# Wind Stress Working Group

2015 IOVWST Meeting
Portland, OR

Summary of Research Topics, Objectives and Questions

*James B. Edson*

*University of Connecticut*

SPURS Mooring, Farrar, WHOI

# Background

Motivation for the working group can be found in a recent ocean flux remote sensing survey paper by Bourassa et al. (2010 TOS):

- *Recent studies find that scatterometers, and presumably other wind-sensing instruments, respond to stress rather than wind, accounting for variability due to* ***wind, buoyancy, surface currents, waves, and air density****.*
- *The basis for this is that radar backscatter is proportion to surface roughness, and we generally assume that surface roughness is most closely correlated with wind stress, $\tau$.*
- *Wind stress is most closely correlated with the equilalent neutral wind speed (squared) relative to the sea surface, computed at a height of 10-m, $U_{r10N}$.*
- *The relationship between $U_{r10N}$ and $\tau$ given found using a neutral drag coefficient $C_{D10N}$:*

$$\tau = \rho_a \overline{uw} \cong \rho_a C_{D10N} \left|\vec{U}_{r10N}\right| \vec{U}_{r10N} \quad \Rightarrow \quad C_{D10N} = \left( \frac{\kappa}{\ln(z/z_0)} \right)^2$$

- *Therefore, the stress can be estimated from scatterometer-derived winds through a drag coefficient without the need for stability corrections.*

# Stress will be nominate as an Essential Climate Variable

Ocean Observation Panel for Climate update by Mark Bourassa

# What Qualifies as an EOV or ECV?

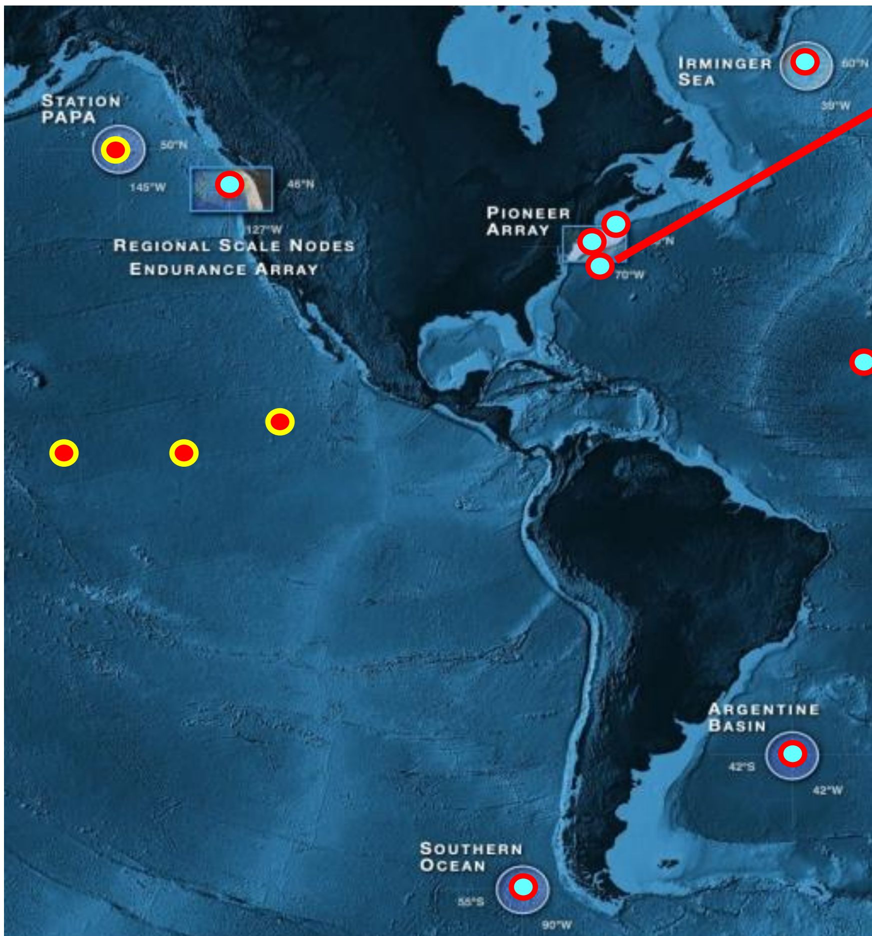
- ECV = Essential Climate Variable
- EOV = Essentail Ocean Variable

- Essential variables have the following characteristics
  - Relevance: Important for monitoring the variability of the ocean (or the climate system for ECVs)
  - Feasible: Technically able to measure at sufficient accuracy
  - Cost Effective: able to support the cost of the observations

- Feasibility and Cost Effectiveness are also critical to get 'buy in' from funders of the observing system  (not just Relevance)
- Furthermore, the goal is to measure a few carefully selected variables very well, rather than try to measure every variable that is relevant to climate

# Preliminary Objectives

- Improved estimates of wind stress derived from scatterometer estimates of the equivalent neutral wind via a WSWG recommended drag coefficient.
- Investigate the need for more direct estimates of wind stress from scatterometer measurements of backscatter: $\vec{\tau} = f(\vec{\sigma}_0, \ldots)$

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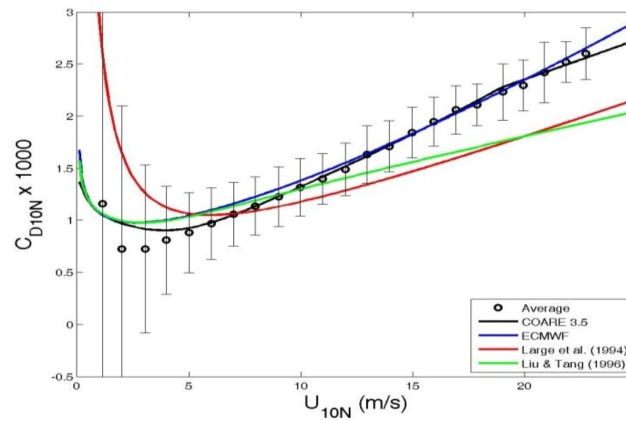


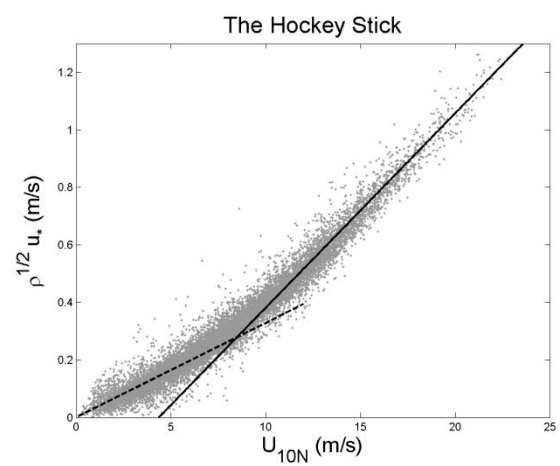

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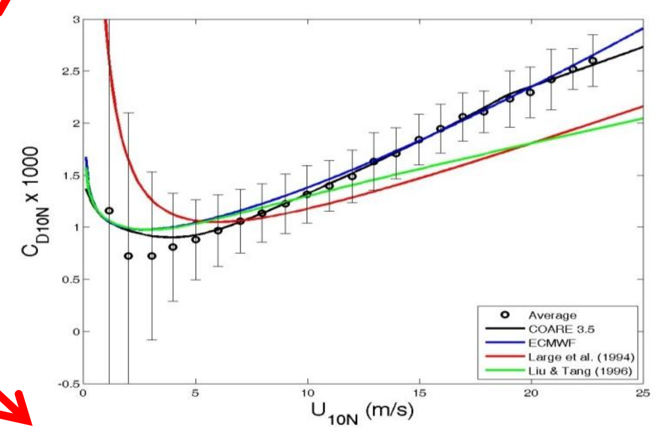


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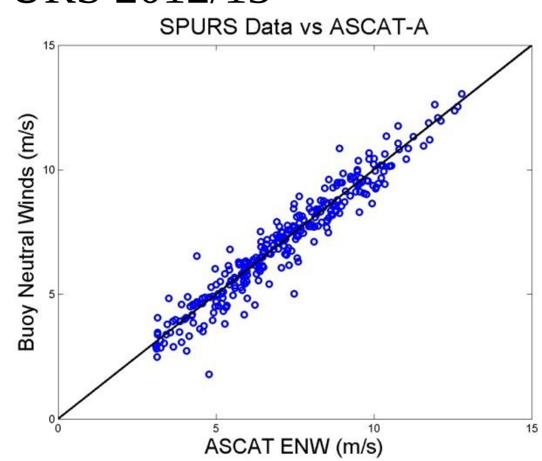

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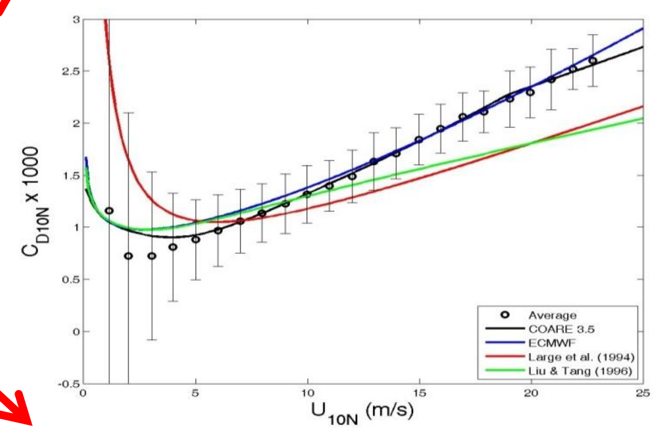


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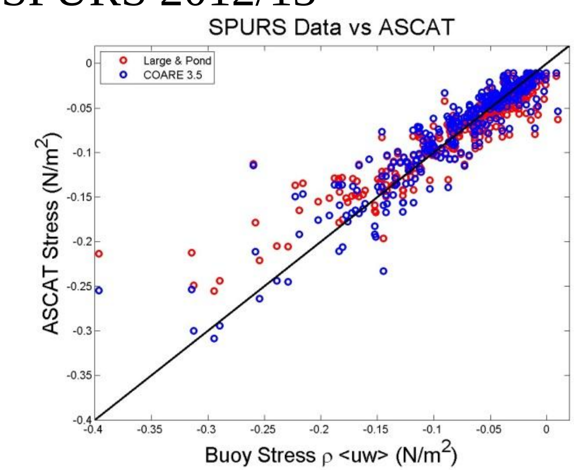

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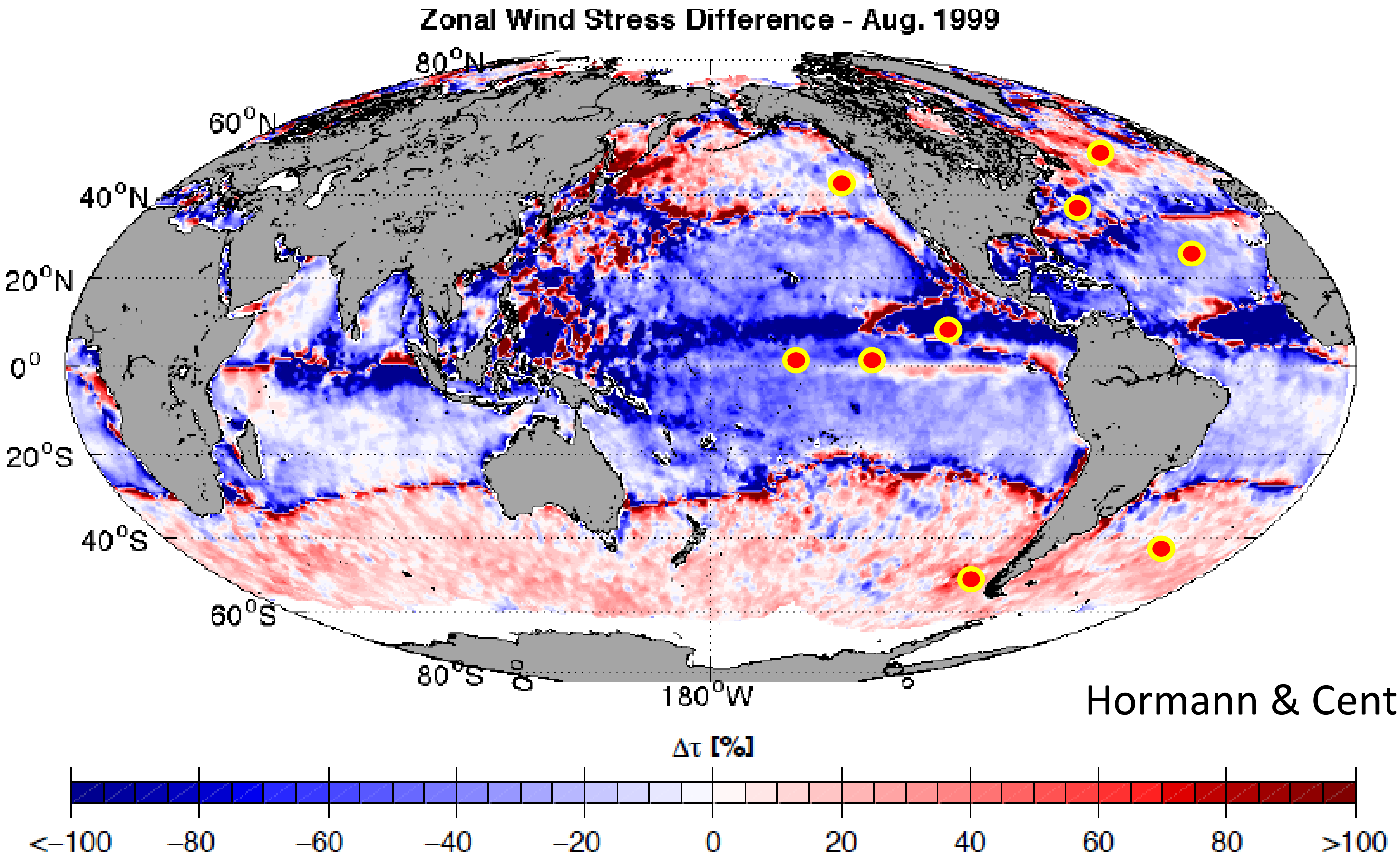
**COARE3.5 w/ ECMWF – QSCAT w/ L&P**



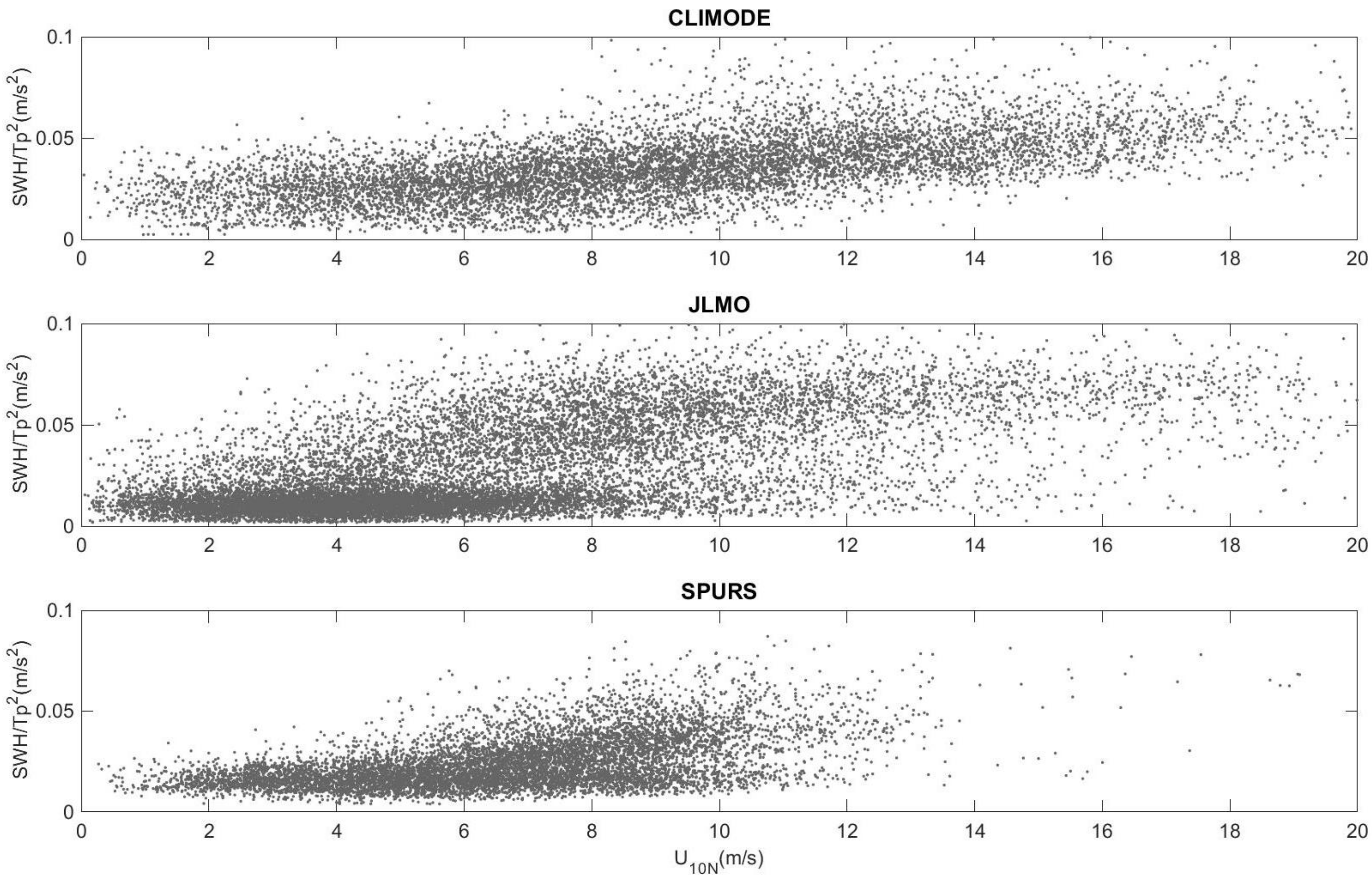

Hormann & Centurioni

# **DCFS Combined Datasets –** Expanded Wave Conditions

CLIMODE

Coastal NE
- bifurcation in steepness

SPURS I
N. Atlantic 24 N



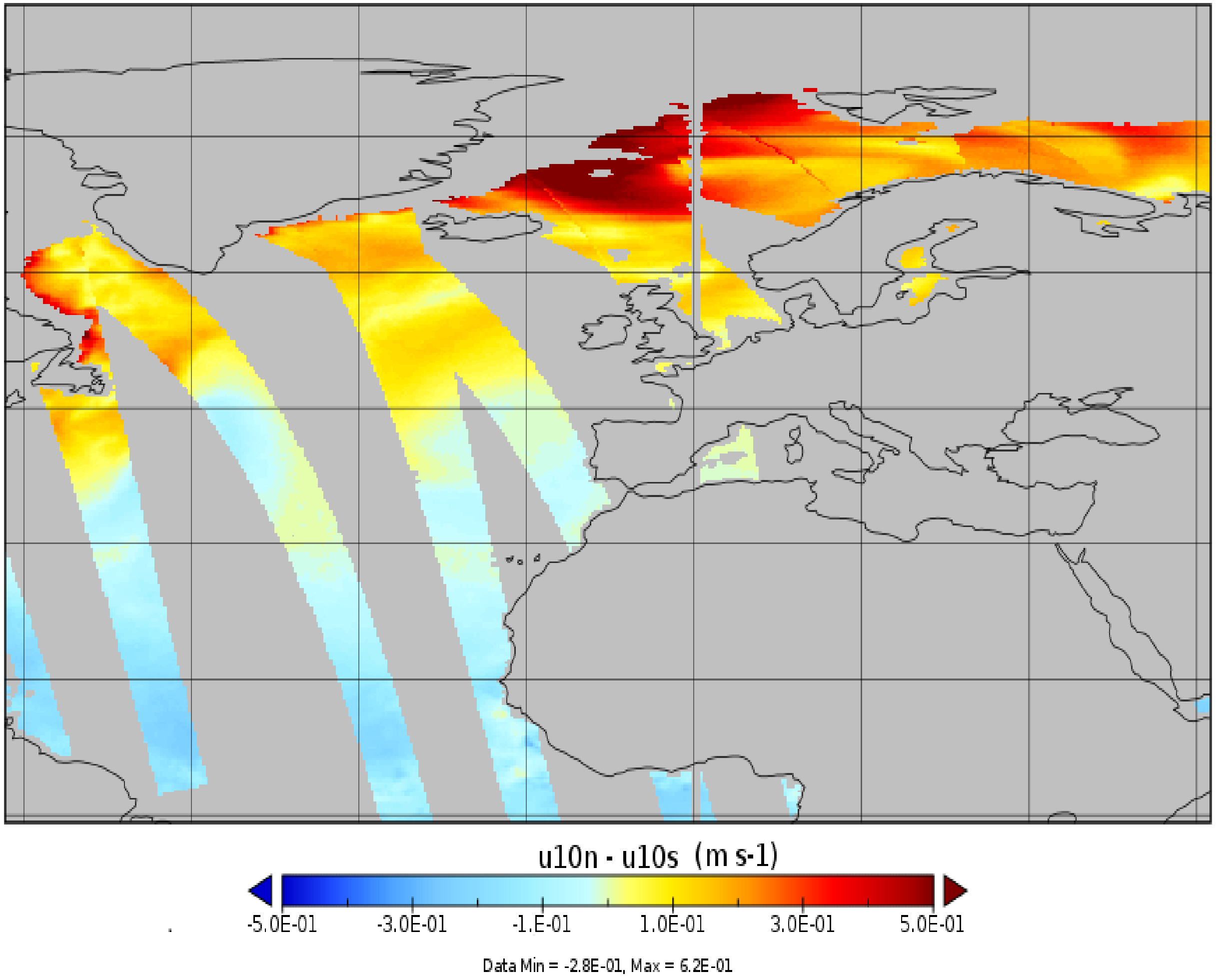
# Stress-equivalent Winds, U10S

Equivalent neutral winds, $\boldsymbol{u}_{\mathrm{r10N}}$ , depend only on $\boldsymbol{u}_*$ , surface roughness and the presence of ocean currents and were used for backscatter geophysical model functions (GMFs)

Stress-equivalent wind is a better input for backscatter GMFs:

$$u_{r10N} = \sqrt{\frac{<\rho_a>}{\rho_a}}\, u_{r10S}$$

Implemented in MyO FO v5 and under evaluation in the IOVWST



# Active Whitecap Coverage Estimates
## Directly from QuikSCAT L1B $\sigma^0$ Measurements

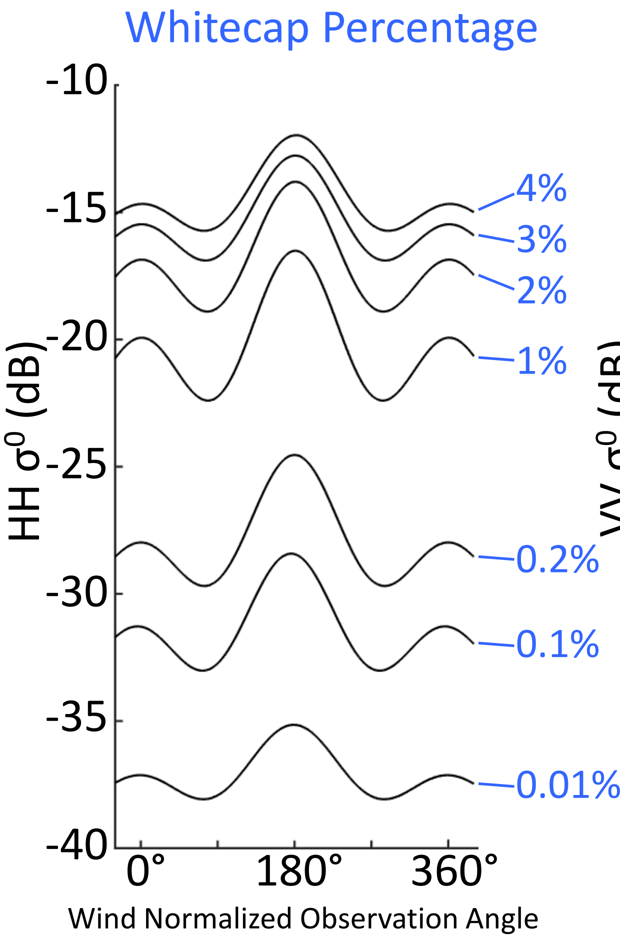
Aaron C. Paget, Ph.D.
BYU - MERS Laboratory

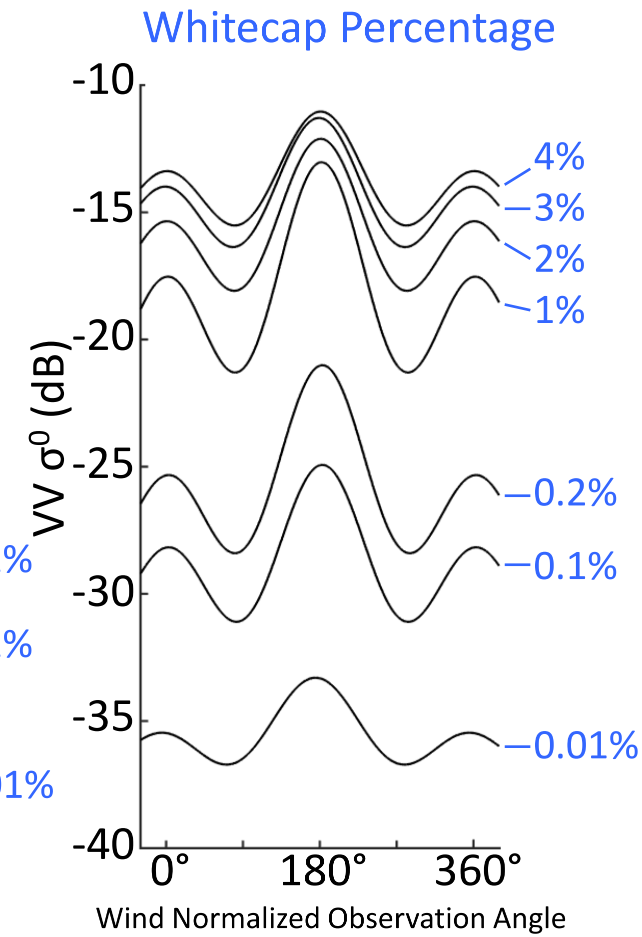
Whitecaps (W) are part of the reported scatterometer signal. We can estimate of W with L1B $\sigma^0$.

- Traditional: $\sigma^0$ -> wind GMF -> Wind -> Whitecap Parameterization -> Whitecap Estimate
- New Approach: $\sigma^0$ -> whitecap GMF -> Whitecap Estimate

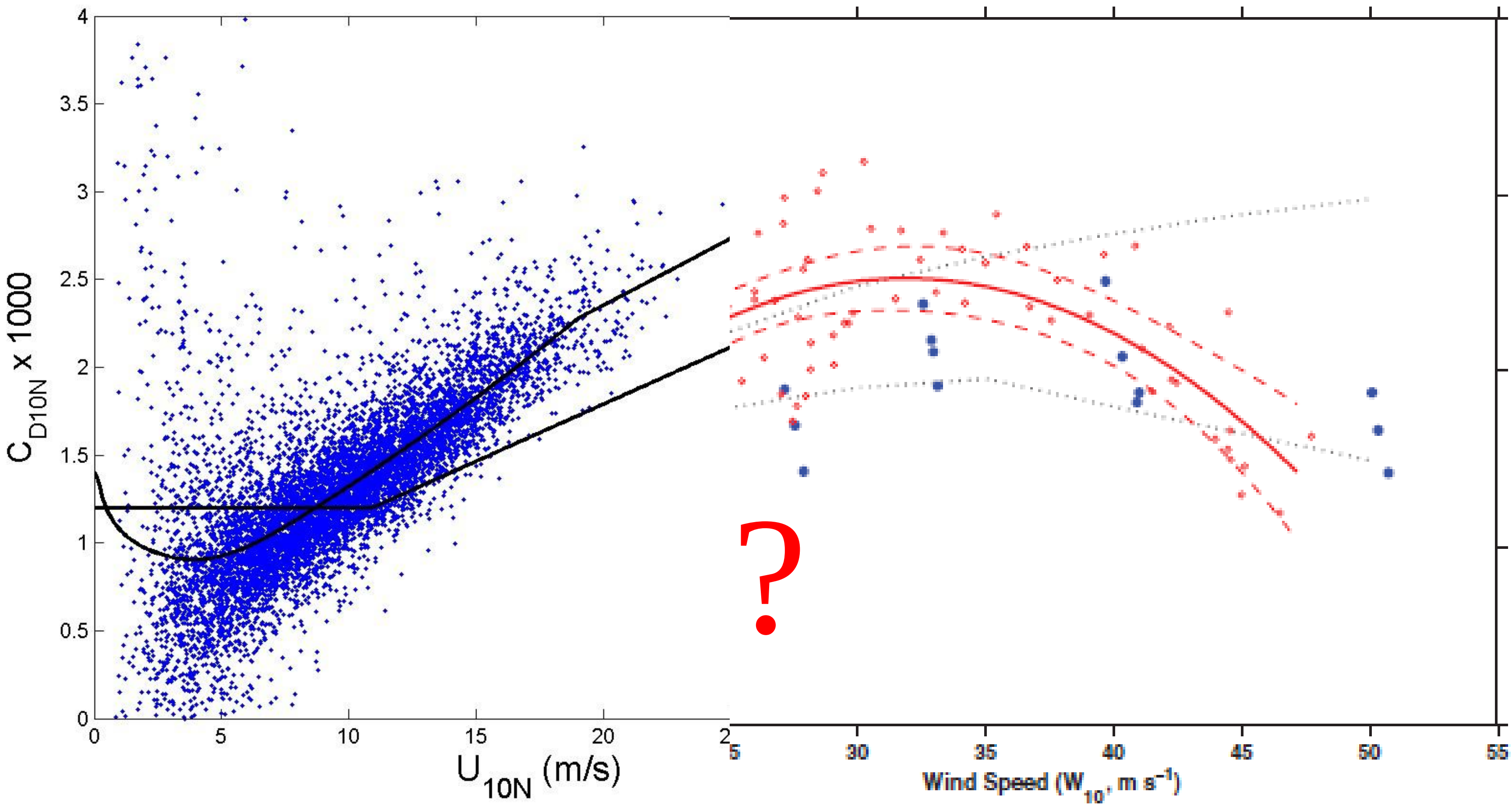
Details

- The traditional approach propagates estimation errors
- New approach bypasses determining the wind speed and estimates W directly
- Whitecap GMF only requires input from data available in the L1B QuikSCAT recorded
- The signal strength varies azimuthally with respect to wind direction
- Preliminary results identify potential for reducing whitecap estimate uncertainties



# Surface Stress and Roughness at High Winds




Refinement of DC Stress Measurements

How do we quantify the behavior at High Winds?

# Summary of Research Issues

The following issues have all been considered by the IOVWSTs. The IOVWSTs have a good handle on some of them and significant disagreement or overall lack of understanding exists with other.

- Shorter wind-waves matter as they support a significant fraction of the surface stress and provide the roughness elements for scatterometers.
- Surface stress is an essential variable as it drives these wind-waves.
  - Stability matters as it modulates the momentum flux
  - Air-density matters as it is a key component of the momentum flux $\vec{\tau} = \rho_a \overline{uw}$
  - Sea-surface temperature, viscosity and tension matter as they govern the surface stress
- Questions addressed in the following talks:
  - What is the behavior of the surface stress and roughness at extreme winds (> 20 m/s)?
  - What is the role of longer waves on surface stress modulation and the geometry of the sea surface seen by scatterometers and radiometers?
  - How does variability across the flux and radar footprints matter in all of the above variables affect wind retrievals?

# Summary of Session – So Far

- Questions addressed in the following talks:
  - What is the behavior of the surface stress and roughness at extreme winds (> 20 m/s)?
    - Interpretation of dropwinsonde data remains an issue, e.g., an approach that utilized a displacement height was presented to estimate both $u_*$ and $U_{10N}$.
    - An approach that utilized Scatterometer data alone with previous parameterizations was presented, which provided reasonable drag coefficients at exteme winds.
    - **An Extreme Wind Workshop to discuss these and other options is warranted.**
  - How do we consistently address air density in satellite wind retrievals?
    - Measurements do show an effect but its not consistent across platforms and products.
    - **There is a need to determine how the GMF (reference wind) for the various products are trained and it would be useful to identify a POC for each product to help sort out the dependence on density, SST and viscosity.**
  - What is the role of longer waves on surface stress modulation and the geometry of the sea surface seen by scatterometers and radiometers?
    - Some dependence of the drag coefficient on surface slope of longer waves has been seen for wind speeds below ~ 7 m/s.
    - The satellite wind products show good agreement with buoy measurements in high-wind, fetch-limited conditions except very near the coast.
  - What groups are producing stress products?
    - **Came we develop and recommend a consensus drag coefficient for stress retrievals (including extreme winds)?**
  - How does variability across the flux and radar footprints matter in all of the above variables affect wind retrievals?

# Time for Talks