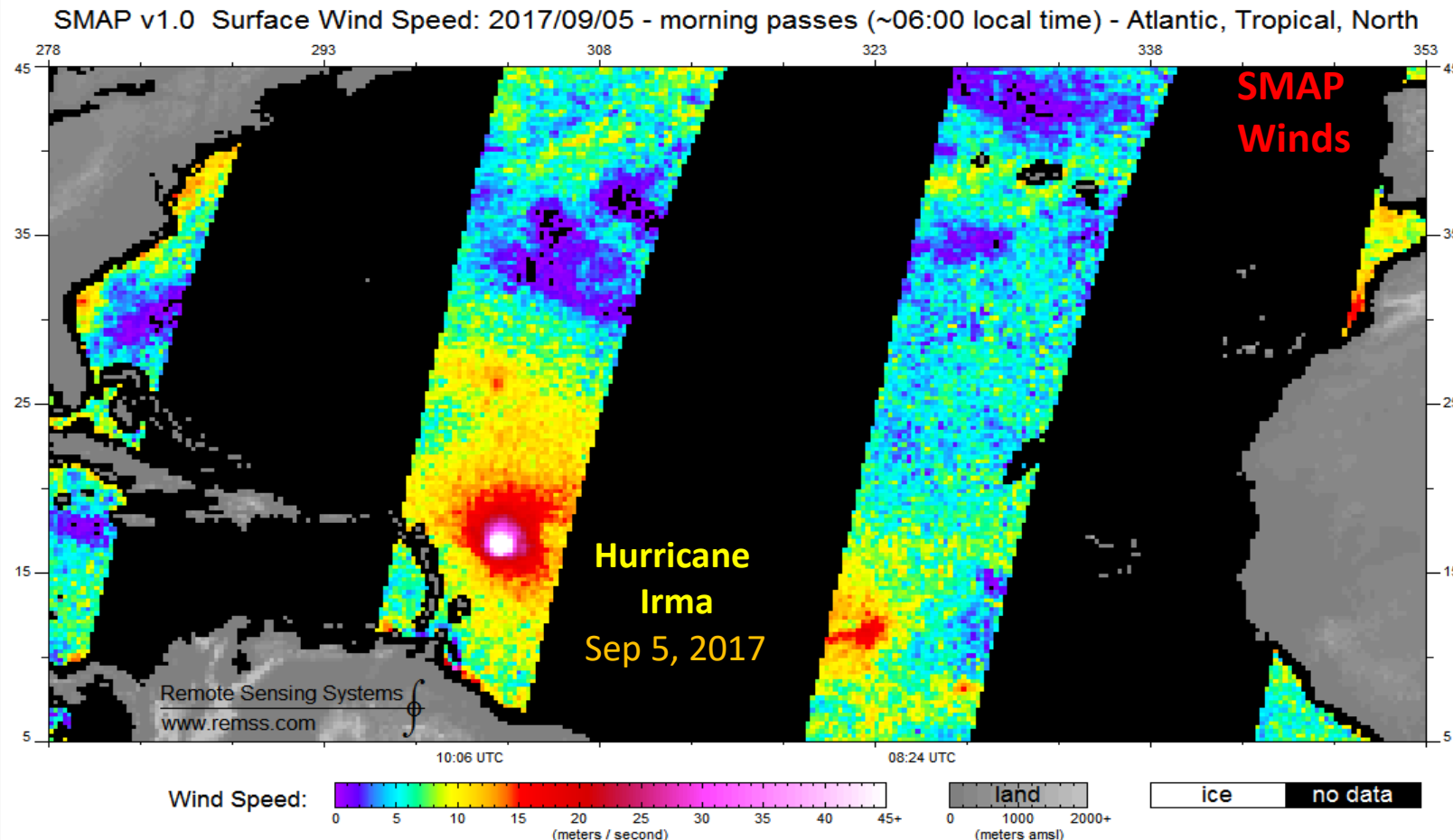




Intensity and Size of Strong Tropical Cyclones in 2017 from NASA's SMAP L-Band Radiometer

Thomas Meissner, Lucrezia Ricciardulli, Frank Wentz, *Remote Sensing Systems, Santa Rosa, USA*
Charles Sampson, *Naval Research Laboratory, Monterey, USA*



AMS 33rd Conference on Hurricanes and Tropical Meteorology
Ponte Vedra, Florida, 4/16 – 4/20, 2018

SATELLITE OBSERVATIONS OF HURRICANE-WINDS: STATUS QUO

Sensor	Dataset	Mission dates (wind)	Performance in hurricanes
SMAP (L-band radiometer)	Wind speed, daily 0.25° grid NRT and Final (RSS V1). 40 km resolution.	April 2015-current	Sensitivity up to 70 m/s (Cat. 5); Minimally affected by rain
ASCAT (C-band scatterometer)	Wind vector	March 2007-current	Decreased sensitivity above Cat. 1 Moderate wind speed bias in rain;
WindSat (MW polarimetric radiometer)	All-weather wind vector	May 2003-current	Some residual bias due to rain, can be improved with new algorithm. Sensitivity ?
QuikSCAT (Ku-band scatterometer)	Wind vector, daily 0.25°	Jun 1999-Nov 2009	Decreased sensitivity above Cat. 1-2 Significant wind speed <u>bias in rain</u> ;

Satellite measurements:

Radiometers (SMAP, WindSat): average wind-induced ocean emissivity over footprint ~25-40km.

Sensitive to foam at high winds.

Scatterometers (QuikSCAT, ASCAT, RapidScat, ScatSat): ocean backscatter from wind-perturbed surface ~25-50km

Challenges of Satellite High Wind Measurements

- Sparse ground truth; Satellite and in situ have different spatial/time scales
- Rain: Error source for most radiometers + scatterometers.
- Decreased sensitivity (signal) at high wind speeds.

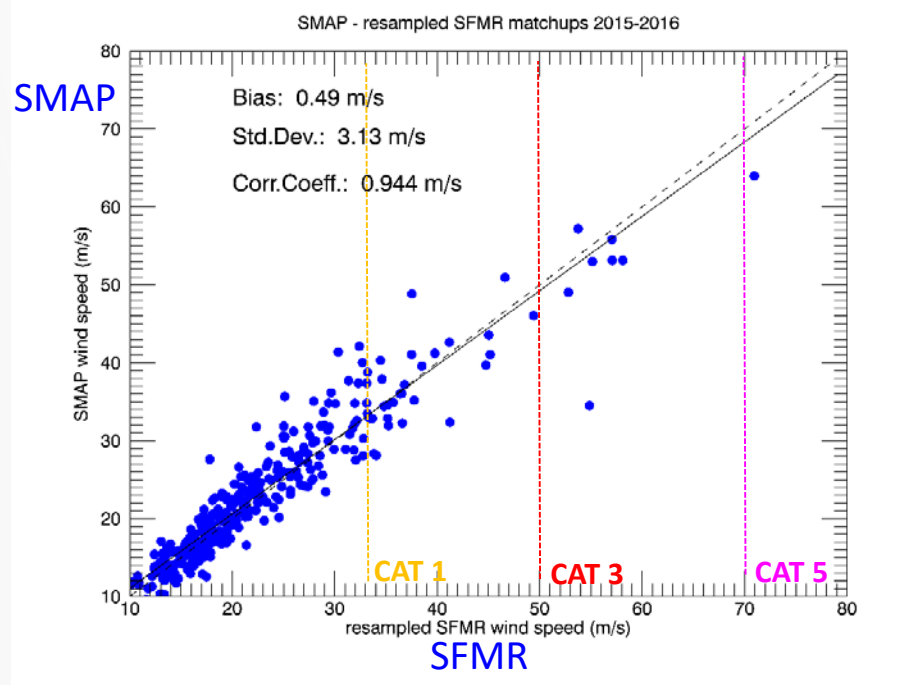


VALIDATION OF SATELLITE HURRICANE-FORCE WINDS

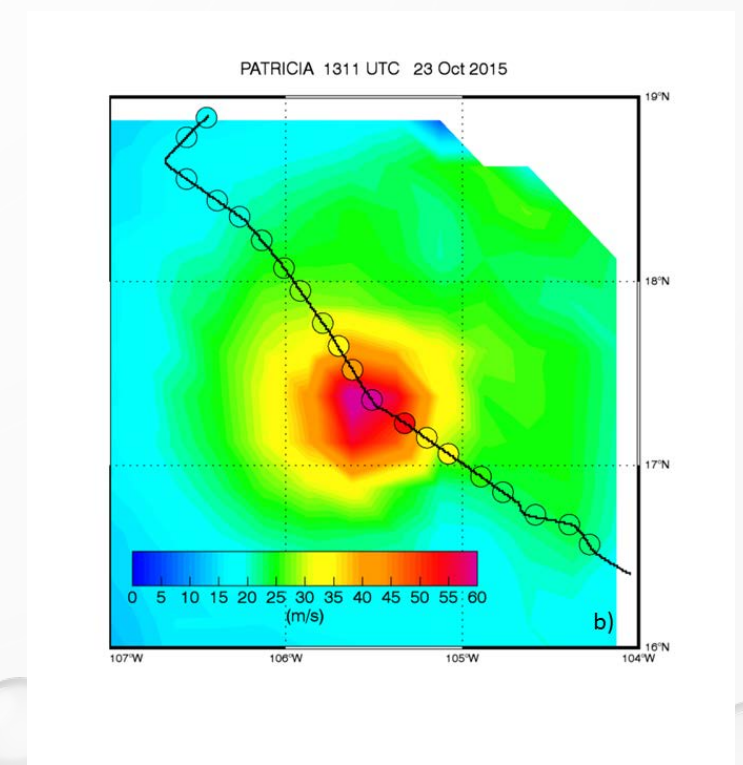
We devoted significant efforts to validate SMAP hurricane-force winds by using the airborne Stepped Frequency Microwave Radiometer (SFMR) observations mounted on hurricane hunter aircrafts . Details in [Meissner et al, BAMS Aug 2017]



COLOCATED SMAP/SFMR WINDS, STORMS 2015-2016



Resample SFMR (track->circles) at SMAP resolution ~25km



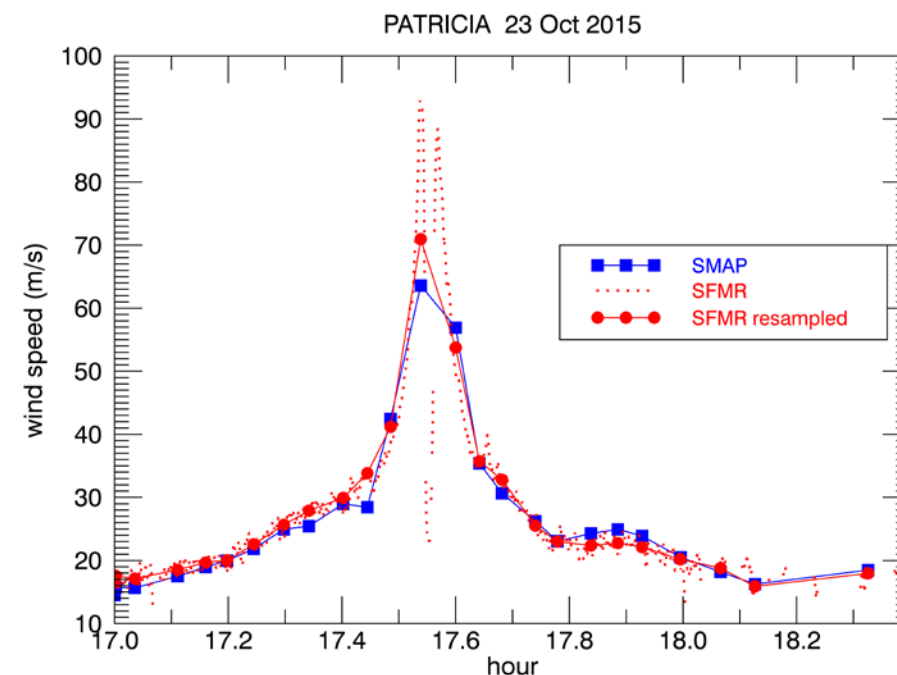
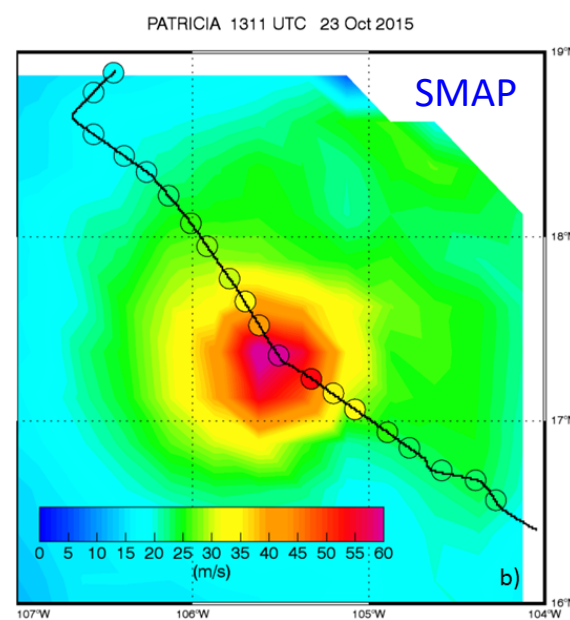
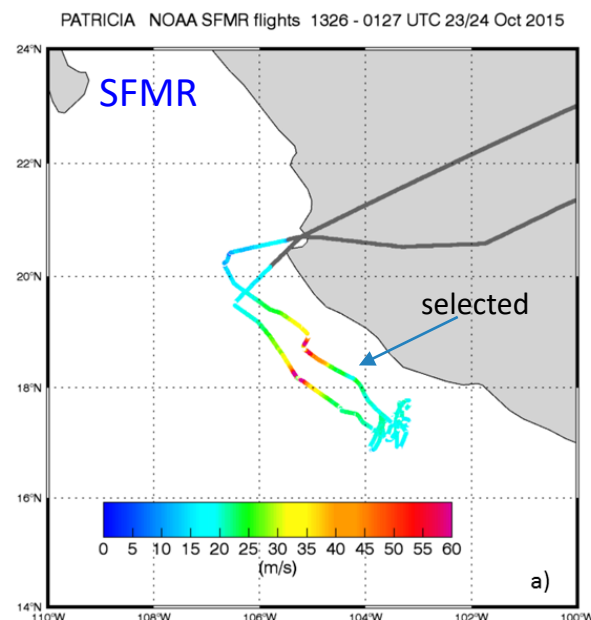
- Very good SMAP-SFMR agreement 10-70 m/s.
- Accuracy ~ 10%
- SMAP (L-band) signal does not saturate at high winds.
- SMAP wind retrievals not affected by rain

HOW TO TRANSFER CALIBRATION FROM SFMR TO SATELLITE

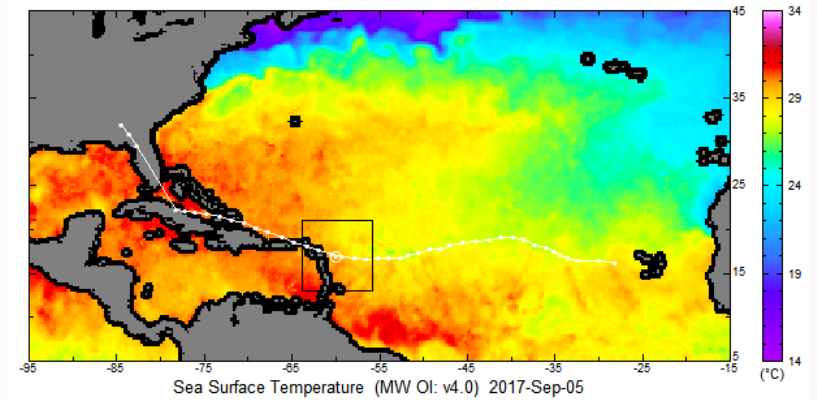
- STEP 1: Select flight pass closest in time to Satellite pass
- STEP 2: Limit temporal mismatch according to storm intensification rate (<5 hours, max 7% intensity change)
- STEP 3: Shift SFMR data in space to overlap with satellite view of storm center
- STEP 4: Resample SFMR data to satellite wind resolution (25-40 Km)



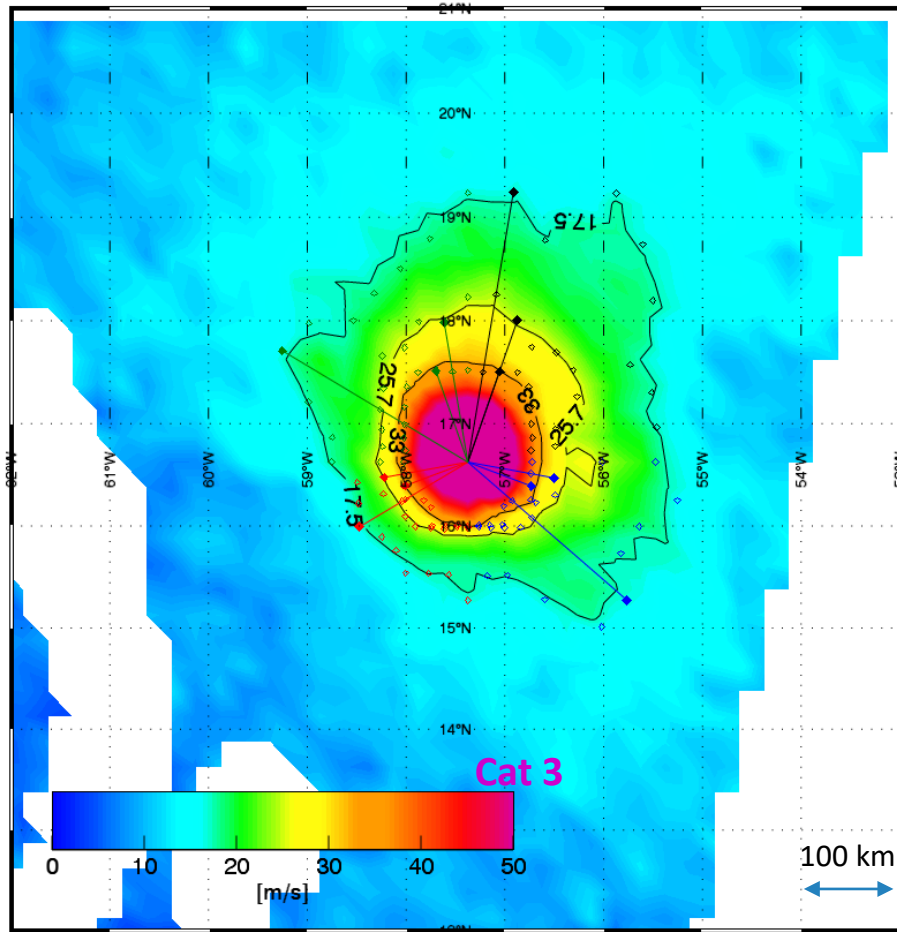
- STEP 5: Resulting overlapping timeseries of SMAP satellite wind and resampled SFMR



IRMA



SMAP Wind 2017-09-05 10:06 UTC



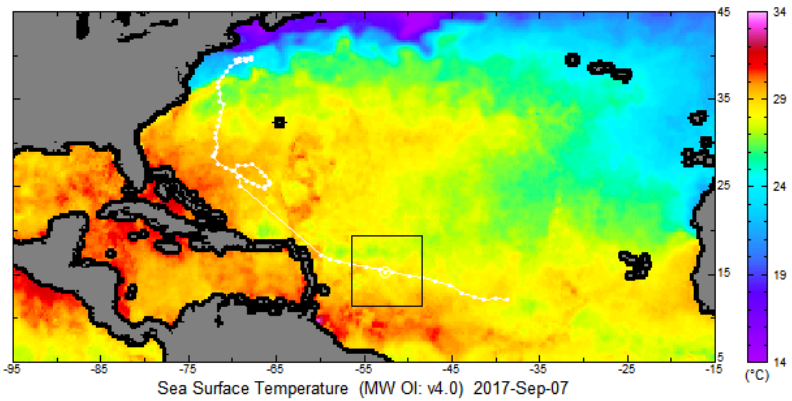
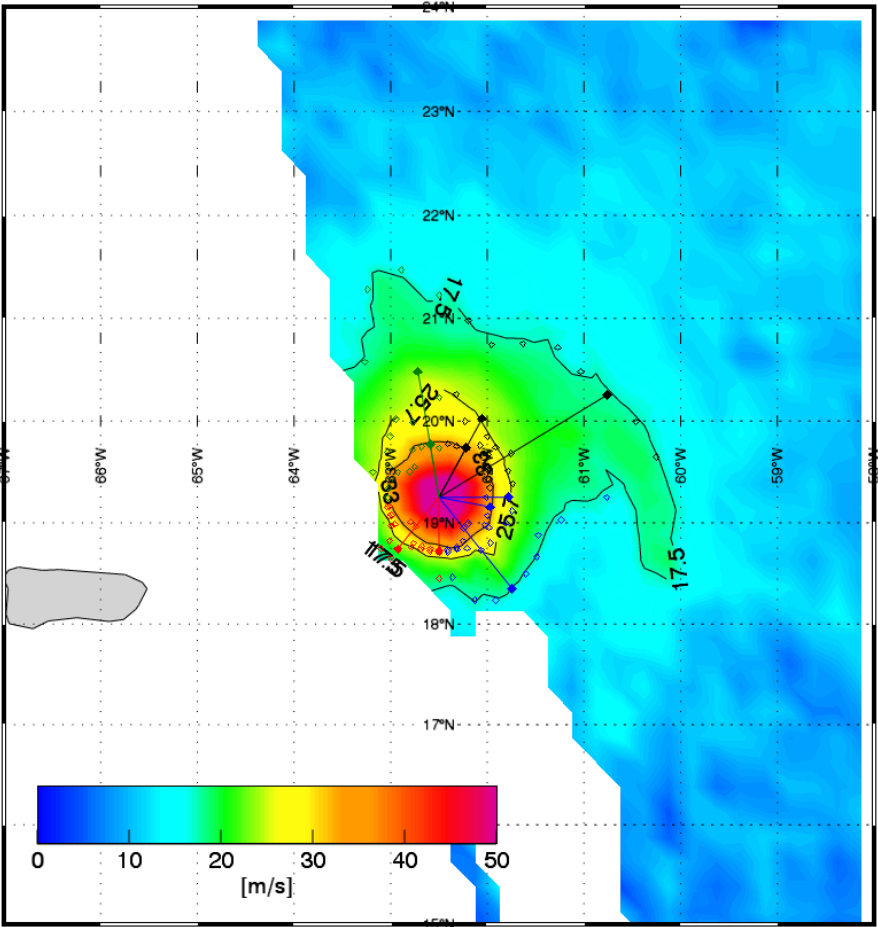
Satellite max sustained winds should be compared with 10-min sustained winds from BT.
Roughness at satellite spatial scales needs time to develop.

Sep 5, 2017

	SMAP 1006 UTC	Best Track 1200 UTC 10 minute sustained
Max 10-min wind	140 kn (Cat 5) (72 m/s)	144 kn (Cat 5) (74 m/s)
R34NE (nm)	141	140
R50NE	76	80
R64NE	48	50

JOSE

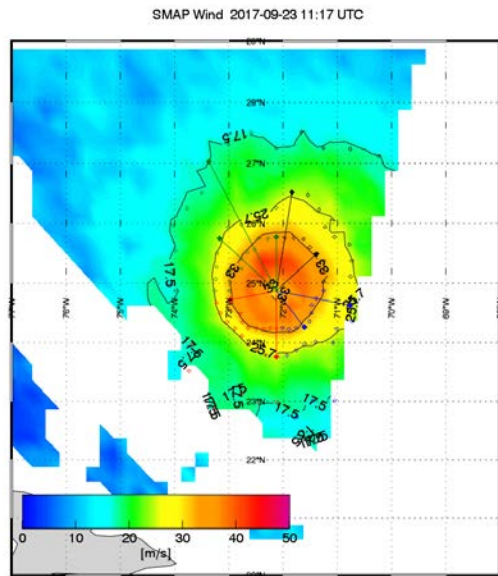
SMAP Wind 2017-09-09 21:46 UTC



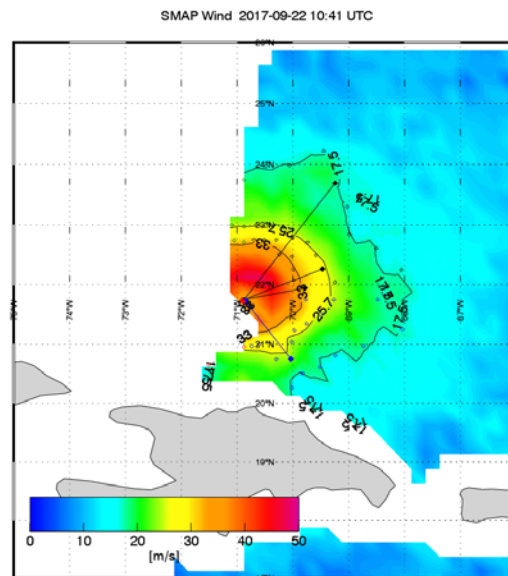
Sep 9,2017

	SMAP 2146 UTC	Best Track 0000 UTC (Sep 10)
Max 10-min wind	107 kn (Cat 3) (55 m/s)	111 kn (Cat 3) (57 m/s)
R34NE (nm)	109	130
R50NE	48	70
R64NE	31	35

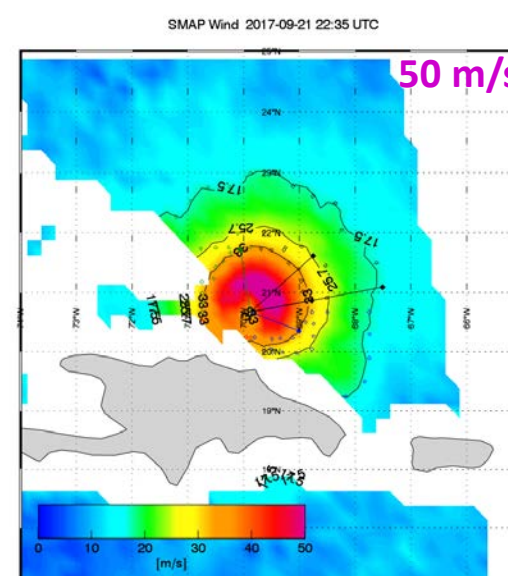
MARIA



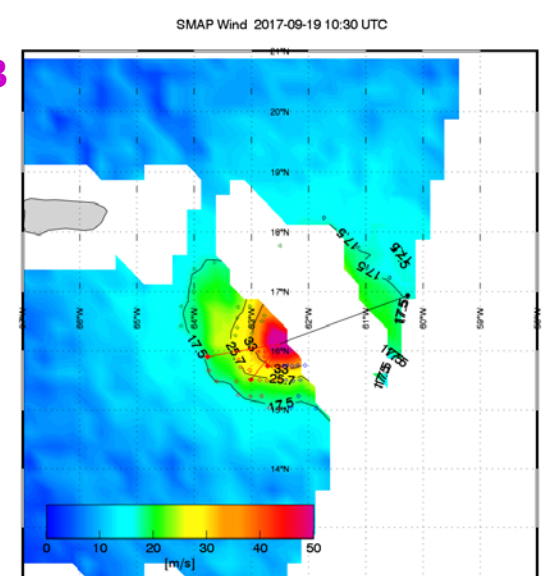
SEP 23



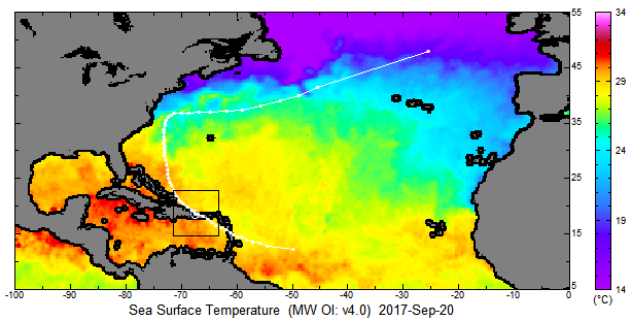
SEP 22



SEP 21



SEP 19



SEP 21	SMAP 2230 UTC	Best Track 0000 UTC (Sep 22)
Max 10-min wind, kn (m/s)	109 (56)	102 (52)
R34NE (nm)	125	140
R50NE	79	90
R64NE	60	60



SMAP WINDS IN FORECAST MODELS

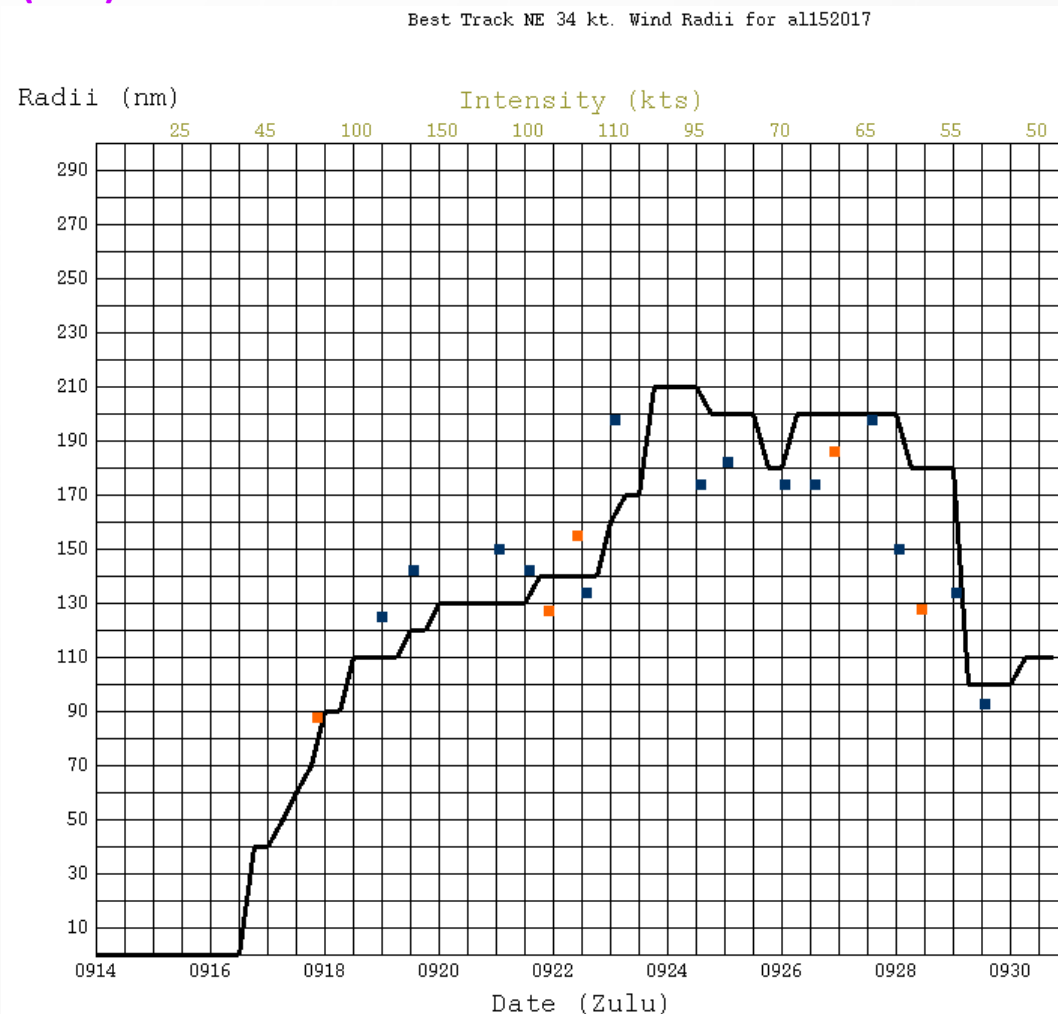
SMAP winds are processed at RSS in Near-Real-Time.
netCDF4 0.25 deg maps.
Current latency: about 3 hours.
Plan to reduce to less than 2 hours using shortcut in spacecraft ephemeris.

Following the extensive validation at hurricane-force wind speeds, SMAP are being ingested into the Automated Tropical Cyclone Forecast (ATCF) system and used by NRL (US Navy) and by the Joint Typhoon Warning Center.

Storm radii for each quadrant were compared to Best Track from ATCF

- 34 kn (17.5 m/s) → most used in TC advisories
- 50 kn (25.7 m/s)
- 64 kn (33 m/s → Category 1)

MARIA 34kn Radii (in nm) NE quadrant (NRL)

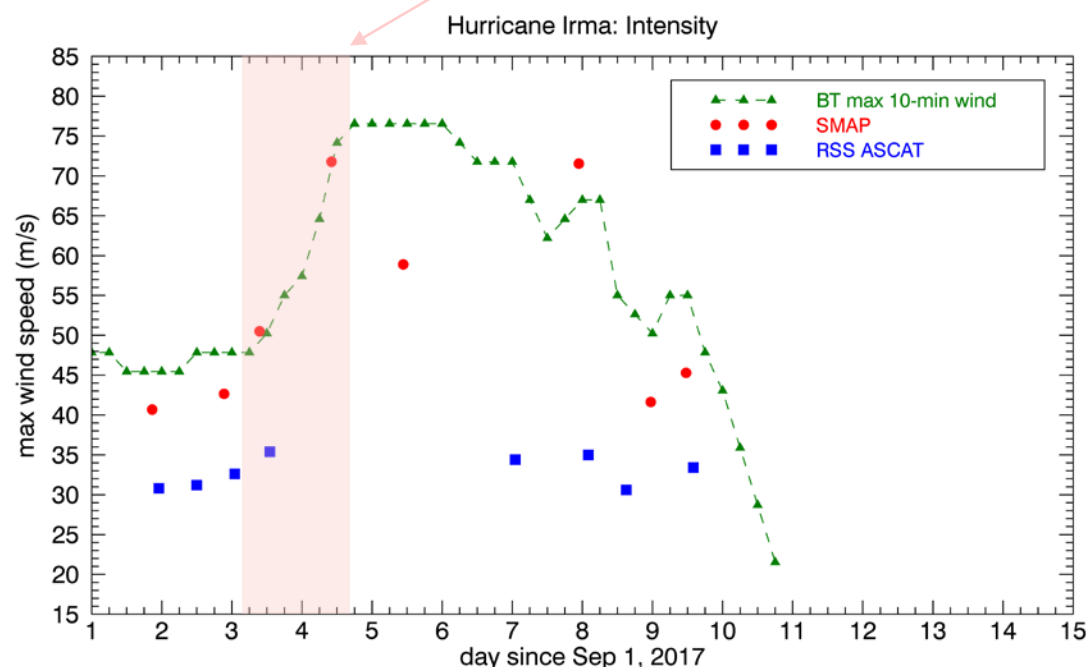


STORM INTENSITY EVOLUTION: SATELLITE VS BEST TRACK DATA

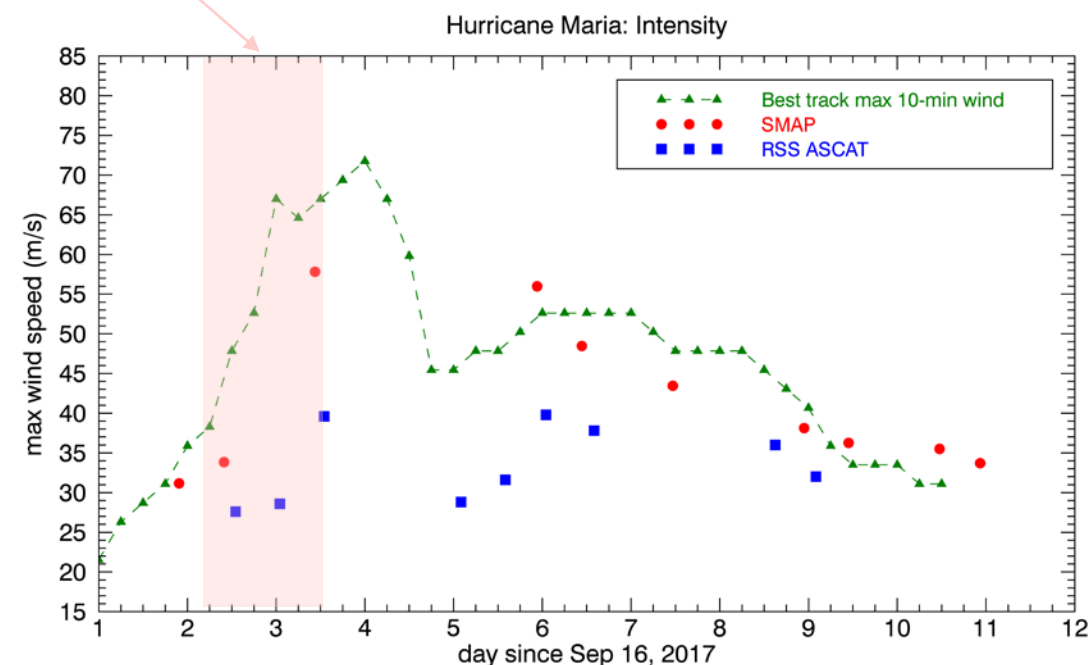
- Max intensity of satellite winds compared to 10-min sustained winds from Best Track (BT)
(10 min sustained winds compare with satellite resolution)
- SMAP consistent with BT max wind evolution
- ASCAT seems to saturate above 35 m/s in most instances

Rapid intensification captured by SMAP

Super-Hurricane IRMA (Cat. 5 > 70 m/s)



Hurricane MARIA (Cat. 4 > 59 m/s)

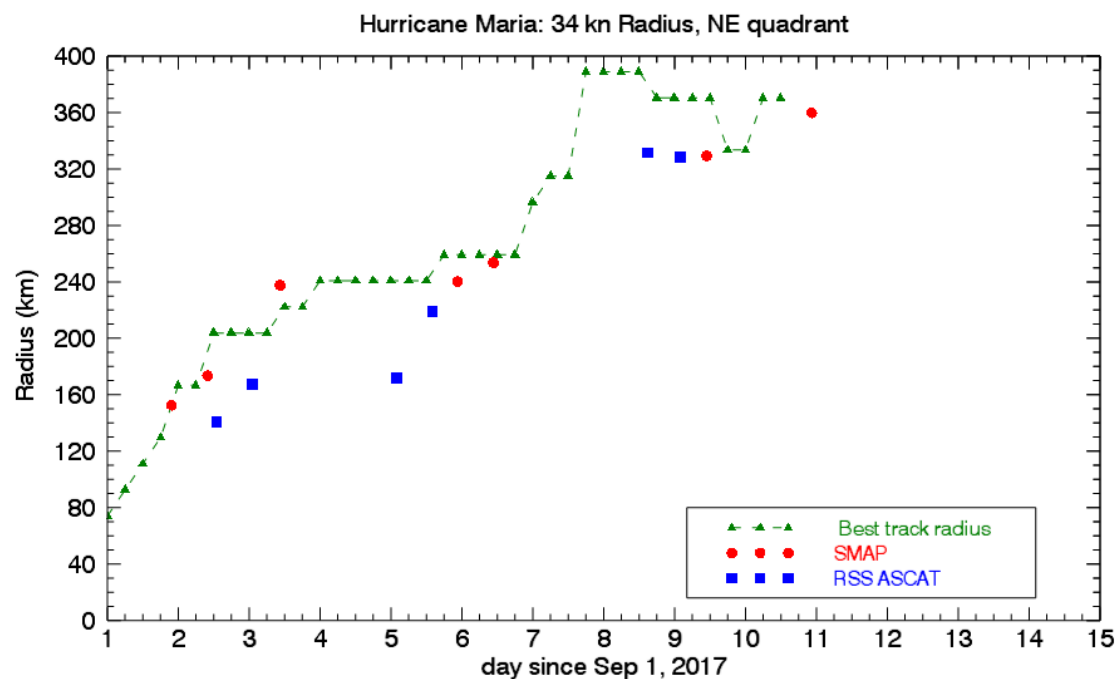




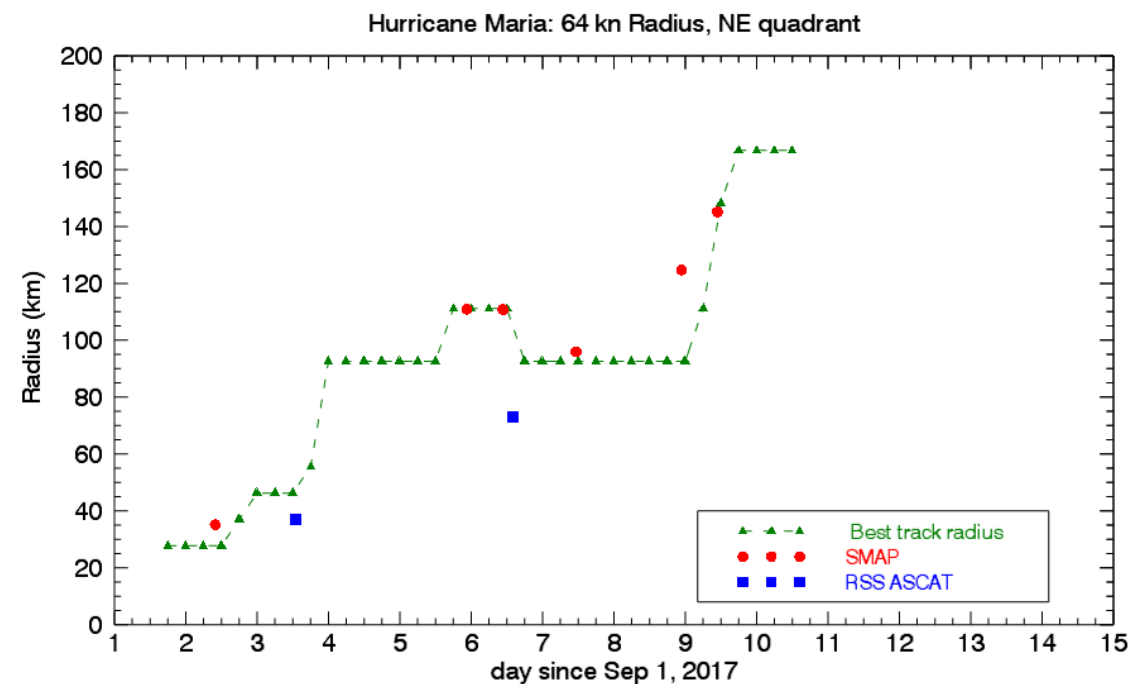
STORM SIZE, SATELLITE VS BEST TRACK DATA

- SMAP and ASCAT both capture storm size at 34kn and 50kn
- At 64kn, SMAP consistently captures storm size
- ASCAT often captures the storm size at 64kn, but not consistently due to its reduced sensitivity.

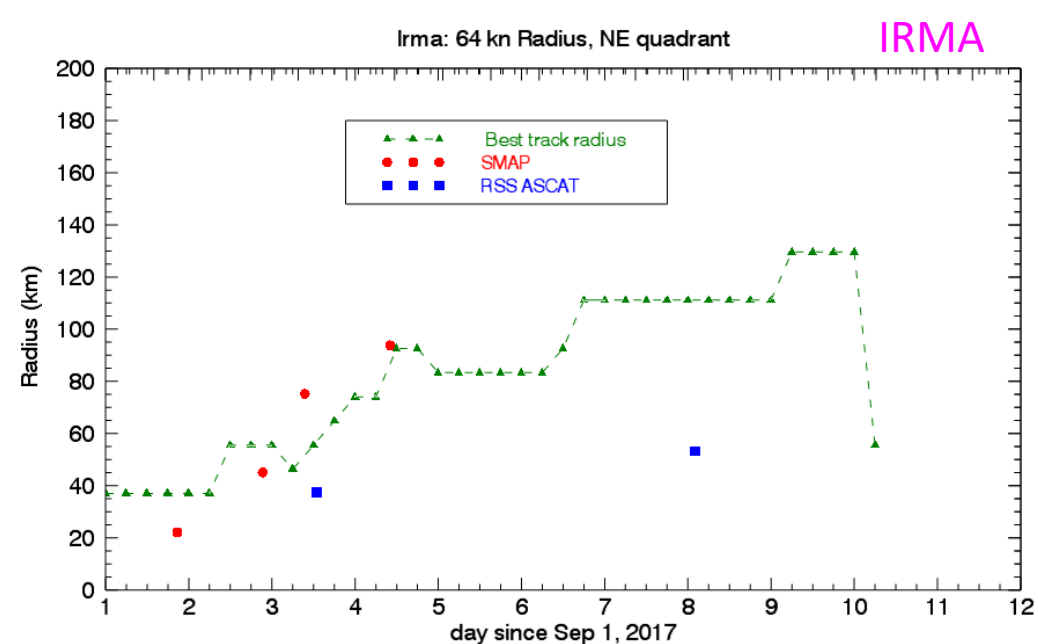
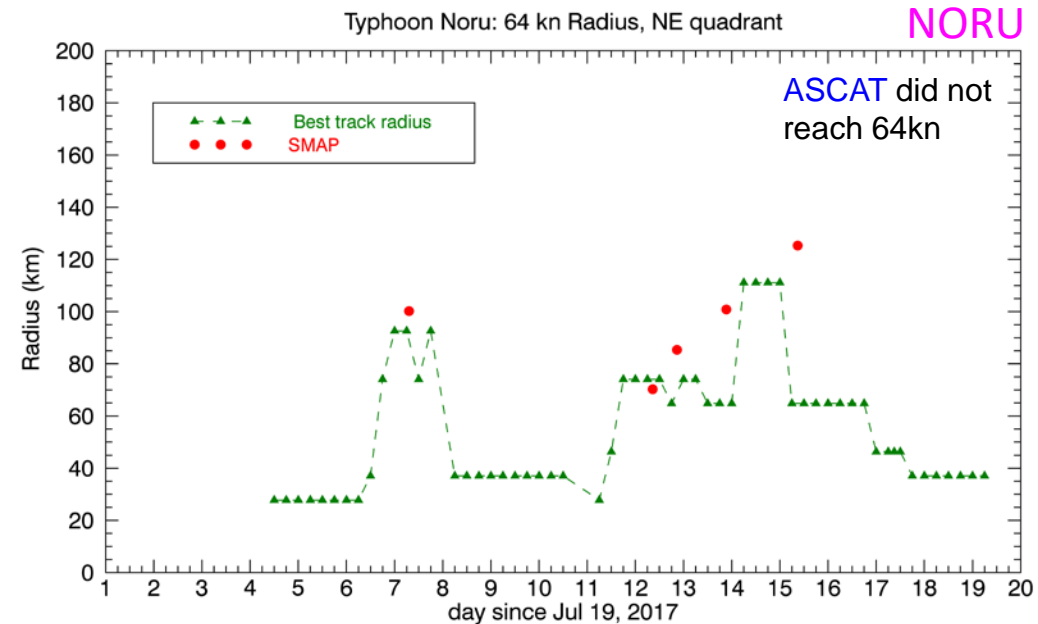
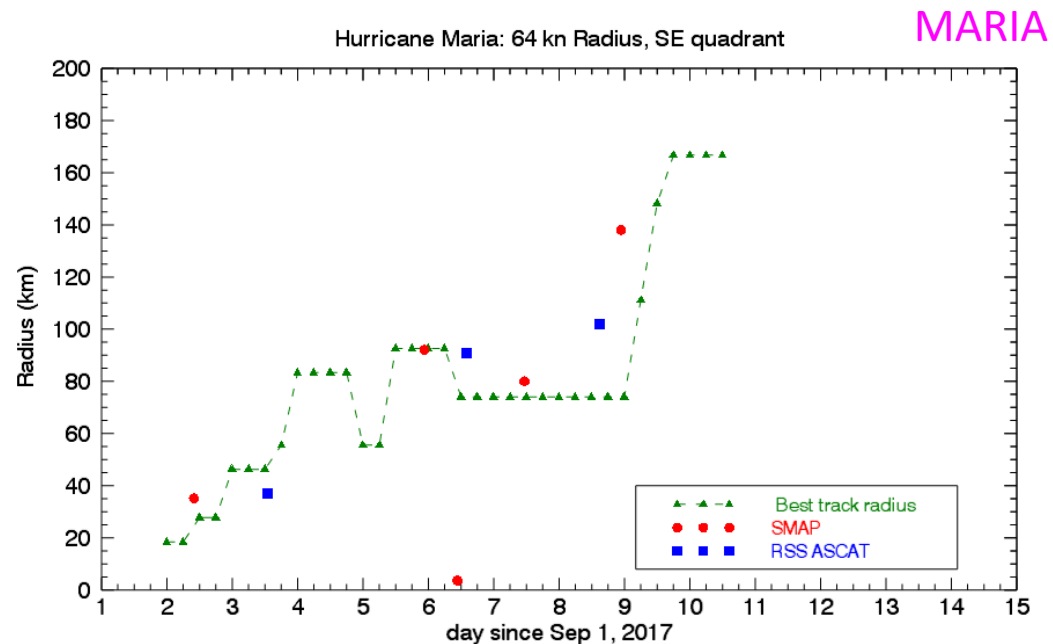
Hurricane MARIA, 34kn radius NE quadrant (17 m/s)

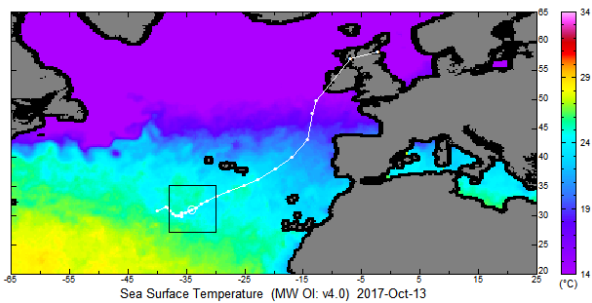


Hurricane MARIA, 64kn radius NE quadrant (34 m/s)

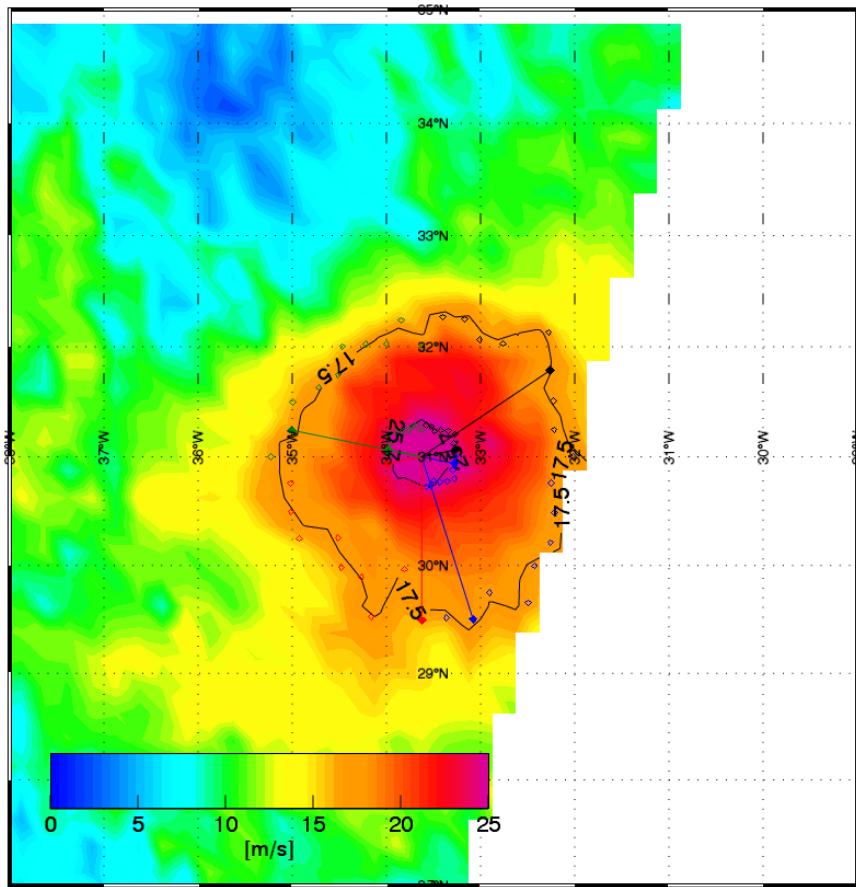


More 64kn Radii for sample storms SMAP, ASCAT vs Best track data

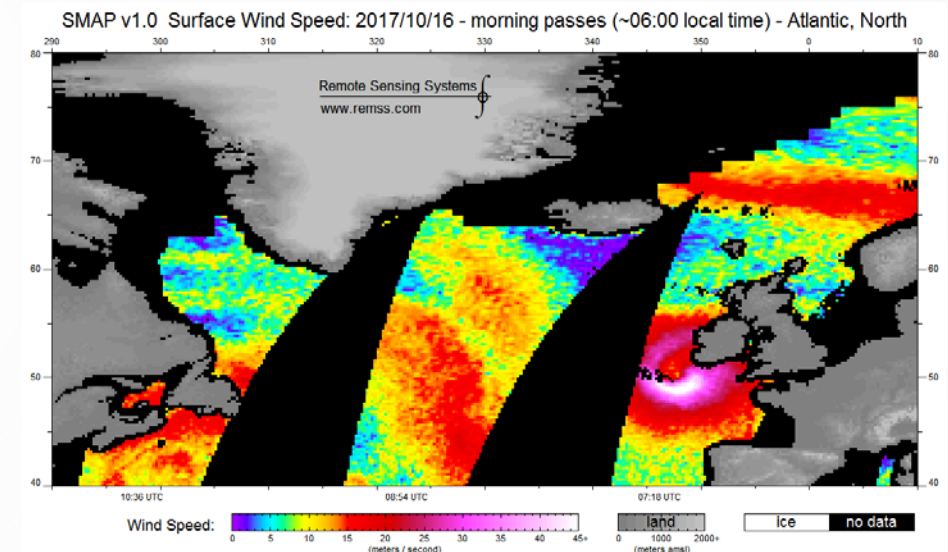




SMAP Wind 2017-10-13 08:48 UTC



OPHELIA

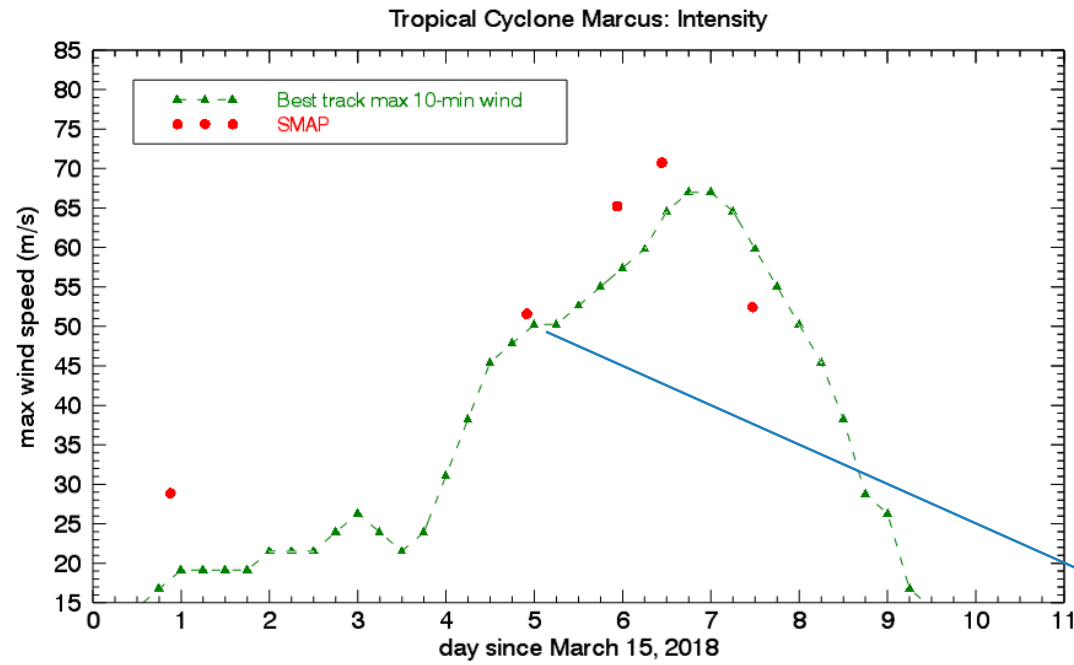


- Easternmost Atlantic hurricane on record
- Mid-October
- Wildfires in Portugal/Spain → 50 casualties
- Transitioned to Extratropical, hit Ireland

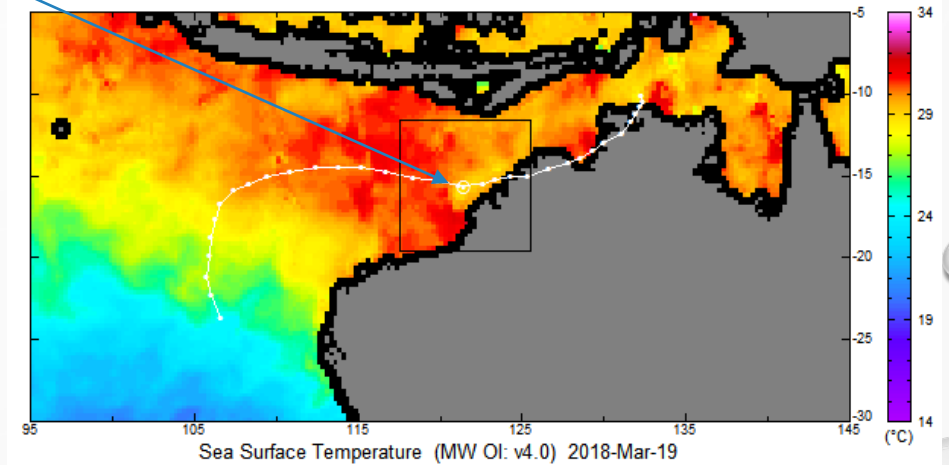
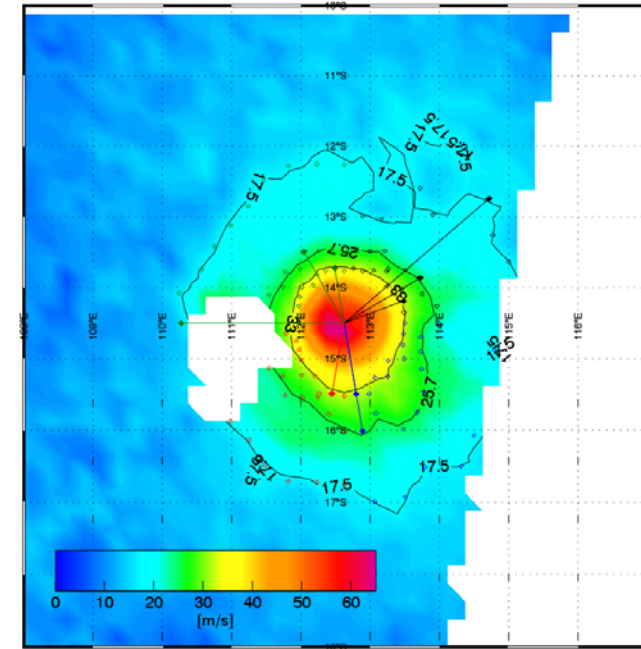
Oct 13, 2017

	SMAP 0848 UTC	Best Track 0600 UTC
Max 10-min wind, kn (m/s)	57 (29)	60 (31)
R34SE (nm)	86	80

MARCUS



SMAP Wind 2018-03-20 22:32 UTC



Data availability:

- Near-Real-Time SMAP winds (L-band radiometer)
- Currently 3 hrs latency. Future: < 2 hrs.
- FINAL product (monthly back-processed)
- Available at www.remss.com/missions/smap
- 0.25 deg twice-daily global maps
- Apr 2015-current.

Validation with SFMR and Best Track winds

- Range: 15 to at least 70 m/s;
- SMAP captures storm size, intensity and rapid intensification up to Cat 5
- Not affected by precipitation, even in heavy rain



(Meissner et al, BAMS Aug 2017)

Very valuable spaceborne sensor for assessing intensity and size of TC especially in remote locations

- Currently used by NRL and JTWC on their ATCF forecasting system

EXTRA SLIDES



MAIN VALIDATION SOURCE FOR HIGH WINDS: SFMR

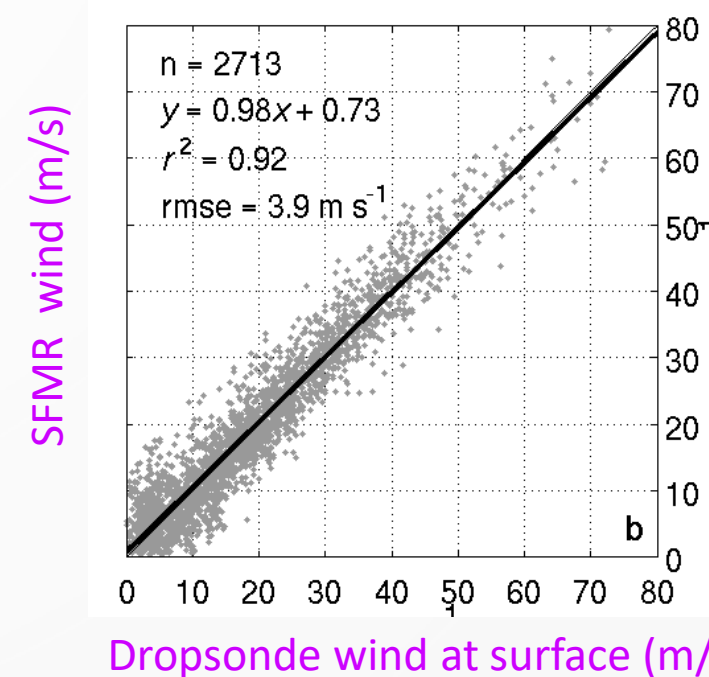
- In situ measurements are indirect and mostly limited to locations close to coastal areas, where **NOAA or US Air Force hurricane reconnaissance aircrafts** are able to fly.
- The most reliable source of validation for satellite hurricane-force winds is from the **Stepped Frequency Microwave Radiometers (SFMR)** mounted on the hurricane hunter aircrafts.
- The SFMRs are themselves validated versus **GPS dropsondes** (wind measurements between flight and surface altitudes).

SFMR winds correlate well with GPS dropsonde wind speeds
No systematic biases. Estimated **accuracy** about **3 m/s**.

SFMR has **not** been used in deriving SMAP wind-emissivity model or Scatterometer backscatter model.
Therefore it provides an **independent** source for validation for satellite winds.



NOAA's Lockheed WP-3D



from: **B. Klotz and E. Uhlhorn, *J. of Atmosph. Ocean. Tech.*, 2014, 41, 2392 – 2408.**

observations between 1999 - 2012

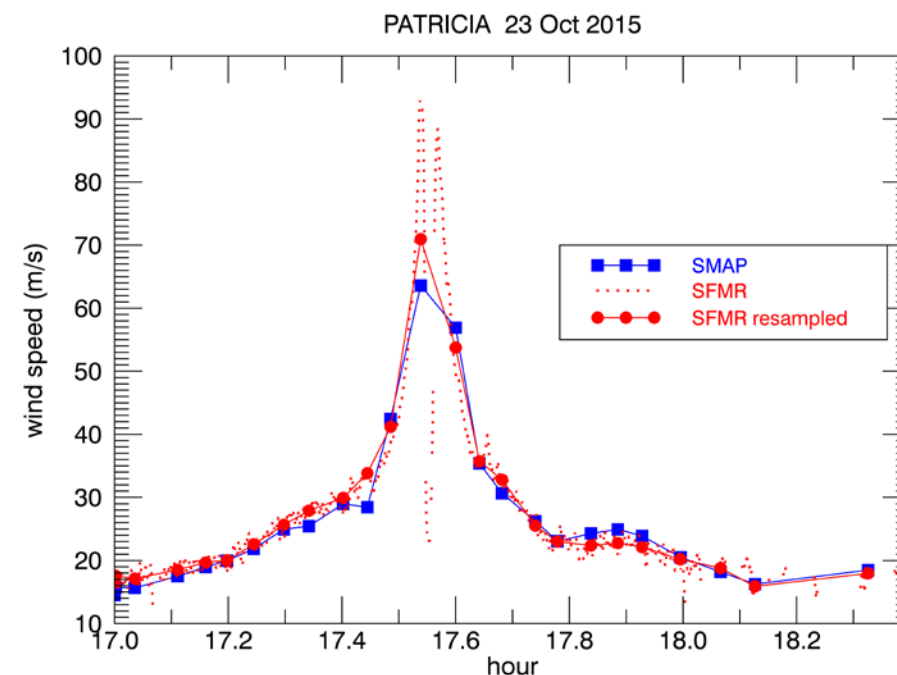
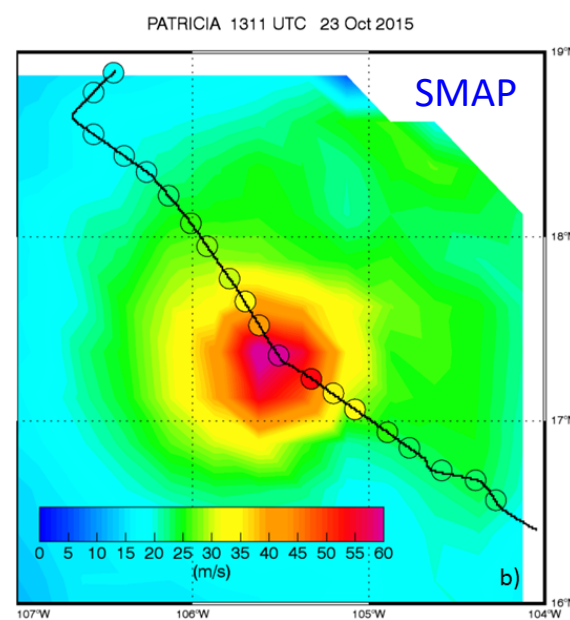
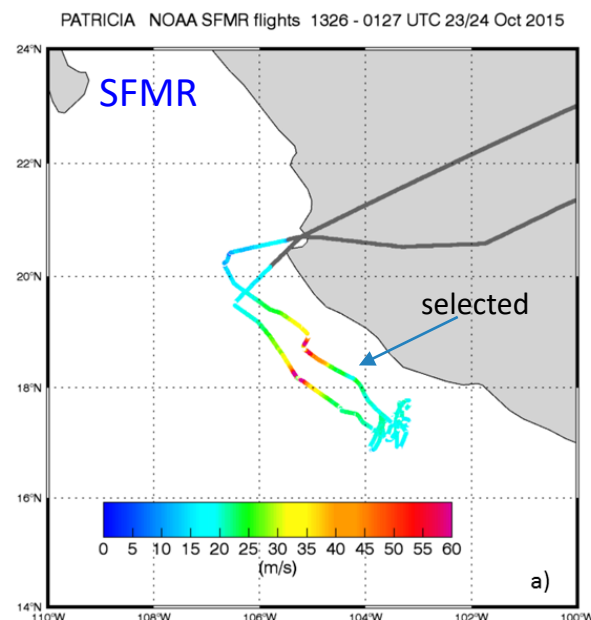
Data available from NOAA AOML HRD http://www.aoml.noaa.gov/hrd/data_sub/

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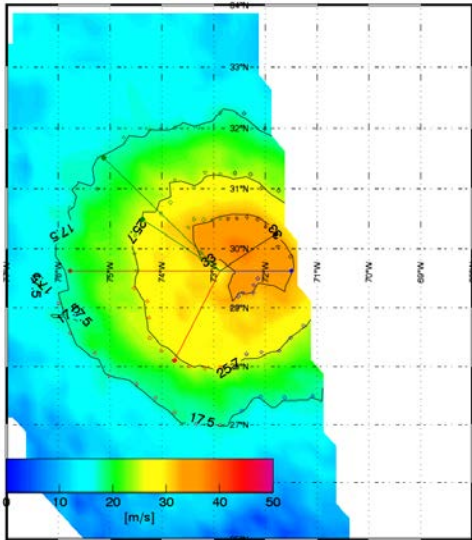


- STEP 5: Resulting overlapping timeseries of SMAP satellite wind and resampled SFMR

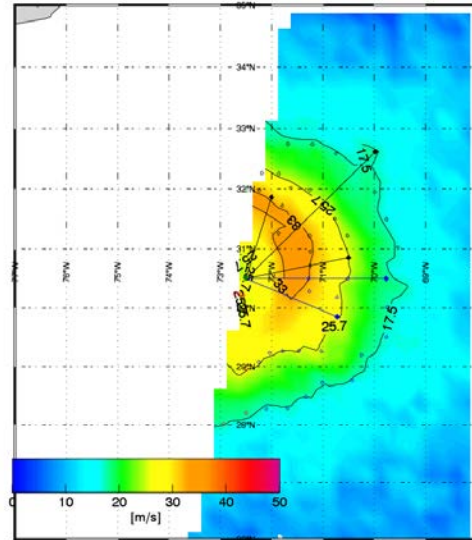


MARIA, DE-INTENSIFICATION

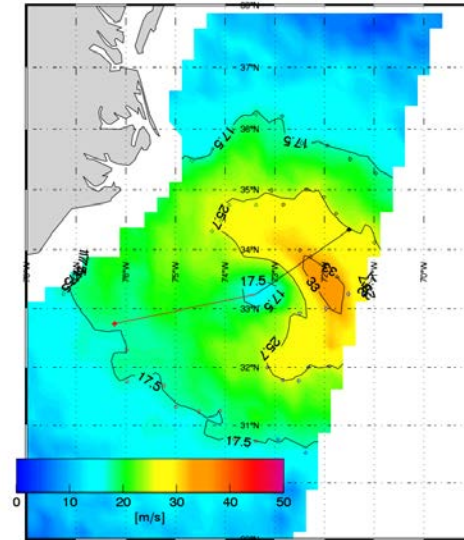
SMAP Wind 2017-09-24 22:49 UTC



SMAP Wind 2017-09-25 10:51 UTC



SMAP Wind 2017-09-26 11:27 UTC



SMAP Wind 2017-09-26 22:26 UTC

