A Satellite Surface Wind Product Benefitting From Boundary-Layer Physics

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With thanks to Jerome Patoux and Ralph Foster,
NASA OVWST, NASA NEWS, and NOAA/COD

* The guy that fixed my misconceptions and did almost all the new work

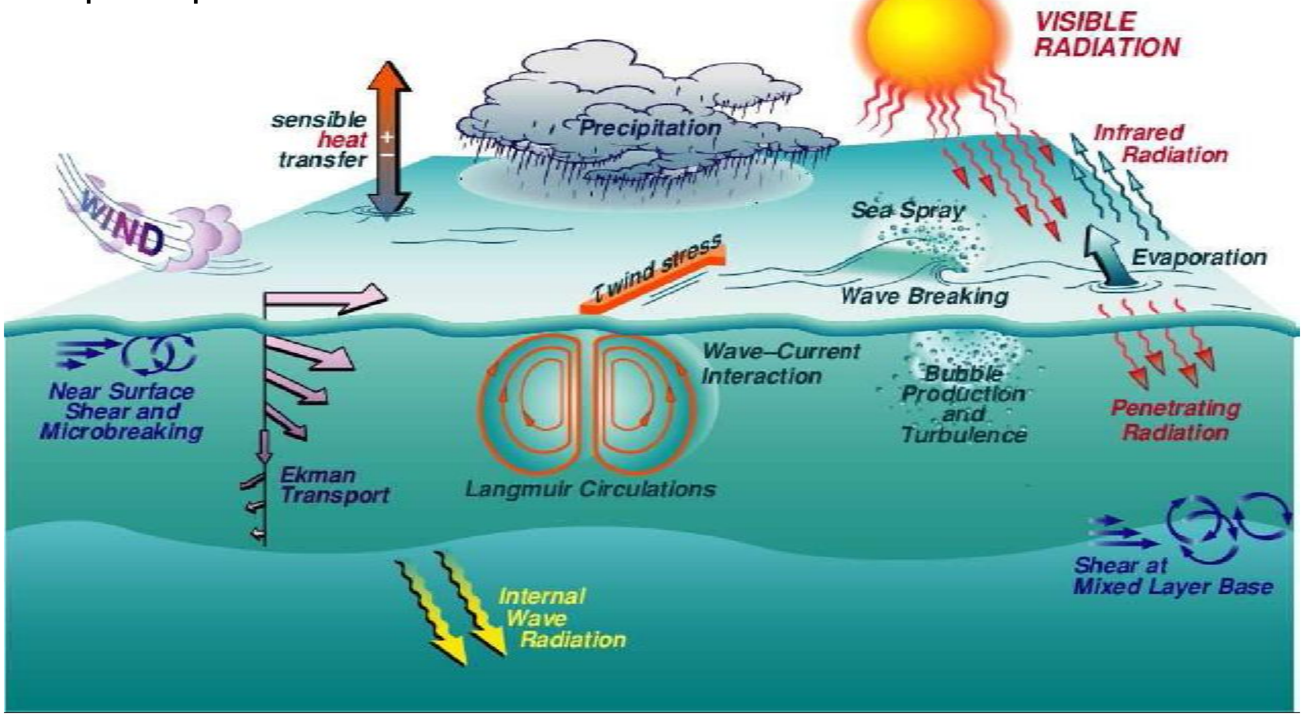
General Goal

- To develop a **new** objective technique that utilizes satellite derived winds, non-wind data (including NWP data) and physics to produce a high-resolution (0.25° and 6-hourly) **oceanic surface vector wind dataset**
  - Develop product with relatively fine spatial and temporal resolution and smaller sampling inhomogeneities
- Today's goal: Interest a few people in testing the product when it is available (soon)
  - 0.25 x 0.25 degree
  - 6 hourly (perhaps 3 hourly for shorter period – future development)
  - Global over ocean – first release poleward of ±20

Oceanic Surface Winds

- **Surface winds** play a major role in the processes that transfer energy, moisture, momentum, gases, and matter across the air-sea interface

Graphic adapted from CBLAST



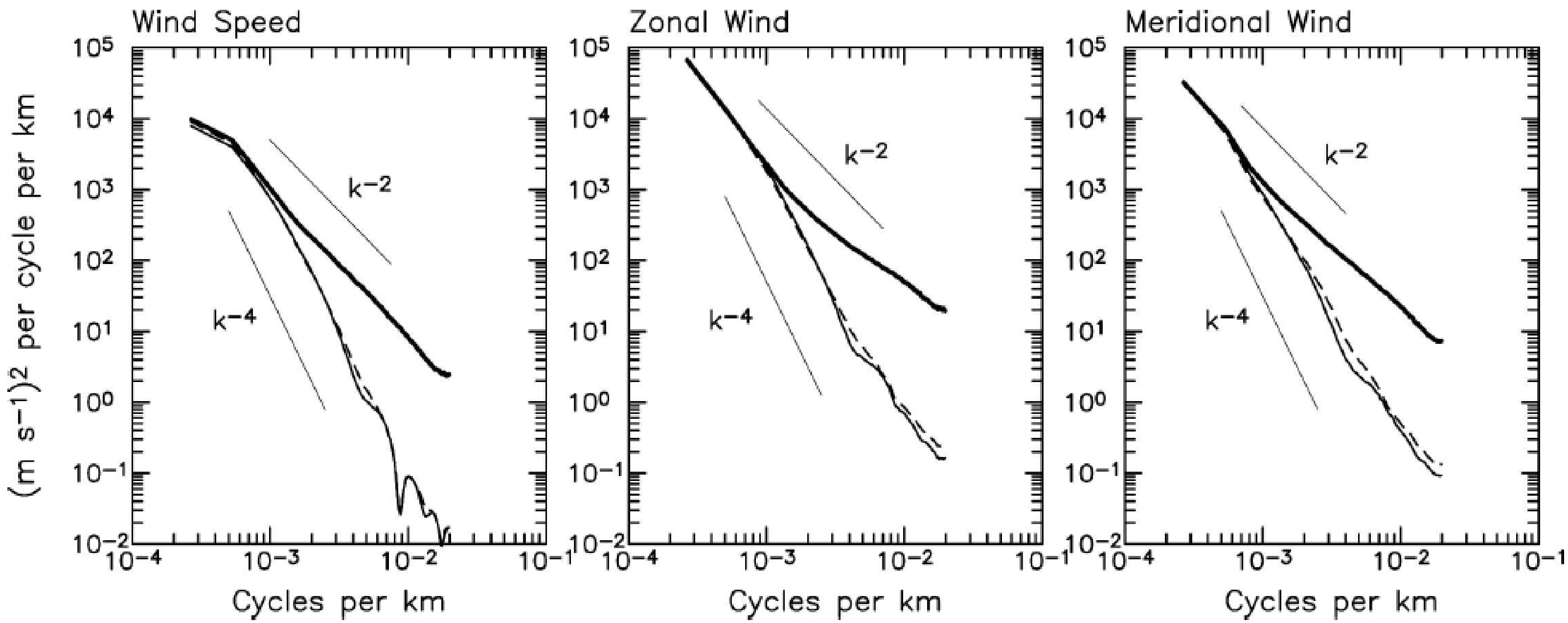
Oceanic Surface Winds

- What characteristics do we want in these **surface wind fields**?
  - Presence of **high-wavenumber energy** throughout
  - Able to more accurately resolve large and **small-scale features** (i.e., high spatial and temporal resolution)
  - **Uniform** and **continuous** with to time and space (i.e., no **data gaps** or **spurious features**)
- Does a single source of oceanic **surface winds** (e.g., ships and buoys, satellite, or NWP models) fulfill **all** of the above specifications? No! Not yet
- We have two improvements in our data assimilation
  - Physical constraint based on UWPBL
  - Assimilation of wind speeds, surface pressure and SST data

Fine Scale Features

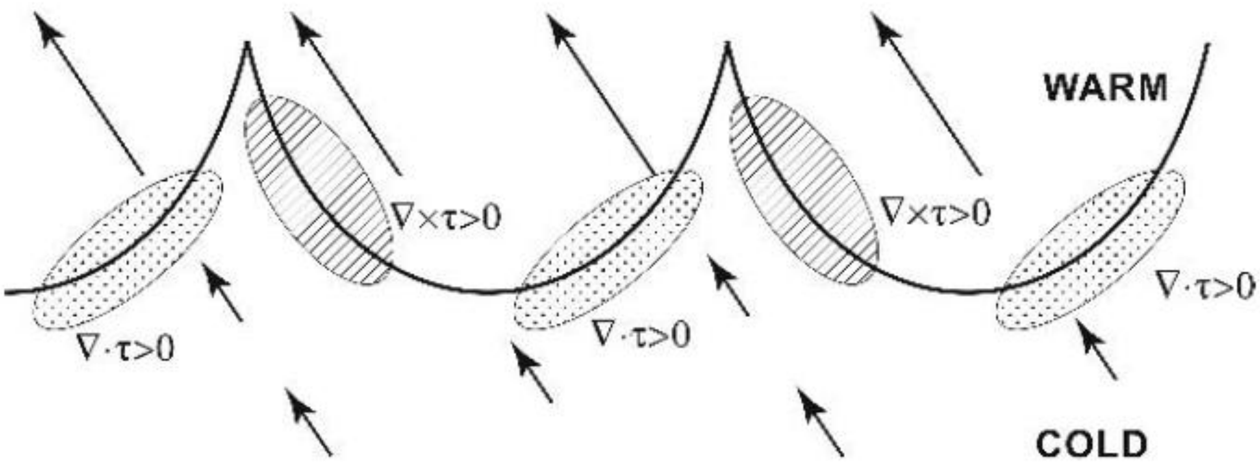
- Assessment of NWP near-surface winds against scatterometer derived winds revealed discrepancies
  - **NWP** winds had considerably **less energy** at spatial scales smaller than ~1000 km (*Wikle et al. 1999; Milliff et al. 2004; Chelton et al. 2006*). Now for less than ~400km
  - **NWP** models **underestimate small-scale** relationship between SST and near-surface winds in regions of strong SST gradients (*Brown et al. 2005,2006; Maloney and Chelton 2006; Chelton et al. 2007; Song et al. 2009*)
  - Observation-based products usually fail to produce sufficient **temporal resolution** (*Hughes et al. 2012*)

Wavenumber Spectra of Near-Surface Wind Fields



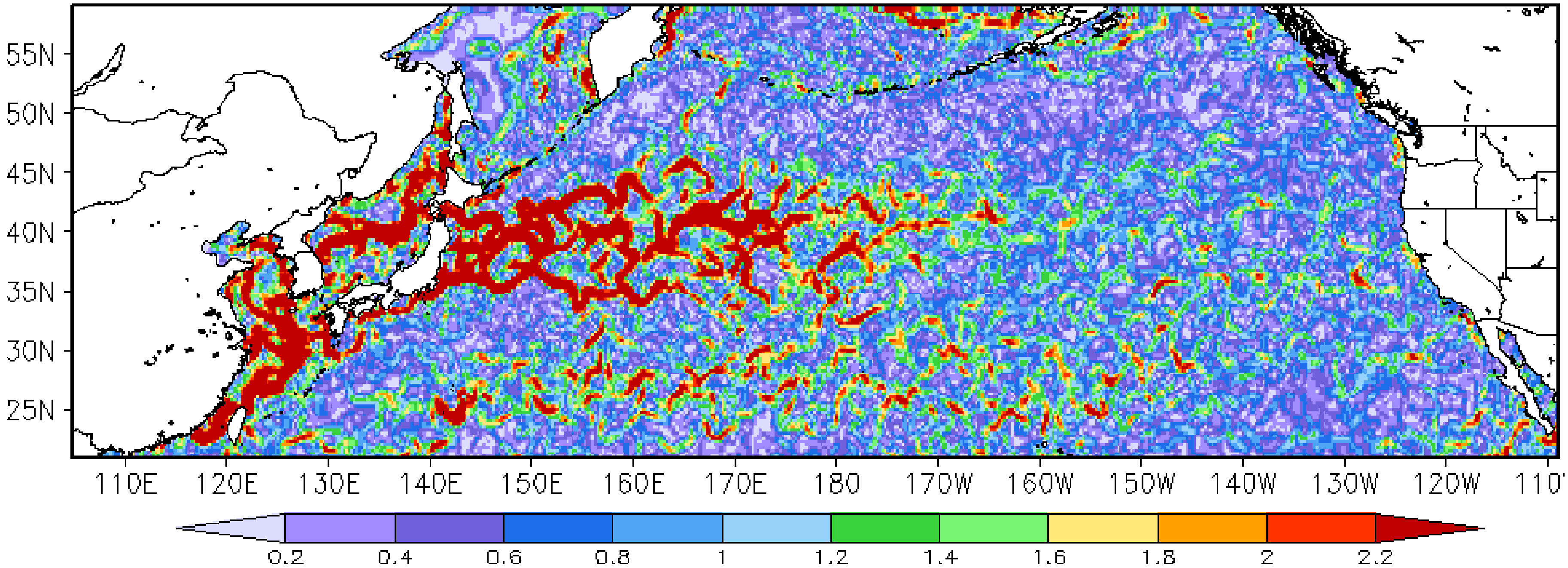
Along-track wavenumber spectra of (left) wind speed and the (middle) zonal and (right) meridional wind components in the eastern North Pacific for 2004 computed from QuikSCAT observations (heavy solid lines), NCEP analyses (thin solid lines), and ECMWF analyses (dashed lines) of 10 m winds bilinearly interpolated to the times and locations of the QuikSCAT observations. From *Chelton et al.* (2006).

Small-scale Relationship Between SST and Wind Stress



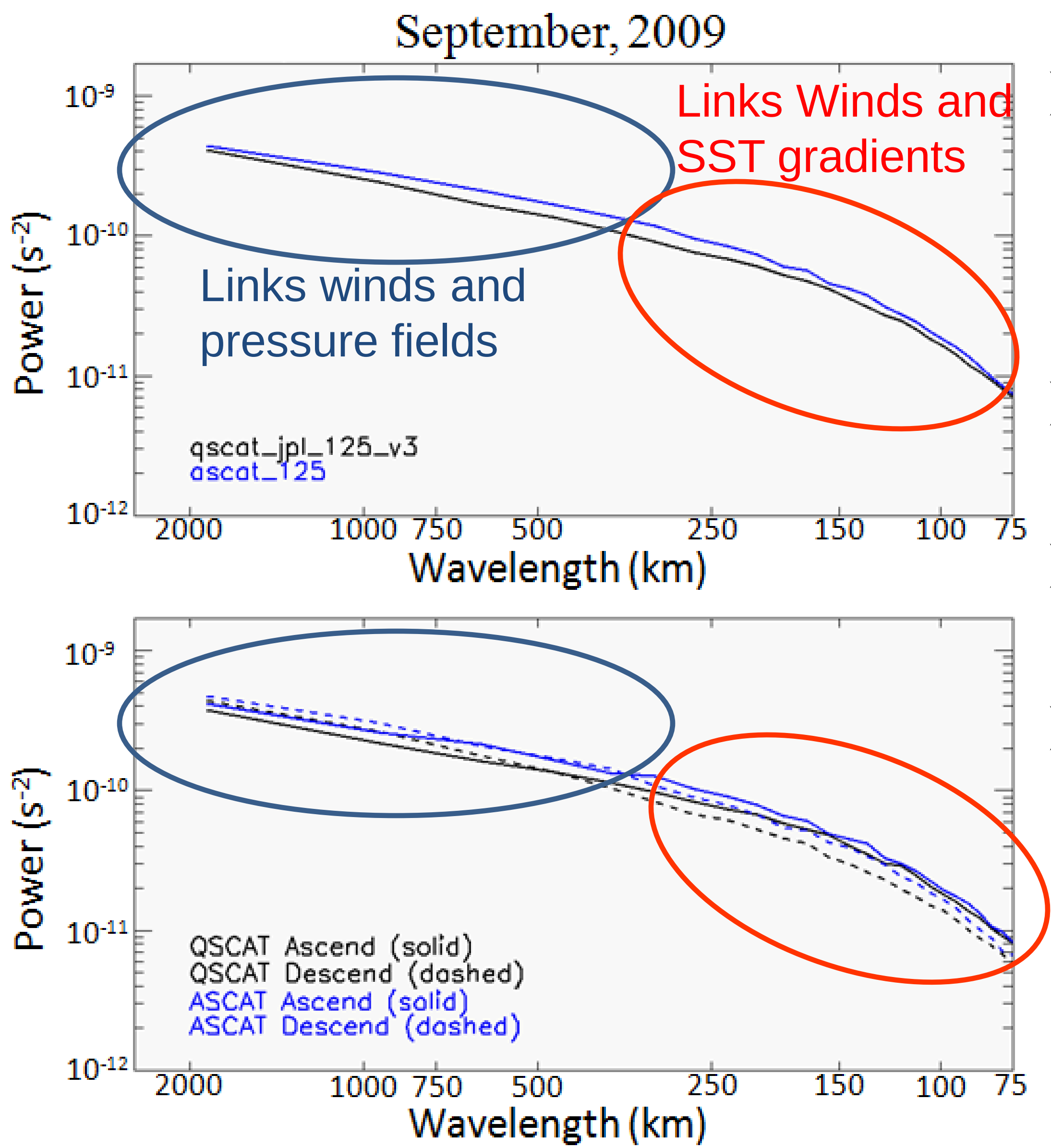
A schematic showing the observed SST influence on near-surface wind stress in regions of strong SST gradients. From *Chelton et al*. (2005).

Example Reynolds SST Gradients



- Example gradients of Reynolds SSTs (K/100km).
  - These fields are noisy and require smoothing
  - Smoothing can be tuned to match the spatial scales in wind observations.

Vorticity Spectra

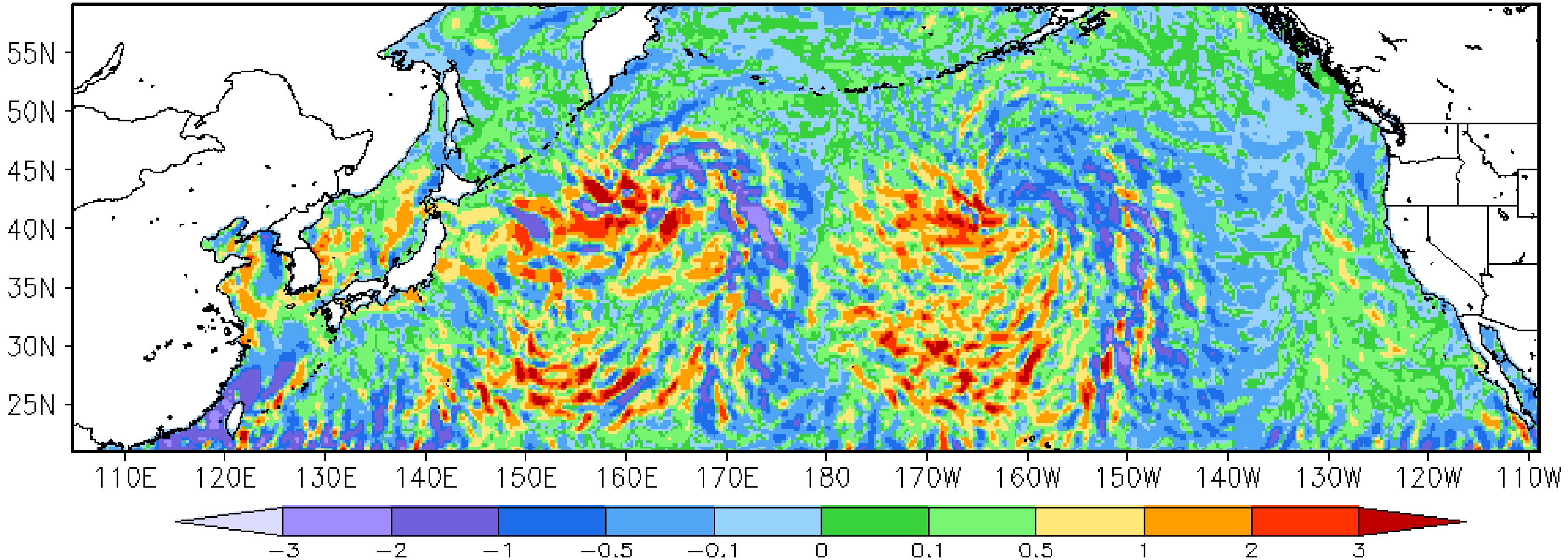


- Vorticity Spectra are remarkably similar from QSCAT, ASCAT, and OSCAT
- See talk by Heather Holbach
- Based on 12.5km products
- 50km diameter averaging scale

Methodology

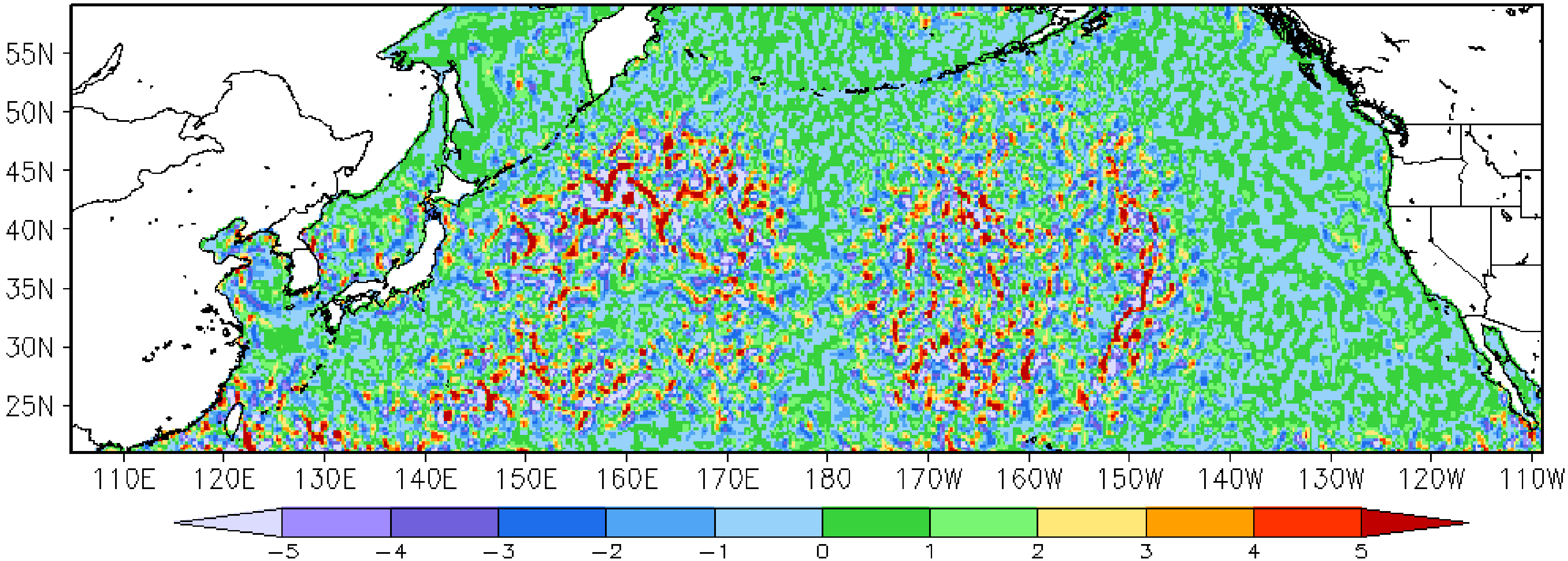
- The objective technique generates a uniformly gridded **near-surface wind** analysis by minimizing a cost function
- The cost function (*f*) incorporates:
  - Non-wind (e.g., SLP and SST) data and wind observations
  - Wind components and speed are physically related to non-wind variables through a PBL model, i.e., observation operator or forward model
  - The University of Washington PBL (UWPBL) model (*Foster et al*. 1999; *Patoux 2004*) solves for the velocity profile in the boundary layer provided a input surface pressure (and SST, air temperature, and/or humidity) field

Example Change in Surface Wind Speed



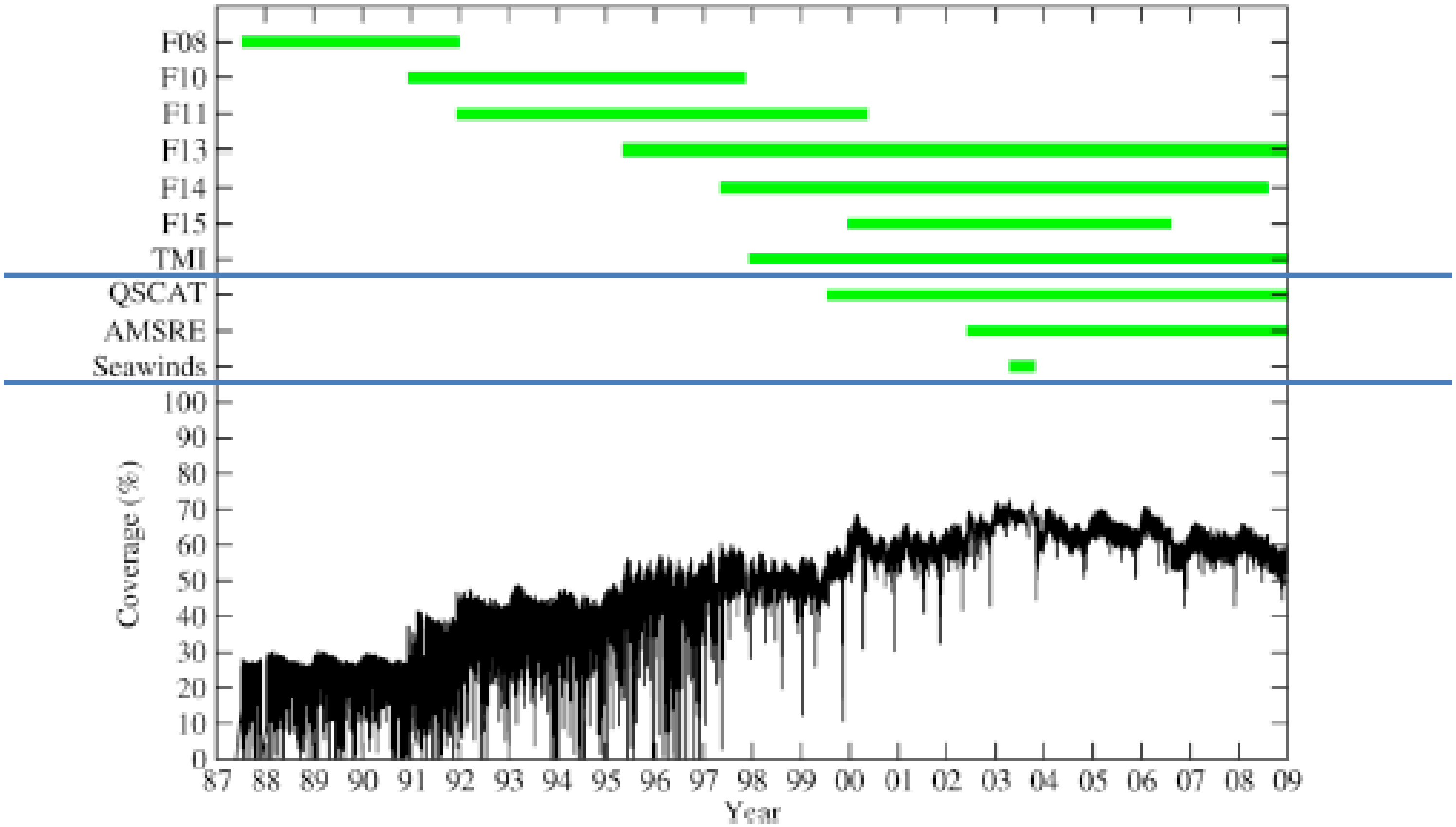
- Change in surface wind speed (ms^{-1}) due to above SST gradients (Reynolds SSTs).
  - These changes are largely observed in OVW swaths
  - SST gradient must be considered to add such features in areas with only speed data and in data voids

Example Change in Curl of Wind



- Changes in curl of the surface wind (10^{-5} s^{-1}) due to above SST gradients. These changes will be important for ocean dynamics.
- Changes in curl are dependent on the SST gradient and on the wind speed

Sampling Changes with Time



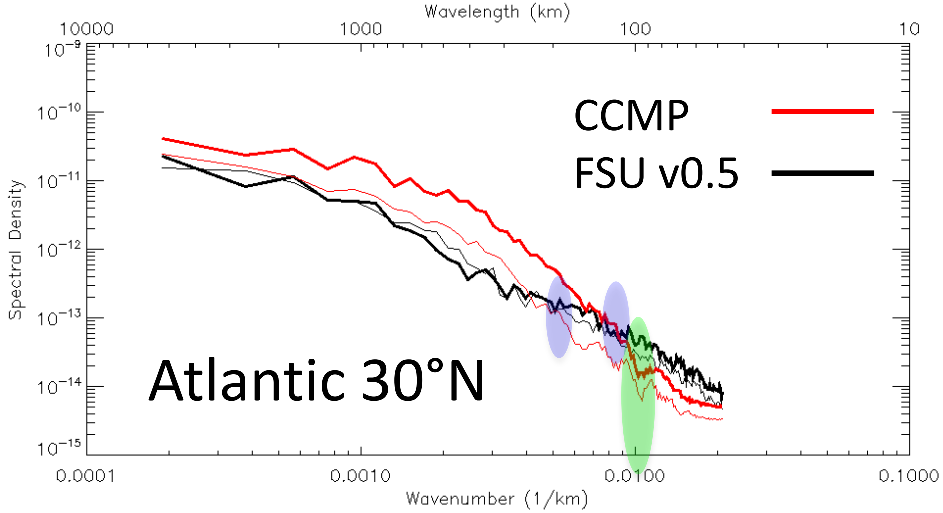
Time availability of satellite surface wind data sets. The SSMI/I instruments are denoted F08 through F15. The percentage of the global oceans observed by these missions in a 6-hour period is shown in the bottom portion of graph. From *Atlas et al. (2011)*.

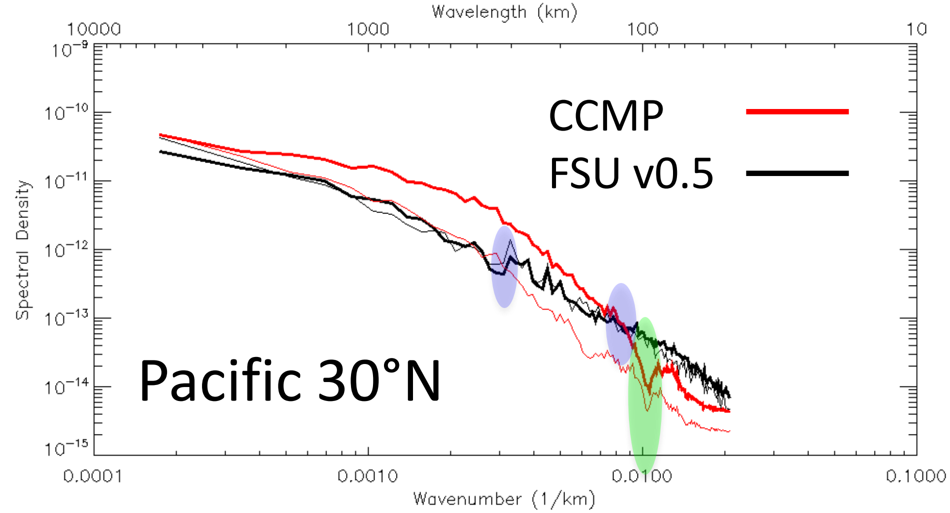
We will try to add all inter-calibrated data provided by RSS

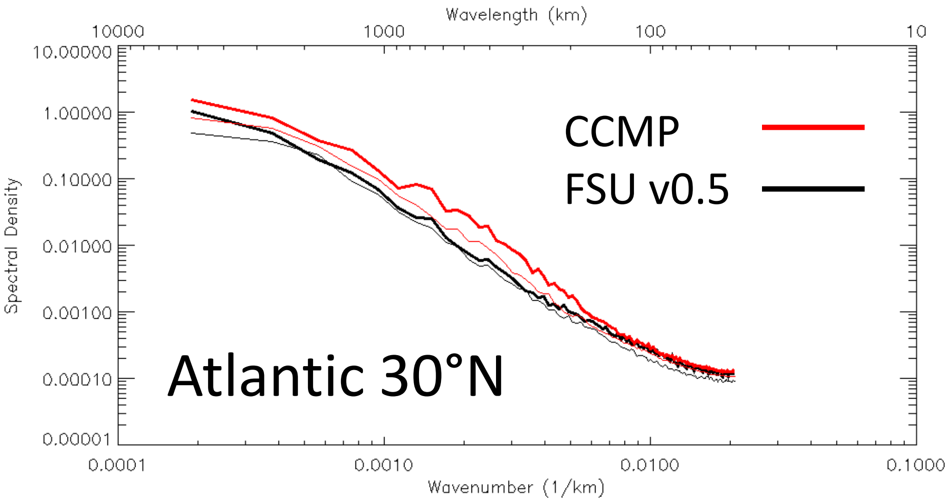
Examples of Improvements

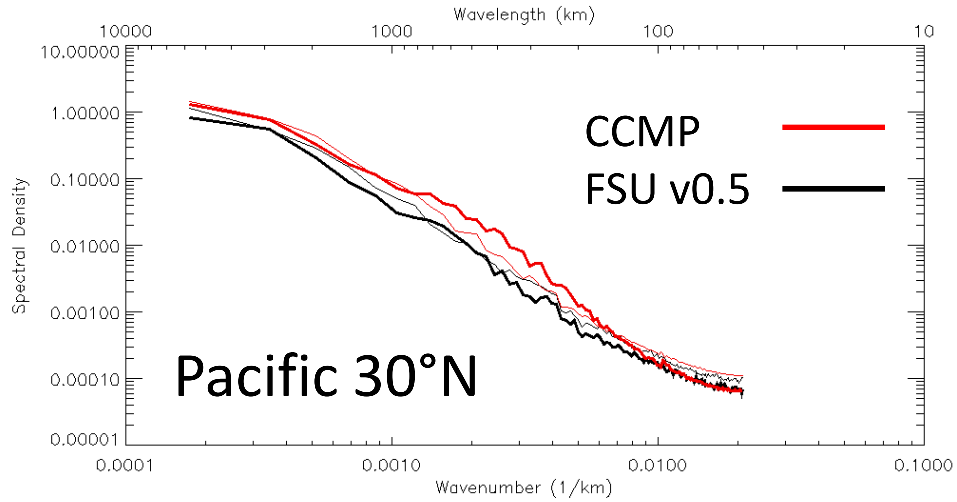
- Compare CCMP (Atlas et al.) winds to our pre-release winds
  - Examine spectra
  - Compare fields from 1988 (1 satellite) and 2003 (7 satellites)

Spectra: Curl (top) & Wind Speed (bottom) for 2003 (thick) and 1988 (thin)



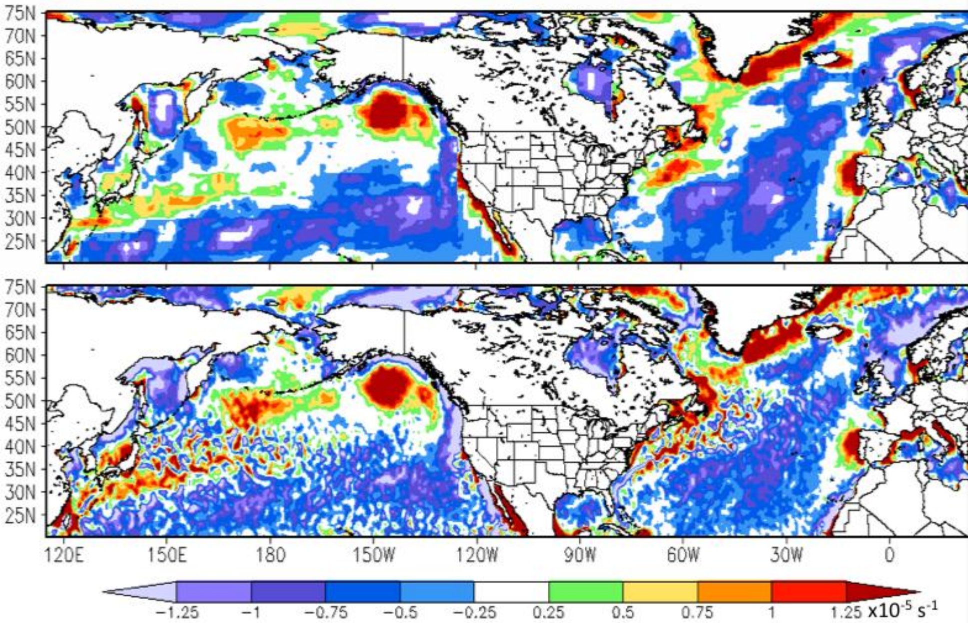




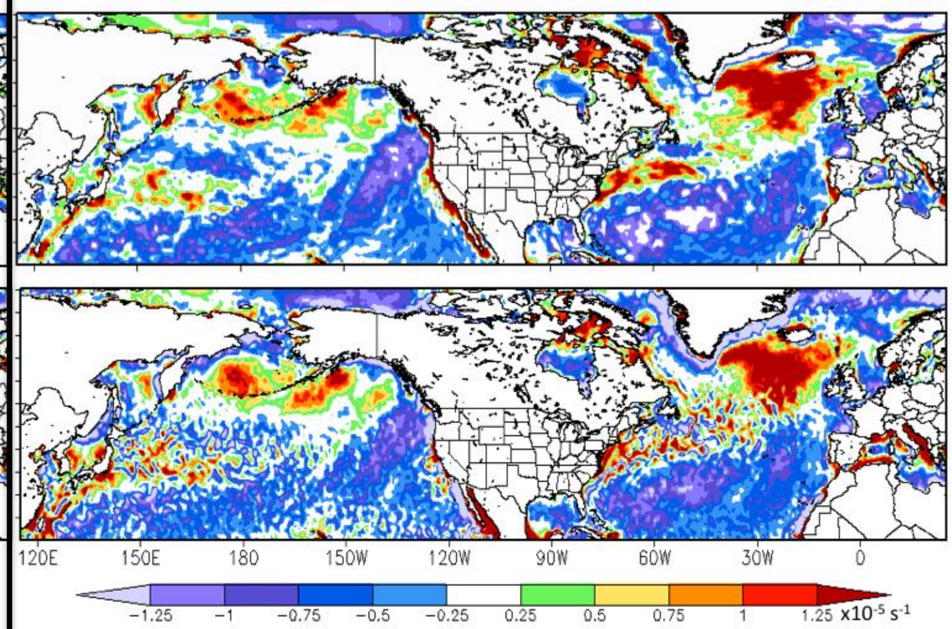


CCMP (top) vs. FSU (bottom): Curl

June **1988**: 1 Satellite Source

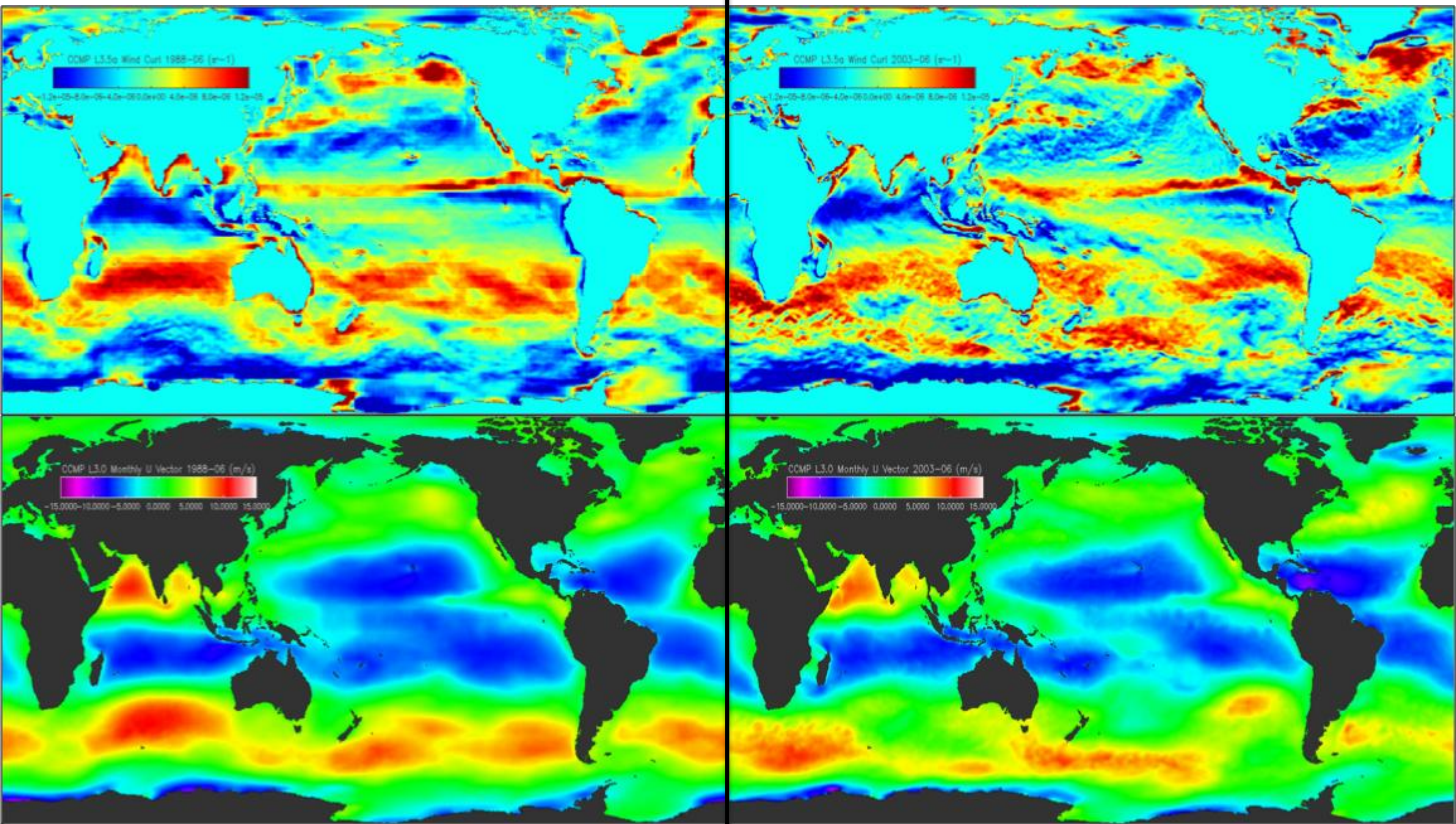


June **2003**: 7 Satellite Sources



Effective Resolution Limits Small Scale Accuracy: CCMP L3.0 Curl (Top) vs. Zonal Wind (Bottom)

June **1988**: 1 Satellite Source | June **2003**: 7 Satellite Sources



Conclusions

- This objective technique greatly **advances** the previous work of *Pegion et al. (2000)* in manner that directly targets
  - Several needs of the scientific community, and
  - Deficiencies of existing near-surface wind data sources
- **We would like people to help test the product**
- We have established a **new foundation,** to which future improvements can be added
  - Allow adjustment over land & ice: should improve accuracy over water near the land & ice
  - Inclusion of satellite derived air temperature and humidity
    - Creation of high quality turbulent flux fields
    - With C.A. Clayson, D.L. Jackson, B. Roberts, and G. W. Wick
  - Inclusion of currents and surface waves
  - Add diurnal changes in SSTs
    - Add modifications related to ocean color

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