Newsroom

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New technique improves retrieval of wind data under hurricane conditions

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A proposed model recalibrates images taken during hurricane Katrina by synthetic aperture radar on RADARSAT-1 in order to estimate near-surface winds over the ocean.

C-band synthetic aperture radar (SAR) is a type of radar that requires a relatively stationary target and produces a narrow effective beam. In recent years, it has been used to collect information about surface winds over the ocean.[1] Compared to other instruments, SAR measurements have very high resolution; hence, SAR-retrieved winds are useful for the study of microscale atmospheric phenomena such as hurricanes.

Due to its wide swath (about 500km), the RADARSAT-1 scanning SAR (ScanSAR) in wide mode A (SWA)[2] is well-suited for the study of hurricanes. However, the radiometric calibration of ScanSAR SWA data can introduce errors.[3,4] Because a well-validated geophysical model function (GMF) for C-band horizontal transmit–horizontal receive (HH) polarization is lacking, the C-band vertical transmit–vertical receive (VV) polarization GMF is modified using a polarization ratio. Although several polarization ratio models have been proposed, none of them fit well for the ScanSAR SWA images acquired during hurricane Katrina. To compensate for the errors induced by calibration and the polarization ratio model, we propose a recalibration method to adjust the ScanSAR SWA measurements collected under hurricane conditions to support retrieval of wind data.

The re-calibrated SAR normalized radar cross section σ°_{re} can be expressed as:

$$\sigma^\circ_{re} = \sigma^\circ_{es} G(\theta) M + O \tag{1}$$

where σ°_{es} is the normalized radar cross section estimate from the SAR images, $G(\theta)$ is a function dependent on incidence angle, M is a power correction parameter, and O is an offset correction parameter. $G(\theta)$ can be expressed as

$$G(\theta) = sin^n(\theta) \tag{2}$$

where n is a real number. The model coefficients are tuned for optimum performance using collocated H*wind, the numerical predicted surface wind fields for hurricanes calculated by the Hurricane Research Division of the National Oceanic and Atmospheric Administration. These are projected through the C-band VV-polarized GMF known as CMOD5[5] and Thompson's polarization model.[6]

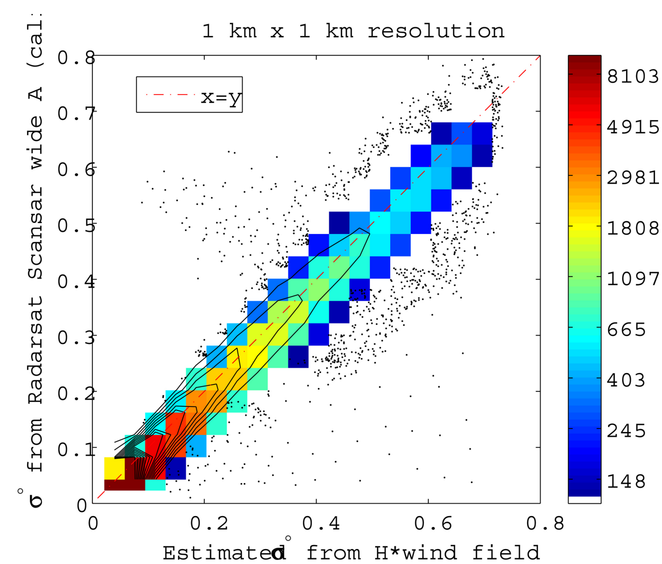

***Figure 1.** This scatter density plot compares σ°, the normalized radar cross section from recalibrated SAR image A, with σ° estimated from collocated H*wind, the numerical predicted surface wind field for hurricanes. The colors indicate the density of the data in a specific area according to the color-bar on the right side. The resolution of the RADARSAT-1 cross-section is 1km by 1km.*

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10.1117/2.120081.0951 Page 2/3

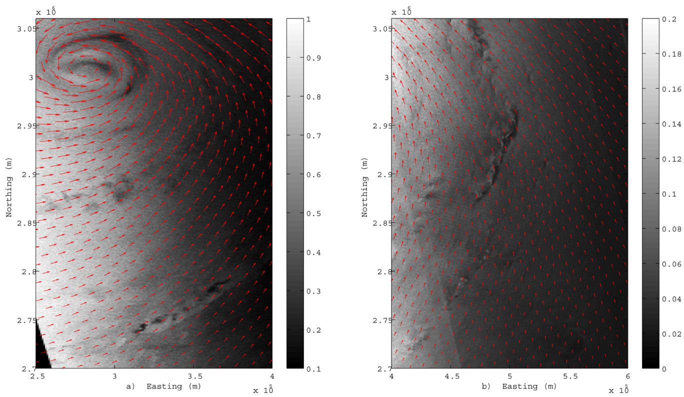

Figure 2. *Scatter density plot between the (a)* σ°_{re} *of image A and (b)* σ° *estimated from collocated H*wind.*

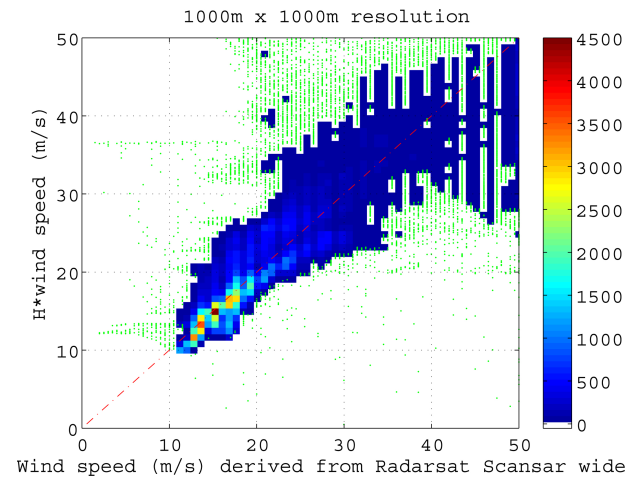

Figure 3. *Scatter density plot for the SAR-derived and H*wind wind speed for SAR image A in (m/s). The colors indicate the density of the data in a specific area according to the color-bar on the right side.*

Since ScanSAR SWA images combine data from four different beams, each with a different incidence angle and radiometric characteristics, the coefficients of the recalibration model are separately tuned for each of the three incidence angle ranges. In this study, we used two 510km×510km ScanSAR SWA images, here called A and B, acquired over the ocean near New Orleans, LA, at midnight on 28 August 2005. At the time of observation, Katrina was a category 5 hurricane with a fully developed eye. Figure 1 presents scatter plots of σ°_{re} from image A and σ° estimated from collocated H*wind in normal space.

Due to the inadequate spatial resolution of RADARSAT-1 ScanSAR SWA images, conventional SAR wind direction retrieval methods, such as spectrum analysis, cannot be employed.[6] Instead, the collocated H*wind wind direction field is used as the wind direction. Wind speed retrieval is done at 1km×1km by inversion of the GMF using σ°_{re}. Figure 2 shows portions of both σ°_{re} and the collocated H*wind wind direction vectors of image A. Since the magnitude range of σ°_{re} is large, we display σ°_{re} in two sub-images. Note that the color scales of the sub-images are different.

To validate the SAR-derived wind speeds, we compared the scatter density plots of the SAR-retrieved and collocated H*wind wind speeds (see Figure 3). Overall, the two wind speeds agree well. Except for the influence of rain, the largest errors in wind speed occur when the speed is very high (more than 25m/s). These errors are mainly due to the saturation of the C-band GMF (CMOD5) at high wind speeds.

In summary, we propose a model to recalibrate the calibrated RADARSAT-1 ScanSAR SWA images taken under hurricane conditions. The SAR-retrieved wind speeds from the recalibrated measurements agree well with collocated H*wind wind speeds for wind speeds less than 25m/s, showing that RADARSAT-1 ScanSAR SWA images processed by the recalibration model are suitable for measuring ocean surface winds in hurricanes. To improve retrieval at high wind speed, a model-based wind retrieval method may be implemented. Rain effects on SAR wind retrieval will be studied in the future.

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Continued on next page

10.1117/2.120081.0951 Page 3/3

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