Stress Working Group Report
Deriving Wind Stress from Satellite Wind Products

Jim Edson*
University of Connecticut

Doug Vandemark & Marc Emond*
University of New Hampshire

IOVWST Meeting
La Jolla, CA
2-4 May 2017

* With help from numerous colleagues

Research supported by grants from the NASA, ONR, and NSF
IOVWST Stress Overview Paper

Introduction

- History of GMFs that link backscatter to ENW for various Satellites
- Relationship between Equivalent Neutral Winds and Stress

Equivalent Neutral Winds

- Density effects
- Role of surface currents
- Role of stratification & Gustiness

Drag Coefficient

- Semi-Empirical Formulations of neutral drag coefficient
- Role of surface roughness
  - Smooth flow & capillary waves (SST effect on viscosity, surface tension)
  - Wind-wave parameterizations
- Large scale waves and sea-state effects
  - Using wave measurements to produce a sea-state/wave-age dependent Charnock parameter.
  - Using a surrogate such as a wind-speed dependent Charnock parameter.

Parameterizations to be tested

Stress measurement and comparison

- Direct covariance data description
- Comparison of flux parameterizations using buoy data
- Comparisons using QuikScat and ASCAT equivalent neutral winds

Recommendations and Conclusion
Long time series data sets are found at:
http://tds-opal.sr.unh.edu/thredds/catalog/opal_ts/opal_asflux/catalog.html
Future Plans: NASA SPURS, NSF’s OOI & NOAA TPOS
IOVWST Stress Overview Paper

Introduction
  History of GMFs that link backscatter to ENW for various Satellites
  Relationship between Equivalent Neutral Winds and Stress
Equivalent Neutral Winds
  Density effects
  Role of surface currents
  Role of stratification & Gustiness
Drag Coefficient
  Semi-Empirical Formulations of neutral drag coefficient
  Role of surface roughness
    Smooth flow & capillary waves (SST effect on viscosity, surface tension)
    Wind-wave parameterizations
  Large scale waves and sea-state effects
    Using wave measurements to produce a sea-state/wave-age dependent Charnock parameter.
    Using a surrogate such as a wind-speed dependent Charnock parameter.
Parameterizations to be tested
Stress measurement and comparison
  Direct covariance data description
  Comparison of flux parameterizations using buoy data
  Comparisons using QuikScat and ASCAT equivalent neutral winds
Recommendations and Conclusion
Introduction

History of GMFs that link backscatter to ENW for various Satellites
Relationship between Equivalent Neutral Winds and Stress

Equivalent Neutral Winds

- Density effects
- Role of surface currents
- Role of stratification & Gustiness

Drag Coefficient

- Semi-Empirical Formulations of neutral drag coefficient
- Role of surface roughness
  - Smooth flow & capillary waves (SST effect on viscosity, surface tension)
  - Wind-wave parameterizations
- Large scale waves and sea-state effects
  - Using wave measurements to produce a sea-state/wave-age dependent Charnock parameter.
  - Using a surrogate such as a wind-speed dependent Charnock parameter.

Parameterizations to be tested

Stress measurement and comparison

- Direct covariance data description
- Comparison of flux parameterizations using buoy data
- Comparisons using QuikScat and ASCAT equivalent neutral winds

Recommendations and Conclusion
IOVWST Stress Overview Paper

Introduction
  History of GMFs that link backscatter to ENW for various Satellites
  Relationship between Equivalent Neutral Winds and Stress
Equivalent Neutral Winds
  Density effects
  Role of surface currents
  Role of stratification & Gustiness
Drag Coefficient
  Semi-Empirical Formulations of neutral drag coefficient
  Role of surface roughness
    Smooth flow & capillary waves (SST effect on viscosity, surface tension)
    Wind-wave parameterizations
  Large scale waves and sea-state effects
    Using wave measurements to produce a sea-state/wave-age dependent
    Charnock parameter.
    Using a surrogate such as a wind-speed dependent Charnock parameter.

Parameterizations to be tested
Stress measurement and comparison
  Direct covariance data description
  Comparison of flux parameterizations using buoy data
  Comparisons using QuikScat and ASCAT equivalent neutral winds
Recommendations and Conclusion
## Quick Survey of Stress Products

<table>
<thead>
<tr>
<th>Product name</th>
<th>Org</th>
<th>Sensor</th>
<th>Time Span</th>
<th>Time Res.</th>
<th>Spatial Res</th>
<th>Variables</th>
<th>Cd and z/L</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cersat daily turb. flux V3</td>
<td>Ifremer</td>
<td>Qscat</td>
<td>1999-2009</td>
<td>daily</td>
<td>0.25°</td>
<td>τx, τy,</td>
<td></td>
<td>τ</td>
</tr>
<tr>
<td>Qscat/NCEP Blend V5</td>
<td>CRA/NRA</td>
<td>QSCAT+NCEP</td>
<td>1999-2009</td>
<td>0.5°</td>
<td></td>
<td></td>
<td></td>
<td>Milliff et al., 2004</td>
</tr>
<tr>
<td>Pseudostress</td>
<td>coaps</td>
<td>Nscat</td>
<td>96-97</td>
<td>daily</td>
<td>1°</td>
<td></td>
<td>τ</td>
<td>,τ.dir</td>
</tr>
<tr>
<td>Pseudostress</td>
<td>coaps</td>
<td>QScat</td>
<td>1999-2009</td>
<td>daily</td>
<td>1°</td>
<td></td>
<td>τ</td>
<td>,τ.dir</td>
</tr>
<tr>
<td>SAF wind stress</td>
<td>KNMI</td>
<td>ERS1-2</td>
<td>1992-2001</td>
<td>6 hourly</td>
<td>0.5°</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CCMP - pseudostress</td>
<td>RSS (GSFC</td>
<td>Satellite blend + ERA Int</td>
<td>6 hourly</td>
<td>0.25°</td>
<td></td>
<td></td>
<td></td>
<td>Atlas et al., 2011</td>
</tr>
<tr>
<td>J-OFURO3</td>
<td>SMST</td>
<td>Blend Passive, ERS, Oscat, ASCAT, QScat</td>
<td>1988-2013</td>
<td>daily</td>
<td>0.25°</td>
<td></td>
<td>Fairall et al., 1996, LKB</td>
<td>Kutsuwada et al., 2016-7</td>
</tr>
<tr>
<td>West Coast Reg. wind stress</td>
<td>OSU</td>
<td>Qscat</td>
<td>1999-2009</td>
<td>0.1°</td>
<td></td>
<td>See podaac</td>
<td></td>
<td>Vanhoff, Risien, Strub, 2011</td>
</tr>
<tr>
<td>Sea surf. wind stress</td>
<td>NOAA/NCDC</td>
<td>Blend</td>
<td>1987-2011</td>
<td>6 hourly, monthly</td>
<td>0.25°</td>
<td>τx,τy</td>
<td></td>
<td>Zhang et al., 2006</td>
</tr>
<tr>
<td>IFR L3 flux</td>
<td>Ifremer</td>
<td>ERS1,2</td>
<td>91-96, 1996-2001</td>
<td>weekly, monthly</td>
<td>1°</td>
<td></td>
<td>See podaac</td>
<td>Also for NSCAT</td>
</tr>
</tbody>
</table>
Sensitivity to Parameterizations

\[ U_{10N} = U(z) + \frac{u_*}{\kappa} \left[ \ln \left( \frac{10}{z} \right) + \psi \left( \frac{z}{L} \right) \right] \]

COARE 3.5

Unstable
Neutral
Stable
Sensitivity to Parameterizations
Discussion Topics

• Is there interest and are we ready to produce a Synthesis Paper on “Surface Stress and Scatterometry” to summarize our recent work? Topics could include:
  – Role of surface currents and the relative wind
  – Role of atmospheric stability and the equivalent neutral wind
  – Role of air density
  – Role of “long” surface waves on surface stress
  – Role of surface variability and gustiness
  – Role of SST and viscosity
  – Impact of SST gradients
  – Recommendation for drag coefficients

• Can the Coastal Working Group provide any guidance on specific phenomena they’d like to revisit including wave age, wave steepness, enhanced breaking, shallow-water waves, wind-wave directional differences, & fetch limited seas.

• How do we move forward in our attempts to combine scatterometers and observations to improve estimates of wind speed and stress at extreme winds (> 25 m/s)?

• Is there any desire to work on a GMF that directly relates stress measurements with backscatter? The stress measurements could include both DC and bulk derived measurements using our recommended algorithm.