Validation of SMAP Radiometer Extreme Wind Speed Data Product with RapidScat and SFMR

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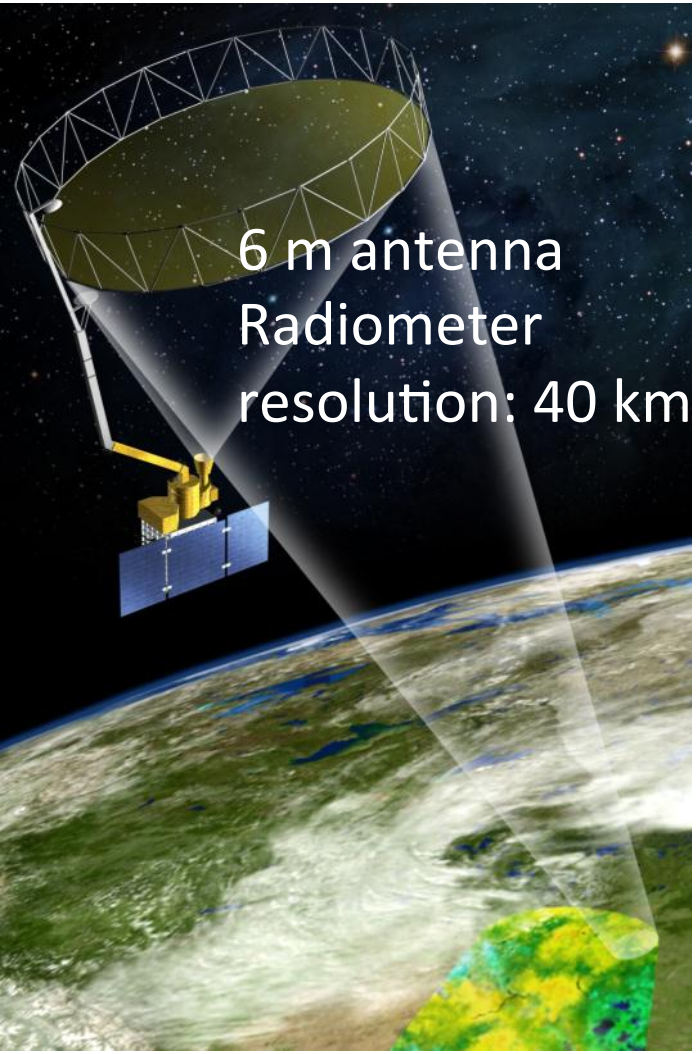
SMAP Overview



http://smap.jpl.nasa.gov/

Primary Science Objectives

- Global, high-resolution mapping of soil moisture and its freeze/thaw state to
  - Link terrestrial water, energy, and carbon-cycle processes
  - Estimate global water and energy fluxes at the land surface
  - Quantify net carbon flux in boreal landscapes
  - Extend weather and climate forecast skill
  - Develop improved flood and drought prediction capability

Mission Implementation

Partners	• JPL (project & payload management, science, spacecraft, radar, mission operations, science processing) • GSFC (science, radiometer, science processing)
Launch	• January 31, 2015 on Delta 7320-10C Launch System
Orbit	• Polar Sun-synchronous; 685 km altitude
Duration	• 3 years
Payload	• L-band (non-imaging) synthetic aperture radar (JPL) • L-band radiometer (GSFC) • Shared 6-m rotating (13 to 14.6 rpm) antenna (JPL)

NRC Earth Science Decadal Survey (2007) recommended SMAP as a Tier 1 mission

Radiometer TB SSS and Wind Processing

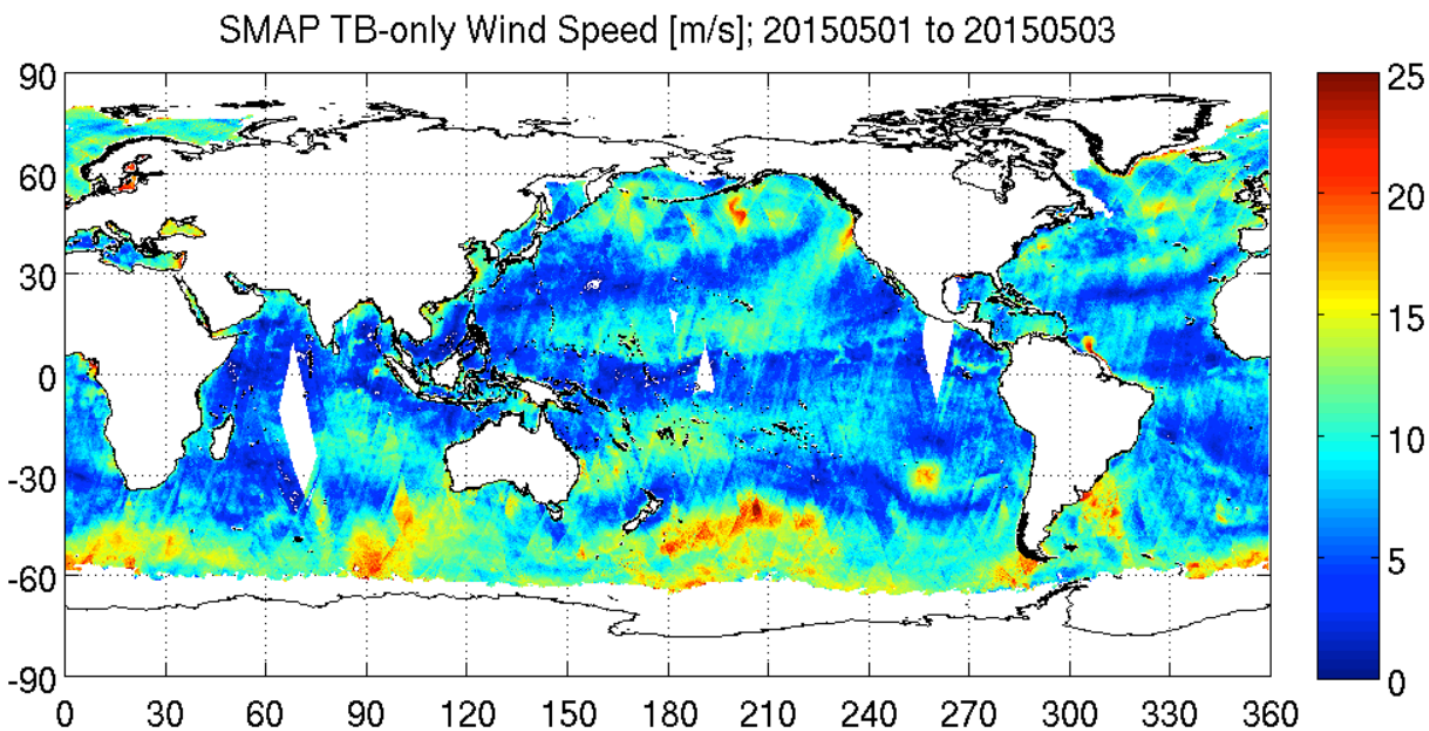
- Compute delta TB using ancillary data and model
  - Average over each day; use 8 day median filtered value
  - Decimated by fore/aft x asc/dec
- Grid into a 25 km L2A swath grid a la RapidSCAT
  - Gridding method oversamples observations onto the grid.
  - Effective resolution is somewhat larger than 40 km
- Estimate wind speed and salinity using constrained objective function minimization

$$F(spd, sss) = \sum_i \left[\frac{T_{B,i} - T_{B,i}^m \left(spd, sss, anc_dir, anc_swh, anc_sst \right)}{NEDT_i} \right]^2 + \left(\frac{spd - spd_anc}{1.5 m/s} \right)^2,$$

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

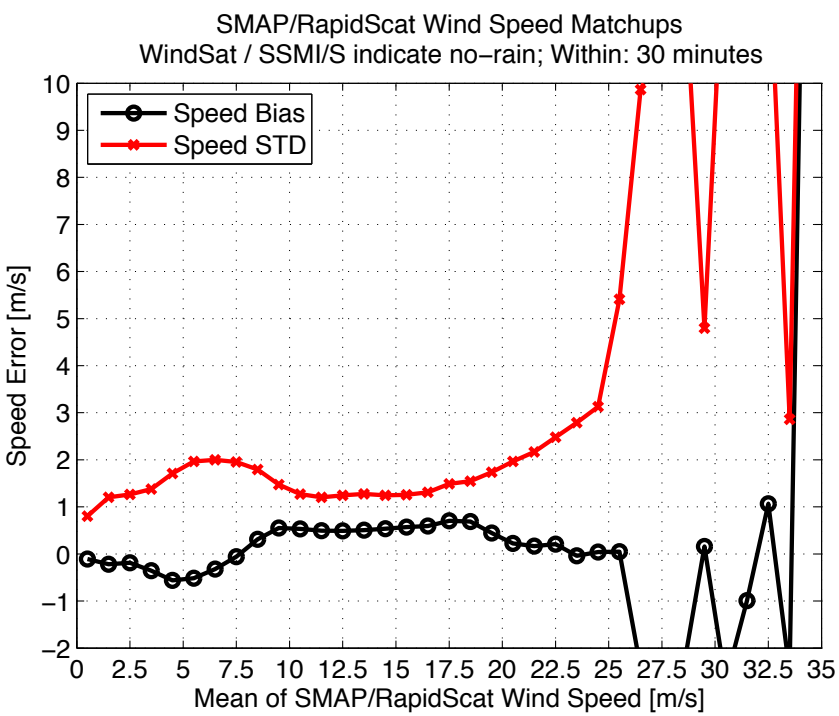
- L-band brightness temperature useful for hurricane wind speed retrieval using two looks, dual-pol TB
- Using HYCOM SSS as ancillary

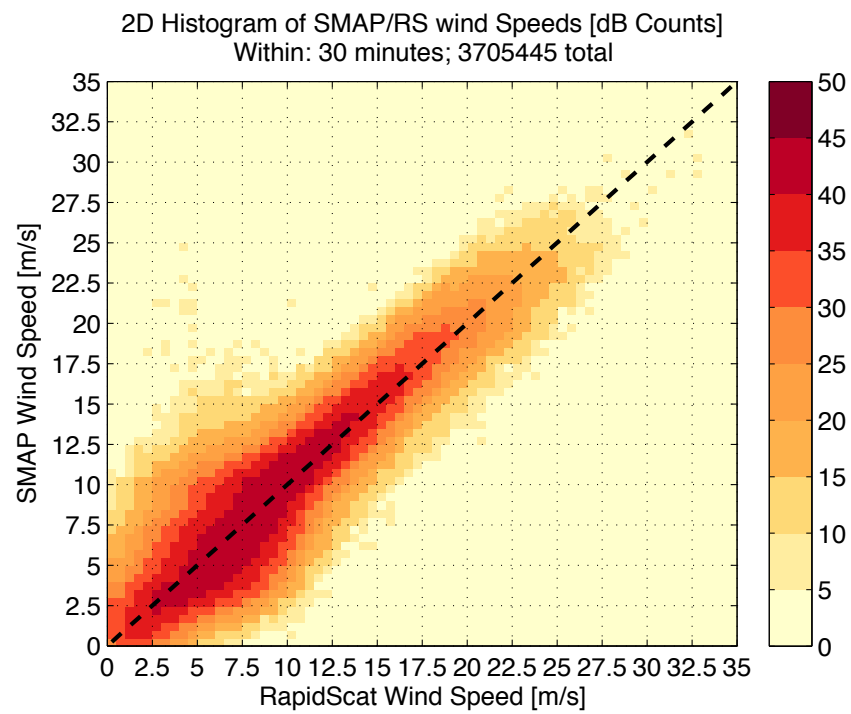
$$C(w,\phi) = \sum_{i=1}^{2} \frac{(T_{BVi} - T_{BVMi})^2}{\Delta T^2} + \sum_{i=1}^{2} \frac{(T_{BHi} - T_{BHMi})^2}{\Delta T^2}$$



SMAP / RapidScat / WindSat collocations (30m)

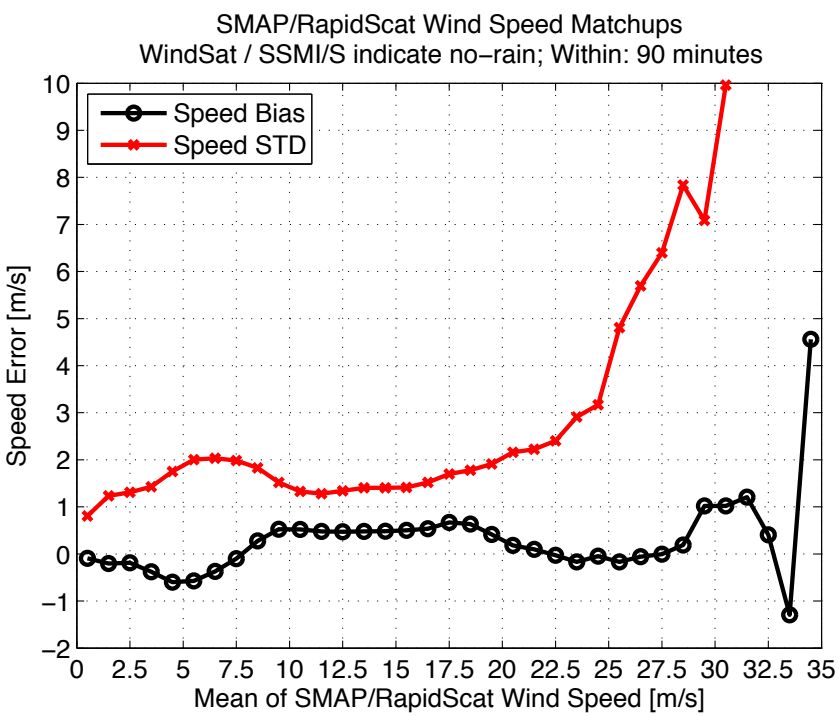
- Only extract joint collocations within 30 minutes of SMAP.
  - 3.7 million matchups.
- Use WindSat to remove rainy observations.
- Find nearly zero speed bias up to 26 m/s, not enough data past that.
- 2d histogram does not show any trend of increasing SMAP speed bias as compared to RapidScat

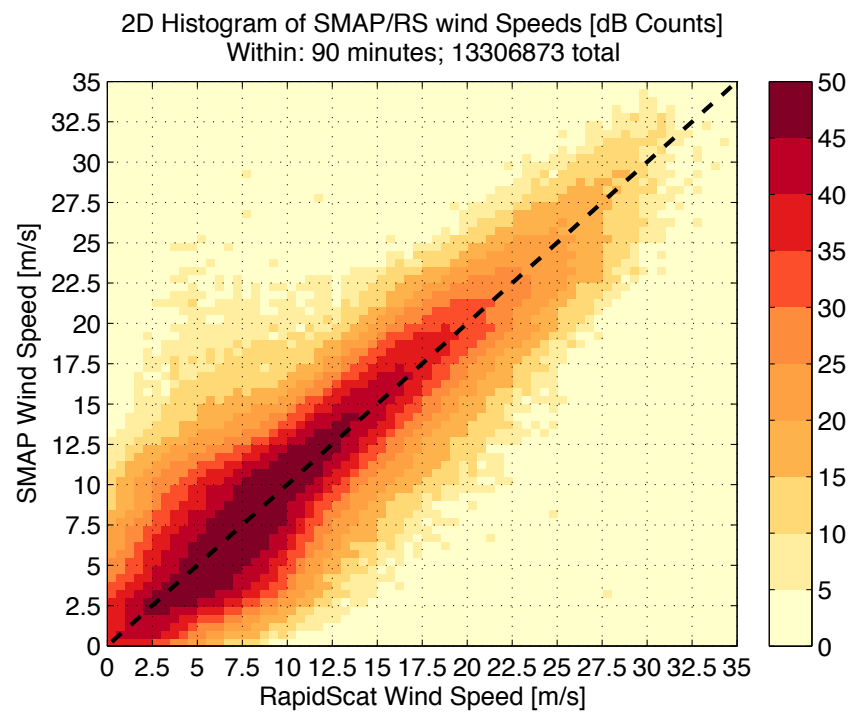


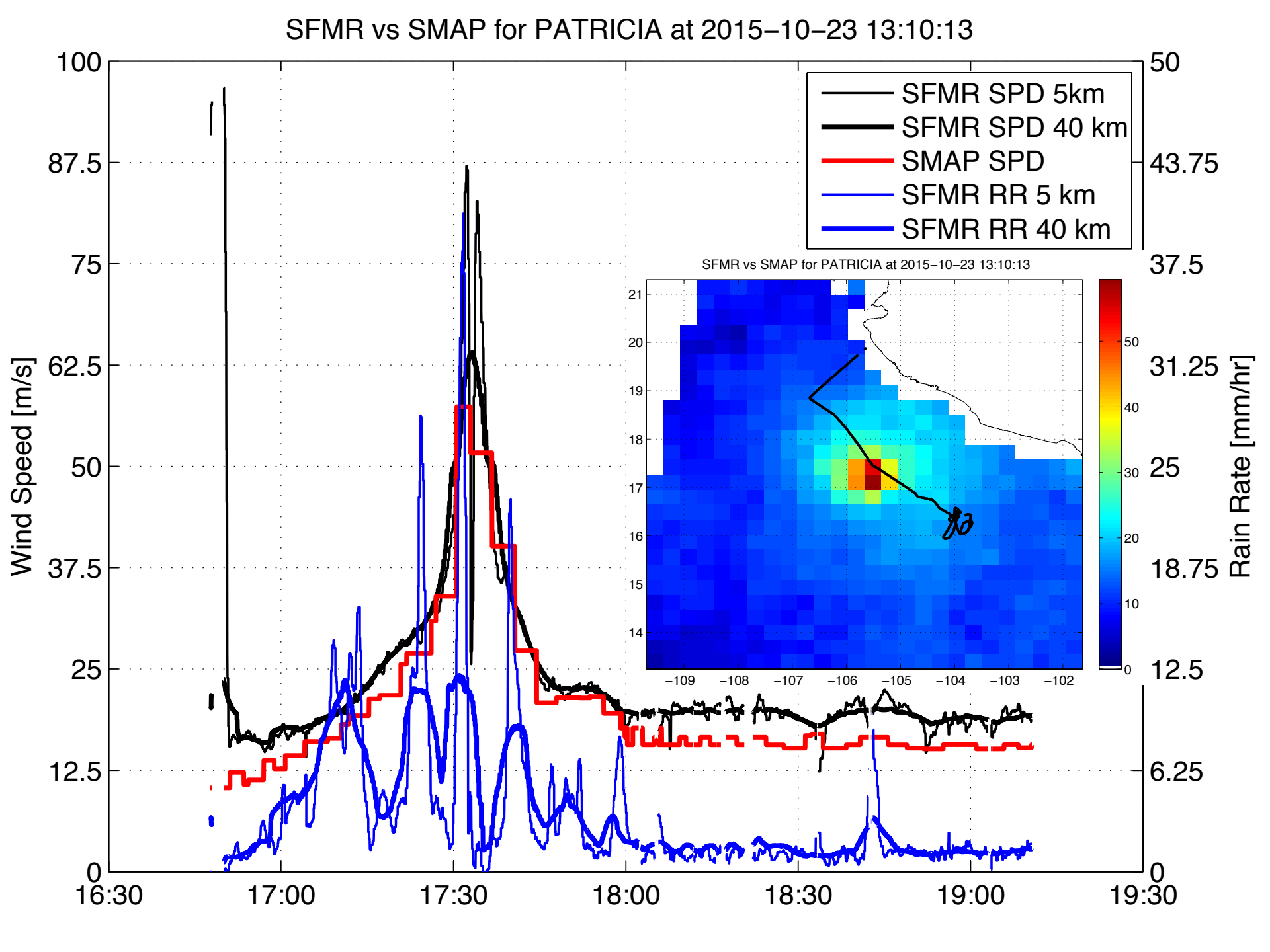


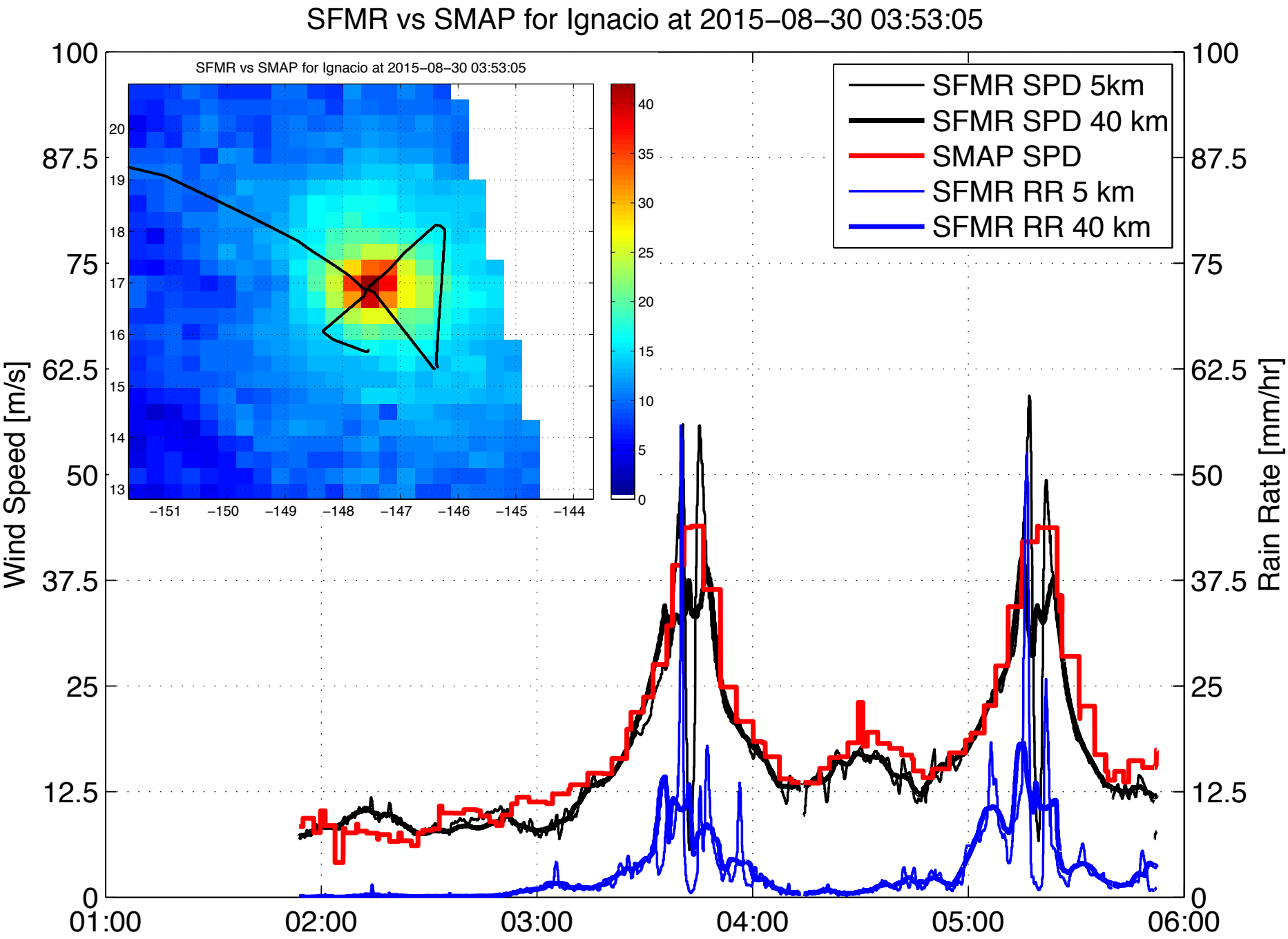
SMAP / RapidScat / WindSat collocations (90m)

- Same as previous with 90 minute collocation time.
  - 13 million matchups.
- Find very small speed bias up to 30 m/s (order 1 m/s).
- 2d histogram show data distributed near 1:1 line, no evidence of large positive SMAP bias near 30 m/s as compared to RapidScat.



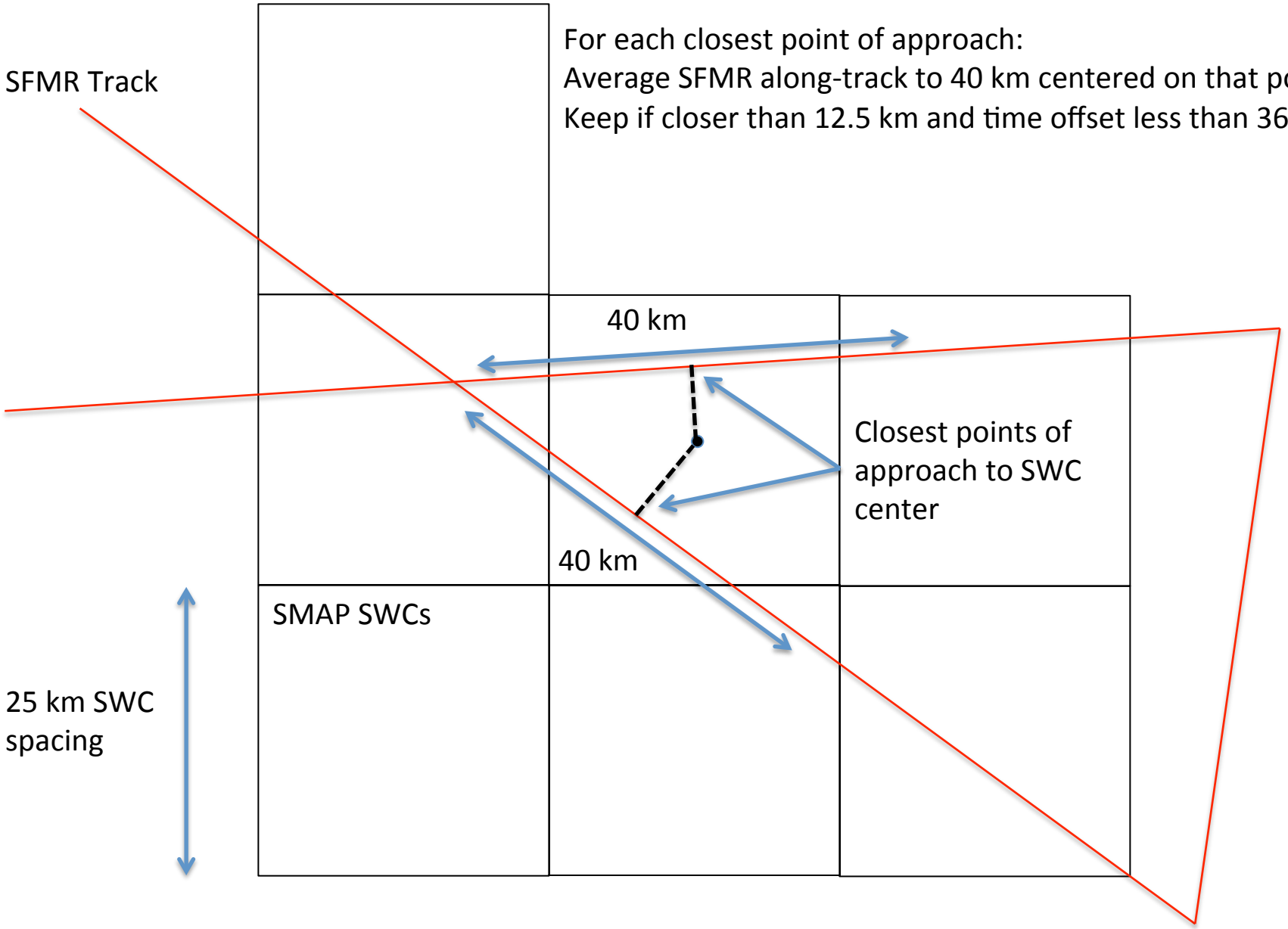


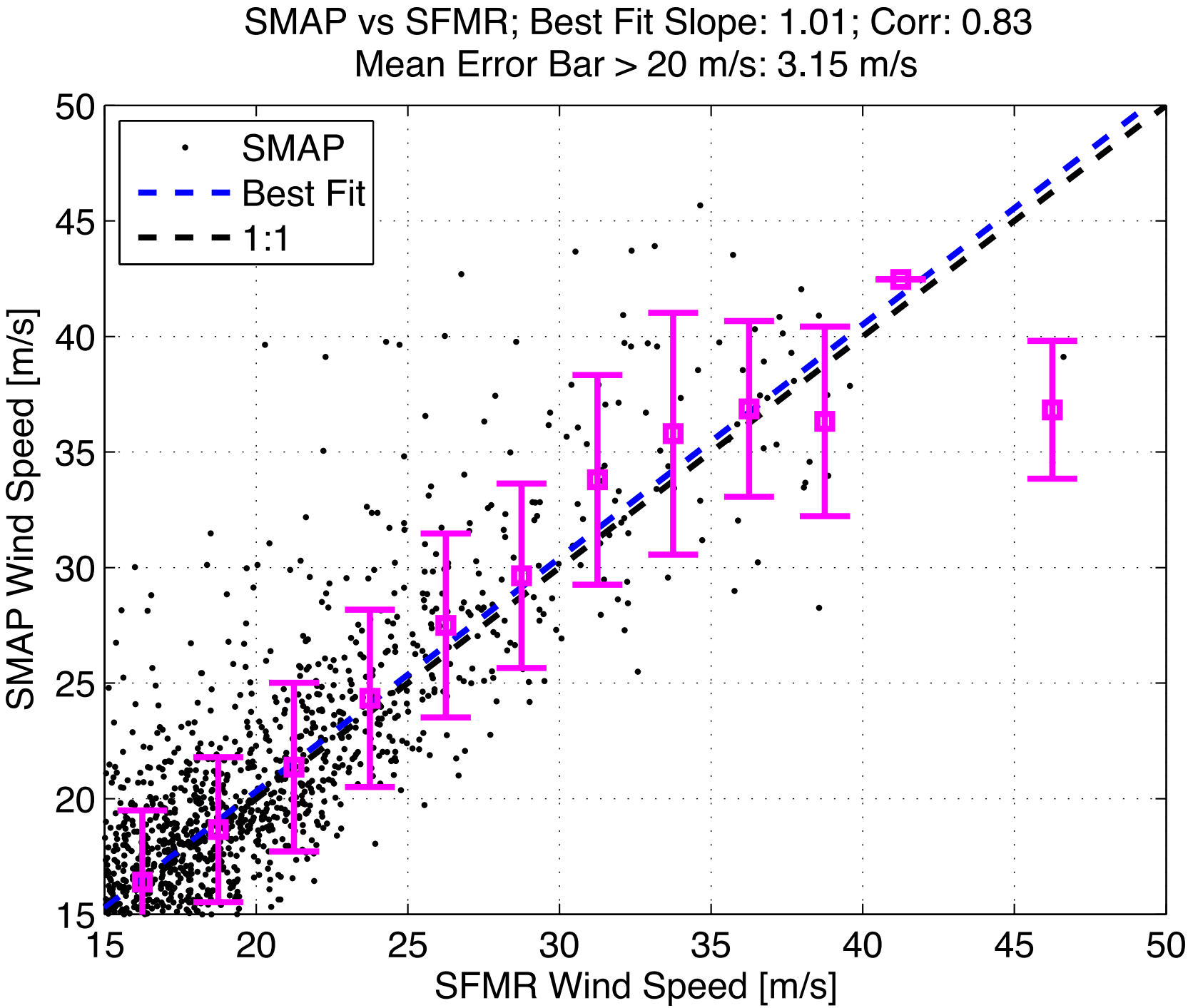

SFMR vs SMAP for PATRICIA at 2015−10−23 13:10:13
Wind Speed [m/s]
Rain Rate [mm/hr]
SFMR SPD 5km
SFMR SPD 40 km
SMAP SPD
SFMR RR 5 km
SFMR RR 40 km
100
87.5
75
62.5
50
37.5
25
12.5
0
50
43.75
37.5
31.25
25
18.75
12.5
6.25
0
16:30
17:00
17:30
18:00
18:30
19:00
19:30
SFMR vs SMAP for PATRICIA at 2015−10−23 13:10:13
21
20
19
18
17
16
15
14
−109
−108
−107
−106
−105
−104
−103
−102
50
40
30
20
10
0


SFMR vs SMAP for Ignacio at 2015−08−30 03:53:05
SFMR vs SMAP for Ignacio at 2015−08−30 03:53:05
SFMR SPD 5km
SFMR SPD 40 km
SMAP SPD
SFMR RR 5 km
SFMR RR 40 km
Wind Speed [m/s]
Rain Rate [mm/hr]
100
87.5
75
62.5
50
37.5
25
12.5
0
01:00
02:00
03:00
04:00
05:00
06:00
20
19
18
17
16
15
14
13
−151
−150
−149
−148
−147
−146
−145
−144
40
35
30
25
20
15
10
5
0

Shift SFMR tracks using best-track (time, location) to SMAP time
Identify closest points of approach to SWC; may be multiple

For each closest point of approach:
Average SFMR along-track to 40 km centered on that point
Keep if closer than 12.5 km and time offset less than 360 min




SMAP vs SFMR; Best Fit Slope: 1.01; Corr: 0.83
Mean Error Bar > 20 m/s: 3.15 m/s
SMAP
Best Fit
1:1
SMAP Wind Speed [m/s]
SFMR Wind Speed [m/s]
15
20
25
30
35
40
45
50

From SFMR stat plot
360 minutes / 40 km avg SFMR

Wind Speed Bin	Bias	STD	Counts
15-20	-0.1572	2.8274	790
20-25	-0.0460	3.7175	345
25-30	0.8172	3.9678	115
30-35	1.9204	4.7075	48
35-40	-0.8474	4.0474	28
40-45	-0.0317	n/a	1
45-50	-10.6739	2.9854	2
50-55	-11.7638	1.6520	2
55-60	-5.8070	n/a	1

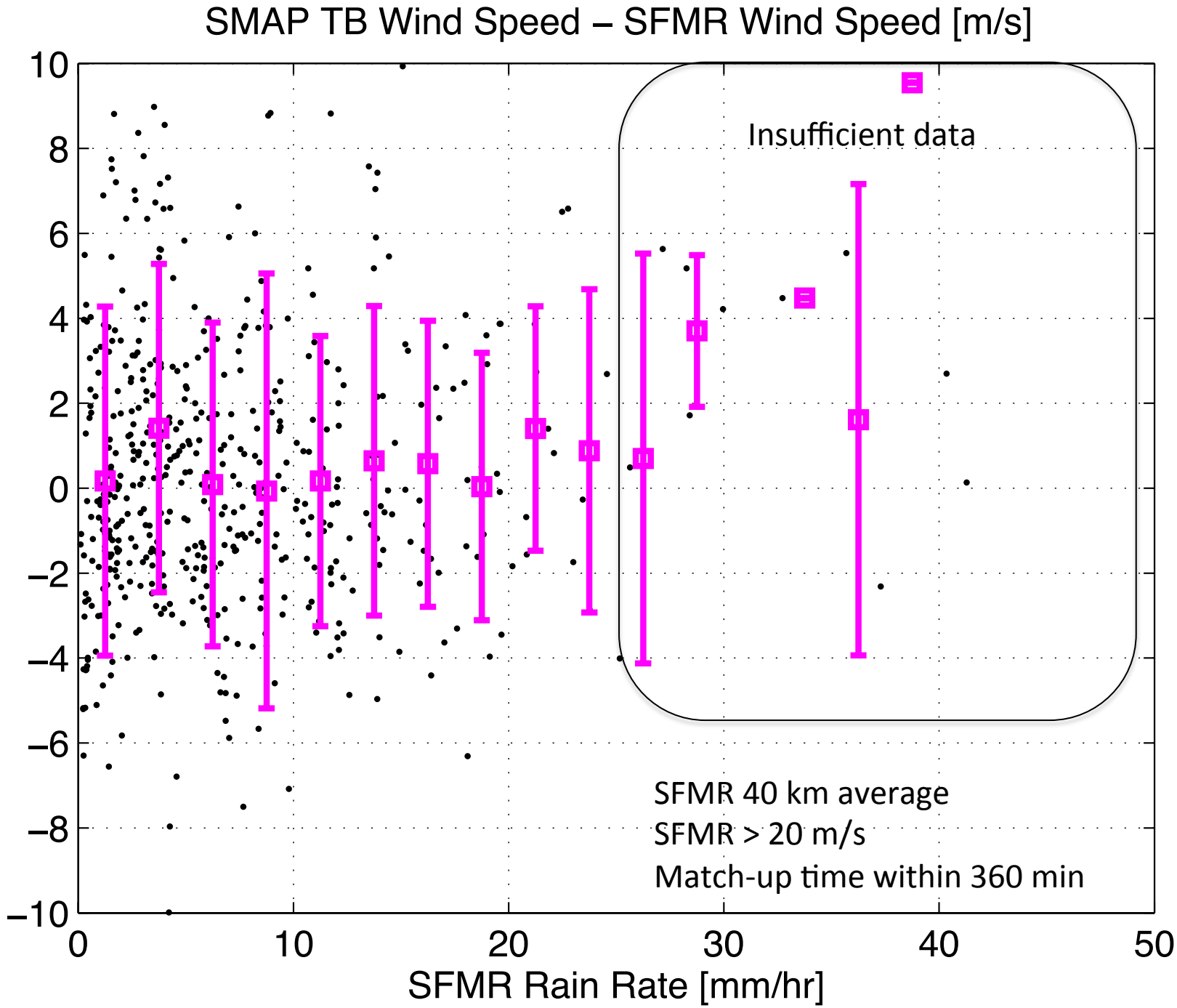
SFMR Matchups for 2015-2016

Matchup Time [min]	Counts >20m/s	Bias [m/s] >20 m/s	STD [m/s] > 20 m/s	Counts > 25 m/s	Bias [m/s] > 25 m/s	STD [m/s] > 25 m/s
15	21	1.30	3.60	9	1.01	4.19
30	47	1.61	3.60	19	1.63	3.38
45	62	2.01	3.85	25	2.38	3.42
90	137	1.49	3.77	57	2.52	3.58
180	284	1.18	3.68	110	2.22	3.54
240	351	0.81	3.71	133	1.61	3.91
300	433	0.78	3.80	162	1.32	4.12
360	542	0.57	4.05	197	0.97	4.57

- Average SFMR along-track to 40 km, pick point of nearest approach to SMAP cell.
- Use best-track to shift SFMR tracks to SMAP observation time.

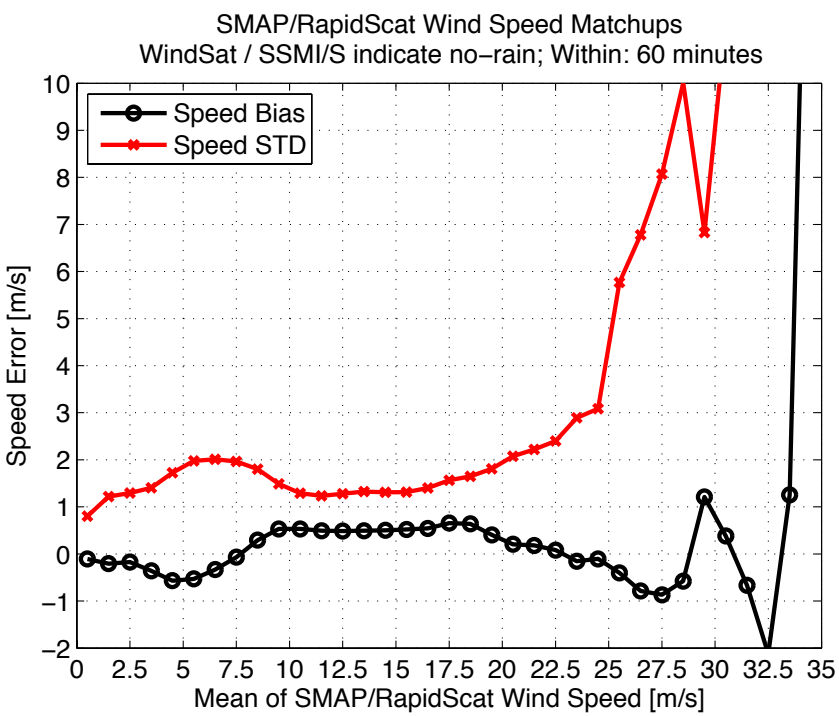
Summary

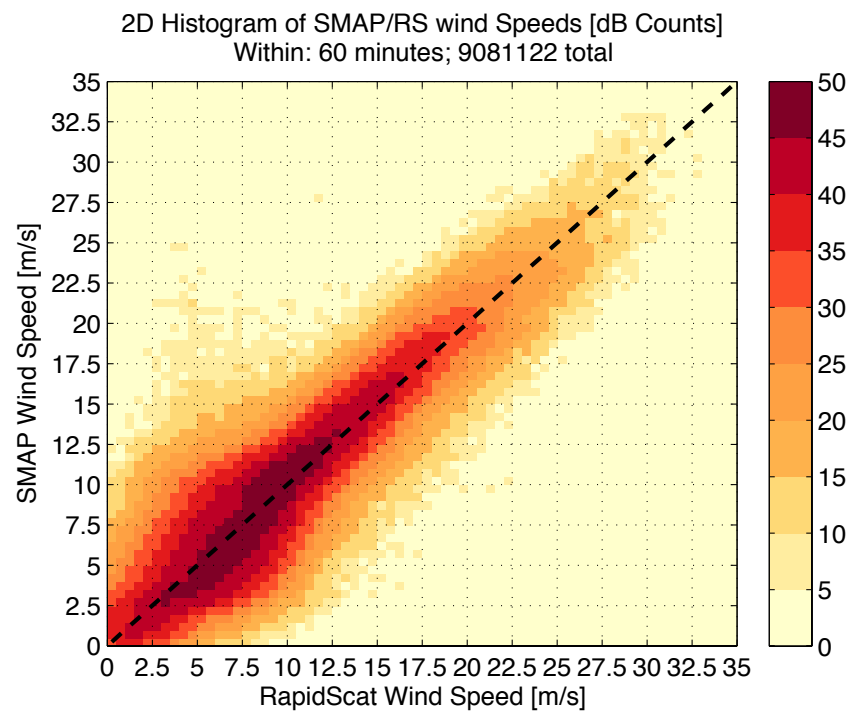
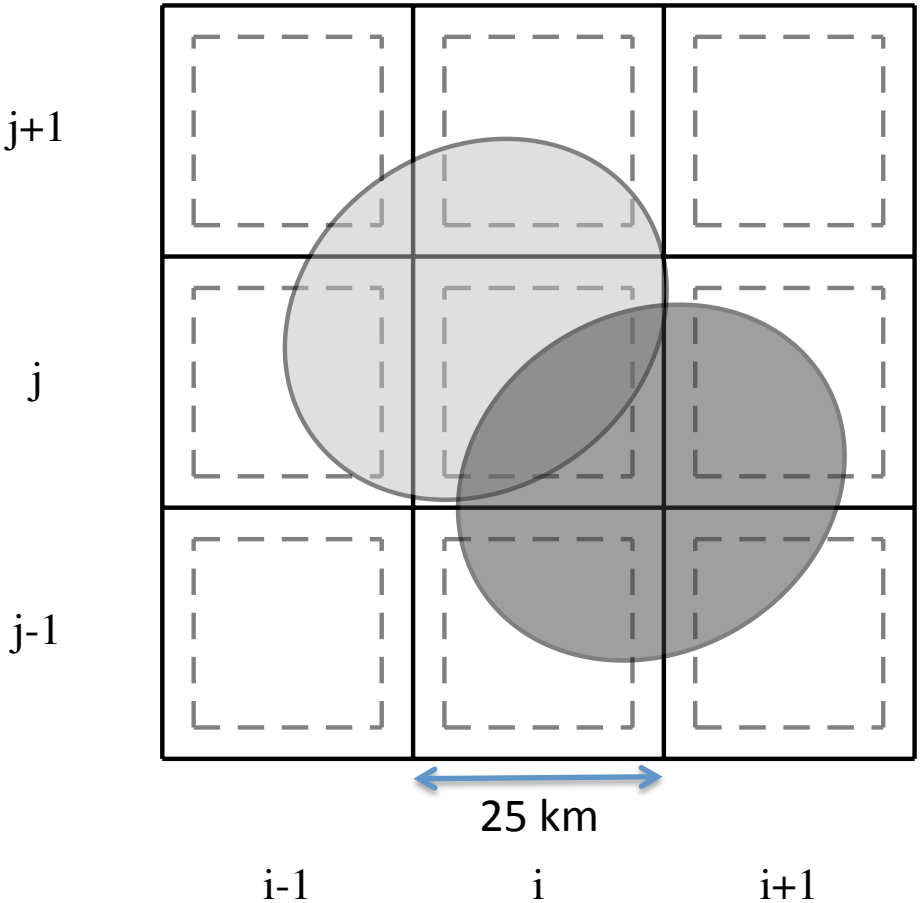
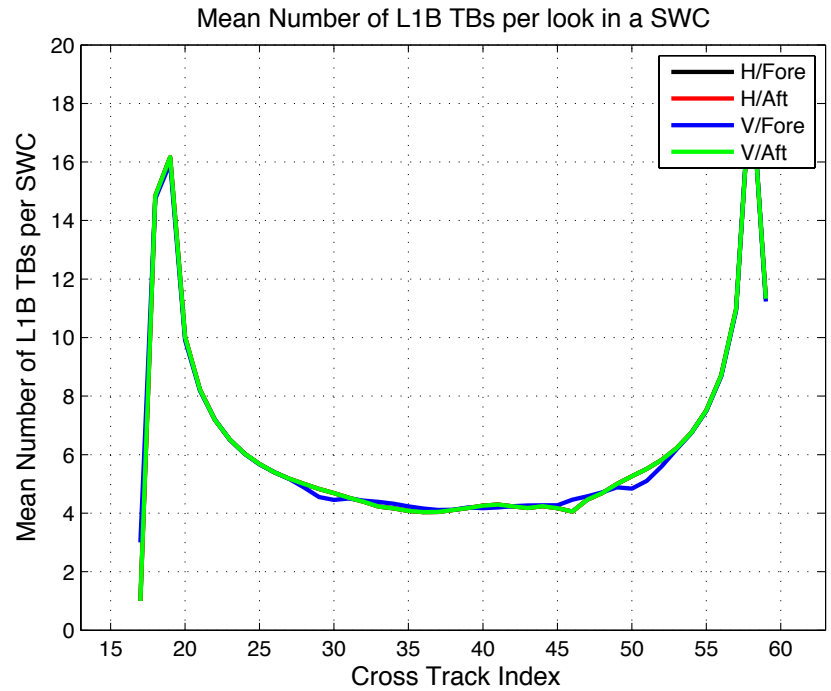
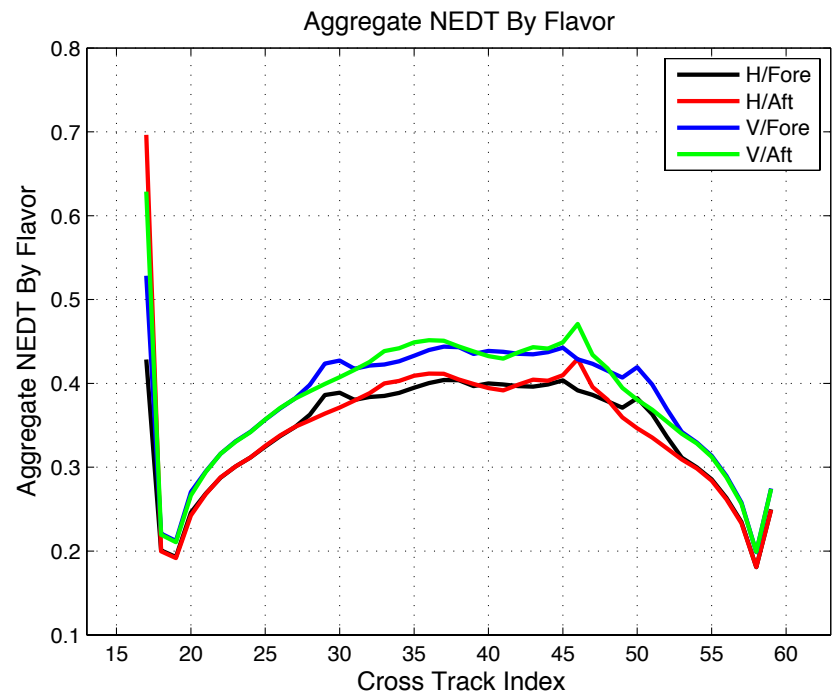
- Comparisons to RapidScat show SMAP L-band passive winds are unbiased between 20-30 ms^{-1}
  - Storm force wind estimates from SMAP are unbiased.
- With SFMR we find good agreement to about 40 ms^{-1}
  - Positive bias between 30-40 ms^{-1} no larger than 3 ms^{-1}
  - Overall STD as compared to SFMR is on the order of 4 ms^{-1} for wind speeds larger than 25 ms^{-1}
- Overall, SMAP can provide valuable information on Tropical Cyclone size and intensity.
- Peer-reviewed publications:
  - S. H. Yueh et al., "SMAP L-Band Passive Microwave Observations of Ocean Surface Wind During Severe Storms," in IEEE Transactions on Geoscience and Remote Sensing, vol. 54, no. 12, pp. 7339-7350, Dec. 2016.
  - A. G. Fore, et al., "Combined Active/Passive Retrievals of Ocean Vector Wind and Sea Surface Salinity With SMAP," in IEEE Transactions on Geoscience and Remote Sensing, vol. 54, no. 12, pp. 7396-7404, Dec. 2016.
  - N. Reul, et al., “A new generate of Tropical Cyclone Size measurements from space,” in BAMS, Early release (online). 10.1175/BAMS-D-15-00291.1


SMAP TB Wind Speed – SFMR Wind Speed [m/s]
10
8
6
4
2
0
−2
−4
−6
−8
−10
0
10
20
30
40
50
SFMR Rain Rate [mm/hr]
Insufficient data
SFMR 40 km average
SFMR > 20 m/s
Match-up time within 360 min

SMAP / RapidScat / WindSat collocations (60m)

- Same as previous with 60 minute collocation time.
  - 9 million matchups.
- Find very small speed bias up to 28 m/s (order 1 m/s).
- 2d histogram show data distributed near 1:1 line, no evidence of large positive SMAP bias near 30 m/s as compared to RapidScat.





L2A Gridding