SPACEBORNE SAR IMAGING OF COASTAL OCEAN PHENOMENA

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Abstract

Wide-swath synthetic aperture radar (SAR) observes the large-scale ocean surface wind field. With SAR instruments, we can actively monitor phenomena in the coastal ocean and marine atmospheric boundary layer at very high spatial resolution (on the order of tens of meters) in all weather conditions day and night. SAR observations are particularly useful in coastal regions where clouds are usually present, causing observation problems for visible and infrared sensors. The ScanSAR beam mode of the SARs onboard the RADARSAT-1/2, ENVISAT, and ALOS satellites can provide swath coverage of about 450 km, wide enough to cover oceanic and atmospheric meso-scale features. SAR has long been used to monitor the sea surface wind field, vessel locations, oil spills, sea state and sea ice at NOAA. The first part of this presentation is an overview of the use of SAR for near-real-time retrieval of these parameters. In addition, oceanic surface signatures associated with surface waves, internal waves (Figure 1) [Li et al, 2008a], tidal convergence fronts, and bottom bathymetry features, as well as marine atmospheric boundary phenomena, i.e., atmospheric gravity waves [Li et al., 2004], vortex streets [Li et al., 2008b], and hurricanes are often observed in SAR images.

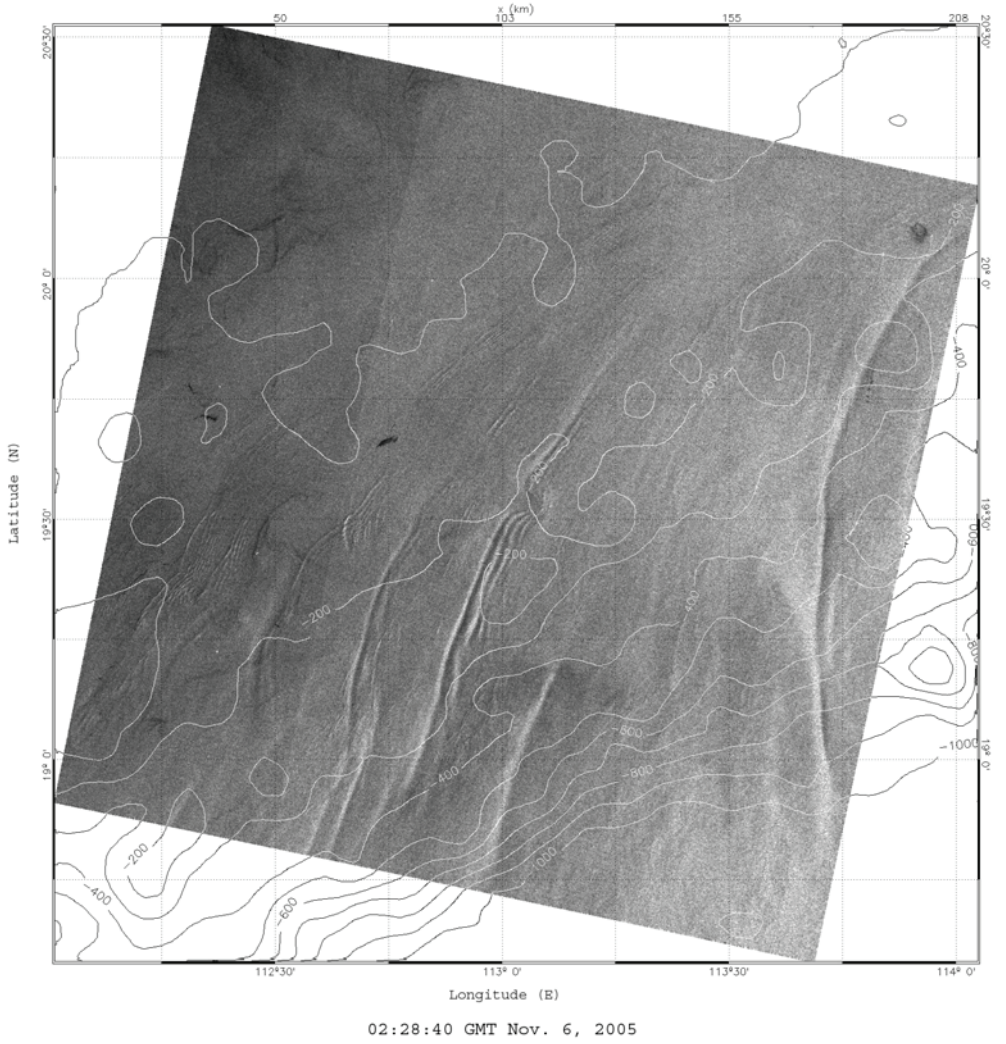

Figure 1. An ENVISAT ASAR image showing the internal wave propagation in the western South China Sea.

To understand these SAR observations, we develop and implement various kinds of analytic fluid mechanics models and numerical weather models to understand the SAR observations. In particular, in the second part of this presentation, we will highlight two case studies. The first is oceanic bathymetry studies using SAR in both shallow and deep waters (Figure 2). The second is a comparison of sea surface wind retrievals between C-band SAR and the Ku-band QuikSCAT scatterometer in coastal waters. We address the QuikSCAT wind retrieval accuracy variations as a function of distance to the shoreline.

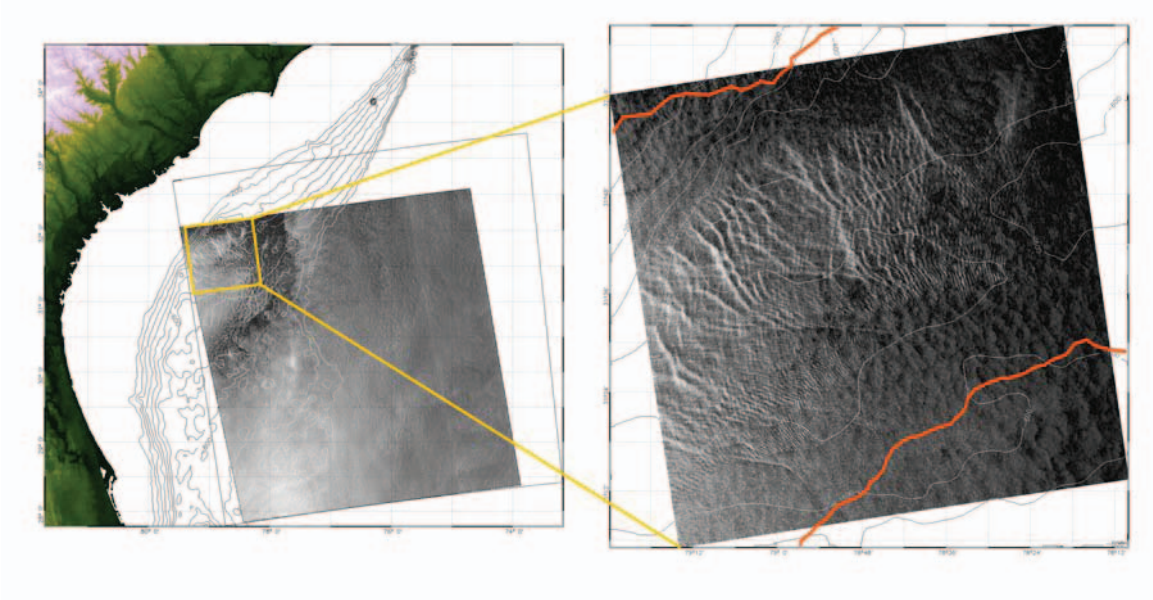

Figure 2. A SAR image showing the bathymetry features. The water depth is over 500 m in this region.

In 2008, The Canadian Space Agency (CSA), in cooperation with the Center for Southeastern Tropical Advanced Remote Sensing (CSTARS), the National Oceanic and Atmospheric Administration (NOAA) and the National Aeronautics and Space Administration (NASA) made 160 RADARSAT-1 SAR hurricane images available to the research community. These images provide detailed observations of hurricane structure, including the eye shape and location of rain bands. With the advance of understanding of the conversion of normalized radar cross-section (NRCS) to sea surface wind, we have a good knowledge of SAR sea surface wind retrieval using various geophysical model functions (GMF), i.e., CMOD4 and CMOD-5, for winds up to 15-20 m/s. At higher winds, GMFs usually saturate around 20 m/s, and a small calibration uncertainty will induce large wind retrieval errors. In this study, we derive hurricane winds from RADARASAT (HH) images contained in the above-mentioned database and ENVISAT (VV) SAR images provided by the European Space Agency (ESA) for several Atlantic and Gulf of Mexico hurricanes using the C-band CMOD5 GMF and CIWRAP, a high wind GMF derived using the Imaging Wind and Rain Airborne Profiler (IWRAP) data. We discuss the behavior of these GMFs for high winds. The derived sea surface hurricane winds (Figure 3) are compared with coincident airborne Stepped Frequency Microwave Radiometer (SFMR) measurements. Using the SFMR wind data as ground

truth, we can best fit the non-rain-contaminated SAR wind retrievals with the SFMR wind to estimate the SAR system calibration errors and, thus, improve SAR hurricane wind retrieval accuracy.

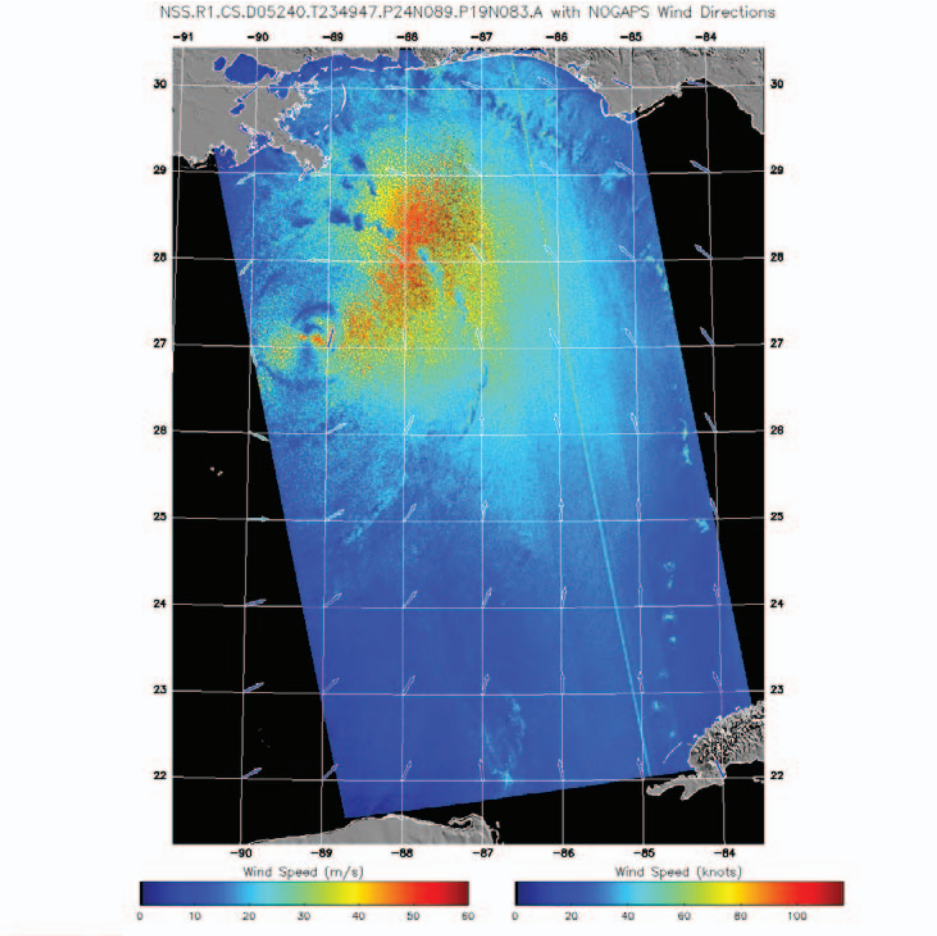

Figure 3. Sea surface wind retrievals from RADARSAT-1 SAR images for Hurricane Katrina

Reference:

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