Impact of Ocean Currents on Wind Stress in the Tropical Indian Ocean

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Motivation and objectives

This study examines the effect of surface currents on the bulk algorithm calculation of wind stress estimated using the scatterometer data during 2007–2020 in the Indian Ocean. In the study region as a whole, the wind stress decreased by 5.4% by including currents in the wind stress equation. The most significant reduction in the wind stress is found along the most energetic regions with strong currents such as Somali Current, Equatorial Jets, and Agulhas retroflection. The highest reduction of 11.5% is observed along the equator where the Equatorial Jets prevail.

A sensitivity analysis has been carried out for the study region and for different seasons to assess the relative impact of winds and currents in the estimation of wind stress by changing the winds while keeping the currents constants and vice versa. The inclusion of currents decreased the wind stress (consistent with scatterometer winds) and this decrease is prominent when the currents are stronger. This study showed that the equatorial Indian Ocean is the most sensitive region where the current can impact wind stress estimation. The results showed that uncertainties in the wind stress estimations are quite large at regional levels and hence better representation of wind stress incorporating ocean currents should be considered in the ocean/climatic models for accurate air-sea interaction studies that are not based on remotely sensed winds.

The inclusion of surface currents into the bulk formula for wind stress modifies Equation (1) to

\[ \tau = \rho a C_d \left( U_w - U_o \right) \]

where, \( U_w - U_o \) is the difference between the surface wind (\( U_w \)) and ocean current (\( U_o \)) vectors. Our surface relative winds come from ASCAT on METOP-A and METOP-B. These are added to OSCAR currents to determine Earth relative winds.

Impact on the wind stress

<table>
<thead>
<tr>
<th>Region of interest</th>
<th>( \tau_{\text{no-Cur}} ) (N/m²)</th>
<th>( \tau_{\text{Cur}} ) (N/m²)</th>
<th>( % ) Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basin Average</td>
<td>0.06448</td>
<td>0.06073</td>
<td>-5.81%</td>
</tr>
<tr>
<td>Somali Current</td>
<td>0.06264</td>
<td>0.05665</td>
<td>-9.56%</td>
</tr>
<tr>
<td>Equatorial Jet</td>
<td>0.03145</td>
<td>0.02664</td>
<td>-15.93%</td>
</tr>
</tbody>
</table>

The results in Table 1 showed that the inclusion of currents into the wind stress formula resulted in a decrease in wind stress by 5.4% in the study region as a whole. The most significant reduction in the wind stress is observed along the equator where the Equatorial Jets prevail.

Map of Mean Annual Stresses and Stress Difference

Figure 2. Zonal average of wind stress difference (\( \tau_{\text{Cur}} - \tau_{\text{no-Cur}} \)) in the tropical Indian Ocean, for the Equatorial Jet region listed above.

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