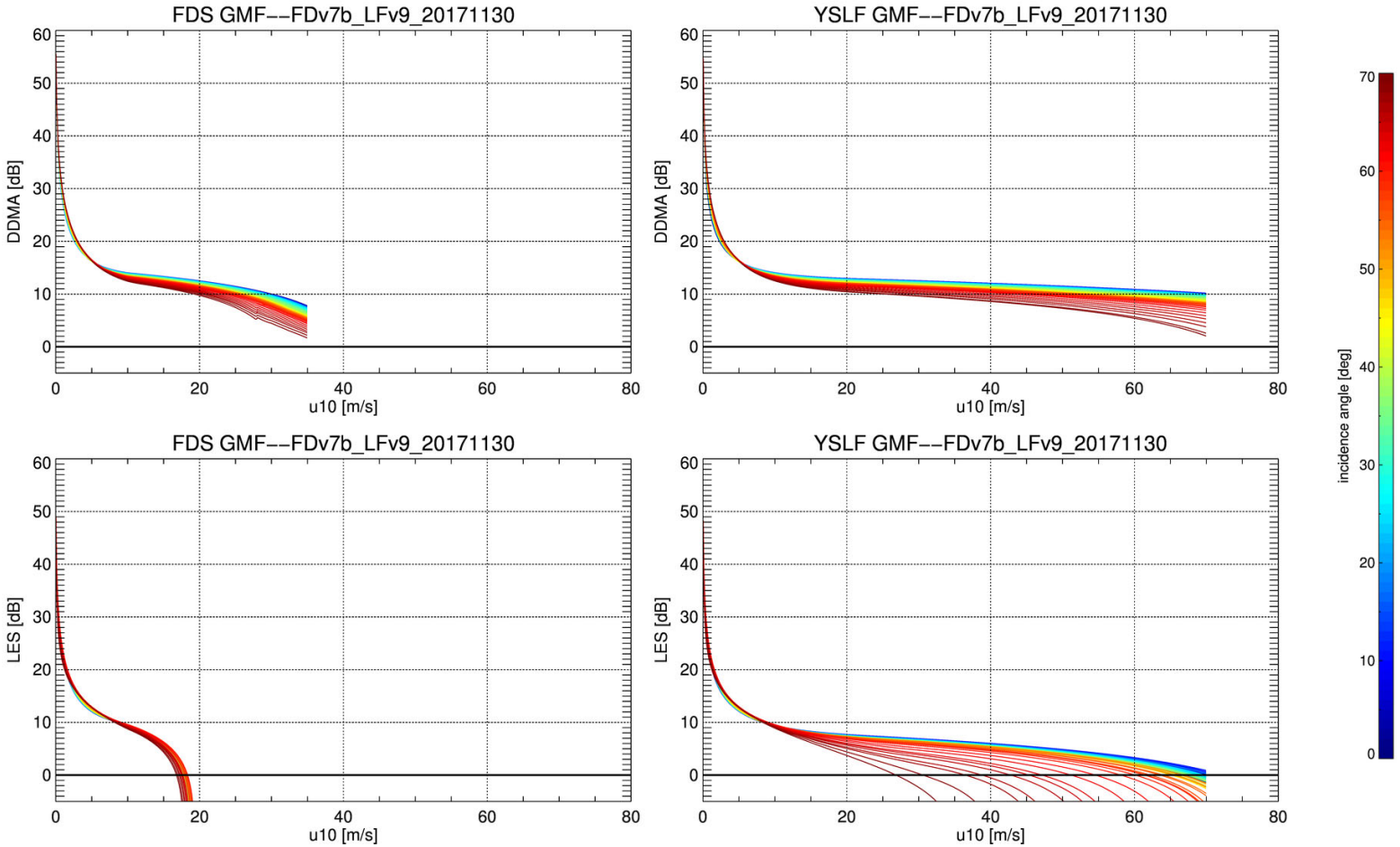
Latest CYGNSS Level 1/2 product performance assessment

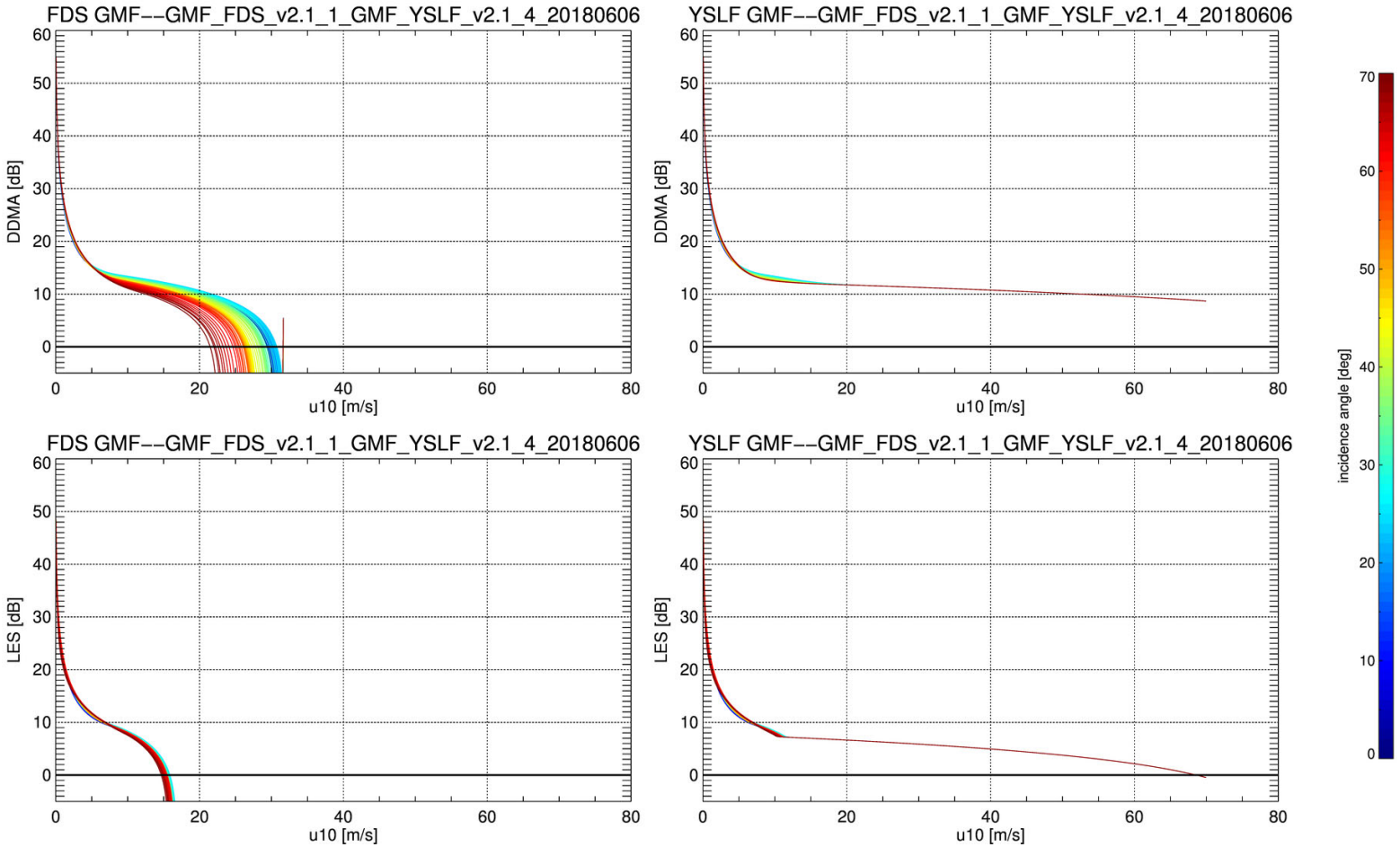
Faozi Said[1,2], Zorana Jelenak[1,3], Paul S. Chang[1], Seubson Soisuvarn[1,3], Jeonghwan Park[1,2]

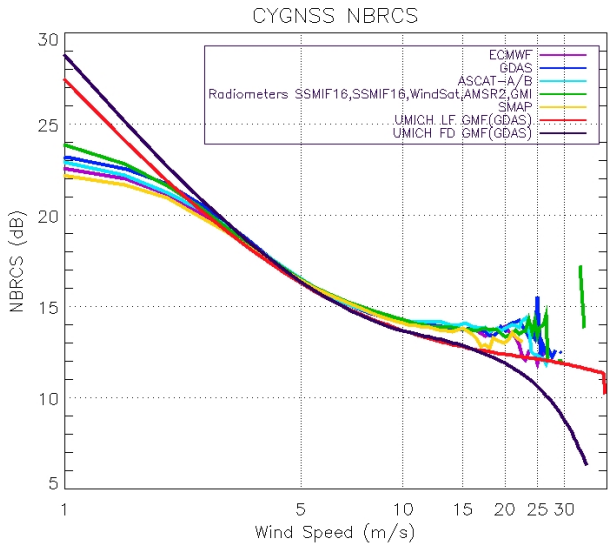
[1]NOAA/NESDIS/STAR

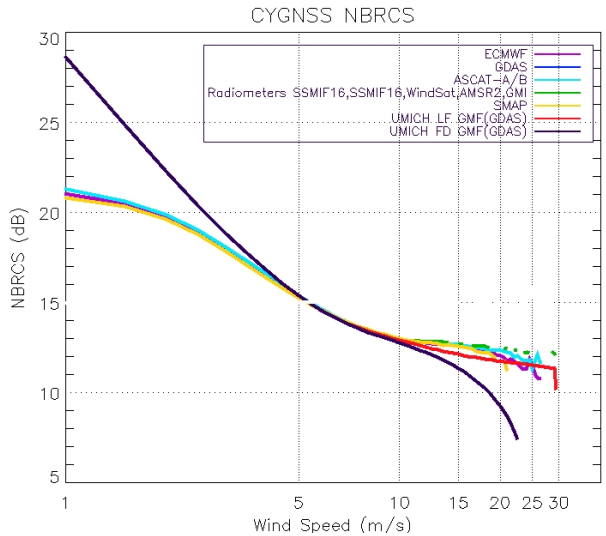
[2]Global Science & Technology, Inc.

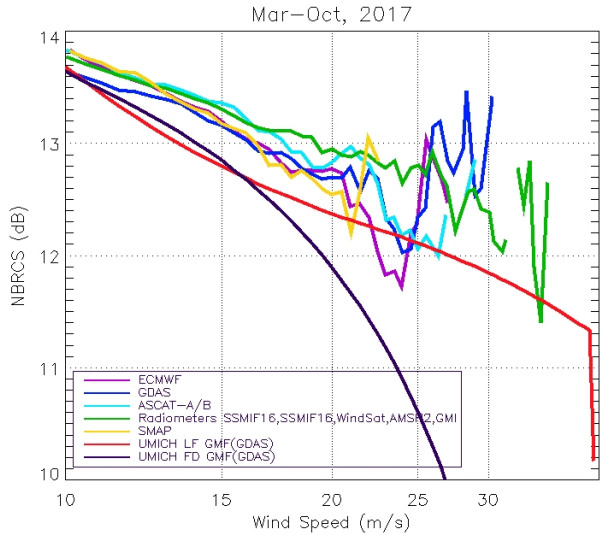
[3]UCAR

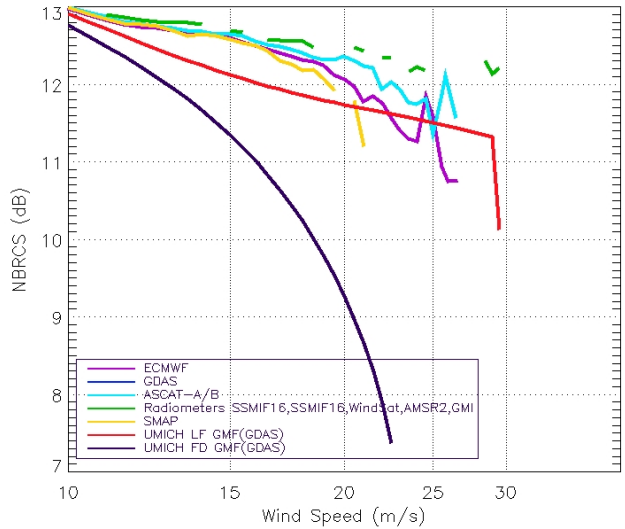

FDS GMF--FDv7b_LFv9_20171130
YSLF GMF--FDv7b_LFv9_20171130
DDMA [dB]
LES [dB]
u10 [m/s]
incidence angle [deg]
0
10
20
30
40
50
60
70
80


FDS GMF--GMF_FDS_v2.1_1_GMF_YSLF_v2.1_4_20180606
YSLF GMF--GMF_FDS_v2.1_1_GMF_YSLF_v2.1_4_20180606
DDMA [dB]
LES [dB]
u10 [m/s]
incidence angle [deg]


CYGNSS NBRCS
ECMWF
GDAS
ASCAT-A/B
Radiometers SSMIF16,SSMIF16,WindSat,AMSR2,GMI
SMAP
UMICH LF GMF(GDAS)
UMICH FD GMF(GDAS)
NBRCS (dB)
Wind Speed (m/s)

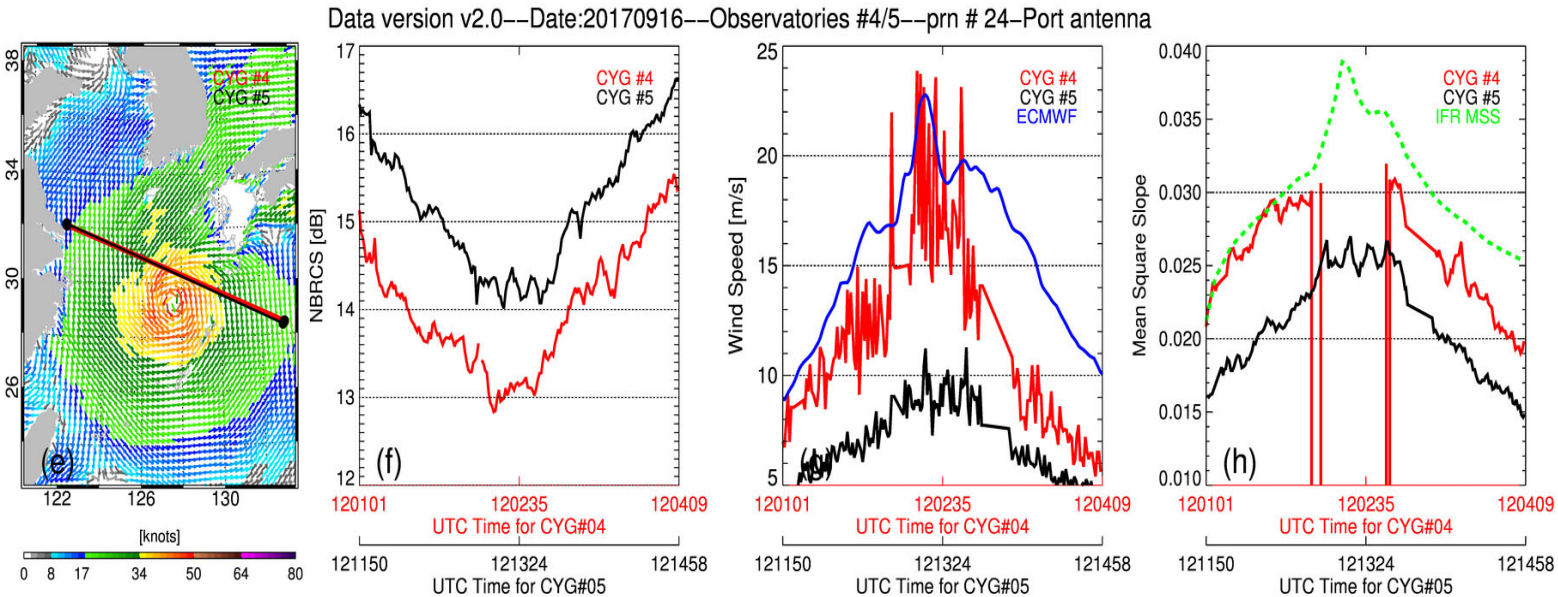

CYGNSS NBRCS
ECMWF
GDAS
ASCAT-A/B
Radiometers SSMIF16,SSMIF16,WindSat,AMSR2,GMI
SMAP
UMICH LF GMF(GDAS)
UMICH FD GMF(GDAS)
NBRCS (dB)
Wind Speed (m/s)


Mar-Oct, 2017
ECMWF
GDAS
ASCAT-A/B
Radiometers SSMIF16,SSMIF16,WindSat,AMSR2,GMI
SMAP
UMICH LF GMF(GDAS)
UMICH FD GMF(GDAS)
NBRCS (dB)
Wind Speed (m/s)

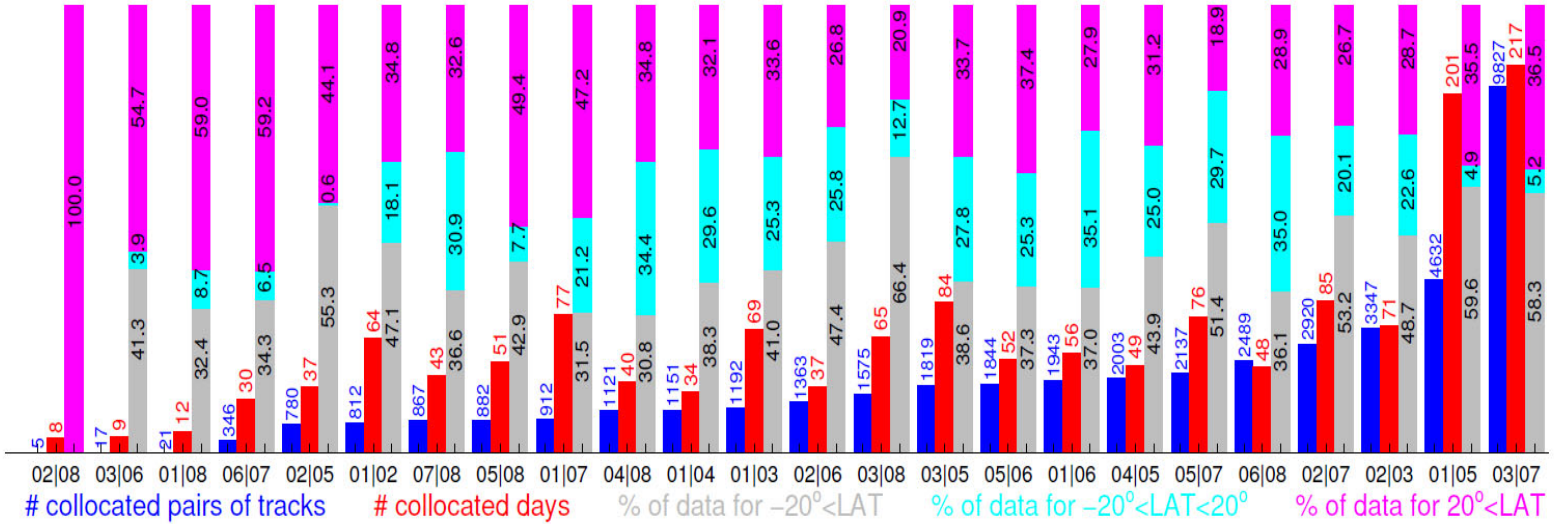

ECMWF
GDAS
ASCAT-A/B
Radiometers SSMIF16,SSMIF16,WindSat,AMSR2,GMI
SMAP
UMICH LF GMF(GDAS)
UMICH FD GMF(GDAS)
NBRCS (dB)
Wind Speed (m/s)

Intersatellite cal/val update..

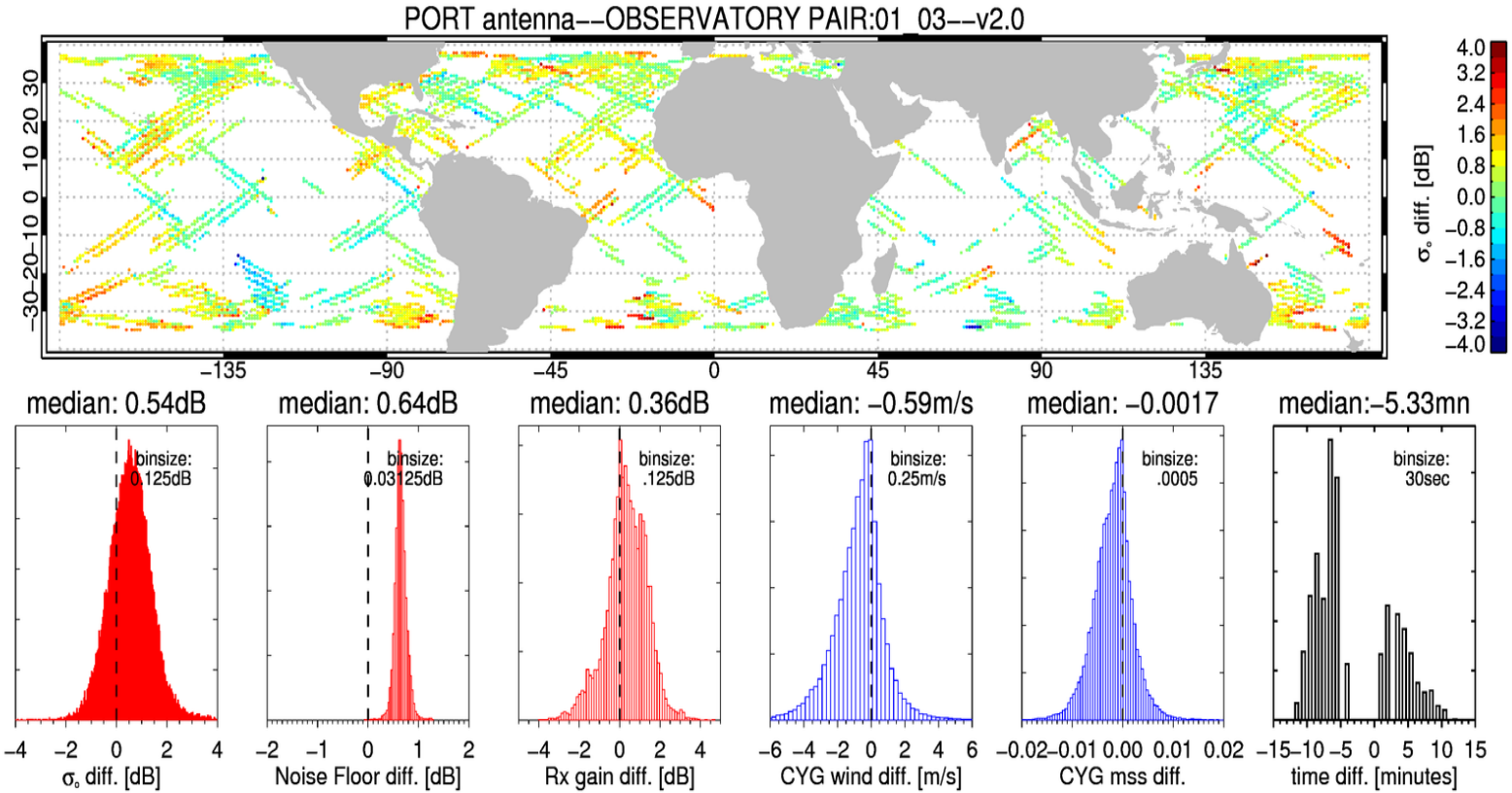
CASE 1

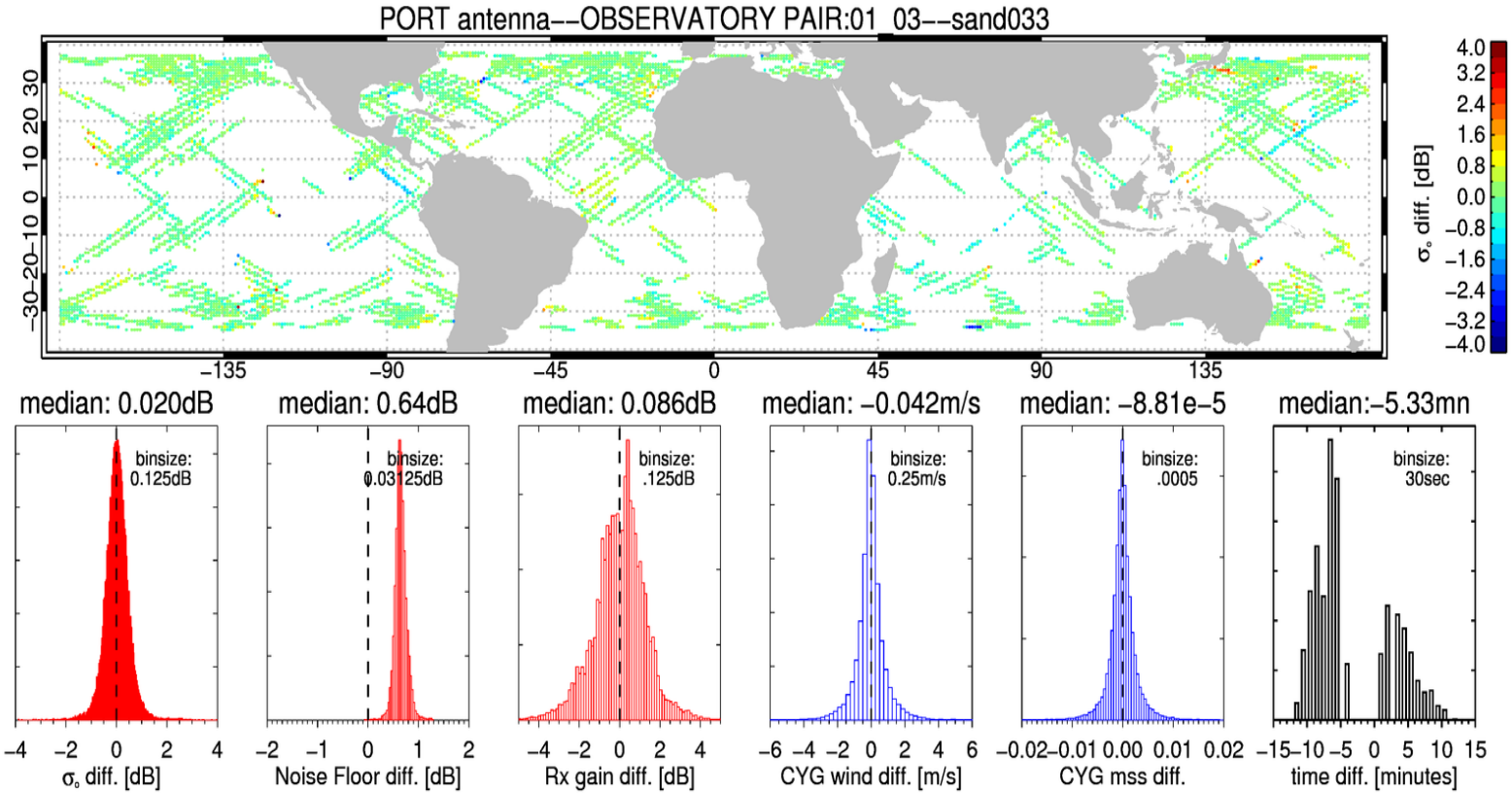

Data version v2.0--Date:20170916--Observatories #4/5--prn # 24-Port antenna
CYG #4
CYG #5
(e)
38
34
30
26
122
126
130
[knots]
0 8 17 34 50 64 80
NBRCS [dB]
(f)
ECMWF
Wind Speed [m/s]
(g)
IFR MSS
Mean Square Slope
(h)
120101
120235
120409
UTC Time for CYG#04
121150
121324
121458
UTC Time for CYG#05

Reminder about methodology:
-collocate pairs of observatories with very strict collocation criteria (+/- 6km // +/- 15mn)
-compare sigma0/noise floor/wind speed/mss difference between collocated pairs
-time period: March-Dec 2017

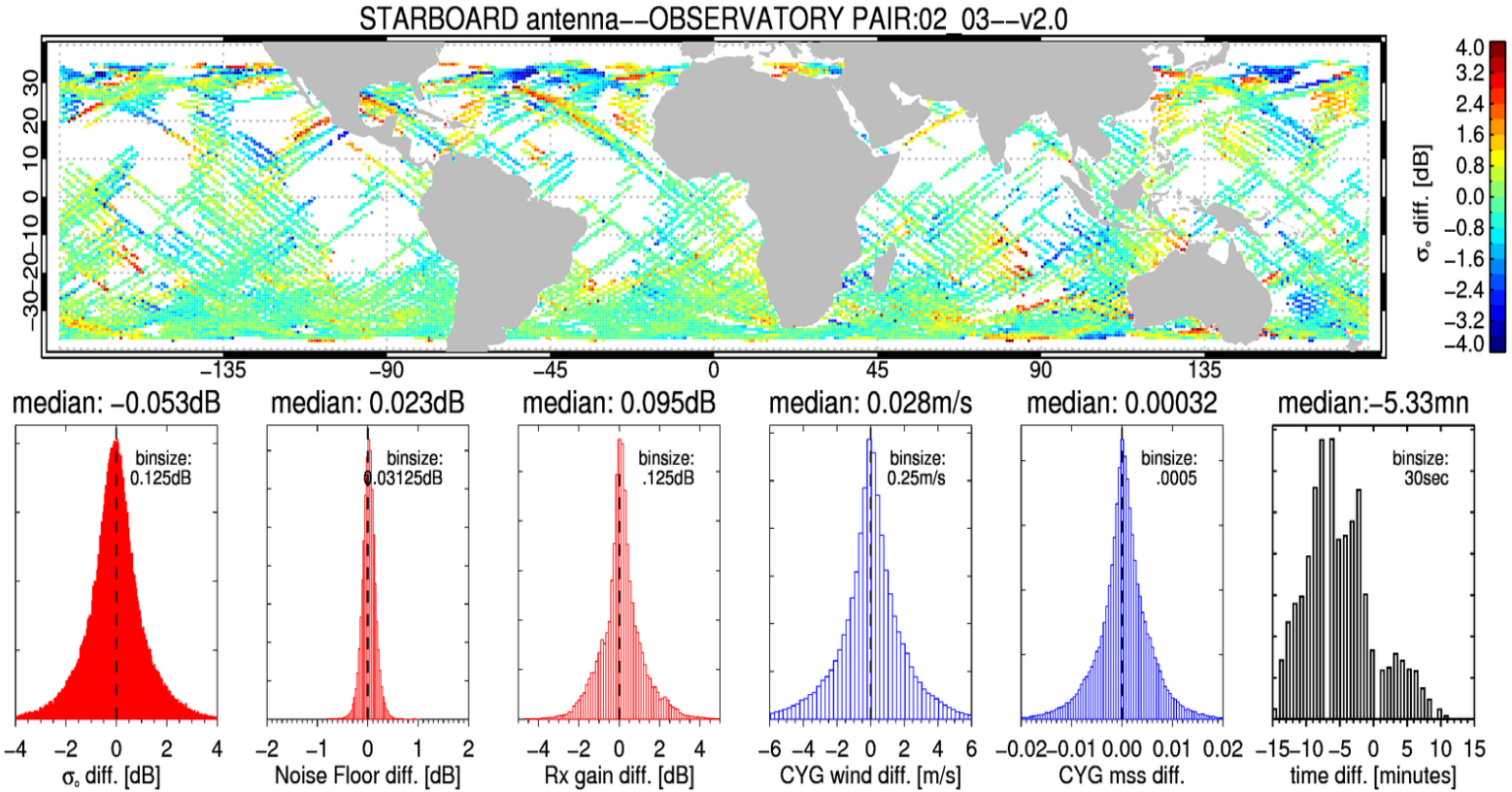


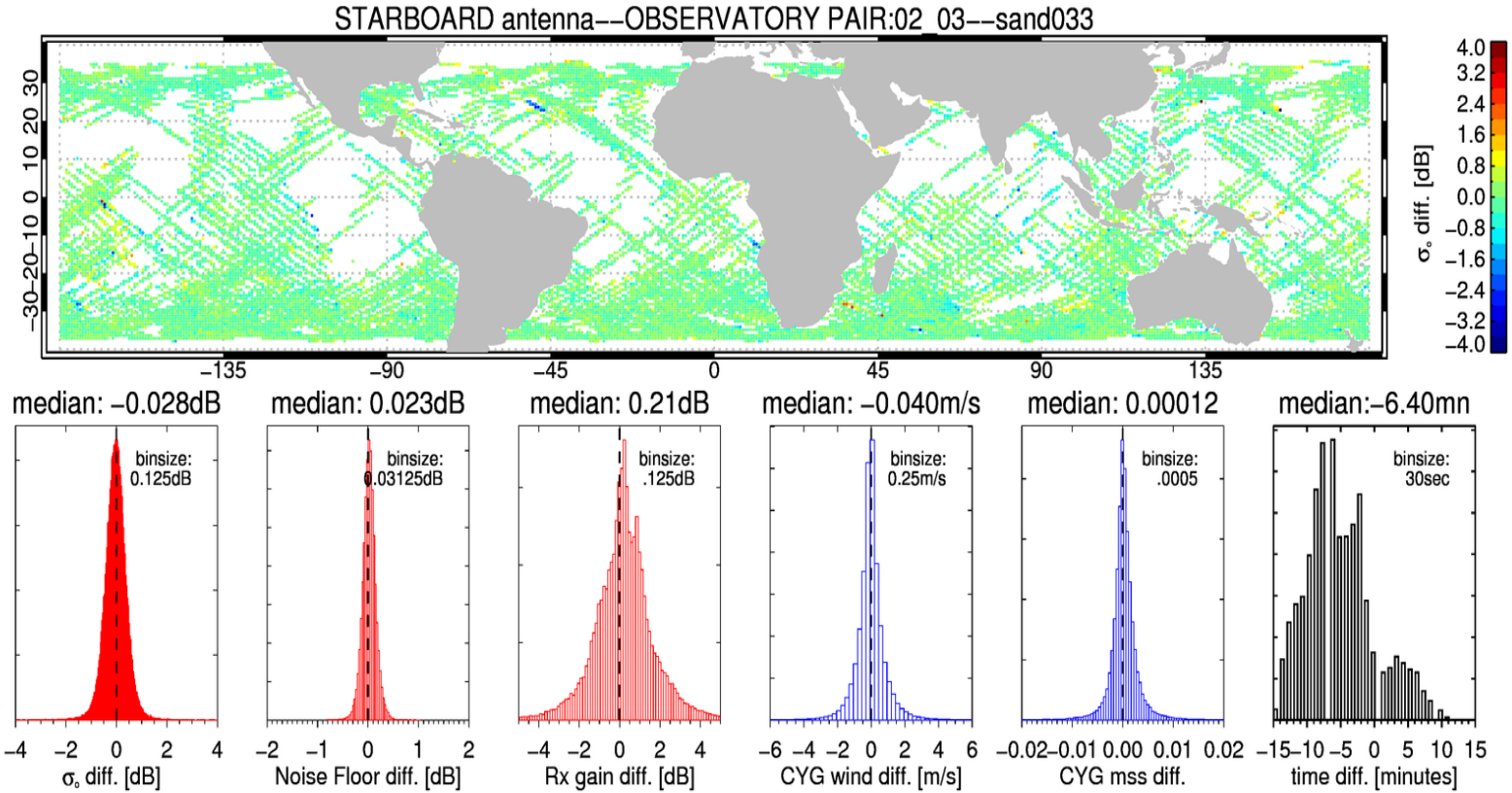
PORT SIDE


PORT antenna--OBSERVATORY PAIR:01_03--v2.0
σ₀ diff. [dB]
median: 0.54dB
binsize: 0.125dB
σ₀ diff. [dB]
median: 0.64dB
binsize: 0.03125dB
Noise Floor diff. [dB]
median: 0.36dB
binsize: .125dB
Rx gain diff. [dB]
median: −0.59m/s
binsize: 0.25m/s
CYG wind diff. [m/s]
median: −0.0017
binsize: .0005
CYG mss diff.
median:−5.33mn
binsize: 30sec
time diff. [minutes]


PORT antenna--OBSERVATORY PAIR:01_03--sand033
σ₀ diff. [dB]
median: 0.020dB
binsize: 0.125dB
σ₀ diff. [dB]
median: 0.64dB
binsize: 0.03125dB
Noise Floor diff. [dB]
median: 0.086dB
binsize: .125dB
Rx gain diff. [dB]
median: −0.042m/s
binsize: 0.25m/s
CYG wind diff. [m/s]
median: −8.81e−5
binsize: .0005
CYG mss diff.
median:−5.33mn
binsize: 30sec
time diff. [minutes]

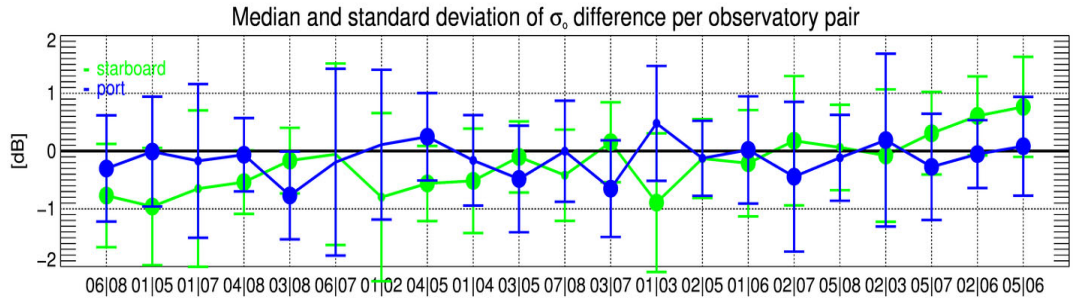
STARBOARD SIDE


STARBOARD antenna--OBSERVATORY PAIR:02_03--v2.0
σ₀ diff. [dB]
median: −0.053dB
binsize: 0.125dB
σ₀ diff. [dB]
median: 0.023dB
binsize: 0.03125dB
Noise Floor diff. [dB]
median: 0.095dB
binsize: .125dB
Rx gain diff. [dB]
median: 0.028m/s
binsize: 0.25m/s
CYG wind diff. [m/s]
median: 0.00032
binsize: .0005
CYG mss diff.
median:−5.33mn
binsize: 30sec
time diff. [minutes]

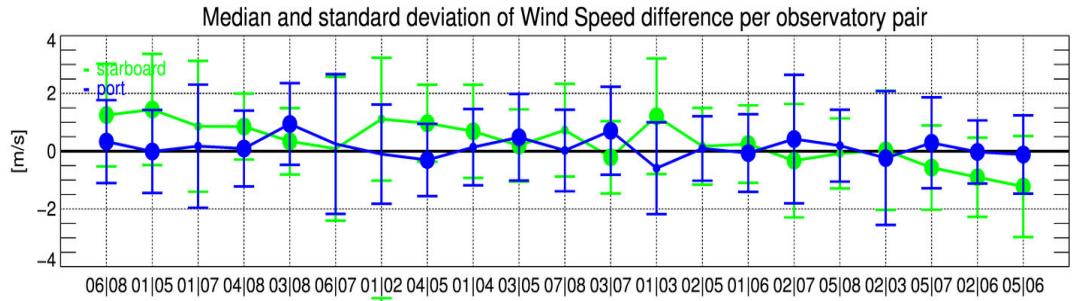

STARBOARD antenna--OBSERVATORY PAIR:02_03--sand033
σ₀ diff. [dB]
median: −0.028dB
binsize: 0.125dB
σ₀ diff. [dB]
median: 0.023dB
binsize: 0.03125dB
Noise Floor diff. [dB]
median: 0.21dB
binsize: .125dB
Rx gain diff. [dB]
median: −0.040m/s
binsize: 0.25m/s
CYG wind diff. [m/s]
median: 0.00012
binsize: .0005
CYG mss diff.
median:−6.40mn
binsize: 30sec
time diff. [minutes]

v2.0

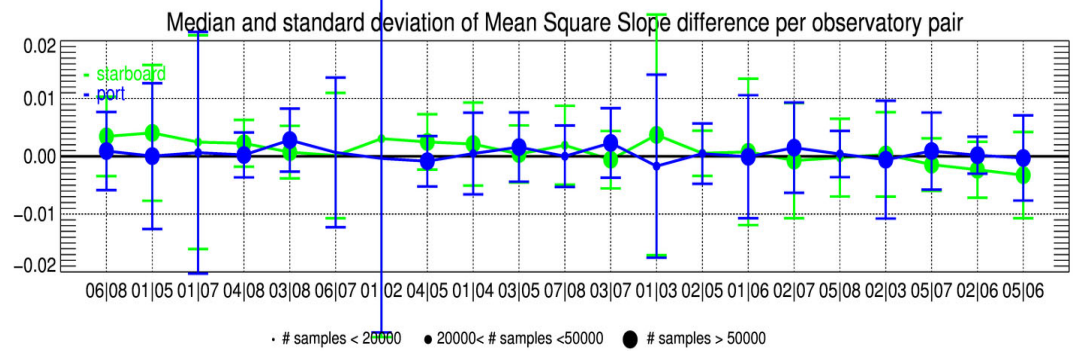
σ_0



ws

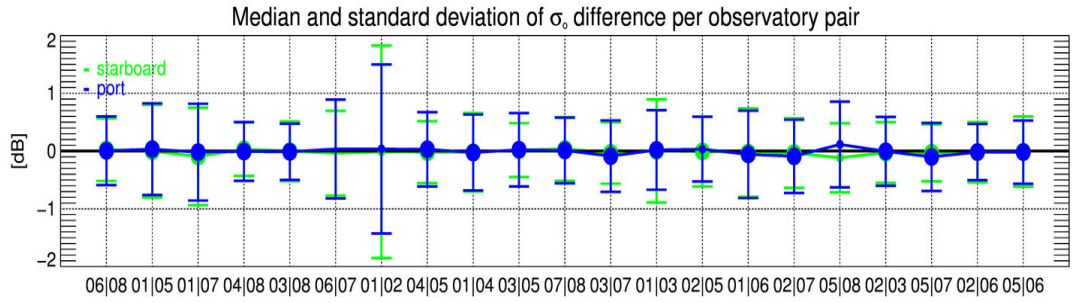


mss

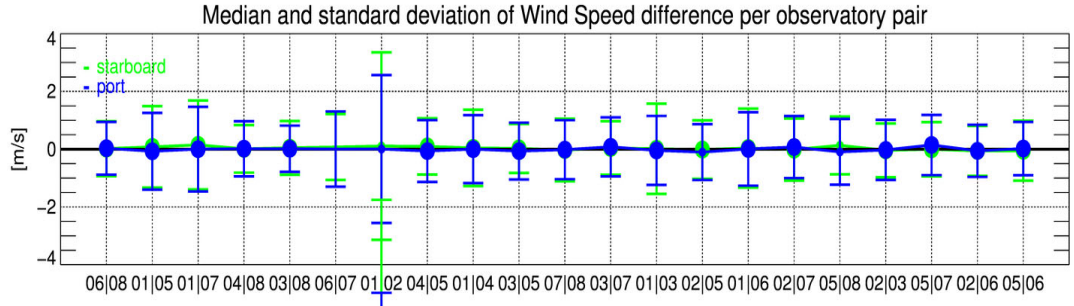


sand033

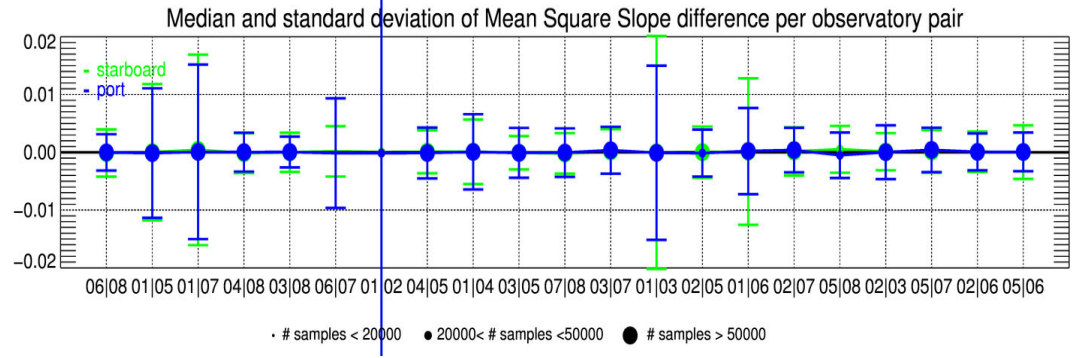
σ_0



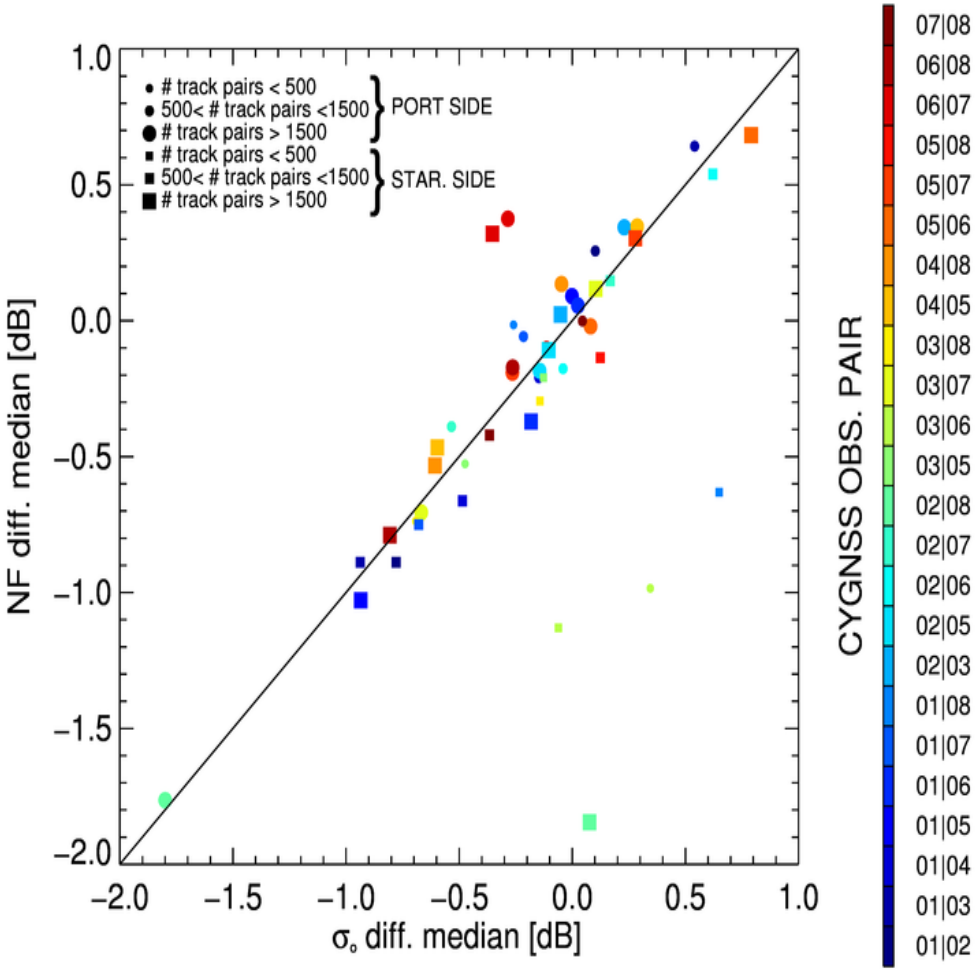
ws



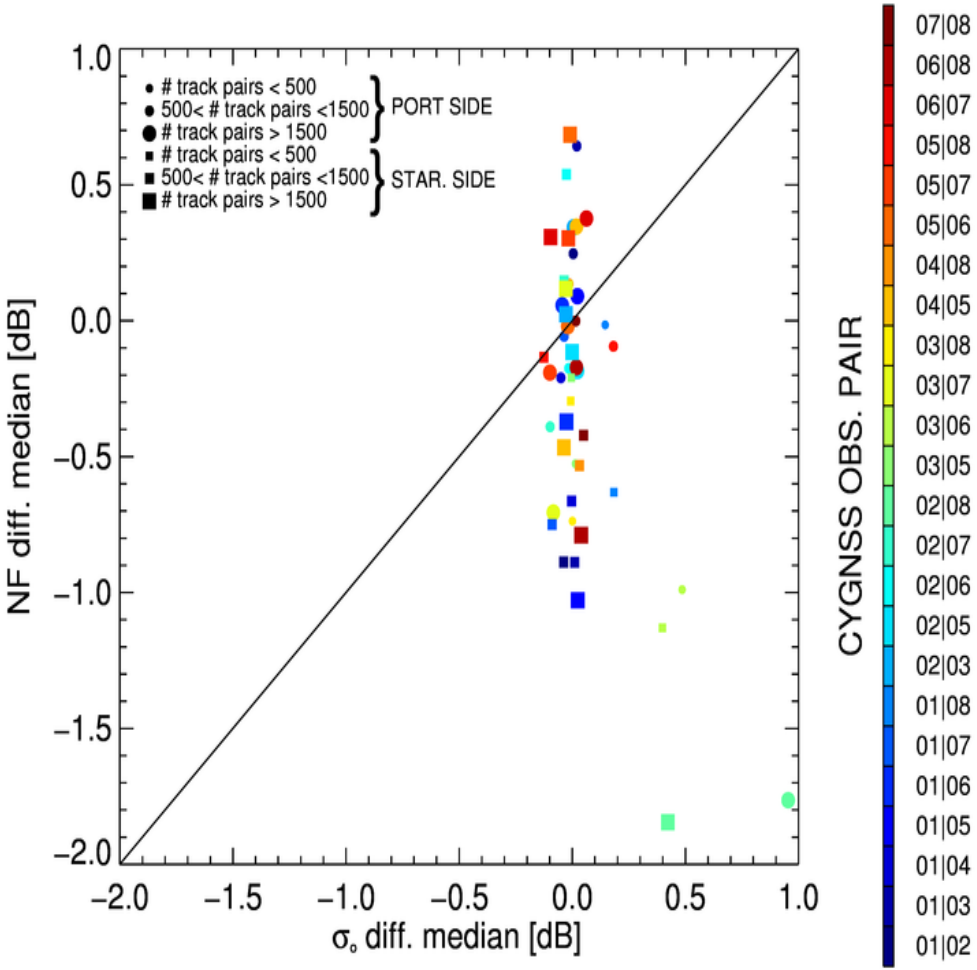
mss



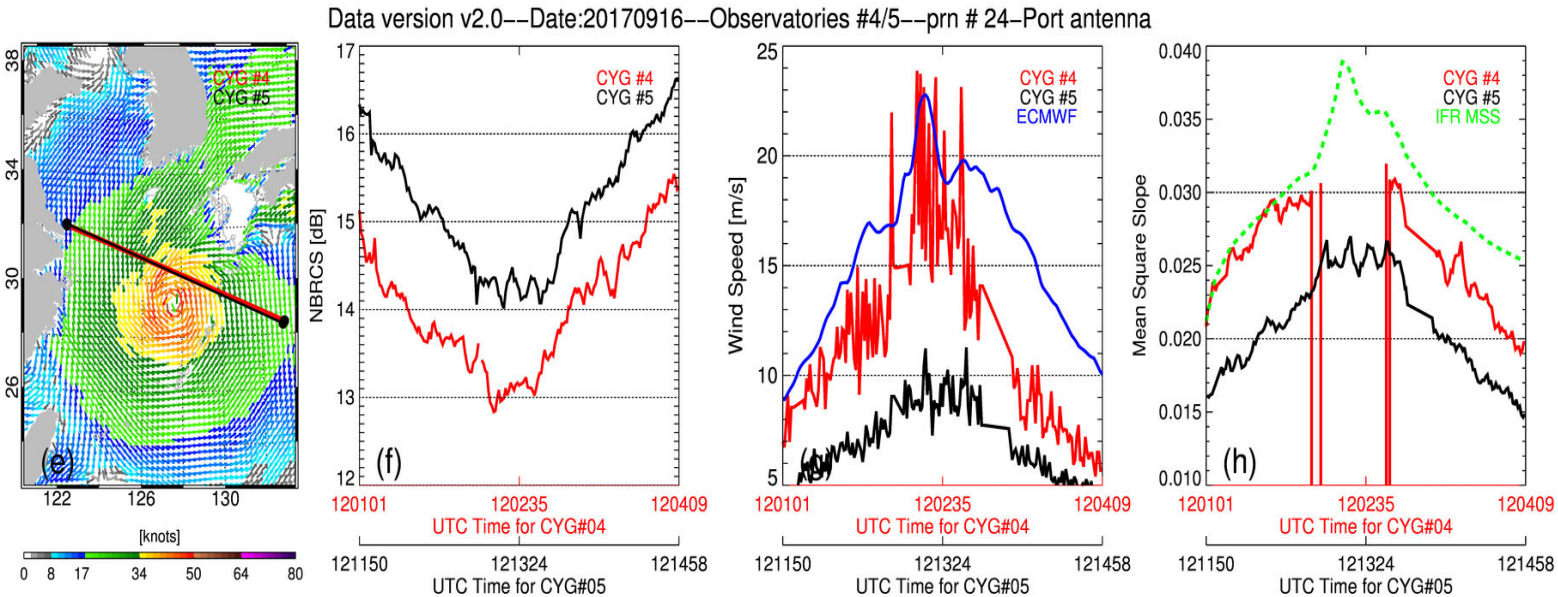
v2.0


• # track pairs < 500
• 500< # track pairs <1500
● # track pairs > 1500
PORT SIDE
▪ # track pairs < 500
▪ 500< # track pairs <1500
■ # track pairs > 1500
STAR. SIDE
NF diff. median [dB]
σ₀ diff. median [dB]
1.0
0.5
0.0
−0.5
−1.0
−1.5
−2.0
CYGNSS OBS. PAIR
07|08
06|08
06|07
05|08
05|07
05|06
04|08
04|05
03|08
03|07
03|06
03|05
02|08
02|07
02|06
02|05
02|03
01|08
01|07
01|06
01|05
01|04
01|03
01|02

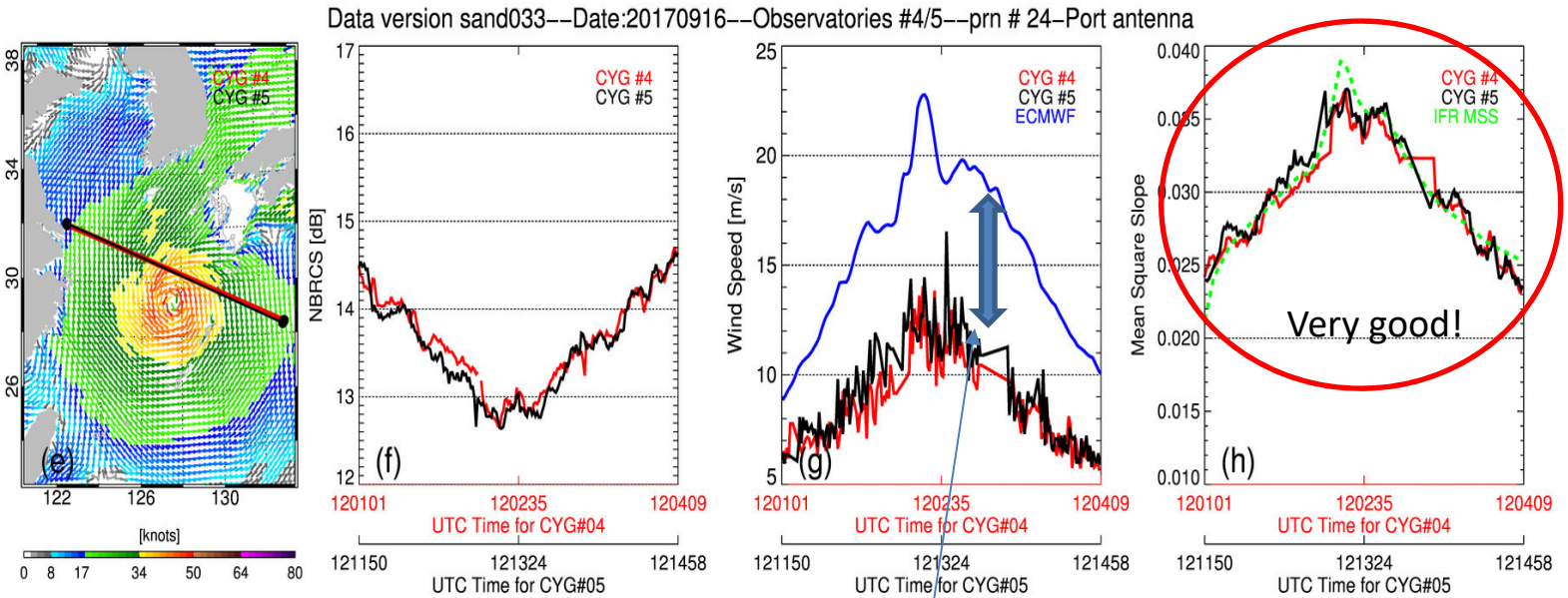
sand033


• # track pairs < 500
• 500< # track pairs <1500
● # track pairs > 1500
PORT SIDE
▪ # track pairs < 500
▪ 500< # track pairs <1500
■ # track pairs > 1500
STAR. SIDE
NF diff. median [dB]
σ₀ diff. median [dB]
1.0
0.5
0.0
−0.5
−1.0
−1.5
−2.0
CYGNSS OBS. PAIR
07|08
06|08
06|07
05|08
05|07
05|06
04|08
04|05
03|08
03|07
03|06
03|05
02|08
02|07
02|06
02|05
02|03
01|08
01|07
01|06
01|05
01|04
01|03
01|02

CASE 1

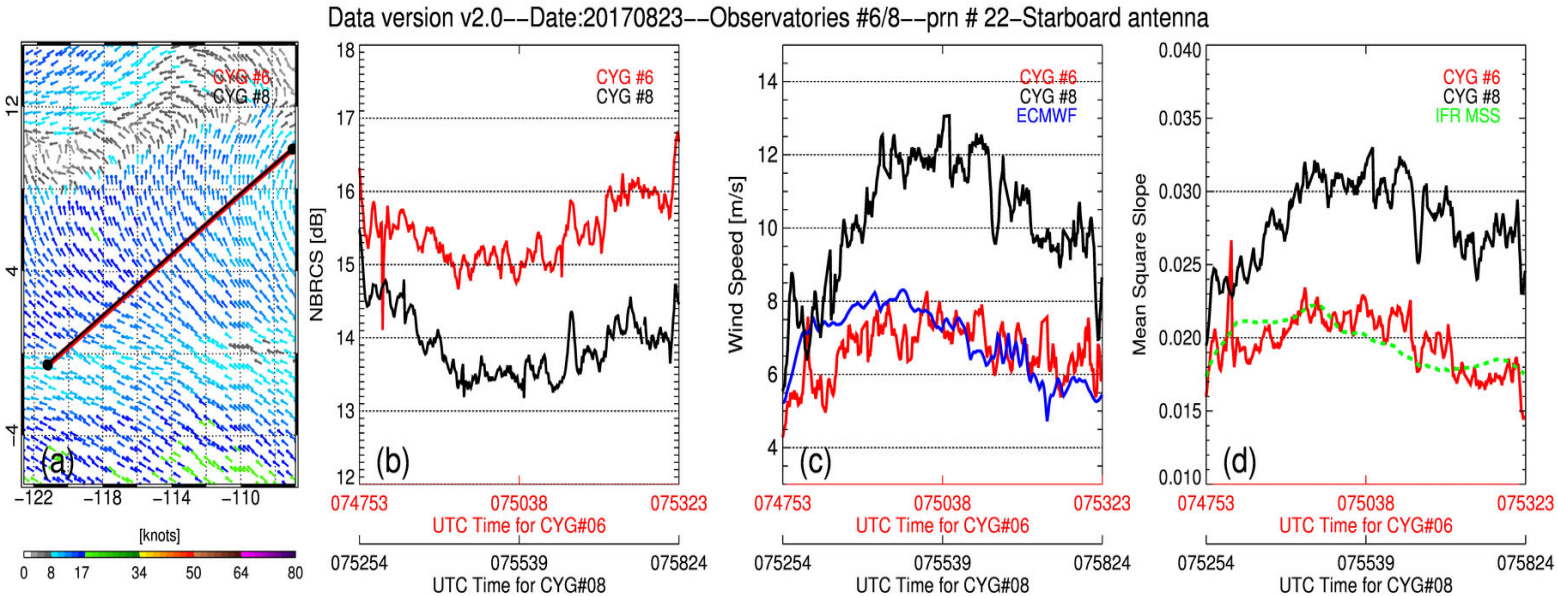

Data version v2.0--Date:20170916--Observatories #4/5--prn # 24-Port antenna
CYG #4
CYG #5
(e)
38
34
30
26
122
126
130
[knots]
0 8 17 34 50 64 80
NBRCS [dB]
(f)
ECMWF
Wind Speed [m/s]
(g)
IFR MSS
Mean Square Slope
(h)
120101
120235
120409
UTC Time for CYG#04
121150
121324
121458
UTC Time for CYG#05

CASE 1

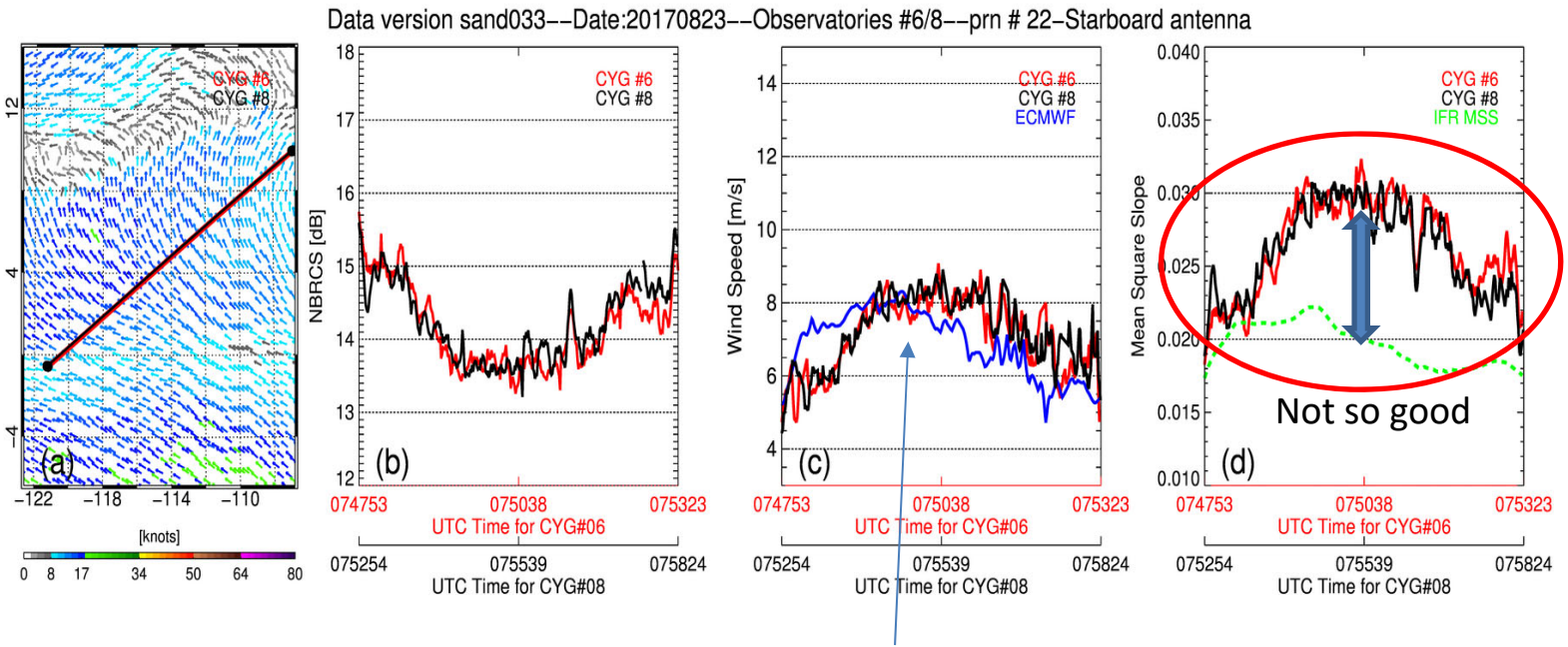


Not so good

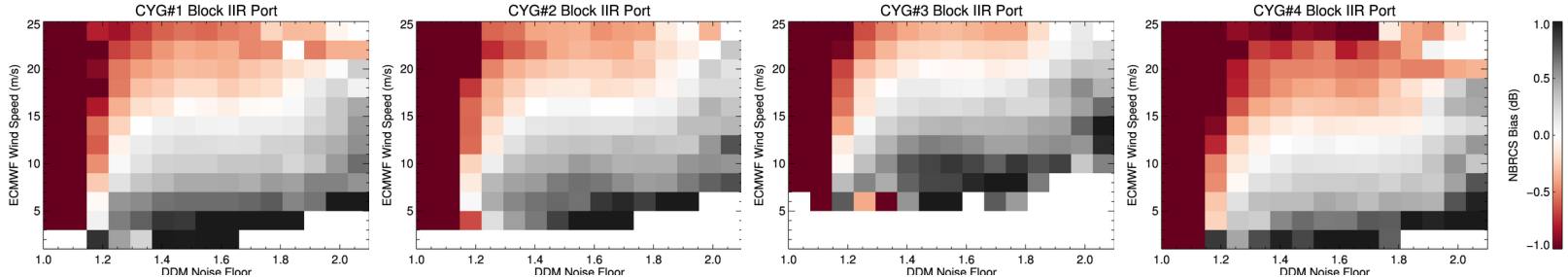
CASE 2

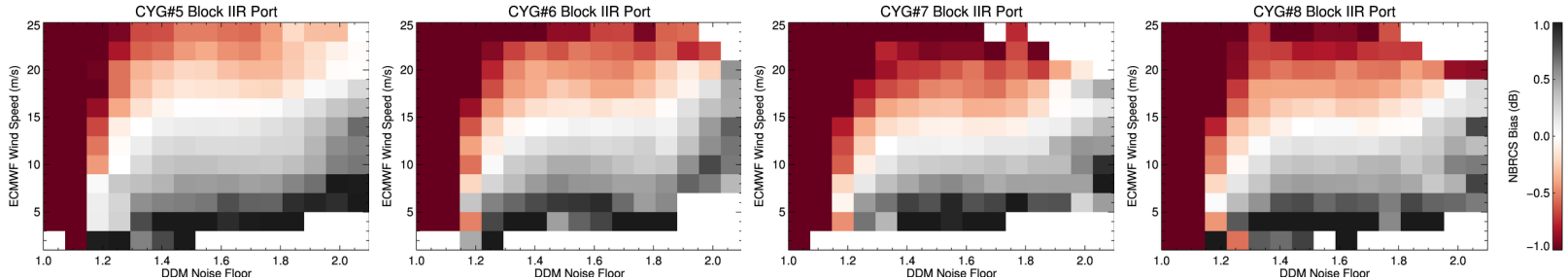

Data version v2.0--Date:20170823--Observatories #6/8--prn # 22-Starboard antenna
CYG #6
CYG #8
(a)
12
4
−4
−122
−118
−114
−110
[knots]
0
8
17
34
50
64
80
(b)
NBRCS [dB]
18
17
16
15
14
13
12
074753
075038
075323
UTC Time for CYG#06
075254
075539
075824
UTC Time for CYG#08
(c)
Wind Speed [m/s]
ECMWF
14
12
10
8
6
4
(d)
Mean Square Slope
IFR MSS
0.040
0.035
0.030
0.025
0.020
0.015
0.010

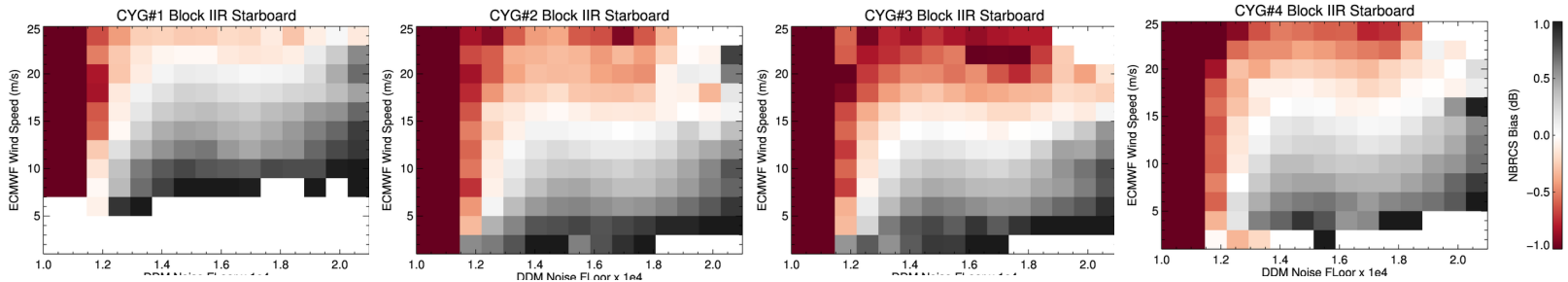
CASE 2

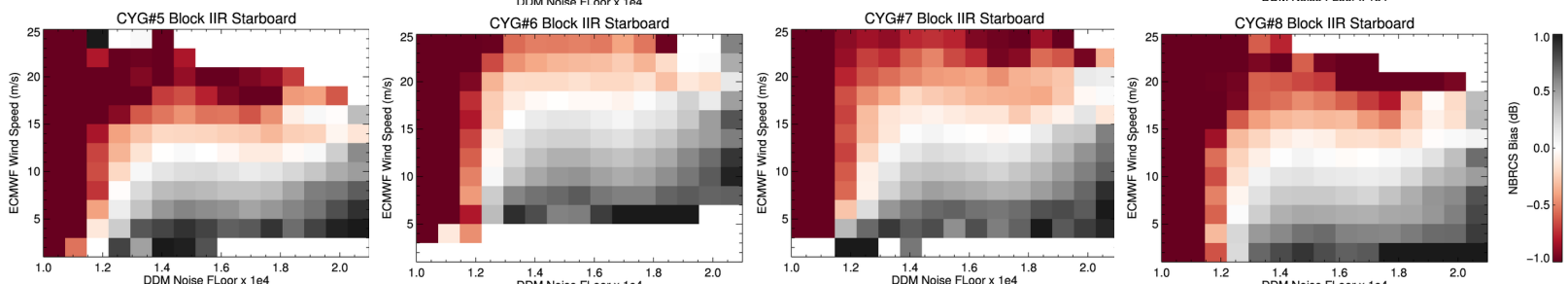


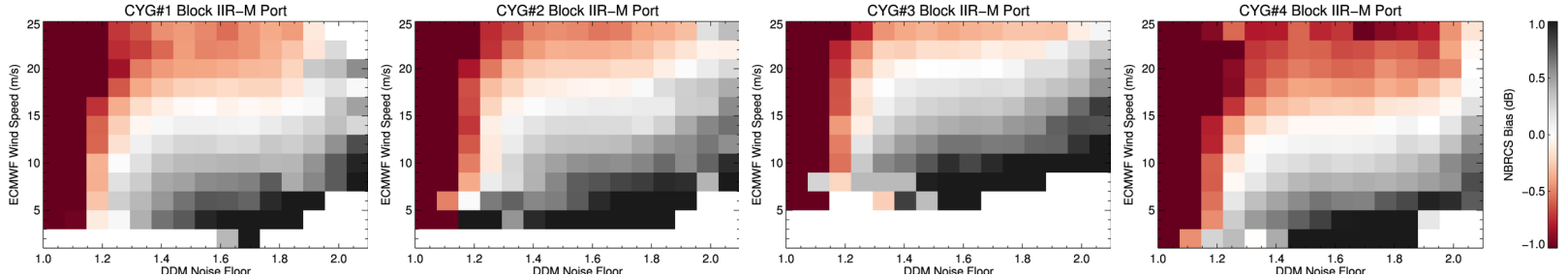
Not bad!

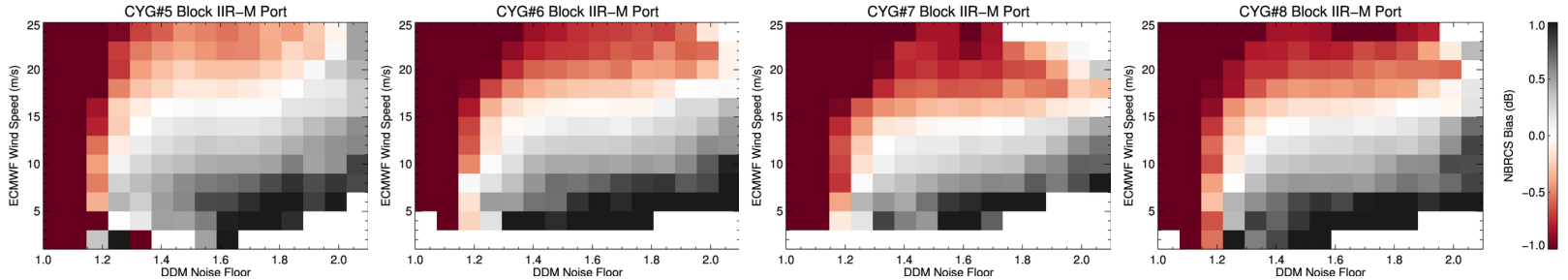

CYG#1 Block IIR Port
CYG#2 Block IIR Port
CYG#3 Block IIR Port
CYG#4 Block IIR Port
ECMWF Wind Speed (m/s)
DDM Noise Floor
NBRCS Bias (dB)

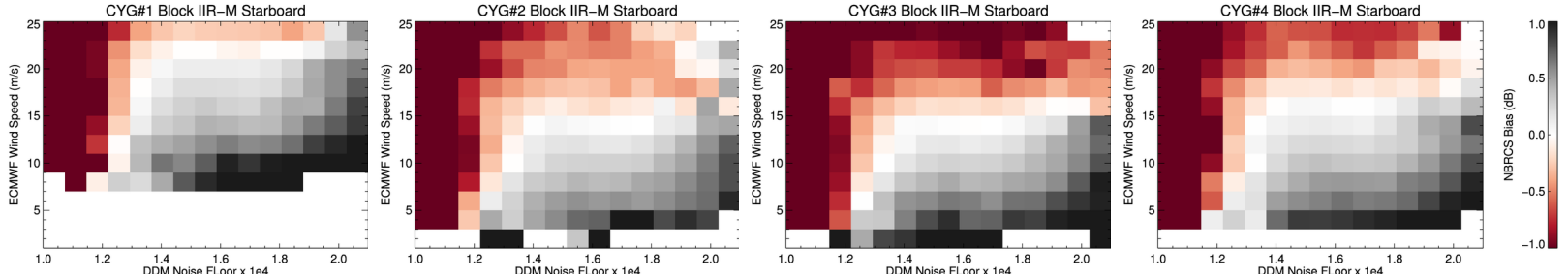

CYG#5 Block IIR Port
CYG#6 Block IIR Port
CYG#7 Block IIR Port
CYG#8 Block IIR Port
ECMWF Wind Speed (m/s)
DDM Noise Floor
NBRCS Bias (dB)

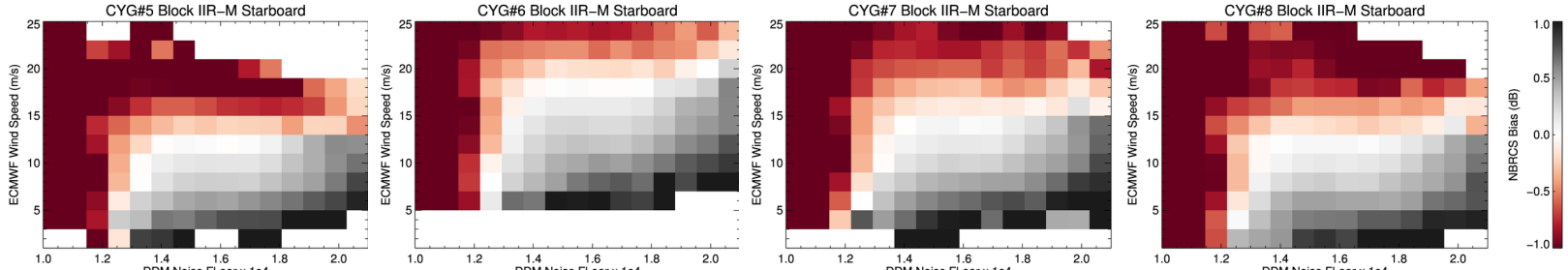

CYG#1 Block IIR Starboard
CYG#2 Block IIR Starboard
CYG#3 Block IIR Starboard
CYG#4 Block IIR Starboard
ECMWF Wind Speed (m/s)
DDM Noise FLoor x 1e4
NBRCS Bias (dB)


CYG#5 Block IIR Starboard
CYG#6 Block IIR Starboard
CYG#7 Block IIR Starboard
CYG#8 Block IIR Starboard
ECMWF Wind Speed (m/s)
DDM Noise FLoor x 1e4
NBRCS Bias (dB)


CYG#1 Block IIR–M Port
CYG#2 Block IIR–M Port
CYG#3 Block IIR–M Port
CYG#4 Block IIR–M Port
ECMWF Wind Speed (m/s)
DDM Noise Floor
NBRCS Bias (dB)


CYG#5 Block IIR–M Port
CYG#6 Block IIR–M Port
CYG#7 Block IIR–M Port
CYG#8 Block IIR–M Port
ECMWF Wind Speed (m/s)
DDM Noise Floor
NBRCS Bias (dB)


CYG#1 Block IIR–M Starboard
CYG#2 Block IIR–M Starboard
CYG#3 Block IIR–M Starboard
CYG#4 Block IIR–M Starboard
ECMWF Wind Speed (m/s)
DDM Noise Floor x 1e4
NBRCS Bias (dB)

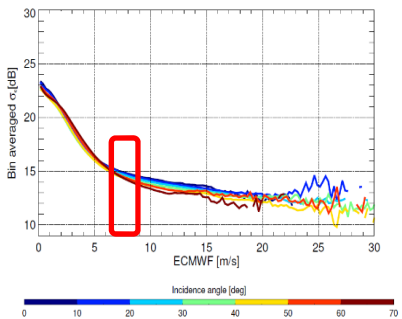

CYG#5 Block IIR–M Starboard
CYG#6 Block IIR–M Starboard
CYG#7 Block IIR–M Starboard
CYG#8 Block IIR–M Starboard
ECMWF Wind Speed (m/s)
NBRCS Bias (dB)

Observations

- much better agreement between pair of observatories with latest data version
- reduced standard deviation
  - although standard deviations are still a bit too high (for both u10/mss)
- correlation between NF diff and NBRCS diff largely reduced
- some dependence of σ_0 bias on noise floor
  - Dependence changes between cygnss satelites and GPS blocks

Incidence Angle Dependence

Bin averaged
Sigma0/les/wind_speed/mss/rcg vs incidence angle
separated by antenna and prn
for a fixed ecmwf wind speed bin (6-6.5 m/s)
Comparing v2.0, sandbox030, sandbox033



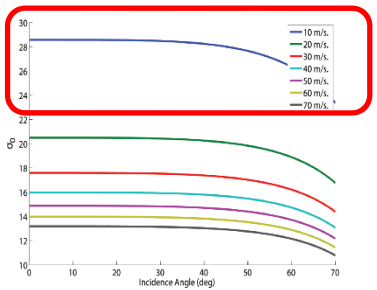
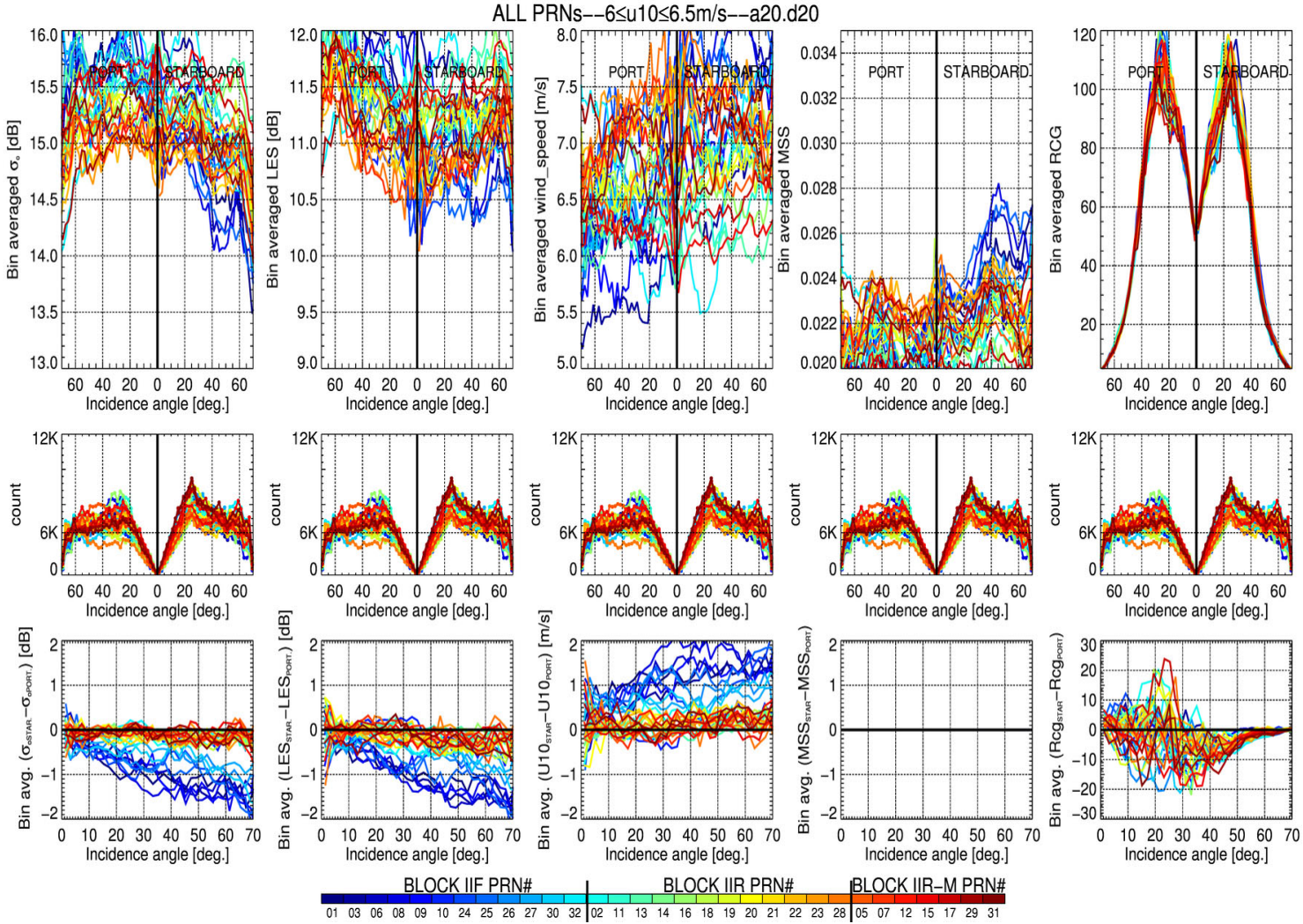
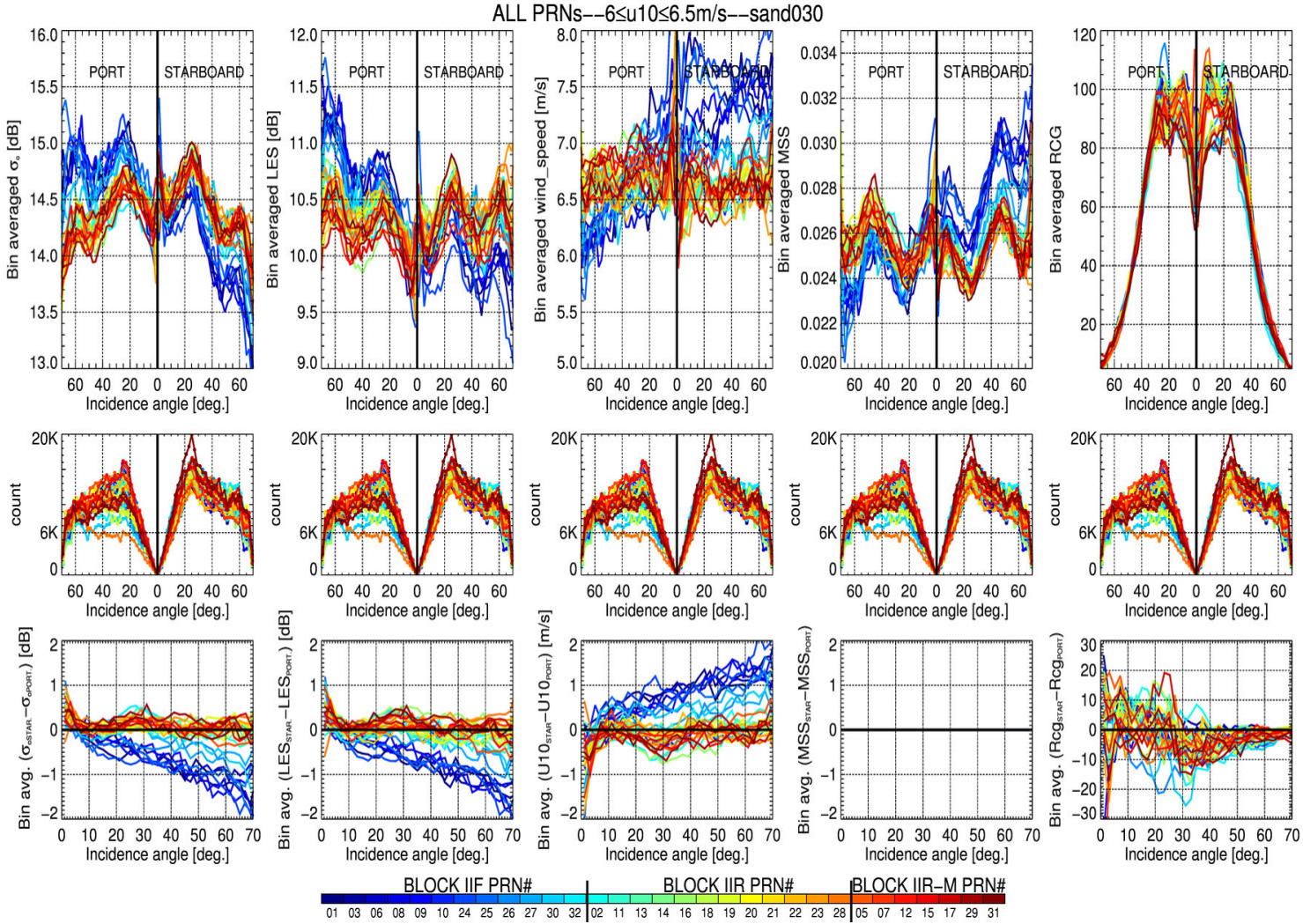


Figure 9.14. Curves of $\sigma_0(\bar{\Gamma}_{sp})$ versus incidence angle, for different wind speed values.

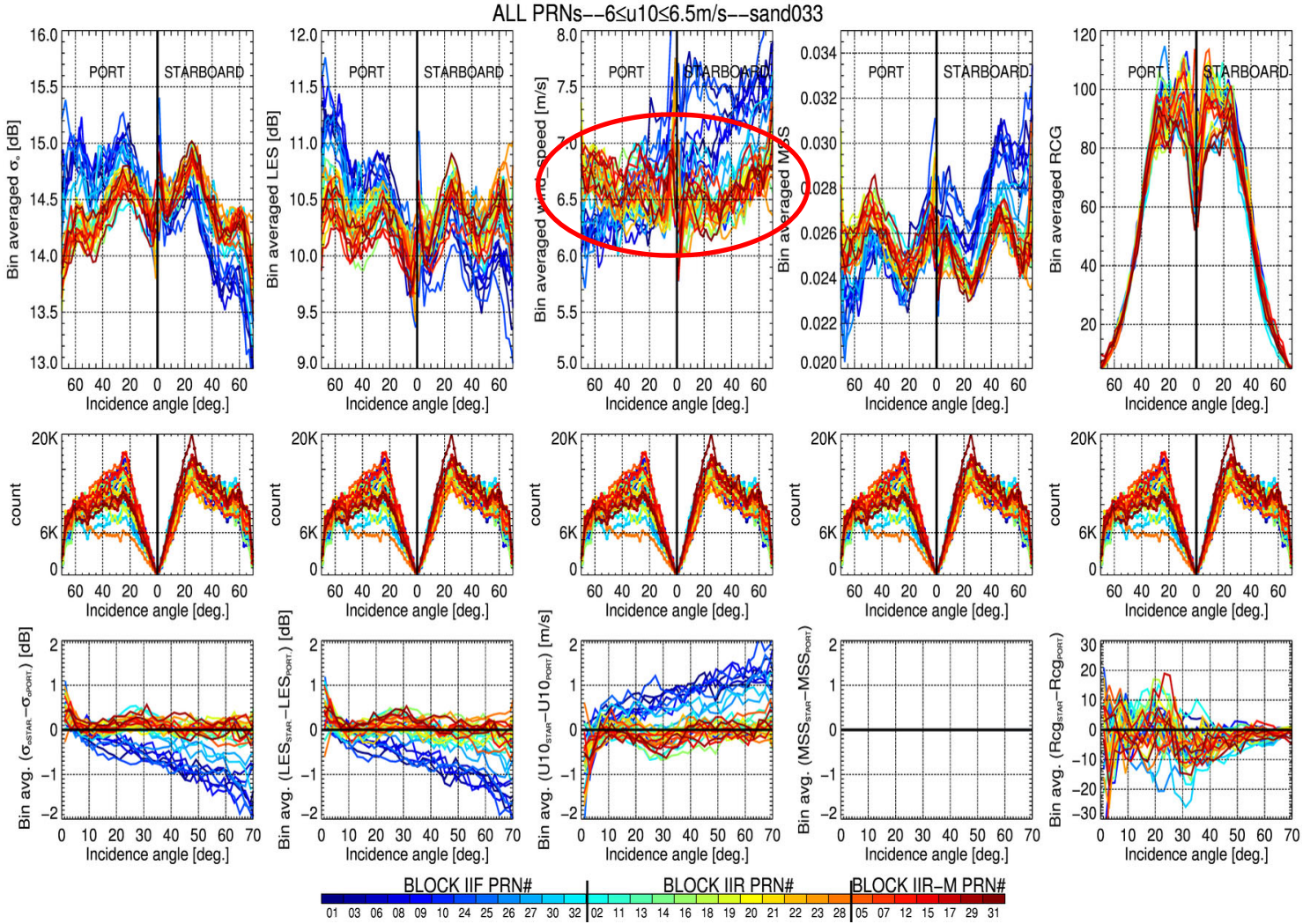
V2.0 ECMWF Wind ~6.5m/s

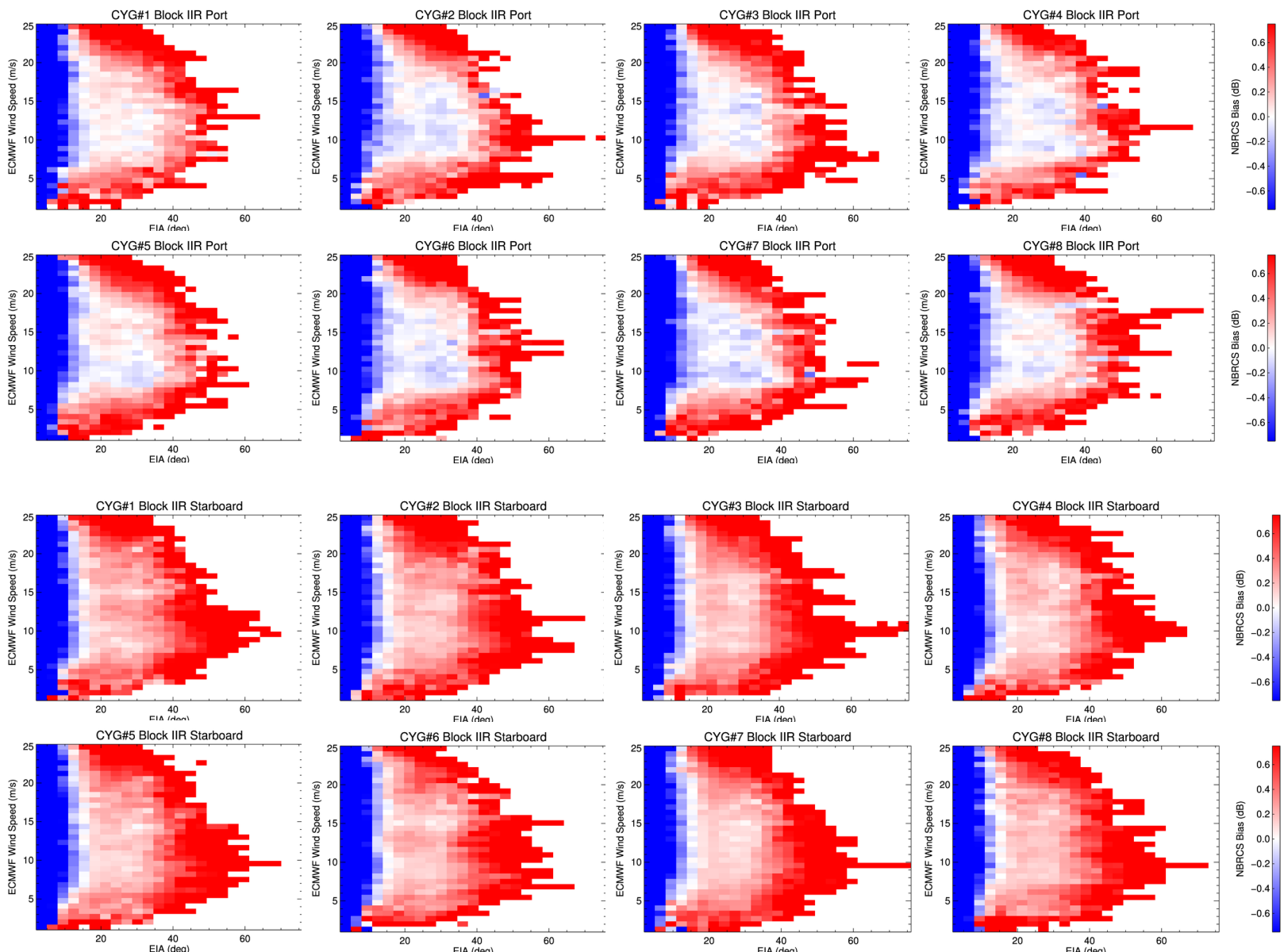


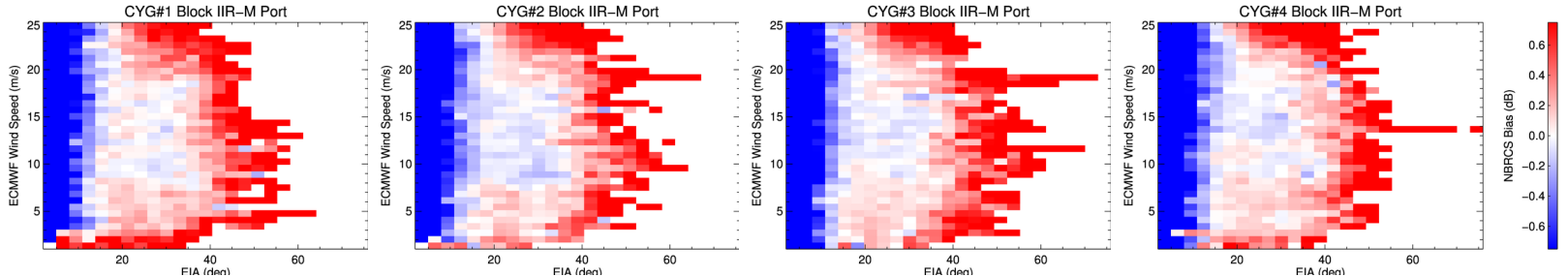
Sand030 ECMWF Wind ~6.5m/s

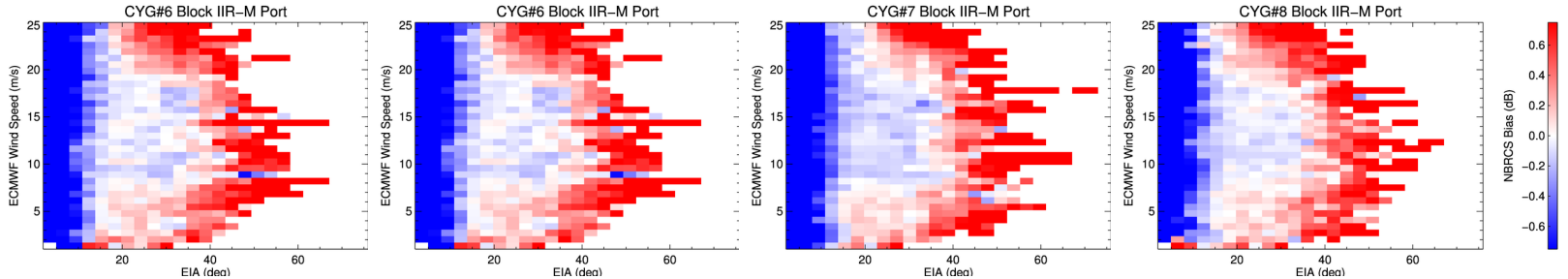


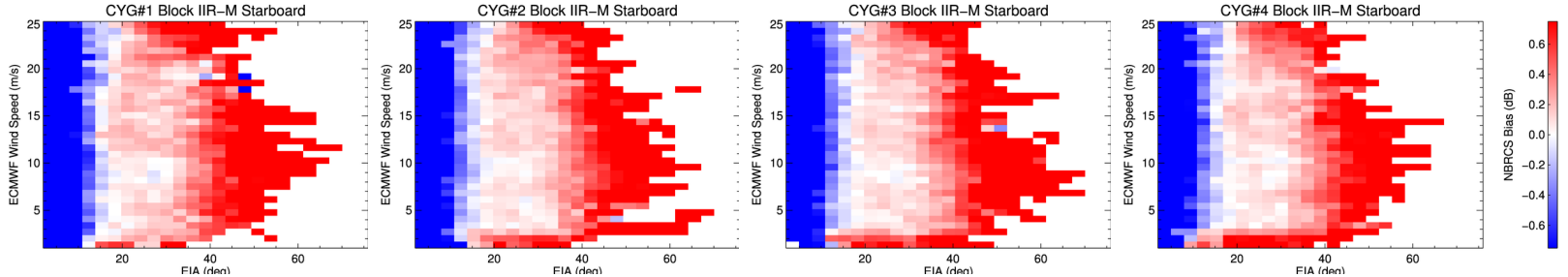
Sand033 ECMWF Wind ~6.5m/s

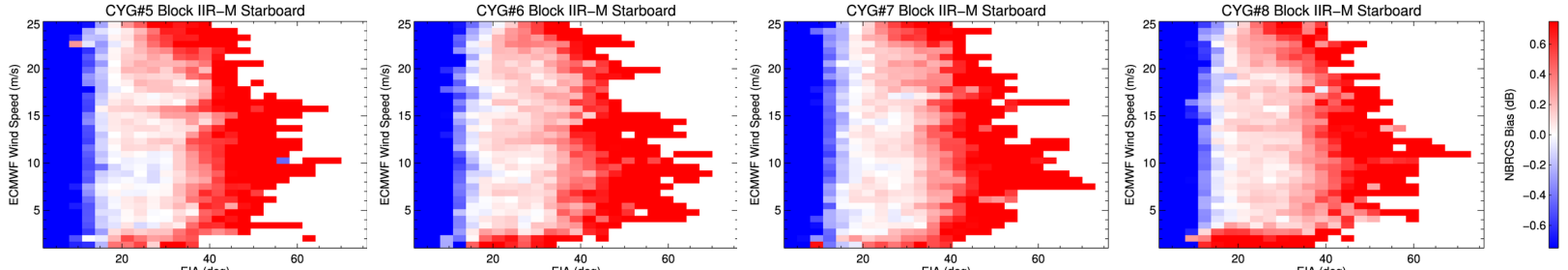


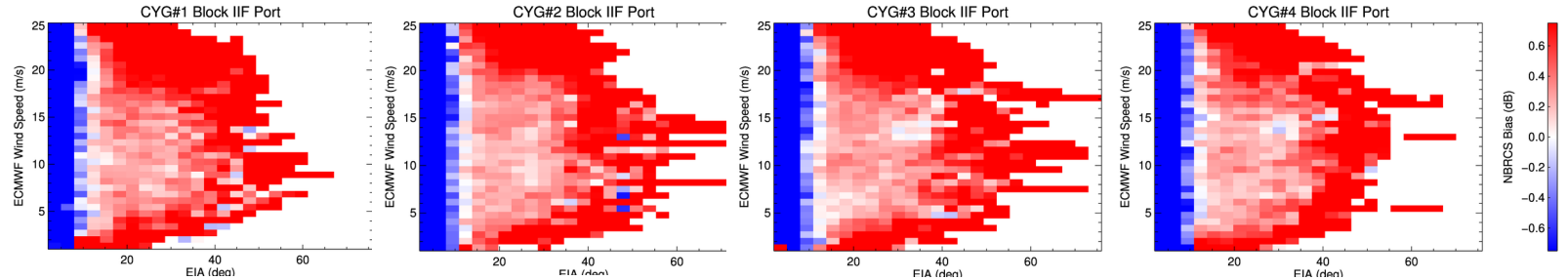

CYG#1 Block IIR Port
CYG#2 Block IIR Port
CYG#3 Block IIR Port
CYG#4 Block IIR Port
CYG#5 Block IIR Port
CYG#6 Block IIR Port
CYG#7 Block IIR Port
CYG#8 Block IIR Port
CYG#1 Block IIR Starboard
CYG#2 Block IIR Starboard
CYG#3 Block IIR Starboard
CYG#4 Block IIR Starboard
CYG#5 Block IIR Starboard
CYG#6 Block IIR Starboard
CYG#7 Block IIR Starboard
CYG#8 Block IIR Starboard
ECMWF Wind Speed (m/s)
EIA (deg)
NBRCS Bias (dB)

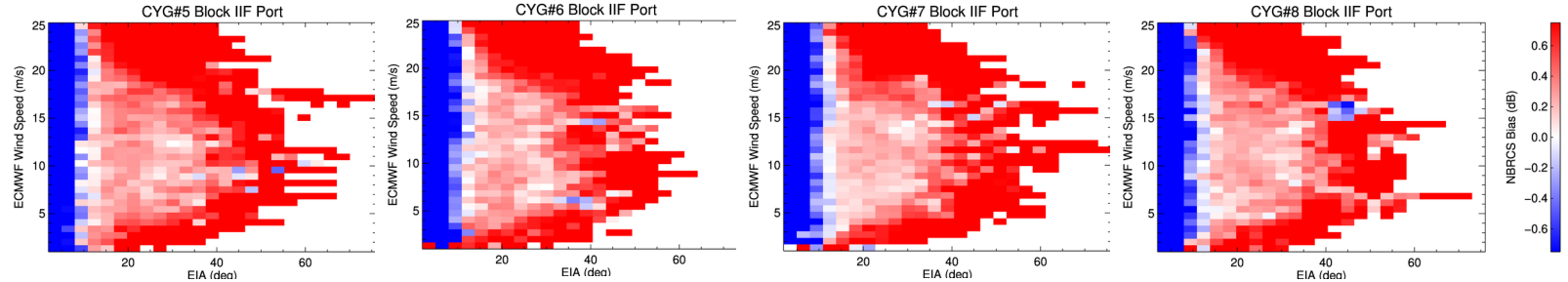

CYG#1 Block IIR−M Port
CYG#2 Block IIR−M Port
CYG#3 Block IIR−M Port
CYG#4 Block IIR−M Port
ECMWF Wind Speed (m/s)
EIA (deg)
NBRCS Bias (dB)

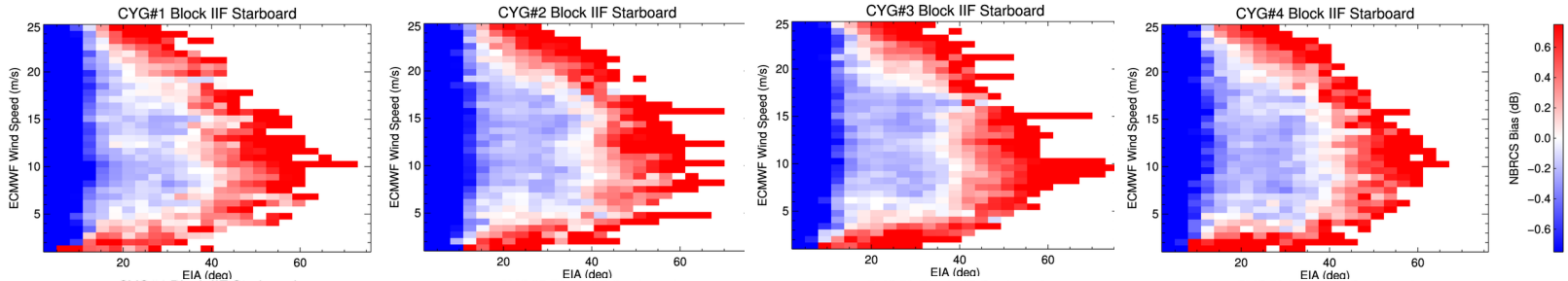

CYG#6 Block IIR−M Port
CYG#6 Block IIR−M Port
CYG#7 Block IIR−M Port
CYG#8 Block IIR−M Port
ECMWF Wind Speed (m/s)
EIA (deg)
NBRCS Bias (dB)

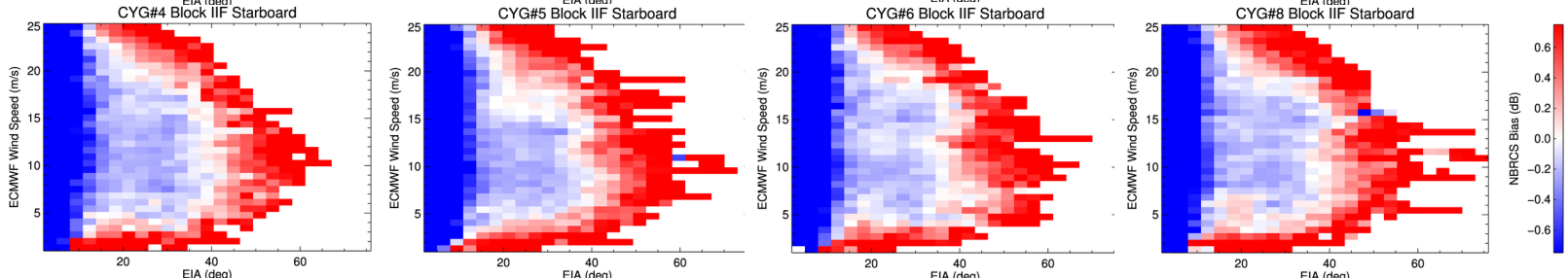

CYG#1 Block IIR−M Starboard
CYG#2 Block IIR−M Starboard
CYG#3 Block IIR−M Starboard
CYG#4 Block IIR−M Starboard
ECMWF Wind Speed (m/s)
EIA (deg)
NBRCS Bias (dB)


CYG#5 Block IIR−M Starboard
CYG#6 Block IIR−M Starboard
CYG#7 Block IIR−M Starboard
CYG#8 Block IIR−M Starboard
ECMWF Wind Speed (m/s)
EIA (deg)
NBRCS Bias (dB)


CYG#1 Block IIF Port
CYG#2 Block IIF Port
CYG#3 Block IIF Port
CYG#4 Block IIF Port
ECMWF Wind Speed (m/s)
EIA (deg)
NBRCS Bias (dB)


CYG#5 Block IIF Port
CYG#6 Block IIF Port
CYG#7 Block IIF Port
CYG#8 Block IIF Port
ECMWF Wind Speed (m/s)
EIA (deg)
NBRCS Bias (dB)


CYG#1 Block IIF Starboard
CYG#2 Block IIF Starboard
CYG#3 Block IIF Starboard
CYG#4 Block IIF Starboard
ECMWF Wind Speed (m/s)
EIA (deg)
NBRCS Bias (dB)


CYG#4 Block IIF Starboard
CYG#5 Block IIF Starboard
CYG#6 Block IIF Starboard
CYG#8 Block IIF Starboard
ECMWF Wind Speed (m/s)
EIA (deg)
NBRCS Bias (dB)

Observations

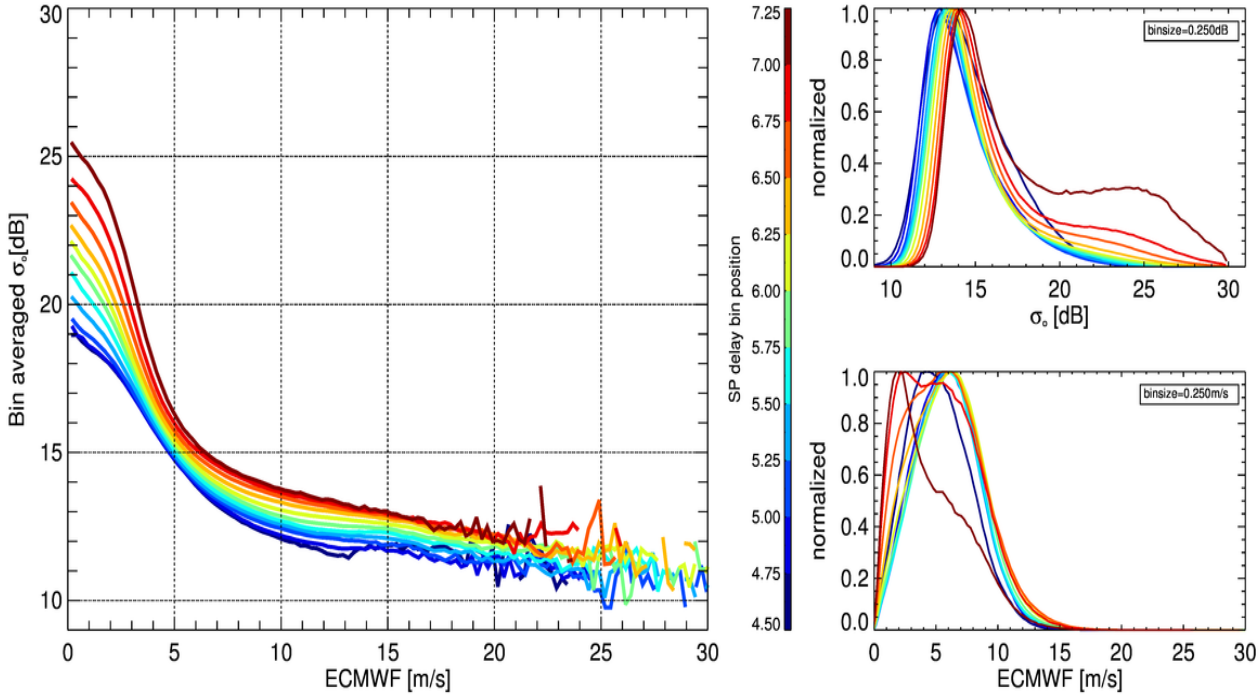
-Again, issues with IIF (asymmetry between antenna, different nbrcs levels compared to the other two blocks)
-changes from sand030 to sand033 is introducing artefacts in the nbrcs vs. incidence angle dependence

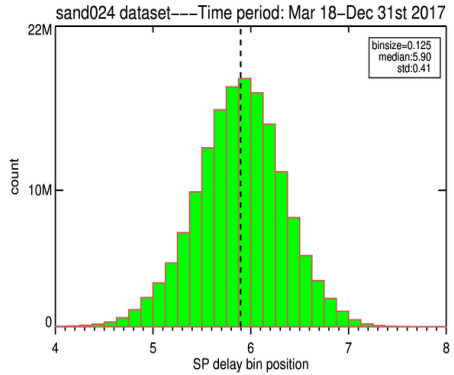
Checking impact on nbrcs due to specular point delay bin position fixes

sand024 vs sand026

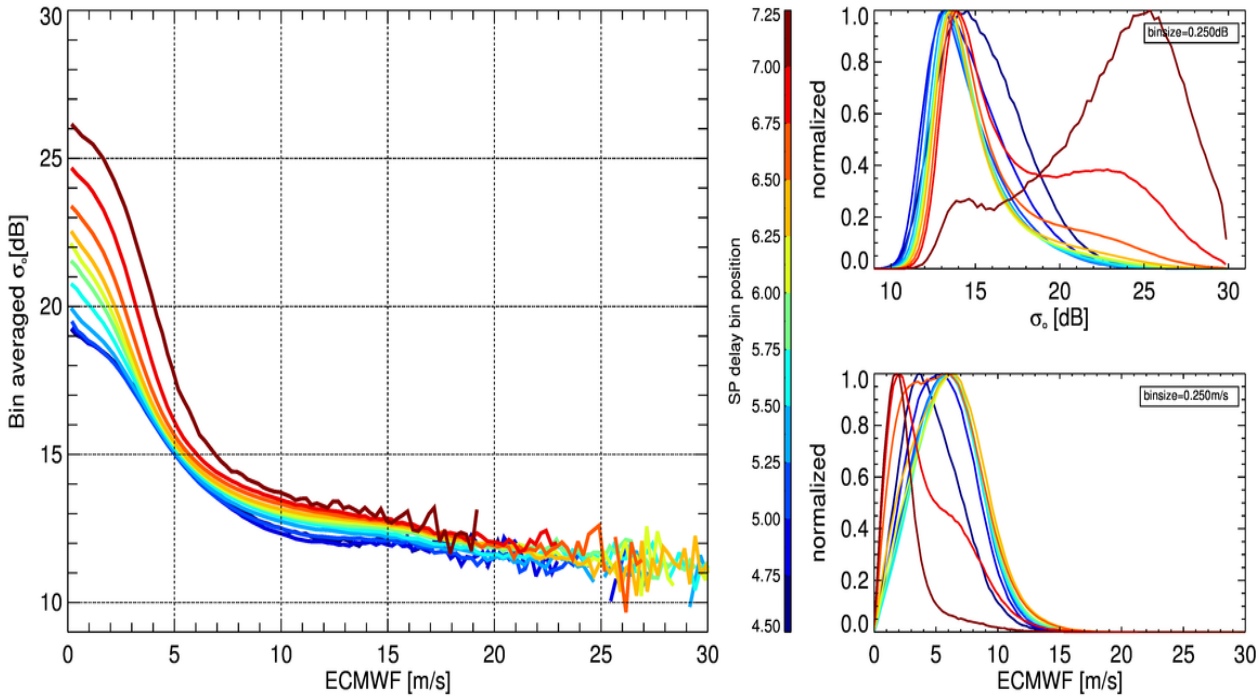
026	L1 run for date range 2017-03-18 through 2018-04-19 ***Changes:*** * Fine Specular Solver is now directly using the additional range to SP that is calculated by the DDMI. ***Summary of prior changes accumulated since v2.0:*** * v.8 GPS EIRP table received from Darren McKague 2018-04-13 * RX antenna gain table: v.6 received from Darren 2018-03-28 * Specular point coordinates calculated by ECEF to Body Frame transformation * Correction to Azimuth angle used in RX gain lookup (corrected issue with high incidence angles) * Digital to Analog Rx power conversion disabled * Large Attitude Error quality flag at 30 degrees (had been 5 degerees due to high incidence angle issue)

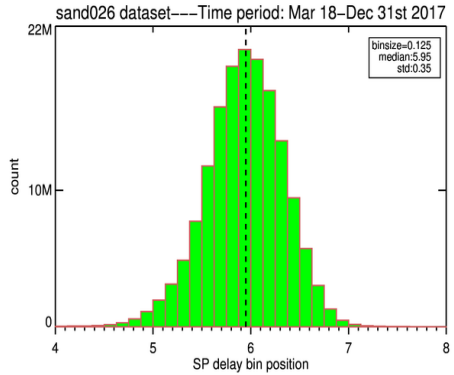
sand024 dataset---Time period: Mar 18–Dec 31st 2017



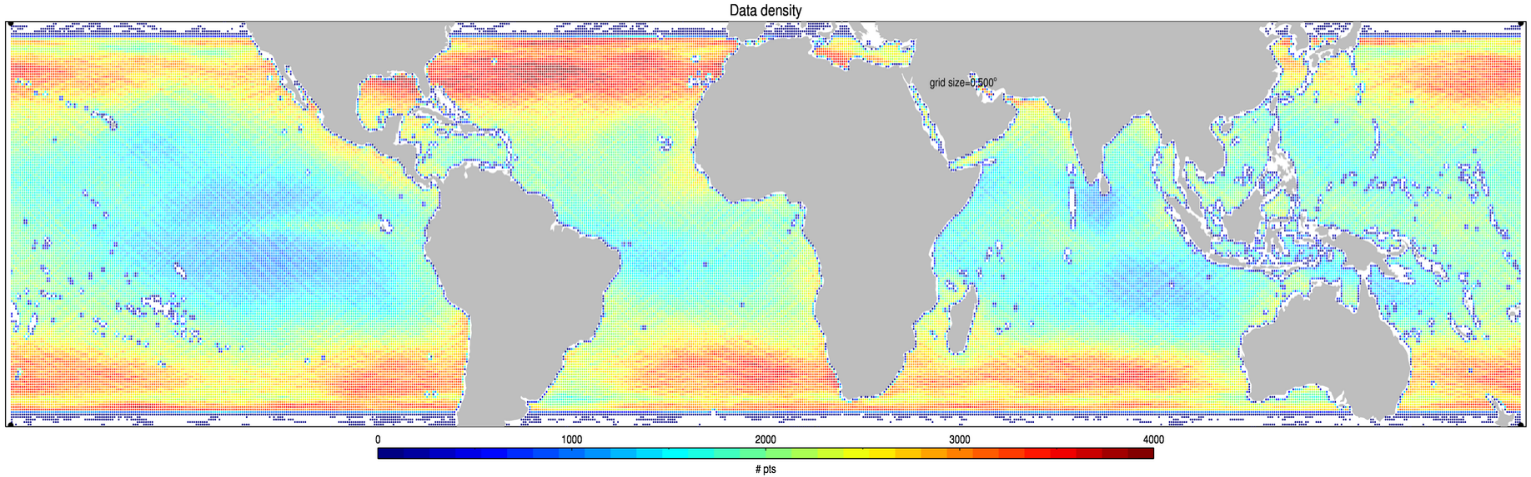


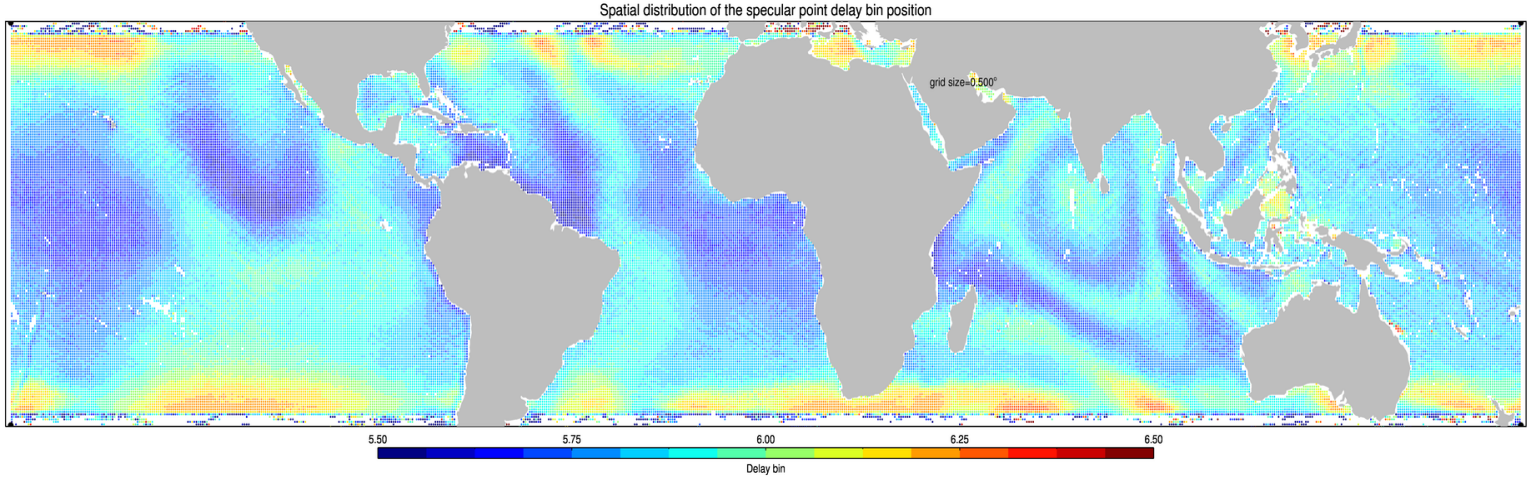
sand026 dataset---Time period: Mar 18–Dec 31st 2017



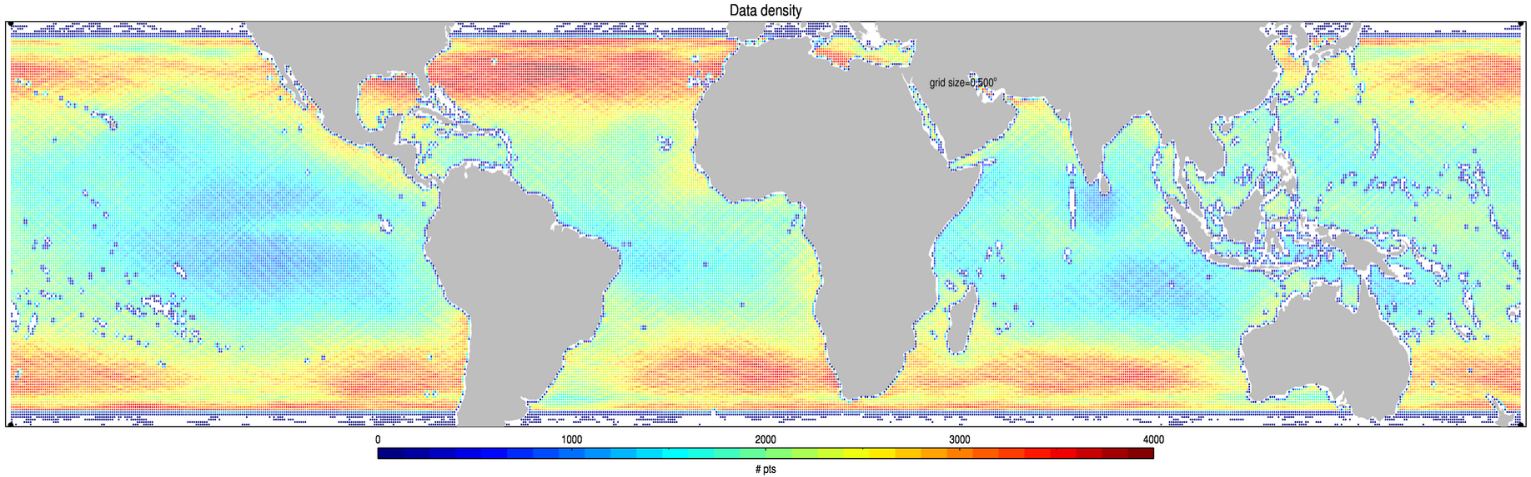


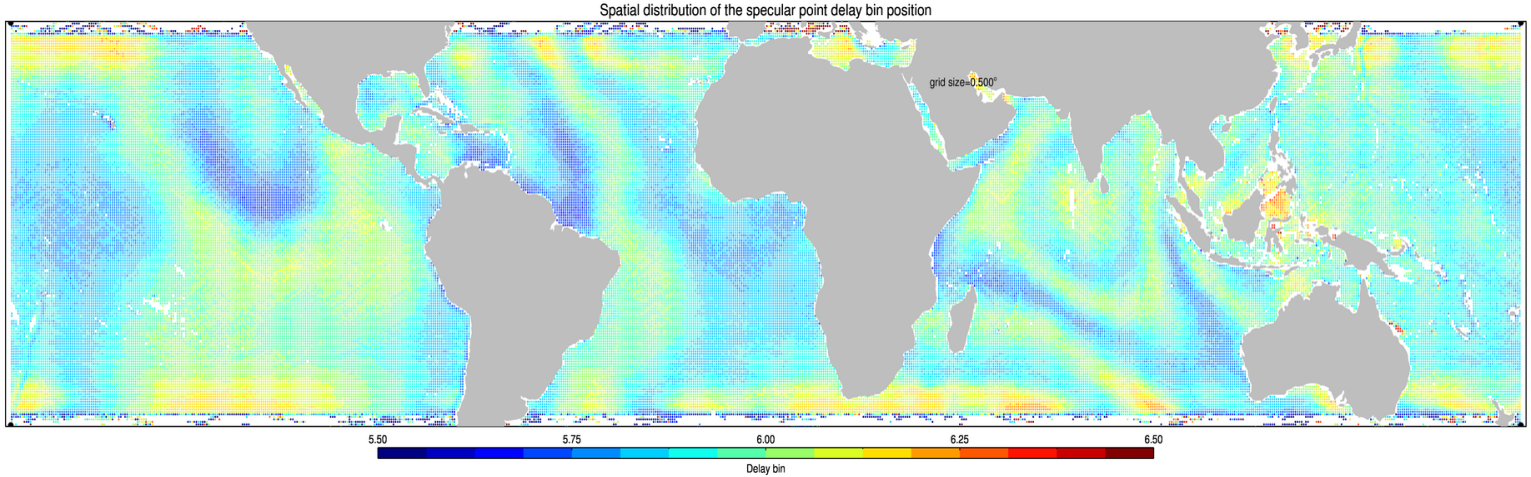
sand023 dataset---Time period: Mar 18–Dec 31st 2017



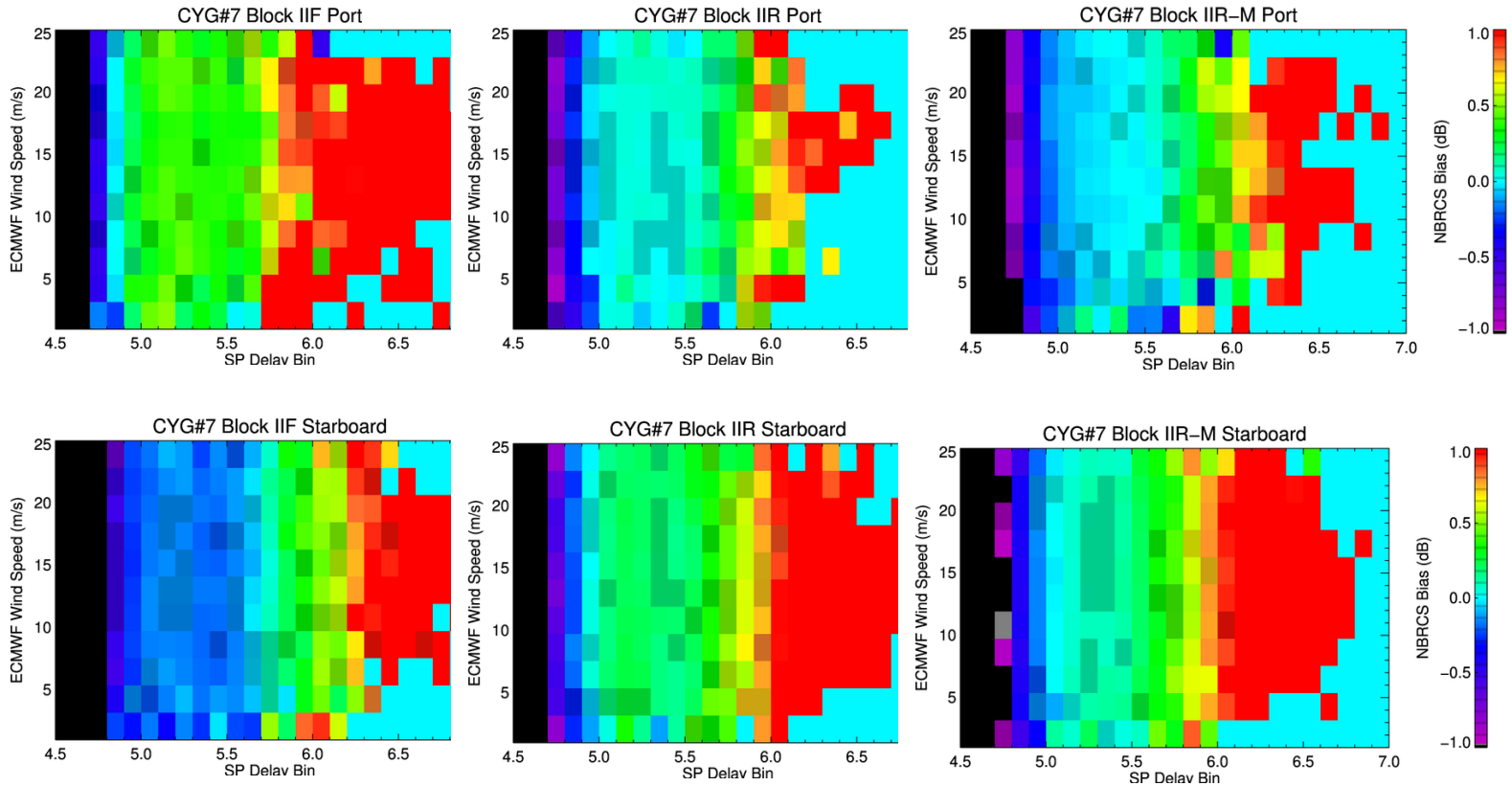


sand026 dataset---Time period: Mar 18–Dec 31st 2017





NBRCS Bias vs Wind Speed and SP Delay Bin Position



Daily Mean-Timeseries

per observatory per antenna

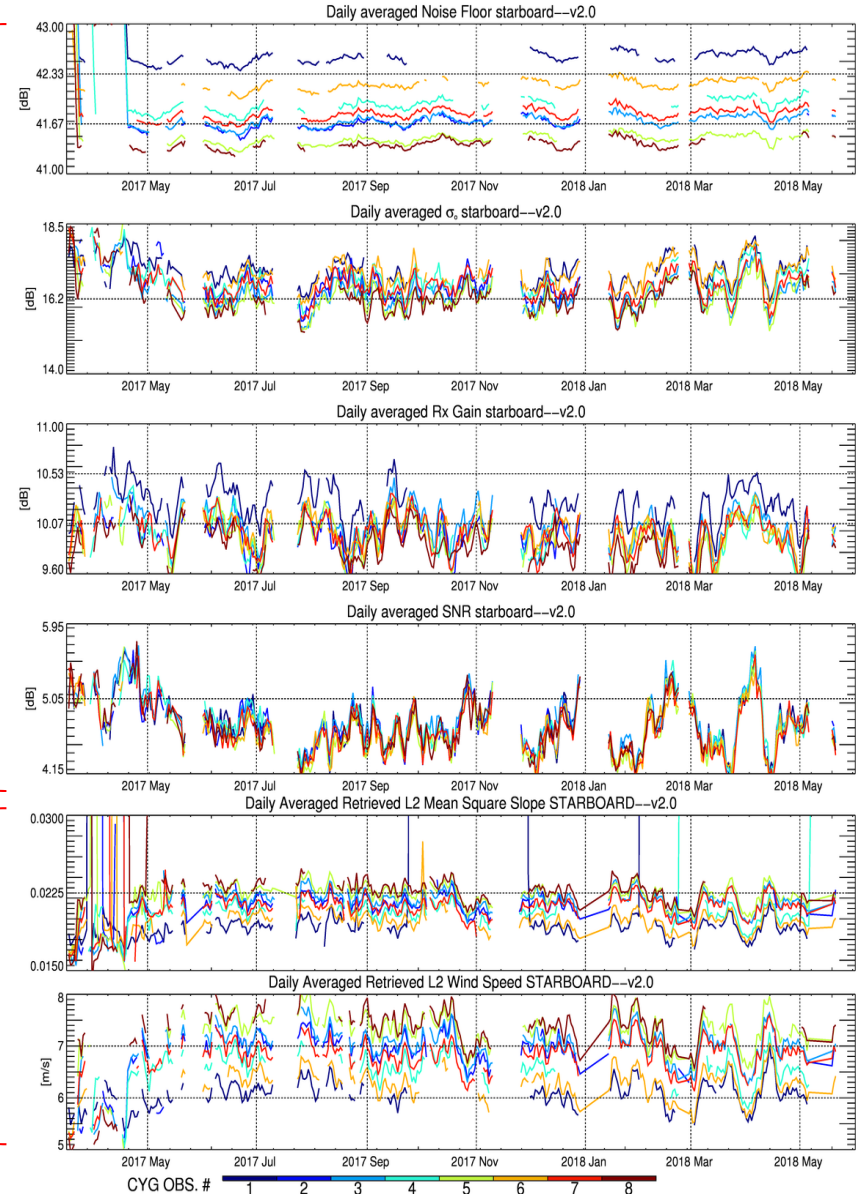
STARBOARD…

V2.0 vs v2.1 beta (Sandbox 31)

STARBOARD V.2.0

L1

L2 mss/u10

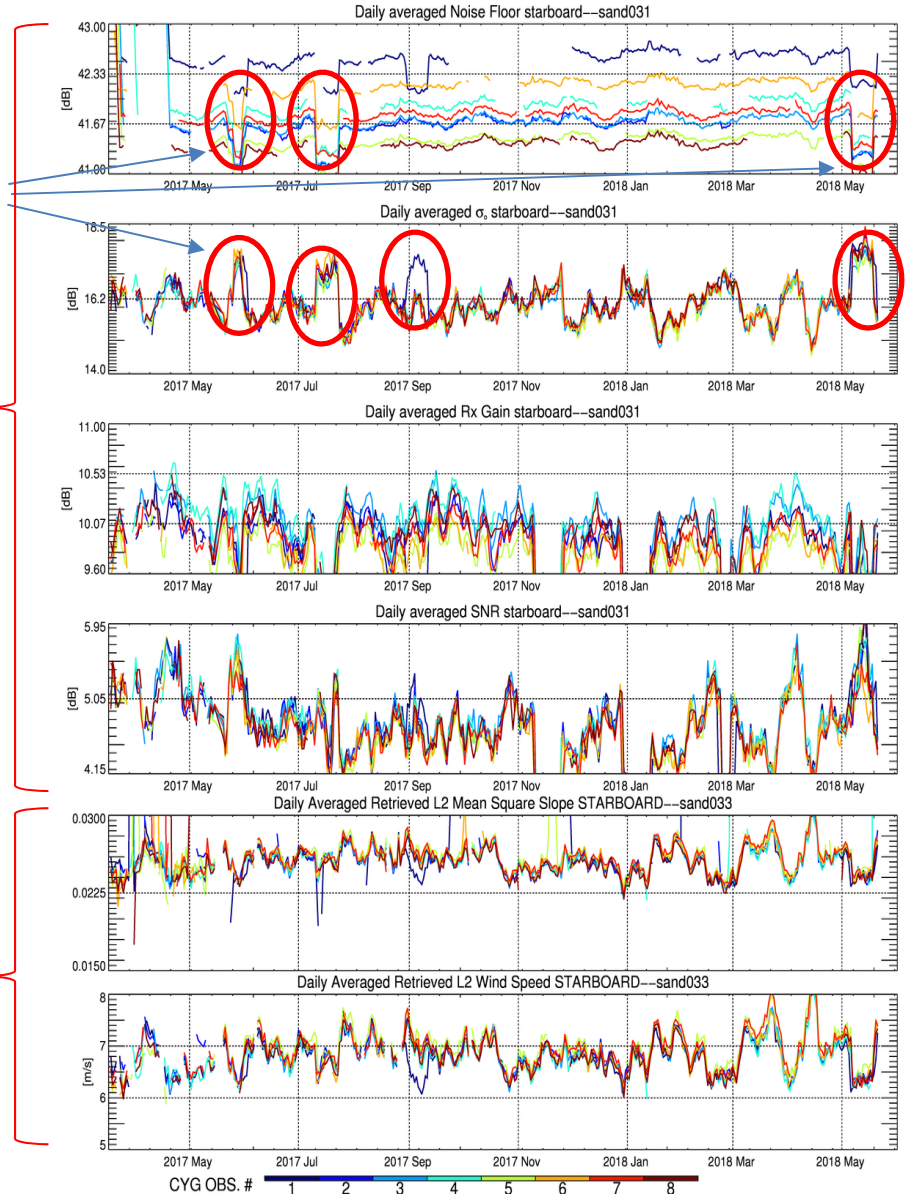


STARBOARD V2.1b

High roll angle

L1

L2 mss/u10



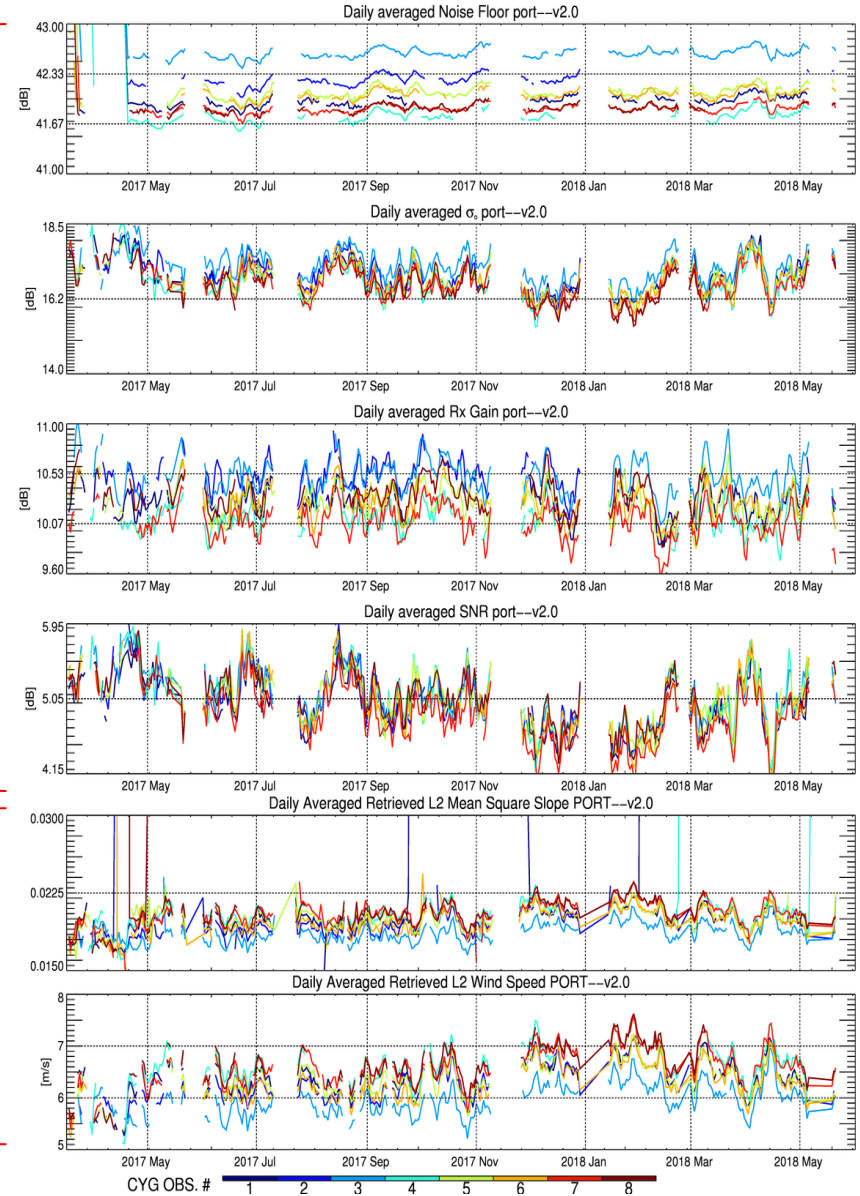
PORT…

V2.0 vs v2.1 beta

PORT V.2.0

L1

L2 mss/u10



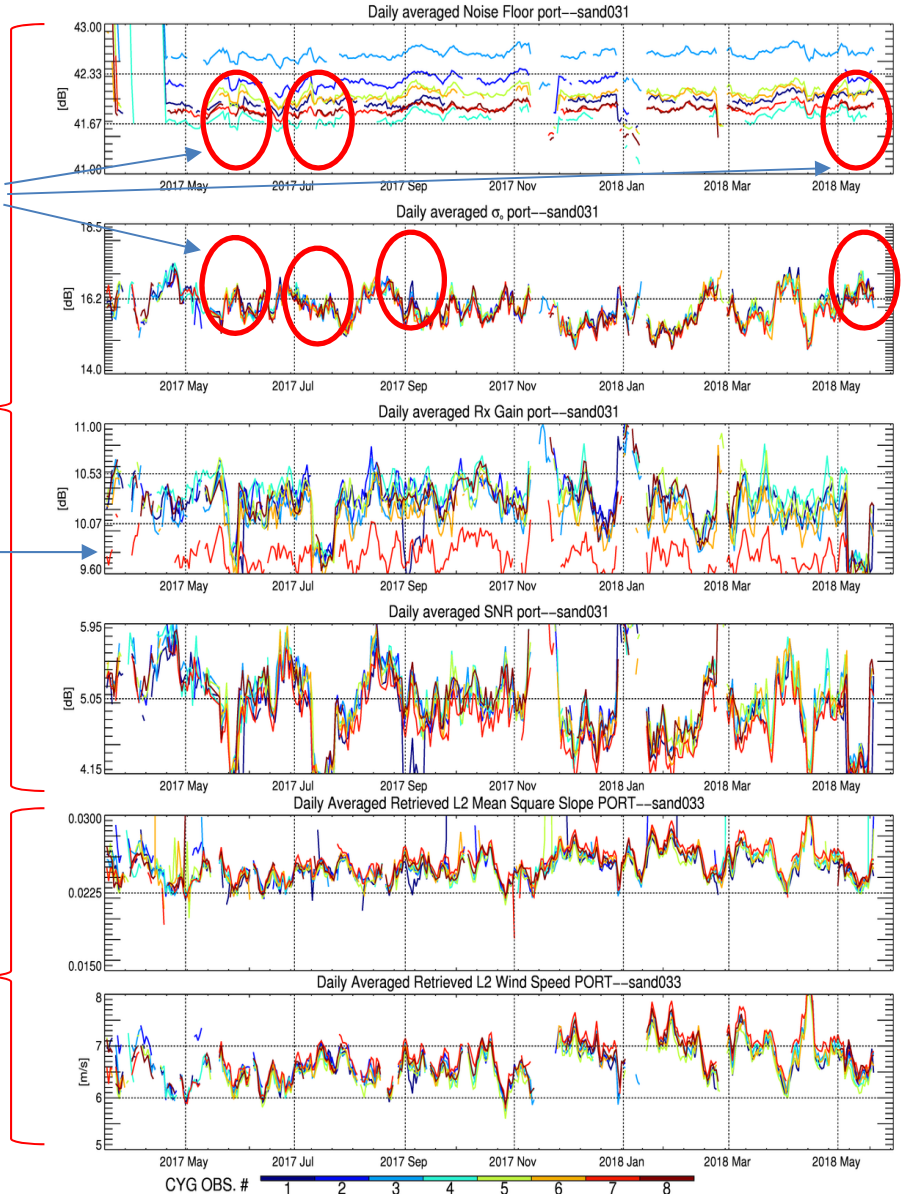
PORT V2.1b

High roll angle

L1

outlier
(FM 7)

L2 mss/u10



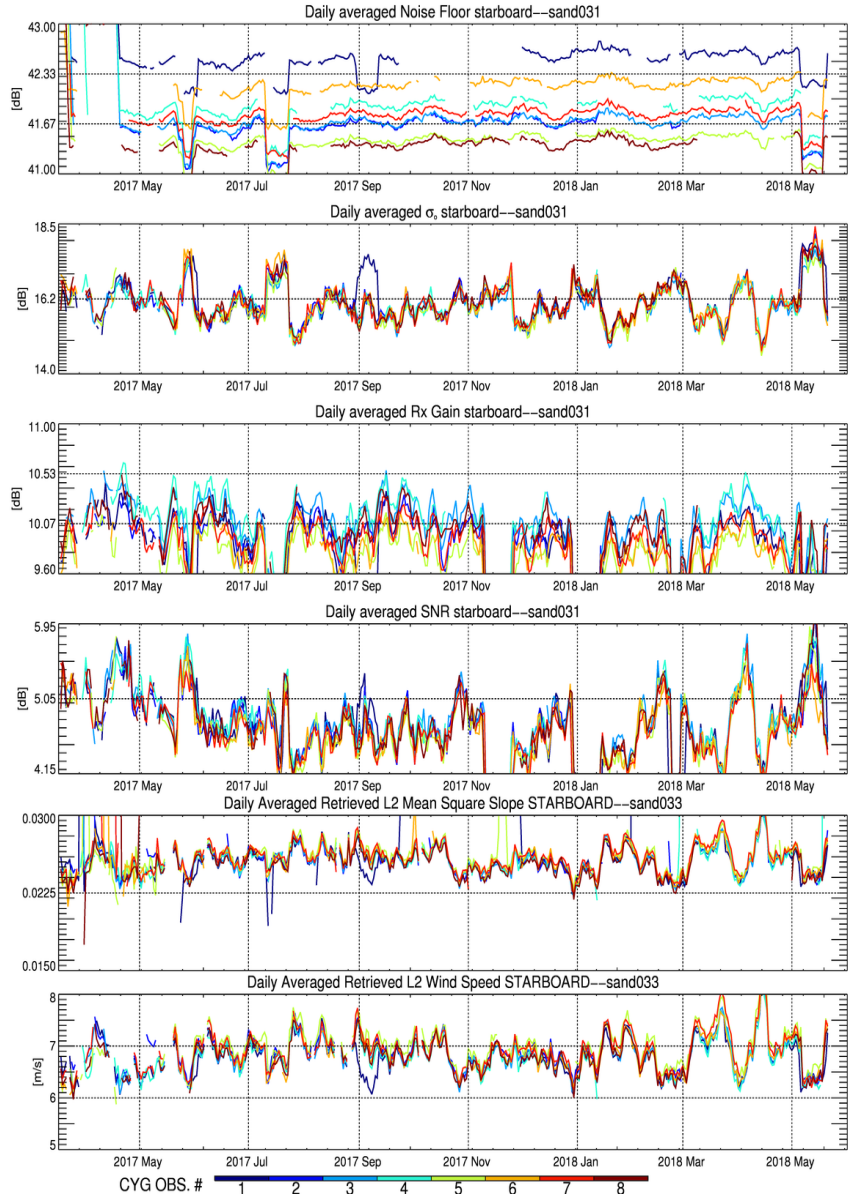
STARBOARD vs. PORT…

v2.1 beta

STARBOARD V2.1b

L1

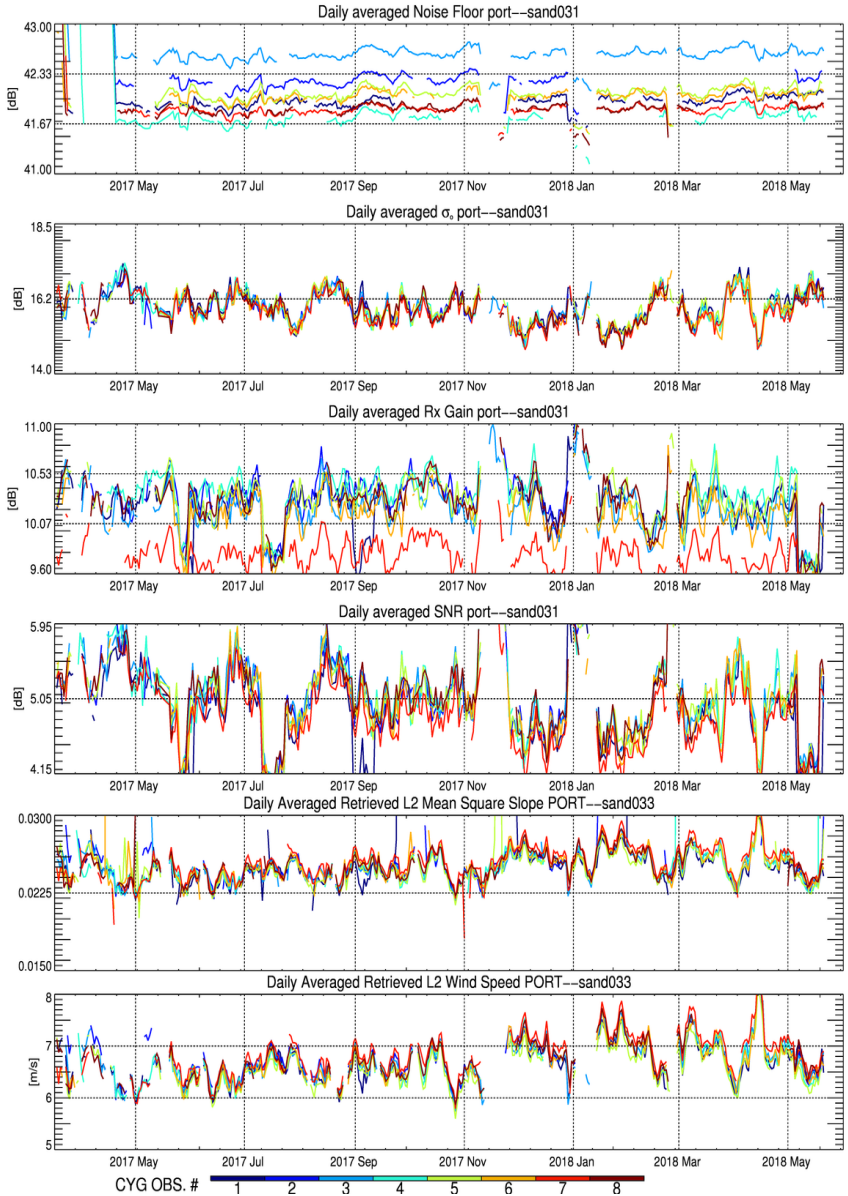
L2 mss/u10



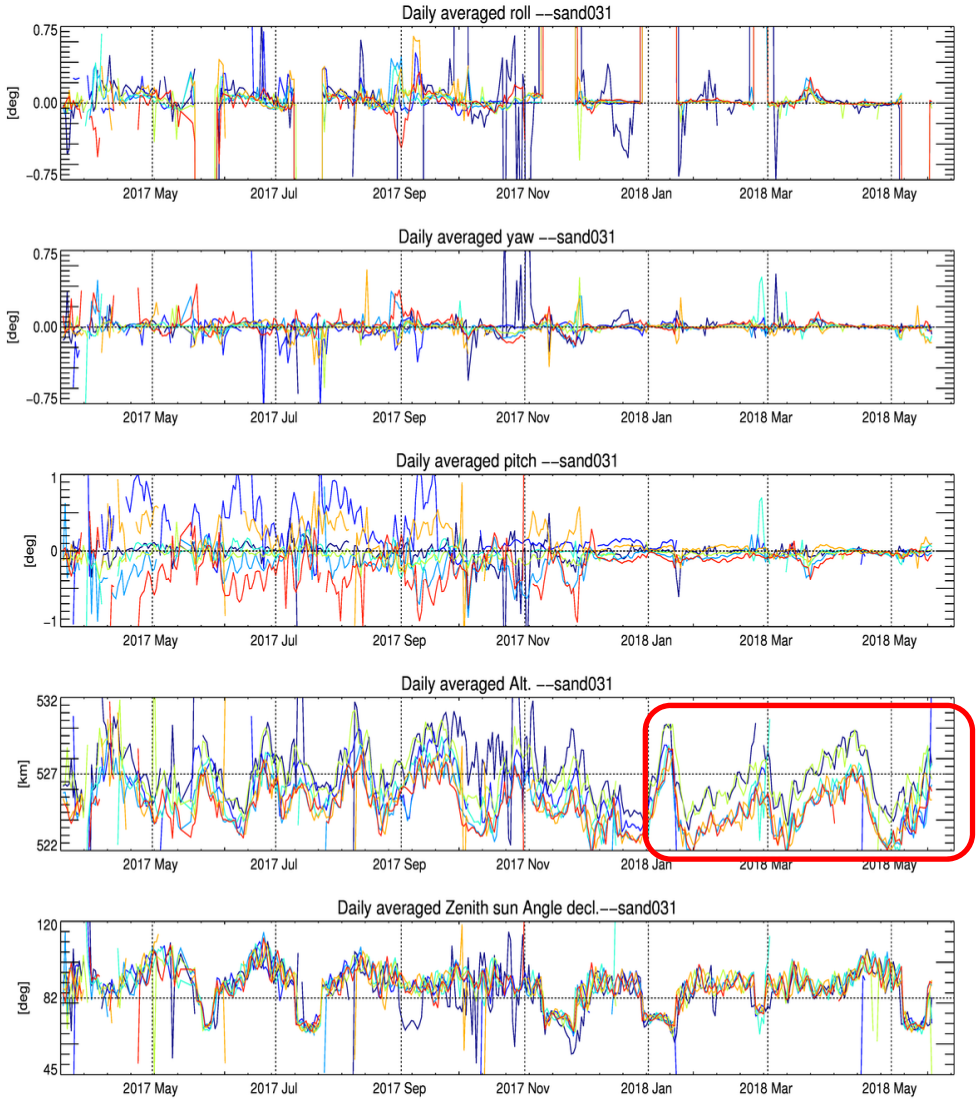
PORT V2.1b

L1

L2 mss/u10



Attitude parameters timeseries check…

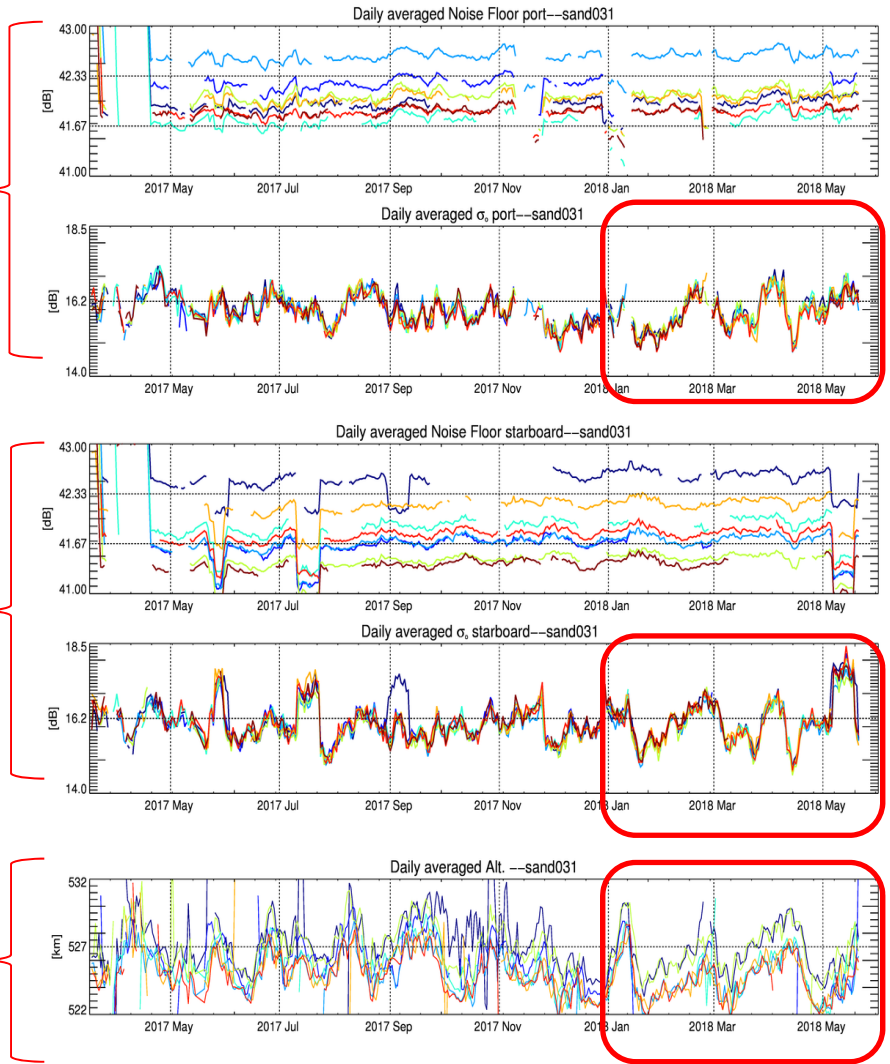


CYG OBS. # 1 2 3 4 5 6 7 8

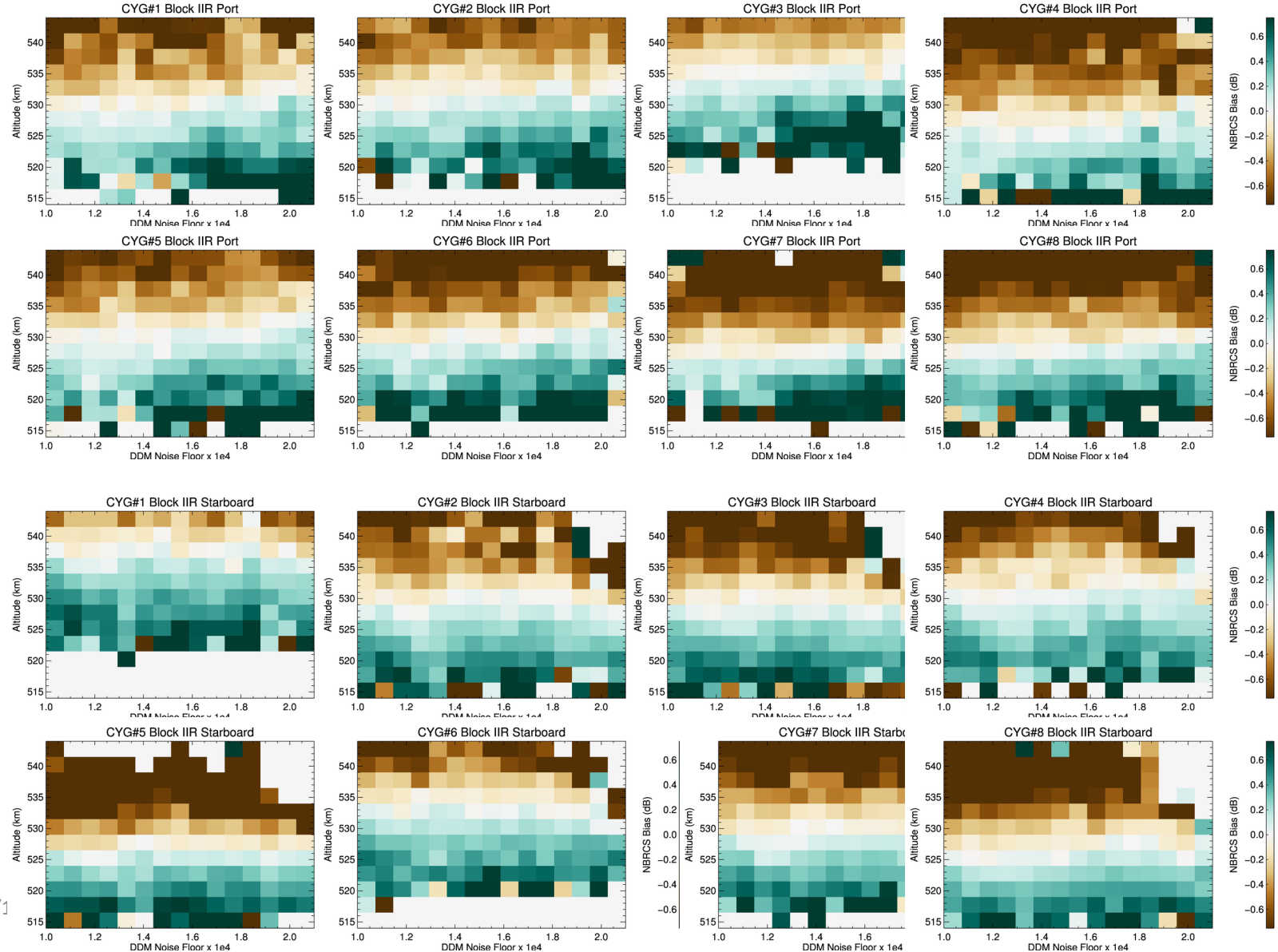
NF/NBRCS PORT

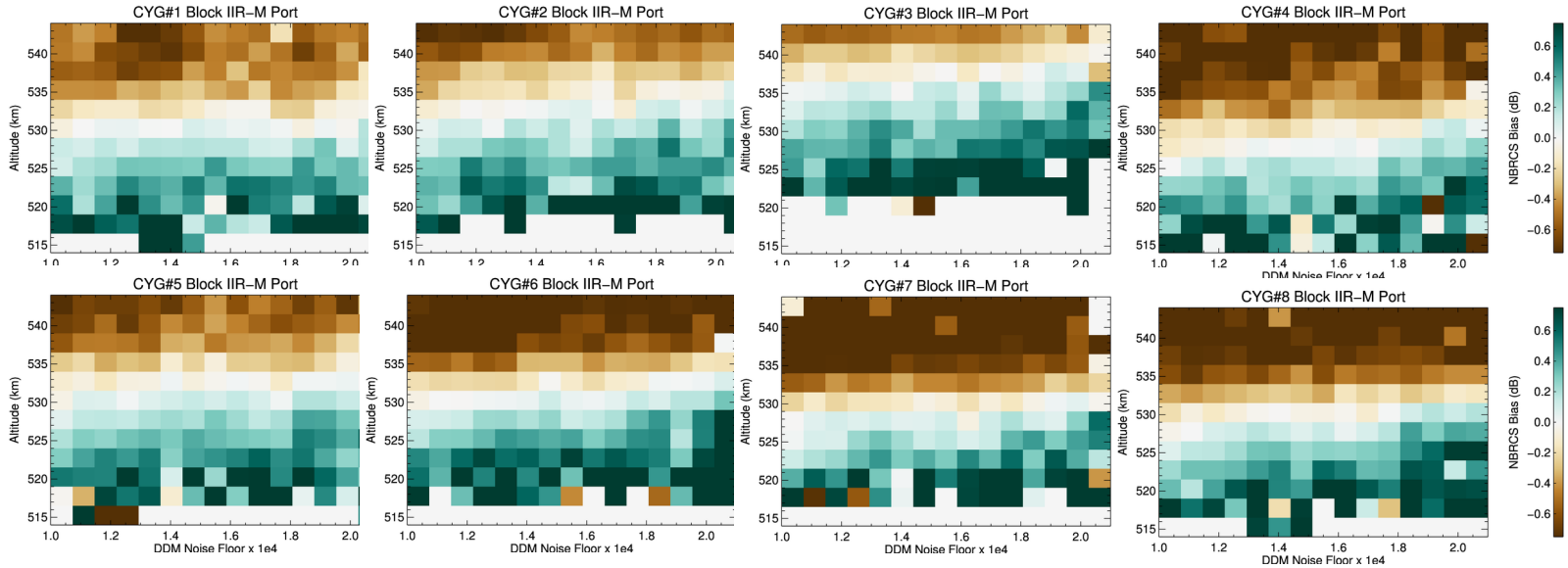
NF/NBRCS STAR

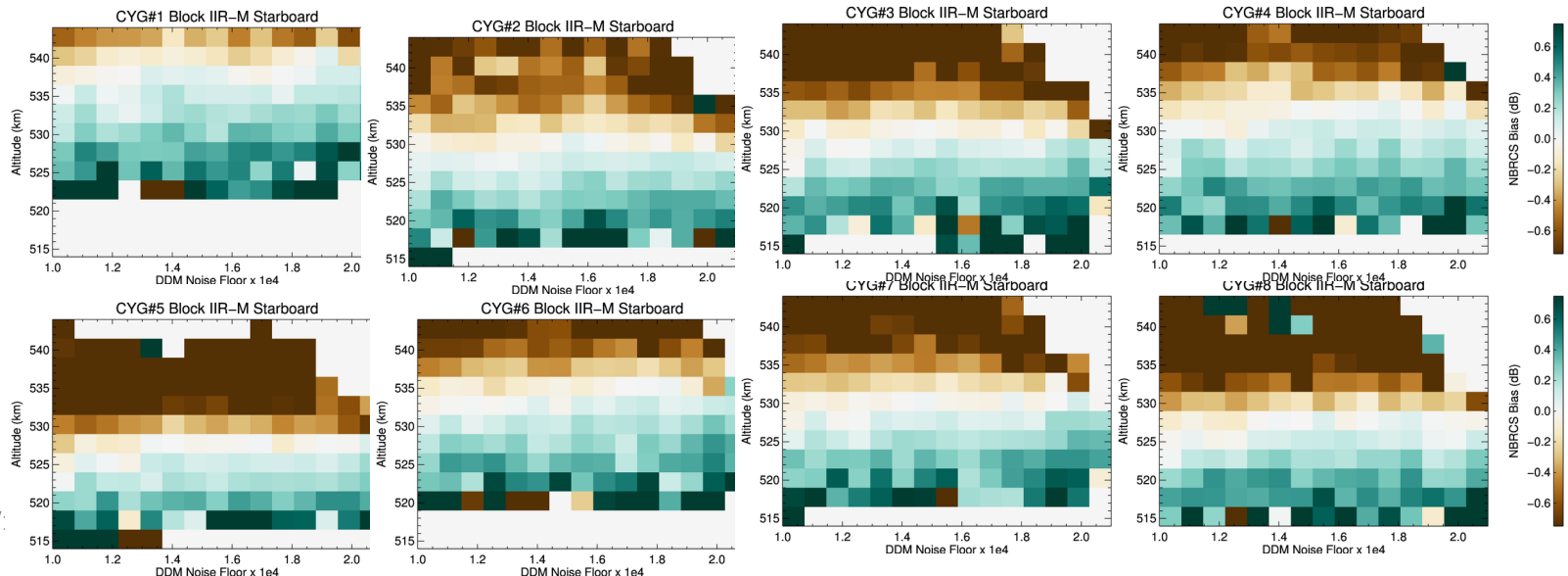
FM ALTITUDE



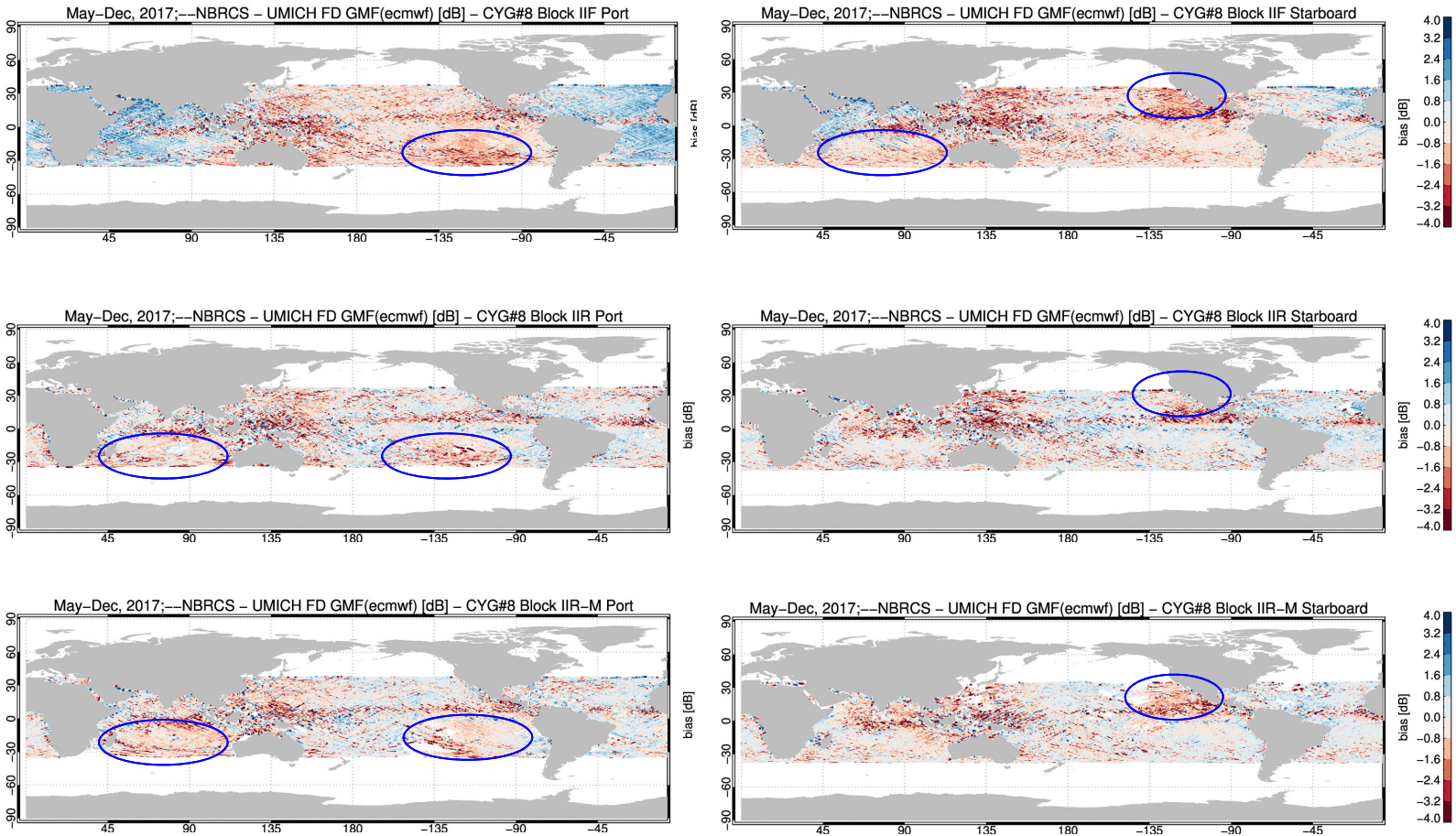
Apparent altitude dependence affecting the mean nbrcs


CYG#1 Block IIR Port
CYG#2 Block IIR Port
CYG#3 Block IIR Port
CYG#4 Block IIR Port
CYG#5 Block IIR Port
CYG#6 Block IIR Port
CYG#7 Block IIR Port
CYG#8 Block IIR Port
CYG#1 Block IIR Starboard
CYG#2 Block IIR Starboard
CYG#3 Block IIR Starboard
CYG#4 Block IIR Starboard
CYG#5 Block IIR Starboard
CYG#6 Block IIR Starboard
CYG#7 Block IIR Starbo
CYG#8 Block IIR Starboard
Altitude (km)
DDM Noise Floor x 1e4
NBRCS Bias (dB)

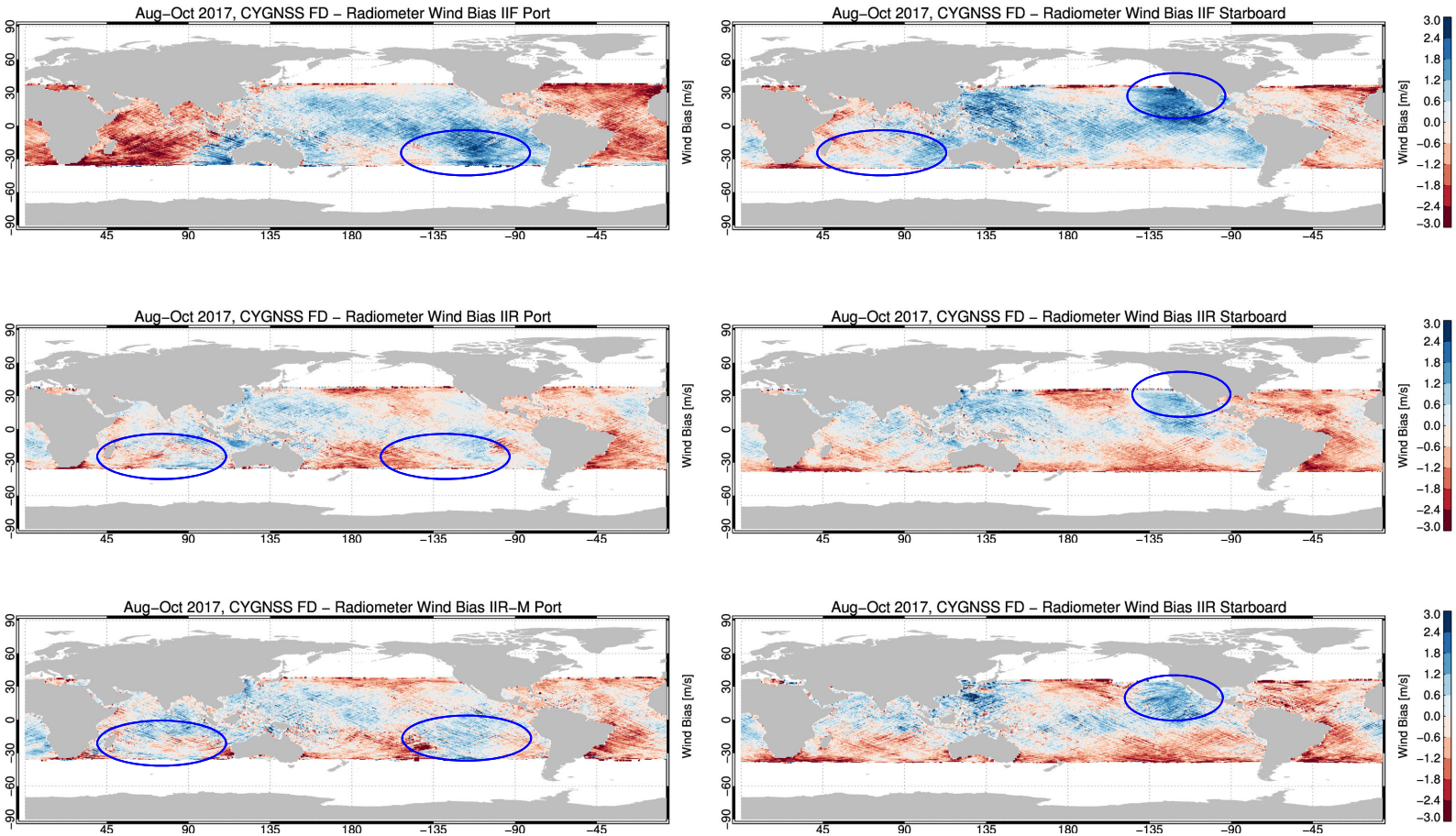

CYG#1 Block IIR–M Port
CYG#2 Block IIR–M Port
CYG#3 Block IIR–M Port
CYG#4 Block IIR–M Port
CYG#5 Block IIR–M Port
CYG#6 Block IIR–M Port
CYG#7 Block IIR–M Port
CYG#8 Block IIR–M Port
Altitude (km)
DDM Noise Floor x 1e4
NBRCS Bias (dB)


CYG#1 Block IIR–M Starboard
CYG#2 Block IIR–M Starboard
CYG#3 Block IIR–M Starboard
CYG#4 Block IIR–M Starboard
CYG#5 Block IIR–M Starboard
CYG#6 Block IIR–M Starboard
CYG#7 Block IIR–M Starboard
CYG#8 Block IIR–M Starboard
Altitude (km)
DDM Noise Floor x 1e4
NBRCS Bias (dB)

Geographical Distribution of NBRCS Bias



Geographical Distribution of Wind Speed Bias



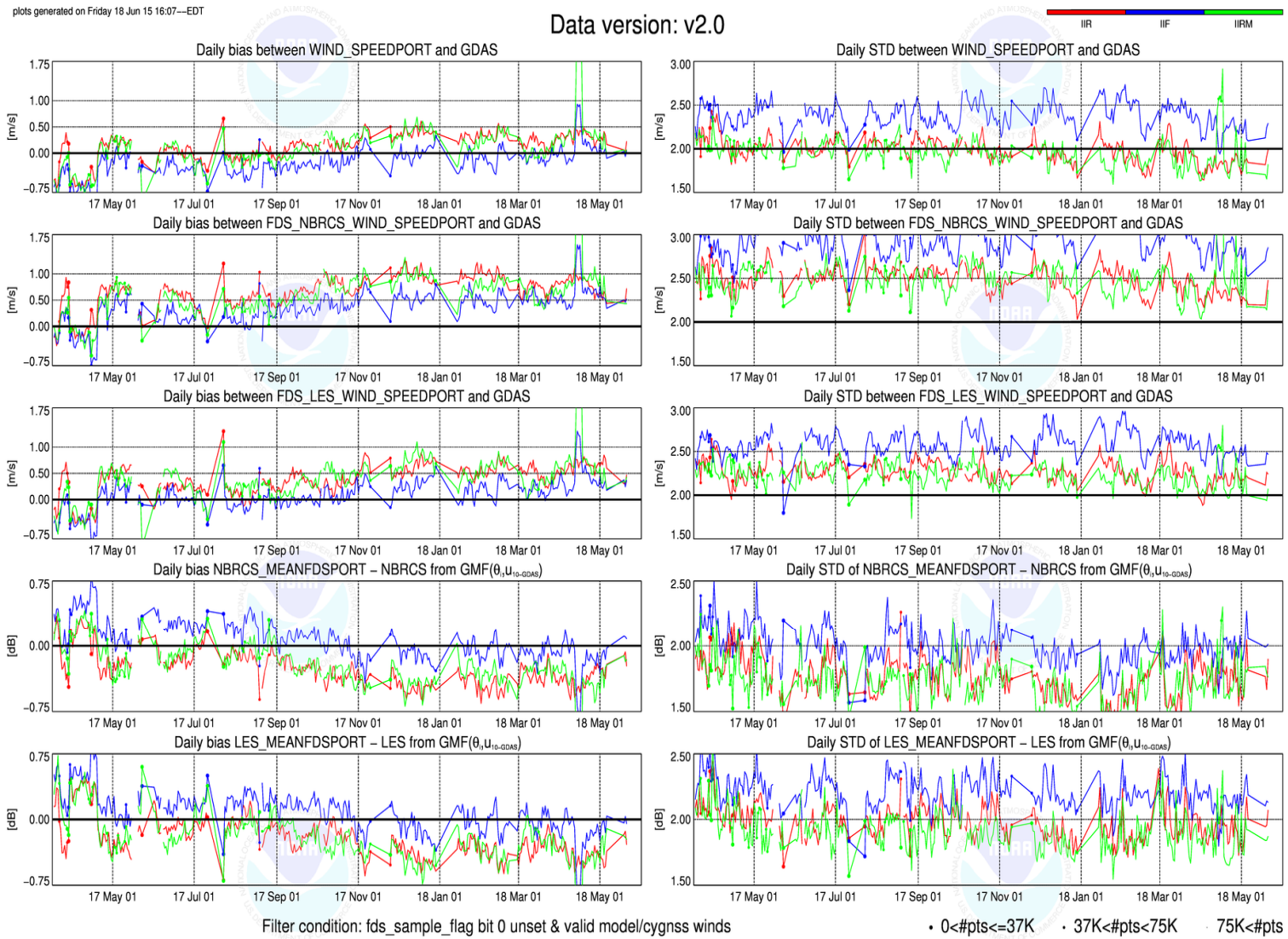
Observations thus far…

- wind speed/mss biases between observatories are *mostly* gone with sand033
- mss levels have noticeably **increased** due to a decrease in sigma0 (which happened when the A/D converter was turned off—sandbox020). This is an issue because the mss values may be unrealistic.
- apparent altitude dependence mostly noticeable after Nov 2017
- Rx gain from CYG 7 on the port side clearly an outlier…
- Data before May 2017 may not be used. NF levels are quite high for all FMs
- L2 data is now available during 'high roll' periods but estimated nbrcs are much higher. Also NF levels are lower than usual during most of these periods for starboard side.

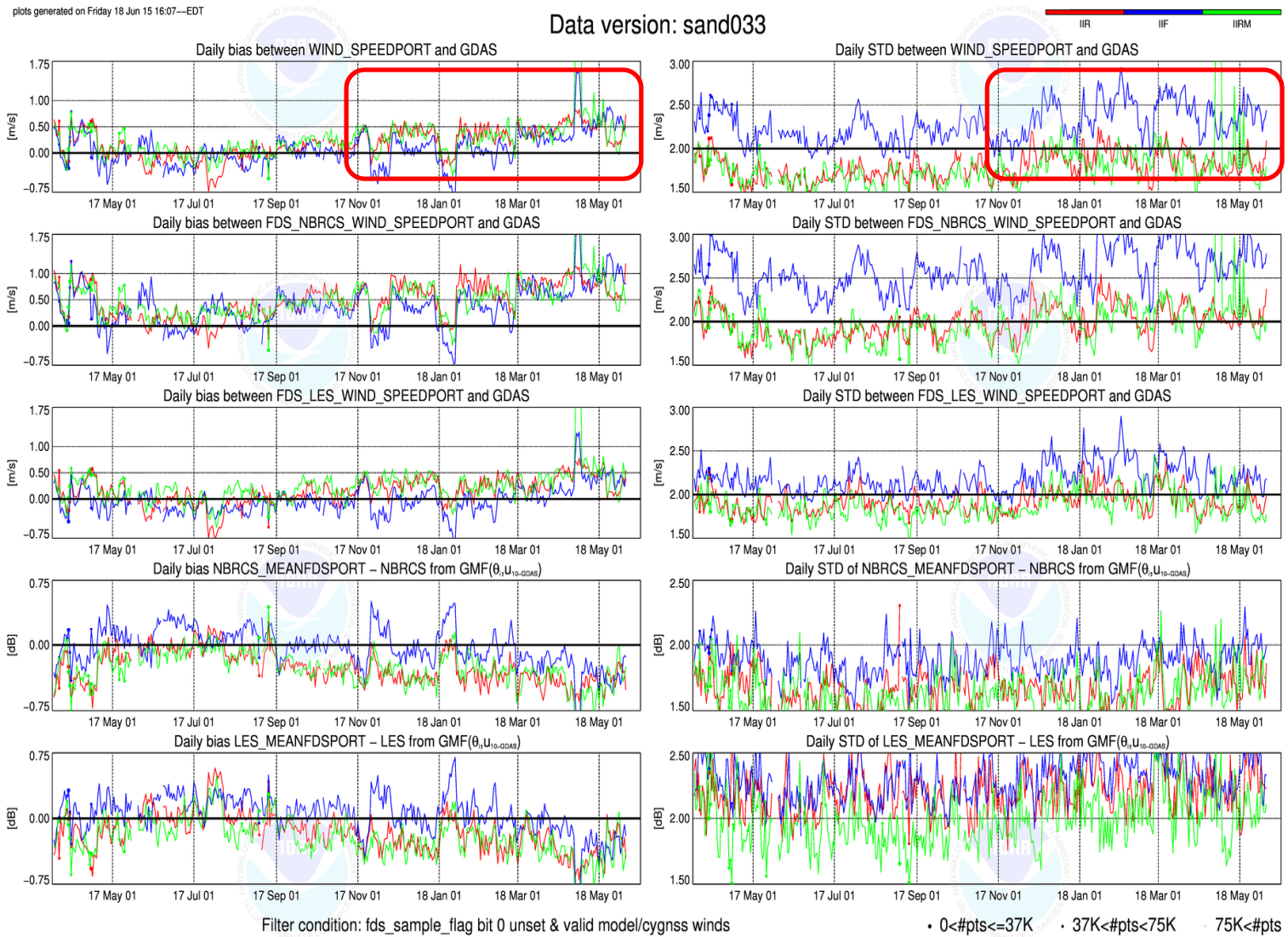
  L2 data may not be trusted during these 'high roll' periods for the time being

(L2) Wind speed (mv, fds_nbrcs/les), nbrcs, les timeseries daily biases/std (with GDAS) **per block type** per antenna

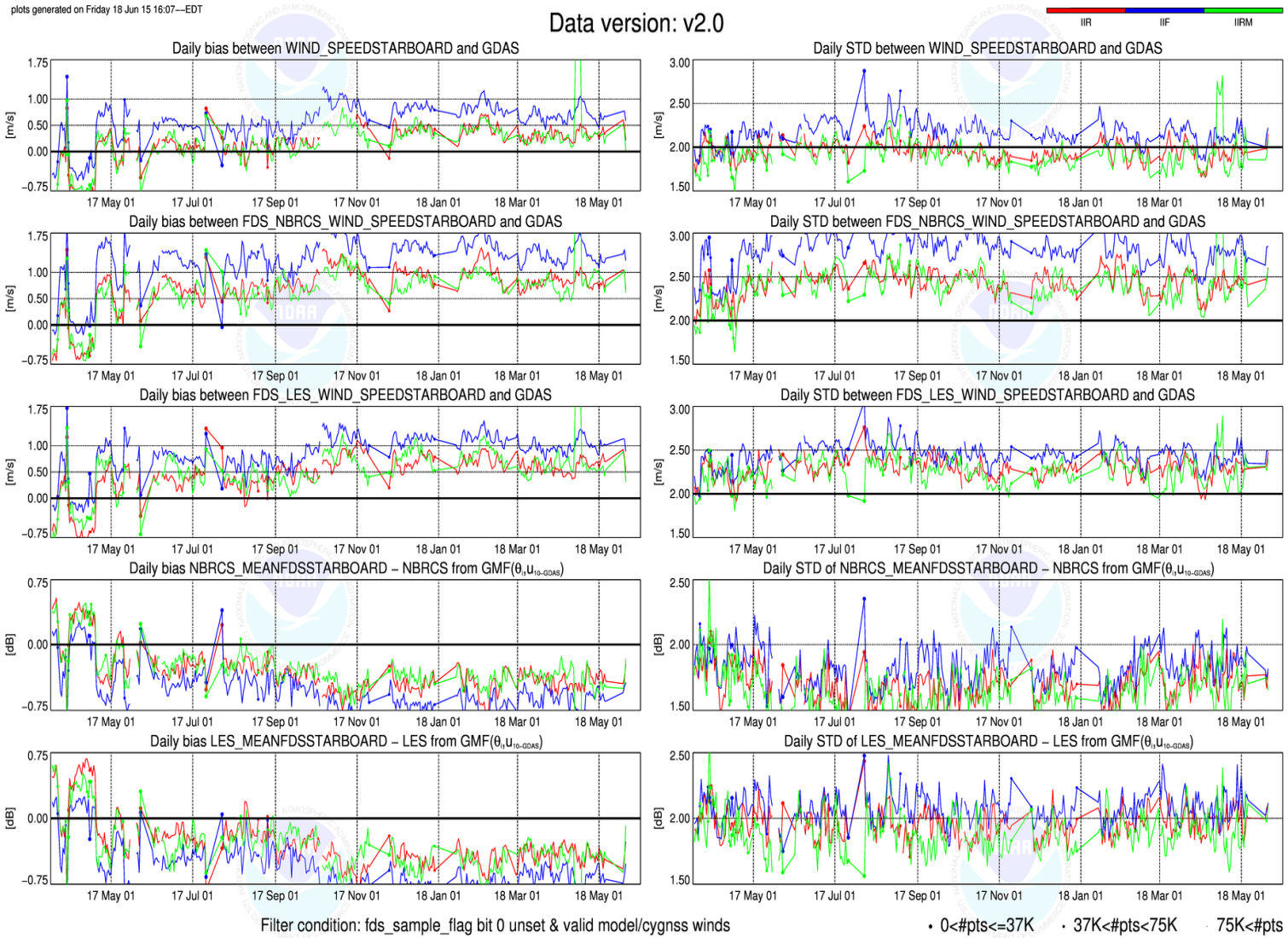
v2.0--FDS WINDS---PORT



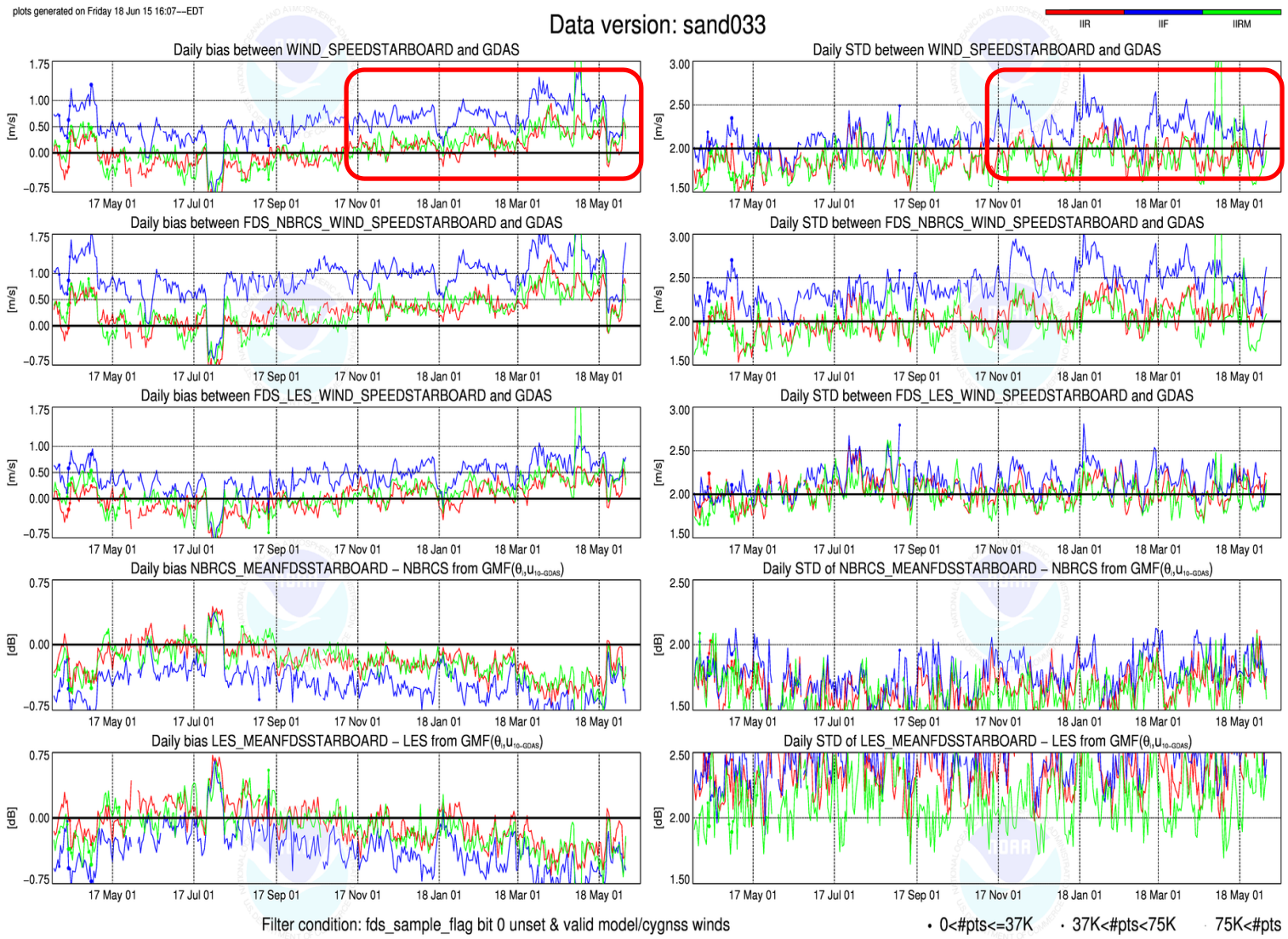
sand033--FDS WINDS---PORT



v2.0--FDS WINDS---STARBOARD



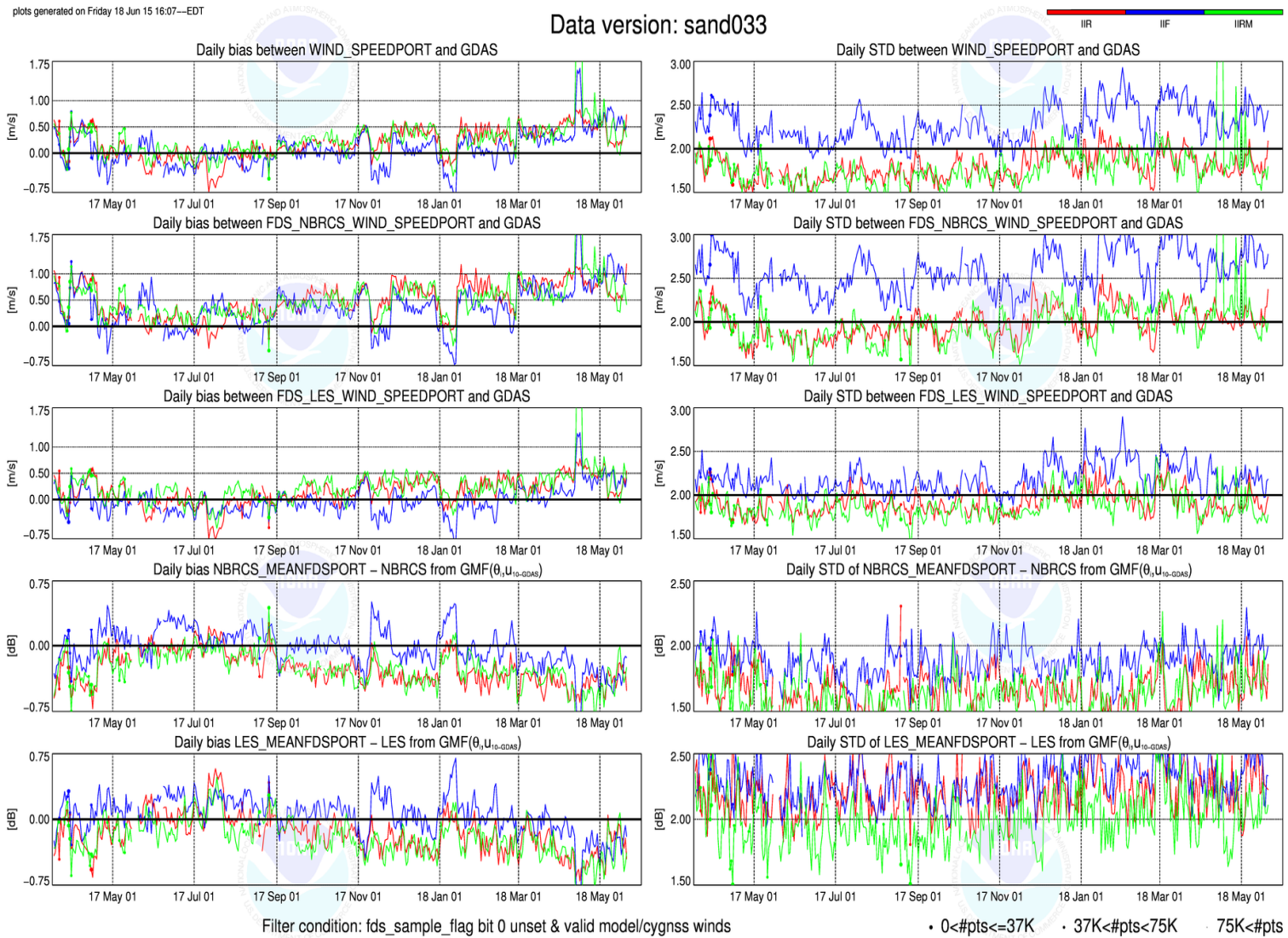
sand033--FDS WINDS---STARBOARD



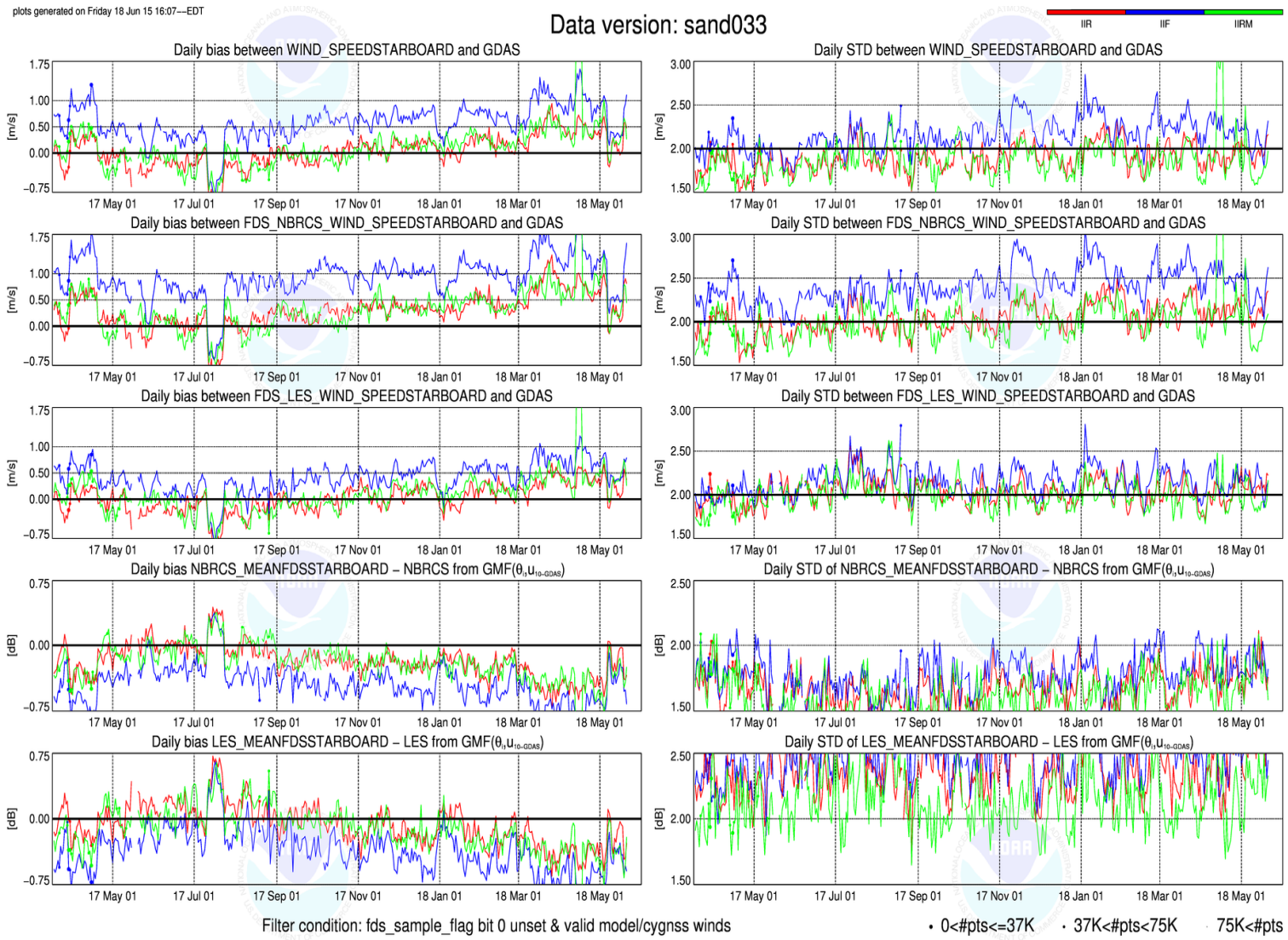
STARBOARD vs. PORT…

v2.1 beta

sand033--FDS WINDS---PORT



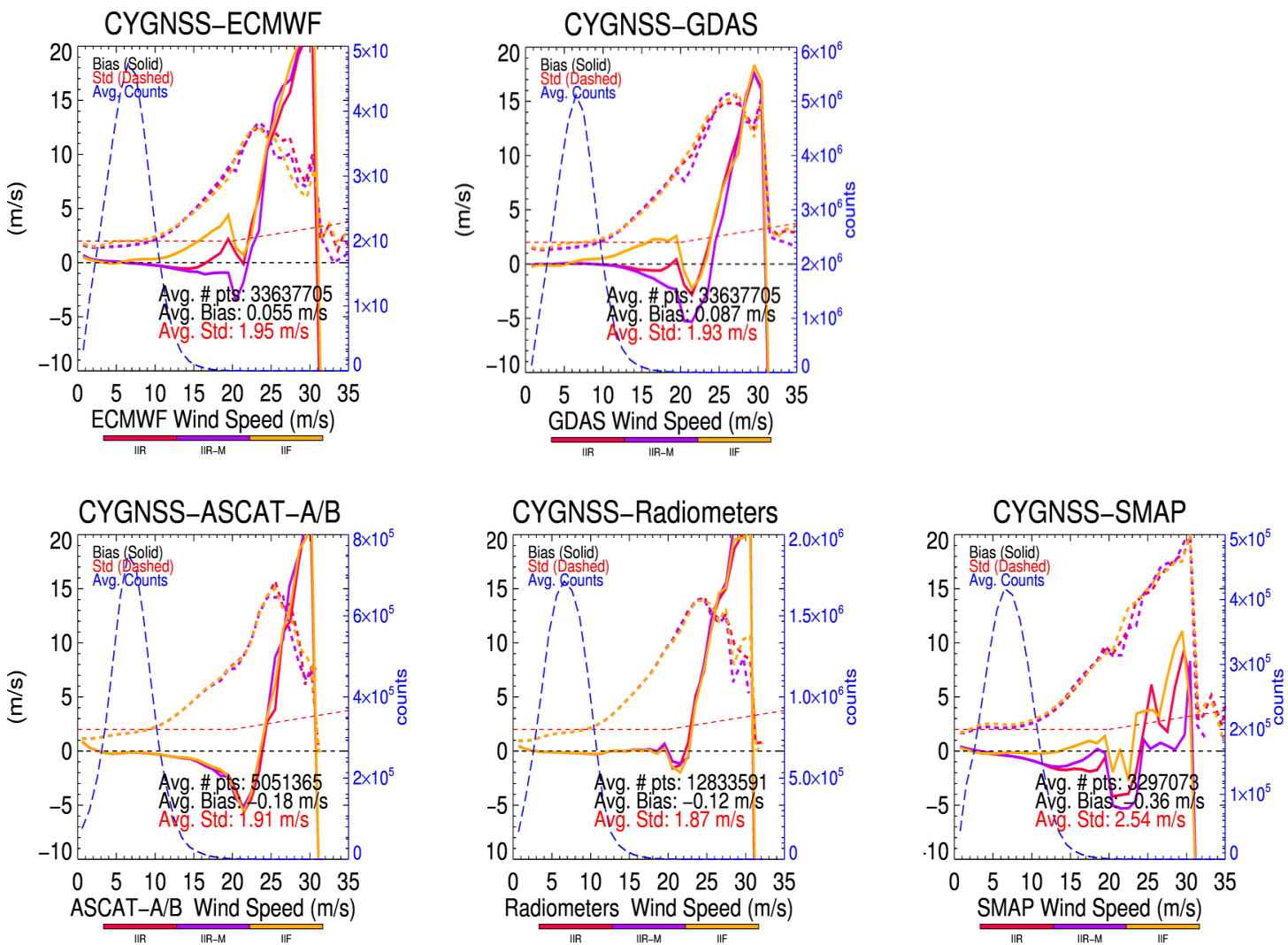
sand033--FDS WINDS---STARBOARD



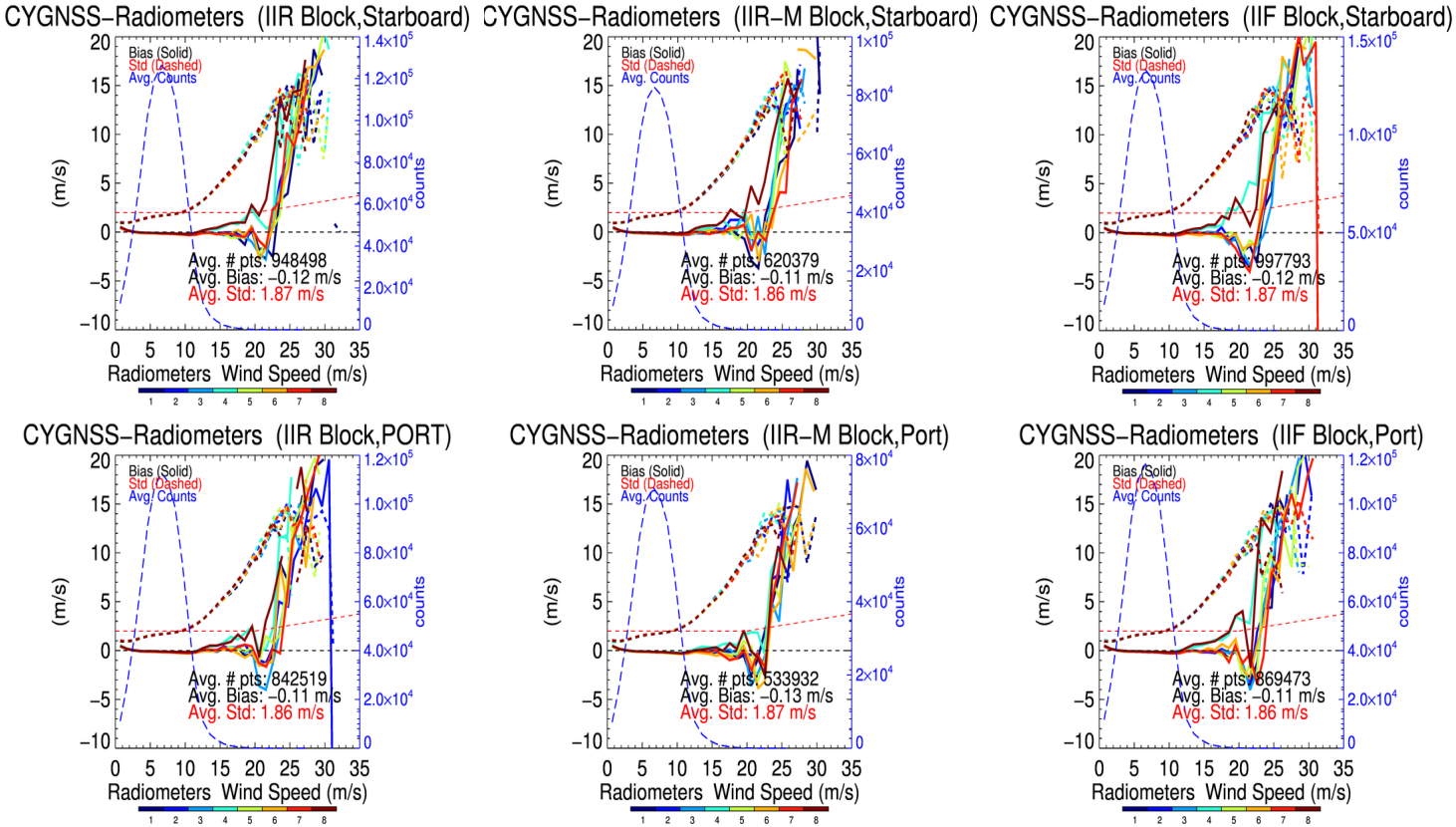
Observations thus far…

- Definitely issues remaining with block IIF
  - More on port side then starboard
- (mv) wind speed std increases after Nov 2017 (most noticeable on the port side)
- Improved std on both port/starboard sides before Nov 2017. Gets worse afterwards.
  - **Is it due to the fact that time period for training data is March-Oct 2017?**
- looks like wind speed increase over time some time after Sep or Nov.
  - **Altitude dependence**

L2 Stats

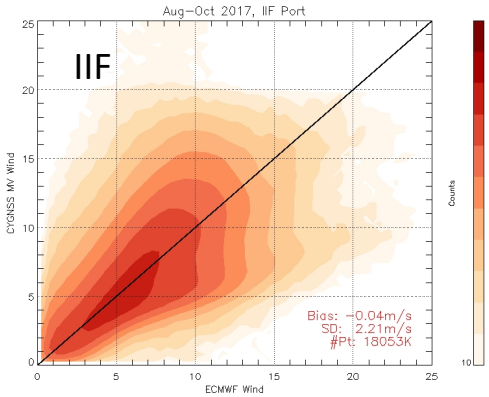

CYGNSS–ECMWF
Bias (Solid)
Std (Dashed)
Avg. Counts
Avg. # pts: 33637705
Avg. Bias: 0.055 m/s
Avg. Std: 1.95 m/s
(m/s)
ECMWF Wind Speed (m/s)
IIR
IIR–M
IIF
CYGNSS–GDAS
Bias (Solid)
Std (Dashed)
Avg. Counts
Avg. # pts: 33637705
Avg. Bias: 0.087 m/s
Avg. Std: 1.93 m/s
(m/s)
counts
GDAS Wind Speed (m/s)
IIR
IIR–M
IIF
CYGNSS–ASCAT–A/B
Bias (Solid)
Std (Dashed)
Avg. Counts
Avg. # pts: 5051365
Avg. Bias: –0.18 m/s
Avg. Std: 1.91 m/s
(m/s)
counts
ASCAT–A/B Wind Speed (m/s)
IIR
IIR–M
IIF
CYGNSS–Radiometers
Bias (Solid)
Std (Dashed)
Avg. Counts
Avg. # pts: 12833591
Avg. Bias: –0.12 m/s
Avg. Std: 1.87 m/s
counts
Radiometers Wind Speed (m/s)
IIR
IIR–M
IIF
CYGNSS–SMAP
Bias (Solid)
Std (Dashed)
Avg. Counts
Avg. # pts: 3297073
Avg. Bias: –0.36 m/s
Avg. Std: 2.54 m/s
counts
SMAP Wind Speed (m/s)
IIR
IIR–M
IIF

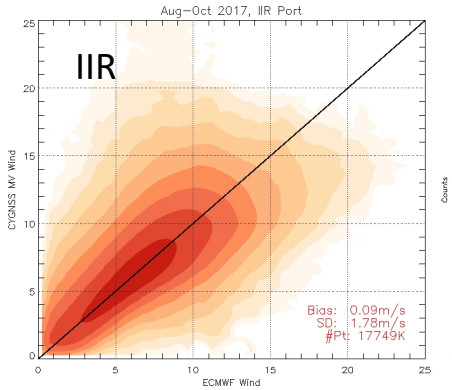
CYGNSS Dataset with Radiometers (Each Block and Antenna)

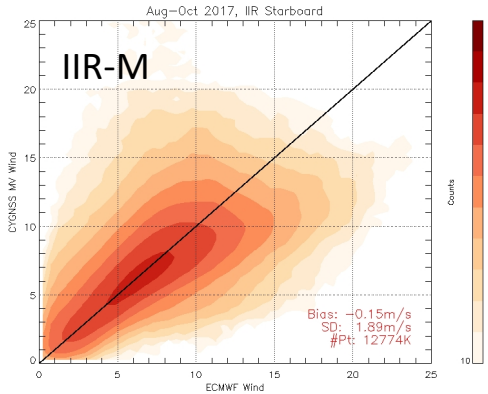


CYGNSS Observatory

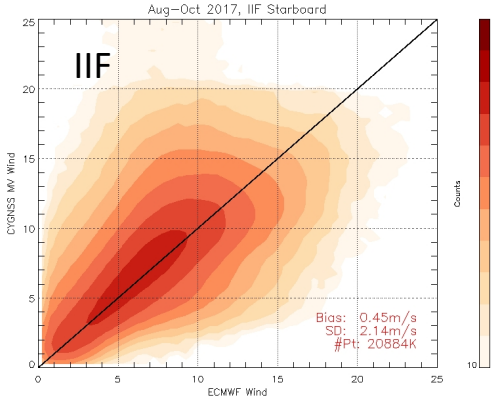
CYGNSS MV Wind Versus ECWMF Wind Speed

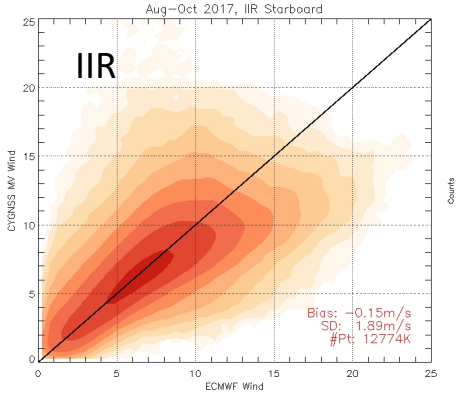


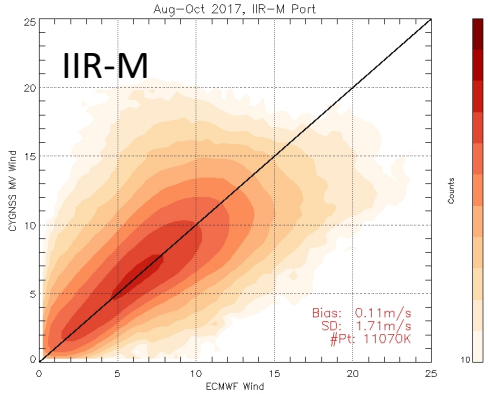




Port

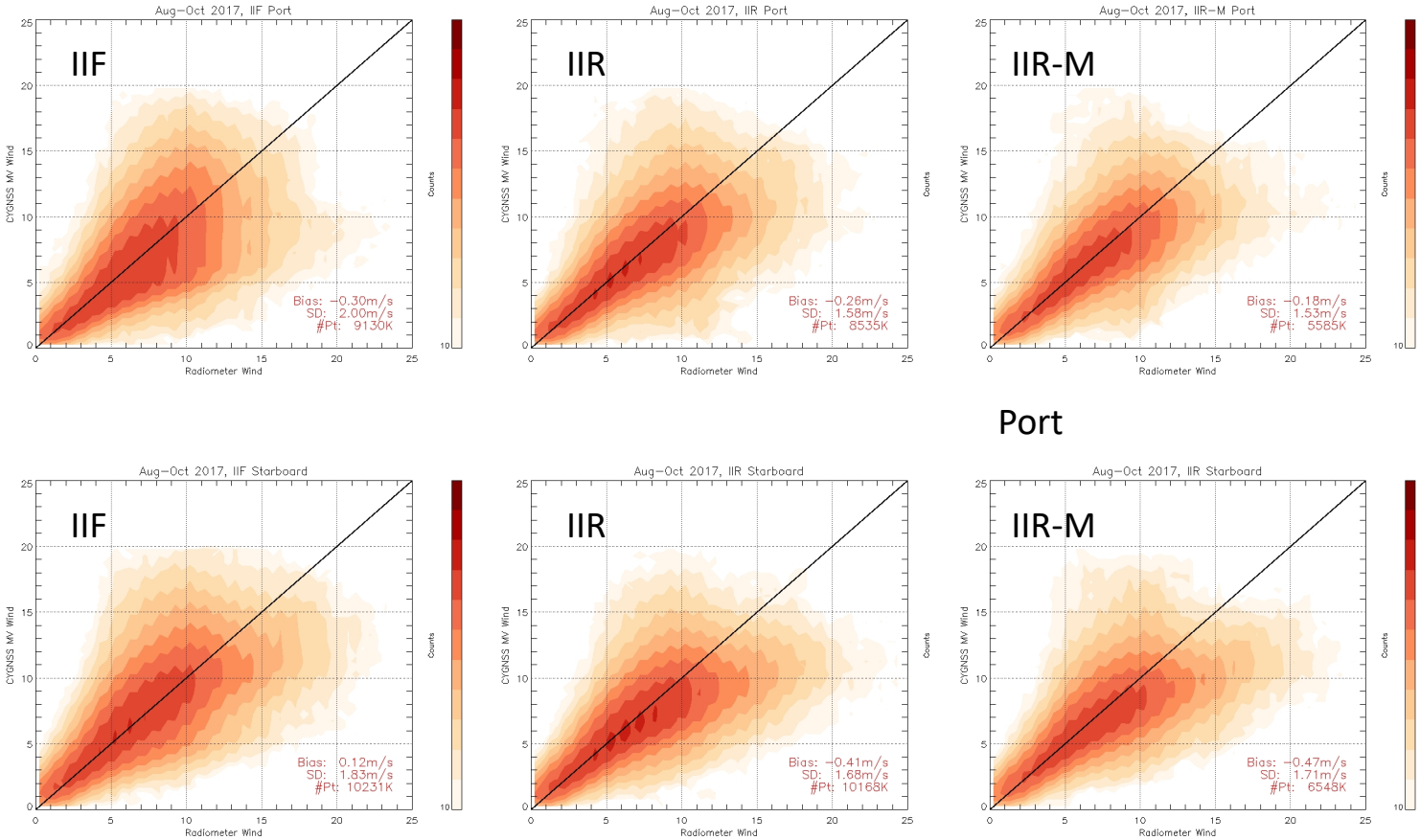






Starboard

CYGNSS MV Wind Versus Radiometer Wind Speed



Port

Starboard

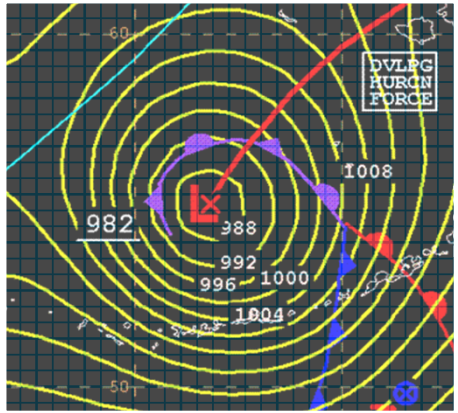
Tropical Cyclone Observations
Atlantic and East Pacific
Aug-Oct, 2017

Storm Composite Procedure

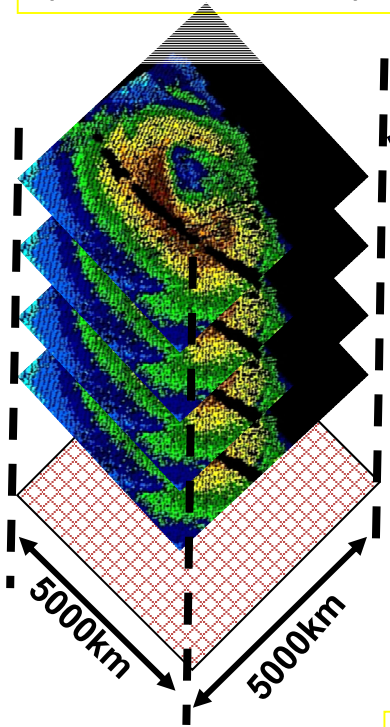
1. Create scenes of matchup between storm best track and CYGNSS L1 and L2 tracks
   - 500 km search radius
   - Filtered by storm type
   - Apply the following flags on Level 1 (Following Slide)
2. Grid matchup scenes into kilometer gridded space
   - Grid spacing is variable i.e. 12.5 km, 25 km
3. Rotate gridded scene according to the storm heading direction
4. Generate storm composite statistic graphics from all the scenes

Storm track file

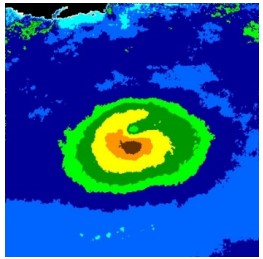
Read HF Cyclone Info.



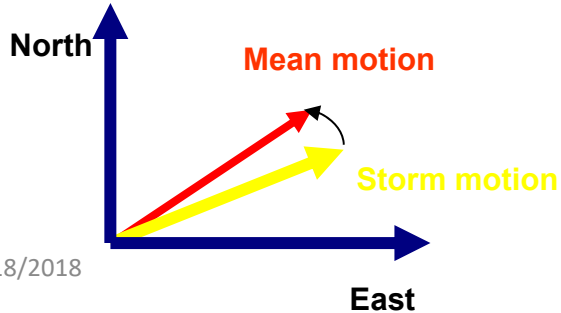
Extract Science QS 12.5km Data
&
Perform QC
(land, ice, coast, rain) flags

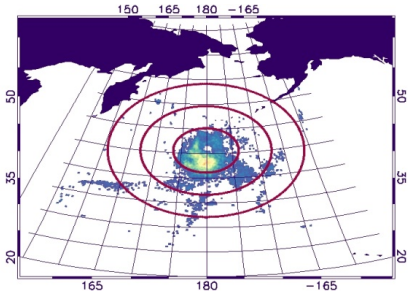


Generate Mean Wind Fields



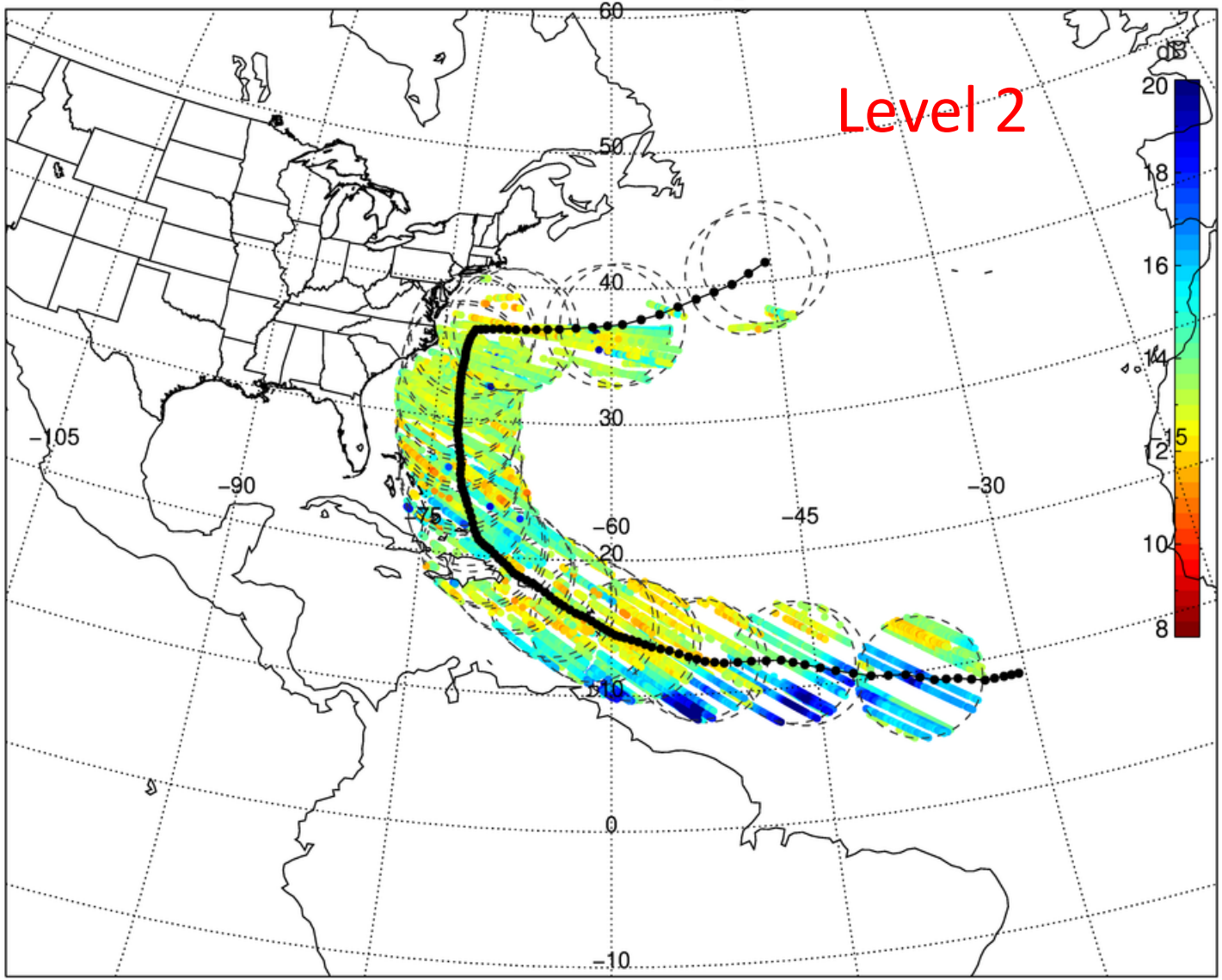
Estimate speed & Angle
(Heading Vector)



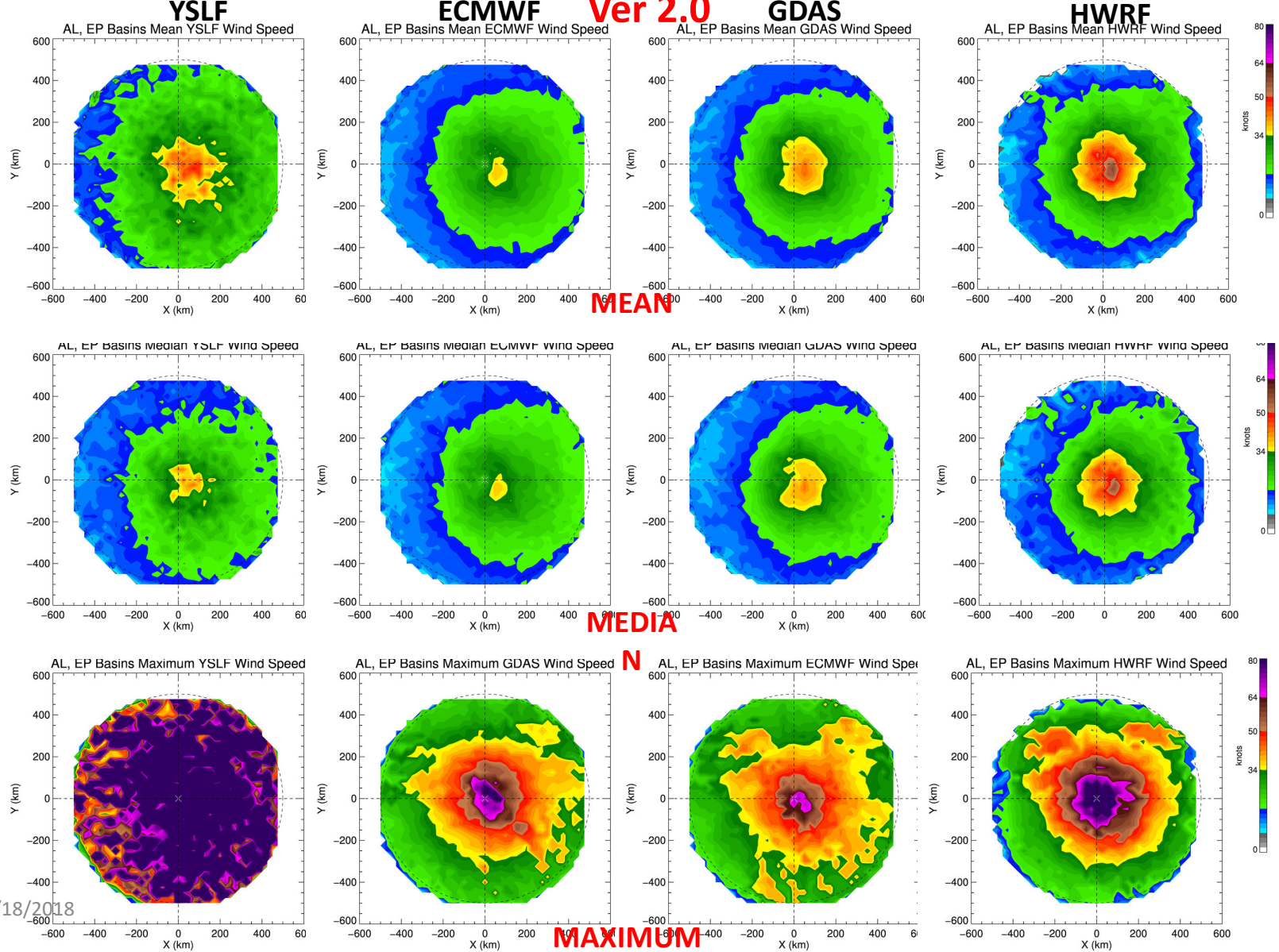


Generate Frequency of HF Occurrence per grid fields

MARIA NBRCS

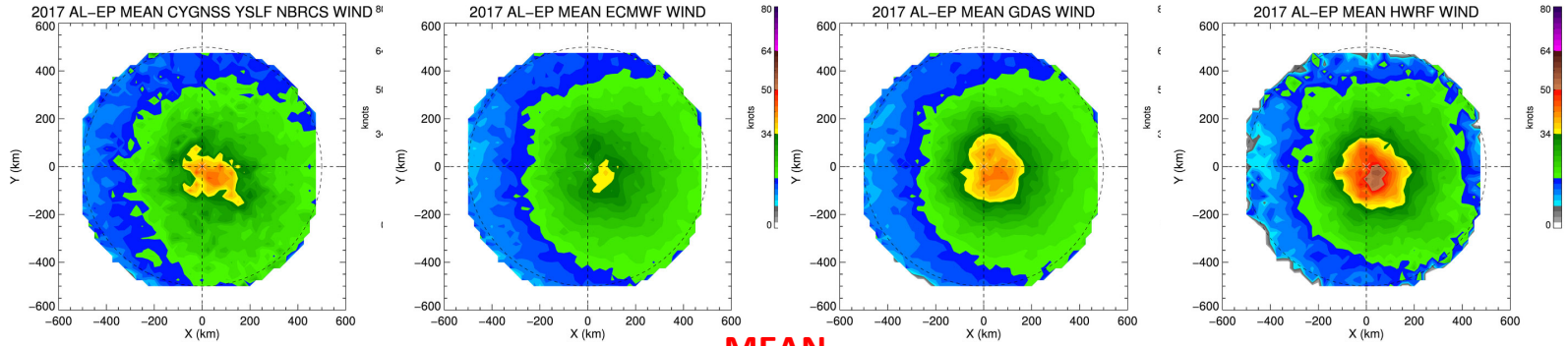


Ver 2.0

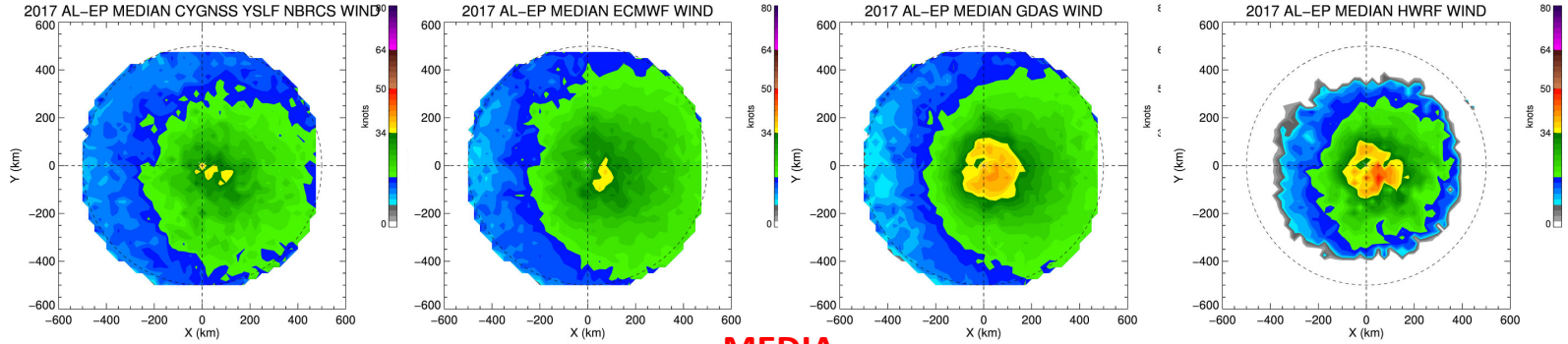

YSLF
ECMWF
GDAS
HWRF
AL, EP Basins Mean YSLF Wind Speed
AL, EP Basins Mean ECMWF Wind Speed
AL, EP Basins Mean GDAS Wind Speed
AL, EP Basins Mean HWRF Wind Speed
MEAN
AL, EP Basins Median YSLF Wind Speed
AL, EP Basins Median ECMWF Wind Speed
AL, EP Basins Median GDAS Wind Speed
AL, EP Basins Median HWRF Wind Speed
MEDIAN
AL, EP Basins Maximum YSLF Wind Speed
AL, EP Basins Maximum GDAS Wind Speed
AL, EP Basins Maximum ECMWF Wind Spe
AL, EP Basins Maximum HWRF Wind Speed
MAXIMUM
X (km)
Y (km)
knots
0
34
50
64
80

Sandbox 33

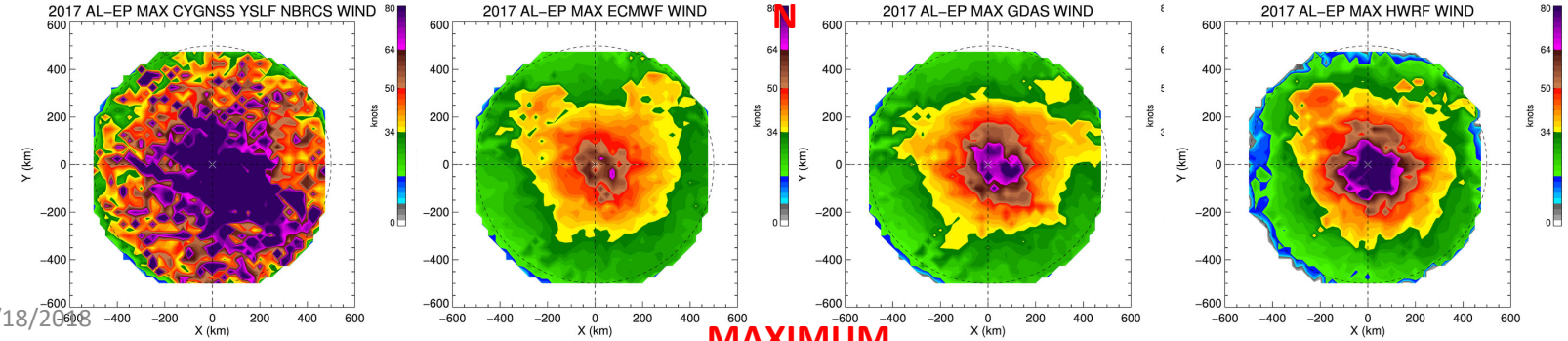
YSLF | ECMWF | GDAS | HWRF



MEAN

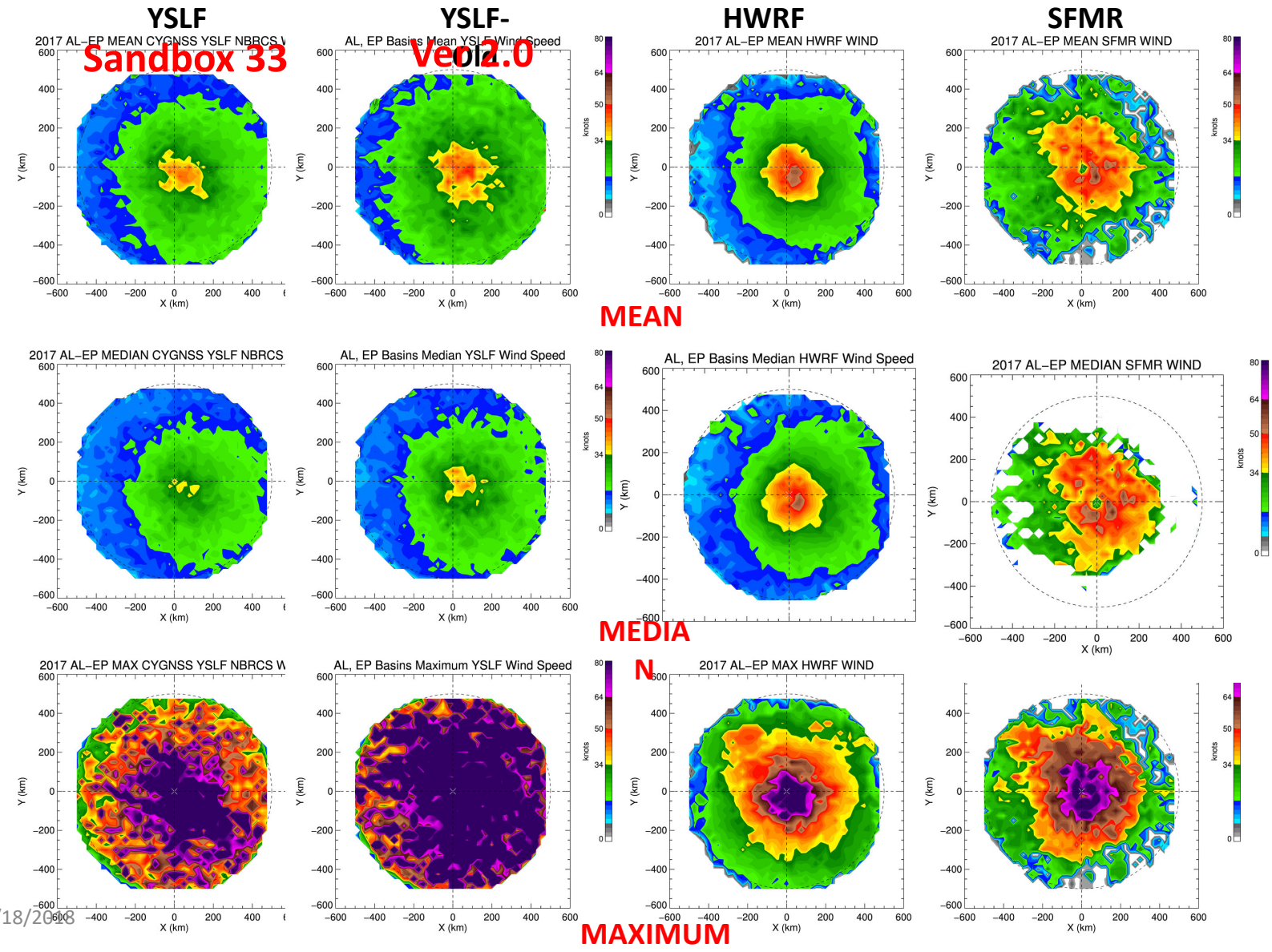


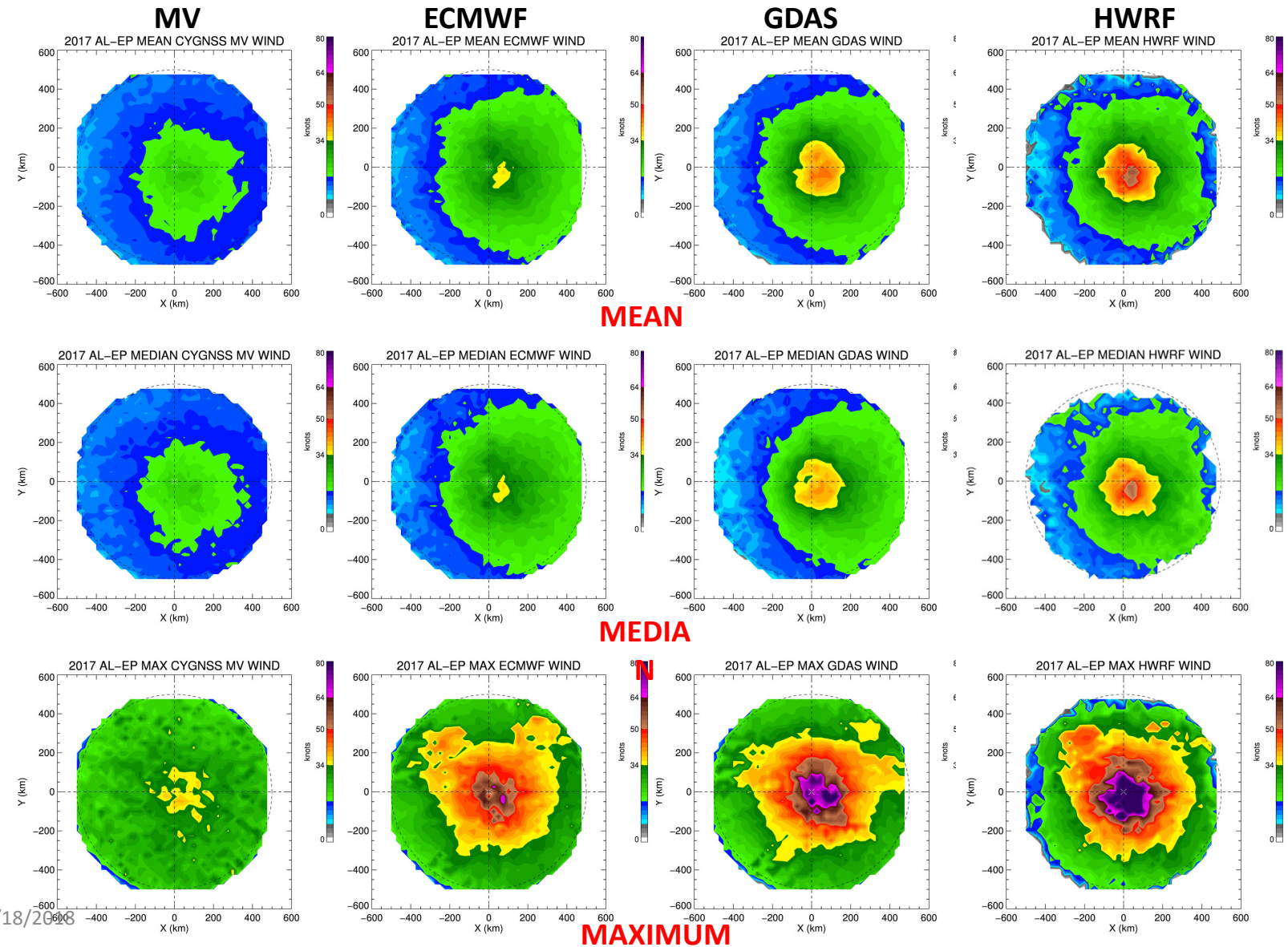
MEDIA

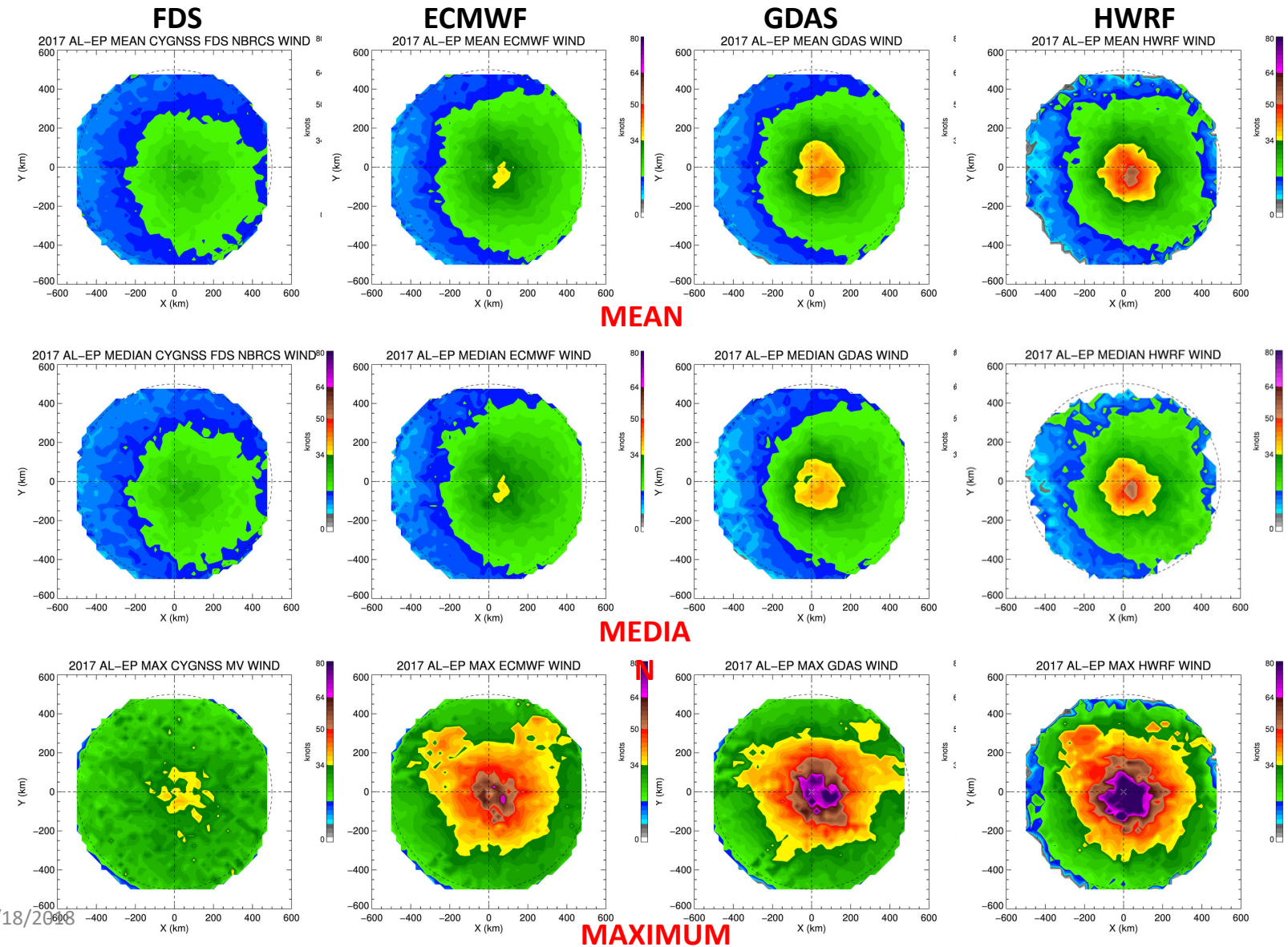


N

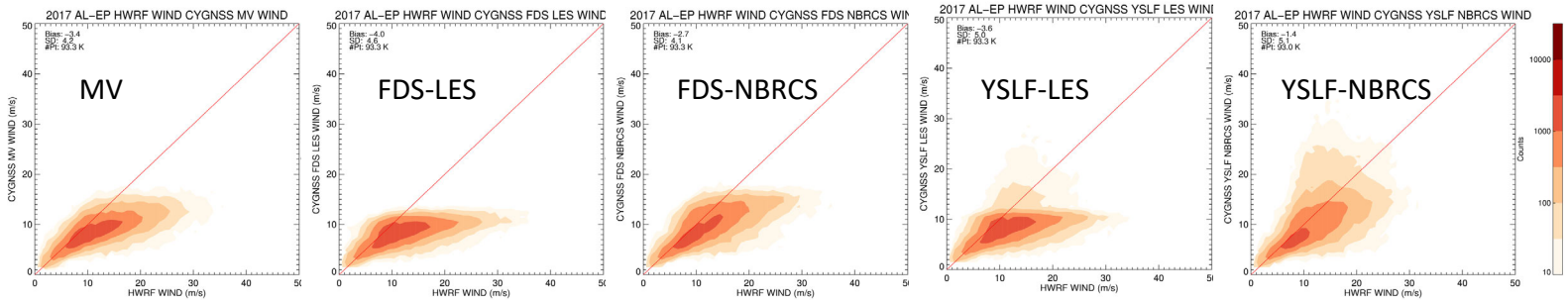
MAXIMUM


YSLF
YSLF-
HWRF
SFMR
Sandbox 33
Ver 2.0
2017 AL–EP MEAN CYGNSS YSLF NBRCS
AL, EP Basins Mean YSLF Wind Speed
2017 AL–EP MEAN HWRF WIND
2017 AL–EP MEAN SFMR WIND
MEAN
2017 AL–EP MEDIAN CYGNSS YSLF NBRCS
AL, EP Basins Median YSLF Wind Speed
AL, EP Basins Median HWRF Wind Speed
2017 AL–EP MEDIAN SFMR WIND
MEDIAN
2017 AL–EP MAX CYGNSS YSLF NBRCS
AL, EP Basins Maximum YSLF Wind Speed
2017 AL–EP MAX HWRF WIND
MAXIMUM
X (km)
Y (km)
knots

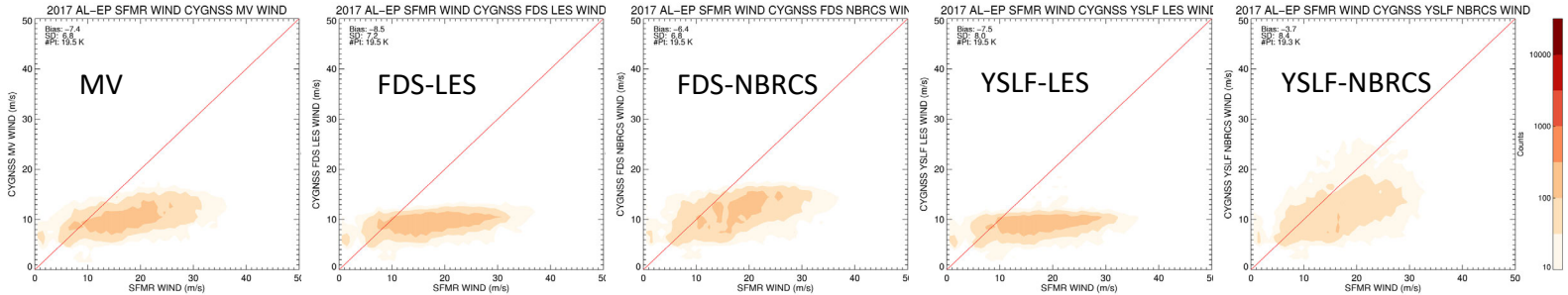

MV
ECMWF
GDAS
HWRF
2017 AL–EP MEAN CYGNSS MV WIND
2017 AL–EP MEAN ECMWF WIND
2017 AL–EP MEAN GDAS WIND
2017 AL–EP MEAN HWRF WIND
MEAN
2017 AL–EP MEDIAN CYGNSS MV WIND
2017 AL–EP MEDIAN ECMWF WIND
2017 AL–EP MEDIAN GDAS WIND
2017 AL–EP MEDIAN HWRF WIND
MEDIA
2017 AL–EP MAX CYGNSS MV WIND
2017 AL–EP MAX ECMWF WIND
2017 AL–EP MAX GDAS WIND
2017 AL–EP MAX HWRF WIND
N
MAXIMUM
X (km)
Y (km)
knots
0
34
50
64
80


FDS
ECMWF
GDAS
HWRF
2017 AL–EP MEAN CYGNSS FDS NBRCS WIND
2017 AL–EP MEAN ECMWF WIND
2017 AL–EP MEAN GDAS WIND
2017 AL–EP MEAN HWRF WIND
MEAN
2017 AL–EP MEDIAN CYGNSS FDS NBRCS WIND
2017 AL–EP MEDIAN ECMWF WIND
2017 AL–EP MEDIAN GDAS WIND
2017 AL–EP MEDIAN HWRF WIND
MEDIA
2017 AL–EP MAX CYGNSS MV WIND
2017 AL–EP MAX ECMWF WIND
2017 AL–EP MAX GDAS WIND
2017 AL–EP MAX HWRF WIND
N
MAXIMUM
X (km)
Y (km)
knots

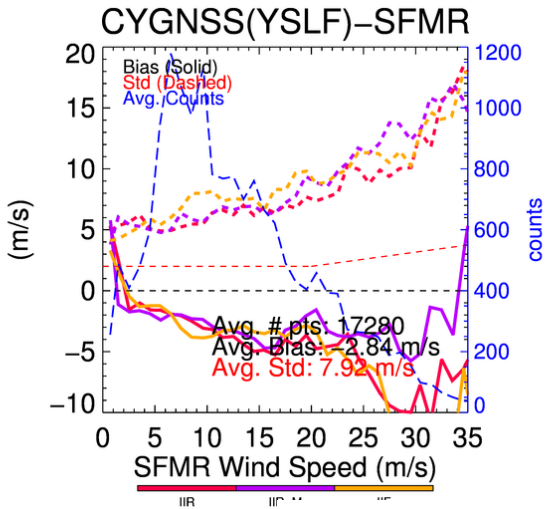
CYGNSS Winds Versus HWRF Winds for 2017 AL-EP Tropical Cyclones

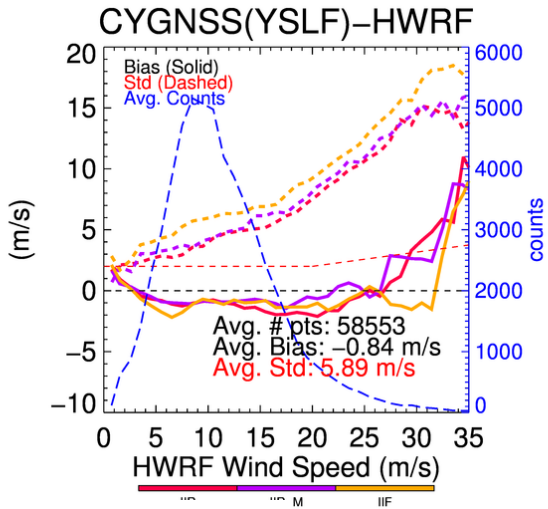


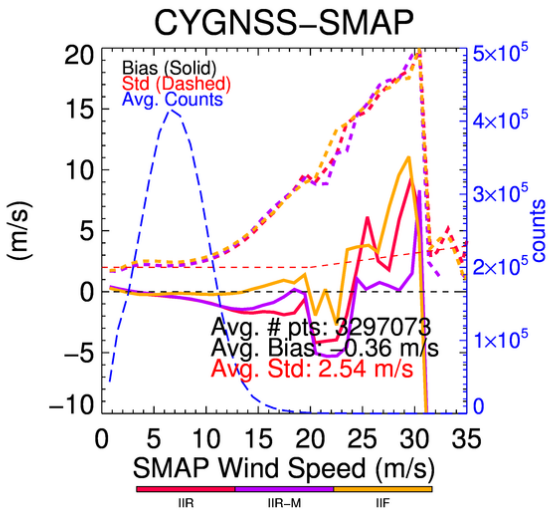
CYGNSS Winds Versus SFMR Winds for 2017 AL Tropical Cyclones



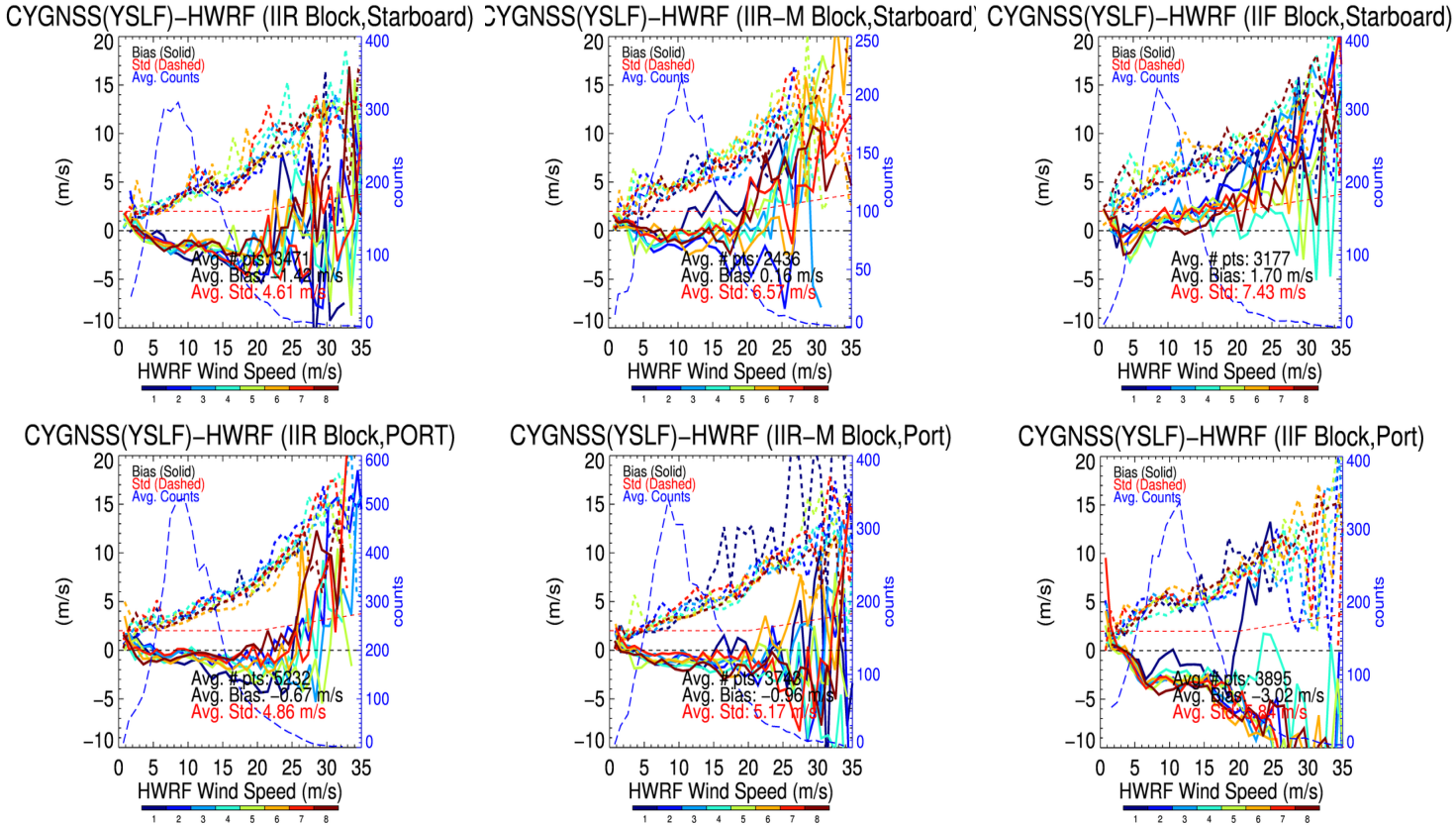
High Wind Observations



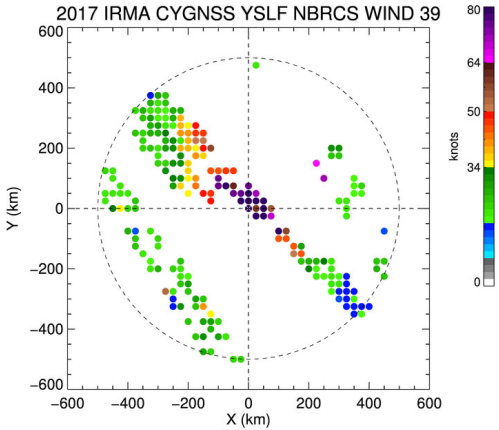


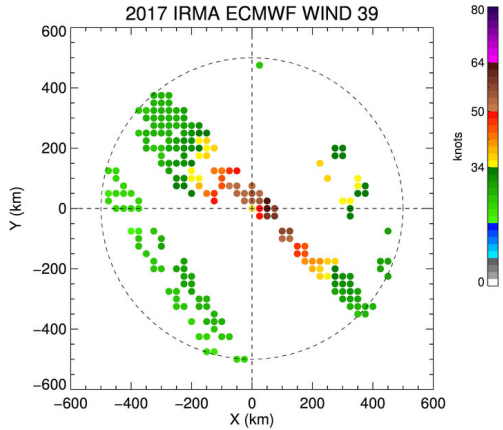


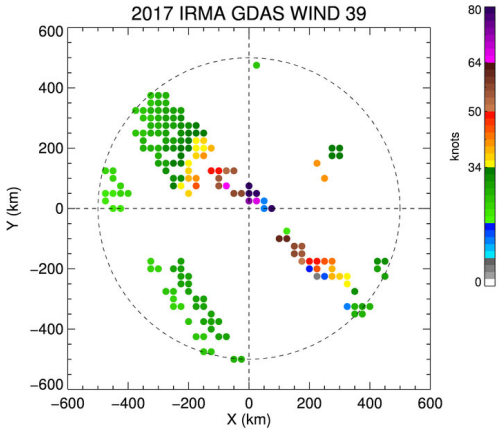
CYGNSS Dataset with HWRF (Each Block and Antenna)

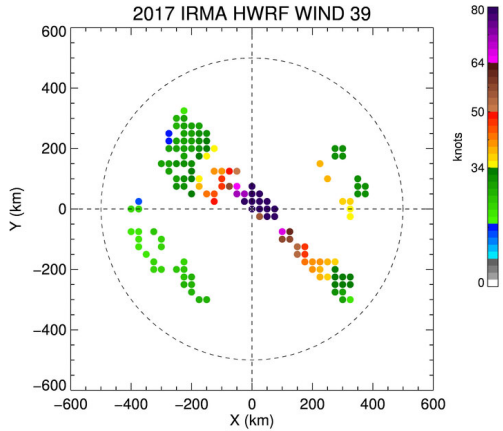


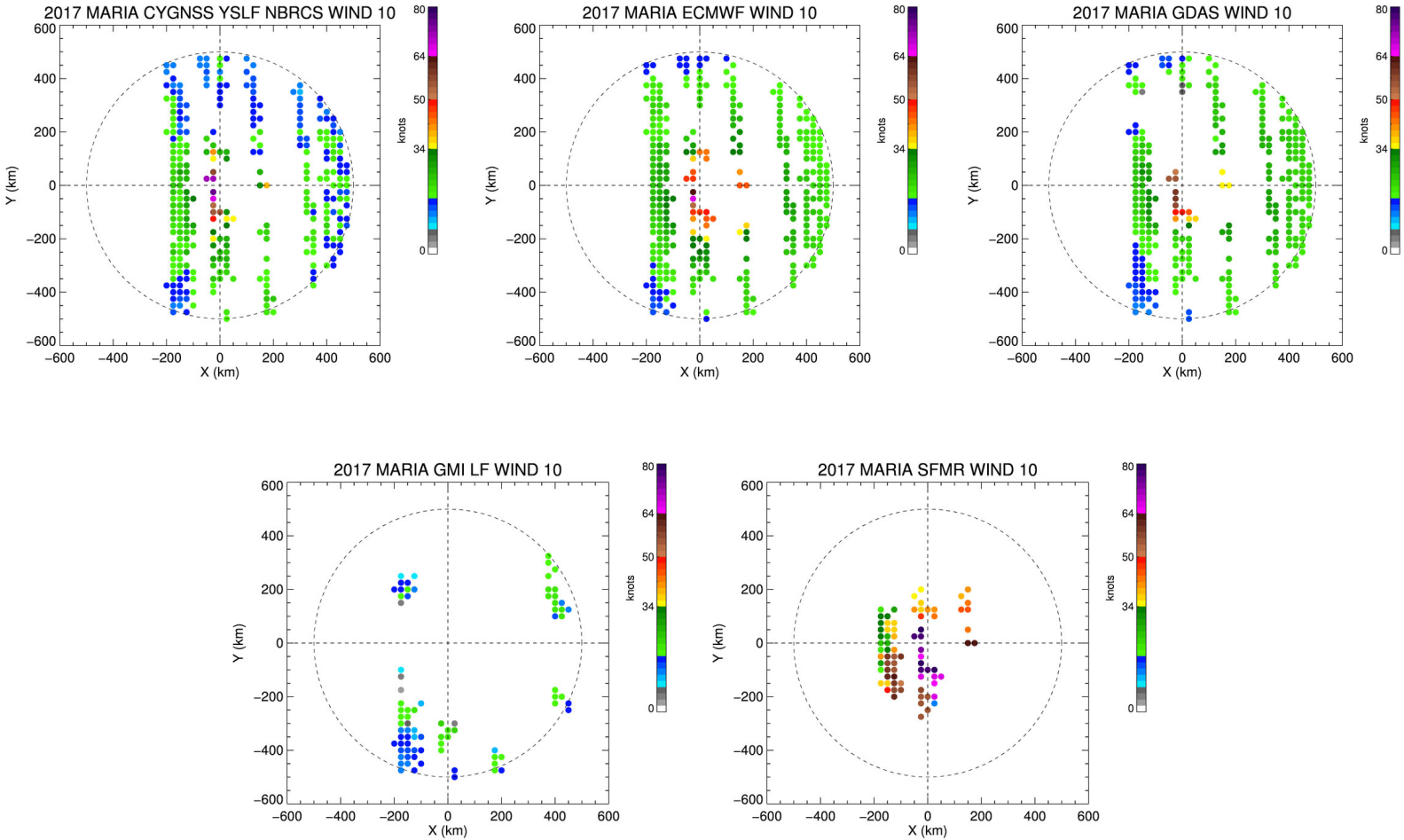
CYGNSS Observatory

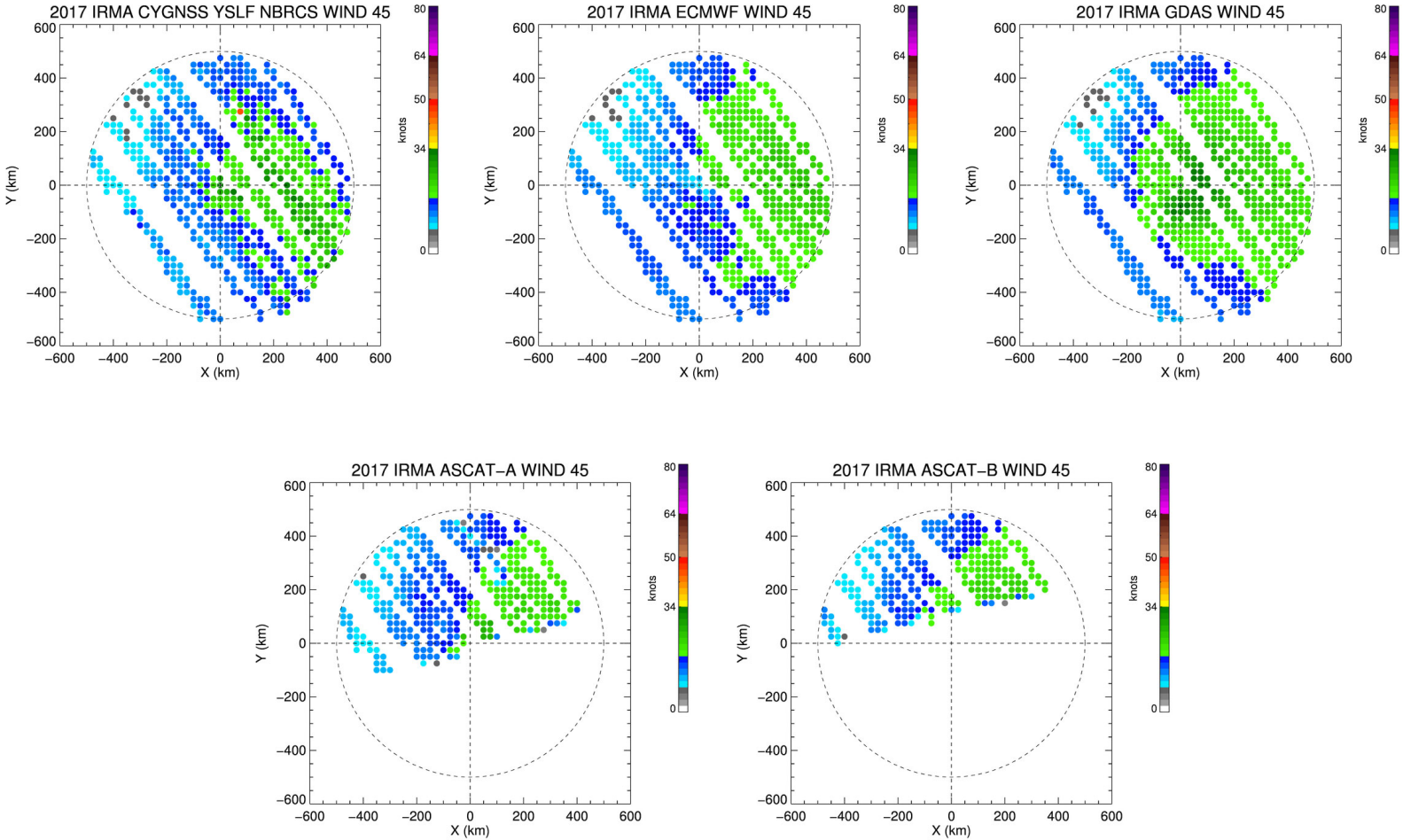

2017 IRMA CYGNSS YSLF NBRCS WIND 39
Y (km)
X (km)
knots
80
64
50
34
0

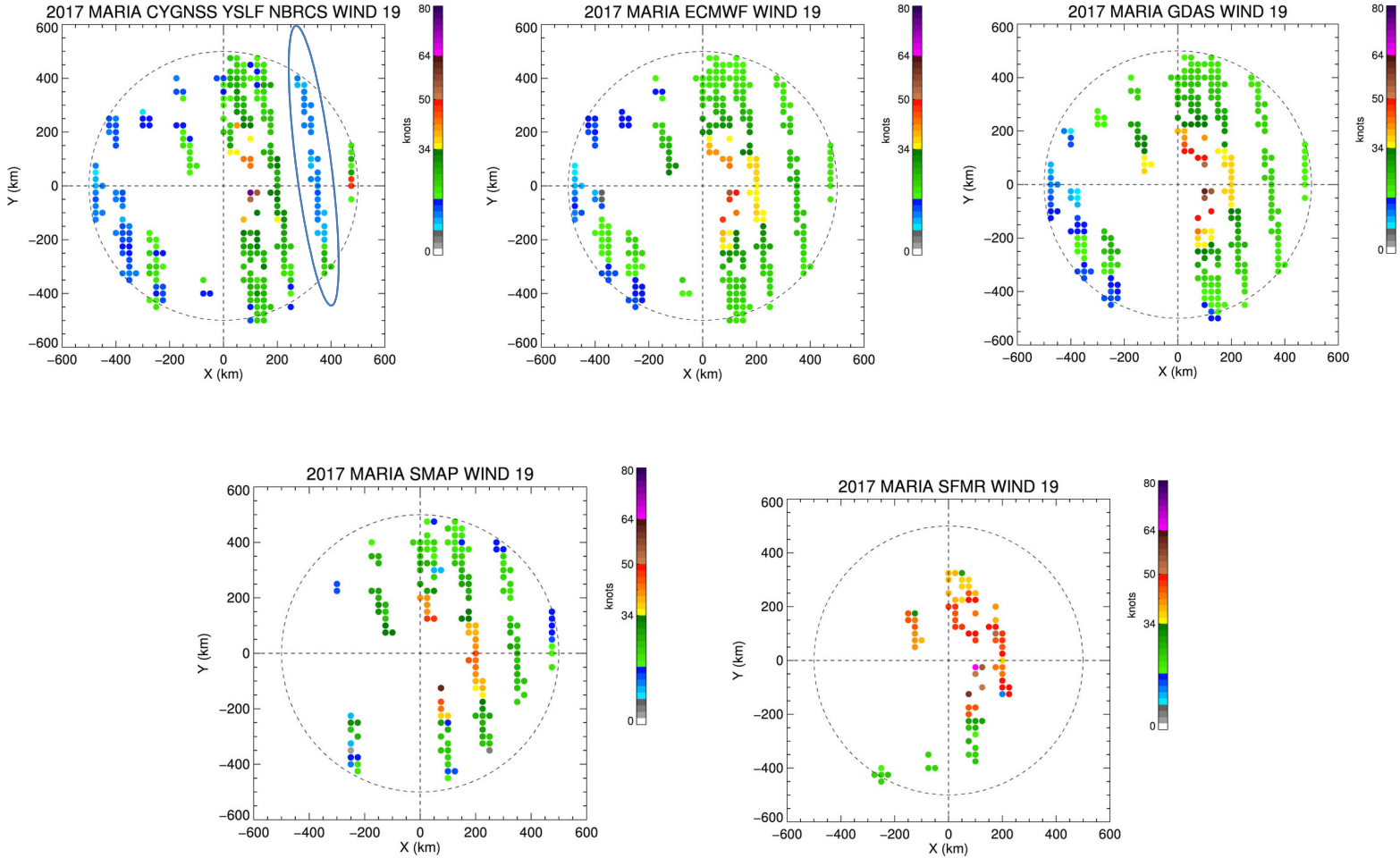

2017 IRMA ECMWF WIND 39
Y (km)
X (km)
knots
80
64
50
34
0

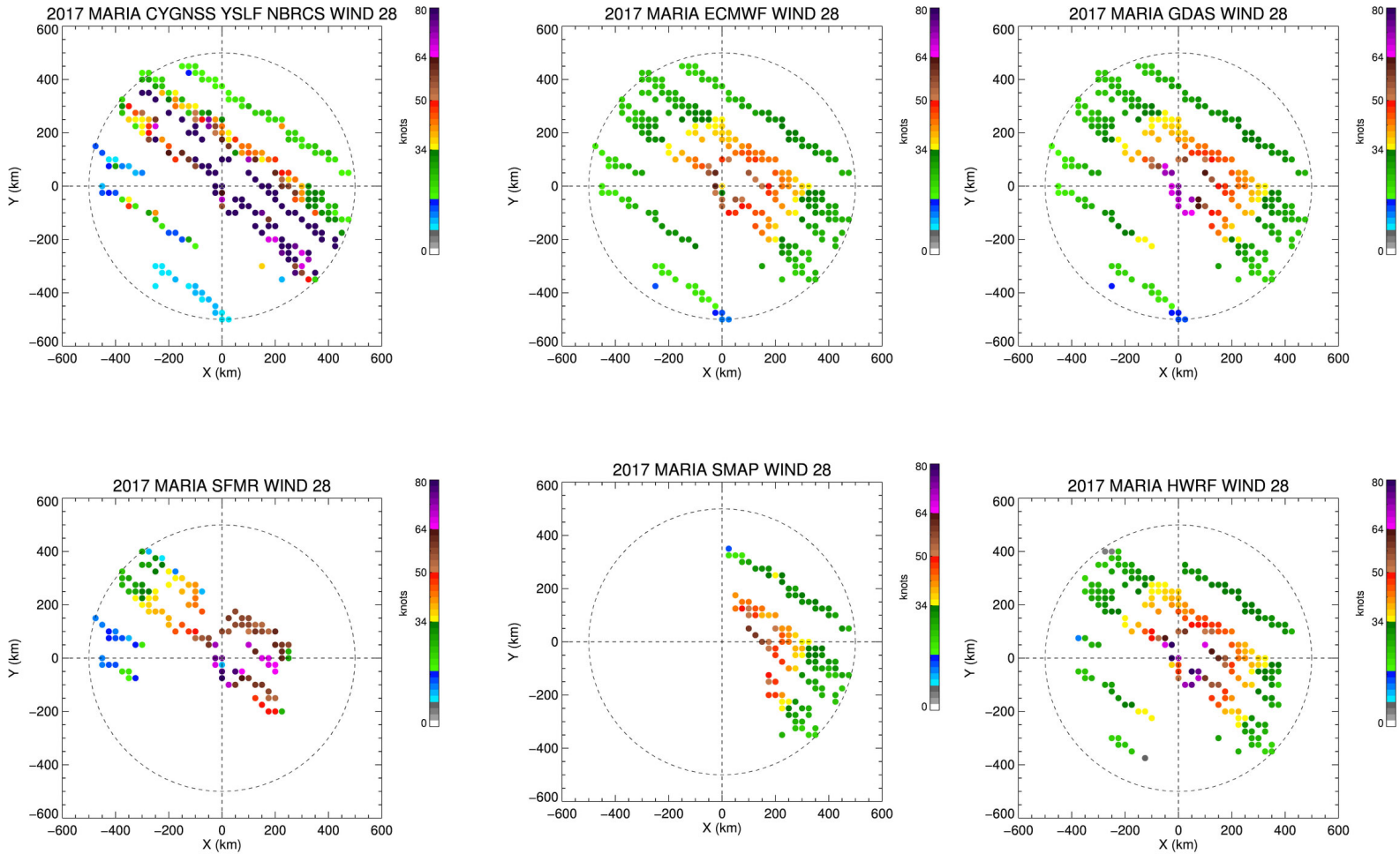

2017 IRMA GDAS WIND 39
Y (km)
X (km)
knots
80
64
50
34
0

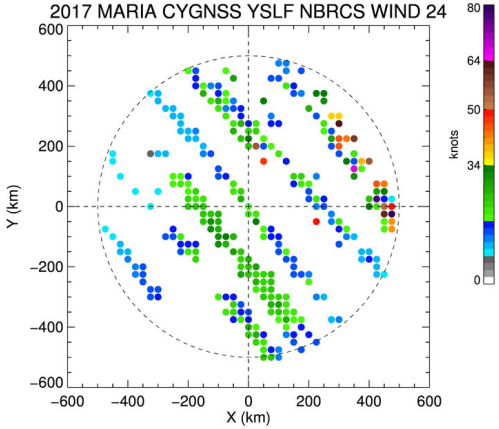

2017 IRMA HWRF WIND 39
Y (km)
X (km)
knots
80
64
50
34
0

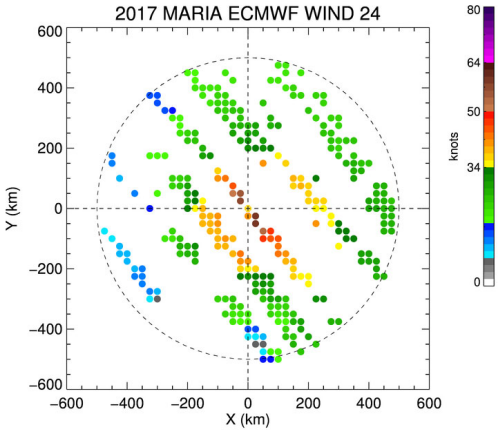

2017 MARIA CYGNSS YSLF NBRCS WIND 10
2017 MARIA ECMWF WIND 10
2017 MARIA GDAS WIND 10
2017 MARIA GMI LF WIND 10
2017 MARIA SFMR WIND 10
Y (km)
X (km)
knots
0
34
50
64
80
600
400
200
0
−200
−400
−600

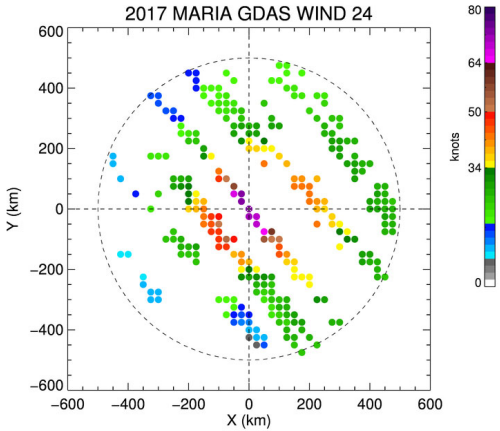

2017 IRMA CYGNSS YSLF NBRCS WIND 45
2017 IRMA ECMWF WIND 45
2017 IRMA GDAS WIND 45
2017 IRMA ASCAT–A WIND 45
2017 IRMA ASCAT–B WIND 45
Y (km)
X (km)
knots
0
34
50
64
80
600
400
200
0
−200
−400
−600

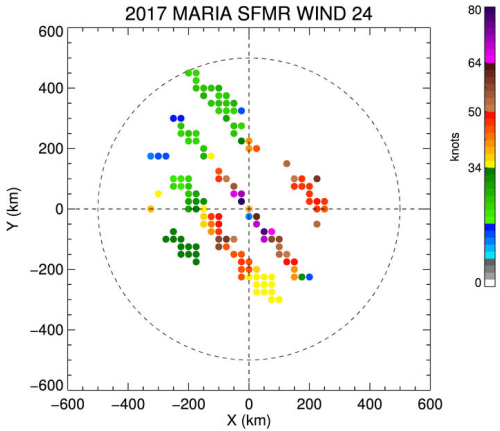

2017 MARIA CYGNSS YSLF NBRCS WIND 19
2017 MARIA ECMWF WIND 19
2017 MARIA GDAS WIND 19
2017 MARIA SMAP WIND 19
2017 MARIA SFMR WIND 19
Y (km)
X (km)
knots
80
64
50
34
0
600
400
200
0
−200
−400
−600

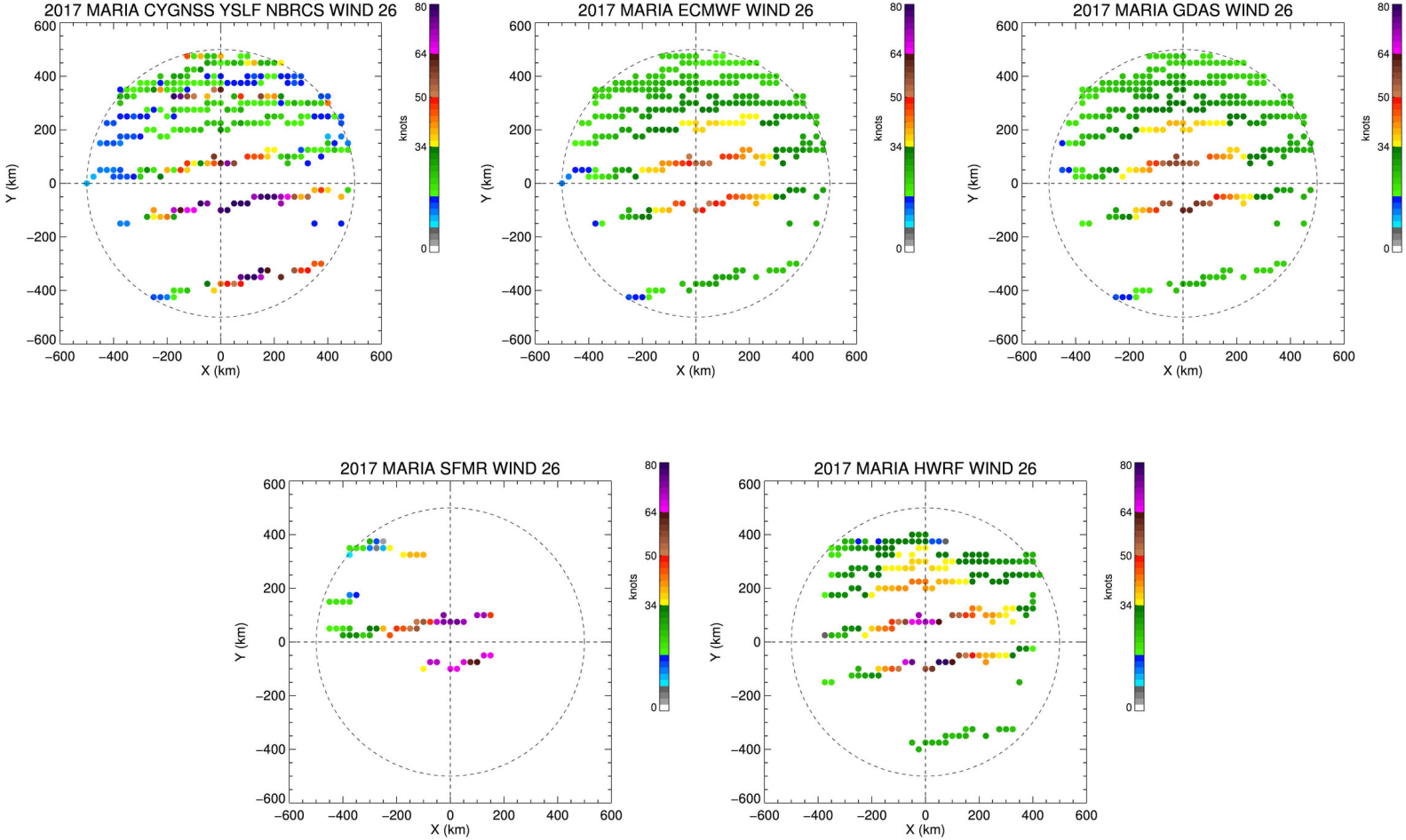

2017 MARIA CYGNSS YSLF NBRCS WIND 28
2017 MARIA ECMWF WIND 28
2017 MARIA GDAS WIND 28
2017 MARIA SFMR WIND 28
2017 MARIA SMAP WIND 28
2017 MARIA HWRF WIND 28
Y (km)
X (km)
knots
600
400
200
0
−200
−400
−600
80
64
50
34
0

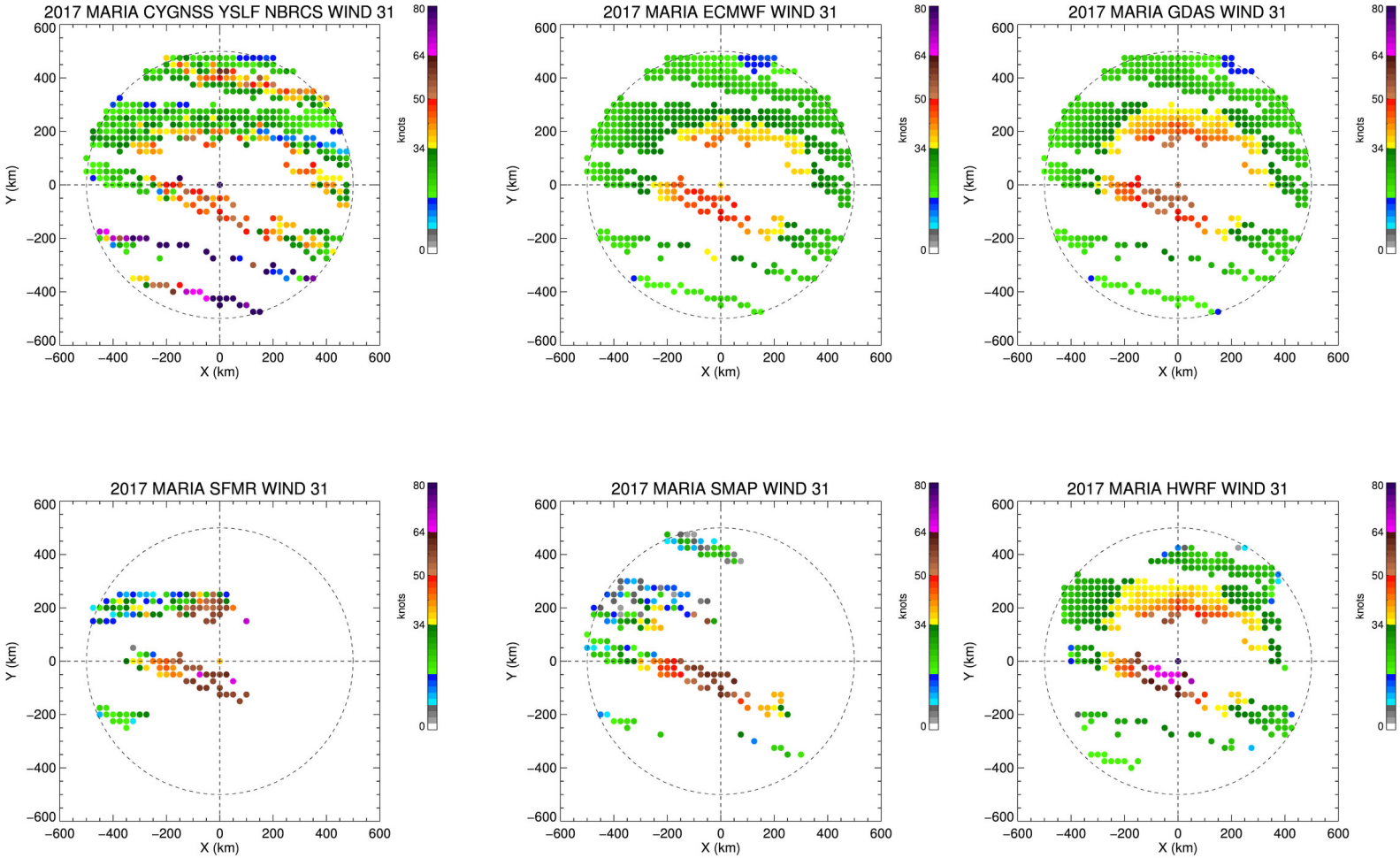

2017 MARIA CYGNSS YSLF NBRCS WIND 24
Y (km)
X (km)
knots
80
64
50
34
0

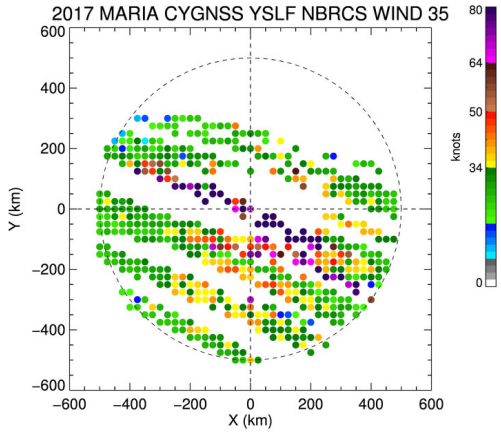

2017 MARIA ECMWF WIND 24
Y (km)
X (km)
knots
80
64
50
34
0

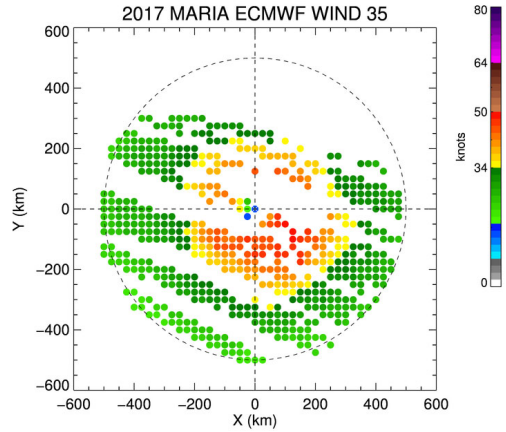

2017 MARIA GDAS WIND 24
Y (km)
X (km)
knots
80
64
50
34
0

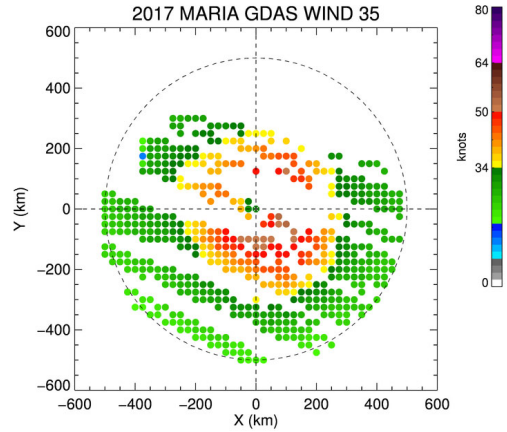

2017 MARIA SFMR WIND 24
Y (km)
X (km)
knots
80
64
50
34
0

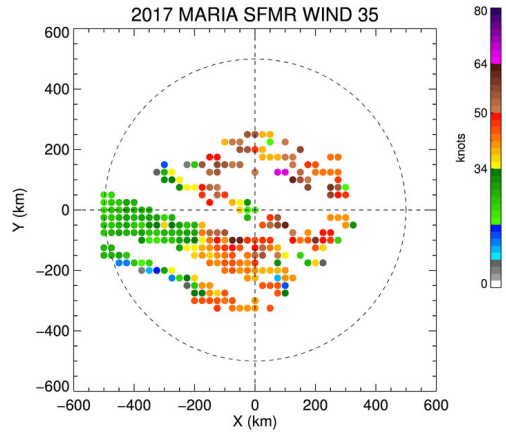

2017 MARIA CYGNSS YSLF NBRCS WIND 26
2017 MARIA ECMWF WIND 26
2017 MARIA GDAS WIND 26
2017 MARIA SFMR WIND 26
2017 MARIA HWRF WIND 26
Y (km)
X (km)
knots
0
34
50
64
80
600
400
200
0
−200
−400
−600

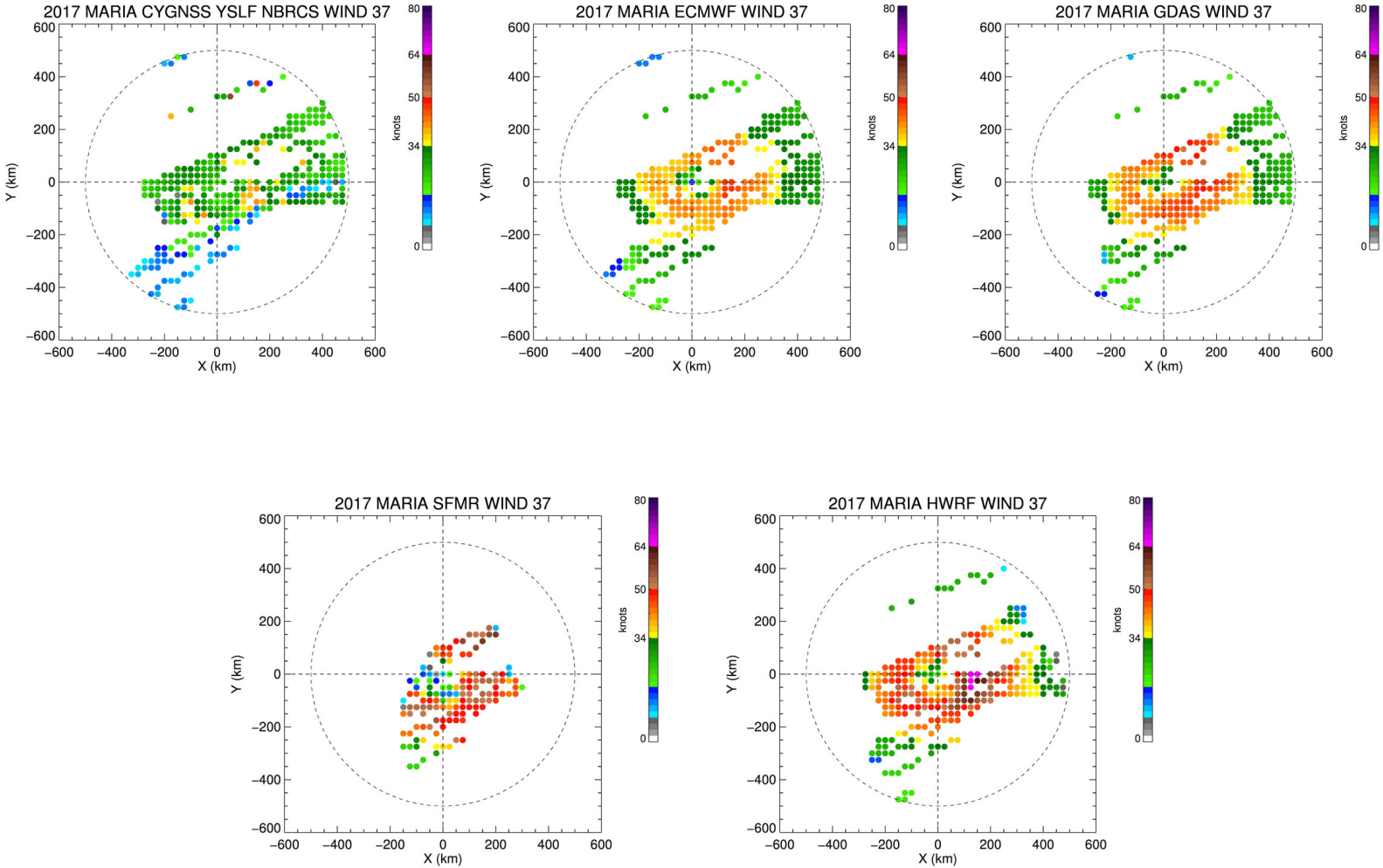

2017 MARIA CYGNSS YSLF NBRCS WIND 31
2017 MARIA ECMWF WIND 31
2017 MARIA GDAS WIND 31
2017 MARIA SFMR WIND 31
2017 MARIA SMAP WIND 31
2017 MARIA HWRF WIND 31
Y (km)
X (km)
knots
600
400
200
0
−200
−400
−600
80
64
50
34
0

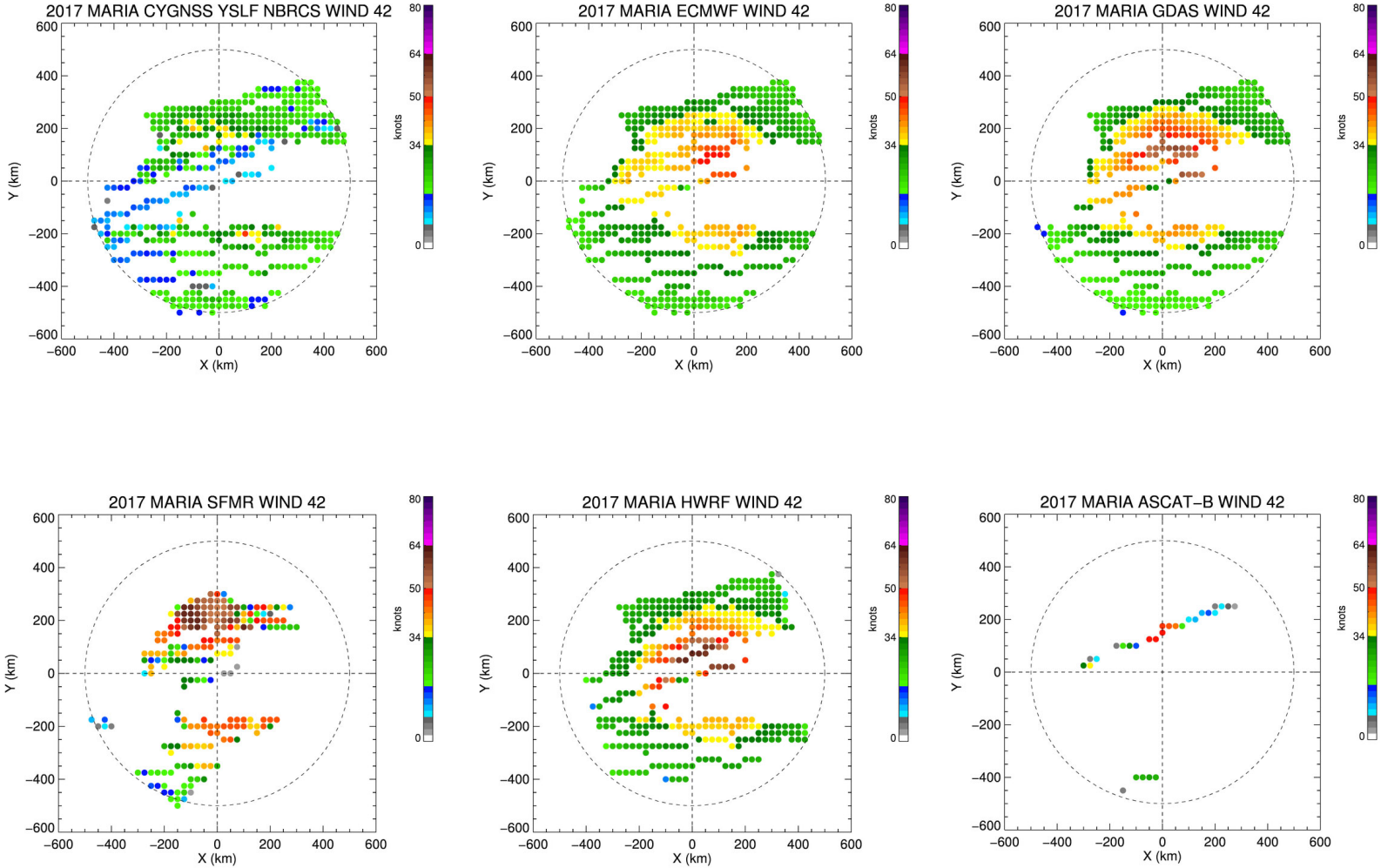

2017 MARIA CYGNSS YSLF NBRCS WIND 35
Y (km)
X (km)
knots
80
64
50
34
0

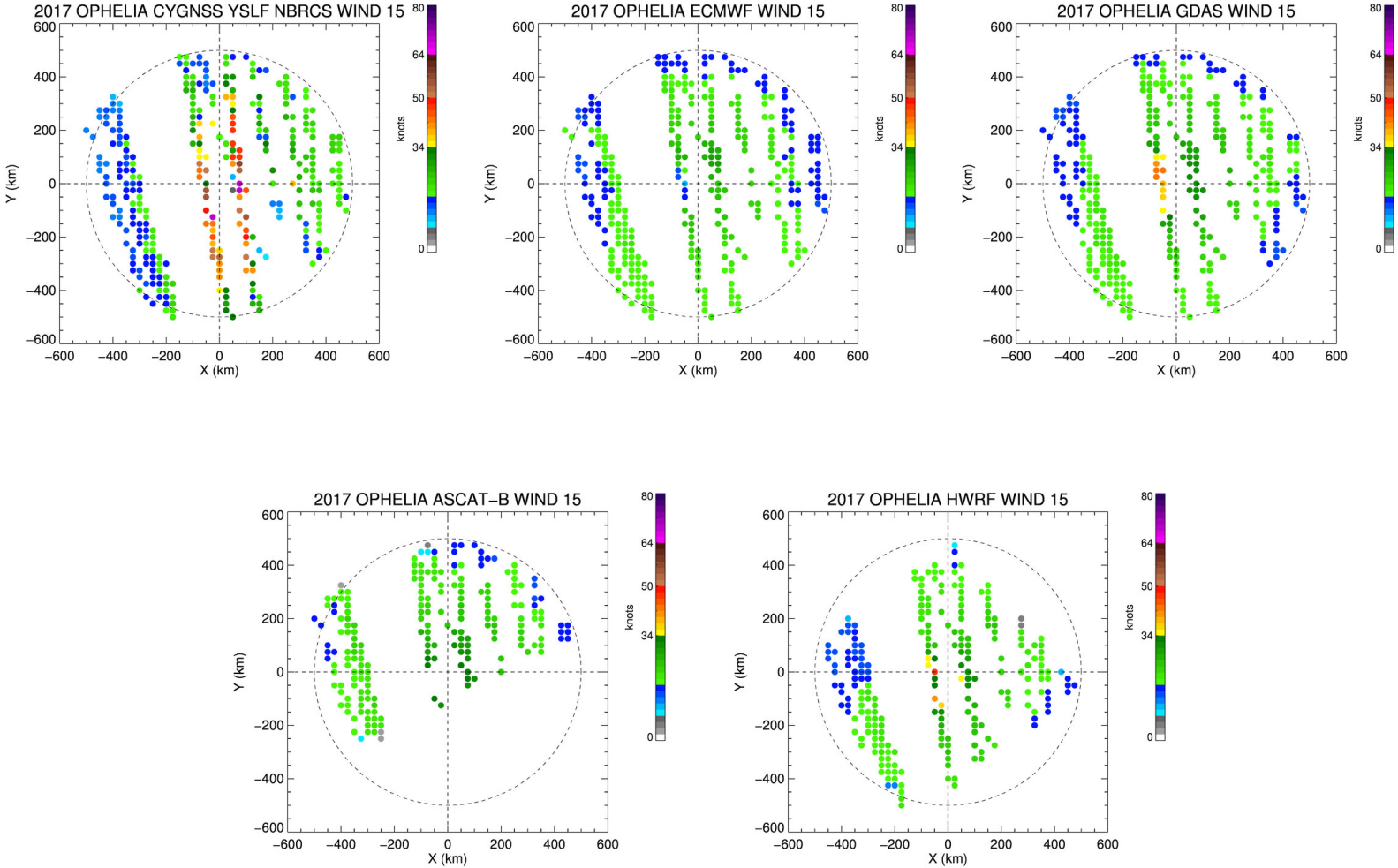

2017 MARIA ECMWF WIND 35
Y (km)
X (km)
knots
80
64
50
34
0


2017 MARIA GDAS WIND 35
Y (km)
X (km)
knots
80
64
50
34
0


2017 MARIA SFMR WIND 35
Y (km)
X (km)
knots
80
64
50
34
0


2017 MARIA CYGNSS YSLF NBRCS WIND 37
2017 MARIA ECMWF WIND 37
2017 MARIA GDAS WIND 37
2017 MARIA SFMR WIND 37
2017 MARIA HWRF WIND 37
Y (km)
X (km)
knots
80
64
50
34
0
600
400
200
0
−200
−400
−600


2017 MARIA CYGNSS YSLF NBRCS WIND 42
2017 MARIA ECMWF WIND 42
2017 MARIA GDAS WIND 42
2017 MARIA SFMR WIND 42
2017 MARIA HWRF WIND 42
2017 MARIA ASCAT−B WIND 42
Y (km)
X (km)
knots
0
34
50
64
80
600
400
200
0
−200
−400
−600


2017 OPHELIA CYGNSS YSLF NBRCS WIND 15
2017 OPHELIA ECMWF WIND 15
2017 OPHELIA GDAS WIND 15
2017 OPHELIA ASCAT−B WIND 15
2017 OPHELIA HWRF WIND 15
Y (km)
X (km)
knots
80
64
50
34
0
600
400
200
0
−200
−400
−600

Huge Improvements but….

- Error dependence on
  - Altitude, noise floor level, SP delay position, lat/lon, port and starboard, GPS block
- Retrieval algorithm needs major overhaul