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Operational Wind Field Retrieval from Synthetic Aperture Radar

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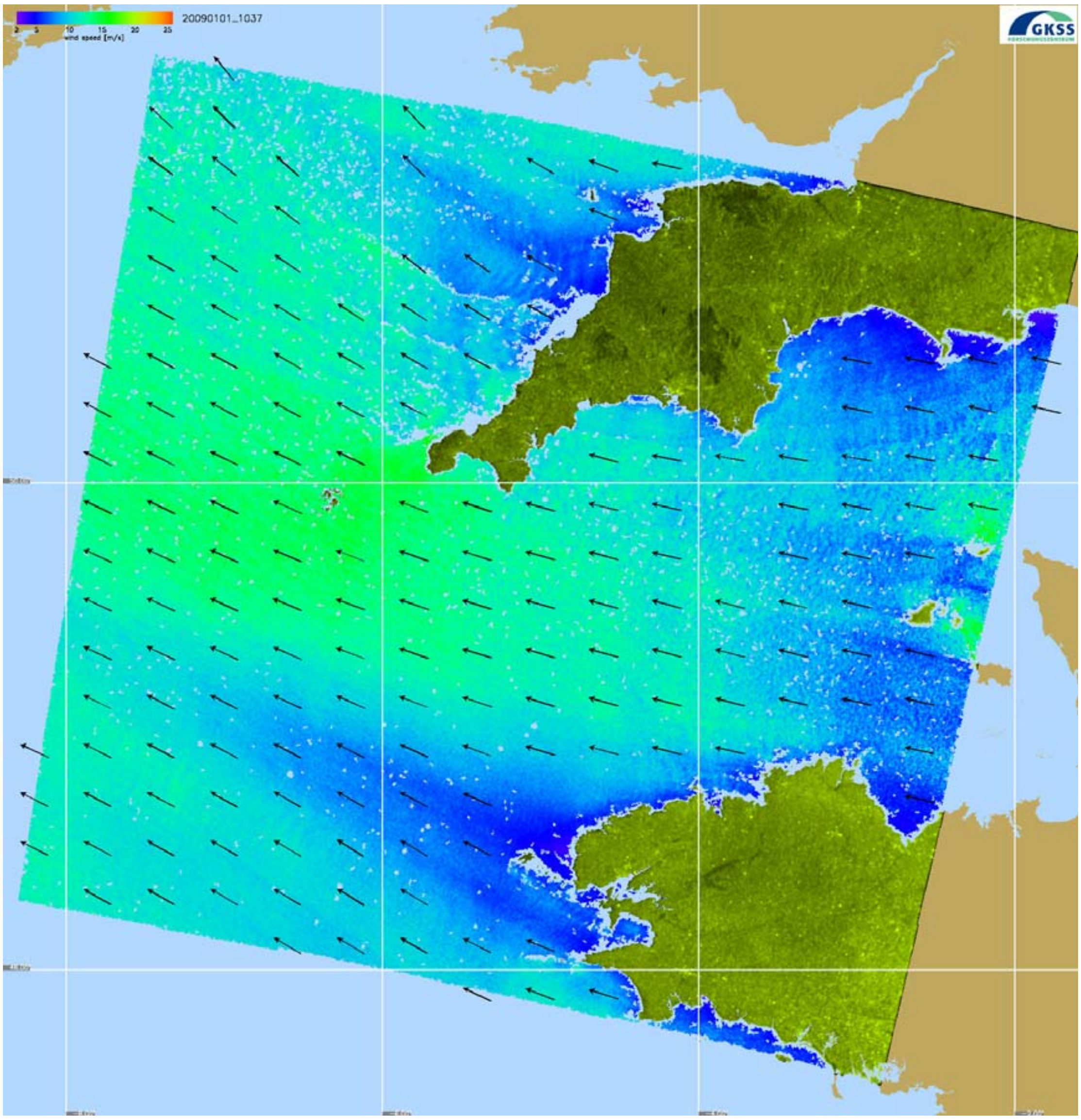
Abstract: Satellite borne synthetic aperture radar (SAR) instruments enable image the ocean surface at a very high resolution, typically below 100 m. Since the launch of the European remote sensing satellites ERS-l, ERS-2 and ENVISAT, as well as the Canadian satellites RADARSAT-1 and RADARSAT-2, SAR images have been acquired on a continuous basis over the oceans for the last 18 years. Their high resolution and large spatial coverage make them a valuable tool for measuring ocean surface winds. The above mentioned SARs operate at C-band and at moderate incidence angles. For this electromagnetic wavelength and range of incidence angles the backscatter of the ocean surface is primarily caused by the small scale surface roughness, which is strongly influenced by the local wind field and therefore allows the backscatter to be empirically related to the wind.

In this paper, we introduce WiSAR a methodology that enables retrieval of high resolution ocean surface wind fields from C-band SAR data on a fully automated and operational basis. Wind directions are extracted from wind-induced phenomena that are aligned in the wind direction. The orientations of these features are derived by determining local gradients of the normalized radar cross section (NRCS) from the SAR data. In this approach, a SAR image is sequentially smoothed and reduced to resolutions of 100, 200, and 400 m. From each of these images, local directions defined by the normal to the local gradient (to within a 180° ambiguity) are computed. Pixels associated with land, surface slicks, and sea ice, are masked and excluded from the analysis by considering land masks and several parameters retrieved from the SAR data. From all of the retrieved directions, only the most frequent directions in a predefined grid cell are selected. For better results this process can be assisted by consideration of results of an atmospheric numerical forecast model. The 180° directional ambiguity is removed by considering external *a priori* information, e.g., weather charts, atmospheric models or *in situ* measurements. Wind speeds are retrieved utilizing a geophysical model function (GMF) that describes the dependency of the NRCS on the local near-surface wind and imaging geometry. For C-band, VV-polarization, there are a number of popular model functions. The most commonly used is Cmod5. Each of these GMFs is directly applicable for wind speed retrieval from C-band VV polarized SAR images. For wind speed retrieval from C-band SAR images acquired at HH-polarization, no similar well- developed GMF exists. To meet this deficiency a hybrid model function is used that consists of one of the prior mentioned GMF and a C-band polarization ratio (PR).

WiSAR is validated on a data set consisting of over 600 ENVISAT ASAR images acquired in European waters and co-located to *in situ* wind measurements from buoys. For the validation WiSAR was run with and without assistance of the numerical atmospheric model NOGAP. The comparison to buoy winds also includes the comparison of the C-band models Cmod_Ifr2, Cmod4, and Cmod5.

Within a demonstration project, WiSAR has been running since September 2005 at the GKSS Research Center on an operational basis. In this project wind field maps of the North and Baltic Sea are generated on a daily basis and made available via the internet. Therefore, WiSAR was setup to process ENVISAT ASAR data of the North and Baltic Sea into ocean surface wind fields fully automated and in near real time.



Example of an Envisat Asar retrieved wind field from the opening of the English channel. The SAR data were collected on the 1. January 2009 at 10:36 GMT.