AMSR-2 HIGH WIND VALIDATION AND PRODUCT UPDATE STAGE I

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Motivation

- There is tremendous interest in both the operational and research communities in high wind event observations
- However, there exist large disparities in wind intensity estimates between different sensor observations as well as between different wind products from the same sensor and there is a general lack of surface truth
- Disagreements stem from differences in:
  - Measurement resolution
  - Sensor sensitivity to high winds
  - Geophysical model functions
  - Retrieval algorithm approaches
  - Atmospheric and sea state impacts on measurements
- High wind algorithm and product developments led by NOAA STAR Winds Team, RSS, JPL, JAXA, Meteo France, ESA

Remote Sensing Systems:

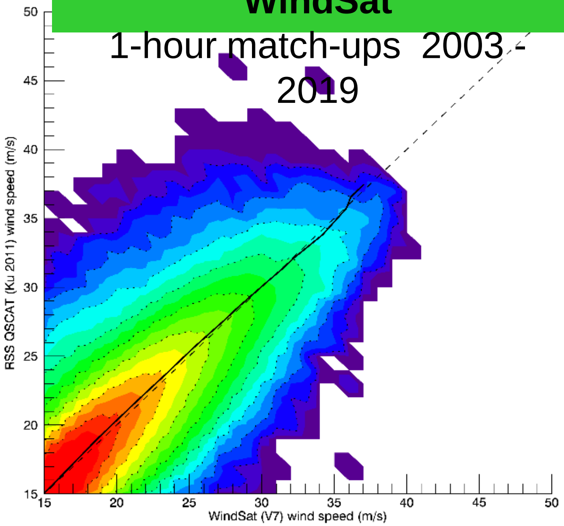
Bringing Consistency into High Wind Measurements with Spaceborne Microwave Radiometers and Scatterometers

Product development based on H*Wind, SFMR, Dropsondes collocated with WindSat. All RSS Radiometer and Scatterometer retrievals calibrated to match WindSat

Remote Sensing Systems
www.remss.com

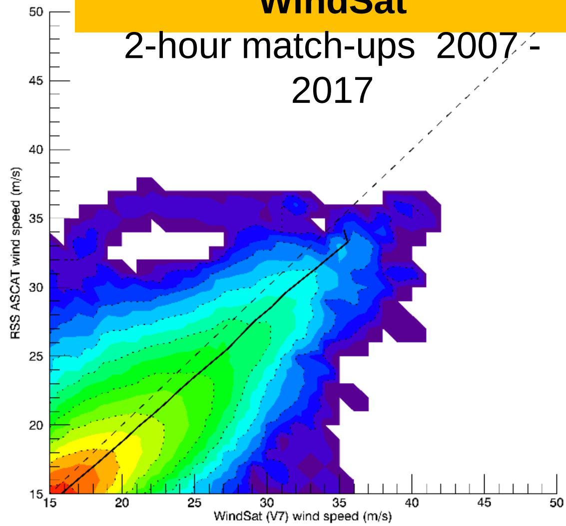
QuikScat (Ku 2011) vs WindSat

1-hour match-ups 2003 - 2019



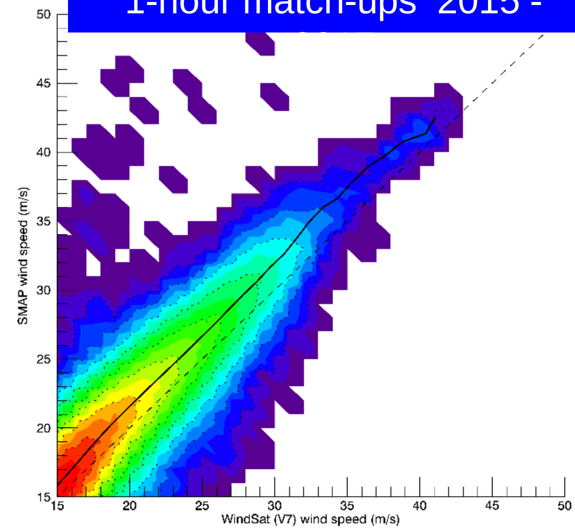
RSS ASCAT (V2.1) vs WindSat

2-hour match-ups 2007 - 2017



SMAP vs WindSat

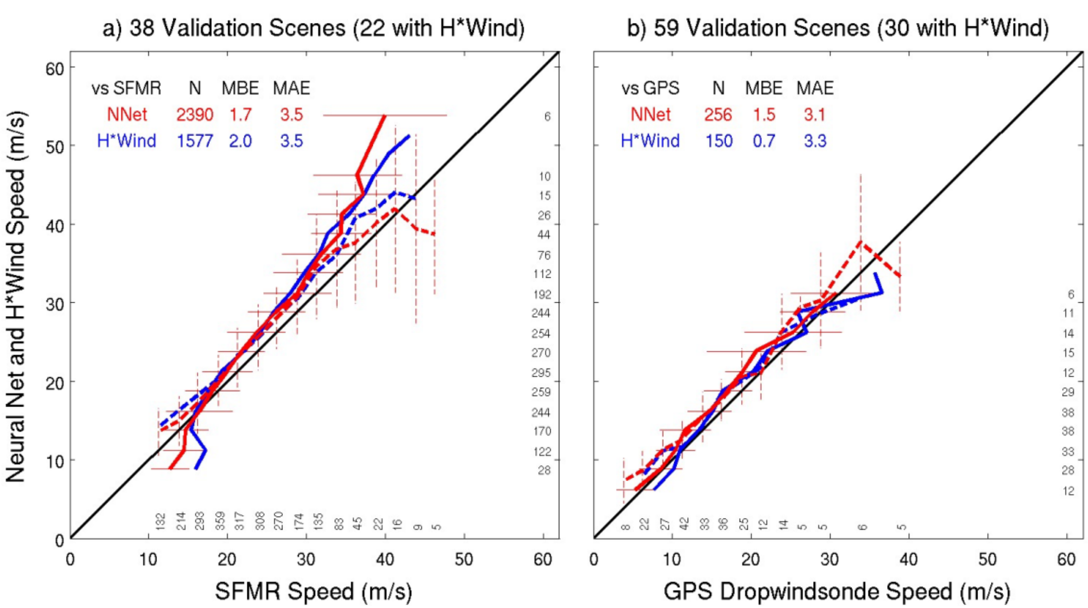
1-hour match-ups 2015 -



Presented by Thomas Meissner IOWVST 2017

BAMS September 2017 issue
http://journals.ametsoc.org/doi/10.1175/BAMS-D-16-0052.1 in print

JPL High Wind Product Development



- Product development based on SFMR, Dropsondes, H*Wind model and best track

Presented by A. Fore (JPL) High winds Workshop Nov 2016, Exeter

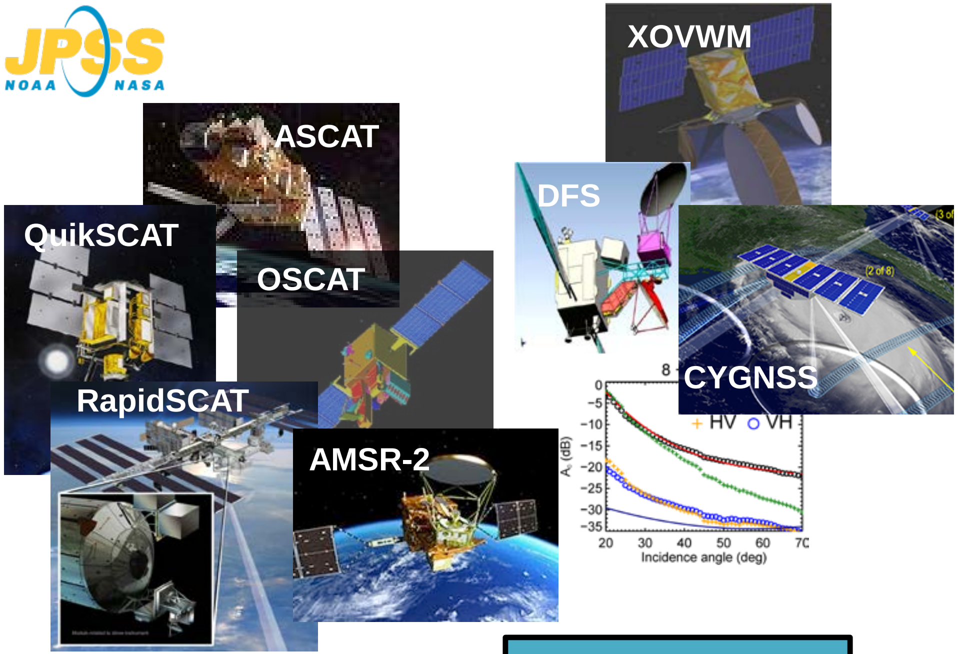
QuikSCAT All weather high wind speed
Presented by B. Stiles
IOVWST 2013

JAXA AMSR-2 High Wind Product

Presented at JAXA/EORC, RESTEC Nov 2015
Developed by Dr Akira Shibata

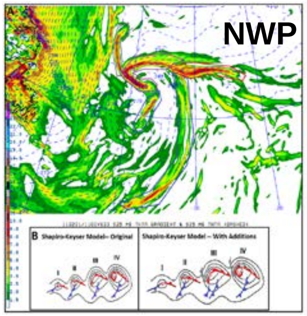
- The product contains wind speeds in the best track of typhoons announced by Japan Meteorological Agency and NOAA National Hurricane Center.
- The wind speeds above 17 m/s retrieved by this algorithm were compared with the maximum wind speeds within 200 km from the center position of the best track or the wind speeds observed by dropsondes.
- Utilizes 6.9- and 10.7- GHz H channels. This algorithm realizes to retrieve the sea surface wind speed more than 70 m/s.

NESDIS/STAR Ocean Winds Aircraft Experiment



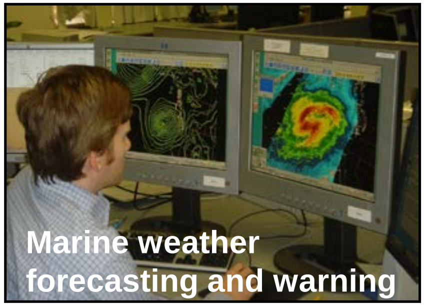
Calibration, validation and product improvements of current scatterometer and radiometer satellite measurements

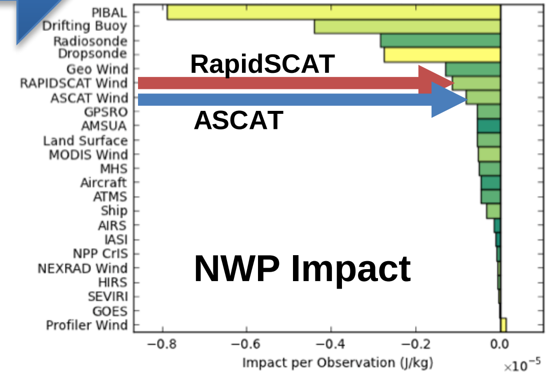
New instrument design and risk reduction for future satellite instruments



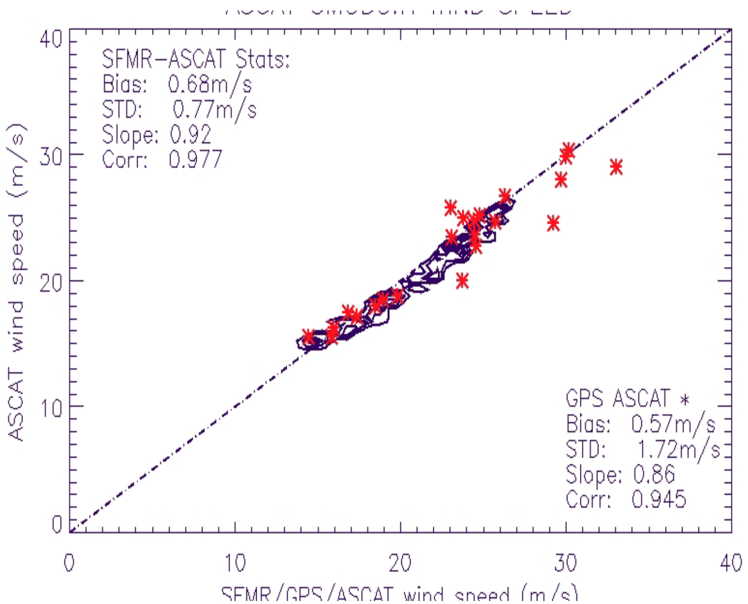
New insights into physics of hurricane force winds within extratropical storms

R2O

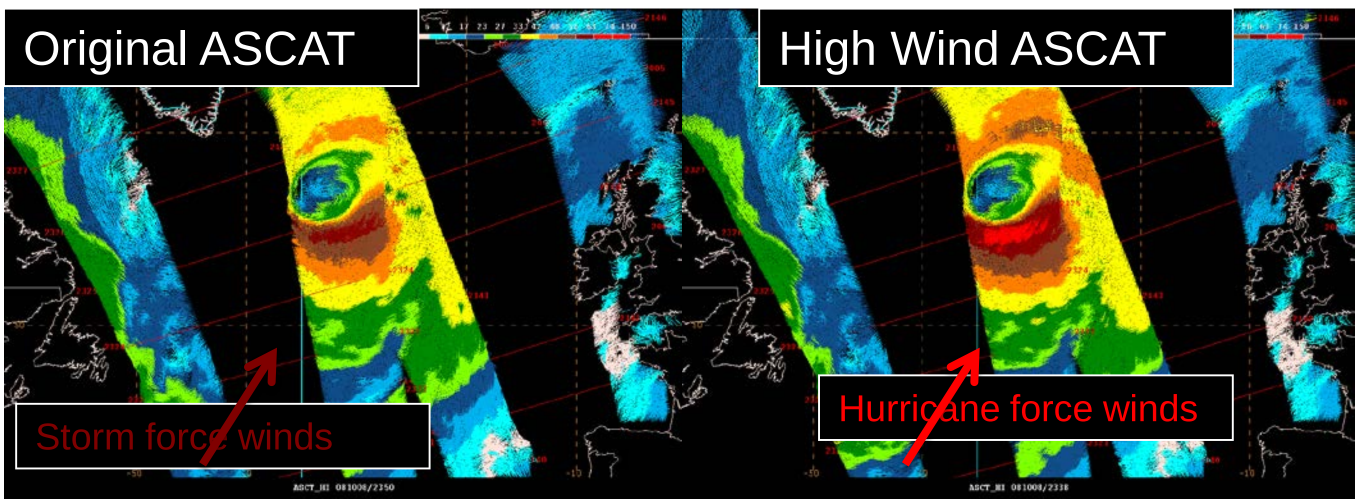




NOAA ASCAT Scatterometer High Wind Product



- Geophysical model function developed using airborne IWRAP scatterometers and SFMR radiometer measurements
- Satellite GMF tuned to match SFMR and dropsonde measurements in ETC
- Utilized in operations since 2011
  - Considered to have best high wind retrievals within ETC by operational community



S. Soisuvarn, Z. Jelenak, P. S. Chang, S. O. Al-sweiss, and Q. Zhu, “CMOD5.H—A High Wind Geophysical Model Function for C-Band Verti- cally Polarized Satellite Scatterometer Measure- ments,” IEEE Transactions on Geoscience and Remote Sensing, pp. 1–17, Nov. 22, 2012. doi: 10.1109/TGRS.2012.2219871.

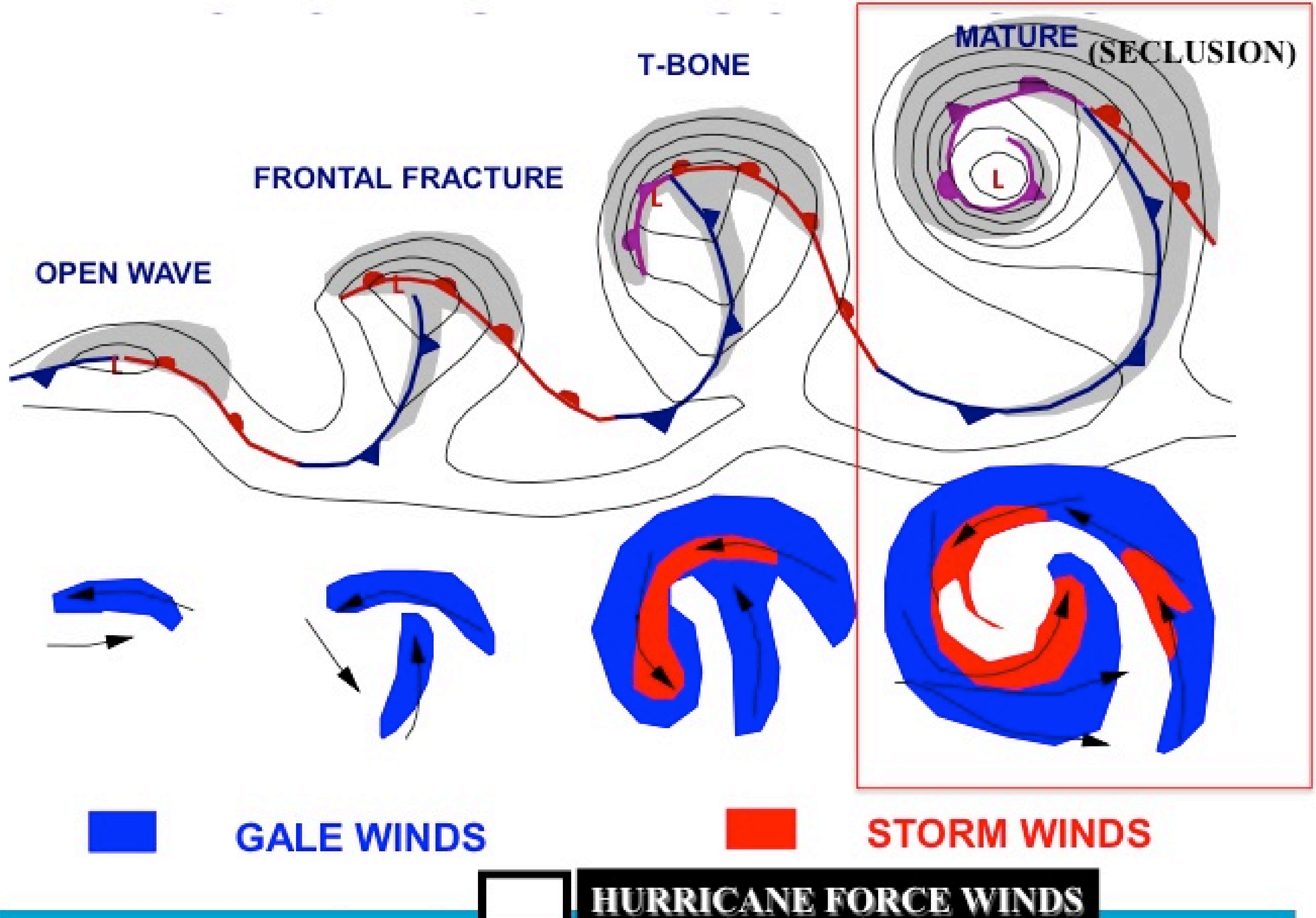
International Satellite High Wind Workshops Recommendations

- Two high wind validation workshops held in 2015 (Miami/NOAA) and 2016 (Exeter/ESA)
  - Agreed that dropsondes WL150 wind speeds will be our standard for truth.
  - SFMR winds will be the transfer mechanism from dropsondes winds to satellite winds
- Intercalibration of multiple-datasets by analyzing differences and similarities between the Passive and Active MW measurements.
  - Two wind regimes of strong interest:
    - overlap range between L-band, C- and Ku-band : 15-32 m/s
      - Extratropical cyclones ideally suited for ensuring consistency between scatterometer and radiometer observations
    - high wind regime > 33 m/s
- Recommendations:
  - Improve calibration by starting where products are similar and moving to
  - Higher wind speeds as sufficient comparison data exist.
  - Attempt to develop model function that also accounts for sea state and heavy rain (if found to be important)
  - Possible dependence on storm motion, SST, latitude, wave directions ? We suggest to use radii at 34Kts (18m/s), 50Kts (25.7) and 64Kts (33m/s) as this is relevant to the forecasters
  - We can also look at EKE, integrated power dissipation
    - look at other indices to help understand the tropical winds (quick ways to compare data sources)

Novel Approach for Satellite High Wind Validation: Comparison of ETC Wind Field Structures

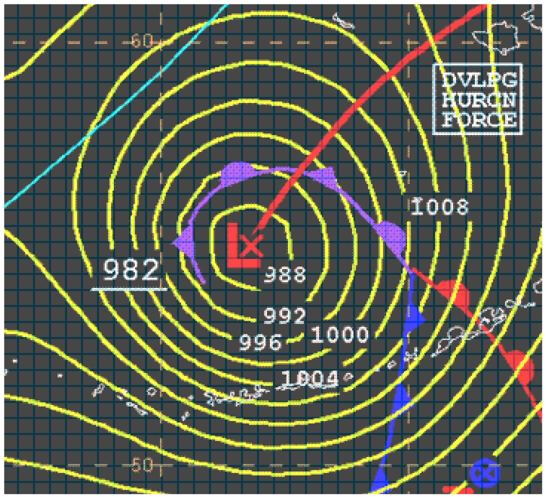
- All currently operational scatterometers and radiometers have adequate spatial resolution to observe high winds in extratropical cyclones
  - Winds in extratropical cyclones span up to 40m/s in most mature storms over the area of 100-1000km
- Satellite observations of extratropical cyclones
  - ASCAT-A: KNMI, NOAA and RSS
  - Microwave Radiometer wind products:
    - SSMIF16, SSMIf17,WindSat, AMSR-E, GMI (RSS)
    - AMSR-2 (NOAA, JAXA, RSS)
- RSS high wind products based on H*wind model and SFMR high wind measurements
- SMAP JPL based on SFMR TC measurements
- JAXA AMSR-2 dropsondes and best track max wind
- NOAA ASCAT high wind gmf based on SFMR/IWRAP observations of extratropical cyclones

Extratropical Storm Life Cycles
(adapted from Shapiro – Keyser Cyclone Model)

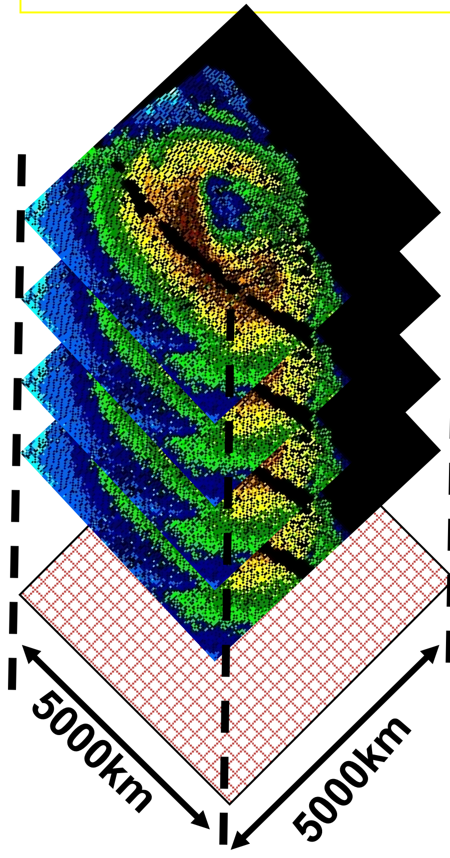


Storm track file

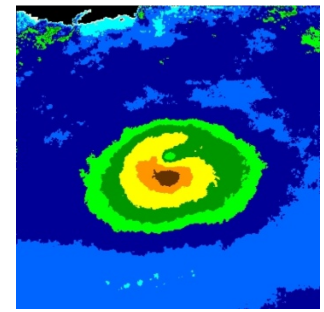
Read HF Cyclone Info.

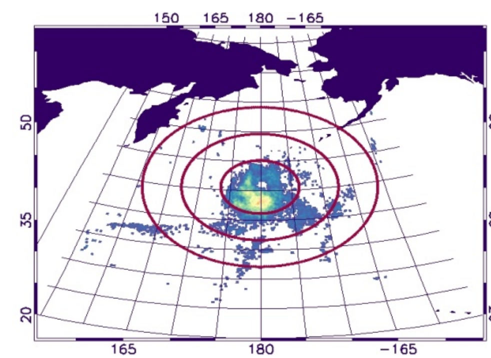


Extract Satellite 12.5km Data & Perform QC (land, ice, coast, rain) flags



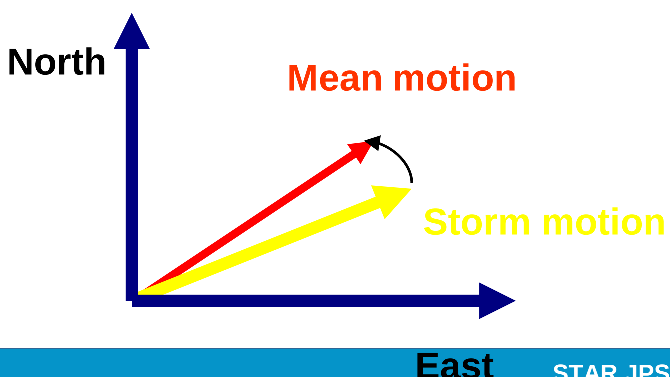
Generate Mean Wind Fields





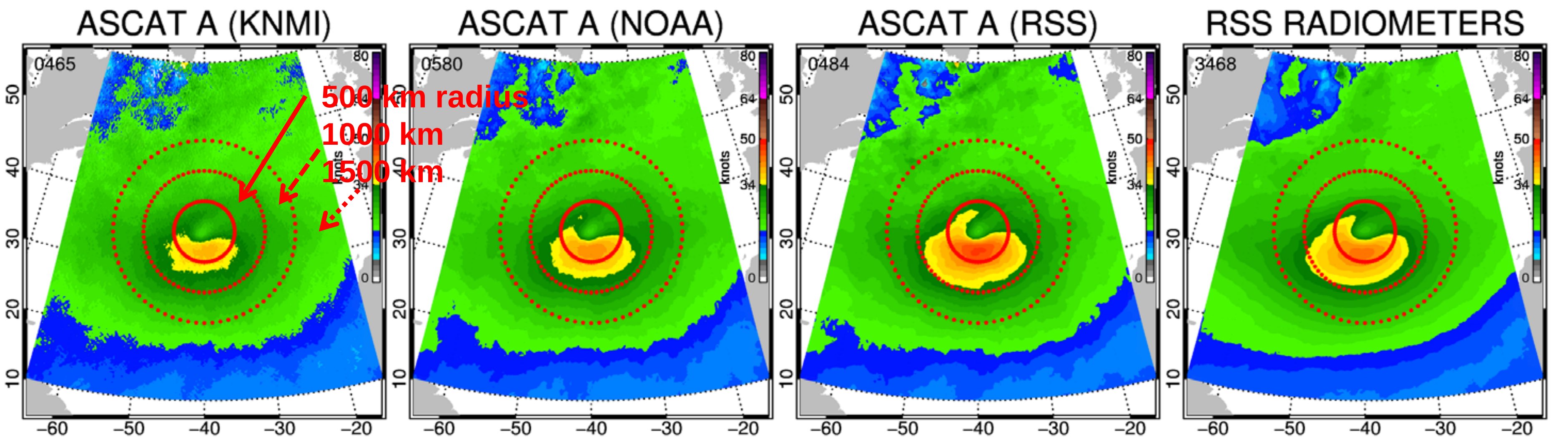
Generate Frequency of HF Occurrence per grid fields

Estimate speed & Angle (Heading Vector)

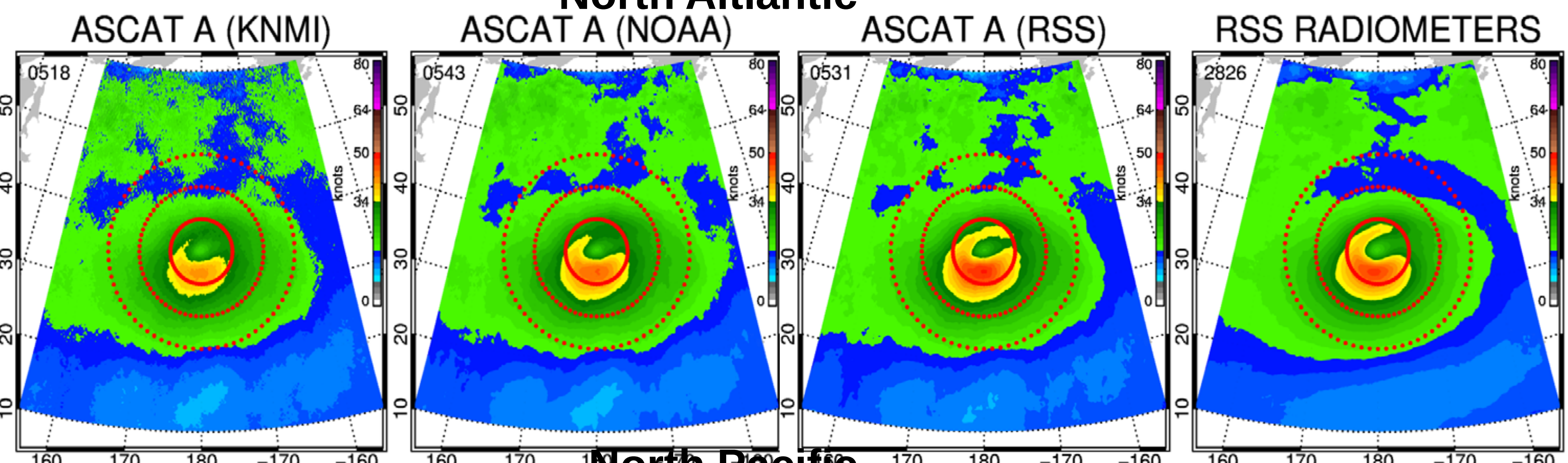


ASCAT-A Products Comparison 2007-2015

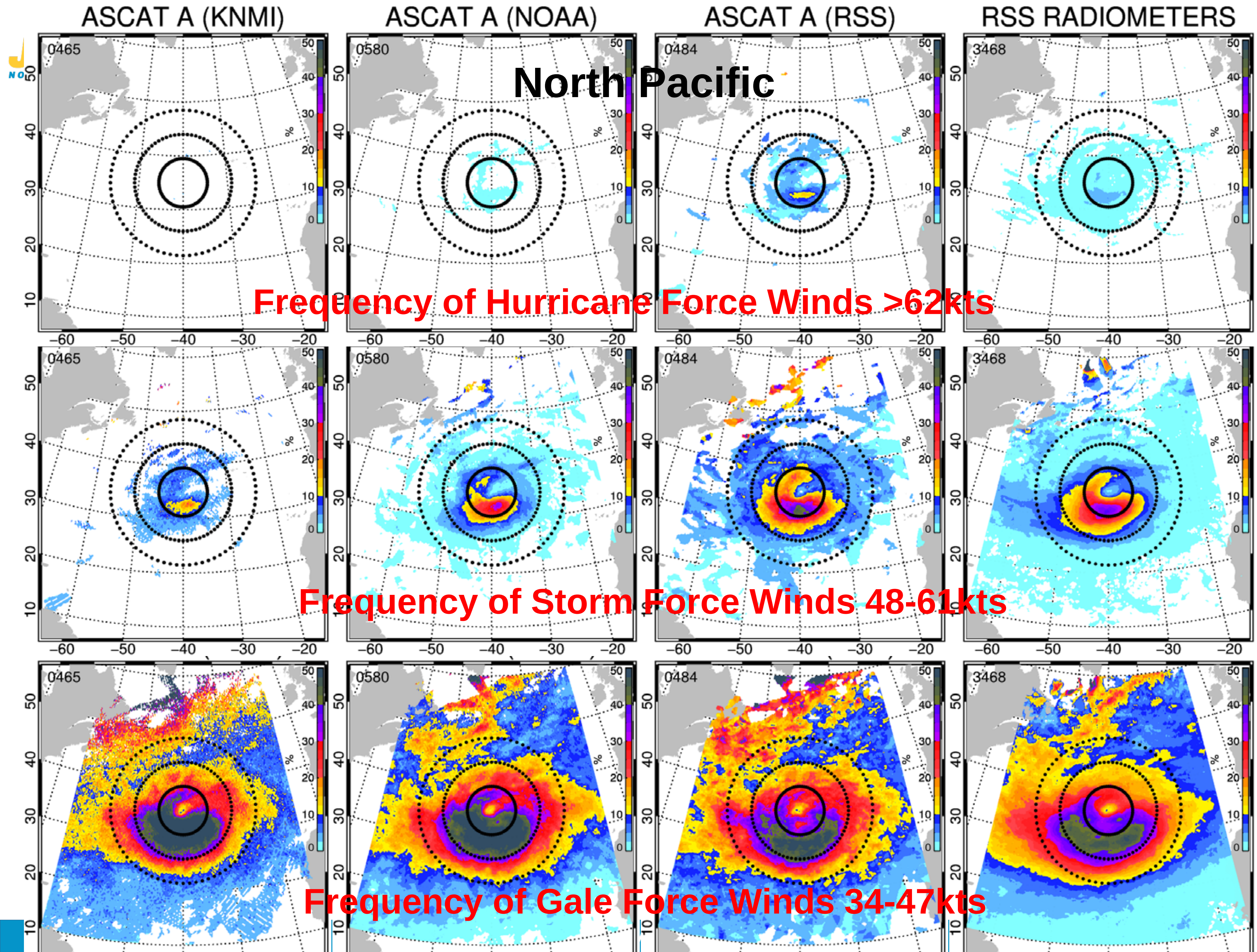
Spatial Resolution 35-60km



North Altlantic

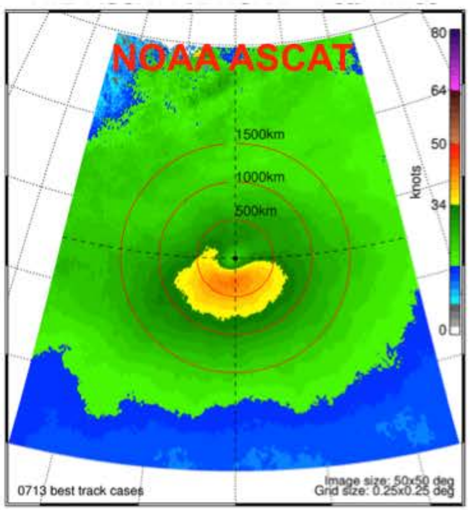


North Pacific

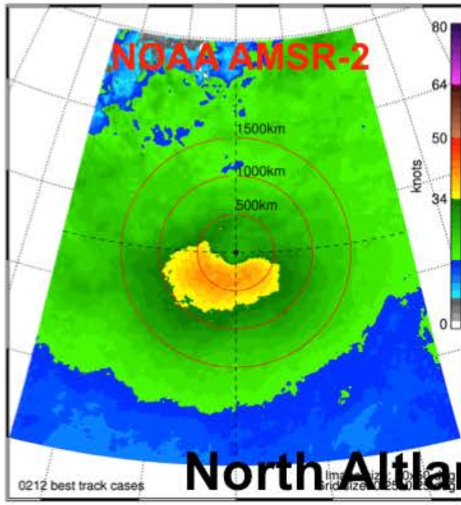

ASCAT A (KNMI)
ASCAT A (NOAA)
ASCAT A (RSS)
RSS RADIOMETERS
North Pacific
Frequency of Hurricane Force Winds >62kts
Frequency of Storm Force Winds 48-61kts
Frequency of Gale Force Winds 34-47kts
0465
0580
0484
3468
%

AMSR-2/ASCAT
Wind Products Comparison 2012-2017
Spatial Resolution ~10-60km

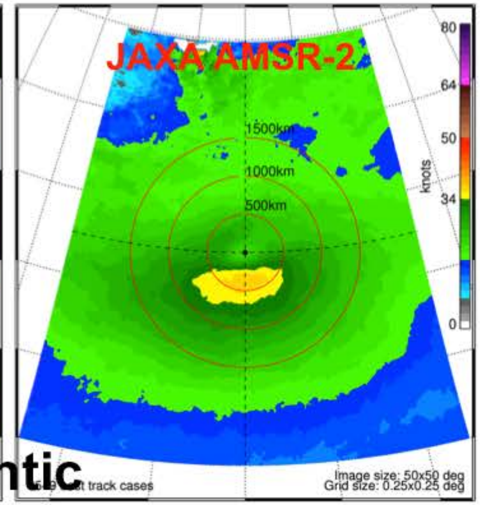
ATL ASCAT A/B NOAA – mean winds



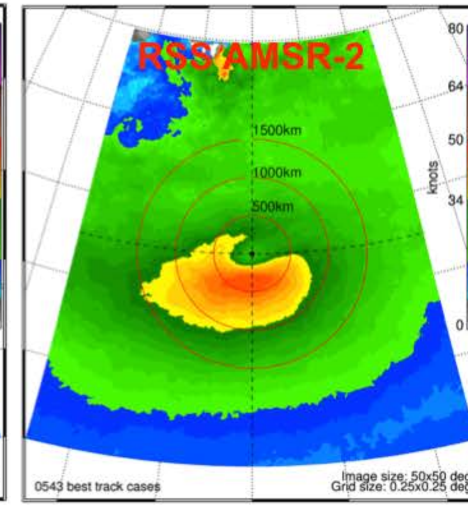
ATL ASMR NOAA – mean winds



ATL ASMR JAXA – mean winds

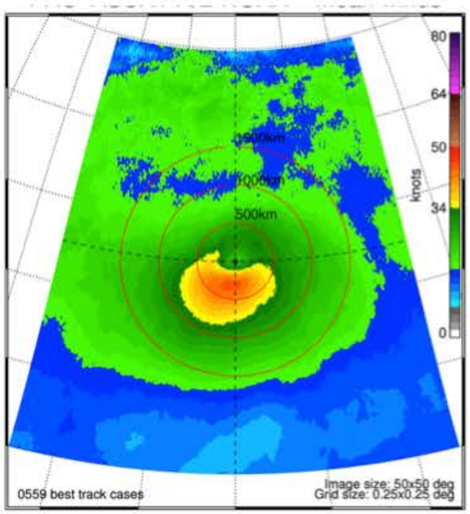


ATL ASMR RSS – mean winds

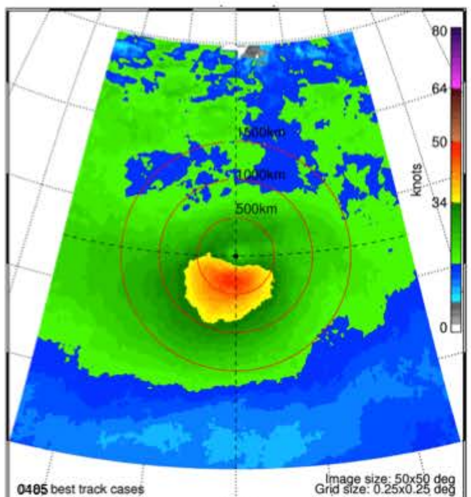


North Altlantic

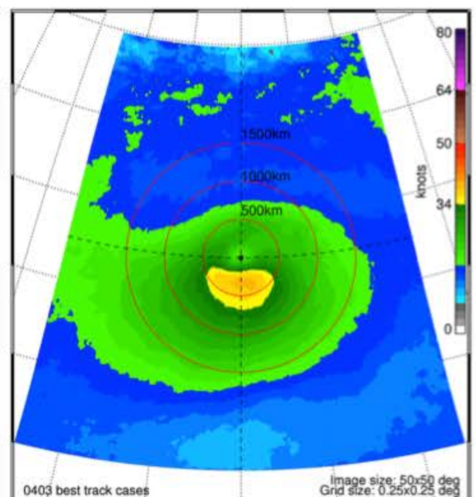
PAC ASCAT A/B NOAA – mean winds



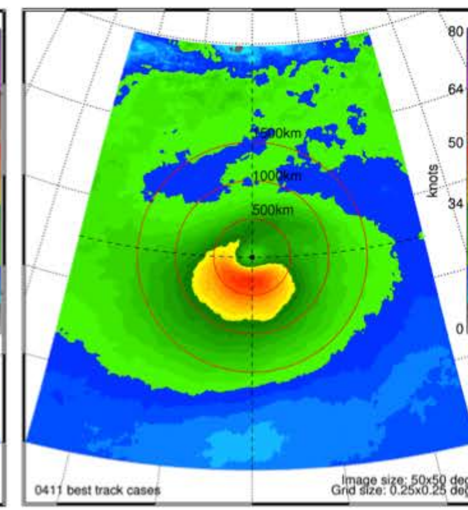
PAC ASMR NOAA – mean winds



PAC ASMR JAXA – mean winds

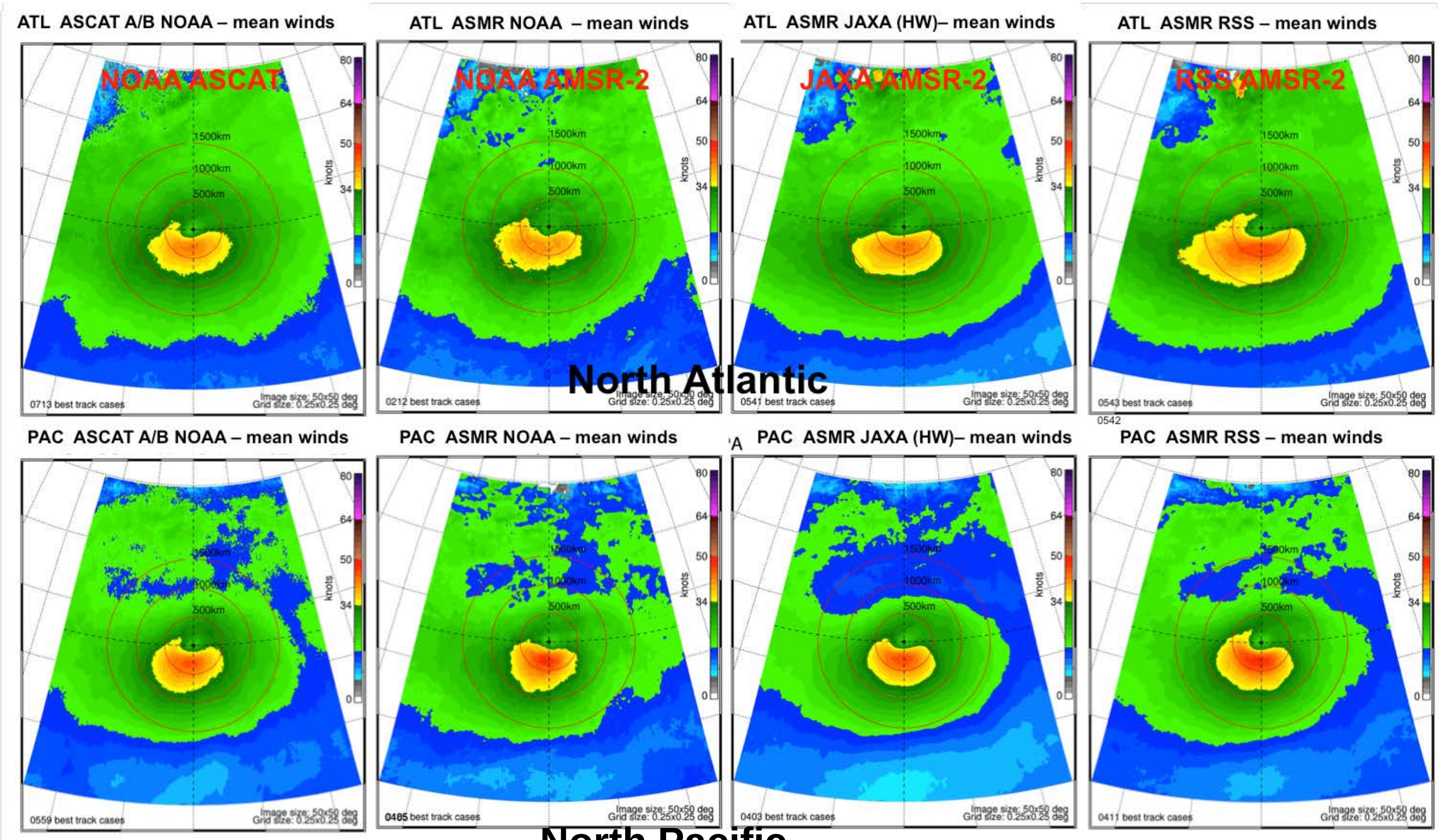


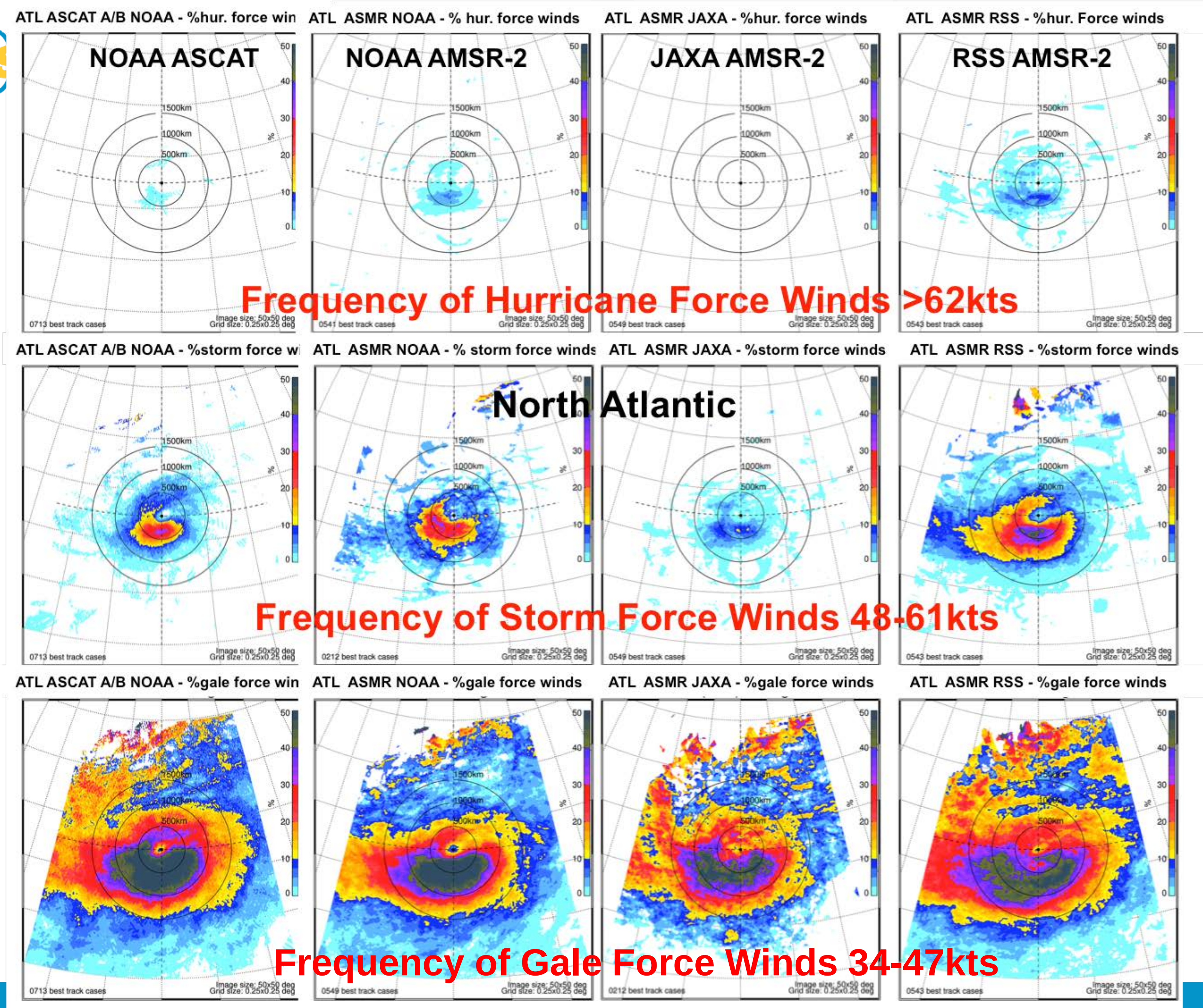
PAC ASMR RSS – mean winds

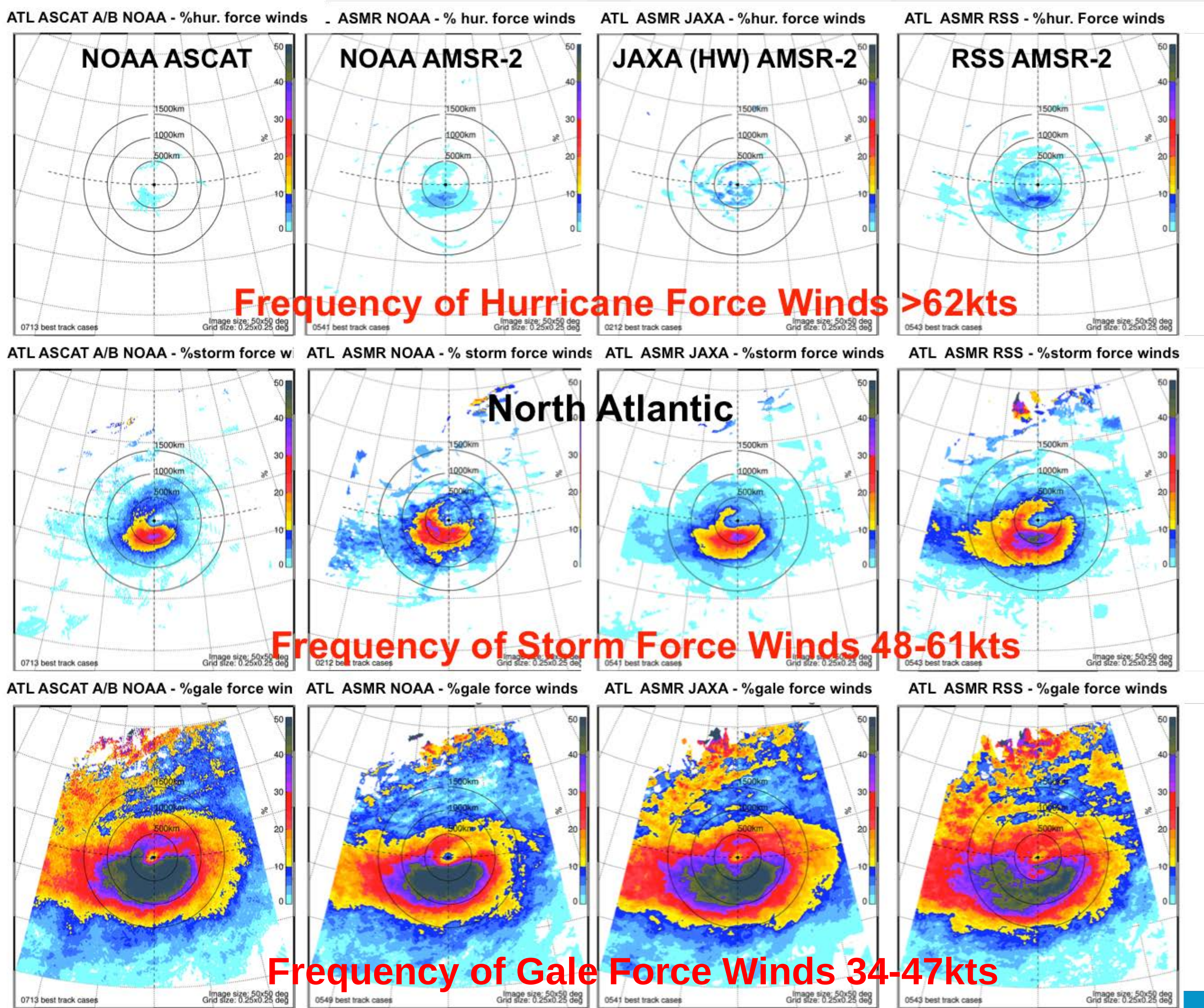


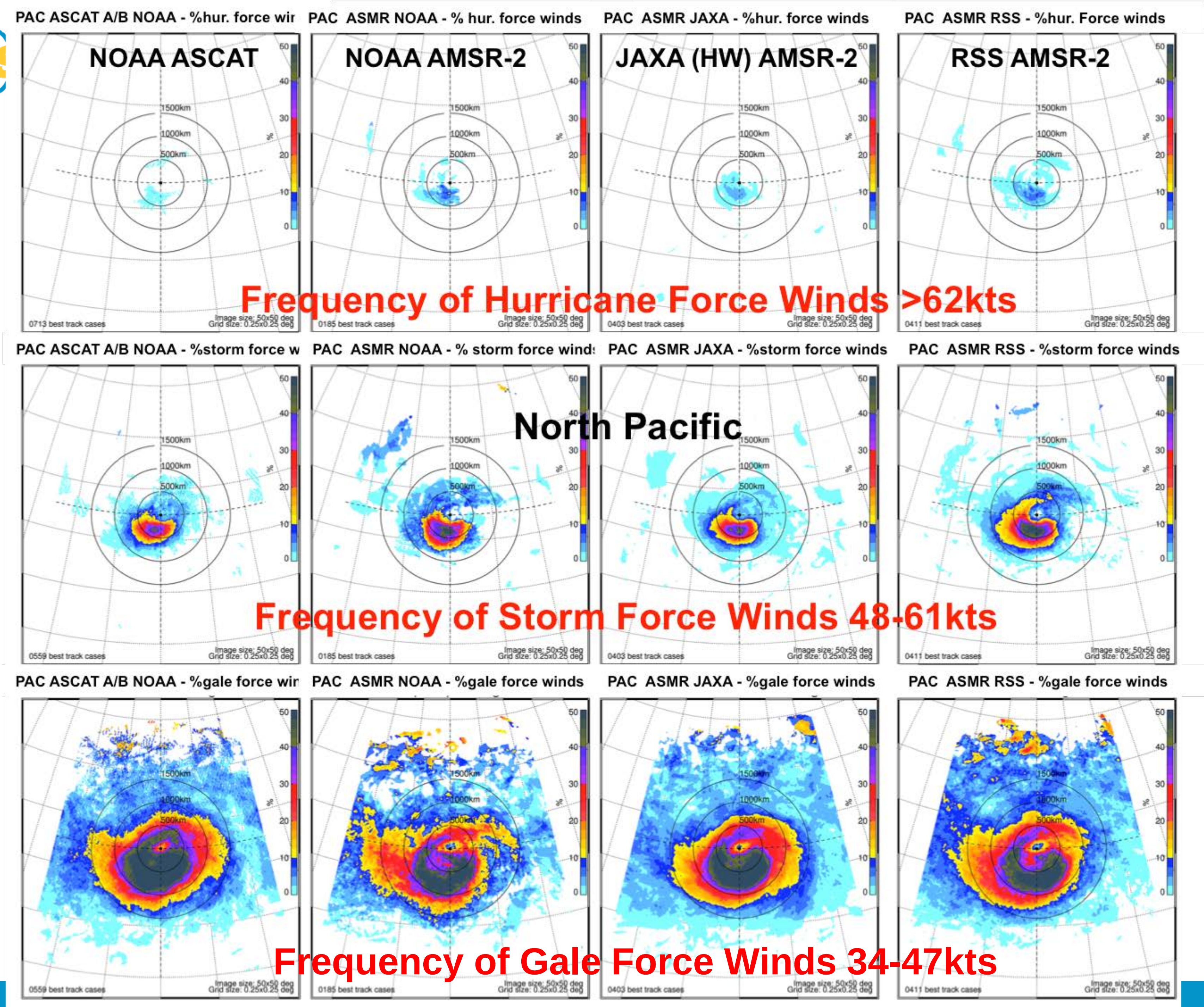
North Pacific

AMSR-2/ASCAT
Wind Products Comparison 2012-2017
Spatial Resolution ~10-60km

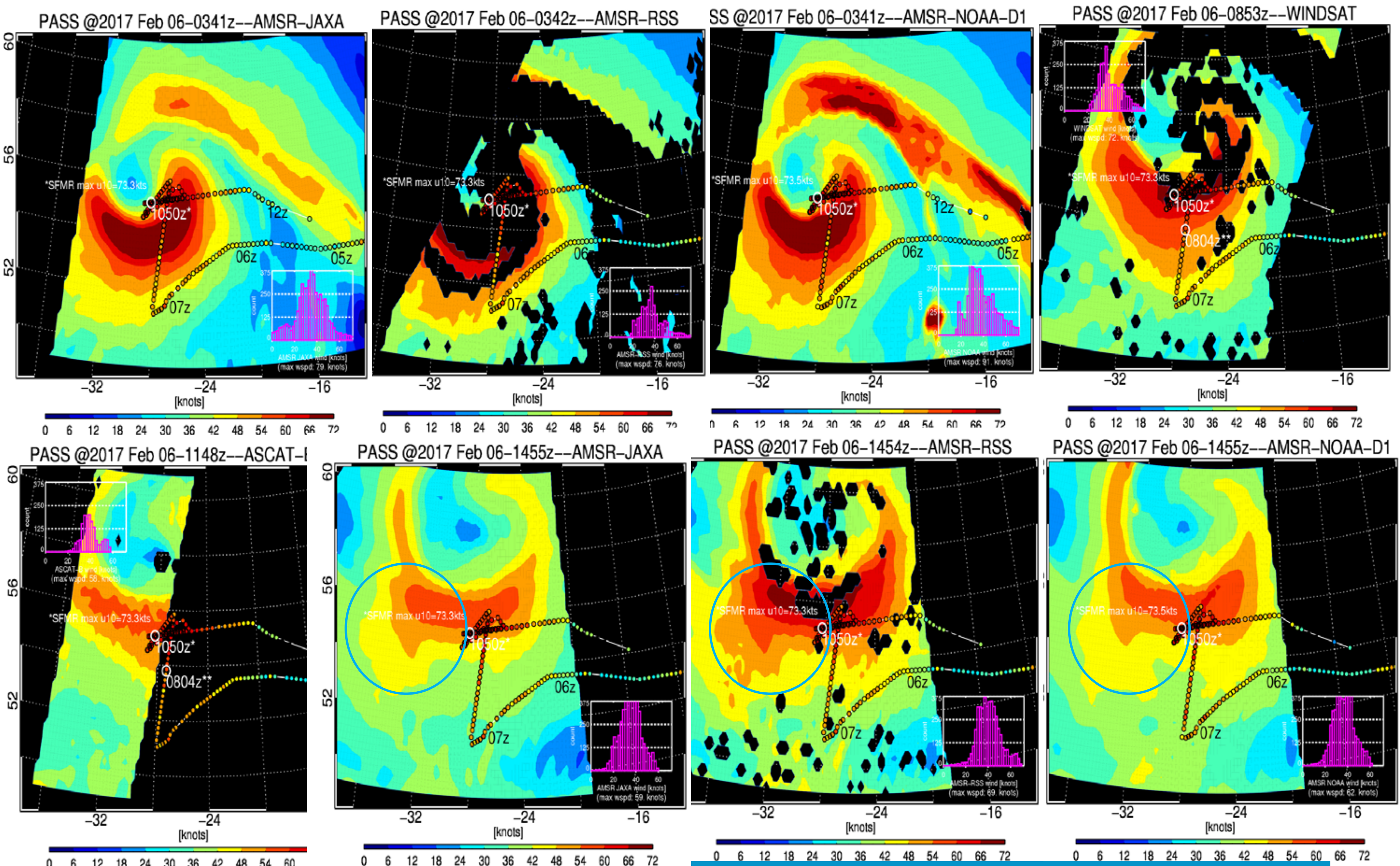



ATL ASCAT A/B NOAA - %hur. force win
ATL ASMR NOAA - % hur. force winds
ATL ASMR JAXA - %hur. force winds
ATL ASMR RSS - %hur. Force winds
NOAA ASCAT
NOAA AMSR-2
JAXA AMSR-2
RSS AMSR-2
Frequency of Hurricane Force Winds >62kts
0713 best track cases
0541 best track cases
0549 best track cases
0543 best track cases
ATL ASCAT A/B NOAA - %storm force wi
ATL ASMR NOAA - % storm force winds
ATL ASMR JAXA - %storm force winds
ATL ASMR RSS - %storm force winds
North Atlantic
Frequency of Storm Force Winds 48-61kts
0713 best track cases
0212 best track cases
0549 best track cases
0543 best track cases
ATL ASCAT A/B NOAA - %gale force win
ATL ASMR NOAA - %gale force winds
ATL ASMR JAXA - %gale force winds
ATL ASMR RSS - %gale force winds
Frequency of Gale Force Winds 34-47kts
0713 best track cases
0549 best track cases
0212 best track cases
0543 best track cases
1500km
1000km
500km
Image size: 50x50 deg
Grid size: 0.25x0.25 deg

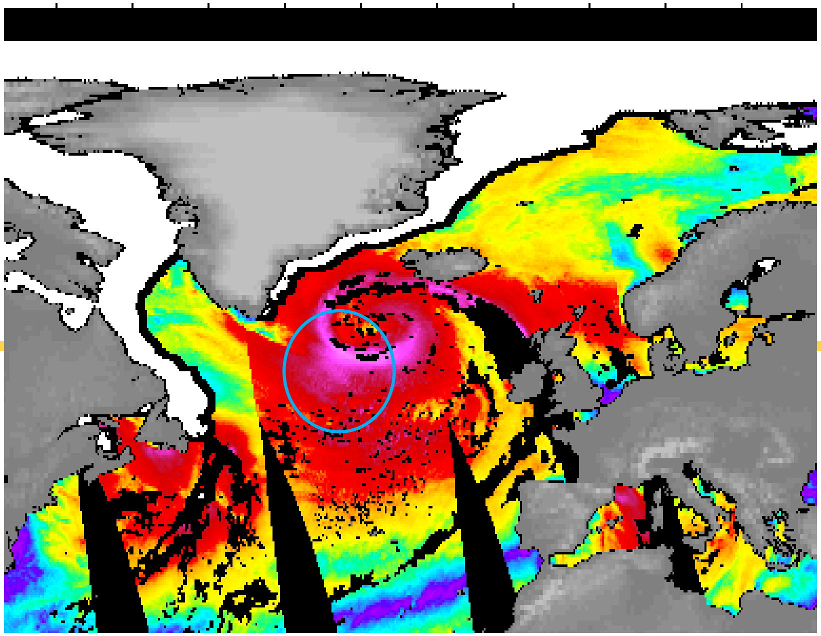

ATL ASCAT A/B NOAA - %hur. force winds
ASMR NOAA - % hur. force winds
ATL ASMR JAXA - %hur. force winds
ATL ASMR RSS - %hur. Force winds
NOAA ASCAT
NOAA AMSR-2
JAXA (HW) AMSR-2
RSS AMSR-2
Frequency of Hurricane Force Winds >62kts
ATL ASCAT A/B NOAA - %storm force wi
ATL ASMR NOAA - % storm force winds
ATL ASMR JAXA - %storm force winds
ATL ASMR RSS - %storm force winds
North Atlantic
Frequency of Storm Force Winds 48-61kts
ATL ASCAT A/B NOAA - %gale force win
ATL ASMR NOAA - %gale force winds
ATL ASMR JAXA - %gale force winds
ATL ASMR RSS - %gale force winds
Frequency of Gale Force Winds 34-47kts
0713 best track cases
0541 best track cases
0212 best track cases
0543 best track cases
0549 best track cases
Image size: 50x50 deg
Grid size: 0.25x0.25 deg
1500km
1000km
500km


PAC ASCAT A/B NOAA - %hur. force wir
PAC ASMR NOAA - % hur. force winds
PAC ASMR JAXA - %hur. force winds
PAC ASMR RSS - %hur. Force winds
NOAA ASCAT
NOAA AMSR-2
JAXA (HW) AMSR-2
RSS AMSR-2
1500km
1000km
500km
Frequency of Hurricane Force Winds >62kts
0713 best track cases
0185 best track cases
0403 best track cases
0411 best track cases
Image size: 50x50 deg
Grid size: 0.25x0.25 deg
PAC ASCAT A/B NOAA - %storm force w
PAC ASMR NOAA - % storm force wind:
PAC ASMR JAXA - %storm force winds
PAC ASMR RSS - %storm force winds
North Pacific
Frequency of Storm Force Winds 48-61kts
0559 best track cases
PAC ASCAT A/B NOAA - %gale force wir
PAC ASMR NOAA - %gale force winds
PAC ASMR JAXA - %gale force winds
PAC ASMR RSS - %gale force winds
Frequency of Gale Force Winds 34-47kts
0, 10, 20, 30, 40, 50

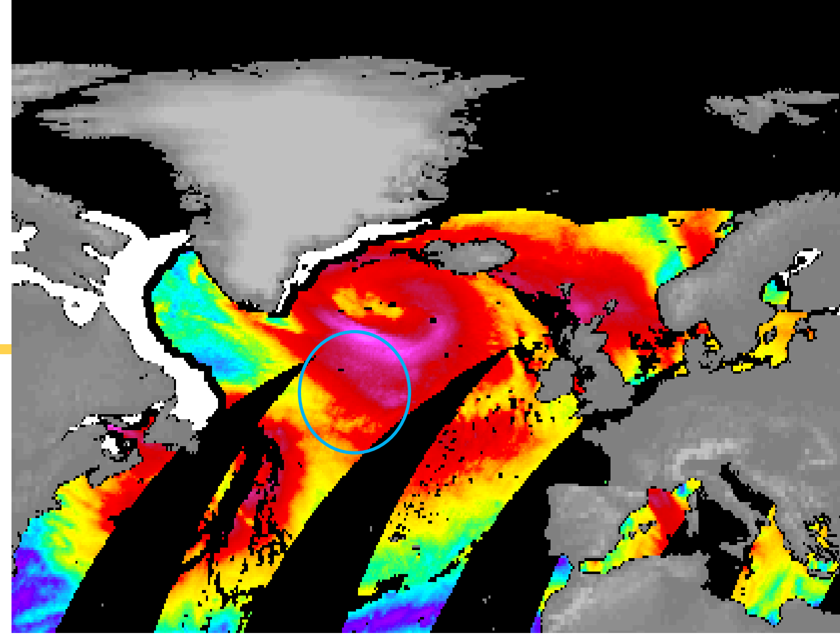
AMSR-2 February 6th,2017 Extratropical Storm Observations



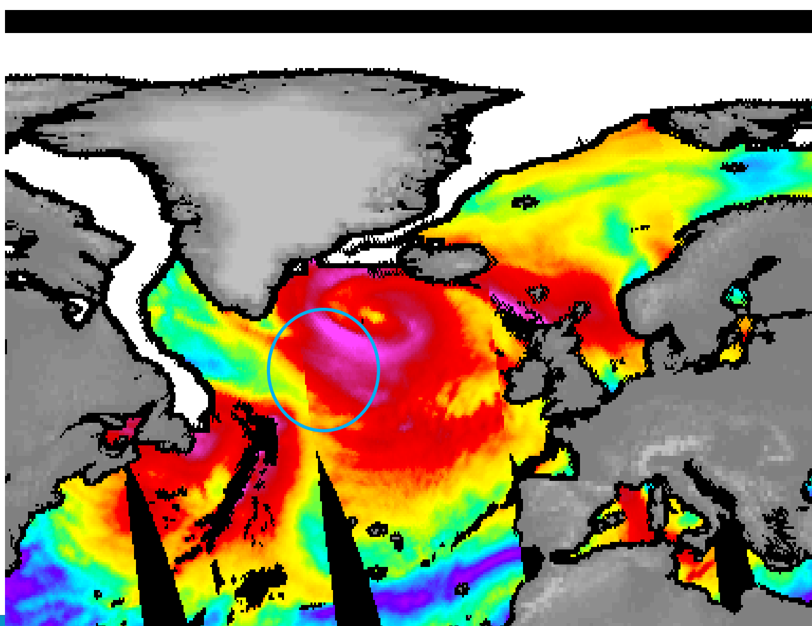
AMSR2 02-06-17 ~ 15 UTC



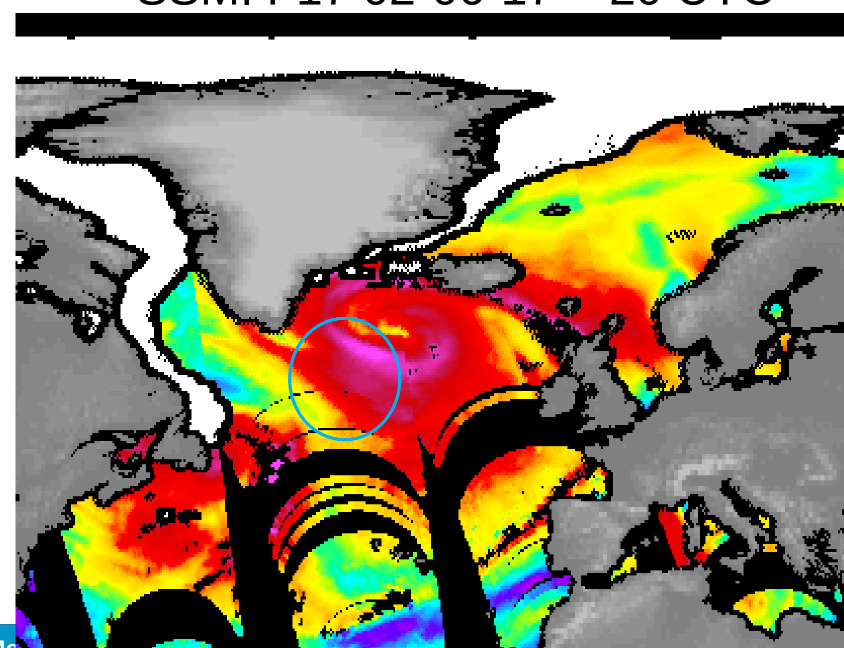
GMI 02-06-17 ~ 15 UTC



SSMI F18 02-06-17 ~ 20 UTC



SSMI F17 02-06-17 ~ 20 UTC



Evaluating Wind Speeds with Respect to Sea State Data Collection

Products:

•12.5km ASCAT A/B winds

•12.5, 25km RapidScat winds, including NRCS

•Windsat, GMI, AMSR-2, SSMI-F16/17 from RSS

•AMSR-2 NOAA

each collocated (via bilinear interpolation) with

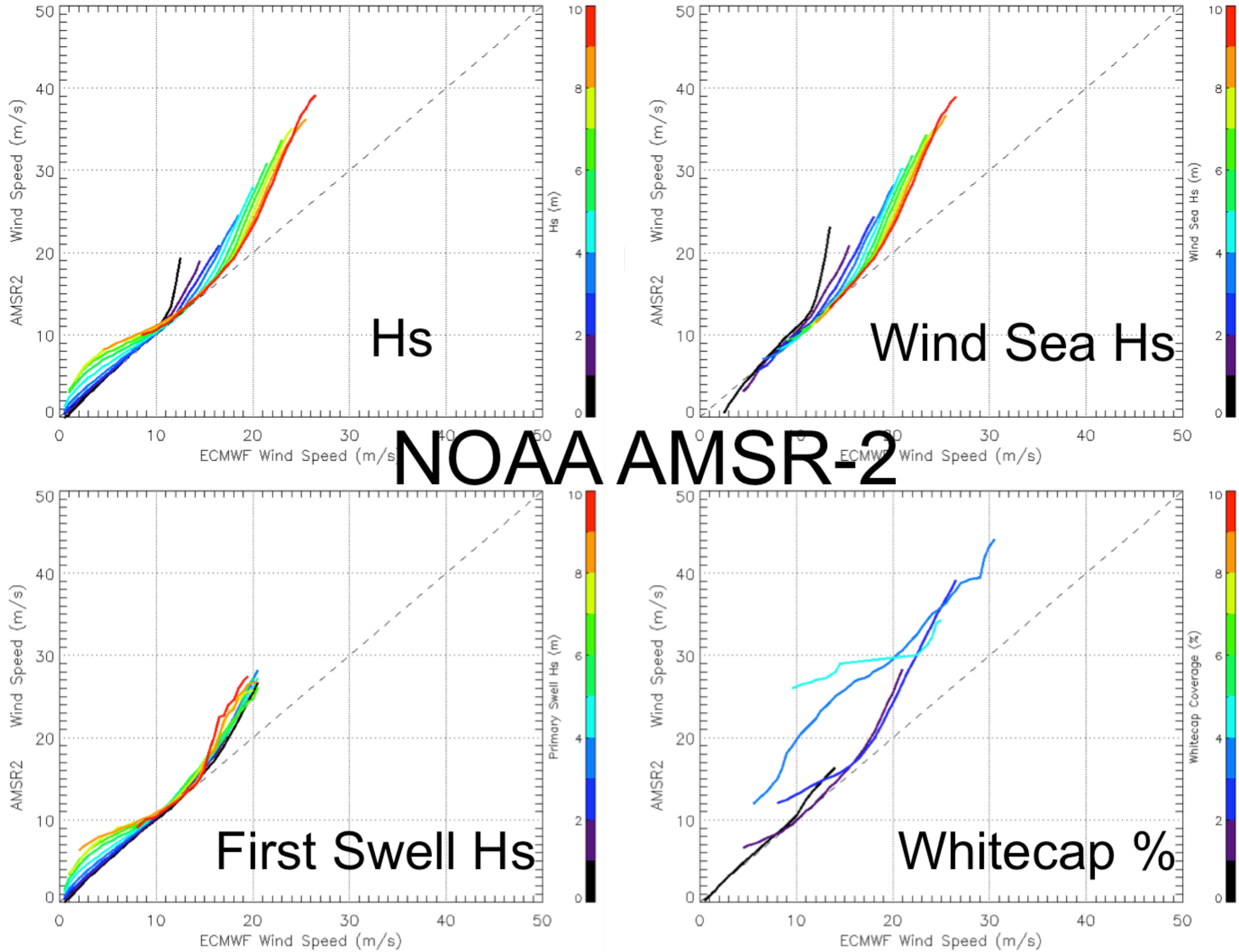
Models:

•ECMWF wind

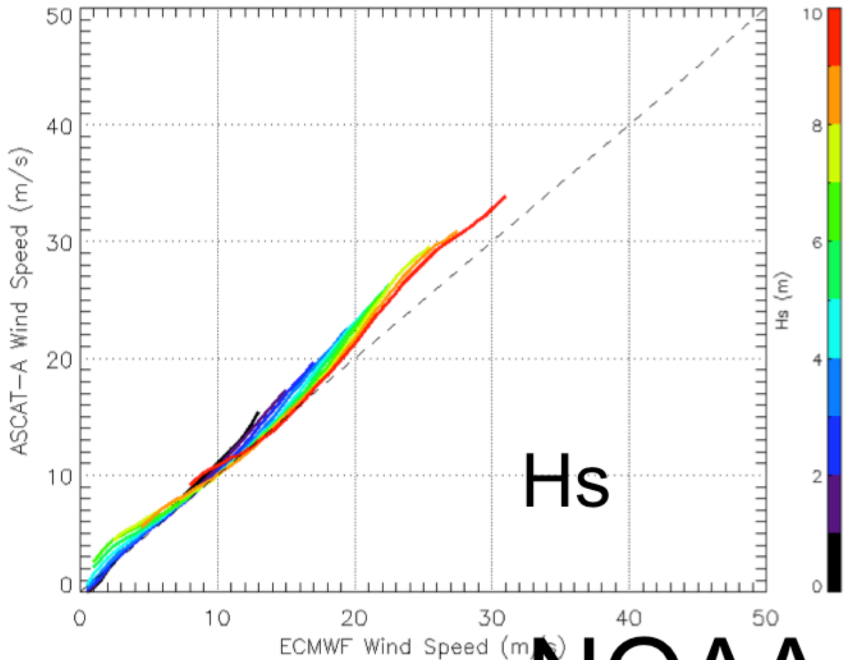
•IFREMER wavewatch (hindcast)

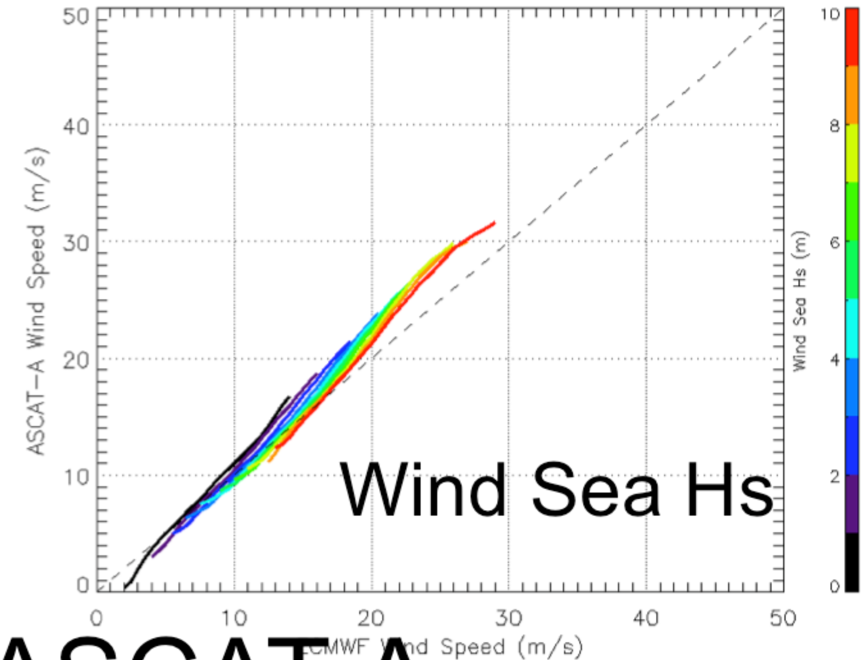
Match up time period: July 1st 2014-Sep 30th 2015

NOAA AMSR-2

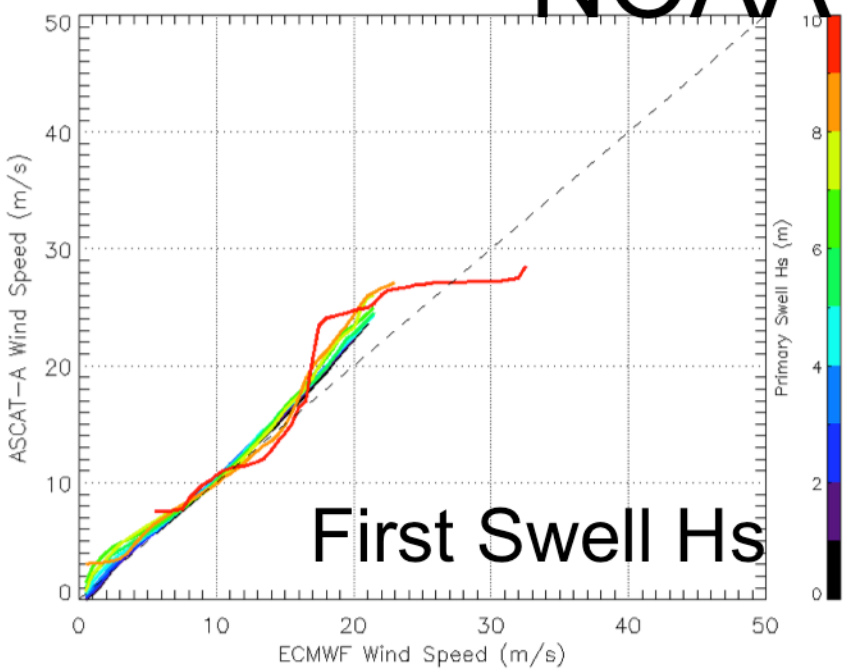


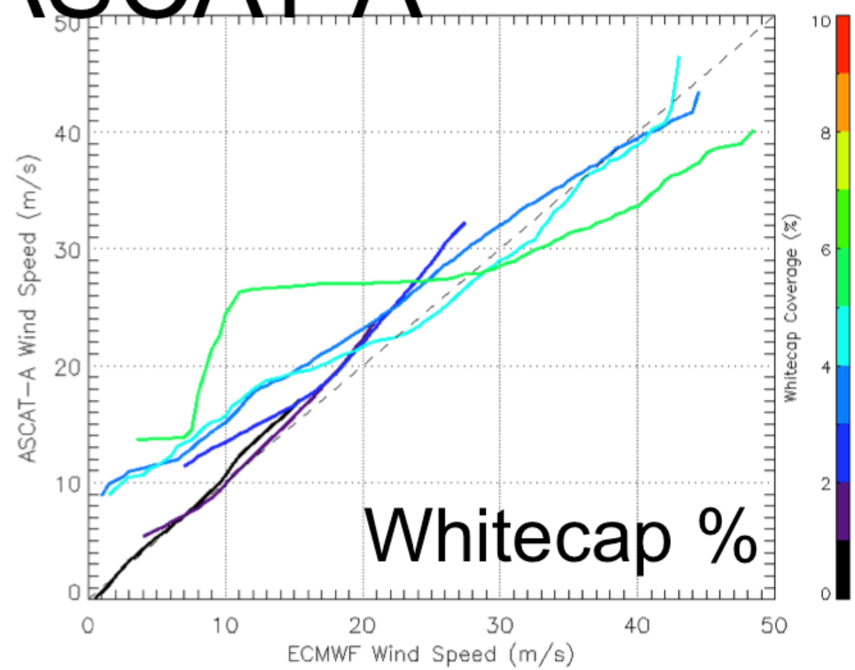
Hs
Wind Sea Hs
First Swell Hs
Whitecap %
AMSR2 Wind Speed (m/s)
ECMWF Wind Speed (m/s)
Hs (m)
Wind Sea Hs (m)
Primary Swell Hs (m)
Whitecap Coverage (%)


Hs
ASCAT−A Wind Speed (m/s)
ECMWF Wind Speed (m/s)
Hs (m)


Wind Sea Hs
ASCAT−A Wind Speed (m/s)
ECMWF Wind Speed (m/s)
Wind Sea Hs (m)

NOAA ASCAT-A

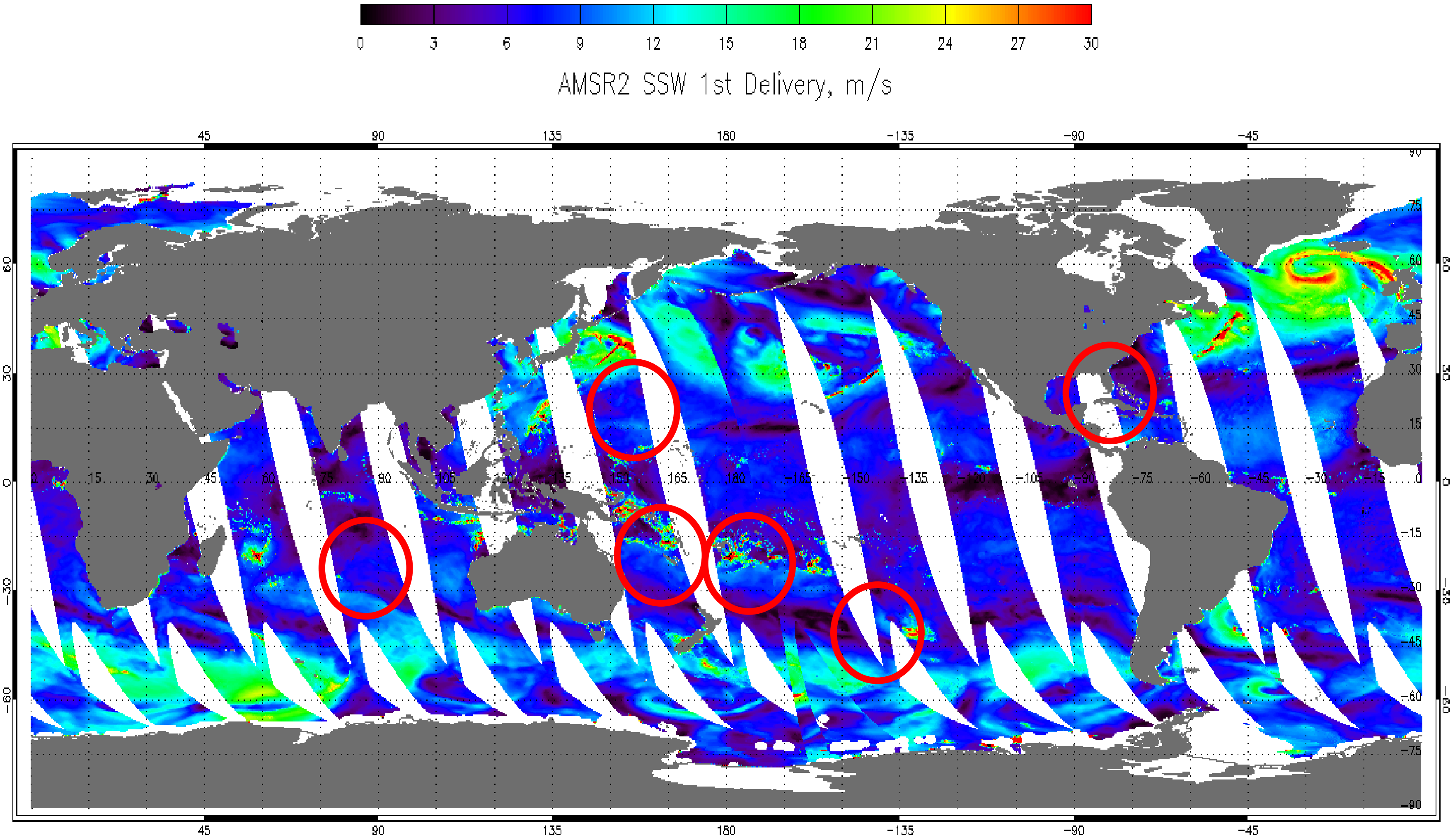

First Swell Hs
ASCAT−A Wind Speed (m/s)
ECMWF Wind Speed (m/s)
Primary Swell Hs (m)


Whitecap %
ASCAT−A Wind Speed (m/s)
ECMWF Wind Speed (m/s)
Whitecap Coverage (%)

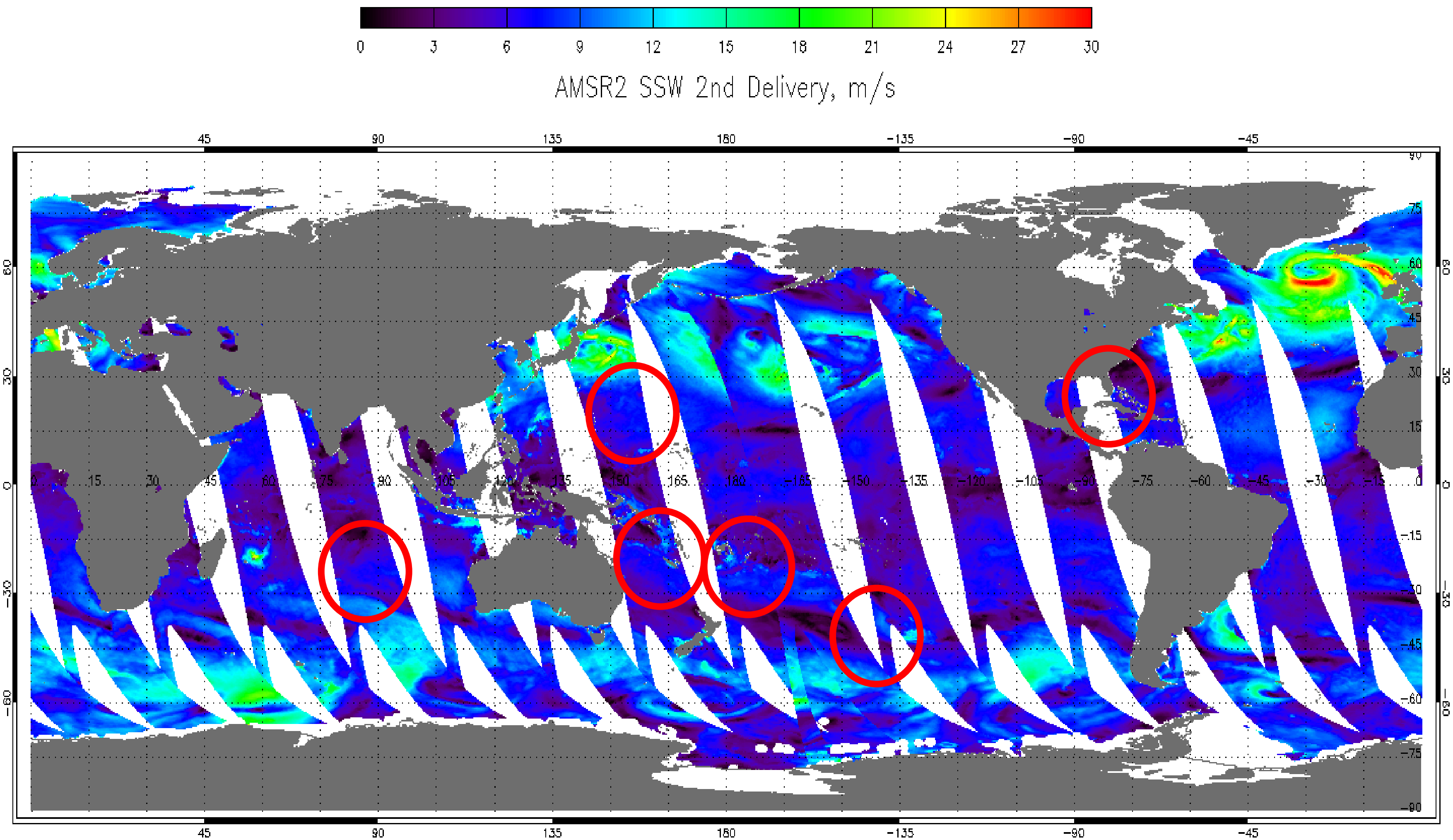
Second Generation NOAA AMSR-2 Wind Speed Product

- 2nd Generation Wind Speed Algorithm
  - Uses all 6-36GHz channels
    - Proper channel weighing functions in different atmospheric regimes ensure that higher resolution features are preserved as much as possible
  - New product is all weather wind product
    - Significant improvement of winds in rain is achieved
    - Improved winds within ITCZ zone
    - Improved winds in Southern Hemisphere
  - Winds as close as 25km of the coast

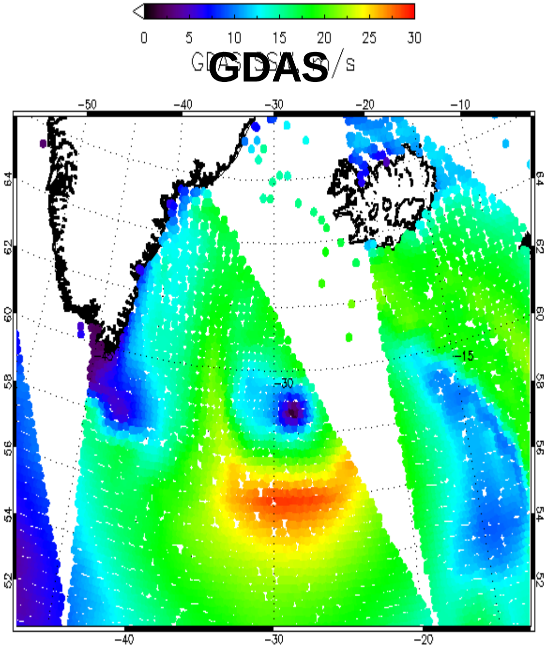
NOAA 1st Delivery



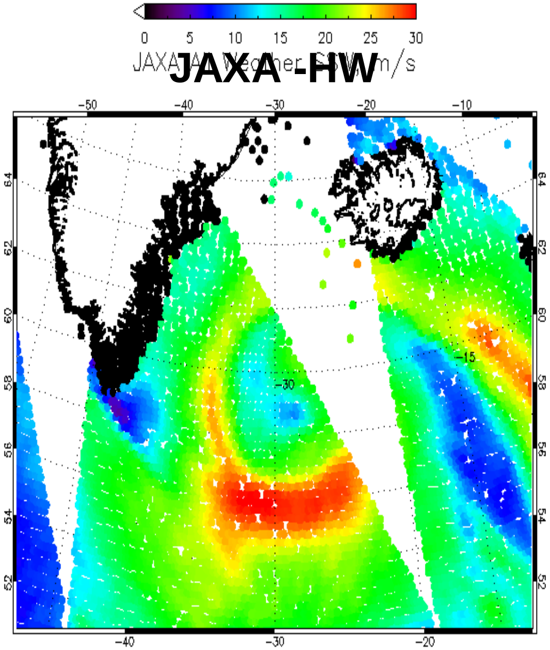
NOAA 2nd Delivery



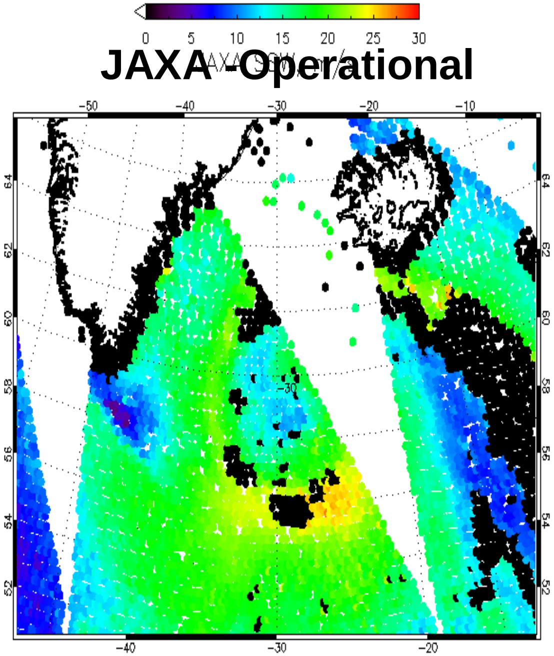
GDAS

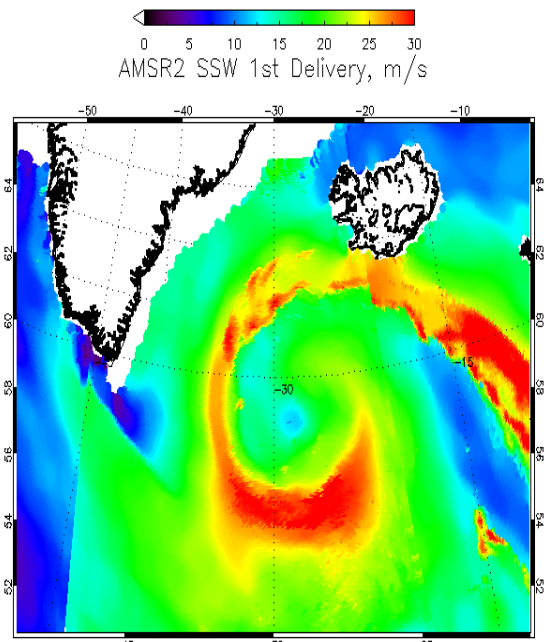


JAXA -HW

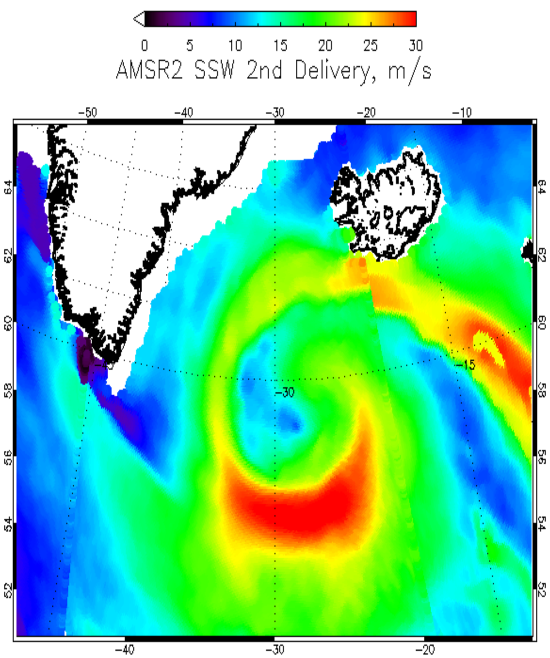


JAXA -Operational

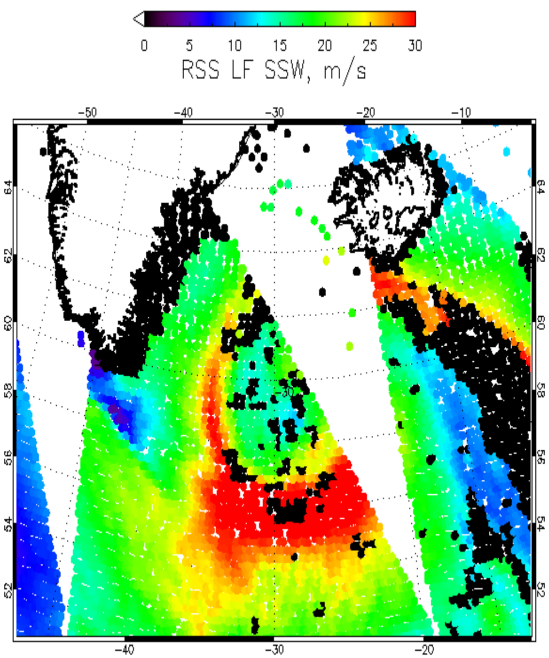




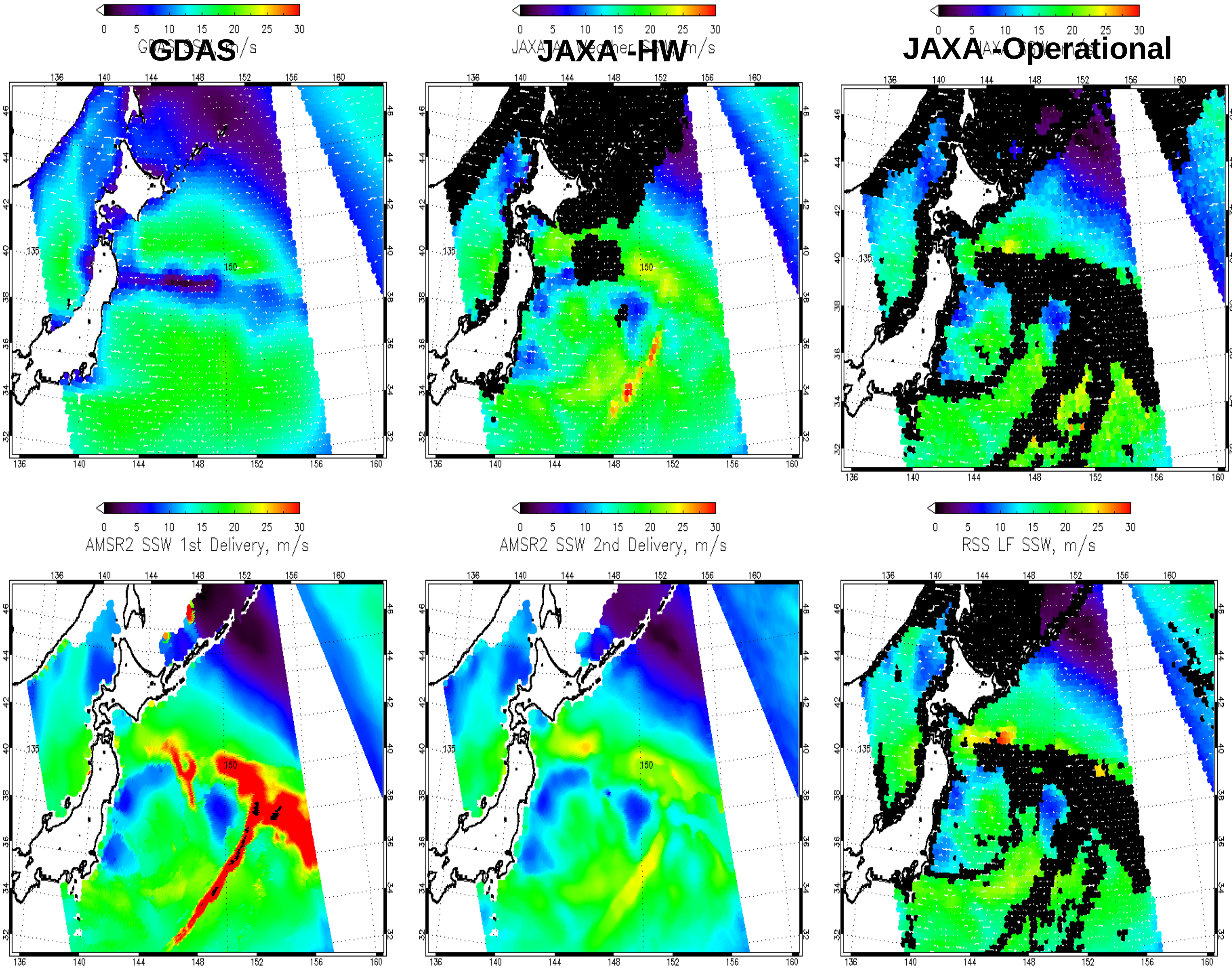
NOAA - Operational



NOAA - 2nd Generation

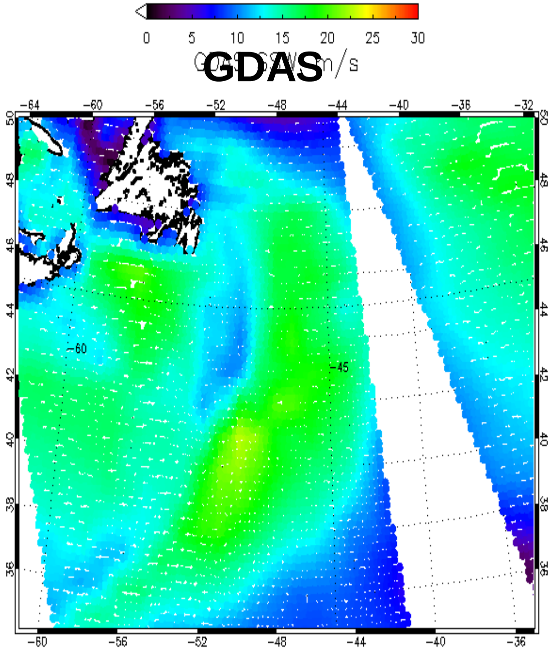


RSS - LF

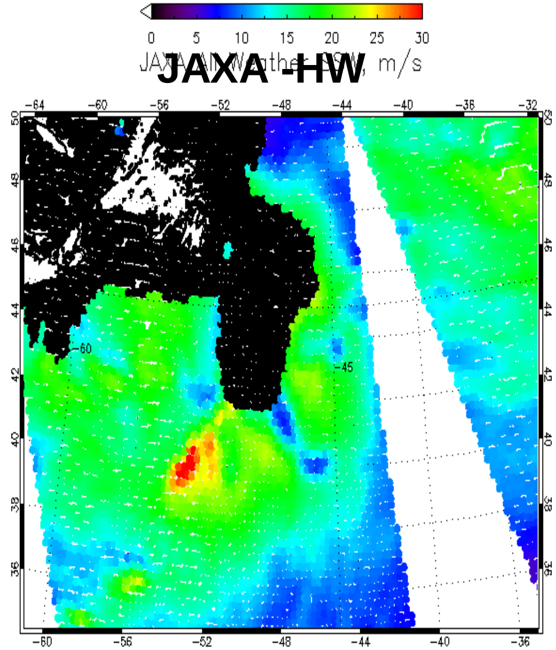


NOAA - Operational **NOAA - 2^{nd} Generation** **RSS - LF**

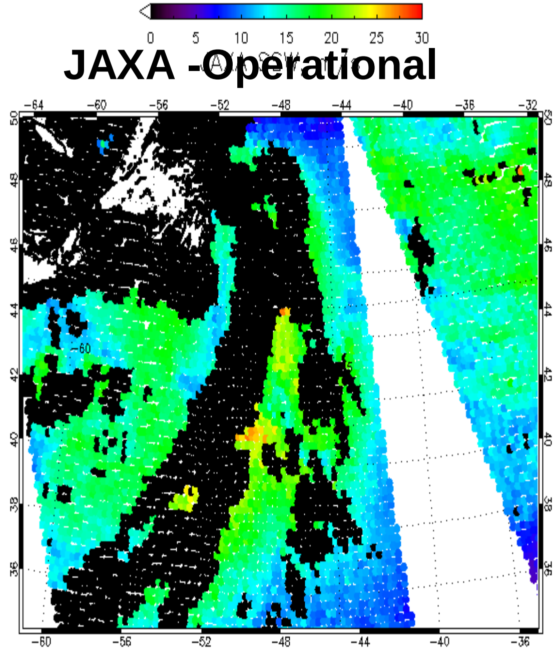
GDAS

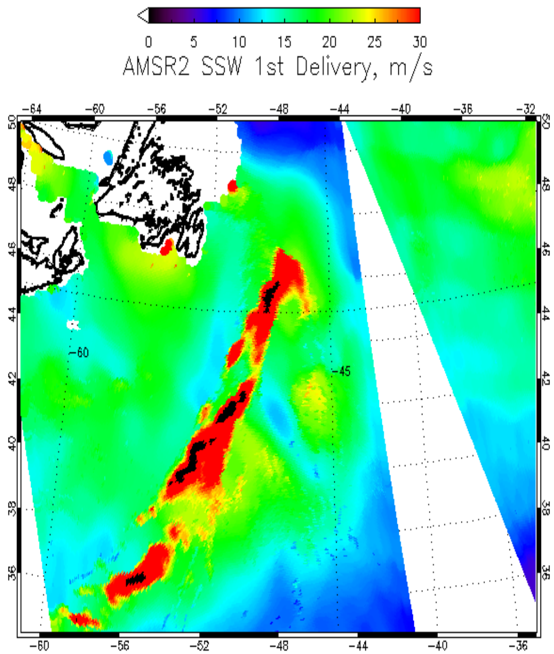


JAXA -HW

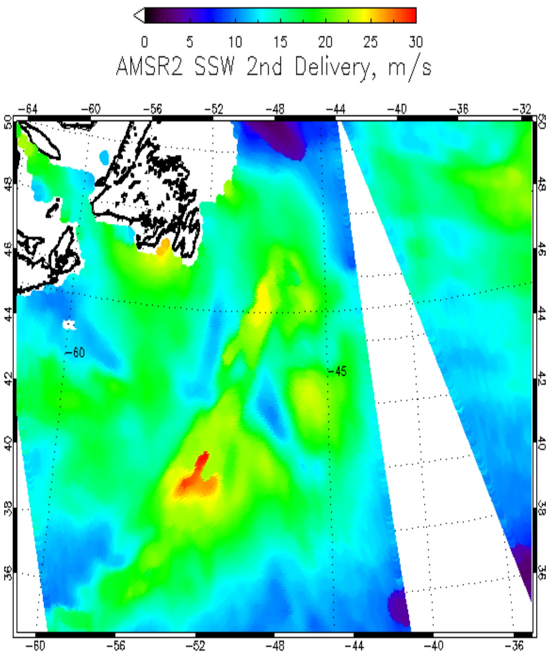


JAXA -Operational

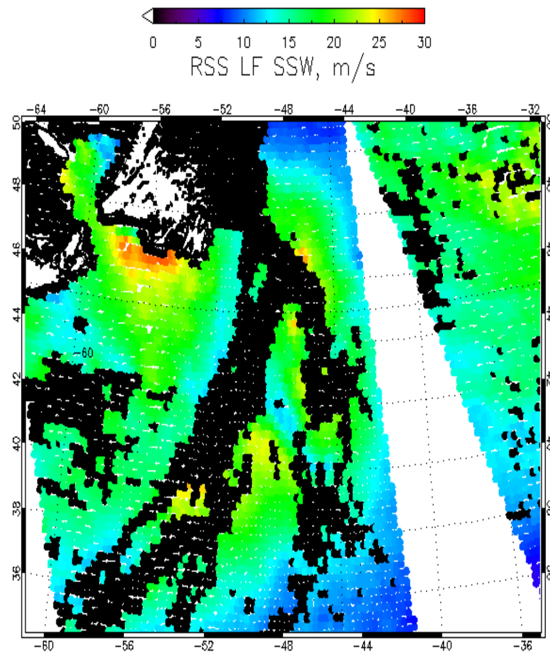




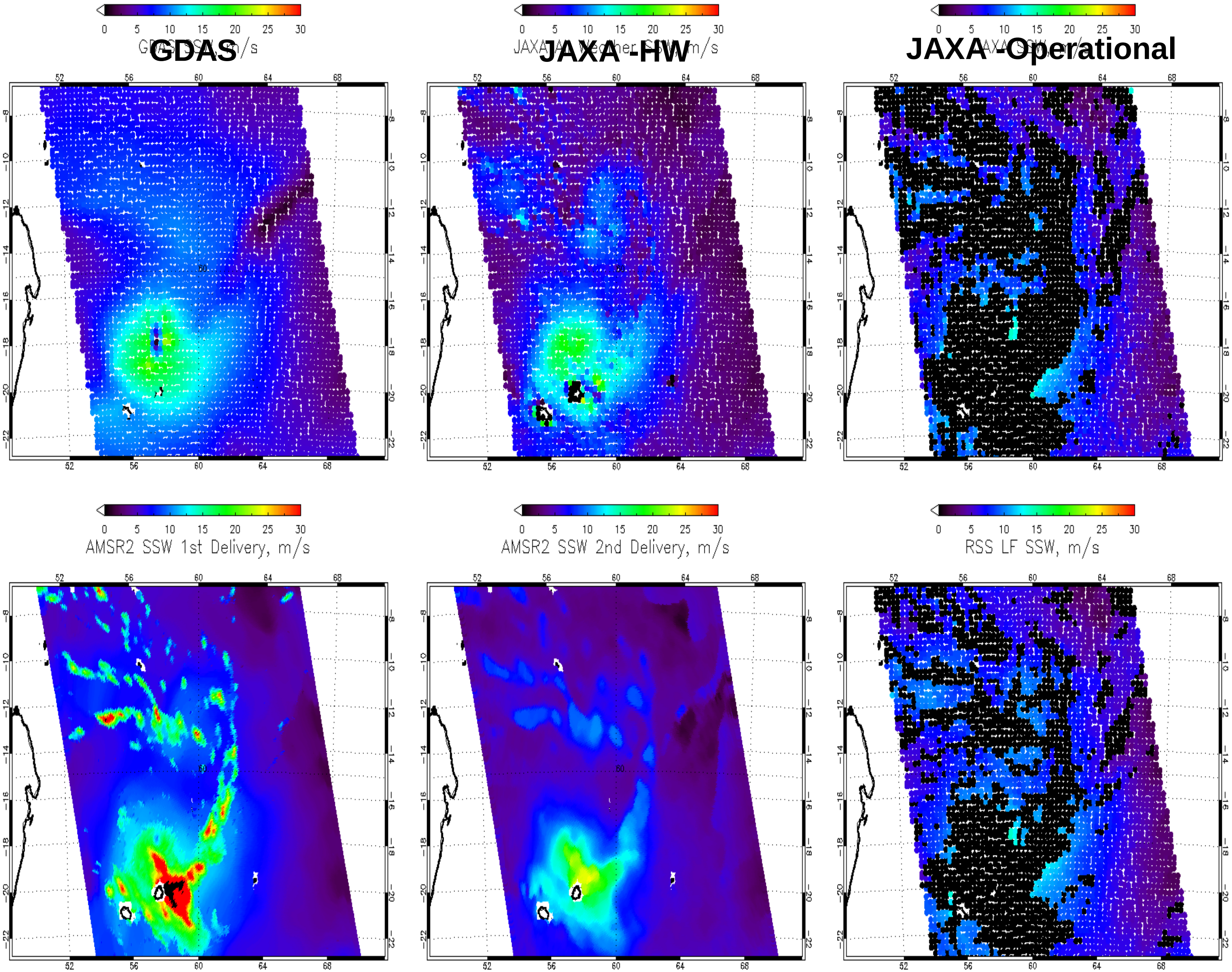
NOAA - Operational



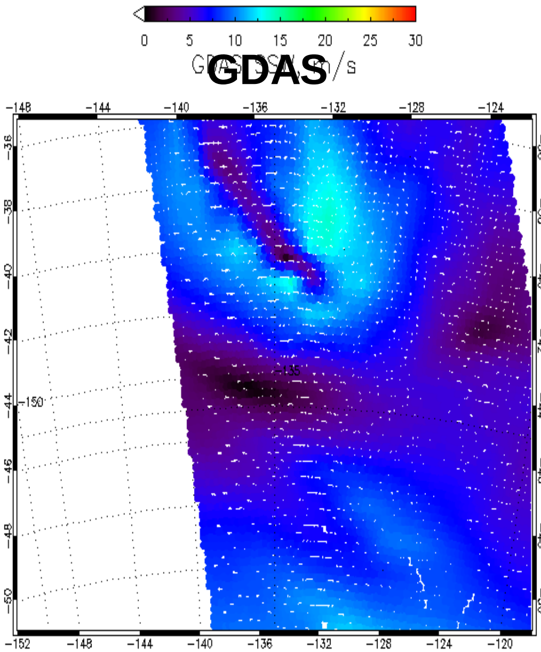
NOAA - 2nd Generation



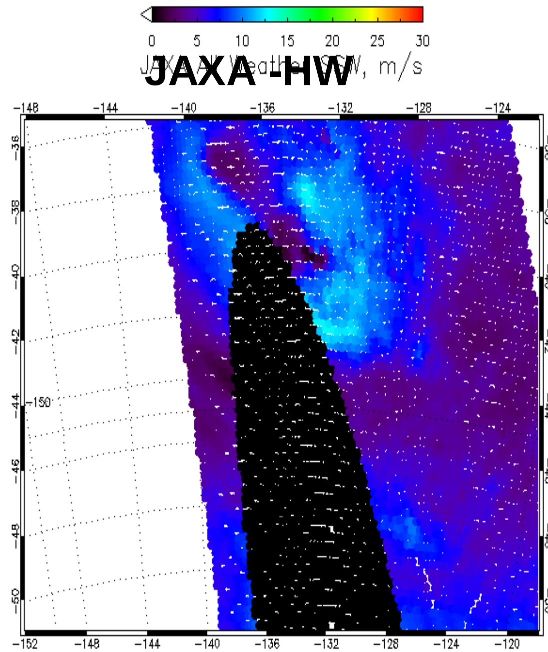
RSS - LF



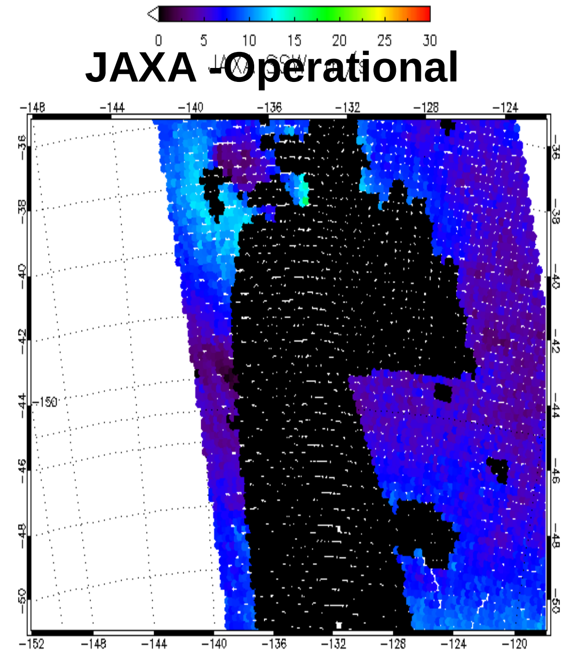
NOAA - Operational **NOAA - 2^{nd} Generation** **RSS - LF**



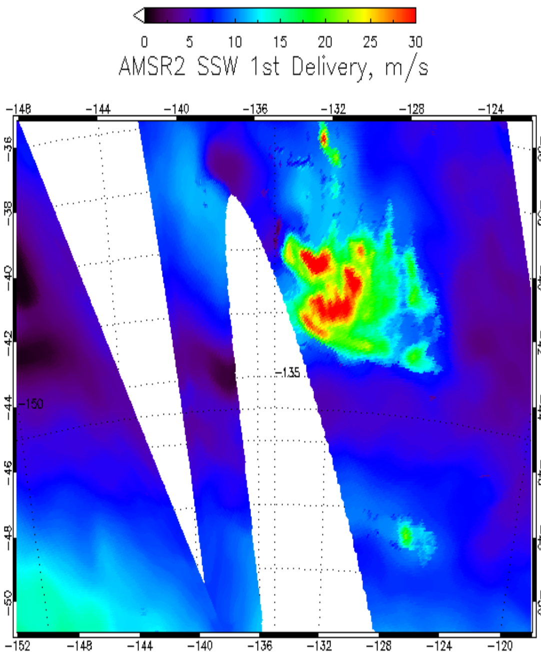
GDAS



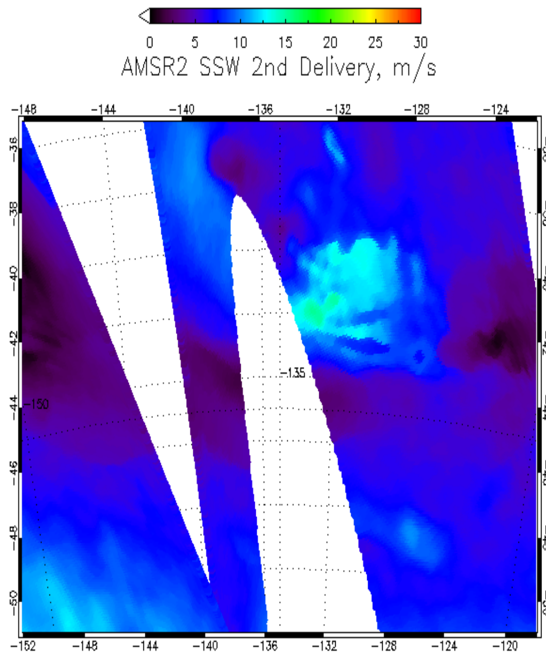
JAXA -HW



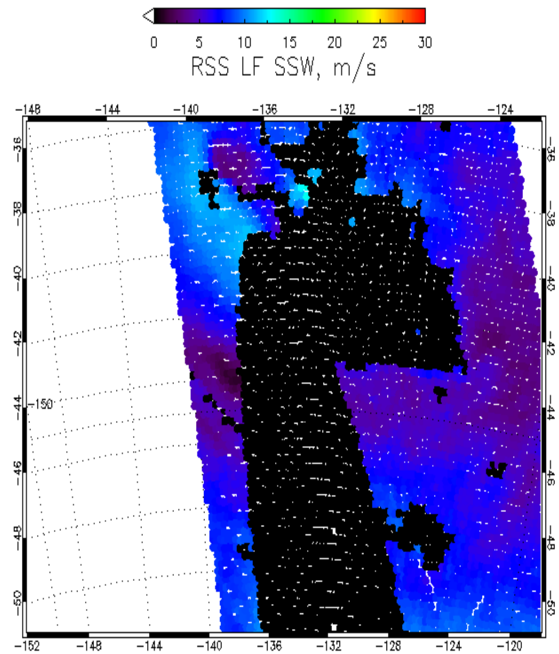
JAXA -Operational



NOAA - Operational



NOAA - 2nd Generation



RSS - LF

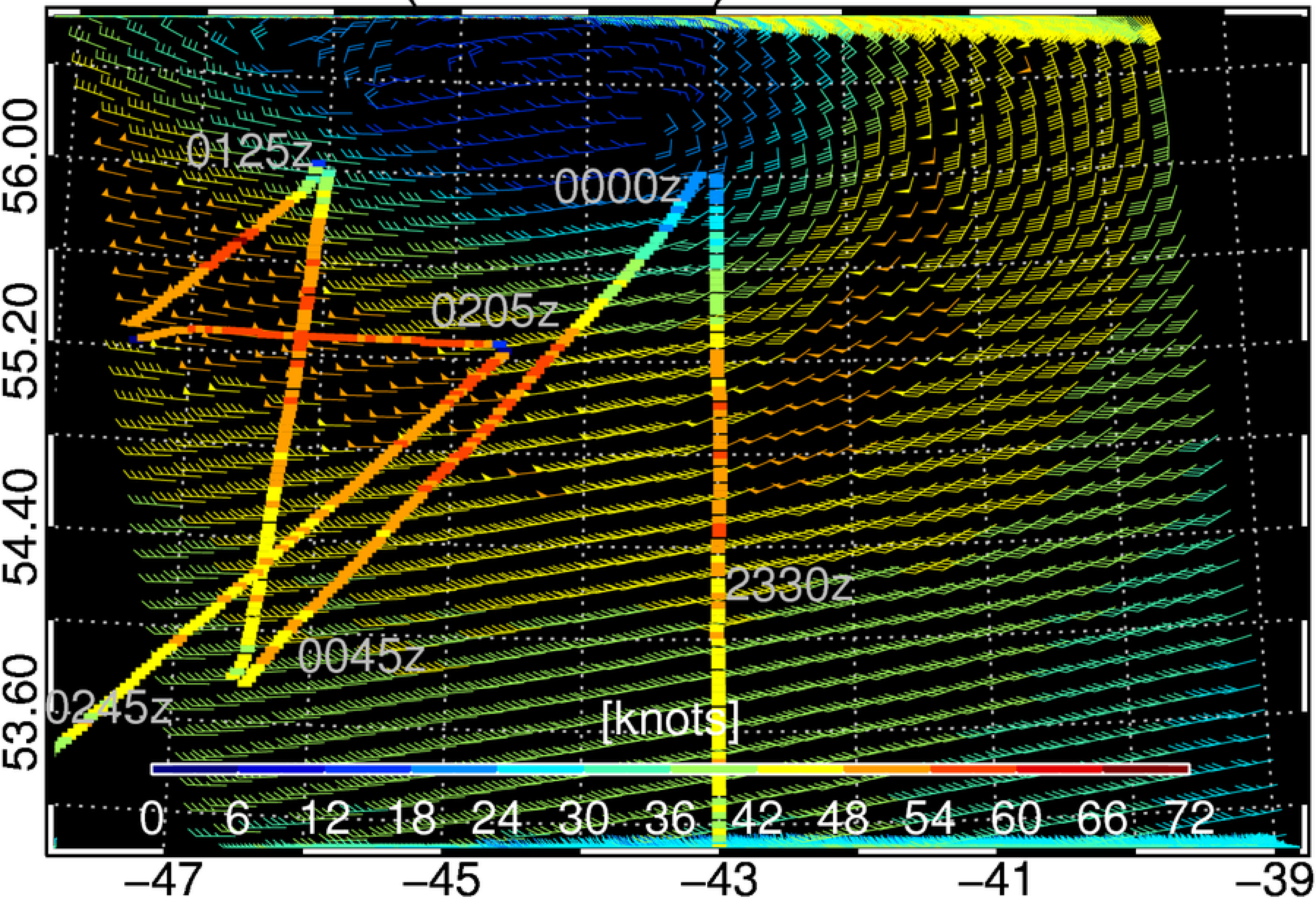
Conclusions

- 1st stage high wind validation performed. We have assessed performance of NOAA AMSR-2 Operational wind speed product performance within extratropical cyclones with respect to NOAA ASCAT, two JAXA wind products and all RSS radiometers
  - Wind field structure from NOAA Operational AMSR-2 product is:
    - On mean close to ASCAT and JAXA high wind product
    - Slightly overestimates storm force wind structure
    - Affected by rain
    - Affected by sea state
    - SFMR, IWRAP and dropsonde database developed and ready to be used for wind validation within tropical cyclones
- 2nd Generation product designed that addresses:
  - Wind retrieval performance in rain
  - High wind estimates overall intensity in rain and southern hemisphere

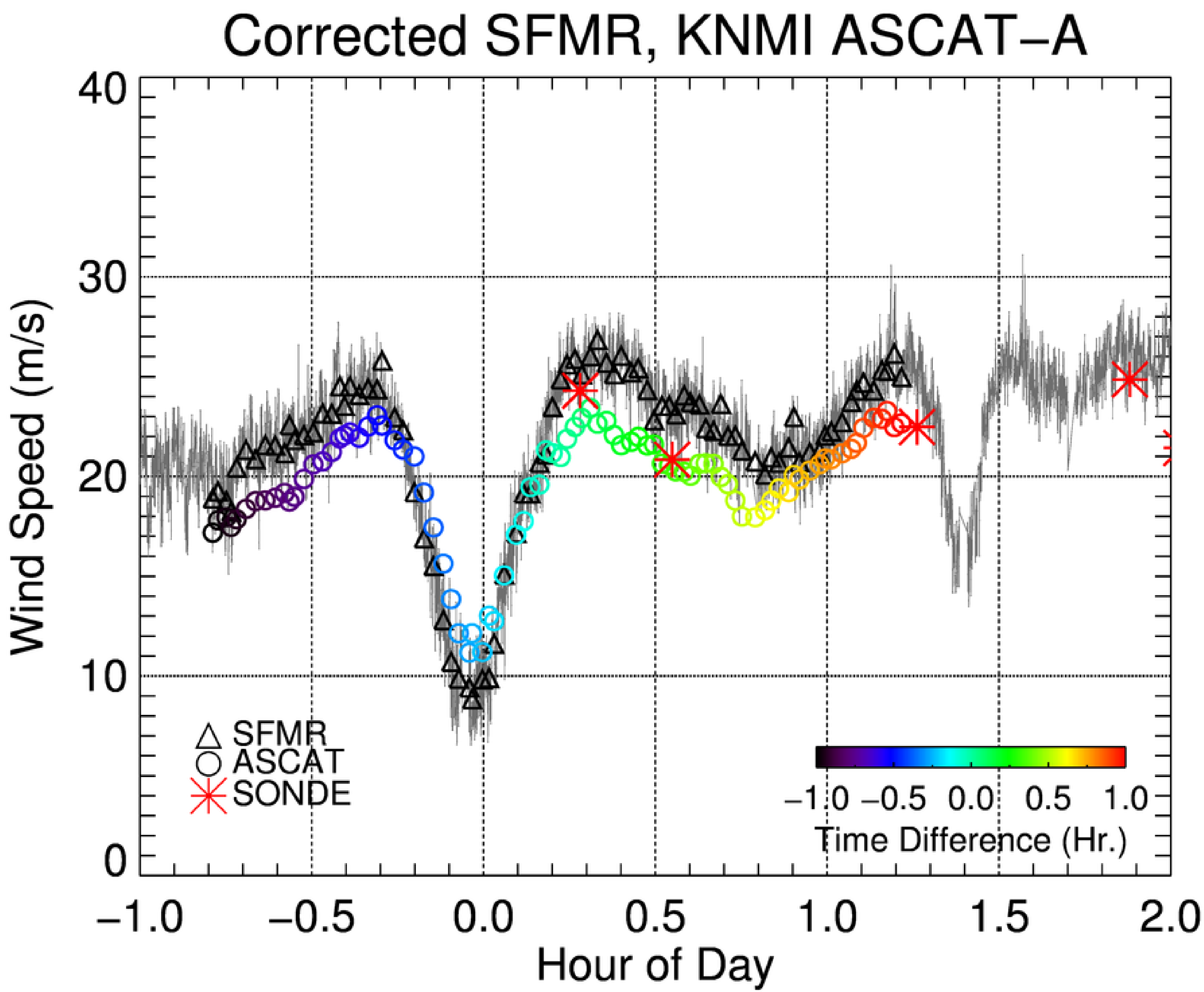
Backup Slides

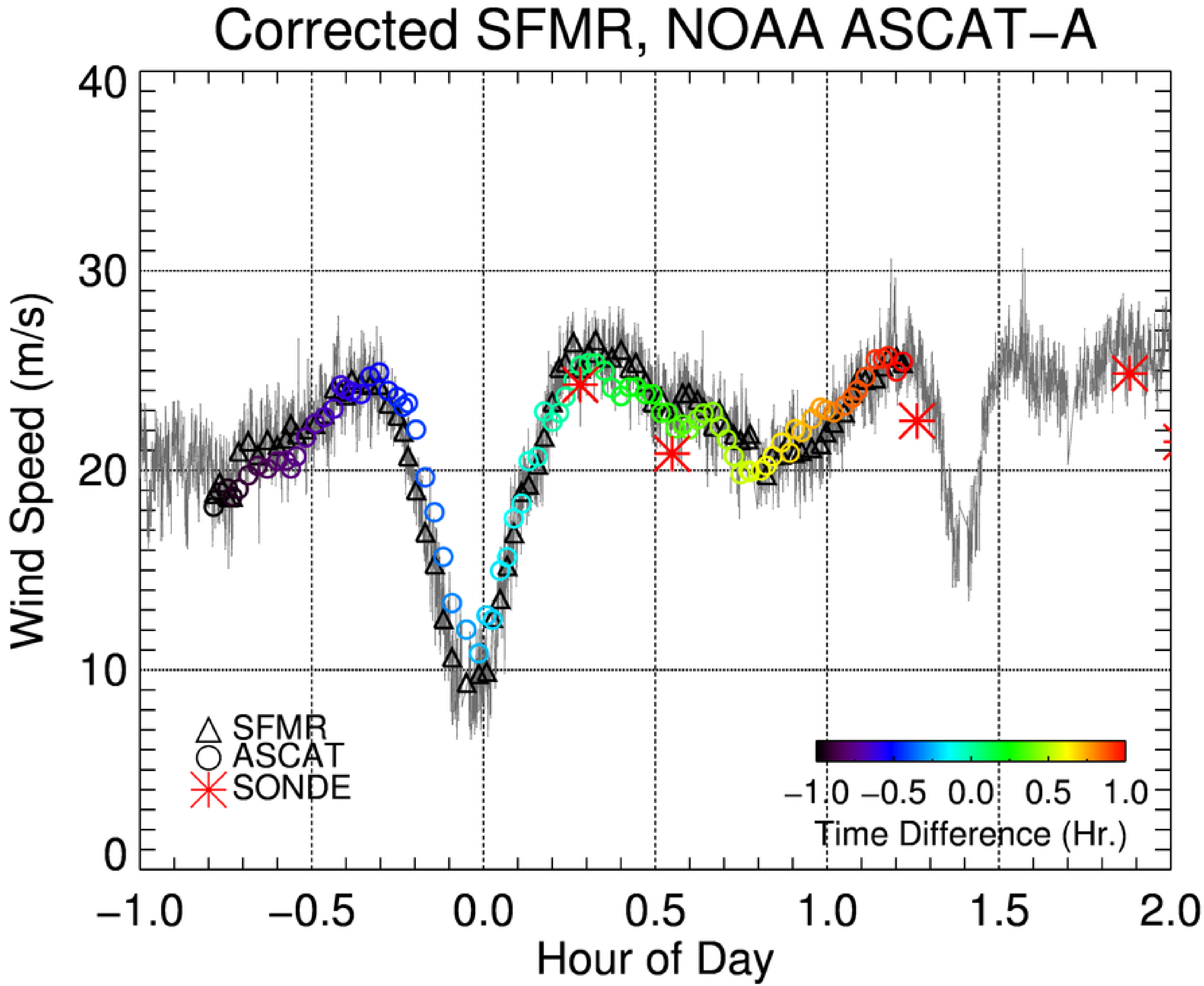
KNMI, NOAA and RSS ASCAT High Winds Case Study Extratropical Storm Feb 1st, 2010 NOAA P3 Flight

Ascat A (CMOD5–H) 201002020012

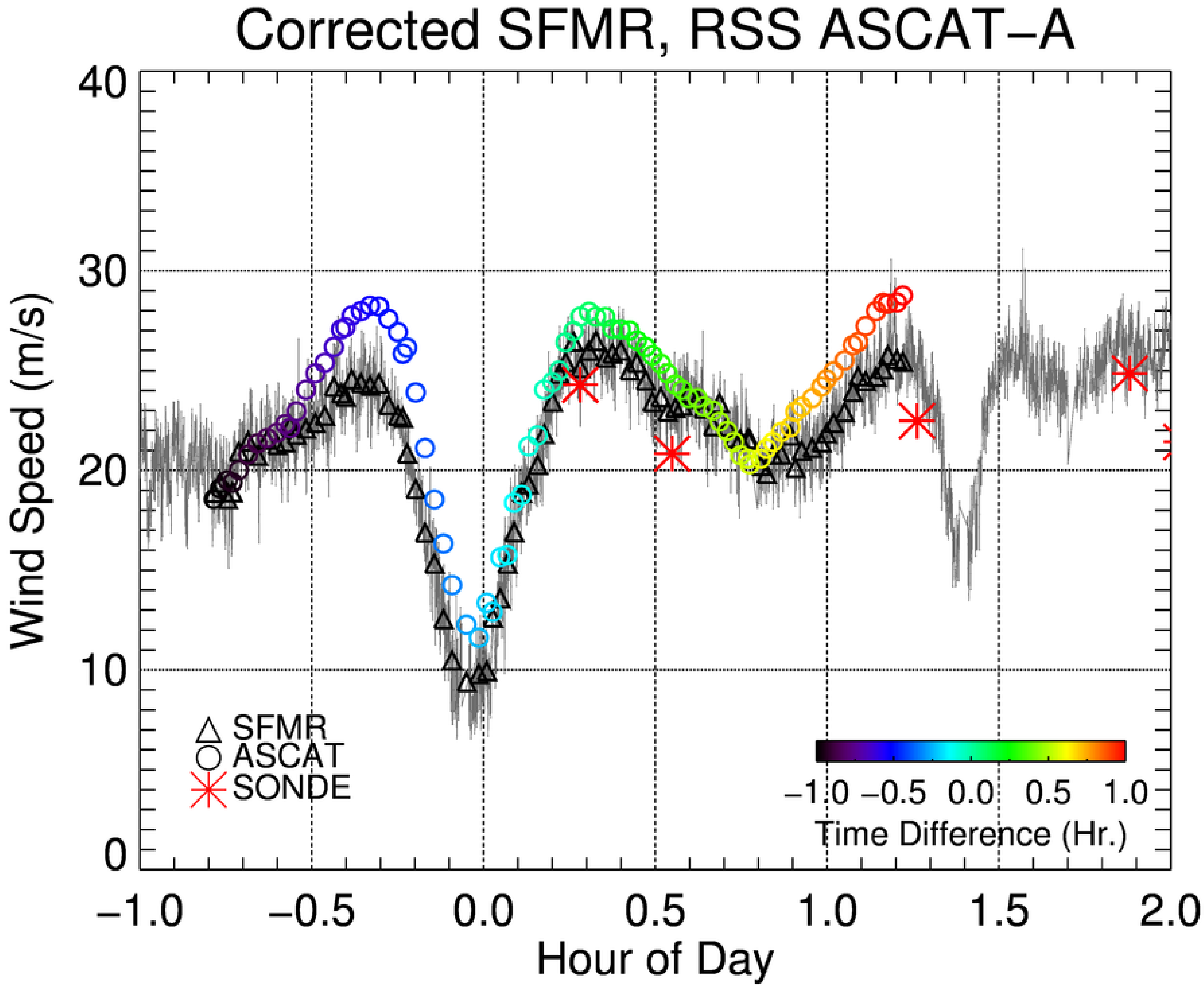


UNCORRECTED SFMR WINDS

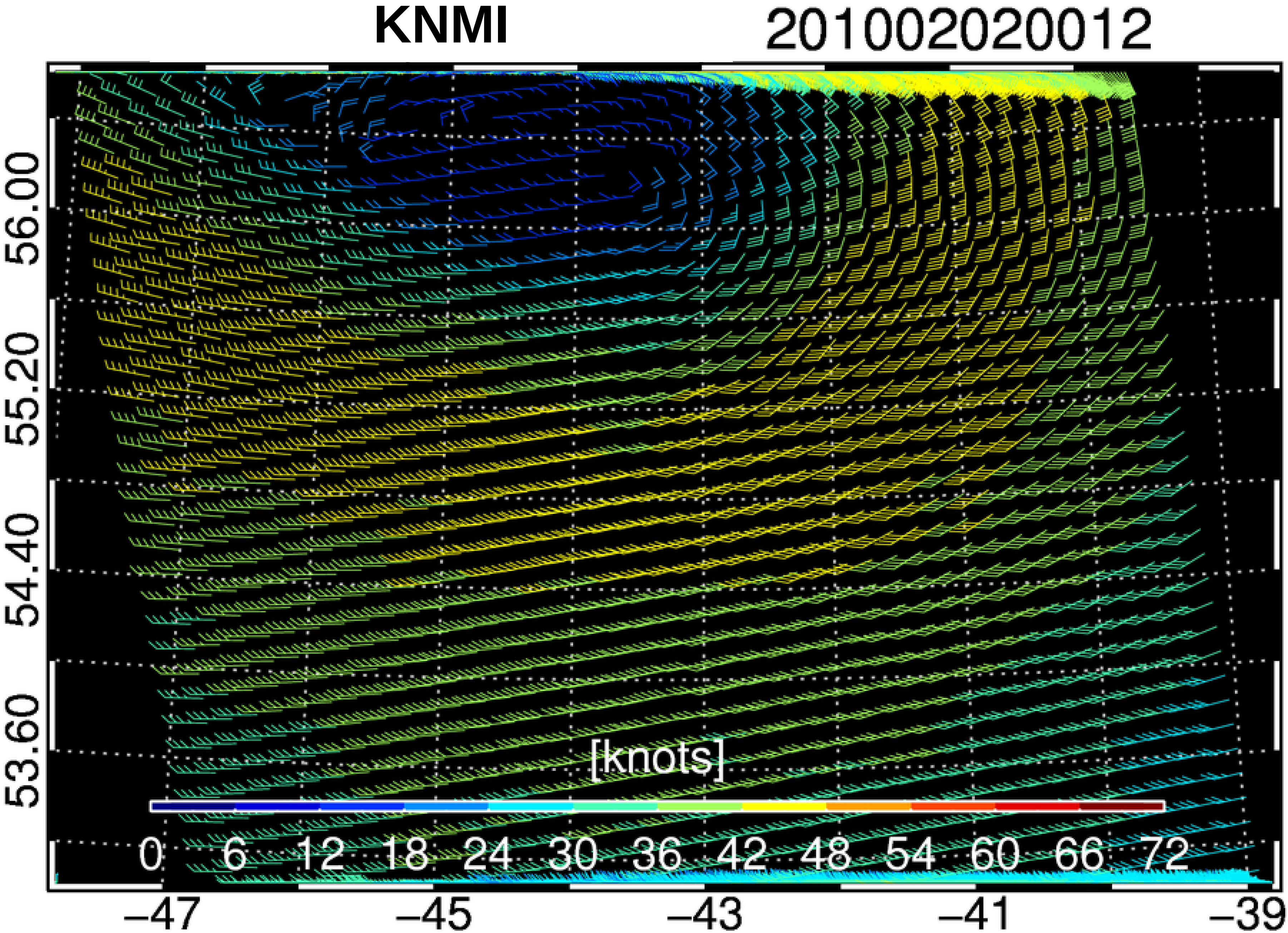

Corrected SFMR, KNMI ASCAT–A
Wind Speed (m/s)
Hour of Day
SFMR
ASCAT
SONDE
–1.0 –0.5 0.0 0.5 1.0
Time Difference (Hr.)
40
30
20
10
0
–1.0
–0.5
0.0
0.5
1.0
1.5
2.0

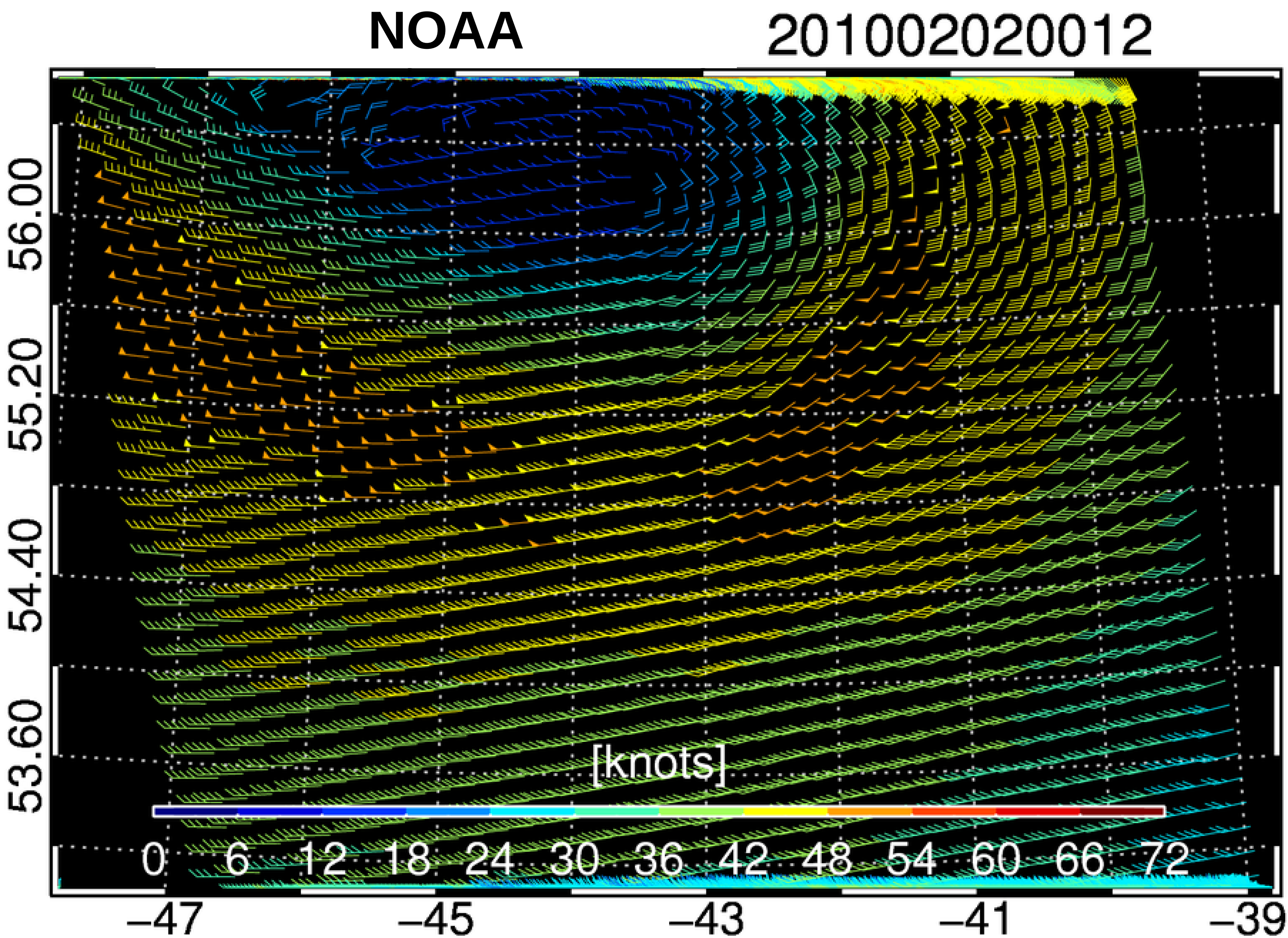


Corrected SFMR, NOAA ASCAT−A
Wind Speed (m/s)
40
30
20
10
0
−1.0
−0.5
0.0
0.5
1.0
1.5
2.0
Hour of Day
SFMR
ASCAT
SONDE
−1.0 −0.5 0.0 0.5 1.0
Time Difference (Hr.)

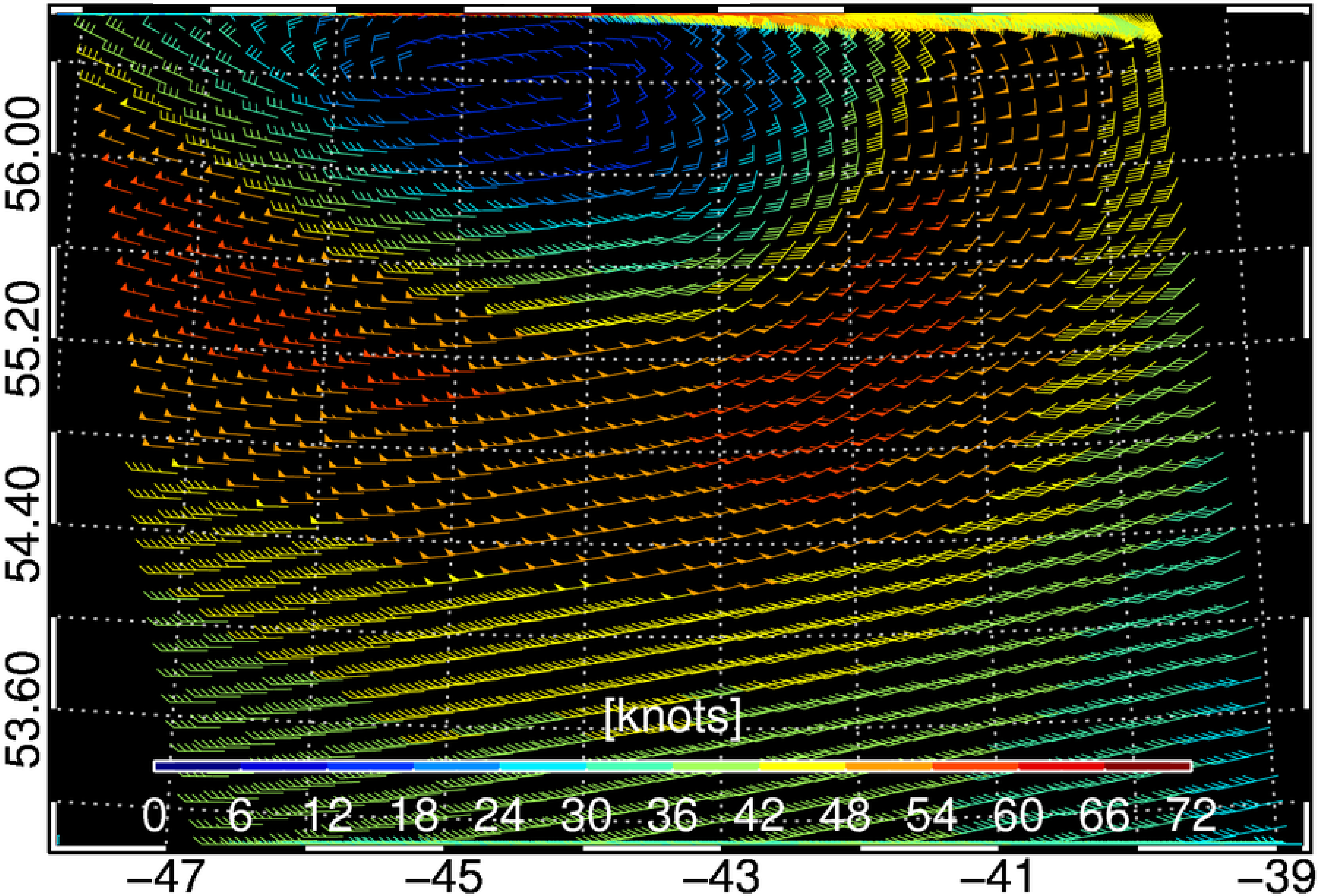


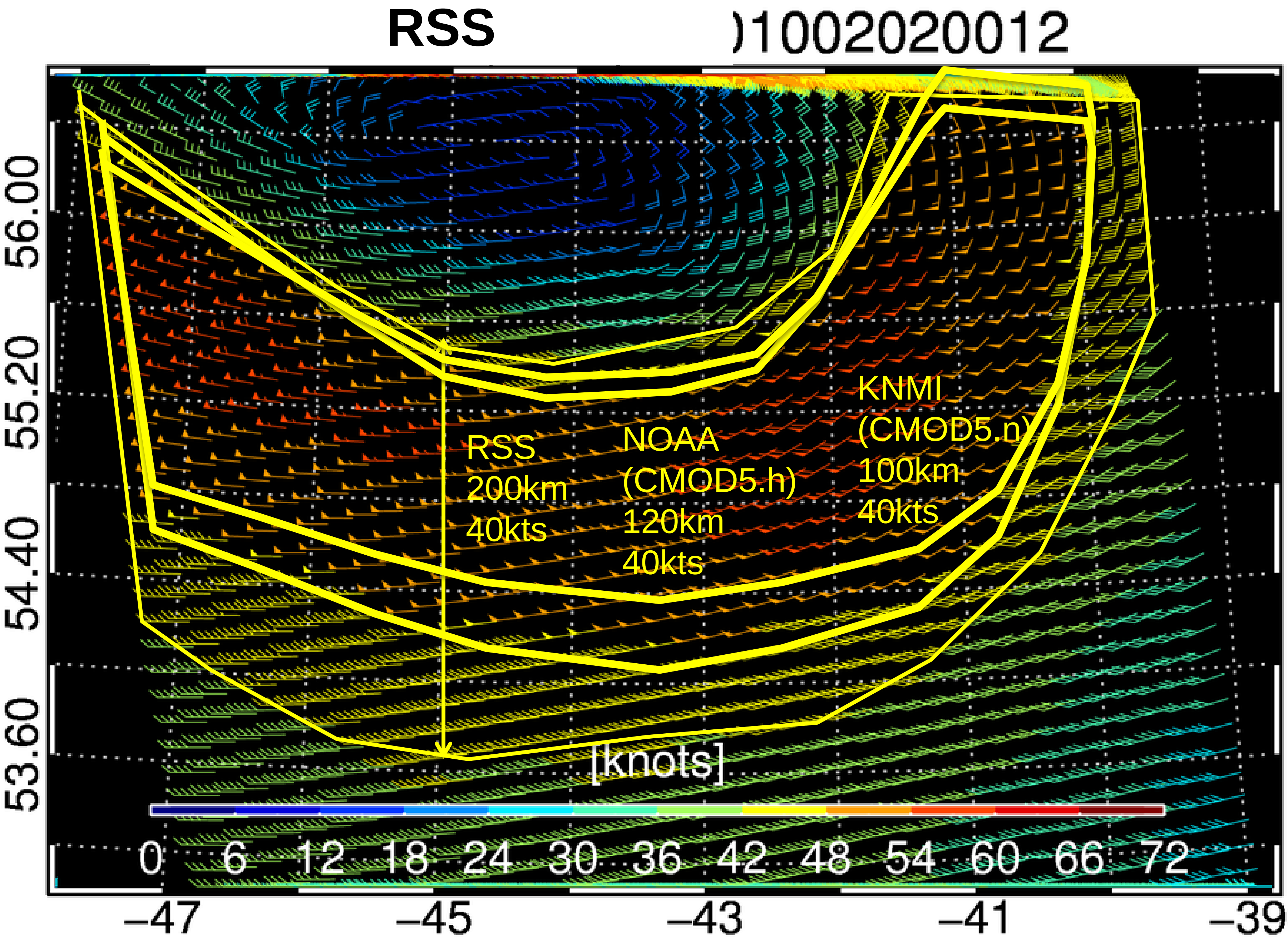
Corrected SFMR, RSS ASCAT–A
Wind Speed (m/s)
40
30
20
10
0
–1.0
–0.5
0.0
0.5
1.0
1.5
2.0
Hour of Day
SFMR
ASCAT
SONDE
–1.0 –0.5 0.0 0.5 1.0
Time Difference (Hr.)

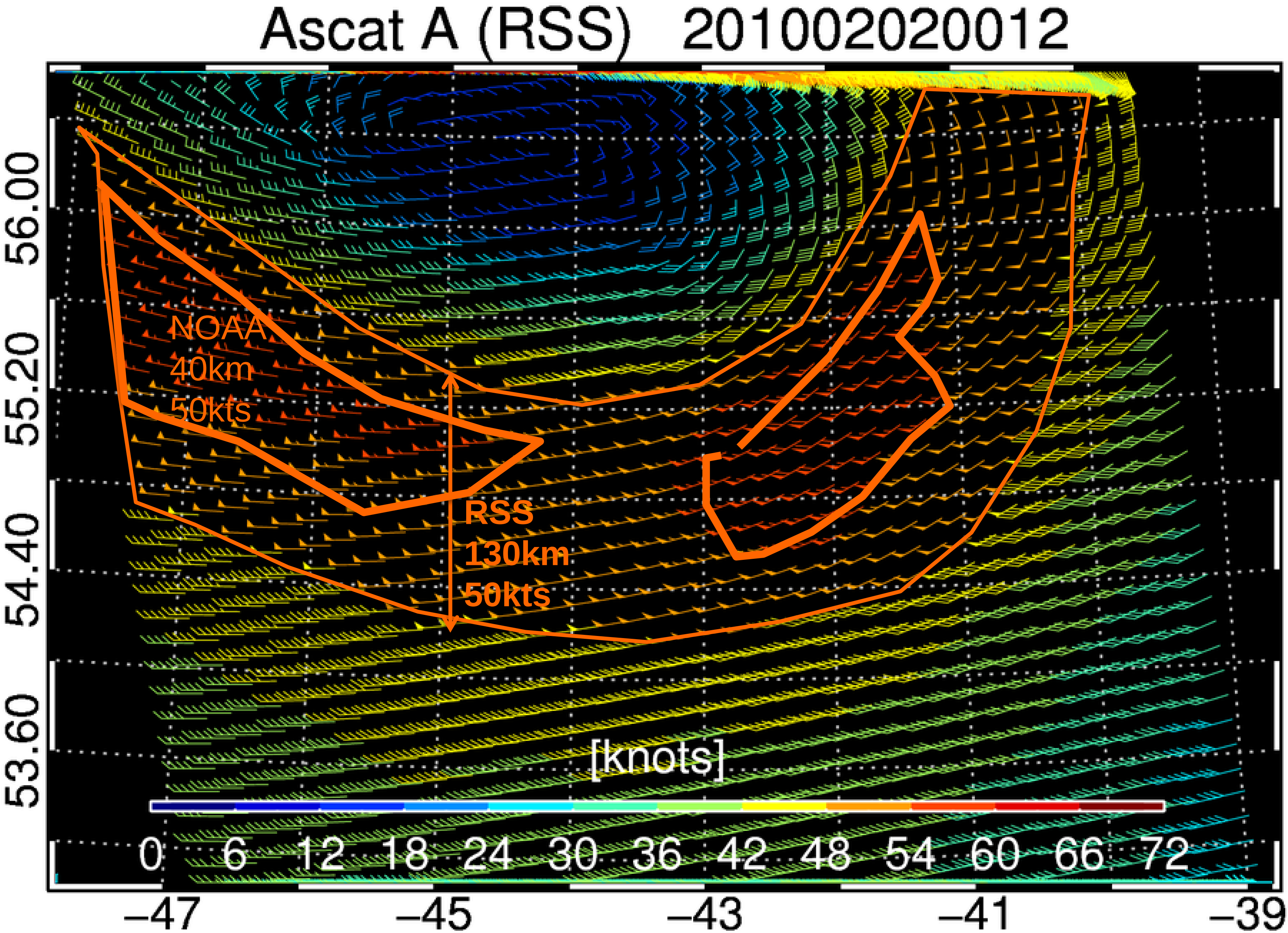

KNMI
201002020012
56.00
55.20
54.40
53.60
[knots]
0 6 12 18 24 30 36 42 48 54 60 66 72
–47
–45
–43
–41
–39


NOAA
201002020012
56.00
55.20
54.40
53.60
[knots]
0 6 12 18 24 30 36 42 48 54 60 66 72
−47
−45
−43
−41
−39

RSS)1002020012




RSS
)1002020012
56.00
55.20
54.40
53.60
RSS
200km
40kts
NOAA
(CMOD5.h)
120km
40kts
KNMI
(CMOD5.n)
100km
40kts
[knots]
0 6 12 18 24 30 36 42 48 54 60 66 72
–47
–45
–43
–41
–39


Ascat A (RSS) 201002020012
NOAA
40km
50kts
RSS
130km
50kts
[knots]
0 6 12 18 24 30 36 42 48 54 60 66 72
56.00
55.20
54.40
53.60
–47
–45
–43
–41
–39