## The Cross-Calibrated Multi-Platform (CCMP) Ocean Vector Wind Analysis (V2.0)

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## Outline

#### 1. What is CCMP?

- 2. What's new in Version 2.0
- **3. Limitations and Future Plans**

#### What is CCMP?



#### Variational Analysis

- CCMP is constructed by minimizing a cost function.
- This function has 2 parts:
  - Agreement with measurements.

 $\sum (V_A - V_O)^2$  or  $\sum (|V_A| - |V_O|)^2$ 

• Agreement with the background field.

Disagreement with the background must be both small, and smooth. Enforced by constraints on the vector magnitude, divergence, vorticity, and Laplacian of the Background minus Analysis difference.

- These terms are weighted by empirically determined weights that affect the behavior of the VAM.
- For CCMP, these are chosen so that observations are much more important than the background.



### Variational Analysis: Effect of the Weights

- So:
  - When an observation exists (and is close in time), CCMP wind speed is very close (0.5 m/s rms) to the observations.
  - When no nearby observations exists, CCMP yields the background field.
  - The smoothness constraints make the transition from these two regimes smooth, with low vorticity and divergence. This helps the VAM assign wind direction to wind speed measurements from satellites.

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#### **ERA-Int Background Field**

ERA-Int wspd 08/28/2005 12Z



#### CCMP V2.0



# Differences Between V1.0 and V2.0

Version 1.0	Version 2.0
Background: ERA-40 (before 1999) ECMWF Operational Analysis	Background: ERA-Interim
Satellite Radiometer Winds Used whatever RSS version was available, so different versions used over time.	Satellite Radiometer Winds Uses RSS Version 7 only, so intercalibration between satellite data is much improved.
Uses SSM/I, AMSRE, QuikScat	SSMIS, Windsat, AMSR2, GMI, and ASCAT added
1987-2011	1987-2016, updated every 6 months or so.
Run at NASA GSFC	Run at Remote Sensing Systems. (this is currently done with zero funding)

Available via FTP at ftp2.remss.com/ccmp/v02.0/

#### Satellites Used in CCMP V2.0



Buoys: TAO, Triton, PIRATA, NDBC, RAMA

#### How Important are the Buoys?

Experiment: Remove most of the TAO Array at 5 degrees and 8 Degrees



Monthly Mean Zonal Wind, Buoys Removed



0

5

10

-5

-10

#### Difference, Buoys Removed - Baseline



#### Pros and Limitations....

Pros:

- Spatially Complete (no gaps between swaths, near land, in rain)
- One dataset spans entire time period.
- Winds in better agreement with observations than Reanalysis (but see limitations below.)
- Additional information on intermediate (~200 km) length scales as compared to reanalysis.

These features have made the product VERY popular. >350 Peer reviewed papers have used CCMP V1 and V2.

#### Limitations:

- Not so good for long-term trends.
- Problems over regions of anomalous stability.
- Problems in regions of high speed ocean currents.
- Not so good for small scale features (< 200 km).

### Sources of these limitations

- Much of these problems are caused by differences between ERA-Interim and the Satellite winds.
  - Satellite winds are 10m Equivalent Neutral Stability Winds
  - But ERA-Int winds are actual 10m winds.
  - Satellites measure relative winds (i.e. relative to the ocean surface, which might be moving)
  - ERA-Interim winds are biased low relative to satellites at winds above about 15 m/s.



## CCMP Long-Term Trend Larger than in its Sources



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### Why?



Number of Observations Analyzed Per Grid Point



Over time, more and more satellite observations are included.

Thus a greater proportion of the winds are adjusted upward to match the higher satellite winds

This results in a spurious upward trend.



# ERA-Int is biased low vs. satellites at high wind speed



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### AMSR2 – ERA-Interim 10m Winds

#### JJA 2013

Regions of Warm Air over Cold Water High Stability ->10m winds don't mix down well. Surface roughness less than usual...



Near the equator, difference are likely due to a combination of stability, ocean currents, and rain effects.



#### ERA-Interim converted to 10m Neutral Equivalent Winds (Liu and Tang, 1996)



1

2

ERA-Interim – AMSR2 (m/s)

0

-2

-1



# Added high wind adjustment to ERA-Interim.



ERA-Interim – AMSR2 (m/s) -2 -1 0 1 2

#### Improvements

- Adjust the Background for Background/Observation Biases, which should reduce spurious global trends.
- Convert background to 10m neutral stability winds before using. This should reduce problems with regions of high/low stability.
- Account for ocean currents, particularly in tropics.
- (Long-Term) generate a stress product using similar methods.

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## **CCMP** Lives!