Impacts of surface currents on derived scatterometer wind at Ku and C band

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David Long (BYU)

This work comes under the OVWST project “**Determining geophysical impacts on scatterometer wind stress accuracy,”** and Jim Edson will be presenting additional work on Wednesday afternoon

Overview

- What do we know-- or what do we think we know?
- Effect of currents on QuikSCAT - buoy residuals at 2 buoys
- Spatial case study of QuikSCAT and currents using models
- Currents and ASCAT - buoy residuals
- Currents altimeter wind (briefly)

Scatterometry and currents

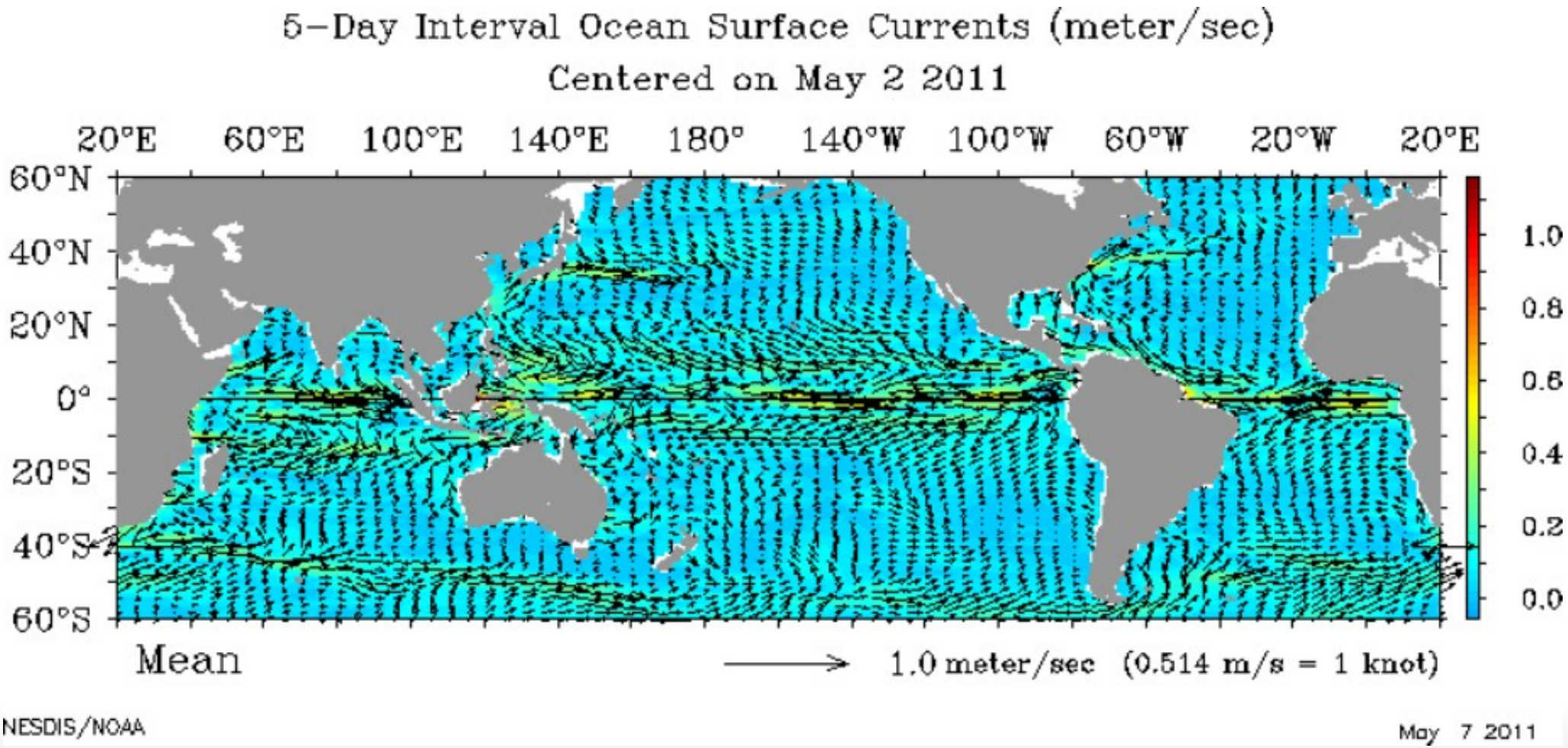
- According to the model [Bourassa 2006], we expect that QuikSCAT should follow the kinematic boundary condition, i.e.:

$$U(z) - U_s = \frac{u_{*a}}{\kappa}\left[\ln\frac{z}{z_0} + \phi(z, z_0, L)\right]$$

surface current

- But:
  - the few existing studies focus mostly in the equatorial region
  - and/or use only climatological currents
  - or non-surface currents (10m depth)
  - and don’t quantitatively validate the model

Dickinson et al. 2001; Kara et al. 2007; Kelly et al. 2005; Quilfen et al. 2001;



http://www.oscar.noaa.gov/datadisplay/oscar_latlon.php

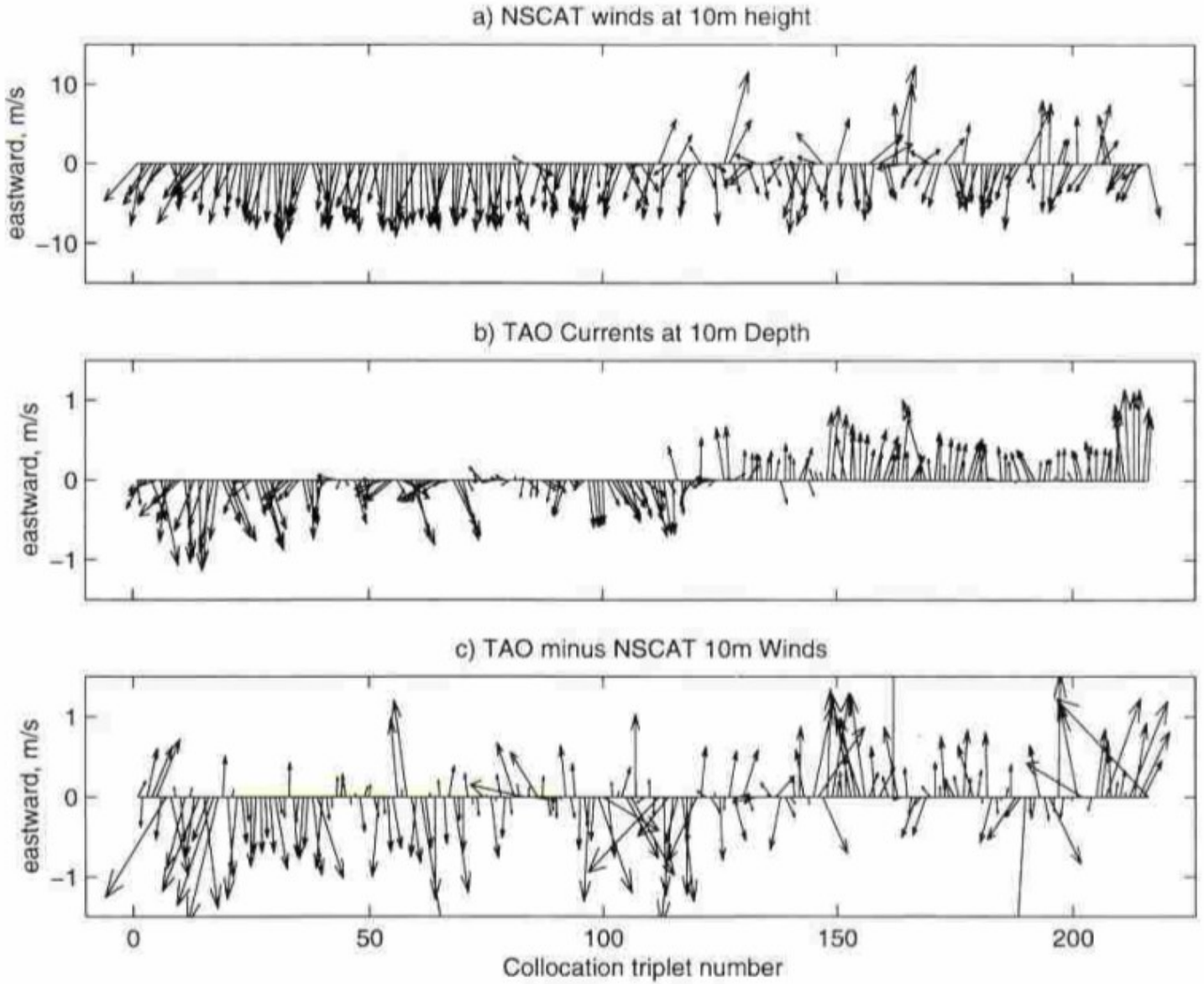


FIG. 4. Effect of ocean currents on NSCAT winds. (a) NSCAT-2 winds (eastward is up). (b) Currents at a depth of 10 m measured from TAO buoys. (c) The difference between TAO buoy and NSCAT-2 vectors at the ocean surface. The difference between the TAO and NSCAT-2 wind speeds is significantly correlated with the component of the ocean currents in the direction of the buoy winds.

Dickinson et al. 2001, *Comparisons between the TAO buoy and NASA scatterometer wind vectors*

Scatterometry and currents

- So:
  - it is hard to find a study that quantifies this in a global sense
  - to get to the physics, need a lot of data, not just in the equatorial regions, but also in coastal regions to examine tidal signals
  - and given that there is so much emphasis now on dual-frequency work, what about C-Band?
- We should also keep in mind that many wave-current interactions occur within the footprint of our sensor: even if they don't show up in the data, it doesn't mean they aren't happening

The Gulf of Maine

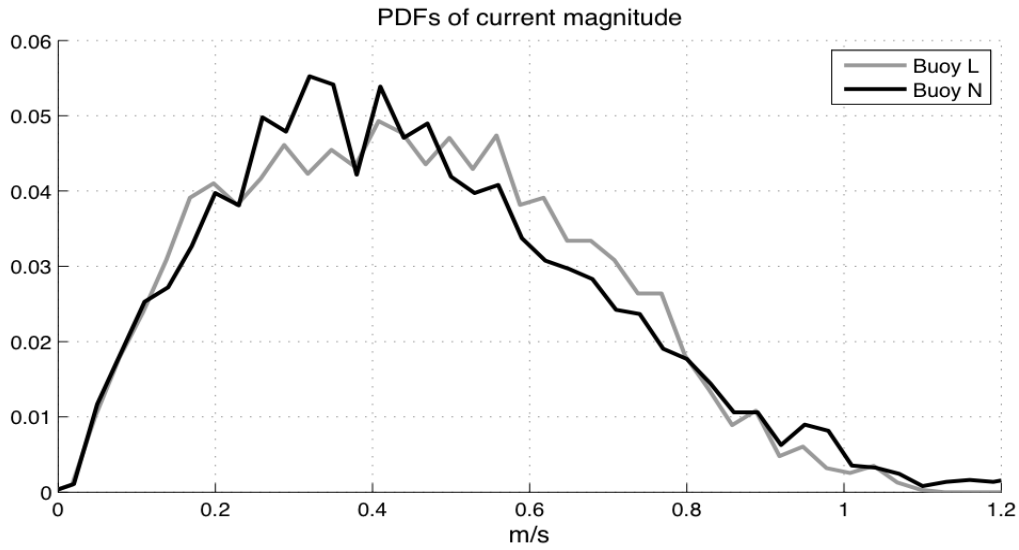
http://app2.iris.usm.maine.edu/gulfofmaine-censusdev/wp-content/images/circulation/fig4.jpg

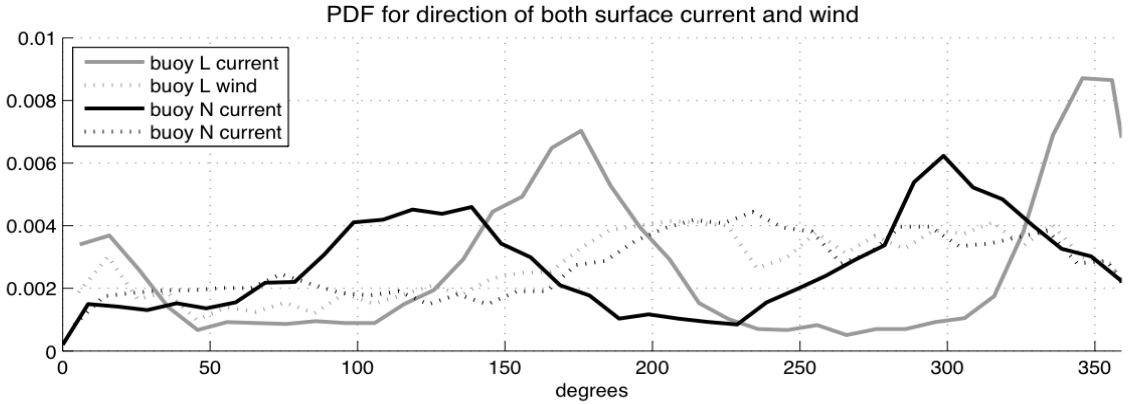
In Situ Data

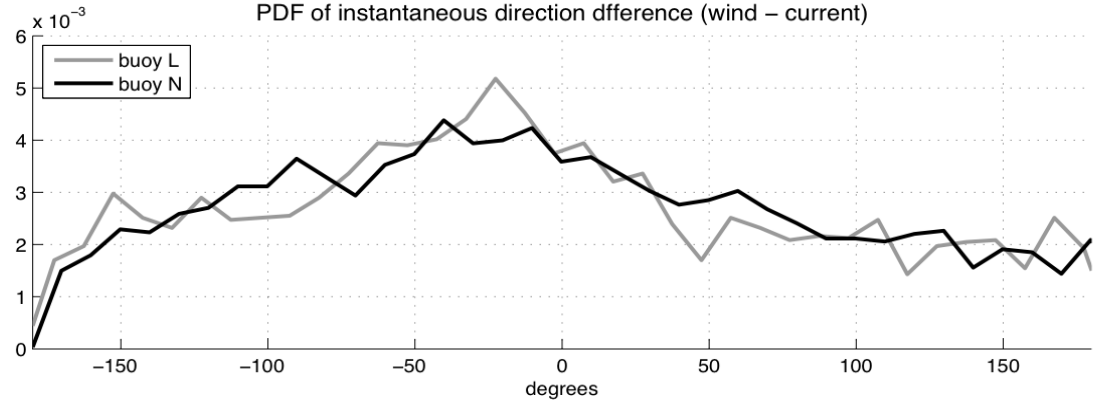
- Focused on two Gulf of Maine Ocean Observing System (GoMOOS) Buoys
  - Buoy N (number 44024 at 42.31 N, -65.93 E)
  - Buoy L (number 44038 at 43.62N, -66.55 E)
- Winds from RM Young anemometers at 4m, corrected to 10m neutral winds using COARE 3.0
- Surface currents from Aanderaa RCM9 meters at 2 m depth
  - $u' = |u| * \cos(\varphi_{buoycurr} - \varphi_{buoywind})$
- Also provide air and water temperatures, relative humidity, atmospheric pressure, etc.

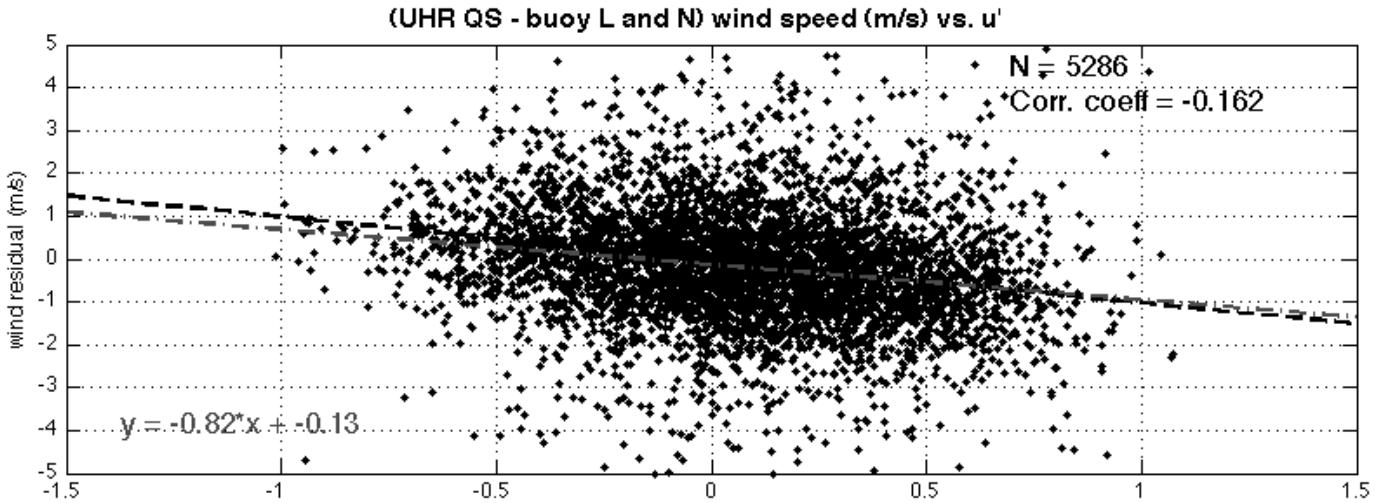
Other Data

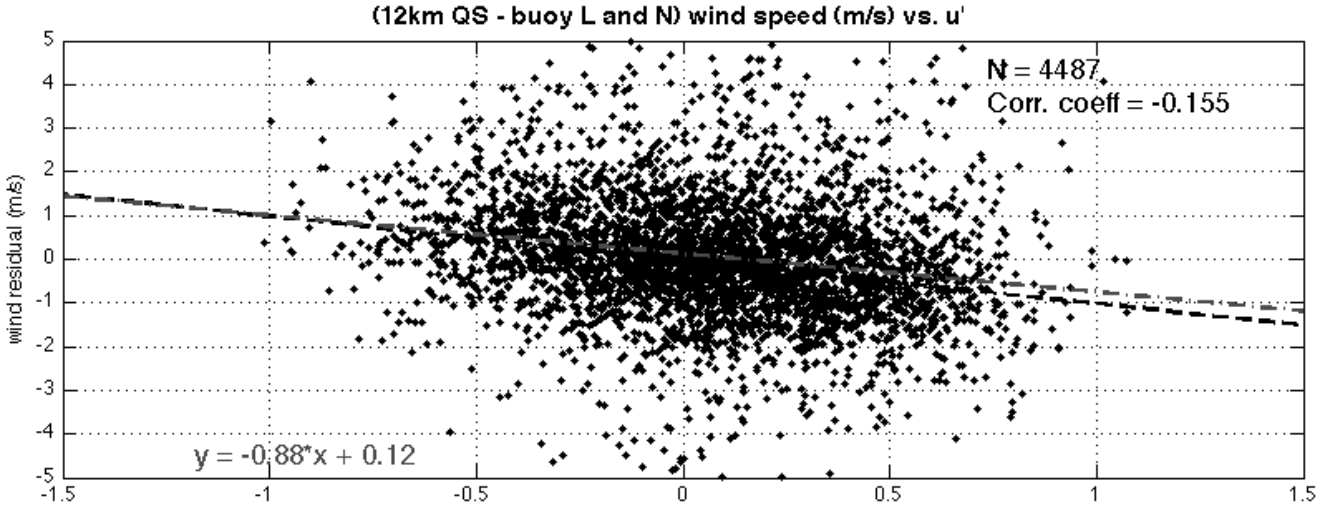
- Satellite:
  - QuikSCAT: L2 25 km and 12km (PO.DAAC); UHR (D. Long); collocations according to Plagge et al. 2009
  - ASCAT collocations from Anton Verhoef (KNMI): 12 km and 25 km at buoy N; 25 km at buoy L
  - Altimeter: Jason-1,-2, and Envisat
- Models:
  - Atmosphere: 9 km WRF (UNH and AER, Inc)
  - Finite Volume Community Ocean Model (FVCOM) circulation model (Dr. Chen at UMass)

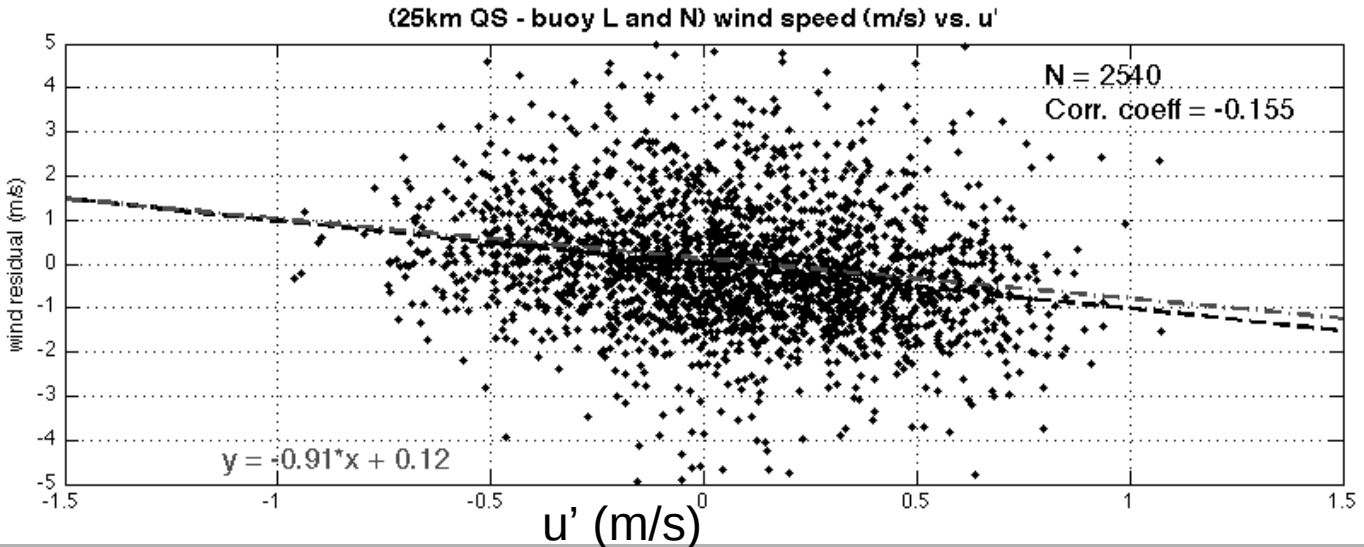

PDFs of current magnitude
Buoy L
Buoy N
0.06
0.05
0.04
0.03
0.02
0.01
0
0
0.2
0.4
0.6
0.8
1
1.2
m/s


PDF for direction of both surface current and wind
buoy L current
buoy L wind
buoy N current
buoy N current
0.01
0.008
0.006
0.004
0.002
0
0
50
100
150
200
250
300
350
degrees


PDF of instantaneous direction dfference (wind – current)
x 10^-3
buoy L
buoy N
6
5
4
3
2
1
0
−150
−100
−50
0
50
100
150
degrees





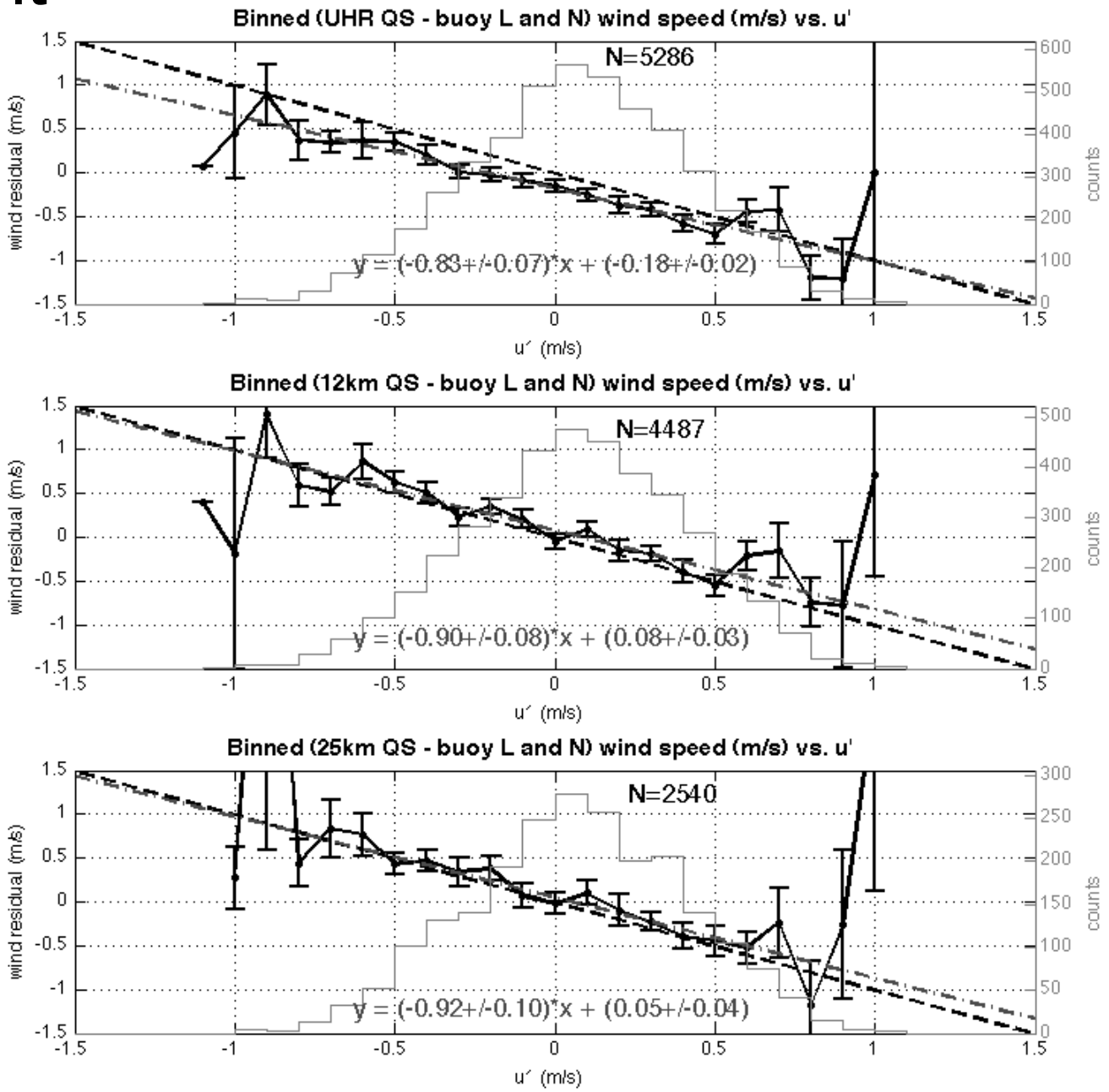


QuikSCAT and buoy wind speed residuals vs. projected current

weighted LS fit

black dashed line indicates $y = -x$

QuikSCAT and buoy wind speed residuals vs. projected current



weighted LS fit

black dashed line indicates $y = -x$

Is it following the kinematic boundary condition?

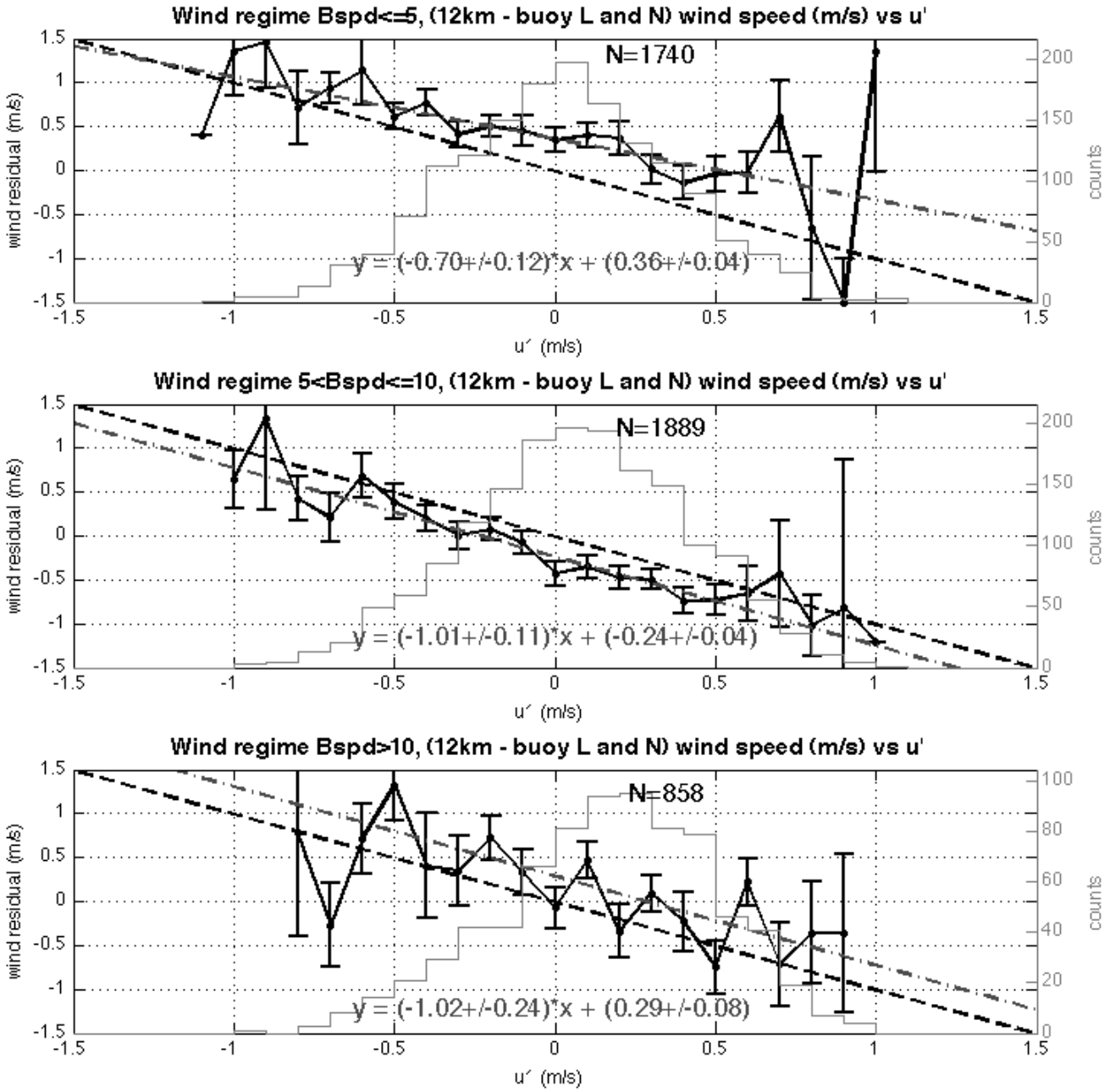
- Relationship for speed residuals very close to 1:1
- If QuikSCAT is truly responding to the kinematic boundary condition, can we make this response any clearer?
- Might there be a difference at light wind for instance?
  - Expected errors: 5 m/s and below there are larger QS-buoy residuals for all resolutions in the Gulf of Maine [Plagge et al 2009]
  - Physics: perhaps fully coupled wind-wave situation not developed
  - Differences in drag coefficient parametrization at speeds below 4 m/s (viscous effects and surface tension)
- Might expect masking due to stability effects: magnitude of these could easily be greater

Is there a speed dependence?

low

moderate

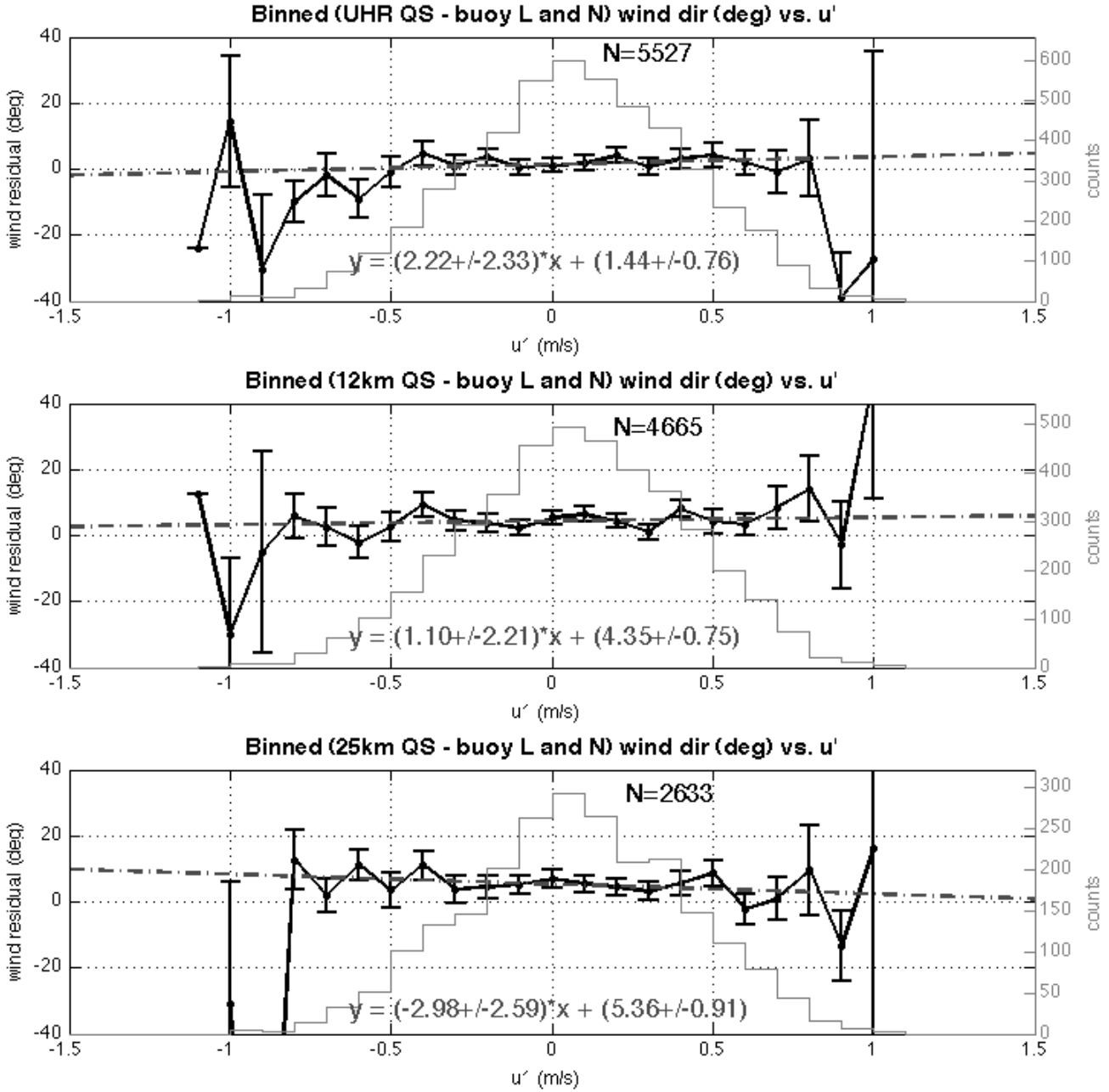
high(er)



weighted LS fit

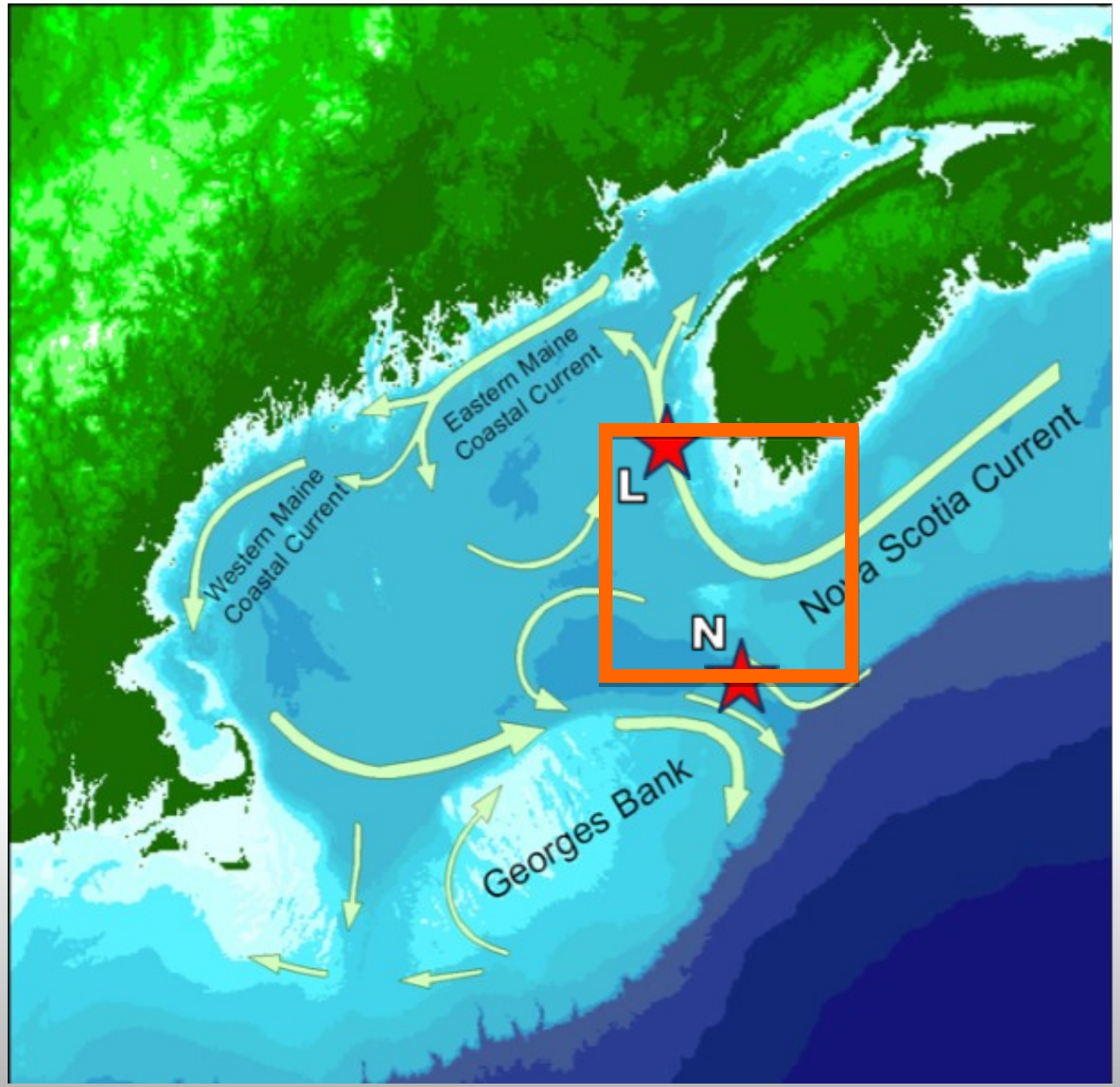
black dashed line indicates $y = -x$

Those were speed residuals. What about direction?



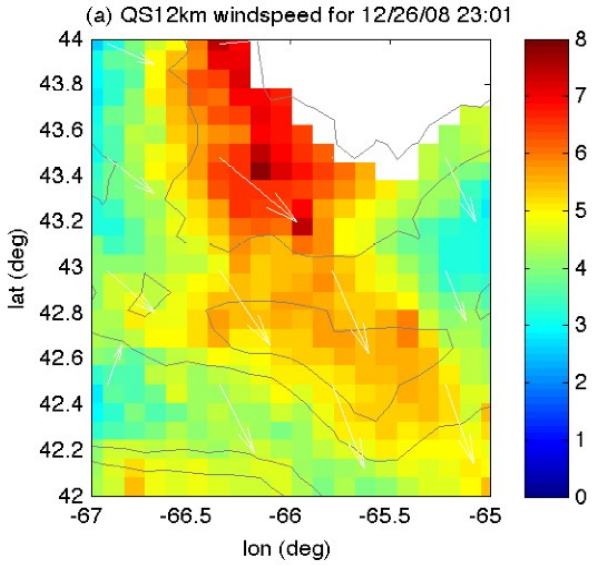
weighted LS fit

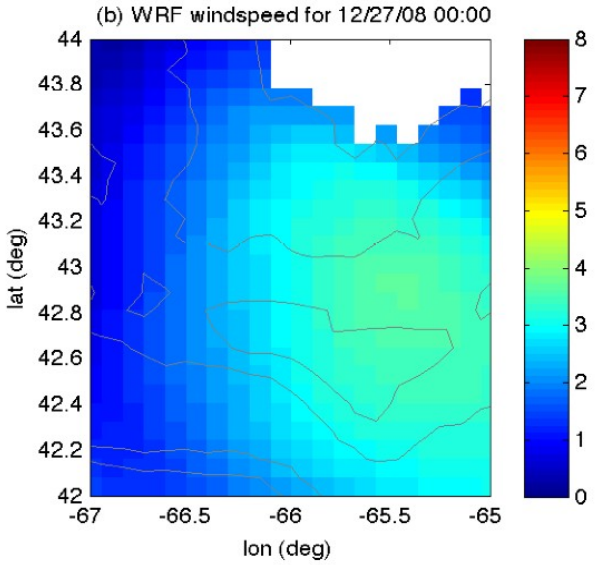
Spatial patterns

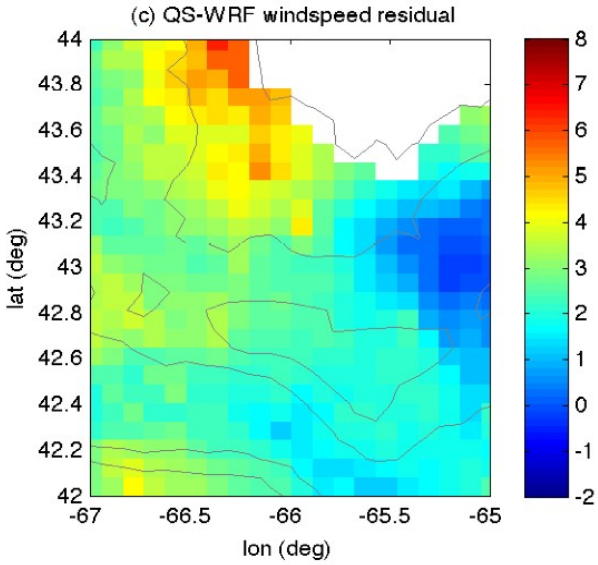


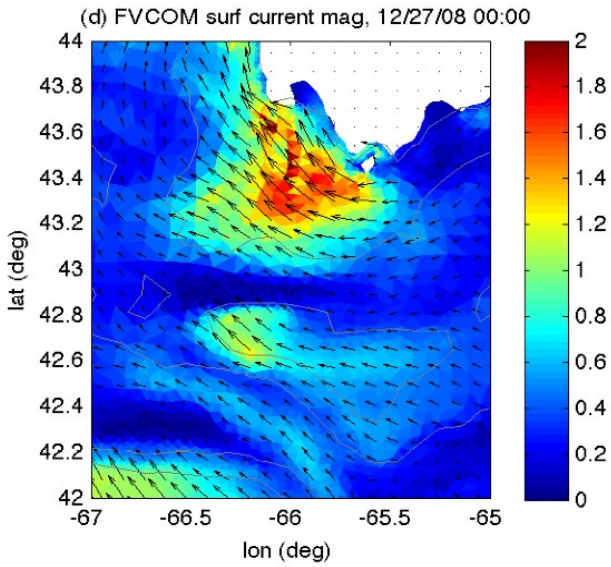
http://app2.iris.usm.maine.edu/gulfofmaine-censusdev/wp-content/images/circulation/fig4.jpg

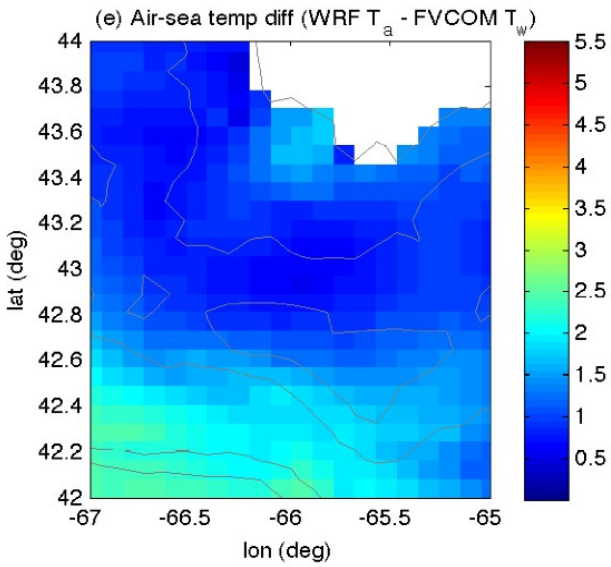
Spatial case study: Dec 26-27 2008

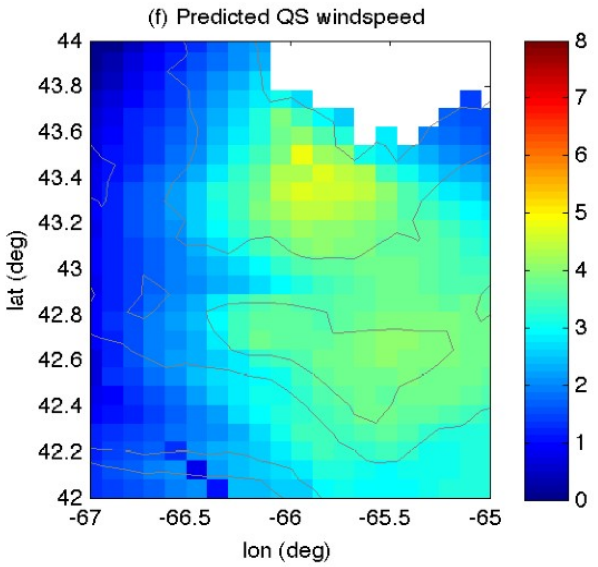








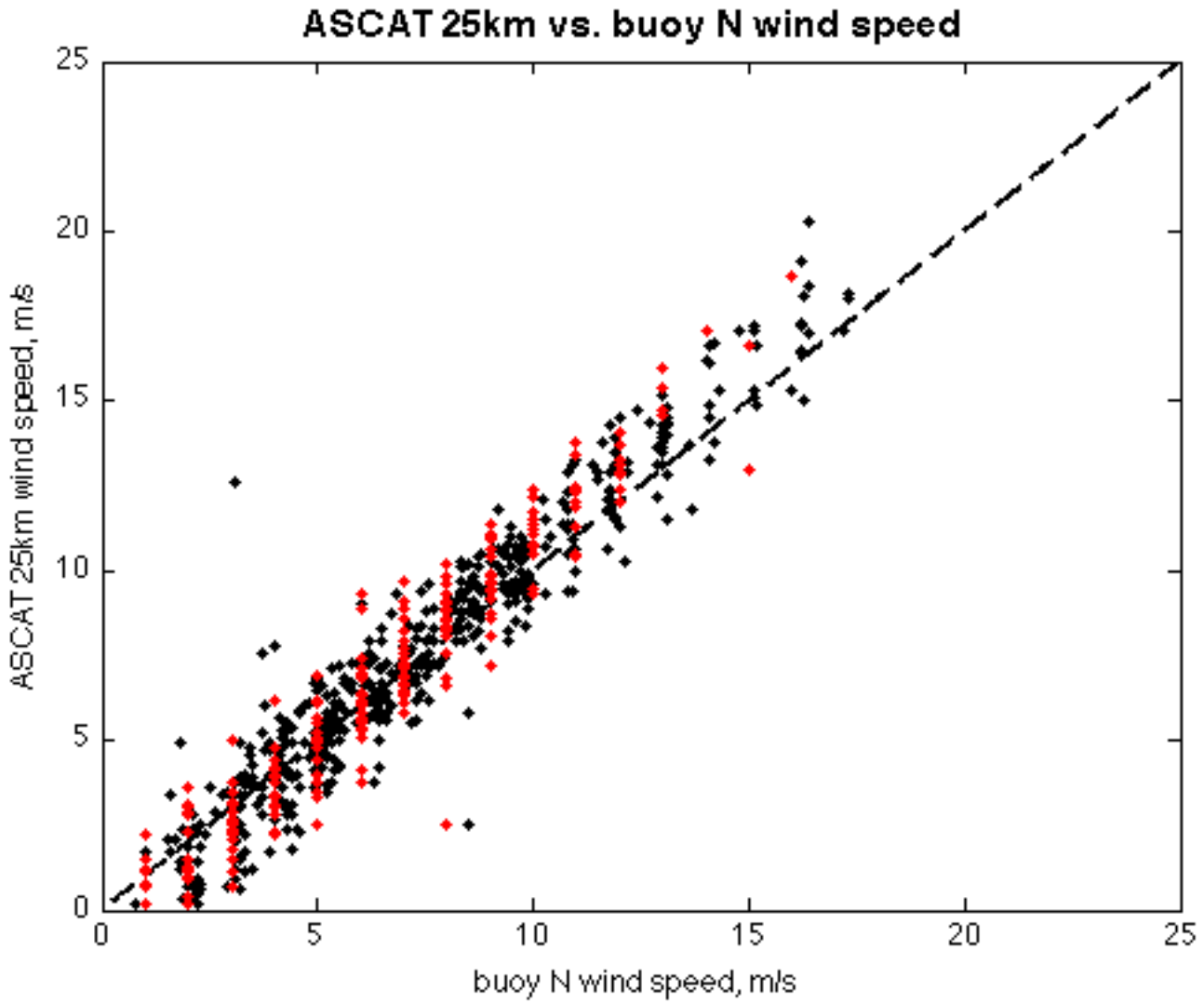




ASCAT

- C-band (5.255 GHz)
- Does the different frequency mean a different response to currents/current shear?
- Notes:
  - Collocations provided by Anton Verhoef
  - No 12 km data at buoy L due to swath patterns
  - Some missing temperature data at buoy N means that some buoy winds are not stability-corrected

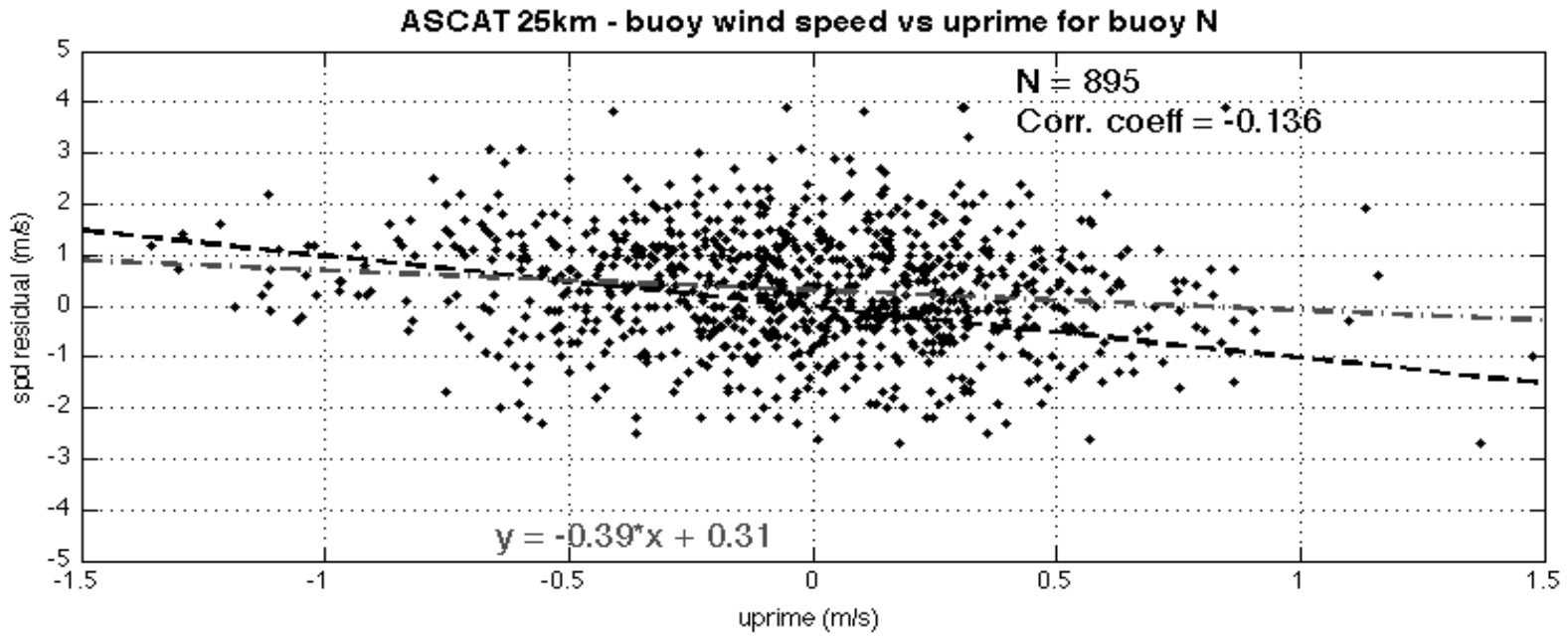
25km ASCAT and buoy N winds

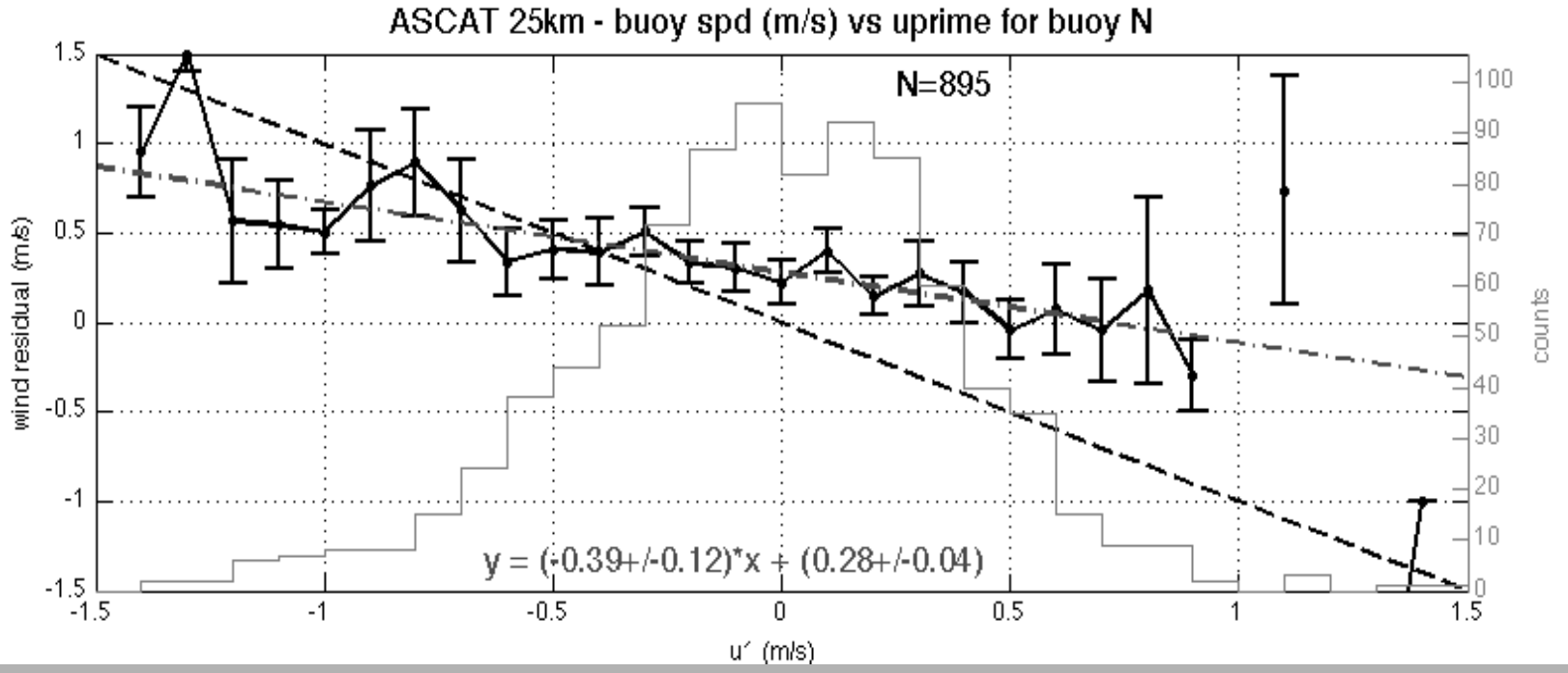


red dots indicate instances of missing buoy water temperatures, meaning the 10m buoy wind was created using law-of-the-wall only; this will be remedied in future.

black dashed line indicates $y = -x$

(25km ASCAT-buoy N) wind speed vs. current

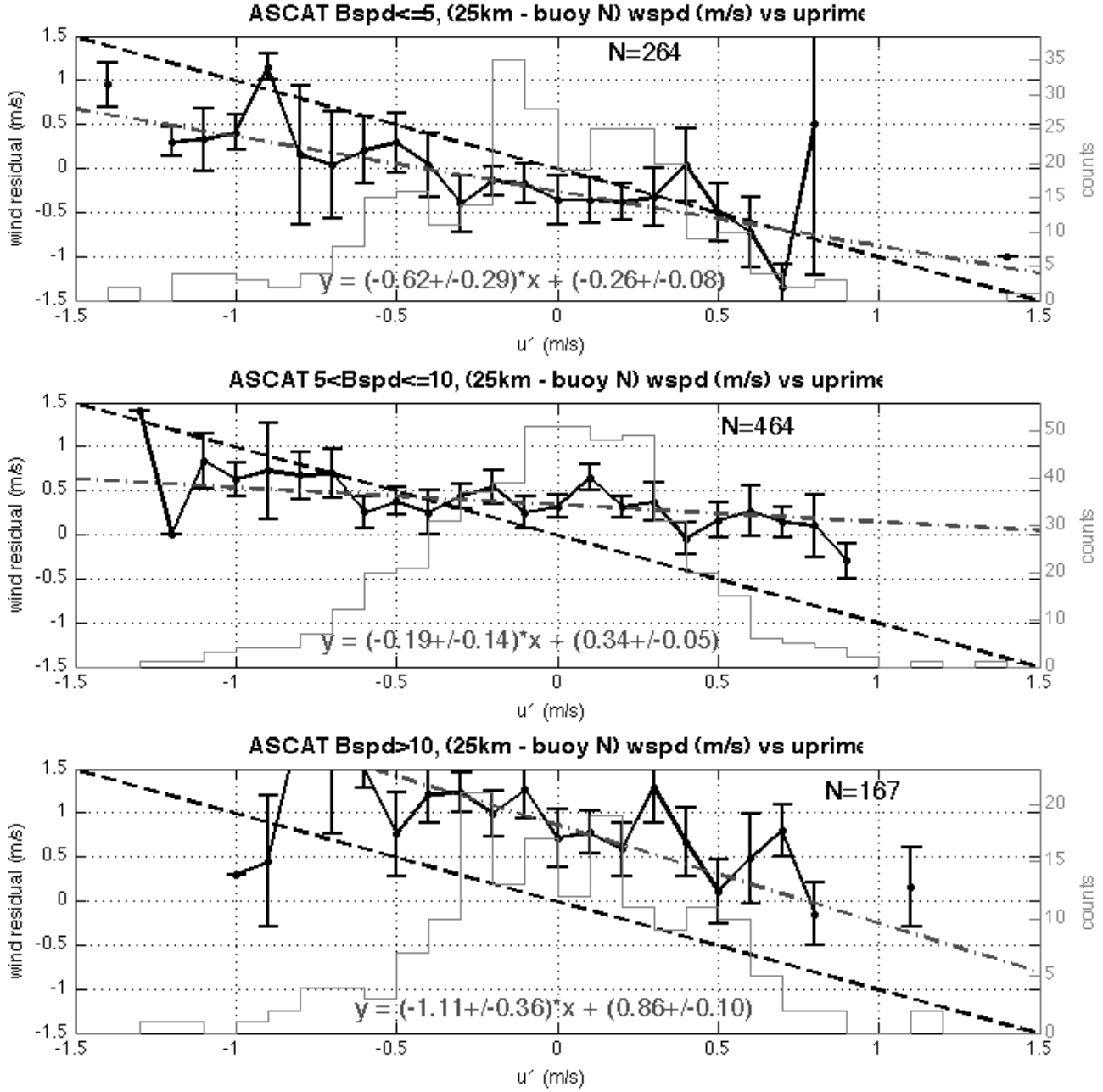




weighted LS fit

black dashed line indicates *y = -x*

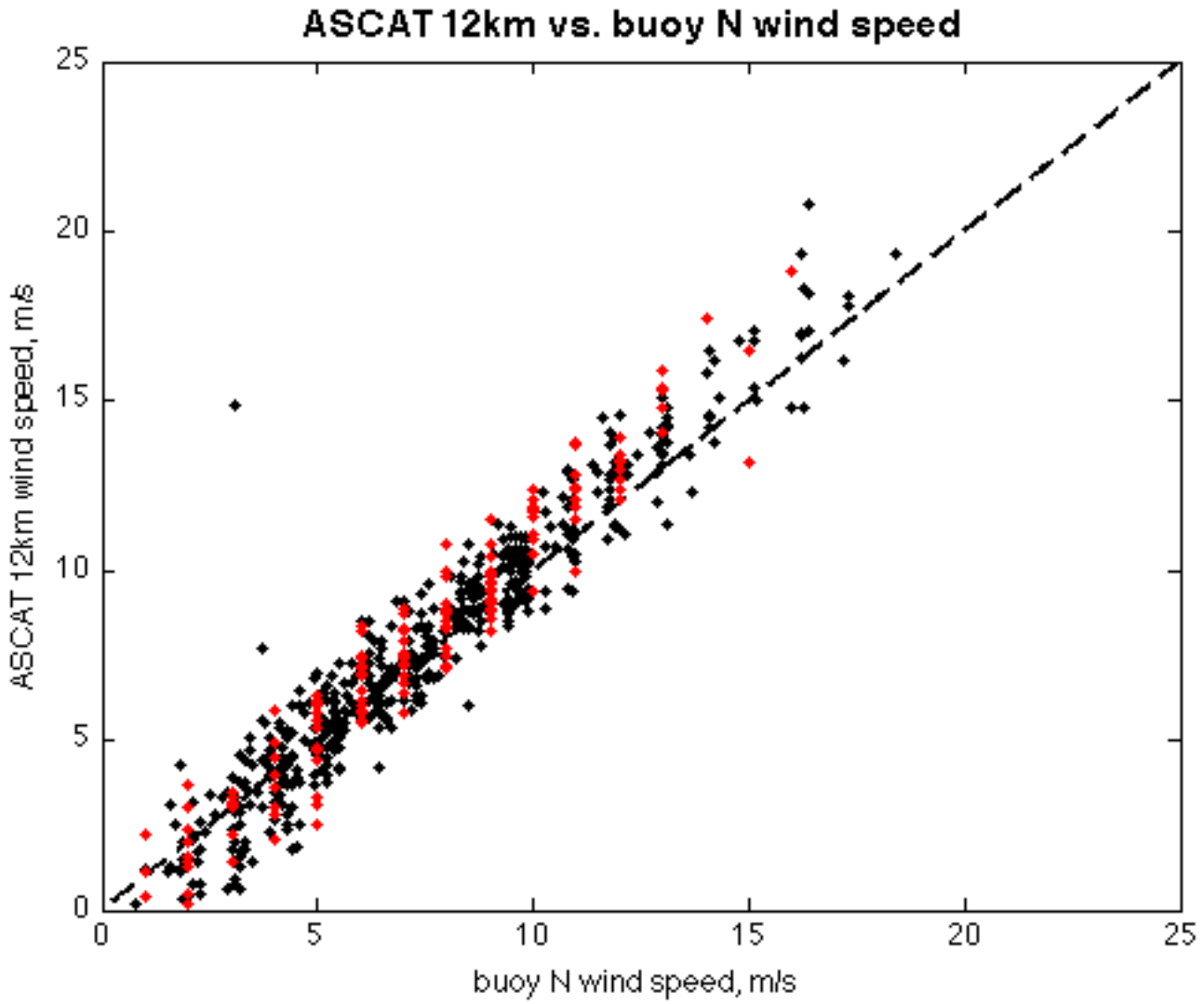
(25km ASCAT-buoy N) wind speed vs. current



weighted LS fit

black dashed line indicates $y = -x$

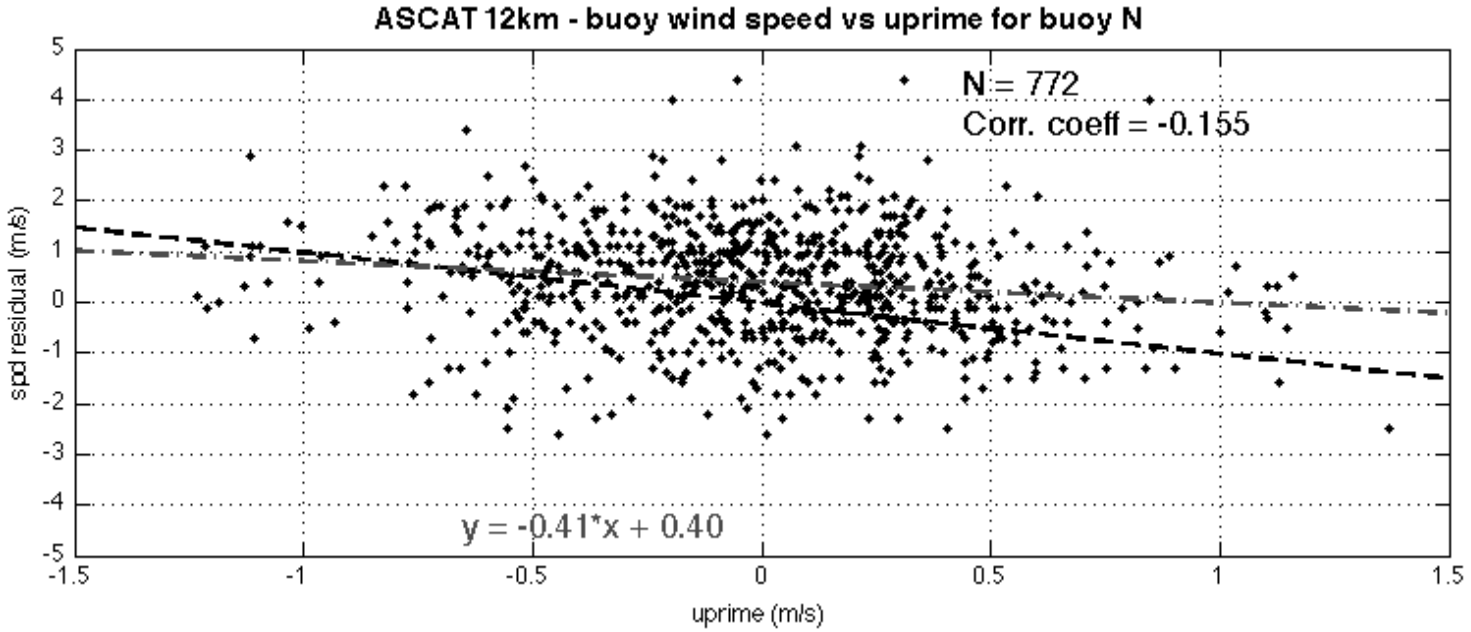
12km ASCAT and buoy N winds

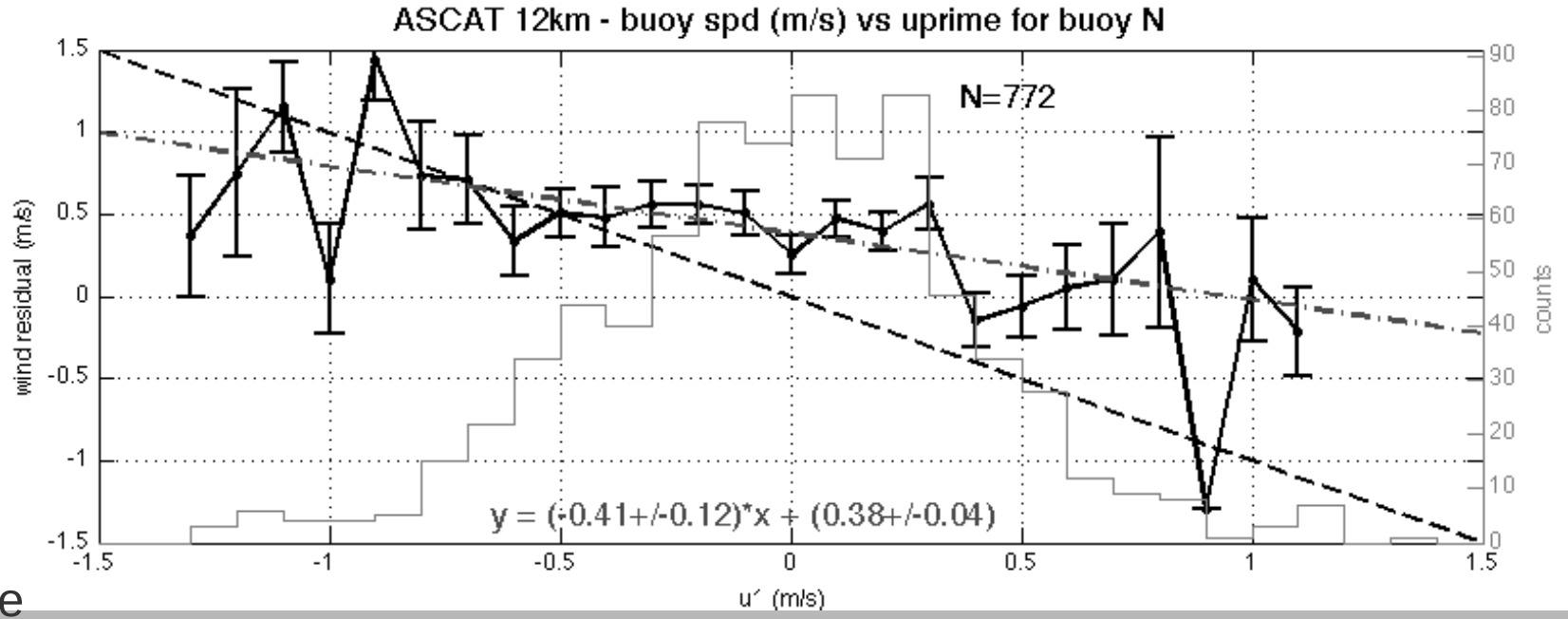


red dots indicate instances of missing buoy water temperatures, meaning the 10m buoy wind was created using law-of-the-wall only; this will be remedied in future.

black dashed line indicates $y = -x$

(12km ASCAT-buoy N) wind speed vs. current

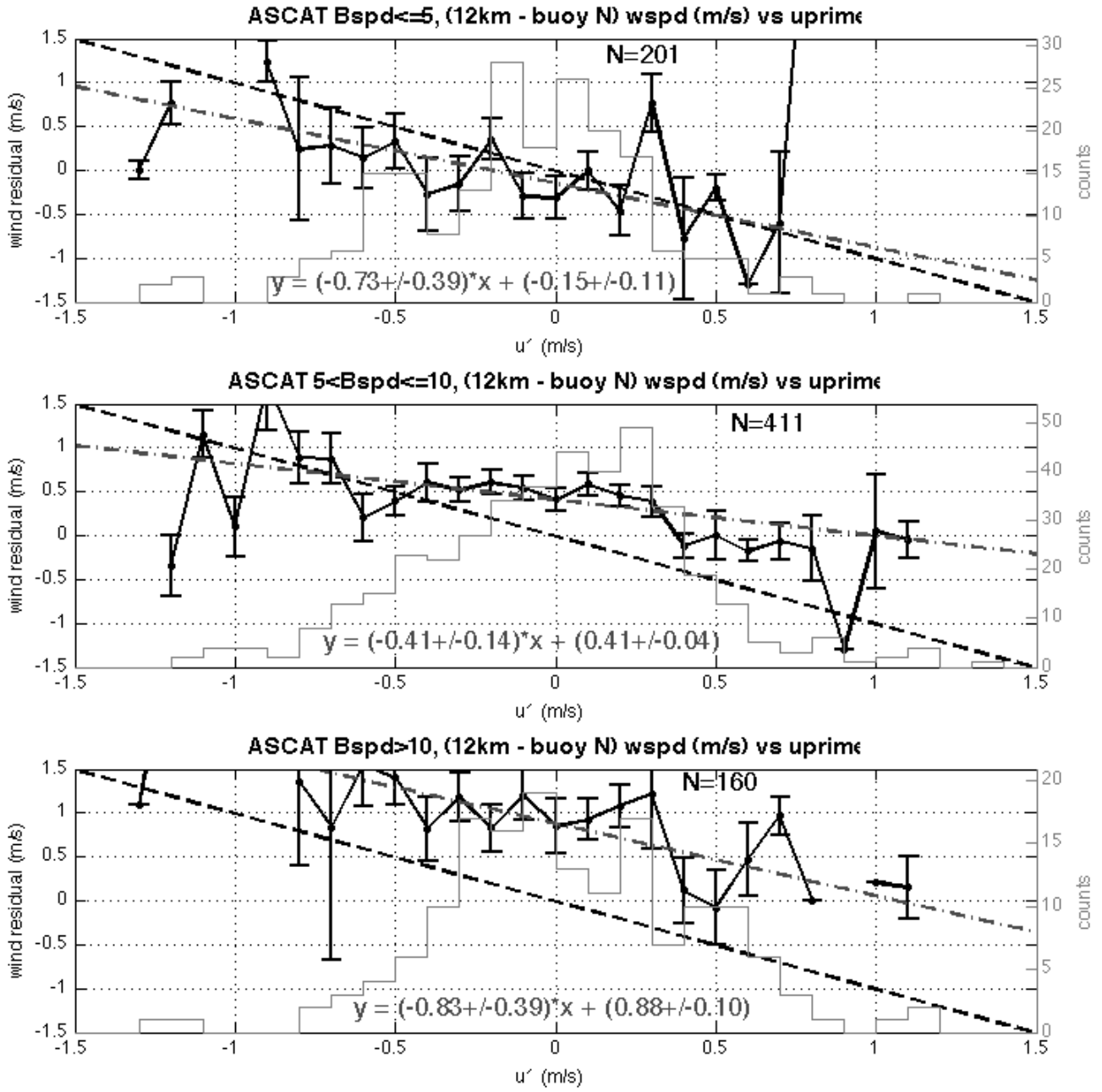




weighted LS fit

black dashed line indicates $y = -x$

(12km ASCAT-buoy N) wind speed vs. current



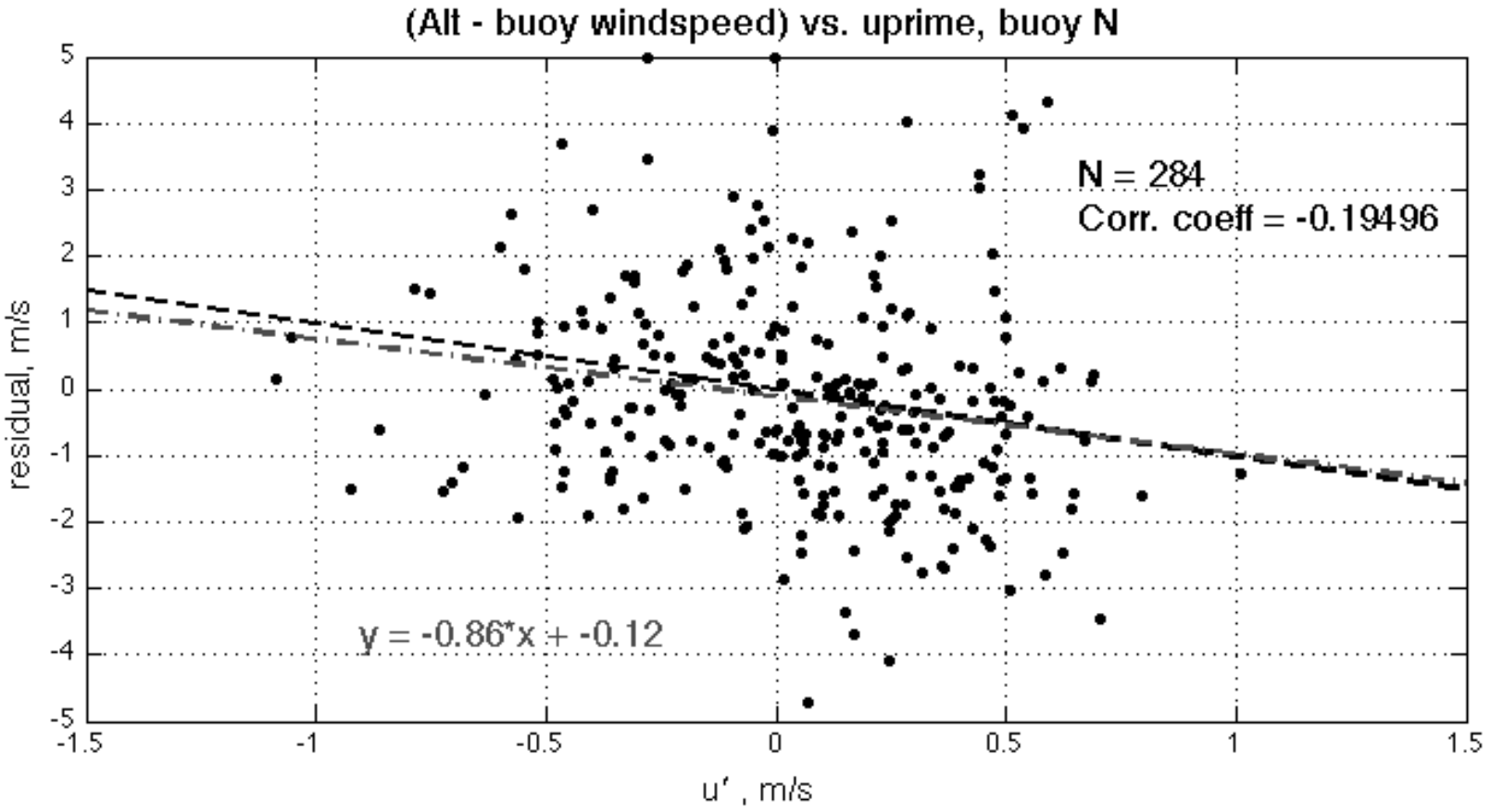
weighted LS fit

black dashed line indicates $y = -x$

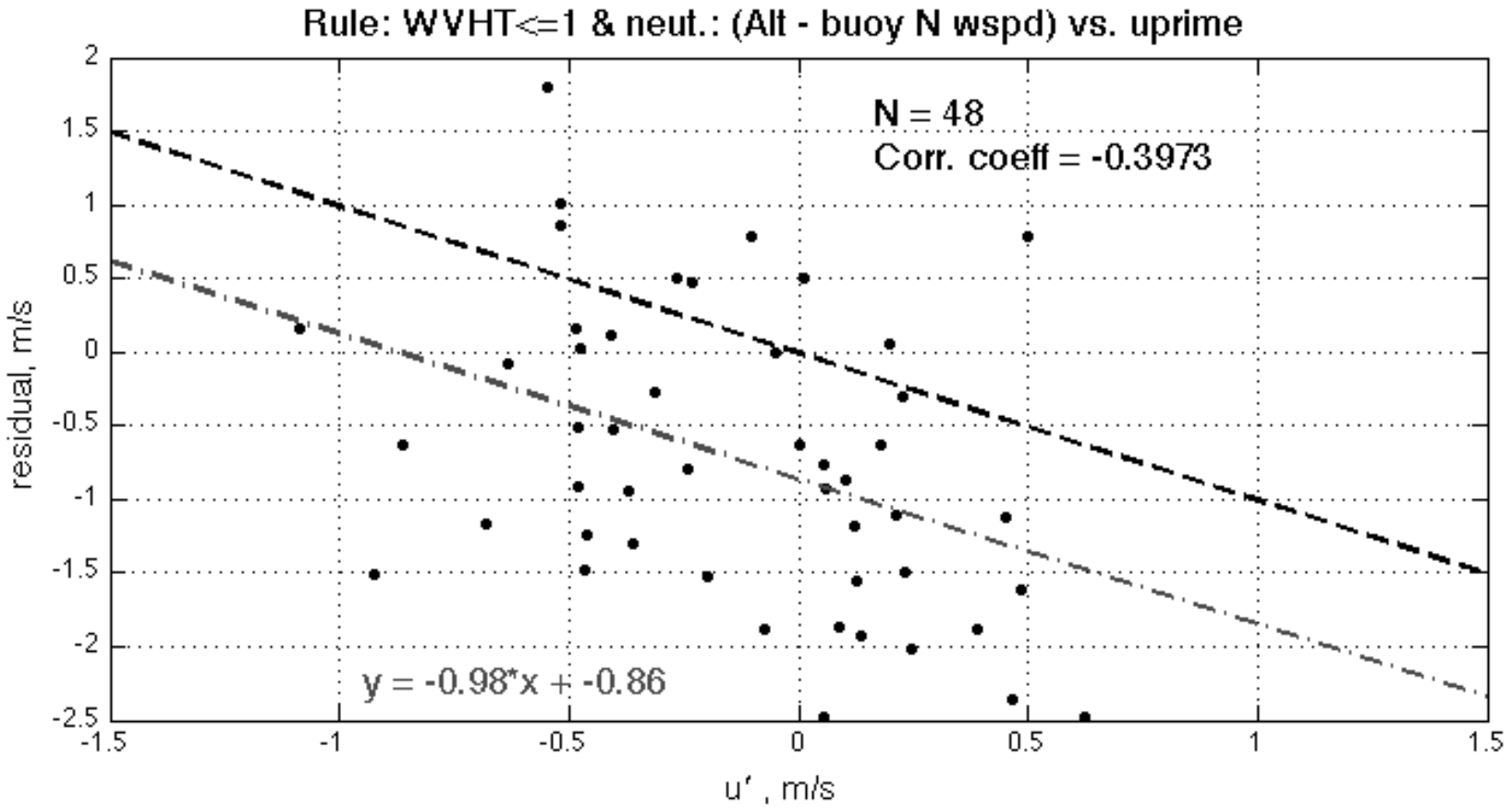
Surface-relative altimeter winds

- Jason-1,-2, Envisat
- We want to check if the response is less than kinematic 1:1 due to the longer waves included in altimeter backscatter (this would be similar in off-nadir radiometry) [Vandemark et al 1998]
- Note: This may not be a representative case, as the dynamic range of waves in the location of buoy N is somewhat limited, and certainly doesn't represent the global ocean

Altimeter and buoy N



Altimeter and buoy N: low wave height and neutral stability



Conclusions and future work

- QuikSCAT-- overall-- follows the kinematic boundary condition for all resolutions at two coastal buoys
- The effect of currents on QuikSCAT wind speed can be seen spatially as well
- ASCAT appears to have a weaker response
- Altimeter may be following kinematic condition despite longer waves

- Can we explain what is happening at low wind speeds?
- Can we retrieve any further information by sorting by z/L or another stability-related parameter?
- Can we determine why Ku-band and C-band seem to have such a different response?
  - Is this universally true or somehow related to the dynamics at our test site?

UNH air-sea discus buoy (ASID) for eddy covariance momentum, mass, and latent heat flux under ASCAT - ongoing in G. Maine

Key features

- Offshore with good ASCAT overpass data
- Synchronized 20 Hz data for hourly flux estimates using:
  - Licor H_20 and CO_2 (Li7500)
  - Direct covariance flux system
- Solar powered for long-term continuous operation
- 3-D near surface current data
- 2-D gravity wave spectra

Special thanks to...

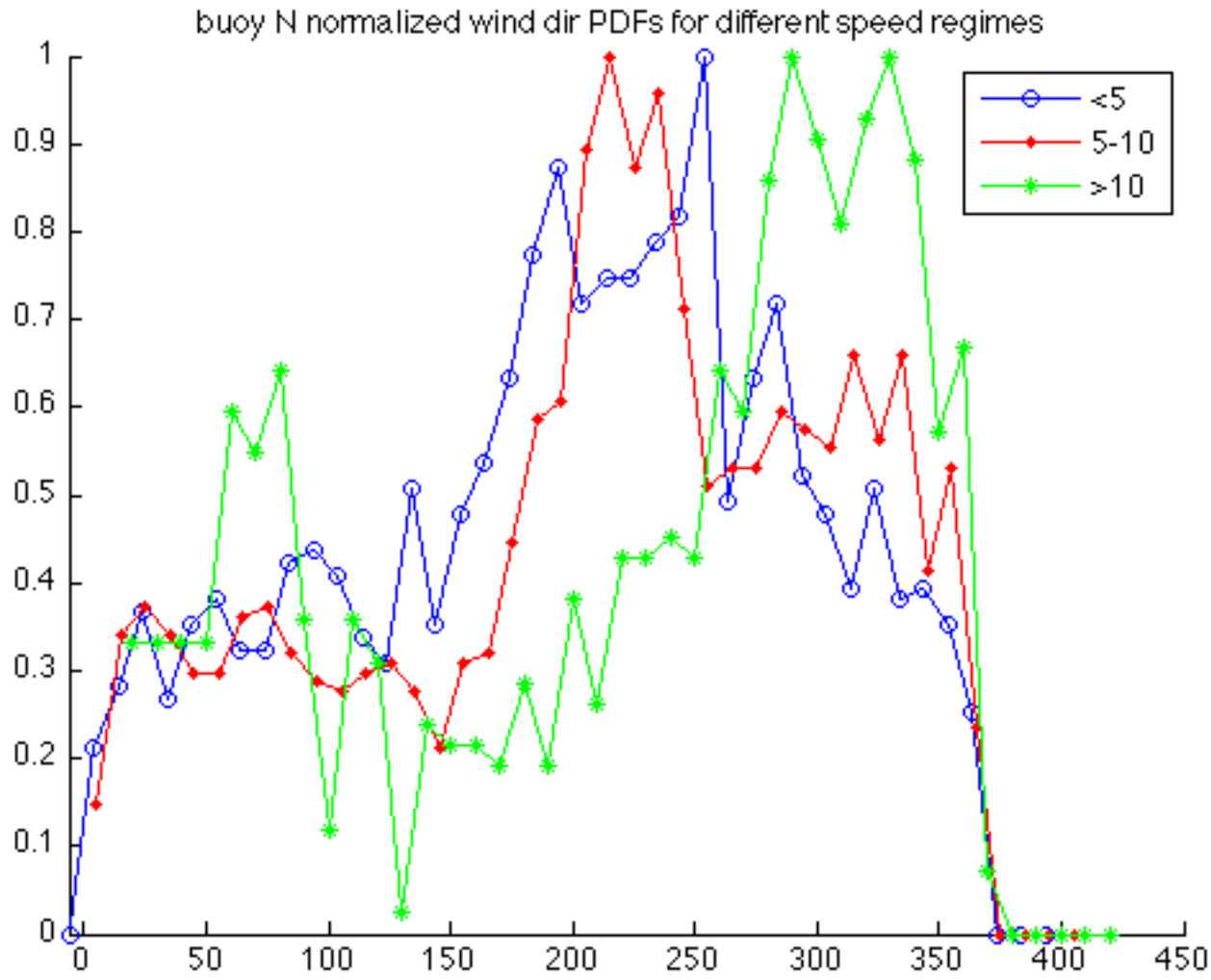
- Ernesto Rodriguez and NASA's Graduate Student Researchers Program
- Anton Verhoef at KNMI
- Hui Feng at UNH
- Rich Signell at USGS
- Dr. Chen at UMass

Questions? Suggestions? Comments?

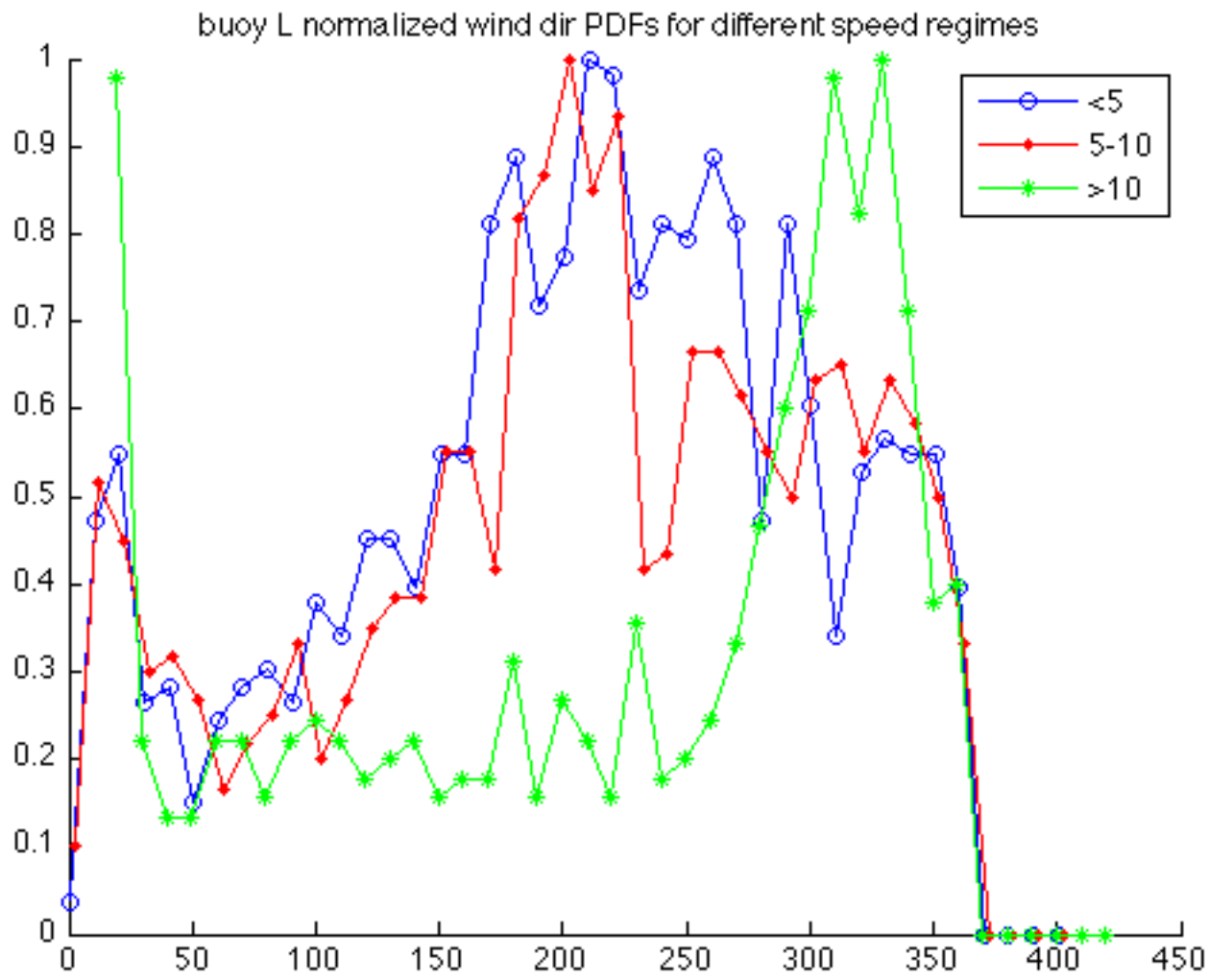
Extra slides

Bourassa's [2006] model

$$U(z) - U_s = \frac{u_{*a}}{\kappa}\left[\ln\frac{z}{z_0} + \phi(z, z_0, L)\right]$$



for both buoys it does look like there are directional differences, especially between low and high winds


buoy L normalized wind dir PDFs for different speed regimes
<5
5-10
>10
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0.2
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0.4
0.5
0.6
0.7
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50
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150
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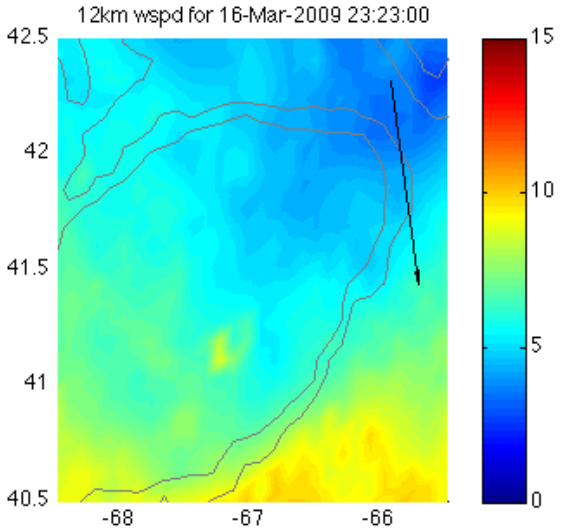
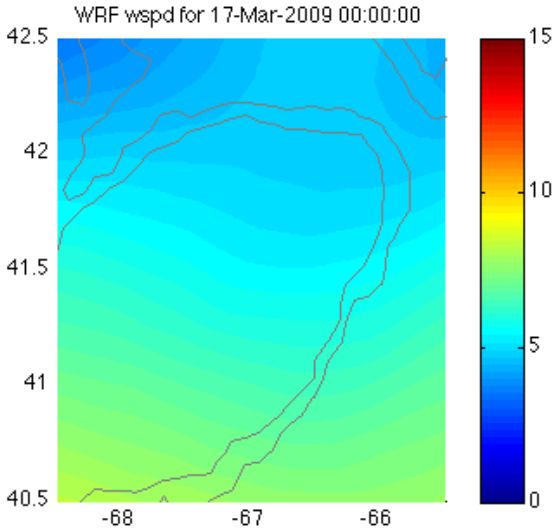
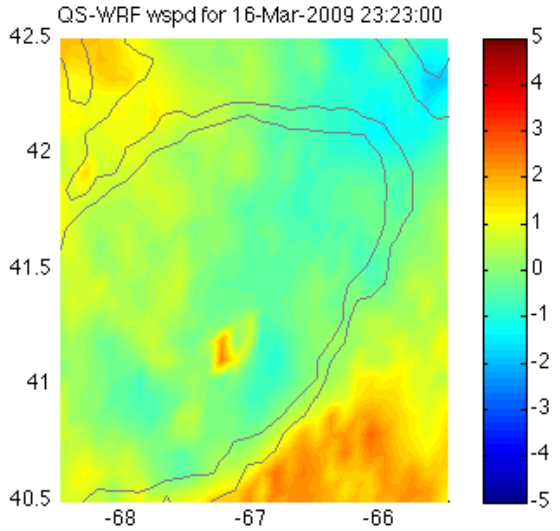
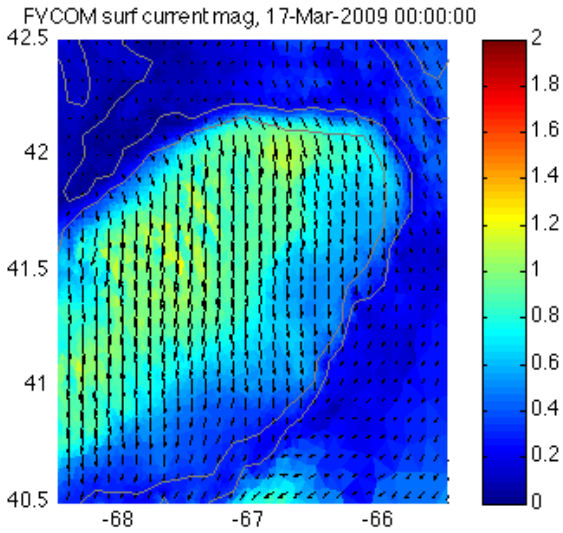
300
350
400
450

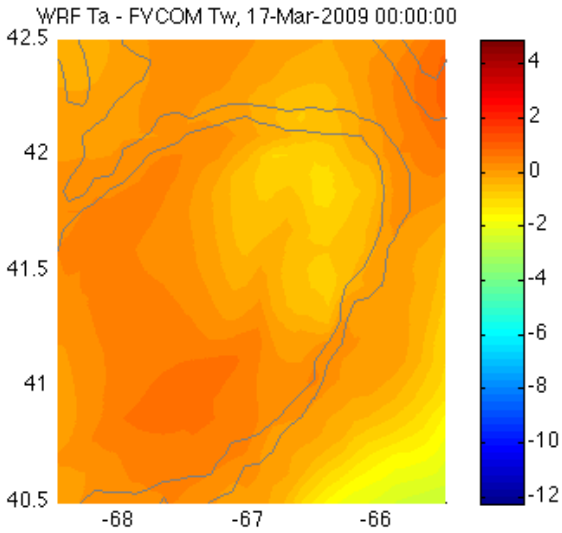
Spatial case study: 16-17 Mar 2009

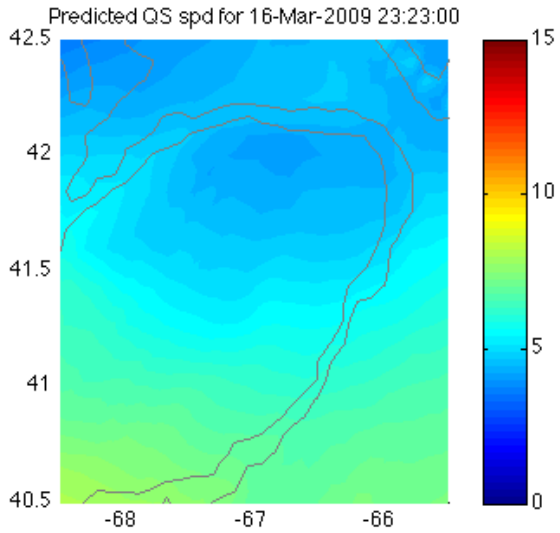




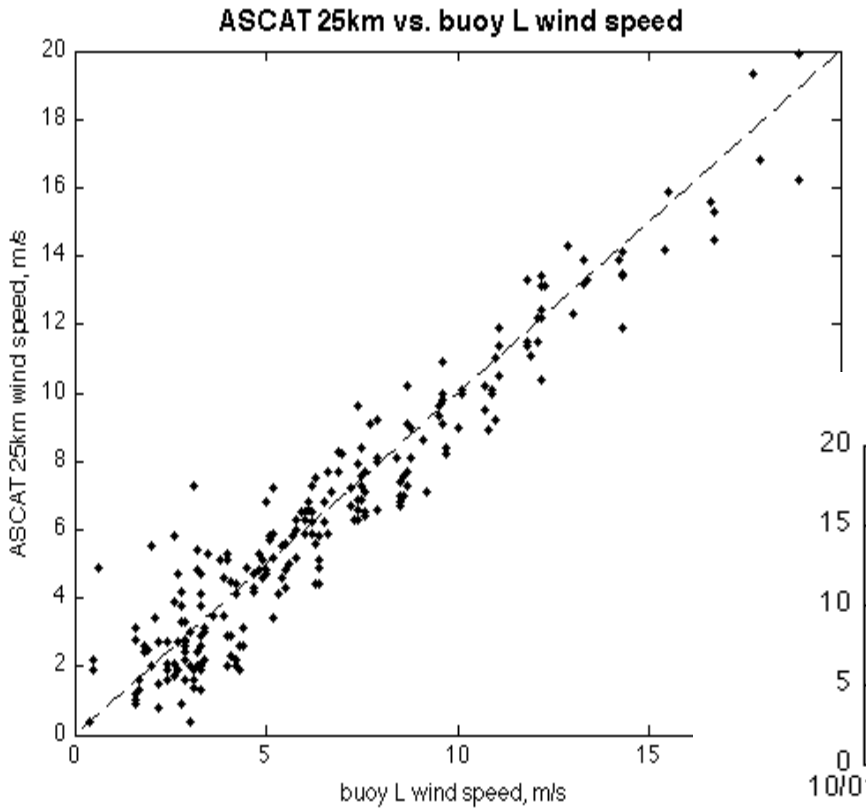


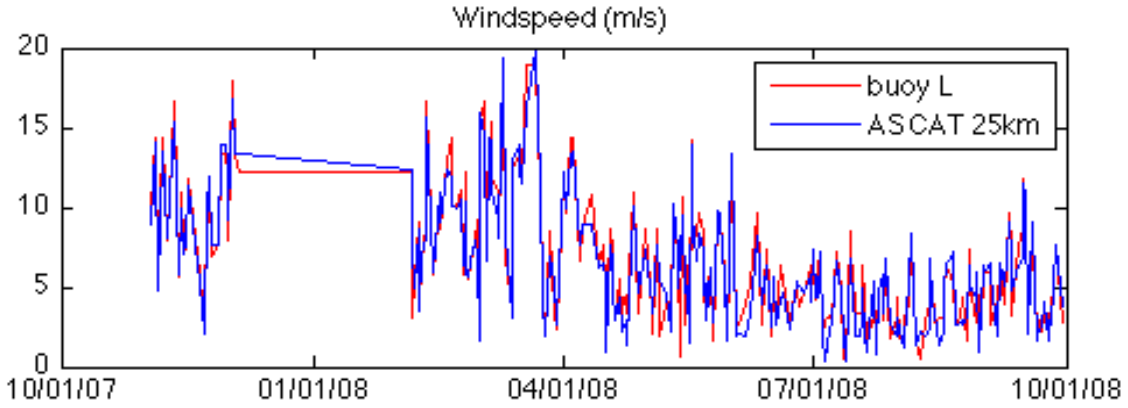


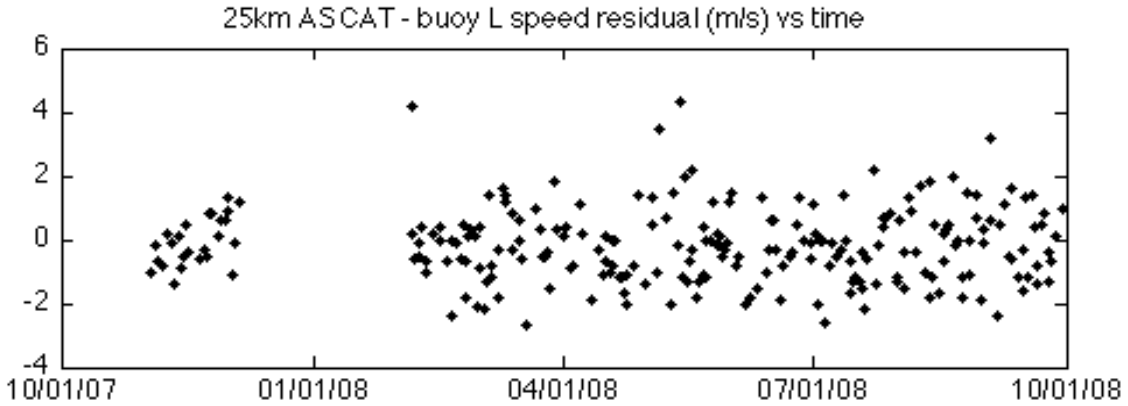




25km ASCAT and buoy L winds

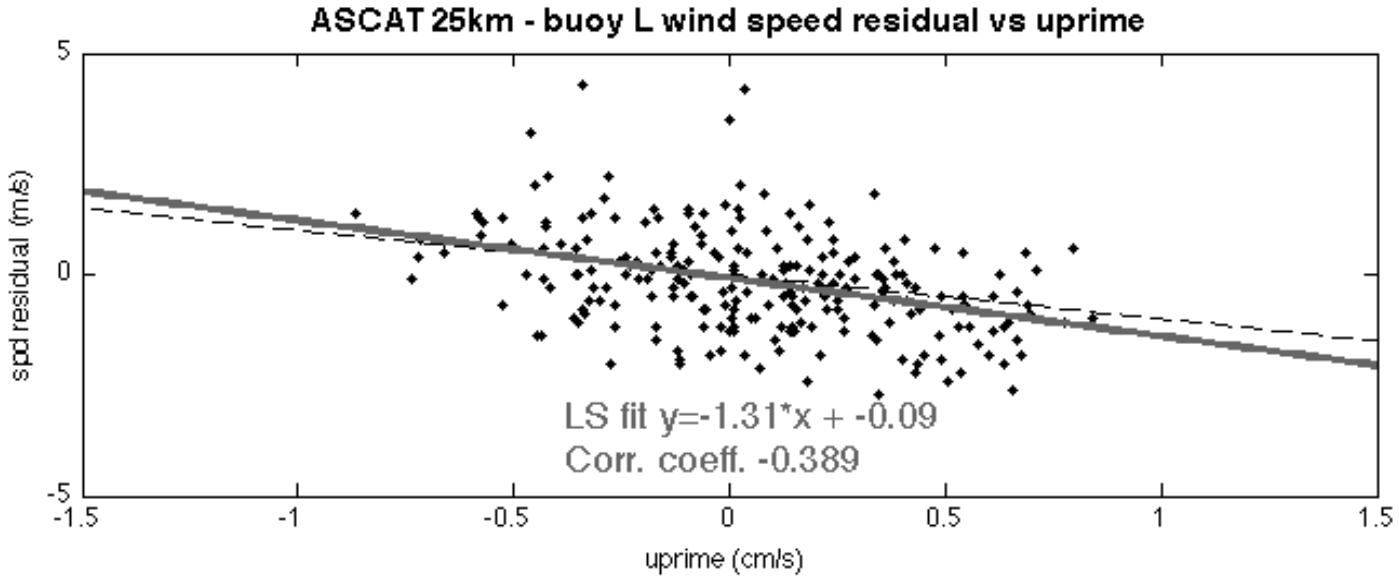


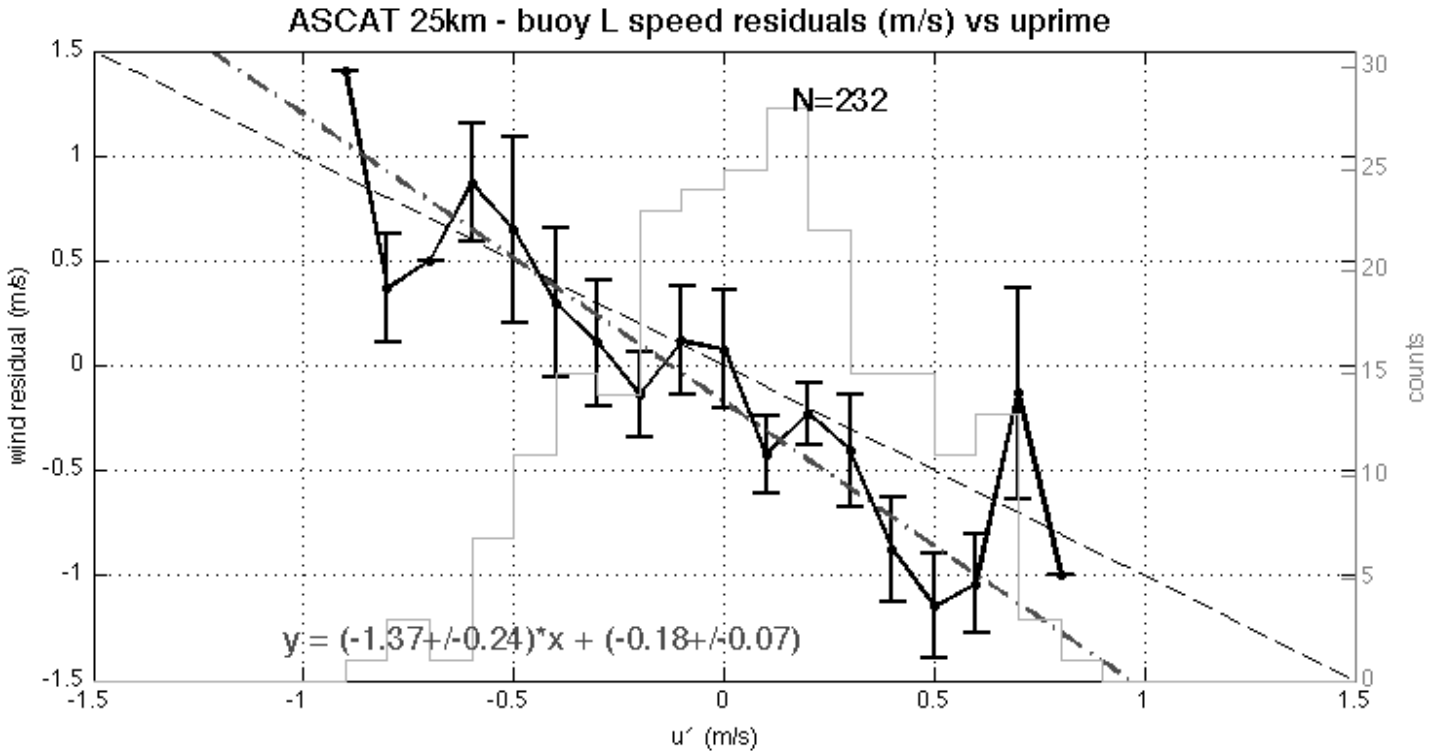




black dashed line indicates $y = -x$

(25km ASCAT-buoy L) wind speed vs. current





weighted LS fit

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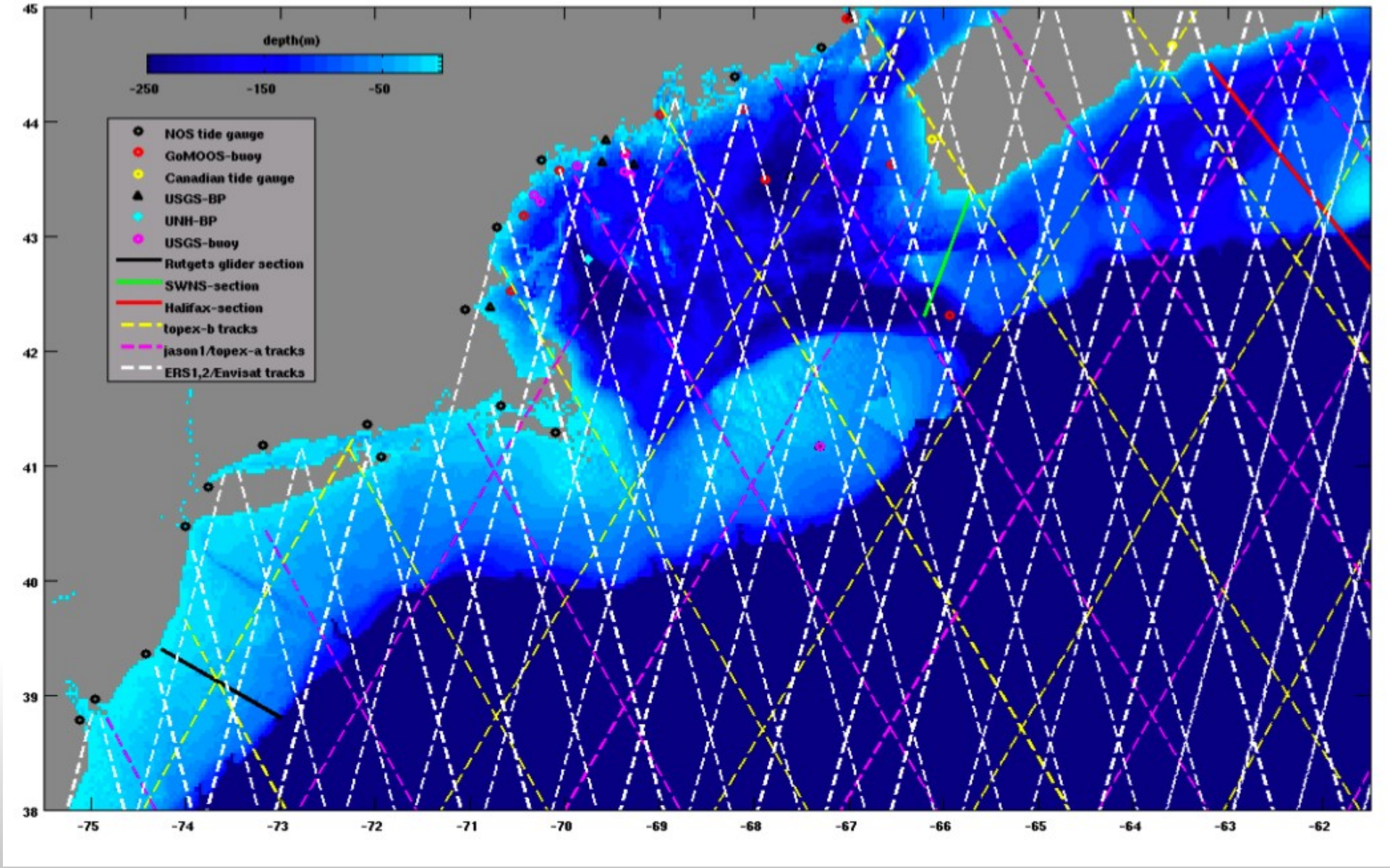
depth(m)
-250
-150
-50
NOS tide gauge
GoMOOS-buoy
Canadian tide gauge
USGS-BP
UNH-BP
USGS-buoy
Rutgets glider section
SWNS-section
Halifax-section
topex-b tracks
jason1/topex-a tracks
ERS1,2/Envisat tracks
45
44
43
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