Obtaining Accurate Ocean Surface Winds in Hurricane Conditions: A Dual Frequency Scatterometry Approach


Ocean Vector Wind Science Team Meeting
Seattle, Nov 19-21, 2008
Outline

• Overview
• Simulation Methodology
  – WRF: Winds, Rain
  – XOVWM Simulation: NRCS values
• Wind Retrieval Method and Results
  – Neural network method
  – Retrieves accurate wind speeds in rain given C and Ku NRCS values.
Overview

• Three Major Problems for Retrieving Accurate Hurricane Winds
  – Need high resolution to resolve high wind speed bands
  – Model functions saturate or drop off at high winds
  – Rain contamination obscures wind speed signal

• Proposed Solutions
  – Burst Mode SAR processing to improve resolution
  – Dual frequency provides unique wind speed solution
  – Dual frequency allows rain correction
Overview Slide 2: IWRAP Model Functions
Overview Slide 3: Rain Effects in Hurricanes w/o correction

C band only

Ku band only

Dual Frequency

Truth
Simulation Method Slide 1: Katrina from Hurricane WRF

Wind

Rain

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Simulation Method Slide 2: Rain Effects on NRCS

Attenuation

Volume Backscatter

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Simulation Method Slide 3: XOVWM Measurement Geometry

SAR Pixels → Antenna Footprints → Antenna Scans
Wind Retrieval: Slide 1

Rain-free Case, MLE Retrievals

C band only

Ku band only

Dual Frequency

Truth
Wind Retrieval: Slide 2
Rainy Case, no correction

C band only

Ku band only

Dual Frequency

Truth

km

speed m/s

km

speed m/s

km

speed m/s

km
Wind Retrieval: Slide 3
Rainy Case with Correction

![Comparison of wind retrieval methods]

**Single Raininess Parameter**

**ANN Only**

**ANN+MLE**

**Truth**
Wind Retrieval Slide 4: ANN Method

- Compute 17-D Input Vector to ANN
  - Mean of 8 NRCS “Flavors”
    - C/Ku, Inner/Outer, Fore/ AFT NRCS
  - Variance of 8 Flavors
  - Cross Track Distance
- Train ANN on 2 simulated Katrina + 2 simulated Rita scenes
  - Using Back-propagation Training Algorithm
- Test on 21 scenes not seen during Training including scenes from Helene.
Wind Retrieval: Slide 5

ANN equations: Multi-Layer Perceptron

\[ y = c_0 + \sum_{i=1}^{M} c_i s\left( w_{i0} + \sum_{j=1}^{N} w_{ij} x_j \right) \]

\[ s(u) = \frac{1}{1 + e^{-u}} \]
Wind Retrieval: Slide 6
Speed Accuracy for Katrina4 Test Scene

ANN RMS = 2.05785 m/s

Truth

ANN - Truth

2-D Log Histogram

True Speed (m/s)

ANN Speed (m/s)
Wind Retrieval: Slide 8
Speed Accuracy for Ku Only ANN

ANN RMS=4.83763 m/s

Truth

ANN - Truth

2-D Log Histogram

True Speed (m/s)

ANN Speed (m/s)
Wind Retrieval: Slide 7
Speed Accuracy for C Only ANN

ANN RMS = 2.09721 m/s

Truth

ANN - Truth

2-D Log Histogram

True Speed (m/s)

ANN Speed (m/s)
Conclusions

- Simulated 25 scenes from Katrina, Rita, and Helene.
- Dual frequency neural net technique retrieves accurate winds up to 55 m/s.
- C band only and Ku-only techniques show severely degraded performance even with similarly trained neural networks.
Backup Slides
# Table of Train and Test Scenes

<table>
<thead>
<tr>
<th>Hurricane and Scene ID</th>
<th>Date and UTC Time (ymmdddThh:mm)</th>
<th>Used for:</th>
<th>RMS speed error (m/s)</th>
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Overall Speed Bias--All Test Scenes

![Graph showing speed bias against true speed with different lines representing different conditions.](image-url)
Overall Speed St. Dev.--All Test Scenes

- Dual ANN
- 5 km ideal
- 10 km ideal
- C Only ANN
- Ku Only ANN

True speed (m/s)

Speed Standard Deviation (m/s)
Rita1

ANN RMS = 1.79279 m/s

Truth

ANN - Truth

2-D Log Histogram

ANN Speed (m/s)

True Speed (m/s)
Helene1

ANN RMS=1.40529 m/s

Truth

ANN - Truth

2-D Log Histogram
Helene11

ANN RMS=2.15052 m/s

Truth

ANN - Truth

2-D Log Histogram

ANN Speed (m/s)

True Speed (m/s)
Simulated Rain Attenuation vs. TRMM

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Simulated Rain Reflectivity vs. TRMM
Simulated vs. Real QuikSCAT Winds

Real

Observed Rita QuikSCAT 12.5 km Winds Sept 21 2005 11:53 UTC

Simulated

12.5 km Winds Sept 21 2005 15:30 UTC