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Retrieving current and wind vectors from ATI SAR data: airborne evidence and inversion strategy

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Conventional and along-track interferometric (ATI) Synthetic Aperture Radar (SAR) sense the motion of the ocean surface by measuring the Doppler shift of reflected signals. Together with the water displacement associated with ocean currents, the SAR measurements are also affected by a Wind-wave induced Artefact Surface Velocity (WASV) caused by the velocity of Bragg scatterers and the orbital velocity of ocean surface gravity waves. The WASV has been modelled theoretically in past studies but has been estimated empirically only once using Envisat ASAR.

Here we propose, firstly, to evaluate this WASV from airborne ATI SAR data, secondly, to validate the airborne retrieved surface current after correction of the WASV against HF radar measurements and thirdly to examine the best inversion strategy for a an Ocean Surface Current (OSC) satellite mission to retrieve accurately both the ocean surface current vector (OSCV) and the wind vector in the frame of an OSC satellite mission.

The airborne ATI SAR data were acquired in the tidally dominated Irish Sea using a Wavemill-type dual-beam SAR interferometer. A comprehensive collection of airborne Wavemill data acquired in a star pattern over a well-instrumented site made it possible to estimate the magnitude and dependence on azimuth and incidence angle of the WASV. The airborne results compare favourably with those reported for Envisat ASAR, empirical model, which has been used to correct for it.

Validation of the current retrieval capabilities of the proof-of-concept has been conducted against HF radar giving a precisions typically better than 0.1 m/s for surface current speed and 7° for direction. Comparisons with POLCOMS (1.8 km) indicate that the model reproduces well the overall temporal evolution but does not capture the high spatial variability of ocean surface currents at the maximum ebb flow. Airborne retrieved currents highlight a short-scale spatial variability up to 100m related to bathymetry channels, which are not observed (HF radar, 4km resolution) or simulated (POLCOMS, 1.8km).

The inversion strategy points to the need for accurate measurement of both the backscatter amplitude and the Doppler information (either as a Doppler centroid frequency anomaly for SAR DCA, or as an interferometric phase for ATI) as well as the need for dual polarization capability (VV+HH) for non-ambiguous inversion. Preliminary inversion results show that the retrieval accuracy for OSC velocity better than 10 cm/s can be achieved but that the OSC accuracy is strongly sensitive to the wind direction relative to the antennas orientation.

This concept is a unique opportunity to improve our understanding of the air-sea interaction, the ocean submesoscale dynamic and its impact on the oceanic vertical transport. This concept is particularly well fitted for these ocean surface current and wind vectors observations in coastal and polar regions.