Evaluation of All-weather Sea Surface Wind Speed Product from GCOM-W/AMSR2

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Outline

• Introduction of GCOM-W and AMSR2
• AMSR2 All-weather Sea Surface Wind Speed Product (AWS)
• Comparison with Airborne Stepped-Frequency Microwave Radiometer (SFMR)
• Comparison of 50-kt radii with typhoon best track data
• Summary
Successor of AMSR-E on Aqua and AMSR on ADEOS-II. Launched in May 2012.

- Deployable main reflector system with 2.0 m diameter (1.6 m for AMSR-E).
- Frequency channel set is identical to that of AMSR-E except 7.3GHz channel for RFI mitigation.
- Two-point external calibration with improved HTS (hot-load).
- Add a redundant momentum wheel to increase reliability.

**GCOM-W1/AMSR2 characteristics**

<table>
<thead>
<tr>
<th>Scan and rate</th>
<th>Conical scan at 40 rpm</th>
</tr>
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<tbody>
<tr>
<td>Antenna</td>
<td>Offset parabola with 2.0m dia.</td>
</tr>
<tr>
<td>Swath width</td>
<td>1450km (effective &gt; 1600km)</td>
</tr>
<tr>
<td>Incidence angle</td>
<td>Nominal 55 degrees</td>
</tr>
<tr>
<td>Digitization</td>
<td>12bits</td>
</tr>
<tr>
<td>Dynamic range</td>
<td>2.7-340K</td>
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**AMSR2 Channel Set**

<table>
<thead>
<tr>
<th>Center Freq. [GHz]</th>
<th>Band width [MHz]</th>
<th>Pol.</th>
<th>Beam width [deg] (Ground res. [km])</th>
<th>Sampling interval [km]</th>
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<tbody>
<tr>
<td>6.925/7.3</td>
<td>350</td>
<td>V</td>
<td>1.8 (35 x 62)</td>
<td>10</td>
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<td>10.65</td>
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<td>1.2 (24 x 42)</td>
<td></td>
</tr>
<tr>
<td>18.7</td>
<td>200</td>
<td>V</td>
<td>0.65 (14 x 22)</td>
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<td>H</td>
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<tr>
<td>89.0</td>
<td>3000</td>
<td></td>
<td>0.15 (3 x 5)</td>
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Frequencies utilized by AMSR2

- 10.65GHz
- 23.8GHz
- 36.5GHz
- 6.9GHz
- 18.7GHz
- 89.0GHz

- Integrated water vapor
- Integrated cloud liquid water
- Precipitation
- Sea surface temperature
- Sea surface wind speed
- Sea ice concentration
- Snow depth
- Soil moisture content

Graph showing relative sensitivity vs. frequency [GHz] with peaks at specific frequencies for different environmental parameters.
**AMSR2 All-weather Sea Surface Wind Speed (AWS) Product (ver. 3.0)**

- Research product of marine wind speed under high-wind and heavy rain conditions (e.g., tropical cyclones) developed by JAXA.

- Based on brightness temperatures at 7 and 10 GHz, which are less affected by rain. (Standard wind speed product mainly utilizes 36 GHz)

- Spatial resolution is 50 km. (15 km for standard product)

- Goal of accuracy is 7 m/s. (1.0 m/s for standard product)

- AWS products is available at https://suzaku.eorc.jaxa.jp/GCOM_W/research/resdist.html
Ignacio (Aug 31, 2015)

GOES-15 (0031Z)

Standard Wind Speed (2301Z)

All-Weather Product

Rain Rate

Integrated Water Vapor

Cloud Liquid Water
Issues concerning Microwave Remote Sensing of Marine Wind under High-wind and Heavy-rain Conditions

- Lack of reliable in-situ measurements
  - Buoy: Low anemometer height, motion and flow separation by high waves
  - Ship, Tower: Distortion of air flow by big structures
  - NWP output: Low spatial and temporal resolutions, inaccurate parameterization of surface boundary layer
- Low numbers of data points for validation
- Saturation of sensitivity to wind speed at high frequencies
- Attenuation by heavy rain
- Most of wind retrieval algorithms has been developed and validated by reference data in low-mid wind speed ranges
Comparison of AMSR2 AWS wind speed with SFMR data

- SFMR data, calibrated by dropsonde observations, were provided by the NOAA/NESDIS/STAR. (Thanks to Drs. Paul Chang, Zorana Jelenak, Joe Sapp, Mark Romer)
- The SFMR data were smoothed along the flight track over 30 km.
- Data of standard deviation greater than 5 m/s in the 30 km section were discarded.
- Collocate the SFMR data with AMSR2 observations allowing temporal difference of 15 min. and temporal separation of 30 km.
- Cases of 12 hurricanes from 2012 to 2016 were selected.
Matthew (Oct 1, 2016)

**GOES-13 (1315Z)**

**AMSR2 All Weather (1731Z)**

**AMSR2 Rain Rate**

Rain

Wind

AMSР2 Rain Rate

Wind Speed (m/s)

Rain Rate (mm/hr)

Longitude (deg)
Edouard (Sep 16, 2014)

GOES-13 (1330Z)

AMSР2 All Weather (1656Z)

AMSР2 Standard

Rain

Wind

AMSR2

62W 54W

34N

28N

34N

28N

35N

30N

62W 54W

65W 60W 55W

Wind Speed (m/s)

AMSР2

Rain

Rain rate (mm/hr)

Longitude (deg)
Comparison of AMSR2 AWS Wind Speed with SFMR

For data points of wind speed higher than 15 m/s.

Number of data points: 347
Bias: -1.94 m/s
RMS difference: 3.26 m/s
Wind Speed Residual
(AMSR2 AWS – SFMR)

15 m/s
Comparison with JMA Typhoon Best-Track Data

Typhoon Nangka (T1511)

Evaluation comparing spatial distribution of extreme wind area (50-kt radius)
Typhoon Nangka (T1511)

10-15, 15-20, 20-25, 25-30, 30- m/s
Time Series of 50-kt Radius and Max Wind Speed (T1511)

- 50-kt Radius (B-T)
- 50-kt Radius (AMSR2 AWS)
- Max Wind Speed (AMSR2 AWS)
- Max Wind Speed (B-T)

Pressure (B-T)
Comparison of 50-kt Radius (28 Typhoons in 2012-2017)

- Number of data points: 154
- Bias: -16.3 km
- RMS difference: 28.2 km
- Correlation: 0.650
Comparison of Maximum Wind Speed
(28 Typhoons in 2012-2017)

Number of data points: 179
Bias: +18.4 m/s
RMS difference: 29.4 m/s
Correlation: 0.646
Summary

- JAXA developed the AMSR2 All-weather Sea Surface Wind Speed (AWS) Product for high-wind and heavy-rain conditions.
- To validate the AWS product, airborne SFMR data, calibrated with dropsonde observations, were smoothed along flight tracks.
- The AWS wind speed agreed well with the SFMR data with RMS difference of 3.26 m/s in the wind speed range higher than 15 m/s.
- However, systematic negative bias were discernible. Further investigations are needed for improvements.
- Spatial distribution of high-wind area of the AWS is evaluated by comparisons of the JMA Typhoon Best-track data.
- Comparison of 50-kt radius around 28 typhoons during a period from 2012 to 2017 showed reasonable correlation (correlation coefficient = 0.650), although the AMSR2 AWS tends to underestimate the 50-kt radius compared to the best-track data.
- It is exhibited that AMSR2 AWS product is useful to monitor wind speed around tropical cyclones under extreme wind and rain conditions.
AMSR2/GCOM-W (Advanced Microwave Scanning Radiometer 2 on Global Change Observation Mission – W)

A Train

GCOM-W/Main Specifications of AMSR2

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Launched on May 18, 2012, and still in operation
Recommendations from the International Workshop on Measuring High Wind Speeds over the Ocean (2016)

- Dropsonde is the most reliable in-situ measurement under high-wind conditions.
- However, the pointwise measurements by dropsondes cannot be directly compared with spaceborne microwave measurements (10-100 km).
- Calibrate Airborne Stepped-Frequency Microwave Radiometer (SFMR) with dropsondes.
- Smooth the calibrated SFMR data along the flight track over 10-100 km.
- Discard data around eye wall, where wind speed rapidly changes.
Stepped-Frequency Microwave Radiometer (SFMR)

- Airborne microwave radiometer operated at 6 frequencies from 4.6 to 7.2 GHz with vertical incidence
- Measures wind speed and rain rate simultaneously.