25-Year Ocean Wind Climatology from Satellite Observations

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Currently there are 11 satellites at Version-7 Calibration Standard
- All 6 SSM/I: F08, F10, F11, F13, F14, and F15
- 2 SSMIS: F16, F17
- WindSat and AMSR-E
- QuikScat
Sensor Calibration and Inter-Satellite Calibration
Engineering Climate Data Records

Challenge
Volume: Nearly 100 satellite-years of observations
Calibration: Each sensor has its own unique set of Sensor Calibration Problems
Precision: High precision required for Climate Studies (0.1 m/s/decade)

Maintain a High Level of Consistency
The steadfast adherence to the same principles and methods in data processing all the way from radiometer counts to climate time series, including:
- Geolocation
- Radiometer/Scatterometer Calibration
- Geophysical Retrievals
- Quality Control and Exclusions

On-going and Comprehension Validation
- Ocean buoy winds
- Radiometer Versus Radiometer Wind Comparisons
- Radiometer Versus Scatterometer Wind Comparisons
- Wind Speed Histogram Alignment
- Much of this validation is done by the User community via peer reviewed papers
Mean Global Ocean Wind Speed 1988-2011
Wind Speed Validation

Buoy Comparison Statistics for:

| 8 MW Imagers (6 SSMI, TMI, AMSR-E) and 3 MW Scatterometers (ERS-1, ADEOS-2, QuikScat) |
|---|---|---|---|
| Number of Overpasses | Mean Difference (sat minus buoy) | Std. Dev. (Individual Overpasses) | Std. Dev. Pre-Averaged Monthly |
| 880770.0 | -0.017 m/s | 1.17 m/s | 0.14 m/s |

**Satellite Versus Buoy**

F13 SSM/I Vs. Buoy

**Radiometer Versus Scatterometer**

F13 SSM/I Vs. QuikScat

**Monthly Time Series of Satellite Versus Buoy**

SSM/I-Buoy Wind (m/s)

Year

F08 High Relative to Buoys

Buoys
**High Wind Trends from Altimeters**

18 years of altimeter data
Derive global wind trend over ocean of 0.2 to 0.4 m/s per decade
This trend is much higher than we find

Wentz and Ricciardulli, 2011: Comment on “Global Trends in Wind Speed and Wave Height”, *Science*, 334

**Trend Discrepancies in NINO4 Region**

![Trend Discrepancies in NINO4 Region](chart.png)
Inter-Comparison of Radiometer Wind Time Series
F13 SSM/I, F16 & F17 SSM/IS, WindSat, and AMSR-E
Agreement is at 0.1 m/s Level

- F16-F13 Wind
- F17-F13 Wind
- F31-F13 Wind
- F32-F13 Wind
- F17-F16 Wind
- F31-F16 Wind
- F32-F16 Wind
- F32-F31 Wind

F16 SSM/I Problem
Inter-Comparison of Radiometer and Scatterometer Wind Time Series

F11, F13, F14, and F15 SSMI and 3 WindSat Retrievals

3 Different WindSat Retrievals Agree

Agreement at 0.1 m/s level
Error in Estimating Global Wind Trend

Standard Least-Squares Estimation

Error in estimating slope = \( \frac{\text{measurement\_error}}{\sqrt{N} \times \text{std}(x)} \)

For a 25 year time series:

\( N=25 \)
\( \text{std}(x) = 7.2 \text{ years} \)
measurement\_error for yearly averages assumed to be 0.1 m/s

Error in slope = 0.03 m/s per decade

An observed 0.1 m/s per decade trend is significant
Inter-Comparison of Satellite and Buoy Wind Trends

8 MW Imagers: 6 SSMI, TMI, AMSR-E
3 MW Scatterometers: ERS-1, ADEOS-2, QuikScat

Mean Dif (sat-buoy) = 0.13 m/s/decade
Std. Dev. = 0.28 m/s/decade
R correlation = 0.96
(One outlier excluded)

Disagreement is greater than 0.1 m/s/decade but probably still reasonable considering difficulties in getting reliable buoy trends and spatial temporal mismatch.
Intensification of Walker Circulation as Evidence by Increasing Surface Winds in Tropical Pacific

SST Trend = -0.155 K per decade
Wind Trend = 0.387 m/s per decade
## New Winds-Through-Rain Product

<table>
<thead>
<tr>
<th>Rain Rate</th>
<th>Bias</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>no rain</td>
<td>0.04</td>
<td>0.9</td>
</tr>
<tr>
<td>light rain (0 – 3 mm/h)</td>
<td>0.70</td>
<td>1.6</td>
</tr>
<tr>
<td>moderate rain (3 – 8 mm/h)</td>
<td>0.02</td>
<td>2.0</td>
</tr>
<tr>
<td>heavy rain (&gt; 8 mm/h)</td>
<td>-0.05</td>
<td>2.5</td>
</tr>
</tbody>
</table>


Additional Satellites to be added
- SSMIS F18
- TRMM MW Imager (now available but not at V7)
- ASCAT
- AMSR-2
- GMI

Winds through rain for WindSat and AMSR

Addition of Error/Accuracy Information
- Formal errors associated with retrieval process
- End-to-end errors estimated via validation activities