



International Ocean Vector Wind
Science Team Meeting
May 17-19, 2016

Remote Sensing Systems
www.remss.com



Ocean Vector Winds in Storms from the SMAP L-Band Radiometer

Thomas Meissner, Lucrezia Ricciardulli, Frank Wentz

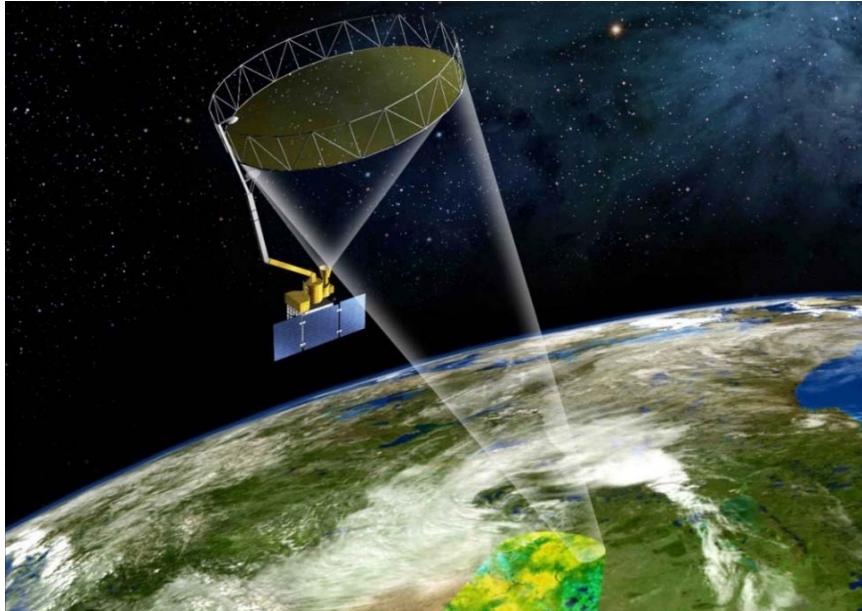
Photo courtesy:
www.DaveSandfordphotos.com



SMAP Soil Moisture Active Passive

Remote Sensing Systems
www.remss.com

Ocean Products: Sea Surface Salinity + Wind Speed

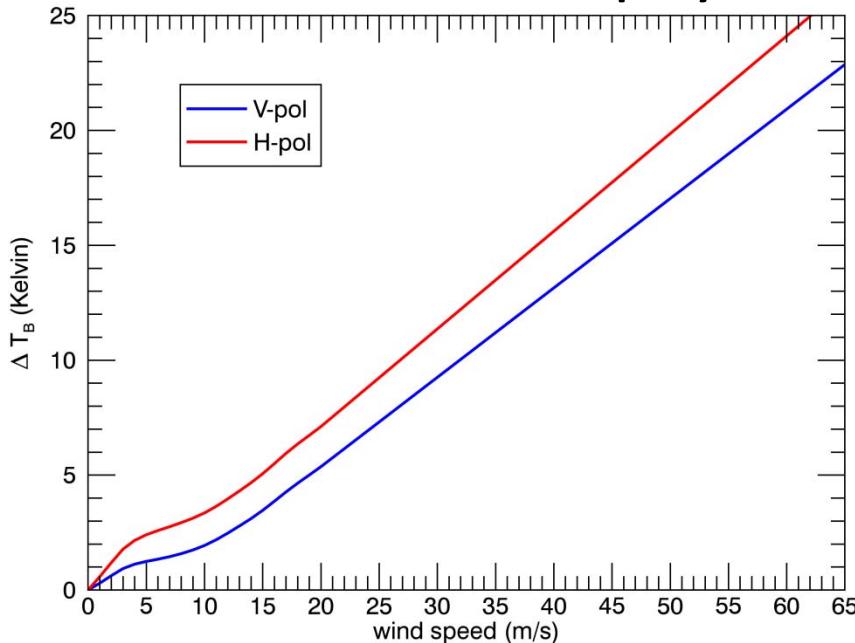


- Orbit Altitude: 685 km.
- Inclination: 98 deg.
- Local ascending/descending time: 6 PM/AM.
- 8-day repeat orbit.

- 6-meter mesh antenna.
- Conical scanning @ 14.6 rpm. Scan time: 4.1 sec.
- Earth Incidence Angle: 40°.
- Radiometer: Center frequency: 1.41 GHz + Radar.
- Full 360° scan views the Earth. 1000 km wide swath.
- 3-dB footprint size: 40 km.
- Time for sampling 1 footprint: 17 msec.

Wind Speed Response

Geophysical Model Function



Wind induced (excess) emissivity:

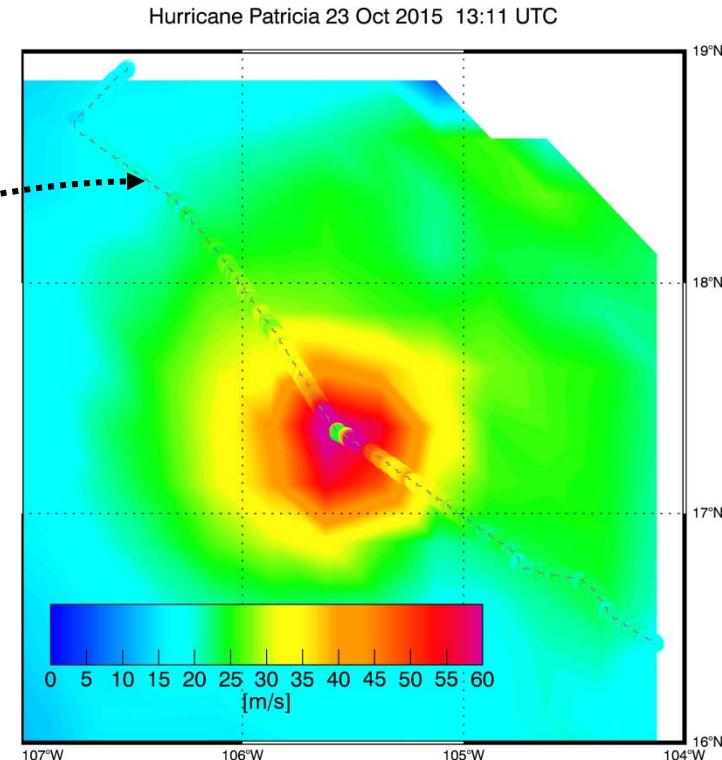
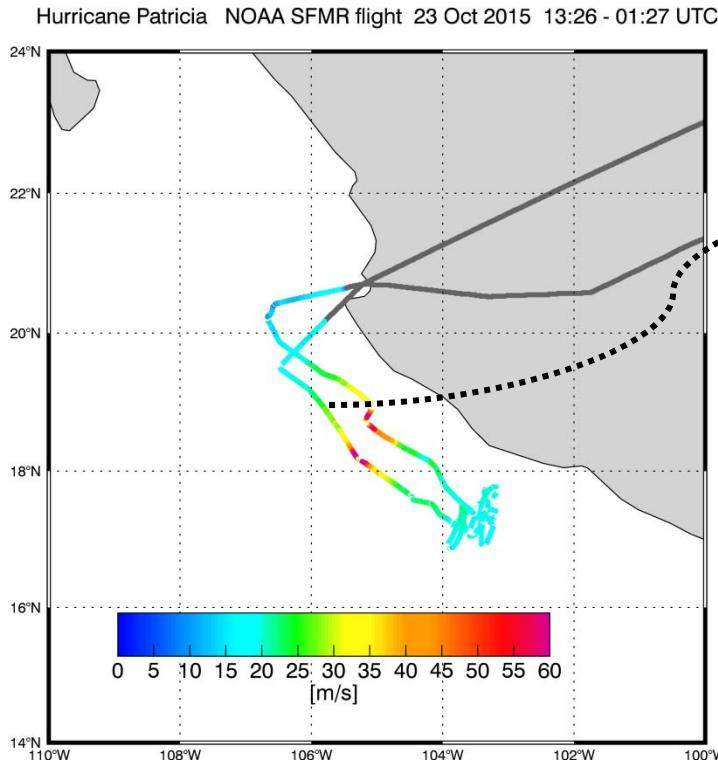
$$\Delta T_B = T_{B \text{ rough}} - T_{B \text{ flat}}$$

- Derived from Aquarius (L-band) TB – WindSat wind speed match-ups.
- *Meissner, Wentz + Ricciardulli, JGR Oceans, 2015.*
- GMF is used in salinity retrieval for Aquarius and SMAP.
- Linearly extrapolated above 25 m/s.

- Wind Speed Retrieval: MLE using V-pol and H-pol.
- Need ancillary input field for salinity (HYCOM) and SST to compute $T_{B \text{ flat}}$.
- Global accuracy: RMS (SMAP – WindSat) ≈ 1.5 m/s
- Focus on high winds (> 25 m/s).
 - Upper ocean layer is well mixed, even in heavy rain.
- Demonstrated for SMOS by *N. Reul et al.*

SMAP – SFMR Match-Ups

Method

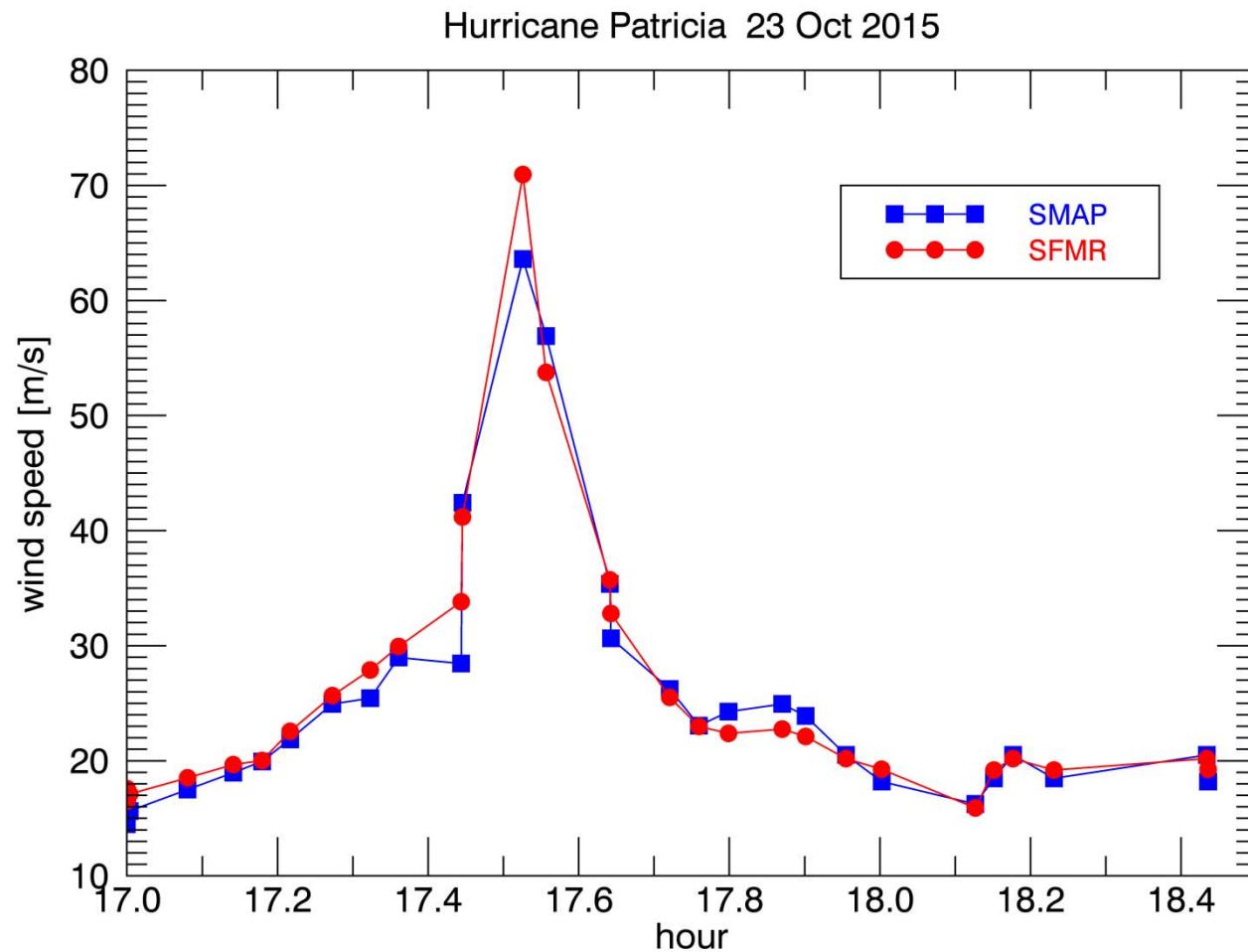


- Lower SFMR segment (17.5 h) closest in time to SMAP overpass (13.1 h).
- Shift SMAP segment so that SMAP and SFMR storm centers overlap.
- Average SMAP observations (≈ 1 sec, 0.1 km) into 0.25° cells.



SMAP-SFMR Match-Ups

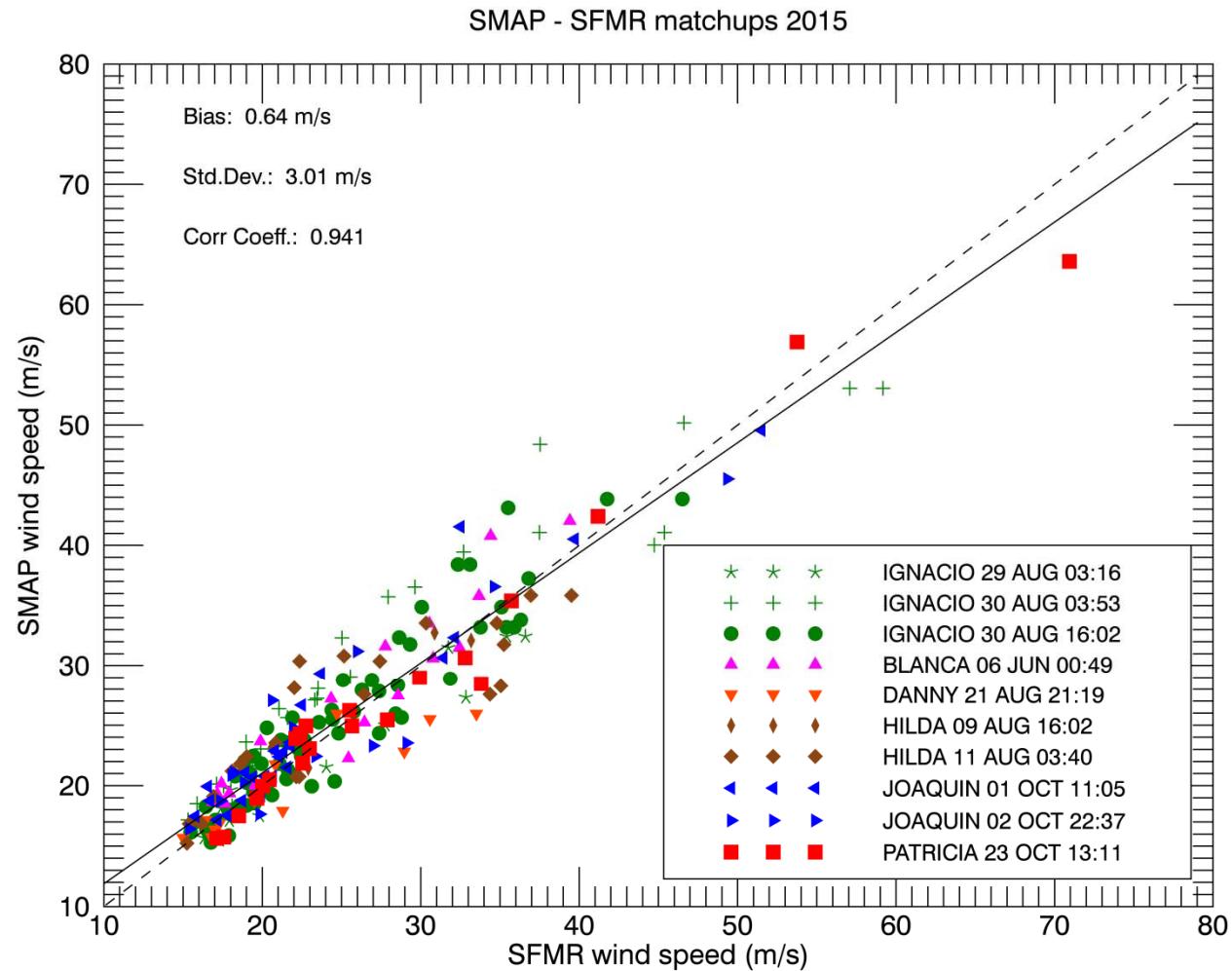
Time Series





SMAP-SFMR Match-Ups

Statistics





SMAP-SFMR Match-Ups

Statistics for different wind speed ranges

SMAP - SFMR		
Wind speed (m/s)	Bias (m/s)	Std.Dev (m/s)
15 – 25	0.76	1.86
25 – 35	0.21	3.83
35 – 45	2.40	4.50
> 45	-2.40	3.96

Small biases
above 35 m/s:
potential fine
tune of GMF.

**Estimated error for SMAP wind speeds above 15 m/s:
10% or better.**



Rain Impact

SMAP – SFMR as function of SFMR Rain Rate

SMAP – SFMR

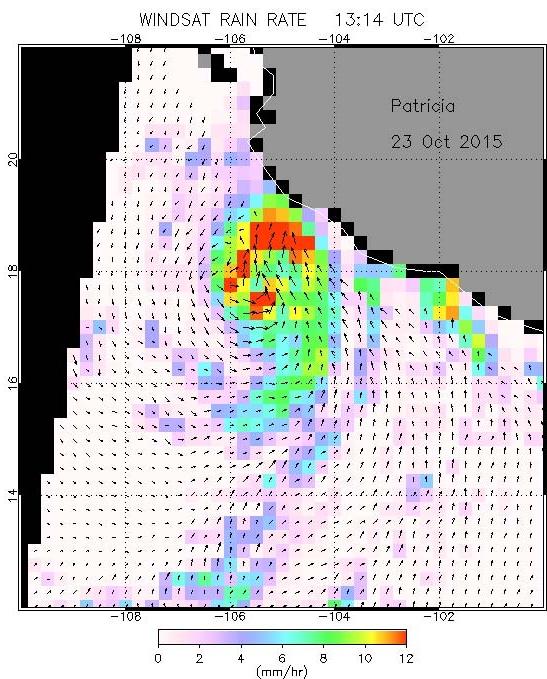
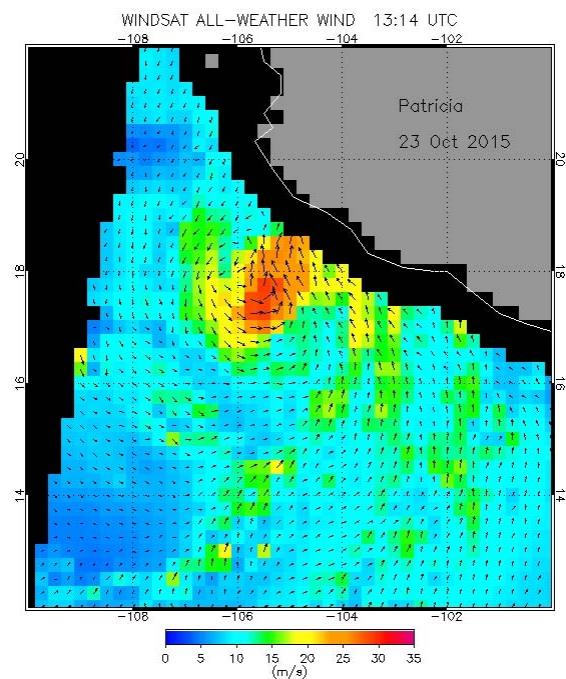
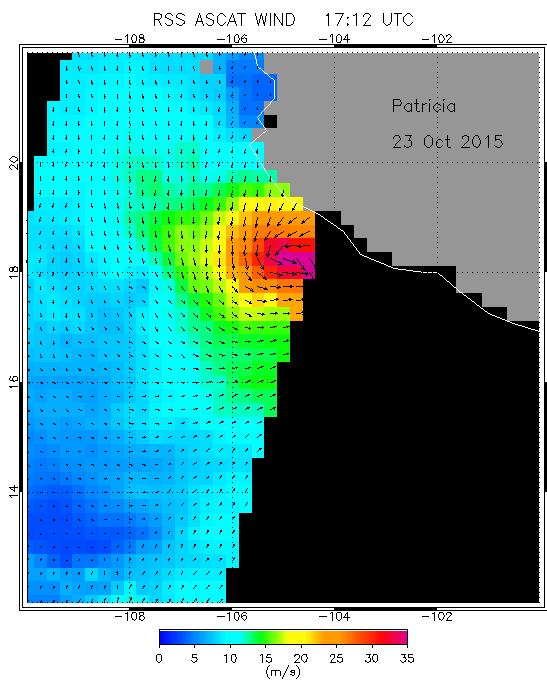
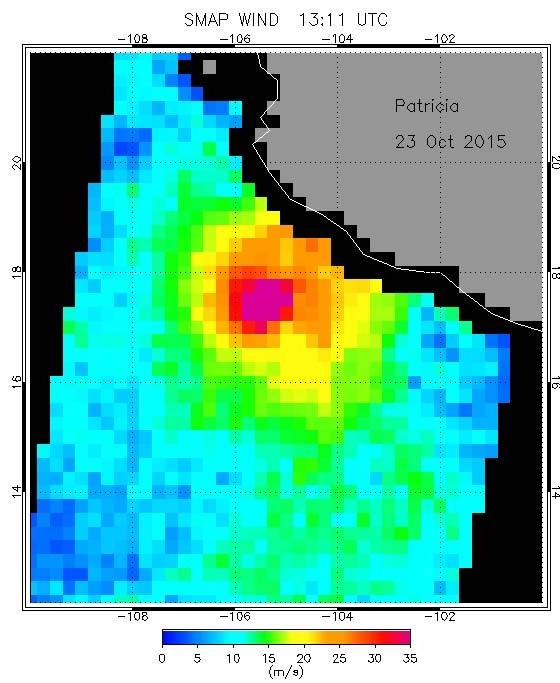
SFMR rain rates were averaged to 0.25°

Rain Rate (mm/h)	Bias (m/s)	Std.Dev (m/s)
0 – 5	0.68	2.55
5 - 10	1.57	3.37
10 - 15	0.46	2.85
> 15	-1.86	3.69

No visible degradation in rain.



Hurricane Patricia 23 Oct 2015

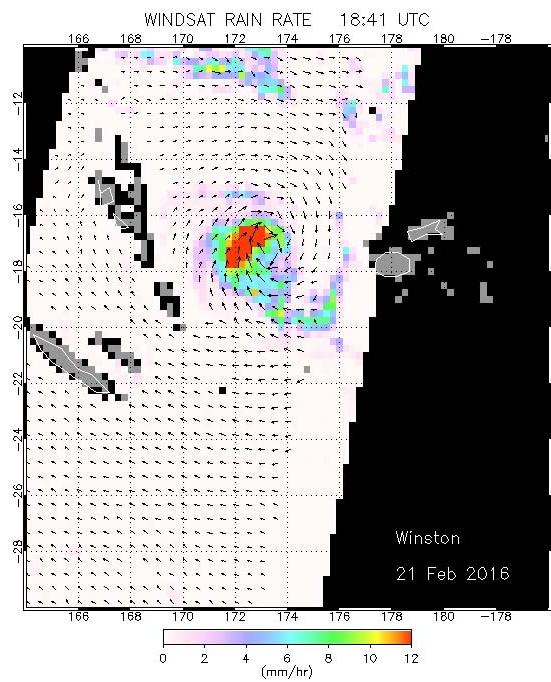
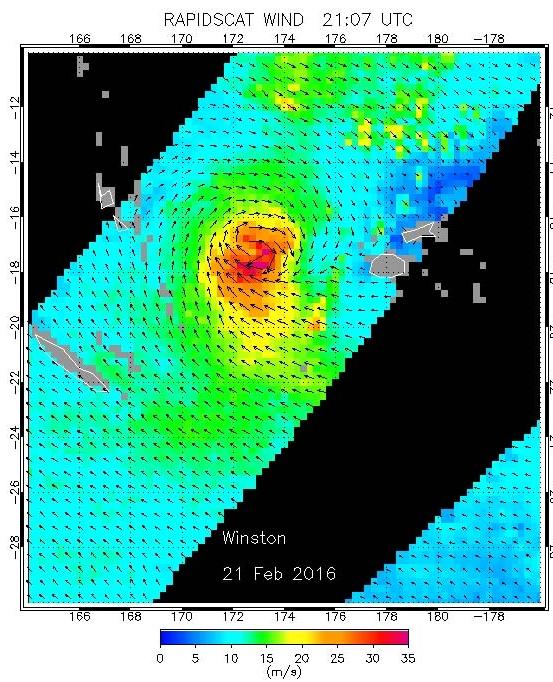
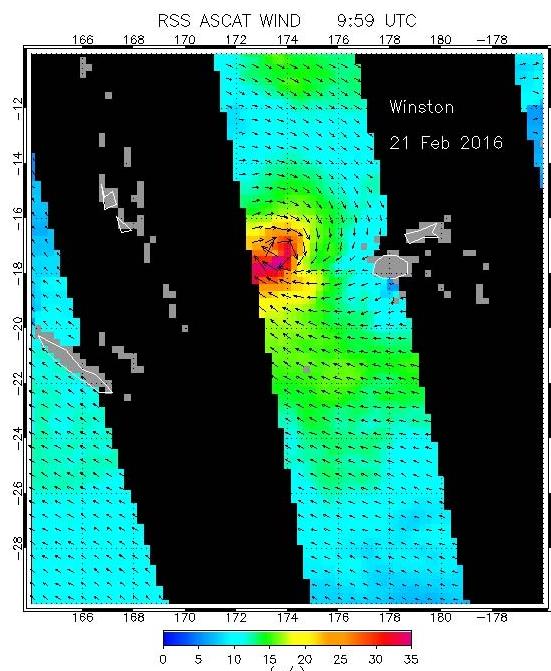
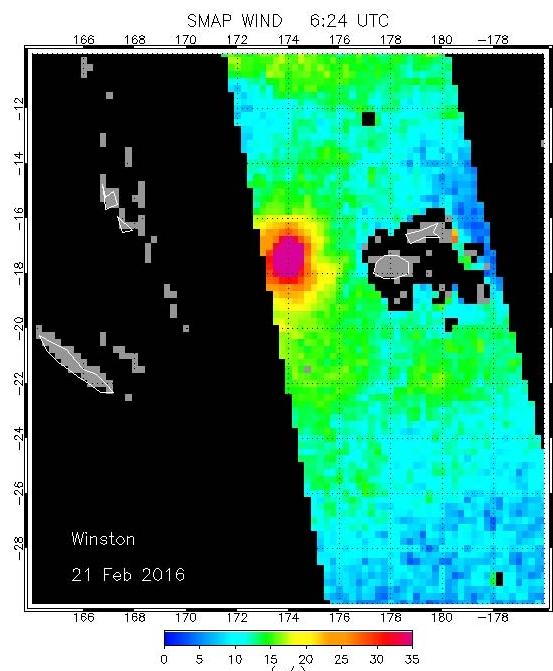


Max wind speeds (m/s)

SMAP	63.6
SFMR (0.25°)	70.9
NCEP 0.25°	70.0
WindSat	29.2
ASCAT	36.2
RapidScat	27.8



Hurricane Winston 21 Feb 2016



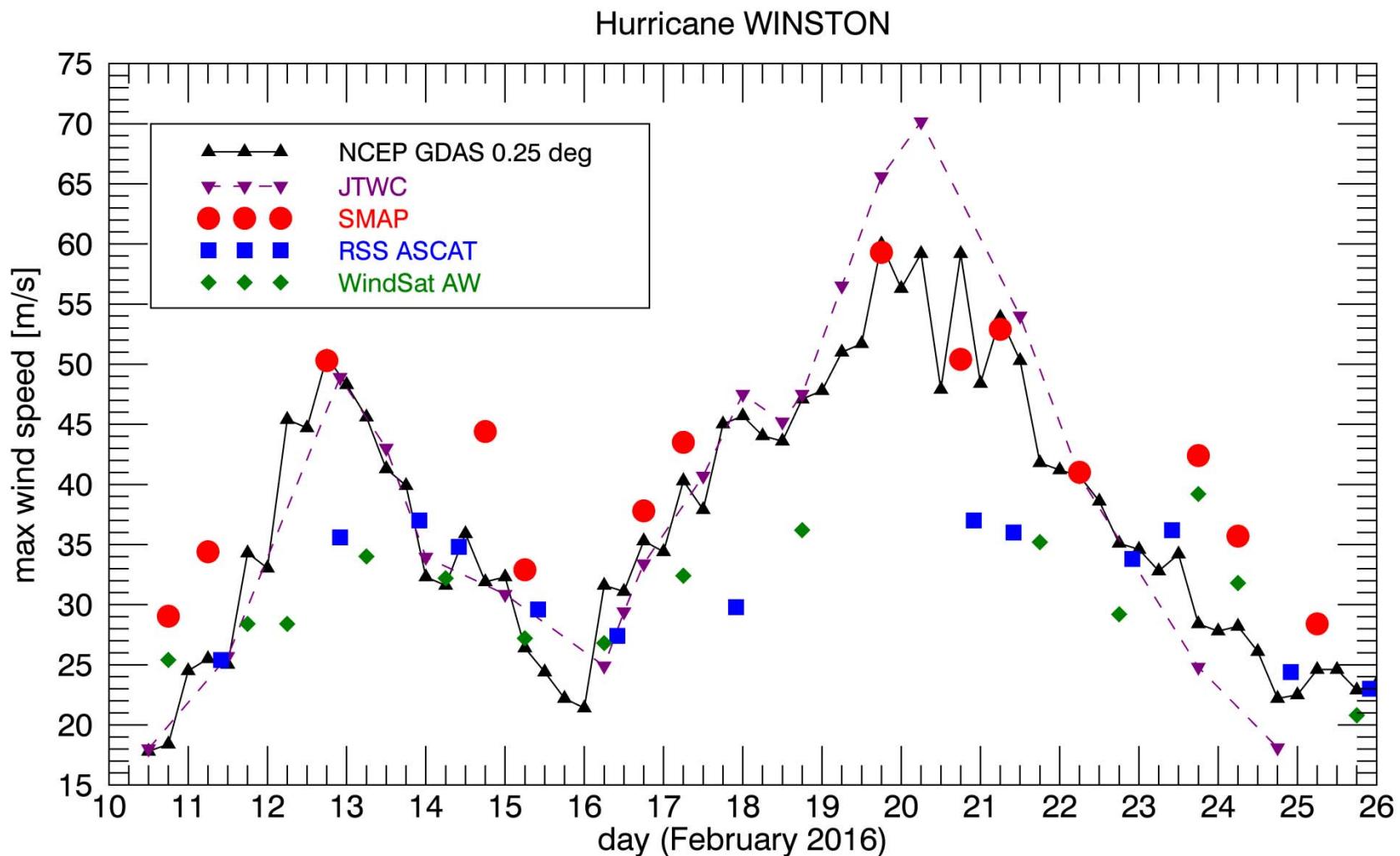
Max wind speeds (m/s)

SMAP	52.9
JTWC	54.1
10 min sustained	
NCEP 0.25°	53.9
WindSat	35.2
ASCAT	36.2
RapidScat	35.8



Hurricane Winston

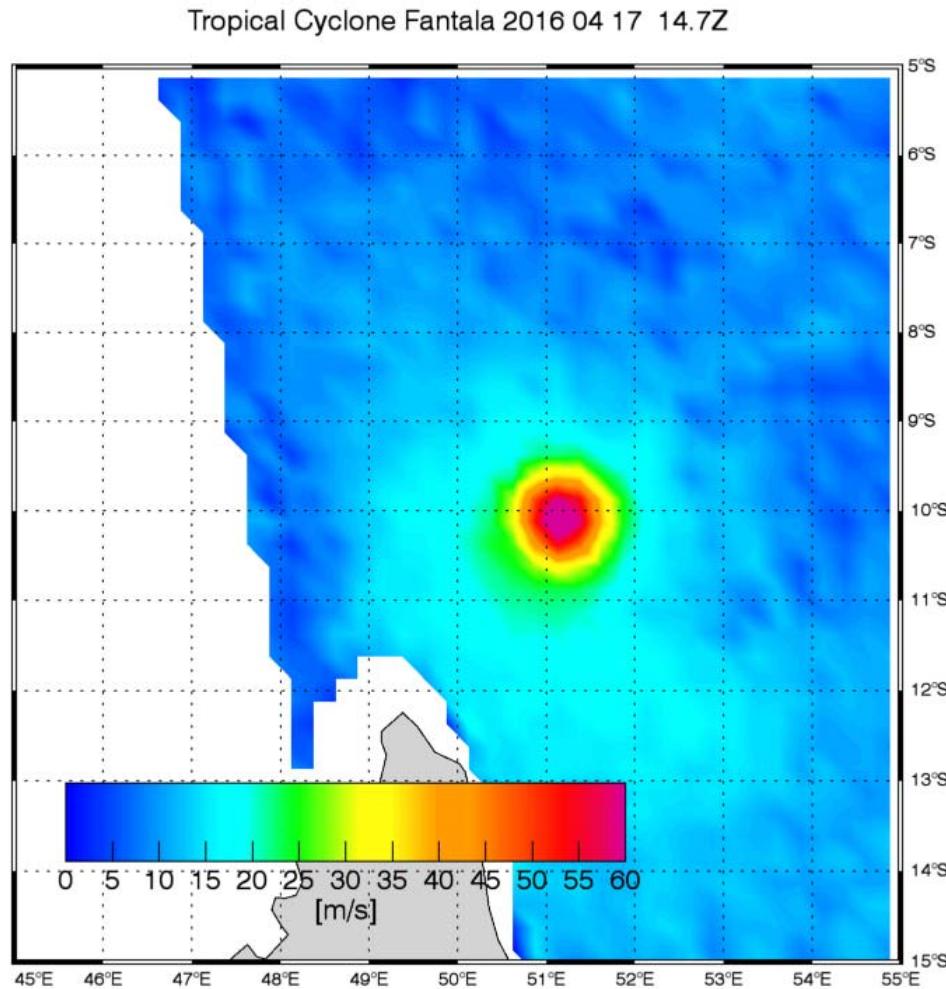
2-week Time Series





Hurricane Fantala

strongest recorded hurricane in the Indian Ocean

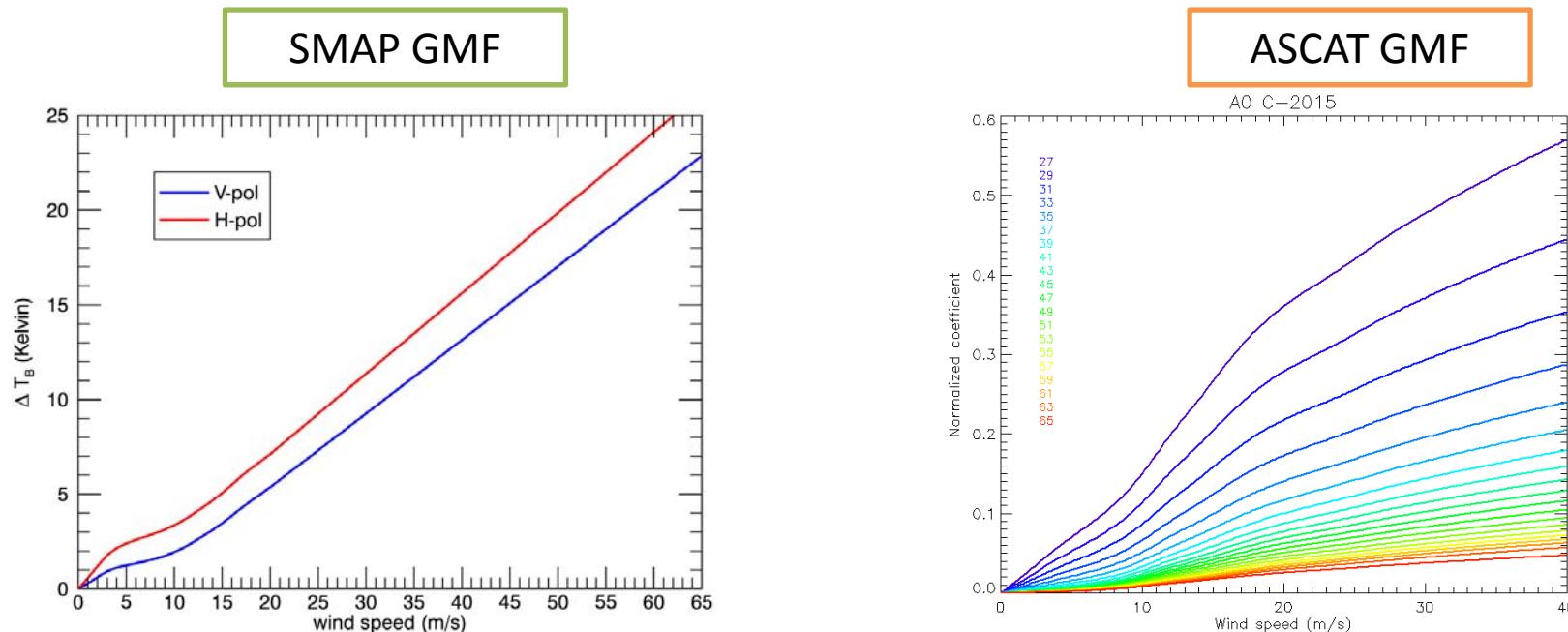


Max wind speeds (m/s)
04/17/2016

SMAP (02 UTC)	60.1
SMAP (14 UTC)	70.1
JTWC (18 UTC) 10 min sustained	69.3
NCEP 0.25° (18 UTC)	66.1
ASCAT (18 UTC)	34.8

Sensitivity in High Winds

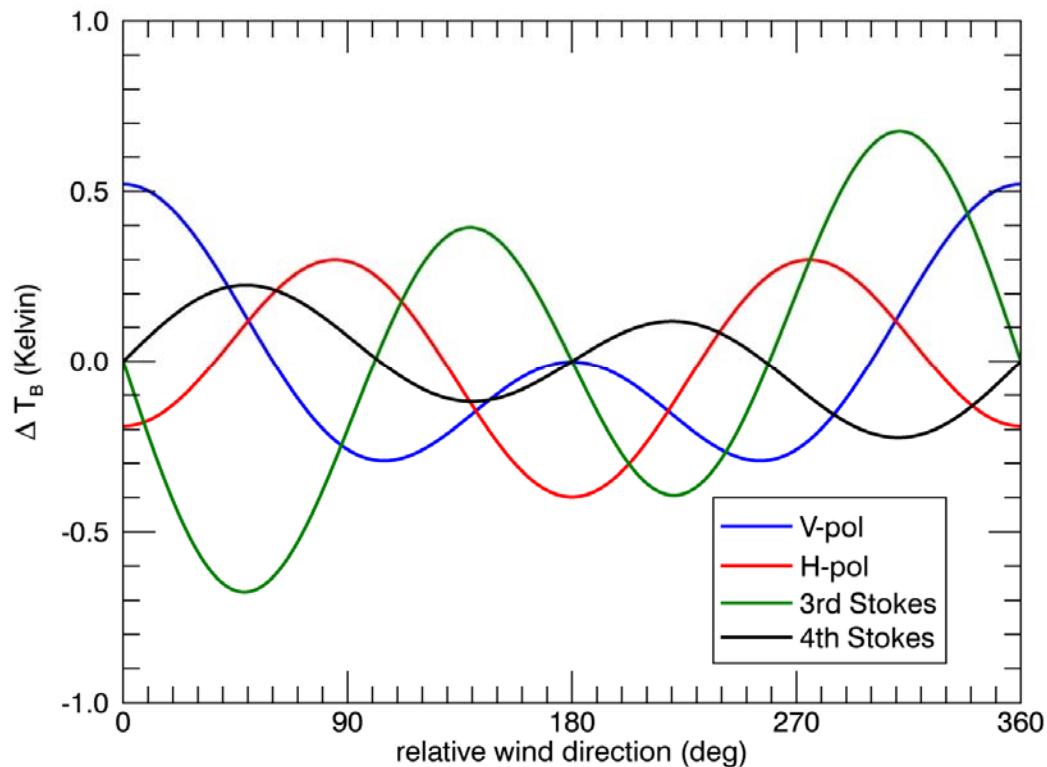
SMAP – Scatterometers - WindSat



- For $W < 30$ m/s + no rain the GMF of scatterometers, SMAP and WindSat are intercalibrated. $W > 30$ m/s ??
- Scatterometers (ASCAT, RapidScat) wind speeds systematic low at very high winds.
- Scatterometer GMF are likely too steep at high winds.
- If flattening of scatterometer possible at high winds, needs to be investigated.
- Signal/noise.
- WindSat: Rain is major problem. WindSat all-weather is statistical algorithm, that was trained from H^* winds.

Wind Direction Response

Polarimetric Signal



- SMAP is fully polarimetric.
- Small directional signal.
- Wind direction retrieval possible above 12 m/s
- • 1° averaging.
- 3rd Stokes signal dominated by Faraday Rotation in Earth's ionosphere.

Use combinations of polarimetric channels that are not affected by Faraday rotation: $(V+H)$, $Q^2+S_3^2$, S_4

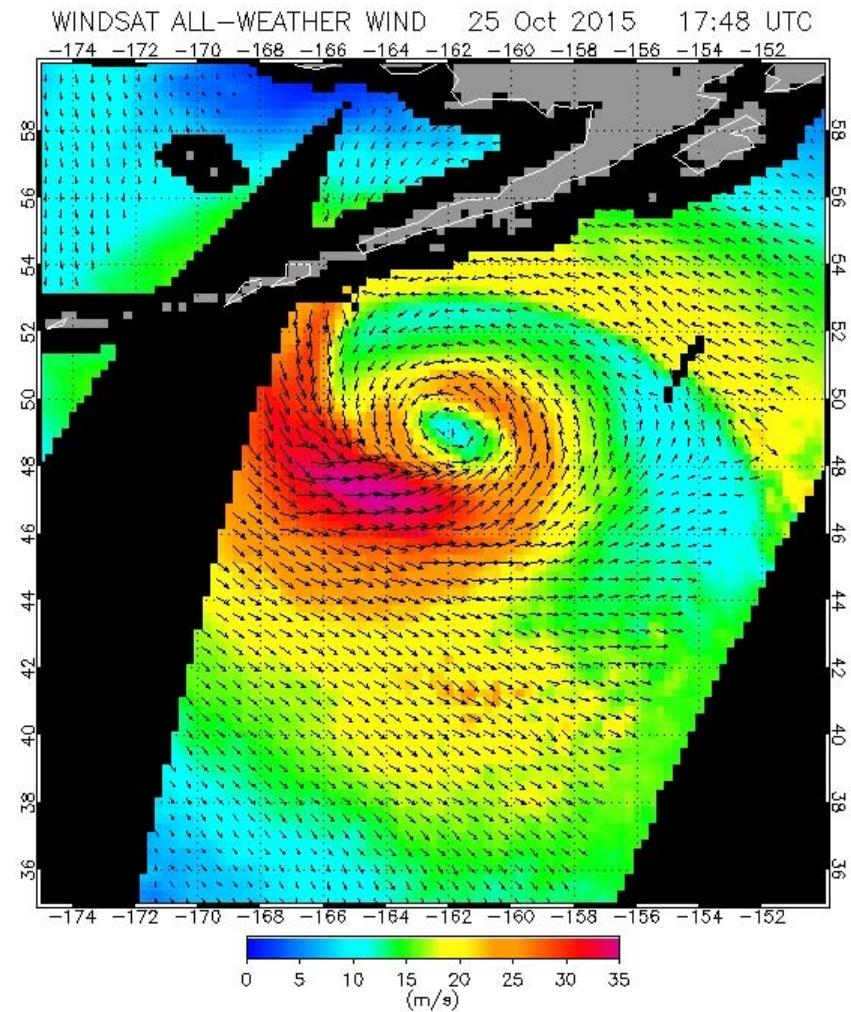
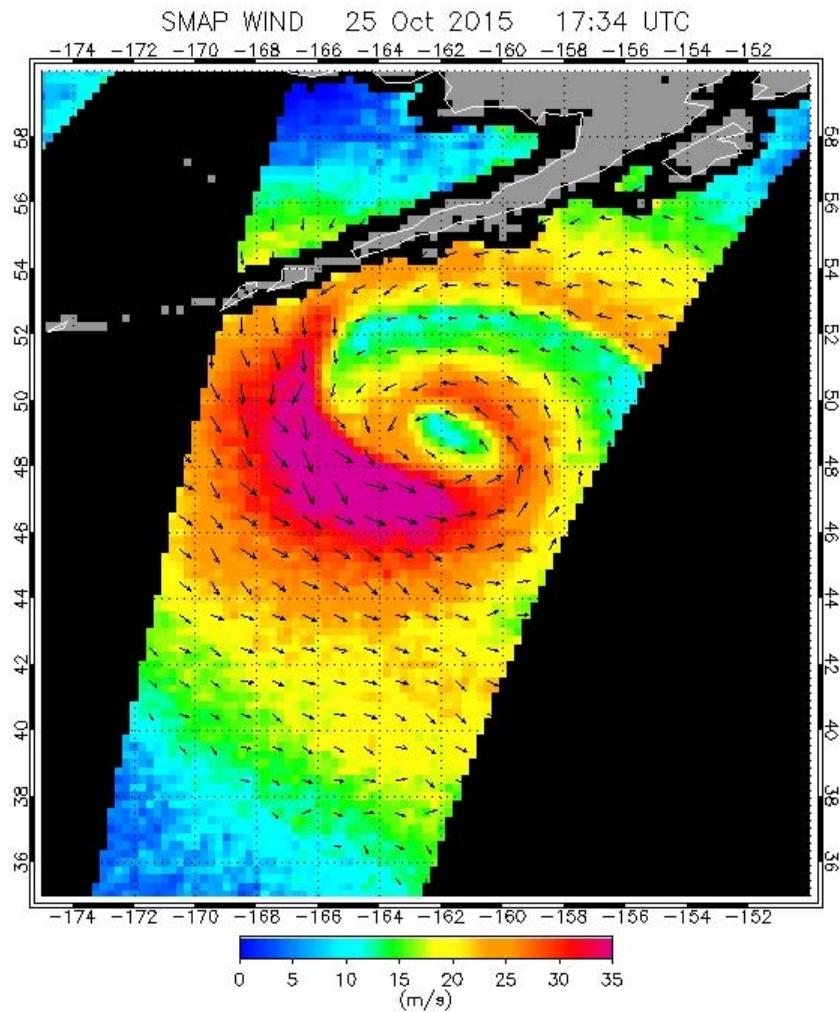
$$Q = V - H$$



Extra-Tropical Cyclone

25 Oct 2015

Remote Sensing Systems
www.remss.com





Summary



- The SMAP L-band radiometer has excellent capabilities to measure very high wind speeds
 - Up to 70 m/s.
 - 40 km resolution.
 - SFMR validation: 10% accuracy.
- Key:
 - Keeps good sensitivity at very high wind speeds.
 - No significant degradation in rain.
- This is currently not possible with scatterometers (ASCAT, RapidScat) or WindSat.
- Polarimetric signal allows wind direction retrievals above 12 m/s at 1° resolution.
- **BAMS manuscript in preparation**