Evaluation of Wind Speed Observed by AMSR Using Data from Ocean Buoys and SeaWinds

Naoto EBUCHI*

Abstract

Wind speed observed by the Advanced Microwave Scanning Radiometer (AMSR) on the Advanced Earth Observing Satellite-II (ADEOS-II) was evaluated using data from global offshore ocean buoys and the SeaWinds scatterometer. The wind speeds contained in the latest AMSR wind product (version 4) exhibit good agreement with buoy data, with a root-mean-square (rms) difference of 1.2 m s\(^{-1}\). The systematic bias observed in the earlier versions has been eliminated by algorithm refinements. Intercomparison of the wind speeds observed globally by SeaWinds and AMSR on the same orbits also shows good agreements. The global wind speed histogram of the latest AMSR wind product (version 4) is closer to those of SeaWinds and ECMWF wind data than those of the earlier versions.

Keywords: ADEOS-II, AMSR, SeaWinds, marine surface wind, validation

1. Introduction

The Advanced Earth Observing Satellite-II (ADEOS-II) was launched by the National Space Development Agency of Japan (NASDA) on 14 December 2002. The mission carries five sensors, including the SeaWinds scatterometer and the Advanced Microwave Scanning Radiometer (AMSR), which measure near-surface winds over the global oceans under all weather and cloud conditions.

Simultaneous observations of the ocean surface by active and passive microwave sensors (SeaWinds and AMSR) on the same satellite (ADEOS-II) presented a unique opportunity to assess the sensor synergy of active and passive microwave sensors. Wind retrieval algorithms for the scatterometer and microwave radiometer can be improved by wind data intercomparisons. Atmospheric correction and rain flagging for scatterometer observations can also be assessed by microwave radiometer data.

Ebuchi\(^{1-3}\) evaluated SeaWinds-derived wind vectors and AMSR-derived scalar wind speed by comparing these data with offshore buoy data, and then compared wind speeds observed by SeaWinds and AMSR on the same satellite orbits to assess the consistency of the measurements. The author concluded that earlier versions (versions 1 and 3) of AMSR wind speeds are systematically lower than buoy and SeaWinds data for wind speeds lower than 5 m s\(^{-1}\), and they behave discontinuously relative to buoy and SeaWinds data at wind speeds of 5–6 m s\(^{-1}\). Reflecting these results, the algorithm used to retrieve wind speed from AMSR brightness temperatures has been refined and a new wind product has been distributed to users. In this short paper, the same validation techniques utilized by Ebuchi\(^{1-3}\) are applied to the latest AMSR wind product (version 4).

2. Data

2.1 AMSR

The AMSR level-2 standard product/sea surface wind, which was processed and distributed by the Japan Aerospace Exploration Agency (JAXA), was utilized in this study. The AMSR standard algorithm developed by Shibata\(^{4}\) was used to derive wind speed from brightness temperatures. The first version (version 1) was released to users in December 2003.

Based on evaluations of the data product, the wind retrieval algorithm was refined and the entire data product was reprocessed using the new algorithm. The version 4 data product is now available to users. The wind data of versions 1, 3, and 4 spanning 10 April 2003 to 24 October 2003 are analyzed in this paper.

2.2 SeaWinds

The SeaWinds science data product, level 2B, which was processed and distributed by the National Aeronautics and Space Administration (NASA)/Jet Propulsion Laboratory (JPL) Physical Oceanography Distributed Active Archive Center (PO.DAAC), were utilized in this study. The wind data were produced using a maximum-likelihood estimator (MLE) with the QSCAT-1 geophysical model function and a

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median filter ambiguity removal algorithm with the numerical weather product (NWP) initialization. The spatial resolution of the wind data is 25 km and the reference level of the wind vectors is 10 m. The impact-based multidimensional histogram (IMUDH) rain flag was applied to indicate the presence of rain. All the flagged data, including rain-flagged data, were discarded. Data observed from 10 April 2003 to 24 October 2003 were used in the present study.

2.3 Ocean buoys

We collected data from offshore buoys operated by the National Data Buoy Center (NDBC), the Tropical Atmosphere Ocean/Triangle Trans-Ocean Buoy Network (TAO/TRITON) and the Pilot Research Moored Array in the Tropical Atlantic (PIRATA) to compare them with the AMSR wind data. Data from 34 NDBC, 48 TAO/TRITON, and 7 PIRATA buoys were utilized. Only those buoys located offshore and in deep water were selected. Locations of the buoys are shown in Fig. 1. Details of the NDBC and TAO buoys, instruments, and stations were described by Meindl and Hamilton and McPhaden, respectively. The PIRATA buoys are identical to the TAO buoys. Data with a high temporal sampling interval of 10 min. were utilized. The wind speed measured by the buoys at various heights above the sea surface and under various stratification conditions was converted to equivalent neutral wind speed at a 10-m height using the method proposed by Liu and Tang.

3. Comparison of wind speed observed by AMSR with buoy data

The AMSR wind data and buoy observations were collocated in time and space. AMSR wind observation cells closest in space to the buoy locations and the buoy data closest in time to the AMSR observations were chosen. The temporal differences and spatial separations between the AMSR and buoy observations were restricted to less than 10 min. and 10 km, respectively.

Figure 2 compares the three versions of AMSR wind speed with buoy observations. Statistical values of the comparisons are listed in Table 1. It is clear that version 1 winds exhibit a discontinuous trend around 5–6 m s⁻¹, as reported by previous studies. In wind speeds lower than 5 m s⁻¹, the wind speeds of the version 1 and 3 products are systematically lower than those from the buoys. These systematic trends have been considerably reduced in the version 4 winds. The -0.24 m s⁻¹ bias (AMSR-buoy) and root-mean-square (rms) difference of 1.17 m s⁻¹ are comparable to or slightly larger than the results of wind speed comparisons observed by

<table>
<thead>
<tr>
<th>Table 1 Statistical values of the comparison of wind speed observed by AMSR and buoy data.</th>
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<tr>
<td>Version</td>
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<tr>
<td>-------------------------------</td>
</tr>
<tr>
<td>Number of data</td>
</tr>
<tr>
<td>Bias (AMSR-buoy) (m/s)</td>
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<tr>
<td>Rms difference (m/s)</td>
</tr>
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<td>Correlation coefficient</td>
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</table>
QuikSCAT/SeaWinds and ADEOS-II/SeaWinds with buoy data. Intercomparison of wind speed observed by AMSR and SeaWinds

Wind data observed globally by SeaWinds and AMSR along identical satellite orbits were collocated by wind cell to cell. Locations of the center of SeaWinds and AMSR wind cells contained in each wind product were used for the collocation. Spatial separation of the wind cells was limited to less than 12.5 km, which was determined as a half of the spatial resolution of the SeaWinds wind product. All the flagged data, including rain-flagged data, were discarded. Only data observed between latitudes 65°S and 65°N were used to avoid contamination by sea ice, which was not detected by AMSR and SeaWinds. The number of collocated data points is greater than 60 million.

Figure 2 compares wind speeds observed by AMSR and SeaWinds for the three versions of the AMSR data. The density of data points in 0.1 × 0.1 m s⁻¹ bins is shown by the shading. Statistics describing the comparisons are listed in Table 2.

Figure 3 more clearly exhibits the systematic trends in the version 1 and 3 wind products that appear in the buoy comparison (Fig. 2). The large number of AMSR-SeaWinds collocated data clearly demonstrates that the discontinuous wind speed trends of versions 1 and 3 have been eliminated in version 4 through algorithm improvement. For version 4, the bias (AMSR-SeaWinds) and rms difference are −0.08 m s⁻¹ and 1.17 m s⁻¹, respectively, indicating that the wind speeds observed by the two sensors are in good agreement.

5. Comparison of global wind speed histogram

Histograms of wind speed over the global oceans were calculated from all the wind speed data from latitudes 65°S to 65°N and for 7 months from April to October 2003. Comparison of global wind speed histograms calculated from the three AMSR wind product versions and SeaWinds wind speeds is shown in Fig. 4. For reference, a histogram calculated from the European Centre for Medium-range Weather Forecasts (ECMWF) analysis (2.5° × 2.5°, 12-hour intervals) in the same period is also shown in the figure.

The histograms of SeaWinds and ECMWF wind speeds are in good agreement. Version 1 of the AMSR wind product exhibits significant deviation from those of the SeaWinds and ECMWF winds, reflecting the discontinuities shown in Figs. 2 (a) and 3 (a). The histogram of version 3 AMSR winds has a peak at a slightly higher wind speed, a lower number density at 3 to 7 m s⁻¹ wind speeds, and a higher number density at 0 to 3 m s⁻¹, corresponding to the systematic underestimates of wind speed shown in Figs. 2 (b) and 3 (b). The histogram of version 4 AMSR winds is closer to those of SeaWinds and ECMWF winds than histograms of earlier versions over the whole wind speed range. The global wind speed histograms also demonstrate improvements in the AMSR wind retrieval algorithm.

Table 2 Statistical values of the intercomparison of wind speed observed by AMSR and SeaWinds.

<table>
<thead>
<tr>
<th>Version</th>
<th>1</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of data</td>
<td>67048608</td>
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</tr>
<tr>
<td>Bias (AMSR-SeaWinds) (m/s)</td>
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<td>0.11</td>
<td>-0.08</td>
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<tr>
<td>Rms difference (m/s)</td>
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<td>1.25</td>
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<tr>
<td>Correlation coefficient</td>
<td>0.940</td>
<td>0.945</td>
<td>0.952</td>
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QuikSCAT/SeaWinds¹ and ADEOS-II/SeaWinds³ with buoy data.

4. Intercomparison of wind speed observed by AMSR and SeaWinds

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6. Summary

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References


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