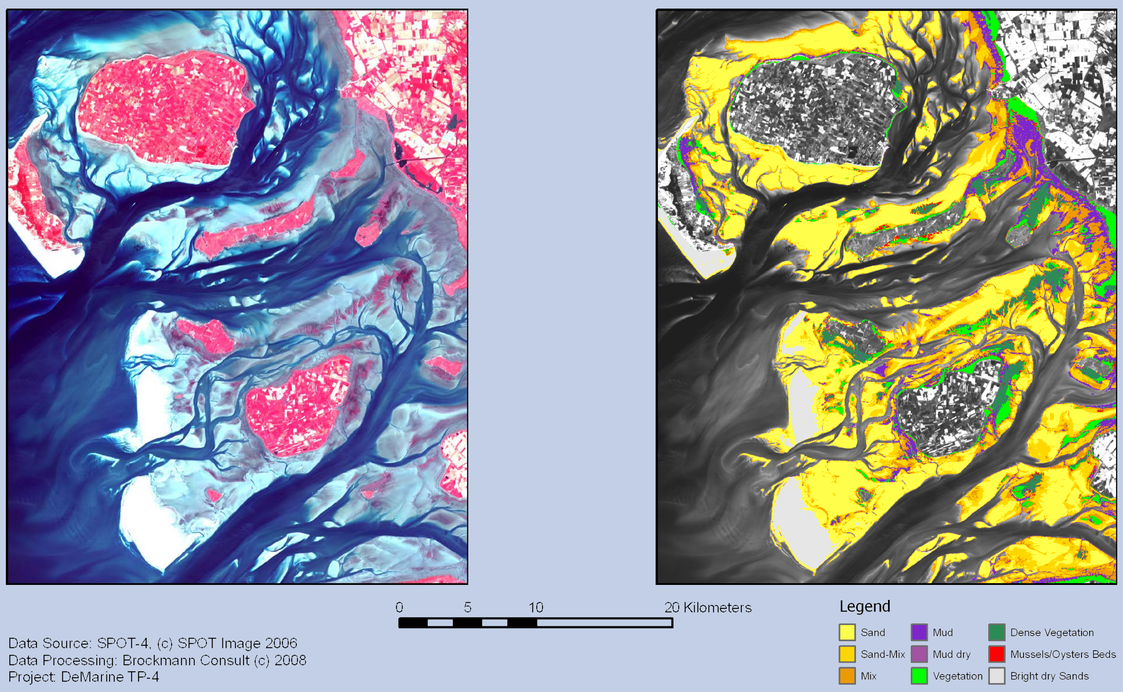
High-resolution multispectral remote sensing data from satellite-borne optical sensors are already being used for the classification of sediments, macrophytes, and mussels on exposed intertidal flats in the German Wadden Sea. Since the use of those sensors in northern latitudes is strongly limited by clouds and haze, we included SAR data, allowing for an observation of intertidal flats that is independent of cloud coverage and daytime. The data acquired at different radar bands (L, C, and X band, from ALOS PALSAR, ERS SAR, Radarsat-2 and ENVISAT ASAR, and TerraSAR-X , respectively) have been used to analyse their potential for crude sediment classification on dry-fallen intertidal flats and for detecting benthic fauna such as blue mussel or oyster beds.

Classification Based on Optical Data

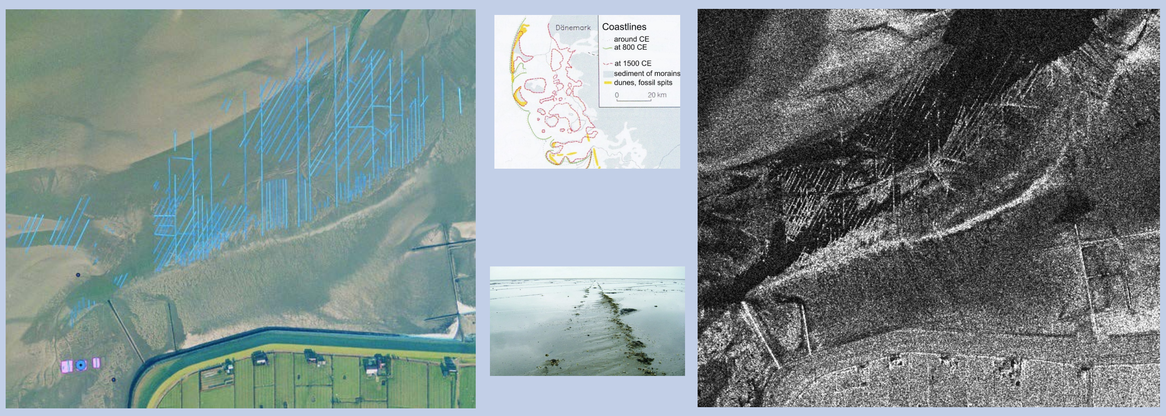
The applied classification method is based on linear spectral unmixing and feature extraction (Brockmann and Stelzer 2008), resulting in nine surface types: three sand and sand-mix classes, two mud classes, two vegetation density classes, one mussel class, and a class for dry and bright sands. Water coverage, having a strong influence on both spectral reflectance and radar backscattering, is considered within the endmember selection. Below is a false-color composite of a SPOT-4 scene acquired on July 27, 2008 (left panel) and the result of the classification applied to the data (right panel).



Archaeological Sites

TerraSAR-X data are used to demonstrate that residuals of former settlements and agricultural areas, lost during storm surges in the 14th and 17th centuries, can be detected from space. This finding has provided a completely new application field for SAR data, and the analysis of TerraSAR-X data has already enhanced the knowledge about land use residuals, which were so far unknown.

Left: Aerial photograph of dry-fallen intertidal flats north of Pellworm, with the locations of residuals of historical land use superimposed. Right: Subsection (1.9 km × 2.0 km) of a TerraSAR-X image of the same area, acquired on 3 August 2009 (05:42 UTC, 54 minutes after low tide). Note the linear features visible in both panels, which are due to historical ditches and lanes (small photograph).

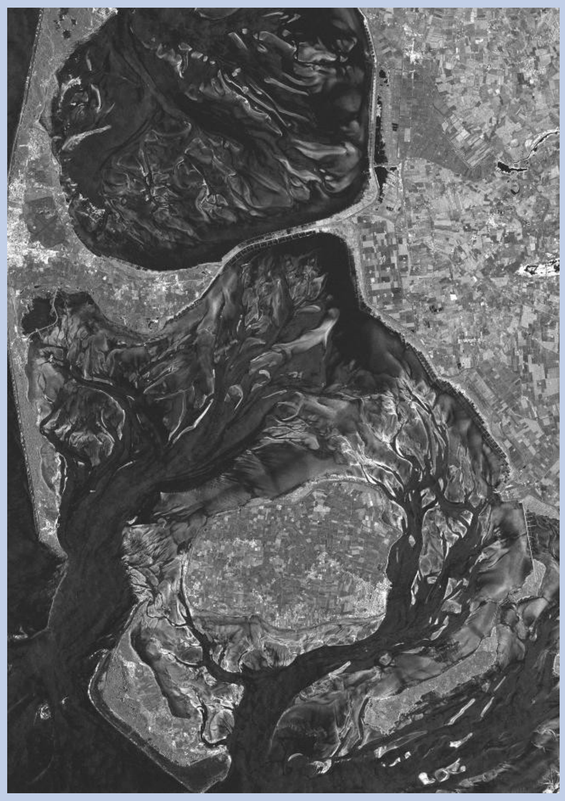


References

Brockmann, C., and K. Stelzer (2008). "Optical Remote Sensing of Intertidal Flats", in "Remote Sensing of the European Seas", V. Barale and M. Gade (Eds.), Springer, Heidelberg, pp. 117-128.

Gade, M., W. Alpers, C. Melsheimer, and G. Tanck (2008). "Classification of sediments on exposed tidal flats in the German Bight using multi-frequency radar data", Remote Sens. Environ., vol. 112, pp. 1603-1613.

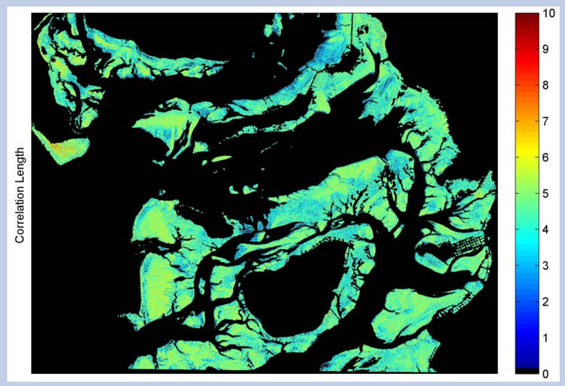
Roughness Parameters Derived from SAR Data

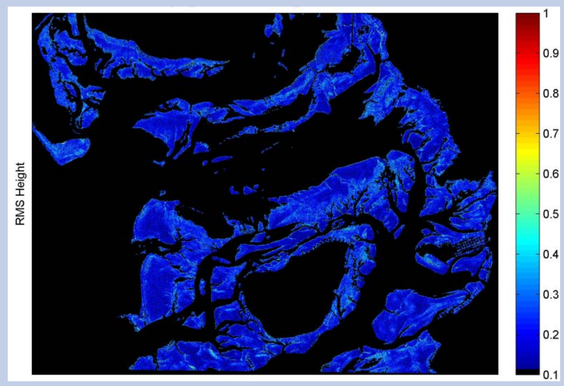


TerraSAR-X image of the German Wadden Sea acquired on 3 May 2008, at 05:50 UTC (1h after low tide)

The integration of SAR data into an existing classification system results in an improved classification of different surface types. We applied an inversion of the Integral Equation Model (IEM) to derive surface roughness parameters, namely the rms height and correlation length (Gade et al. 2008). Since the radar signatures of intertidal flats are similar at C and X band we always used for our inversions an L band SAR image (ALOS PALSAR) together with a second SAR image acquired at either C or X band.

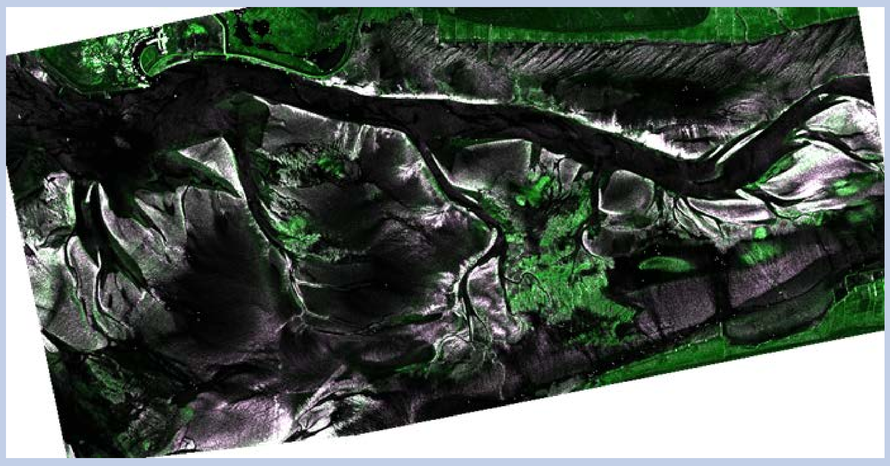
Results of the IEM inversion for the same test area shown on the left, based on an ALOS PALSAR image of 18 October 2007 (21:36 UTC, 110 minutes before low tide) and an ENVISAT ASAR image of the same day (09:55 UTC, 87 minutes before low tide). Left: correlation lengths, right: rms heights.





Multi-Temporal SAR Data Analysis

Mussel and oyster beds can be detected at all deployed frequency bands, i.e. by all sensors used. In this frame, our statistical, multi-temporal analyses provided most promising results. The figure below shows indicators for mussel beds south of the island of Norderney, derived through a statistical analysis of four TerraSAR-X images of 2009 (acquired between 1 h before and 1 h after low tide). Green colour marks high mean NRCS and low NRCS standard deviation. White colour marks high mean NRCS and high NRCS standard deviation. Oyster and (blue) mussel beds can be delineated in the image center.



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