Multi-Sensor Remote Sensing of the Wadden Sea Ecosystem on the German North Sea Coast

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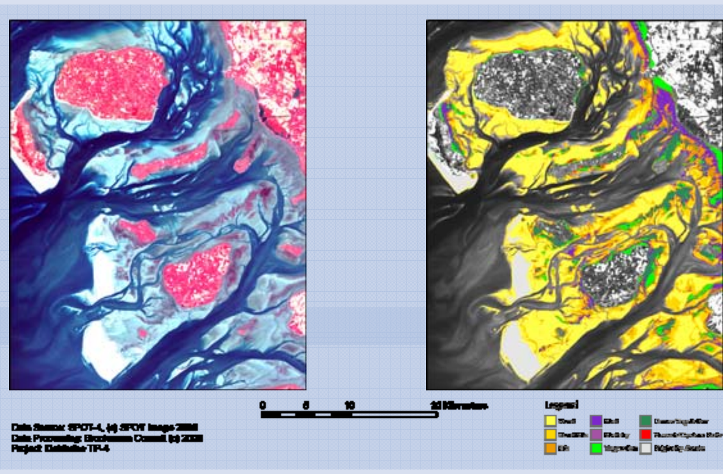
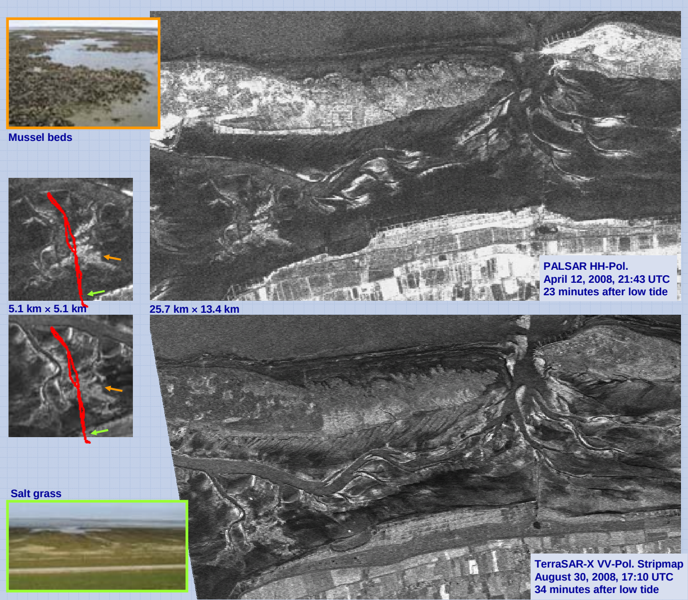
High-resolution multispectral remote sensing data from satellite-borne optical sensors are used for the classification of sediments, macrophytes, and mussels in the German Wadden Sea. Since the use of those sensors in northern latitudes is strongly limited by clouds and haze, we include synthetic aperture radar (SAR) data, allowing earth observation 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 and ENVISAT ASAR, and TerraSAR-X, respectively) are used to analyze their potential for crude sediment classification on dry-fallen intertidal flats and for detecting benthic fauna such as blue mussel or oyster beds. The information gained from optical and SAR sensors, together with in-situ observations, will yield an improved classification of different sediment types, together with mussel beds and sea grass.

Classification Based on Optical Data

The classification method using optical remote sensing data is based on a linear spectral unmixing and feature extraction from the spectral reflectances (Brockmann and Stelzer 2008). All extracted information from the optical data is combined in a decision tree, which is used to relate each pixel to a class representing different surface types: five sediment types, two vegetation density classes, one mussel class, and a dry and bright sands class. The water coverage, having a strong influence on the spectral reflectance and on the radar backscattering, is considered within the endmember selection for the linear spectral unmixing. The right figure shows a false color composite of a SPOT-4 scene of the test site “Halligwatt”, acquired on July 27, 2008 (left panel) and the result of the classification applied to the data (right panel).



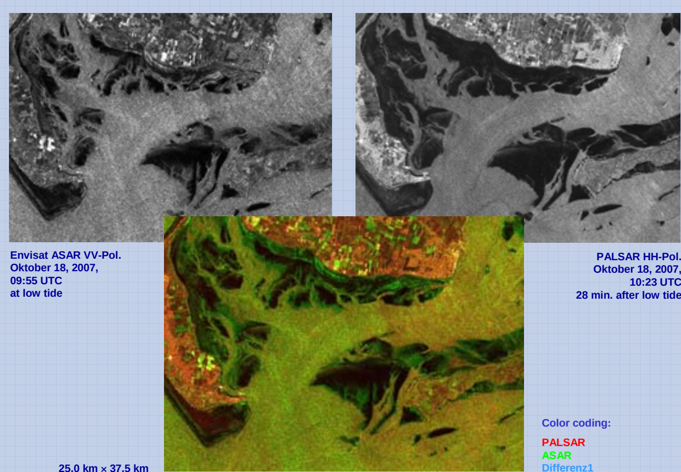


SAR Data From Test Site “Lütetsburger Plate“

The southern test site “Lütetsburger Plate” in Lower Saxony is dominated by a strong spatial variation of different sediment types, along with a high coverage by mussels. During summer season, some regions are covered by sea grass and green algae. Thus, a simple classification method that assumes bare sediments cannot be applied in this area. The above figure demonstrates how the test site is imaged by SAR sensors working at different radar bands: the upper panel shows an ALOS PALSAR (L-band) image acquired on April 12, 2008, at 21:43 UTC, 23 minutes after low tide, and the lower panel shows a TerraSAR-X (X-band) image acquired on August 30, 2008, at 17:10 UTC, 34 minutes after low tide. The location of the tidal creeks can be identified through enhanced radar backscattering from the sediment on the creek edges. This local enhancement of the radar backscatter was already found by Gade et al. (2008) who attributed it to an enhanced current-induced surface roughness of the sediments (i.e. sand ripple height). However, some irregular bright patches in the left part of both SAR images are not due to sand ripples, but due to mussel beds. That is, for the first time, benthic fauna on exposed intertidal flats has been imaged by multi-frequency (L, C, and X band) SAR sensors.

SAR Data From Test Site “Halligwatt“

The test site “Halligwatt” in Schleswig-Holstein shows spatial variations of different sediment types, mussel beds, see grass, and macro algae. The figure below shows two SAR images of the test site, acquired by different satellites on the same day, during, or shortly after, low tide. The ENVISAT ASAR image (upper left panel) was acquired on October 18, 2007, at 09:55 UTC (at low tide), and the ALOS PALSAR image (upper right panel) was acquired on the same day, at 10:23 UTC (28 minutes after low tide). Note the different radar contrast of the exposed intertidal flats, which cannot be attributed solely to the different acquisition time (sea level), but which may be caused by remnant water that is roughened by the strong north-westerly wind (12-13 m/s). Note that, in general, the radar backscattering from the exposed tidal flats is much lower than that from the surrounding wind-roughened sea surface.



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.

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