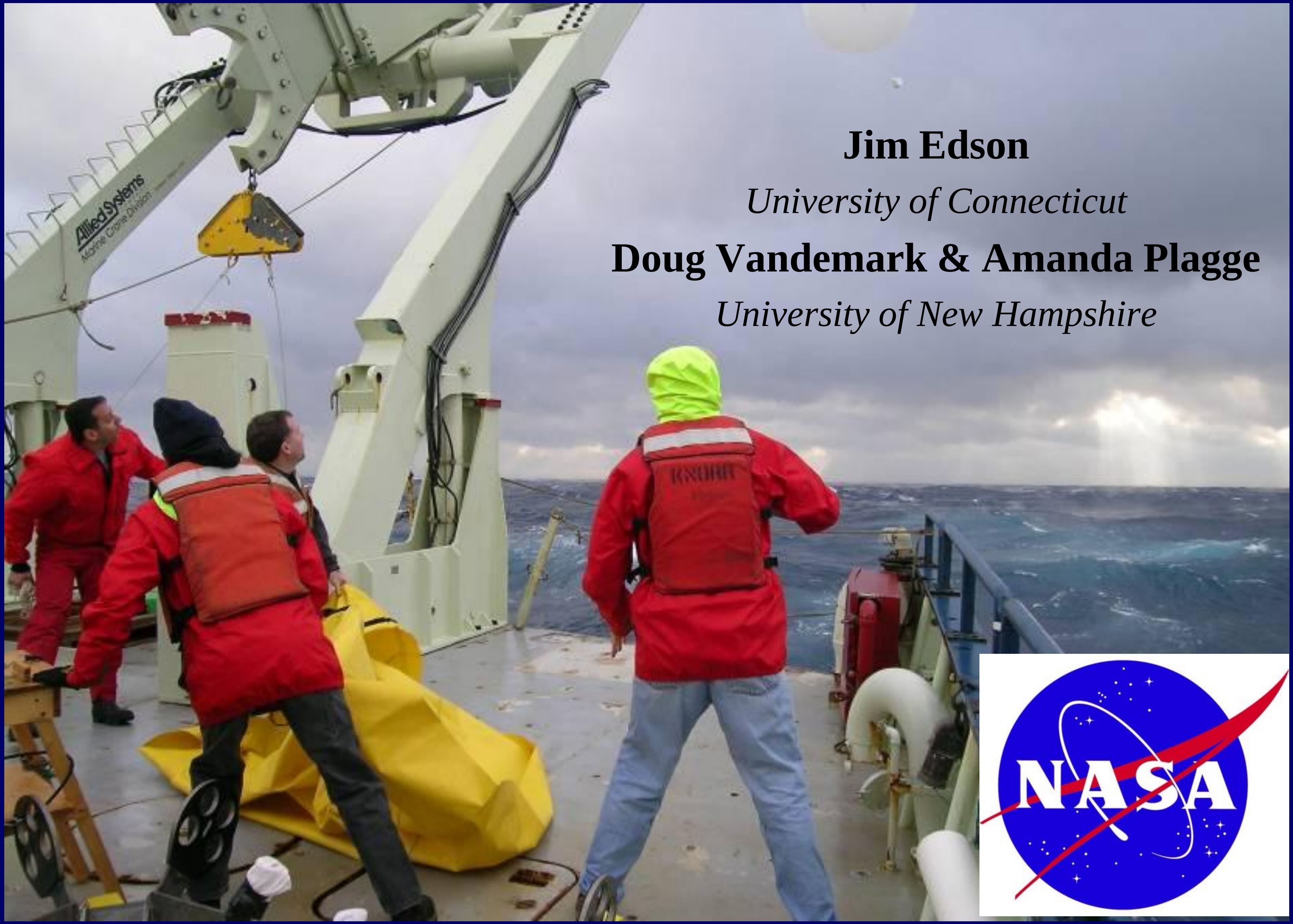
The Response of Surface Winds, Wind Stress and Pressure to SST Variability on Monthly to Seasonal Time Scales



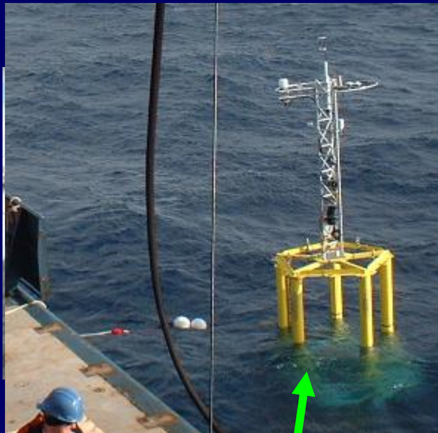
Jim Edson

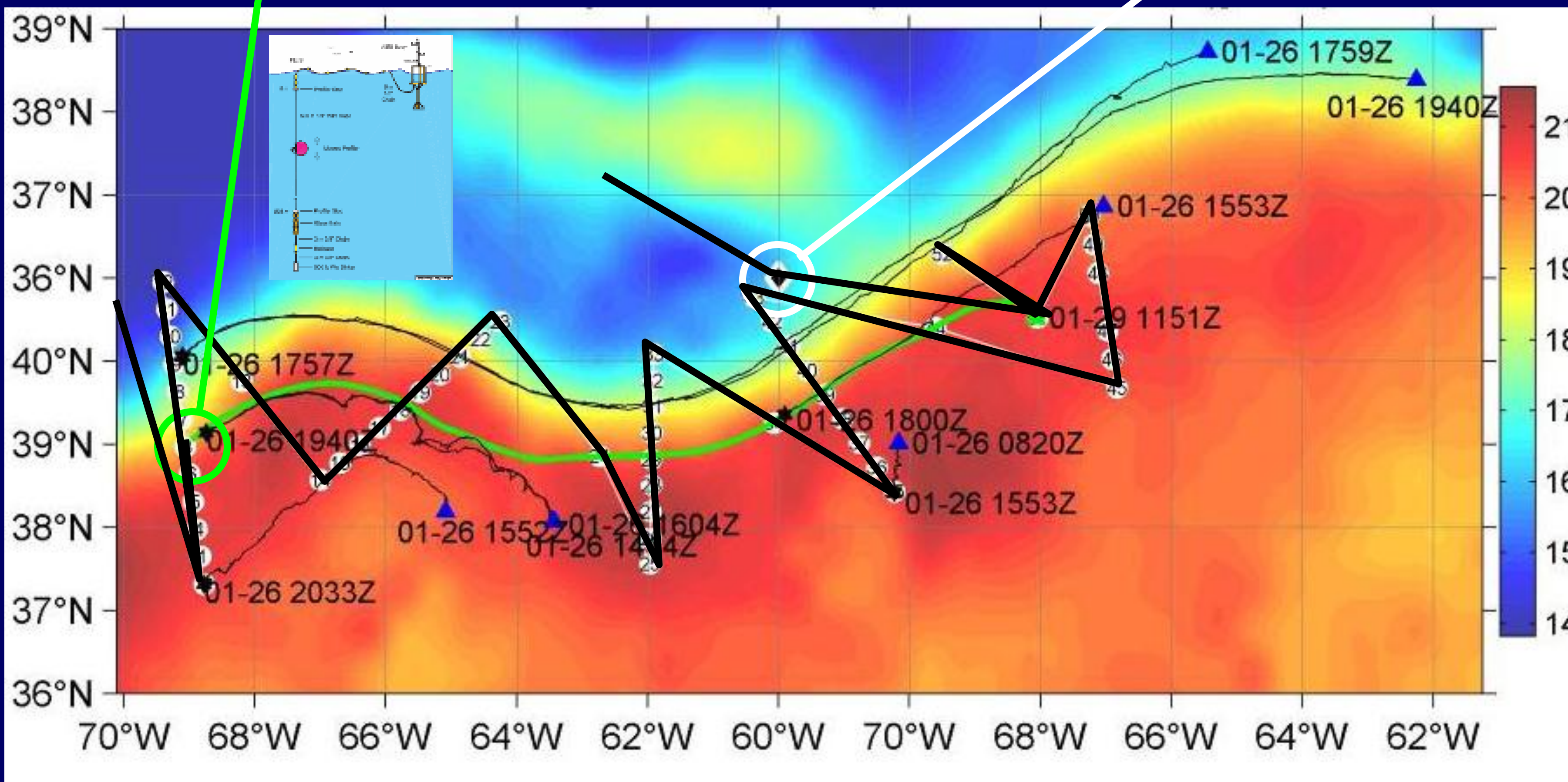
University of Connecticut

Doug Vandemark & Amanda Plagge

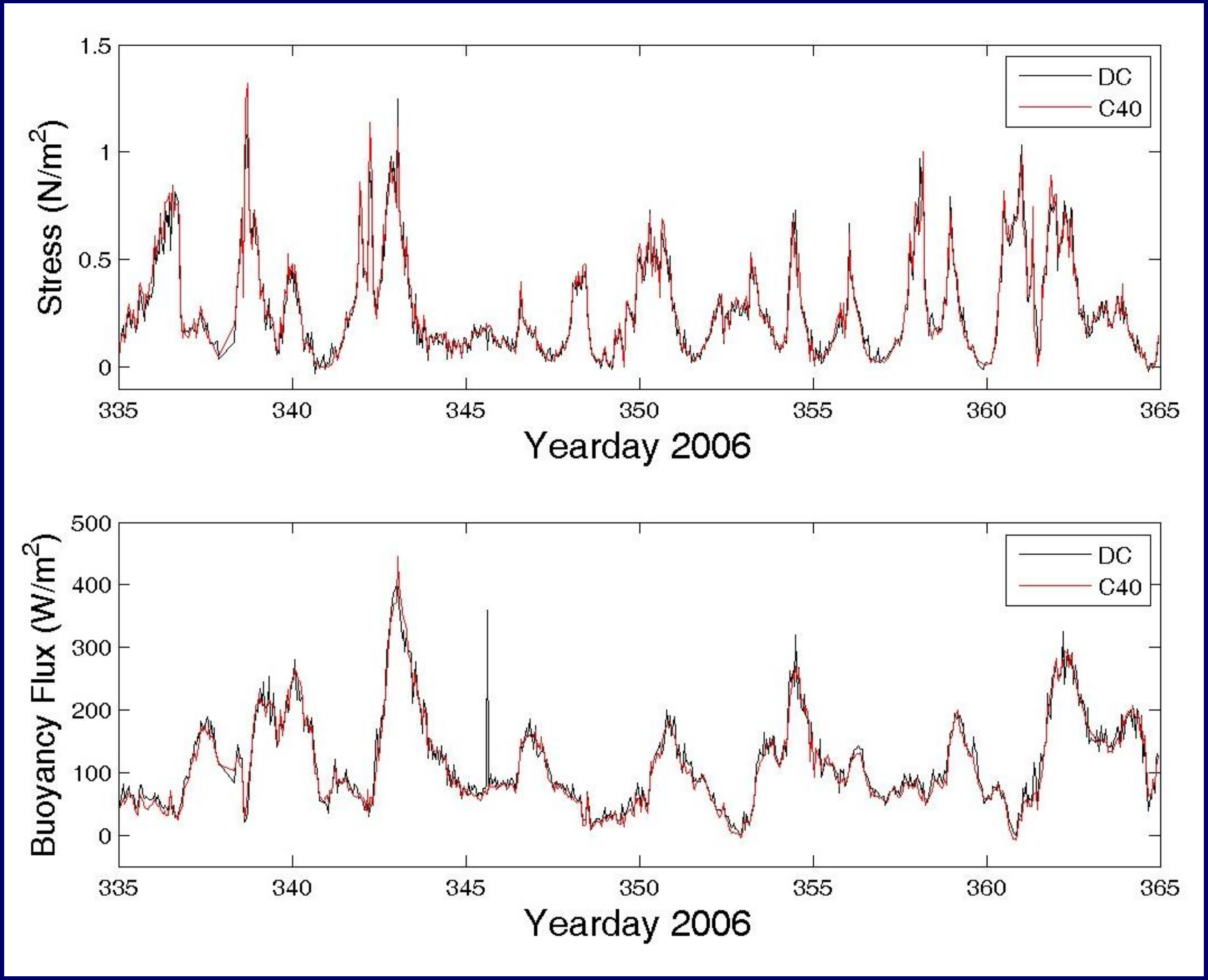
University of New Hampshire

CLIMODE Platforms





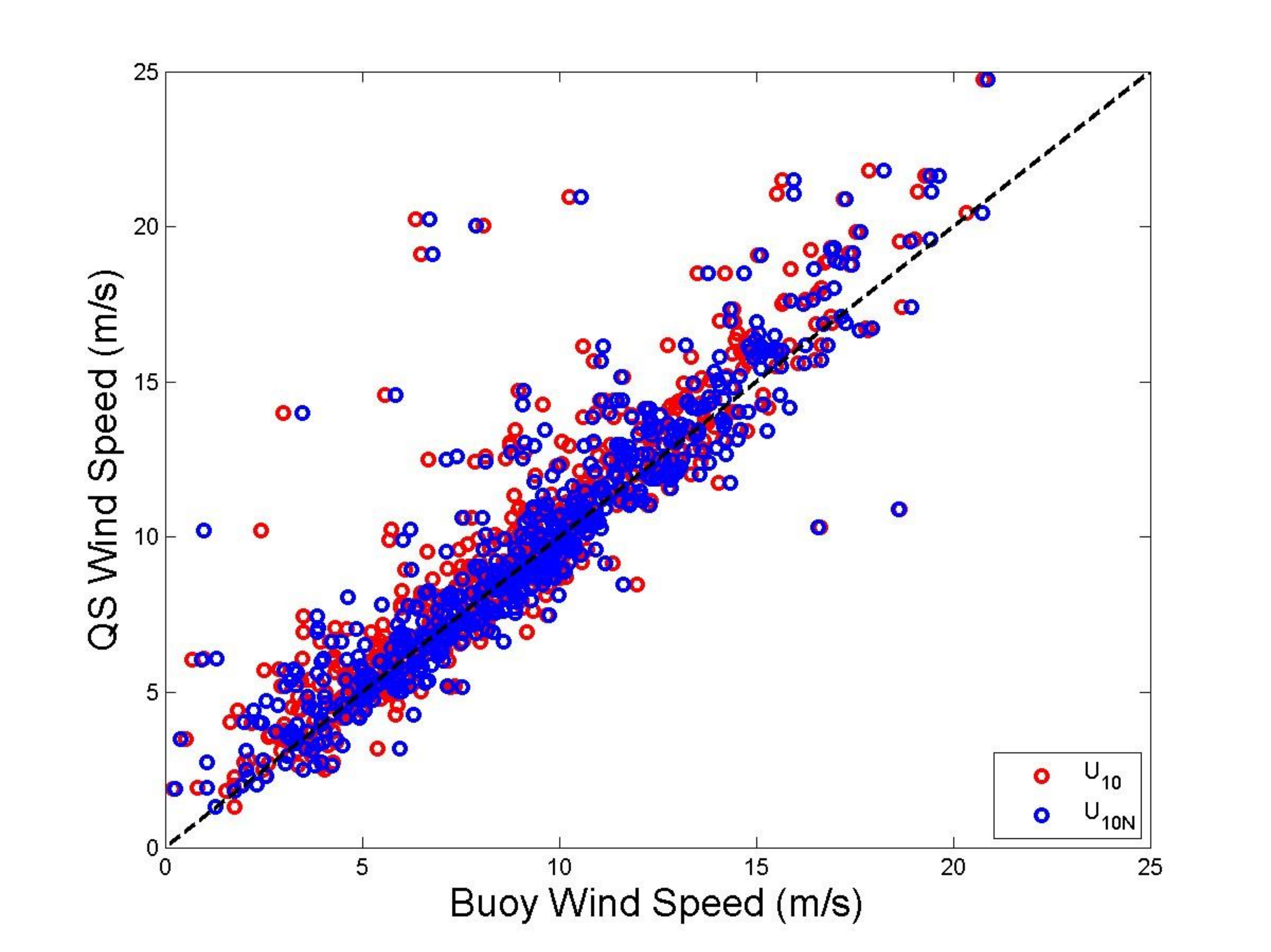
Flux Time Series



Stability/Baroclinic Effects Near SST Fronts

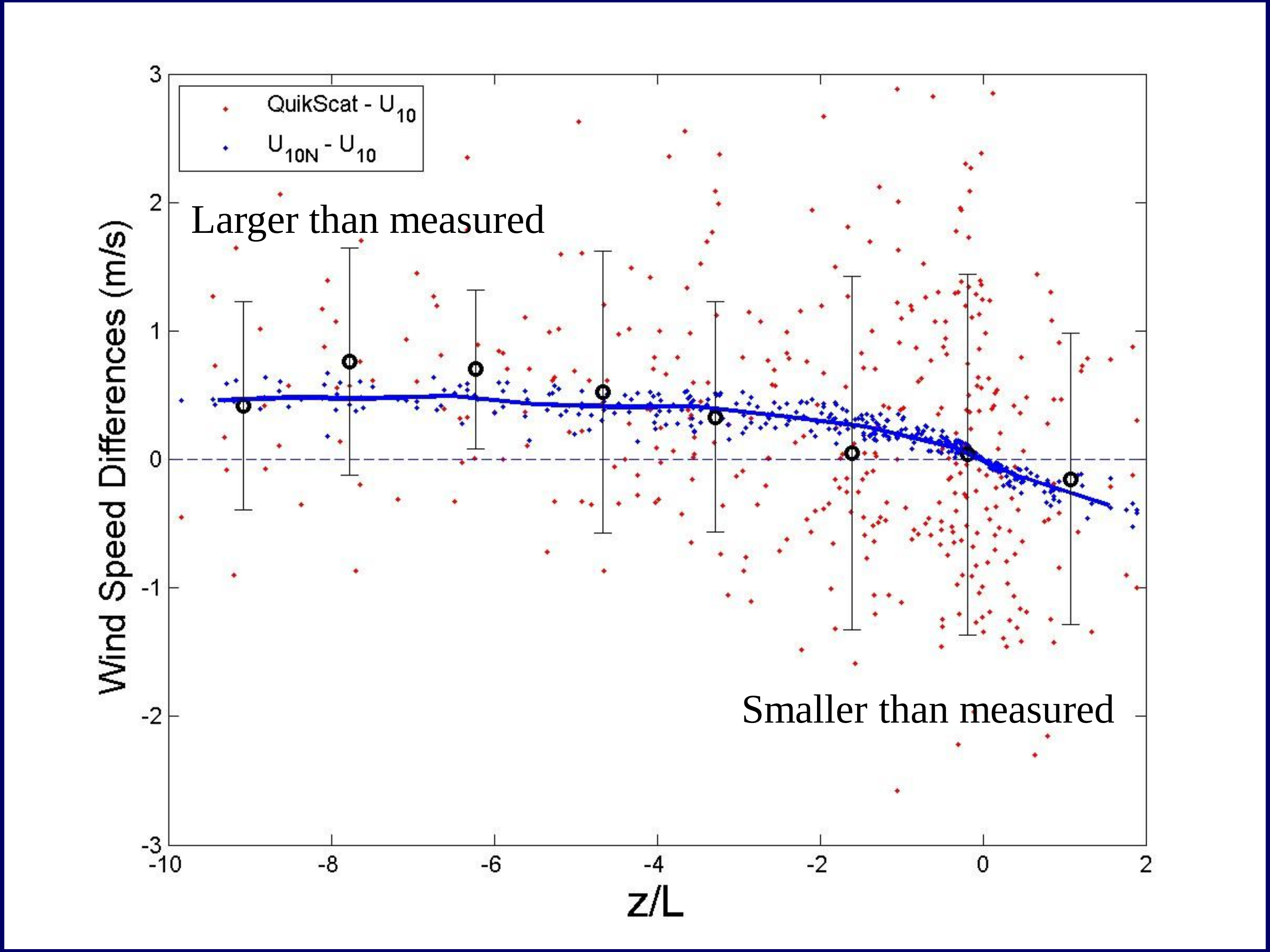
- Coupling Coefficient $\Delta U = \alpha_v \Delta T_{sea}$ with higher winds over warmer and lower winds over cooler SST.
- Surface Layer Adjustment
  - QuikSCAT measures surface roughness/stress
  - Surface stress is proportional to neutral winds, U_N
  - MO similarity predicts:
    - $U_N < U$ in unstable conditions
    - $U_N > U$ in stable conditions
- Boundary Layer Adjustment
  - Acceleration/deceleration of surface winds.
  - Enhancement of vertical mixing due to cool-air advection over warmer water that mixes down larger momentum from aloft.
  - Pressure perturbations driven by the adjustment of air temperature and humidity to the underlying SST.
  - Both!

QuikSCAT vs. Buoy Wind Speeds



QuikSCAT vs. Buoy Wind Speeds

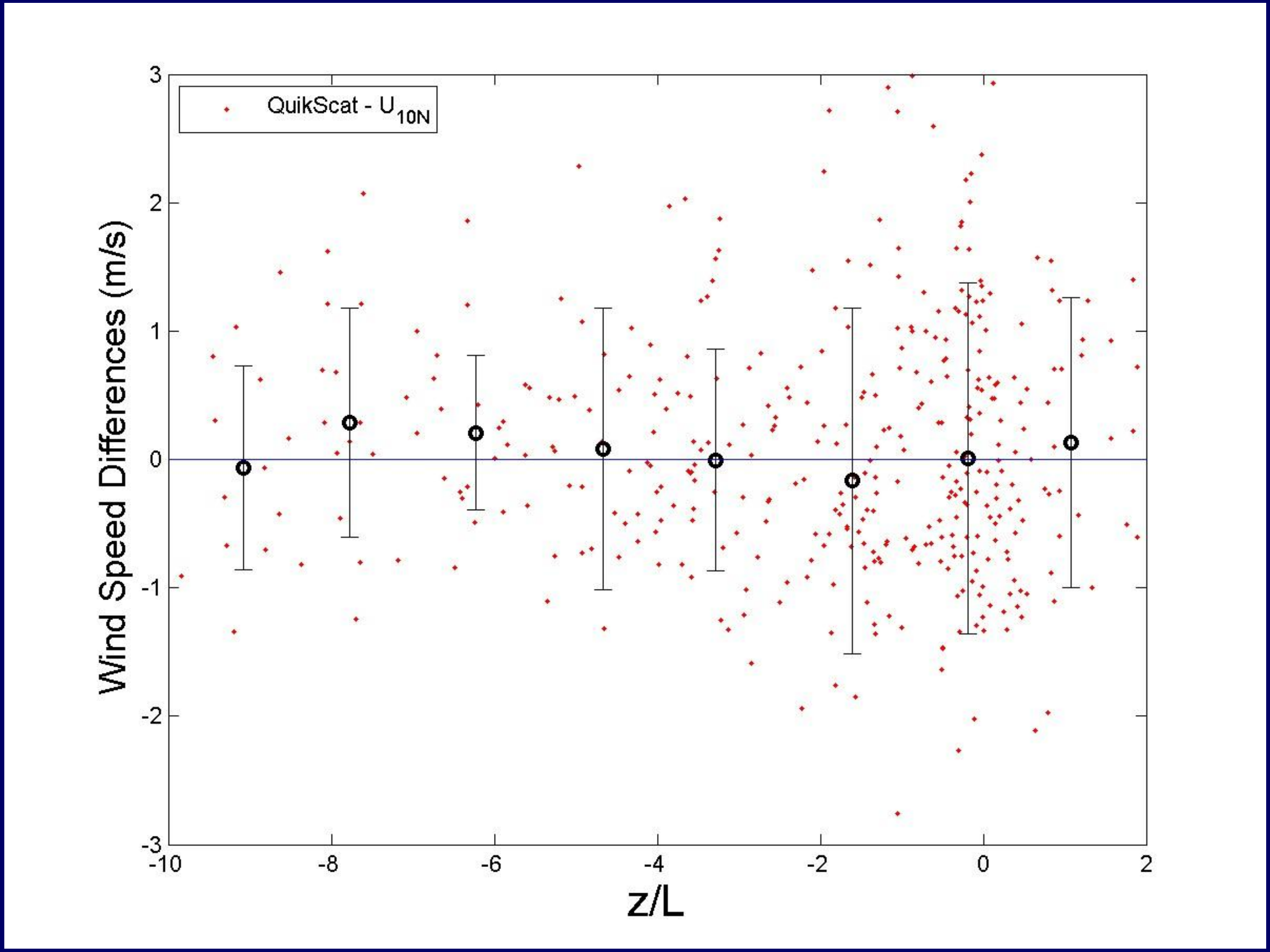
“Surface Layer Adjustment”



$U(z) = u_*/\kappa[\ln(z/z_o) - \psi_m(z/L)]$ $U_N(z) = u_*/\kappa[\ln(z/z_o)]$

QuikSCAT vs. Buoy Wind Speeds

"Surface Layer Adjustment"



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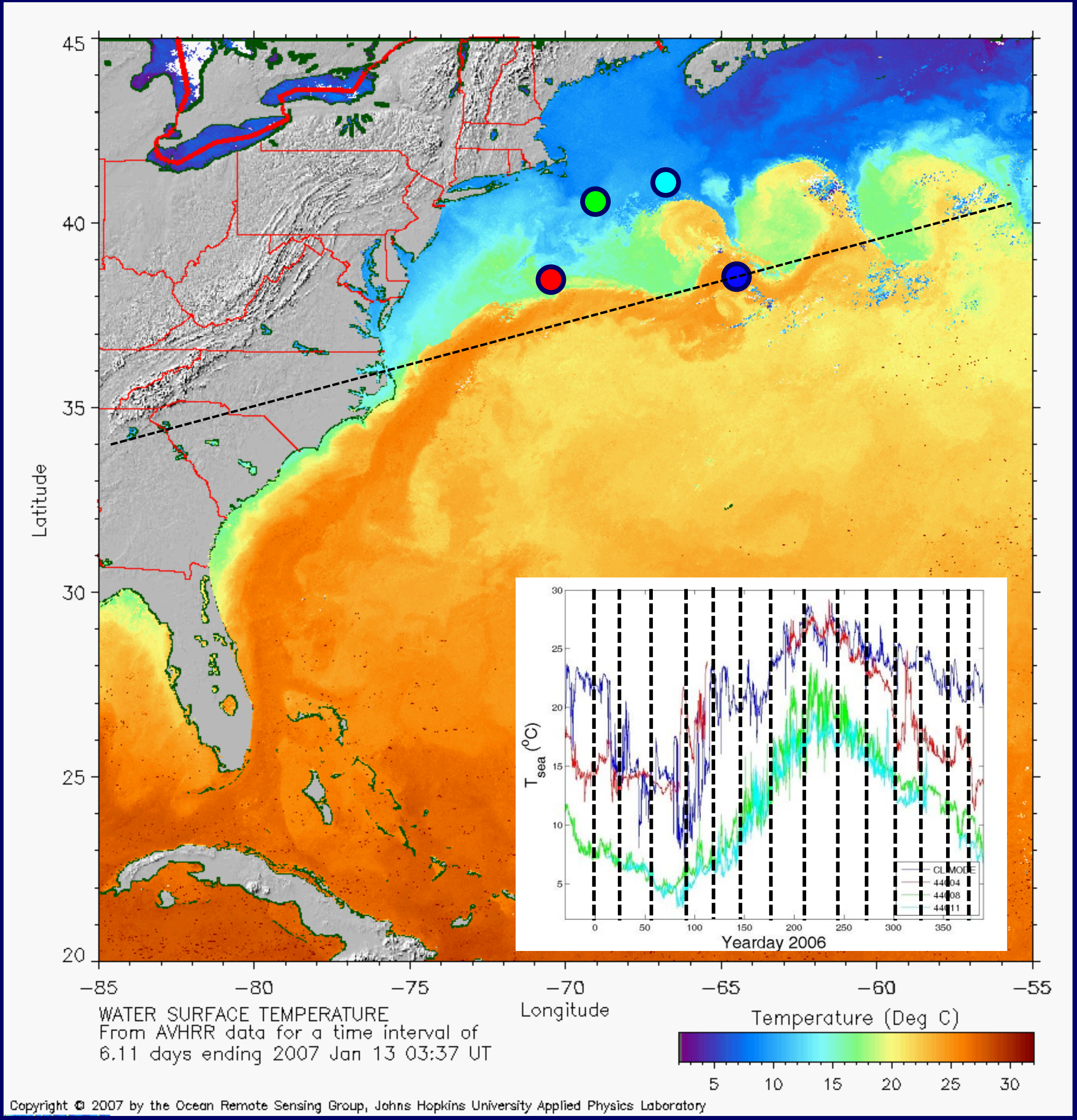
Buoy-Pair Approach

$$\Delta U = \alpha_v \Delta T_{sea}$$

O'Neill (2012)



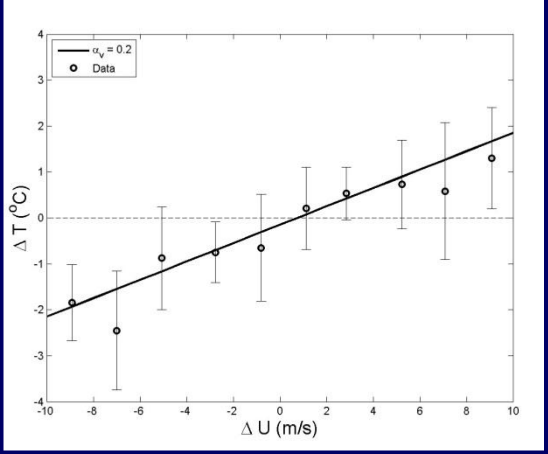


Image courtesy of JHU/APL

Single Buoy Approach

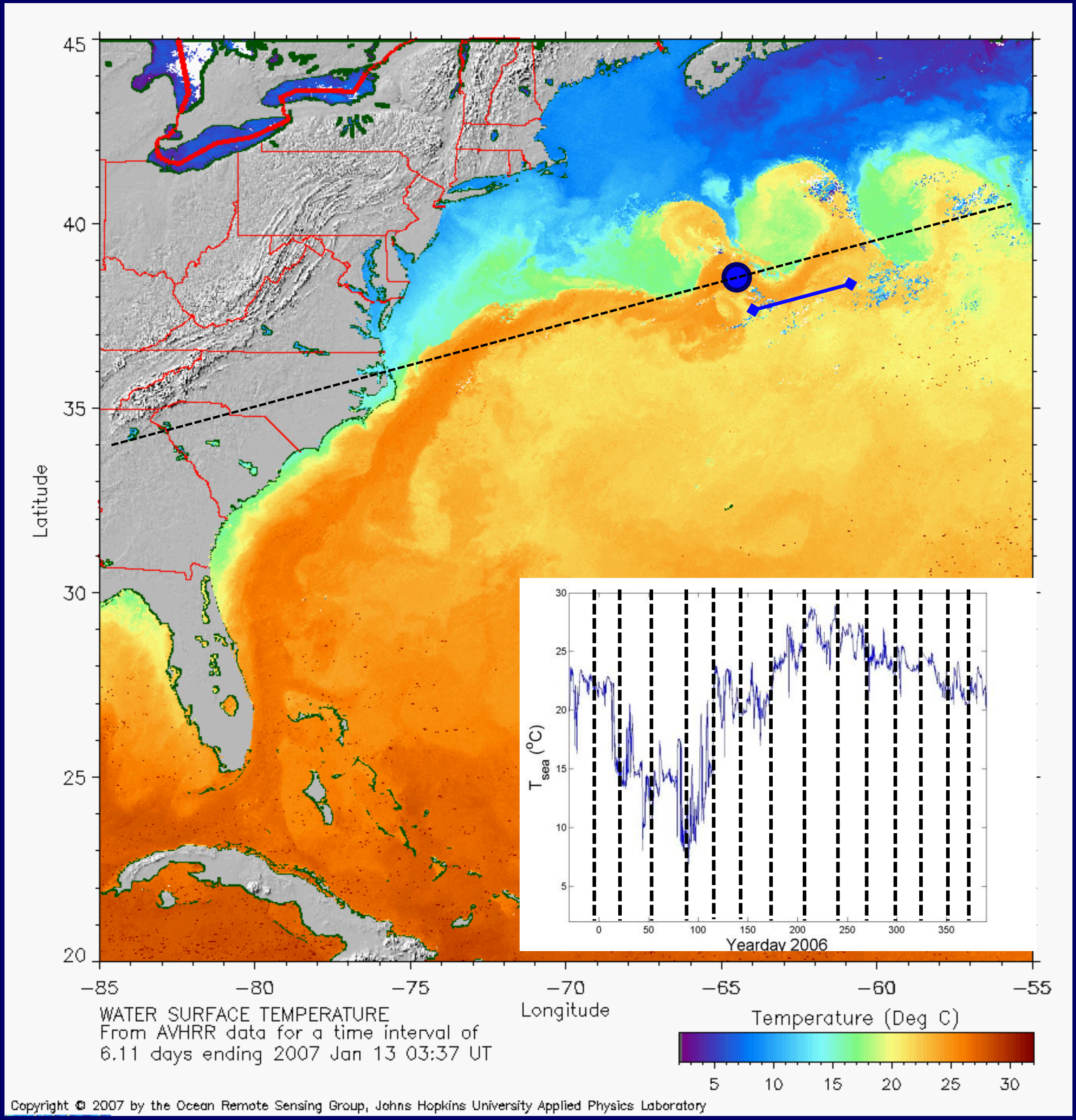


Image courtesy of JHU/APL

$$\Delta U = \alpha_v \Delta T_{sea}$$

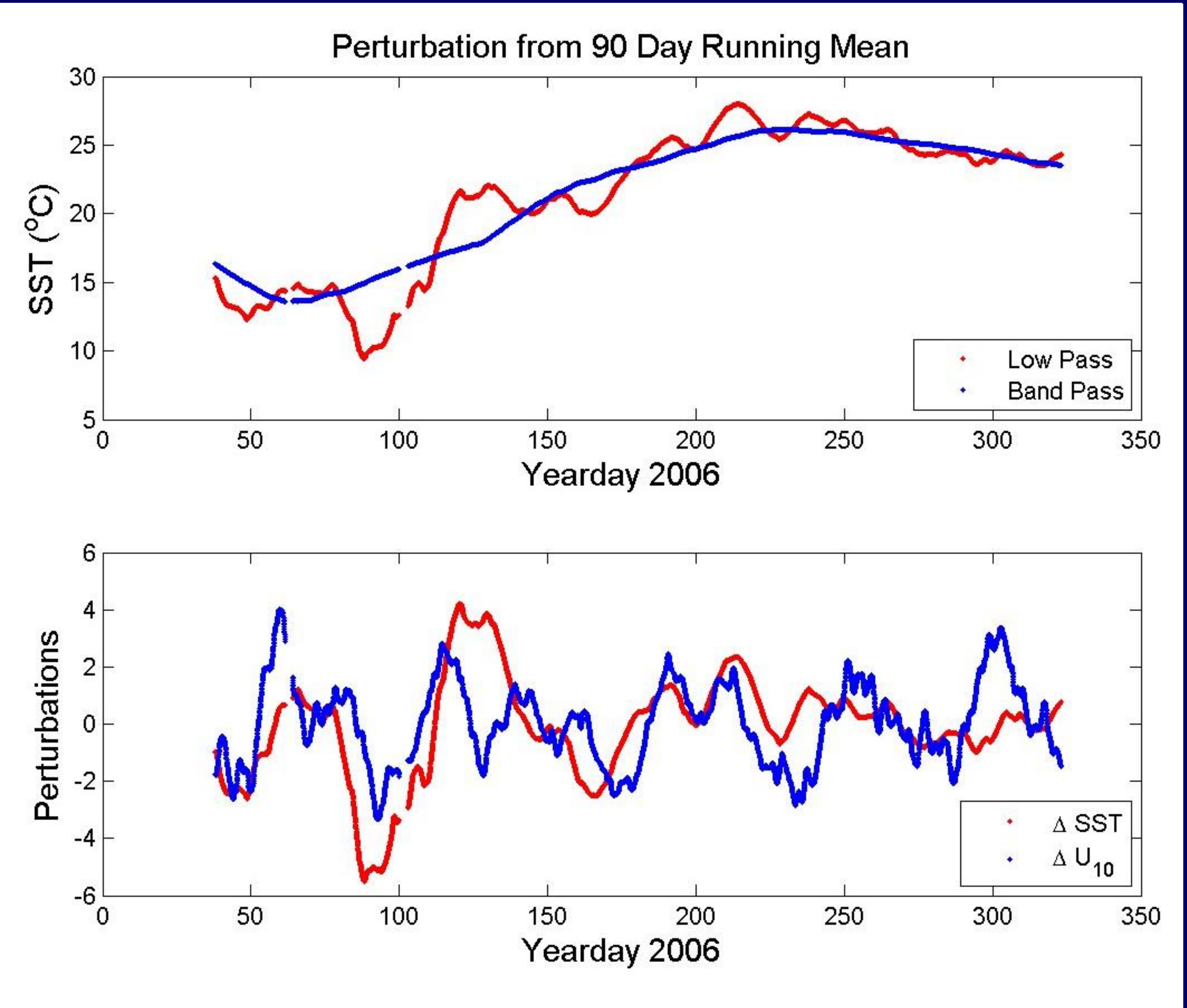
Halliwell & Mooers (1983)

Gulf Stream Meanders

Wavelength 200-400 km

Phase speed 5-10 cm/s

Single Buoy Approach



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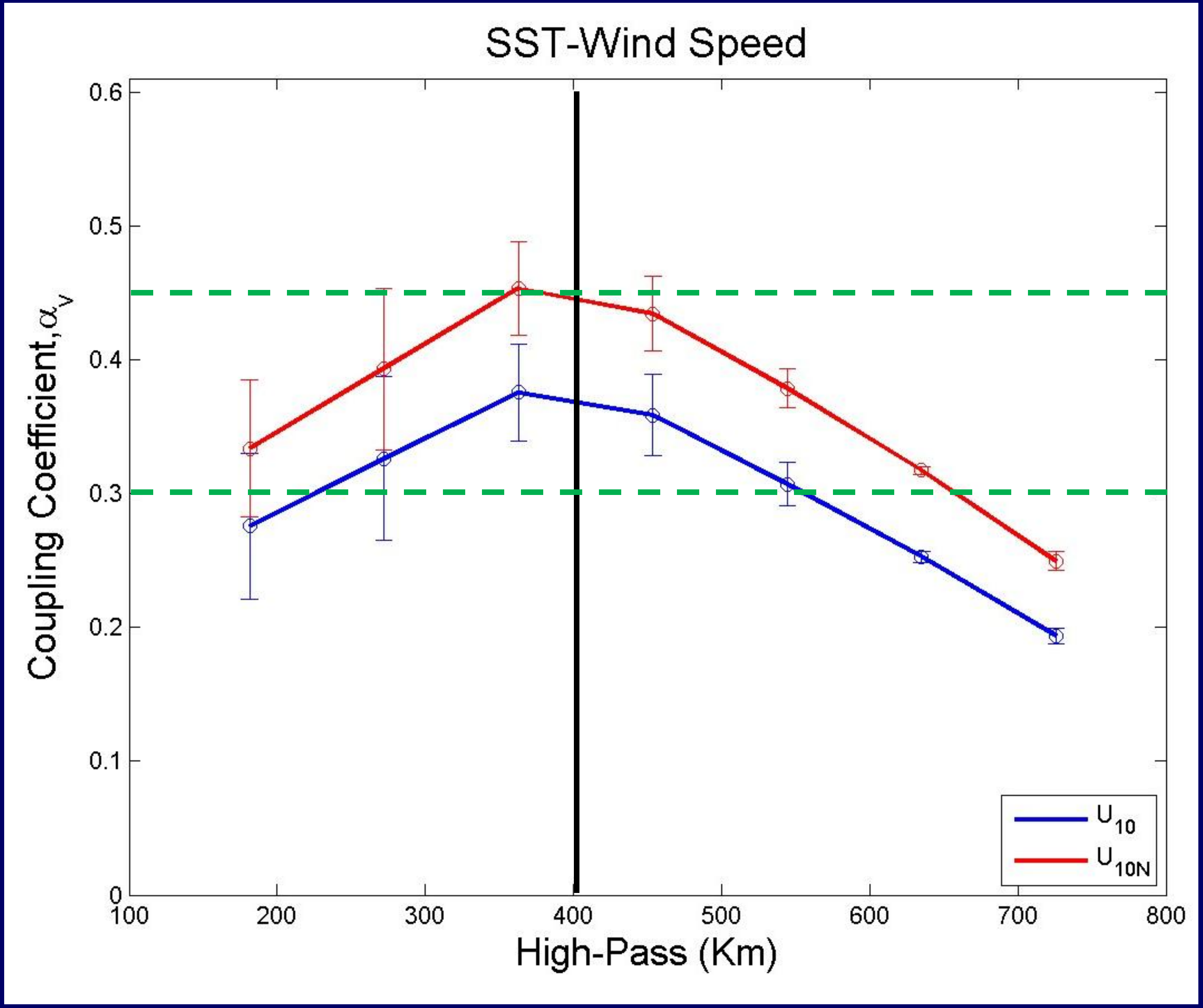

Halliwell & Mooers (1983)

Gulf Stream Meanders

Wavelength 200-400 km

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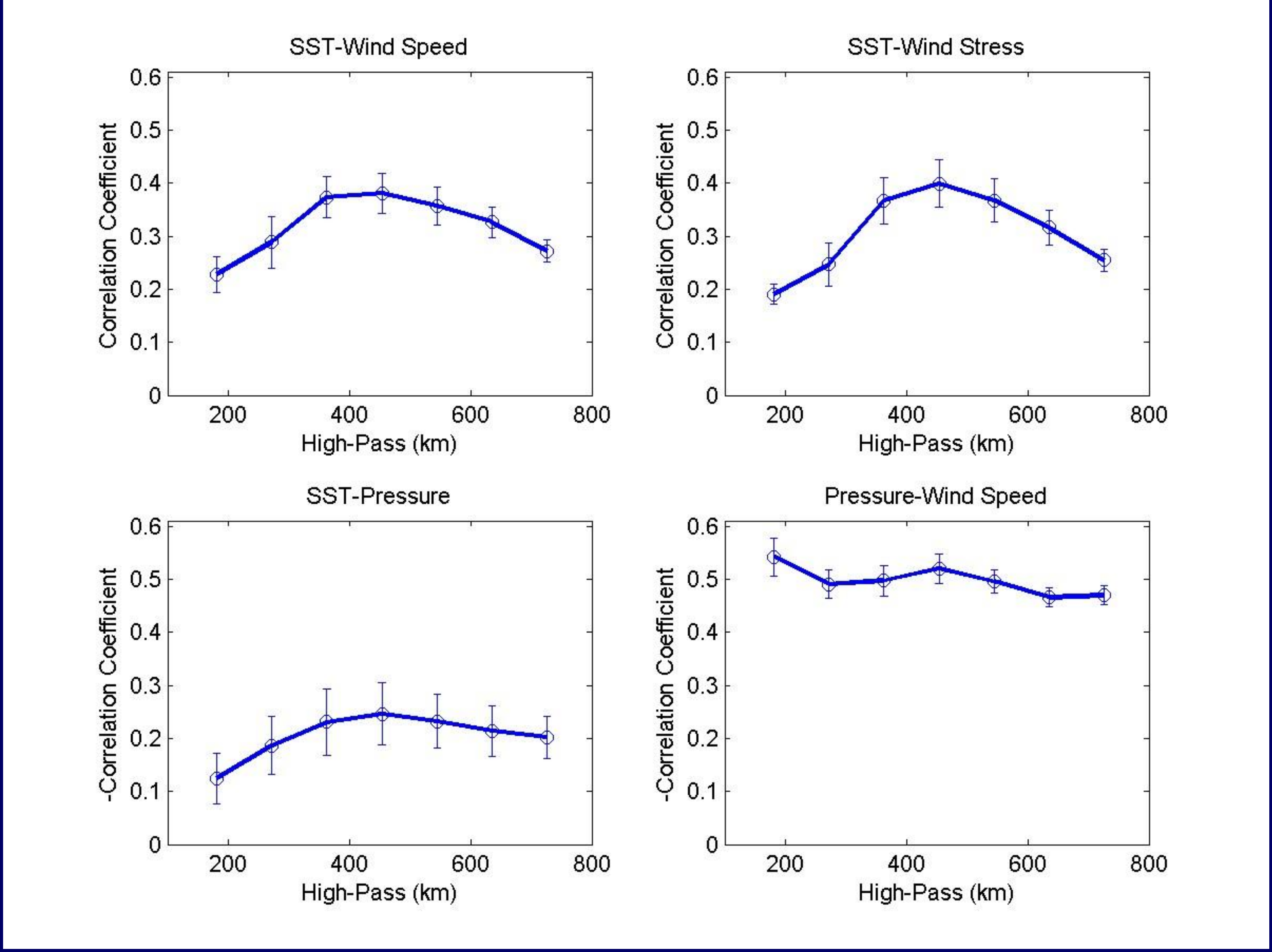
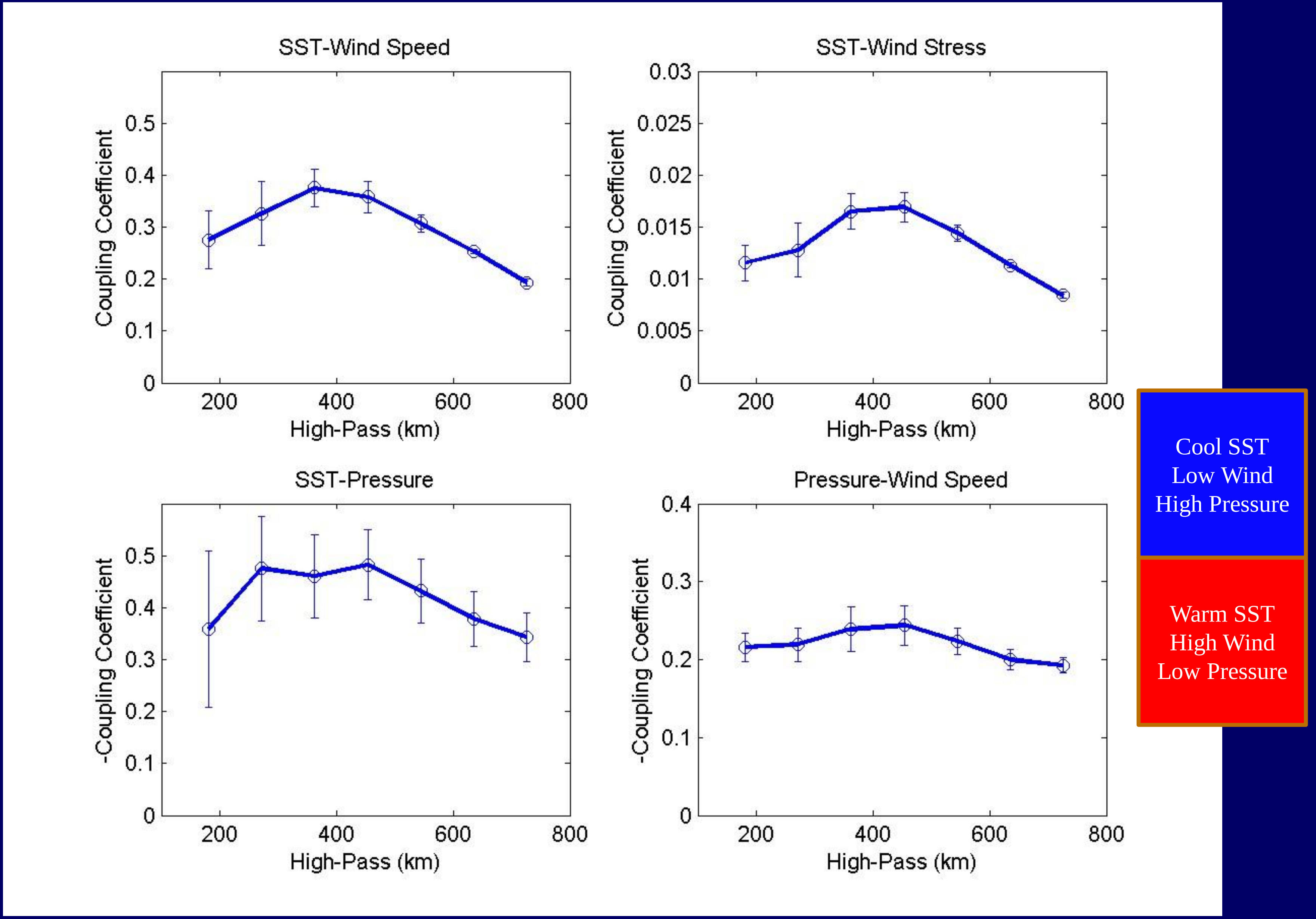
O'Neill et al. (2010a)
Agulhas Current

O'Neill et al. (2010b)
Gulf Stream

Correlations



Coupling Coefficients

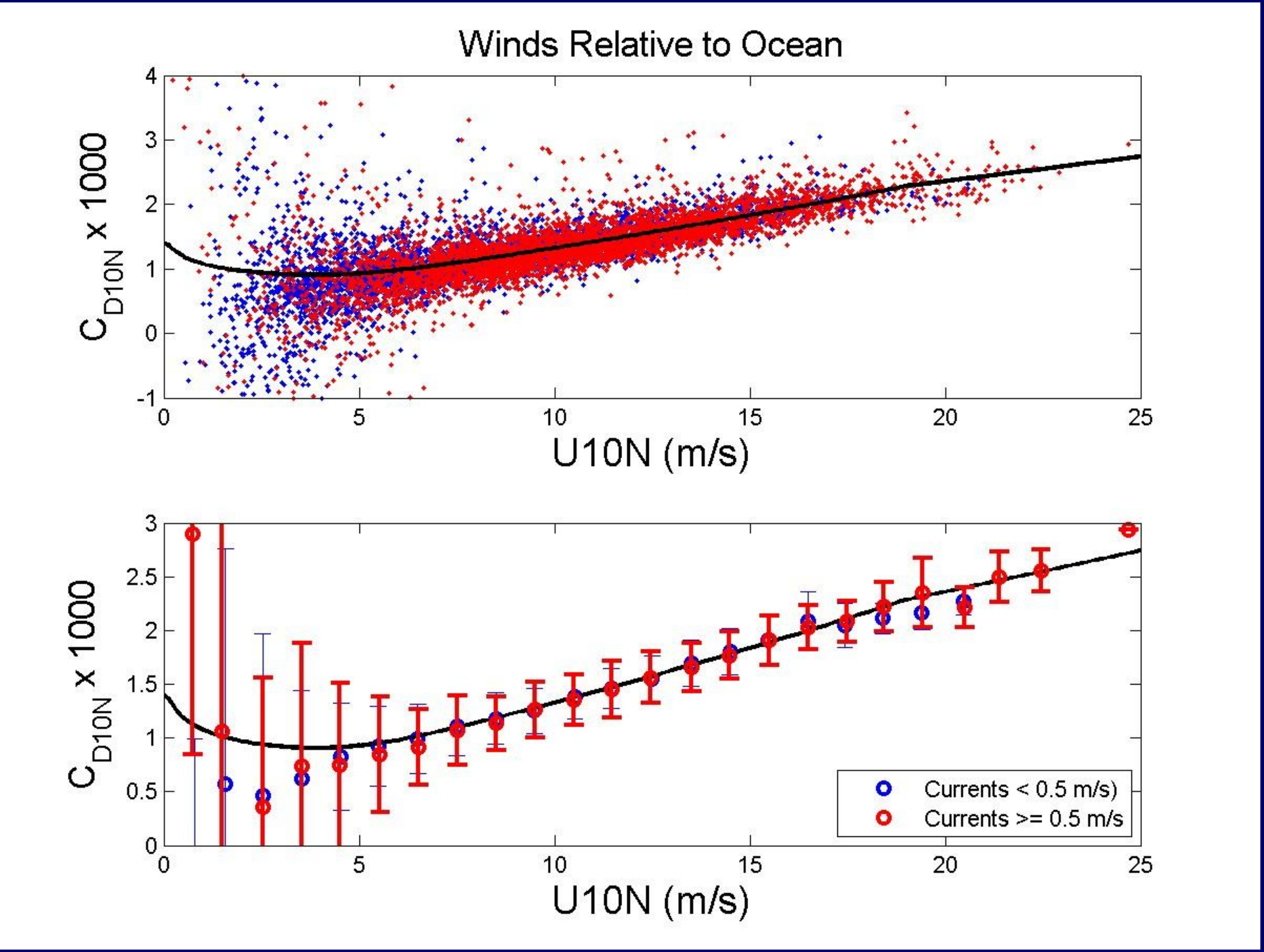


Summary

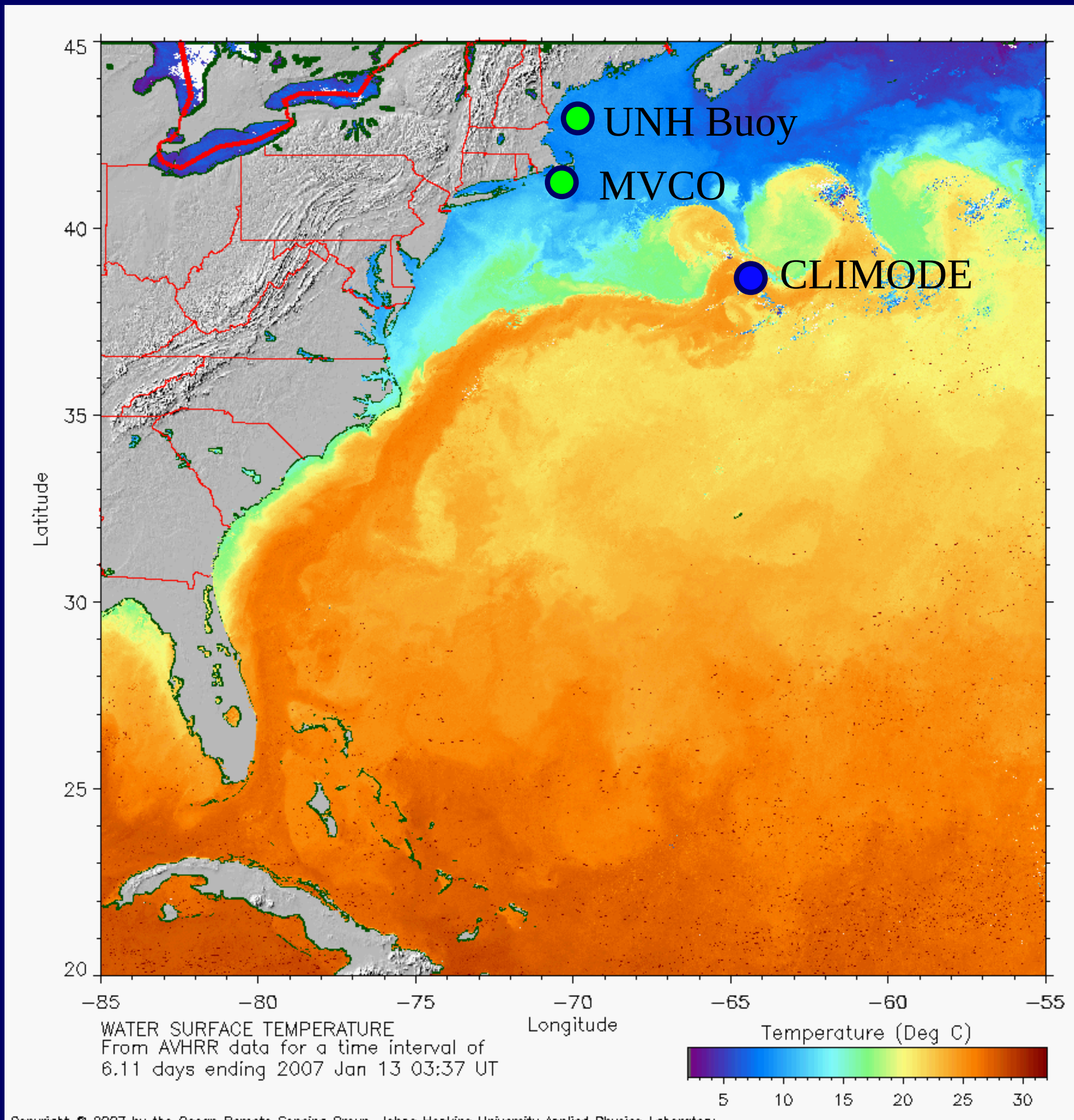
- Some of the variability in the QuikSCAT winds is due to adjustment of the neutral wind to changes in stratification and not changes in the actual wind speeds.
  - This variability obeys MO-Similarity in the mean.
  - Scatterometer winds represent ENW.
  - This effect enhances the gradient in neutral winds but not actual.
  - This accounts for about 20% of the coupling coefficient, which should be considered artificial, i.e., an artifact of measuring ENW.
  - However, significant variability in the QuikSCAT winds is not explained by this effect
- The one-buoy approximation of the coupling coefficients is in good agreement with previous studies.
  - The coupling coefficient depends on the scale of the SST variability.
  - In the Gulf Stream regions, the variability is driven by Gulf Stream meanders.
  - Results suggest that pressure adjustment is mainly responsible for observed coupling between wind speed/wind stress and SST at these scales.
- Next: Scatterometers as stressmeters

Relative Velocity

$$C_{DN}(z/z_o) = \frac{-\overline{uw}}{\Delta U_N\, G} = \left(\frac{\kappa}{\ln(z/z_o)}\right)^2$$



Future Research w/ Surface Stress Measurements



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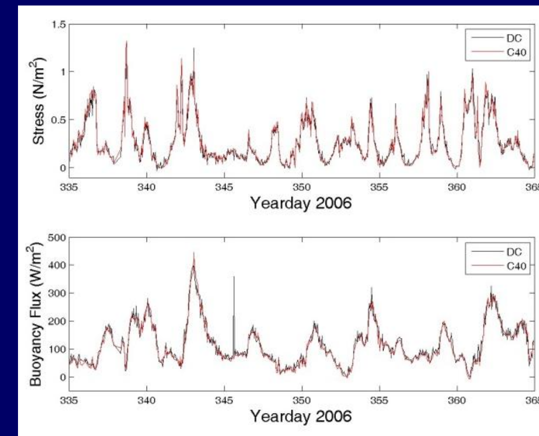


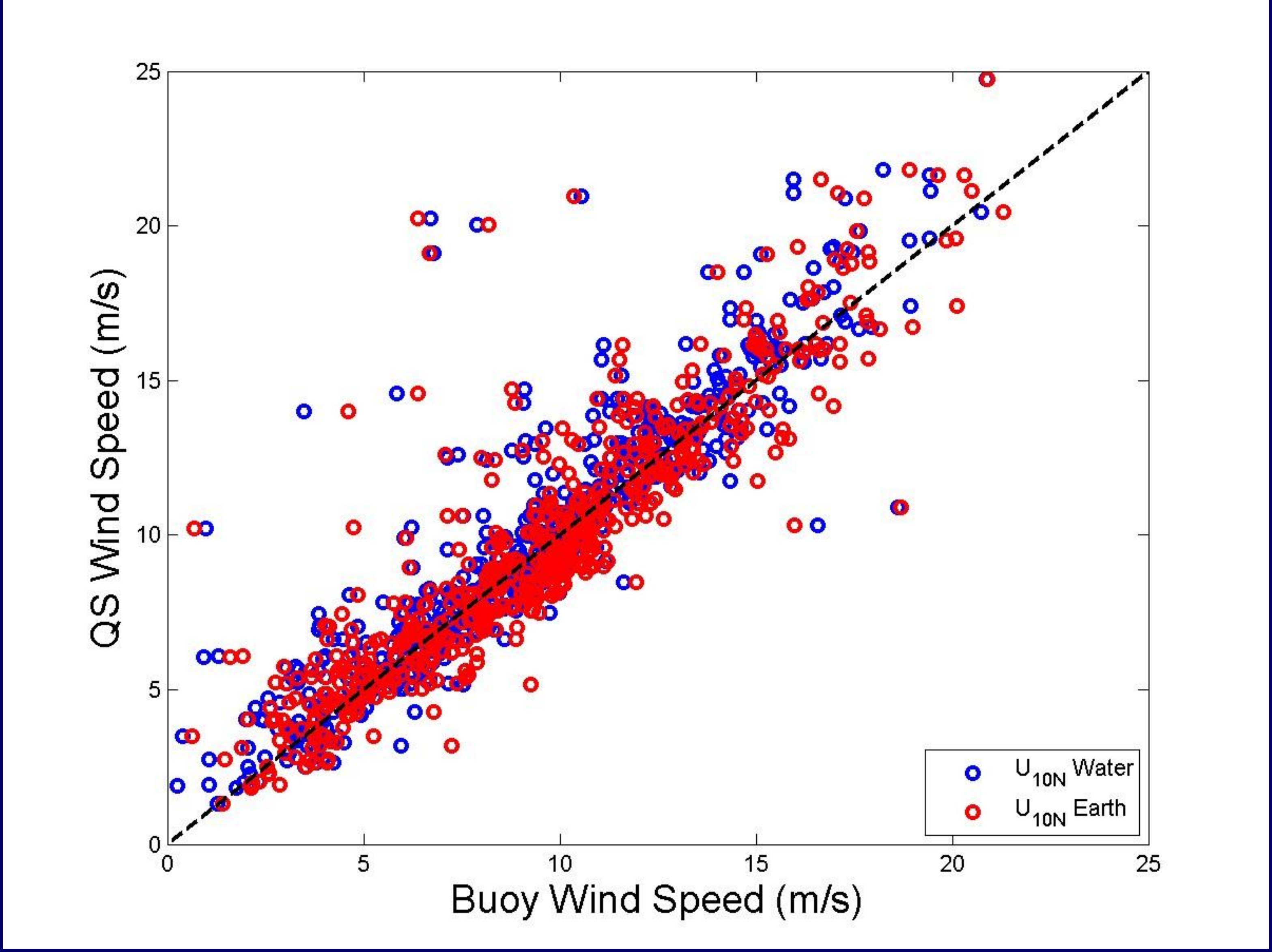
MVCO: 2002-2013
UNH Buoy: 2009-2012
CLIMODE: 2005-2007
SPURS: 2012-2013

SPURS

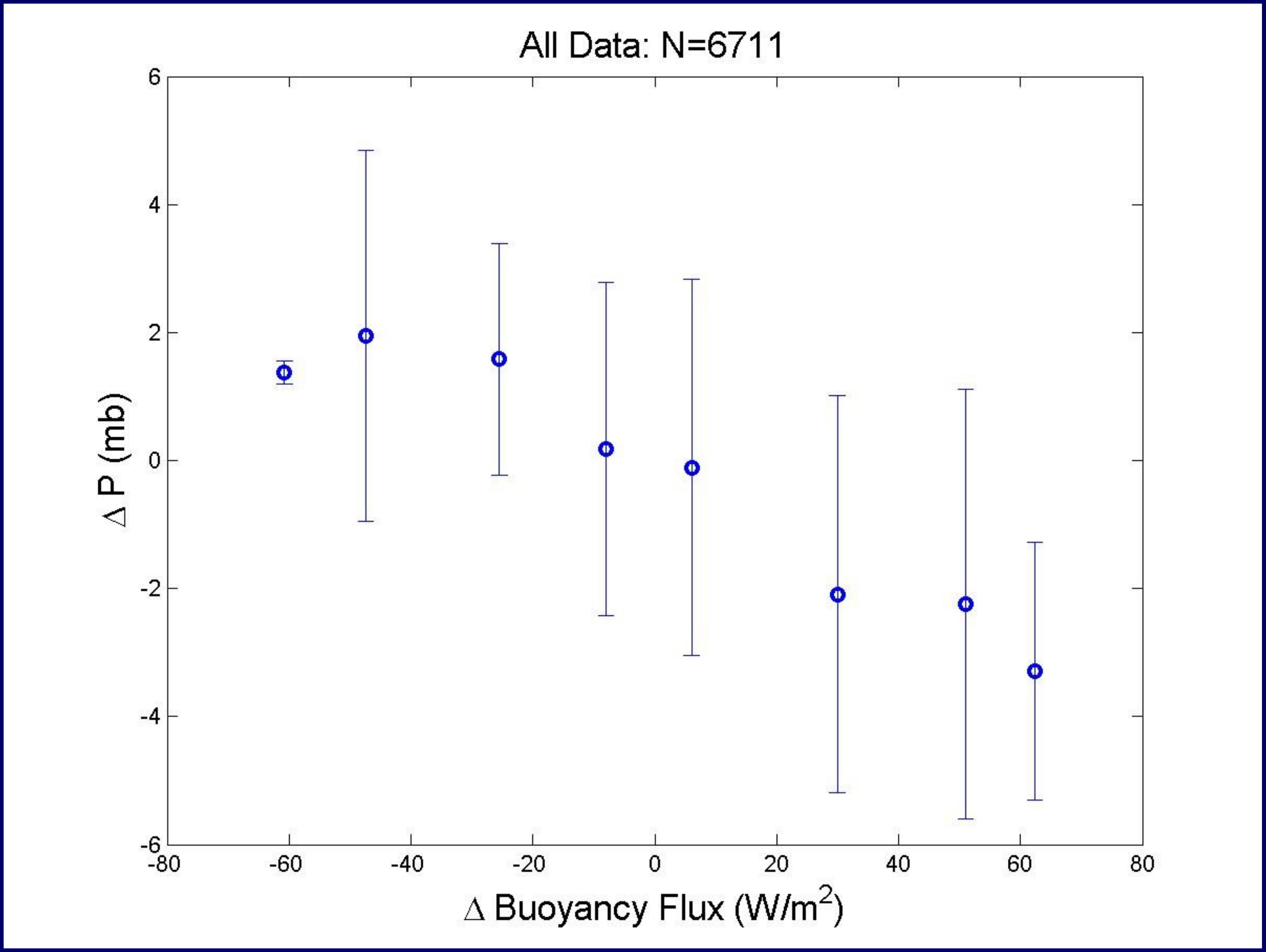
- Exploit scatterometers as stressmeters.
- Develop model functions using direct covariance stress with ASCAT and OSCAT.
- Explore, e.g., sensitivity to currents, SST and long waves.

Thanks to NASA for supporting this research.

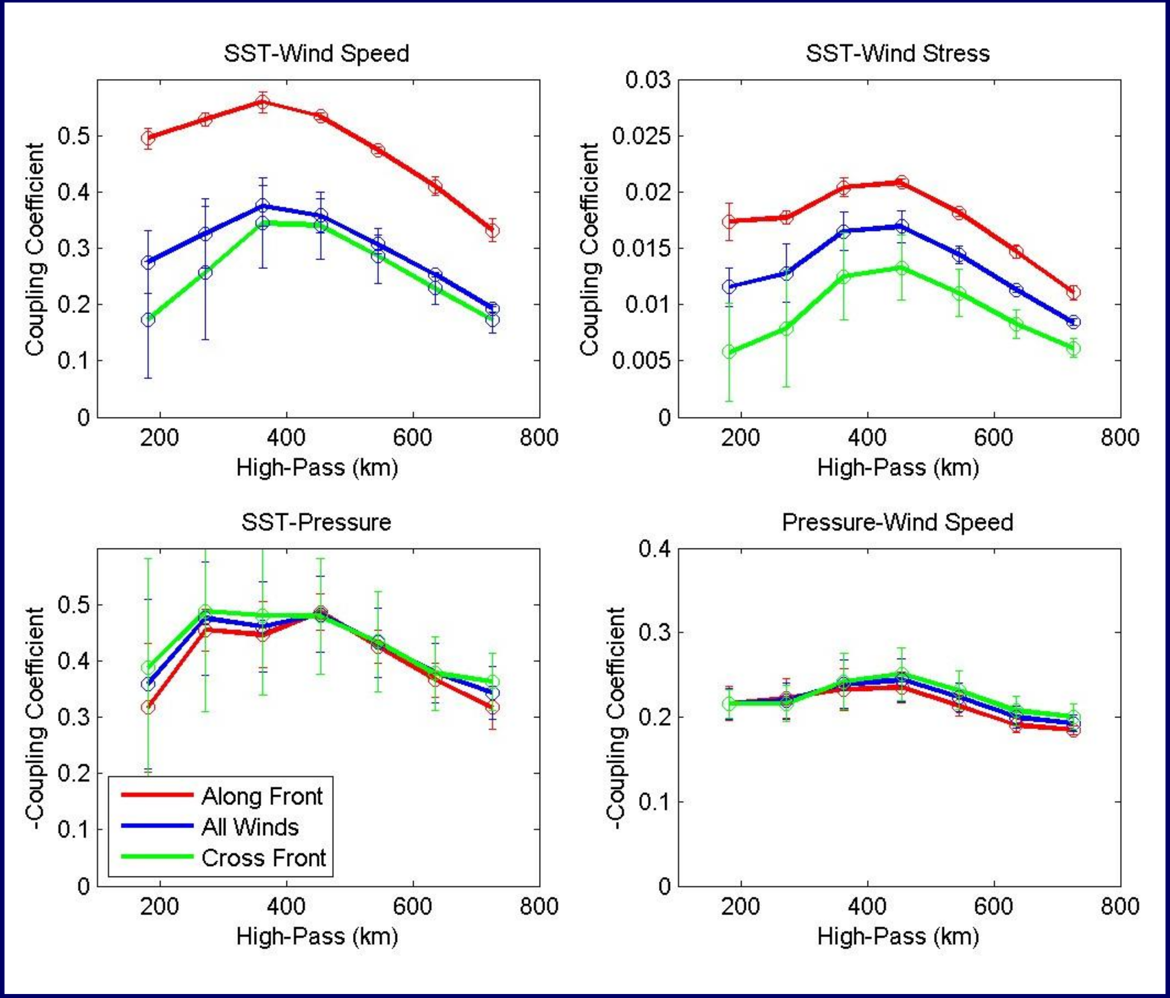
QuikSCAT vs. Buoy Wind Speeds



Correlations with Buoyancy Flux



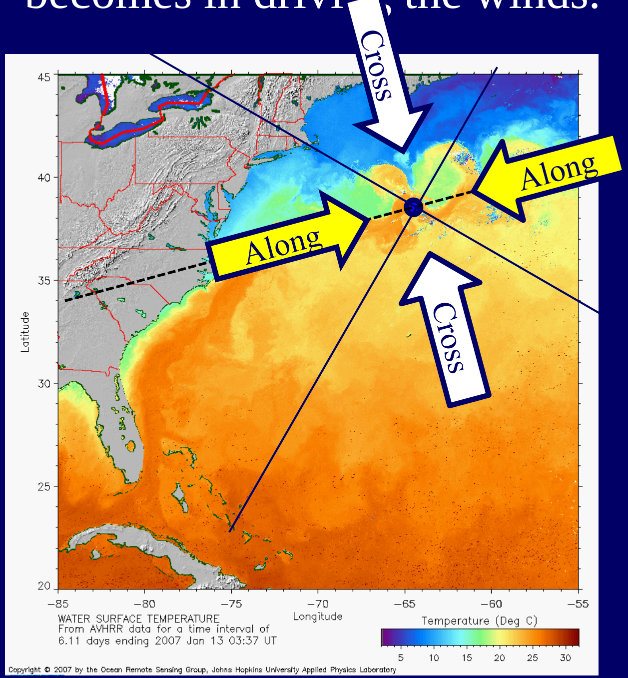
Cross Frontal Velocity & Advective Adjustment



Length scale over which the PG changes (Spall 2007):

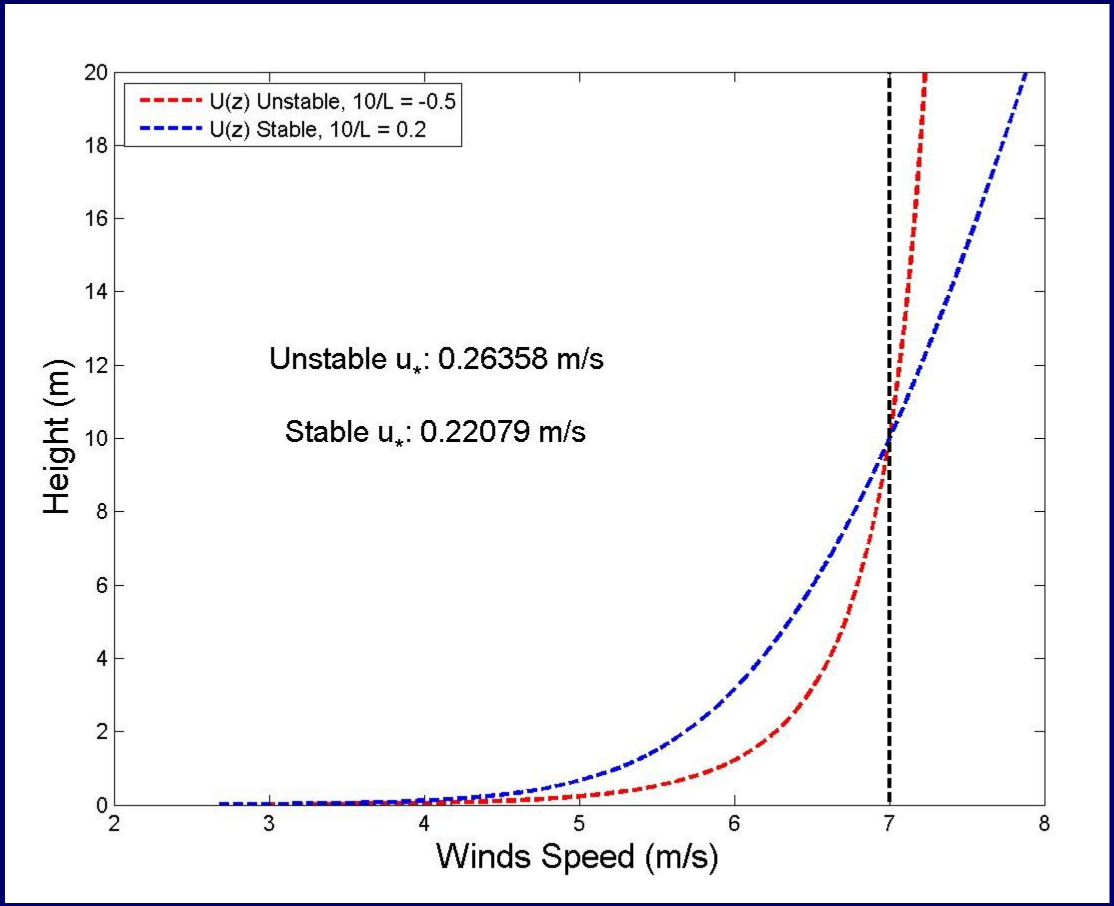
$$L_P = \frac{U_{cross} H^2}{K_m} \propto \frac{U_{cross}}{f}$$

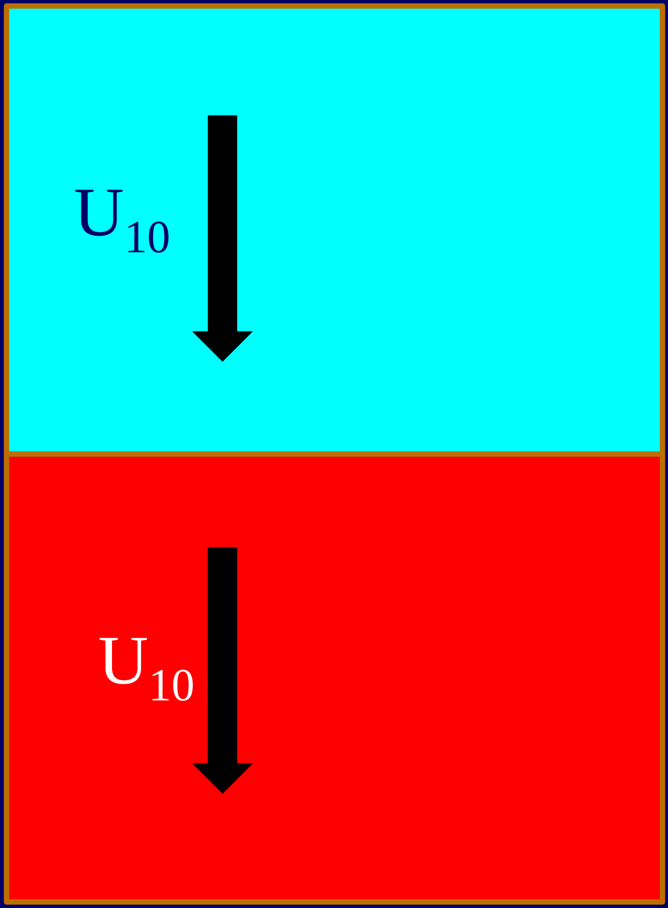
The shorter this scale, the quicker the PG can adjust to the SST gradient and the more important it becomes in driving the winds.



QuikSCAT vs. Buoy Wind Speeds

"Surface Layer Adjustment"





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QuikSCAT vs. Buoy Wind Speeds

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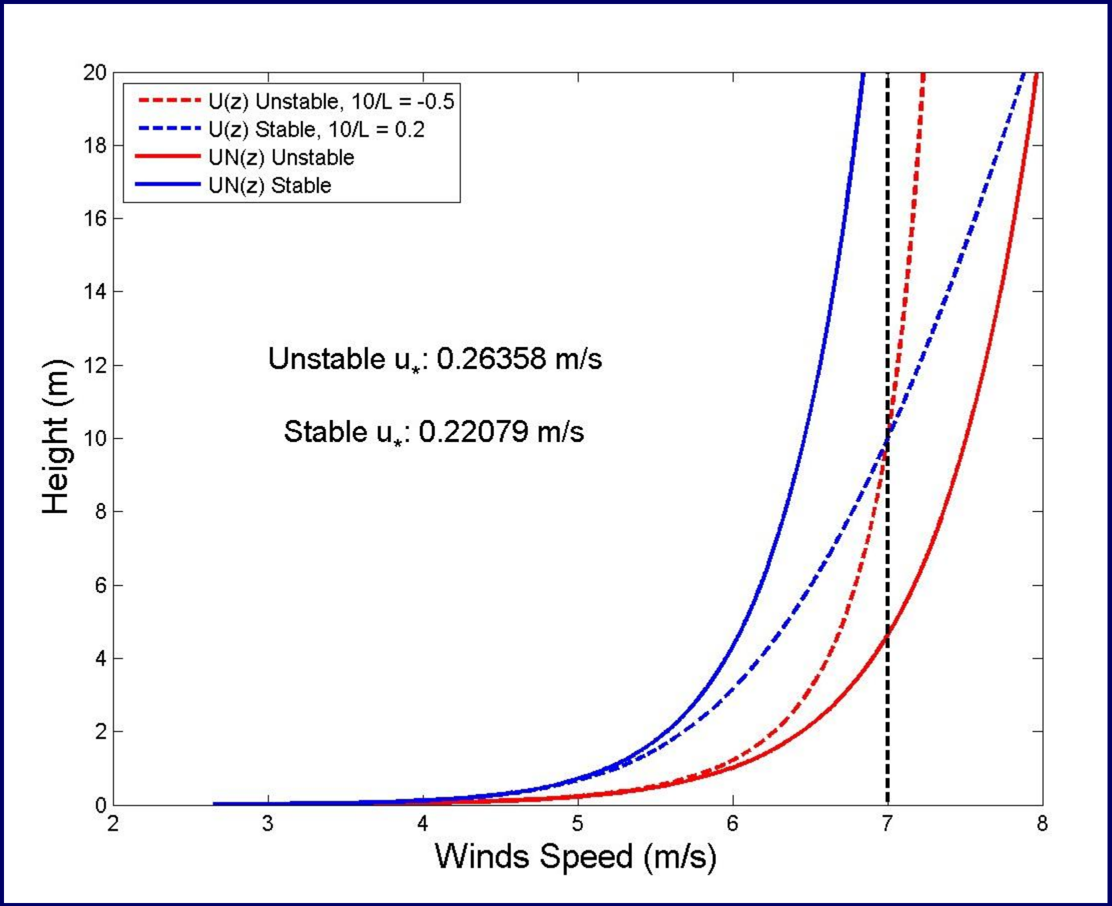

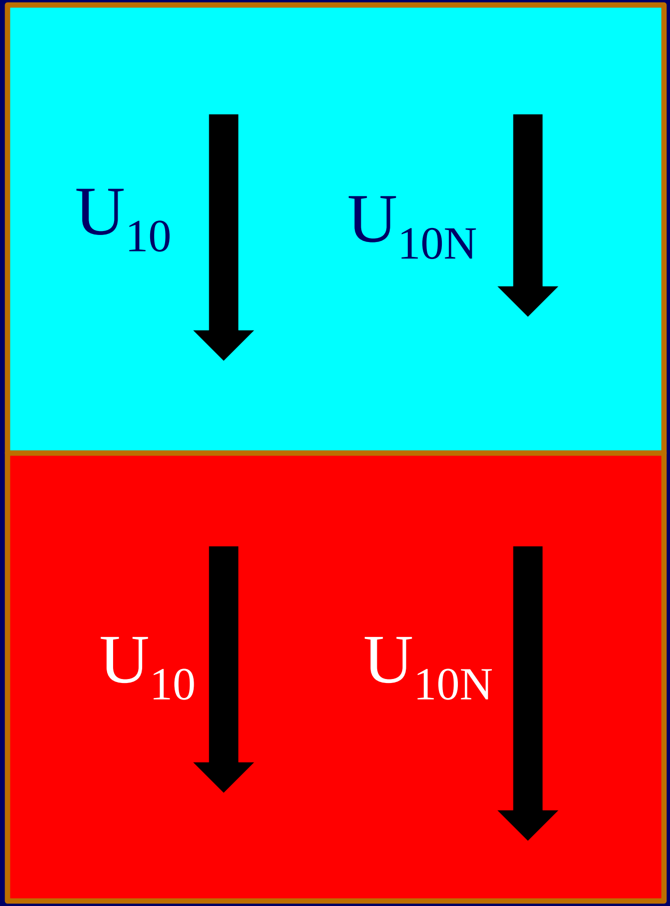

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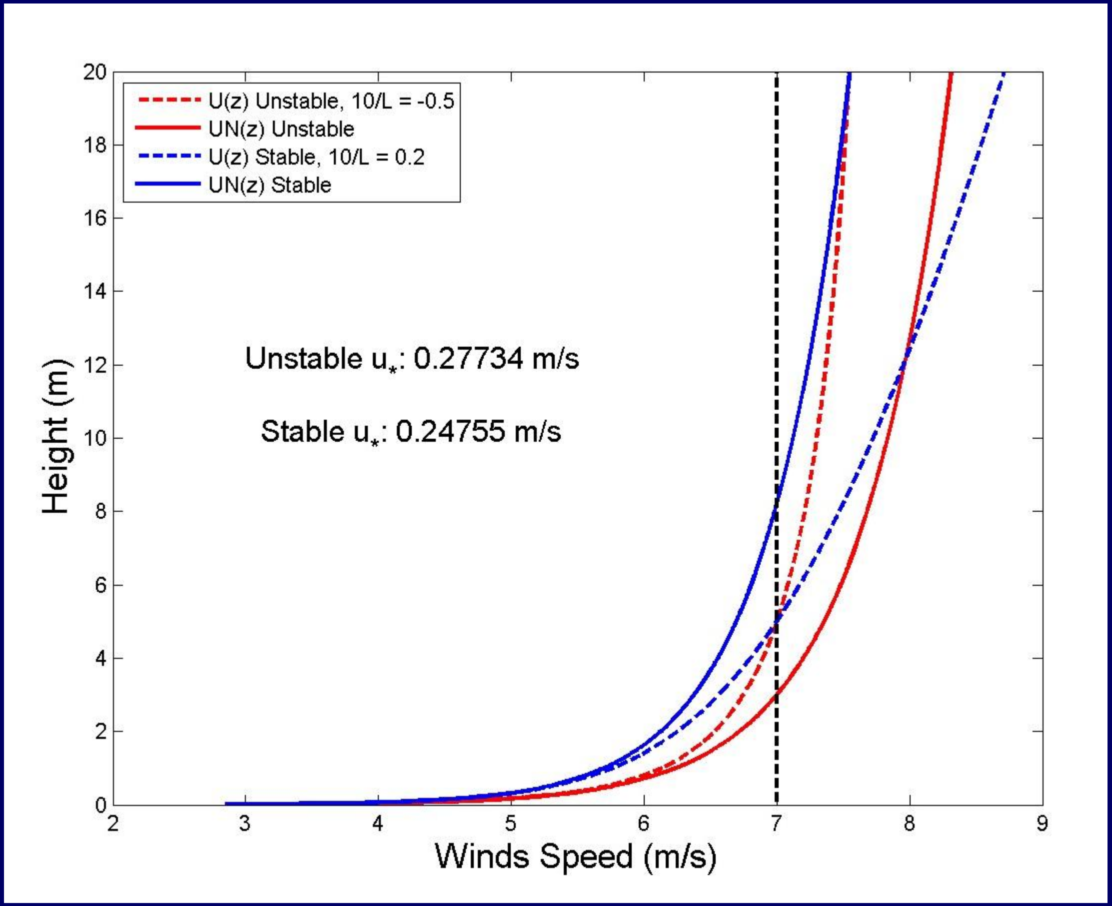

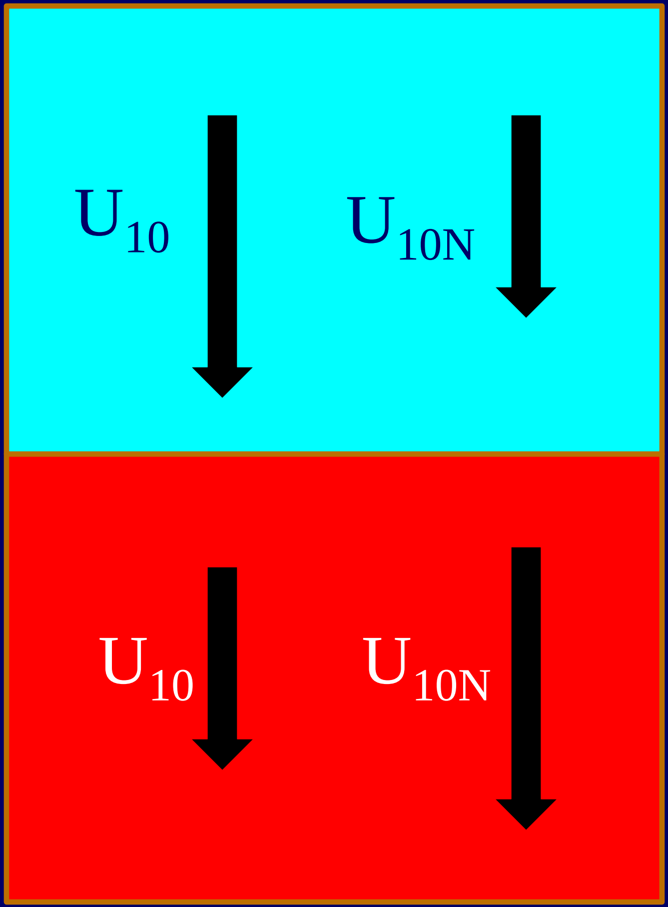

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