Wind and Stress Science (L3) Products

Summary of L3 Splinter Meeting Held at the Portland AMS Meeting 8/07

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Motivation

- Science data products (level 3) from the QuikSCAT project or other sources are the most widely used QuikSCAT data products.
- Original project intent was to provide a quick-look data product
  - Nevertheless, the L3 products are often used for other purposes (sometimes incorrectly)
- A limited survey of the user community showed that there was a desire for products better suited for the specific needs of the communities using them:
  - Consistently sampled stress data products for assimilation into ocean models
  - Meteorological applications desire gridded wind products with improved temporal sampling & resolve data gaps (other wind sources?)
- **In order for NASA to react to these needs, a broad community consensus needs to be achieved on the desired product characteristics**

Portland AMS Splinter Meeting

Agenda

Part 1: Background

- Welcome, purpose and expected outcome of meeting: **Foster, Perigaud, Rodriguez**
- Existing QuikSCAT Level3 product review: **Perry** (PODAAC)
- Sampling characteristics of scatterometer data: **Chelton** (OSU)
- Wind stress issues: **Bourassa** (COAPS/FSU)

Part 2: Candidate products

- Remote Sensing Systems wind products: **D. Smith** (RSS)
- CerSAT Winds: **Bentamy** (IFREMER)
- CoRA Winds: **Milliff/Morzel** (CoRA)
- FSU Winds: **Bourassa** (COAPS/FSU)
- PBL: **Foster/Patoux** (UW/APL)
- Multiplatform merged winds. **Ardizzone, Atlas, Hoffman** (GSFC/NOAA/AER)

• Three topics emerged naturally from the meeting:

- Limitations due to sampling
- Gridded data products
- Stress data products

• Detailed presentations available at http://winds.jpl.nasa.gov/L3splinter/index.cfm

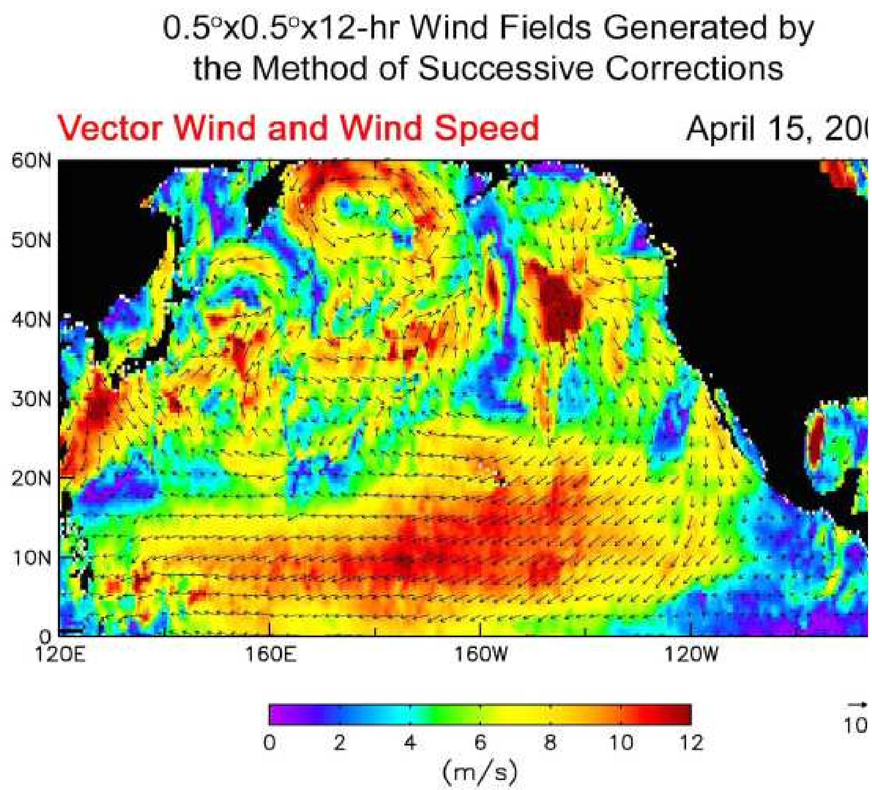
Considerations For Gridded Fields

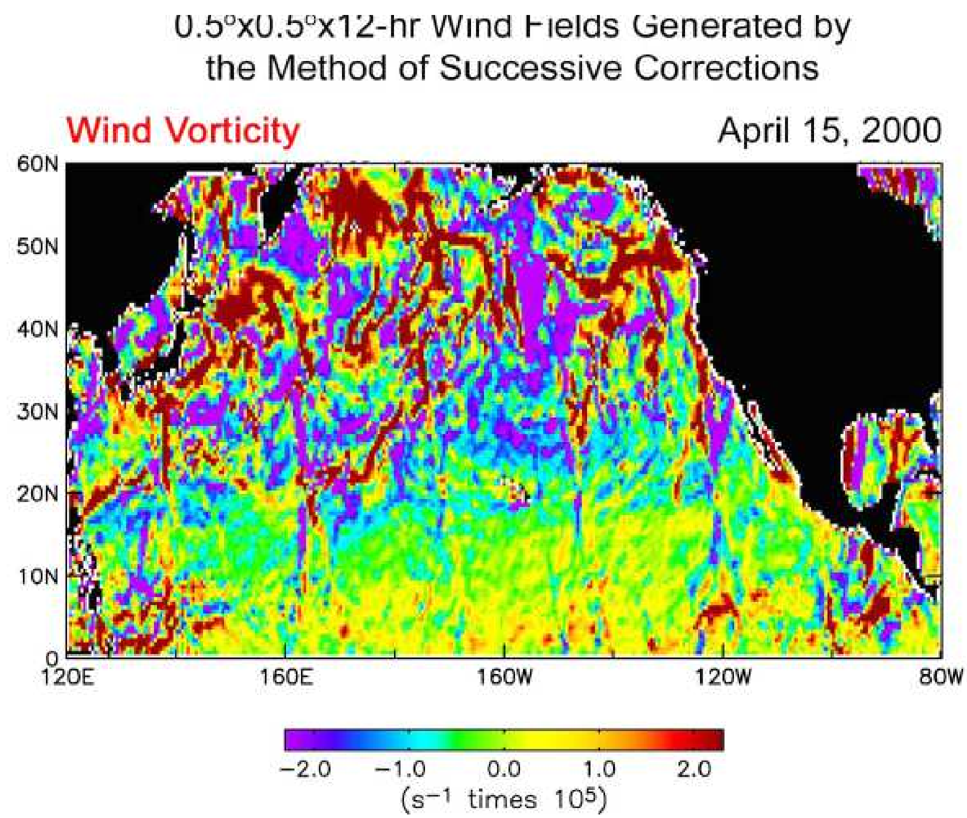
Key Considerations

- **Filling the gaps**
  - A good approximation
  - Should have physically realistic spatial trends (Continuity and Smoothness)
- **Removing the edge effects** due to overlapping swaths
  - Poor techniques will introduce too much spurious divergence/curl
  - Ocean models are highly sensitive to divergence/curl
- Avoid excessive **smoothing**
- Filter out **bad data**
- Ideally (rarely achieved) spatial/temporal **consistency in error statistics.**
  - However, the products are often tailored to a particular application.
  - The degree of sensitivity to this problem is rarely considered in the generation of these products! Very dangerous, since weaknesses of these products have NOT been documented!

Courtesy M. Bourassa, FSU

Derivatives are most sensitive to rebinning errors

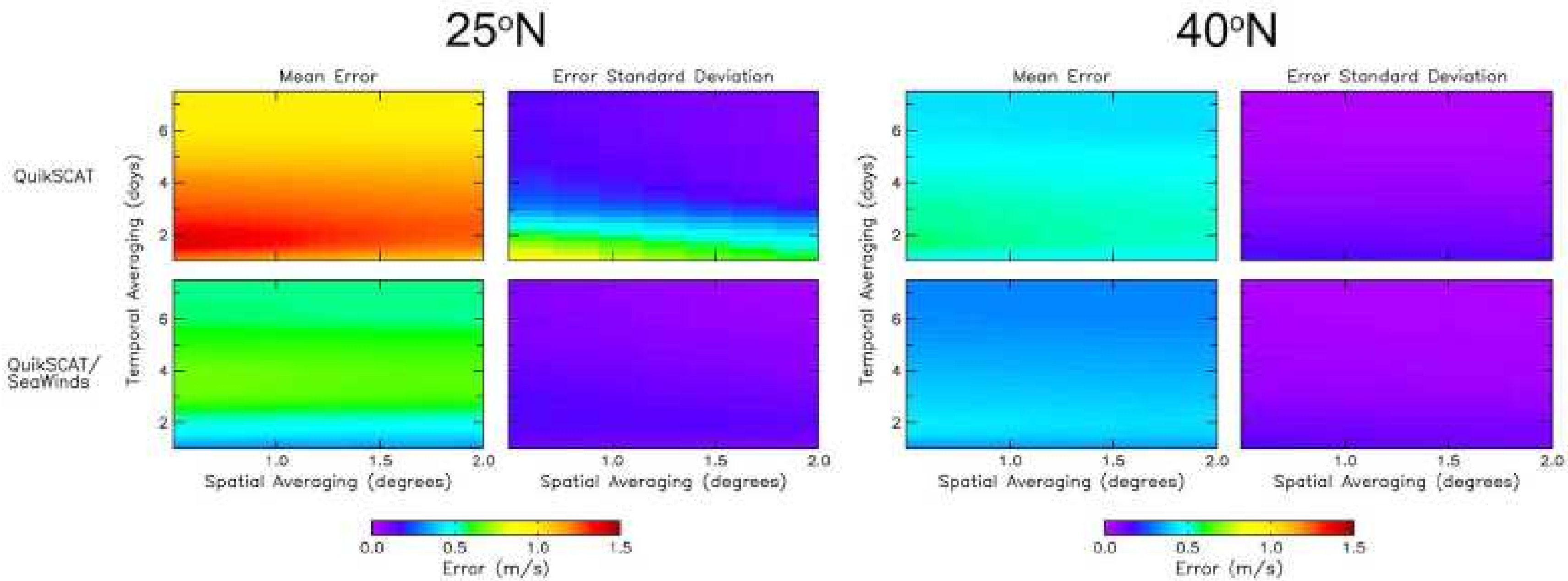




Courtesy D. Chelton, OSU

Dependencies of Mean and Standard Deviation of Mapping Errors on Spatial and Temporal Smoothing

for QuikSCAT and Tandem QuikSCAT/SeaWinds



Note that errors are more sensitive to temporal smoothing than to spatial smoothing.

This is an indication that mapping errors are dominated by temporal sampling.

Courtesy D. Chelton, OSU

Candidate Gridded Wind Products-1

- "Standard" uninterpolated QuikSCAT gridded products
  - PODAAC L3 gridded winds (and stress- temp. retired)
  - RSS winds (3 day, weekly, monthly average)
- FSU winds/pseudo stress
  - Sensors: QuikSCAT
  - Technique: Variational method
  - Availability: http://coaps.fsu.edu/scatterometry
  - Improvements proposed: incorporate UWPBL as hard constraint, improve mesoscale resolution, multiple sensors/data sources, speeds to be assimilated consistently
- CoRA
  - Sensors: QuikSCAT
  - Technique: blending QuikSCAT + NCEP for improved temporal coverage, enhance NCEP to match KE spectrum at high wavenumbers
  - Availability: http://dss.ucar.edu/datasets/ds744.4
  - Improvements proposed: transition to Bayesian Hierarchical Model blending of multiple sensors, NWP, generate multiple realizations/errors, enforce high frequency KE spectrum

Candidate Gridded Wind Products-2

- Ardizzone, Atlas, Hoffman
  - Sensors: multiple (SSM/I, TRMM, TMI, AMSRE, QuikSCAT, Seawinds) + ships + buoys
  - Technique: Variational Analysis Method (VAM)
  - Availability: http://podaac.jpl.nasa.gov
  - Improvements proposed: None (need community validation)
- CERSAT
  - Sensors: multiple (SSM/I, Scatterometer) + ECMWF Analysis
  - Objective method: external drift
  - Availability: http://www.ifremer.fr/cersat/facilities/mwf-blended-nrt
  - Improvements proposed: None

Candidate Gridded Wind Products-3

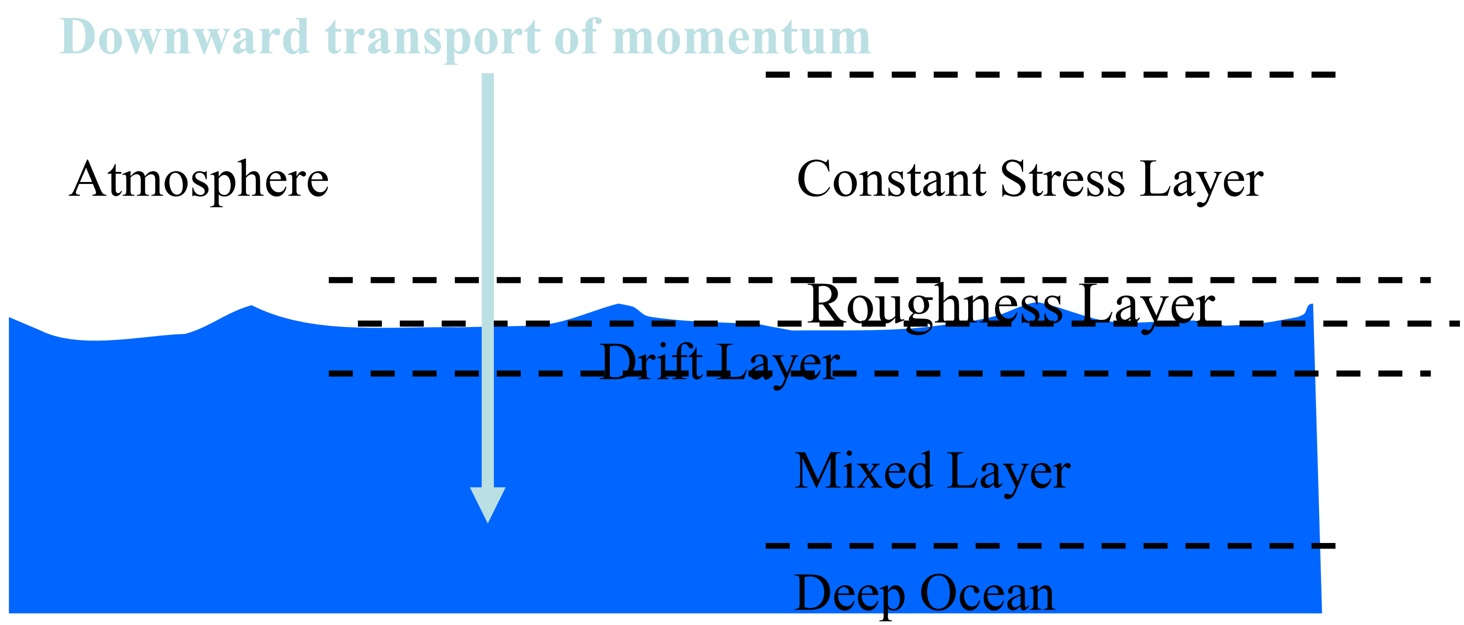
- Foster, Patoux, Brown UW PBL
  - Sensors: can be applied to multiple wind sensors (currently QuikSCAT)
  - Technique: PBL model to derive Sea Level Pressure (and gradient winds). Can be used as constraint for other models, as validation, for ambiguity removal, or as gridding
  - Improvements proposed: better handling of gaps: wavelet continuation a la Milliff et al., Ensemble Kalman Filtering
  - This is a product that could be developed at UW or in collaboration with other groups

Gridded Data Product Issues

- No cross-comparison or validation to the same data sets
- Little or inconsistent level of documentation
- Error bars are usually not available
- **Proposed short term solutions**
  - Use PODAAC to provide “universal” interface to all data sets, supplement and store documentation
  - OVWST community to provide guidance on a uniform validation process
  - Proposed validation tests:
    - Climatic consistency of wind/stress vector fields
    - Derivative fields (curl, divergence)
    - Kinetic energy spectrum preserved
    - Validation against ocean models
    - Others to be defined by OVWST
  - Validation results to be documented in a report to NASA
- **Longer term solutions**
  - If warranted by validation results, improvements to existing wind products will be recommended in the validation report for NASA funding consideration

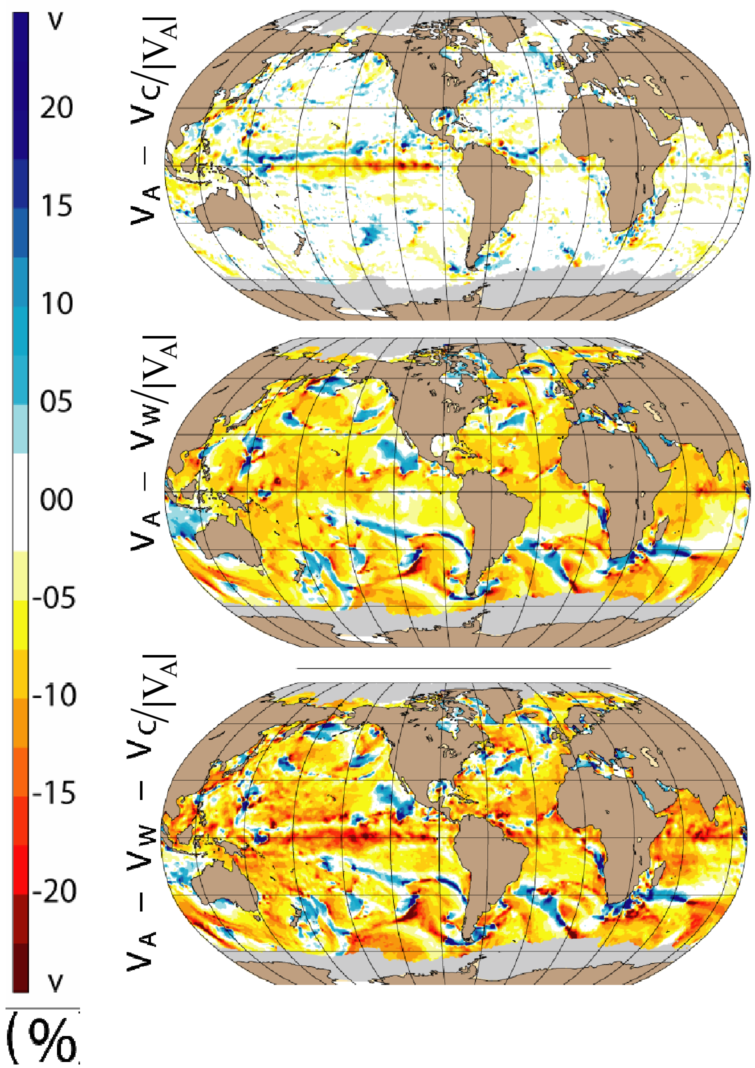
Objective = Estimate Ocean Stress Vectors for Climate/Weather from Scatterometers

Scatterometers, sensitive to small scale sea surface roughness, are a function of the Stress Vector in the "Constant Stress Layer".



OGCM would benefit from Stress Vectors at the bottom of the "Drift layer".

Contributions of Currents and Waves on Wind-Derived Stress



Δ U/U ~ Δ energy flux/energy flux.

$2\Delta U/U \sim (\Delta U / U)^2 \sim \Delta \tau/\tau$

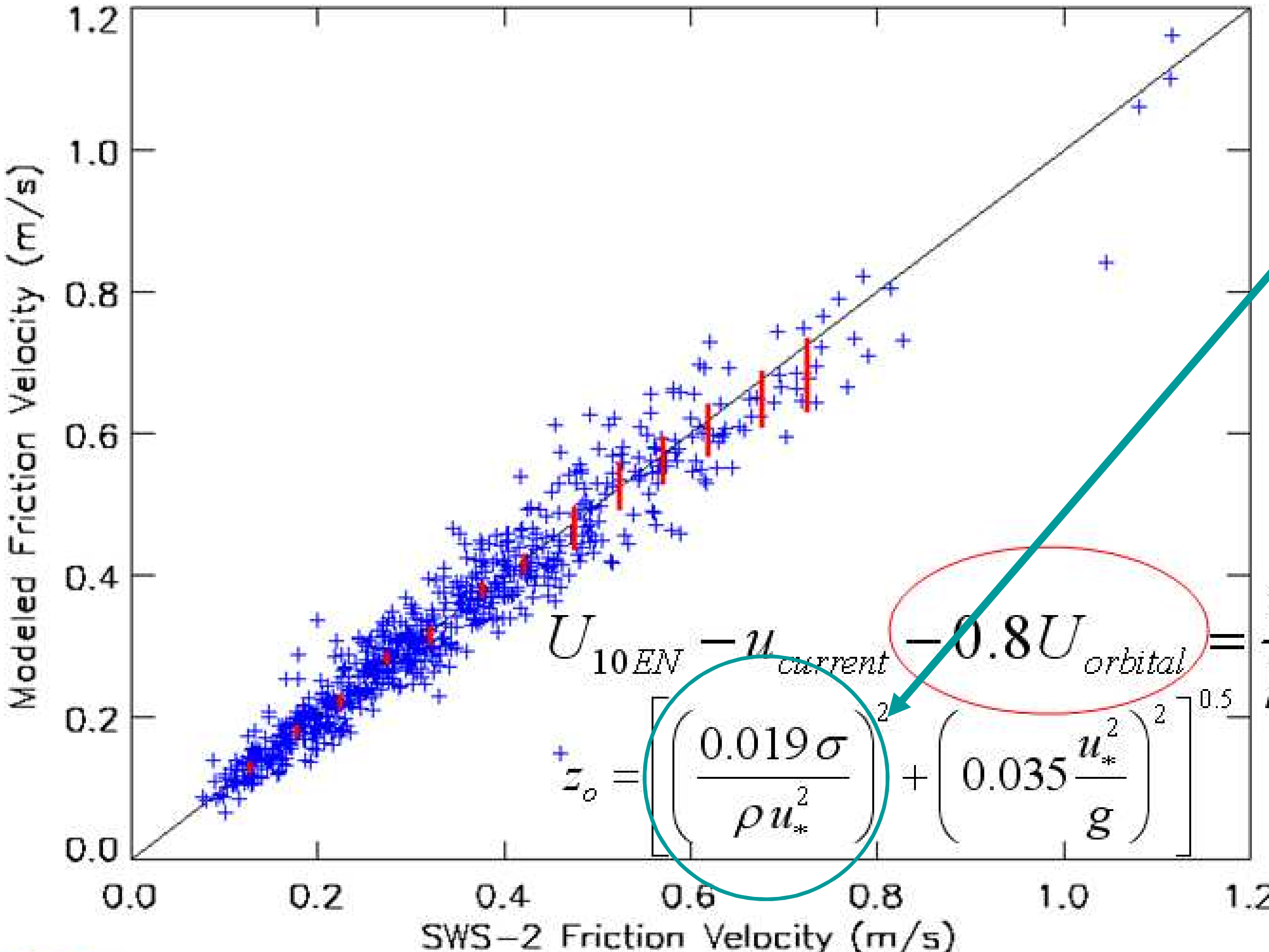
>50% changes in stress associated with strong storms!

>Can have opposite changes nearby.

>Huge change in the curl of the stress!

From *Kara et al.*, GRL, 2007

Results of Bourassa (2006) Compared to SWS2 Observations



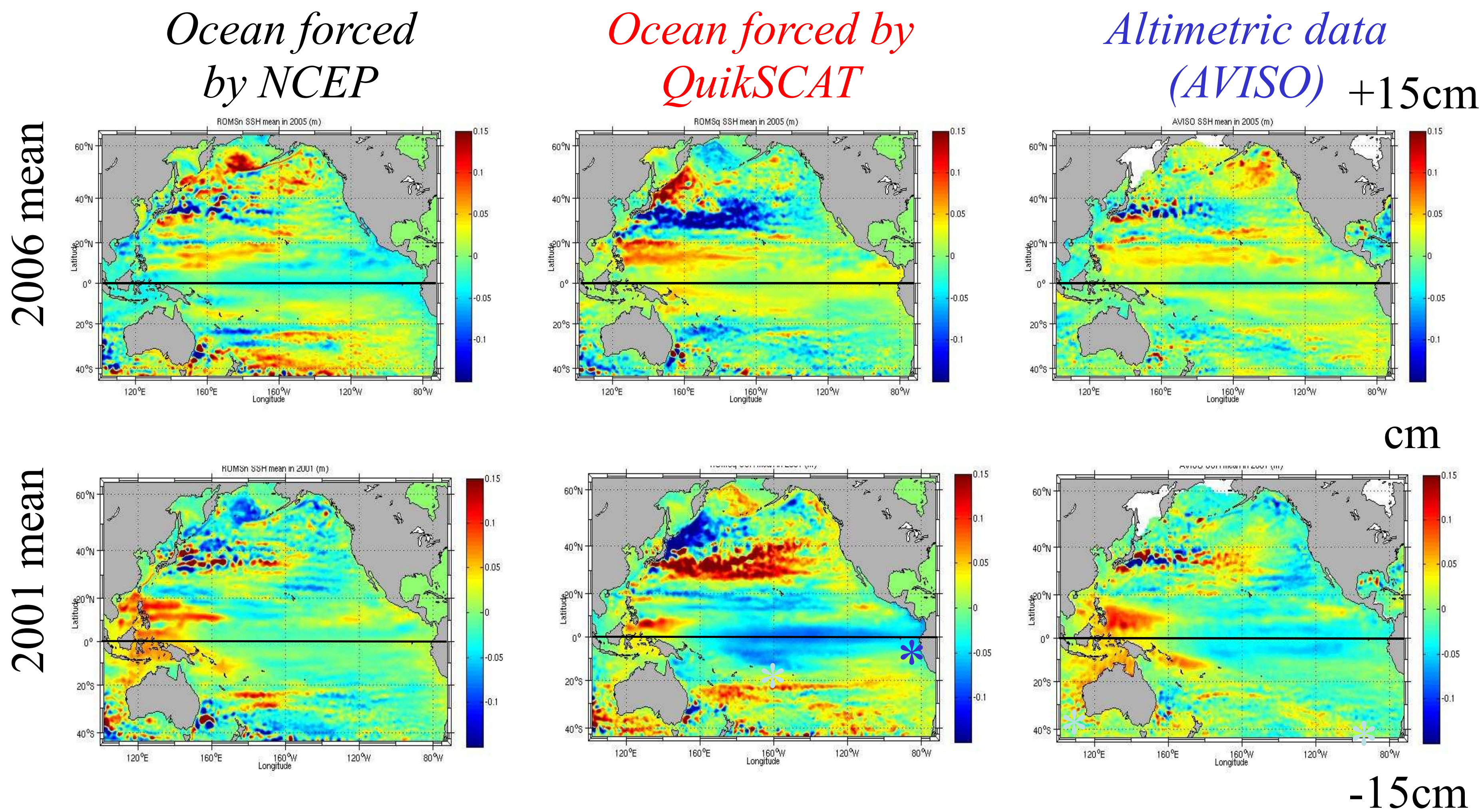
Charnock's constant is actually constant.

Fraction of surface covered by ripples modifies roughness (Plant, JGR 2000).

$$U_{10EN} - u_{current} - 0.8U_{orbital} = \frac{u_*}{k_v}\log\left(\frac{z-0.8H_s}{z_o}\right)$$

$$z_o = \left[\left(\frac{0.019\sigma}{\rho u_*^2}\right)^2 + \left(0.035\frac{u_*^2}{g}\right)^2\right]^{0.5}$$

Year-averaged sea level forced by NCEP or QuikSCAT compared to altimetric data

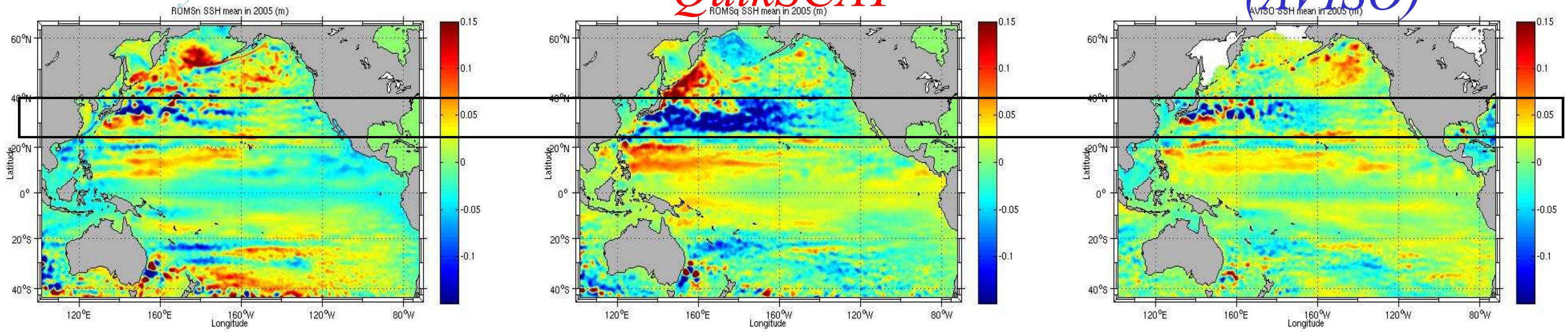


Courtesy Y. Chao

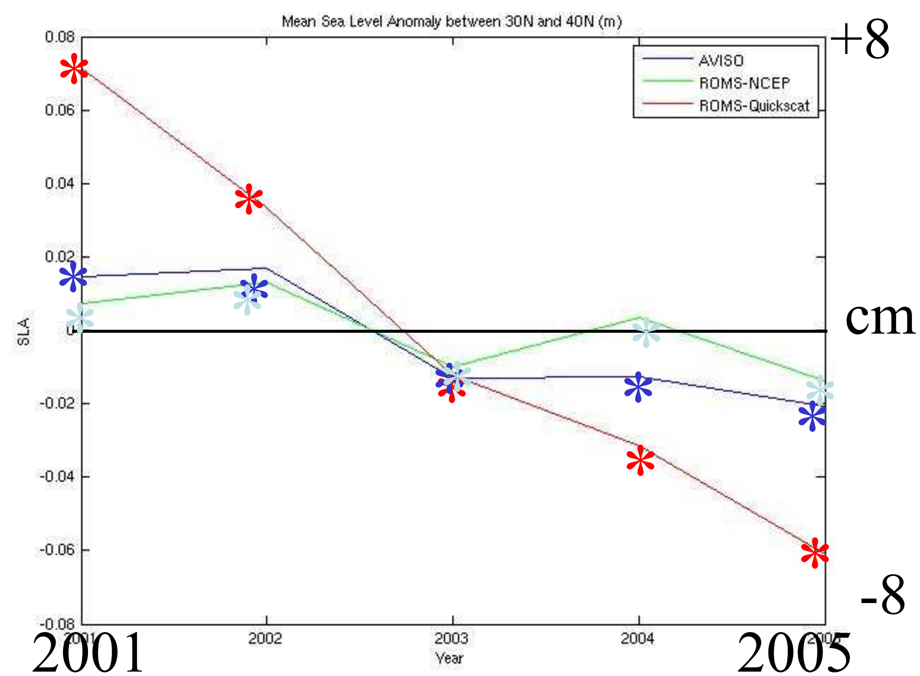
Year-averaged sea level forced by NCEP or QuikSCAT compared to altimetric data

Ocean forced by NCEP *Ocean forced by QuikSCAT* *Altimetric data (AVISO)*

2006 mean



[30ºN-40°N]-averaged Sea Level Anomaly



* SL from Run.NCEP

* SL from Run.QSCAT

* SL from TPJE

How Would We Get Stresses From Scatterometers

Several suggestions were made at the Portland workshop.

- **For regional studies** using high resolution and realistic friction, realistic stresses would be useful:
  - In the short term, a set of drag coefficients will be provided, including the current state of the art.
  - In the long run, a new model function could be developed from direct observations of stress, coupled with estimates determined with wave and current data.

- **For large scale oceanography**, stresses have to be modified to account for the OGCMs spatial scales and parameterization of friction
  - In the short term, we could provide a user input drag coefficient to take into account large scale seasonal modulations of direction and intensity induced by sea surface roughness.
  - In the long term, the effective oceanic stress vectors could be estimated through constraints related to Sea Surface Height.

Short Term Resolvable Issues

- Scatterometer calibrated for winds ($U_{10} < 20ms^{-1}$) are suspect at high wind speeds ($U_{10} > 30ms^{-1}$).
  - Calibrations have been tuned to wind speed rather than equivalent neutral wind speed.
- Density related bias in stress (ρu_*^2) determined from equivalent neutral winds.
  - The density of air is a little greater than 1.0 in the tropics, and can be greater than 1.4 above polar seas.
  - Equivalent neutral winds assume that scatterometers respond to u_* rather then $\tau = \rho u_*^2$
  - This question could be resolved with currently available stress observations

. Training of the GMF can be done for stress and u_* .

Remaining Issues to be solved in the long-term

- Estimating magnitudes and directions for very high winds/stress/sigma0.
- Potentially smaller corrections:
  - Estimating difference between wind and stress azimuthal dependence in the scatterometer model functions.
    - A great deal of stress observations (or good estimates; including wave influences and currents) are needed to address the above issues
  - Determing the ocean stress vectors below the surface drift layer for OGCMs, constraining the large scale stress-driven response in sea surface height from altimetry.