The RSS WindSat Version 7
All-Weather Wind Vector Product

Thomas Meissner
Lucrezia Ricciardulli
Frank Wentz
Outline

1. Overview: RSS WindSat V7 Level 2B Products
2. Wind Speed Algorithm
   - Rain Free Wind Speeds
   - Global Wind Speeds Through Rain
   - Wind Speed in Hurricanes
   - Blended All-Weather Wind Speeds
   - Performance Analysis
3. Wind Direction Algorithm
4. Tropical and Extratropical Cyclones
5. Summary + Outlook
RSS Version 7 Products

Intercalibrated multi-platform suite
100 years satellite data
Release in progress

DMSP SSM/I, SSMIS
8 Total, 4 currently operating

TRMM TMI

AMSR-E, AMSR

WindSat

QuikSCAT
## WindSat V7 Level 2B Products

<table>
<thead>
<tr>
<th>Product</th>
<th>Resolution + Required Channels</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Very Low C-band ≥ 6.8 GHz 50 km</td>
</tr>
<tr>
<td></td>
<td>Low X-band ≥ 10.7 GHz 32 km</td>
</tr>
<tr>
<td></td>
<td>Medium K-band ≥ 18.7 GHz 22 km</td>
</tr>
<tr>
<td></td>
<td>High ≥ 37.0 GHz 10 km</td>
</tr>
<tr>
<td>SST</td>
<td>Yes</td>
</tr>
<tr>
<td>Wind Speed No Rain</td>
<td>Yes</td>
</tr>
<tr>
<td>Wind Speed Through Rain</td>
<td>Yes</td>
</tr>
<tr>
<td>Wind Direction</td>
<td>No</td>
</tr>
<tr>
<td>Water Vapor</td>
<td>Yes</td>
</tr>
<tr>
<td>Tot Liquid Water</td>
<td>Yes</td>
</tr>
<tr>
<td>Cloud Water</td>
<td>Yes</td>
</tr>
<tr>
<td>Rain Rate</td>
<td>No</td>
</tr>
</tbody>
</table>

- **Optimized swath width by combining for and aft looks at each band**

### Polarimetric Radiometer:

- 6.8 V H
- 10.7 V H +45 -45 LC RC
- 18.7 V H +45 -45 LC RC
- 23.8 V H
- 37.0 V H +45 -45 LC RC
Wind Speed Algorithms

- No-Rain Algorithm (X-band)
  - Physical algorithm
  - Based on RTM (emissivity model)
  - Trained with random wind speed distribution

- H-wind (Hurricane) Algorithm (C-band)
  - Statistical algorithm
  - Trained from collocation of WindSat TB with HRD (Hurricane Research Division) wind speeds
    - **HRD winds need to be resampled to WindSat C/X band resolution**
      - Not possible to resolve small scale effects.

- Global wind speed through rain algorithm (C-band)
  - Wind speed below 10 m/s: Statistical algorithm
    - Trained from collocation of WindSat TB with NCEP GDAS wind speeds
  - Wind speed above 15 m/s: Semi-statistical algorithm
    - Lack of ground truth at high winds
    - Atmosphere statistical ensemble
    - Calculate emissivity from RTM
    - Smooth transition between 10 m/s and 15 m/s

Winds in Rain:
OVWST meeting Seattle 2008, Meissner + Wentz, TGRS 47(9), 2009, 3065 - 3083
No-Rain Wind Speeds

Post-hoc corrections were applied to all other products to align them with buoys.
Global Wind Speeds in Rain
Hurricane Wind Speeds

Versus HRD wind speed
High Wind Speed Validation

- Validation for high wind speeds (> 25 m/s) is difficult
  - Few reliable *ground truth* observations
    - No buoys
    - QuikScat Ku 2001 high winds not valid (rain-free or rain)
    - Rain: All other radiometers invalid
    - NWP models unreliable in high winds
- Crucial question: Is emissivity model valid at high winds
  - Have assumed linear extrapolation
  - Does it saturate?
- H-wind algorithm has been trained + validated with HRD winds
  - Meissner + Wentz, IEEE TGRS 47(9), 2009, pp 3065 – 3083
  - **Assume that HRD winds are correct in tropical cyclones after resampling to WindSAt resolution**
  - H-wind algorithm does not use emissivity model
  - Global wind speed through rain algorithm uses emissivity model at high winds but no HRD winds
- **Cross validation: Global algorithm versus H-wind**
- **Indirect validation of emissivity model at high winds**
- WindSat high wind speeds will be used as basis for developing updated QuikSCAT geophysical model function
  - See presentation by L. Ricciardulli on Wednesday
WindSat TB over:
SSM/I F13 V6
QuikSCAT Ku2001
HRD
Challenge: Remove atmosphere (rain)

RTM:
- best fit
- smoothed

Used for:
- no-rain wind speed
- global wind speed through rain
No indication that wind emissivity model saturates at high winds
Consistency between H-wind and global wind through rain (RTM)
Greenland Tip Jet: Aircraft Measurement

- Aircraft observations taken during the Greenland Flow Distortion Experiment (GFDex), Feb and Mar 2007
- 150 data points spread over 6 days with each data point equivalent to a 12 km spatial average
- Observations taken at 30-50 m above sea level and adjusted to standard 10m height

- Good correlation
- Overall positive bias
  - Sea ice zone
  - Instrument bias
All-Weather Wind Speed

- Blending between no-rain, global wind speed in rain and H-wind algorithms
- Takes place in L, T, W space
- Smooth transitions between zones

![Diagram showing the blending of no-rain, global wind speed in rain, and H-wind algorithms. The diagram uses L, T, W space to illustrate smooth transitions between zones. The specific values L=0.2 mm, W=15 m/s, and SST=28°C are highlighted.]
Wind Directions
**Wind Directions**

<table>
<thead>
<tr>
<th>RMS [deg]</th>
<th>low winds (&lt;6 m/s)</th>
<th>moderate winds (6-12 m/s)</th>
<th>high winds (&gt; 12 m/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>no rain</td>
<td>40</td>
<td>16</td>
<td>11</td>
</tr>
<tr>
<td>light rain (&lt; 3 mm/h)</td>
<td>52</td>
<td>27</td>
<td>18</td>
</tr>
<tr>
<td>moderate rain (3 – 8 mm/h)</td>
<td>61</td>
<td>44</td>
<td>35</td>
</tr>
<tr>
<td>heavy rain (&gt; 8 mm/h)</td>
<td>65</td>
<td>52</td>
<td>49</td>
</tr>
</tbody>
</table>

**WindSat versus CCMP Wind Direction Wind – Rain Performance Matrix**
High Southern Latitude Storm
04/01/2006 14:30 UTC
Rain in cell
No C-band
Northern Latitude Extratropical Storm
17/02/2003 19:30 UTC
Hurricane Fabian
09/04/2003 10:30 UTC
Summary: All-Weather Winds

- Version 6: Rain areas needed to be blocked out
- Version 7: Rain areas will have wind speeds
  - C-band required: only WindSat, AMSR-E, GCOM
  - Possible with only X-band (TMI, GMI)
  - Degradation in Rain