Applications Scatterometry for Ocean Surface Stress

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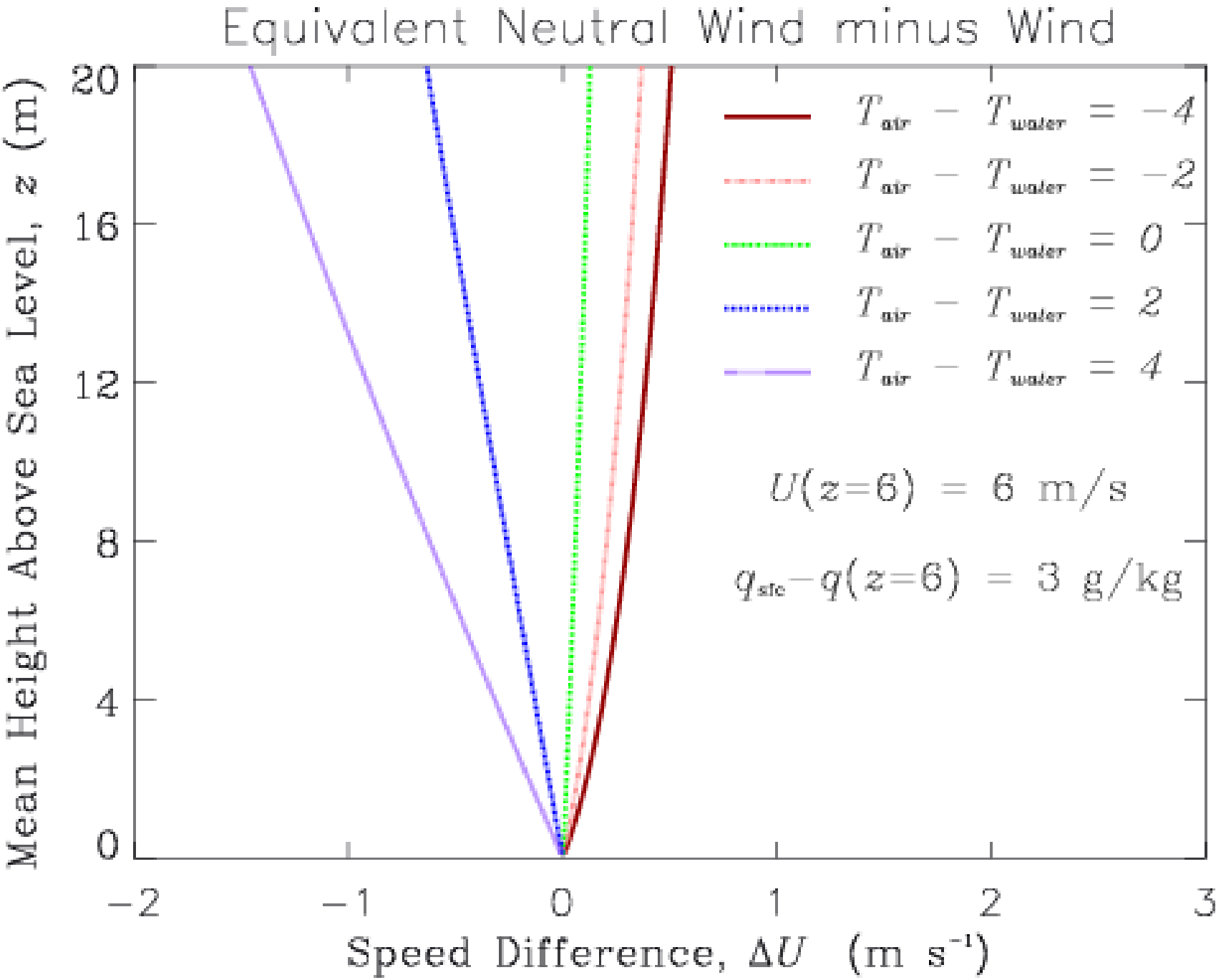
The Need:

- Winds (via surface wind stress) at the surface (but not at 10m) drives the ocean
- Scatterometers measure sea surface roughness, which is related to the surface stress
- Since numerical weather models use winds at ship deck or buoy level (standardized at 10 m), GMFs are derived that relate 10 m wind to the measured roughness
- For a given observed roughness, 10 m winds can vary with atmospheric conditions by up to 2 m/s
- Stress desired is derived from the 10 m winds assuming a neutrally stable atmosphere, which is consistent with how scatterometer winds are derived.


Equivalent Neutral Wind minus Wind
Mean Height Above Sea Level, z (m)
Speed Difference, ΔU (m s⁻¹)
20
16
12
8
4
0
−2
−1
0
1
2
3
$T_{air} - T_{water} = -4$
$T_{air} - T_{water} = -2$
$T_{air} - T_{water} = 0$
$T_{air} - T_{water} = 2$
$T_{air} - T_{water} = 4$
$U(z=6) = 6$ m/s
$q_{sfc} - q(z=6) = 3$ g/kg

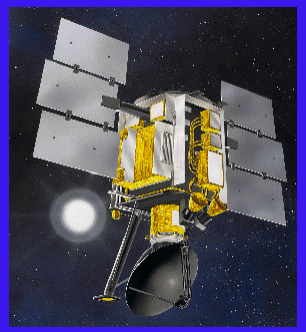
APPROACH:

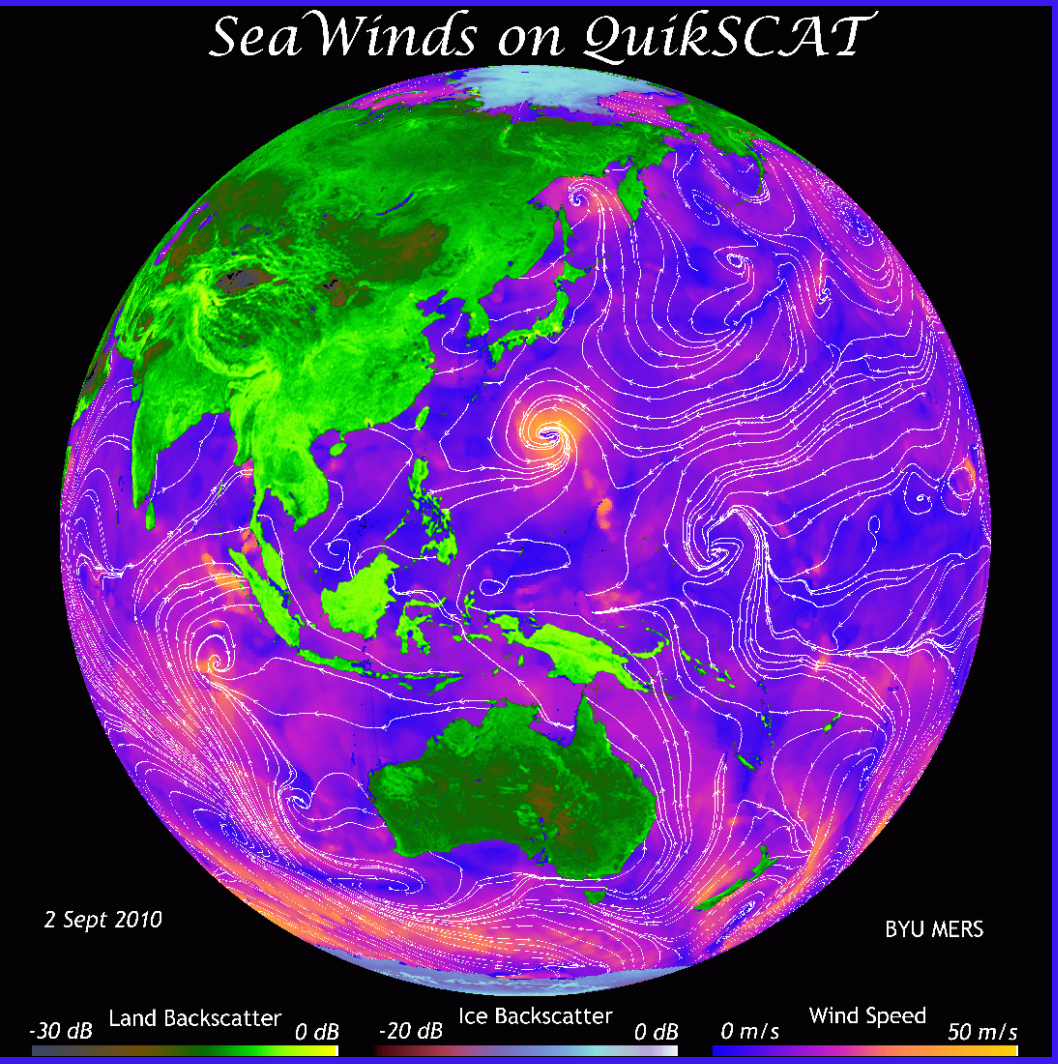
In Situ

- **Data Buoy Observations (EPO):**

  Wind Vectors, Air Temp, Humidity at 3 m and SST
- **Wind stress estimated from the bulk flux algorithm based on Monin-Obukhov similarity theory that accounts for changes in stability**
- **MO theory relates surface stress, heat and moisture flux to the variation of wind with height.**
- **If mean quantities are available at the surface & reference height, fluxes can be calculated**
- **Ocean currents and waves not considered**

QuikSCAT Measurements





- SeaWinds on QuikSCAT scatterometer operated at Ku-band, collecting 5x25km (slice) and 25x35 km (egg) dual-polarization backscatter measurements and 25 km wind measurements globally
- Collocated the nearest set (dual polarization, four azimuth angles) backscatter measurements and nearest winds to each 6 hour TAO buoy report
- Collocations: closest within 100 mins and 25 km extracted from QuikSCAT L1B and L2B files from 1999-2003. Only values passing all quality flags used.

ANN Analysis:

Input:

Four sets of sigma-0, IA, AA (wrt ECMWF wind direction), cos(AA), cos(2AA)

Output:

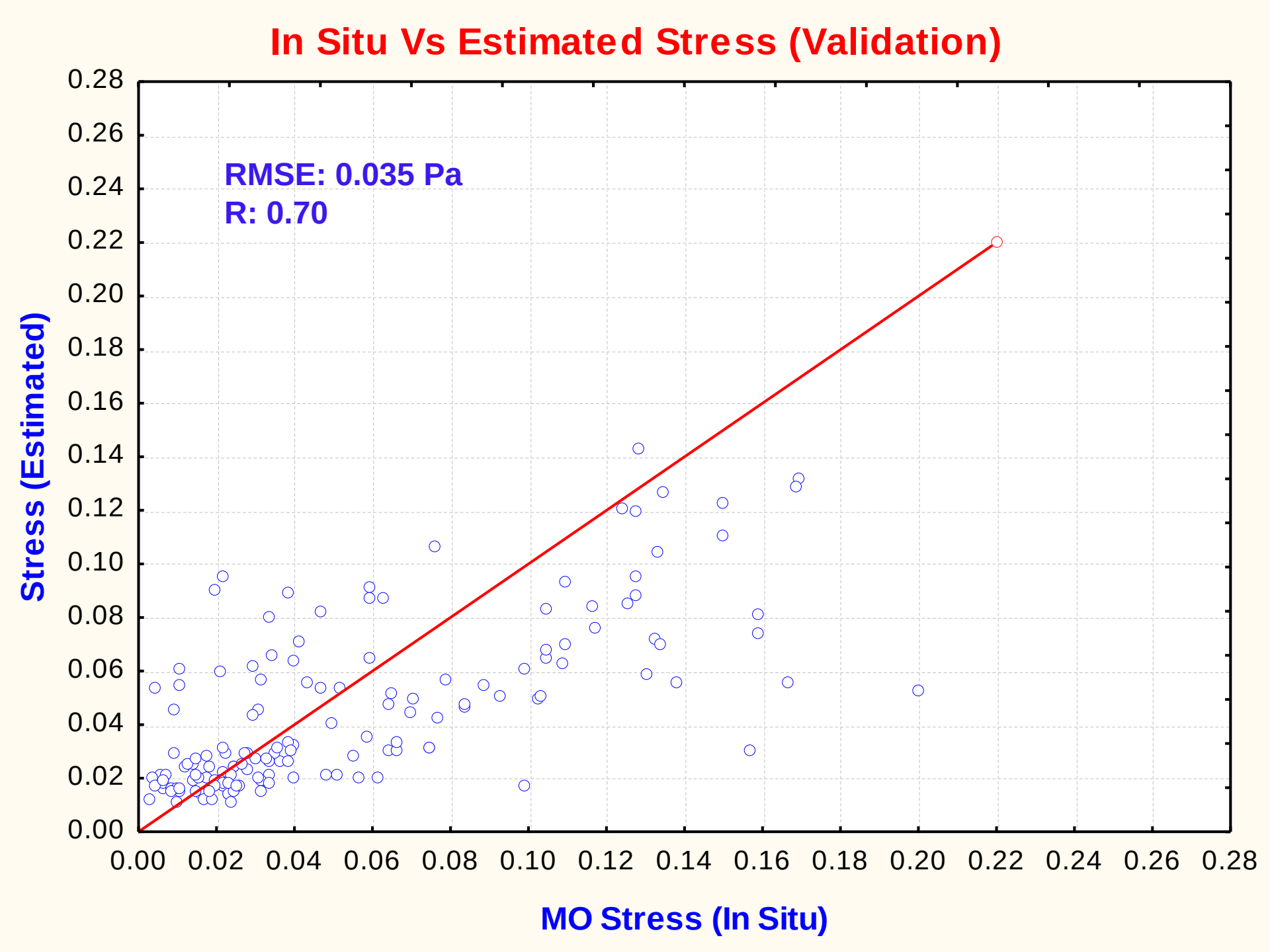
Wind stress estimated using MO Theory (assumed as in situ stress)

Period:

Training: 1999-2001 (840 Obs.)

Testing: 2002 (1010 Obs.)

Validation: 2003 (150 Obs.)

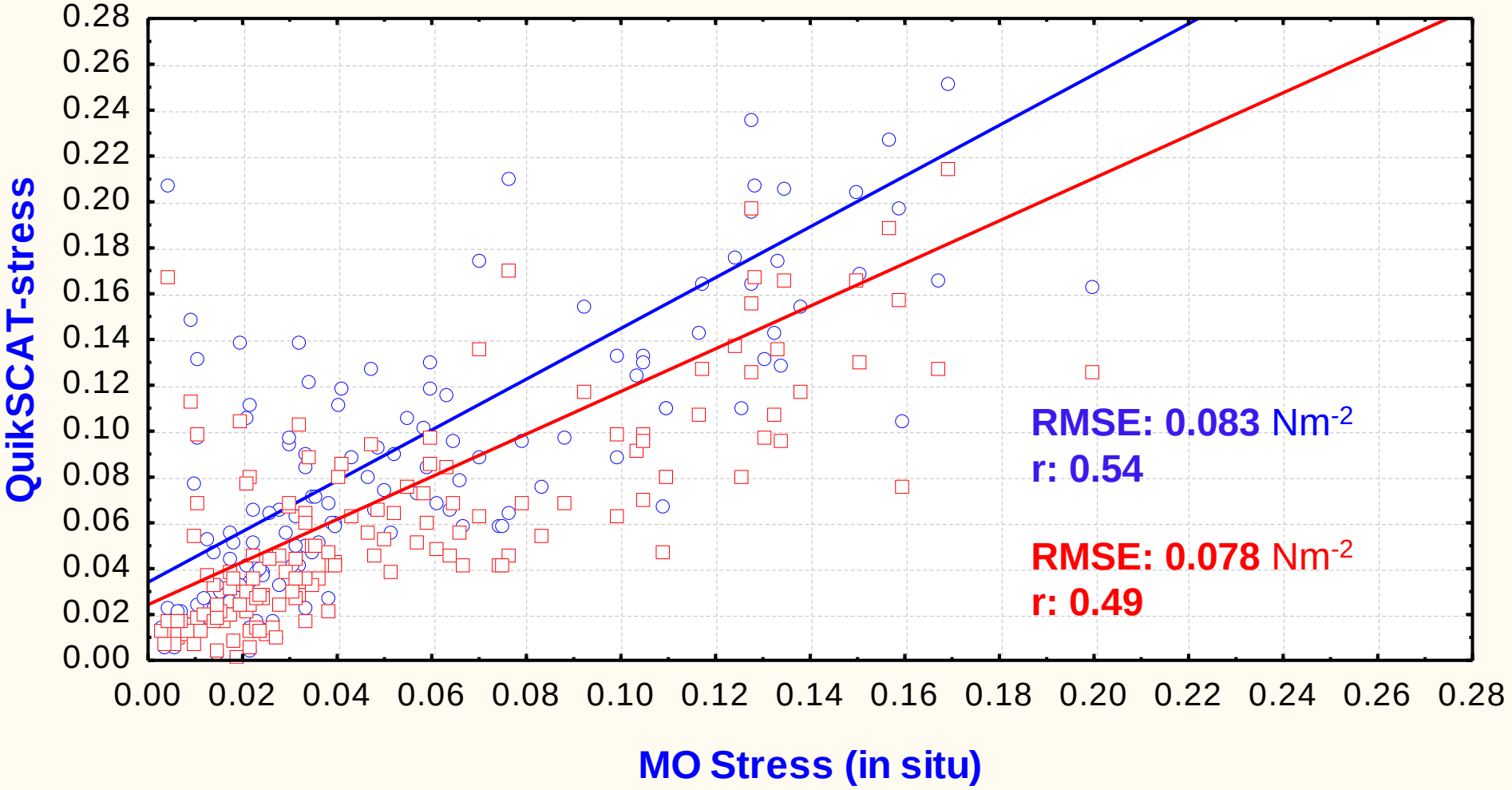

In Situ Vs Estimated Stress (Validation)
RMSE: 0.035 Pa
R: 0.70
Stress (Estimated)
MO Stress (In Situ)
0.00
0.02
0.04
0.06
0.08
0.10
0.12
0.14
0.16
0.18
0.20
0.22
0.24
0.26
0.28

Buoy-Stress vs QuikSCAT-Stress
(Estimated using winds at 10m)

Blue: With Constant CDNc (0.0015)

Red: With Wind Dependent CDNw

[CDNw=(2.70/ws+0.142+0.0764*ws)/1000.]



Comparison of Buoy Stress with Estimated Values Statistical Results

Method ►	ANN-Stress	QuikSCAT-Stress	
		With Constant CD	With Wind Dependent CD
RMSE	0.035 Pa	0.083 Pa	0.078 Pa
R	0.70	0.54	0.48
SI	0.64	1.79	1.43
SDR	0.71	1.58	1.64

SI (Scatter Index)=RMSE/Data Mean
SDR (Std. Ratio)= Error SD/Data SD

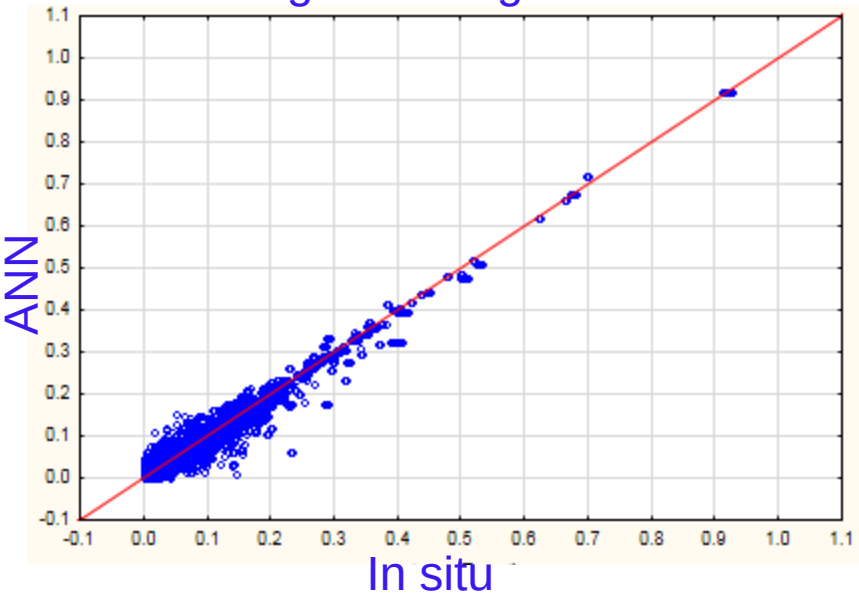
Ali et al. (2013), GRSL

Stress from OSCAT (2012)

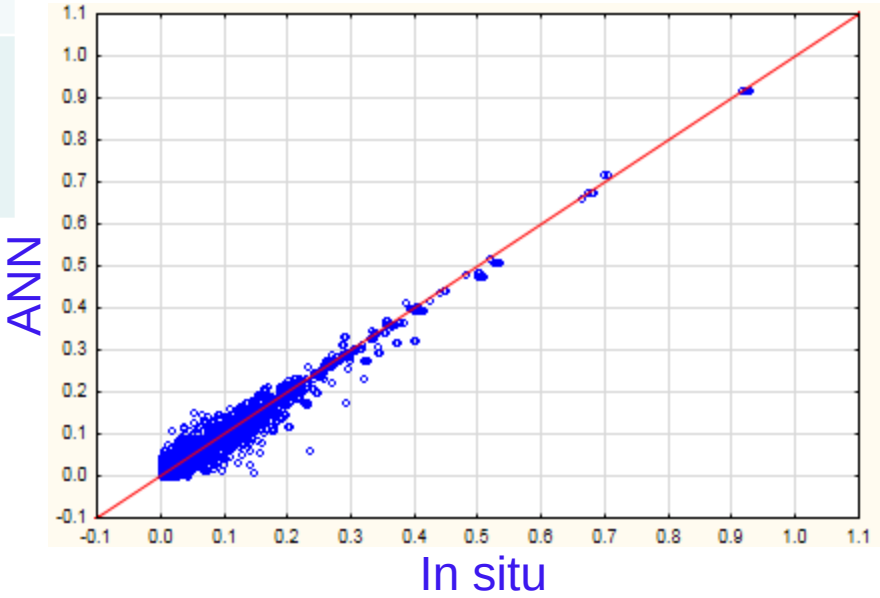
Scatteer between in situ and ANN stresses

Data Set	Mean	Abs. Error Mean	RMS E	Scat, Index	Corr. Coeff
Training	0.083	0.015	0.021	0.25	0.97
Testing	0.087	0.015	0.022	0.25	0.97
Validation	0.083	0.015	0.021	0.25	0.97

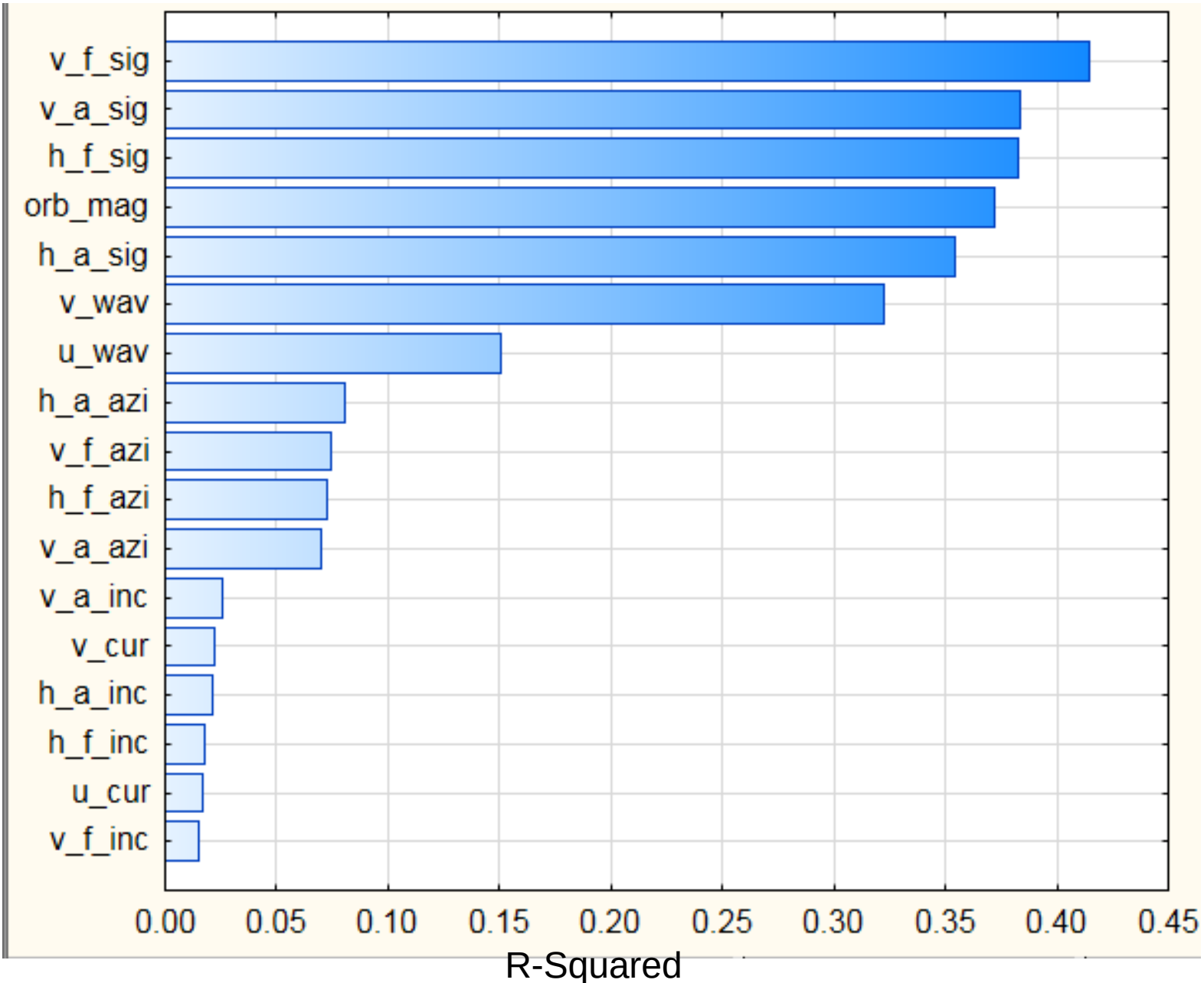
Training & Testing data sets

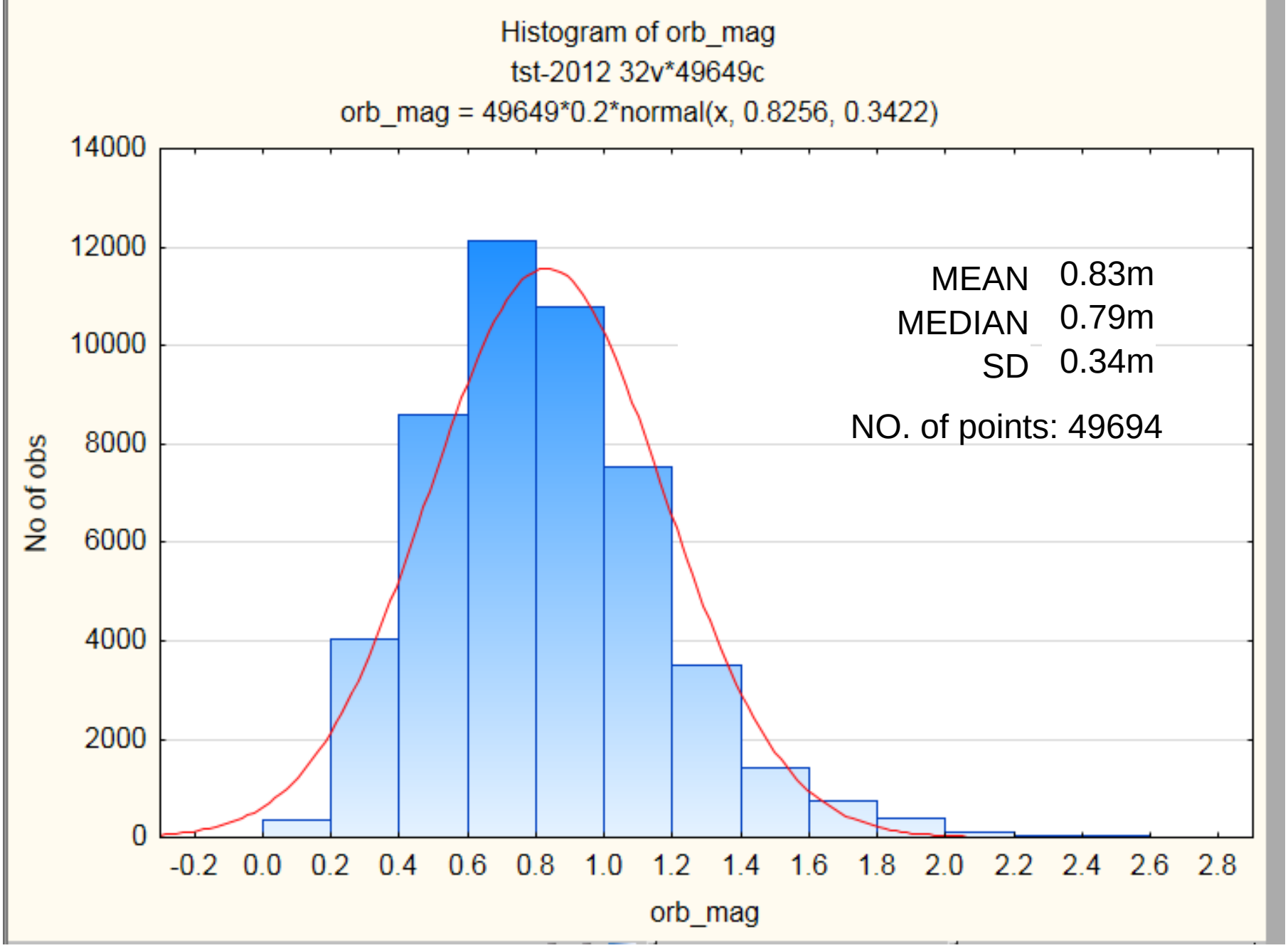


Validation data set



Importance of OSCAT parameters for Stress: R-Squared




Histogram of orb_mag
tst-2012 32v*49649c
orb_mag = 49649*0.2*normal(x, 0.8256, 0.3422)
MEAN 0.83m
MEDIAN 0.79m
SD 0.34m
NO. of points: 49694
No of obs
orb_mag
14000
12000
10000
8000
6000
4000
2000
0
-0.2
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
2.6
2.8

Summary

- Stress derived directly at the surface matches well with in situ observations compared to that derived from 10 m winds
- Currents do NOT significantly influence the stress estimations
- Ocean surface orbital velocities have strong signals in the stress.
- Can we estimate these orbital velocities from scatterometers?

…… would be able to answer this question in a few months

Questions/Suggestions?

Thank you