



NOAA CyGNSS Wind Product – Ver 1.0

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NOAA CYGNSS Wind Retrieval Approach

- SATISFY NOAA Wind Product Requirements for User Applications
 - Stability
 - Consistency
 - Repeatability
 - Bias, RMS
- PRESERVE CYGNSS measurement sensitivities while correcting for large calibration errors
 - Rigorous quality control of the data
 - Implement track debiasing to help with unknown GPS power fluctuations and calibration issues between CYGNSS antennas
 - *No other bias correction applied to the final wind product*

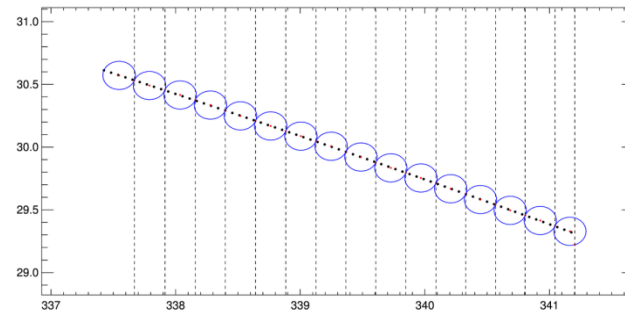


Outline

- Wind Retrieval approach
- Performance analysis
- Data hosting site
- Manati site brief demo
- Summary and Future plans

A few points regarding the retrieval approach..

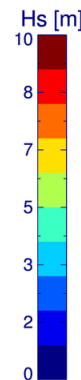
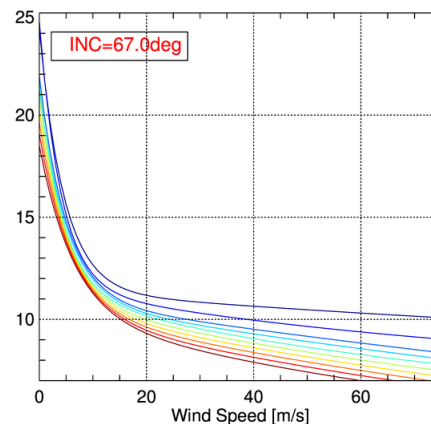
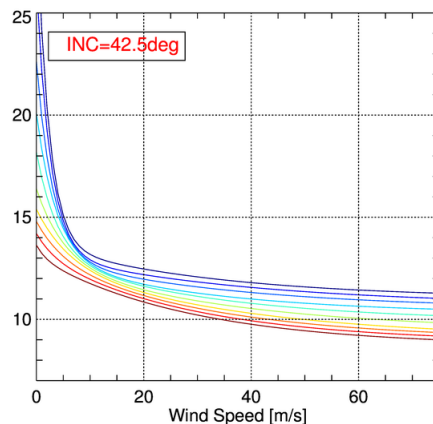
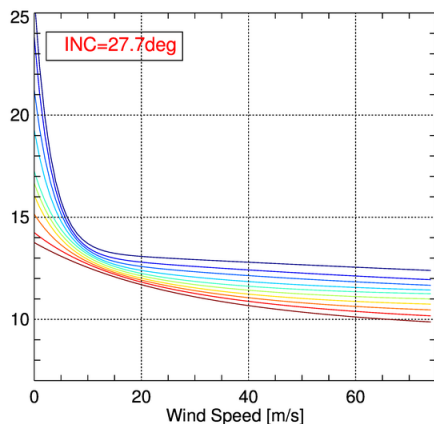
- Implemented **25km gridding** along each track
- Fine tuned the **Geophysical Model Function** $\sigma^0(u_{10}, H_s, \Theta_i)$ using large data set (May 2017-Nov 2018), excluding power flex events



$\sigma^0(\{u_{10}, H_s\} | \Theta_i \sim 27.7^\circ)$

$\sigma^0(\{u_{10}, H_s\} | \Theta_i \sim 42.5^\circ)$

$\sigma^0(\{u_{10}, H_s\} | \Theta_i \sim 67.0^\circ)$



Refresher...

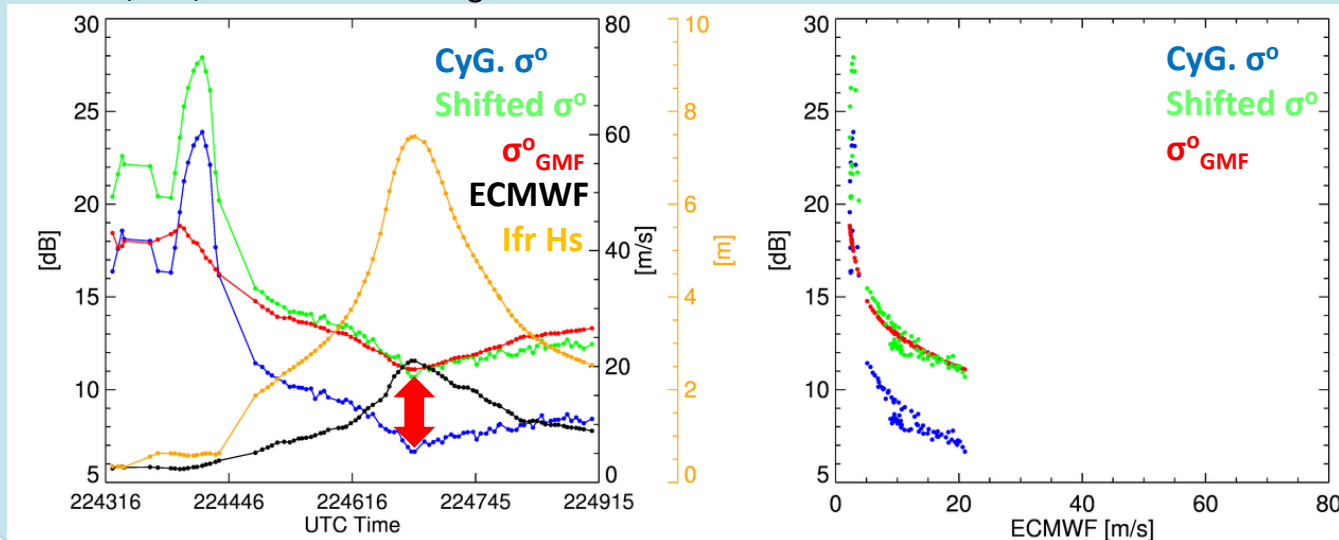
General bias removal and wind retrieval procedure:

1. For a given track (i.e. where consecutive specular points are 'locked' to a particular GPS transmitter), **grid** σ^0
2. Generate corresponding σ^0 timeseries using the GMF
3. Compute overall σ^0 bias between the two excluding 'poor quality' σ^0 (e.g. samples with star tracker flag set, L1 Poor overall qual flag, etc..)
4. Apply this fixed bias correction to **all** measured σ^0 along the track
5. Pointwise wind retrieval scheme using a priori knowledge of H_s

Example: FM#5--2017 Sep 04—block IIR-M—trackID 893

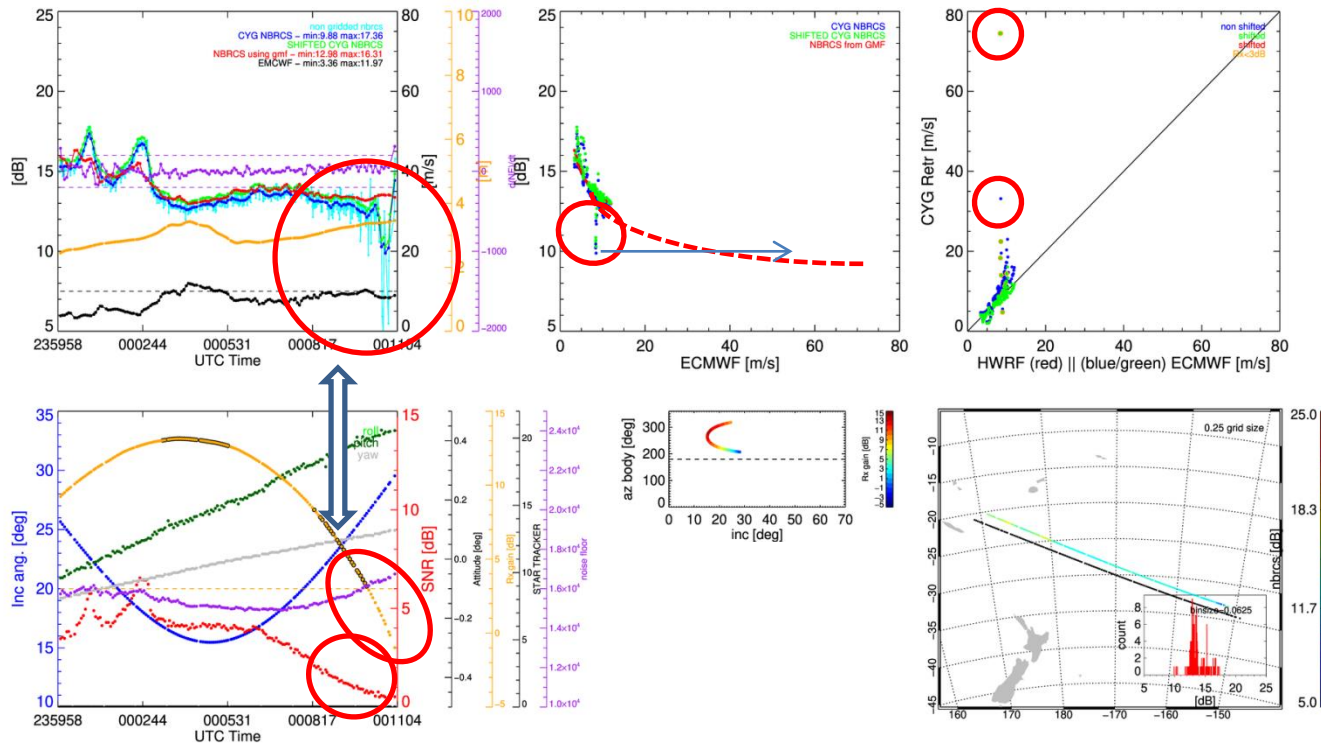
σ^0 /u10/ H_s timeseries along the track

σ^0 vs. ECMWF



Quality control

- Low Rx gain combined with Low SNR ranges mostly filtered out
- Algorithm implemented to detect block IIF tracks affected by power flex event
- Roll, Pitch, Yaw > 5 deg*
- Track associated to Starboard antenna but showing on the Port side and vice versa





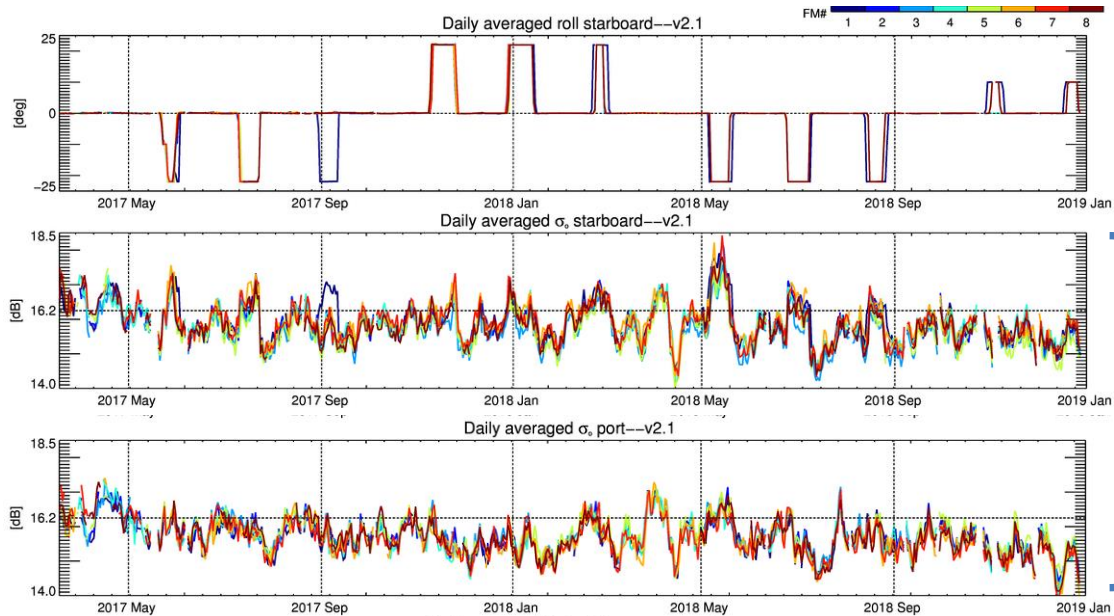
Additional Quality control

- Data filtered depending on probability of $|\text{wind speed bias}| > 2 \text{ m/s}$ given Rx gain, SNR and Incidence Angle
- A 3D flag table is developed accordingly (using a 4-month period –July-Oct 2017)
- Flagged data is currently excluded from L2 product

Evaluation

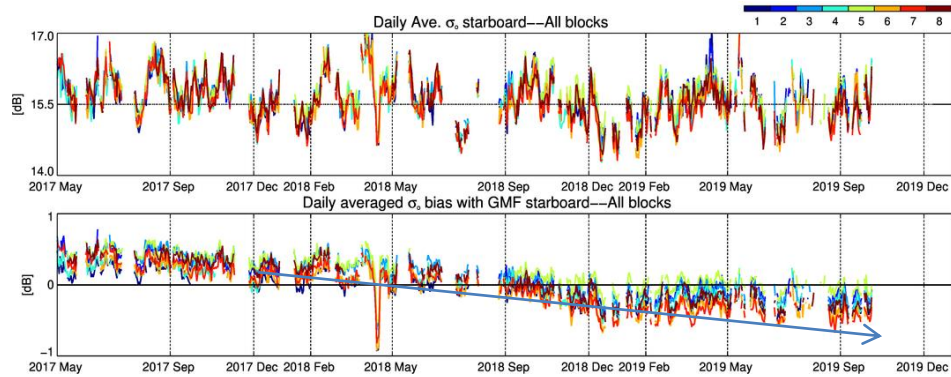
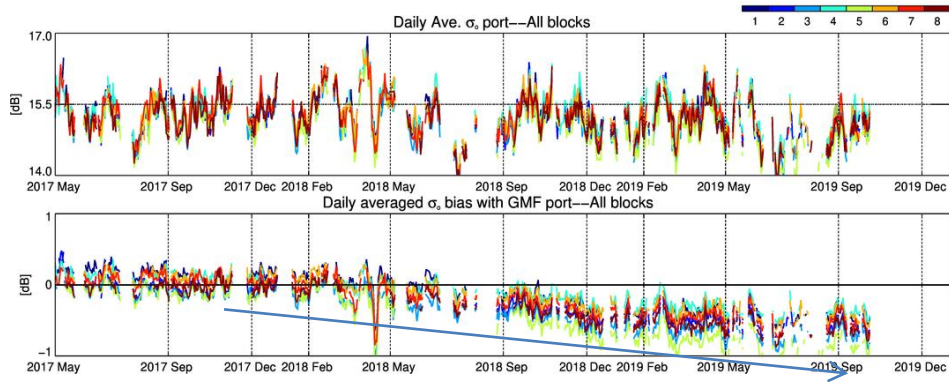
- Timeseries of Selected L1/L2 variables
- Bin averaged Sigma0 vs incidence angle
- σ_0 distribution
- Global Statistics
 - Ascending/Descending
 - Full Mission or separated by years
- With Sensors (Performance Period: 1st May 2017-30th Nov 2018):
 - ASCAT A/B
 - AMSR-2, SSMI F16-F17, WINDSAT
 - SMAP
- NWP Models (Performance Period: 1st May 2017-5th Oct 2019)
 - HWRF
 - ECMWF

Timeseries

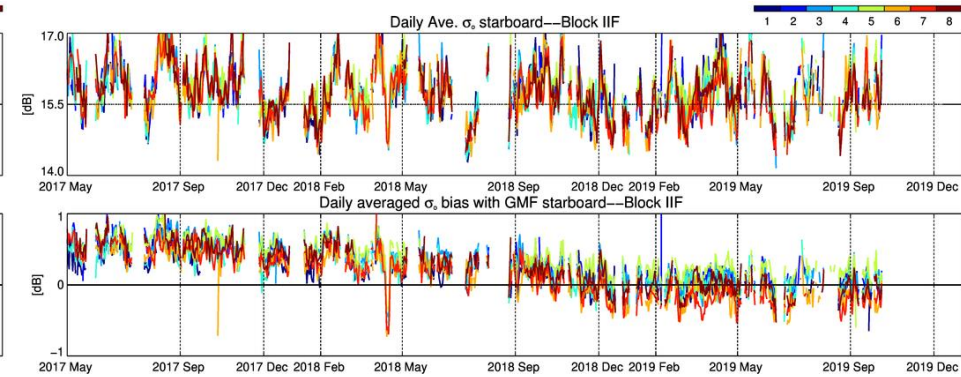
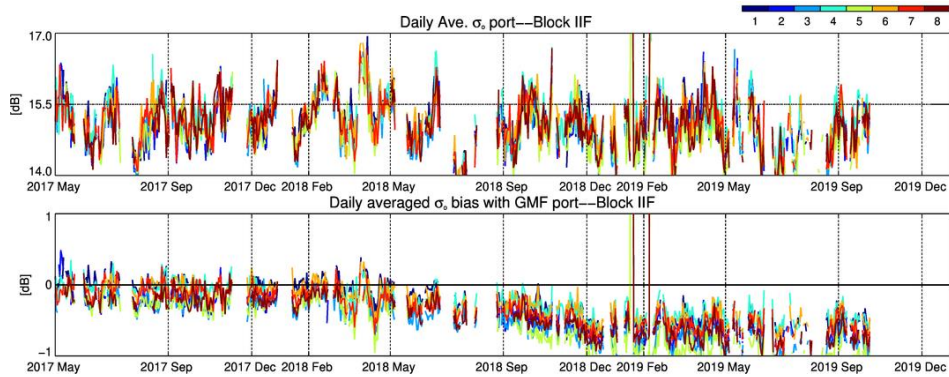


ROLL
DAILY AV. SIG.

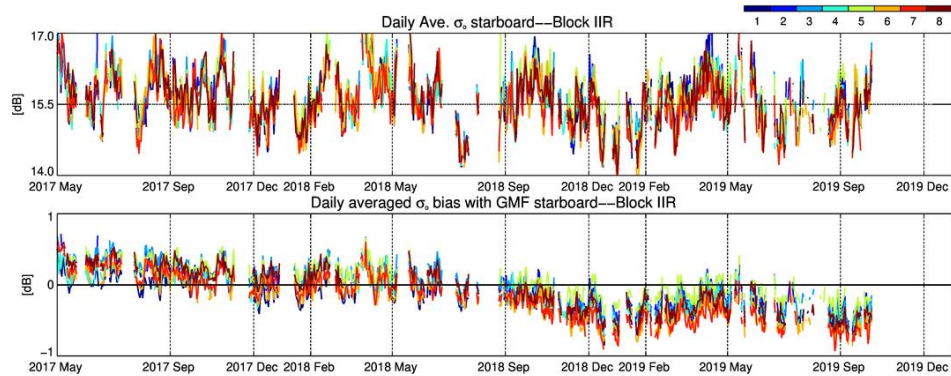
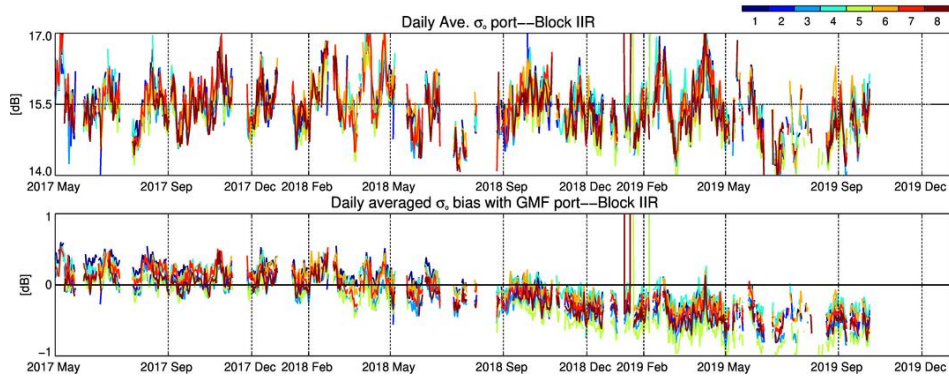
All Blocks



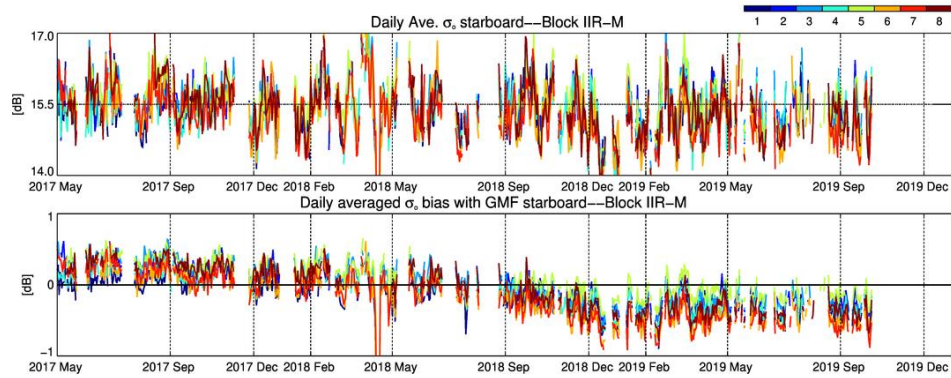
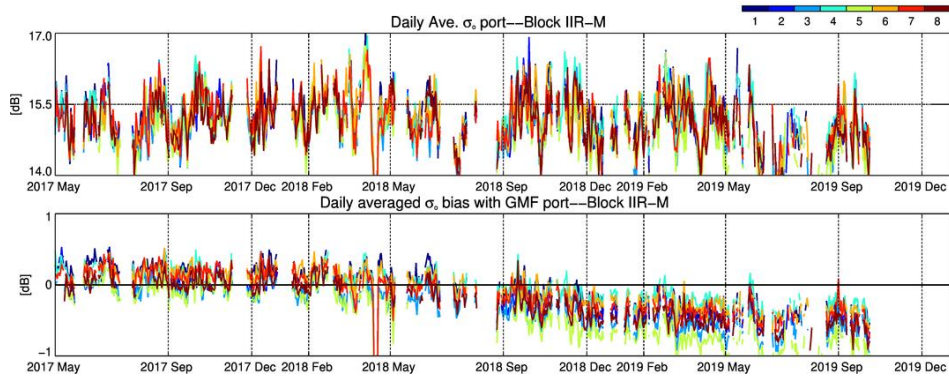
Block IIF



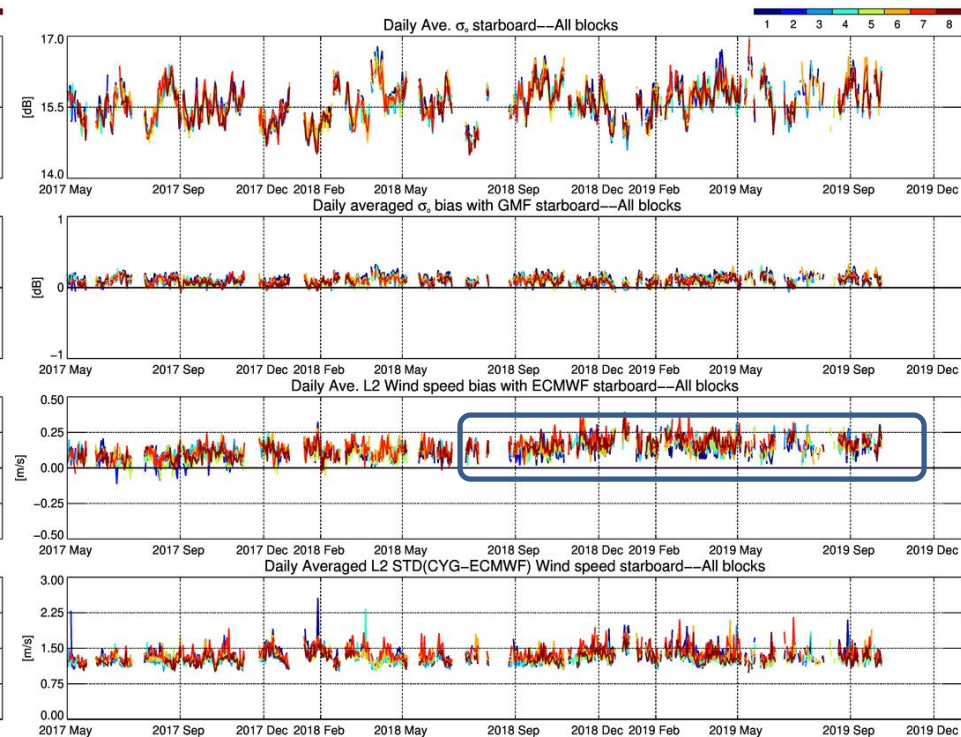
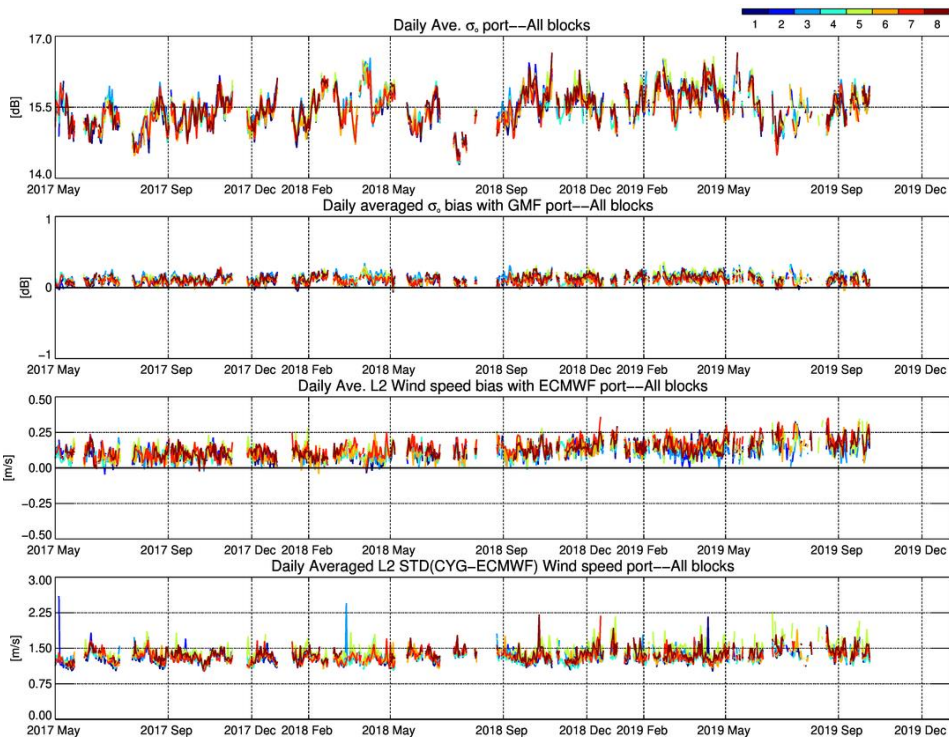
Block IIR



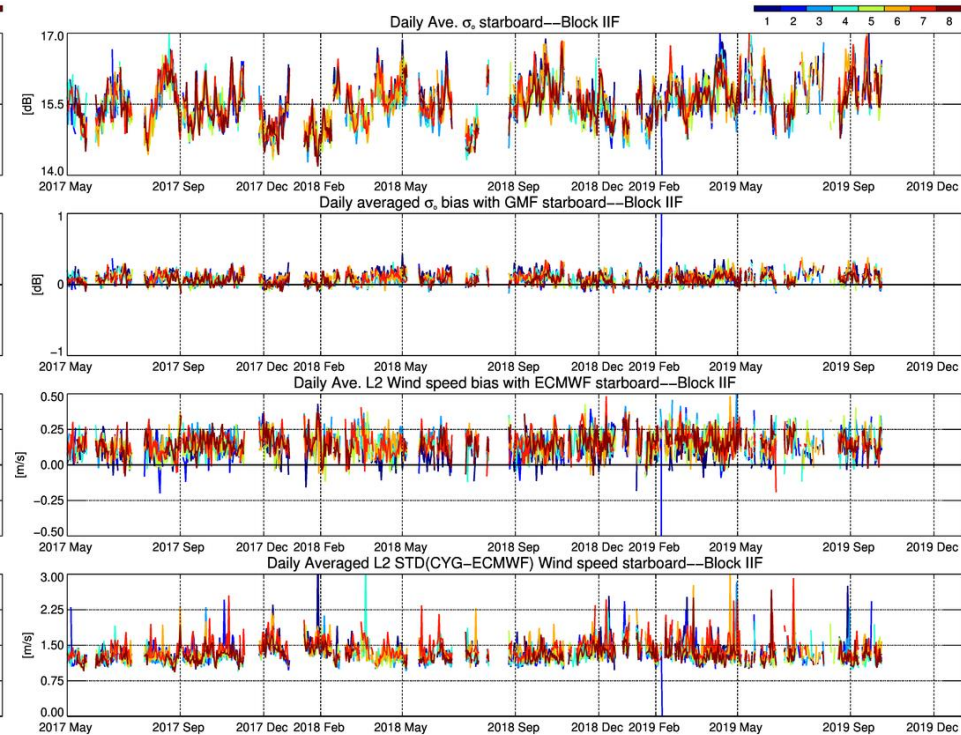
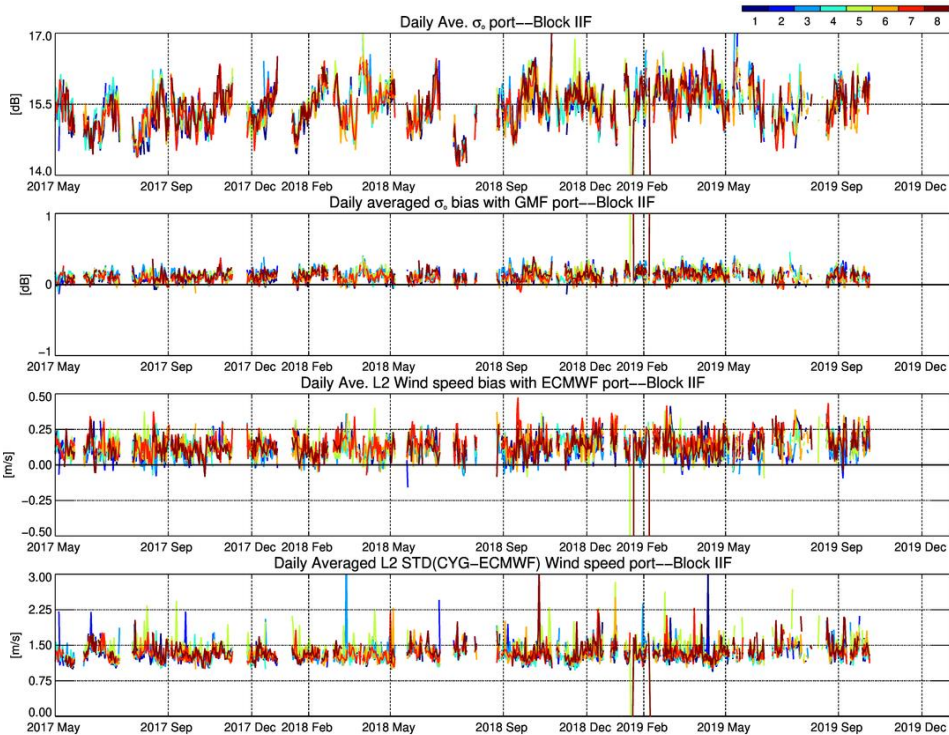
Block IIR-M



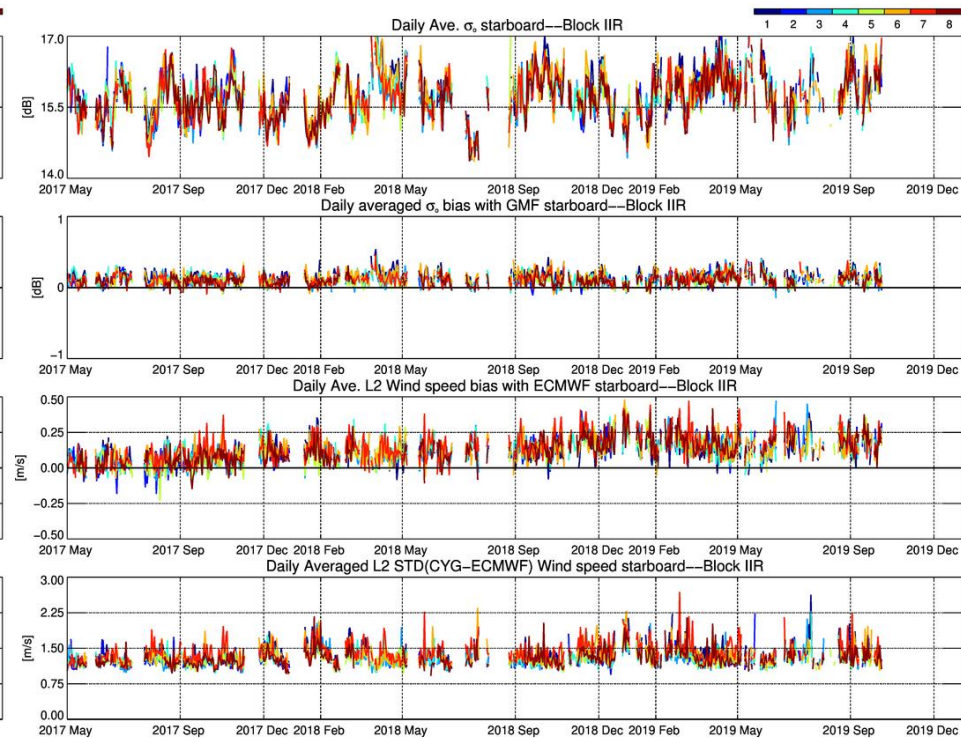
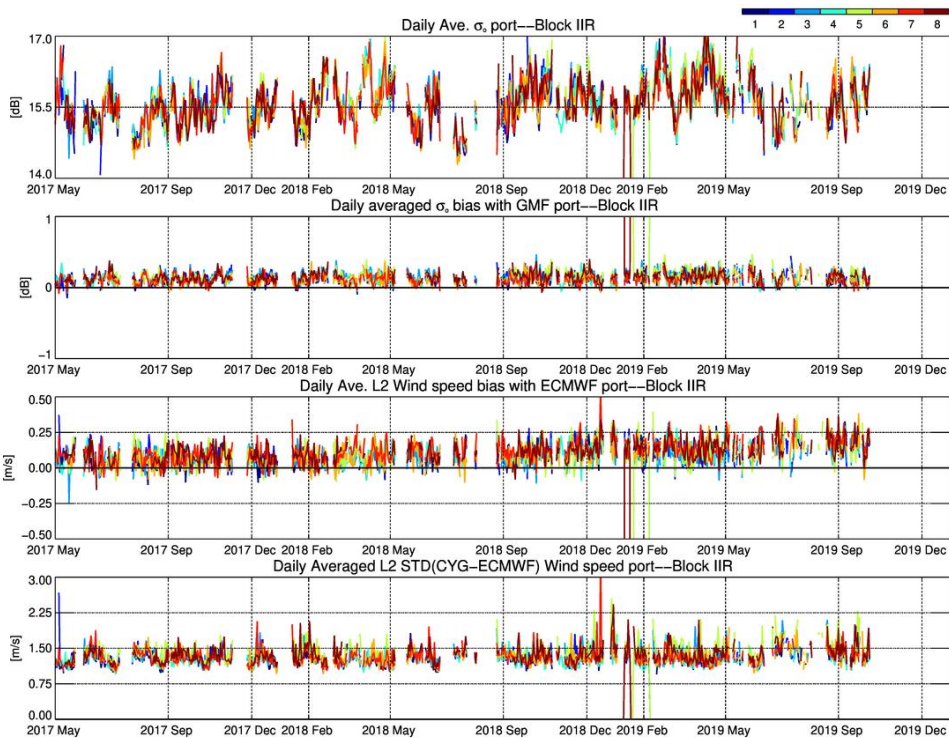
All Blocks -- Trackwise cor.



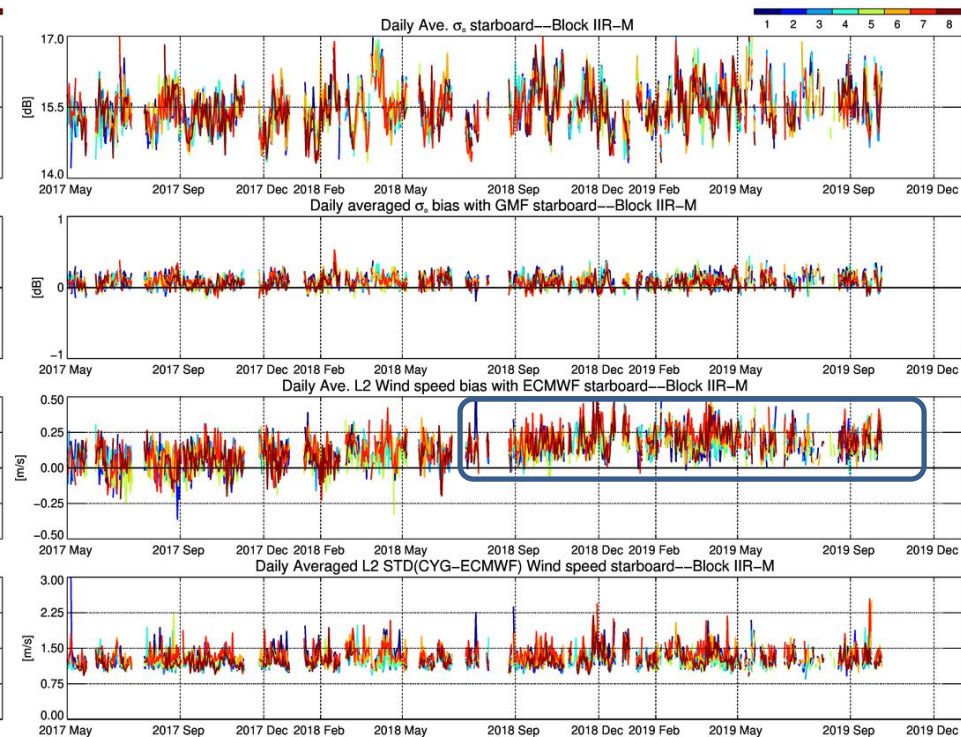
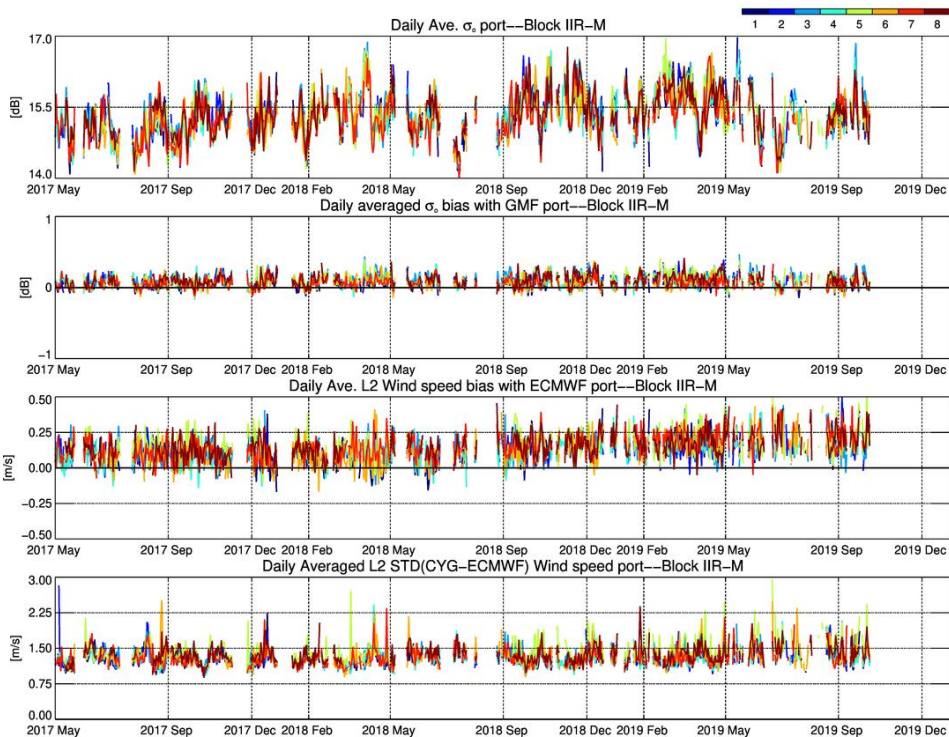
Block IIF -- Trackwise cor.



Block IIR -- Trackwise cor.

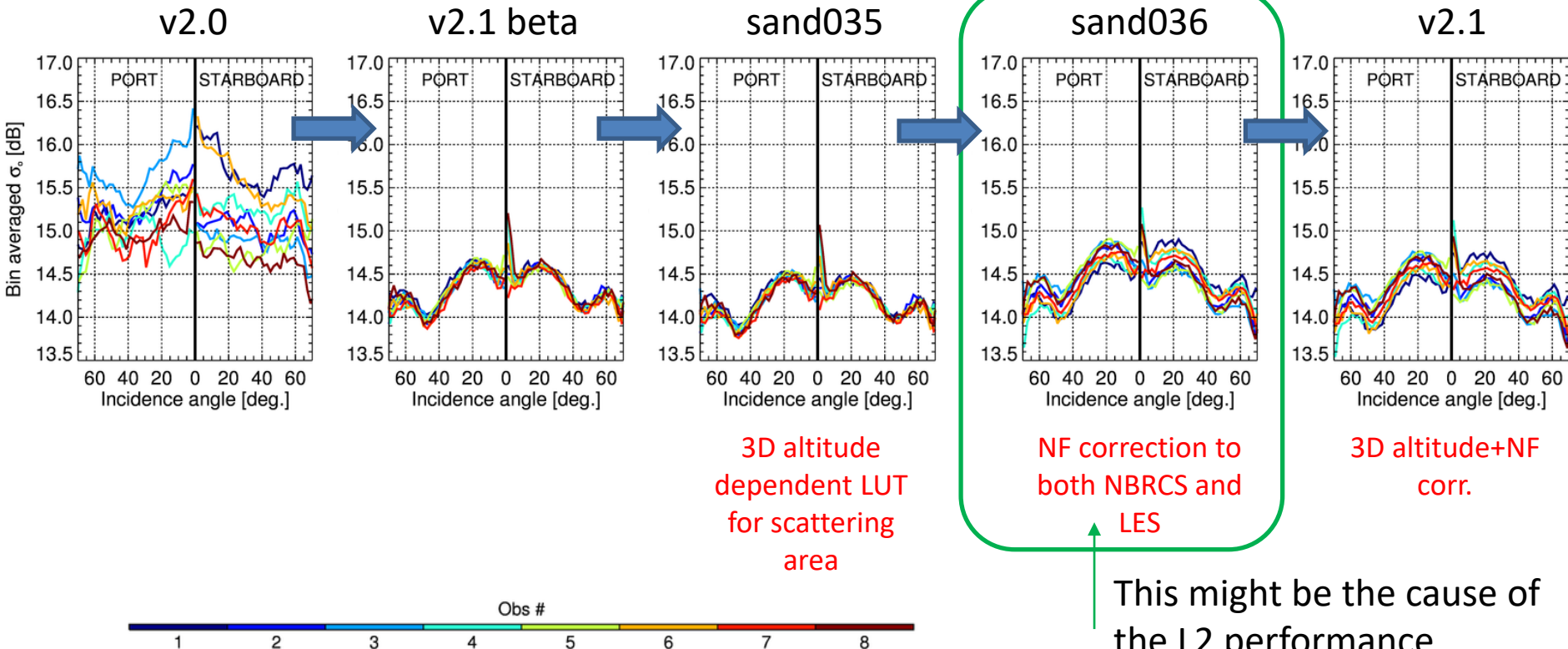


Block IIR-M -- Trackwise cor.



Bin averaged Sigma0 vs incidence angle separated by antenna and observatory

ALL PRNs except block IIF— $-6 \leq u_{10} \leq 6.5 \text{ m/s}$ —time period: May–Dec 2017



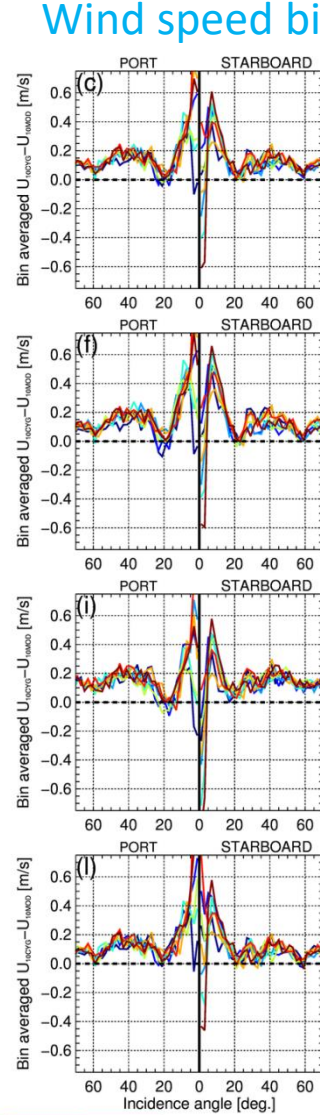
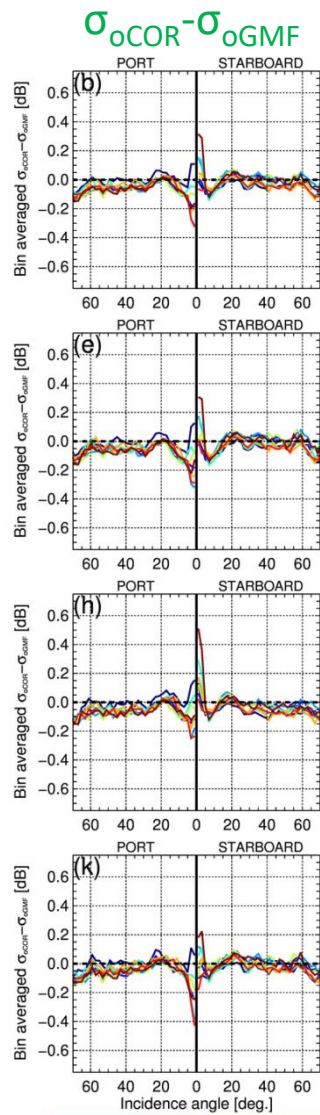
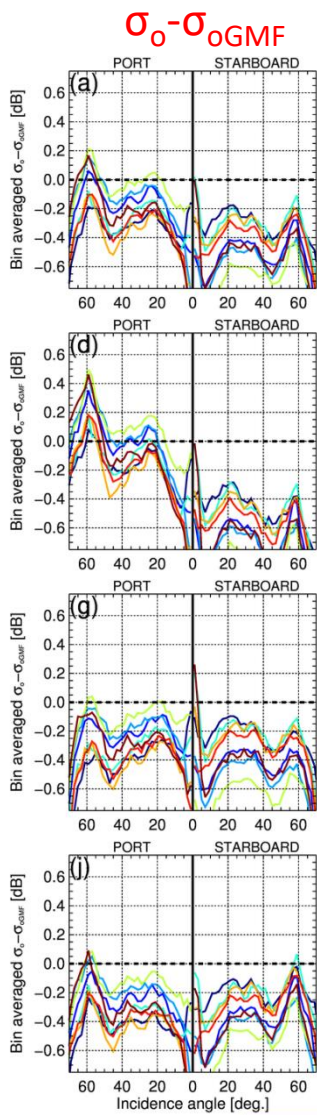
This might be the cause of the L2 performance degradation previously noted

All block

Block IIF

Block IIR-M

Block IIR



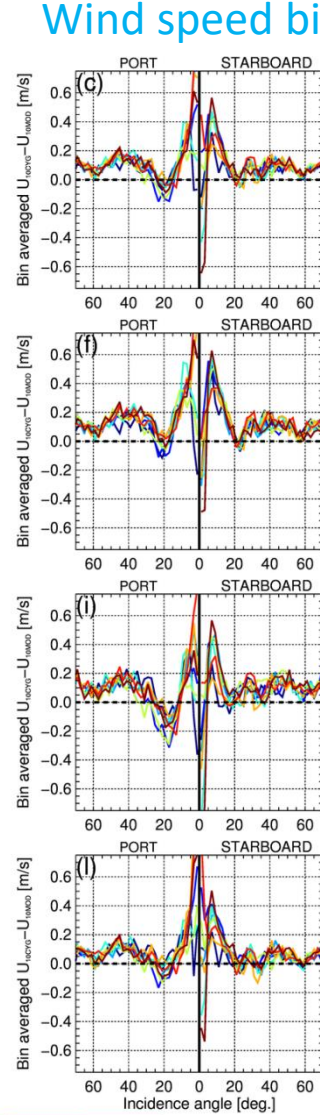
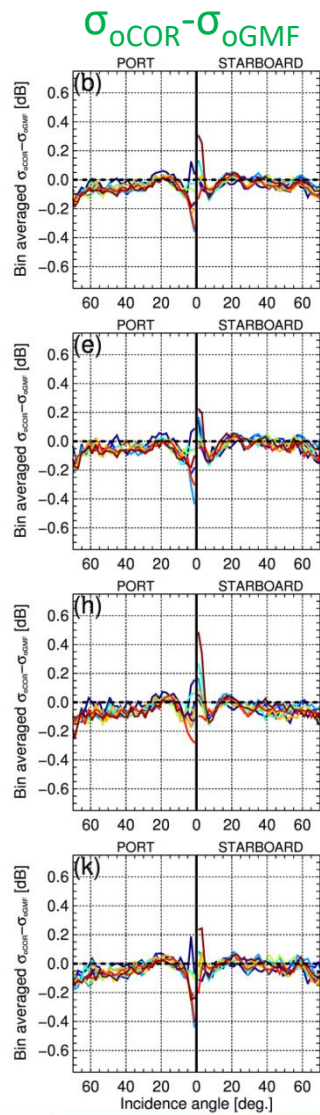
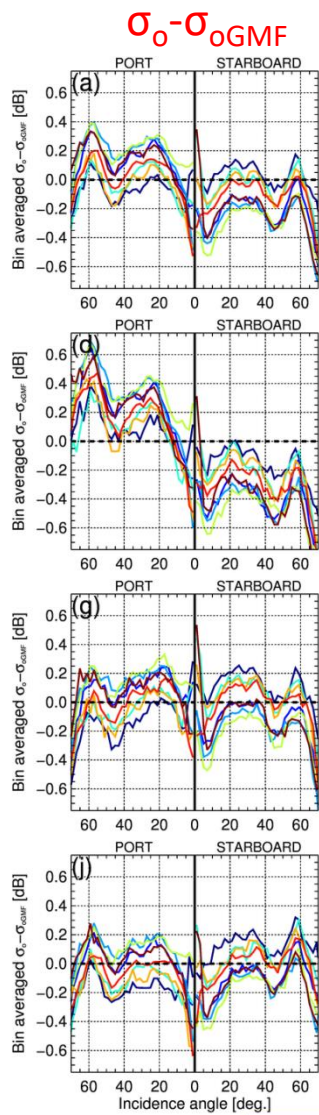
2017 May 1st-
2019 Oct 5th

All block

Block IIF

Block IIR-M

Block IIR



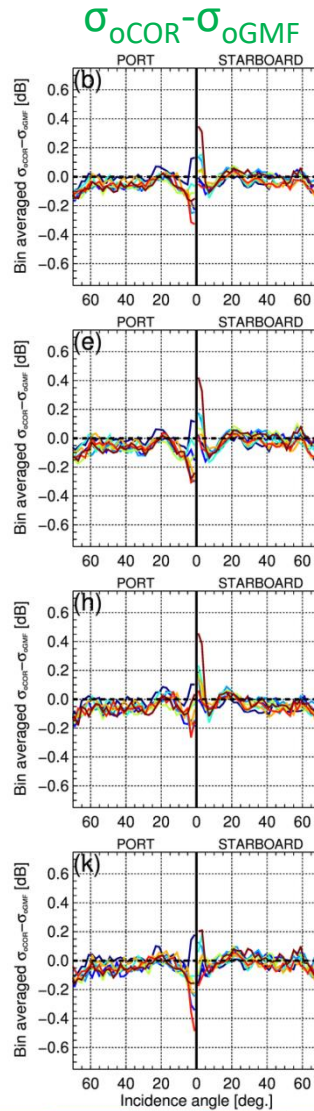
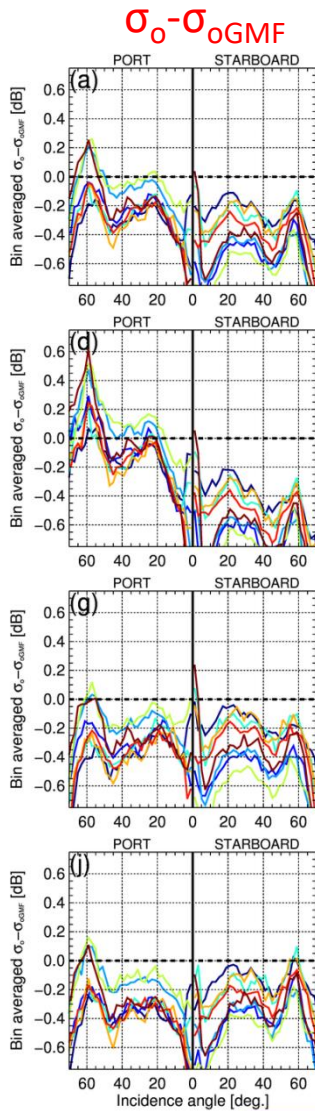
May-Dec
2017

All block

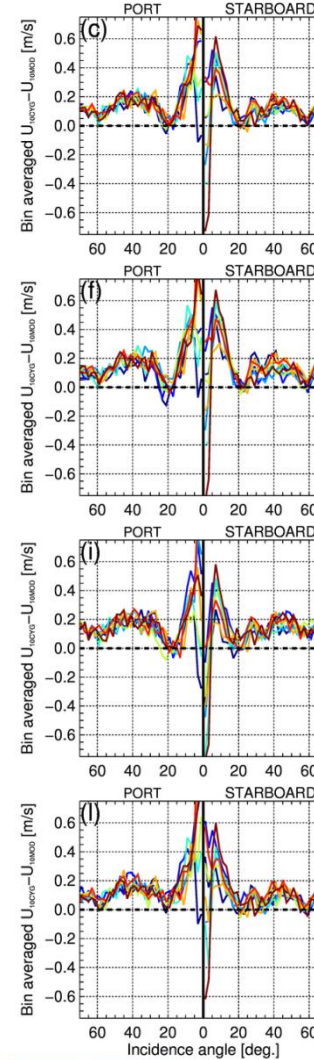
Block IIF

Block IIR-M

Block IIR



Wind speed bias



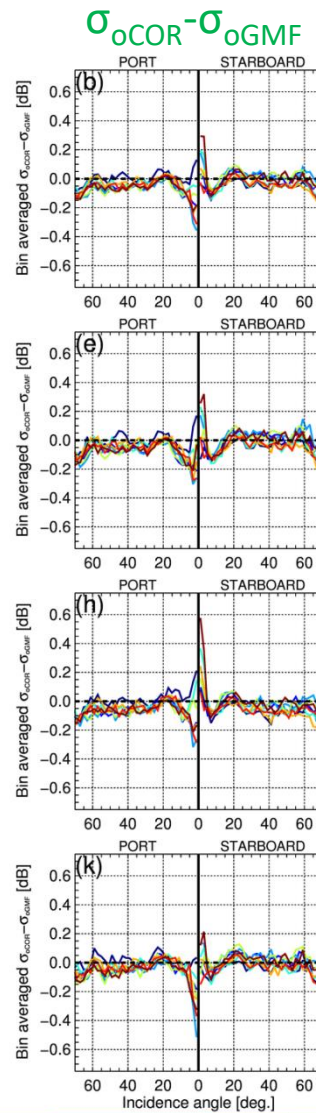
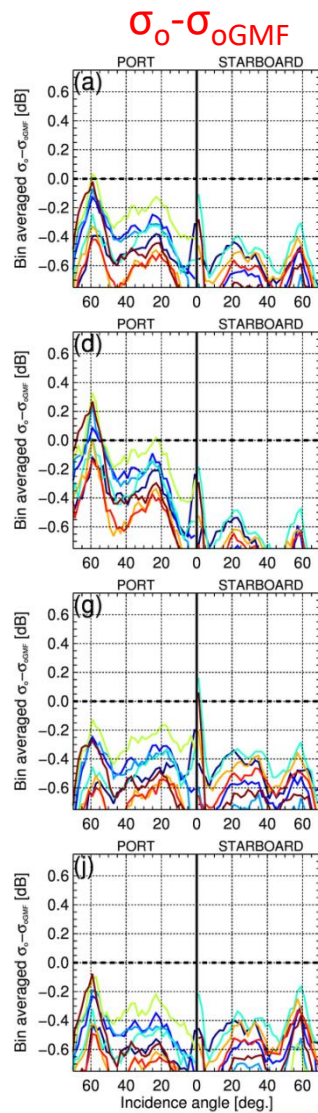
Jan-Dec 2018

All block

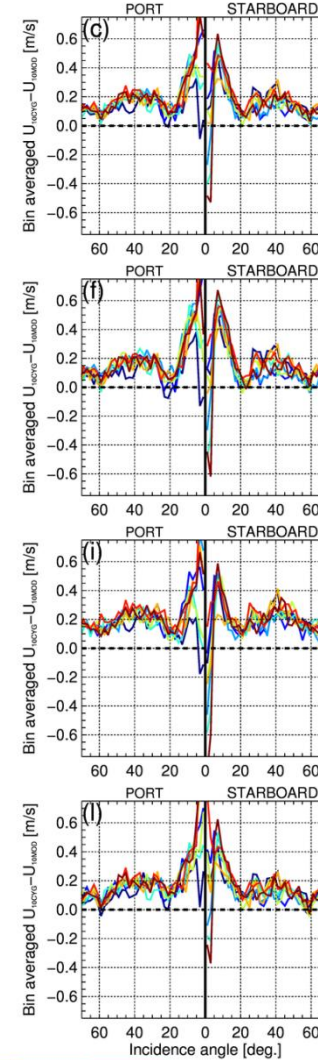
Block IIF

Block IIR-M

Block IIR



Wind speed bias



Jan-Oct 2019

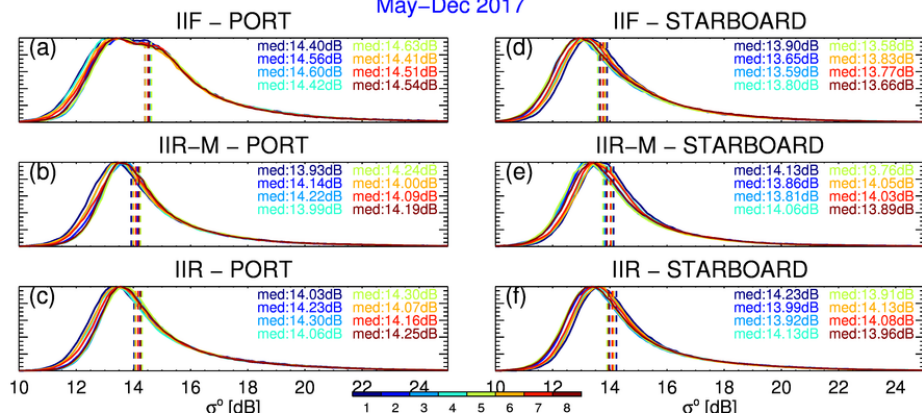
Potentially
impacting
higher wind



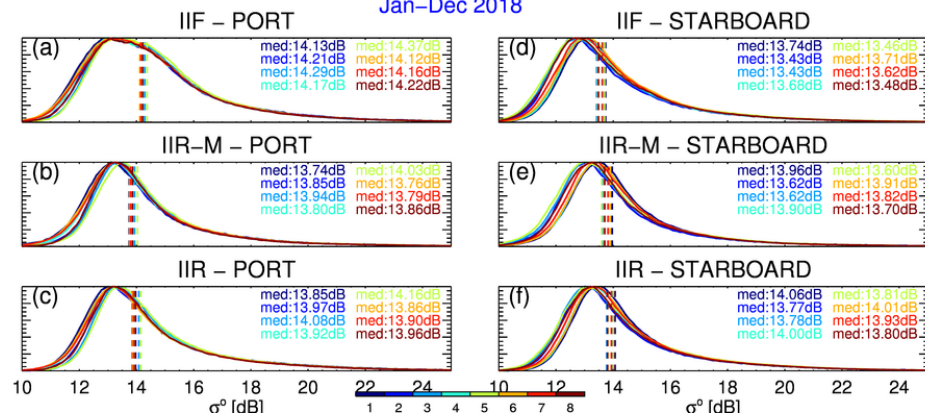
σ_0 distribution
**separated by antenna,
observatory,
GPS block type,
and time period**

Uncorrected σ_0

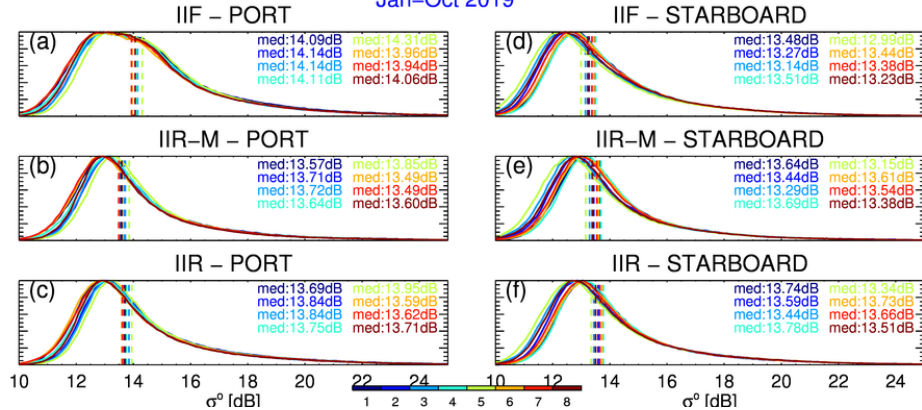
May-Dec 2017



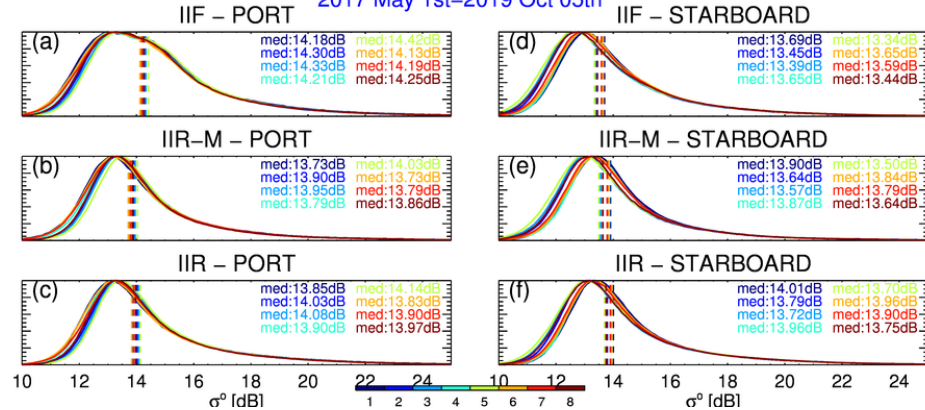
Jan-Dec 2018



Jan-Oct 2019

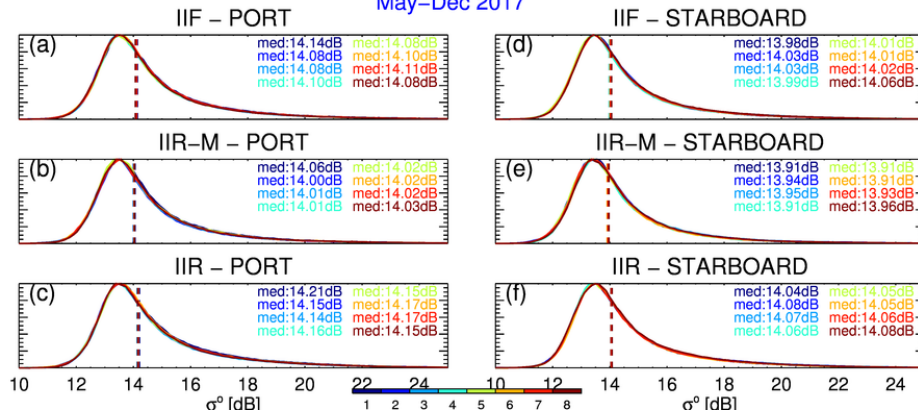


2017 May 1st-2019 Oct 05th

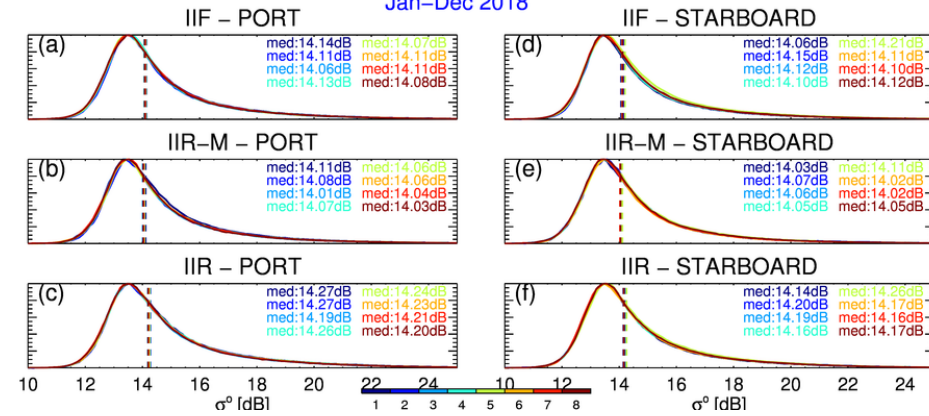


Trackwise bias corrected σ_0

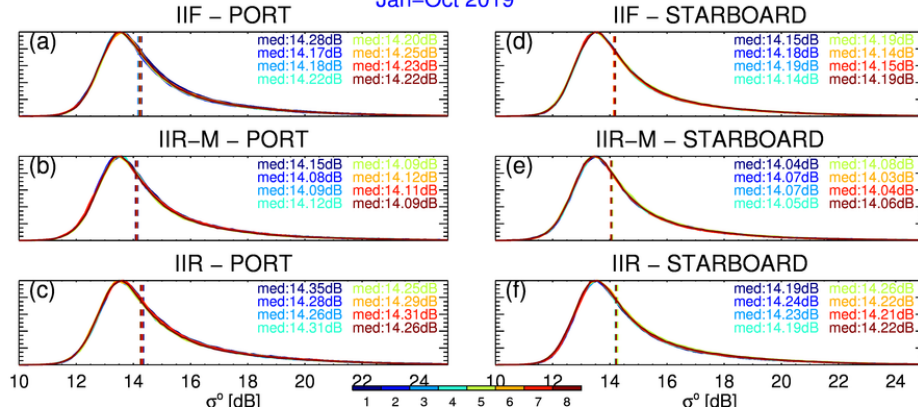
May-Dec 2017



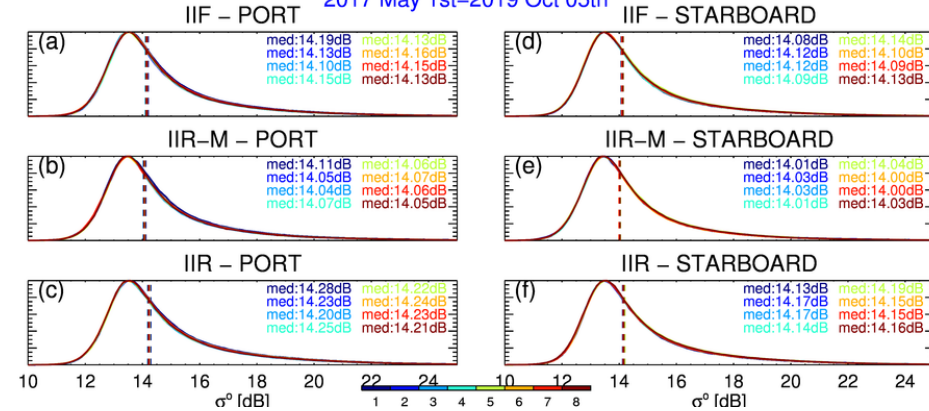
Jan-Dec 2018



Jan-Oct 2019



2017 May 1st-2019 Oct 05th



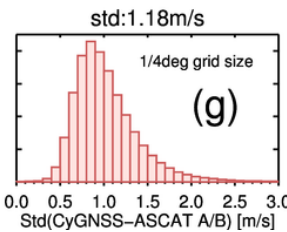
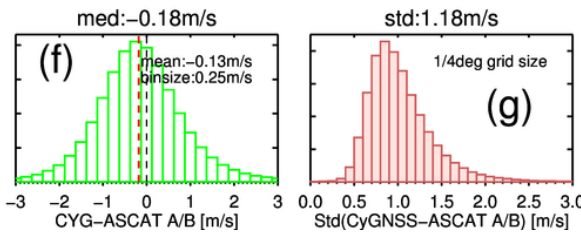
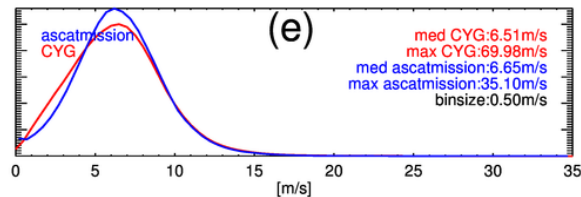
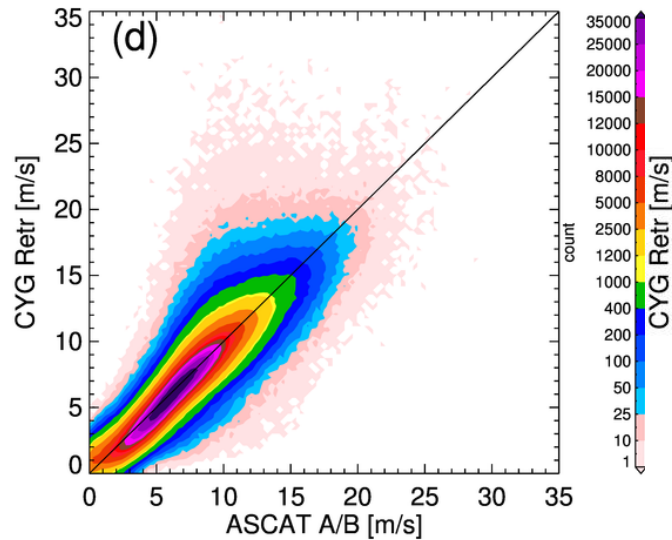


CYGNSS winds vs Sensors

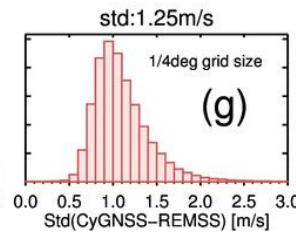
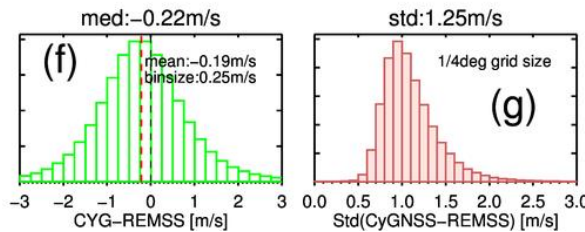
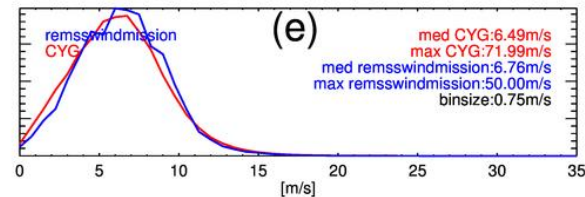
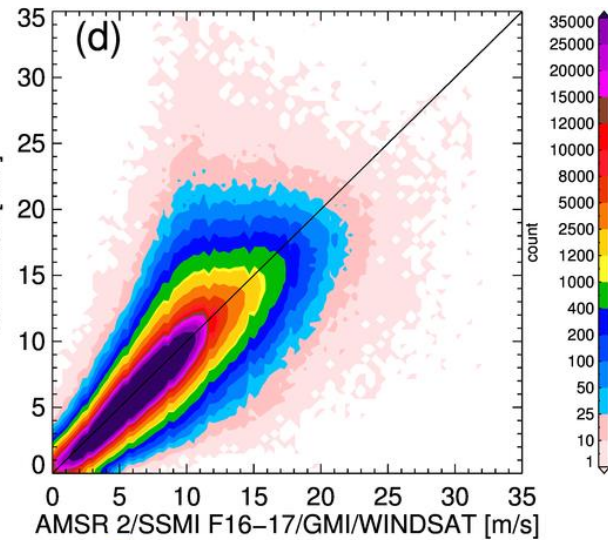
Performance Period: 1st May 2017- 30th Nov 2018

CYGNSS Descending

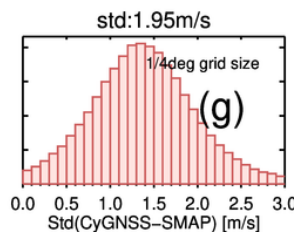
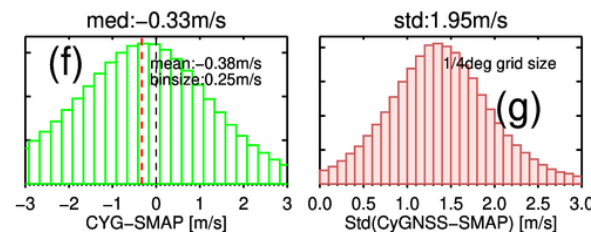
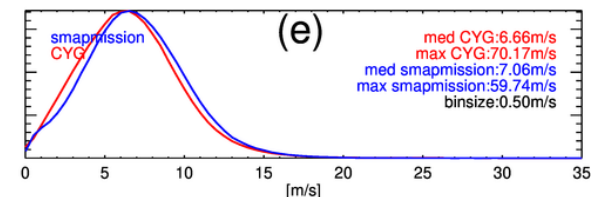
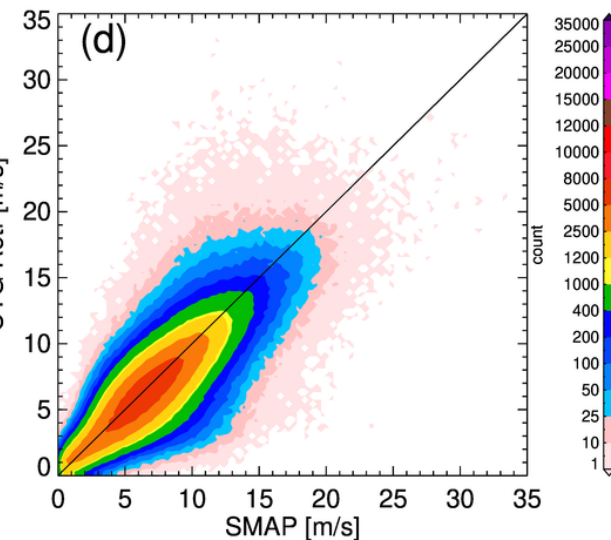
ASCAT



RSS-Radiometers



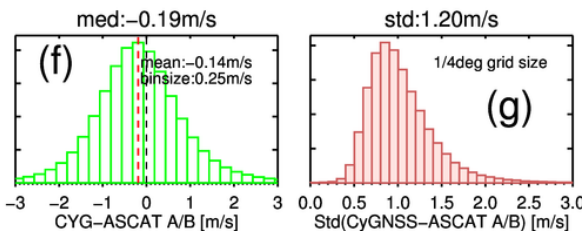
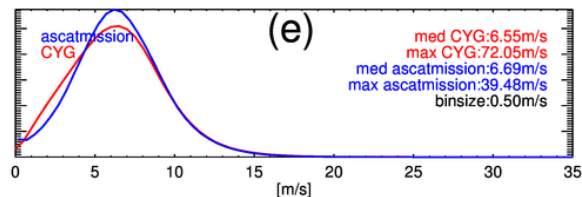
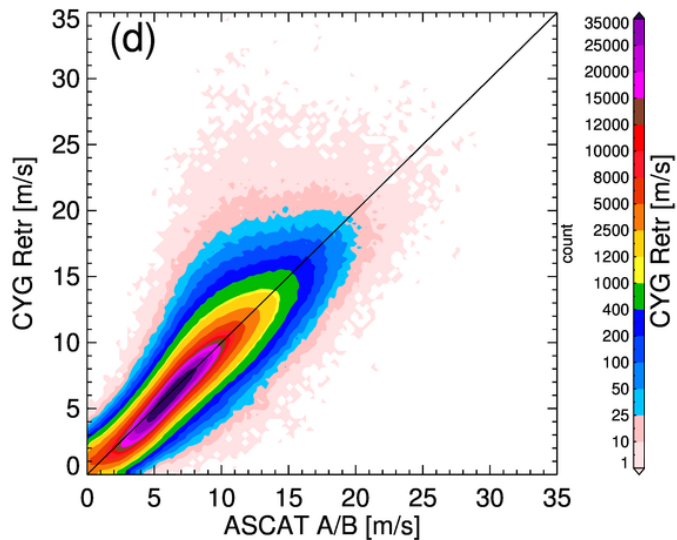
RSS-SMAP



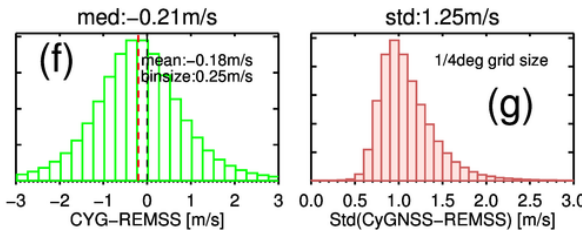
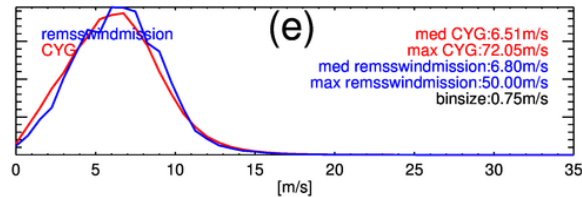
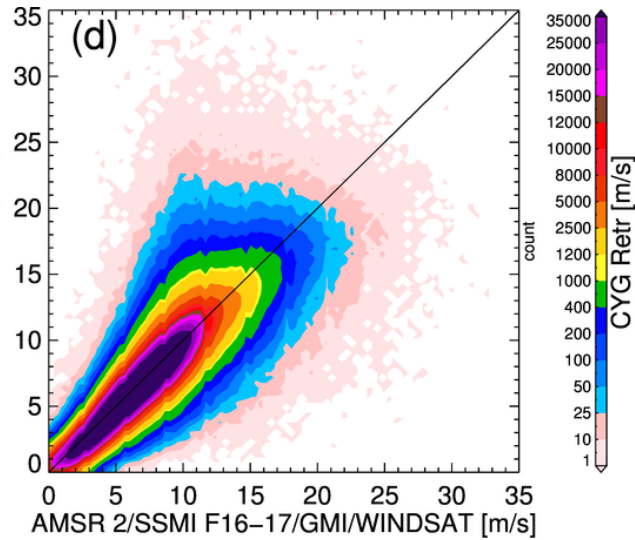
Performance Period: 1st May 2017- 30th Nov 2018

CYGNSS Ascending

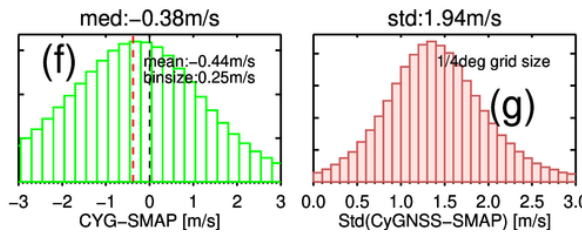
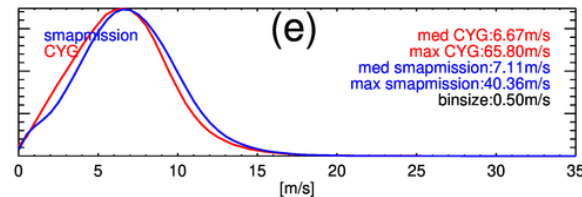
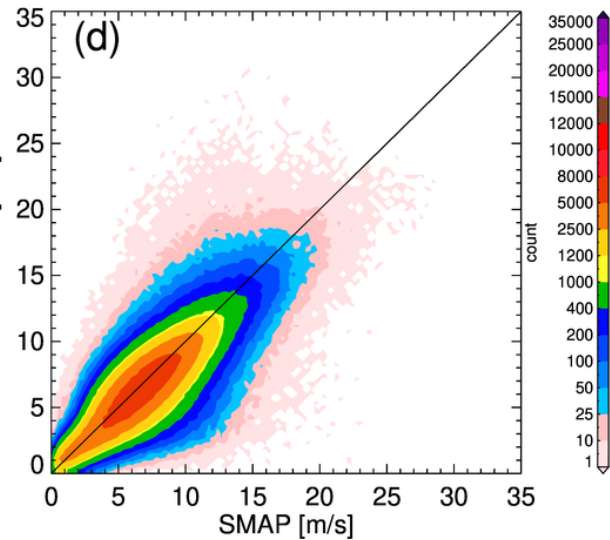
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RSS-Radiometers



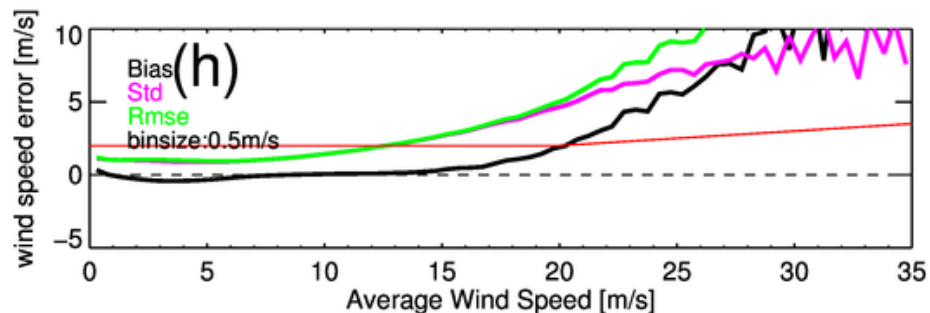
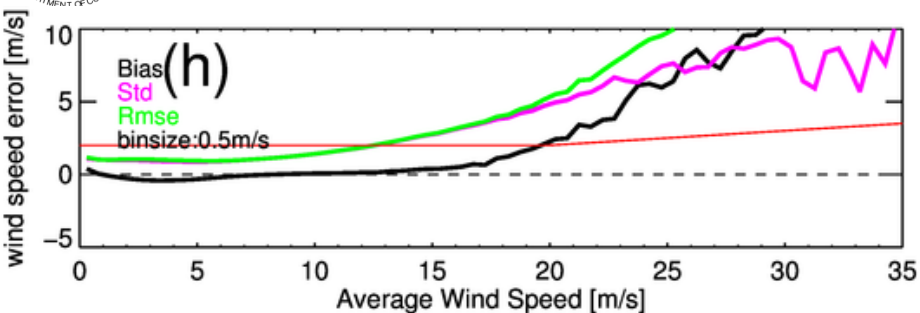
RSS-SMAP



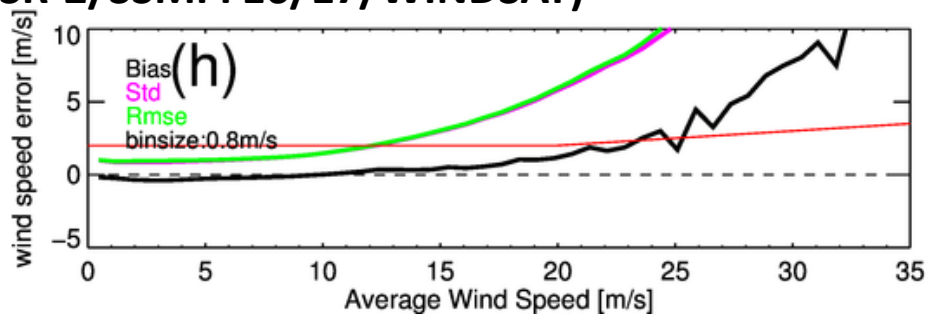
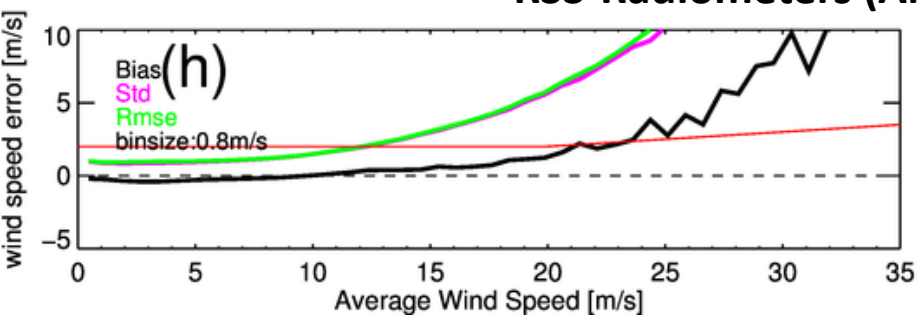
Descending

ASCAT

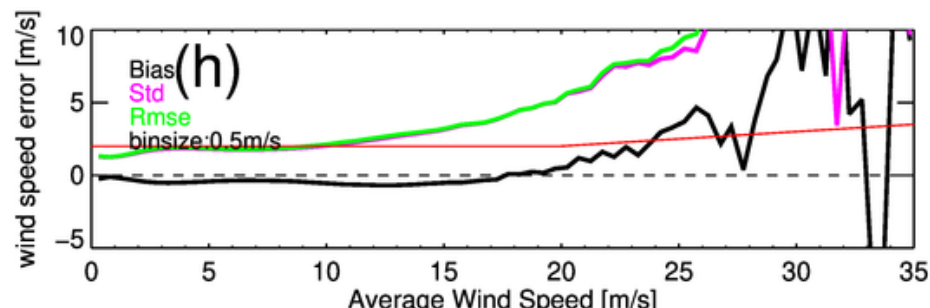
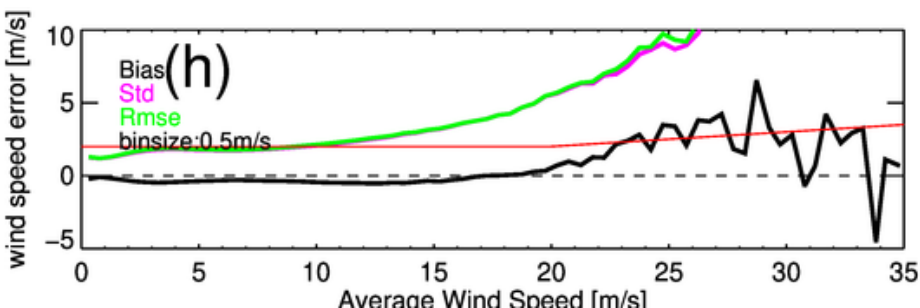
Ascending



RSS-Radiometers (AMSR-2/SSM/I F16/17/WINDSAT)



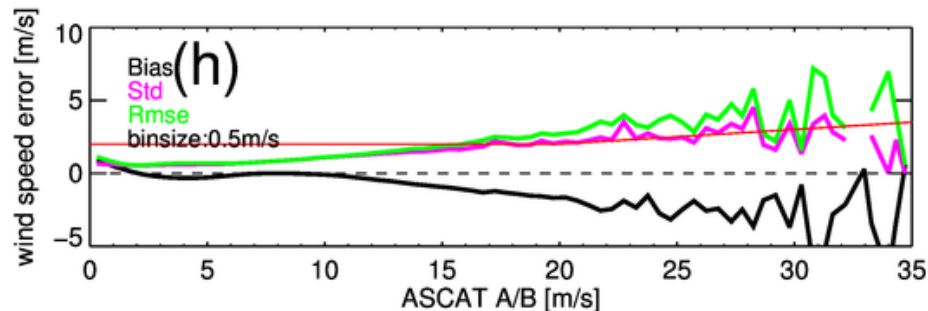
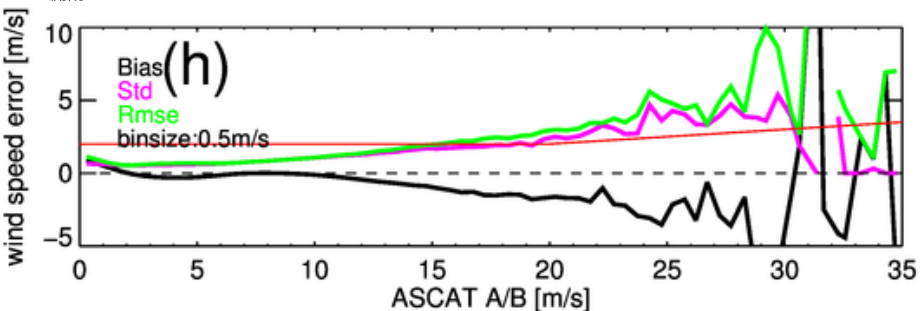
SMAP



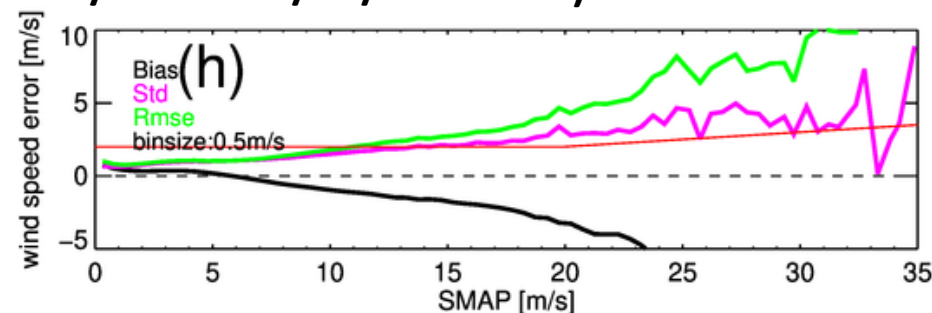
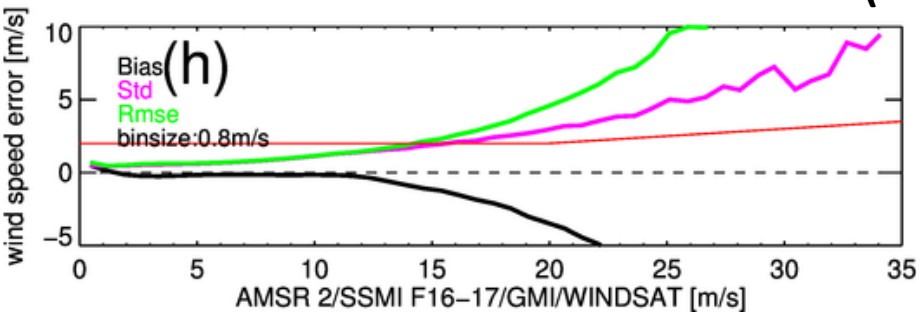
Descending

ASCAT

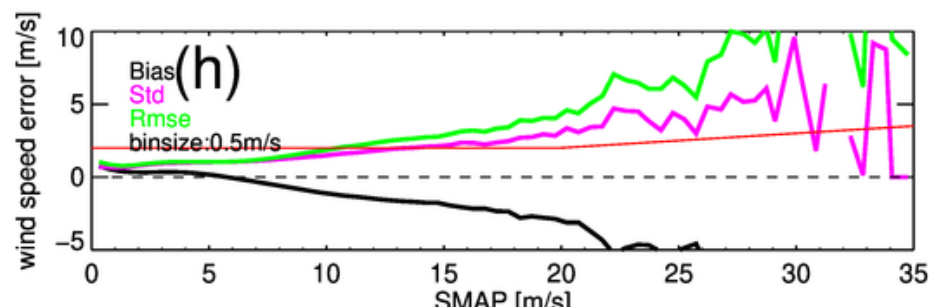
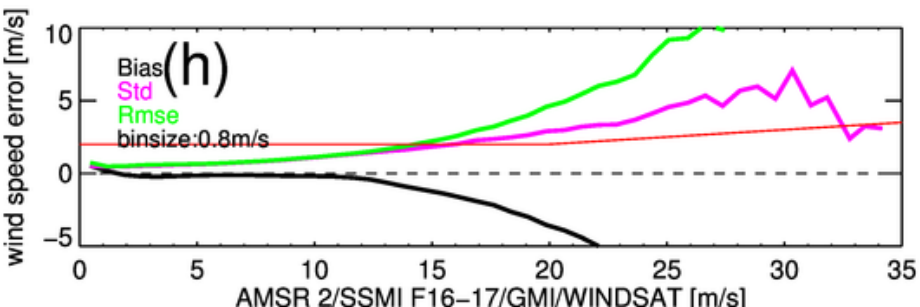
Ascending



RSS-Radiometers (AMSR-2/SSM/F16/17/WINDSAT)



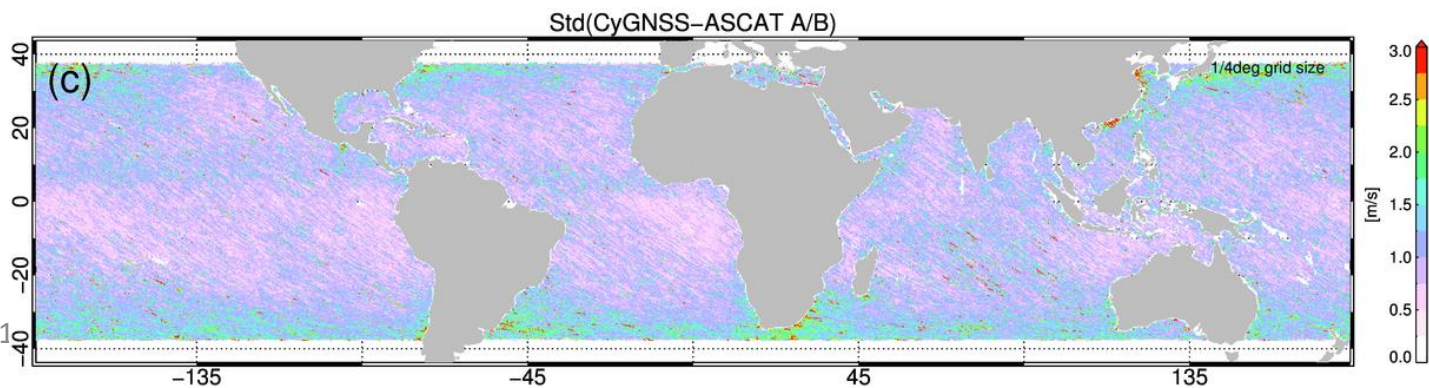
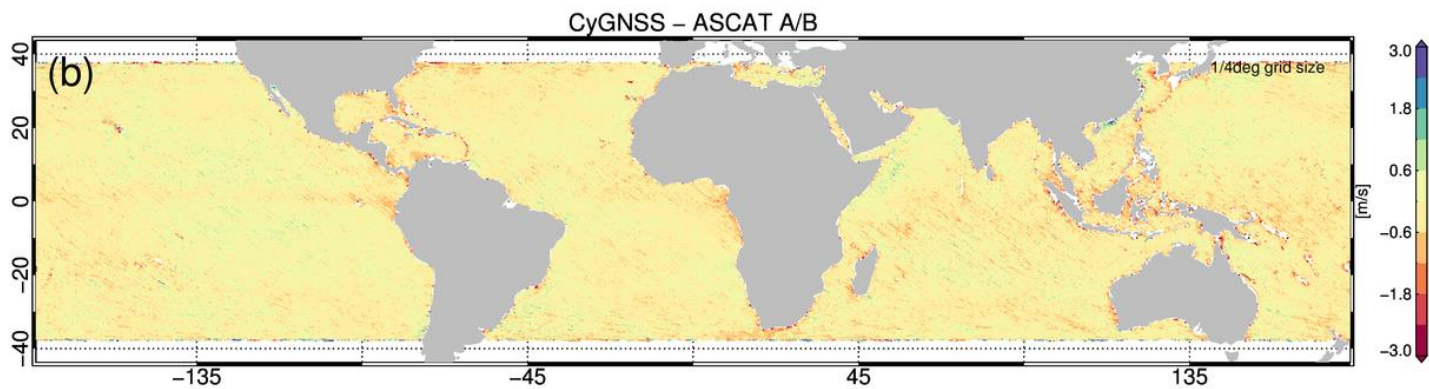
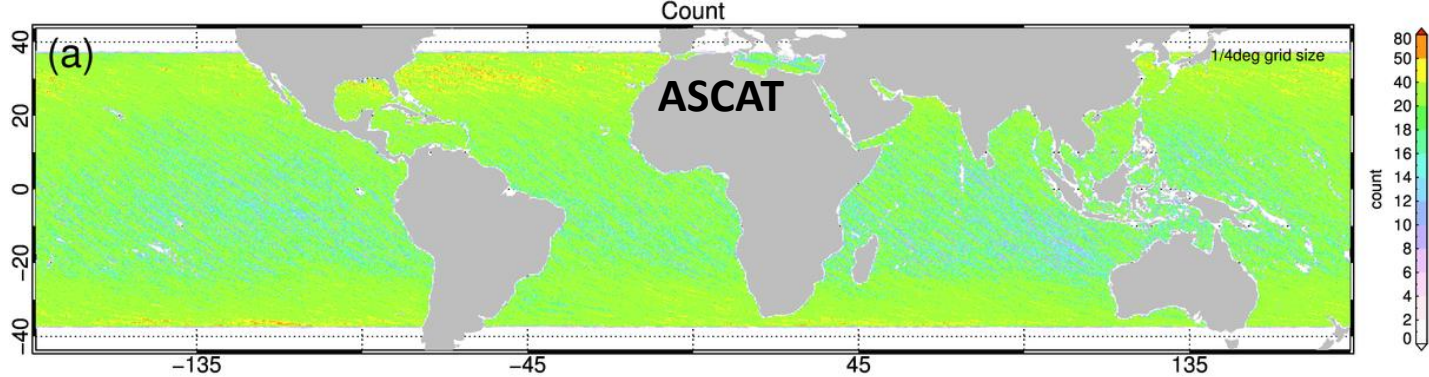
SMAP

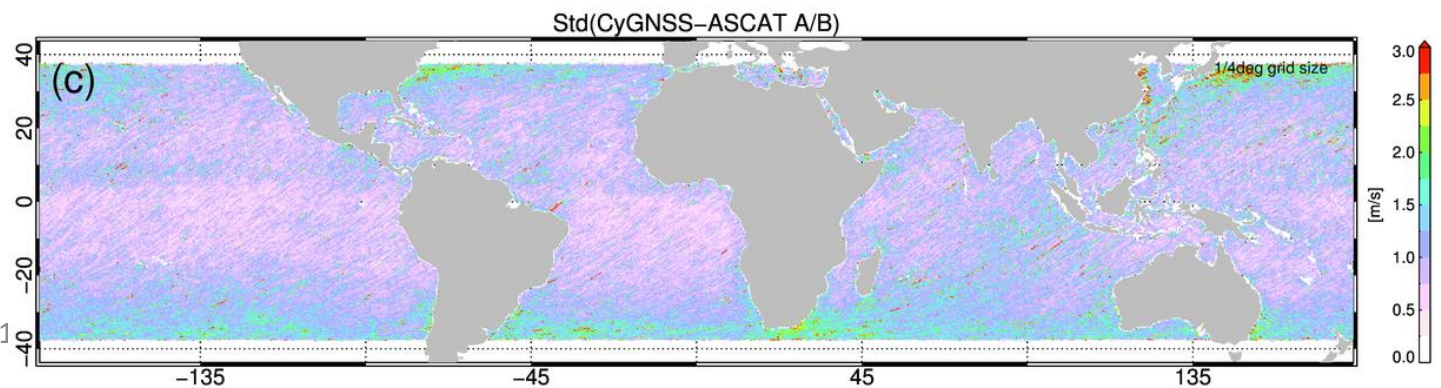
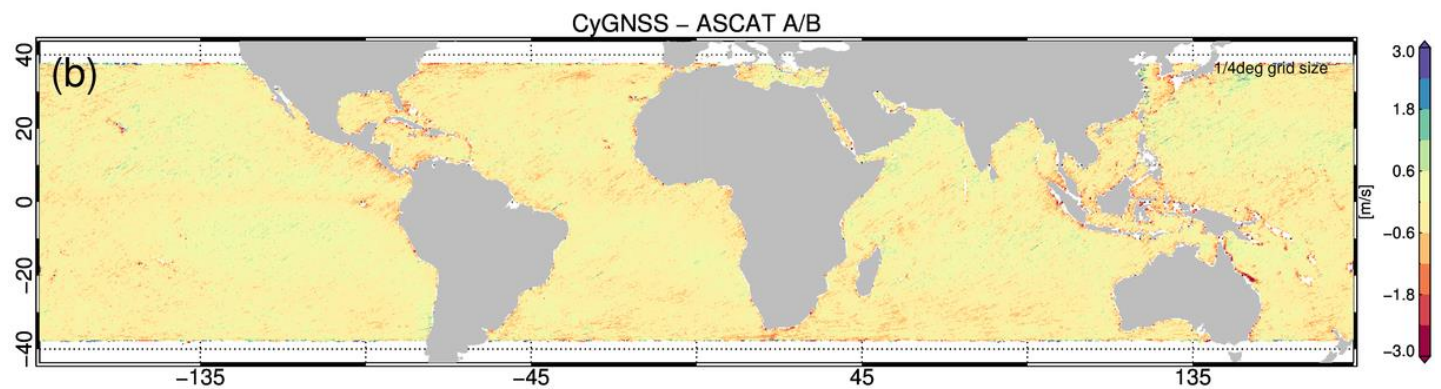
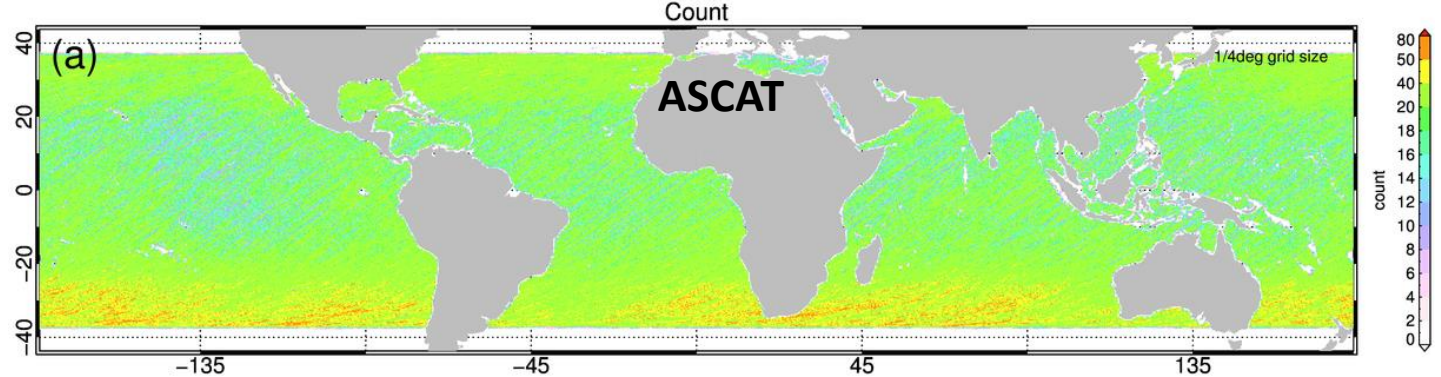




Geographical Error

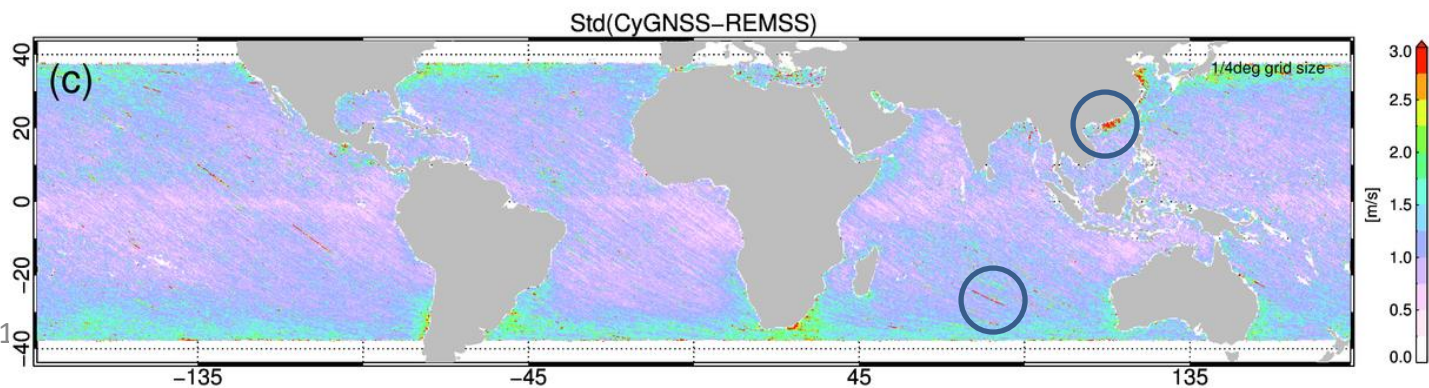
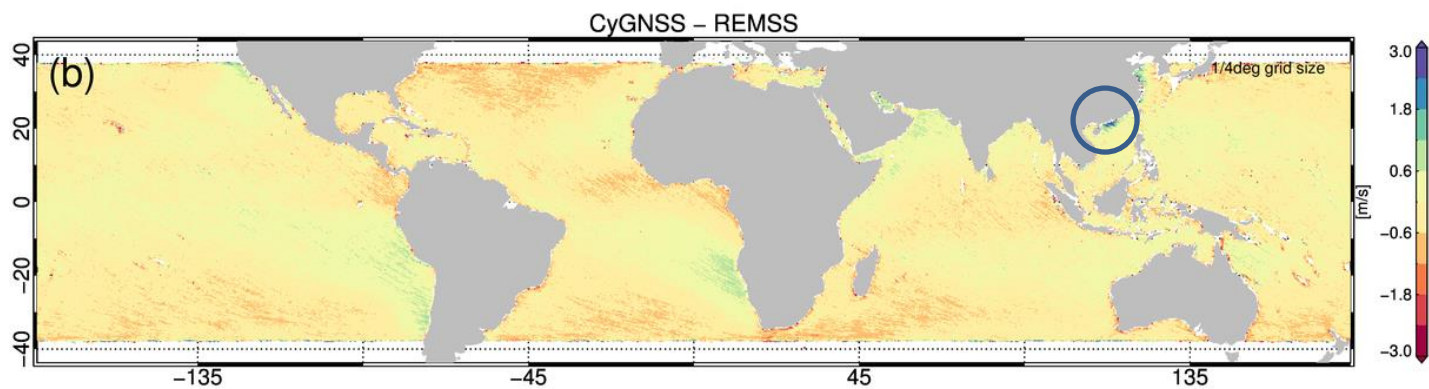
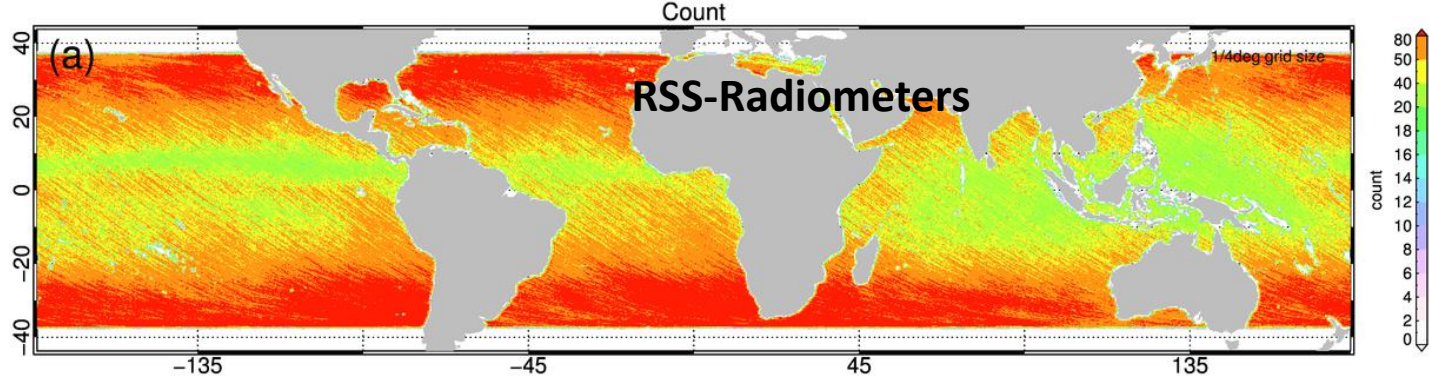
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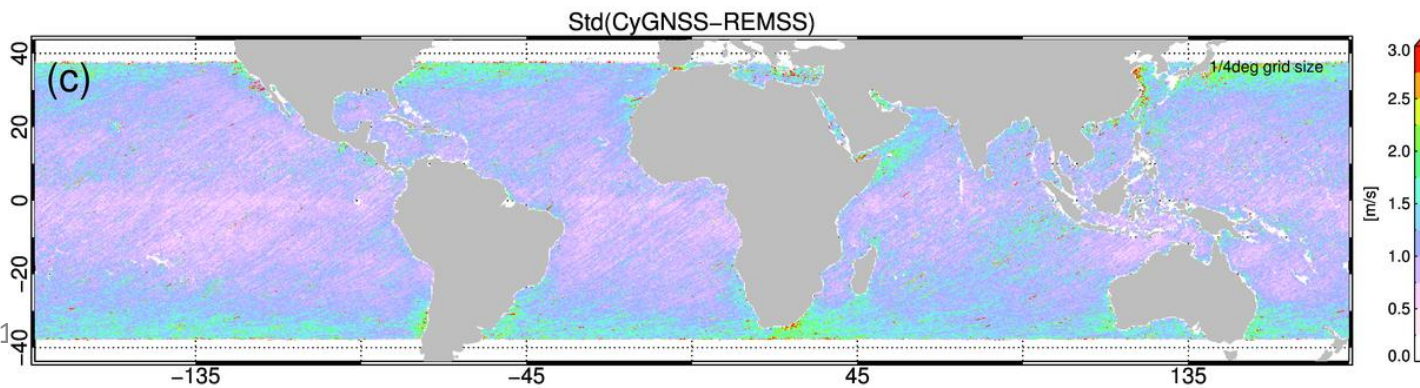
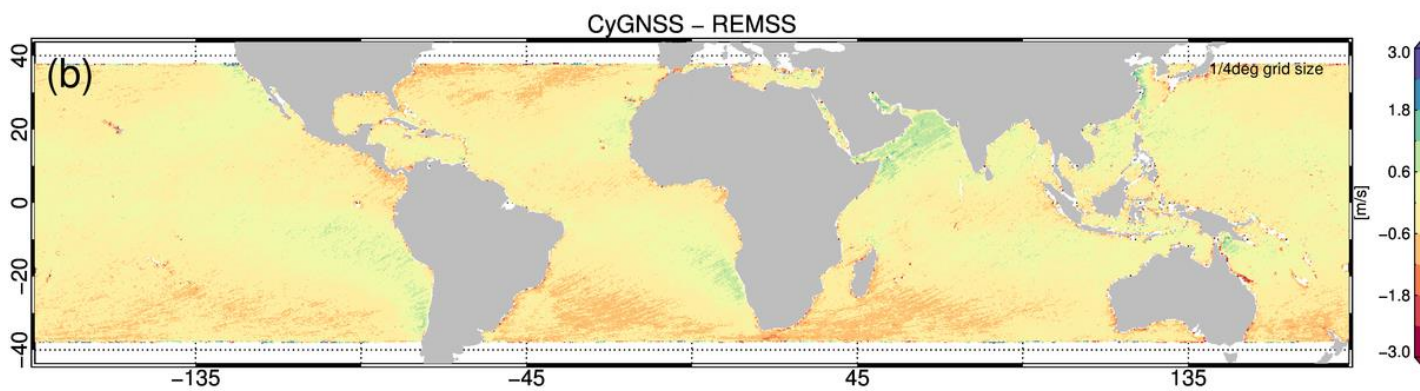
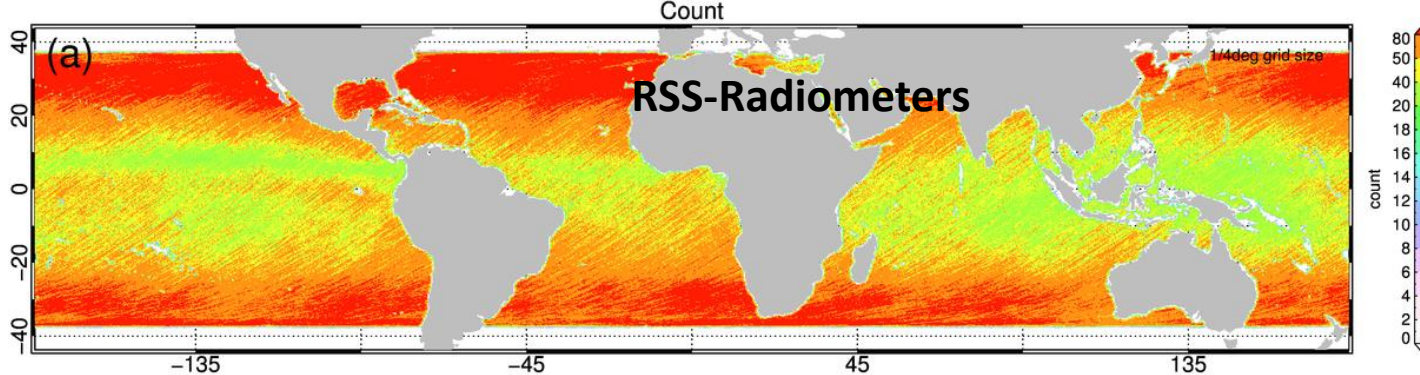




Ascending

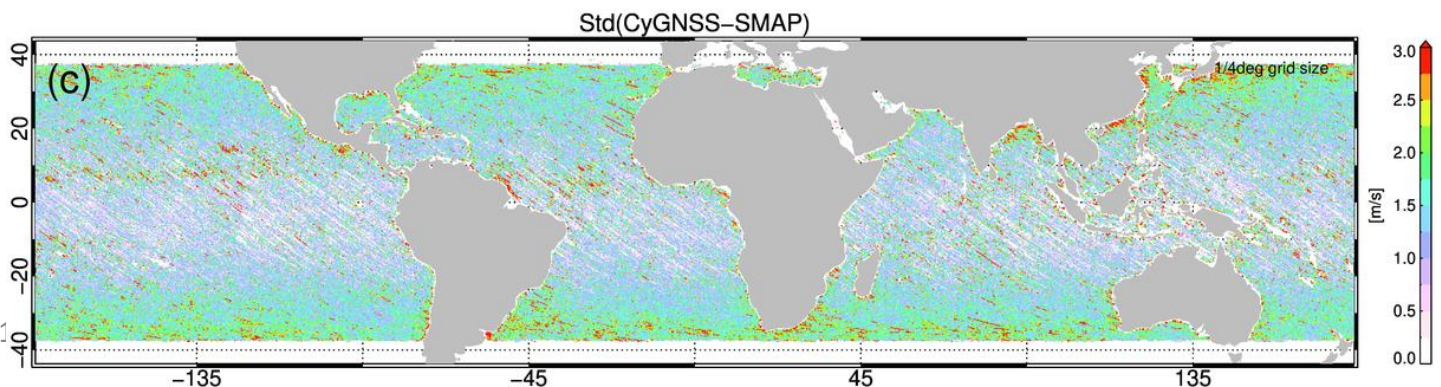
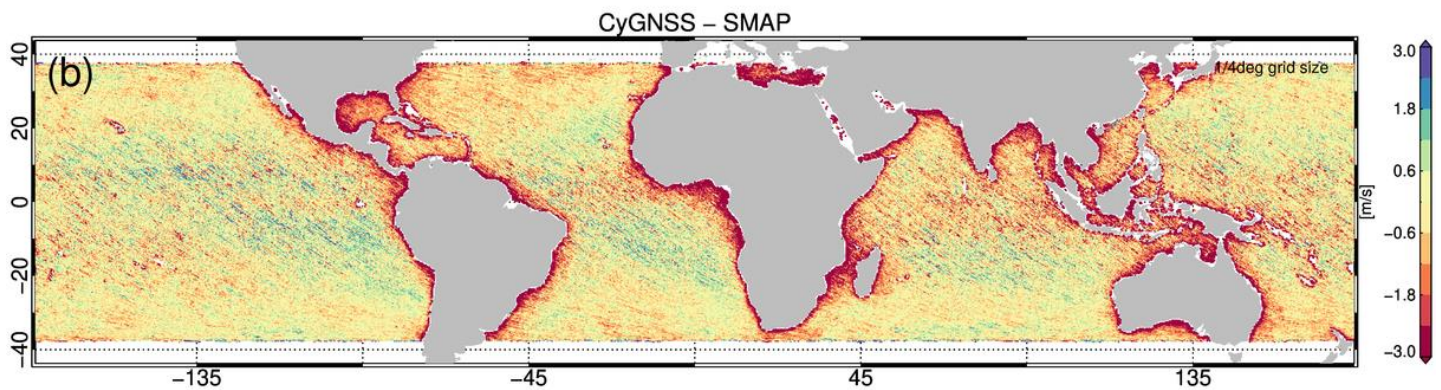
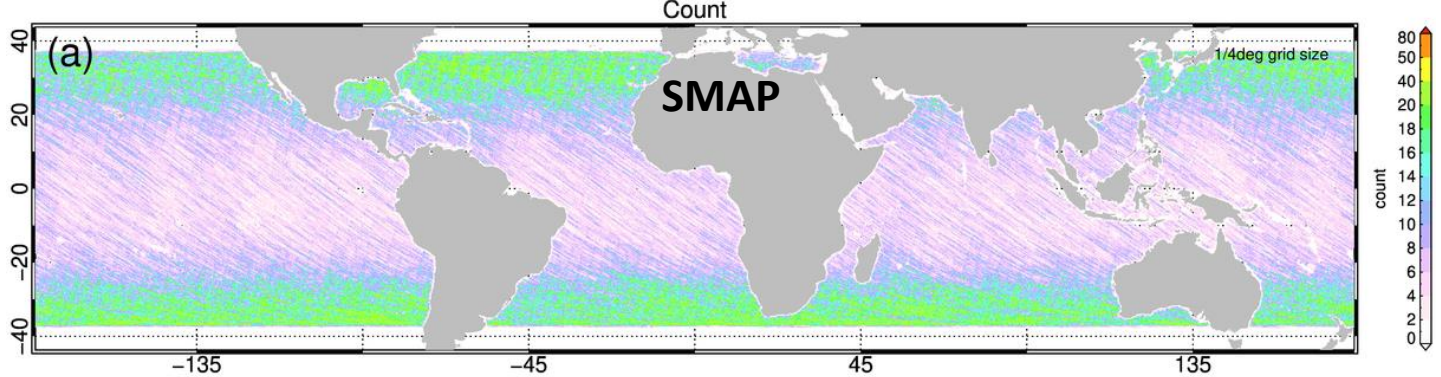
Descending



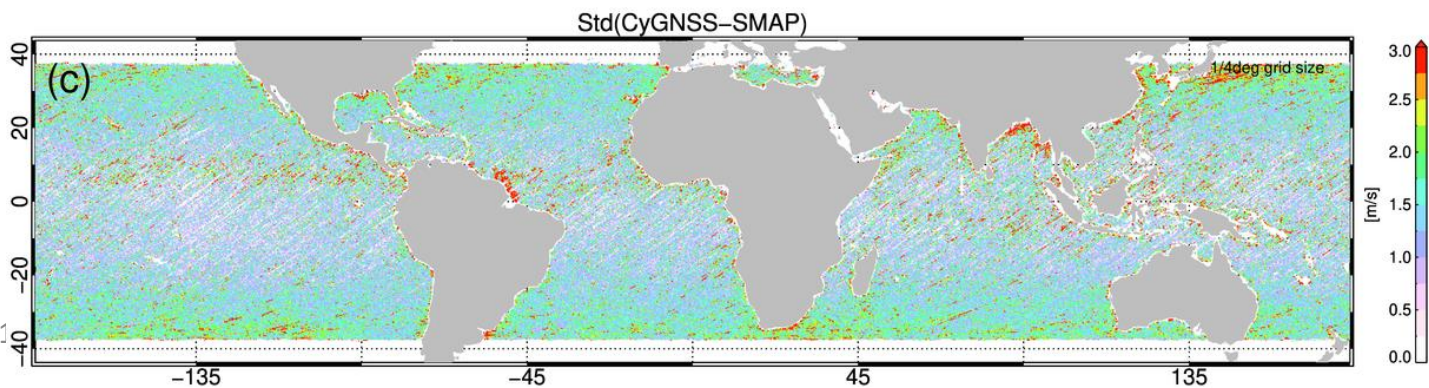
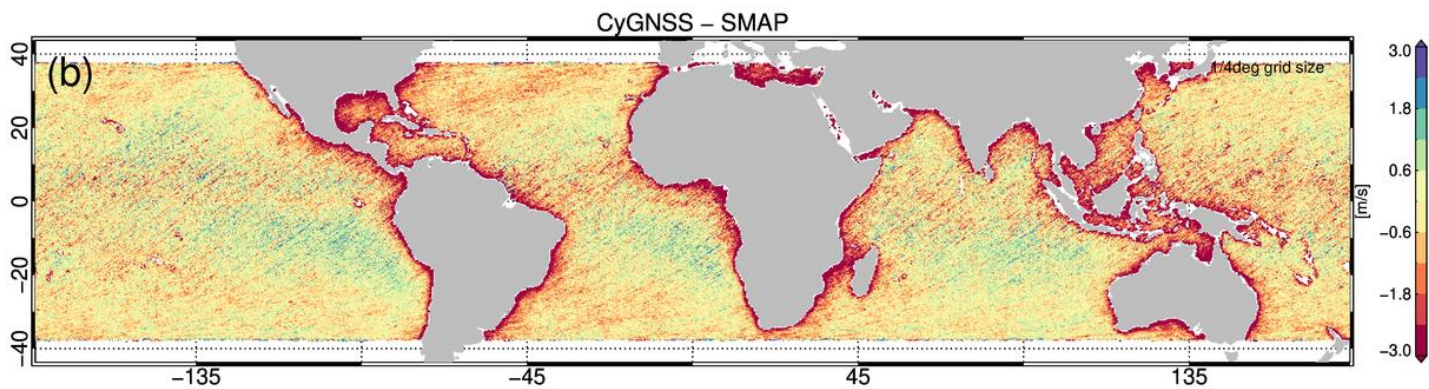
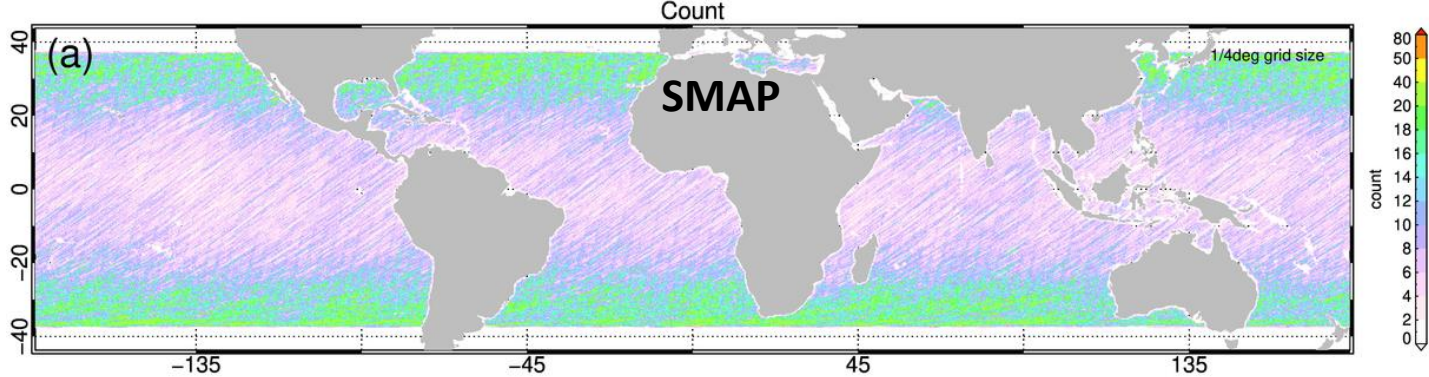


Ascending

Descending



Ascending

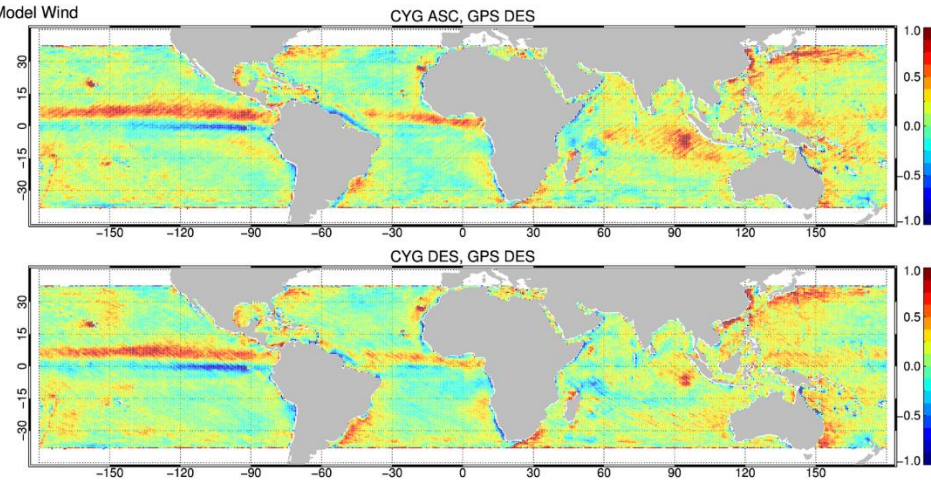
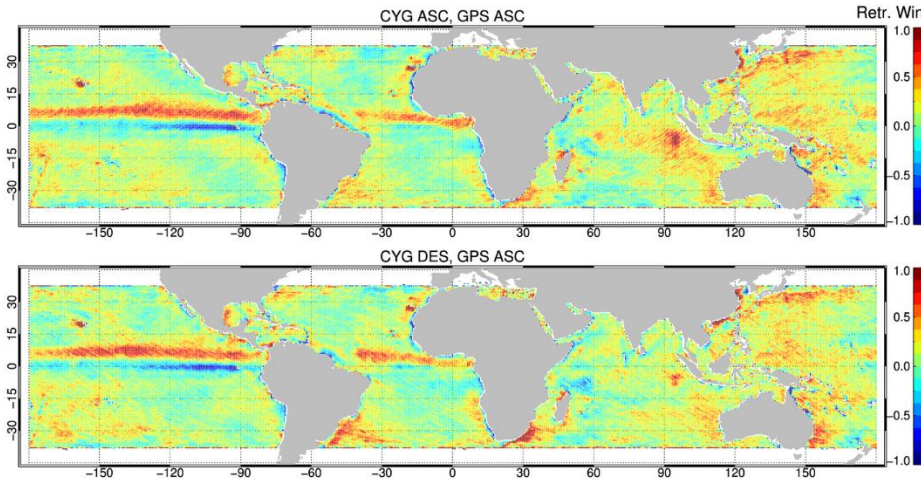




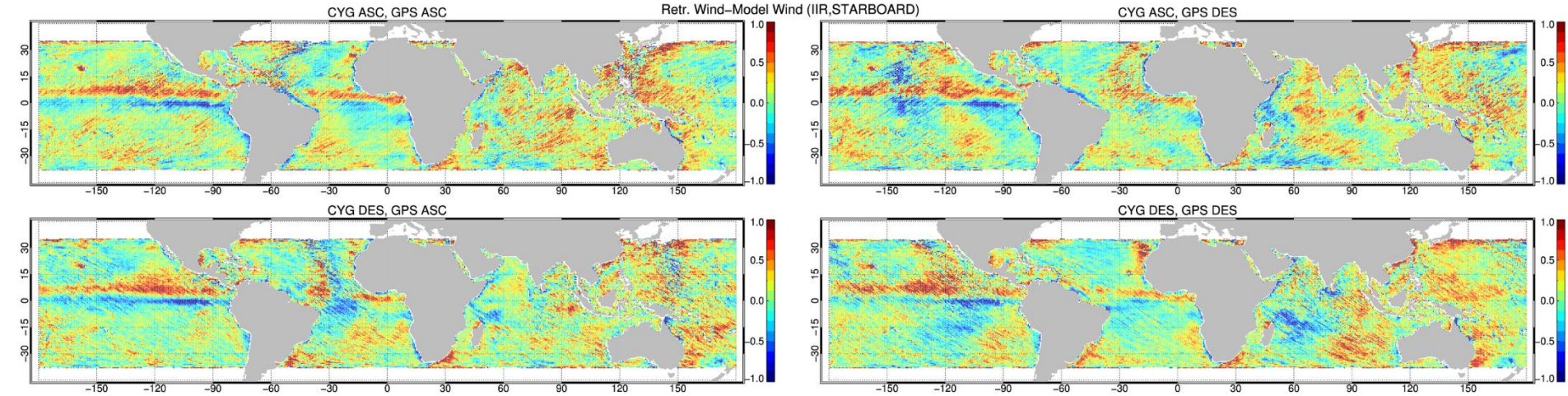
Geographical Error Dependence per Block and Antenna Evaluation with ECMWF winds

Performance period: 1st May 2017- 5th Oct 2019

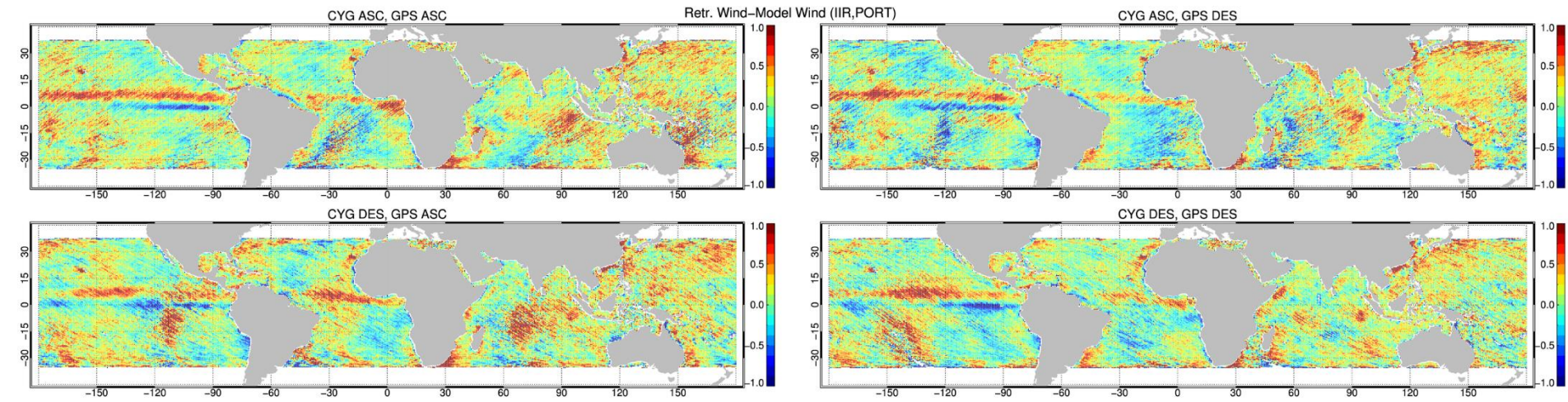
ALL



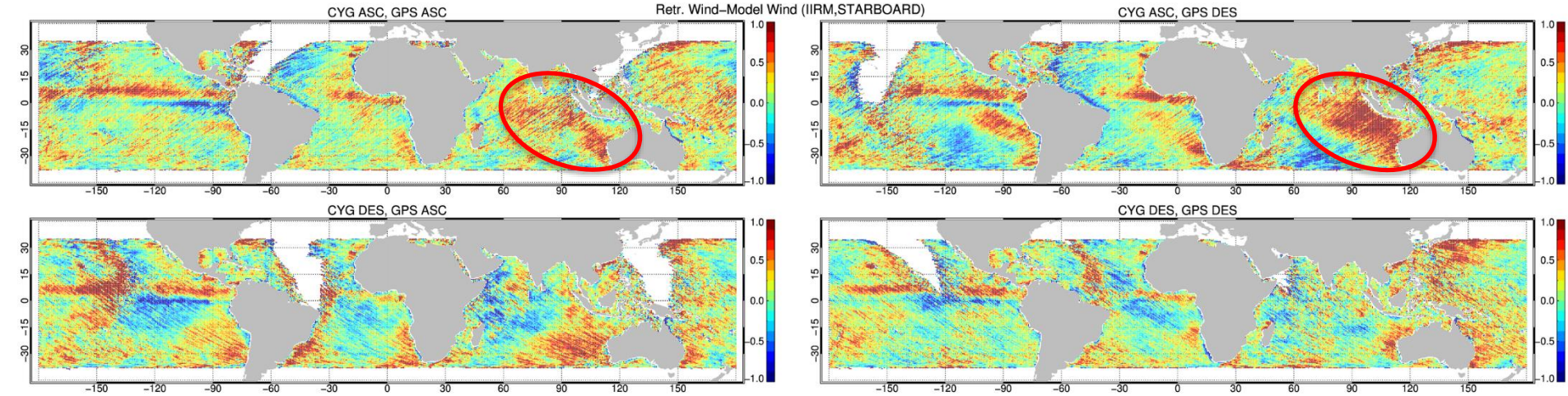
IIR and STARBOARD



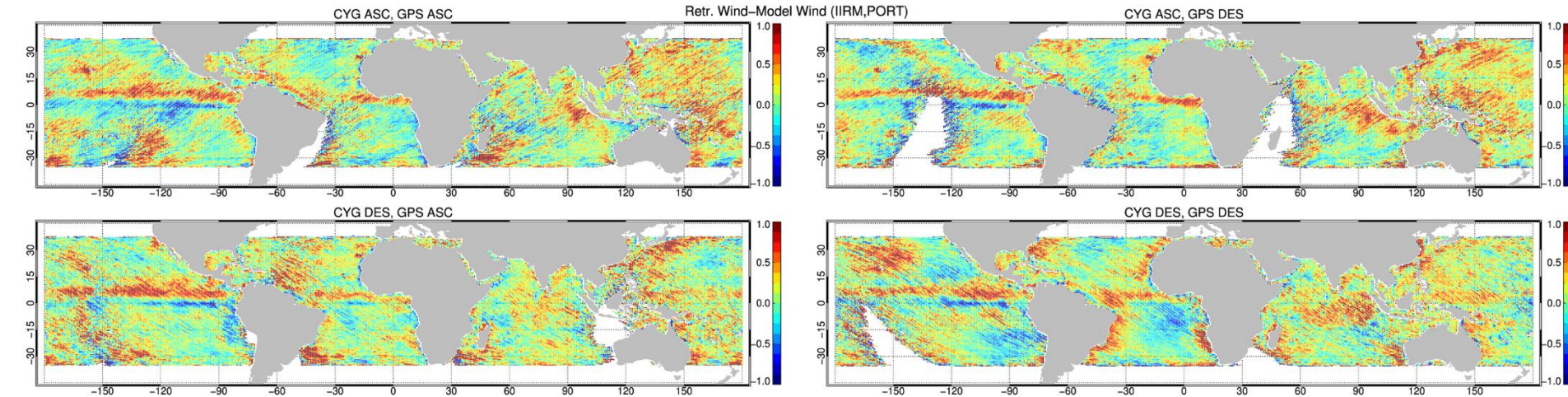
IIR and PORT



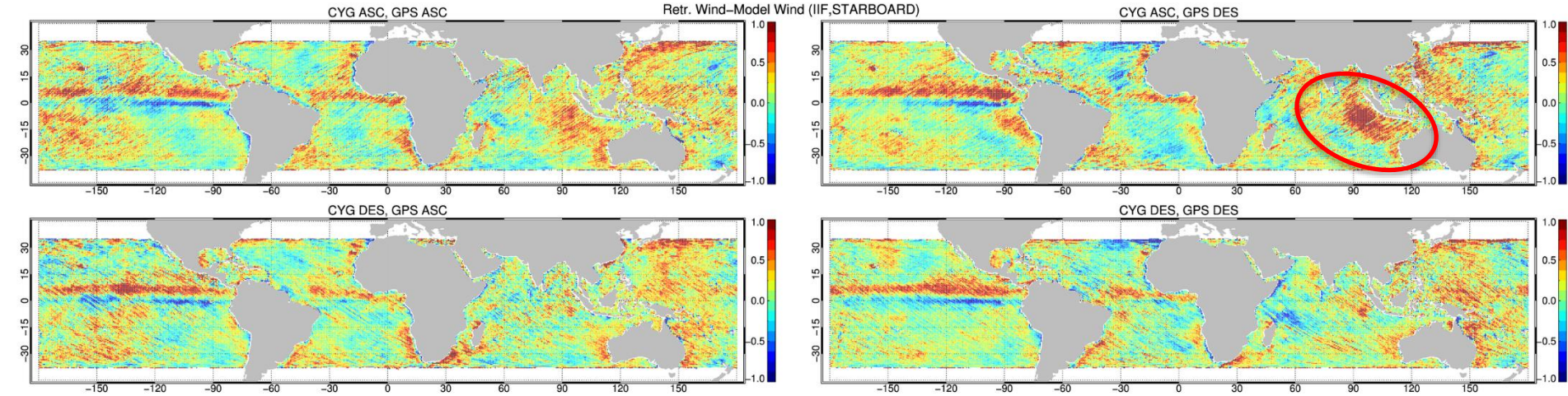
IIRM and STARBOARD



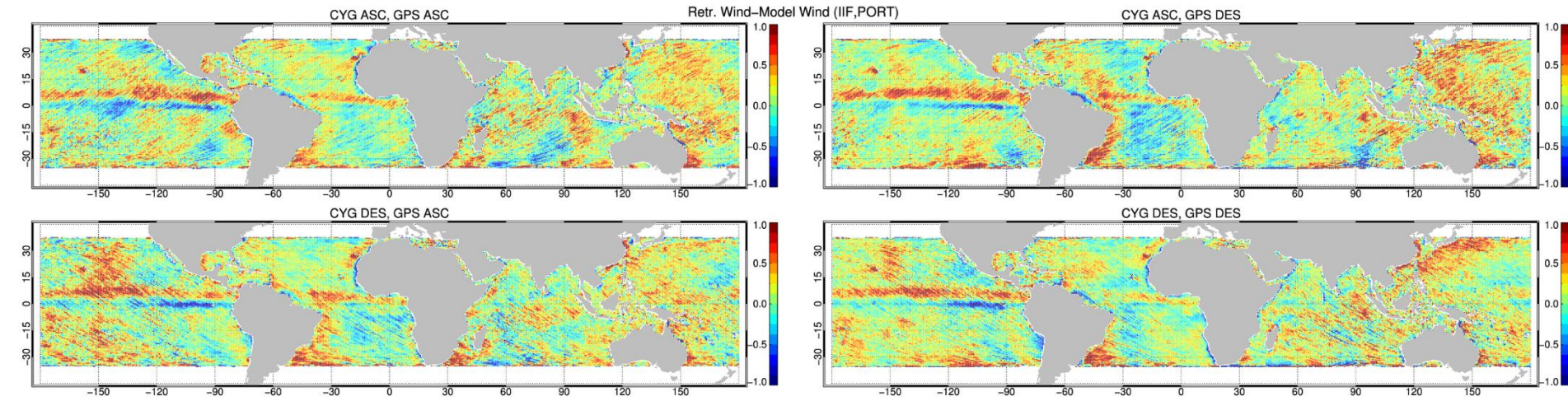
IIRM and PORT



IIF and STARBOARD



IIF and PORT



CYGNSS L2 winds vs Sensors Overall Statistics

		2017		2018		2017-2018	
		DES	ASC	DES	ASC	DES	ASC
ASCAT	Bias	-0.18	-0.15	-0.13	-0.14	-0.13	-0.14
	STD	1.13	1.19	1.23	1.22	1.18	1.20
Radiometers	Bias	-0.18	-0.16	-0.19	-0.19	-0.19	-0.18
	STD	1.23	1.21	1.26	1.27	1.25	1.25
SMAP	Bias	-0.28	-0.28	-0.38	-0.46	-0.36	-0.44
	STD	1.93	1.90	1.96	1.97	1.95	1.95

CYGNSS L2 winds vs ECMWF Overall Statistics

PORT		2017		2018		2019		2017-2018	
		DES	ASC	DES	ASC	DES	ASC	DES	ASC
ECMWF	Bias	0.0099	-0.0024	0.034	0.029	0.051	0.036	0.034	0.026
	STD	1.24	1.25	1.33	1.32	1.34	1.34	1.32	1.31

STARBOARD		2017		2018		2019		2017-2018	
		DES	ASC	DES	ASC	DES	ASC	DES	ASC
ECMWF	Bias	-0.012	-0.011	0.0014	0.0087	0.018	0.032	0.0037	0.012
	STD	1.31	1.30	1.31	1.32	1.37	1.39	1.33	1.34

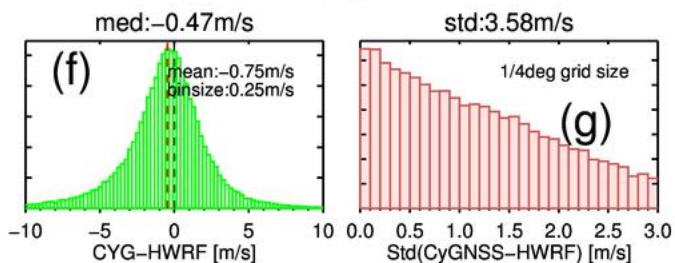
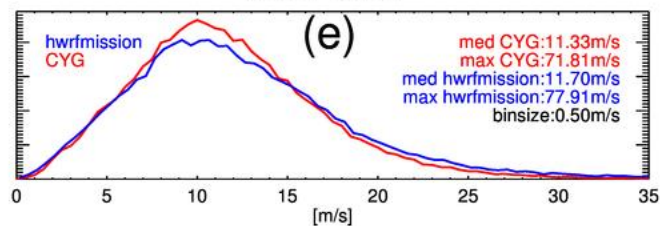
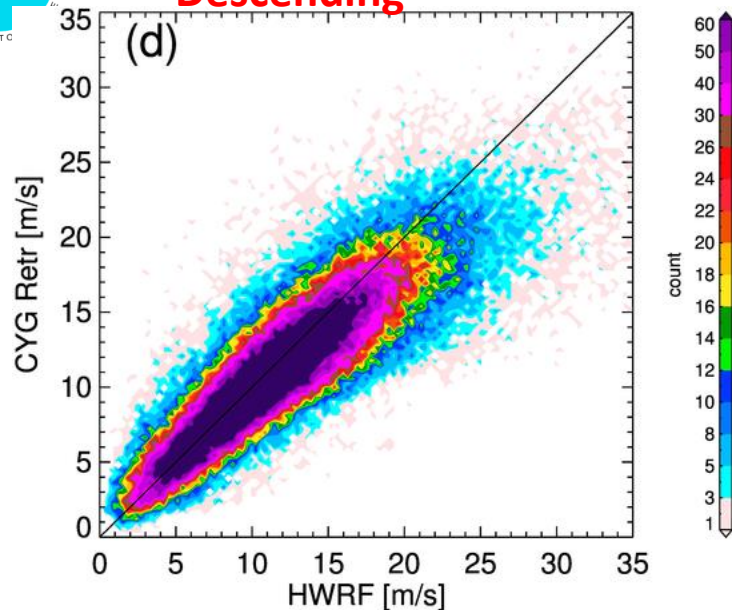


TC Evaluation

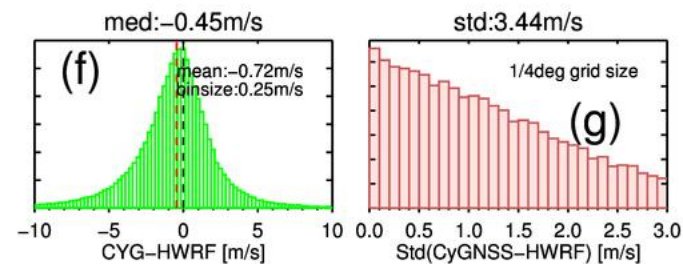
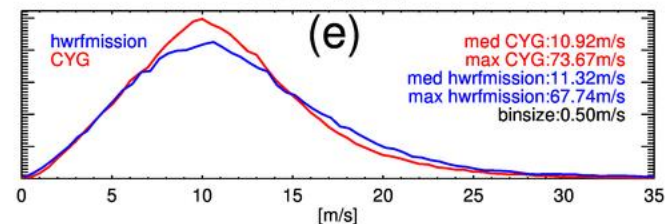
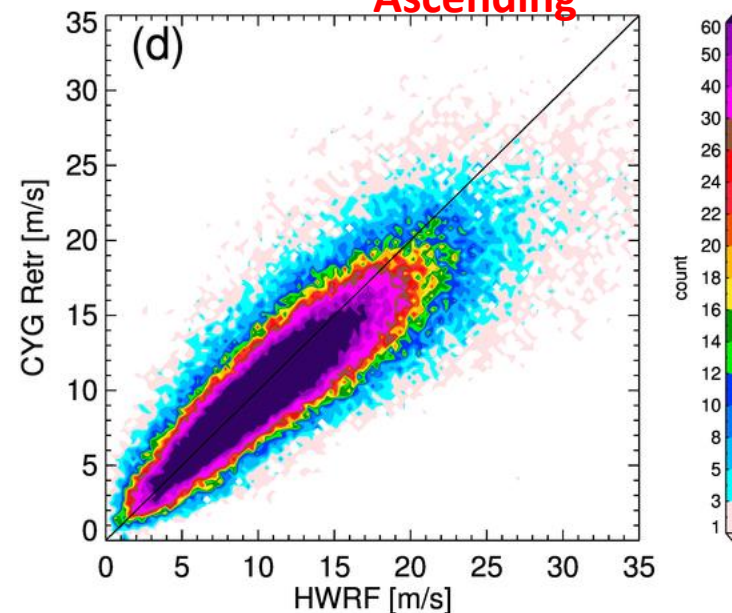
Time Period: May 2017-Oct 2019

Performance Period: 1st May 2017- 5th Oct 2019

Descending



Ascending



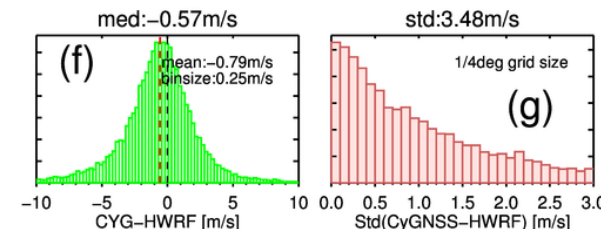
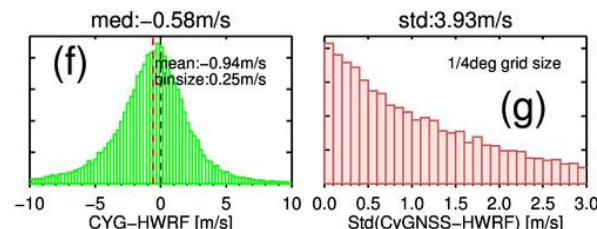
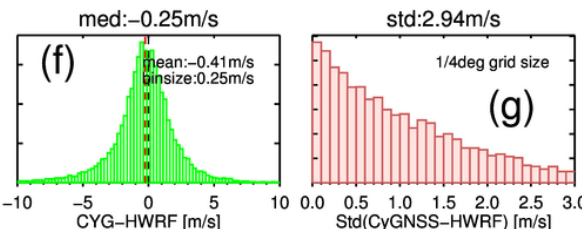
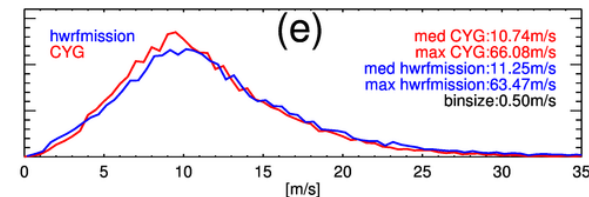
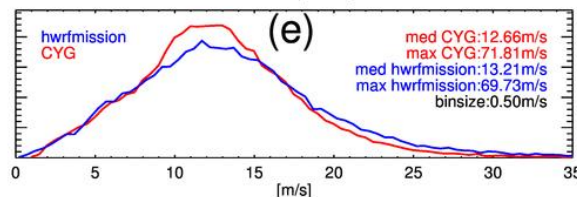
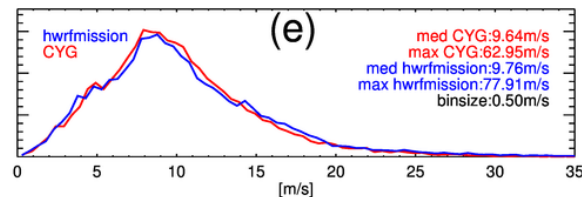
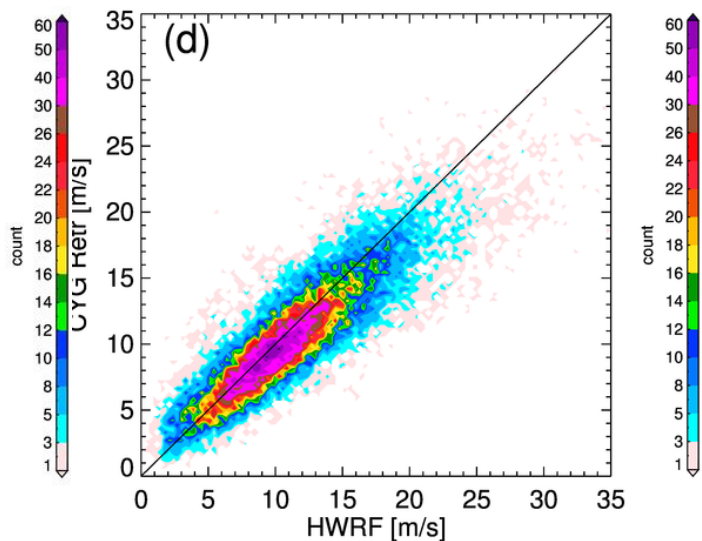
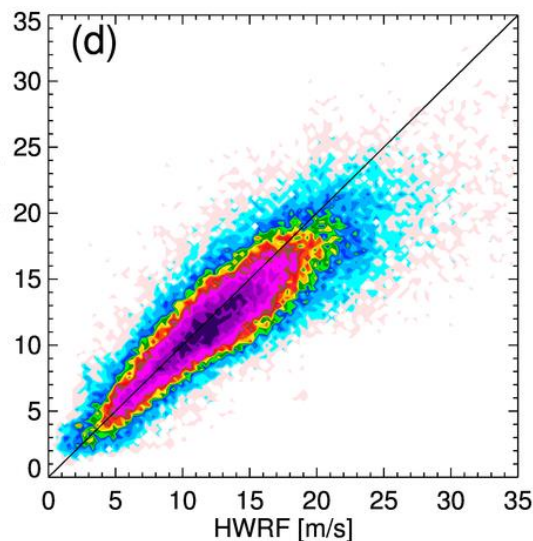
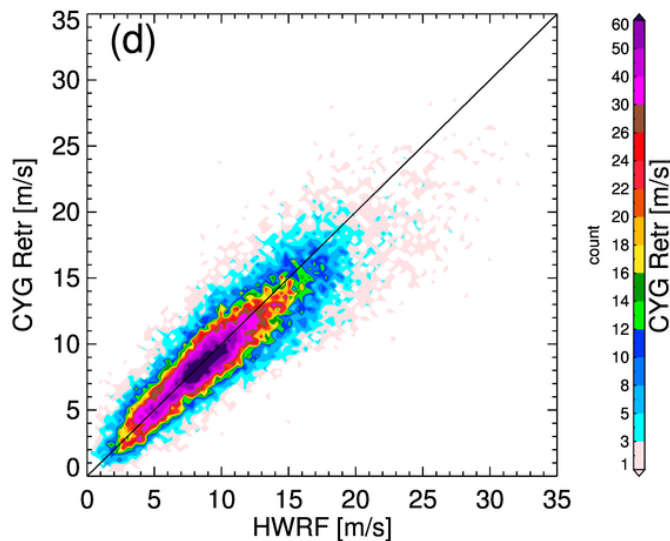
Performance Period: 1st May 2017- 5th Oct 2019

CYGNSS Descending

2017

2018

2019



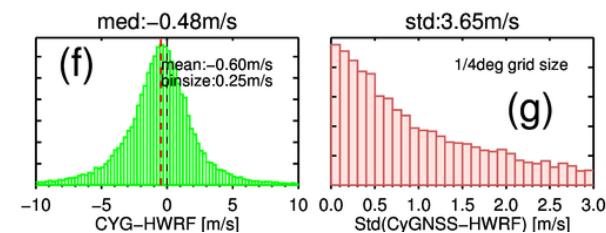
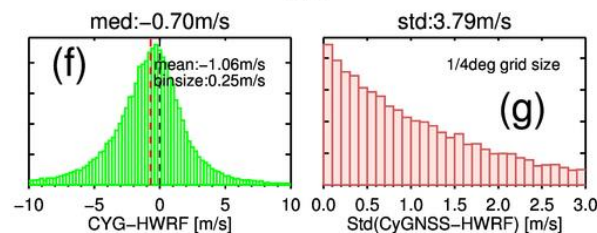
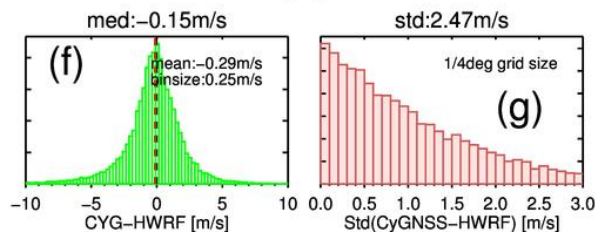
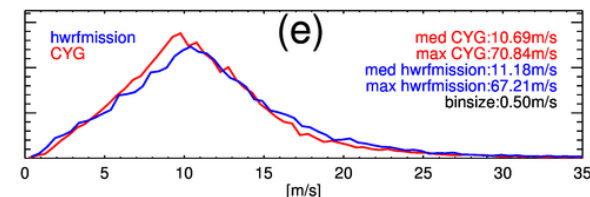
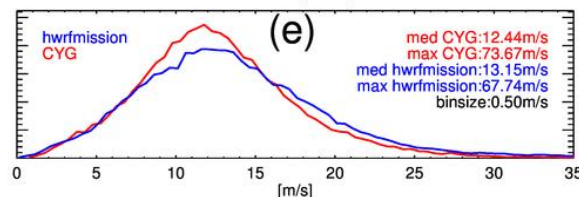
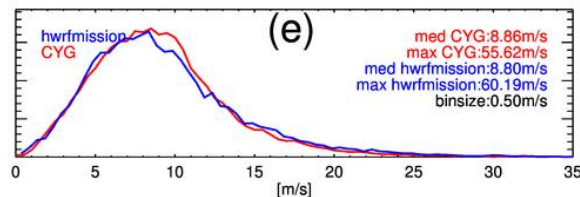
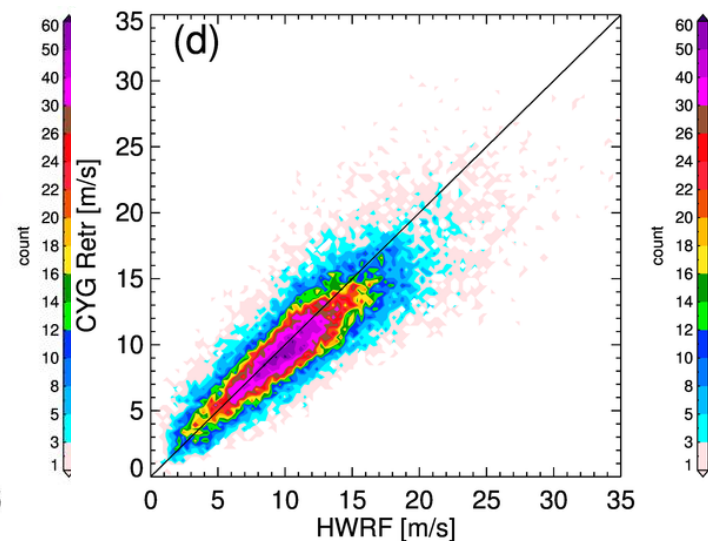
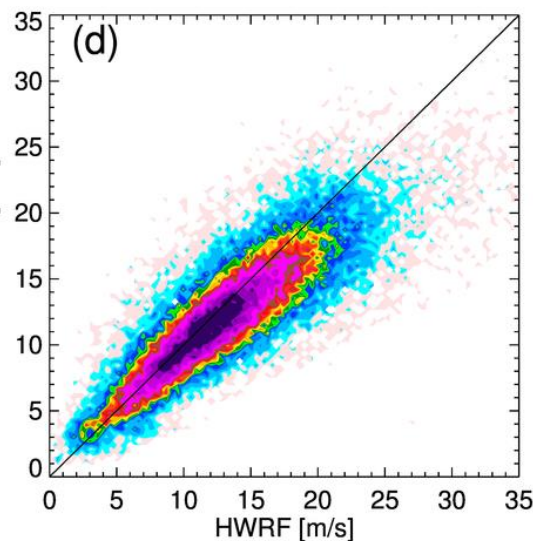
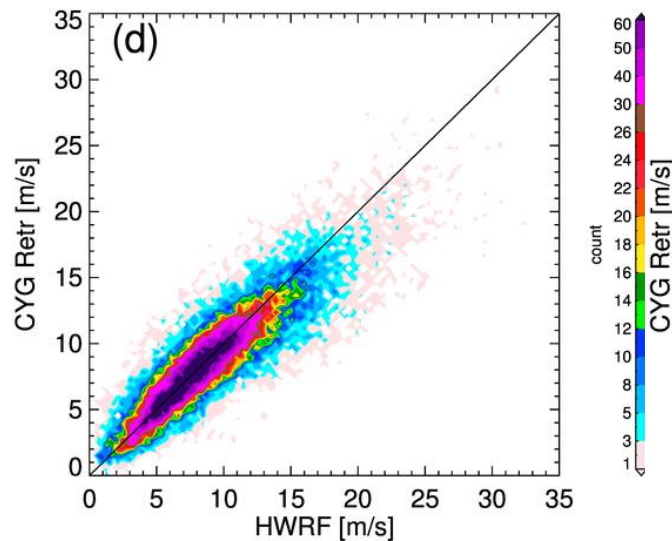
Performance Period: 1st May 2017- 5th Oct 2019

CYGNSS Ascending

2017

2018

2019

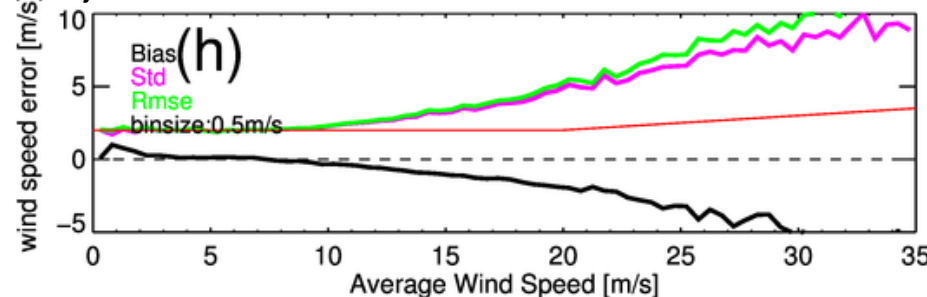
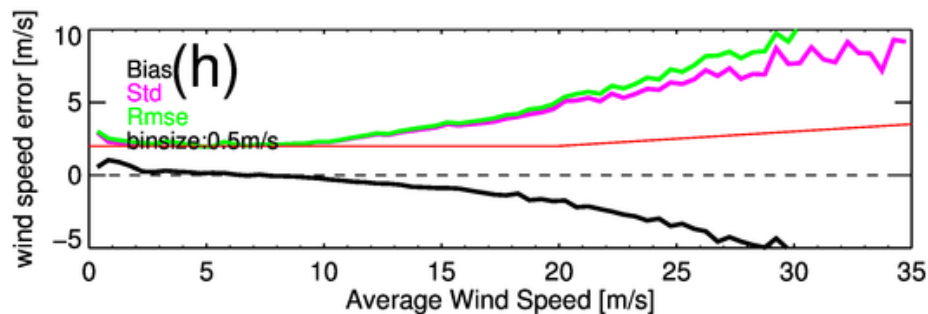


Performance Period: 1st May 2017- 5th Oct 2019

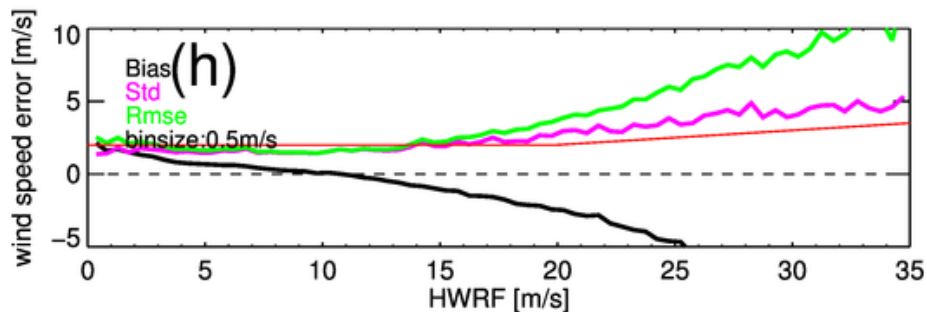
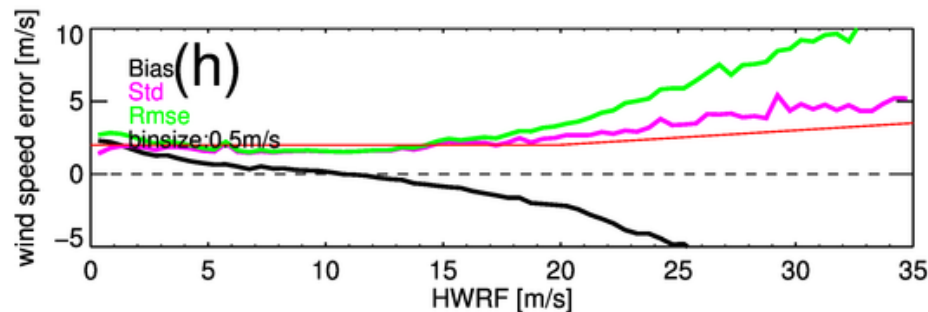
Descending

Truth: <CYGNSS, HWRF>

Ascending



Truth: <HWRF>





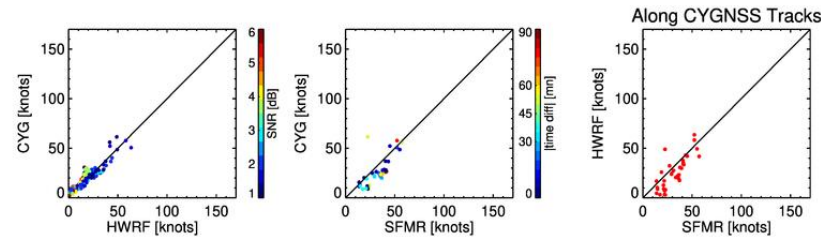
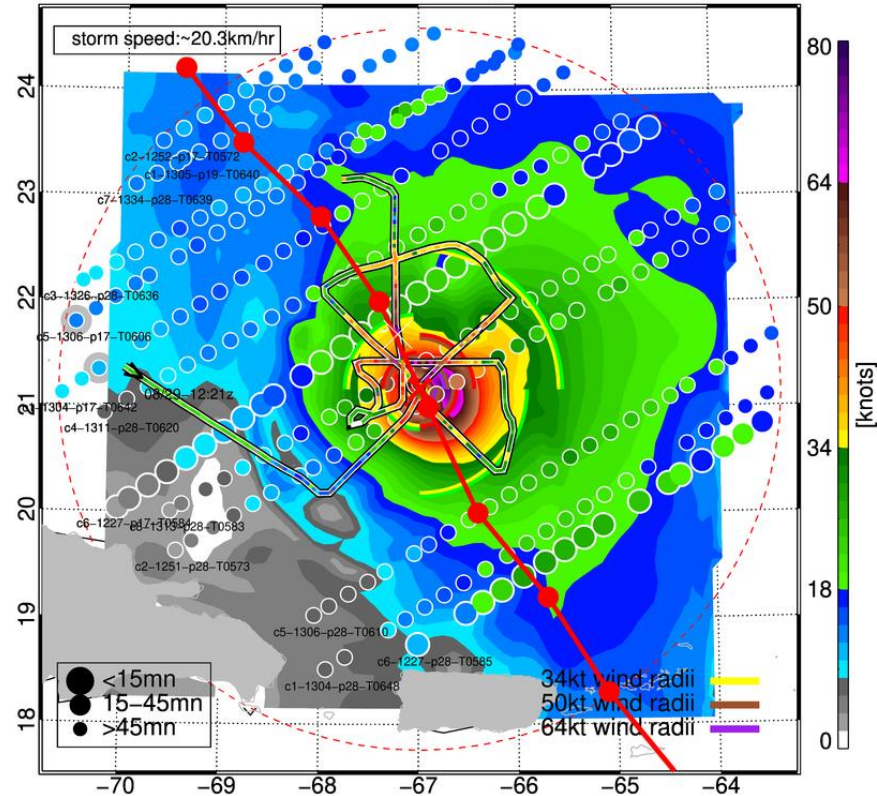
CYGNSS L2 winds vs HWRF Overall Statistics

		2017		2018		2019		2017-2019	
		DES	ASC	DES	ASC	DES	ASC	DES	ASC
HWRF	Bias	-0.25	-0.15	-0.58	-0.70	-0.57	-0.48	-0.47	-0.45
	STD	2.94	2.47	3.93	3.79	3.48	3.65	3.58	3.44

CASE 1

DORIAN type:HU 2019/08/29-13:02:08 utc – NOAAv1.0

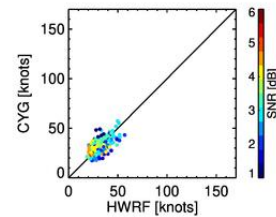
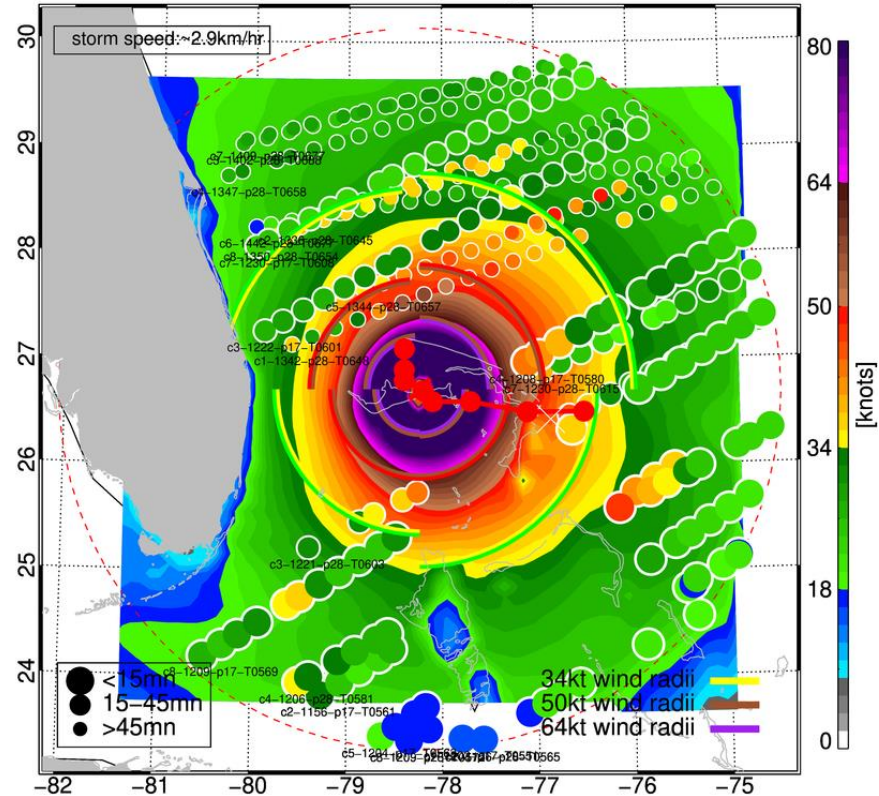
MAX SFMR WIND:98.5knots @ 20190829-1535



CASE 3

DORIAN type:HU 2019/09/02-13:04:35 utc – NOAAv1.0

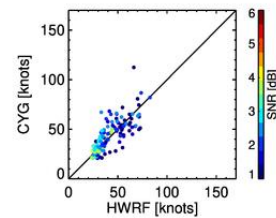
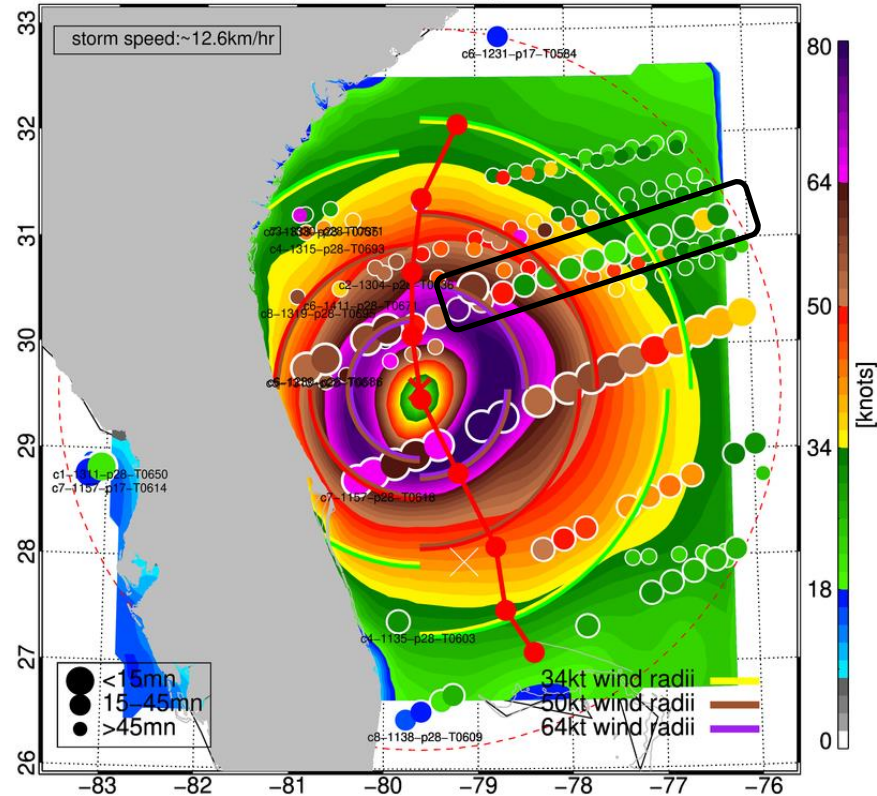
MAX SFMR WIND:180.0knots @ 20190901-1621



CASE 4

DORIAN type:HU 2019/09/04-12:57:38 utc – NOAAv1.0

MAX SFMR WIND:91.0knots @ 20190903-1650



L2 File description and Data hosting site

File naming convention:

cyg.ddmi.s20170506-000000-e20170506-235959.l2.wind_trackgridsize25km_NOAAv1.0_L1a21.d21.nc



<https://manati.orbit.nesdis.noaa.gov/cygnss/>

NOAA CYGNSS Global Wind Web Page

<https://manati.star.nesdis.noaa.gov/datasets/CYGNSSData.php>

Product Description

Data Products

- QuikSCAT/SeaWinds
- OSCAT
- RapidSCAT
- ASCAT (METOP-A)
- ASCAT (METOP-B)
- WindSAT
- Altimeter
- CYGNSS >>**
- ERS-2
- SSM/I

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Data from Satellite/instruments: [CYGNSS](#)

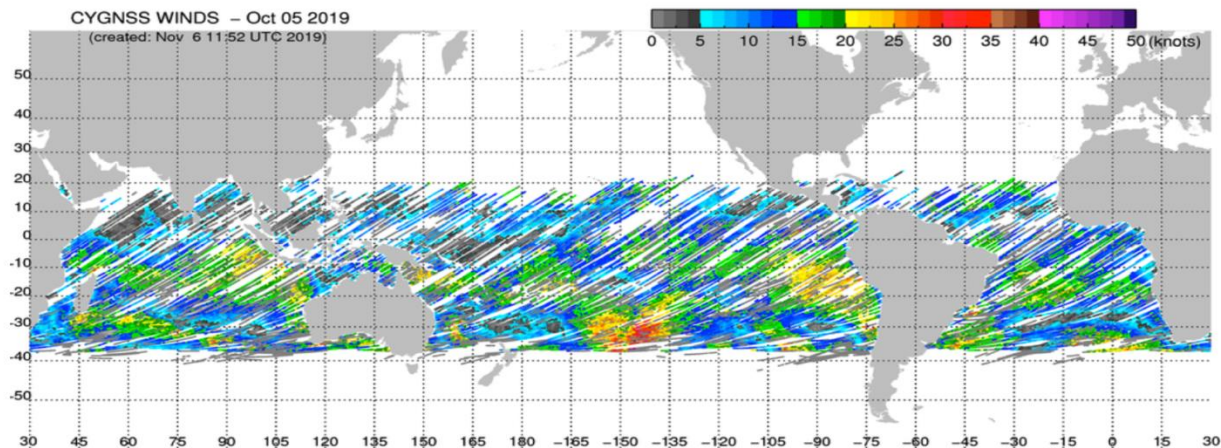
Additional Products

☒ CYGNSS Winds
Storm

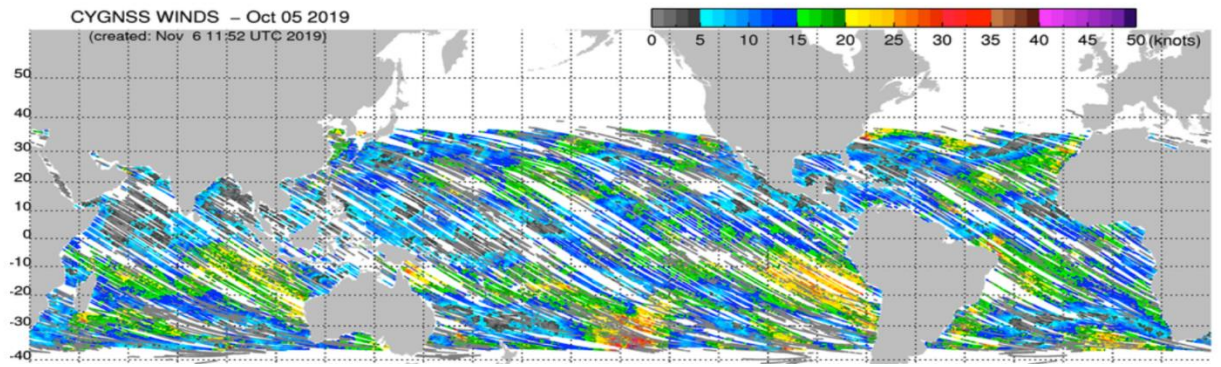
Year: 2019 Month: 10 Day: 5

☐ Global(80N80S-180E180W)

Ascending Pass



Descending Pass



NOAA CYGNSS Storm Web Page

<https://manati.star.nesdis.noaa.gov/datasets/CYGNSSData.php>

[OSWT Home](#)
[Product Description](#)
[Data Products](#)
 [QuikSCAT/SeaWinds](#)
 [OSCAT](#)
 [RapidSCAT](#)
 [ASCAT \(METOP-A\)](#)
 [ASCAT \(METOP-B\)](#)
 [WindSAT](#)
 [Altimeter](#)
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 [ERS-2](#)
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Data from Satellite/Instruments: [CYGNSS](#)

Additional Products:
 Year:
 Storm_ID:
☐ Atlantic ocean
☐ Eastern pacific
☐ Western pacific
☐ Central pacific
☐ Indian ocean
☐ Southern Hemisphere

CYGN	
DORIAN	19082500
DORIAN	19082506
DORIAN	19082512
DORIAN	19082518
DORIAN	19082600
DORIAN	19082606
DORIAN	19082612
DORIAN	19082618
DORIAN	19082700
DORIAN	19082706
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Summary

NOAA CYGNSS wind product Ver 1.0 released on Nov 6th, 2019

Wind product gridded along track every 25km

Track debiasing implemented on sigma0's prior to retrievals

Rigorous data quality control performed

Wind product evaluated vs ASCAT A/B scatterometers, ASMR-2, SSMI F16/17, WindSat and SMAP radiometers, HWRF and ECMWF models

Validation analysis showed:

- NOAA requirement for consistent, reliable and repeatable wind product has been achieved
- Consistency between CYGNSS sensors reduced to within 0.1m/s
- Small but consistent global wind bias increase since the mission start is still present. However **significantly reduced**
- Systematic difference between starboard and port measurements still presents. However starboard error is only ~1% higher than port
- Larger wind biases noticed in Indian ocean for IIRM and IIF blocks when CYGNSS is in ascending orbit and GPS is in descending orbit. This error requires further investigation
- Larger wind biases along Asia coast more noticeable in descending passes. This error requires further investigation.

NOAA CyGNSS Level 2 Netcdf file location: <https://manati.orbit.nesdis.noaa.gov/cygnss/>

For data access email: Faozi.Said@noaa.gov

Web site with NOAA CYGNSS global wind images: <https://manati.star.nesdis.noaa.gov/datasets/CYGNSSData.php>

(currently being populated with historical data)

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