SAR Wind Field Retrieval with Respect to Tropical Cyclones

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Motivation for using SAR

0.5 km grid
General Approach for Ocean SAR Wind Field Retrieval (WiSAR)

Local Gradient Method

$$\left(B^2 B_{xy}^4\right)^3 \xrightarrow{\text{Sobel}} \left(B^2 B_{xy}^4\right) \xrightarrow{\Phi}$$

- Binomial filter
  - 2 dim. $B^2$ Filter
  - 2 dim. $B^4$ Filter

Geophysical Model Function

$$\sigma_0^{pol} = a(\theta) u_{10}^{\gamma(\theta)} [1 + b(\theta) \cos \phi + c(\theta) \cos(2\phi)]$$

- GMF for C-, X- and L-band
- $\Phi$, $\theta$, $u_{10}$, $\sigma_0$
Surface Streaks Imaged by X-band Marine Radar

160 sec mean NRCS with 30 sec time step
General Approach for Ocean SAR Wind Field Retrieval (WiSAR)

Local Gradient Method

\[(B^2 B_{xy}^4)^3 \rightarrow \text{Sobel} \rightarrow (B^2 B_{xy}^4) \rightarrow \Phi\]

Geophysical Model Function

\[\sigma_{o pol} = a(\theta)u_0^{\gamma(\theta)}[1 + b(\theta)\cos \phi + c(\theta)\cos(2\phi)]\]

Optimized Sobel-Filter

\[
\begin{array}{ccc}
3 & 0 & -3 \\
10 & 0 & -10 \\
3 & 0 & -3 \\
\end{array}
\]
Flagging of Land and Non Wind Induced Areas
Wind Direction Ambiguity Removal
Wind Direction Ambiguity Removal

1. Select grids with only one wind direction (400m)
Wind Direction Ambiguity Removal

2. Select nearest neighbor for the other wind directions
3. Polar wind directions around hypothetic eye with 180 deg ambiguity
4. Limit radius around the eye
Wind Direction Ambiguity Removal

5. Retrieve 60% quantile of simulated polar wind - 400 m grid wind
6. Use eye location and polar wind to remove 180 deg ambiguity and wind directions with difference above 60 deg
Wind Direction Ambiguity Removal

7. Select nearest neighbor of all scales to previously selected wind directions
8. Smooth wind directions
Flagging

ENVISAT ASAR
6. Sep. 2004
Estimation of uncertainties
Estimation of uncertainties

uncertainty of NRCS (0.5 dB) > 2 m/s or 20%
Different C-band GMF

CMOD5
(empirical + polarization ratio)

CWaR
(scattering model + fit to data)
Different C-band GMF

CMOD5 (empirical + polarization ratio)  CWaR (scattering model + fit to data)

SAR Typhoon Processing System within the ITOP Project of ONR

SAR processing

Descalloping
Recalibration
Debanding

NRCS
Incidence angle
Satellite heading
Longitude & Latitude
Land mask
Filter mask
NRCS better

Eye Location
Wind speed
Wind direction
Pressure
Wave direction
Wave height

NURC eye
GD eye
Model eye
WiSAR
GD wind

APL pressure
GD waves
CSTARS wave
Summary and Outlook

- corrections schemes for:
  - Recalibration
  - banding
  - scalloping

- Typhoon eye detection via
  - wind directions
  - wind speeds
  - correlation
  - wind direction

- choice of Polratio is still an open question

- Correction of areas with NRCS beyond definition of Cmod5

- Removal of wind speed ambiguities (Cmod5)

- Uncertainty estimates with respect to NRCS
Wind Speed Ambiguities in CMOD5

Radarsat-1
Wind Speed Ambiguities in CMOD5

CMOD5: Wind direction is upwind

CMOD5: Wind direction is crosswind

CMOD5: Incidence angle of 30°

CMOD5: Incidence angle of 50°
Simulated Effect of Wind Speed Ambiguities

H_{wind} + SAR  |  Upper solution  |  Lower solution

Cluster-Mask  |  Rebuilt Wind
Scalloping Removal in the Spectral Domain

Romeiser et al., 2010
Possible wave effects on SAR wind retrieval

SAR winds

SAR waves (long waves)

Provided by BOOST Technologies
Doppler Centroid Estimates for Directional Ambiguity Removal