Characteristics of high resolution winds from SAR

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Overview

• Synthetic Aperture Radar
  – Winds from Synthetic Aperture Radar
  – Strengths and weaknesses
  – Coastal winds
• Hurricane watch program
• Hurricane analysis
  – Katrina comparison with QS winds
  – Eye wall gallery
• Future SAR
• Summary
Winds from SAR

- High (300 – 500 m) Resolution Scatterometer
- CMOD 4/5
- A priori wind directions
- Local wind direction from model or wind streaks using the Local Gradient Method
- RMS 1.76 m/s (buoys), 1.24 m/s (QS), 2.8 m/s (models)
Strengths and weaknesses

• Strengths
  – Accuracy comparable to scatterometry
  – Sub km resolution winds
  – Near shore measurements

• Weaknesses
  – Wind speed errors related to wind direction errors
  – Absolute calibration of backscatter, particularly in wide scan mode
  – Limited coverage
Fronts

- Station LKWF1 – 8.8 m/s, gust 11.8 m/s
- Station FWYF1 – 6.7 m/s, gust 7.2 m/s
- Winds from ENE
- Frontal features from 2 – 7 km
Features of SAR winds

- Mountain wakes
- Gap flows
- Lee waves
- Point wakes
- Synoptic fronts and lows
Hurricane Watch

- The Center for Southeastern Tropical Advanced Remote Sensing (CSTARS) with the Canadian Space Agency (CSA) and the U.S. National Oceanic and Atmospheric Administration / Atlantic Oceanographic and Meteorological Laboratory (NOAA/AOML)
- Analysis of C-band Synthetic Aperture Radar (SAR) data acquired over hurricanes
- Started in 1999 and has collected over 300 images of tropical cyclones
Katrina

- Max wind speed 150 kts
- Cat 1 landfall at Miami
- Aug 27 – Doubled in size
- Cat 5 Aug 28 1200 GMT
- Cat 3 landfall Aug 29 1100
QuikSCAT 12.5 km
Ultra High Resolution Winds
Future SAR

• **Radarsat 2**
  - 2007 launch
  - HH, VV, HV, VH
  - Global, 1 – 3 days revisit time
  - 20° - 60° incidence angle
  - 3 – 100 m resolution; 20 – 500 km swath

• **TerraSAR-X**
  - X-band, 2007 launch
  - HH, VV, HV, VH
  - Global, 1 – 3 days revisit time
  - 20° - 60° incidence angle
  - 1 – 16 m resolution; 10 – 100 km swath x (up to 1,500 km)
Future SAR

- **COSMO-SkyMed**
  - 4 satellites equipped with X-band multipolarimetric SAR
    - 2 in 2007, 1 in 2008, 1 in 2010
  - 90º phased sun-synchronous
  - Global, < 12 hr revisit time
  - HH, VV, HV, VH
  - 20º - 59º incidence angle
  - ~1 – 100 m resolution; 10 – 200 km swath
Summary

• SAR winds show mountain wakes, lee waves point wakes, frontal instabilities and near coastal winds.
• Hurricane eye wall structures vary in size and shape and are clearly identified by SAR.
• Wind fields derived from SAR good accuracy at moderate winds.
• The RMS is significantly larger for hurricane winds and more work is required.
• The next generation of SAR are orbiting.
Questions?
Supporting slides
HH Polarization

\[ \sigma^o_H = \sigma^o_V \left[ \frac{1 + \alpha \tan^2 \theta}{1 + 2 \tan^2 \theta} \right]^2 \]

\( \alpha \)  Dependent on nature of scattering

\( \theta \)  Nadir incidence angle
Wind direction sensitivity
Model Comparison (Katrina)
Development of an empirical XMOD using the GMFs of C- and Ku-band

\[ \sigma_0^{pol} = a_0(U, \theta)u(U, \theta) + a_1(U, \theta) \cos \phi + a_2(U, \theta) \cos(2\phi) \]
Comparison of wind speeds to numerical model results

- Number of Points: 23467
- Correlation (Cor.): 0.98
- Bias: -1.9°
- Root Mean Square (Rms): 16.6°

- Number of Points: 23467
- Correlation (Cor.): 0.83
- Bias: 0.4 m/s
- Root Mean Square (Rms): 2.8 m/s
Climatology from SAR considering 450 SAR acquisitions
Applications: Climatology
Mean wind speed

NCEP and QuikSACT
0.5 km grid

Motivation for High Resolution Winds
## Synthetic Aperture Radars

<table>
<thead>
<tr>
<th>Launched</th>
<th>Satellite</th>
<th>Band</th>
<th>Resolution</th>
<th>Swath</th>
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<tr>
<td>1978</td>
<td>Seasat</td>
<td>L</td>
<td>25 m</td>
<td>100 km</td>
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<td>ERS-1</td>
<td>C</td>
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<tr>
<td>1991</td>
<td>JERS-1</td>
<td>L</td>
<td>&lt; 25 m</td>
<td>75 km</td>
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<tr>
<td>1995</td>
<td>Radarsat</td>
<td>C</td>
<td>25 – 100 m</td>
<td>400 km</td>
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<tr>
<td>2002</td>
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<td>C</td>
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