Retrieval of Sea Surface Salinity and Wind from The NASA Soil Moisture Active Passive Mission Data

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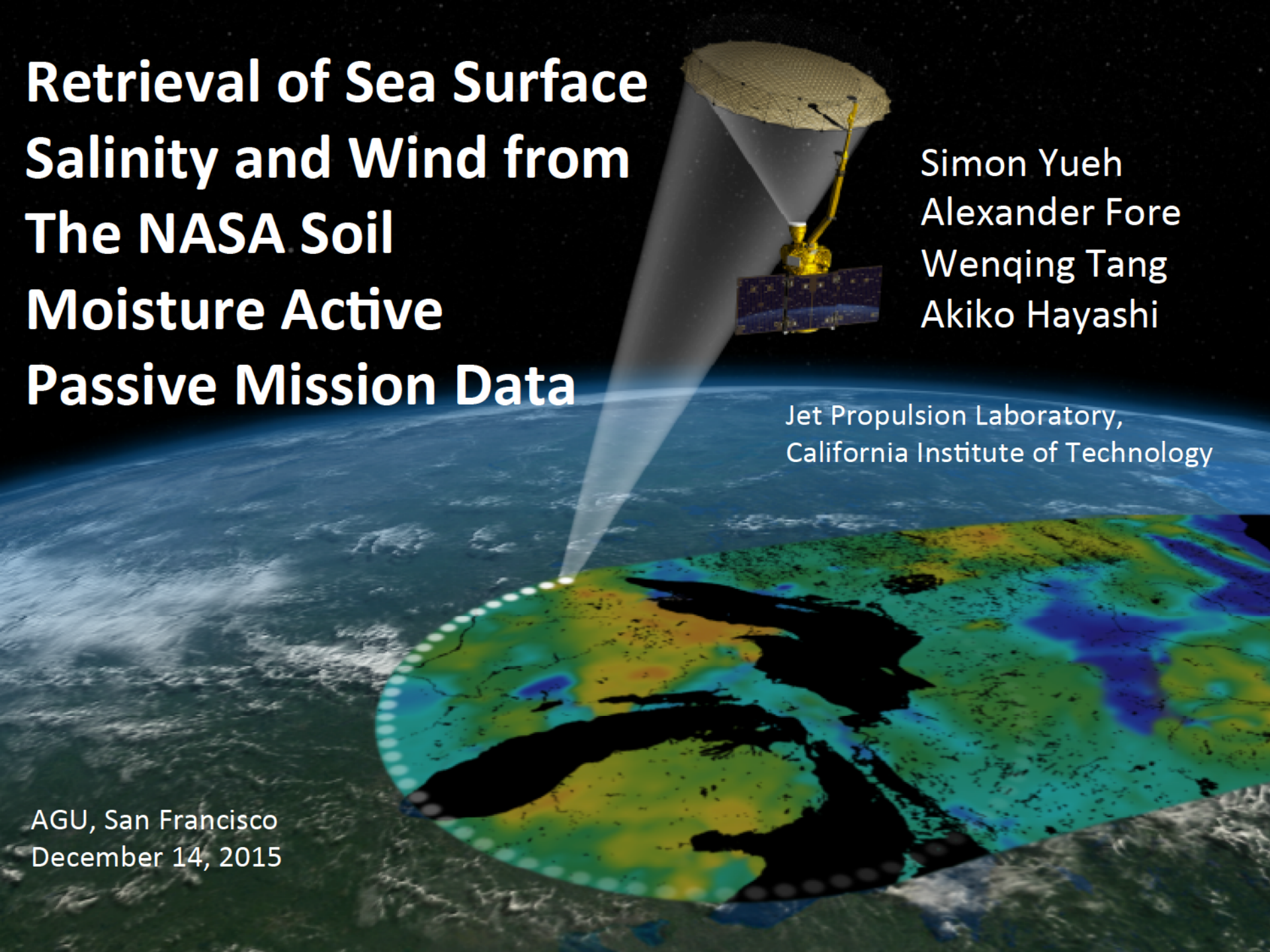

AGU, San Francisco
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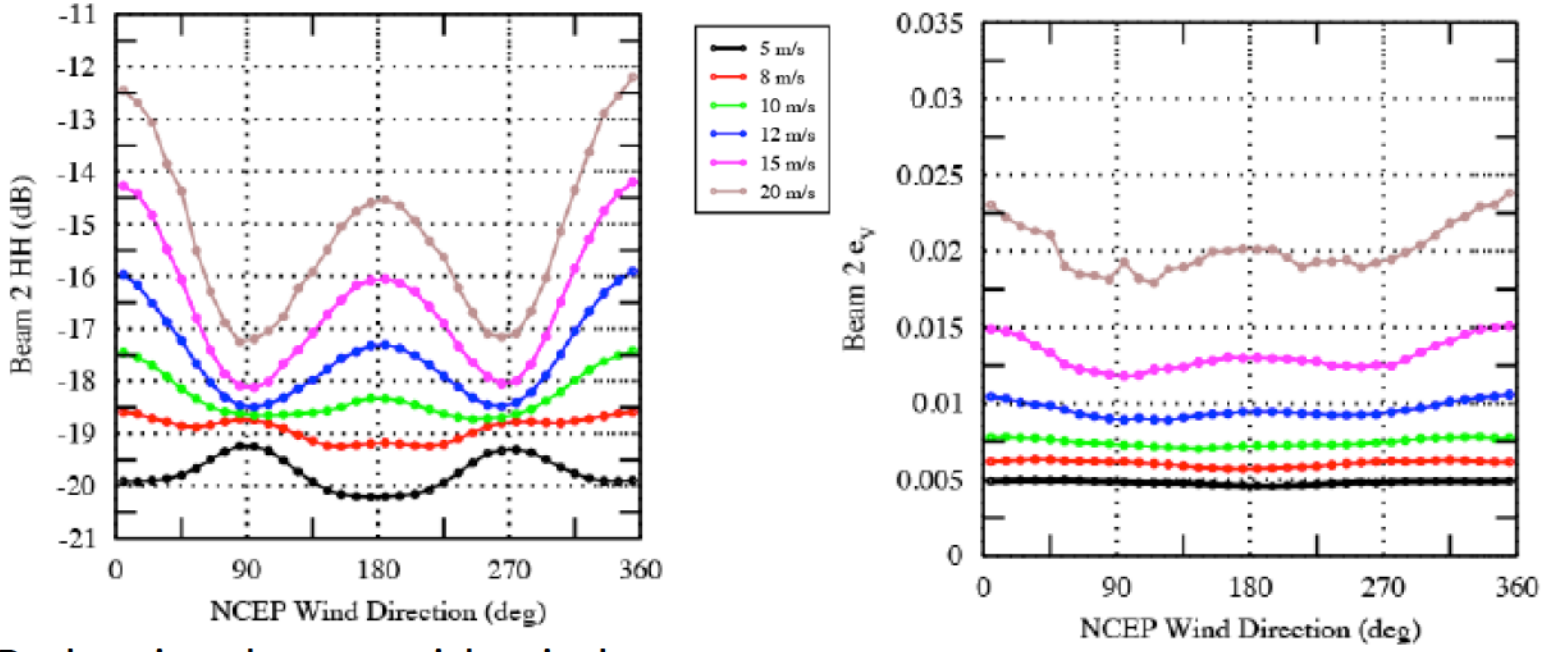
Objectives

- Develop ocean surface salinity and surface wind products from the SMAP's radiometer data
  - Continuity to JPL's CAP salinity Product for Aquarius
  - Provide product for severe ocean wind observations
  - JPL SMAP SSS/Wind products to be available from ourocean.jpl.nasa.gov
- Demonstrate the use of SMAP's combined active and passive (CAP) data for ocean applications

Effects of Wind/Wave on Radar and Radiometer Signals Observed by Aquarius

- The matchup of Aquarius data with NCEP wind direction, SSMIS wind speed indicates impact of ocean wind on radar and radiometer signals.
  - The charts below indicate the signal sensitivity for the data from Aquarius beam# 2 (~39 deg incidence angle)

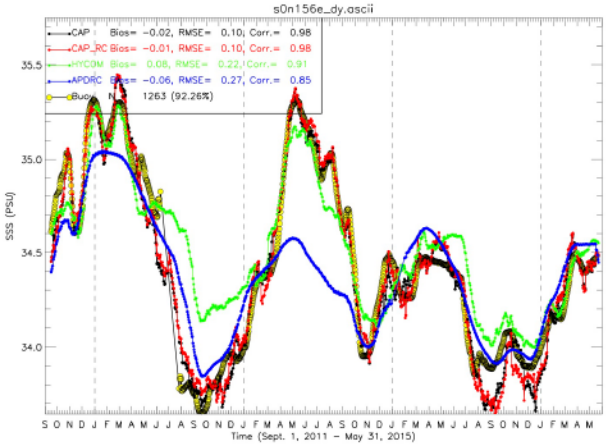


- Radar signals vary with wind speed and wind direction
  - Cosine signal changes sign at about 8 m/s

- Radio emissivity (TB/Ts) varies with wind speed and wind direction

Validation of JPL's Aquarius Combined Active-Passive (CAP) Version 4 Retrieval With Buoy Data

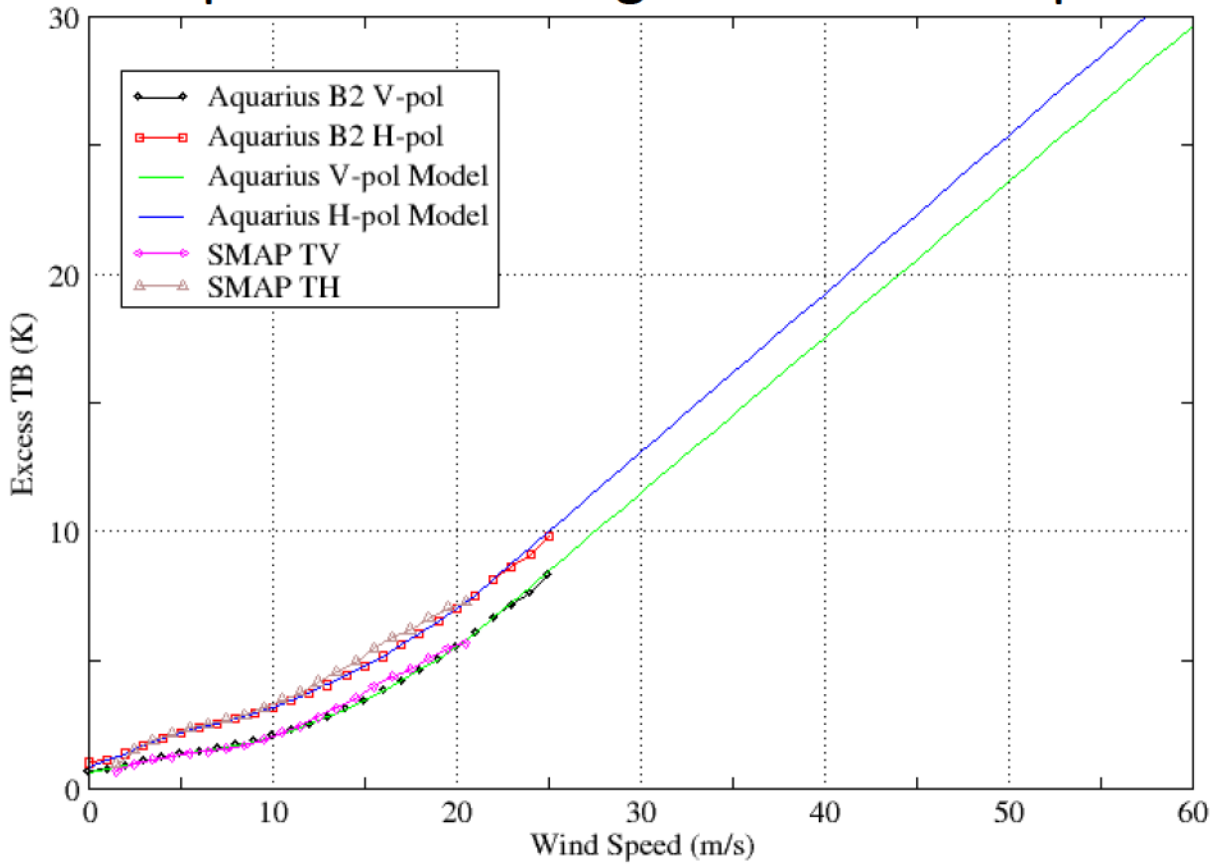
- 0.14 (RMSD) psu with respect to buoy data
- Better agreement with buoy data than Hycom and APDRC (0.19 psu, RMSD)



	CAP	CAP_RC	HYCOM	APDRC
Bias [PSU]	0.032	0.036	0.043	0.001
RMSD [PSU]	**0.141**	**0.141**	**0.191**	**0.190**
Correlation	0.710	0.711	0.611	0.600

SMAP Data Agree with Aquarius Excess Brightness Temperature Model

- Aquarius Model Function Derived from V.4 data
- SMAP data acquired to date agree with the Aquarius GMF.



Research Approach

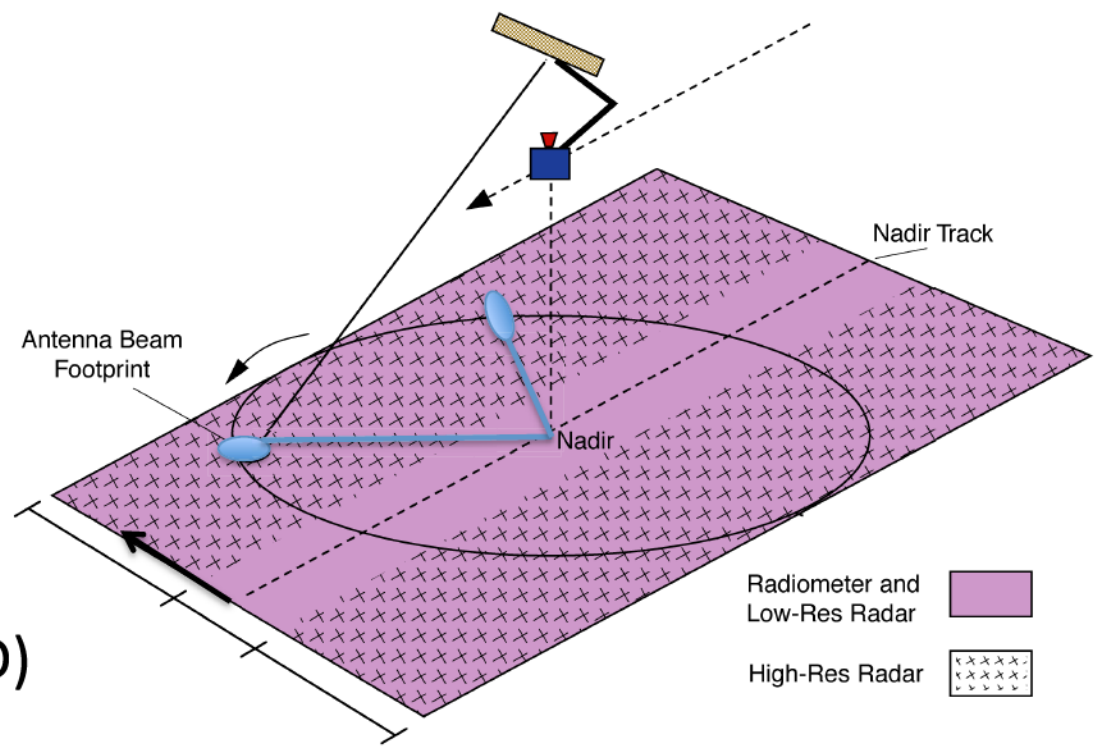
- Implement algorithms with active-only, passive-only and combined active-passive (CAP)
  - Radar-only wind speed and direction
  - Radiometer-only wind speed and salinity
  - Radiometer-only wind speed for hurricanes (similar to Reul's SMOS algorithm)
  - Combined active-passive for salinity and wind
- Comparative analysis for error estimation

Wind Speed and Direction Retrieval From SMAP's Radar Data (2 Azimuth Looks)

- Cost function with two looks

$$F_{pol}(W,\phi) = \sum_{i=1}^{2} \frac{(\sigma_{0i} - \sigma_{0mi})^2}{k_p \sigma_0^{\ 2}}$$

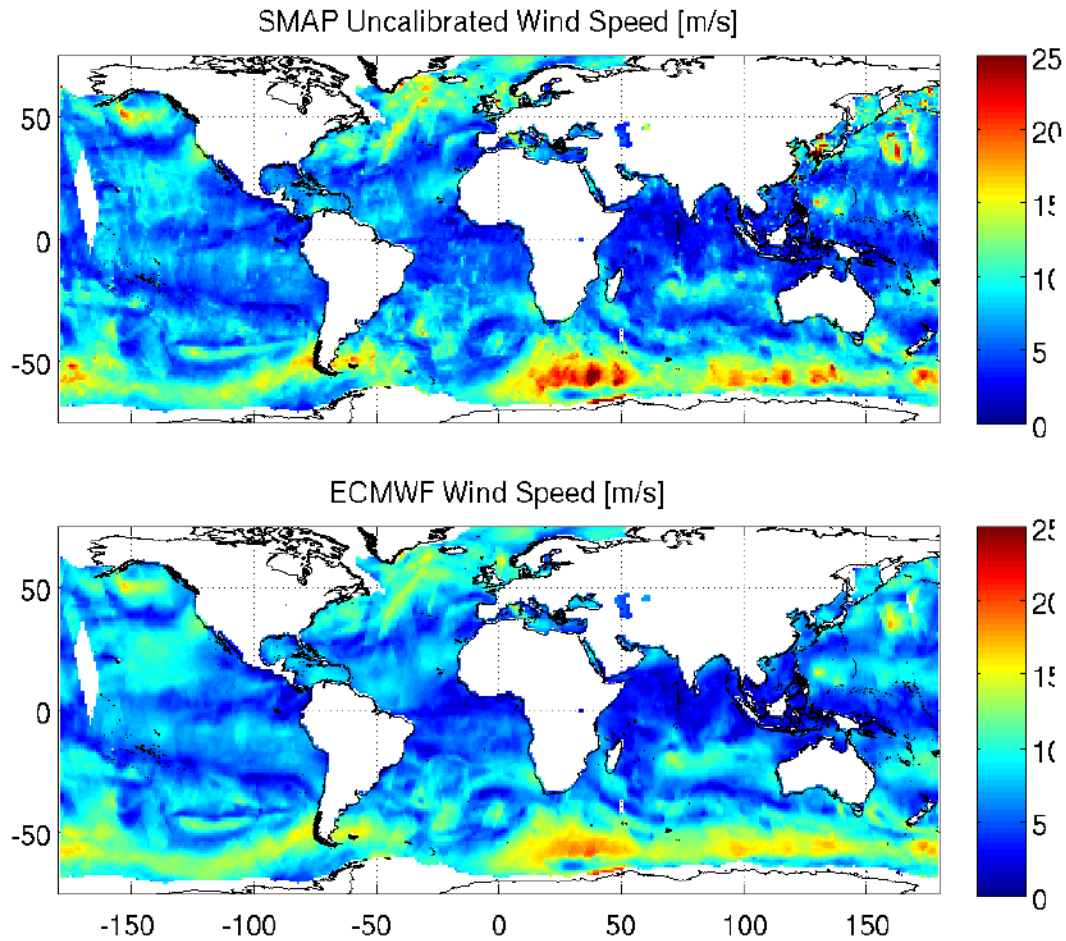
Footprint resolution ~ 30km



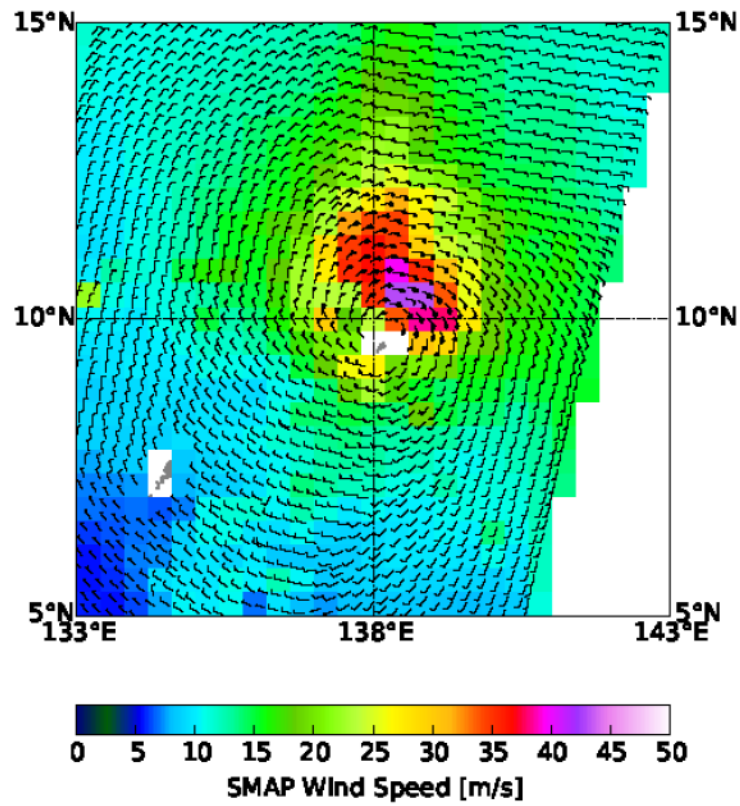
Cross-Track Distance (CTD)

L-band Radar Data for Ocean Surface Winds

- SMAP two look radar data used to produce ocean surface winds based on JPL's QuikSCAT/RapidSCAT algorithm – good agreement with the ECMWF analysis
- Research effort supported by the NASA Oceanography program



SMAP radar wind for super typhoon Maysak on 2015-090

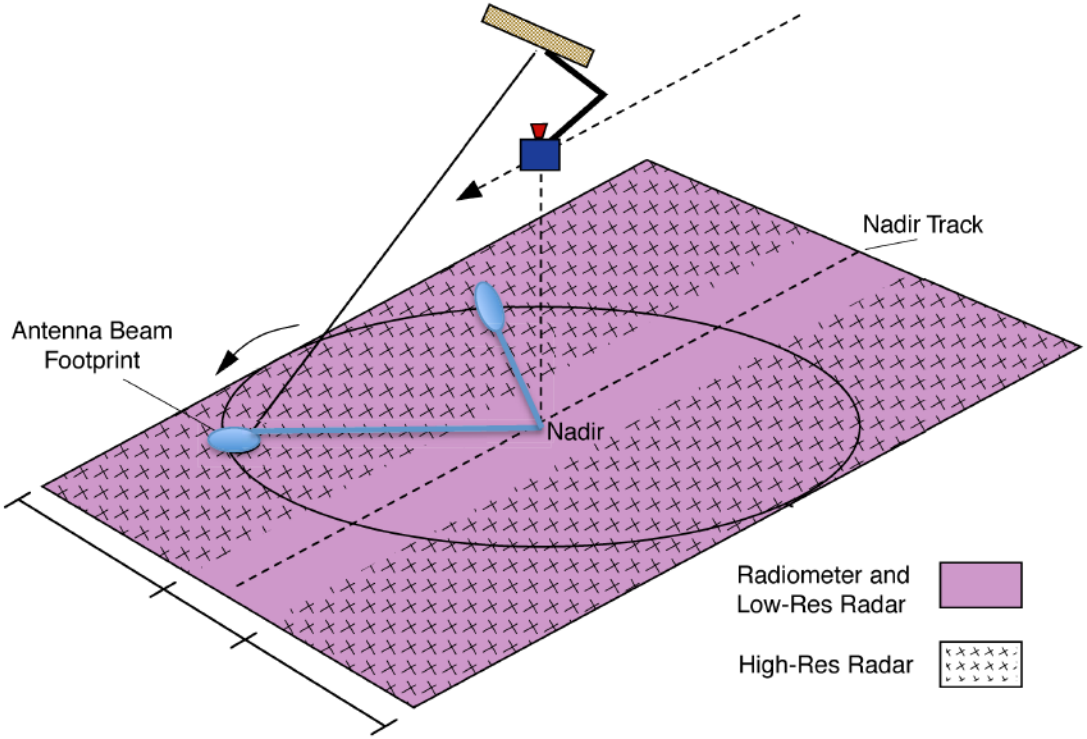


Salinity and Wind Retrieval From SMAP's Radiometer Data (2 Azimuth Looks)

- Cost function with two looks

$$F(SSS,w)=\sum_{i=1}^{2}\frac{(T_{BVi}-T_{BVmi})^2}{\Delta T^2}+\frac{(T_{BHi}-T_{BHmi})^2}{\Delta T^2}+\frac{(w-w_{NCEP})^2}{\Delta w^2}$$

- Require NCEP wind speed constraint for moderate to high winds

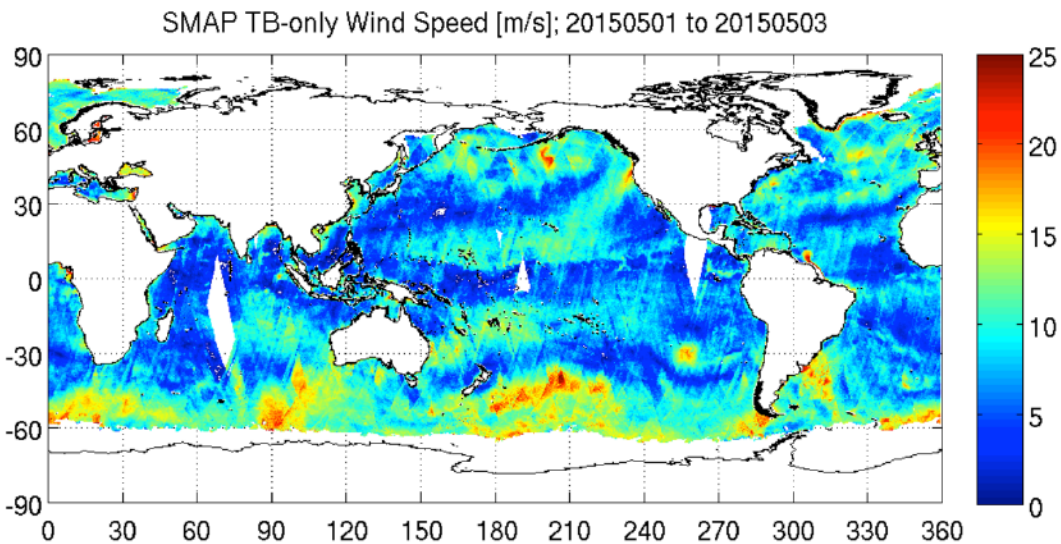


SMAP L-band Radiometer Data For Severe Weather

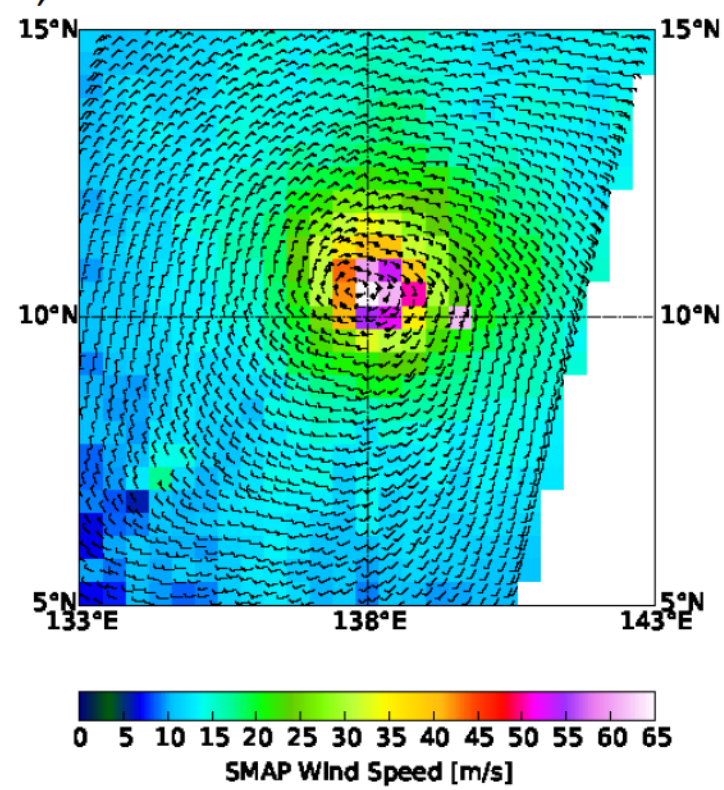
All Weather Ocean Surface Wind speed

- L-band brightness temperature useful for hurricane wind speed retrieval using two looks, dual-pol TB data given the NCEP wind direction

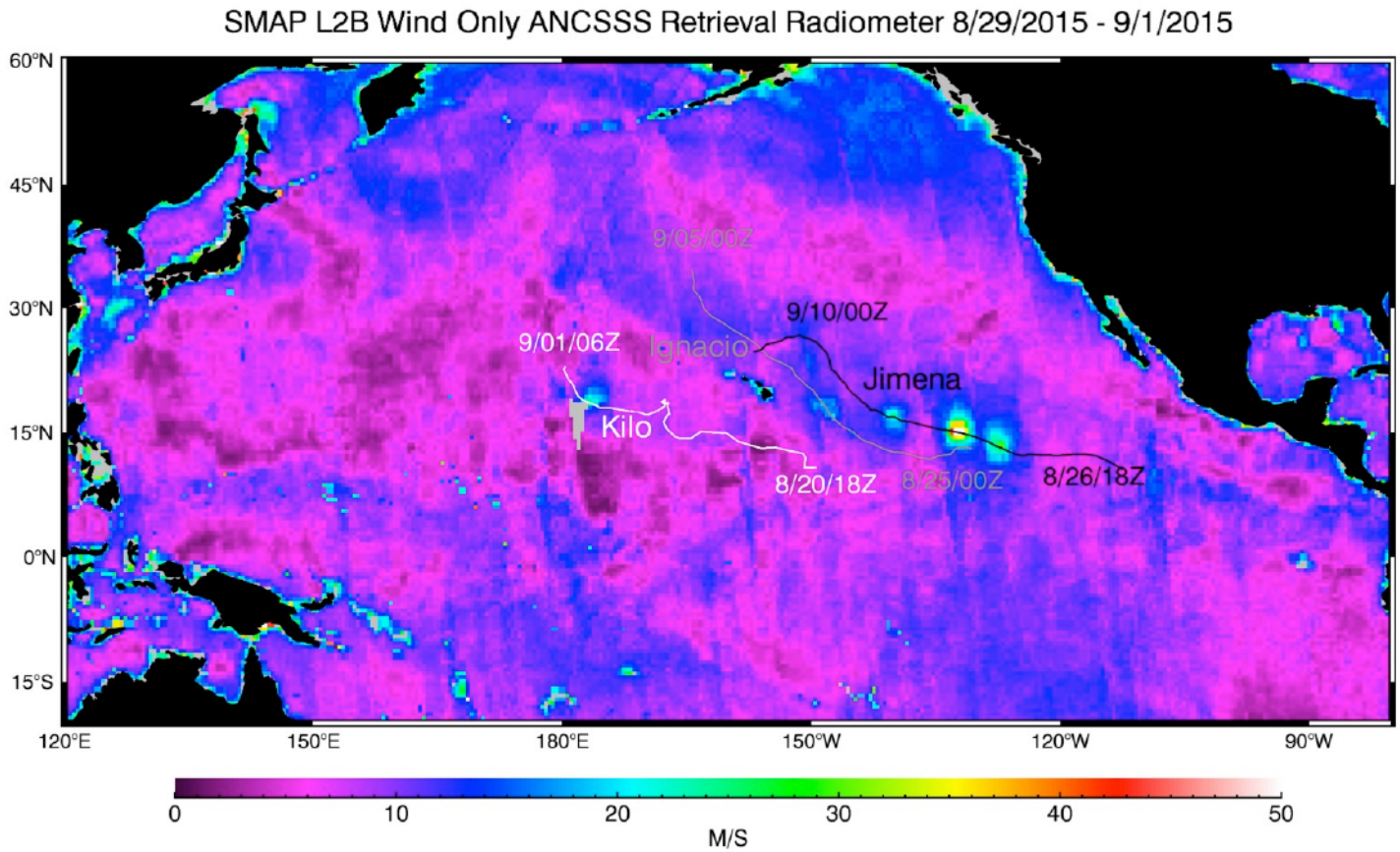
$$C = \sum_{i=1}^{2} \frac{(T_{BVi} - T_{BVMi})^2}{\Delta T^2} + \sum_{i=1}^{2} \frac{(T_{BHi} - T_{BHMi})^2}{\Delta T^2}$$



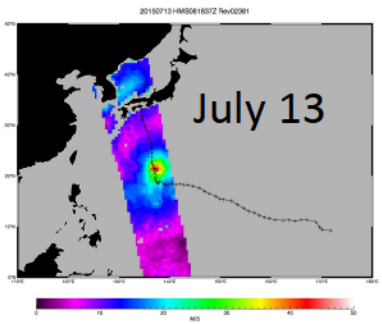
SMAP Wind for Super Typhoon Maysak on Mar 31, 2015 reached 120 knots

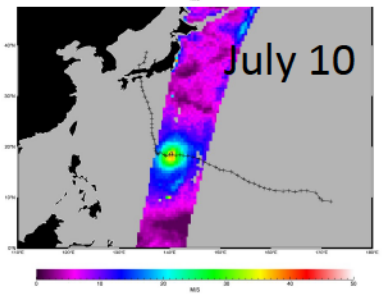


SMAP captured three C4 Pacific Hurricanes August-September 2015

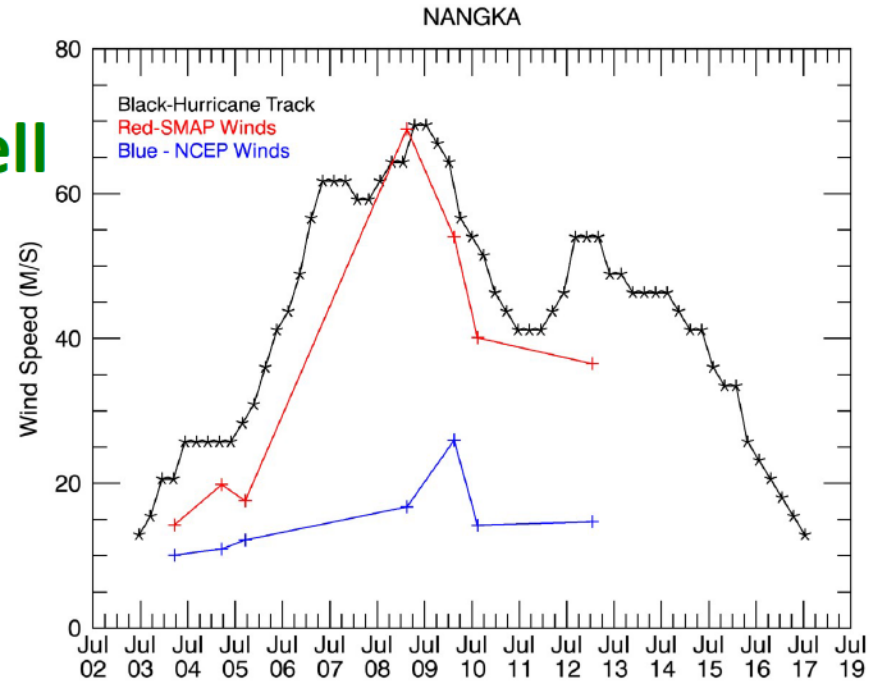


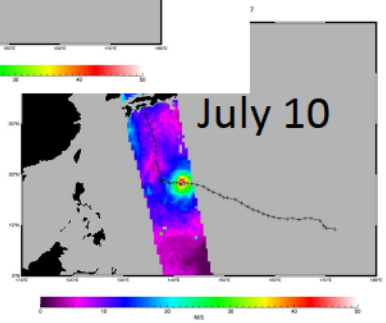
SMAP Wind Speed for Typhoon NANGKA (Cat 4)

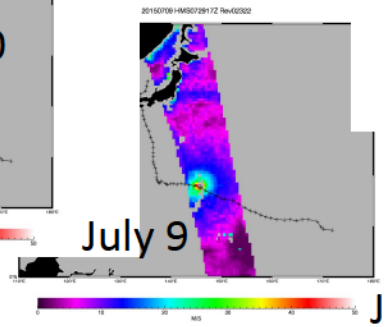


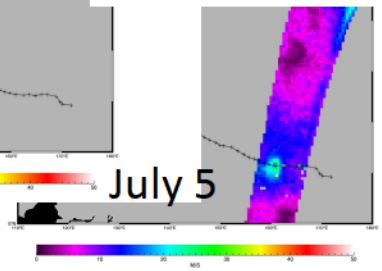


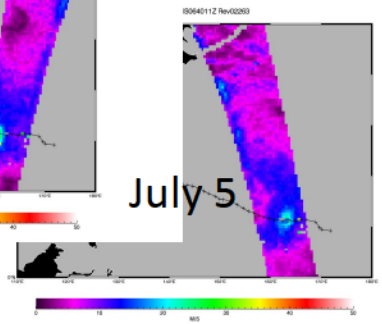
Maximum wind speed agreed well with TPC's best track analysis

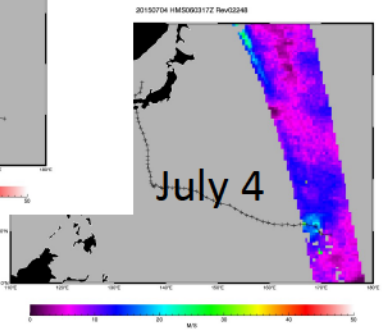






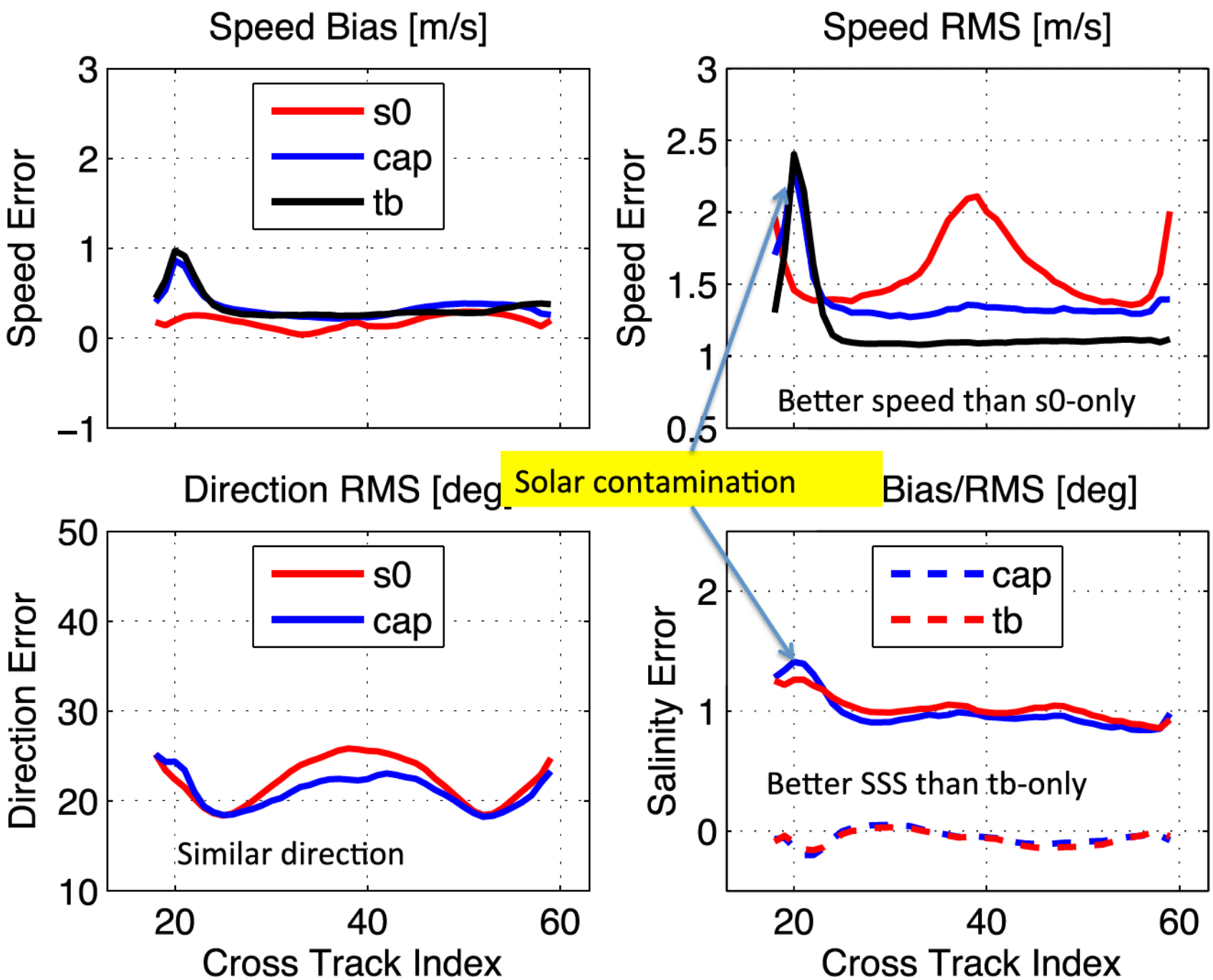


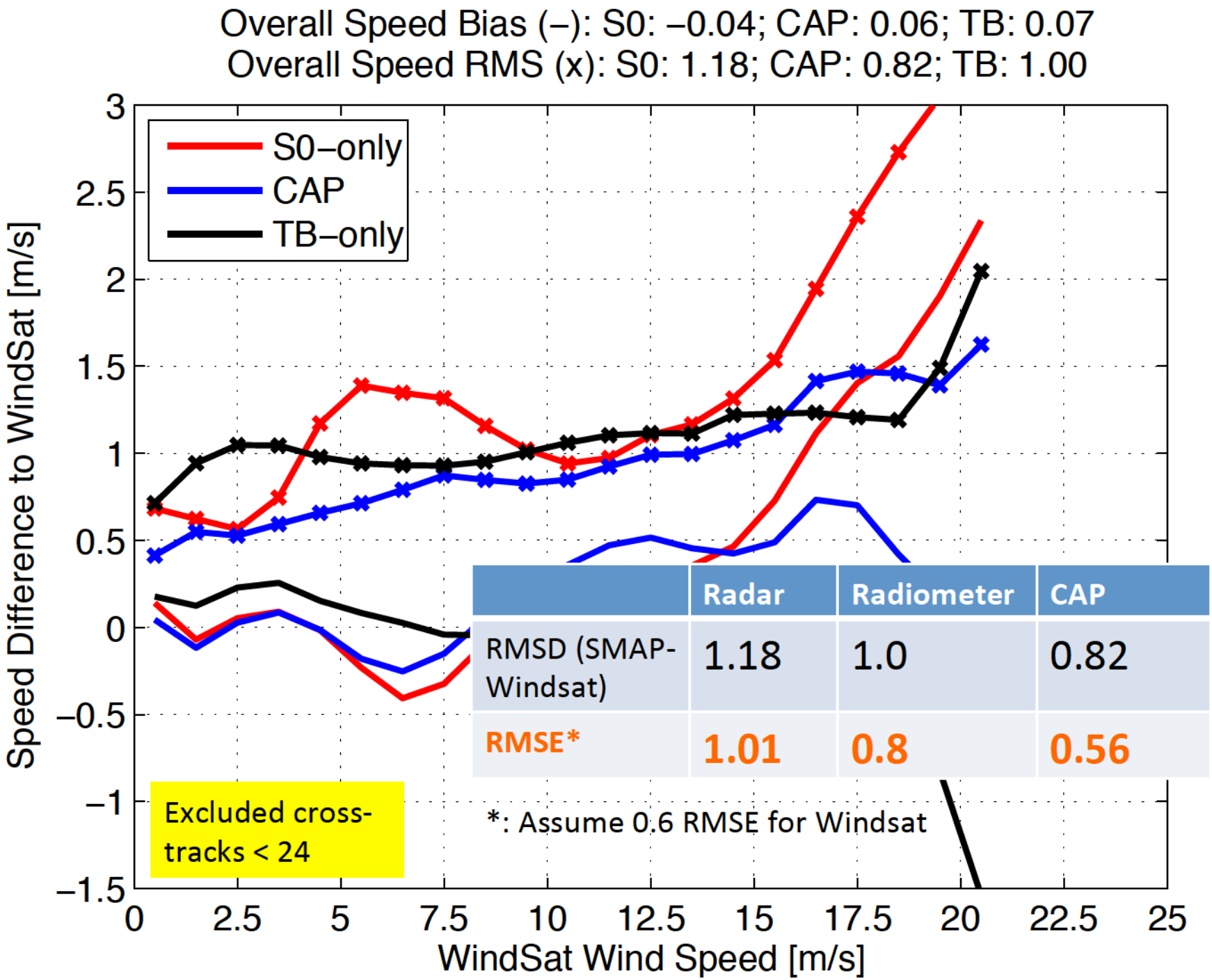




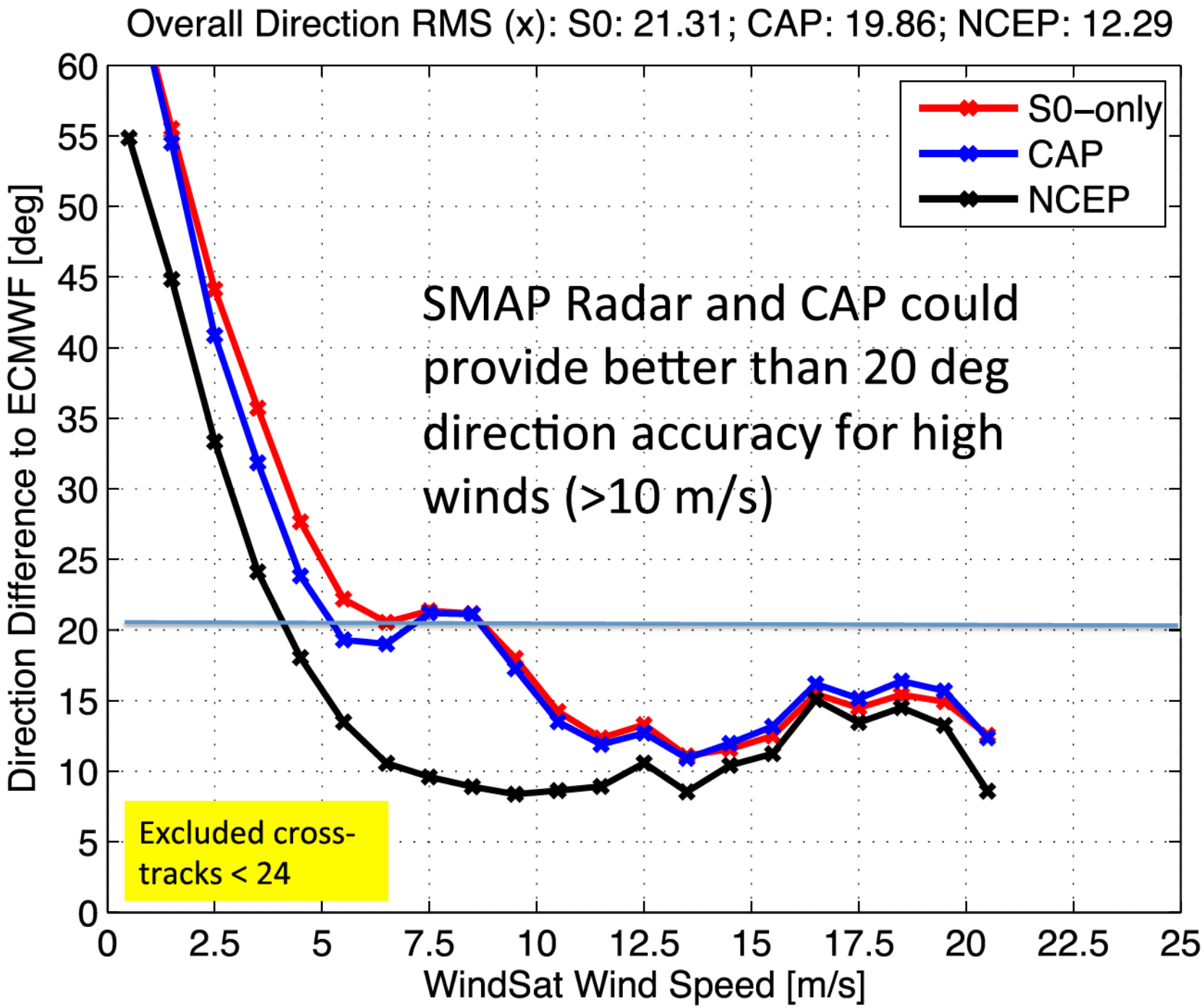
Combined Active-Passive (CAP) Processing

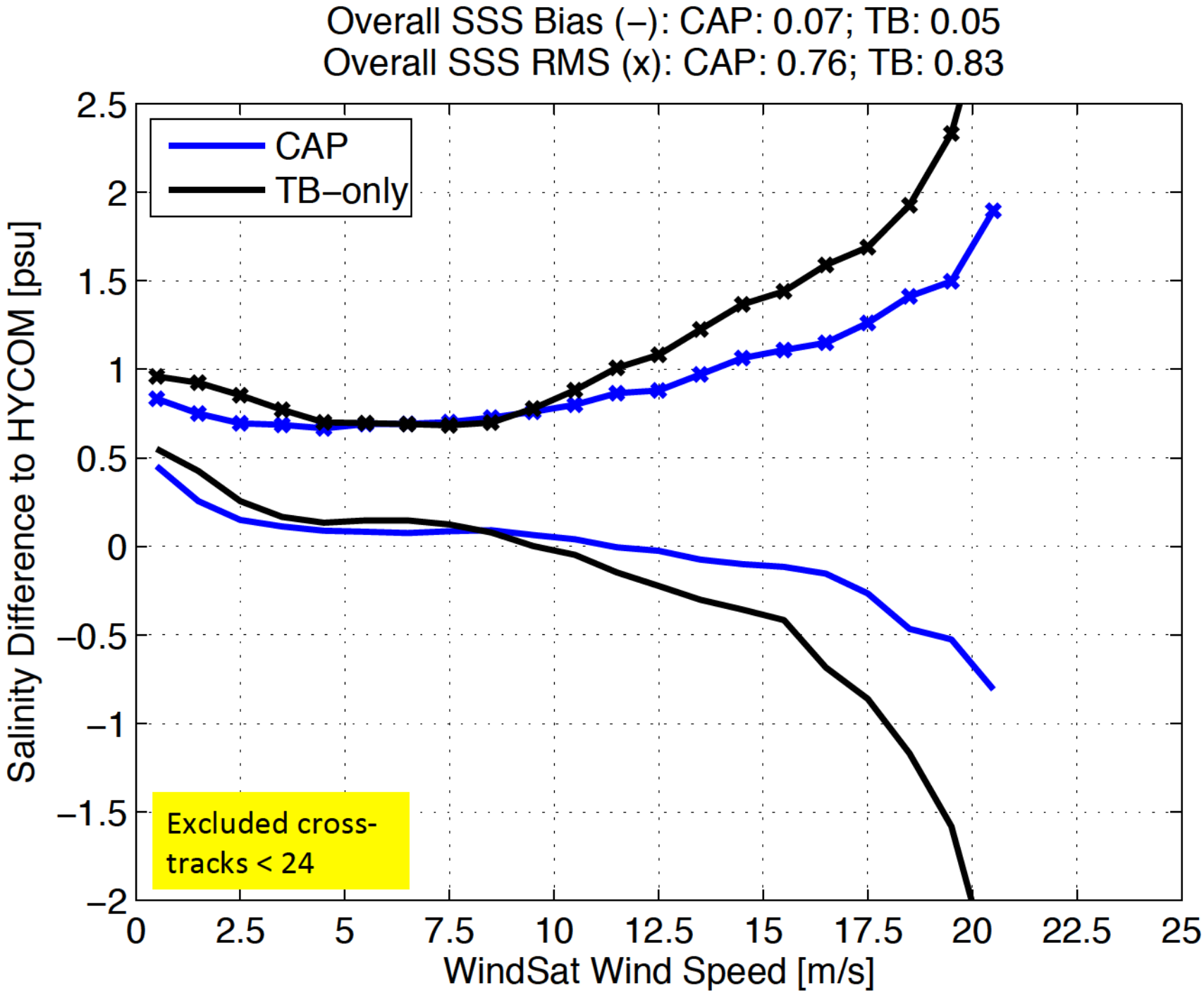
- Step 1: TB-only SSS and wind speed processing
- Step 2: Radar S0-only wind vector processing (DIRTH)
- CAP Processing: Two step algorithm
  - Fix SSS at TB-only retrieval:
    - Compute best-speed, best-obj curves for all relative azimuths.
    - Identify minima (ambigs)
    - Pick nearest to s0-only wind vector and do DIRTH processing on it.
  - Fix wind vector
    - Do TB-only SSS retrieval using wind vector from previous step

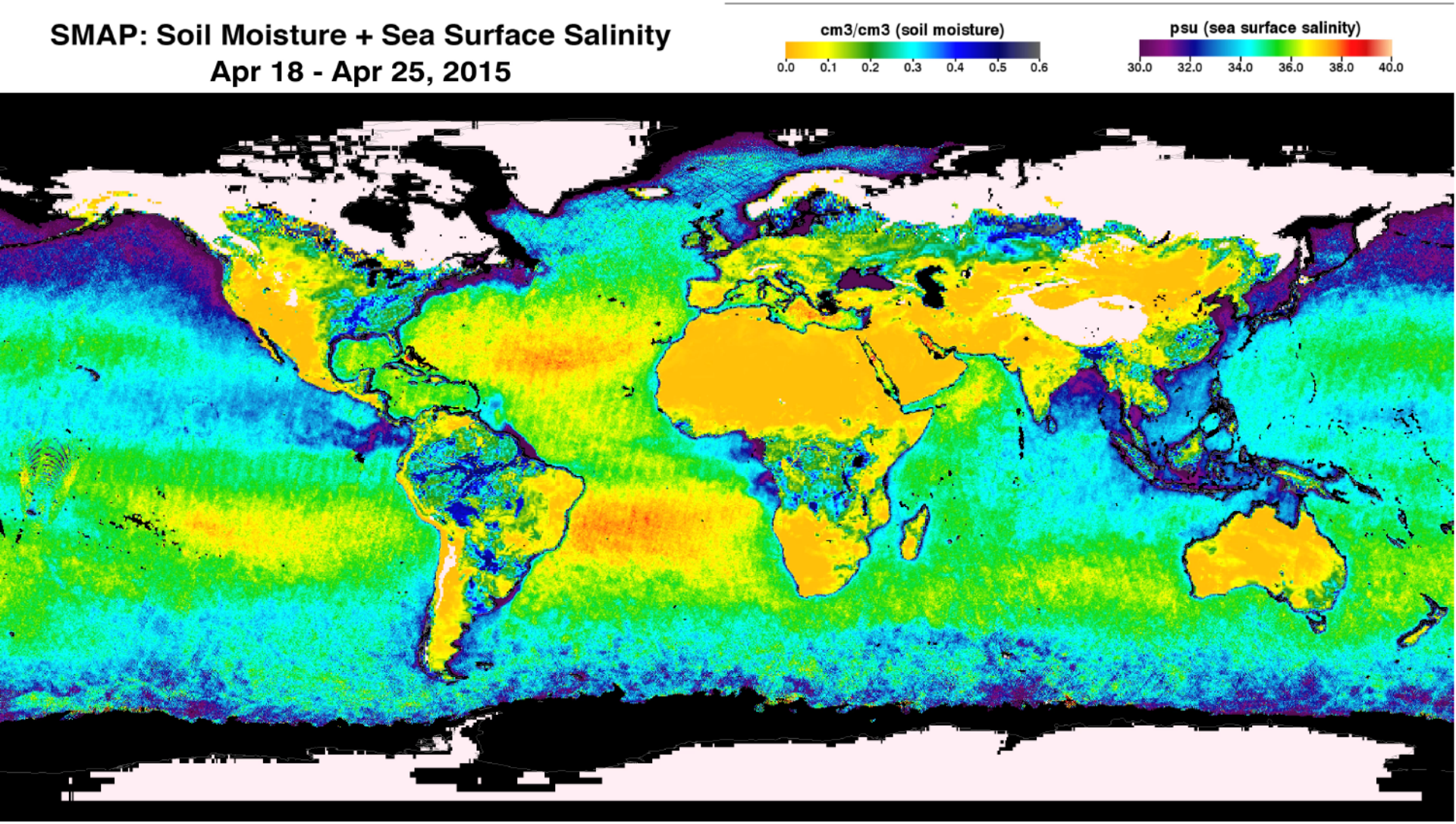

Speed Bias [m/s]
Speed Error
s0
cap
tb
Speed RMS [m/s]
Speed Error
Better speed than s0-only
Solar contamination
Direction RMS [deg]
Direction Error
s0
cap
Similar direction
Cross Track Index
Bias/RMS [deg]
Salinity Error
cap
tb
Better SSS than tb-only
Cross Track Index



	Radar	Radiometer	CAP
RMSD (SMAP-Windsat)	1.18	1.0	0.82
RMSE*	1.01	0.8	0.56


Overall Direction RMS (x): S0: 21.31; CAP: 19.86; NCEP: 12.29
S0–only
CAP
NCEP
SMAP Radar and CAP could provide better than 20 deg direction accuracy for high winds (>10 m/s)
Excluded cross-tracks < 24
Direction Difference to ECMWF [deg]
WindSat Wind Speed [m/s]
0
5
10
15
20
25
30
35
40
45
50
55
60
0
2.5
5
7.5
10
12.5
15
17.5
20
22.5
25


Overall SSS Bias (–): CAP: 0.07; TB: 0.05
Overall SSS RMS (x): CAP: 0.76; TB: 0.83
CAP
TB–only
Salinity Difference to HYCOM [psu]
WindSat Wind Speed [m/s]
2.5
2
1.5
1
0.5
0
–0.5
–1
–1.5
–2
0
2.5
5
7.5
10
12.5
15
17.5
20
22.5
25
Excluded cross-tracks < 24



SMAP soil moisture and salinity reveal detailed features of water cycle.

JPL SMAP Salinity/Wind Products (v1 beta) to be available through ourocean.jpl.nasa.gov

Summary

- SMAP's radiometer data will provide valuable sea surface salinity and severe ocean wind speed.
  - JPL SMAP Salinity/Wind Products (v1 beta) to be available through ourocean.jpl.nasa.gov
- SMAP's active-passive data provided highly accurate ocean surface wind vectors for high winds and improved salinity retrieval accuracy
  - Justify the L-band Active-Passive ocean remote sensing for the next decadal Earth Science missions