Measurements of Air-Sea Interaction from the HY-2A Scatterometer

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The HY-2A L2B wind products used in this study are provided by the Chinese National Satellite Ocean Application Service (NSOAS) through a trilateral collaboration among IOWVSTST members.
Overview

1. Brief summary of air-sea interaction over SST fronts from past studies.

2. Summary of data processing:
   - HY-2A Versions 1, 2 and 3
   - Filtering applied to investigate air-sea interaction

3. 13-year history of coupling coefficients for wind speed, divergence and vorticity from *monthly averages* of QuikSCAT and ASCAT-a.

4. Coupling coefficients for January-December 2012 monthly averages:
   - from HY-2A Versions 1, 2 and 3
   - from ASCAT-a

Equivalent Neutral Wind Speed Response to SST Anomalies
June 2002 - May 2009 Averages

![Map of Equivalent Neutral Wind Speed Response to SST Anomalies](image)

- The maps show the spatial distribution of equivalent neutral wind speed responses to SST anomalies over the Agulhas and Kuroshio regions.
- The contours overlaid in each map are the spatially high-pass-filtered AMSR-E SST averaged over the same period.
SST Effects on the Curl and Divergence of Surface Wind and Stress

Wind vorticity and curl of the wind stress associated with crosswind SST gradients

Wind divergence and wind stress divergence associated with downwind SST gradients
Equivalent Neutral Wind Divergence Response to Downwind SST Gradients

June 2002 - May 2009 Averages

[Graphs showing divergence response to downwind SST gradients.

Slope = 0.42

Slope = 0.70]
Equivalent Neutral Wind Vorticity Response to Crosswind SST Gradients

June 2002 - May 2009 Averages
The coupling coefficients for all three variables are quite stable and generally similar for all three datasets.

Exceptions: 1) abrupt drop in divergence in SW Atlantic and ARC in January 2007; 2) RSS QuikSCAT is biased low for divergence and vorticity; 3) some minor trends; 4) some seasonal variability.
<table>
<thead>
<tr>
<th>Parameter</th>
<th>HY2-SCAT</th>
<th>QuikSCAT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transmit power $P_t/ \text{W}$</td>
<td>120</td>
<td>110</td>
</tr>
<tr>
<td>Antenna gain/ dB</td>
<td>38</td>
<td>Inner beam: 38.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Outer beam: 39</td>
</tr>
<tr>
<td>Wavelength, $\lambda/ \text{m}$</td>
<td>0.022 616</td>
<td>0.022 385</td>
</tr>
<tr>
<td>Transmit pulse width $T_r/ \text{ms}$</td>
<td>2.1</td>
<td>1.7</td>
</tr>
<tr>
<td>Instrument loss $L_f/ \text{dB}$</td>
<td>7</td>
<td>3.6</td>
</tr>
<tr>
<td>Repetition bandwidth/ MHz</td>
<td>1</td>
<td>0.375</td>
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<tr>
<td>Noise bandwidth/ MHz</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Polarization</td>
<td>HH at Inner beam, VV at outer beam</td>
<td>HH at Inner beam, VV at outer beam</td>
</tr>
<tr>
<td>Incidence angle</td>
<td>Inner beam: 41°, Outer beam: 48°</td>
<td>Inner beam: 46°, Outer beam: 54°</td>
</tr>
<tr>
<td>Swath/ km</td>
<td>Inner beam: 1 350, Outer beam: 1 700</td>
<td>Inner beam: 1 400, Outer beam: 1 800</td>
</tr>
</tbody>
</table>
HY-2A scatterometer winds

- HY-2A satellite was launched on August 16, 2011.

- On-orbit testing phase was completed on December 31, 2011 for all three payloads (scatterometer, radiometer, and altimeter).

- V1 HY-2A wind product (L2B) was released in January 2012 (operational).

- V2 HY-2A wind product was released in February 2014 (operational).

- V3 HY-2A was released in May 2014.
HY-2A wind retrieval algorithms

V1: NSCAT-2 based wind retrievals

- The design of the HY-2A scatterometer is similar to that of QuikSCAT.

- However, due to the different incidence angles from QuikSCAT, the geophysical model function (GMF) used in the HY-2A wind retrievals is NSCAT-2.

- V1 HY-2A winds are retrieved through finding maxima of objective function and then applying a median number filter algorithm to find the best estimate of wind vector.
V2: NWP initialization of ambiguity removal procedure

- The baseline ambiguity removal algorithm for HY-2A incorporates the NCEP operational wind products.

- In this “nudging” technique, a median filter algorithm is initialized with either the first or the second ranked wind vector solution, whichever is closer to the direction of the NCEP wind.

- The median filter algorithm then proceeds to generate the final wind vector selections.
V3: Using HY-2A radiometer to flag rain wind vector cell

- The design of the HY-2A radiometer is similar to that of AMSR-E

- The collocated HY-2A radiometer measurements of cloud liquid water (CLW) are used to flag rain-contaminated wind vector cells.

- The threshold of CLW for a rain-contaminated wind vector cell is 0.18 kg/m².
<table>
<thead>
<tr>
<th>Time</th>
<th>Wind direction</th>
<th>Wind speed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>V2</td>
<td>V3</td>
</tr>
<tr>
<td>RMS</td>
<td>Bias</td>
<td>RMS</td>
</tr>
<tr>
<td>2012, Jan-Jun</td>
<td>35.990</td>
<td>1.229</td>
</tr>
<tr>
<td>2012, Jul-Dec</td>
<td>36.521</td>
<td>0.797</td>
</tr>
</tbody>
</table>
Summary of the Data Processing for Investigation of Air-Sea Interaction from HY-2A Scatterometer Data

1. In-swath equivalent neutral wind vectors were smoothed onto a 0.25° grid using a 2-d loess smoother with a 75-km half-power filter cutoff.

2. Wind divergence and vorticity were computed from these gridded wind vectors with derivatives computed by centered differences.

3. For each HY-2A dataset (V1, V2 and V3), wind speed, divergence and vorticity were monthly averaged on a 0.25° grid in 4 regions: Kuroshio, Gulf Stream, SW Atlantic and Agulhas Return Current.

4. The Reynolds Daily OI SST fields constructed from AVHRR data only were monthly averaged for the same 4 regions.

5. All of the wind and SST fields were spatially high-pass filtered with half-power cutoffs of 20° x 10°.

6. The resulting wind and SST fields were spatially low-pass filtered with half-power cutoffs of 2° x 2°.
Annual Average Maps of Wind Speed, Divergence and Vorticity with Contours of SST, Downwind SST Gradient and Crosswind SST Gradient
Agulhas Return Current Region, Calendar Year 2012

Wind Speed and SST
Wind Divergence and Downwind SST Gradient
Wind Vorticity and Crosswind SST Gradient

- The lower correlation for wind speed in V3 may indicate a problem with the rain flagging.
- The lower correlations for wind divergence and vorticity in V1 indicates better wind direction accuracy in V2 and V3.
The lower correlation for wind speed in V3 may again indicate a problem with the rain flagging.

The lower correlations for wind divergence in V1 indicates better wind direction accuracy in V2 and V3.

Wind vorticity is difficult to judge in the Gulf Stream region because of the effect of the strong currents on the relative wind.
The correlations between the wind wind speed and SST are similar for all three versions of HY-2A data.

The correlations between wind divergence and downwind SST gradient, and between vorticity and crosswind SST gradient are lower for V1 than for V2 and V3, especially for the SW Atlantic and Agulhas Return Current regions => better wind direction accuracy in V2 and V3.
• V2 and V3 are more similar to each other than either is to V1, again indicating better wind direction accuracy in V3.
• The differences between the coupling coefficients are largest in the Kuroshio and Gulf Stream regions.
The HY-2A coupling coefficients are consistent with the ASCAT-A coupling coefficients.

The differences are again largest in the Kuroshio and Gulf Stream regions.
• The HY-2A and ASCAT-A coupling coefficients are consistent with historical values for 2008 from QuikSCAT and ASCAT-A.
• The variability is again largest in the Kuroshio and Gulf Stream regions.
Summary and Conclusions

1. SST influence on the surface wind field is clearly evident in all 3 versions of HY-2A data for the January-December 2012 period analyzed here.
   - The coupling coefficients are consistent with the values obtained from ASCAT-a for the same time period.
   - The results are also consistent with the coupling coefficients obtained from QuikSCAT for January-December 2008.

2. Comparisons of V1, V2 and V3:
   - Wind direction errors are significantly reduced in V2 and V3, as evidenced from the wind divergence and vorticity fields.
   - Improvements of V3 compared with V2 do not significantly improve the analysis of air-sea interaction from monthly averages presented here.

3. Close inspection of various aspects of the wind fields suggests that we may not be interpreting the rain flagging correctly in V3.
   - For example, this may explain the curious lower correlation between wind speed and SST in the annual averages from the V3 data.

4. An important point to note is that the analysis of monthly averages presented here is somewhat less demanding of wind speed and direction accuracy than are many other applications of scatterometer data.