Aquarius Wind Speed Retrievals and Implications for SMAP Ocean Vector Winds

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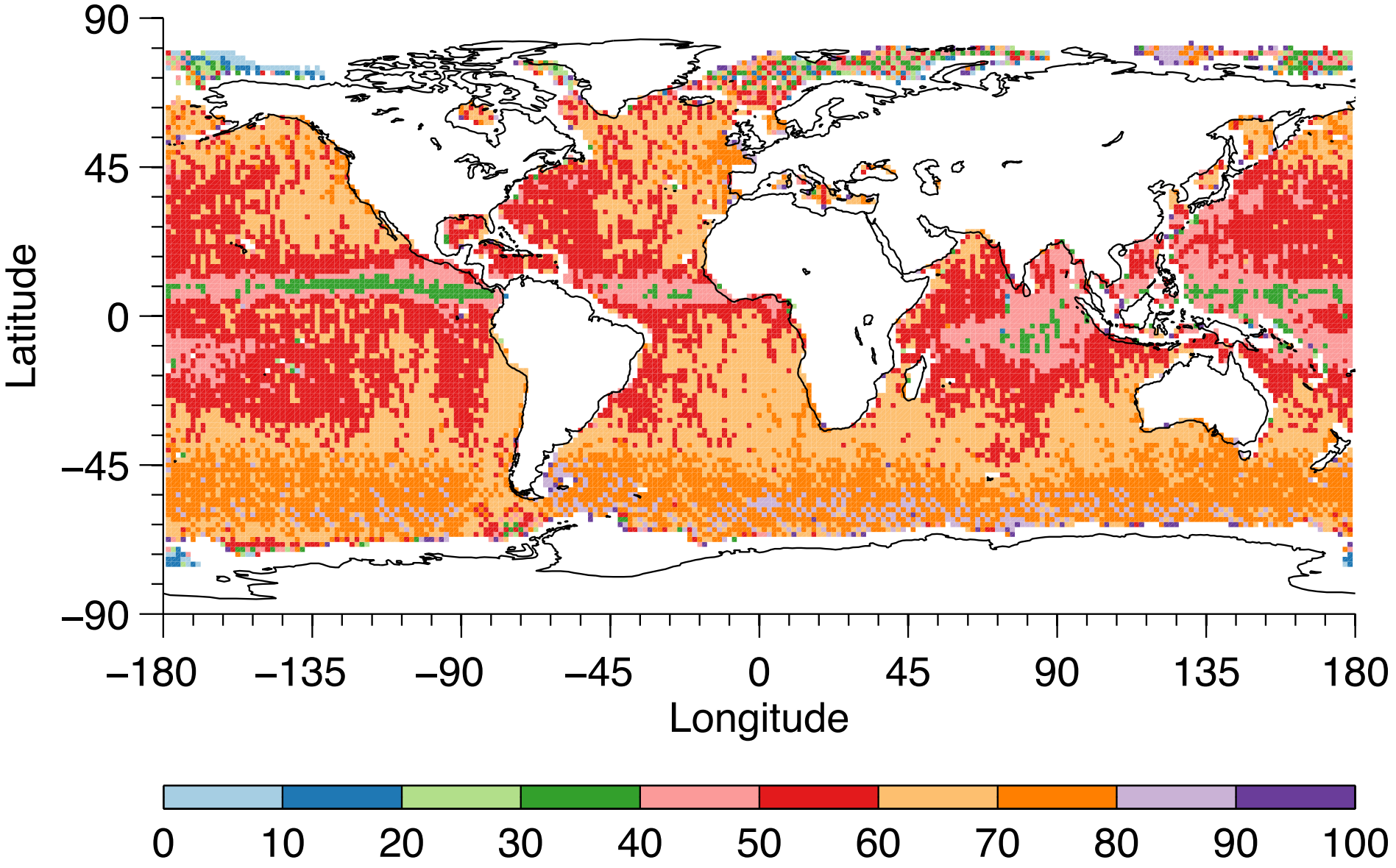
Model Function Generation

- Collocate with both SSMI/S and WindSat wind speed, rain rate, and NCEP wind vectors.
  - Require < 1 hour offset; average all data that fall within 25 km of Aquarius location.
  - Exclude non-zero rain-rates.
  - Use SSMI/S / WindSat wind speed with NCEP wind direction.
- Have included corrections for significant wave height (SWH).
- Rain corrections have also been included in the model function.



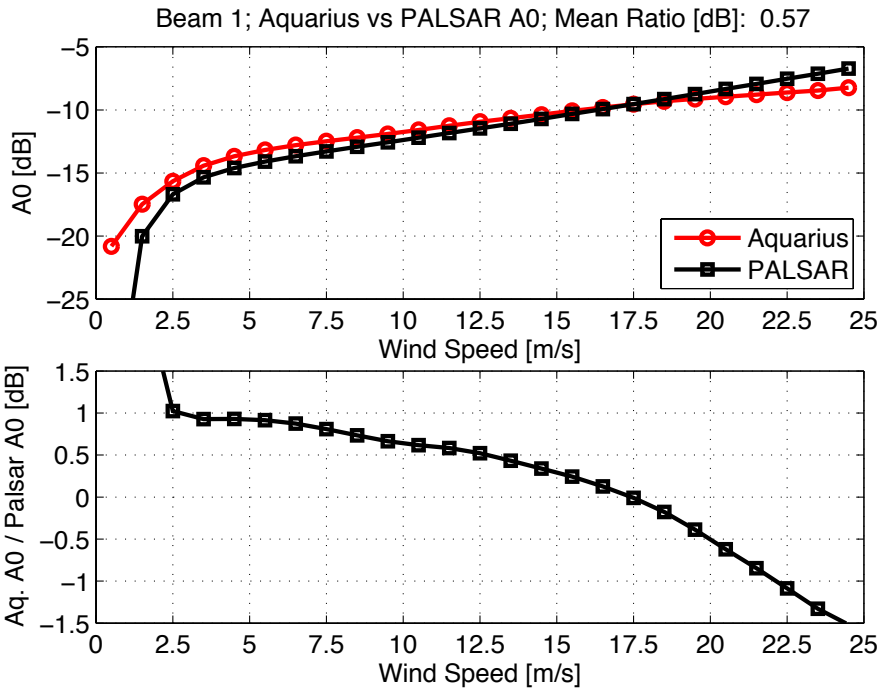
Most regions have > 60 % match-ups with SSMI/S

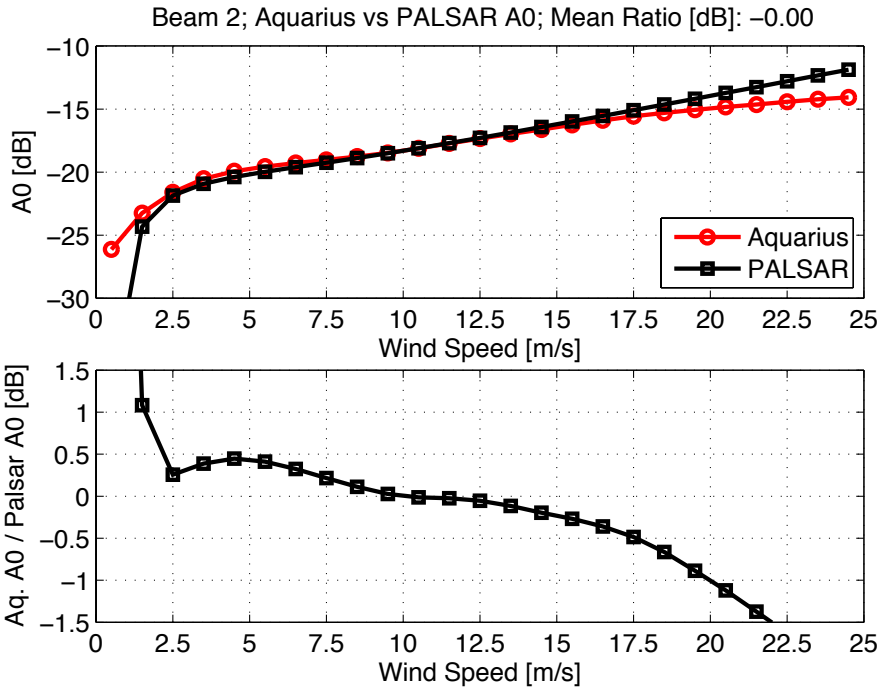
Ocean Comparison Aquarius HH / PALSAR HH

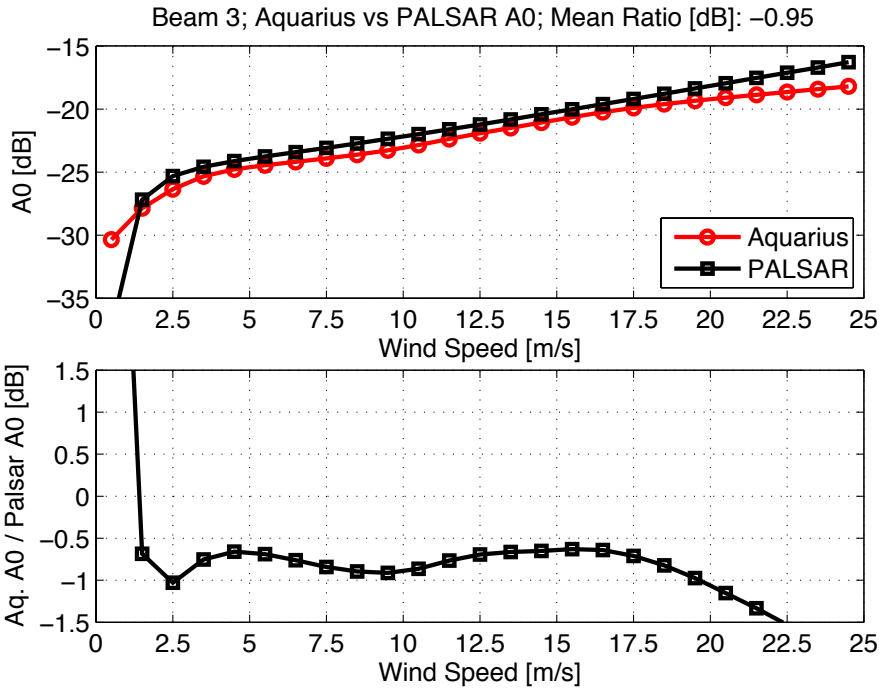
Plot of PALSAR HH GMF (black square) and our Aquarius HH GMF (red o).

-Compute wind speed PDF weighted mean ratio of Aquarius GMF divided by PALSAR GMF.

Beam	1	2	3
Mean Ratio [dB]	0.57	0	-0.95



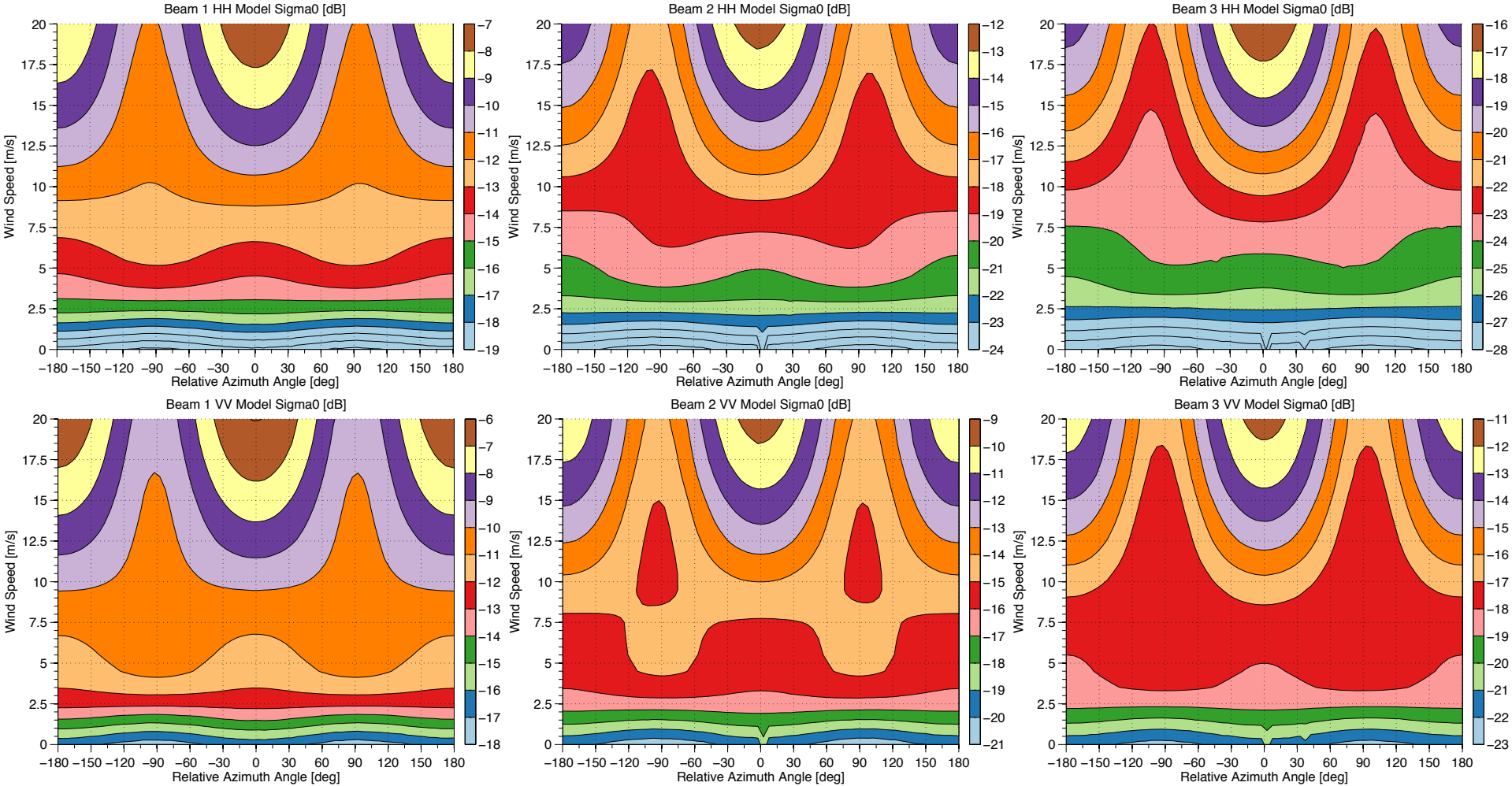




Aquarius Active Model Function

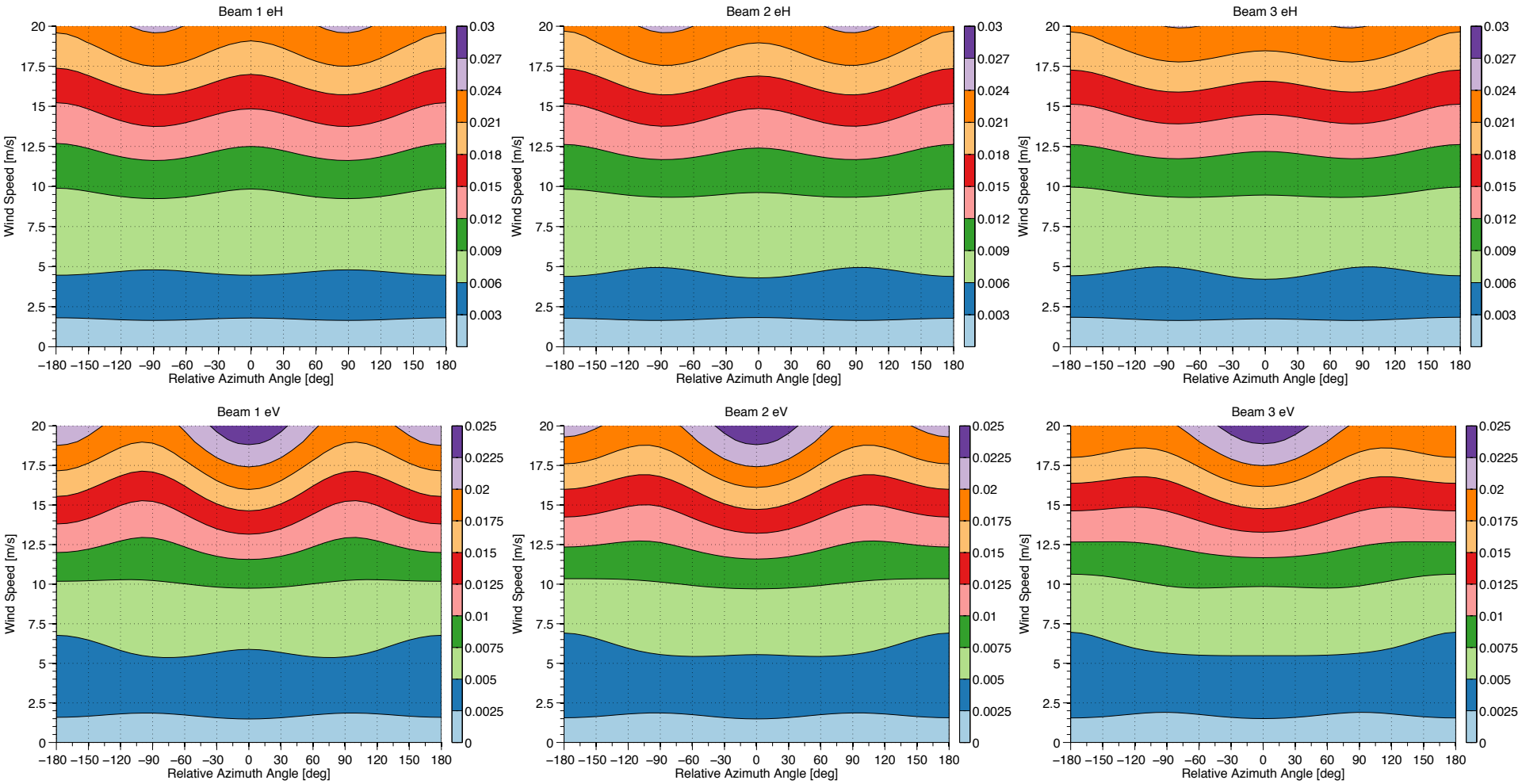
HH (top),VV (bottom); Beam 1 (left), 2 (middle), and 3 (right)

Note flat / non-monotonic behavior near ±90 degrees relative azimuth



Aquarius Passive Model Function

H emissivity (top), V emissivity (bottom);
Beam 1 (left), 2 (middle), and 3 (right)

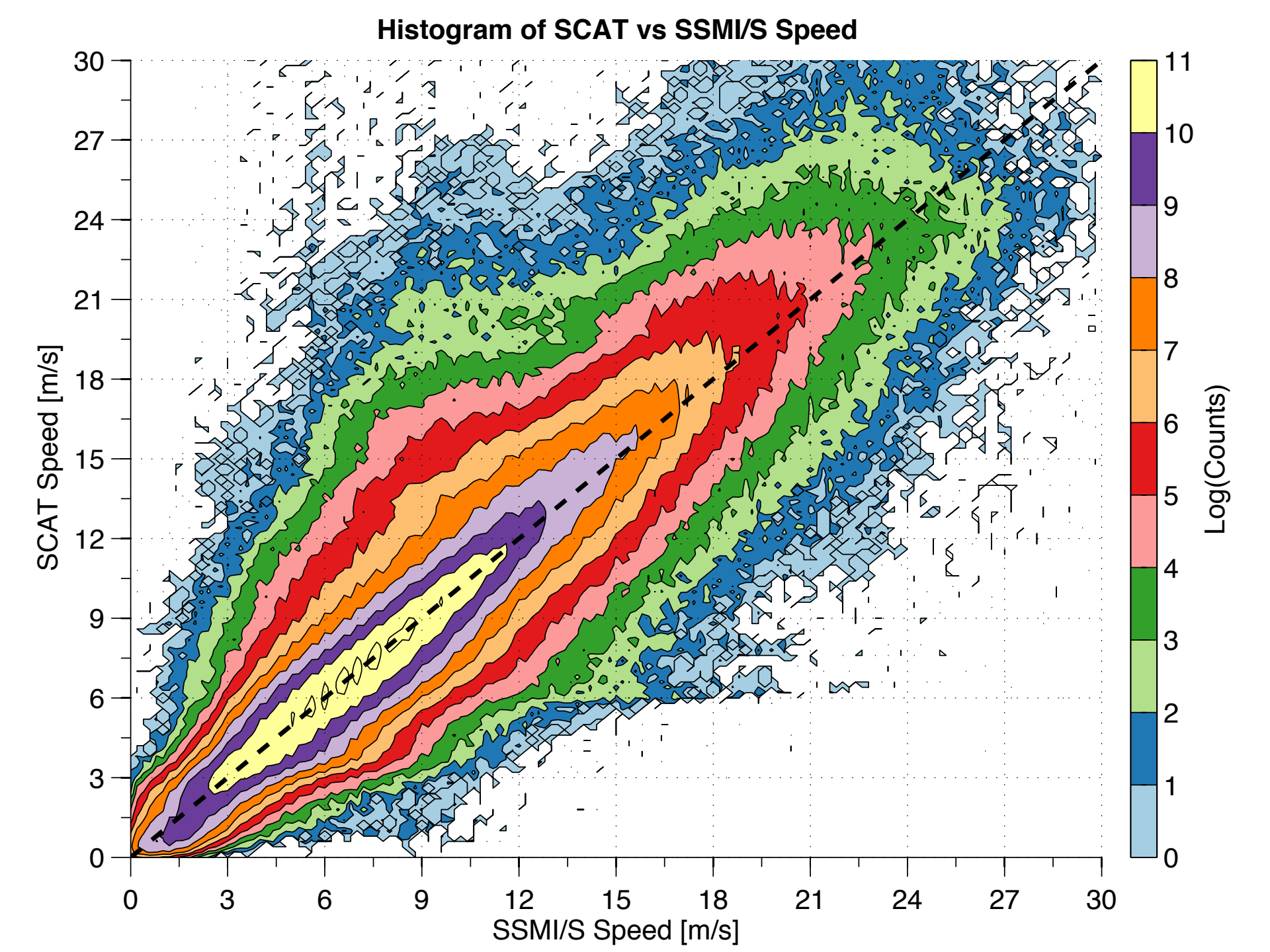


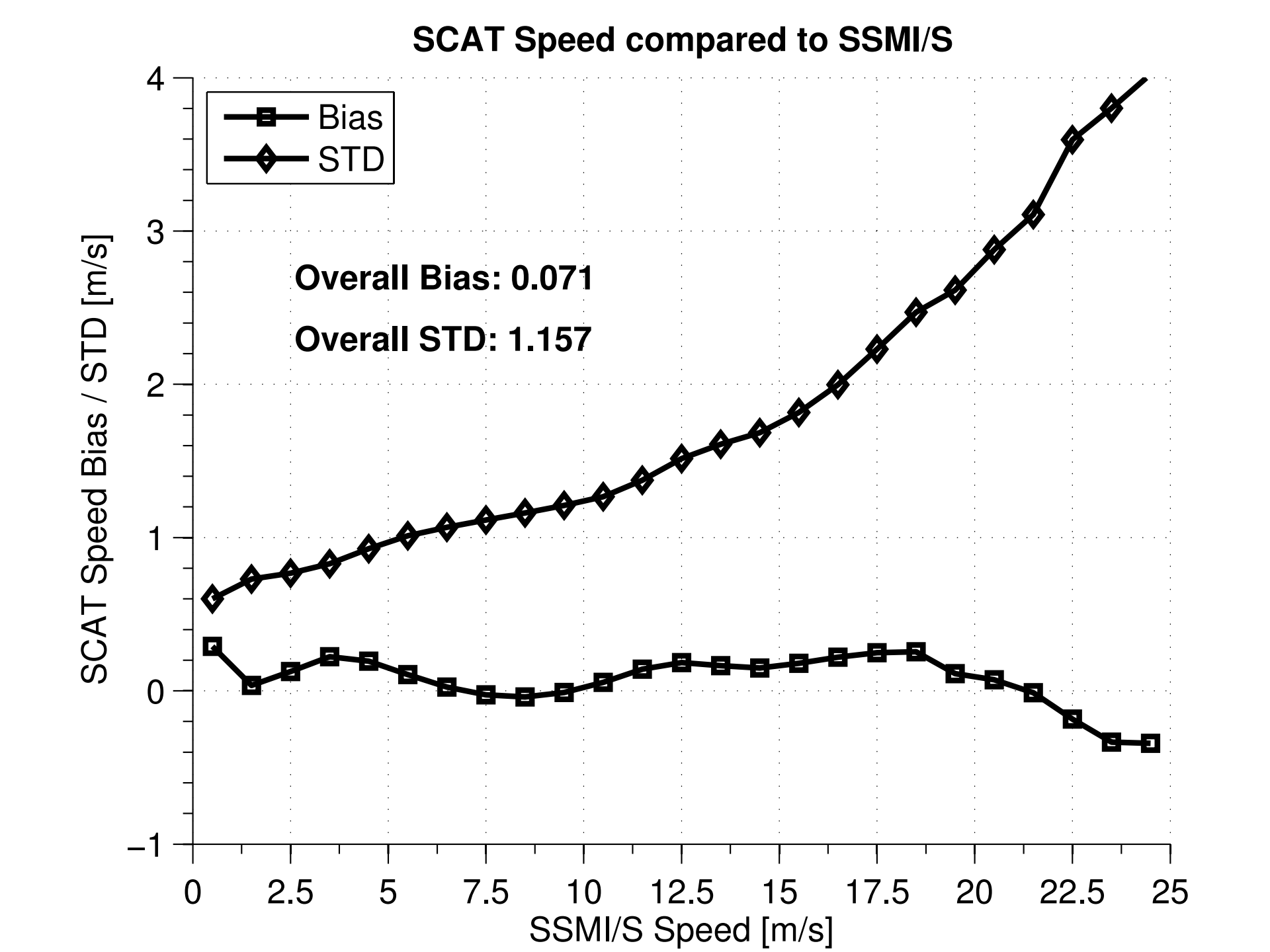
Aquarius Scatterometer-Only Wind Speed Algorithm

- Use σ_0 HH and VV polarization.
- With only one azimuthal look, require additional information to constrain problem.
  - Assume the wind direction from NCEP
  - Retrieve best wind speed given the σ_0 HH, σ_0 VV, and NCEP wind direction.
- Flatness in model function causes significant problems at cross-wind (±90) relative azimuth angles.

Scatterometer-Only Cost Function:

$$J = -\left[\frac{\left(\sigma_{0,HH}^{gmf} - \sigma_{0,HH}^{obs}\right)}{kp_{HH}\sigma_{0,HH}^{obs}}\right]^2 - \left[\frac{\left(\sigma_{0,VV}^{gmf} - \sigma_{0,VV}^{obs}\right)}{kp_{VV}\sigma_{0,VV}^{obs}}\right]^2$$


Histogram of SCAT vs SSMI/S Speed
SCAT Speed [m/s]
SSMI/S Speed [m/s]
Log(Counts)
0
3
6
9
12
15
18
21
24
27
30
0
1
2
3
4
5
6
7
8
9
10
11


SCAT Speed compared to SSMI/S
Bias
STD
Overall Bias: 0.071
Overall STD: 1.157
SCAT Speed Bias / STD [m/s]
SSMI/S Speed [m/s]
4
3
2
1
0
−1
0
2.5
5
7.5
10
12.5
15
17.5
20
22.5
25

Triple-Collocation Results (SCAT)

The scatterometer-only wind speed product has performance within 0.1 m/s RMS of QuikSCAT

	Bias	Slope	RMS Error
SSMI	0	1	0.6767
ECMWF	0.2700	0.9590	0.8461
SCAT 2.10.1	-0.2193	1.0386	0.9337

	Bias	Slope	RMS Error
SSMI	0	1	0.6373
QuikSCAT	0.4890	0.9477	0.9535
SCAT 2.10.1	0.0418	1.0036	0.9448

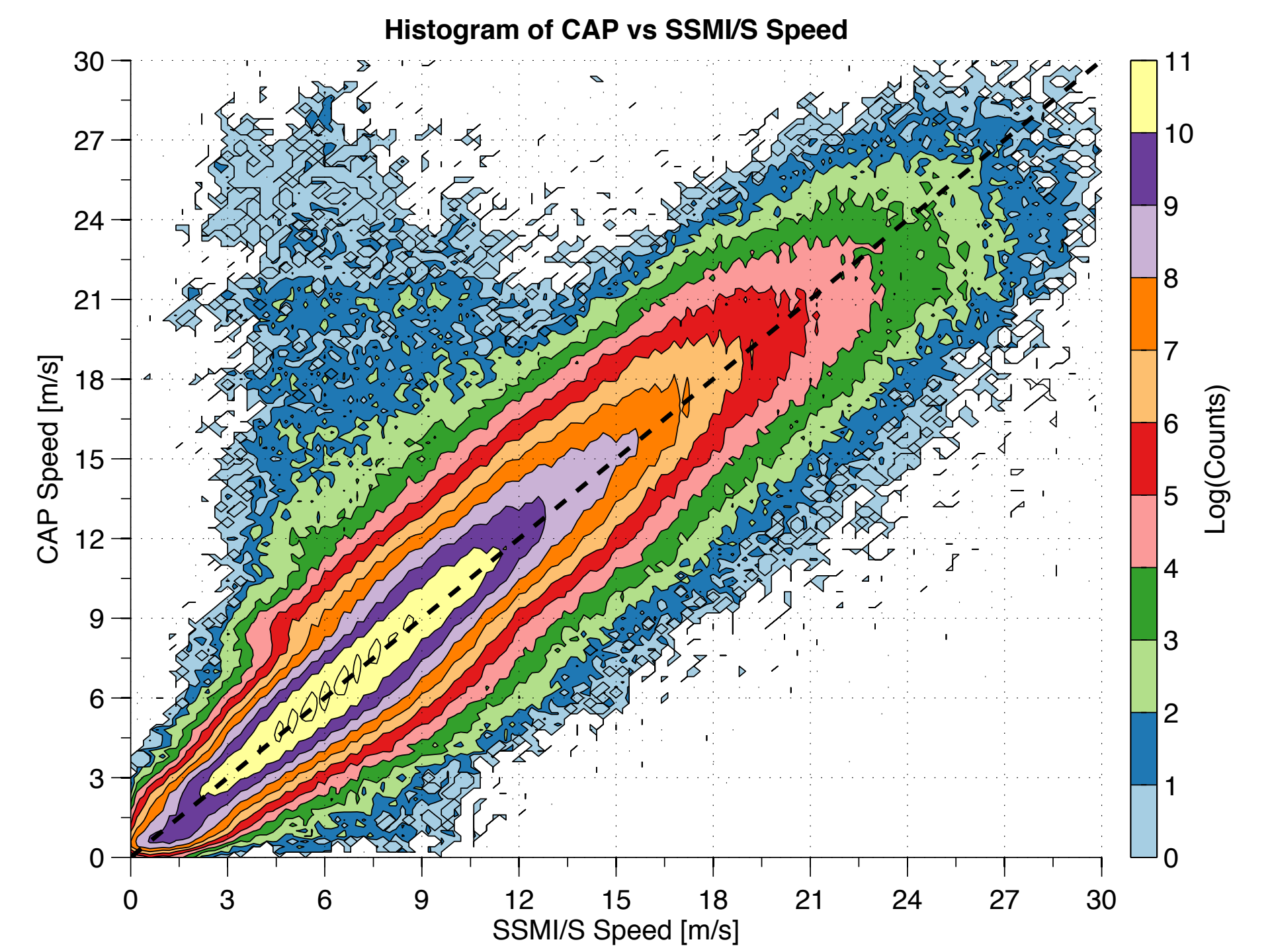
Aquarius Combined Active / Passive Retrieval

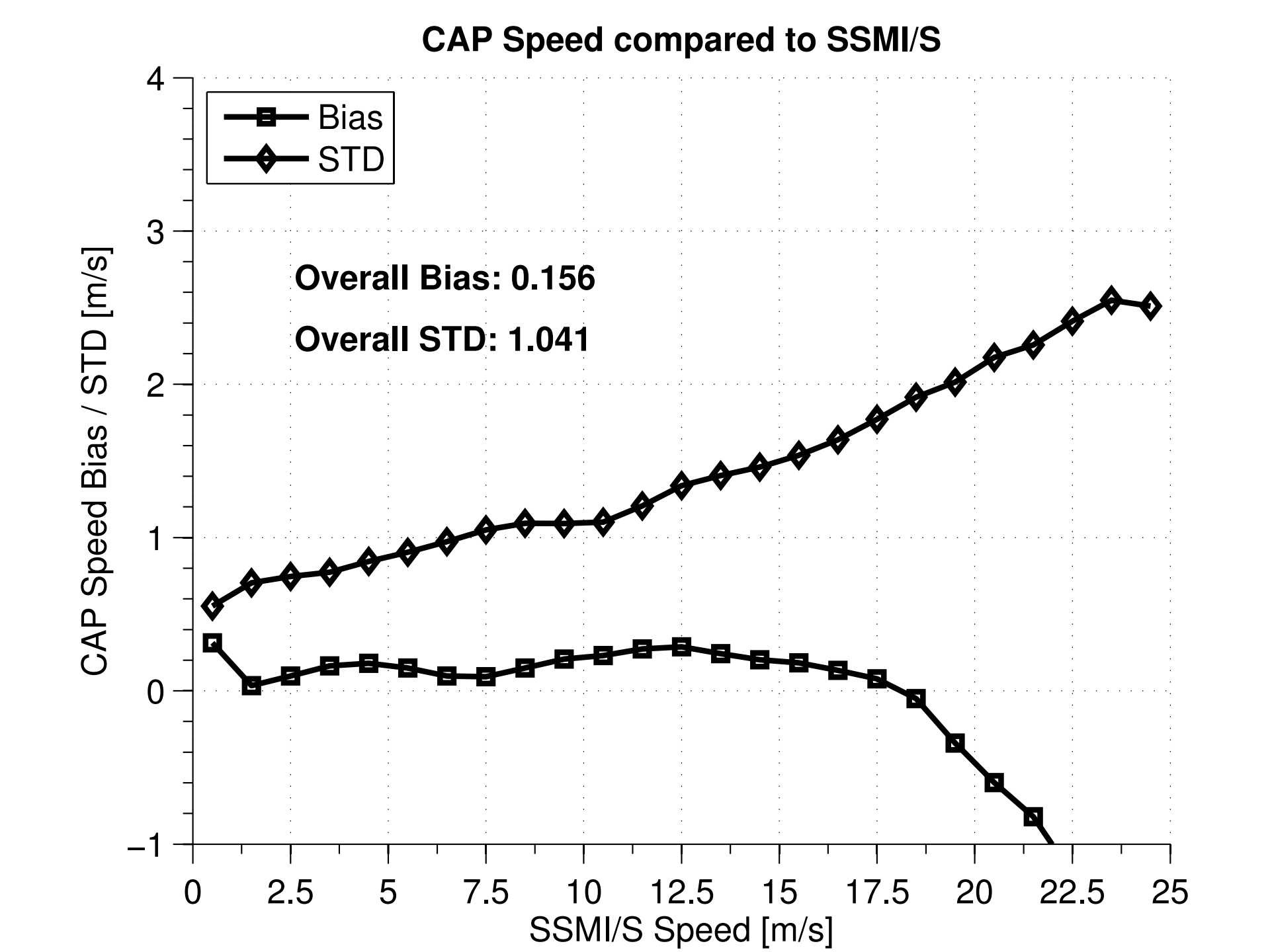
- Use σ_0 HH, σ_0 VV, T_{BH}, and T_{BV} observations.
  - Requires ancillary sea-surface temperature values.
  - Requires accurate estimate and removal of galaxy.
  - We include significant wave height and rain in the model function when ancillary data are available.
- Simultaneous retrieval of Ocean vector wind and sea surface salinity.

Combined Active/Passive Cost Function:

$$F_{ap}(SSS, w, \phi) = \frac{(T_{BV} - T_{BVm})^2}{\Delta T^2} + \frac{(T_{BH} - T_{BHm})^2}{\Delta T^2} + \frac{(\sigma_{VV} - \sigma_{VVm})^2}{k_{pc}{}^2 \sigma_{VV}{}^2} + \frac{(\sigma_{HH} - \sigma_{HHm})^2}{k_{pc}{}^2 \sigma_{HH}{}^2} + \frac{(w - w_{NCEP})^2}{\Delta w^2} + \frac{\sin^2((\phi - \phi_{NCEP})/2)}{\delta^2}$$

$$Q = T_{BV} - T_{BH} \qquad I = T_{BV} + T_{BH}$$


Histogram of CAP vs SSMI/S Speed
CAP Speed [m/s]
SSMI/S Speed [m/s]
Log(Counts)
0
3
6
9
12
15
18
21
24
27
30
0
1
2
3
4
5
6
7
8
9
10
11


CAP Speed compared to SSMI/S
Bias
STD
Overall Bias: 0.156
Overall STD: 1.041
CAP Speed Bias / STD [m/s]
SSMI/S Speed [m/s]
4
3
2
1
0
−1
0
2.5
5
7.5
10
12.5
15
17.5
20
22.5
25

Triple-Collocation Results (CAP)

The CAP wind speed product has performance that is about 0.1 m/s better than QuikSCAT, and is nearly the same as SSMI/S

Wind Speed	Bias	Slope	RMS Error
SSMI	0	1	0.7258
ECMWF	0.2207	0.9656	0.8075
CAP 2.10.1	-0.2652	1.0561	0.7291

Wind Speed	Bias	Slope	RMS Error
SSMI	0	1	0.6398
QuikSCAT	0.4868	0.9480	0.9520
CAP 2.10.1	0.0010	1.0339	0.8364

Triple-Collocation Results (CAP)

The vector triple-collocation results suggest that the CAP wind direction is not as good as that from QuikSCAT.

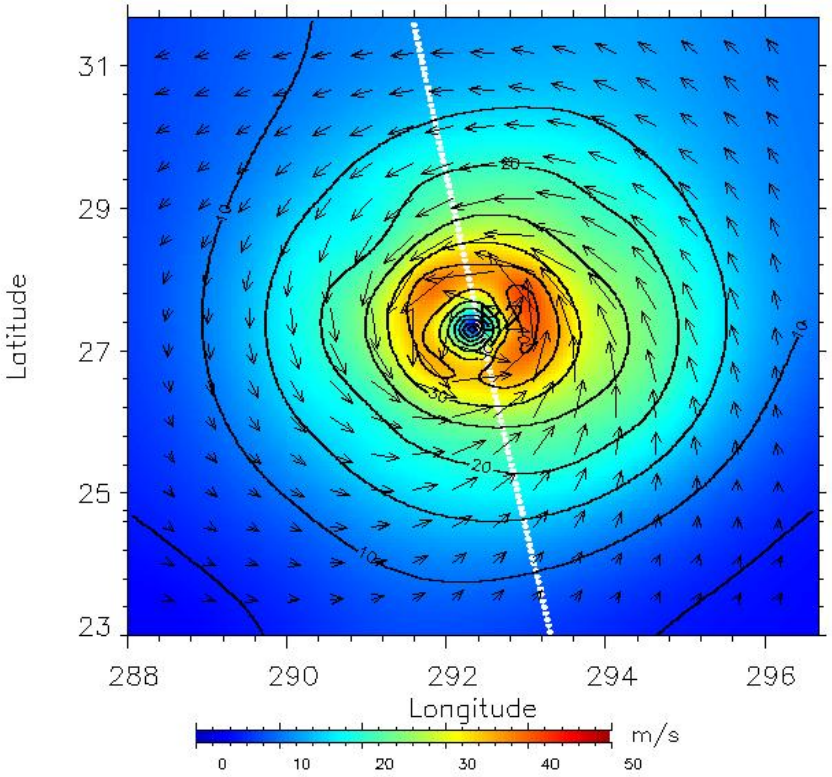
U Component	Bias	Slope	RMS Error
ECMWF	0	1	0.7882
QuikSCAT	-0.0146	1.0059	1.2073
CAP 2.10.1	-0.0175	1.0238	1.3166

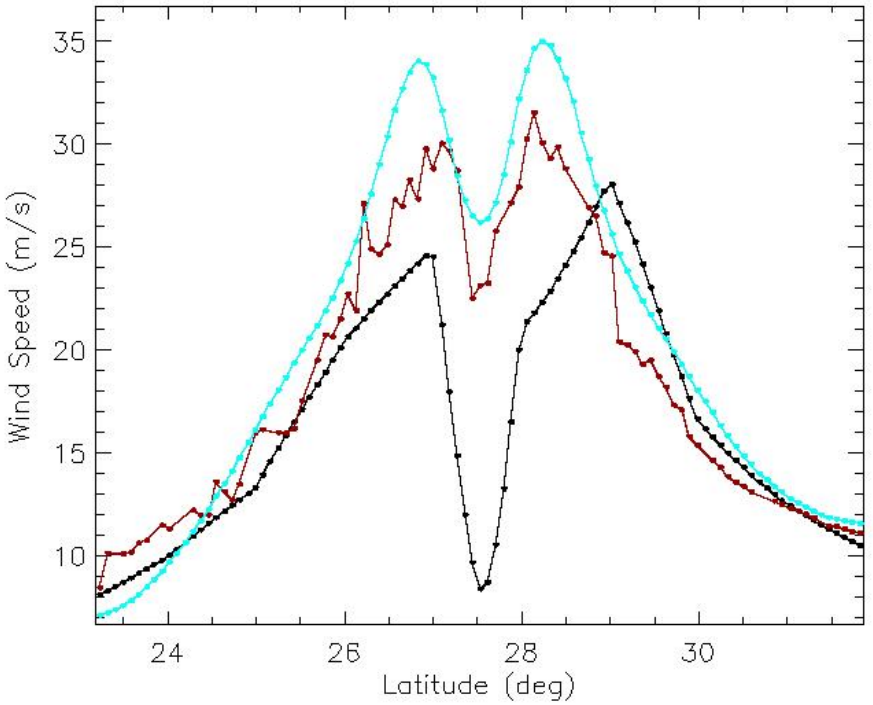
V Component	Bias	Slope	RMS Error
ECMWF	0	1	0.7804
QuikSCAT	-0.0385	1.0222	1.1817
CAP 2.10.1	-0.0934	1.0340	1.5697

Potential of Combined Active/Passive L-band

- Hurricane / High winds
- One platform for Ocean vector winds, salinity and soil moisture.
- We are very interested in SMAP data over the ocean to see what L-band is capable of!
  - Hurricanes
  - L-band scatterometery

Hurricane Katia





Aquarius CAP Speed (red)
H*Wind (cyan)
NCEP Wind (black)

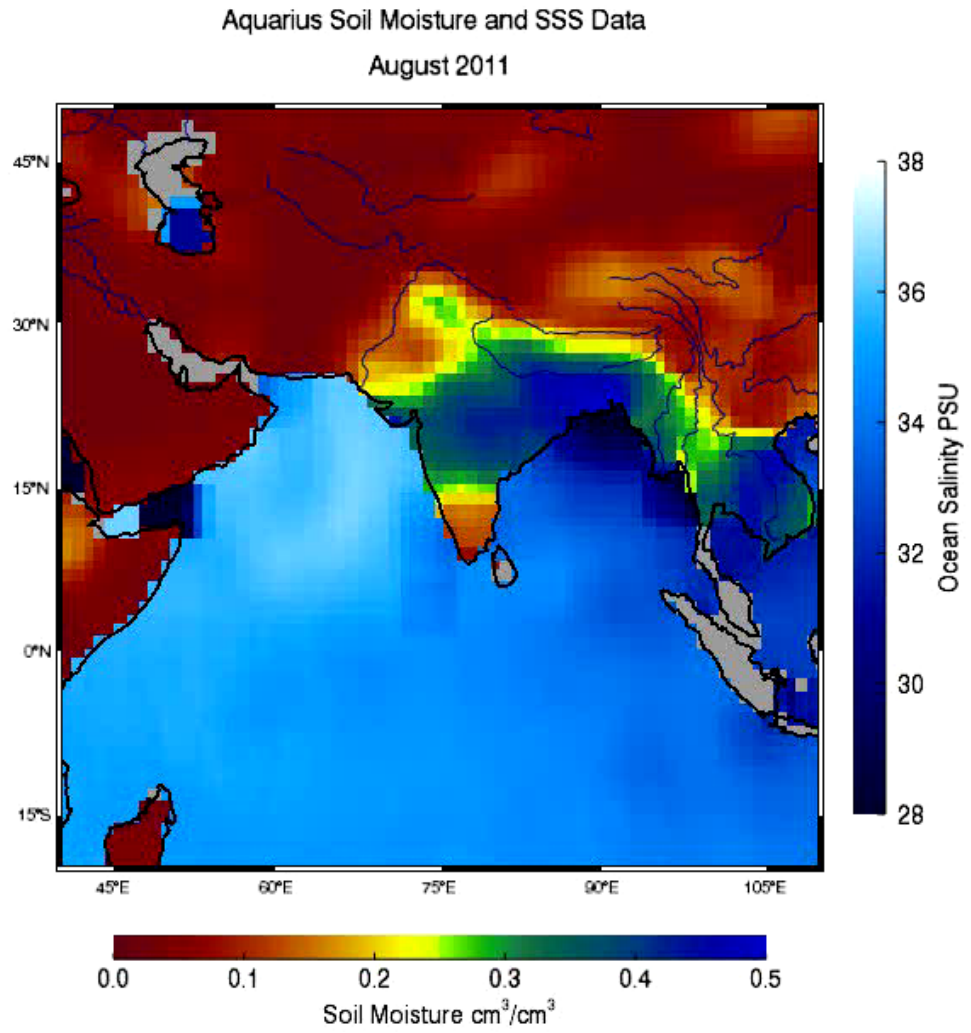
Aquarius CAP Data Distributed via PO.DAAC

- Aquarius CAP product is processed at JPL
  - Sea surface salinity
  - Ocean wind speed
  - Ocean wind direction
- CAP V2.8.1 L2 and L3 products available at PO.DAAC
  - http://podaac.jpl.nasa.gov/seasurfacesalinity
  - Follow FTP Data Access link

Summary

- Model functions for Aquarius generated using SSMI/S, SWH, and NCEP wind direction
- Wind performance:
  - The scatterometer-only wind speed performance is slightly worse than that for QuikSCAT
  - The Combined active/passive wind speed performance is better than that of QuikSCAT, however the direction is worse.
- Salinity Performance:
  - CAP has a monthly RMS difference with ARGO that is less than the V2.10.1 data product.
  - Including the effects of rain in the salinity model function seem to give additional improvements.
  - We seem to have achieved the 0.20 psu salinity performance that was the goal for Aquarius monthly data products.
  - *There is an overall zonal bias that still needs to be corrected.*

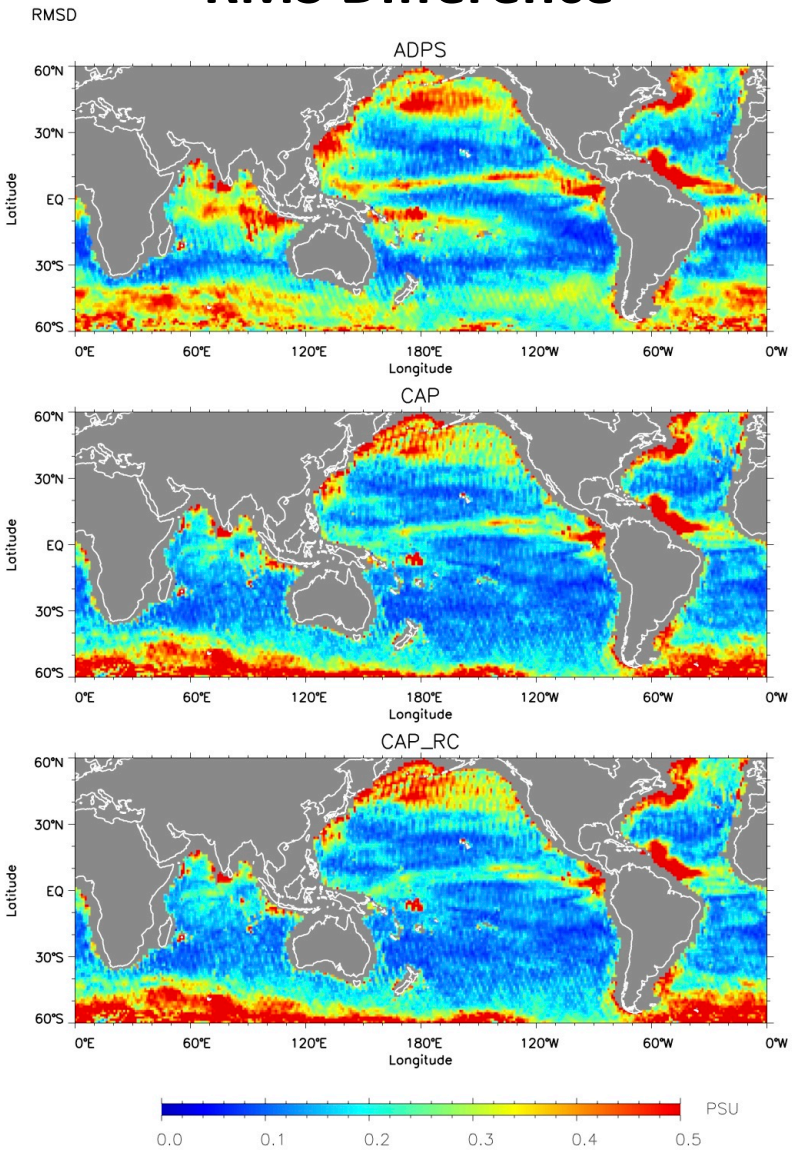
Water Cycle in Indian Subcontinent Illustrated by Aquarius Data



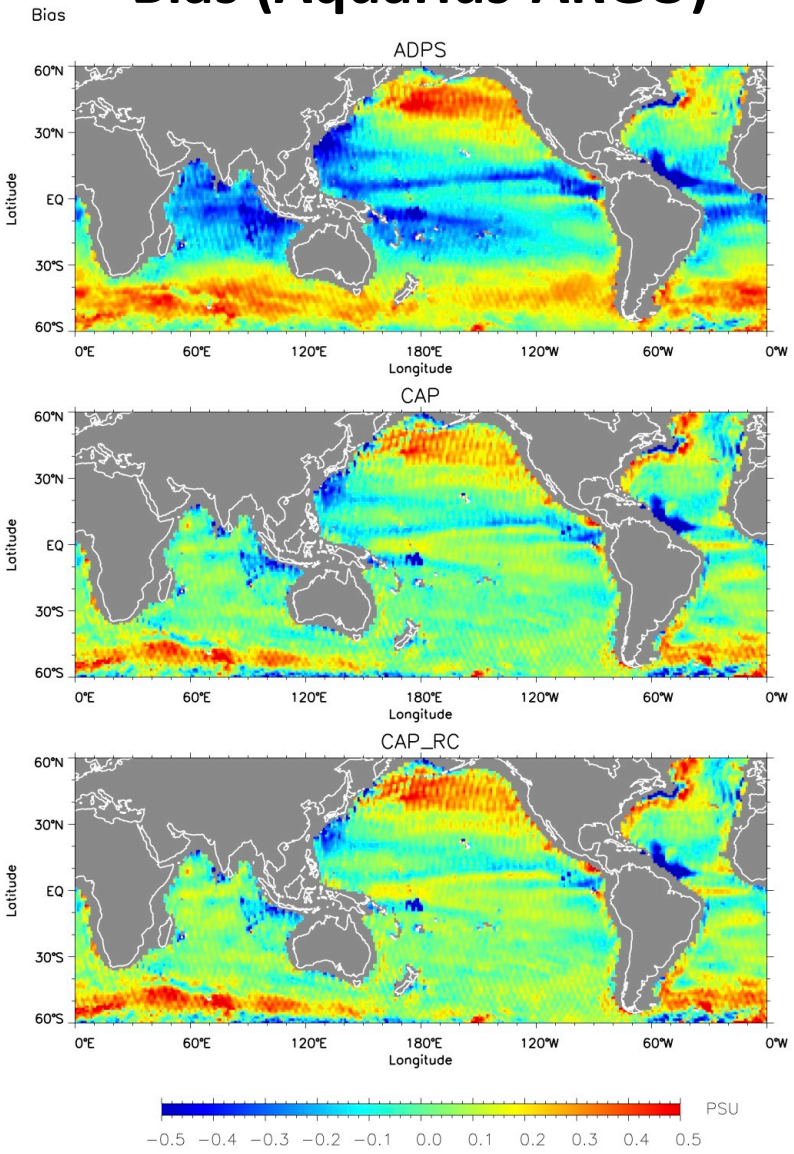
Sea Surface Salinity

Comparison with ARGO monthly maps (Sept. 2011 – Dec. 2013) V2.10.1

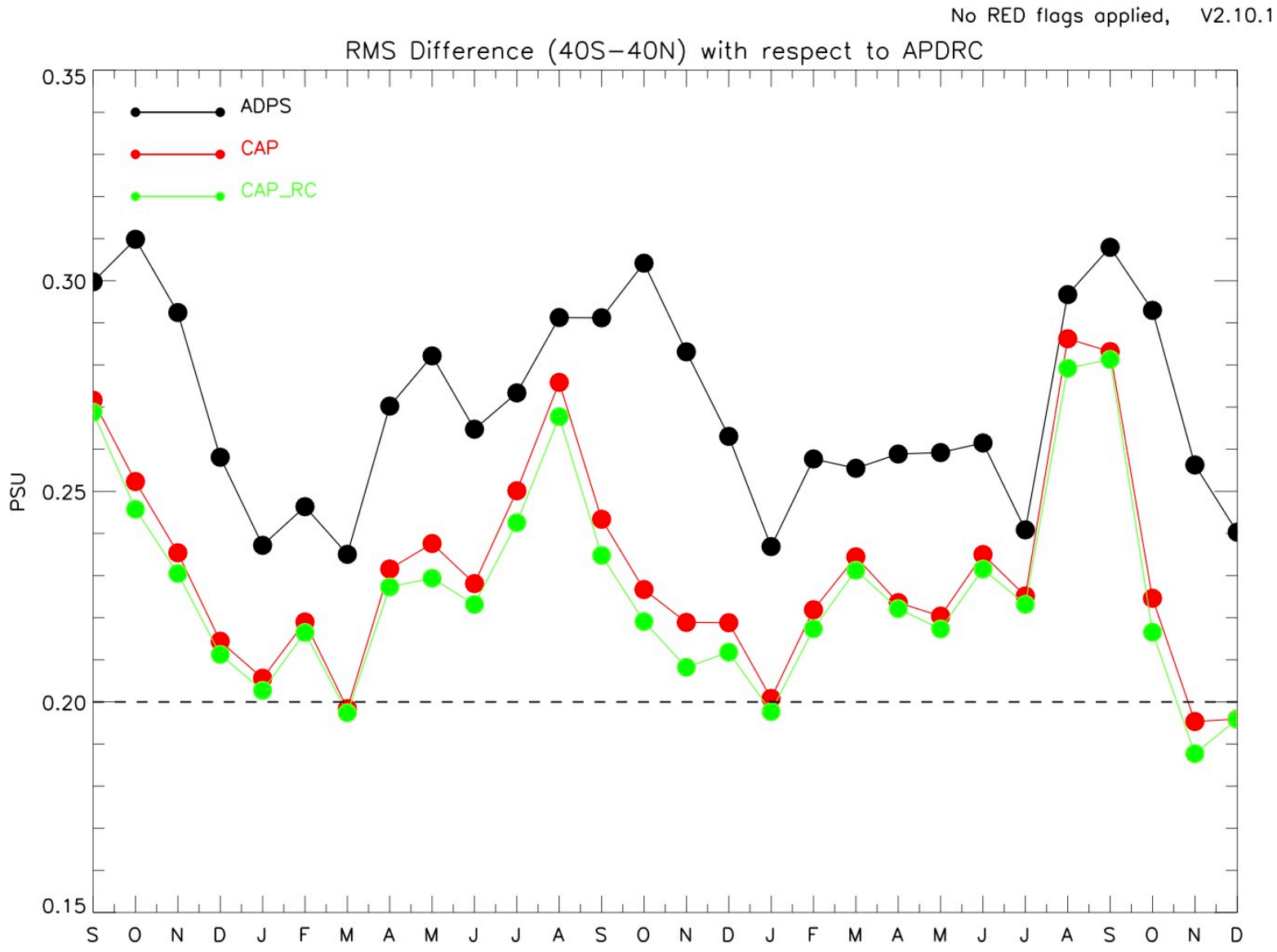
RMS Difference



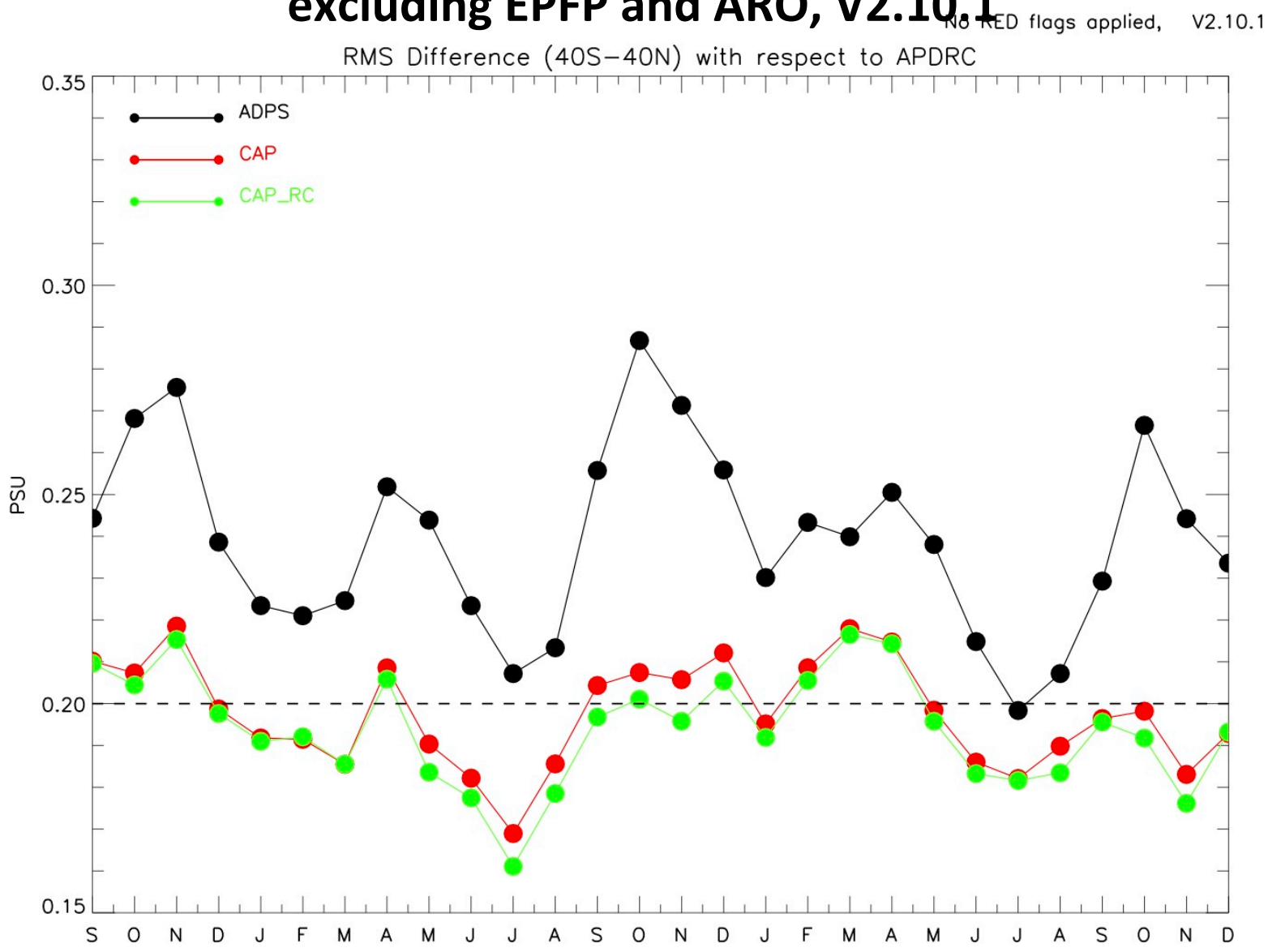
Bias (Aquarius-ARGO)

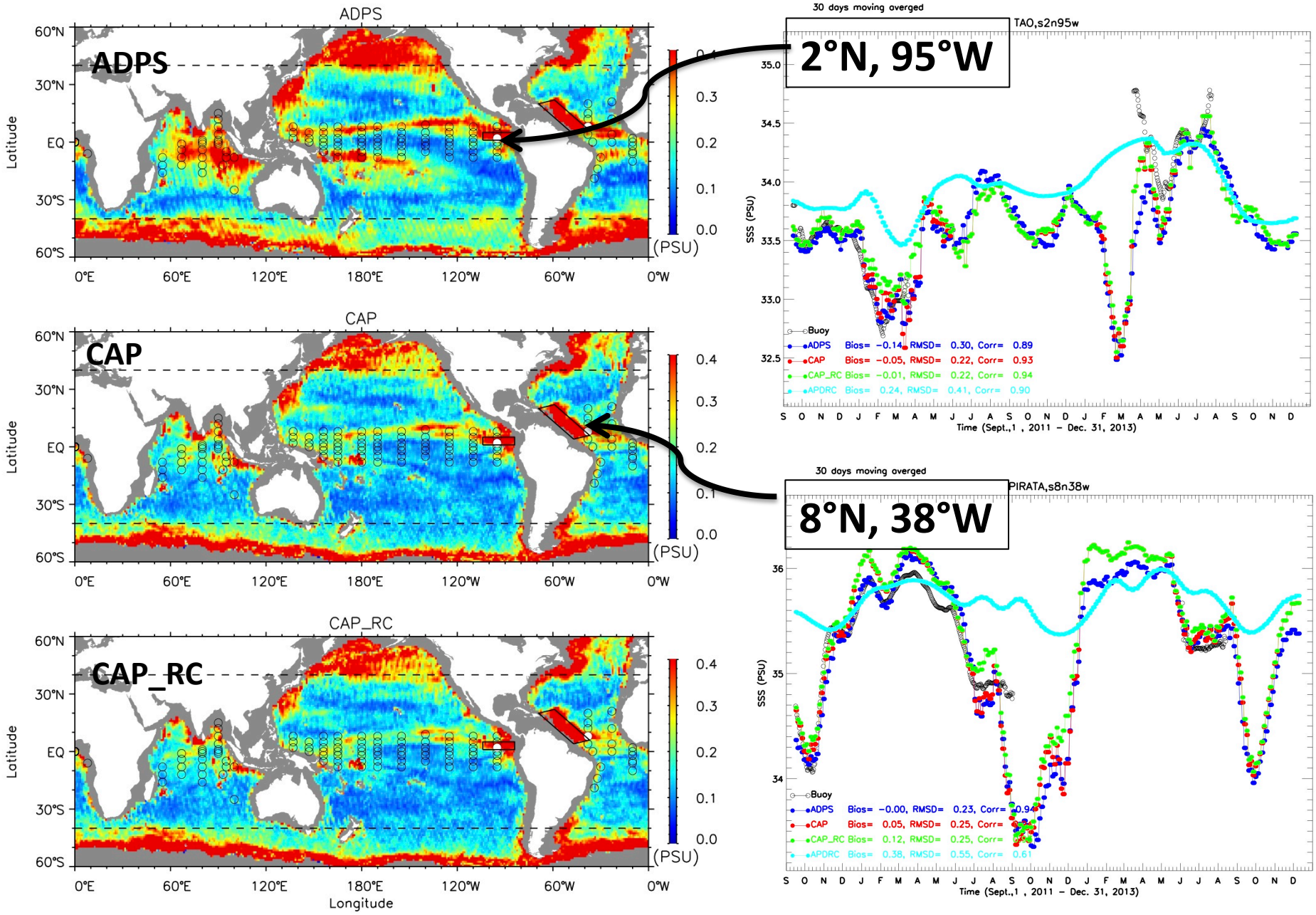


SSS Monthly RMS difference w.r.t. ARGO between 40S-40N, V2.10.1

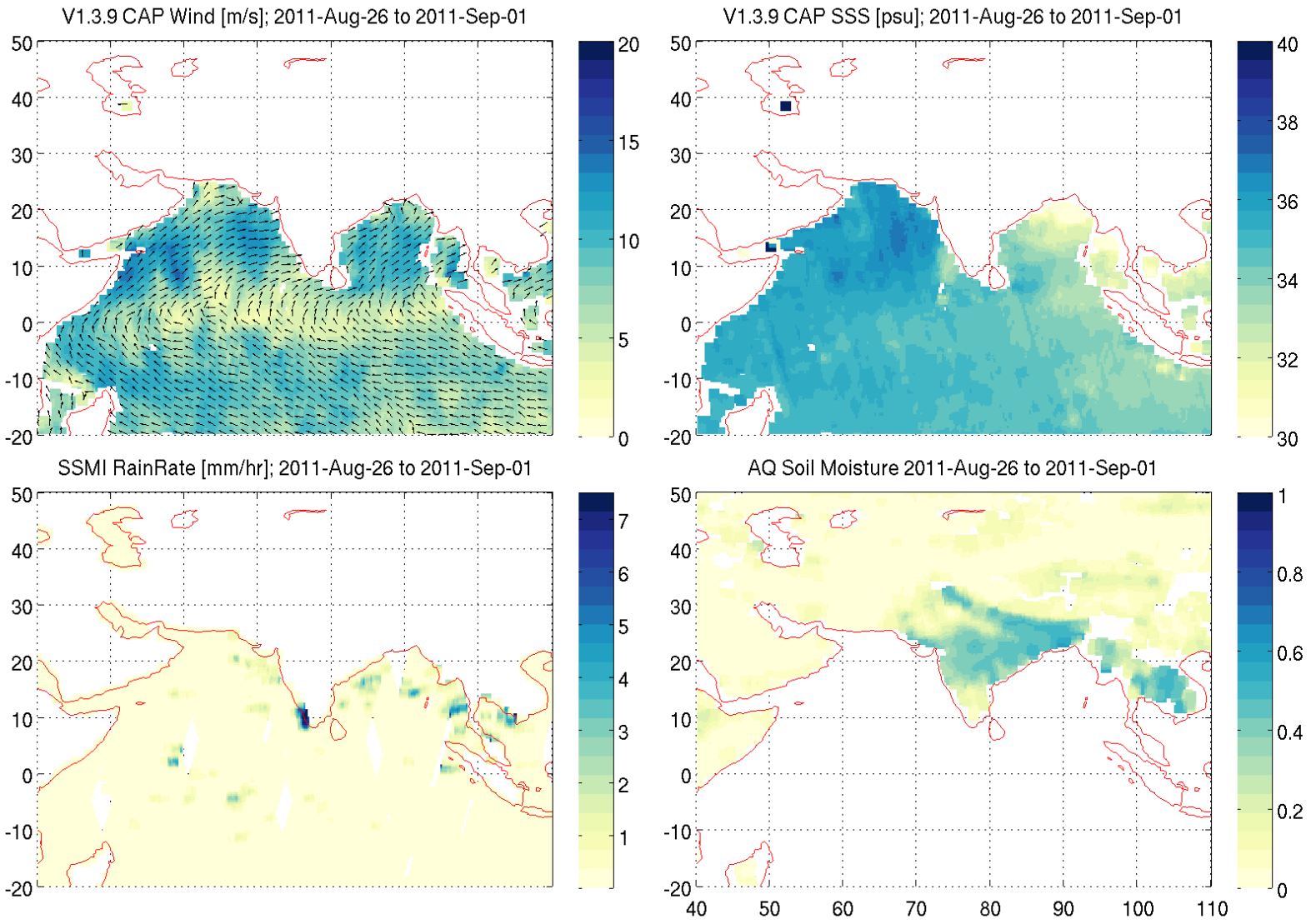


SSS Monthly root-mean-square difference between 40S-40N, excluding EPFP and ARO, V2.10.1




ADPS
CAP
CAP_RC
60°N
30°N
EQ
30°S
60°S
0°E
60°E
120°E
180°E
120°W
60°W
0°W
Latitude
Longitude
0.4
0.3
0.2
0.1
0.0
(PSU)
30 days moving overged
TAO,s2n95w
2°N, 95°W
SSS (PSU)
Buoy
ADPS Bias= −0.14, RMSD= 0.30, Corr= 0.89
CAP Bias= −0.05, RMSD= 0.22, Corr= 0.93
CAP_RC Bias= −0.01, RMSD= 0.22, Corr= 0.94
APDRC Bias= 0.24, RMSD= 0.41, Corr= 0.90
S O N D J F M A M J J A S O N D J F M A M J J A S O N D
Time (Sept.,1 , 2011 – Dec. 31, 2013)
PIRATA,s8n38w
8°N, 38°W
ADPS Bias= −0.00, RMSD= 0.23, Corr= 0.94
CAP Bias= 0.05, RMSD= 0.25, Corr=
CAP_RC Bias= 0.12, RMSD= 0.25, Corr=
APDRC Bias= 0.38, RMSD= 0.55, Corr= 0.61

Aquarius SSS, Wind, and Soil Moisture Products



Aquarius soil moisture from Jackson and Bindlish; SSMI/S rain from RSS