L-BAND ACTIVE-PASSIVE MICROWAVE REMOTE SENSING OF OCEAN SURFACE WIND DURING HURRICANES

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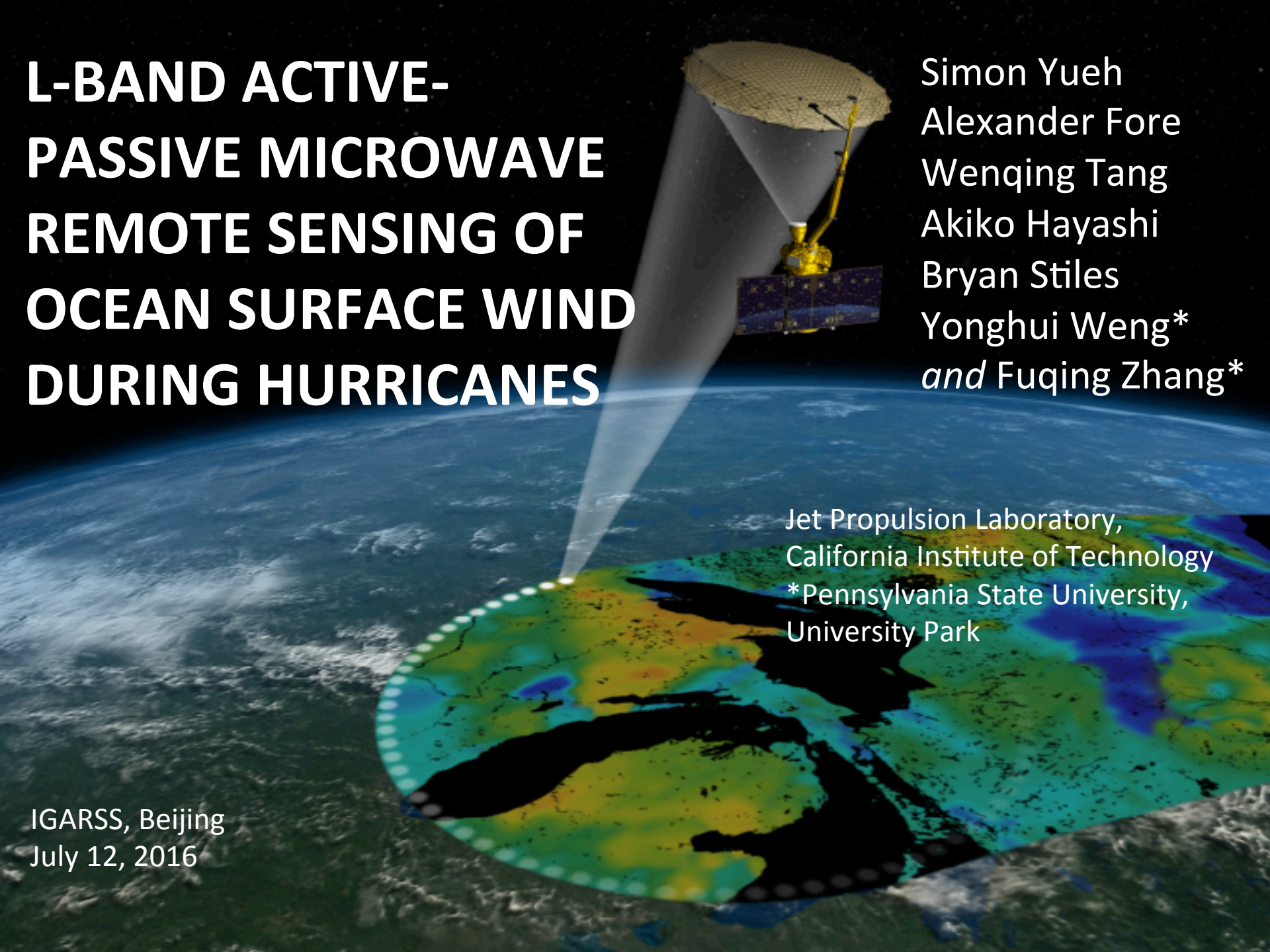

IGARSS, Beijing
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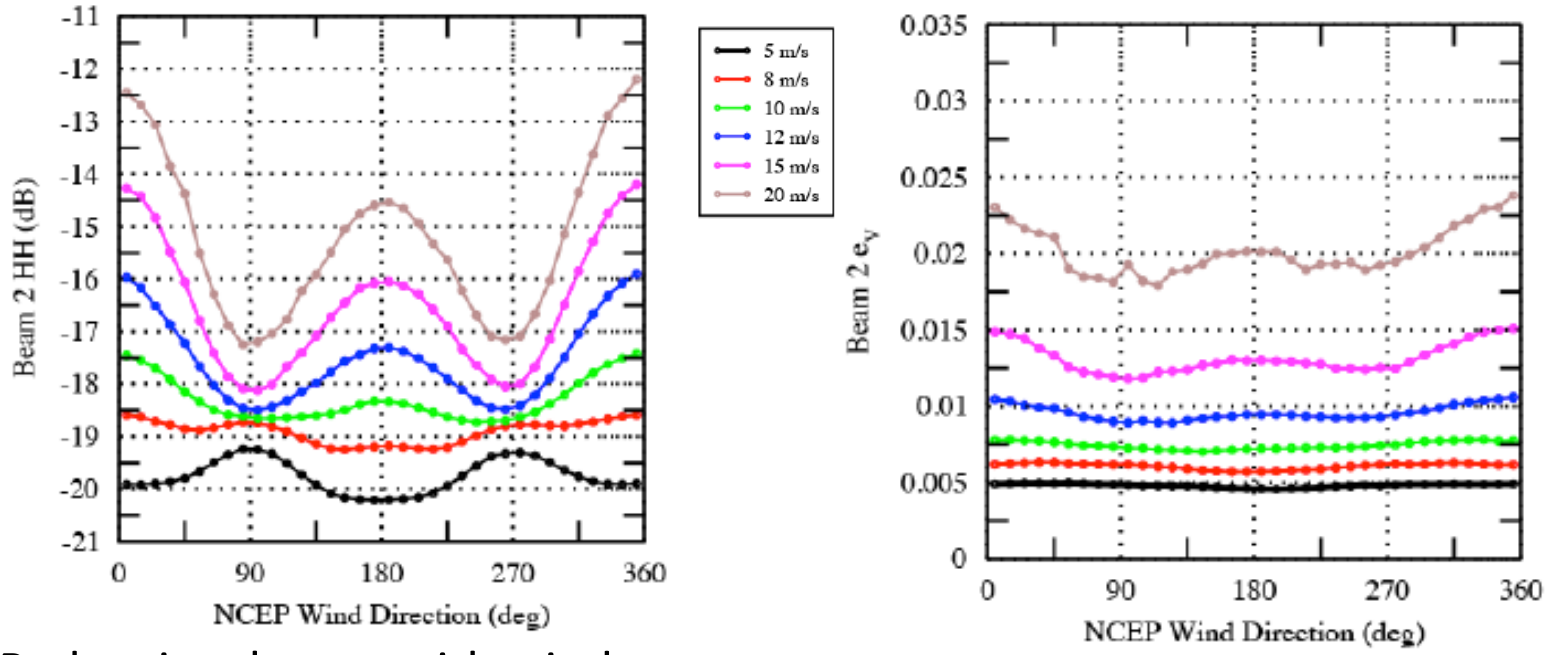
Objectives

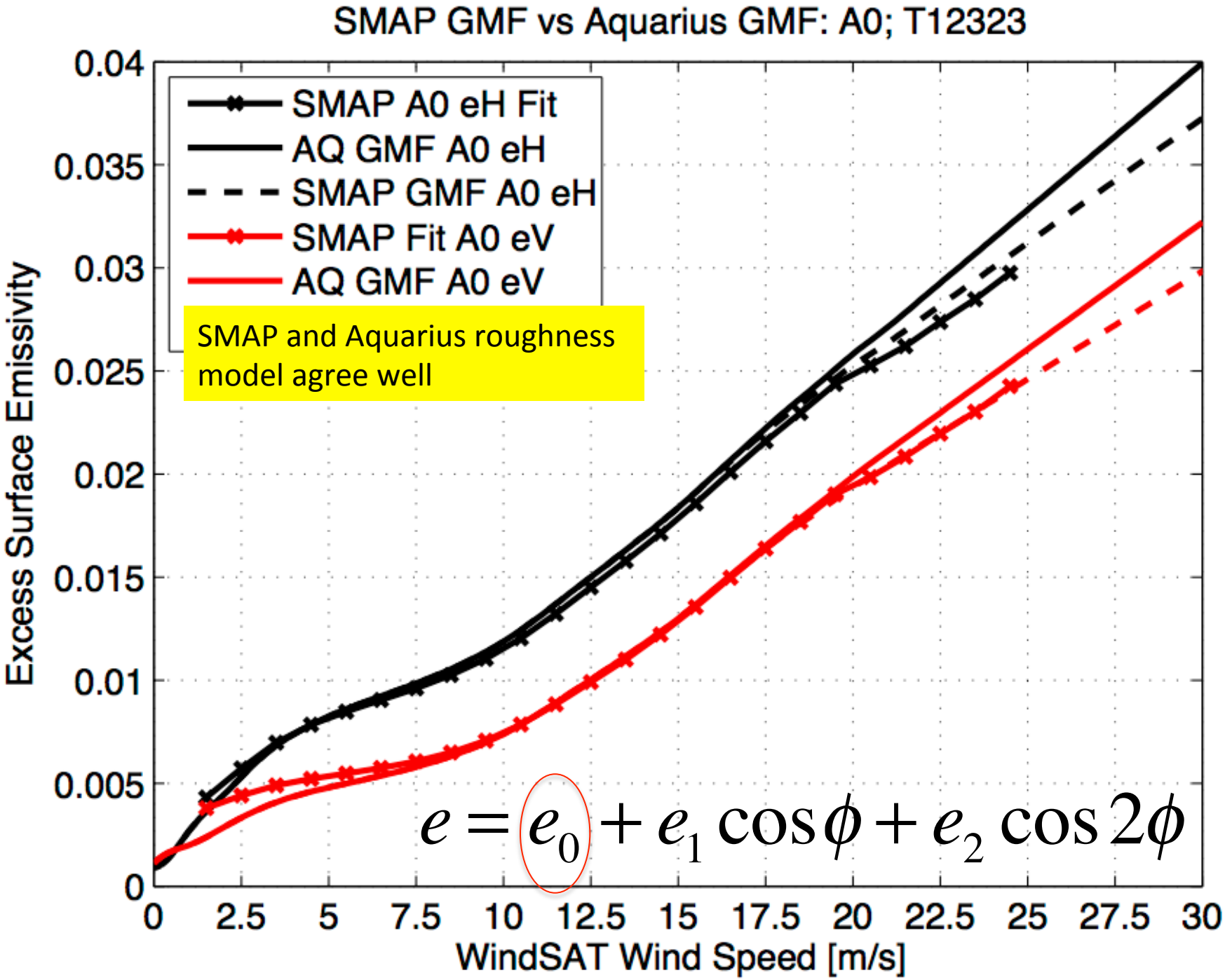
- Develop ocean surface wind products from the SMAP's radiometer data
  - Provide product for severe ocean wind observations
  - JPL SMAP SSS/Wind products available from ourocean.jpl.nasa.gov
- Demonstrate the use of SMAP's combined active and passive (CAP) data for ocean applications

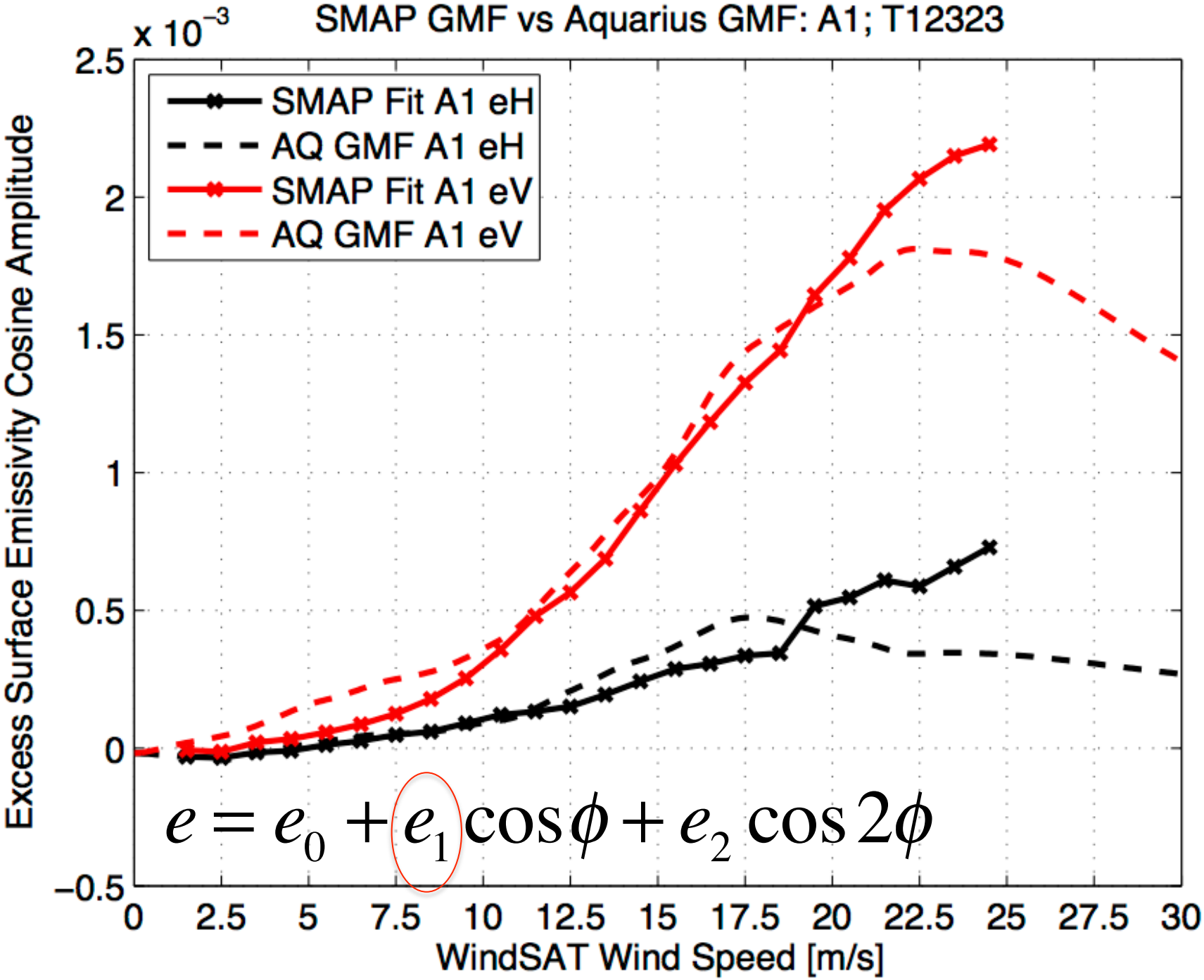
Effects of Wind/Wave on Radar and Radiometer Signals Observed by Aquarius

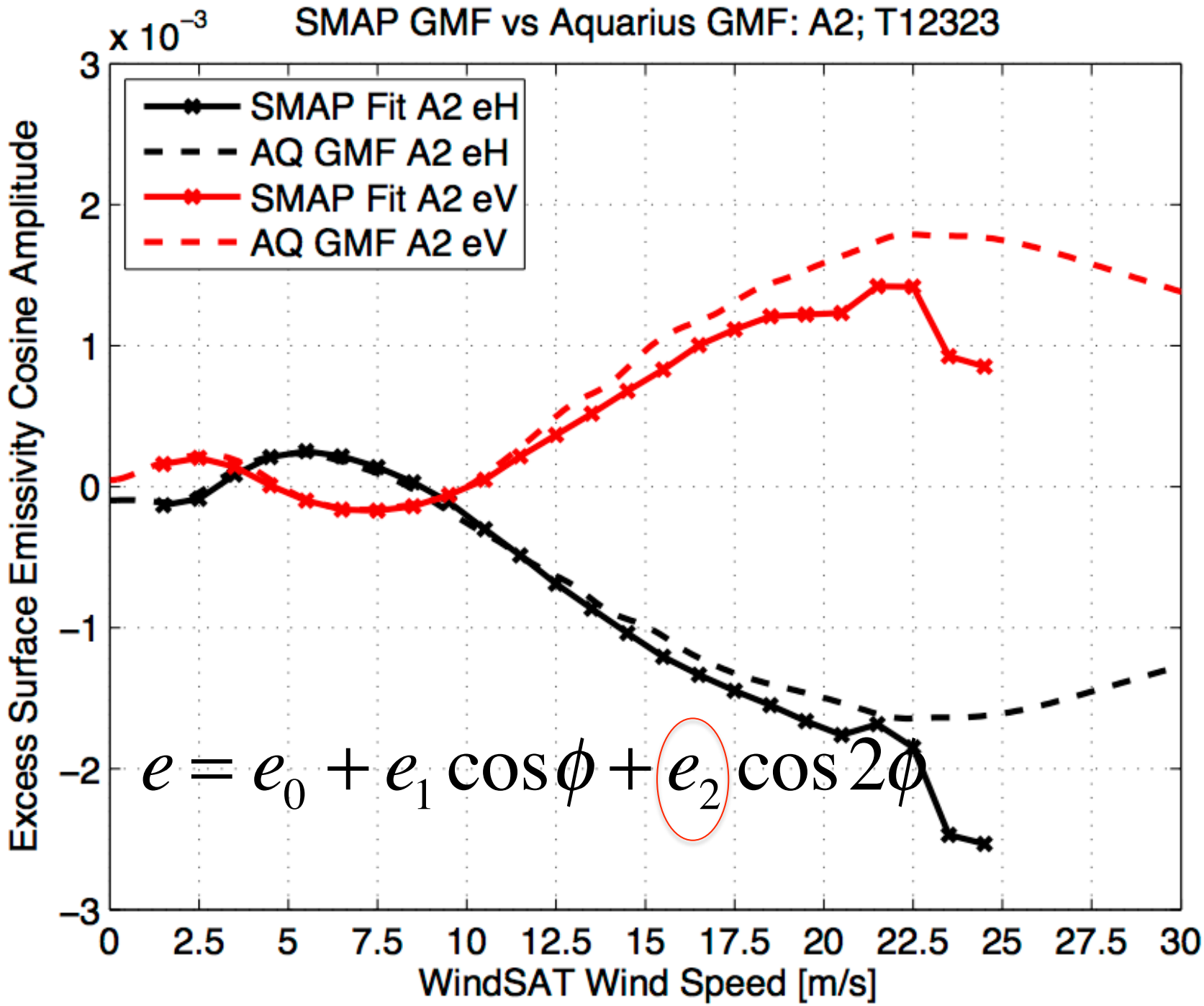
- The matchup of Aquarius data with NCEP wind direction, SSMIS wind speed indicates impact of ocean wind on radar and radiometer signals.
  - The charts below indicate the signal sensitivity for the data from Aquarius beam# 2 (~39 deg incidence angle)



- 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


SMAP GMF vs Aquarius GMF: A0; T12323
SMAP A0 eH Fit
AQ GMF A0 eH
SMAP GMF A0 eH
SMAP Fit A0 eV
AQ GMF A0 eV
SMAP and Aquarius roughness model agree well
$e = e_0 + e_1 \cos\phi + e_2 \cos 2\phi$
Excess Surface Emissivity
WindSAT Wind Speed [m/s]
0.04
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
0
2.5
5
7.5
10
12.5
15
17.5
20
22.5
25
27.5
30

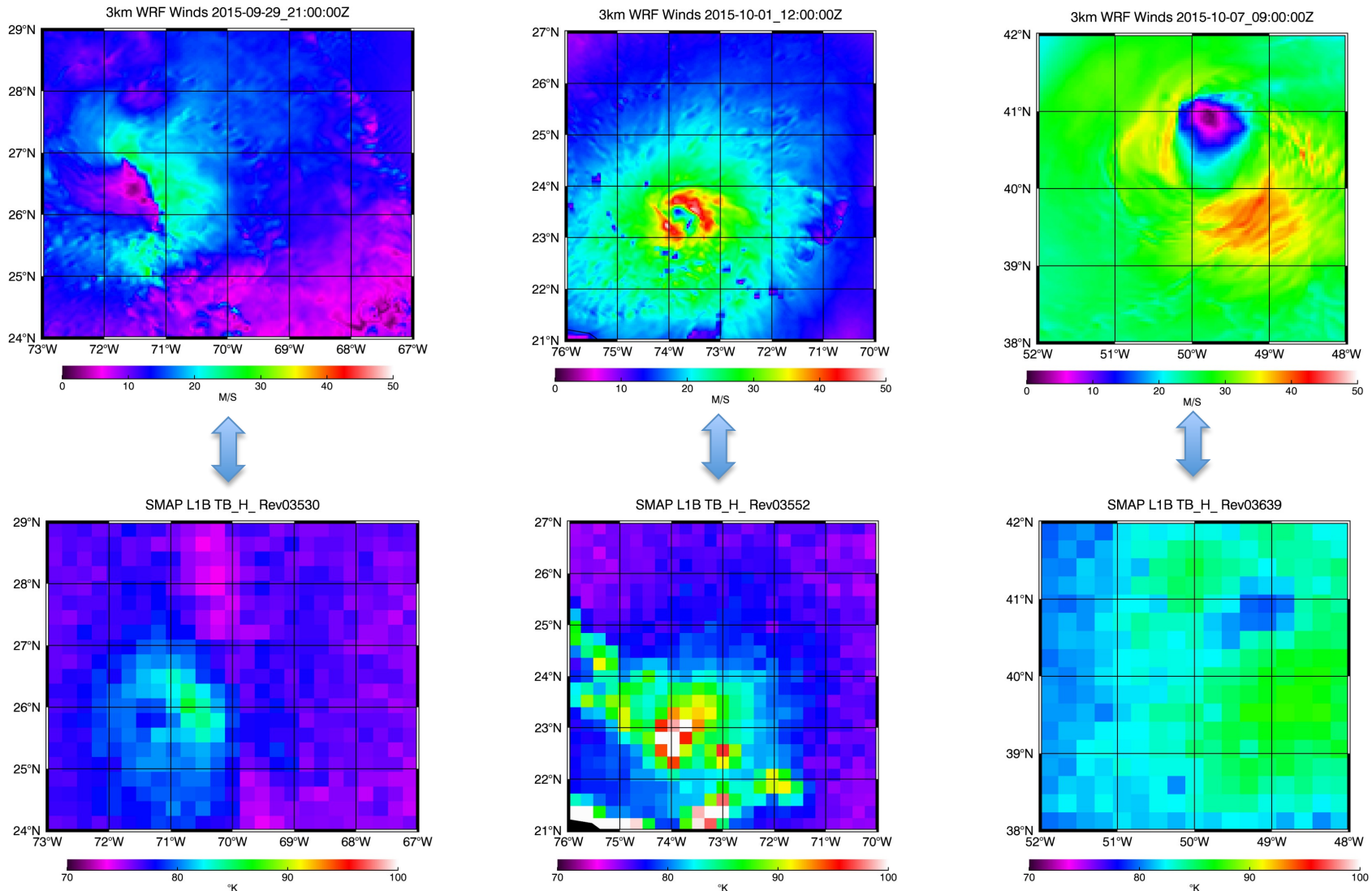

SMAP GMF vs Aquarius GMF: A1; T12323
x 10^-3
SMAP Fit A1 eH
AQ GMF A1 eH
SMAP Fit A1 eV
AQ GMF A1 eV
Excess Surface Emissivity Cosine Amplitude
WindSAT Wind Speed [m/s]
2.5
2
1.5
1
0.5
0
−0.5
0
2.5
5
7.5
10
12.5
15
17.5
20
22.5
25
27.5
30
$e = e_0 + e_1 \cos\phi + e_2 \cos 2\phi$


SMAP GMF vs Aquarius GMF: A2; T12323
x 10^-3
SMAP Fit A2 eH
AQ GMF A2 eH
SMAP Fit A2 eV
AQ GMF A2 eV
Excess Surface Emissivity Cosine Amplitude
WindSAT Wind Speed [m/s]
3
2
1
0
−1
−2
−3
0
2.5
5
7.5
10
12.5
15
17.5
20
22.5
25
27.5
30
$e = e_0 + e_1 \cos\phi + e_2 \cos 2\phi$

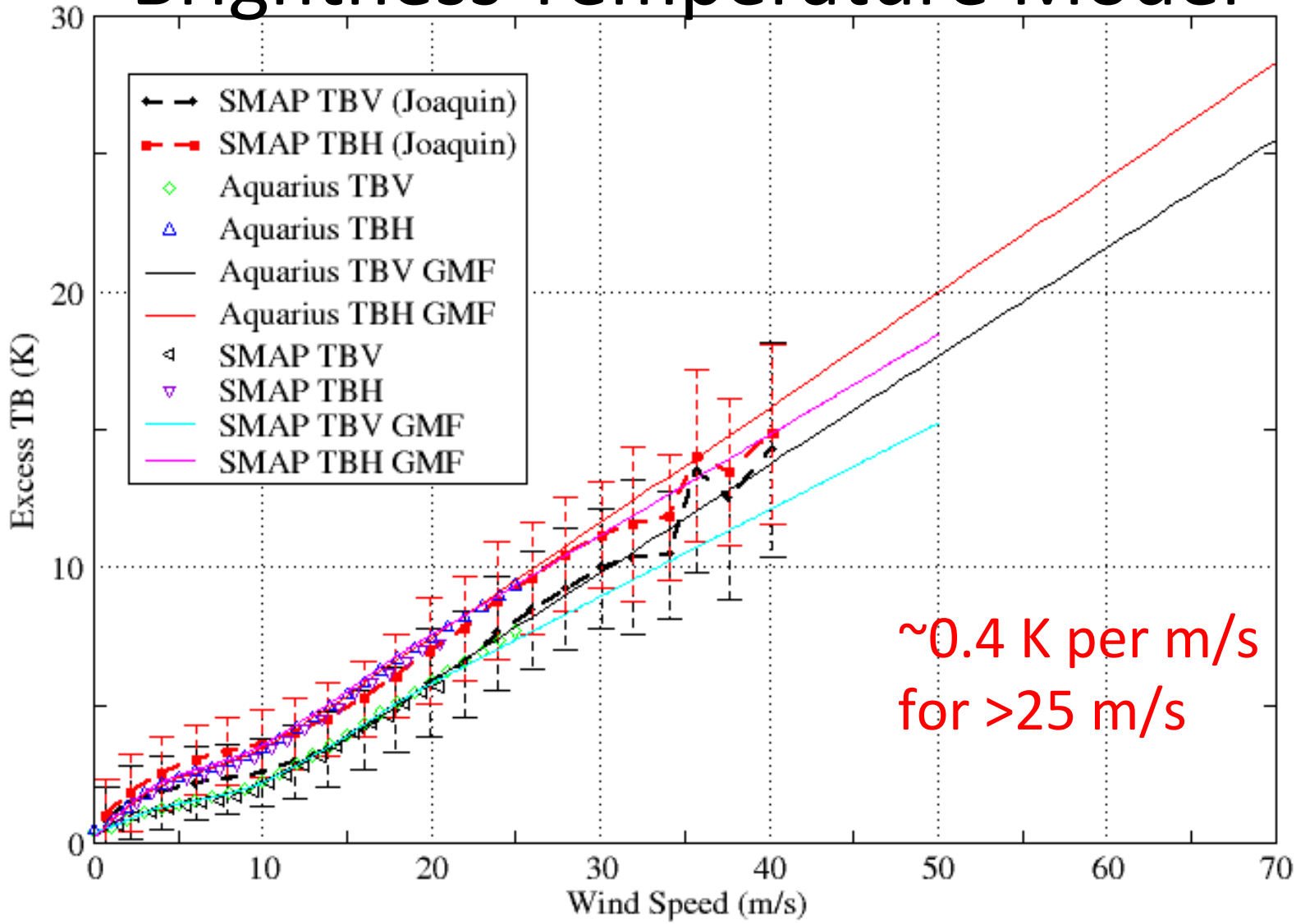
SMAP TBs of Hurricane Joaquin

- Matchup with the surface wind from Penn State University's (PSU) Weather Research and Forecasting (WRF) Ensemble Kalman-Filtering (EnKF) hurricane

Fig. 3



SMAP Data Agree with Aquarius Excess Brightness Temperature Model



Research Approach

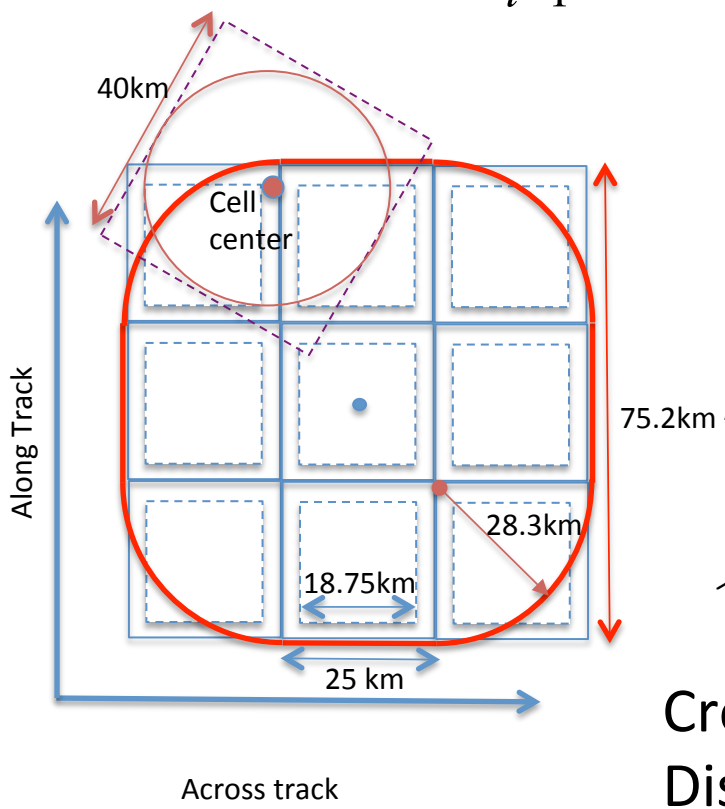
- Implement algorithms with active-only, passive-only and combined active-passive (CAP)
  - Radar-only wind speed and direction
  - Radiometer-only wind speed and salinity
  - Radiometer-only wind speed and direction for hurricanes (differ from Reul's SMOS algorithm)
- Comparative analysis for error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

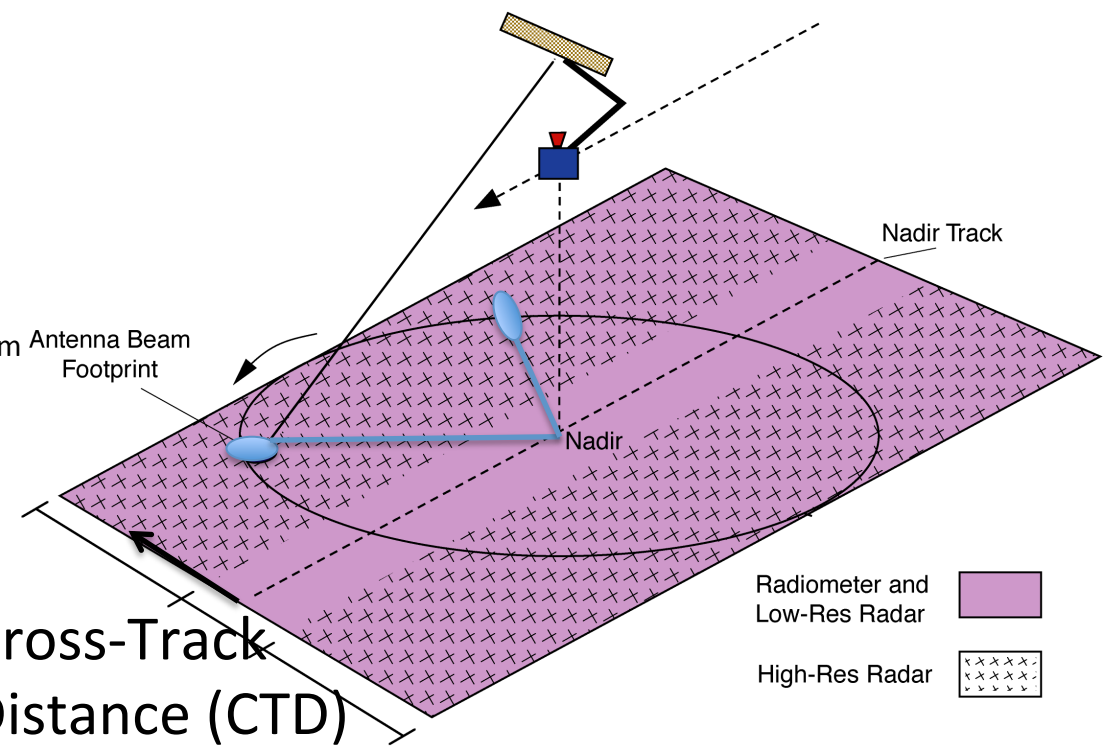
Wind Speed and Direction Retrieval From SMAP's Radar Data (2 Azimuth Looks)

- 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

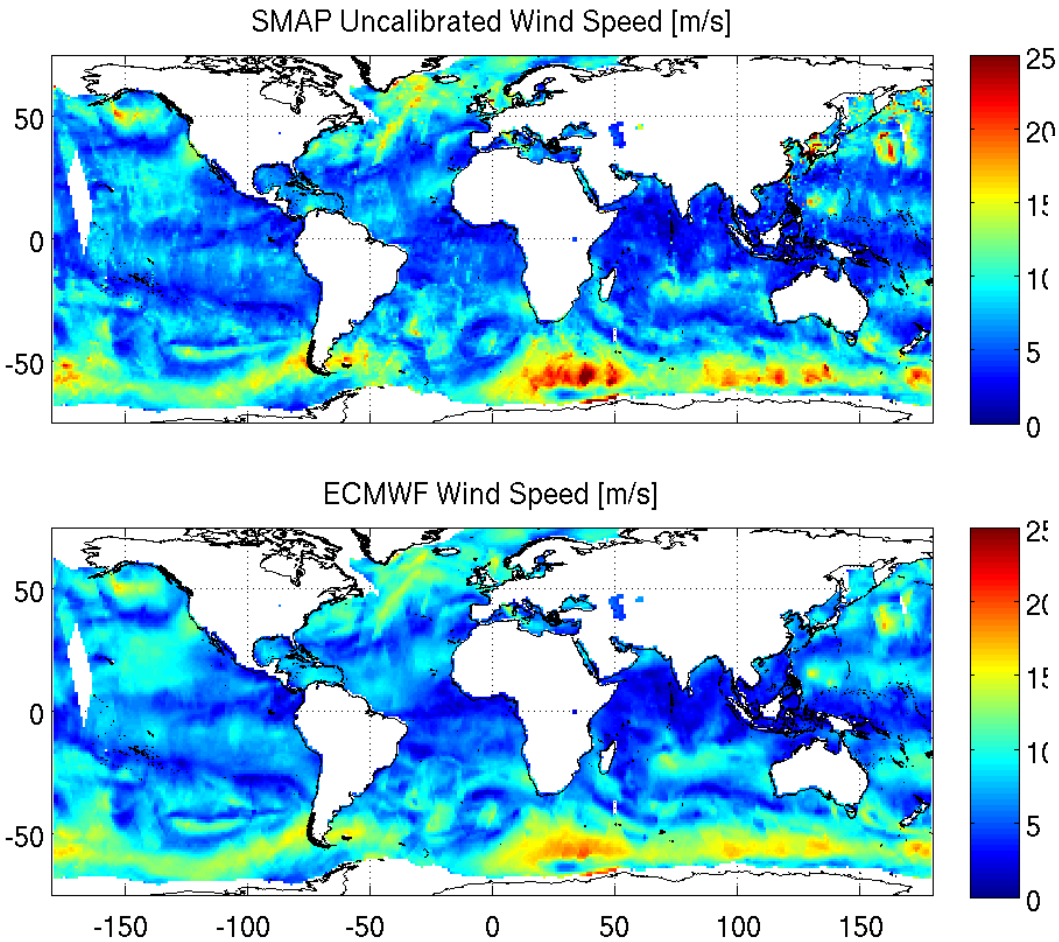




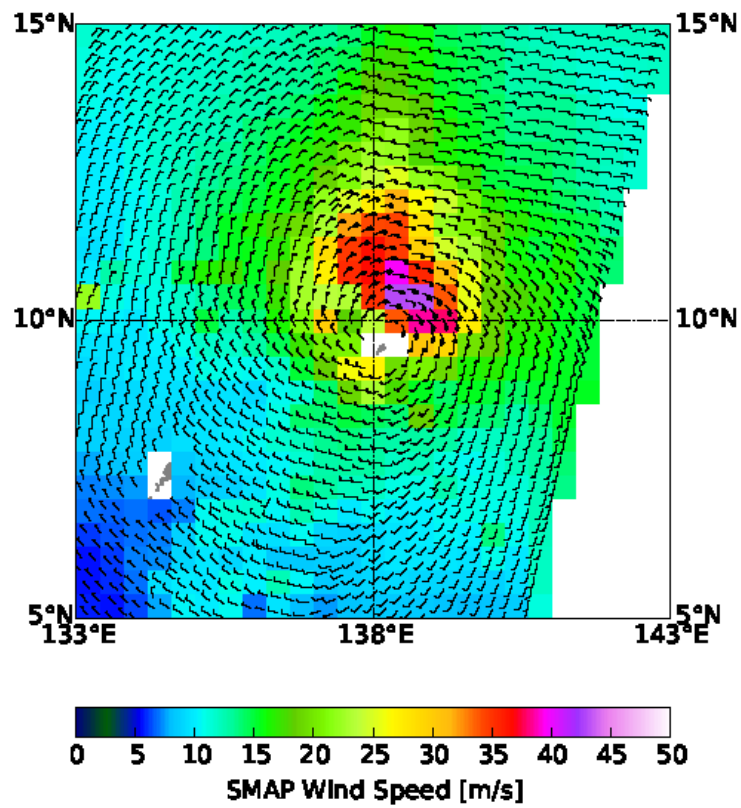
Cross-Track Distance (CTD)

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



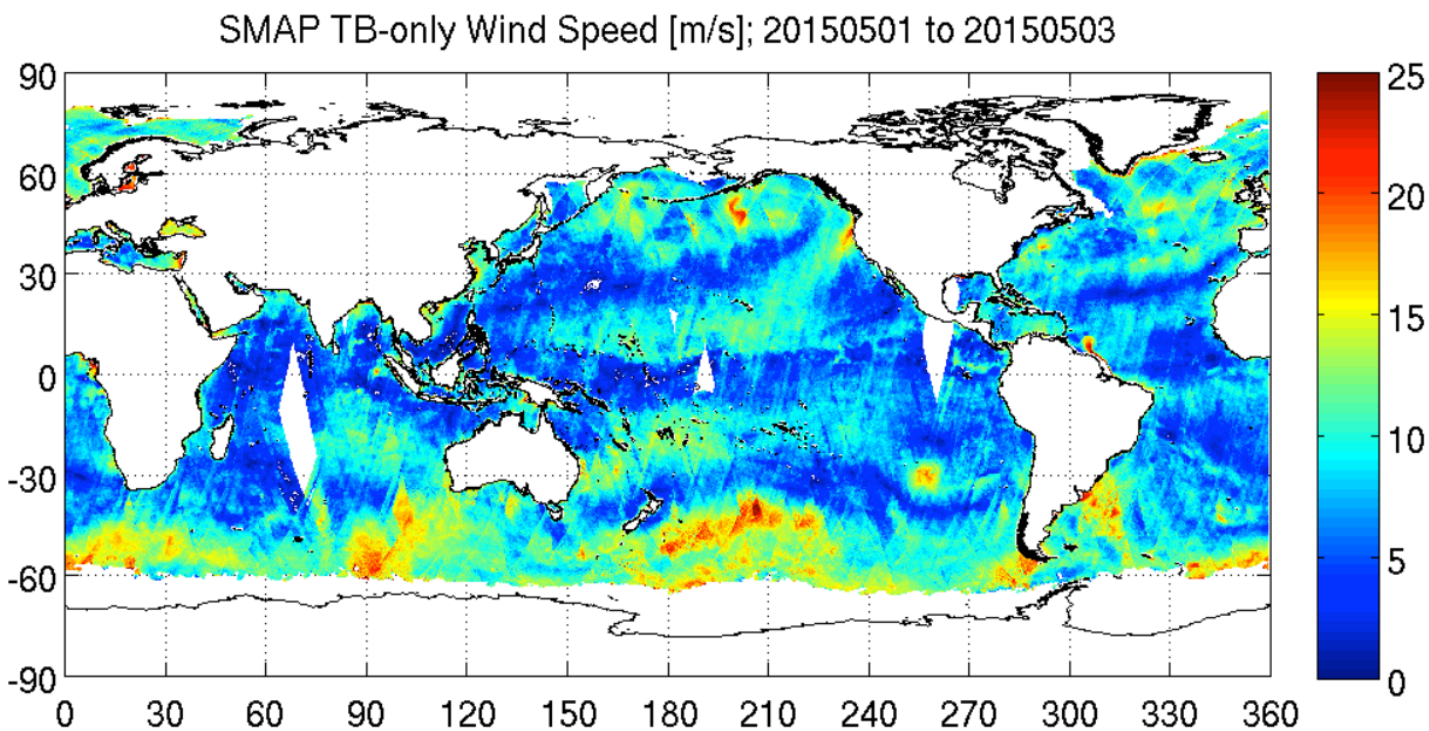
SMAP radar wind for super typhoon Maysak on 2015-090



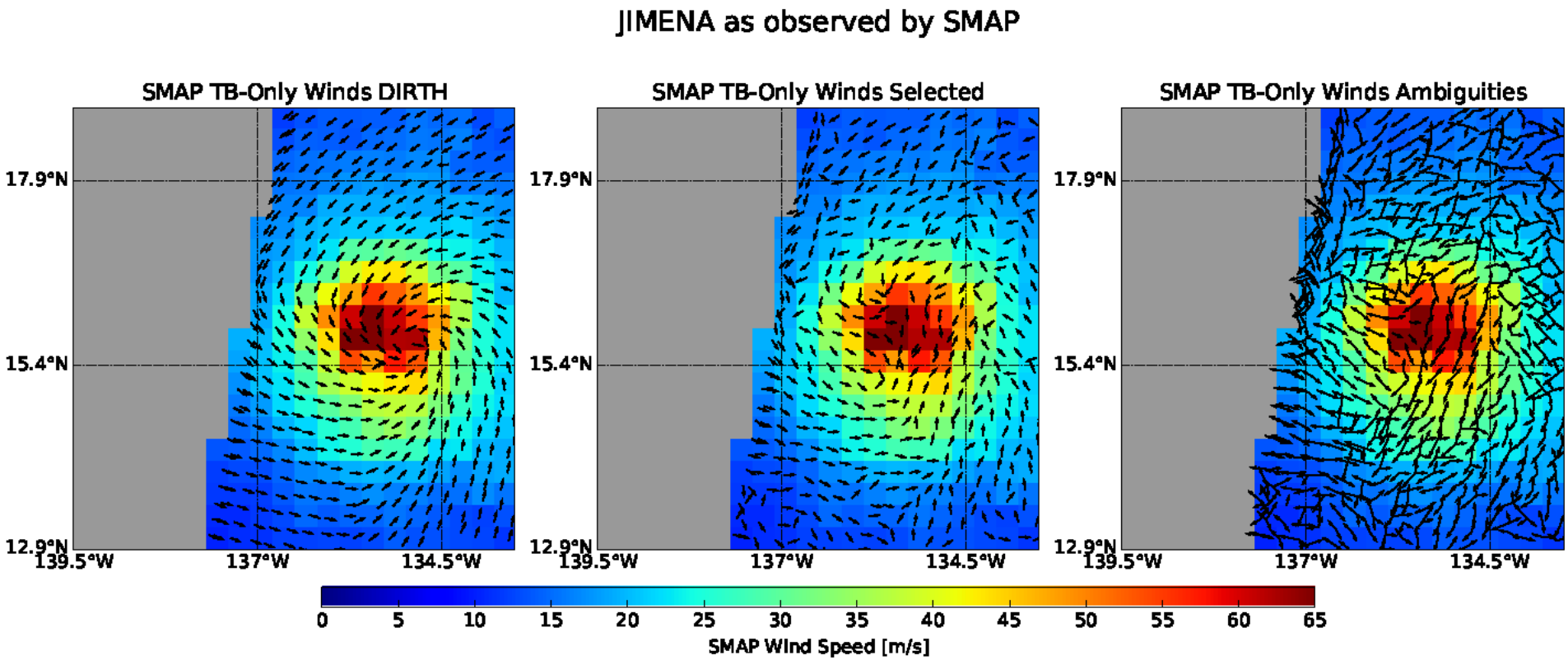
SMAP L-band Radiometer Data For Severe Weather – Ocean Vector Wind

- L-band brightness temperature useful for hurricane wind speed retrieval using two looks, dual-pol TB
- Using Hycom SSS as ancillary

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

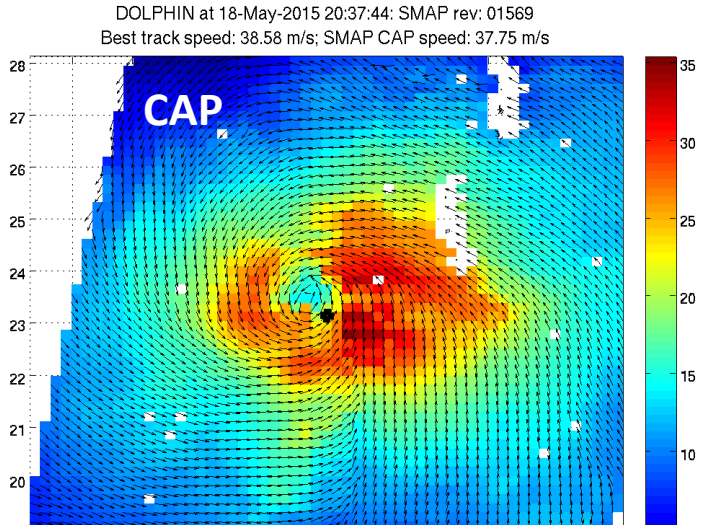


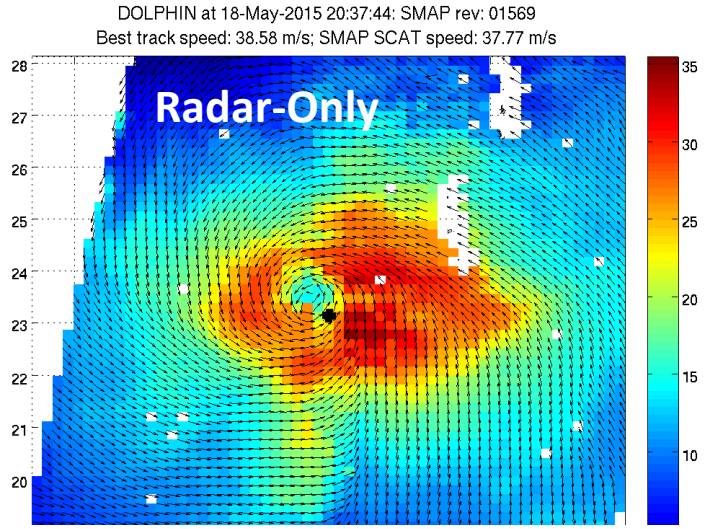
SMAP L-band Radiometer Vector Wind – Ambiguity Selection and DIRTH

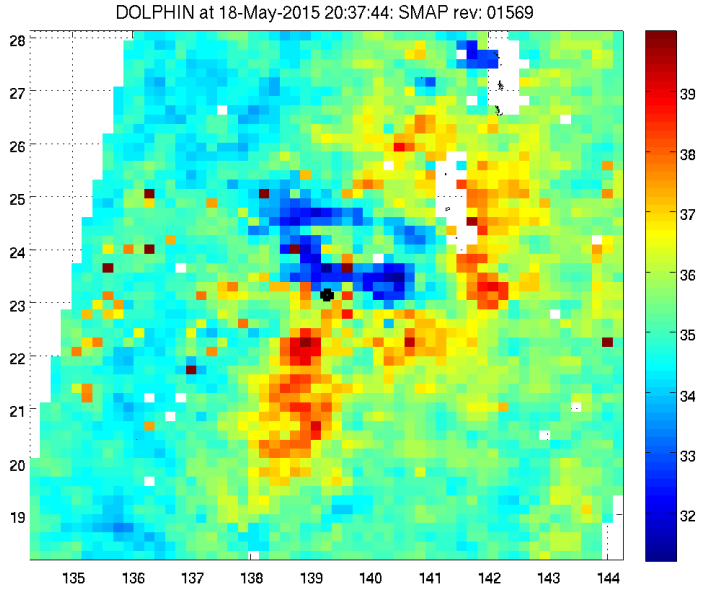


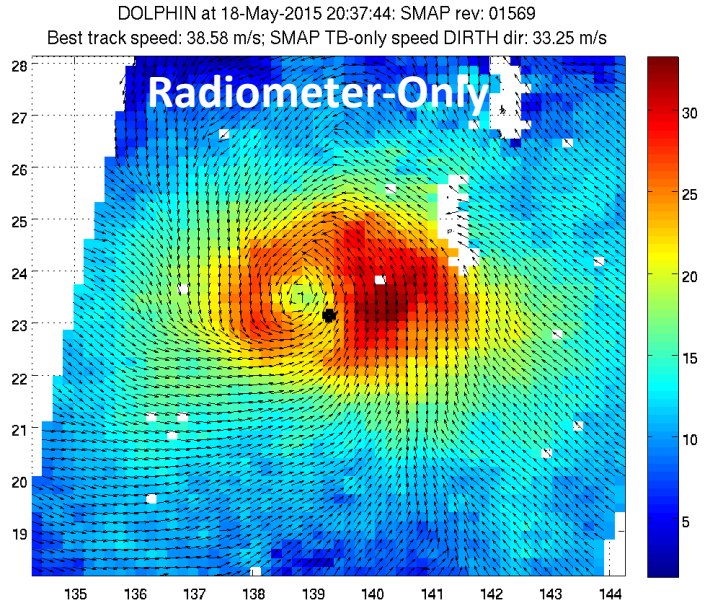
Directional skill becomes reliable for wind speed > 15 m/s

SMAP Wind for Dophin

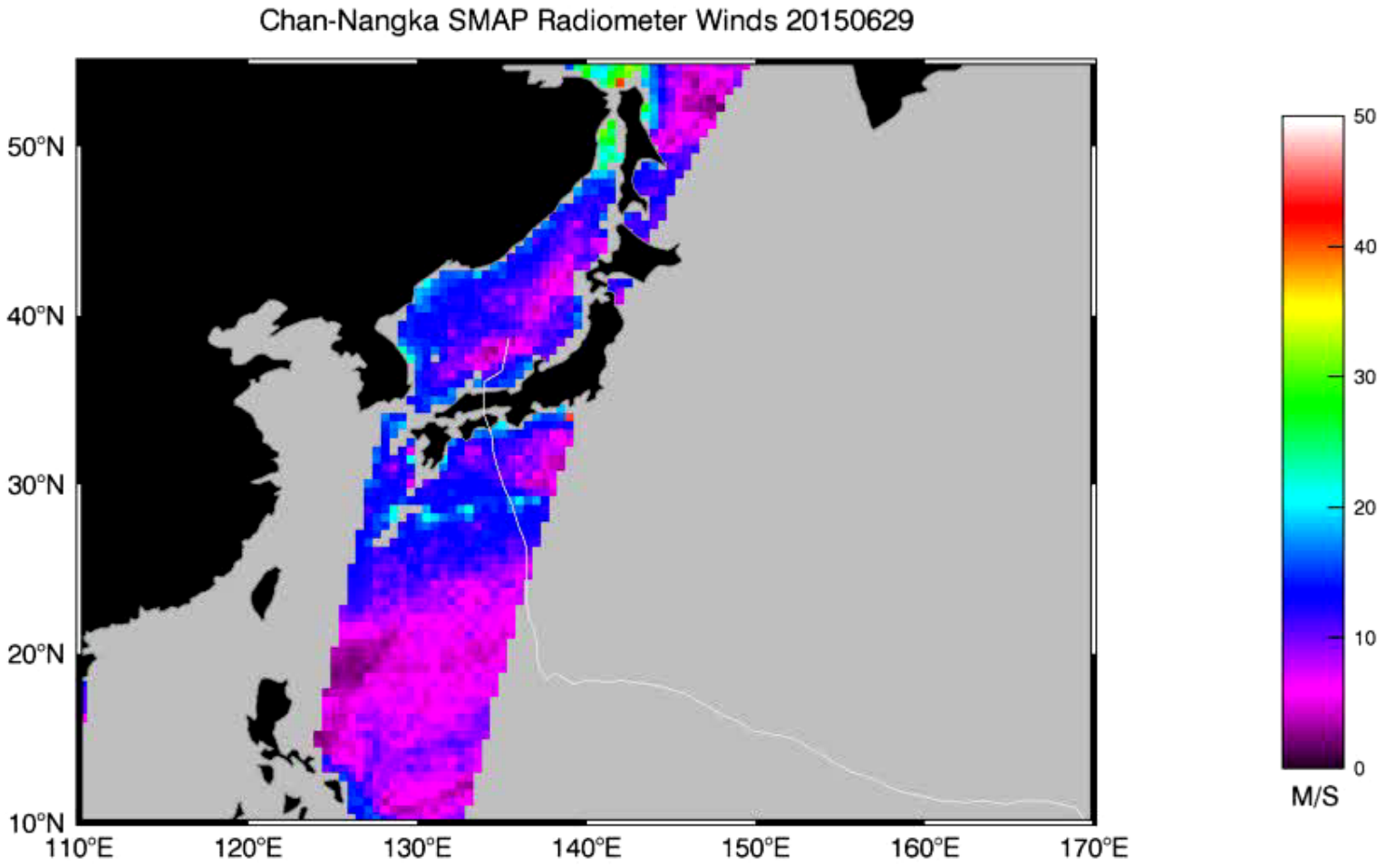


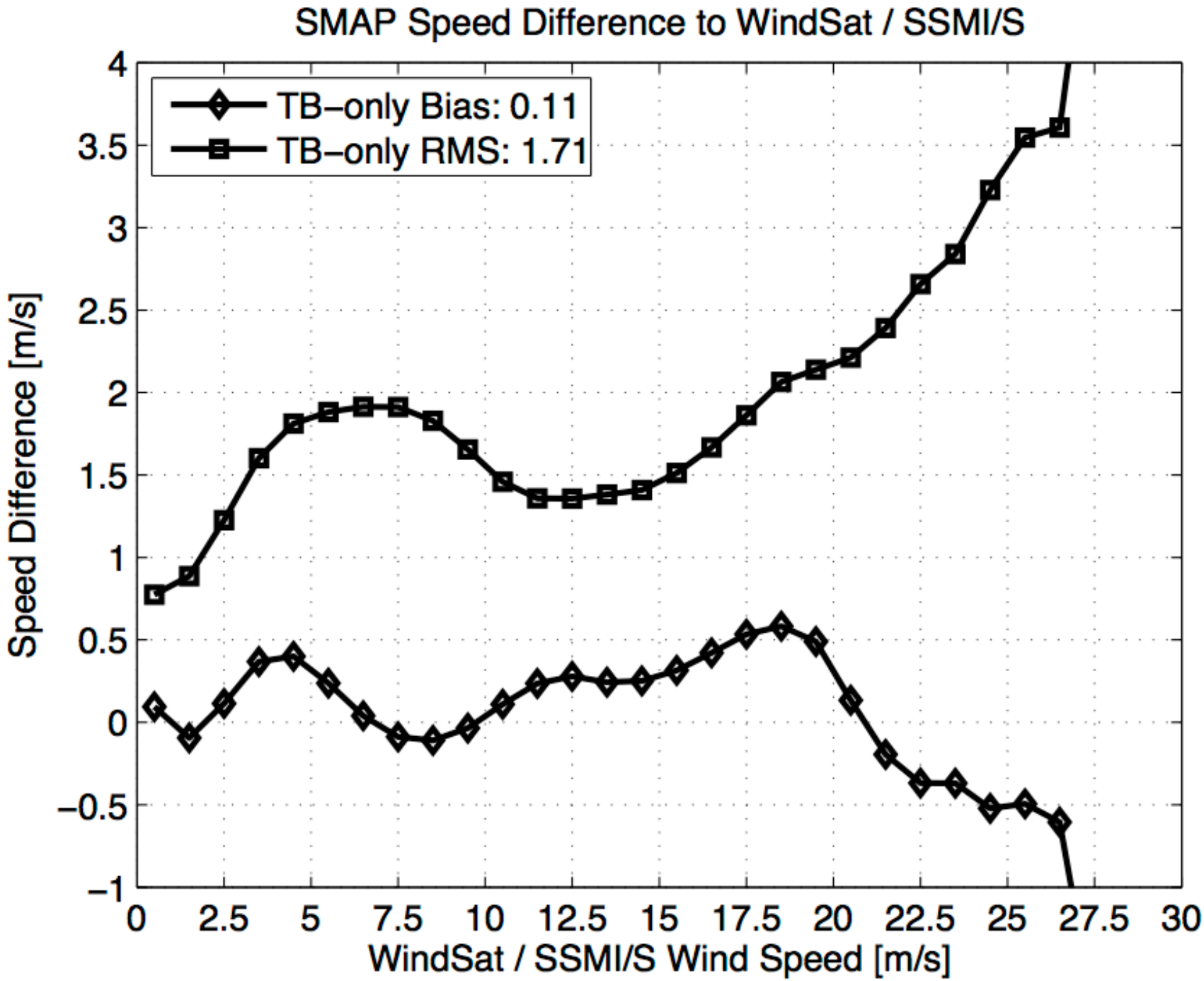


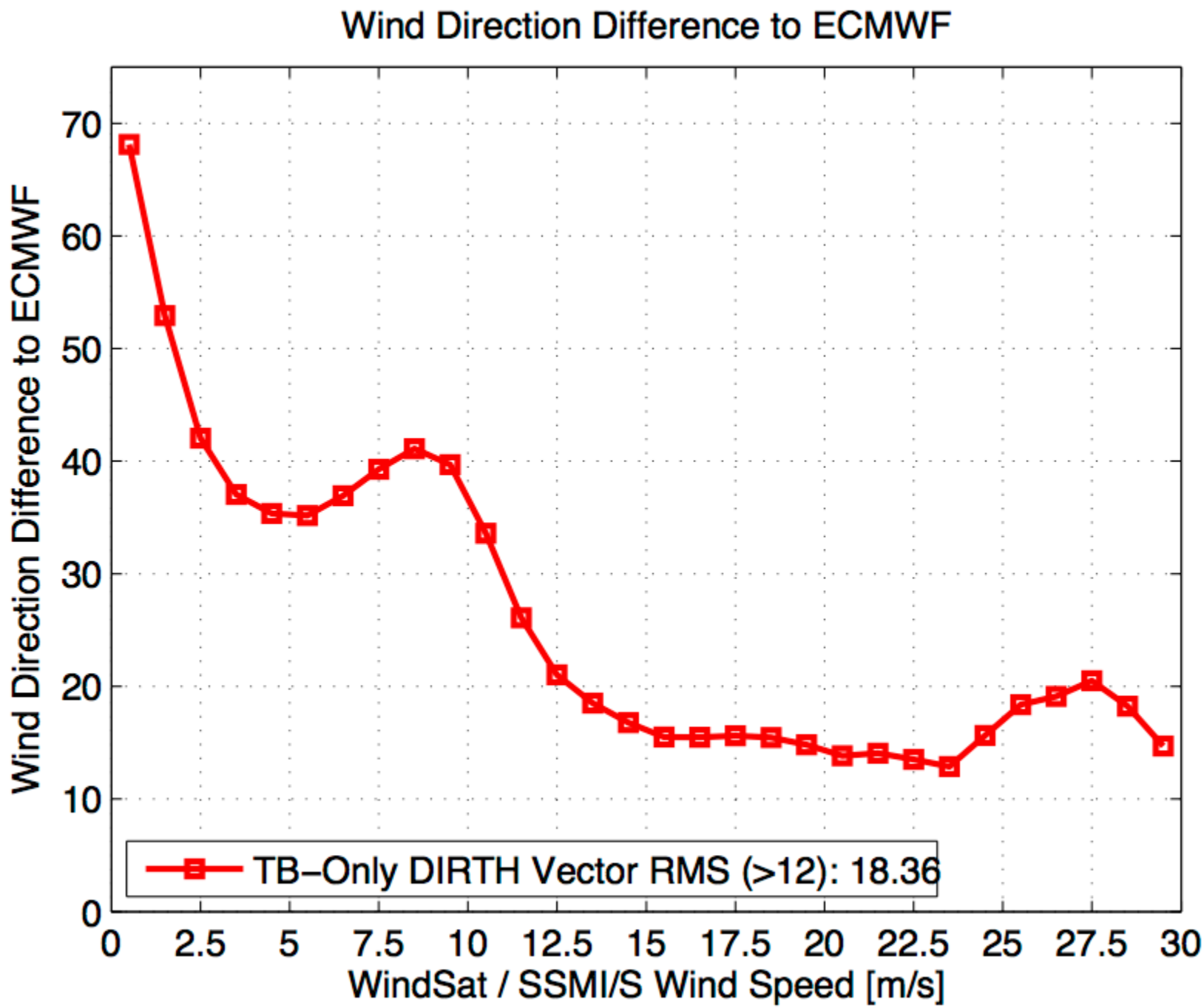




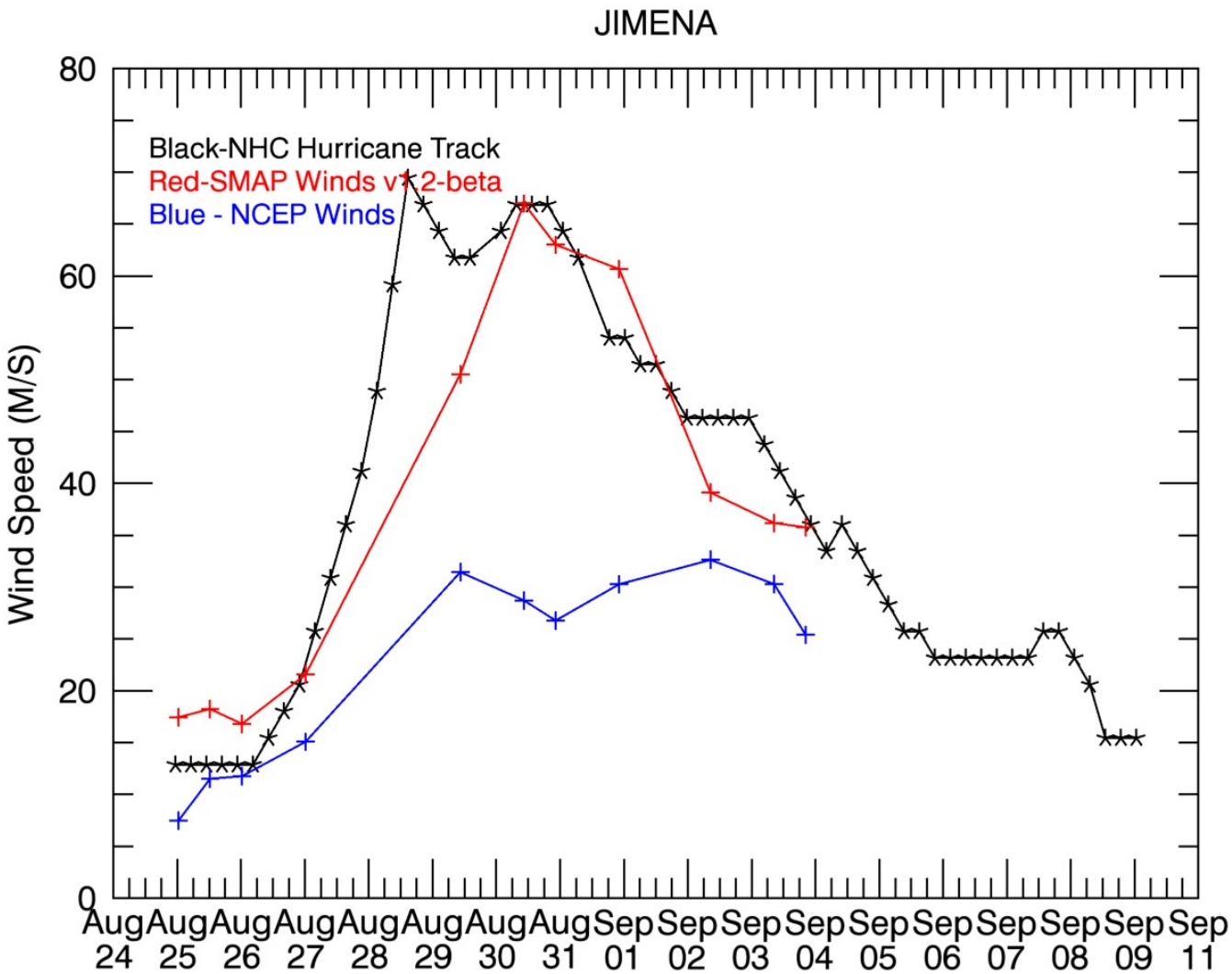
Typhoons Chan_Hom and Nangka in July 2015



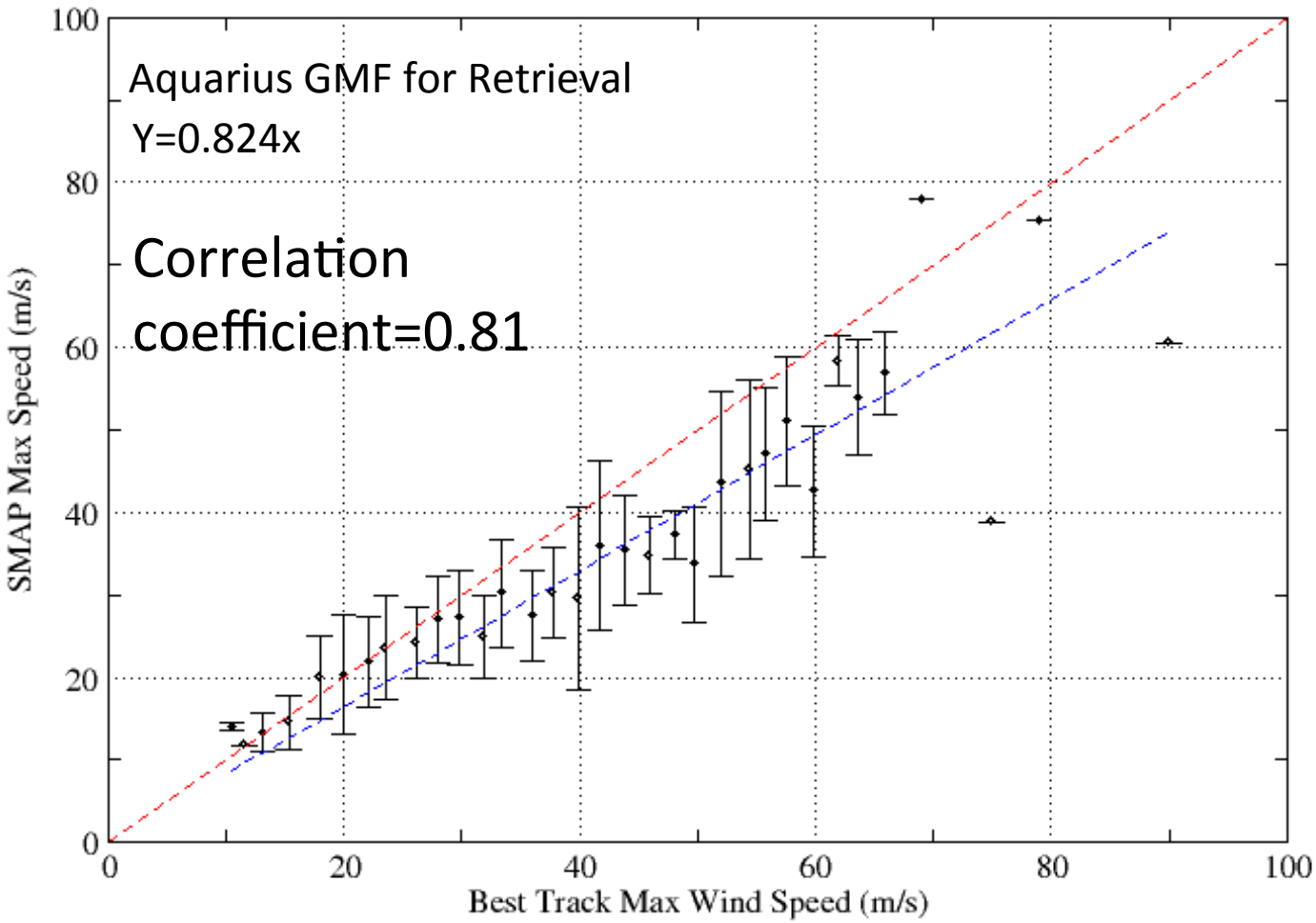

SMAP Speed Difference to WindSat / SSMI/S
TB−only Bias: 0.11
TB−only RMS: 1.71
Speed Difference [m/s]
WindSat / SSMI/S Wind Speed [m/s]
4
3.5
3
2.5
2
1.5
1
0.5
0
−0.5
−1
0
2.5
5
7.5
10
12.5
15
17.5
20
22.5
25
27.5
30


Wind Direction Difference to ECMWF
Wind Direction Difference to ECMWF
70
60
50
40
30
20
10
0
0
2.5
5
7.5
10
12.5
15
17.5
20
22.5
25
27.5
30
WindSat / SSMI/S Wind Speed [m/s]
TB–Only DIRTH Vector RMS (>12): 18.36

Maximum Jimena Wind Speed (Cat 4) August-September 2015

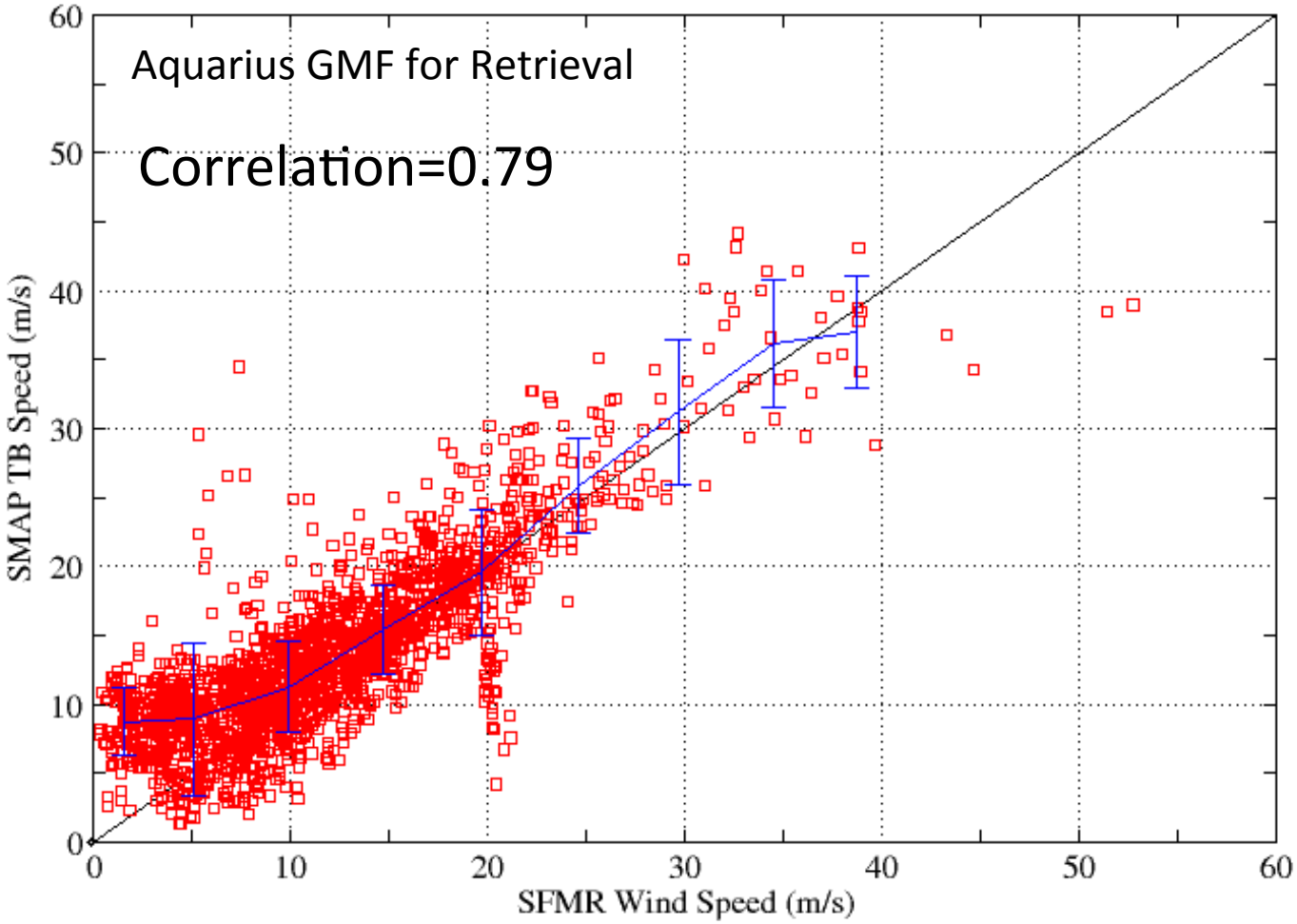


Comparison of Best Track's Max Wind Speed



Comparison with SFMR wind

RMSD of SMAP-SFMR ~ 4.6 m/s above 20 m/s



Summary

- SMAP-APSU based estimates of roughness model agree very well with that from Aquarius
- Radar GMF remains to be improved
- SMAP's L-band active-passive data can provide highly accurate ocean surface wind for high winds
  - RMSD of SMAP and SFMR wind speeds ~ 4.5 m/s between 20 and 40 m/s
  - Wind direction STD with ECMWF ~ 18 deg between 12-30 m/s