Integrating Multiple Scatterometer Observations into a Climate Data Record of Ocean Vector Winds

Lucrezia Ricciardulli and Frank Wentz
Remote Sensing Systems, CA, USA
E-mail: Ricciardulli@remss.com

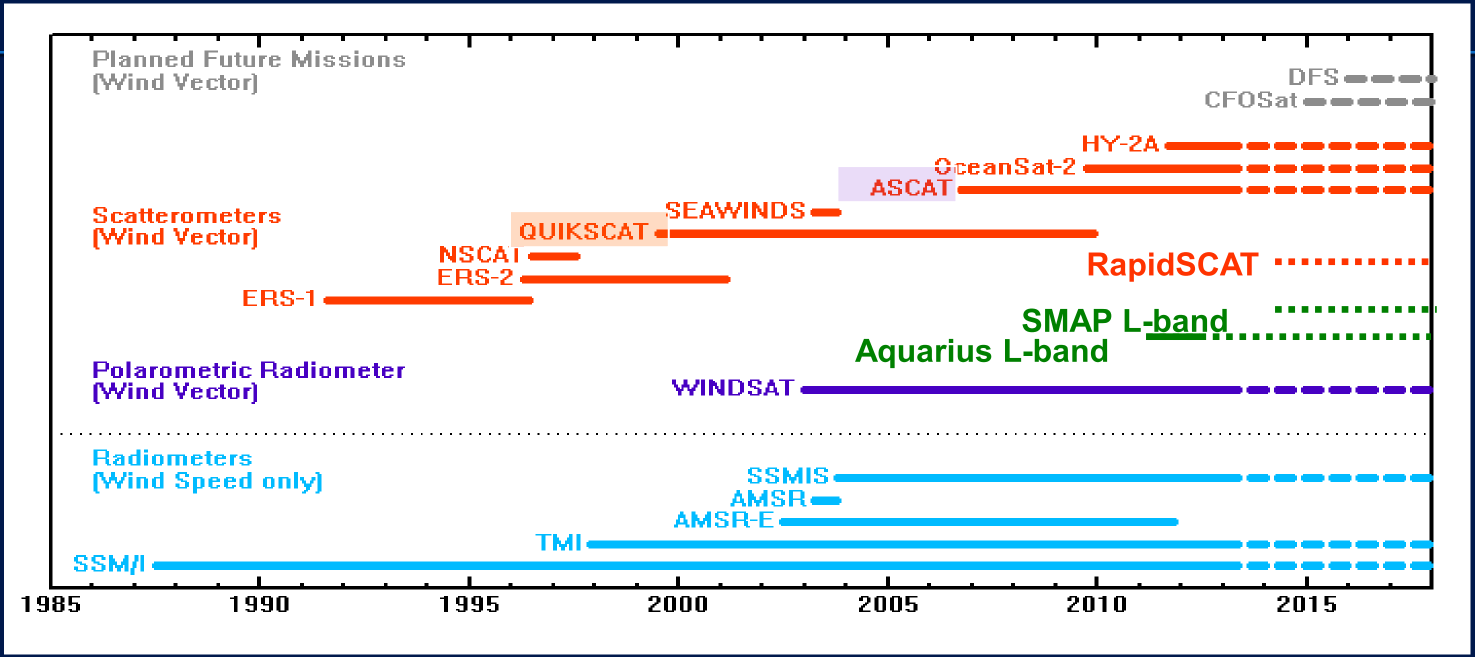
presented at
2014 AGU Ocean Science meeting
February, 24-28, 2014
Honolulu, Hawaii

Remote Sensing Systems
www.remss.com

NASA

Remote Sensing Systems
www.remss.com

Ocean Vector Wind Missions



Long-term goal:

Integrating all scatterometers measurements into a 20+ year Climate Data Record (CDR) of Ocean Vector Winds

Priorities:

1. Accurate intercalibration of different scatterometers
2. Removal of diurnal signals
3. Continuous monitoring and removal of other sources of bias

Challenges

- Scatterometers operate at different frequencies:
  - Ku-band: QuikSCAT, NSCAT, OSCAT, RapidScat
  - C-band: ASCAT, ERS
  - L-band: Aquarius, SMAP
- Different geometry
- Observations obtained at different times of the day
- Different rain impact at different frequencies
- Different sensor might have different sources of bias

Methodology

Completed Work:

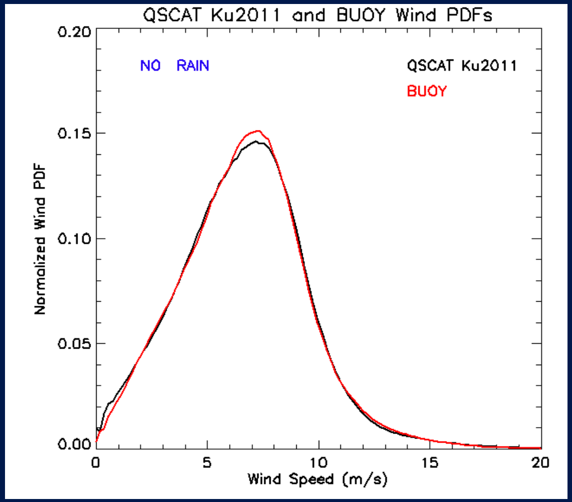
✓ Use QuikSCAT as backbone for the CDR
✓ QuikSCAT reprocessed with a new model function (GMF) Ku-2011, developed to improve retrievals at high winds
✓ Using methodology and wind algorithm similar to QuikSCAT, we developed ASCAT GMF and we produced ASCAT Winds (Remote Sensing Systems)

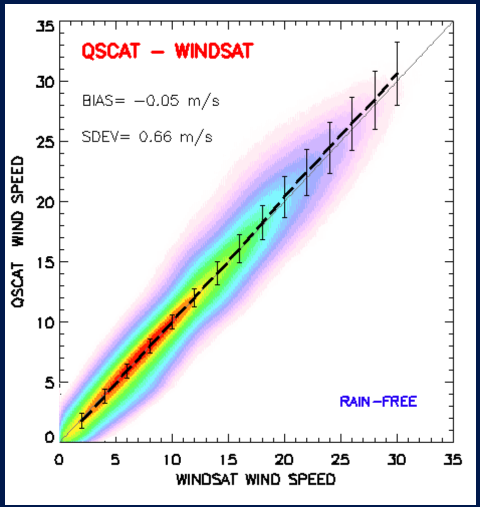
On-going Work:

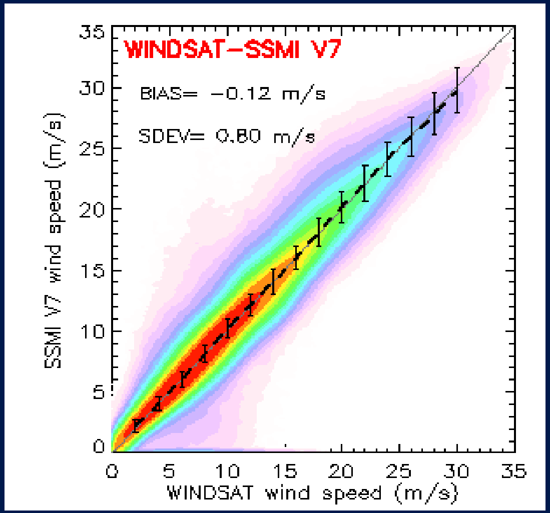
- Use same methodology to add OSCAT, RapidSCAT, ERS to CDR
- Understand and remove sources of bias
- Use L-band and radiometers to understand rain signal
- Use RapidScat to understand and remove diurnal variability signal

Note: The GMF is a model that relates the observed backscatter to ocean wind speed and direction

QuikSCAT and ASCAT Calibration Reference

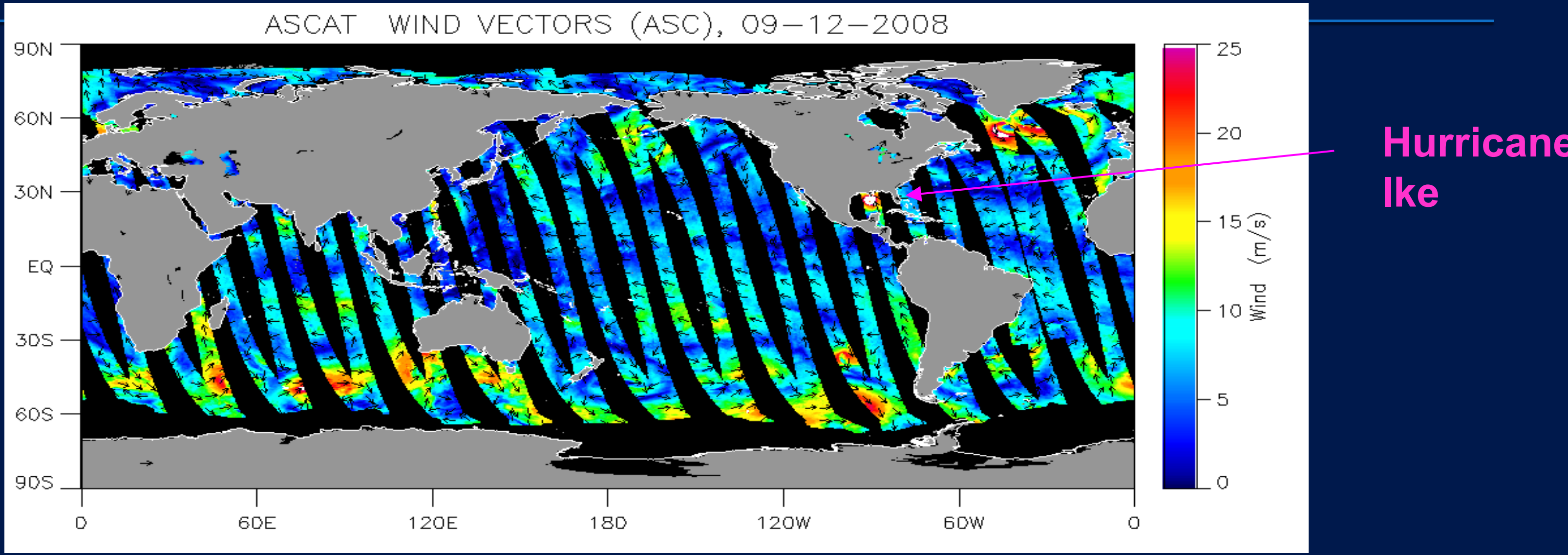






- In 2011, a new QuikSCAT GMF Ku-2011 was developed to improve high wind speed retrievals between 20-30 m/s (Ricciardulli and Wentz, 2011). WindSat was used as ground truth for high winds and to rain-flag the QuikSCAT backscatter observations.
- WindSat is reliable at 20-35 m/s, even in storms (Meissner and Wentz, 2009; 2012).
- WindSat is part of our intercalibrated V7 winds, which include retrievals from SSM/I and SSMIS. The V7 wind products can be considered our scatterometer calibration reference.

New RSS ASCAT, GMF C-2013

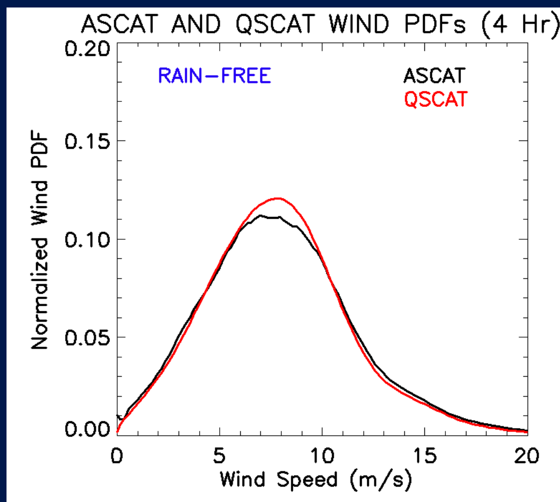


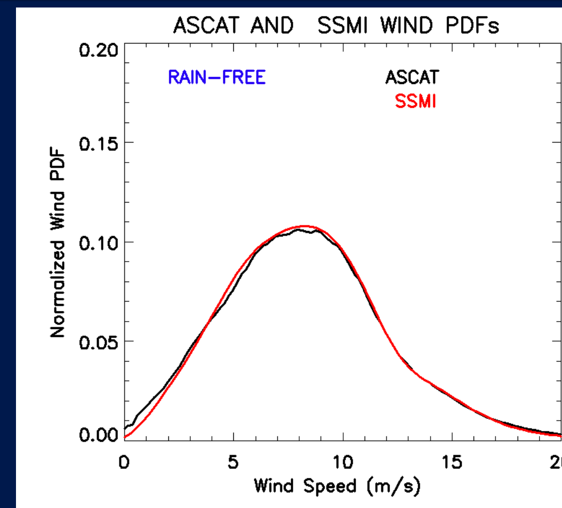
- To develop the new ASCAT GMF we used 4 years of ASCAT backscatter obs colocated with SSMI and WindSat wind speeds (120-min), and CCMP wind directions. SSMI was also used to rain-flag ASCAT backscatter
- We developed an ASCAT wind algorithm similar to the QuikSCAT one, with the added complexity of a viewing geometry with multiple incidence angles.
- The new ASCAT C-2013 winds are available via ftp at www.remss.com.

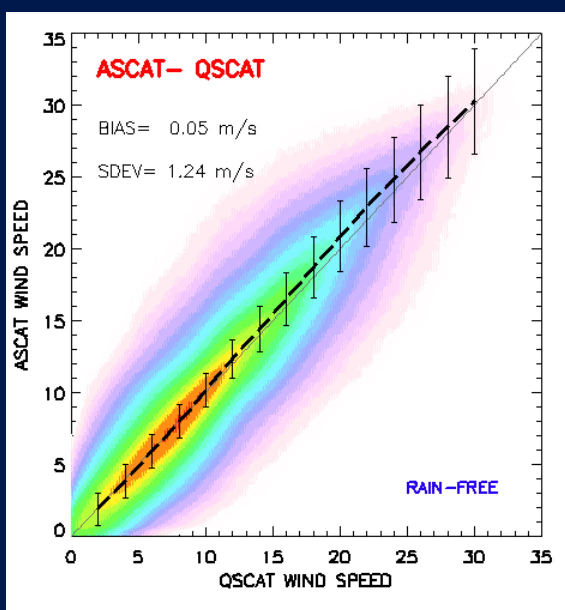
Remote Sensing Systems
www.remss.com

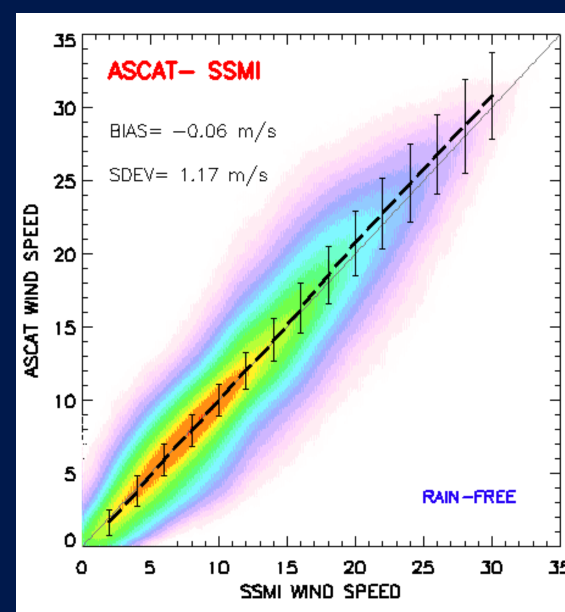
ASCAT Wind Speed PDFs Validation

ASCAT VERSUS QSCAT | **ASCAT VERSUS SSMI**





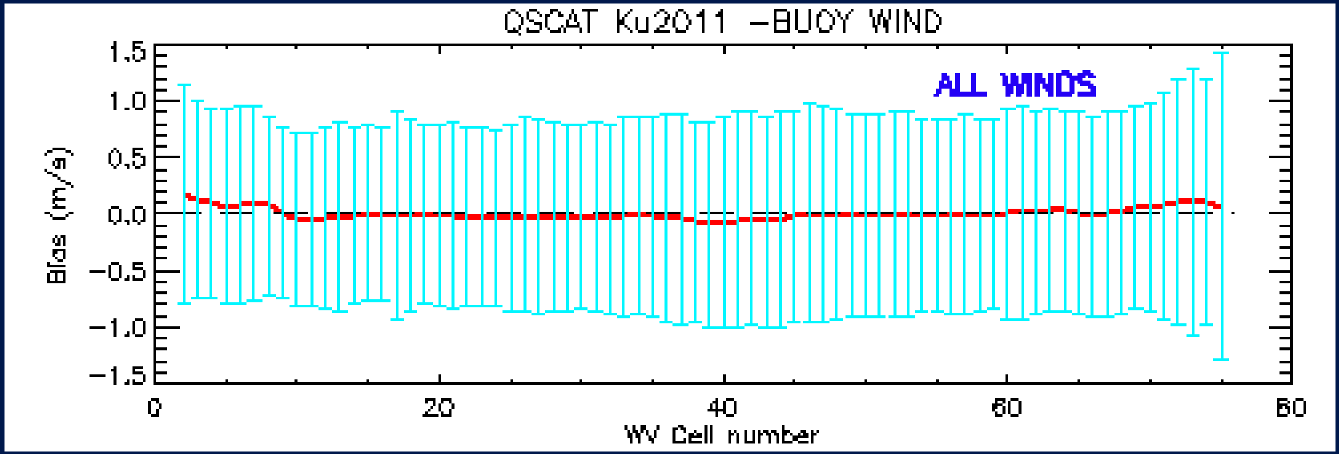




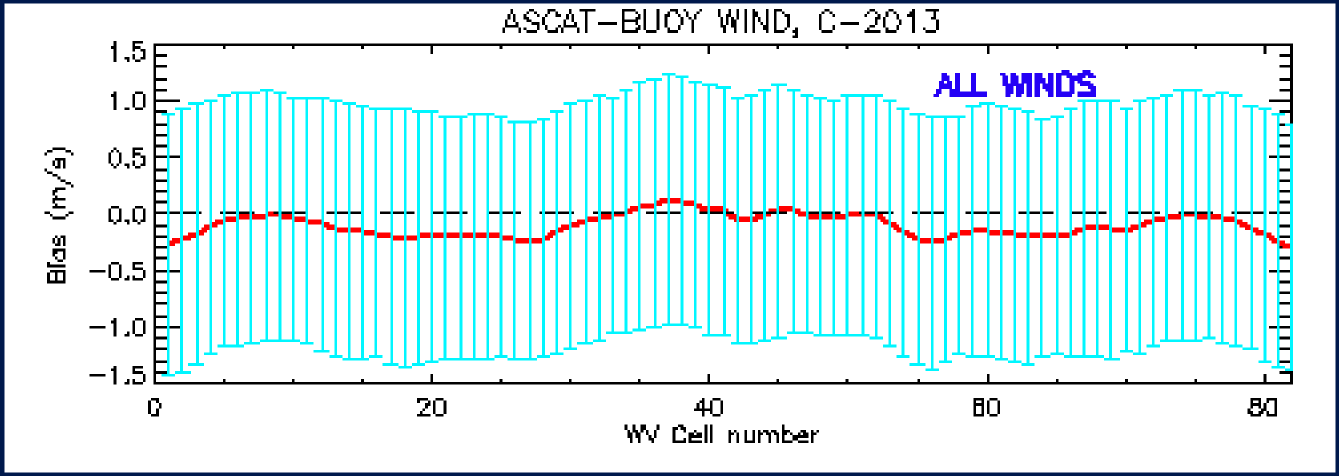
Remote Sensing Systems
www.remss.com

Across-Track Bias

QuikSCAT

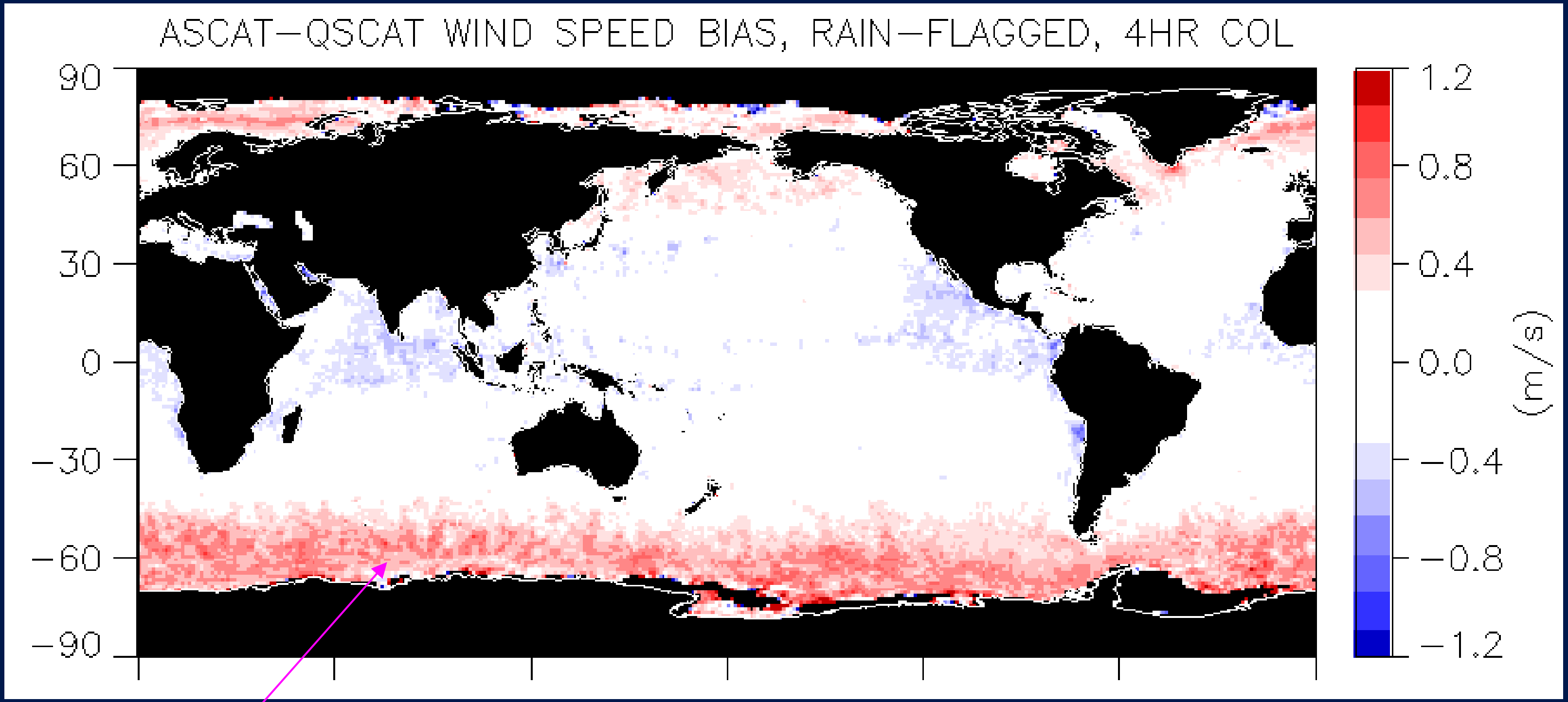


ASCAT



Swath width

ASCAT-QuikSCAT Bias Map

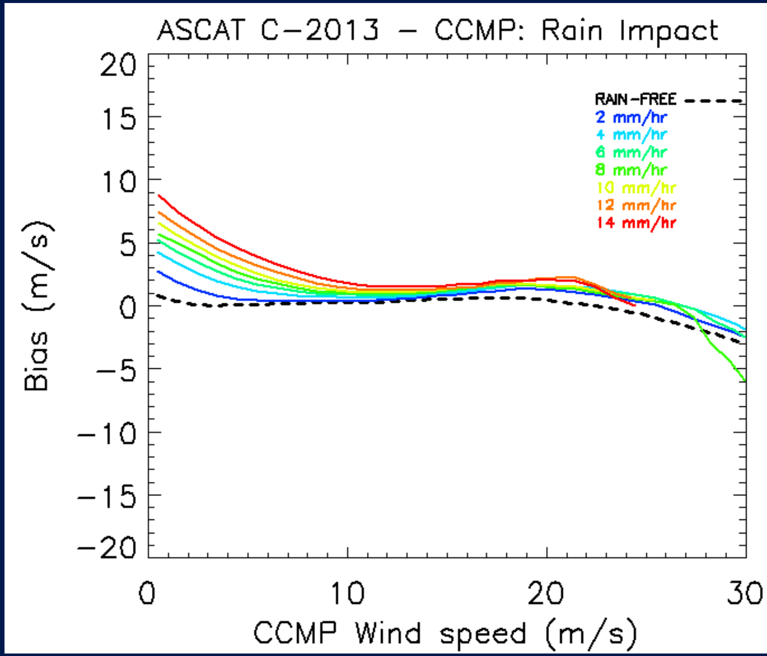


ASCAT shows positive bias relative to QuikSCAT at high winds.
It will be addressed in the next ASCAT version.

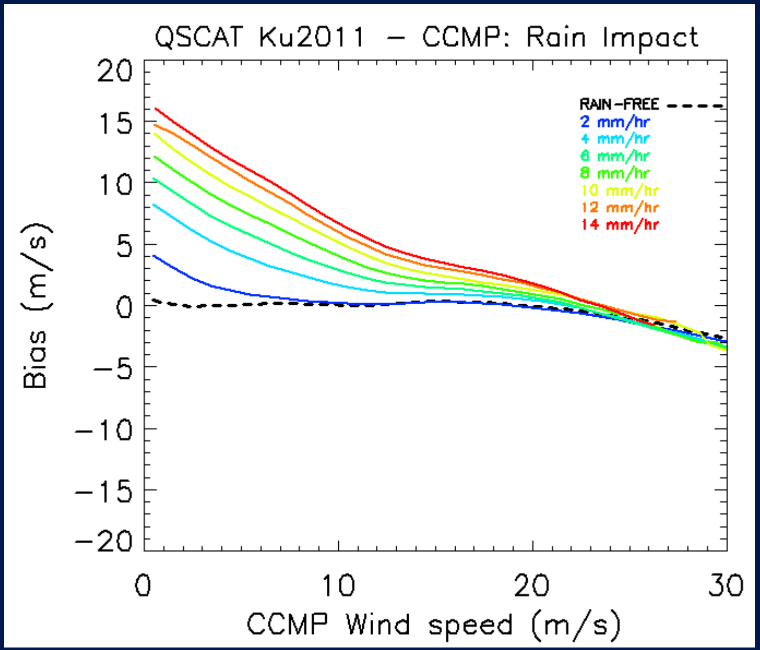
Rain Impact at C-band and Ku-band

- GMFs were designed to be for rain-free retrievals
- We used QSCAT and ASCAT wind retrievals in rain to determine the statistics of the rain impact
- Bias is proportional to rain intensity
- QuikSCAT (Ku-band) more affected then ASCAT (C-band)

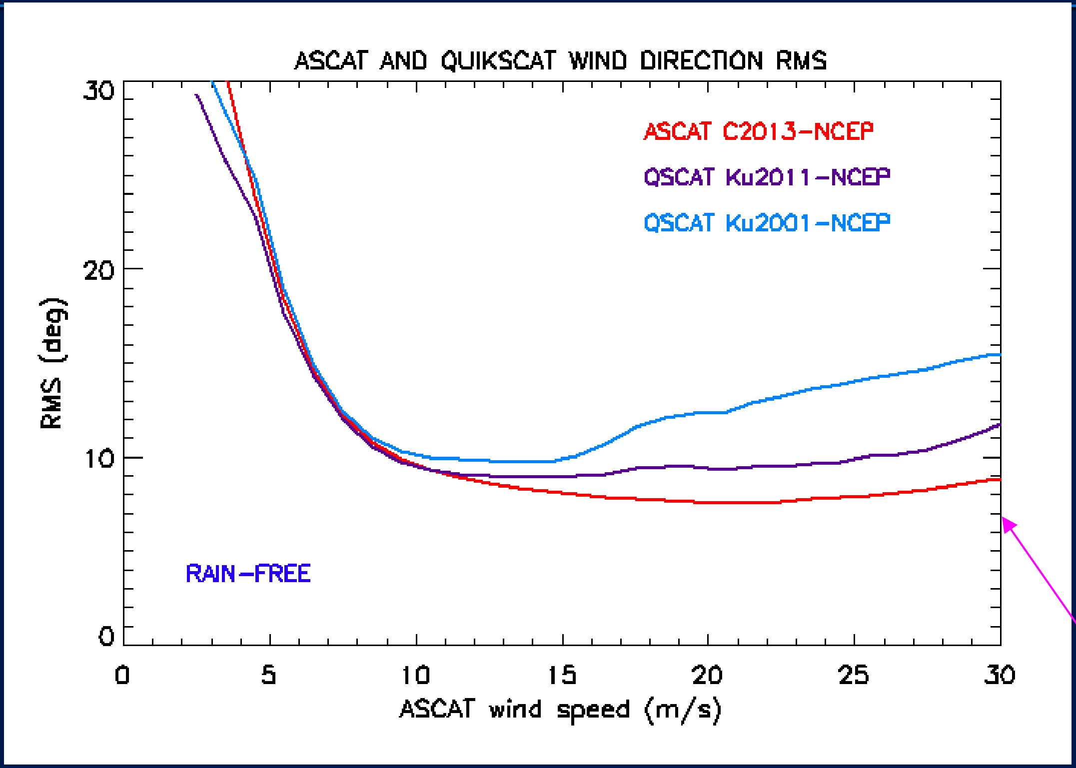
ASCAT (C-band)



QuikSCAT (Ku-band)



Wind Direction Skill

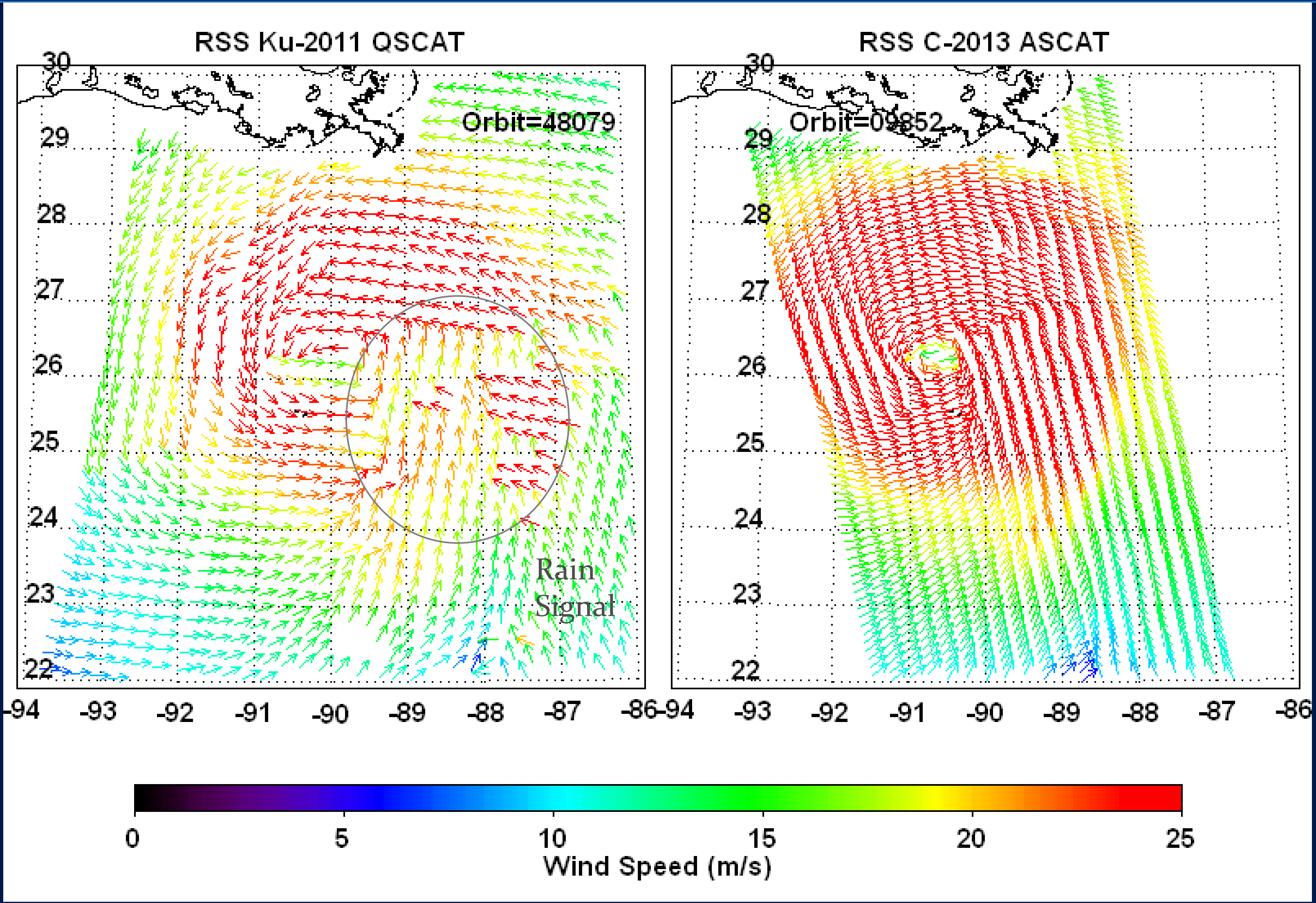


GMF Ku2001

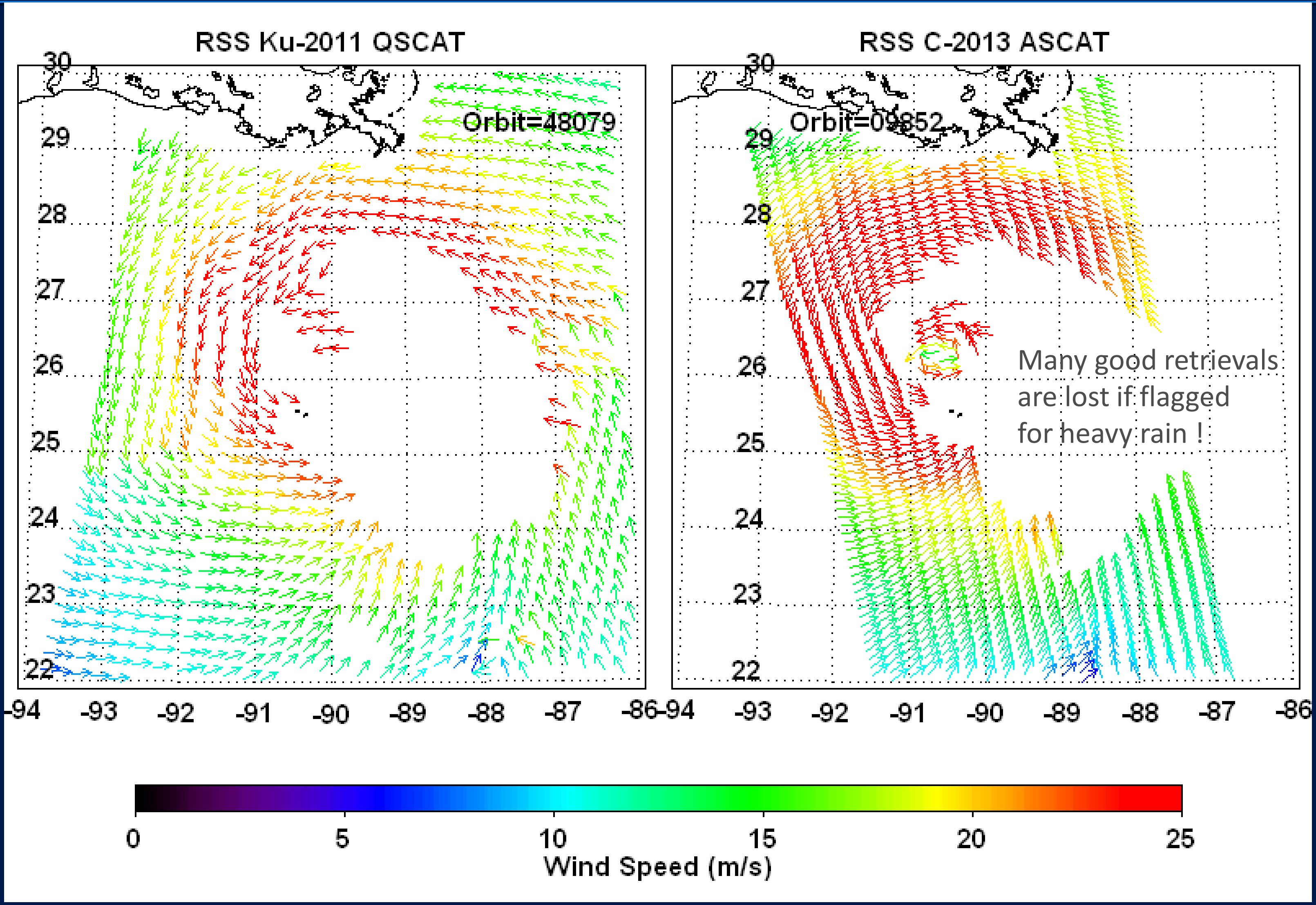
GMF Ku2011

With a properly designed GMF it is possible to have very good retrievals of wind direction at high winds, and for C-band even in hurricanes under heavy rain (next slides)

Hurricane Ike, Sep 11, 2009, 24:00 UT; All retrievals

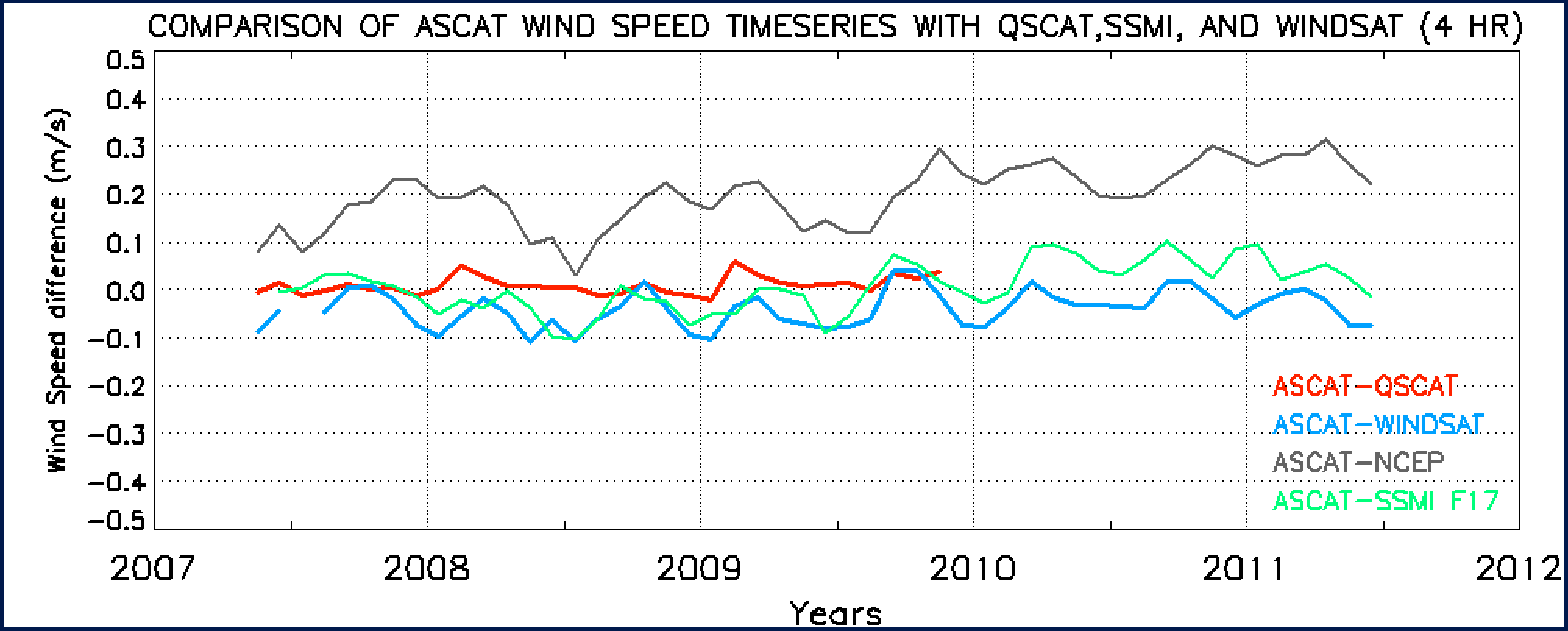


Hurricane Ike, Sep 11, 2009, 24:00 UT; Heavy-rain flagged



Remote Sensing Systems
www.remss.com

Temporal Stability of QuikSCAT-ASCAT



ASCAT-QSCAT GLOBAL WIND ANOMALY TIMESERIES IS VERY STABLE

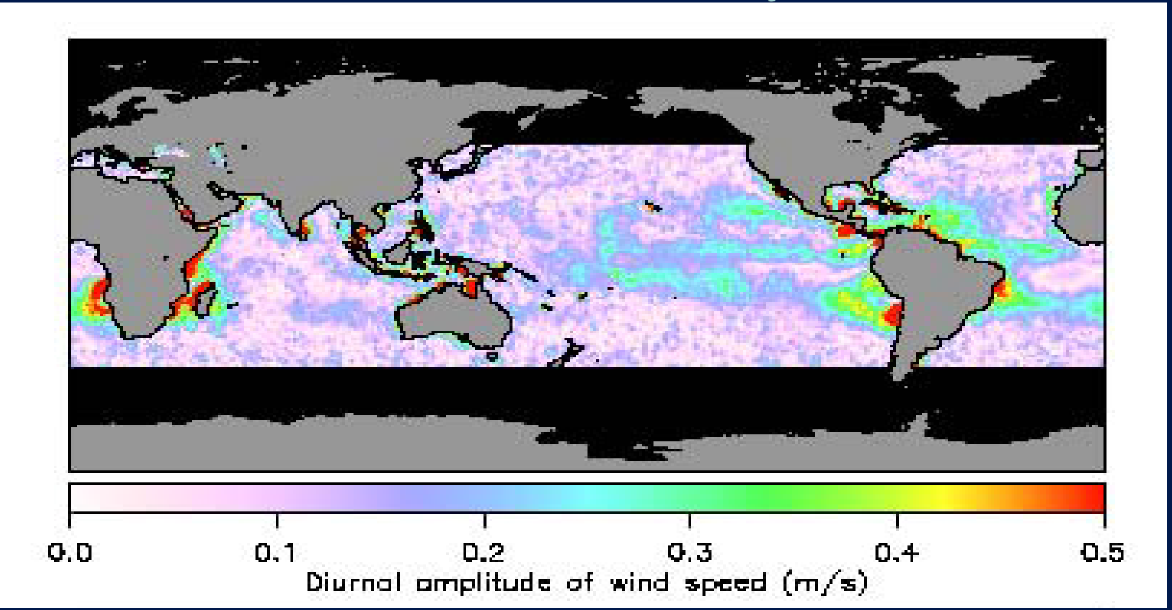
Differences in the ASCAT and QuikSCAT wind anomaly timeseries are well within 0.1 m/s, the accuracy limit necessary for climate studies.

Diurnal Signal in Ocean Surface Wind

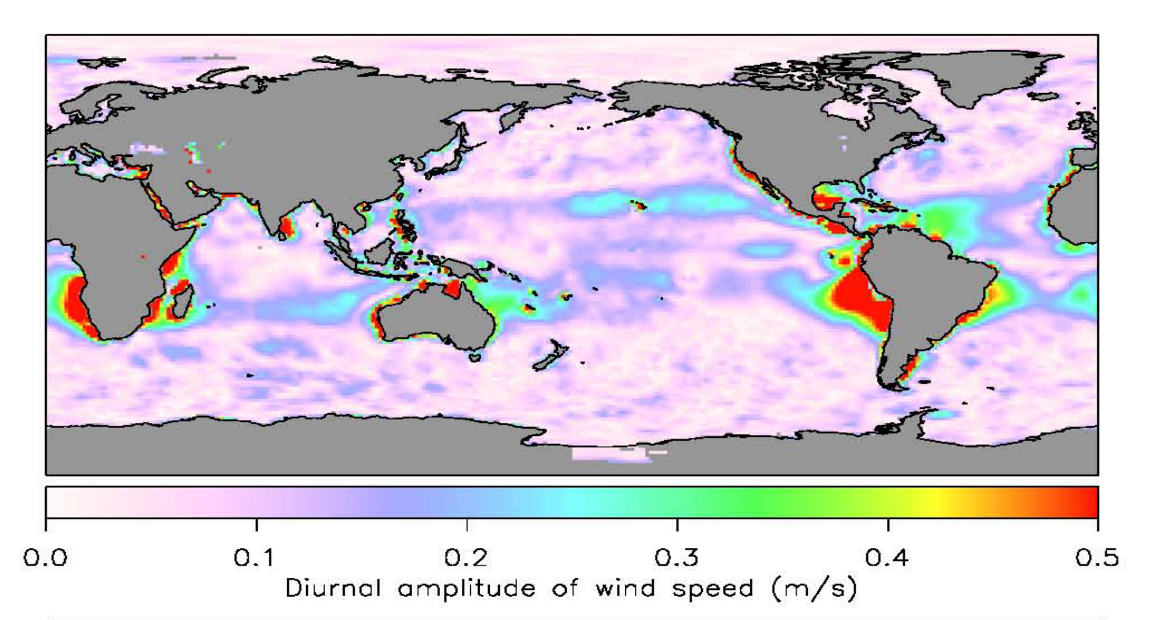
- Diurnal variability of the ocean surface winds needs to be removed from the ASCAT and QuikSCAT data before integrating them in a CDR. As of today, there is some uncertainty in the amplitude/phase of the diurnal.
- One way to discern diurnal signals is looking at the difference in wind between ascending and descending passes for QuikSCAT, ASCAT and for some radiometer winds. Most of the PM-AM signals in the scatterometers are present also in the radiometers. Tropical buoys show a weaker diurnal signal. Here we use also the MERRA reanalysis as independent dataset.
- Unlike radiometers, scatterometer have the advantage of providing insight into the diurnal cycle of each wind component. Diurnal signal is mostly in V, semidiurnal in U.
- A complete understanding of the diurnal cycle will be achieved with RapidSCAT (Launch planned for June 2014).

Amplitude of Diurnal Wind Variability

Derived from QSCAT/ASCAT (4 years data)



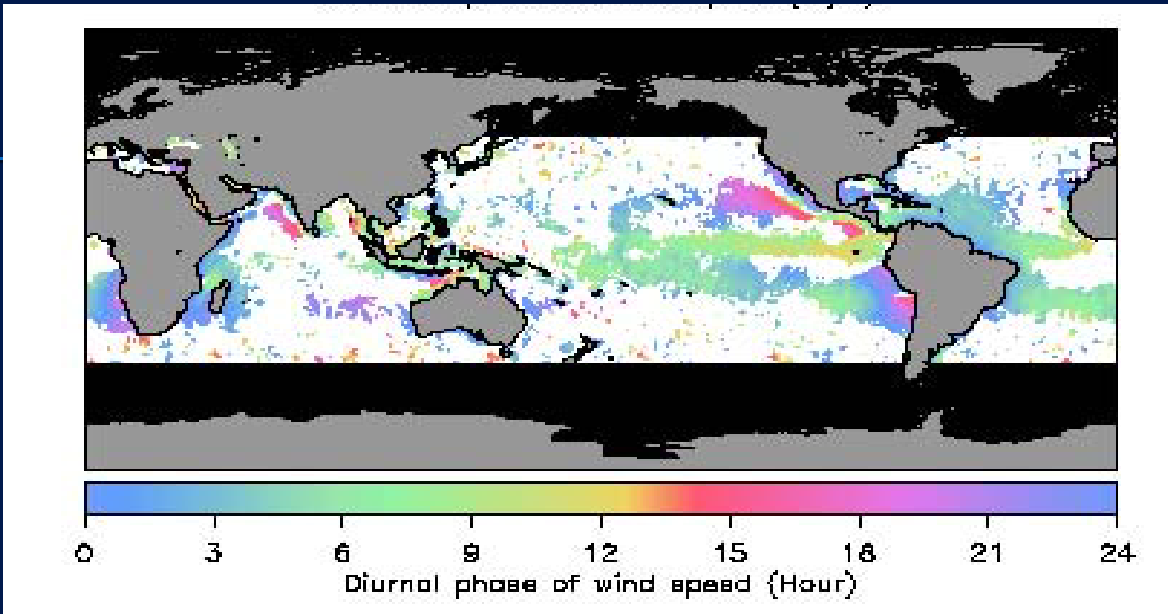
Derived from MERRA Reanalysis (5 years data, pre-QuikSCAT)



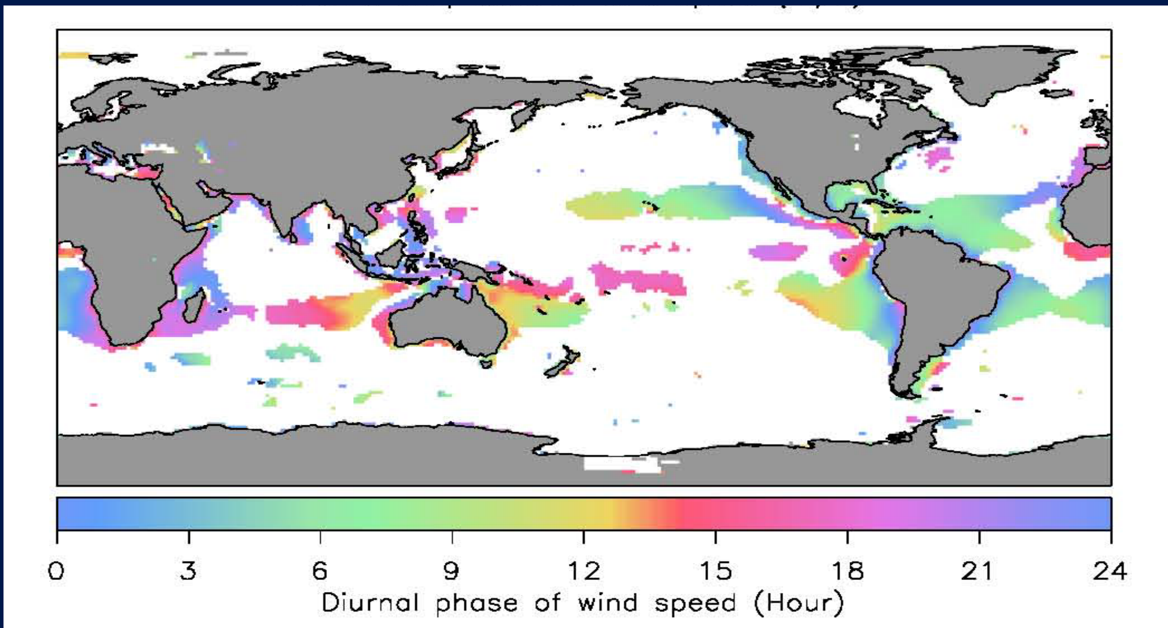
Phase of Diurnal Wind Variability

Remote Sensing Systems
www.remss.com

Derived from QSCAT/ASCAT (4 years data)



Derived from MERRA Reanalysis (5 years data, pre-QuikSCAT)



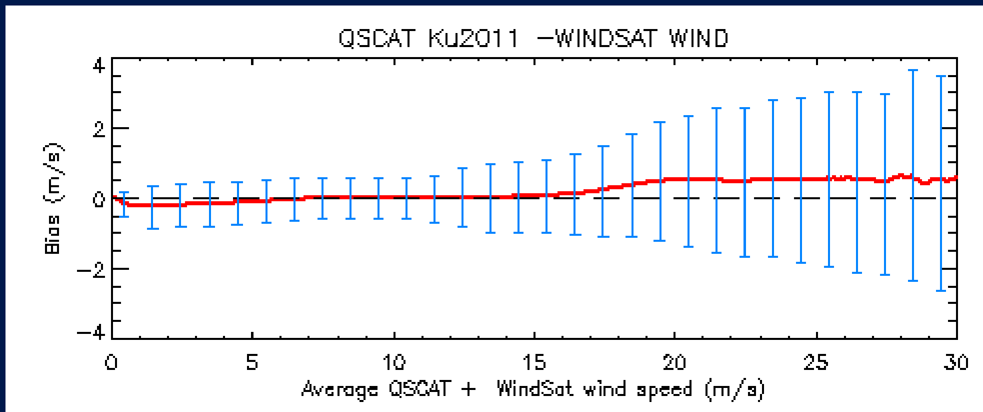
Summary and Conclusions

- Long term goal: integrate observations from multiple scatterometers into a 20+ year Climate Data Record (CDR).
- Developed QuikSCAT Ku-2011 and ASCAT C-2013 with similar methodologies and calibration targets
- Comparison of RSS ASCAT and QuikSCAT shows very good agreement.
- In the two and half years of QuikSCAT/ASCAT overlapping, the timeseries of their wind anomalies are stable and well within a 0.1 m/s margin required for climate studies.
- Very good wind direction retrievals at all wind speeds.
- Very good RSS ASCAT wind retrievals in storms
- Ongoing study of the impact of diurnal variability on wind measurements
- Additional scatterometers will be added to the timeseries following the same methodology (OSCAT, RapidScat,ERS)

Thank you

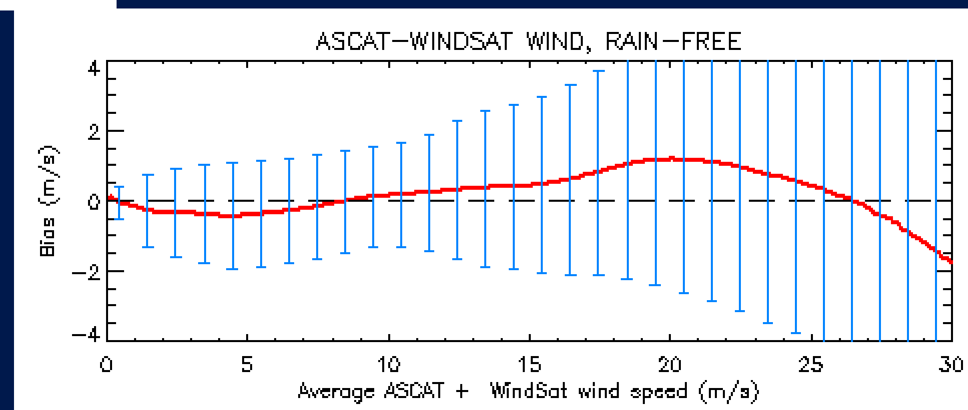
Remote Sensing Systems
www.remss.com

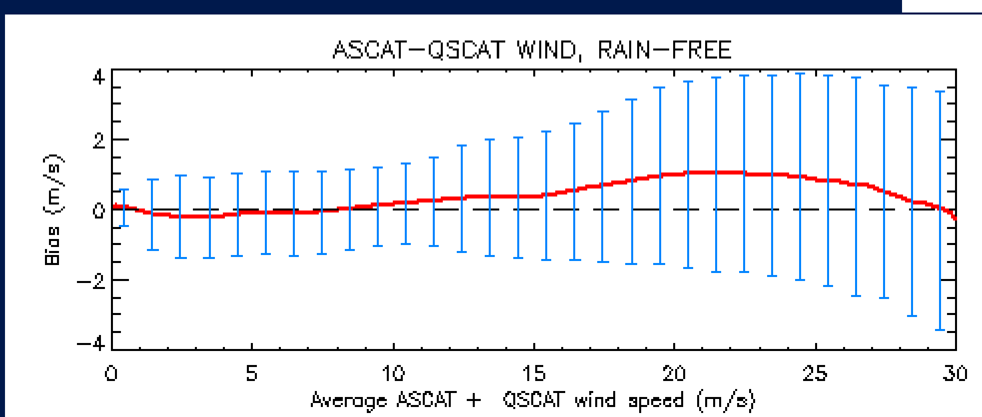
QSCAT versus ASCAT and WindSat



QSCAT-WINDSAT

ASCAT-WINDSAT





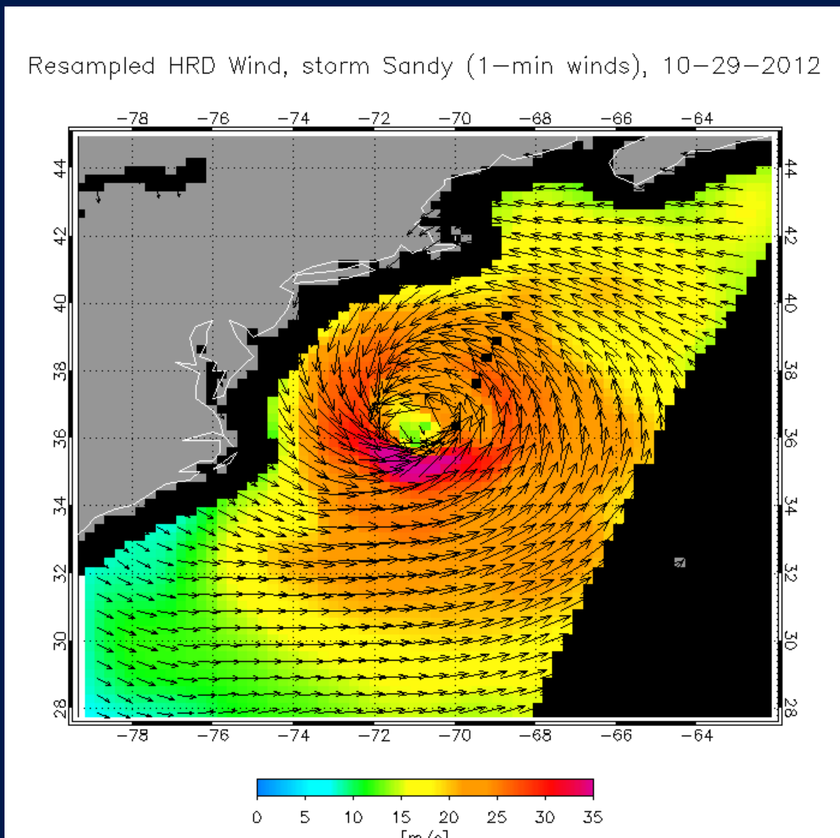
ASCAT-QSCAT

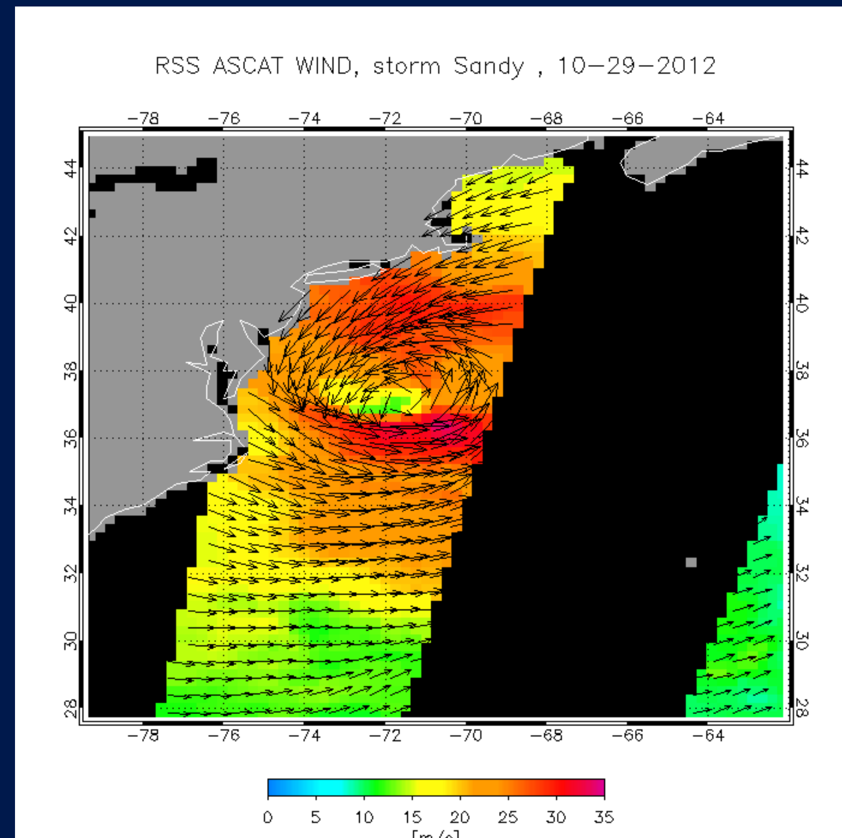
Remote Sensing Systems
www.remss.com

Tropical Storm SANDY, Oct 29, 2013

HRD Winds 10:30 UTC

RSS ASCAT Winds, 14:20 UTC





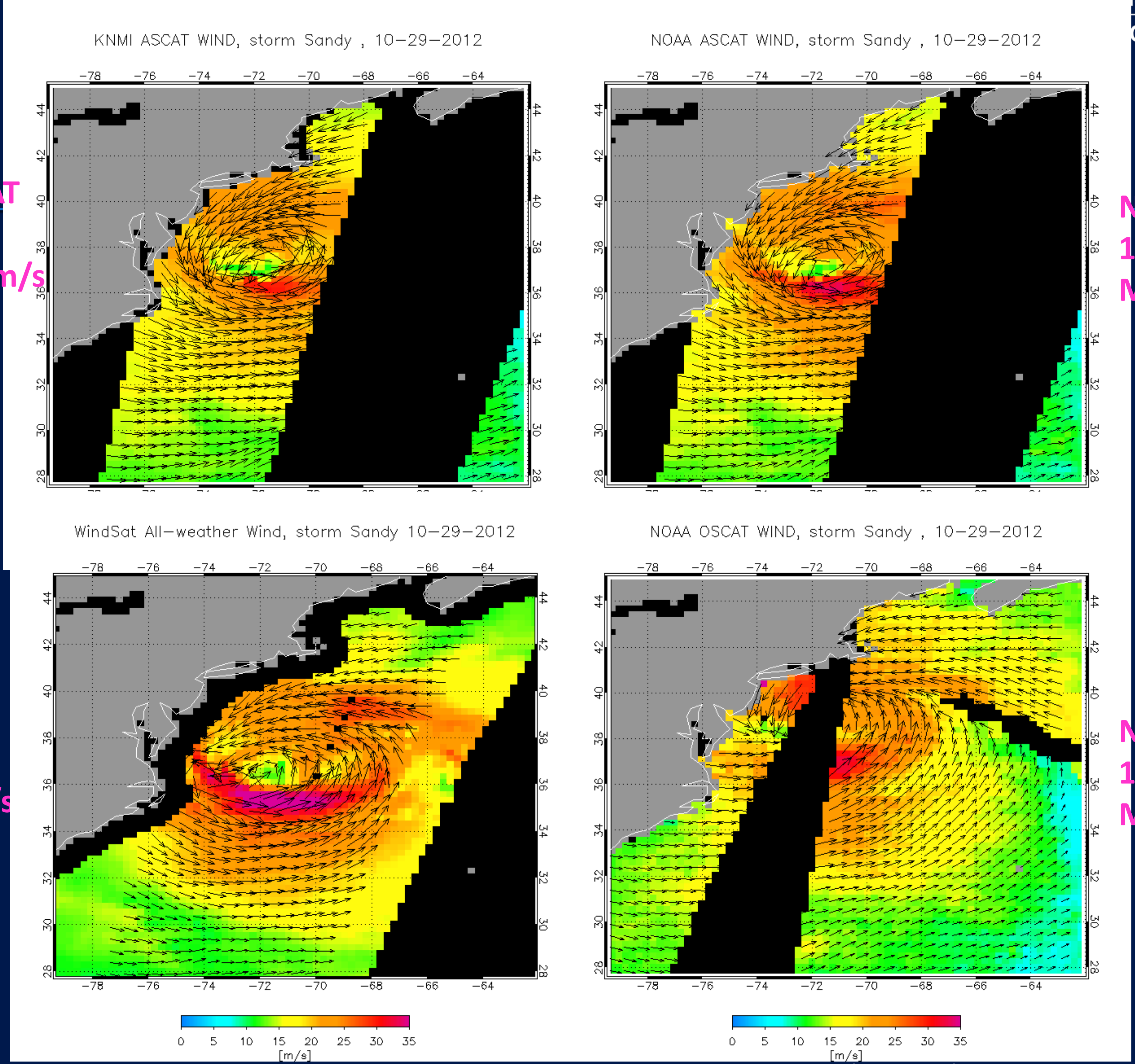
Maximum 1-min winds: 39 m/s
Maximum 10-min winds: 34.6 m/s
NWS reported winds (touchdown): 35-40 m/s

Maximum RSS ASCAT winds: 34 m/s

Remote Sensing Systems
.com

KNMI ASCAT
14:20 UTC
Max=30.4 m/s

NOAA ASCAT
14:20 UTC
Max=34.0 m/s



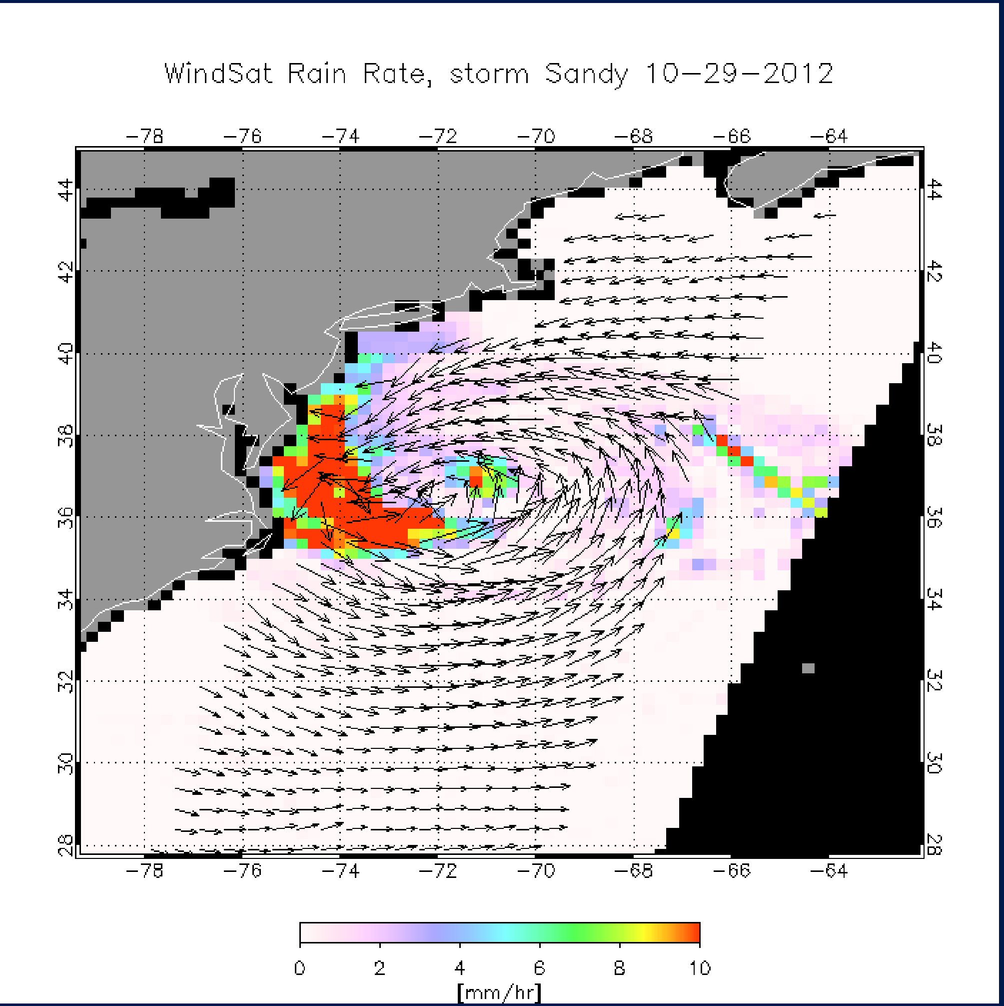
WINDSAT
11:24 UTC
Max=42 m/s

NOAA OSCAT
16:30 UTC
Max=32.6 m/s

Aknowledgments: ASCAT and OSCAT data kindly provided by Paul Chang, at NOAA/NESDIS/STAR

Remote Sensing Systems
www.remss.com

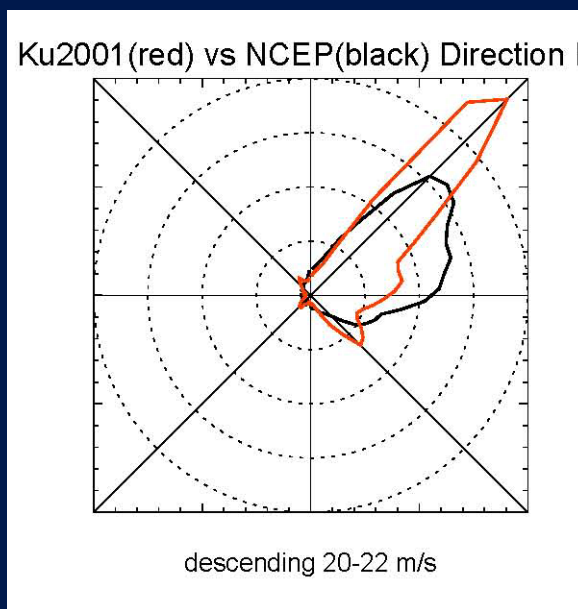
Storm Sandy : Rain rates Observed by WindSat

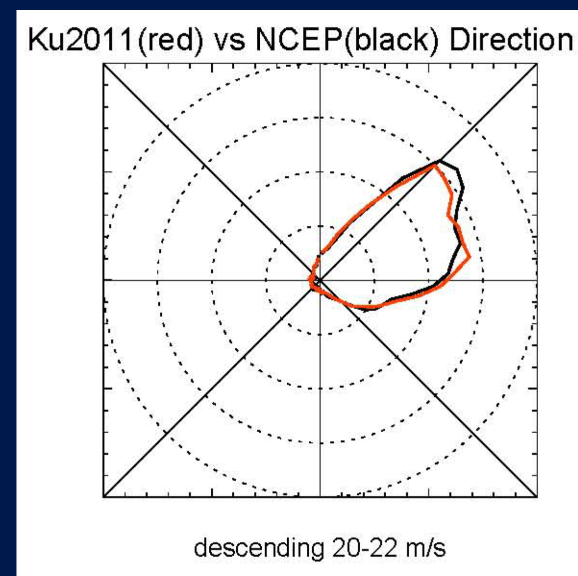


QuikSCAT Directional Histograms: High Winds Old GMF (Ku-2001) versus New GMF (Ku-2011)

Ku-2001
NCEP

Ku-2011
NCEP

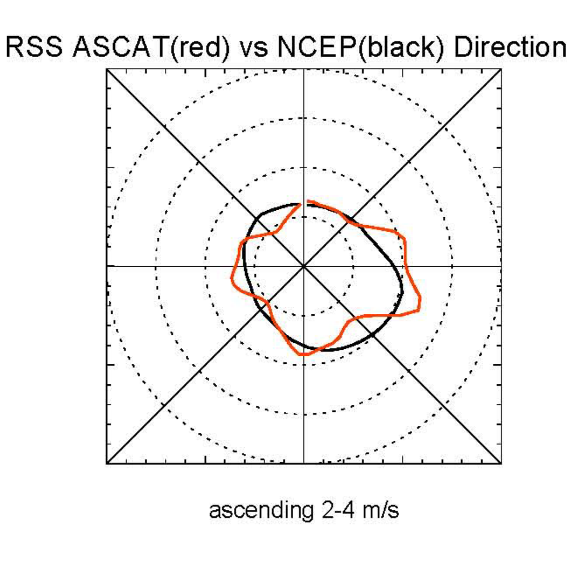


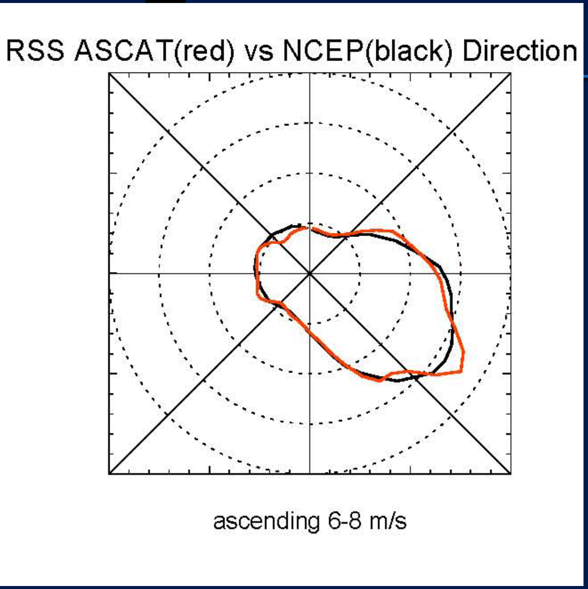


ASCAT Directional Histograms: Low to high winds

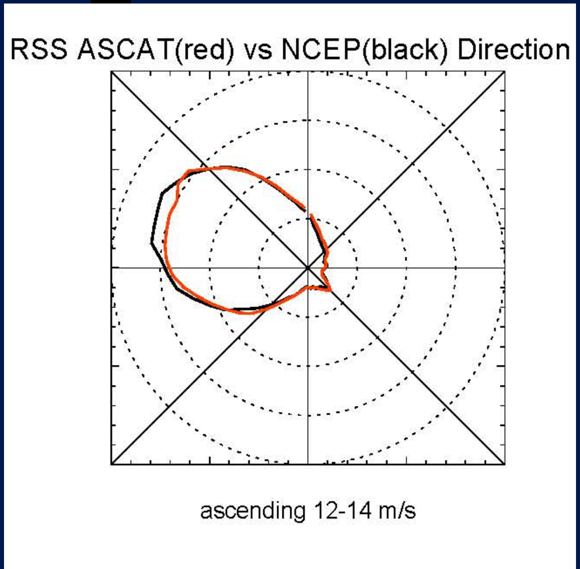
ASCAT
NCEP

2-4 m/s

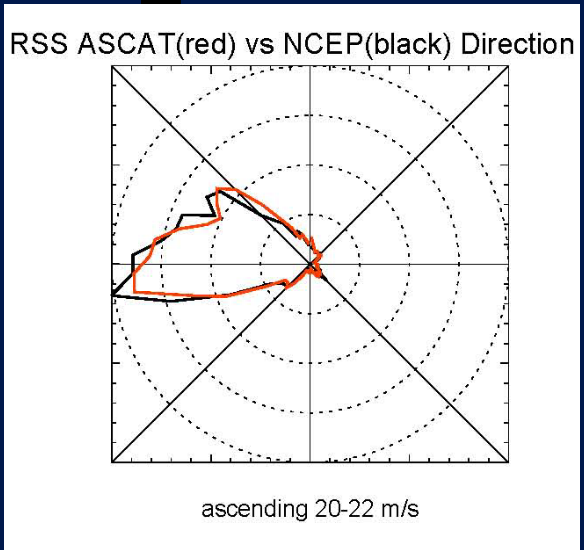




6-8 m/s



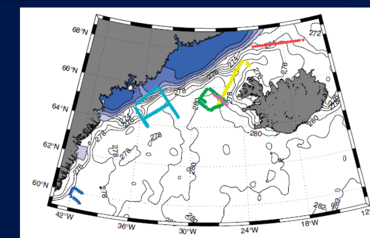
12-14 m/s



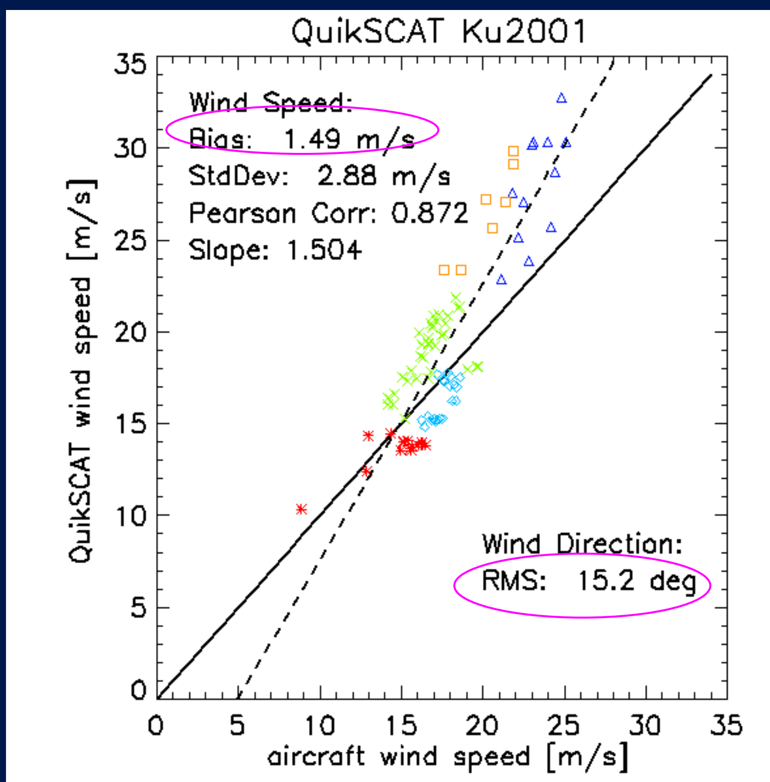
20-22 m/s

High Winds Validation: AIRCRAFT

Aircraft turbulent probe observations taken during the Greenland Flow Distortion Experiment (GFDex), Feb and Mar 2007 (Renfrew et al, QJRMS 2009).



Ku-2001



Ku-2011