



# Extreme Wind Speed Measurements from NASA's SMAP L-Band Radiometer

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**Barcelona, Spain**



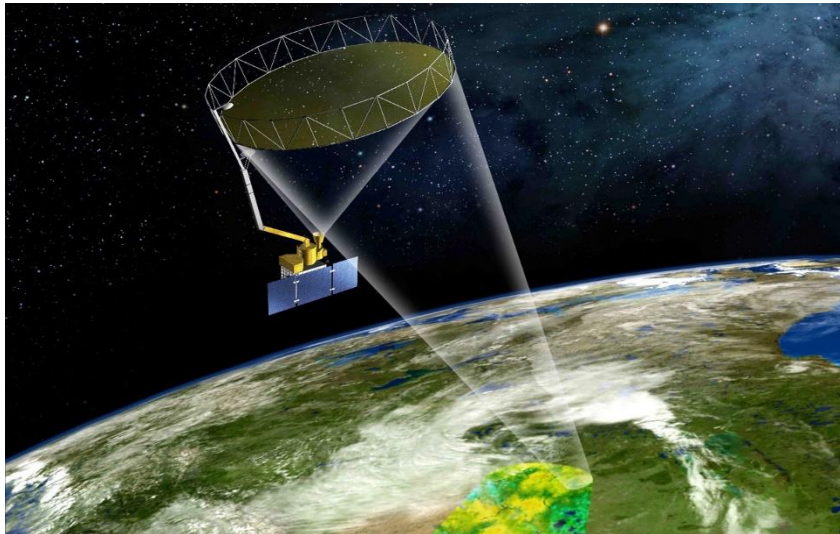
**T. Meissner, L. Ricciardulli + F. Wentz:  
BAMS August 2017.**



# NASA SMAP (Soil Moisture Active + Passive)

Taking observations since April 2015

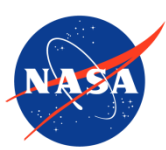
Ocean Products: Sea Surface Salinity + Wind Speed



- Frequency 1.41 GHz (L-band)
  - In line with SMOS (ESA) + Aquarius (NASA)
- Polar Orbit @ altitude: 685 km.
- 8-day repeat.
- Local ascending/descending time: 6 PM/AM.

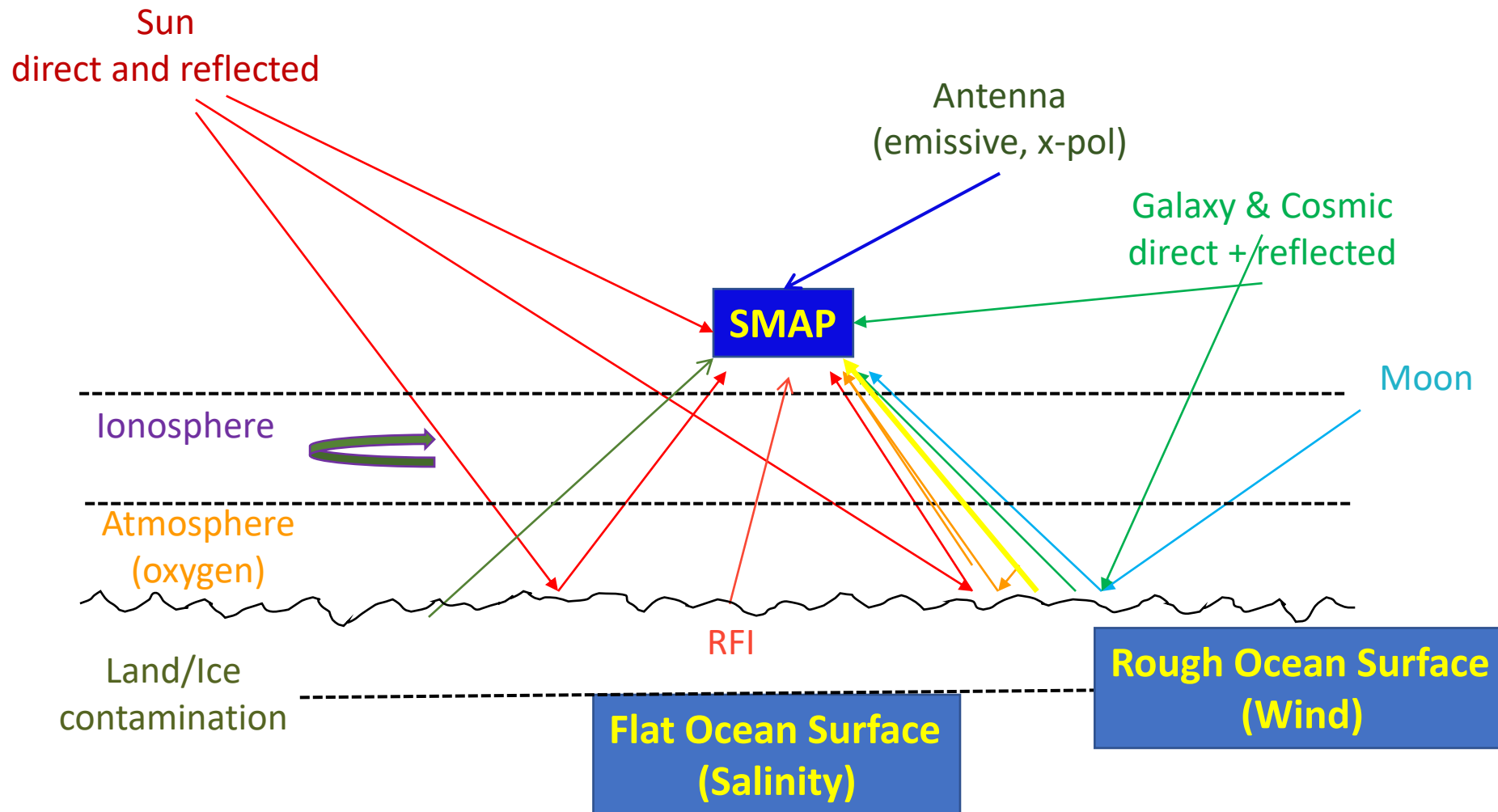


- Full 360° conical scan views the Earth.
- 6-meter mesh antenna.
- 1000 km wide swath.
- **3-dB (half power) footprint size: 40 km.**
- **2 polarizations: V + H**



# Signals Received by the SMAP Sensor

Challenge: Many sizeable spurious signals other than wind + salinity

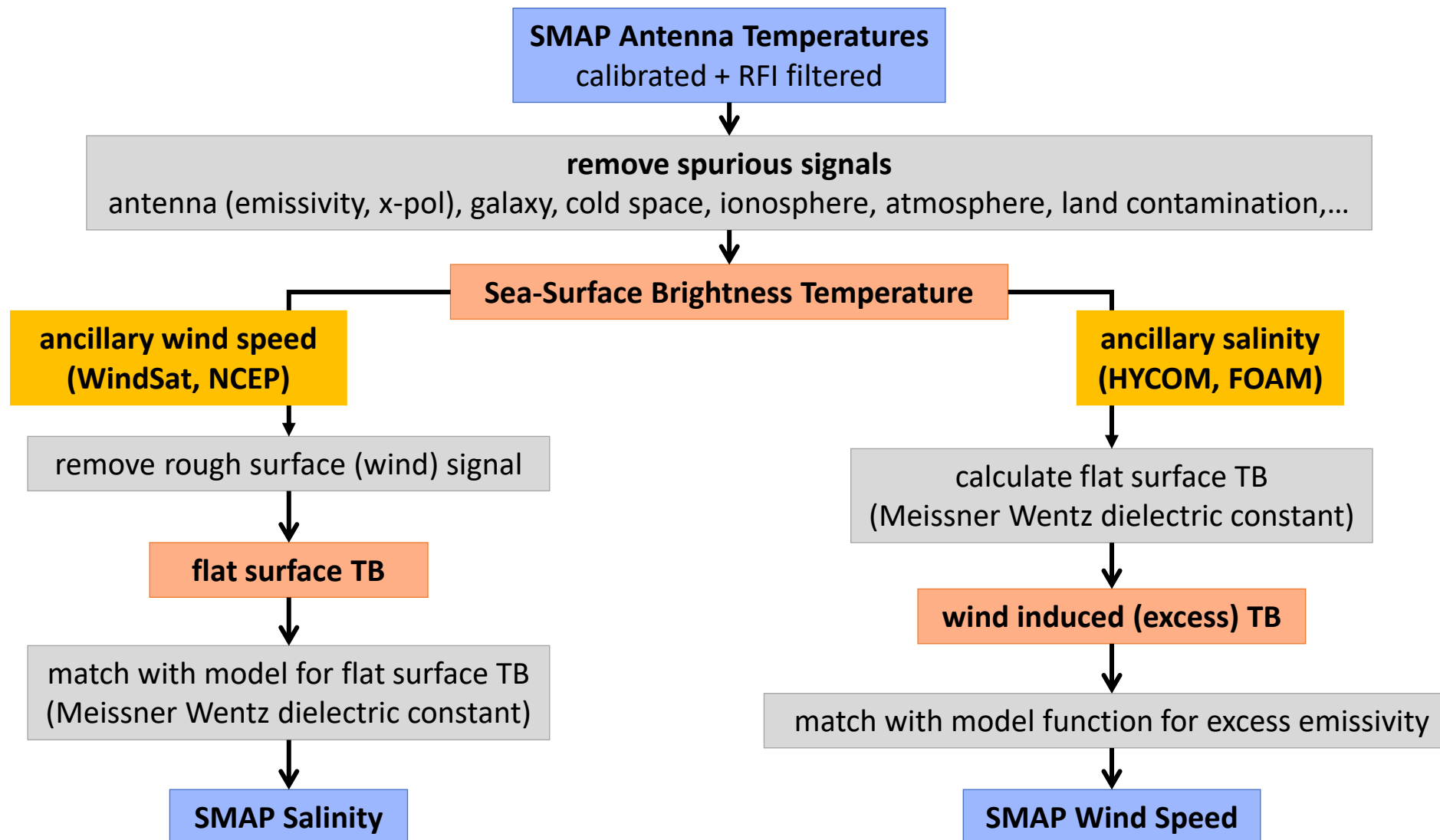




# Algorithms for SMAP Salinity + Wind Speed

There is not enough information in the two SMAP (V-pol/H-pol) channels for simultaneous retrievals of both parameters.

Two separate algorithms are needed with different ancillary input.

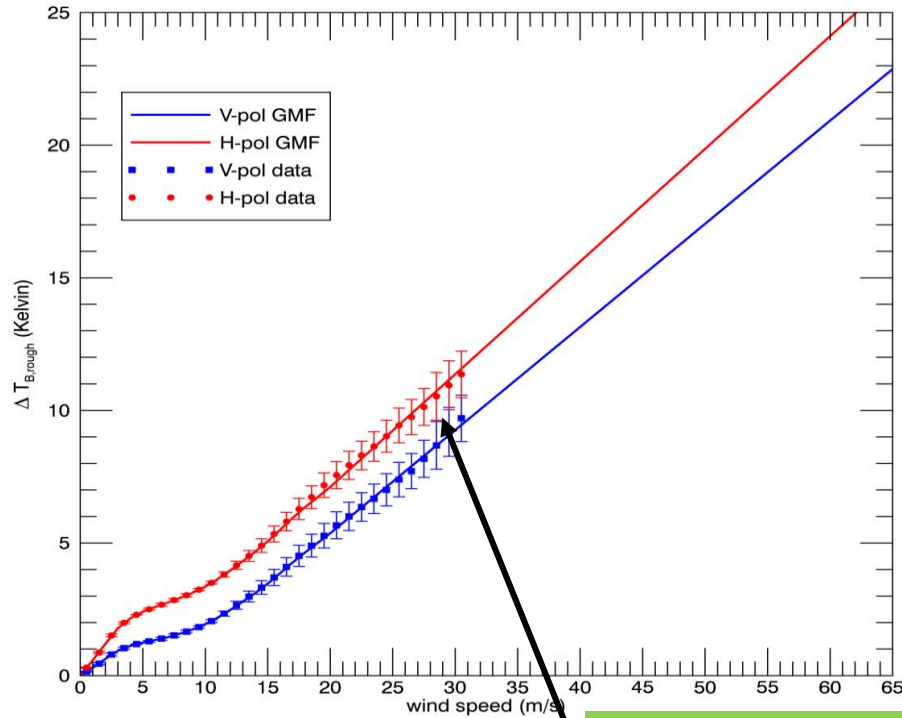


## Signal at L-Band

Wind response = Wind induced (excess) emissivity  $\Delta T_B = T_{B \text{ rough}} - T_{B \text{ flat}}$   
Above 10 m/s: Sea foam

### Signal

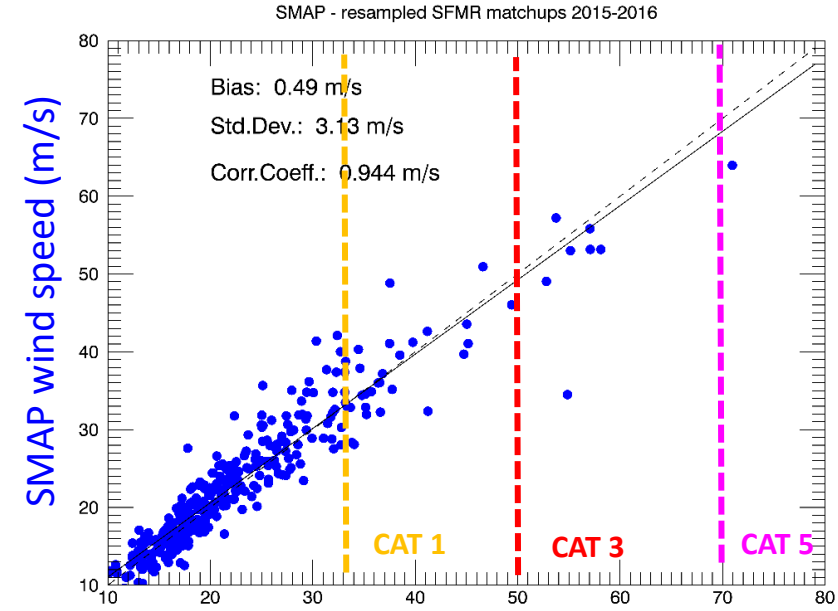
$\Delta T_B$  (kelvin)



Wind speed (m/s)

keeps good sensitivity even at very high wind speeds

### Validation: SMAP vs SFMR (resampled)



SFMR wind speed (m/s) resampled to SMAP spatial resolution

- Very good **SMAP-SFMR** agreement 10-70 m/s.
- Accuracy ~ 10%
- L-band radiometer signal does not saturate at high winds.
- No rain impact.



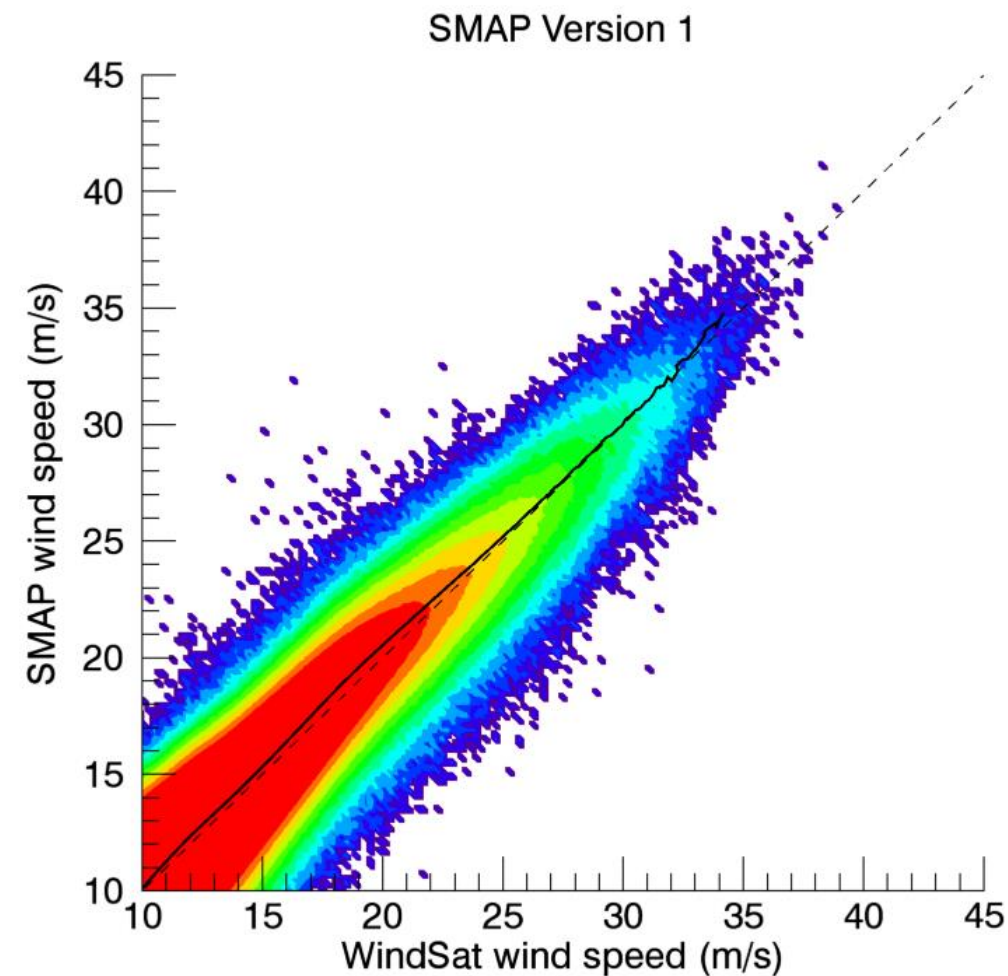
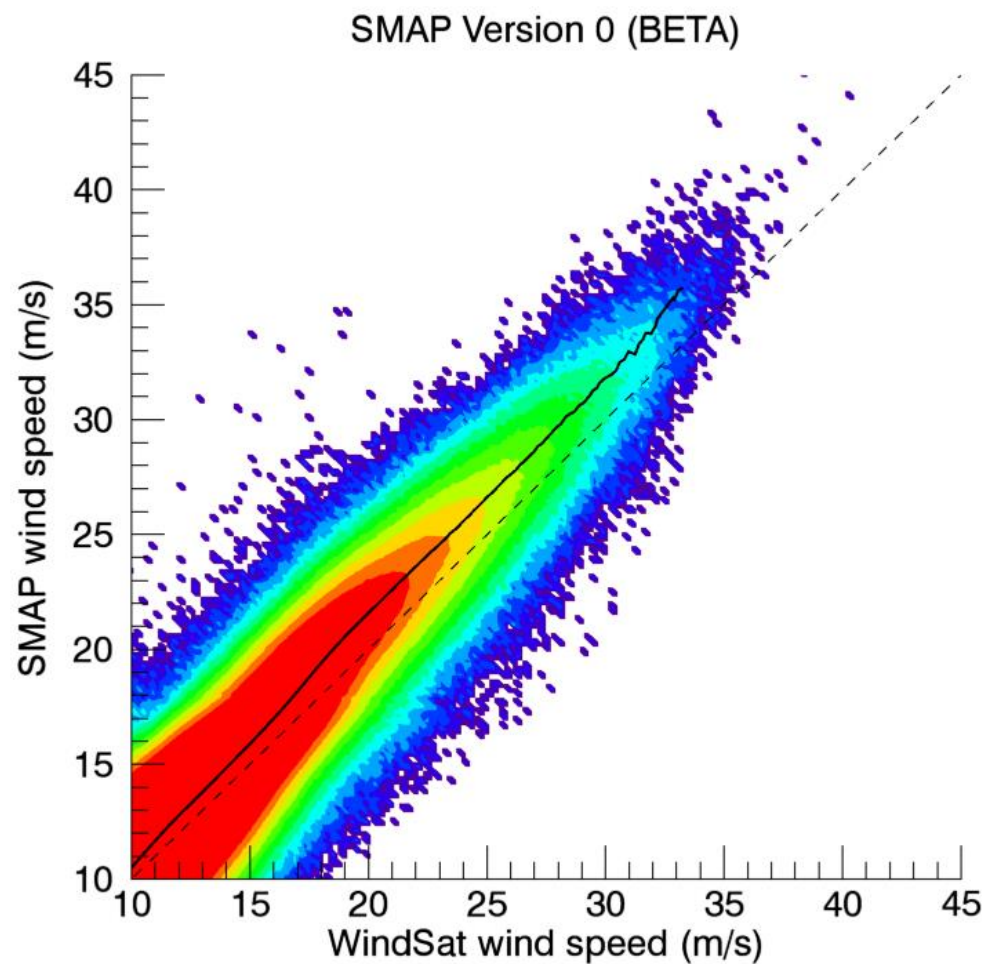
# Version 1.0 Release

## February 2018. Supersedes BETA (V0).

1. Improved flagging for land and sea ice.
2. SST dependence of wind induced emissivity model.
  - Had been neglected in BETA release.
  - In Version 1 we use the same SST dependence as for Aquarius End of Mission (Version 5) salinity algorithm.
  - Steeper slope = lower wind speeds (by about 6%) in cold water (extratropical cyclones) compared to BETA release.
  - Little change in warm water (tropical cyclones) compared to BETA release.
3. Handling of river plumes.
4. Ancillary salinity input.

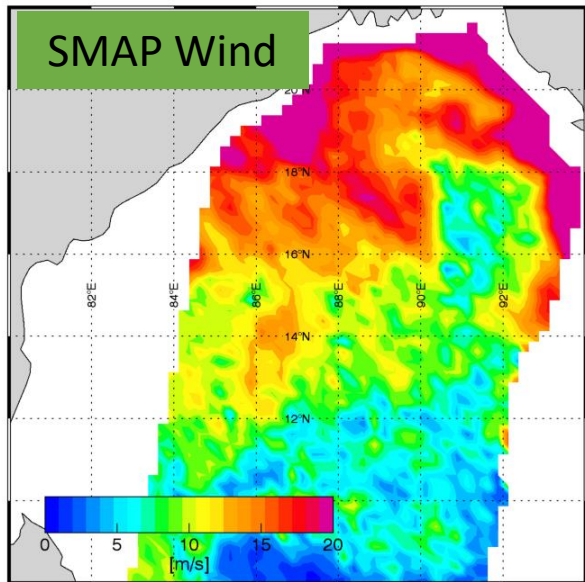


# SMAP versus WindSat



Validation with oil-platform anemometers (see following talk by L. Ricciardulli)

Better match with WindSat high winds in Version 1.



# River Plumes

## Example: Gulf of Bengal

### Version 0 (BETA):

Uses HYCOM as ancillary salinity input.

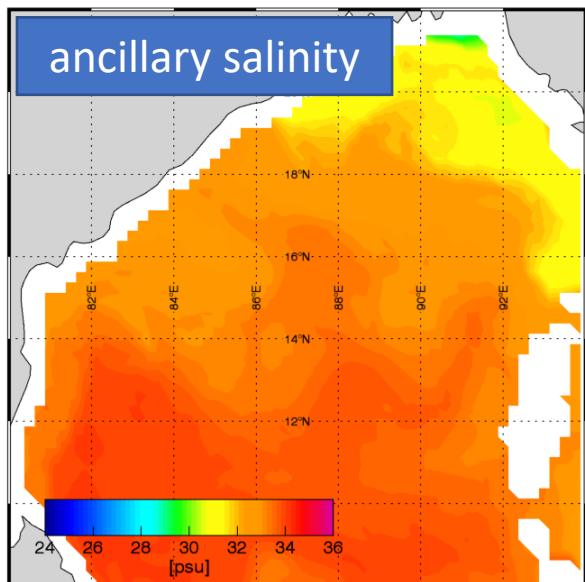
Misses strong freshening from Ganges outflow.  
Results in unrealistic high wind speeds.

### Version 1:

Uses SMAP 8-day salinity average as ancillary salinity input.

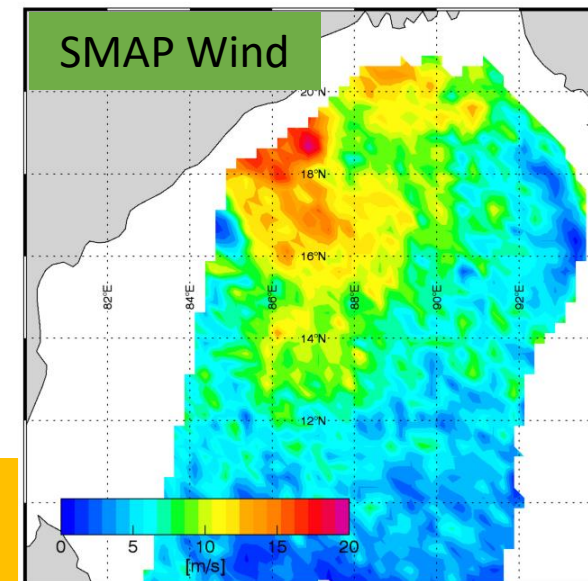
Captures strong freshening from Ganges outflow.  
Realistic wind speeds.

2017 11 16 HYCOM forecast SSS (8-day average)

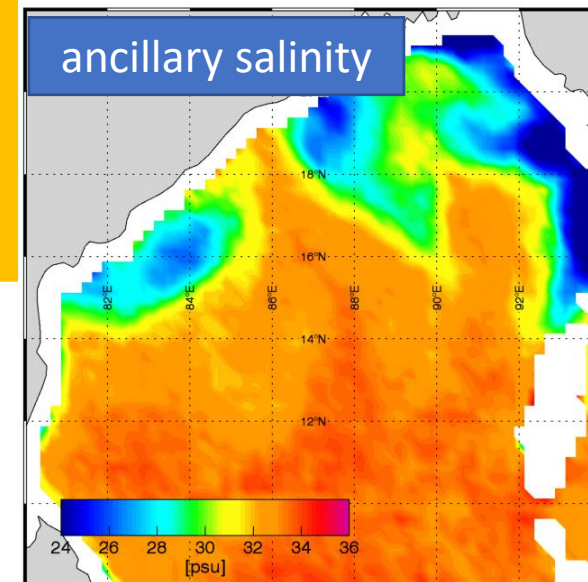


### Rain freshening?

This is not an issue for high winds (> 15 m/s) in rain, because the upper ocean layer mixes.



2017 11 16 SMAP SSS (8-day average)

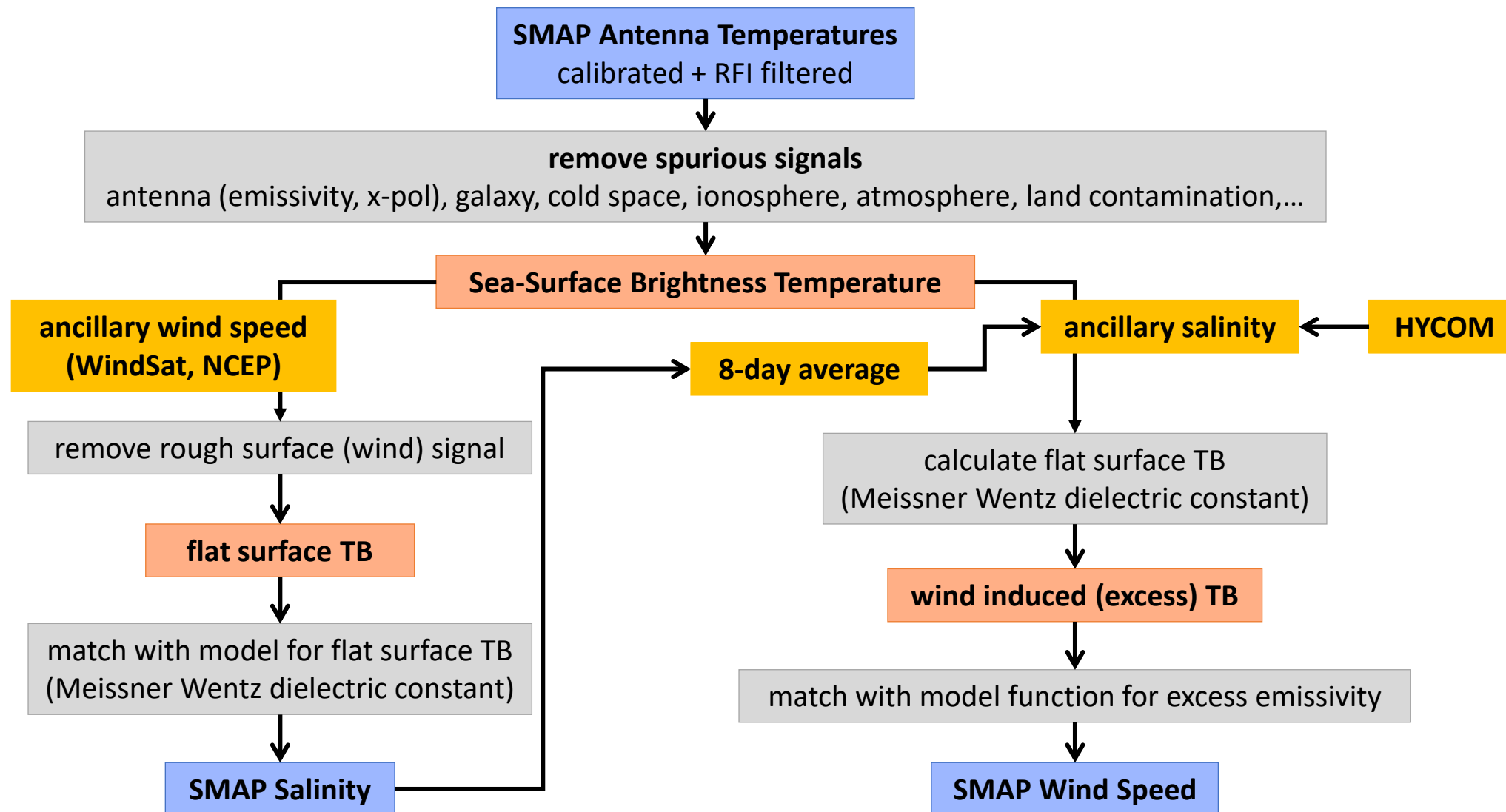


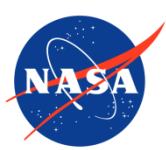


# Algorithms for SMAP Salinity + Wind Speed



We cannot use the SMAP salinity directly in the SMAP wind retrieval. However, it is possible to use an 8-day averaged SMAP salinity in the SMAP wind retrievals. Salinity changes very little within 8 days. Wind speed is very variable.





# Version 1.0 Release

## Processing Streams

### 1. Near-Real Time (NRT).

- Aimed for tropical cyclone forecast community.
- As soon as SMAP measurements (antenna temperatures) become available.
- Currently: About 3-hours latency.
- Plan to further cut it to less than 2 hours using shortcut in SMAP ephemeris processing.
- Uses static climatology ancillary salinity input (salinity, atmosphere,...)
- Masks river plumes (Amazon, Ganges, Congo, ...) = areas with large salinity variations.

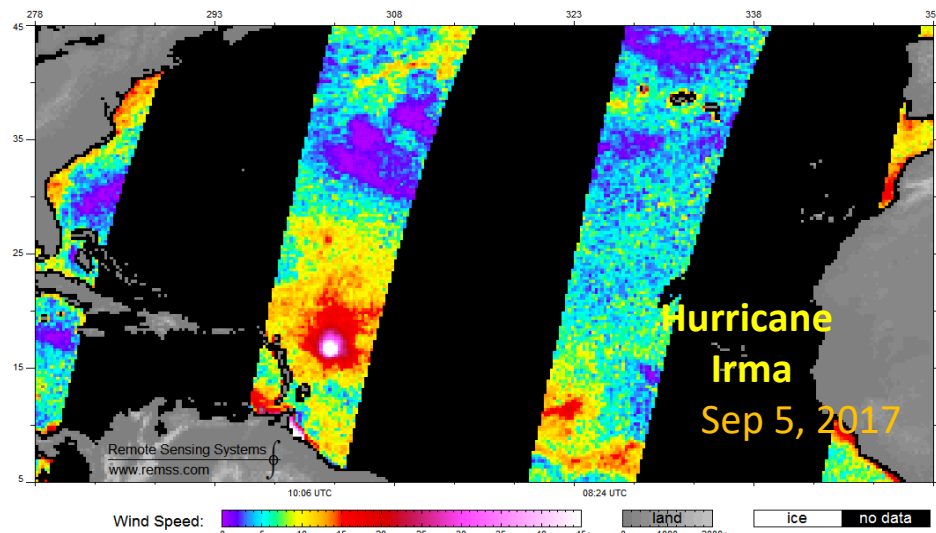
### 2. Final product.

- Back processed about twice a months.
- Uses high-quality dynamic ancillary input.
- E.g.: SMAP 8-day salinity average.

**Wind speed range: 12 – 70 m/s**

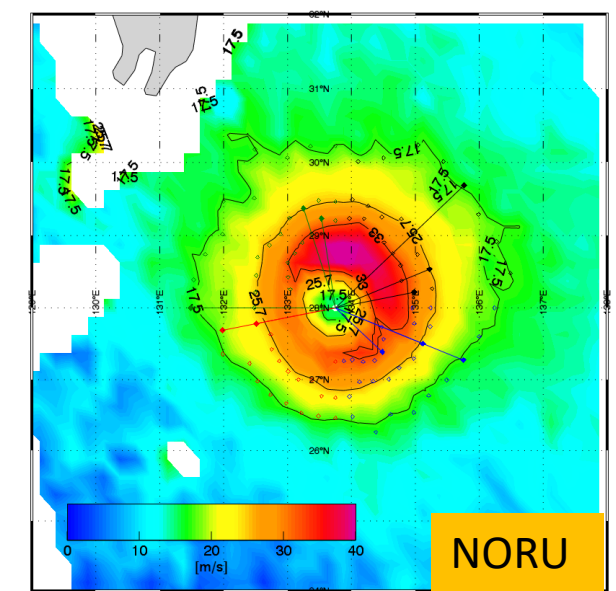
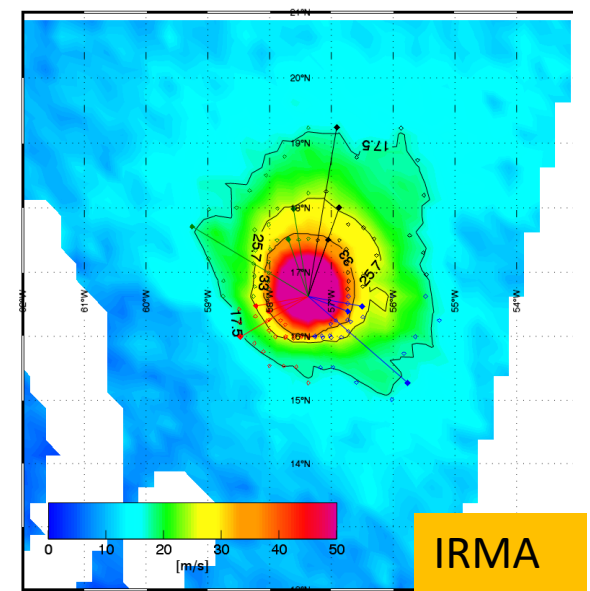
# Data Products and Distribution @ RSS

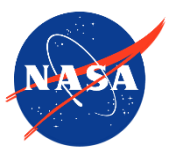
- [www.remss.com/missions/smap/](http://www.remss.com/missions/smap/)
- **Level 3 daily maps**
  - Separate for ascending (PM) and ascending (AM) swaths.
  - Spatial sampling: 0.25°.
  - Actual spatial resolution: 40 km.
  - netCDF4.
  - NRT and Final.
- **Storm intensity + size for TC**
  - TC Images.
  - ASCII files containing intensity and the 17.5 m/s, 25 m/s, 33 m/s radii.
  - ingested into the Automated Tropical Cyclone Forecast (ATCF) system
  - **used by NRL (US Navy) + by the Joint Typhoon Warning Center.**
  - We plan to extend it to extra-tropical storms.



SMAP Wind 2017-09-05 10:06 UTC

SMAP Wind 2017-08-03 08:52 UTC



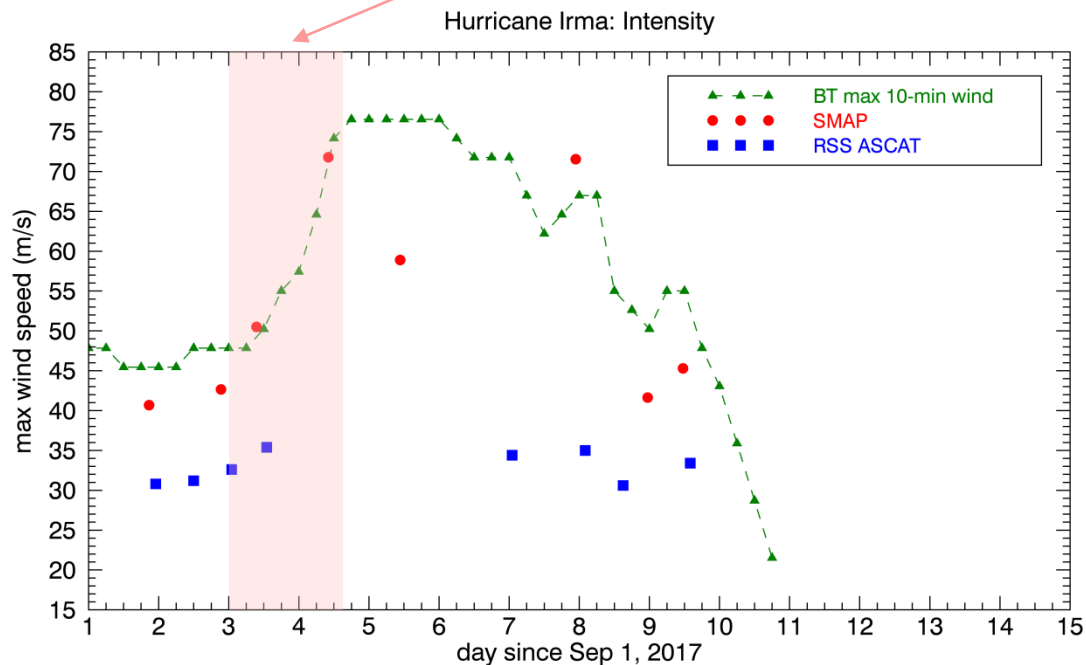


# Storm Intensity Evolution vs Best Track Data

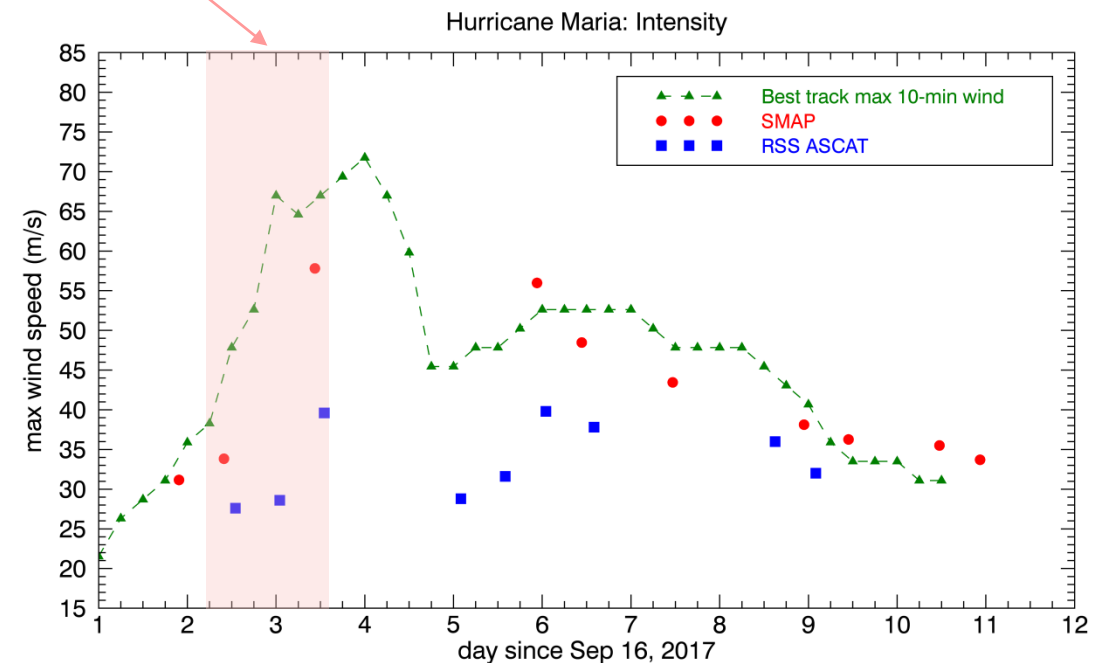
- Max intensity of satellite winds compared to 10-min sustained winds from Best Track
- SMAP consistent with BT max wind evolution
- ASCAT saturates above 35 m/s in most instances.

## Rapid intensification captured by SMAP

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



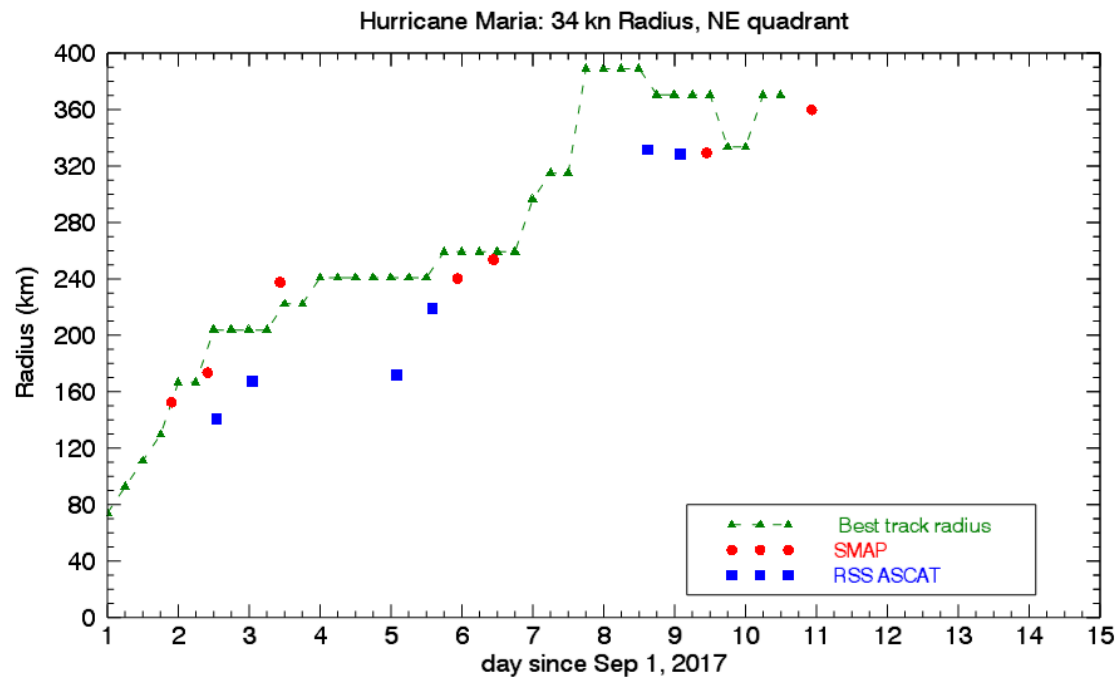
### Hurricane MARIA (Cat. 4 > 59 m/s)



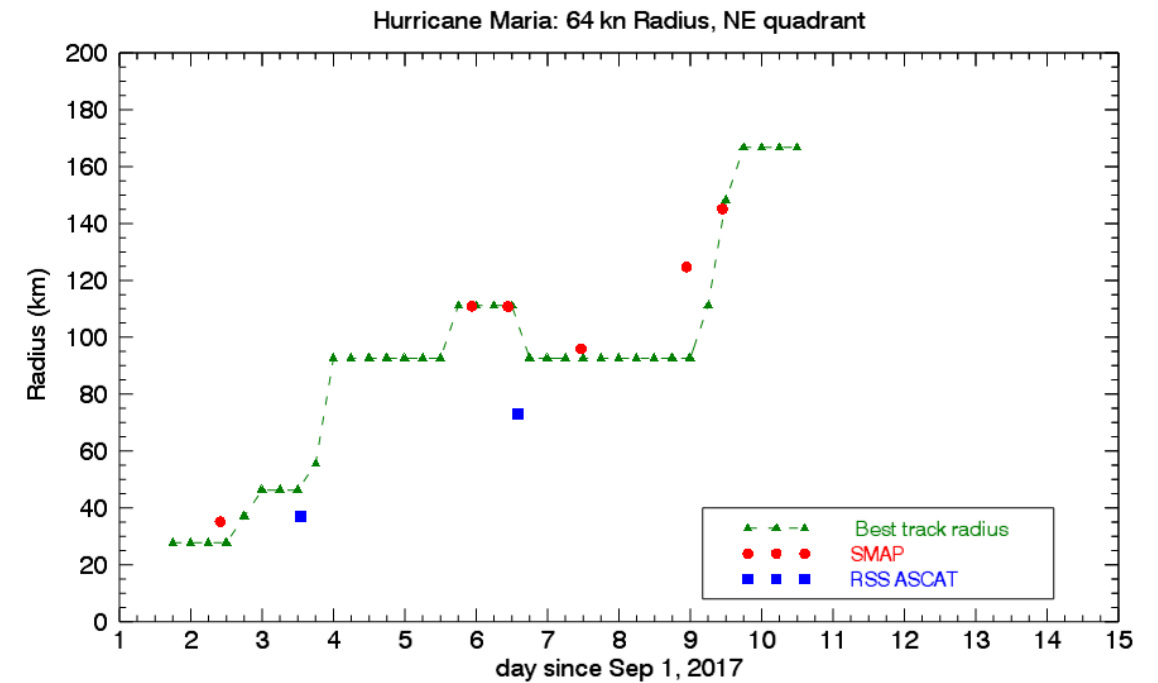
# Storm Size Evolution vs Best Track Data

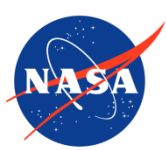
- SMAP and ASCAT both capture storm size at 34kn and 50kn
- At 64kn, SMAP consistently captures storm size
- ASCAT often captures the storm size at 64kn, but not consistently due to its reduced sensitivity.

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

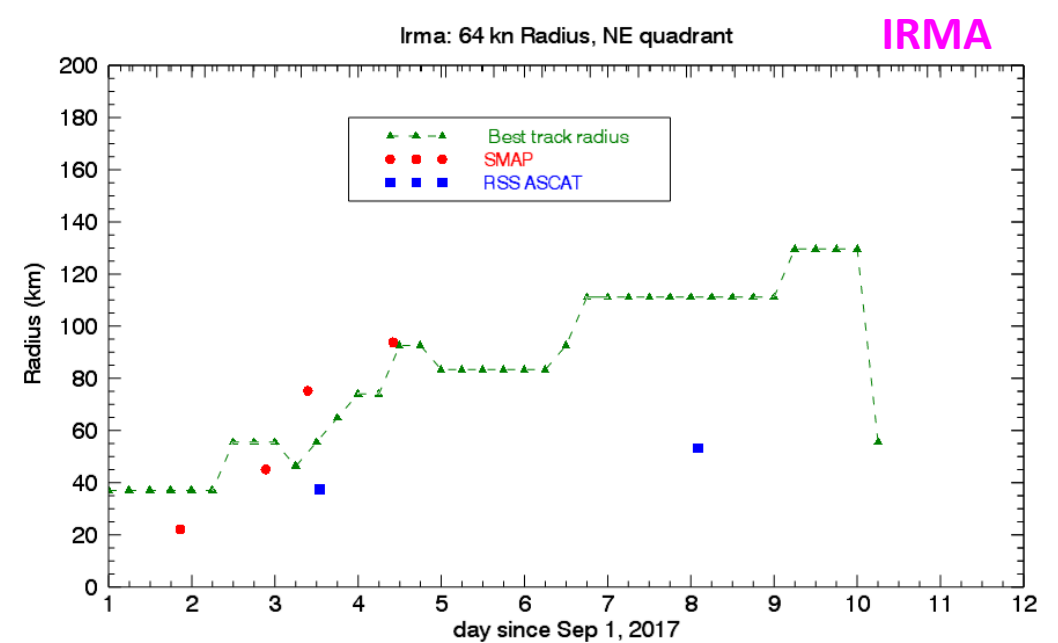
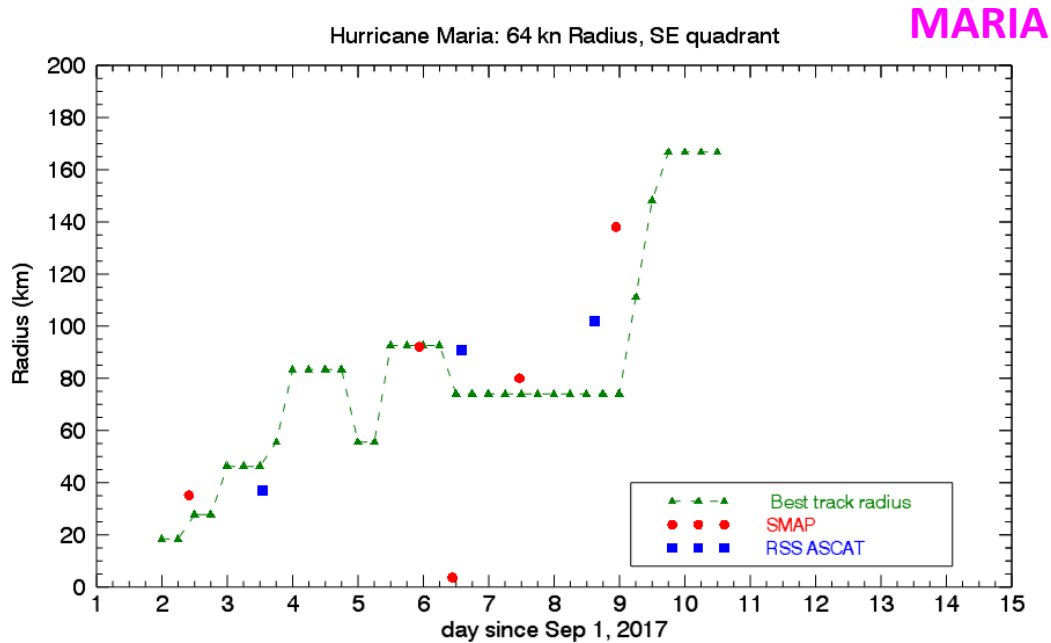
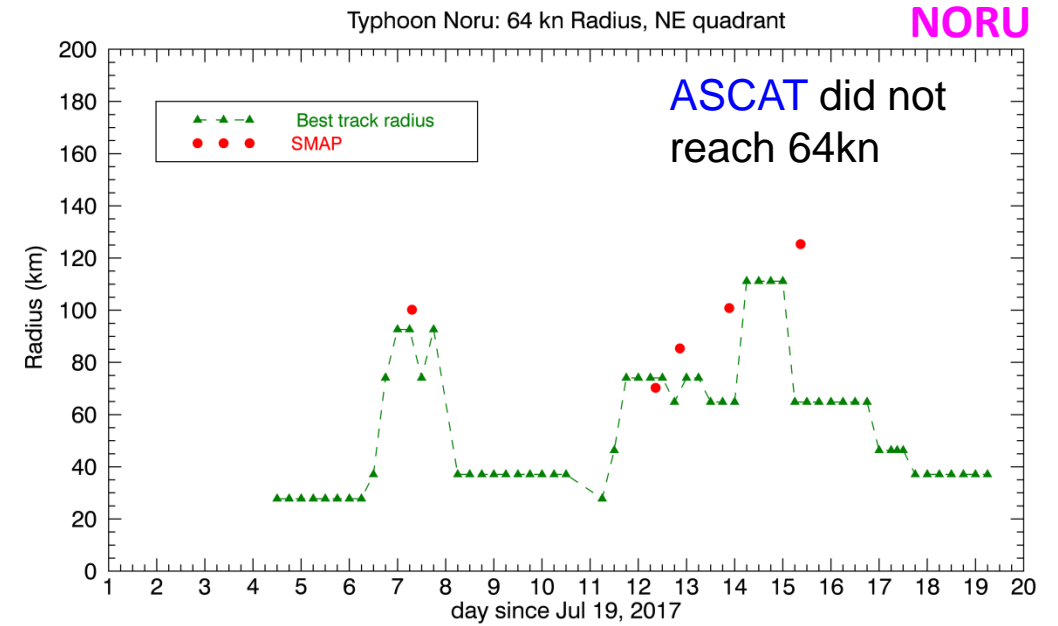


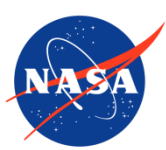
Hurricane MARIA, 64kn radius NE quadrant (33 m/s)





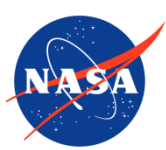
# More 64kn Radii for sample storms SMAP, ASCAT vs Best track data





# Summary

- **RSS SMAP Version 1** released Feb 2018
- **Near Real Time** and **Final** processing.
- Ancillary salinity input becomes important in river plume areas, corrects winds.
- Good match with WindSat in extratropical cyclones.
- **Validated against SFMR** in TC.
- **Very good agreement with Best Track** data of intensity and size of TC.
- **Realistic assessment of Rapid Intensification** of TC between 12 - 70 m/s.
- We plan to use SMAP winds for validation and geophysical model function tuning at high winds (CYGNSS, ASCAT, ...).
  - Much easier to use than collocating with SFMR.



# Extra Slides

### Super-Typhoon NORU (Cat. 5)

