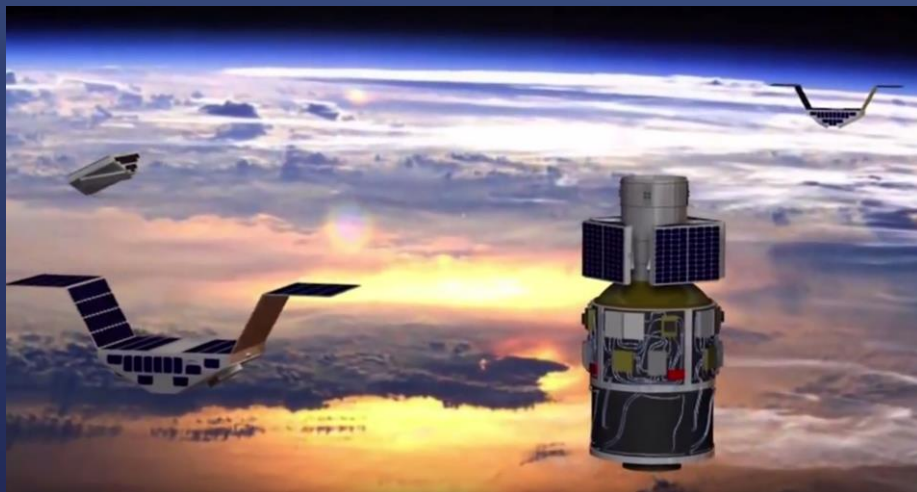




# VALIDATION OF CYGNSS WINDS USING MICROWAVE SCATTEROMETERS/RADIOMETERS

Lucrezia Ricciardulli, Thomas Meissner and Frank Wentz  
*Remote Sensing Systems, Santa Rosa, CA, USA*



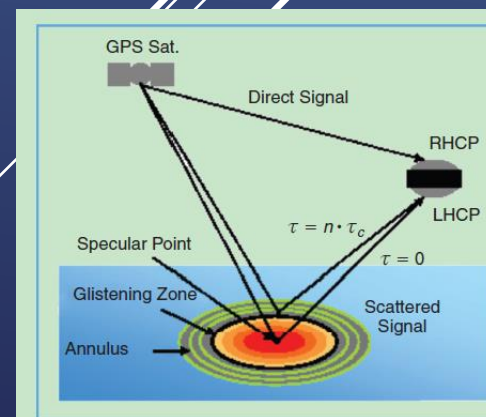
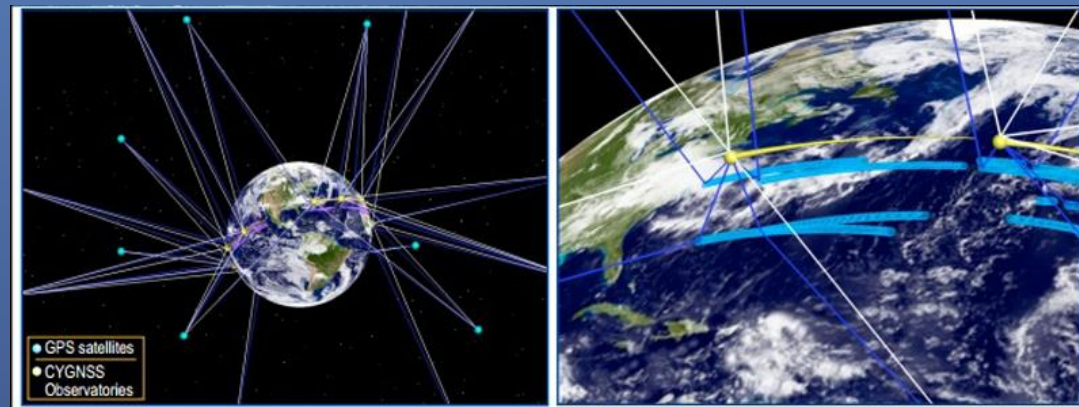
Acknowledgements: This work is supported by the NASA OVWST and SMAP Science



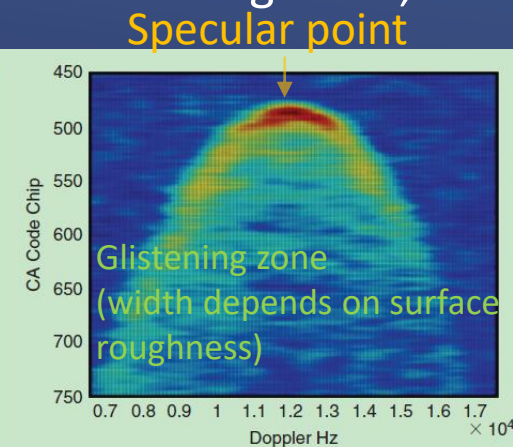
# CYGNSS

## Cyclone Global Navigation Satellite System

- Mission launched Dec 2016
- Objective: New approach to reduce cost and gather more data in **tropical cyclones**.
- PI: Chris Ruf, University of Michigan Ann Arbor
- 8 LEO micro satellites: Use GPS technology to measure wind speed in the tropics (40NS)
- GPS bi-static scatterometry measures ocean surface winds at all speeds and under all levels of precipitation.
- The direct signals pinpoint S/C positions, while the reflected signals respond to ocean surface roughness, from which wind speed is retrieved.
- Observations by Doppler Delay Mapping:
  - CYGNSS satellites collect direct GPS signal (L-band) and signal scattered off the ocean surface around specular points.



(a)



(b)

# SCIENCE DATA RELEASE HISTORY:

Launch: Dec 2016

Version 1.1: June 2017 (beginning of Hurricane season): Significant calibration issues

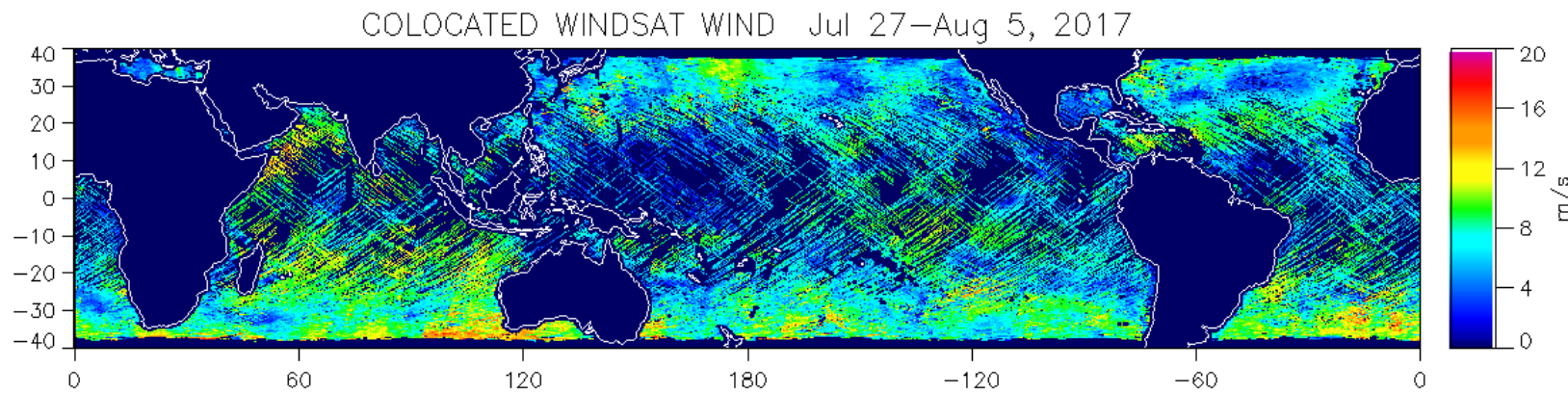
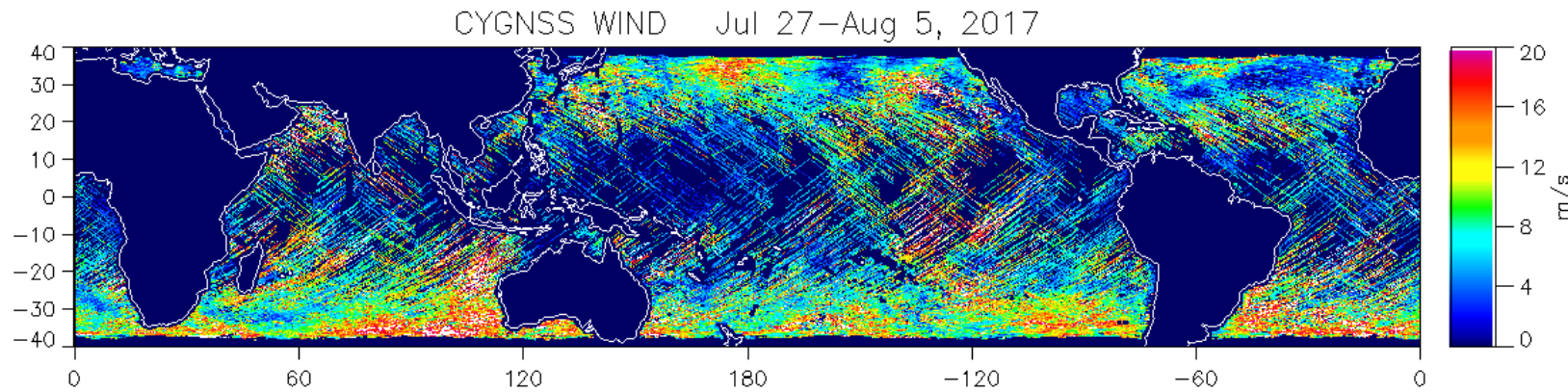
Version 2.0: December 2017: Quality improved but not yet sufficient for reliable TC observations

- Some errors were fixed
- Changes in Quality Control/Flagging
- Possibly different GMF

Version 2.1: To be released before summer: Major calibration improvements expected

# VERSION 1.1: FIRST LOOK, SEP/OCT 2017

10-day average of colocations with WindSat



In CYGNSS V1.1, higher winds are on average higher than WindSat


CYGNSS V1.1

Major biases at high winds, poorly intercalibrated individual receivers

WindSat  
(3 hr colocations shown)

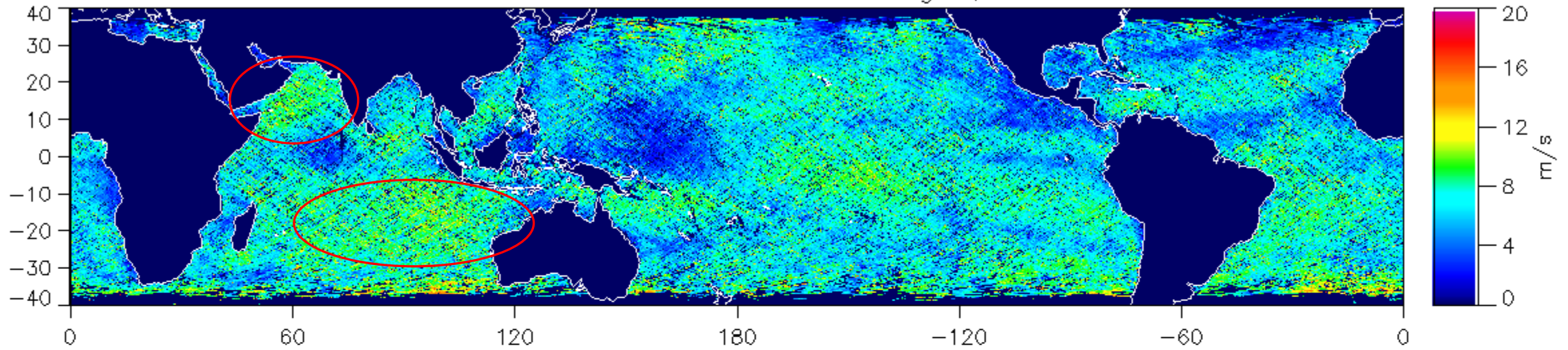
# RSS Analysis of CYGNSS V2.0 vs SMAP and ASCAT

## METHOD

- We collocated CYGNSS vs SMAP and vs ASCAT within 60 minutes
  - Used CYGNSS V2.0 Level 3 (L3) complete dataset, from March 2017 to mid February 2018
  - ASCAT was rain flagged using scatterometer rain flag
  - SMAP data is not rain flagged because is not affected by rain
  - We found about 5 million collocations with SMAP, 8 millions with ASCAT
  - At very high winds  $w > 20$  m/s, we found 4500 collocations with SMAP.
  - Note: SMAP winds below 15 m/s are not as accurate as ASCAT
  - The strength of SMAP retrievals is for  $w > 15$  m/s, up to 70 m/s
  - Statistical analysis of biases, and analysis of some sample storms
- 

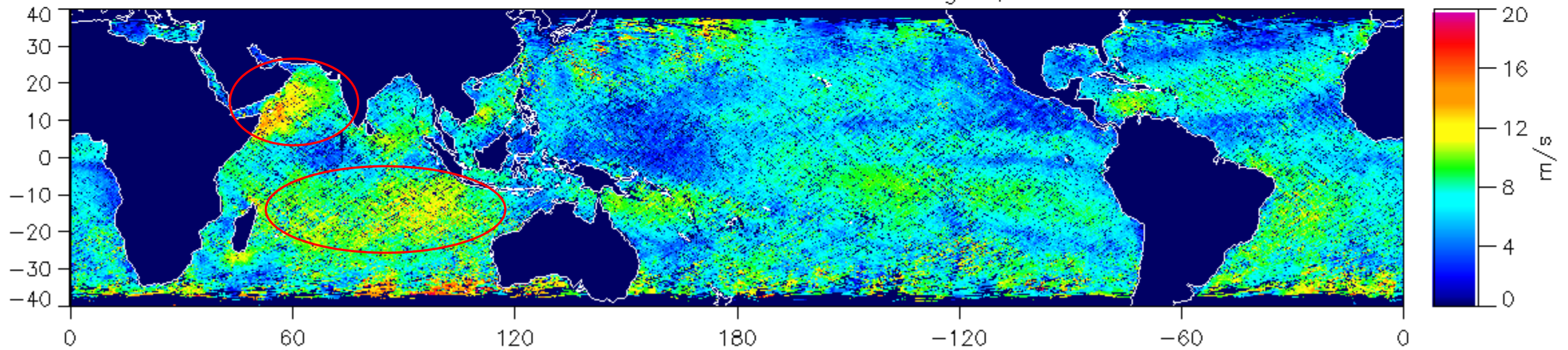
CYGNSS V2.0 WIND Jul 27–Aug 5, 2017

**CYGNSS V2.0**



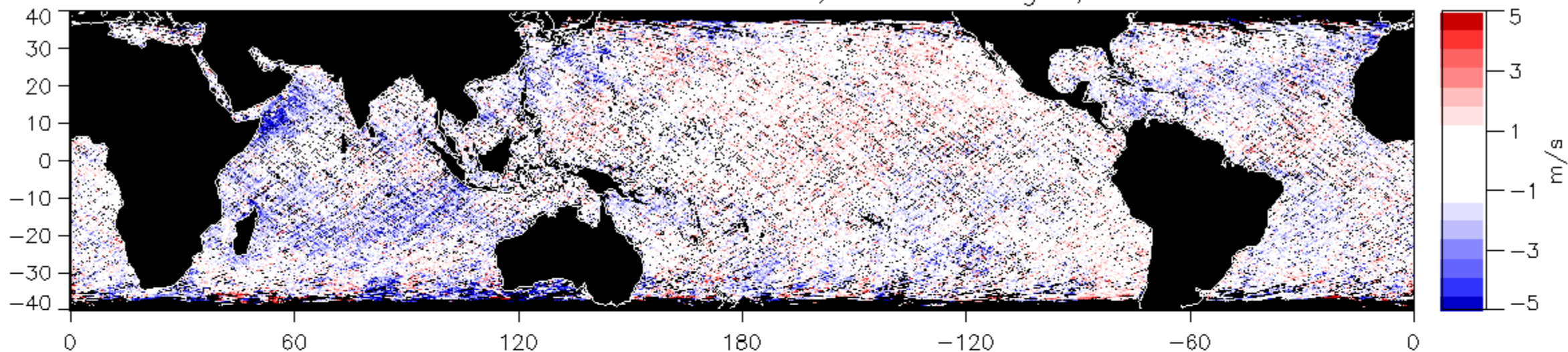
COLOCATED ASCAT WIND Jul 27–Aug 5, 2017

**Col. ASCAT**



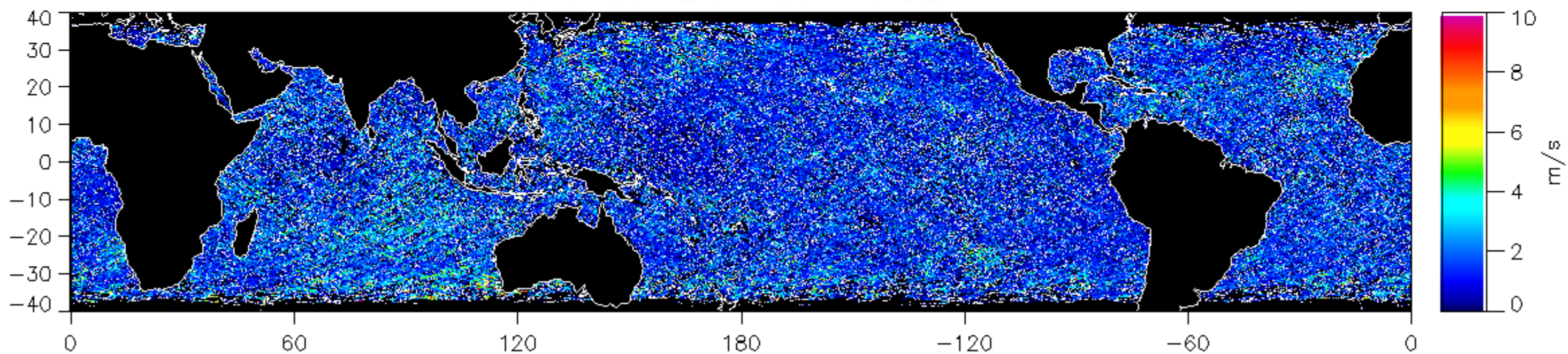
In CYGNSS V2, higher winds are significantly lower than ASCAT or other satellite winds

CYGNSS V2.0-ASCAT WIND BIAS, Jul 27-Aug 5, 2017 **CYGNSS V2.0-ASCAT bias**



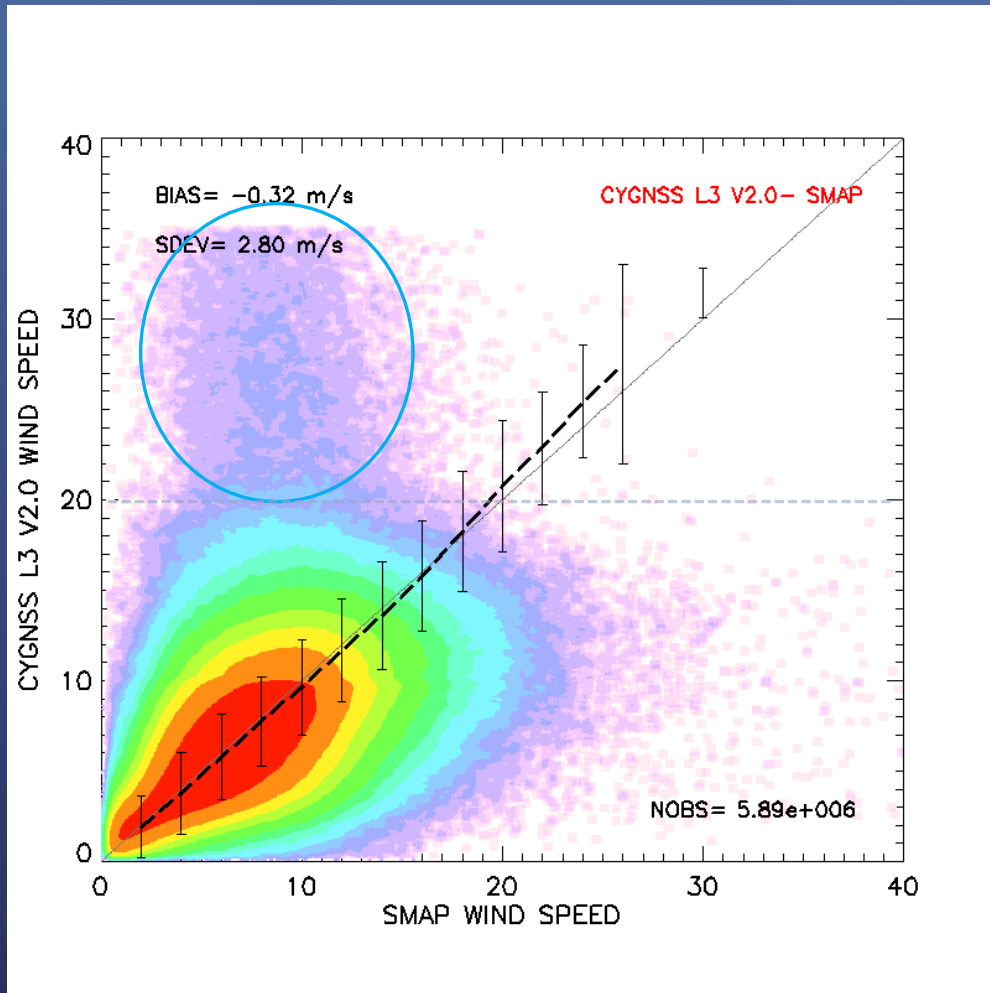
CYGNSS V2.0-ASCAT STDEV

**CYGNSS V2.0-ASCAT St Dev**



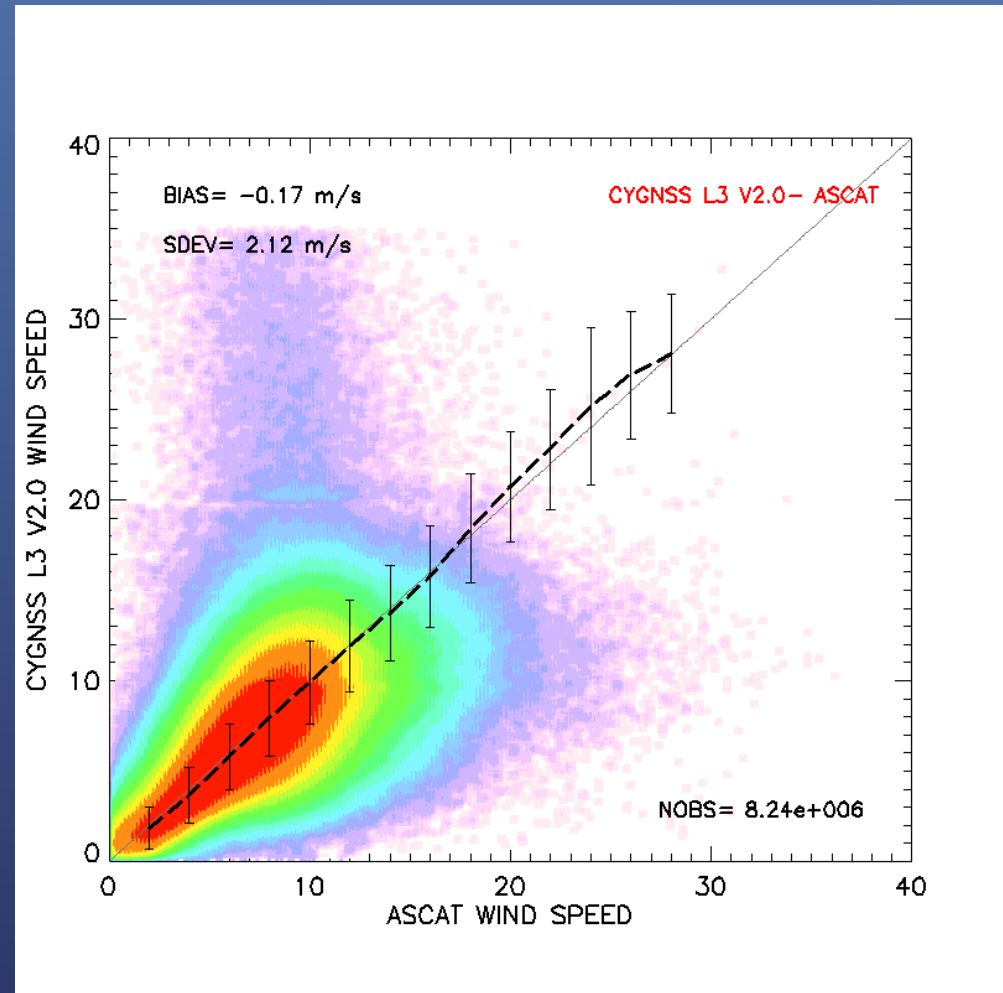
# Comparison CYGNSS V2.0 vs SMAP and ASCAT

CYGNSS



SMAP

CYGNSS

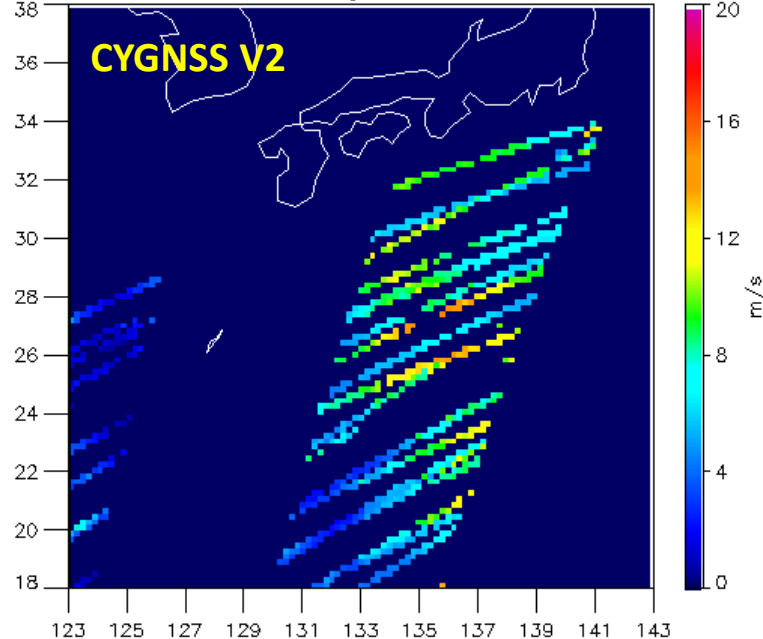


ASCAT

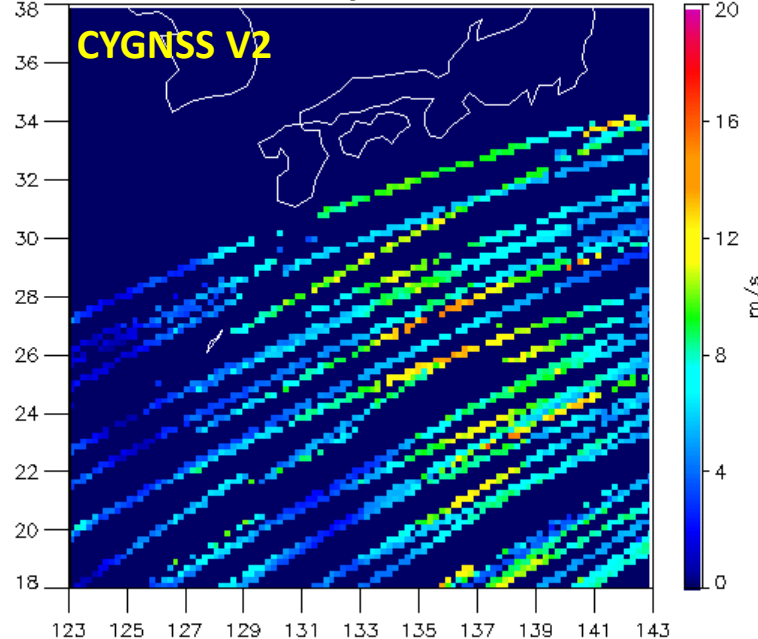
- The average bias line (dashed) might seem good, but on a closer look, those high winds in CYGNSS are just bad retrievals.
- The real high winds are missing in CYGNSS V2 L3. See next slides

# NORU super typhoon (Cat 5 !), CYGNSS V2.0: Almost no sign of a storm in V2 L3 data

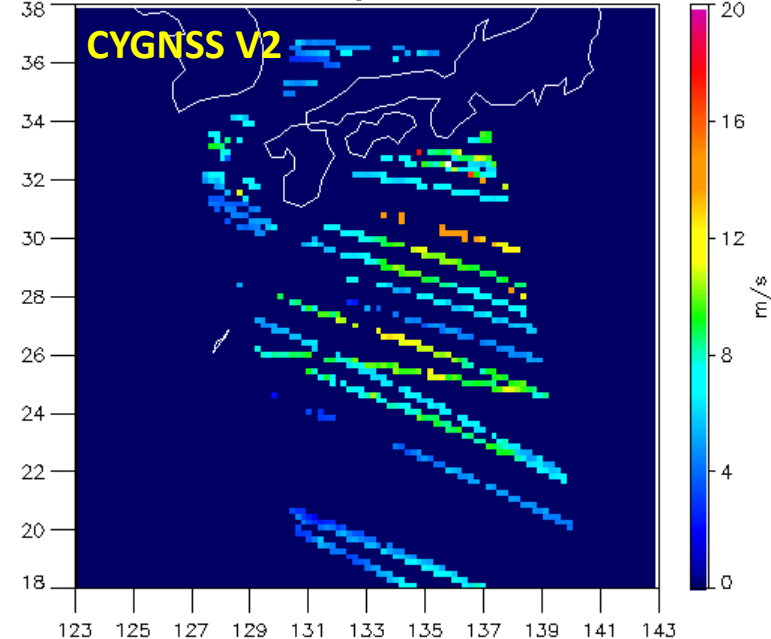
CYGNSS V2.0 WIND Aug 3, 2017, 0000-0400 UTC



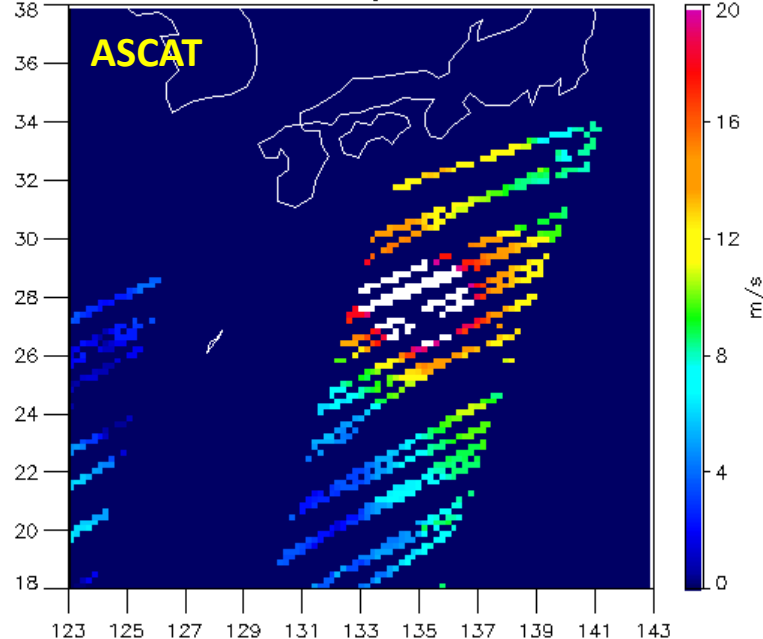
CYGNSS V2.0 WIND Aug 3, 2017, 0000-0400 UTC



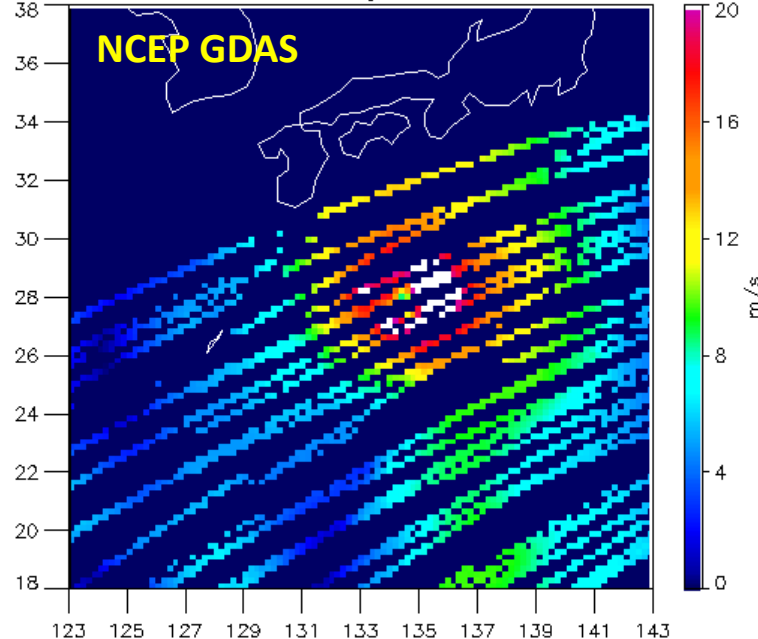
CYGNSS V2.0 WIND Aug 3, 2017, 0800-1000 UTC



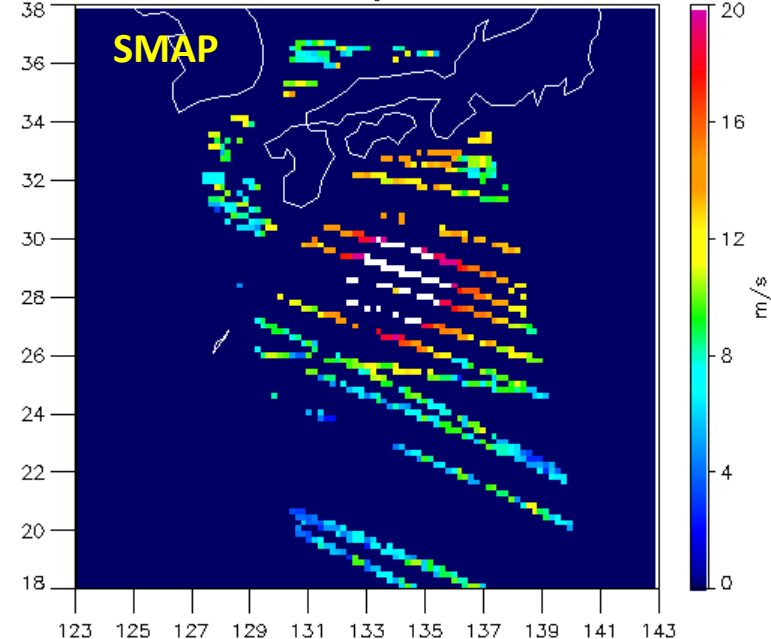
COLOCATED ASCAT WIND Aug 3, 2017, 0000-0400 UTC



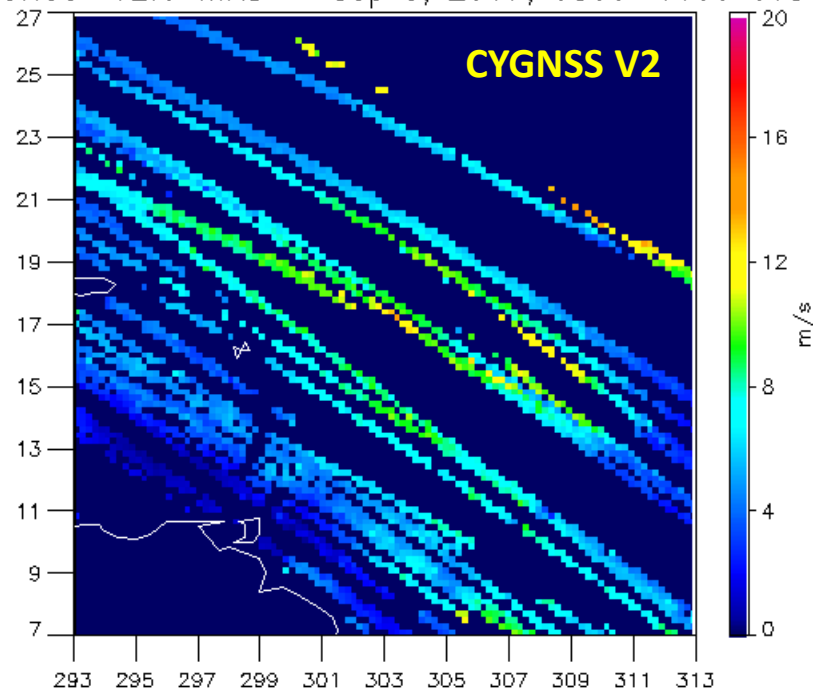
COLOCATED NCEP WIND Aug 3, 2017, 0000-0400 UTC



COLOCATED SMAP WIND Aug 3, 2017, 0800-1000 UTC

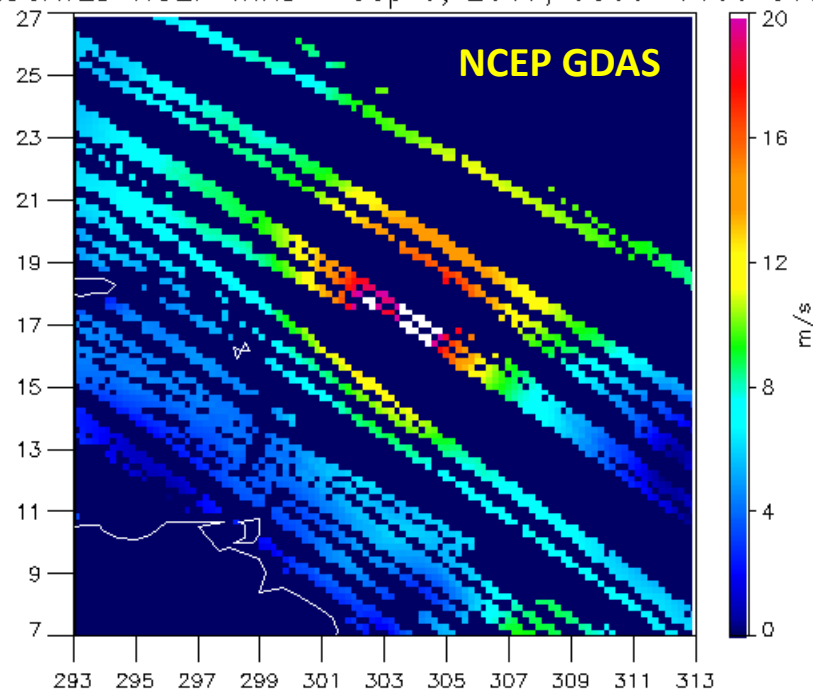


CYGNSS V2.0 WIND Sep 5, 2017, 0800-1100 UTC

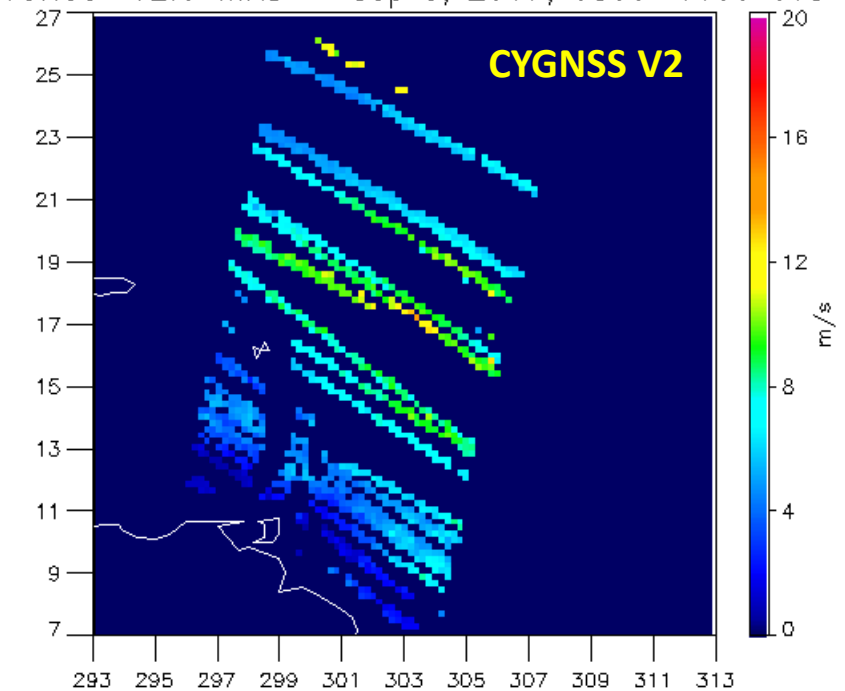


# IRMA

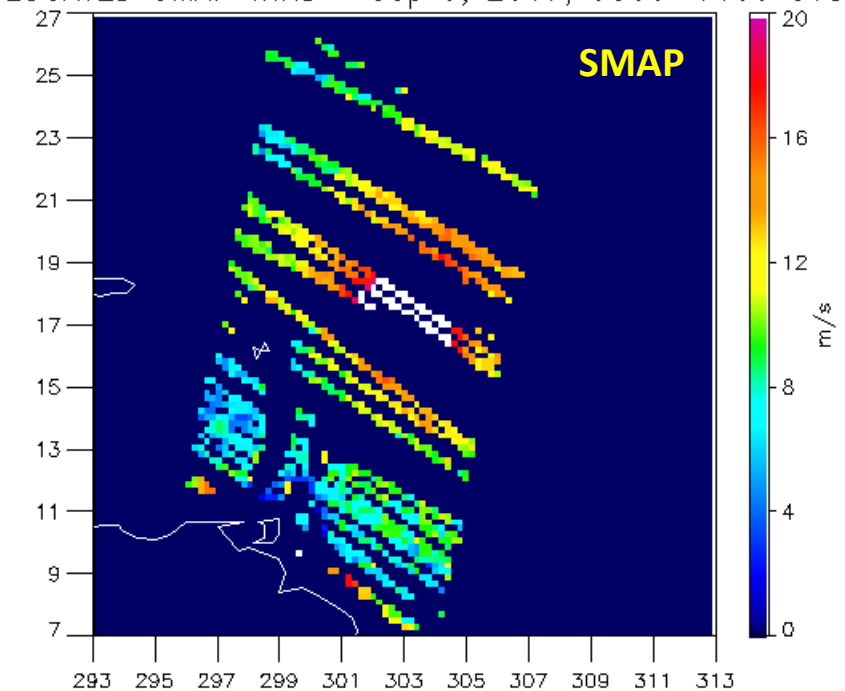
COLOCATED NCEP WIND Sep 5, 2017, 0800-1100 UTC



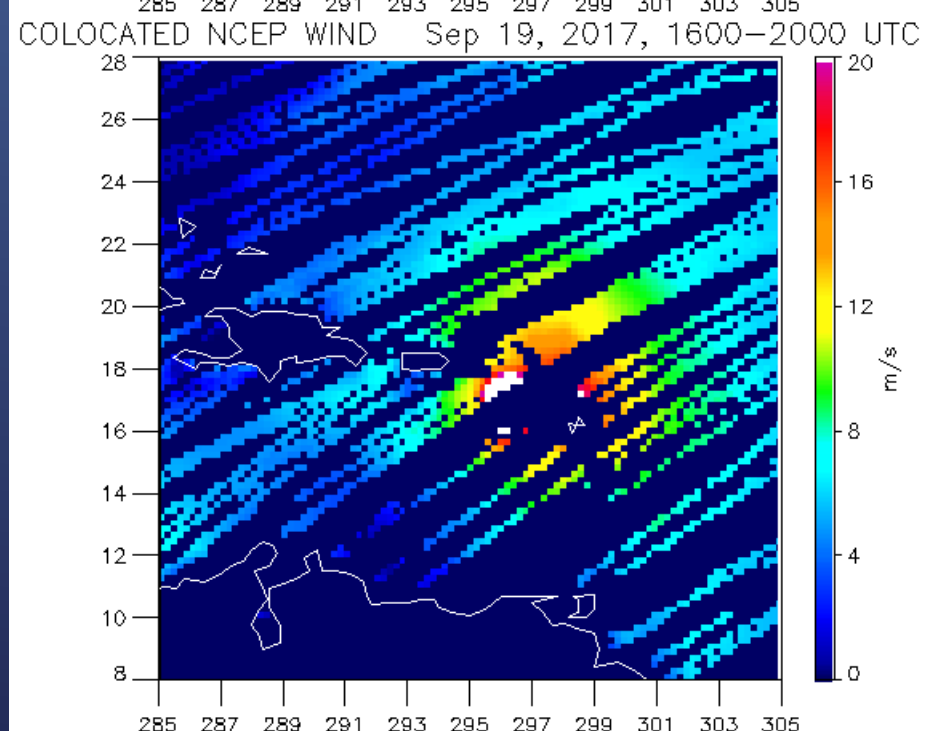
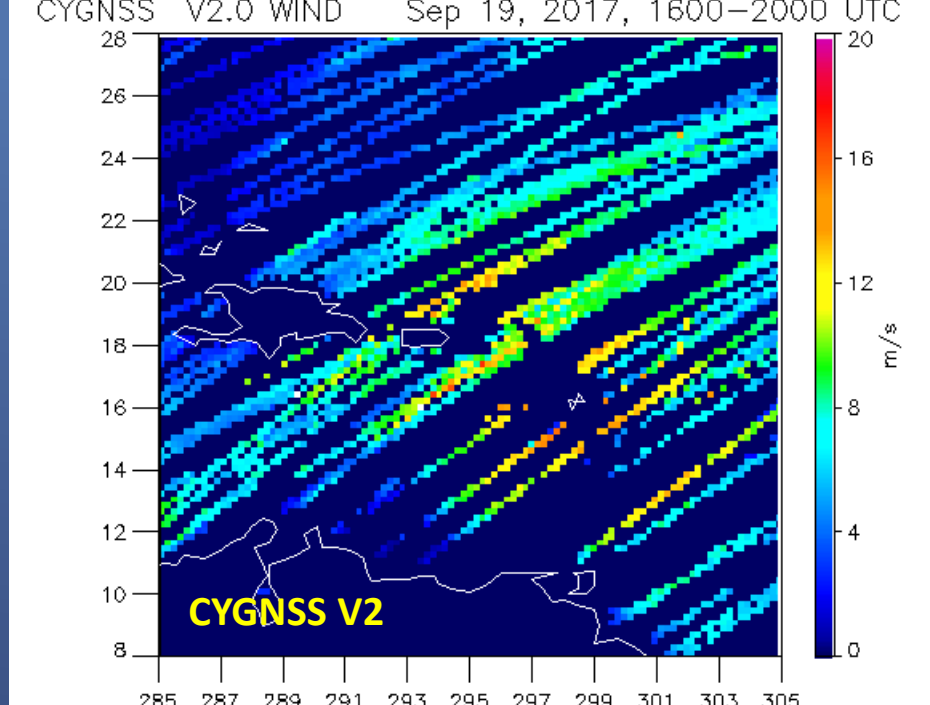
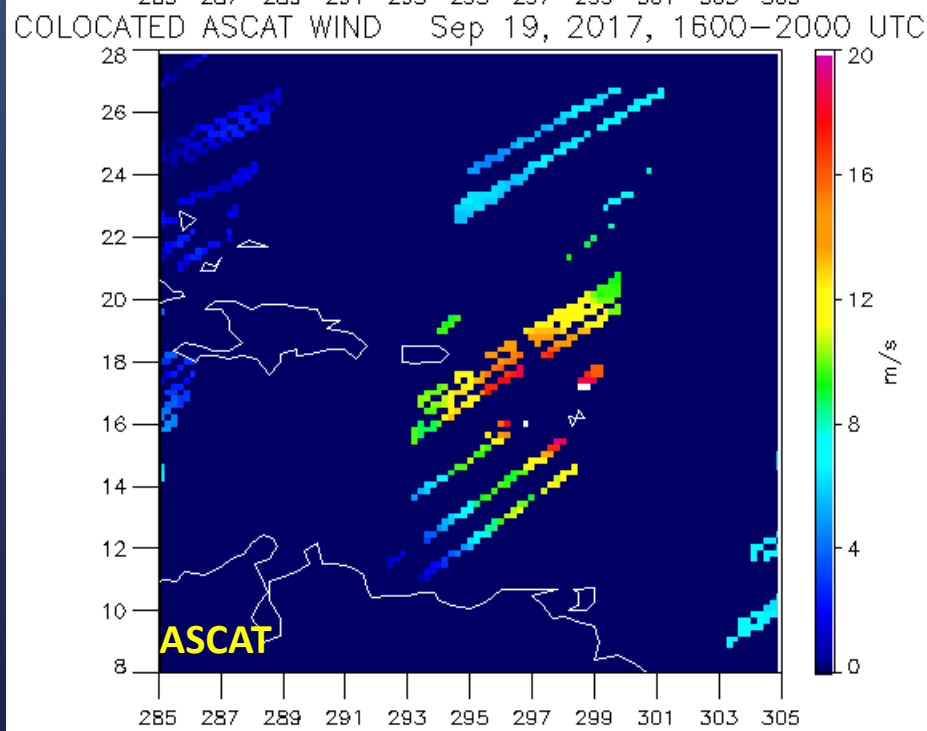
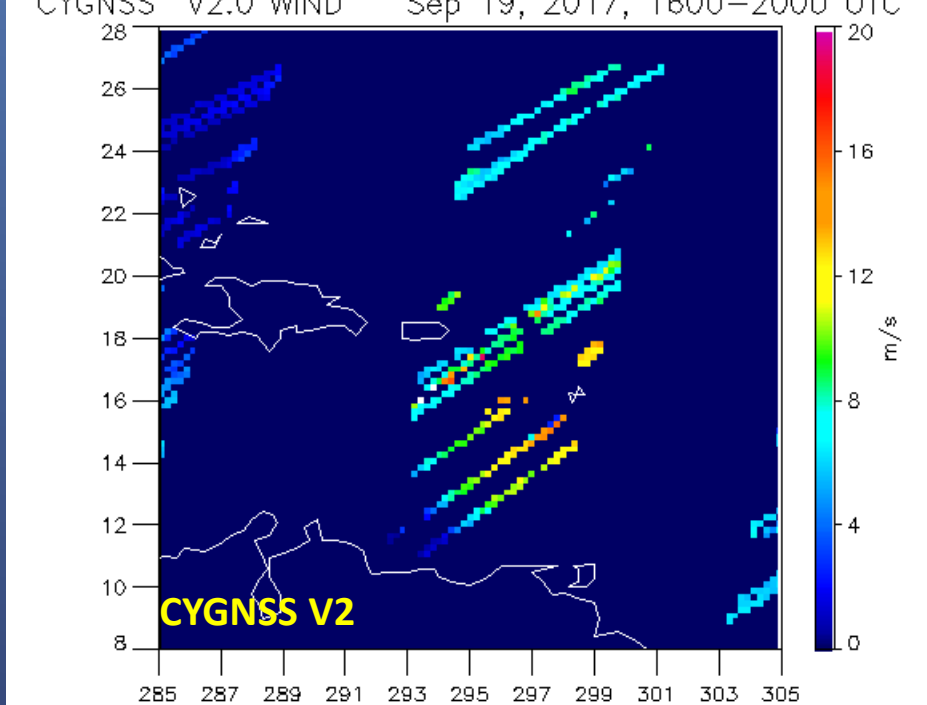
CYGNSS V2.0 WIND Sep 5, 2017, 0800-1100 UTC



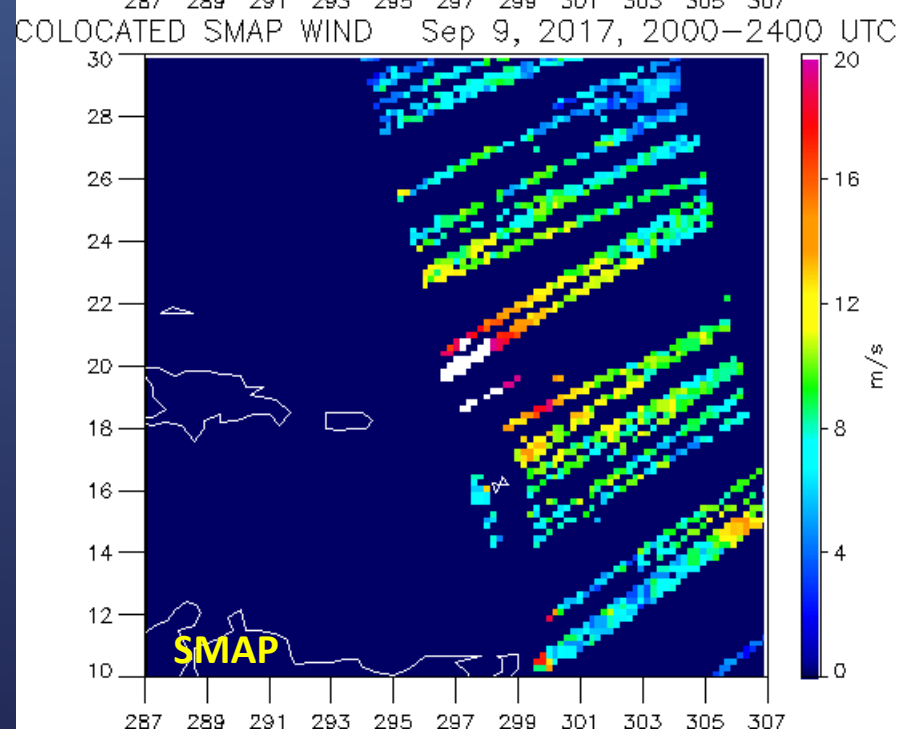
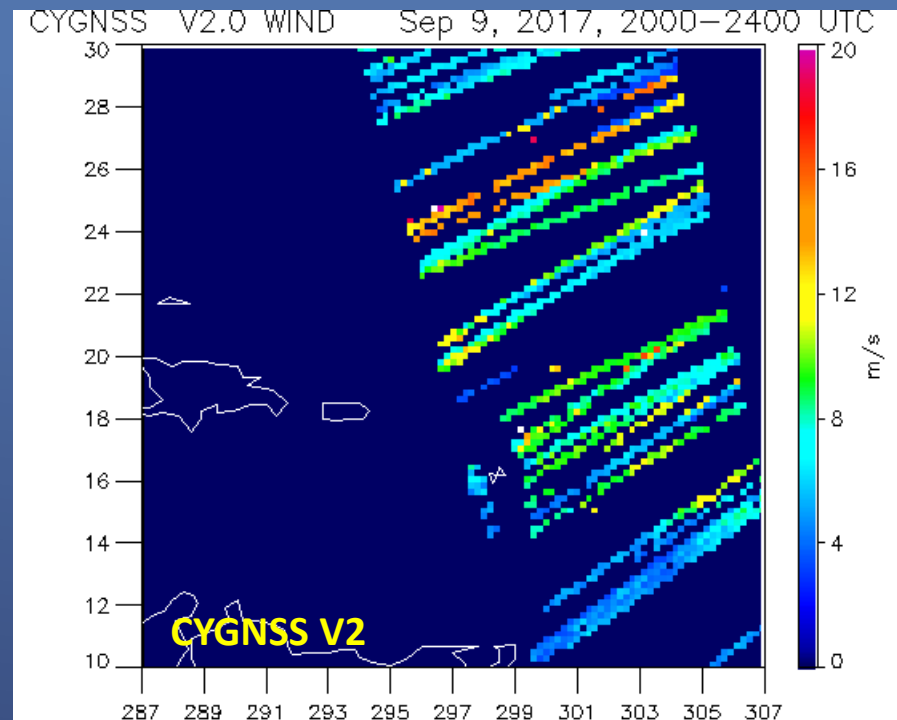
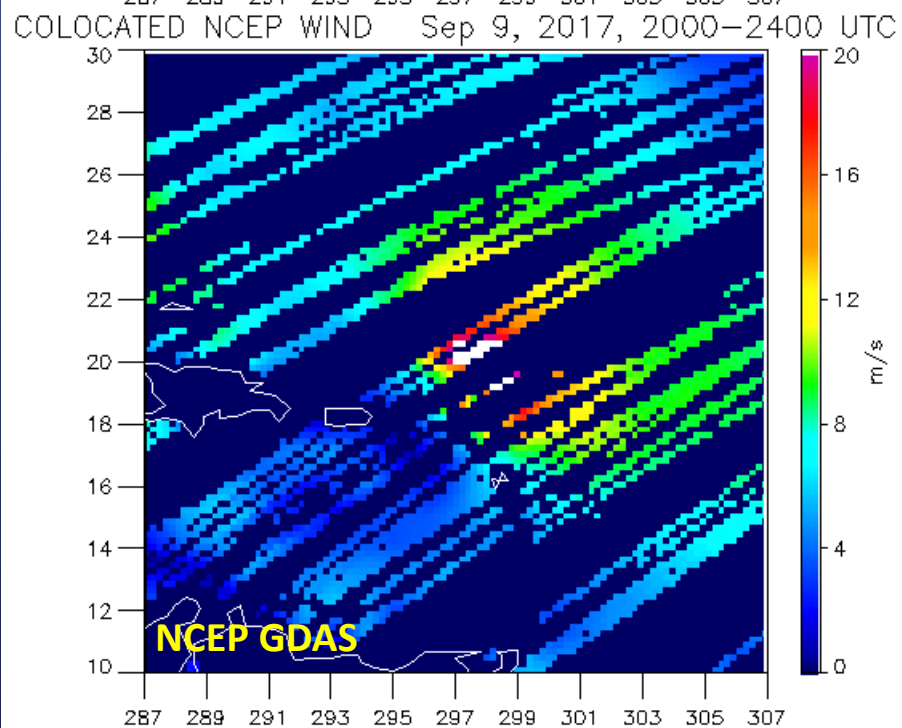
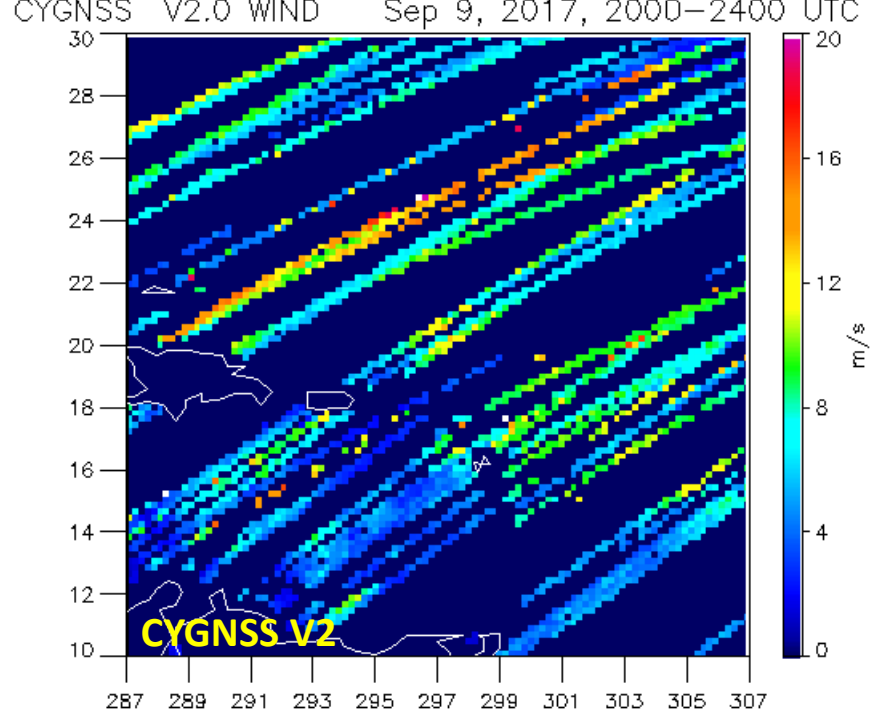
COLOCATED SMAP WIND Sep 5, 2017, 0800-1100 UTC



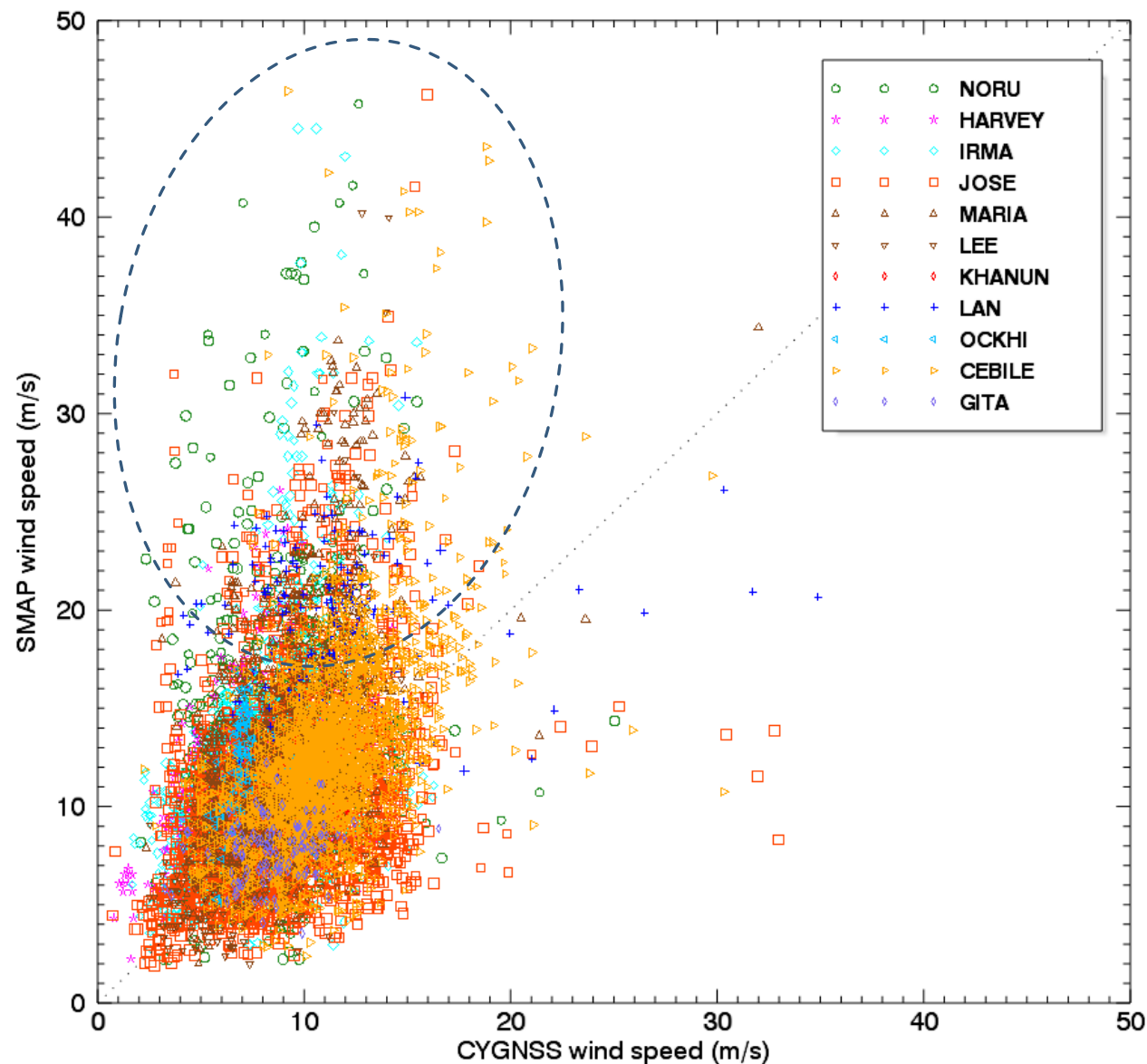
# MARIA



# JOSE



SMAP - CYGNSS matchups 2017-2018



## Comparison of SMAP winds vs CYGNSS V2 During last hurricane season

Storm winds observed by SMAP in the range 25-50 m/s are instead 5-20 m/s in CYGNSS

# CYGNSS PROPOSAL

- Submitted Nov 2017, ROSES 2017; Granted February 2018, 3 yr project;

## Title: User-Oriented Level 4 Ocean Wind Products from the CYGNSS Wind Retrievals

L. Ricciardulli, C. Mears ,T. Meissner; Collaborator: Z. Jelenak (NOAA/NESDIS) and C.Sampson (NRL/NAVY)

**Main objective:** Facilitate use of CYGNSS wind data, repackage winds in user-friendly form

1. L4 product: CYGNSS wind speed with added ancillary wind direction from models/satellite
2. Assimilate CYGNSS in CCMP, benefit of filling rainy areas where radiometers have no data
3. Incorporate CYGNSS winds into RSS Storm Watch page, determine intensity and size of storms, similar to SMAP

### Side products:

- Extensive Cal/Val using all available radiometers/scatterometers
- Use SMAP winds for in depth Validation of CYGNSS winds in Tropical Cyclones
- Determine bias adjustments for the 8 different receivers, if needed
- Determine actual uncertainty maps: Right now L3 data has a theoretical uncertainty associated that is far from reality

# Summary of CYGNSS L3 comparison with ASCAT/SMAP

- CYGNSS winds compare well to SMAP and ASCAT for w < 15 m/s, but with standard deviation higher (2+ m/s) than other satellite data (typically 1 m/s or less)
- At high winds > 15 m/s CYGNSS V2 L3 winds lose correlation with SMAP winds, and they are significantly lower
- We think that SMAP could be useful for calibrating CYGNSS very high winds, if CYGNSS has enough sensitivity.
- We created colocation files for each storm scene in 2017/2018 written in ASCII format.
- CYGNSS V2.0: Overall bias is much decreased and Standard Deviation is much reduced too compared to V1
  - BUT: L3 not good at TC wind intensity (only Fully Developed Sea GMF used, invalid at high winds).
  - For high winds, L2 dataset provides additional wind product based on different Geophysical Model Function for high winds (Young Sea/Limited Fetch GMF, Ruf et al., 2018)

## What's next:

- Science Team announced that a new and improved version V2.1 will be released before Atlantic Hurricane season 2018
- Significant improvements in calibration of the L1 (sigma0) was presented to Science Team
- No L2,L3 (wind) data available yet
- Science Team experimenting with different GMFs for winds and working on other issues
- We will focus on validation of L2 data for both FDS and YSLF wind data products