Advanced Microwave Scanning Radiometer-2 (AMSR2) All-Weather Wind Speed

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Introduction

• The Ocean Surface Winds Team at NOAA provides a suite of oceanic environmental data records (EDR) derived from AMSR2 measurements
  • SST, SSW, TPW, CLW, Precipitation, SST anomaly, TPW percentage normal
    • Sampled at 0.1° similar to AMSR2 L1B

• An all-weather wind speed (AWS) product will be added to the collection of AMSR2 EDRs offered by NOAA
  • Provides wind speeds in normal and extreme weather conditions with minimal flagging and excellent accuracy

• A near-real-time demonstration of NOAA’s AMSR2 EDRs is available for users
  • [https://manati.star.nesdis.noaa.gov/datasets/GCOM2Data.php](https://manati.star.nesdis.noaa.gov/datasets/GCOM2Data.php)
Problem Statement: Rain Contamination

• Rain contamination increase measured Tbs
  • Raindrops are more effective emitters than sea surface
  • This problem is particularly noticeable at the tropics where rain-layers are deep
• Rain contamination leads to erroneous retrievals
  • Sea surface winds (SSW) retrievals from radiometers can be within ~1 m/s accuracy but tend to degrade rapidly in the presence of rain

AMSR2 pass over Hurricane Teddy (09/19/2020)

Rain heavily contaminates Tbs observed by AMSR2
AMSR2 Overview

- AMSR2 on board the Global Change Observation Mission-Water (GCOM-W) was launched in May 2012 by the Japanese Aerospace Exploration Agency (JAXA)
  - Passive remote sensing instrument that acquires microwave emission from the Earth’s surface and atmosphere at 6.9, 7.3, 10.65, 18.7, 23.8, 36.5, & 89.0 GHz
  - Conically scans Earth’s surface at a nominal incidence angle of 55° which results in a wide swath of 1450 km

<table>
<thead>
<tr>
<th>Freq. (GHz)</th>
<th>6.9</th>
<th>7.3</th>
<th>10.6</th>
<th>18.7</th>
<th>23.8</th>
<th>36.5</th>
<th>89</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polarization</td>
<td>Vertical &amp; horizontal</td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>Along-track IFOV width (km)</td>
<td>62</td>
<td>58</td>
<td>42</td>
<td>22</td>
<td>26</td>
<td>12</td>
<td>5</td>
</tr>
<tr>
<td>Cross-track IFOV width (km)</td>
<td>35</td>
<td>34</td>
<td>24</td>
<td>14</td>
<td>15</td>
<td>7</td>
<td>3</td>
</tr>
</tbody>
</table>
NOAA’s AWS Product: Characteristics

• Sensitive to all wind speed regimes including hurricane force winds
  • Trained with 1000 AMSR2 hurricane overpasses
  • Collocated with high resolution (25 km) GDAS
  • Collocated with HWRF (10 km)

• Less susceptible to rain in all weather conditions
  • Rain contamination can be mitigated via the linear combination of different channels
    • AMSR2 observe dual polarized Tbs at multiple frequencies

• Minimal flagging
  • Salvages majority of points in extreme weather events and/or intense rain
NOAA’s AWS Product: Model Development (1)

- **AMSR2 AWS** algorithm is *statistical* based that relies on 2-stage multiple linear regression
  - Suitable for all weather algorithms to avoid issues with modeling rain
  - Stage-1 regression coeffs. are a function of SST
  - Stage-2 regression coeffs. are a function of wind speed obtained from stage-1
- The algorithm exploits the linear combination of AMSR2 6, 10, and 18 GHz H- & V-pol channels to derive 3 empirical quantities ($\zeta_1, \zeta_2, & \zeta_3$)
  - Serve as regression independent variables
  - Less susceptible to rain while maintain sensitivity to wind speed
- Regressions were trained with GDAS & HWRF
  - Interpolated temporally & spatially to AMSR2 measurements’ location
NOAA’s AWS Product: Model Development (2)
Extreme Winds Validation: Composite Plots

• A composite plot is a compound of several snapshots of wind speed retrievals in storms
  • These snapshots are gathered by defining a circle with a specified radius from the center of a storm
    • A storm centric coordinate system
  • The storm-centric snapshots are stacked with the center point being the storm center
  • Statistical analysis can be performed on the stacked snapshots for validation and comparison
    • Different algorithms and/or sensors
Composite Plots: Mean Wind Speed

Mean Wind Speed

NOAA

RSS

JAXA

HWRF

Error (Retrieved - GDAS)

NOAA

RSS

JAXA

HWRF

700 snapshots used
Composite Plots: Prob. of Extreme Winds

- Prob. of hurricane force winds
- Prob. of storm force winds
- Prob. of gale force winds
Standard Validation

![Graphs showing GDAS and GDAS/HWRF WSPD comparisons](image-url)

- **NOAA AWS**
- **RSS AWS**
- **JAXA AWS**
Radial Wind Speed Comparison

Beaufort Scale

- Hurricane: >64 knots
- Violent Storm: 56–65 knots
- Storm: 48–55 knots
- Severe Gale: 41–47 knots
- Gale: 33–40 knots
- Near Gale: 24–33 knots
- Breeze: 22–27 knots

Retrieved WSPD, knots

Radial Distance, km
Examples

0  5  12  15  20  25 (m/s)

(mm/hr) 0  2  4  6  8  10  12  14

Example 1

NOAA AWS

RSS AWS

JAXA AWS

Rain

Example 2

NOAA AWS

RSS AWS

JAXA AWS

Rain
Conclusions & Future Work

• NOAA’s AMSR2 AWS product was briefly described and evaluated
  • Statistical based trained using 1000 AMSR2 orbits from 2013–2021
  • It complements the set of AMSR2 standard satellite data products
  • Global & runs in near-real-time

• Validation results from independent data demonstrated the efficacy of the retrieval algorithm under different wind speed regimes
  • 0 m/s mean bias and < 2 m/s RMS error when compared to numerical weather models
  • Mitigates rain effect under normal and extreme wind events

• Next …
  • Validation with other wind speed retrievals from satellites and SFMR