Aquarius' Combined Active-Passive (CAP) SSS and Wind Retrieval

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Outline

- Introduction
- V2.0 Changes from V1.3 processing
  - Roughness dependence – wind and wave
  - CAP Wind speed/direction products
  - CAP SSS products
- Towards v3
- Summary

Aquarius CAP Products distributed through PO.DAAC

- Aquarius CAP (combined active-passive) product processed at JPL:
  - SSS
  - Wind speed
  - Wind direction
- **CAP 2.0 products available at PO.DAAC in a days**
  - **http://podaac.jpl.nasa.gov/SeaSurfaceSalinity**
  - **Follow the FTP Data Access link for Aquarius data**

Changes from V1.3 processing

- TB and sigma0 model functions updated and wave effects modeled
- The following effects corrected for retrieval
  - Significant wave height
  - Water dielectric constant (SST effect bias)
  - Galactic reflection (increase the effective wave slope)
- Constrain the wind speed retrieval near crosswind
- Constrain the wind direction retrieval at low-mid wind speed
- Added a rain flag by adding 10 to the cap_flag if the SSM/I rain >0

Geophysical Model Function

- Two versions of GMFs are built
  - AQ data, SSM/I wind speed, NCEP wind direction, NOAA WW3 SWH
  - AQ data, NCEP wind speed, NCEP wind direction, NOAA WW3 SWH

Aquarius TB GMF
built using more than one year of data

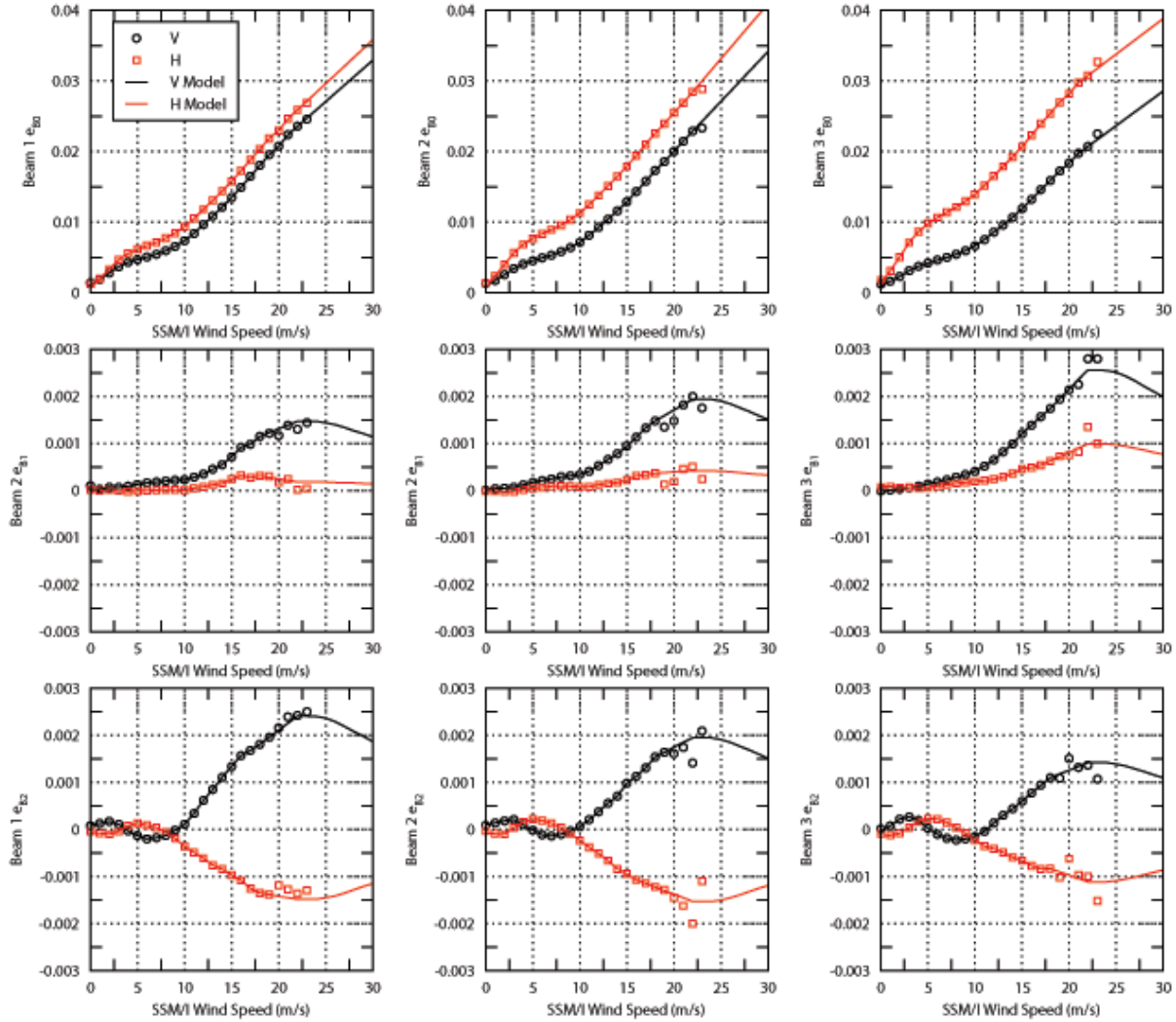
- Match up with SSM/I wind speed

$$\Delta e(w,\phi) = e_0(w) + e_1(w)\cos\phi + e_2(w)\cos 2\phi$$

e0

e1

e2



Effects of SWH on Aquarius TB GMF Matchup with SSMI wind speed

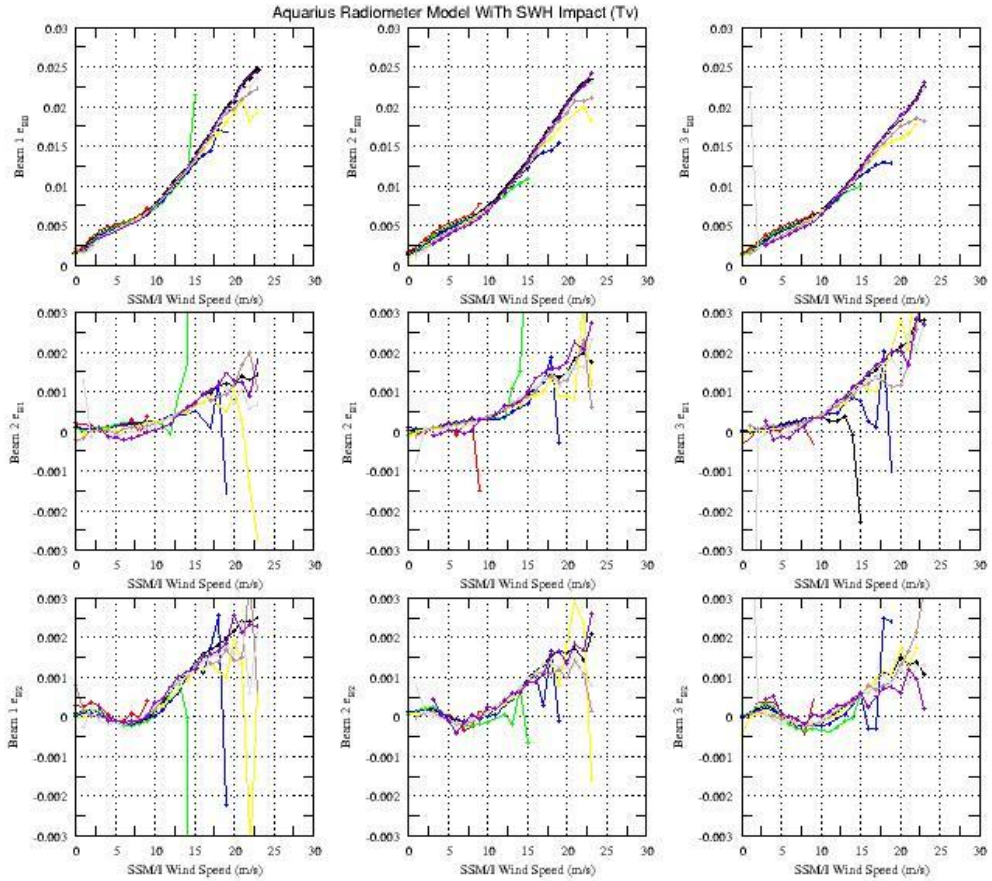
- Match up with SSM/I wind speed for V-pol for 0 to 7 m NOAA WW3 SWH

$$\Delta e(w,\phi) = e_0(w) + e_1(w)\cos\phi + e_2(w)\cos 2\phi$$

eV0

eV1

eV2



- Impact of SWH on e0 is clear
- Impact of SWH on e1 and e2 inconclusive

Effects of SWH on Aquarius TB GMF Matchup with SSMI wind speed

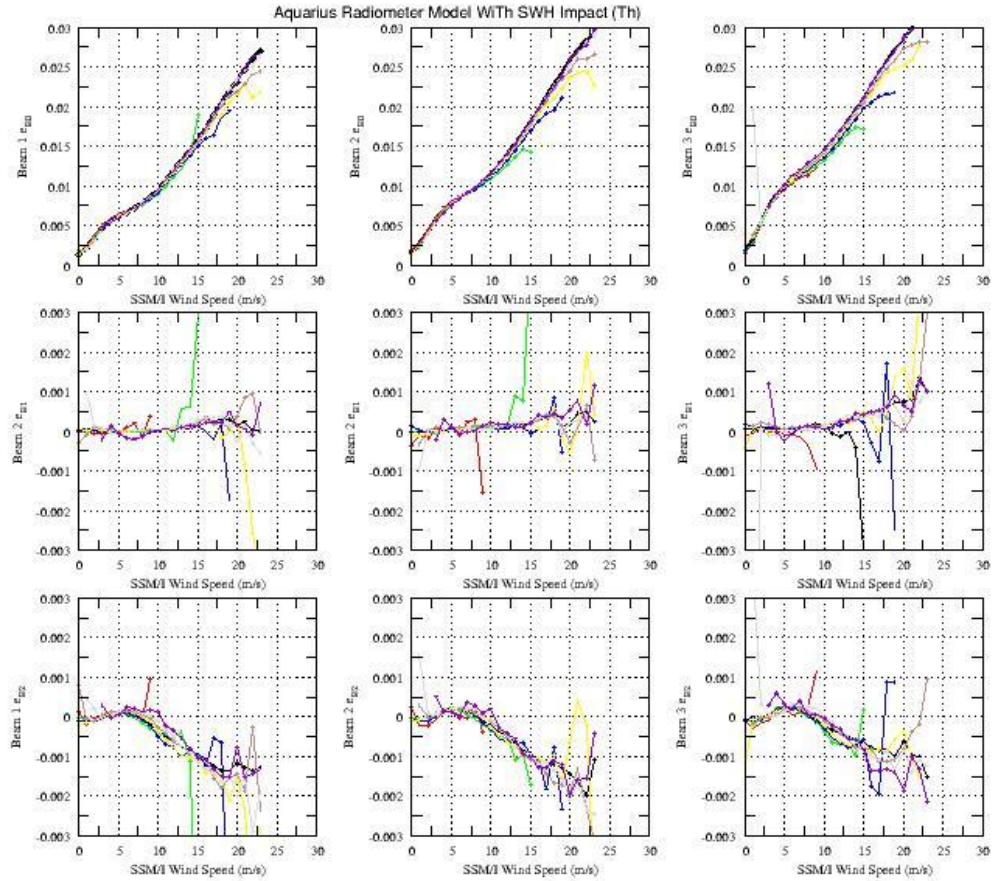
- Match up with SSM/I wind speed fro H-pol for 0 to 7 m SWH

$$\Delta e(w,\phi) = e_0(w) + e_1(w)\cos\phi + e_2(w)\cos 2\phi$$

eH0

eH1

eH2

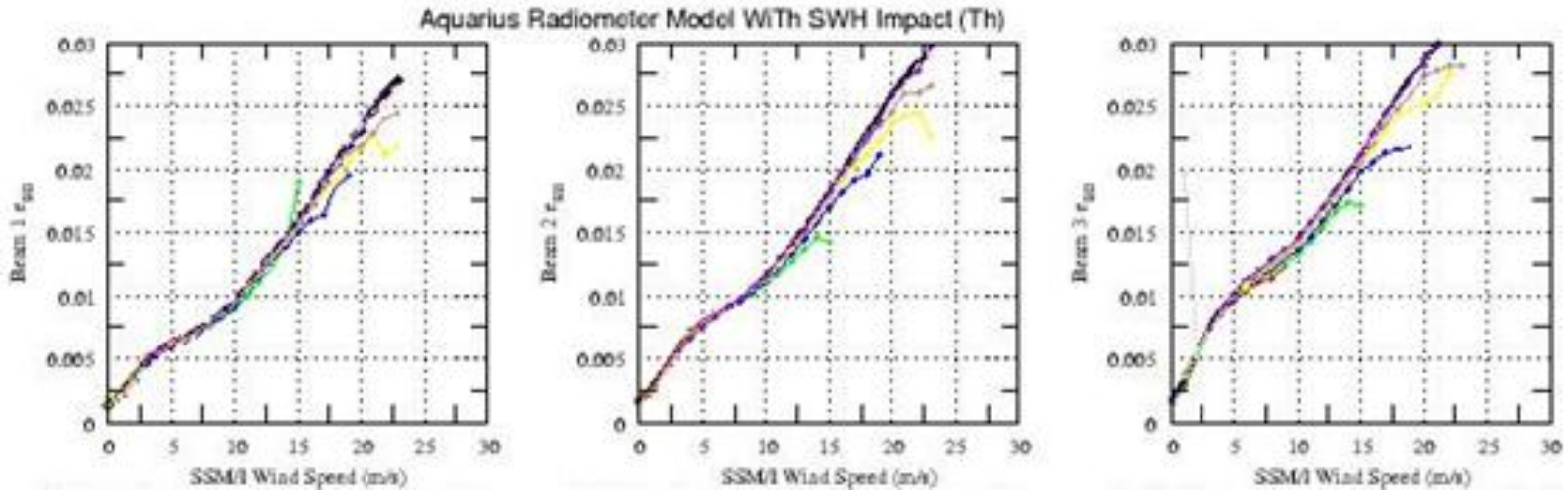


- Impact of SWH on e0 is clear
- Impact of SWH on e1 and e2 inconclusive

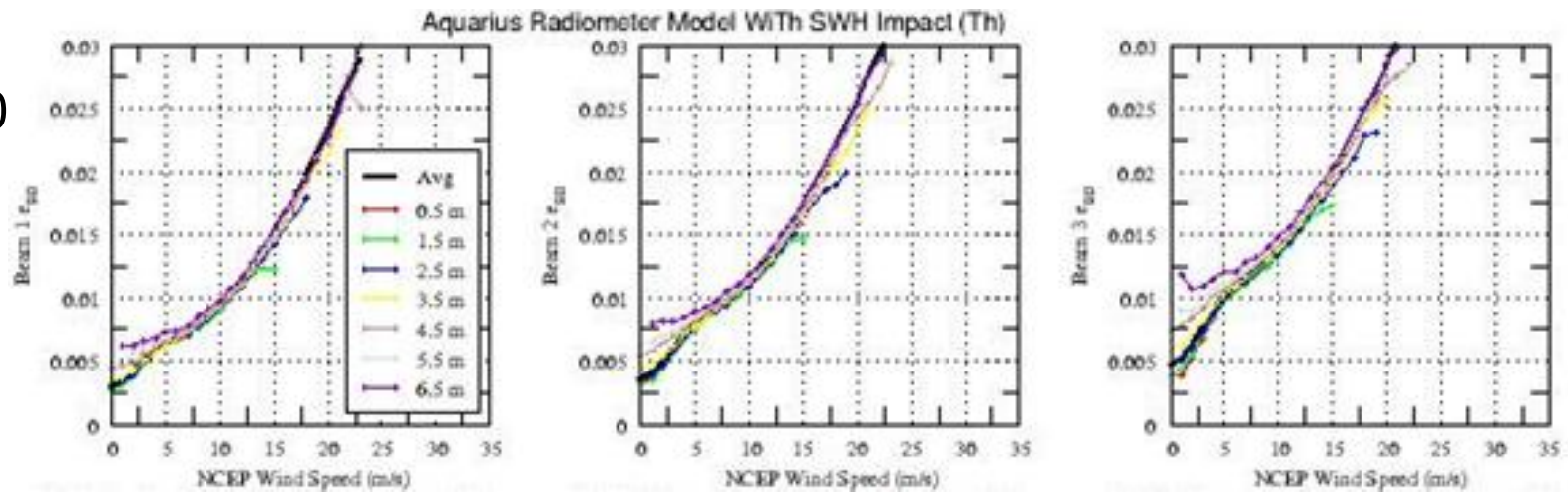
Interpretation of SWH Effects on Aquarius TB GMF

- SWH has small impact on EH0 for SSMI matchup for light to mid-winds
- SWH has positive impact on EH0 for NCEP matchup

SSMI eH0



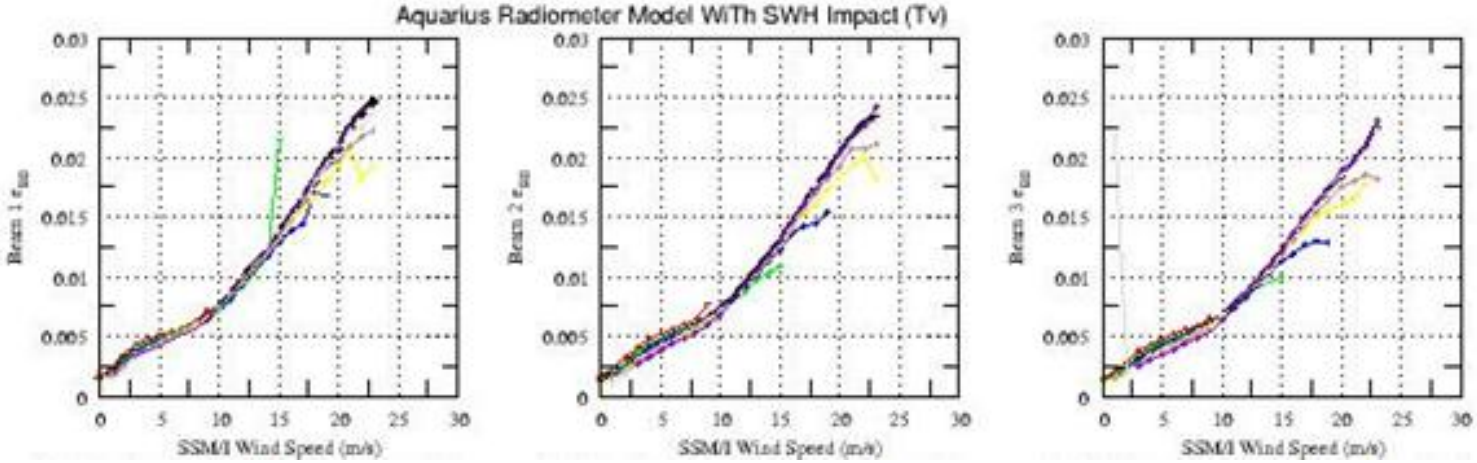
NCEP eH0



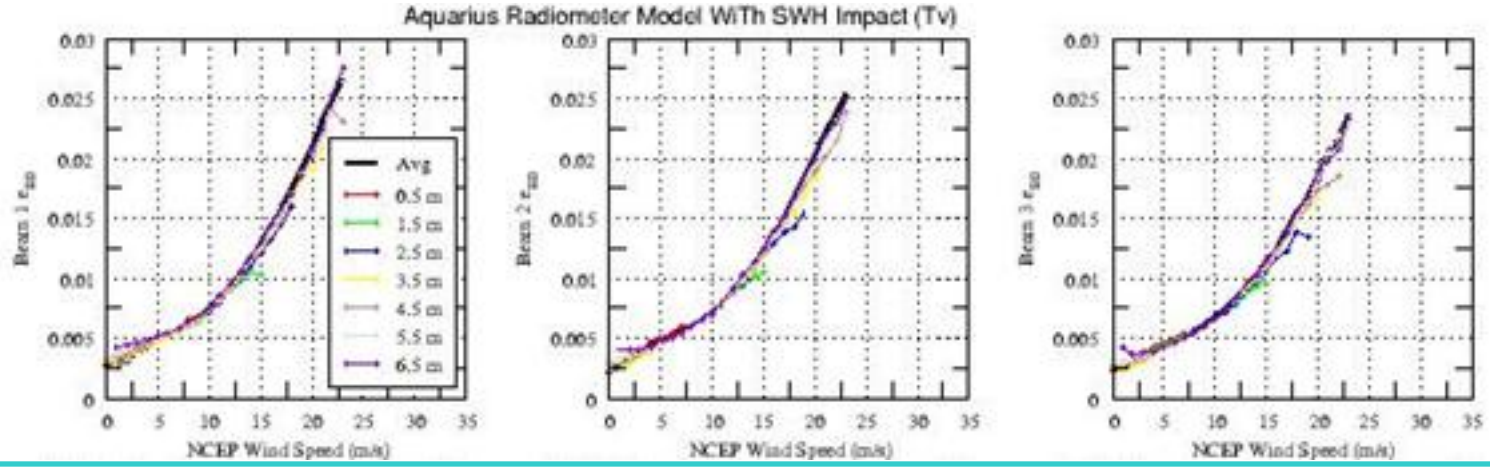
Interpretation of SWH Effects on Aquarius TB GMF

- SWH has negative impact on EV0 for SSMI matchup for light to mid-winds
- SWH has positive impact on EV0 for NCEP matchup

SSMI eV0



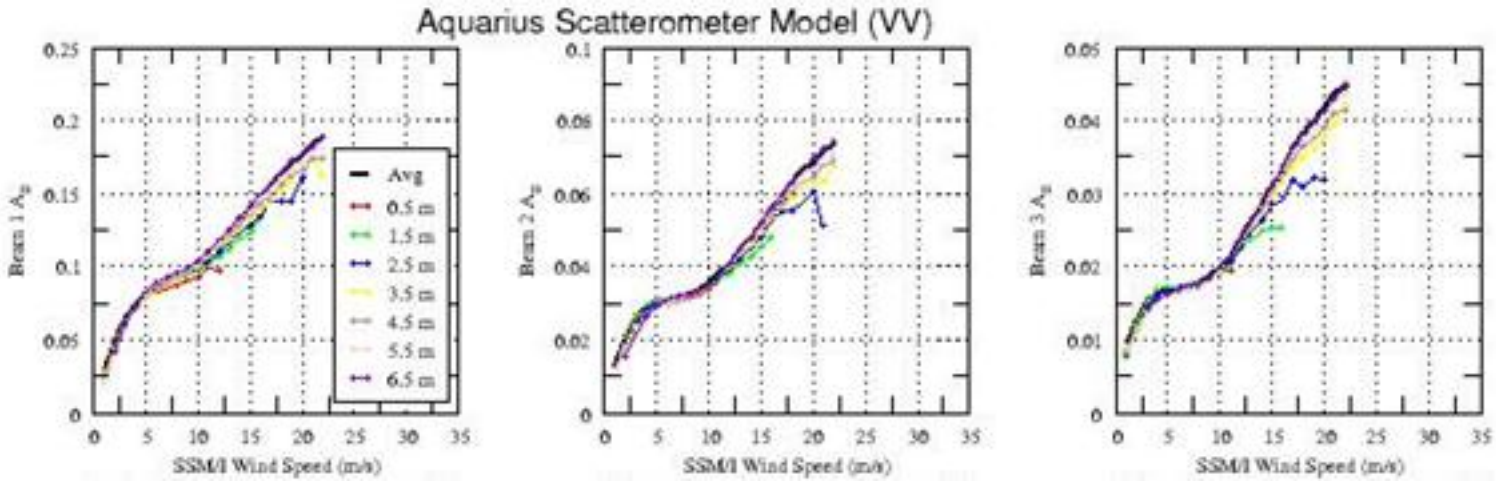
NCEP eV0



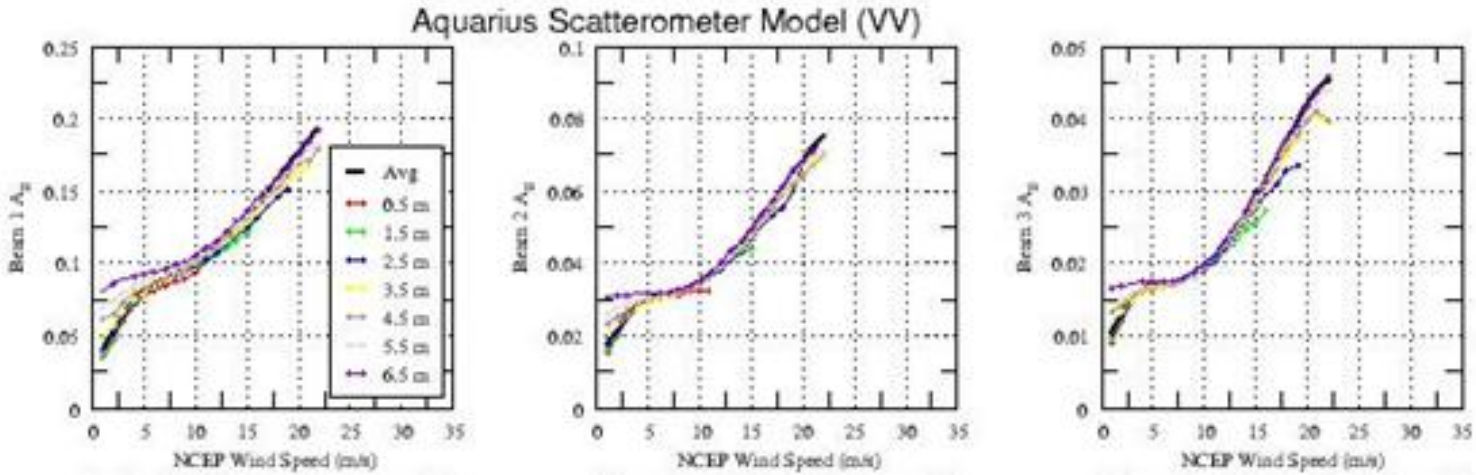
Interpretation of SWH Effects of SWH on Aquarius Radar GMF

- SWH has small to negative impact on VV for SSMI matchup for light to mid-winds
- SWH has positive impact on VV for NCEP matchup

SSMI VV



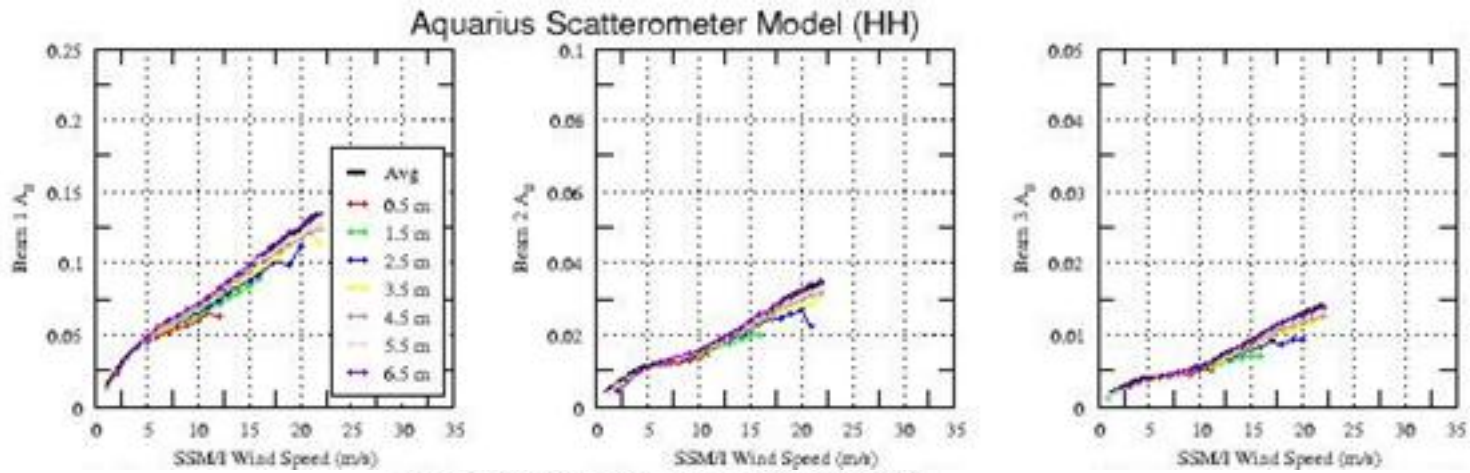
NCEP VV



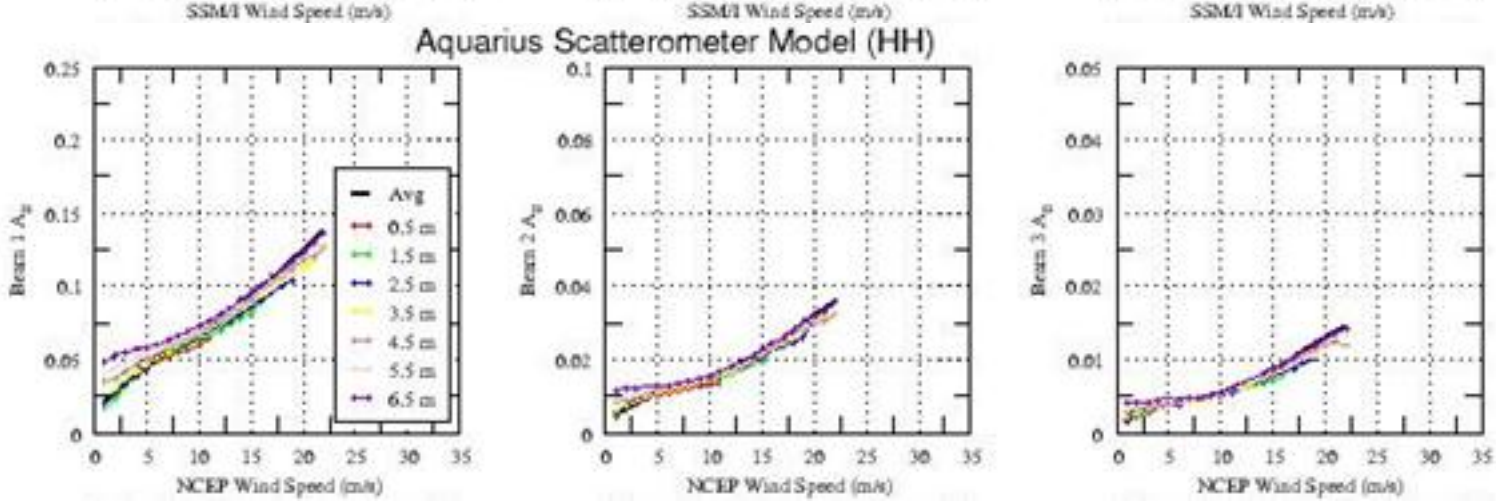
Interpretation of SWH Effects on Aquarius Radar GMF

- SWH has small impact on HH for SSMI matchup for light to mid-winds
- SWH has large positive impact on HH for NCEP matchup

SSMI-HH



NCEP-HH



Aquarius GMF for Roughness Effects

- Radiometer Model Function

$$T_{Bp}(SSS, SST, w, \phi) = T_{Bp0}(SSS, SST) + SST \cdot [e_{p0}(w, SWH) + e_{p1}(w)\cos\phi + e_{p2}(w)\cos 2\phi]$$

  - TBp0 evaluated using a hybrid of Meissner-Wentz and Klein-Swift dieletric models

- Scatterometer Model Function

$$\sigma_p(w, SWH, \phi) = A_{0p}(w, SWH)[1 + A_{1p}(w)\cos\phi + A_{2p}(w)\cos 2\phi]$$

Aquarius Combined Active-Passive (CAP) Retreival

- V1.3 - Combined Active-Passive (CAP) Algorithm (v1.3)
  - Retrieve SSS, Wind Speed and Direction Using Combined Passive and Active Data
  - Do not use NCEP winds for TB correction

$$F_{pol}(SSS,W,\phi)=\frac{(I-I_m)^2}{2\Delta T^2}+\frac{(\sqrt{Q^2+U^2}-\sqrt{Q_m^2+U_m^2})^2}{2\Delta T^2}+\frac{(\sigma_{0VV}-\sigma_{0VVm})^2}{(k_p\sigma_{0VV})^2}+\frac{(\sigma_{0HH}-\sigma_{0HHm})^2}{(k_p\sigma_{0HH})^2}$$

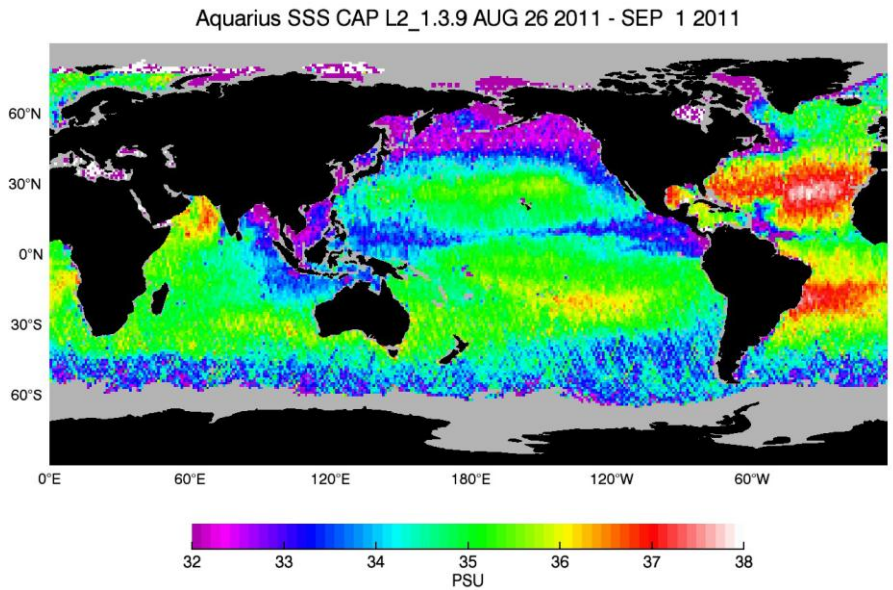
$$Q=T_{BV}-T_{BH}$$
$$I=T_{BV}+T_{BH}$$

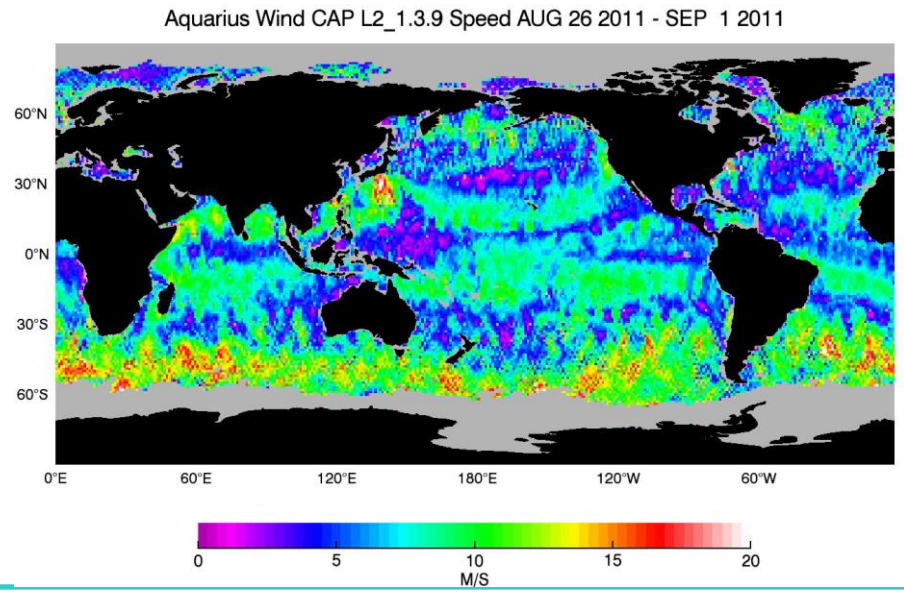
Yueh and Chaubell, IEEE TGRS, April 2012

- V2.0: constrain wind speed retrieval at crosswind and direction retrieval for light-mid winds – ΔW=1.5 and δ=0.2

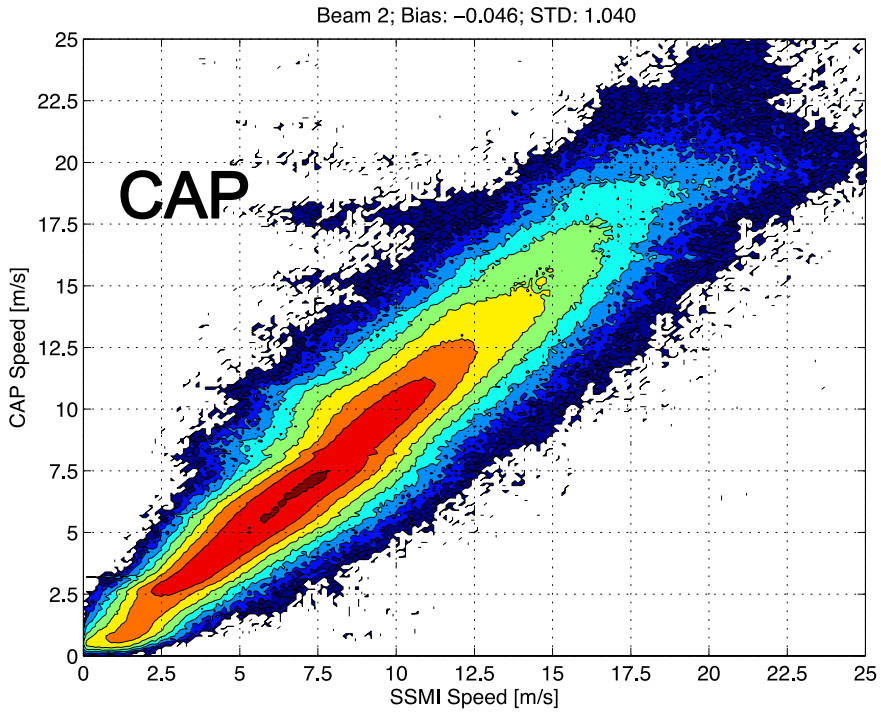
$$F_{ap}(SSS,w,\phi)=\frac{(T_{BV}-T_{BVm})^2}{\Delta T^2}+\frac{(T_{BH}-T_{BHm})^2}{\Delta T^2}+\frac{(\sigma_{VV}-\sigma_{VVm})^2}{k_{pc}{}^2\sigma_{VV}{}^2}+\frac{(\sigma_{HH}-\sigma_{HHm})^2}{k_{pc}{}^2\sigma_{HH}{}^2}+\frac{(w-w_{NCEP})^2}{\Delta w^2}+\frac{\sin^2((\phi-\phi_{NCEP})/2)}{\delta^2}$$

Aquarius CAP v1.3.9 SSS and Wind Products





Aquarius CAP V1.3.9 Wind Speed Accuracy



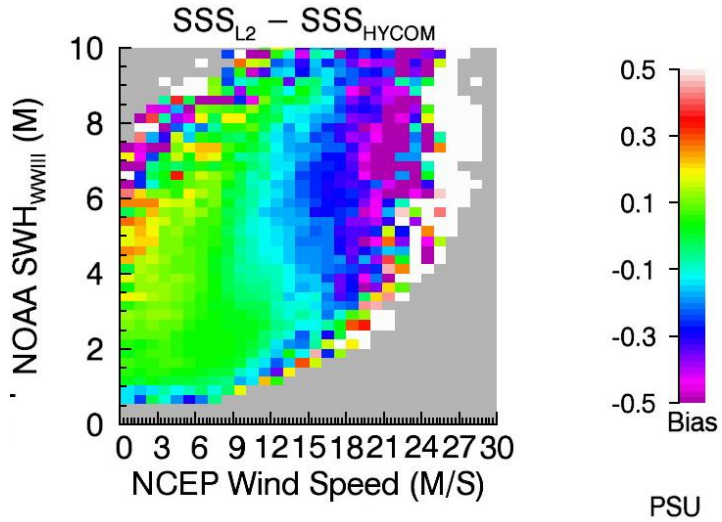
- AQ CAP wind speed accuracy is about 0.7 m/s
  - Triple collocation analysis of Aquarius CAP Wind Speed, SSMI and ECMWF

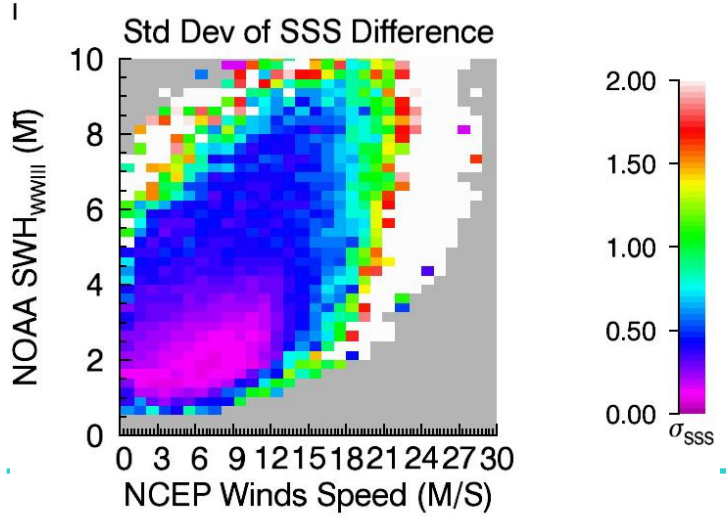
	SSMI	ECMWF	CAP
Error (m/s)	0.714	0.935	**0.700**

SSS Bias and Std wrt Hycom vs SWH and Wind Speed
28 day average on 1x1 deg grids

L2 V1.3.9

- has systematic biases vs SWH and Wind Speed



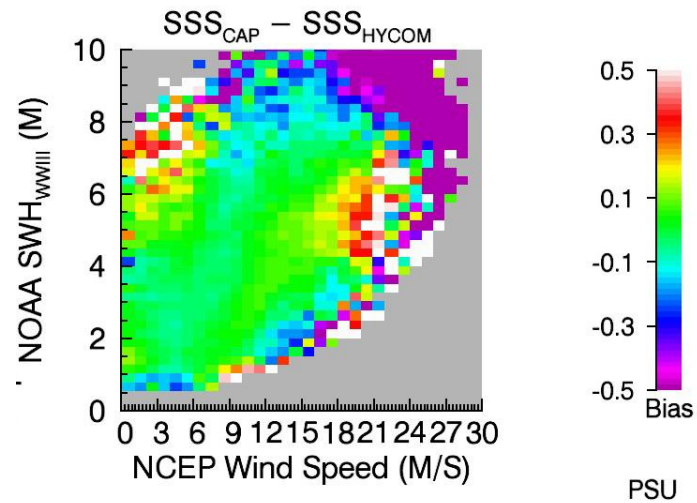


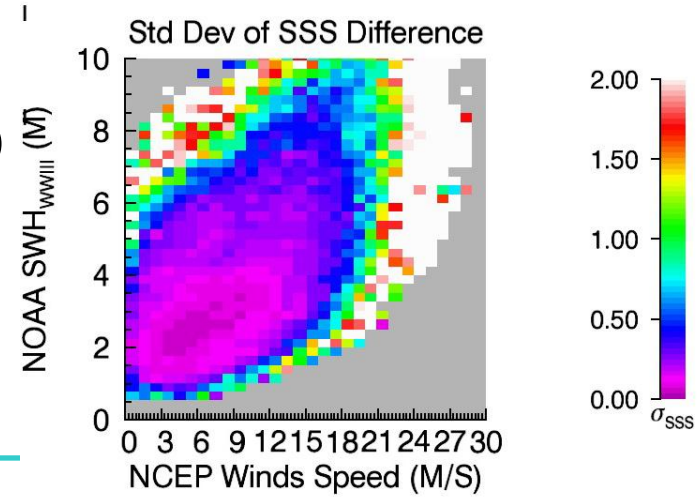
Introduce the NOAA WW3 SWH as an additional model parameter for the GMF

- TB= $TB(w, \phi, SWH)$
- σ0=σ0 (w, ϕ, SWH)

CAP V1.3.9

- The systematic and std are reduced in CAP

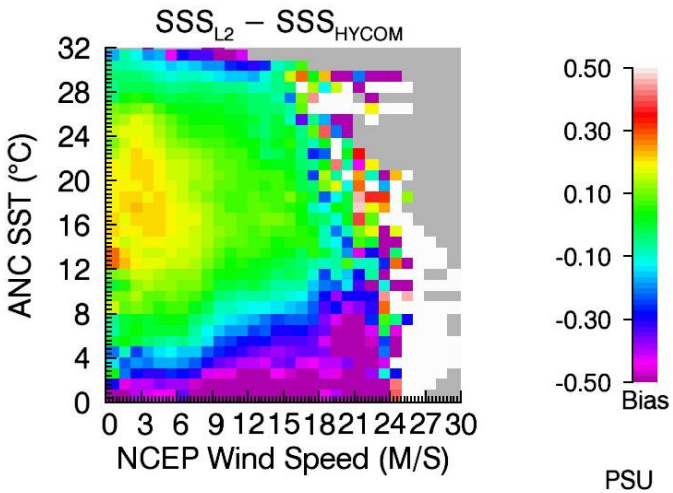


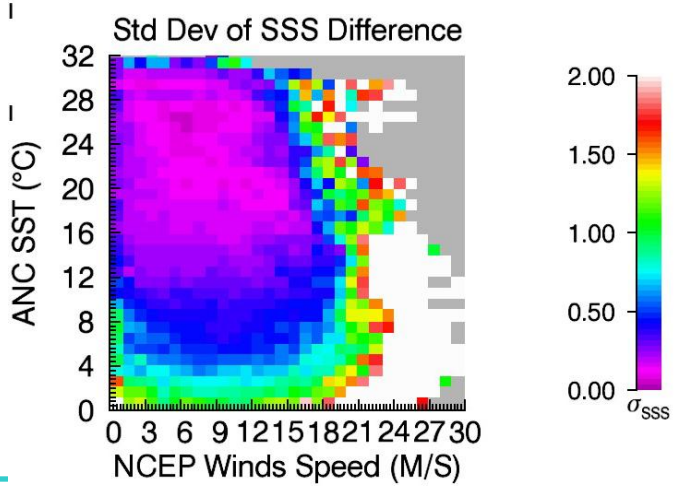


SSS Bias and Std wrt Hycom vs SST and Wind Speed
28 day average on 1x1 deg grids

L2 V1.3.9

- has systematic biases vs SST and Wind Speed

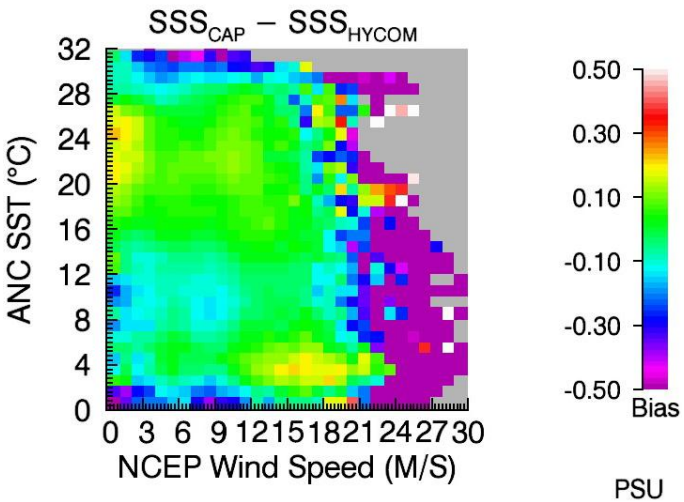


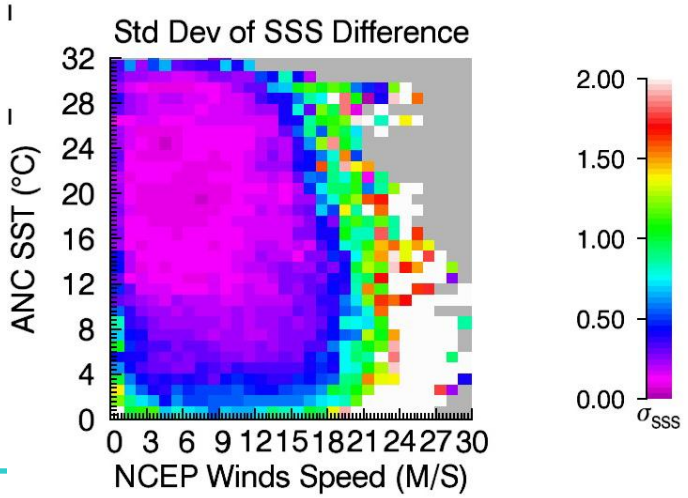


Use the linear combination of MW and KS models

CAP V1.3.9

- The systematic and std are reduced in CAP

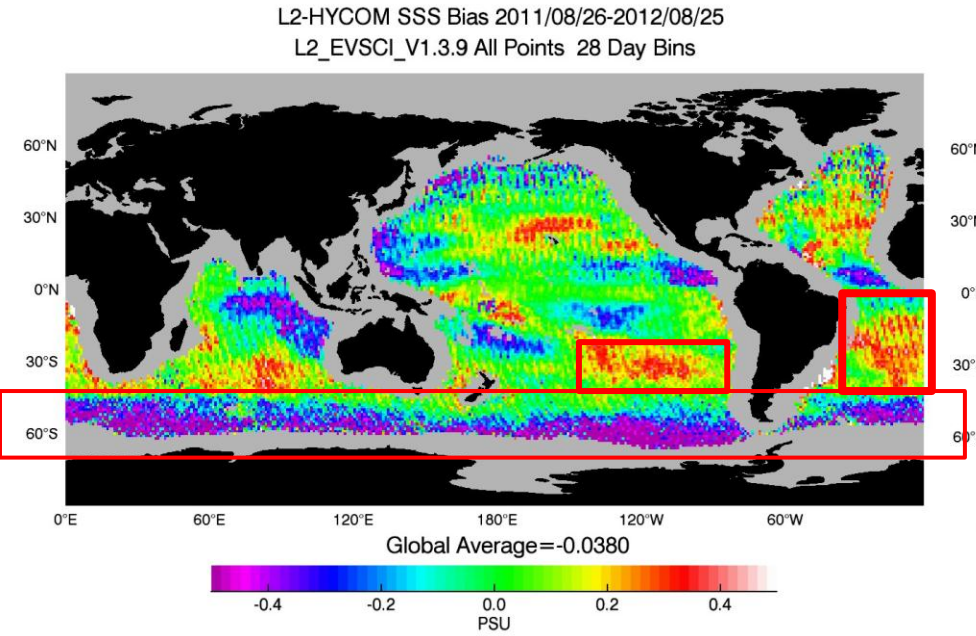




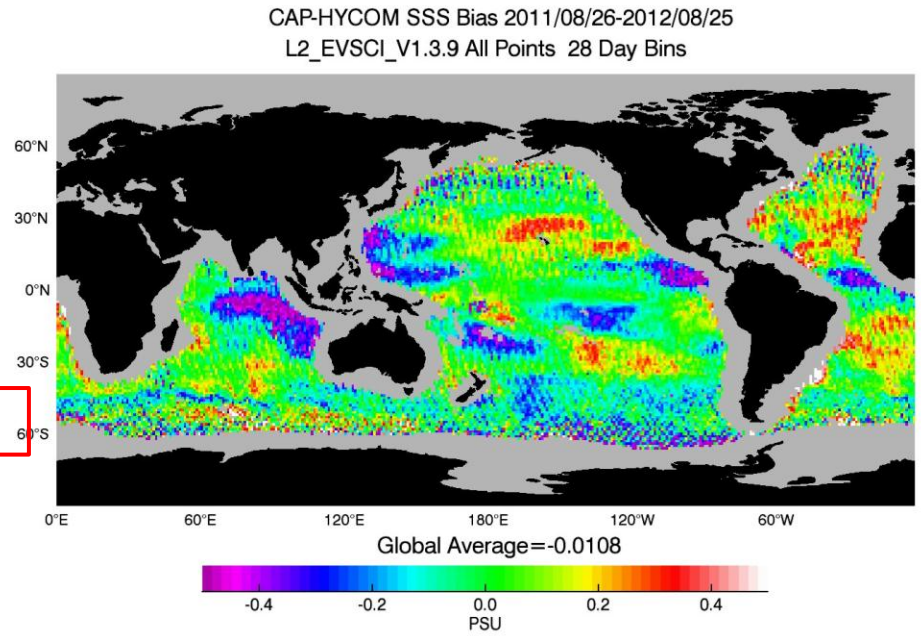
V1.3.9 SSS Bias wrt Hycom
Average of 28-day, 1x1 deg grids (8/26/2011-8/25/2012)

- CAP has a smaller bias than L2 V1.3.9, particular for cold water and high wind speed

L2 V1.3.9



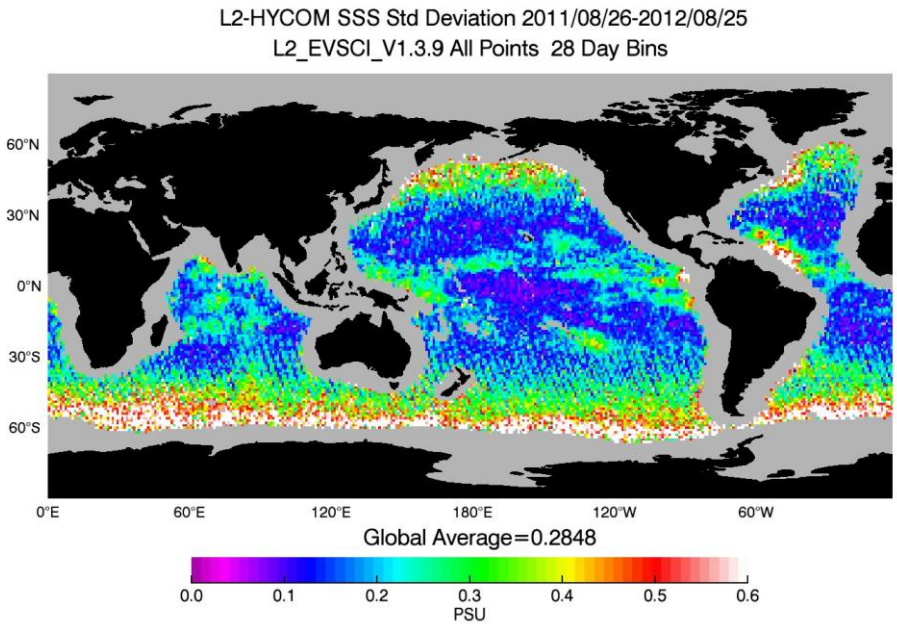
CAP V1.3.9



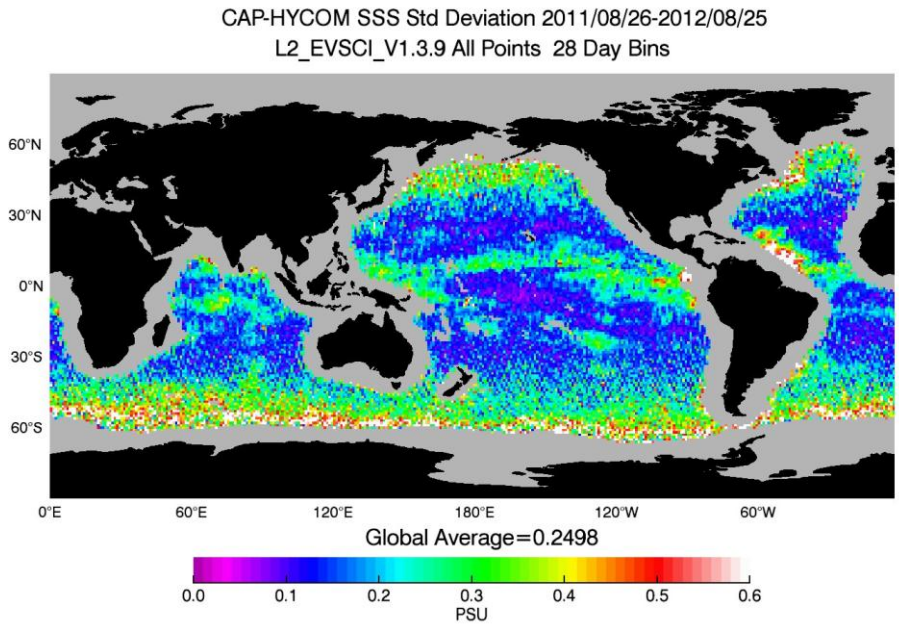
V1.3.9 SSS Bias wrt Hycom
Average of 28-day, 1x1 deg grids (8/26/2011-8/25/2012)

- CAP has a smaller standard deviation
  - L2: 0.285 psu
  - **CAP: 0.250 psu – 14% better than L2**

L2 V1.3.9

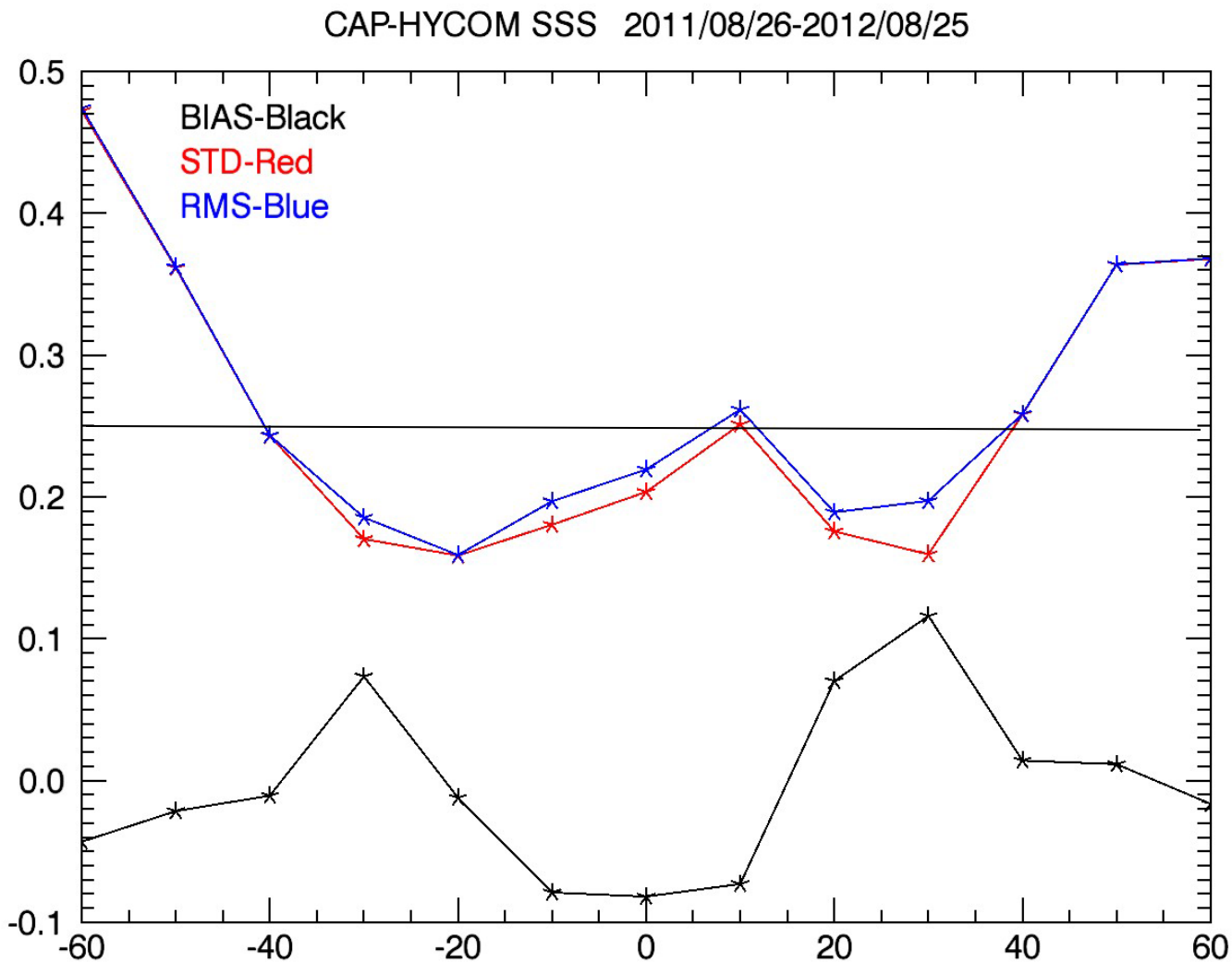


CAP V1.3.9



Aquarius and Hycom Differences
28 day global average on 100km grid

- The RMS error is under 0.25 psu from -40 to 40 deg latitude mostly

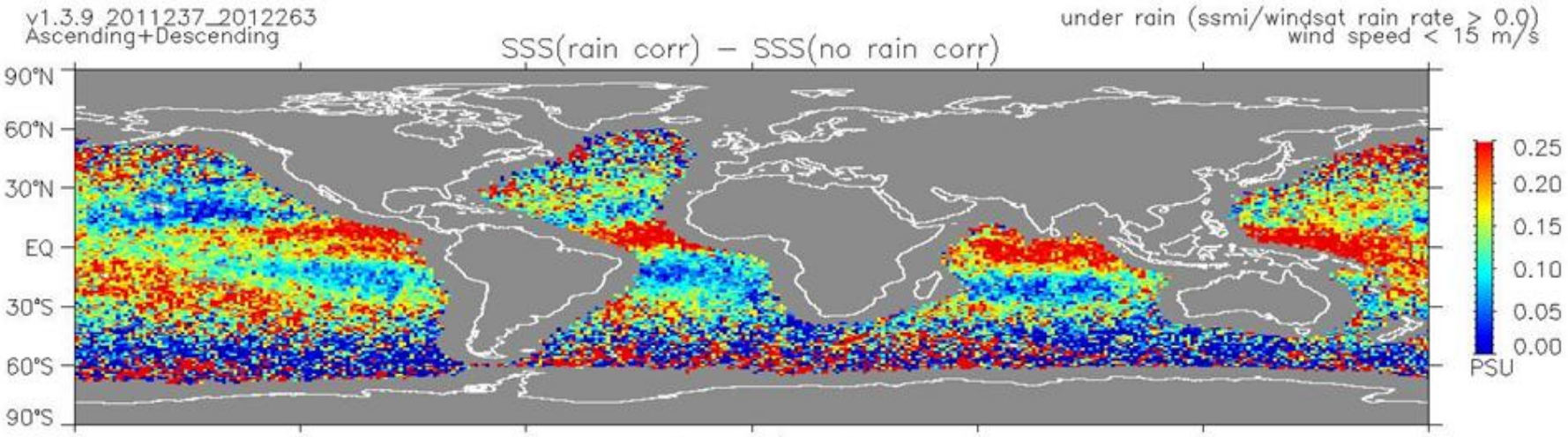


Towards V3.0

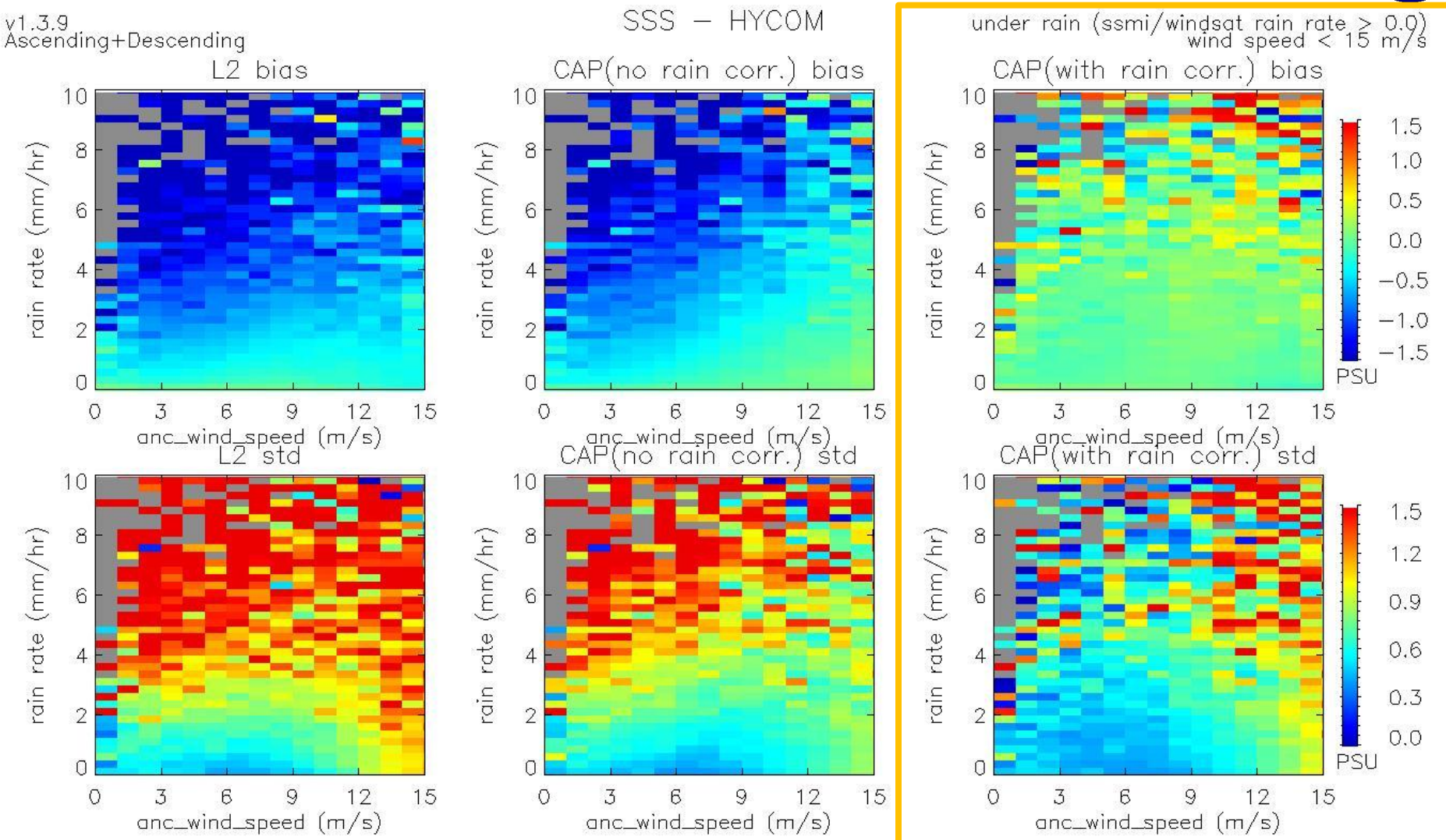
- Rain correction
- Improved galactic reflection correction
- Remove regional systematic bias in the scatterometer and radiometer model functions and retrieval
- Improved land contamination correction

Preview of Rain Correction (not in v2.0)

- Develop TB and sigma0 model functions to model the rain effects
- Apply the CAP cost function for retrieval using the SSM/I rain rate as ancillary
- Current results of bias adjustment from the rain correction under rainy conditions



Distribution of SSS Bias & RMSE in Wind-Rain Domain (8/25/2011-9/19/2012)



Significant improvement from rain correction

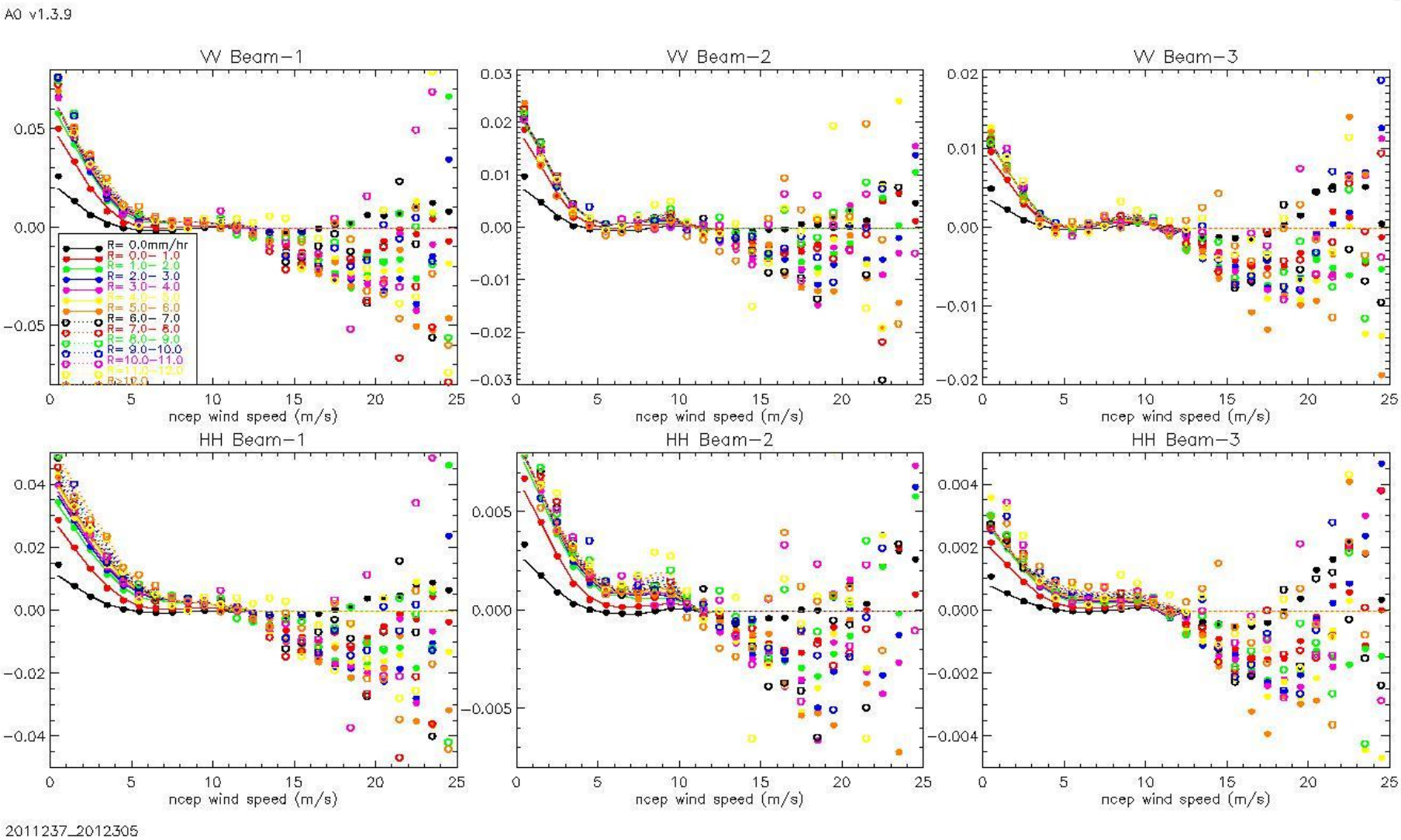
Summary

- CAP is more accurate than the L2 product
  - Smaller bias with respect to SST, wave and wind speed
  - Smaller standard deviation
- The Aquarius salinity product (CAP) – about 0.25 psu RMS for 28-day average
  - There are systematic regional biases, which could be caused by rain, wave, galactic radiation, and so on.
- Aquarius CAP wind speed is highly accurate (0.7 m/s error) – slightly better than SSM/I

Aquarius CAP Products distributed through PO.DAAC

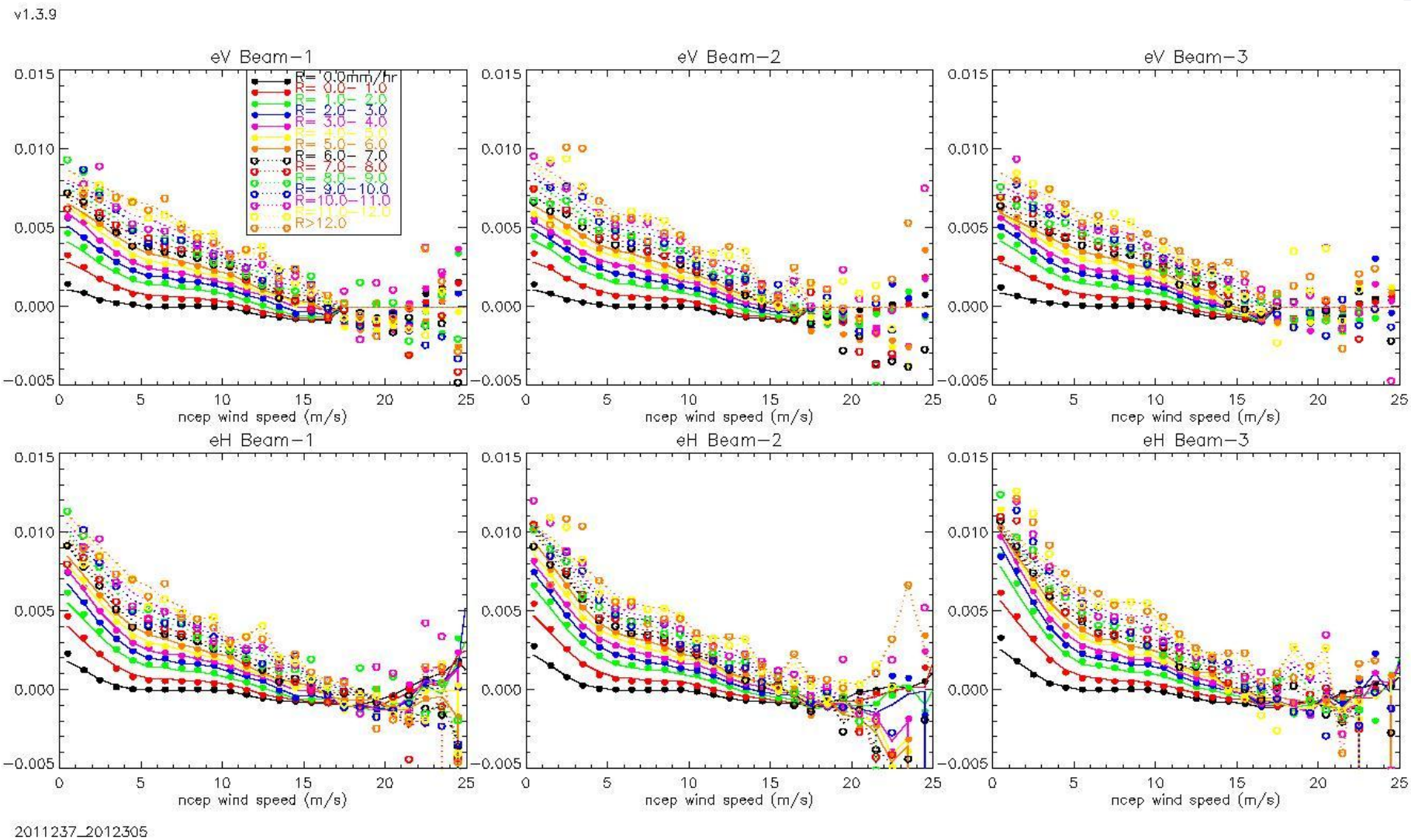
- Aquarius CAP (combined active-passive) product processed at JPL:
  - SSS
  - Wind speed
  - Wind direction
- **CAP 2.0 products available at PO.DAAC in a days**
  - **http://podaac.jpl.nasa.gov/SeaSurfaceSalinity**
  - **Follow the FTP Data Access link for Aquarius data**

Rain correction for radar backscatter: $\Delta A_{0,p}(w,r)$



$$s_{0,p}(w,f,r) = A_{0,p}(w,swh) + A_{1,p}(w)\cos f + A_{2,p}(w)\cos 2f + \Delta A_{0,p}(w,r)$$

Rain correction for radiometer emissivity: $\Delta e_p(w,r)$



$$e_p(SSS,SST,w,f,r) = e_p^{flat}(SSS,SST) + e_{0,p}(w,swh) + e_{1,p}(w)\cos f + e_{2,p}(w)\cos 2f + De_p(w,r)$$