Scatterometry and Climate Meeting

Overview & Goals

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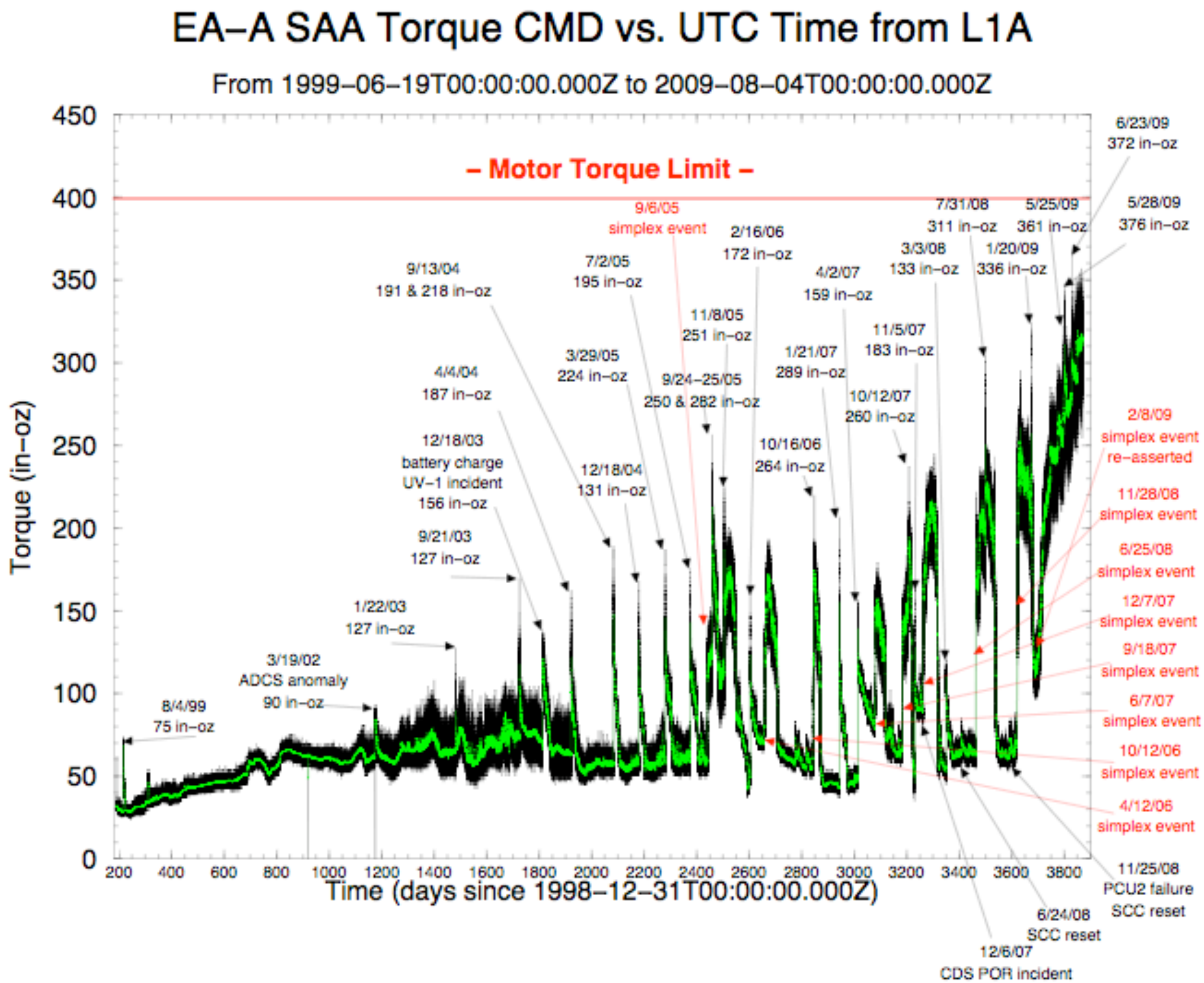
(3) NOAA/NESDIS/STAR
(4) Tohoku University, JAXA
(5) NASA HQ
(6) NOAA/NESDIS

A scary picture…



Meeting Goals

- To provide a comprehensive case for the importance of continued scatterometer measurements for climate studies
  - The meeting will result in a public report that will be used as part of the rationale for the next-generation scatterometer instrument
  - You have received a draft outline of the report
  - To have the appropriate impact, the report should be finished by mid to late October
  - We will be using your presentations as direct inputs for the report
  - We are also looking for volunteers to help write or review the report
- We will be asking you to help us refine the climate requirements for the next-generation U.S. scatterometer
- We will also be asking for a statement of endorsement from this group for the next-generation U.S. scatterometer

Some things to keep in mind in the discussion

- What have been the prior climate accomplishments from scatterometry?
- What impact would a dual frequency (Ku + C) system with 10-20 km resolution have?
- If in addition to that, one had co-located AMSR data, what impact would that have?

Overview of Past, Present, and Future Scatterometer Measurement Capabilities

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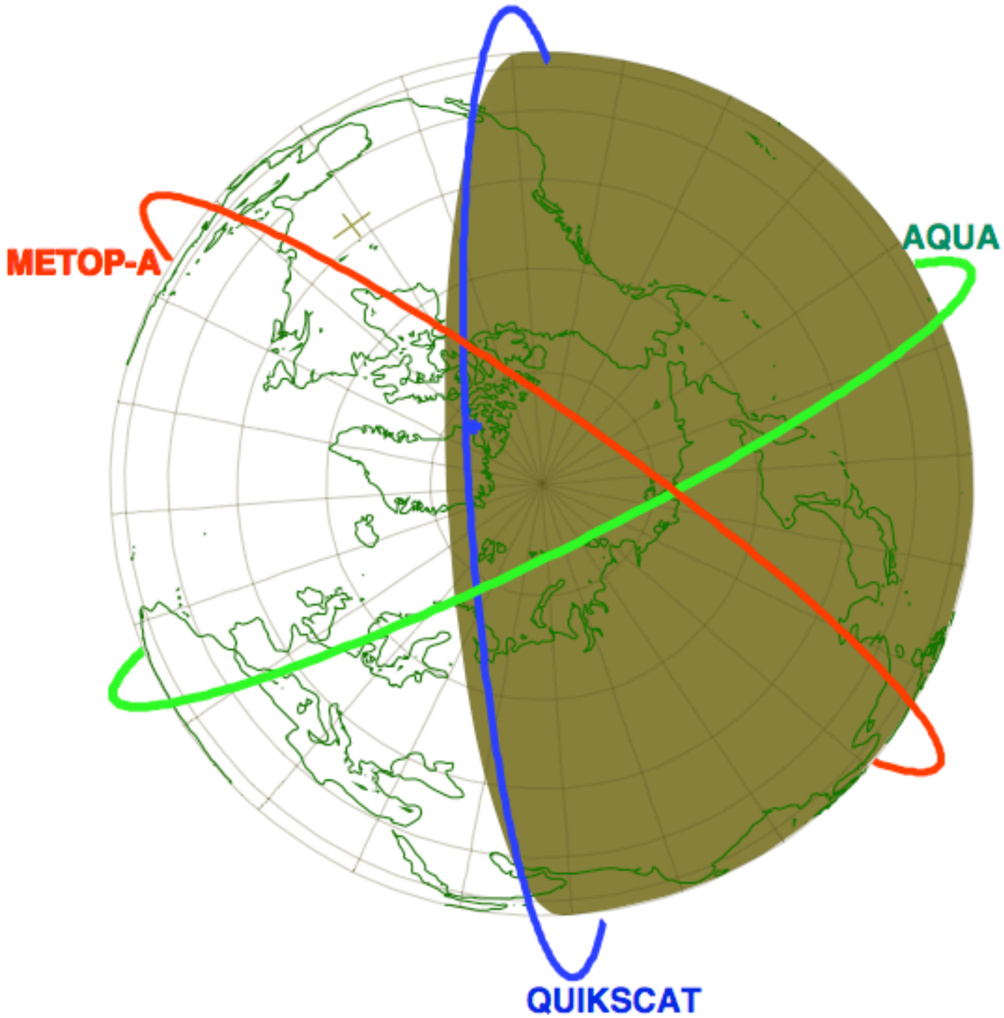
Jet Propulsion Laboratory
California Institute of Technology

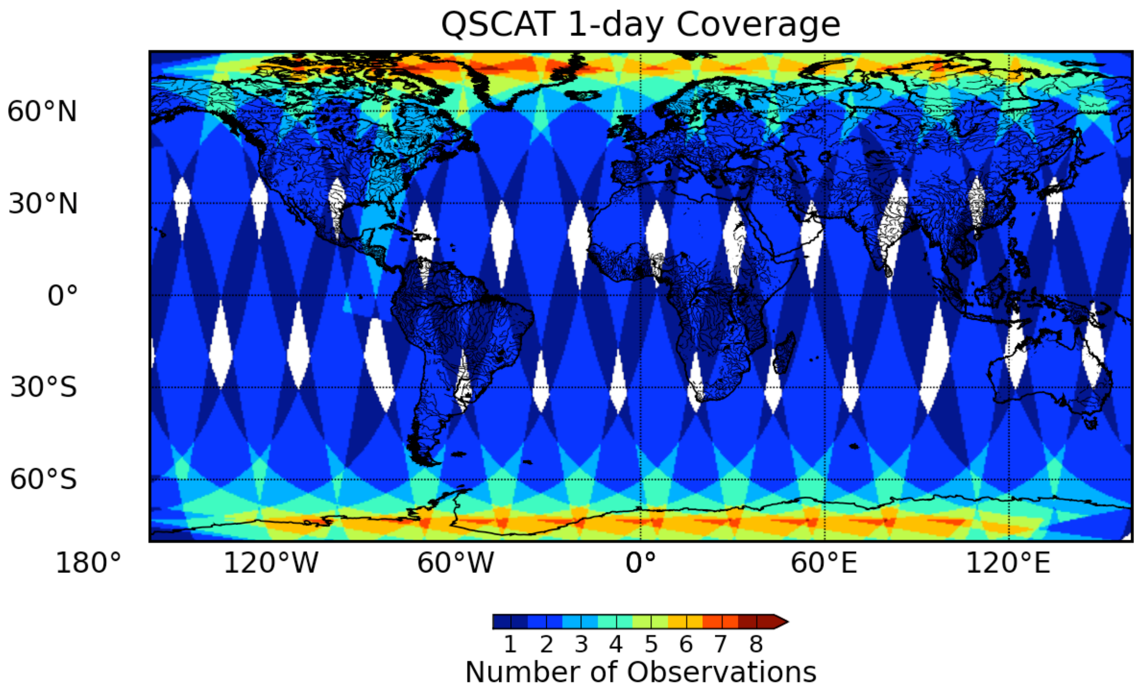
Past & Present Scatterometers

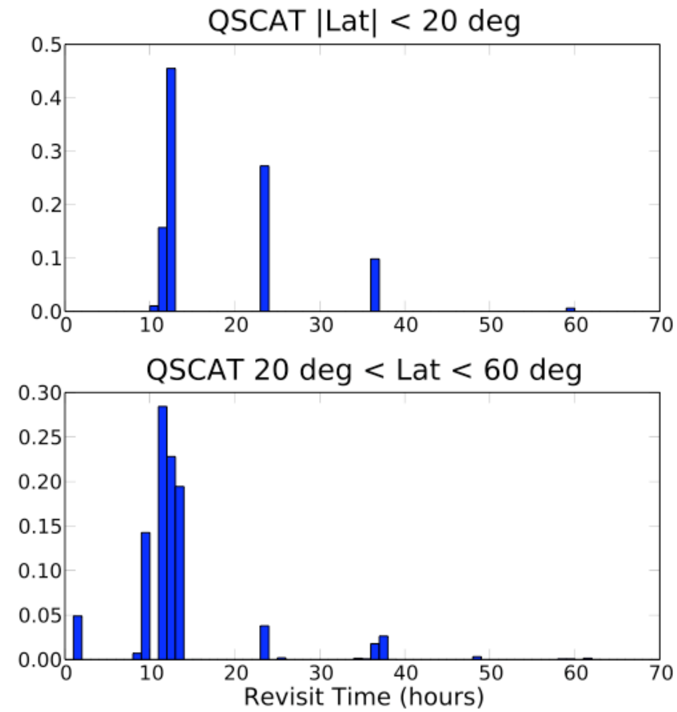
Short Background	Period in Service	Spatial Resolution	Scan Characteristics	Operational Frequency	Crossing Time
SeaSat-A Scatterometer	1978/7/7 - 1978/10/10	50 km with 100 km spacing	Two sided, Double swath	Ku band (14.6 GHz)	
ERS-1 Scatterometer	1991/7 - 1997/5/21	50 km	One sided, Single swath	C band (5.3 GHz)	10:30 am
ERS-2 Scatterometer	1997/5/21 - Present	50 km	One sided, Single swath	C band (5.3 GHz)	10:30 am
NSCAT	1996/9/15 - 1997/6/30	25 km and 50 km	Two sided, Double swath	Ku band (13.995 GHz)	10:30 am
SeaWinds on QuikSCAT	1999/7/19 - Present	25 km	Conical scan, one wide swath	Ku band (13.4 GHz)	6 am
SeaWinds on ADEOS II	2001/12 - Present	25 x 6 km	Conical scan, One wide swath	Ku band (13.4 GHz)	10:30 am
ASCAT	2006/10 - Present	50km	Two sided, Double swath	5.255 GHz	9:30 pm

Scat Constellation Orbits: not optimal?

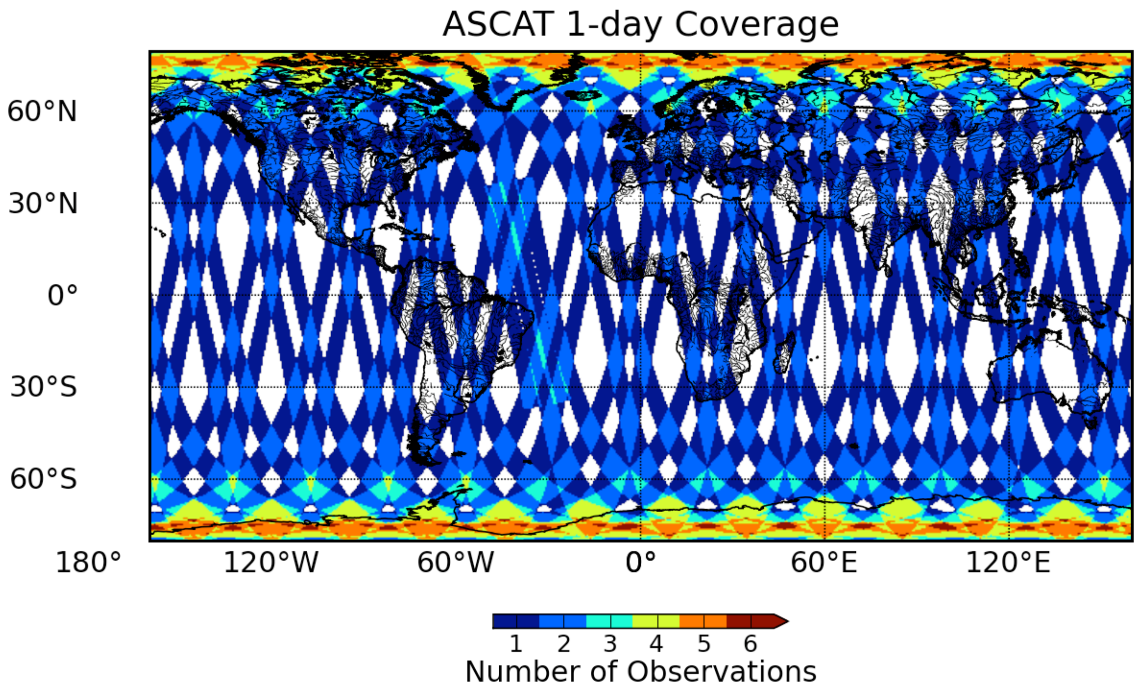


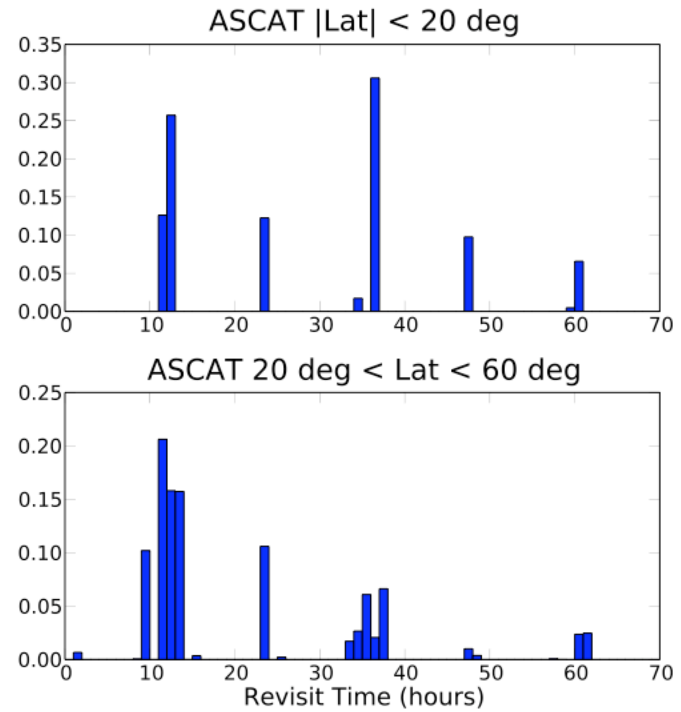
QuikSCAT Coverage



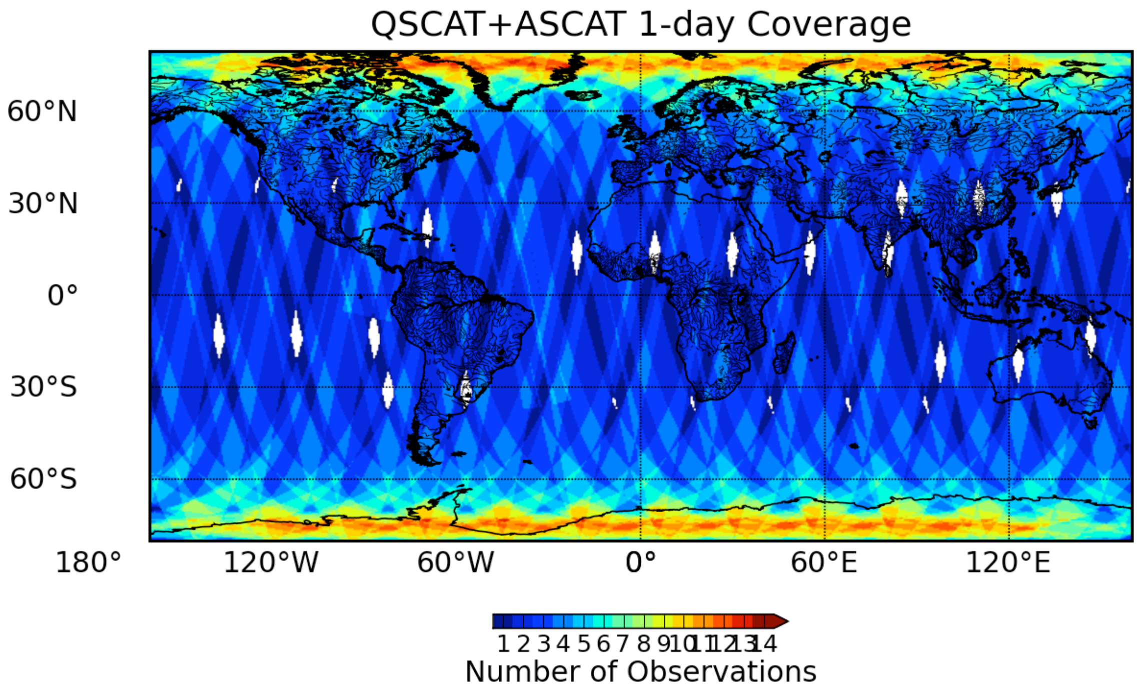


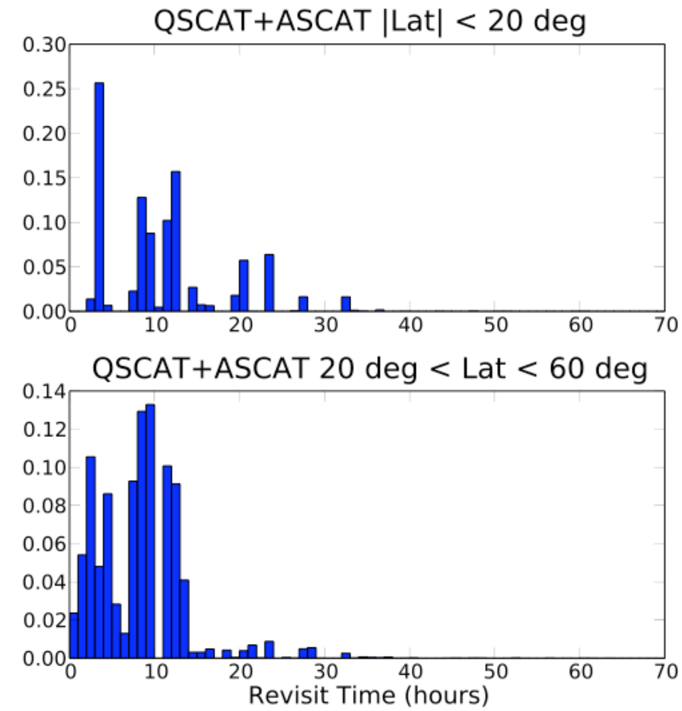
ASCAT Coverage



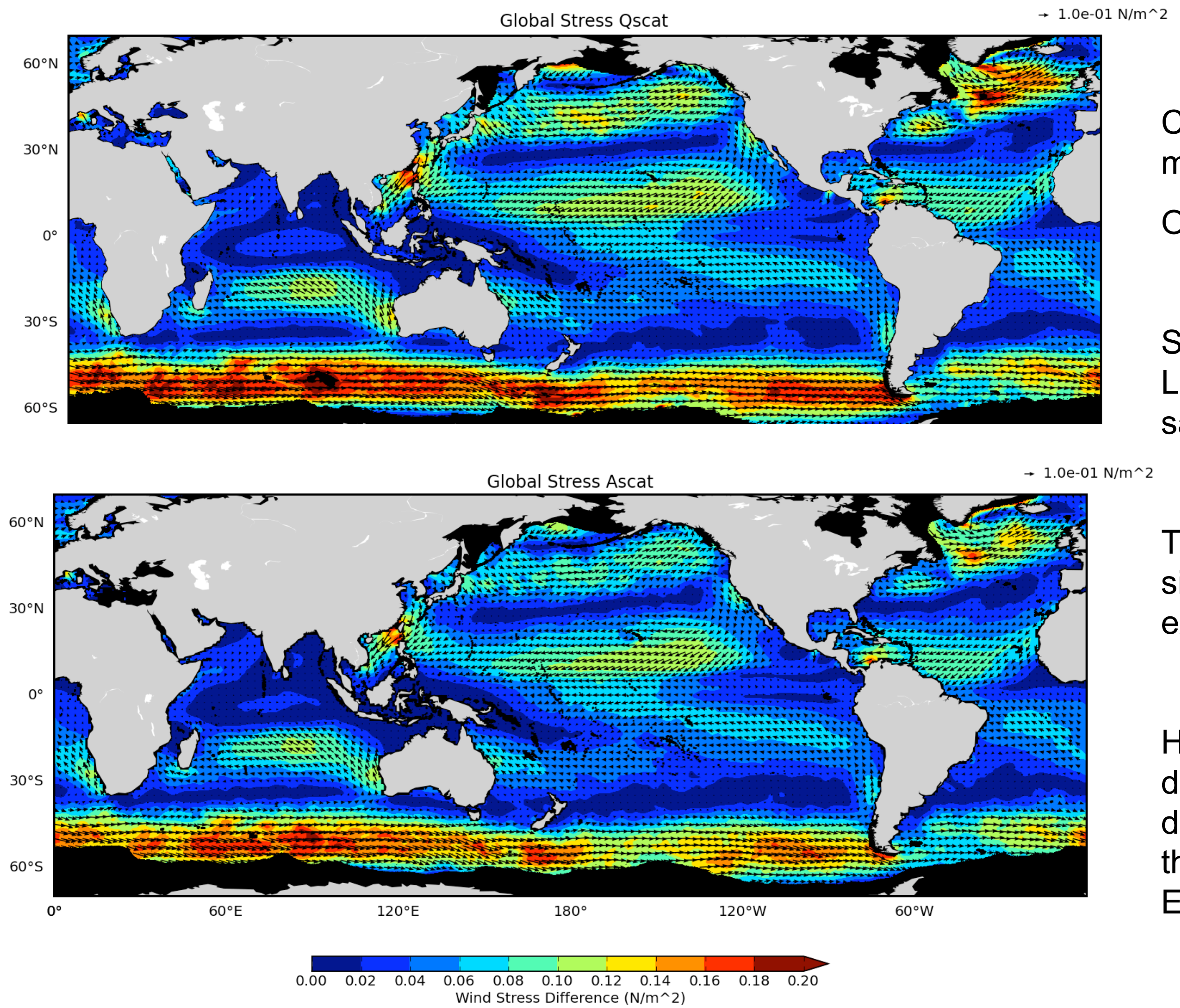


QuikSCAT+ASCAT Coverage





“Naïve” QuikSCAT & Ascat “Climatology” Stress



Climatologies based on 7 month average:

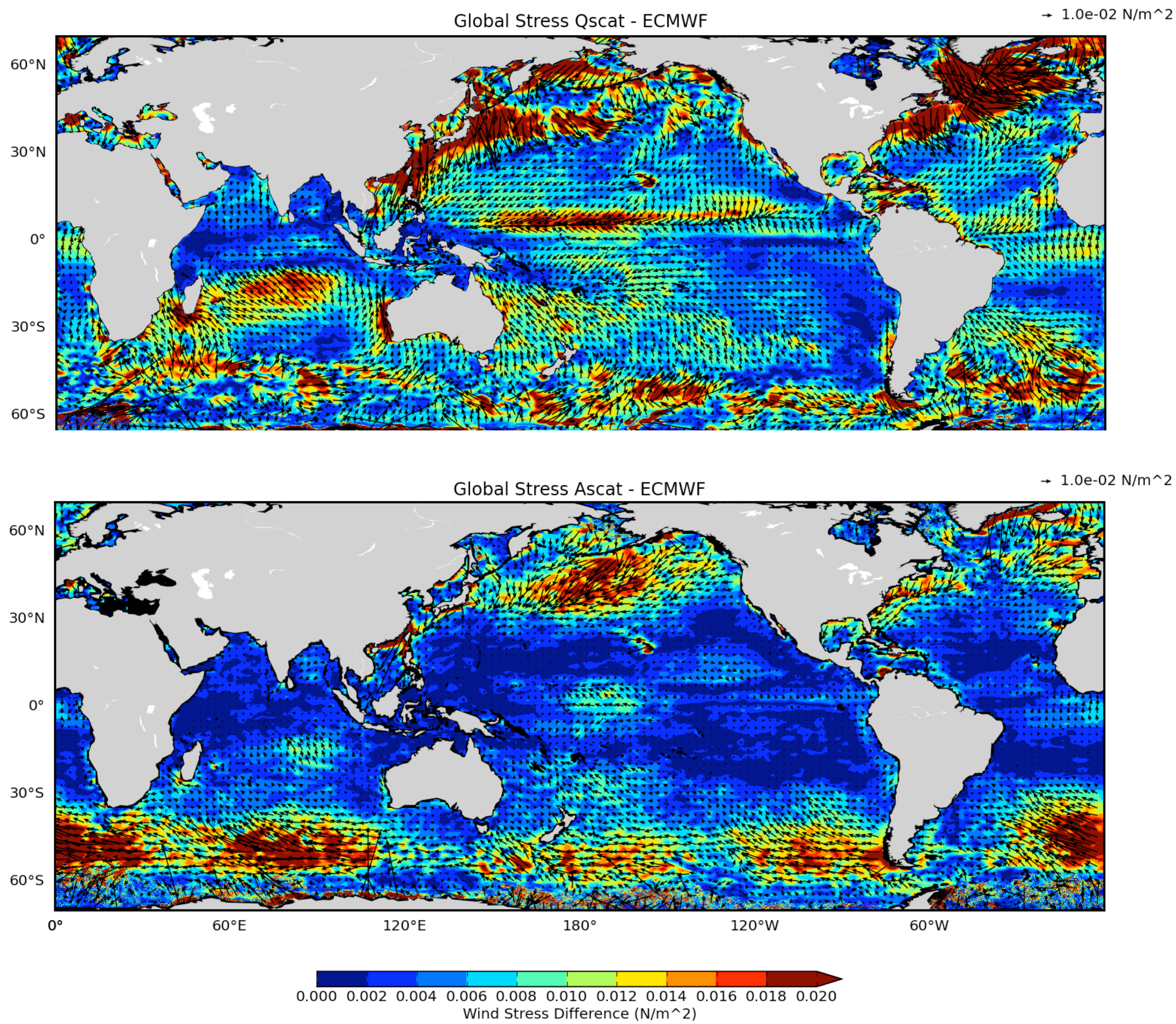
October ‘07 to May ‘08

Stresses calculated from L2 wind products and the same drag coefficient

The overall pattern is similar, but differences exist.

However, most of these differences are due to diurnal variability, since they are also present in ECMWF

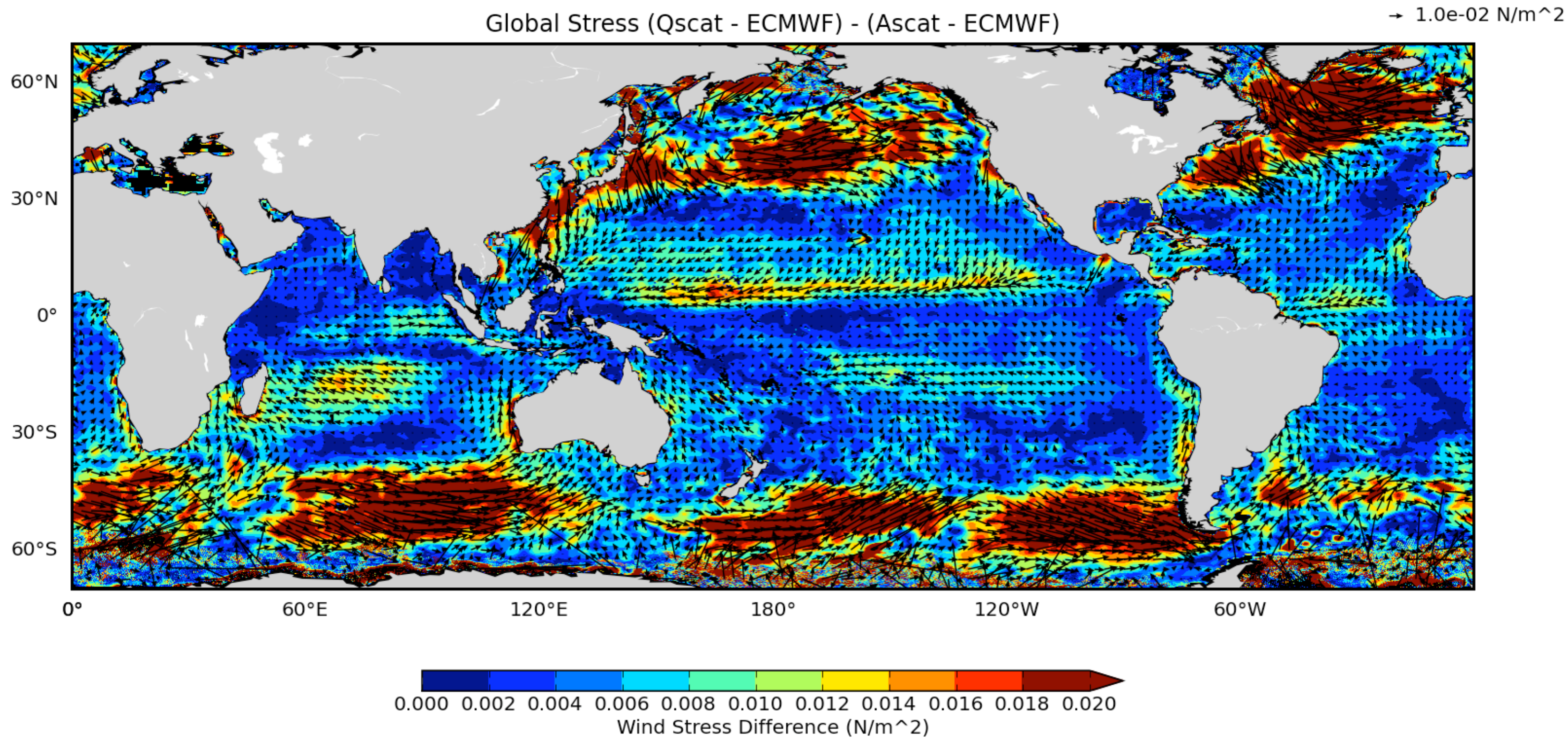
"Naïve" QuikSCAT & Ascat "Climatology" Stress Differences from ECMWF



Removing ECMWF field at the time of collection removes diurnal variability captured by ECMWF

Some unmodeled diurnal variability may remain!

"Naïve" QuikSCAT & Ascat "Climatology" Stress Differences



In the near future…

- Scat on Indian ISRO OCEANSAT-2
  - Launch September '09
  - Ku-band, pencil-beam, 1400 km swath
  - Local crossing time: noon
  - Design life: 3 years (?)
  - Data availability + calibration: science AO + being negotiated
  - Near-real time data: ?
  - Global coverage: ?
- Scat on Chinese HY-2 scatterometer
  - Launch 2010 (?)
  - Ku-band, pencil-beam, 1400-1700 km swath
  - Local crossing time: 6 am
  - Design life: 3 years (changes orbit after 2 years)
  - Data availability: being negotiated
  - Near-real time data: unlikely(?)
  - Global coverage: ?
- There will be a coverage gap after QuikSCAT, that can be partly mitigated by other planned scats. However, even with these, there is likely to be a major gap after 2013, with only ASCAT on METOP-B being officially planned

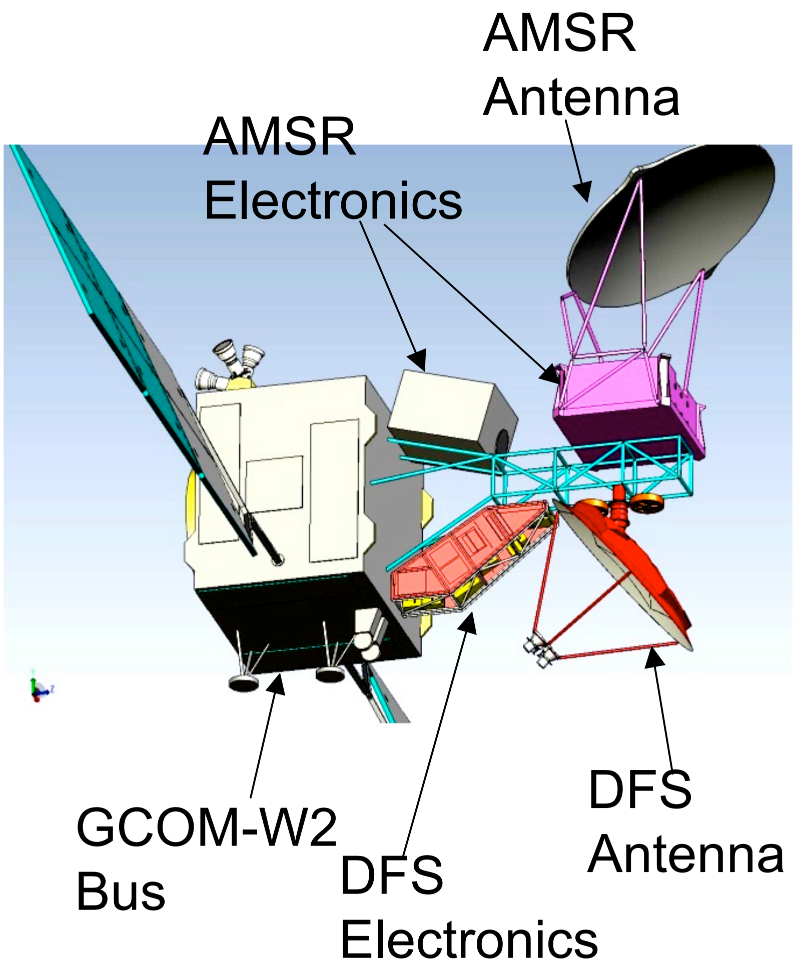
NOAA should transition three research observations to operations, as recommended in Table ES.1. These are **vector sea surface winds**, GPS radio occultation temperature, water vapor, and electron density sounders; and total solar irradiance (restored to NPOESS). Approaches to these transitions are provided through the **XOVWM**, GPSRO, and CLARREO missions recommended in this report.

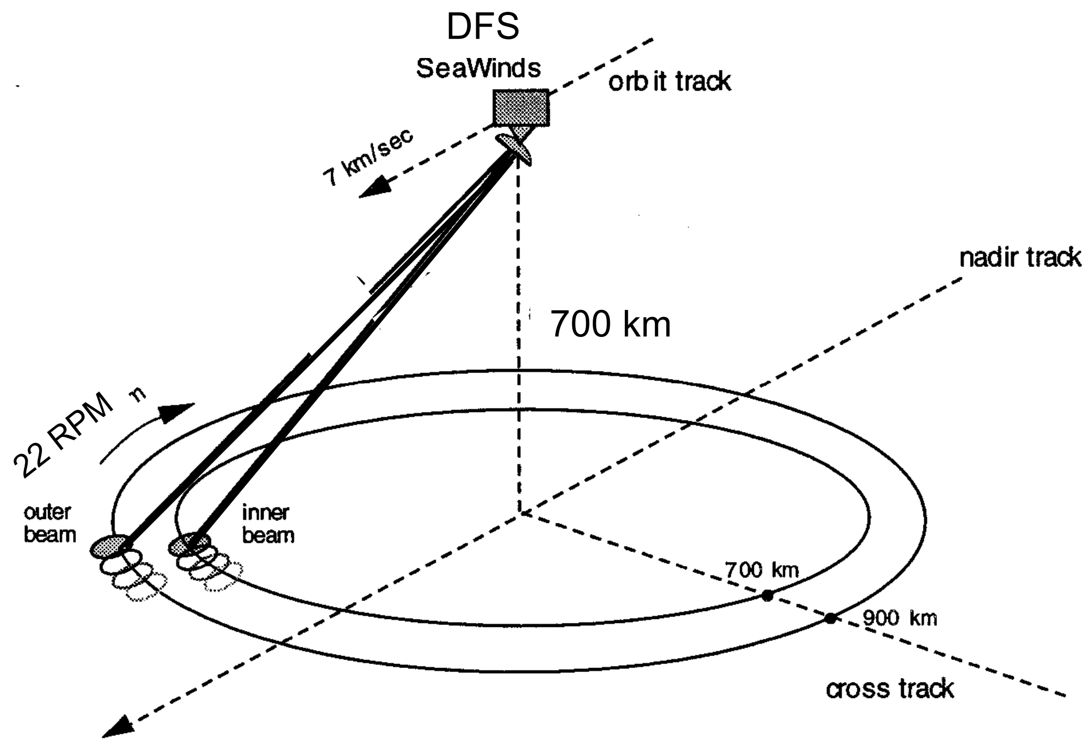
Decadal Survey Mission	Mission Description	Orbit	Instruments	Rough Cost Estimate
Timeframe 2010 - 2013—Missions listed by cost				
CLARREO (Instrument Re-flight Components)	Solar and Earth radiation characteristics for understanding climate forcing	LEO, SSO	Broadband radiometers	$65 M
GPSRO	High accuracy, all-weather temperature, water vapor, and electron density profiles for weather, climate and space weather	LEO	GPS receiver	$150 M
Timeframe 2013 – 2016				
XOVWM	Sea surface wind vectors for weather and ocean ecosystems	LEO, SSO	Backscatter radar	$350 M

Where are we now?

- In 2007, NOAA funded JPL to study the XOVWM system
  - XOVWM mission designed and presented to NOAA in 2008
    - Ku/C/X-band pencil beam SAR scatterometer radiometer
  - http://winds.jpl.nasa.gov/publications/index.cfm
- Due to fiscal constraints, NOAA and JPL sought partners to implement the mission
- JAXA showed strong interest in hosting a scatterometer as part of the GCOM-W2 mission (2015 launch) that includes an AMSR
  - XOVWM too large to fit in GCOM-W2
  - XOVWM redesigned to fit in GCOM-W2
    - Real aperture Ku/C band pencil-beam scatterometer (1.9m antenna)
    - Radiometer capabilities from AMSR
    - Renamed "Dual-Frequency Scatterometer" (DFS)
    - Mission confirmation (US) and mission definition (JAXA) reviews are scheduled to be completed before December 2009
  - The DFS is under active study with funding from NOAA and NASA
- XOVWM is viewed as a longer term solution, endorsed by NOAA users

Dual-Frequency Scatterometer Configuration





Inner Beam: H-pol Ku, H-pol C

Outer Beam: V-pol Ku, H-pol C

Ku azimuth footprint: ~15 km

C azimuth footprint: ~35 km

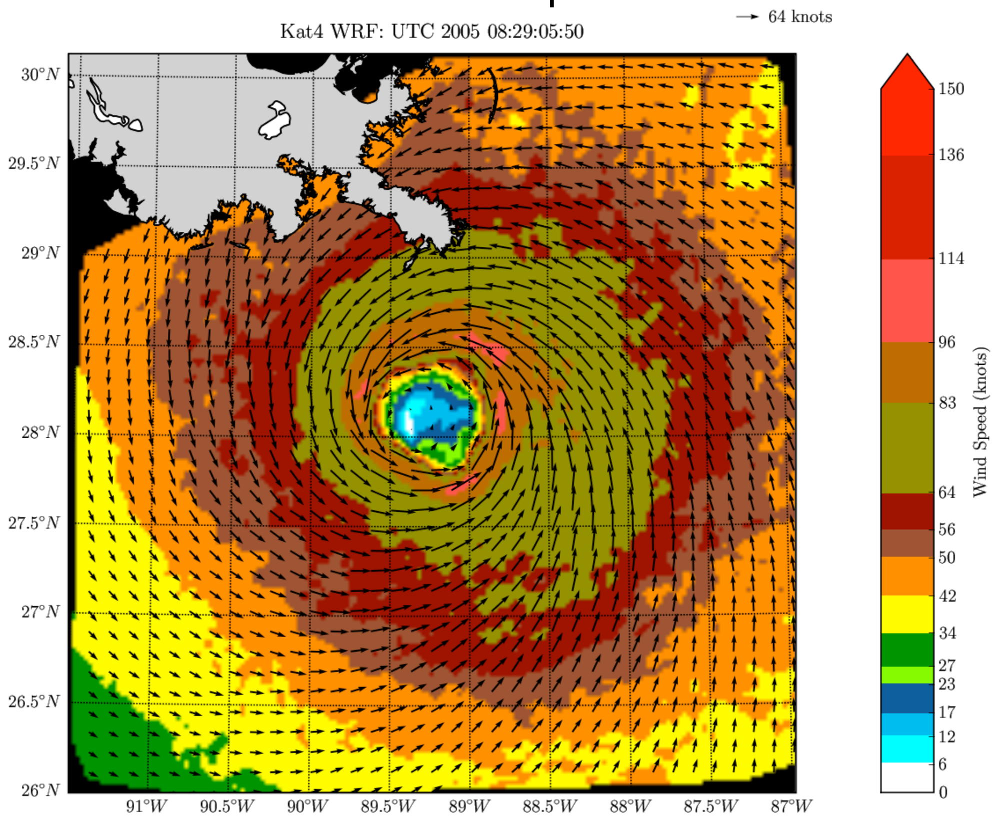
*Note: the details of this conffguration are not correct, and are expected to change. The GCOM-W2 bus is notional and has not been selected.

Key System Differences

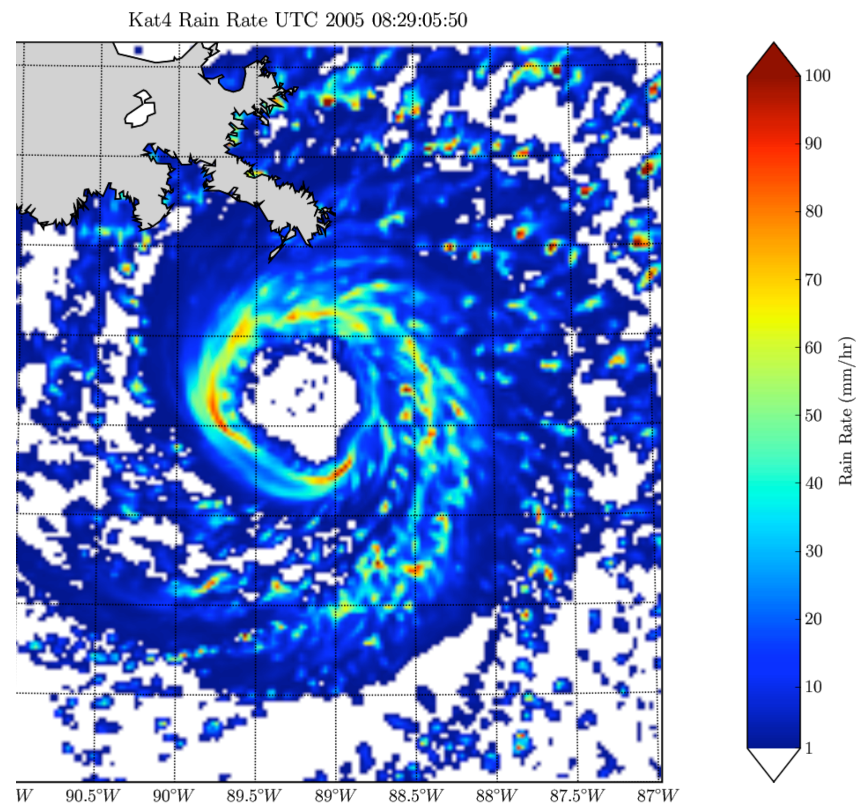
Parameter	QuikSCAT	DFS	XOVWM
Swath	1800 km	1800 km	1800 km
Channels	Ku HH & VV	Ku HH & VV C 2xHH	Ku HH & VV C 2xHH X radiometer
Peak Transmit Power	110W	220W	110W
Antenna Dimension	~1m	~2m	3.5m x 5m
Radar type	Real aperture	Real Aperture	Synthetic Aperture
C Azimuth Resolution	NA	~25 km Inner ~35 km Outer	14km Inner 19 km Outer
Ku Azimuth Resolution	~25 km	~15 km	< 5km
Range Slice Size (C&Ku)	~6 km	~3km	~2 km

Hurricane Katrina
Simulation Input

The JPL instrument simulation results include the effects of surface winds and rain contamination, which are derived from high-resolution WRF simulation output. Very high rain rates and winds are present in the hurricane simulations.

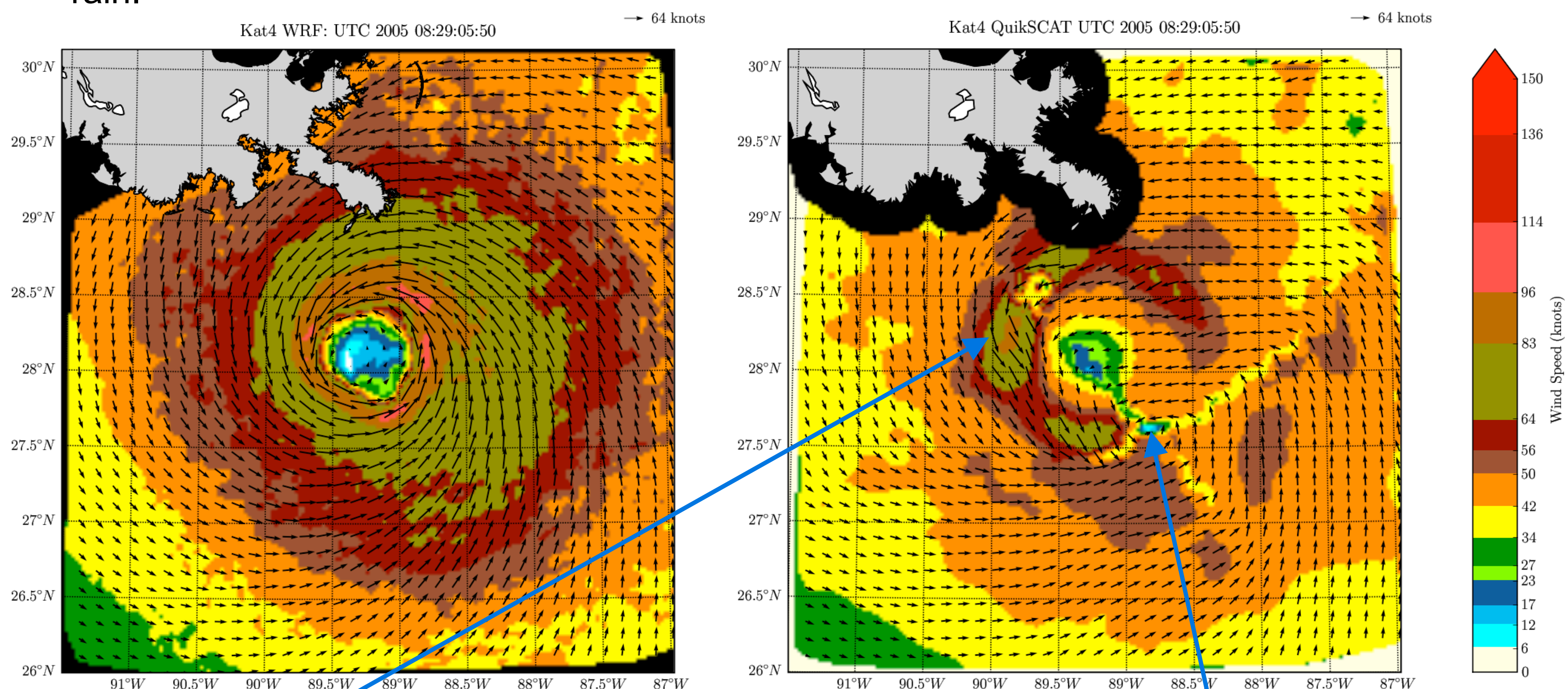


WRF Surface Winds



WRF Rain Rate

QuikSCAT Near-Real Time data products can only measure within 20km from land. QuikSCAT also significantly underestimates wind speeds at very high winds and under rain.



WRF

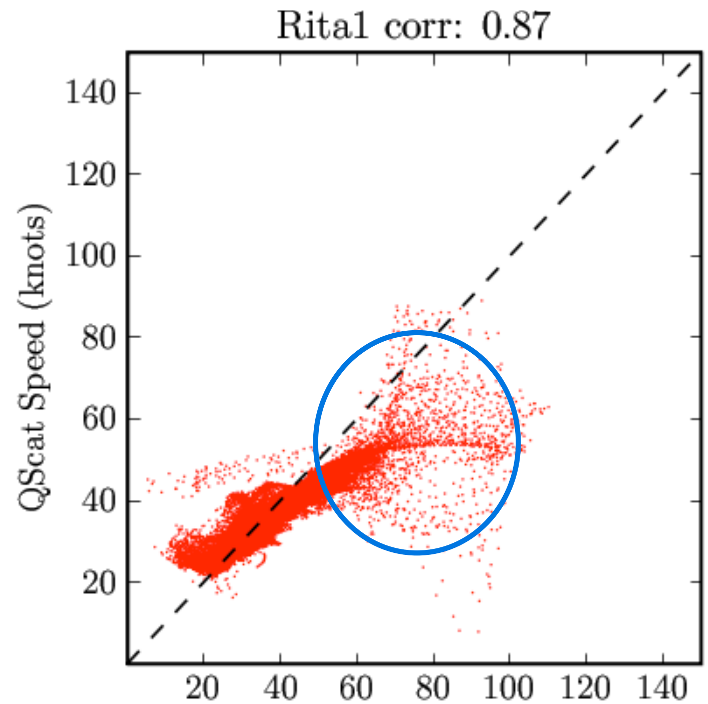
QuikSCAT

High winds estimated where rain is high

Notice QuikSCAT has the wrong hurricane circulation center

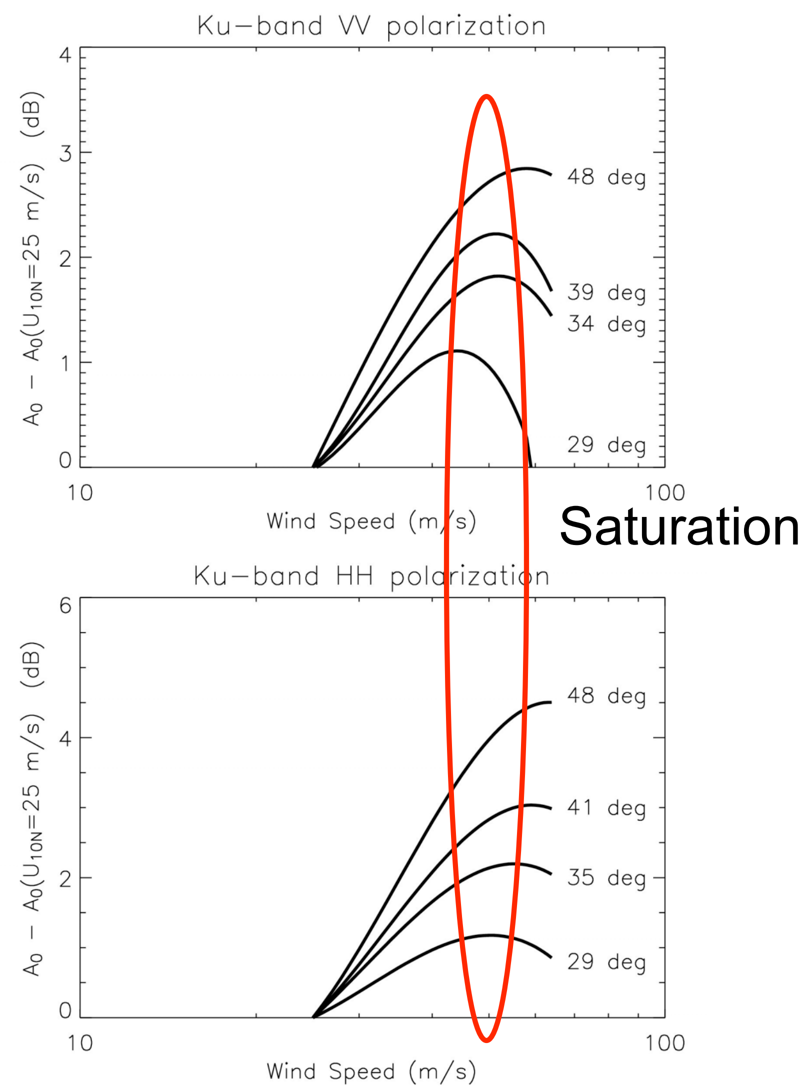
QuikSCAT Limitations for Hurricanes

QuikSCAT



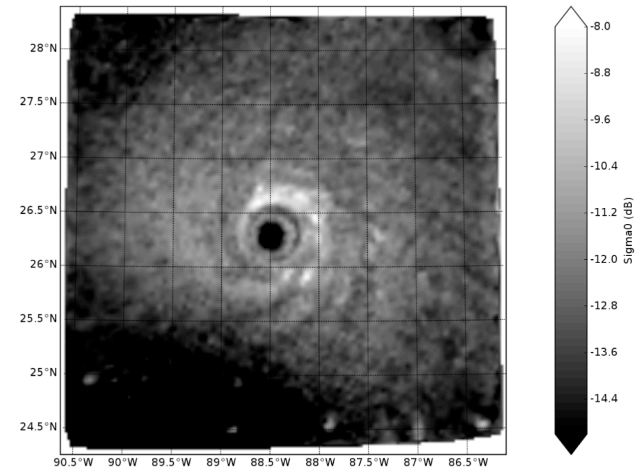
QuikSCAT significantly underestimates high wind speeds under tropical hurricane conditions. This figure is representative of all cases studied.

Model Functions - Ocean Backscatter vs. Wind Speed

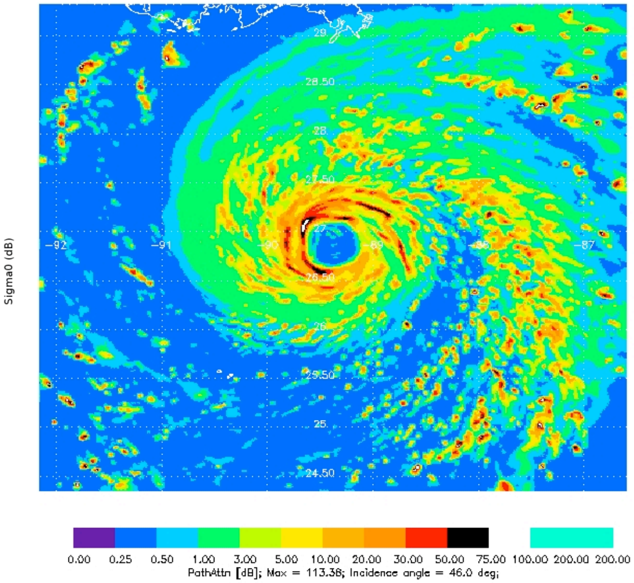


Rain Associated Distortions

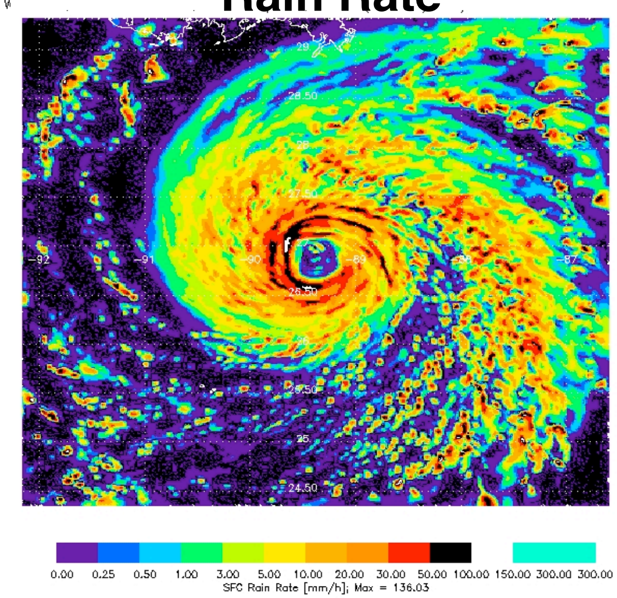
Ku-band Sigma0



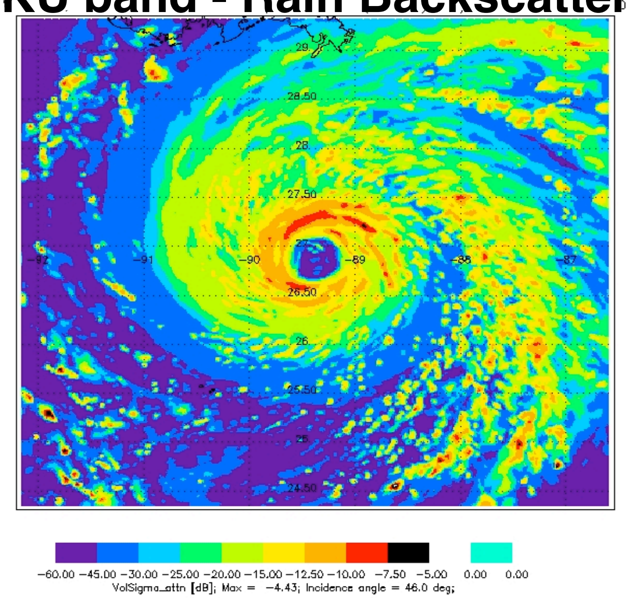
KU band - Attenuation



Rain Rate

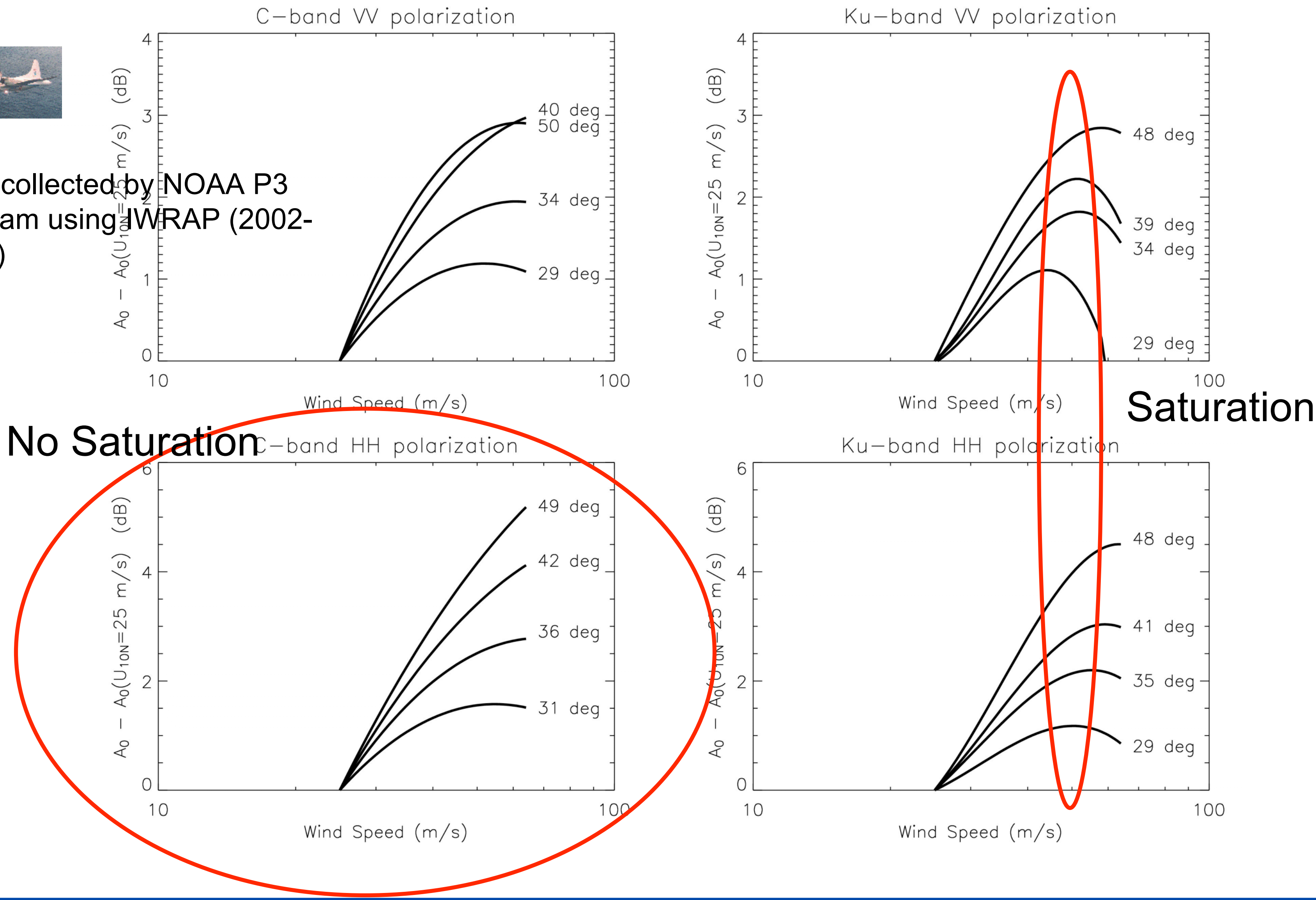


KU band - Rain Backscatter



Model Functions - Ocean Backscatter vs. Wind Speed

Data collected by NOAA P3 program using IWRAP (2002-2005)



Rain Associated Distortions

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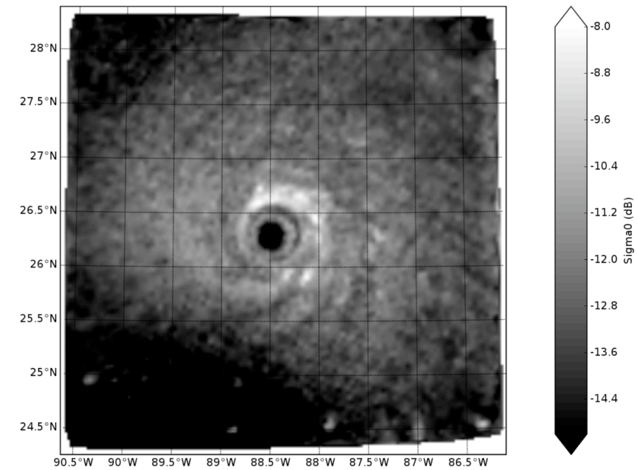
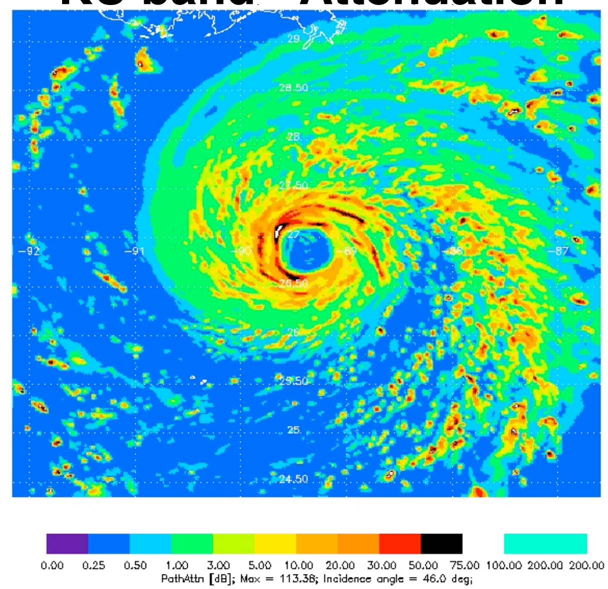
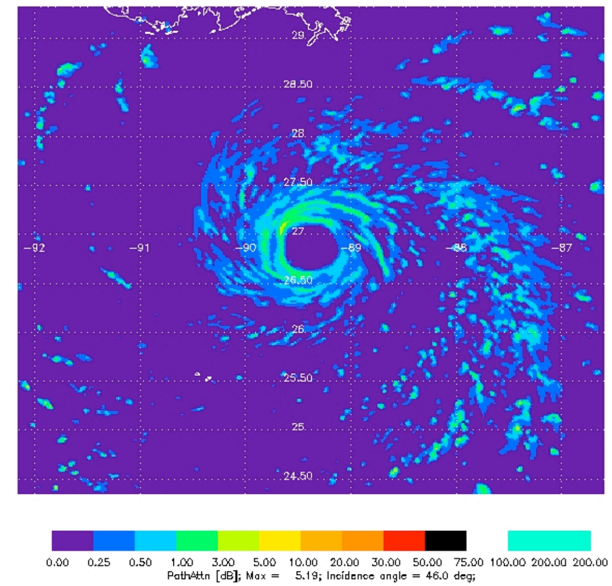


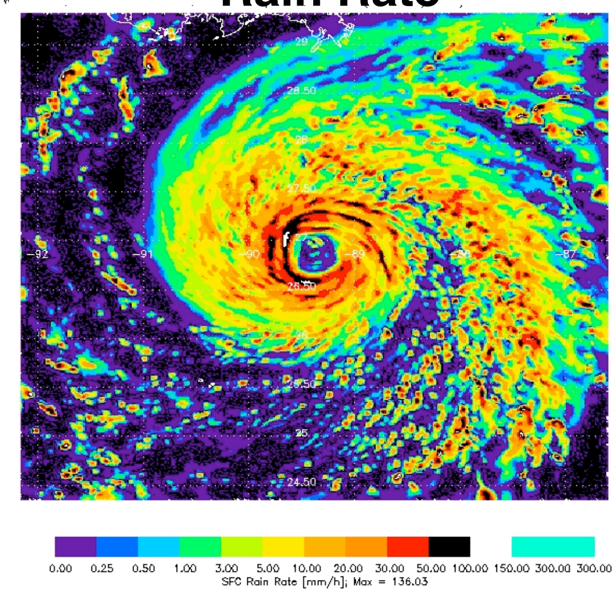
KU band - Attenuation



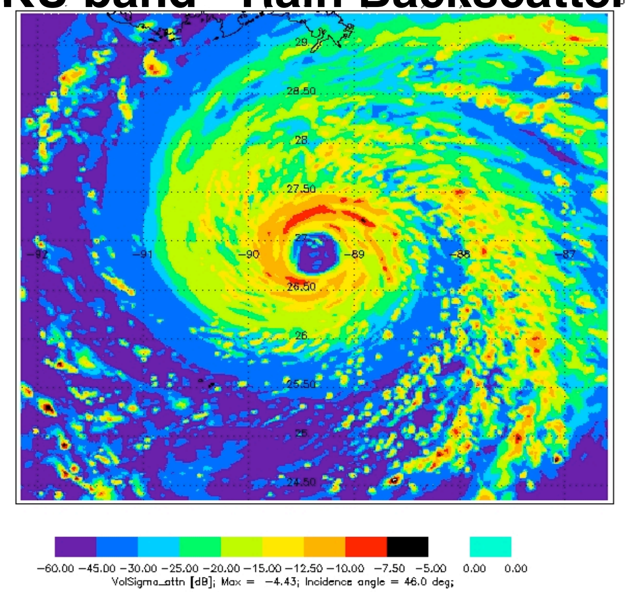
C band - Attenuation



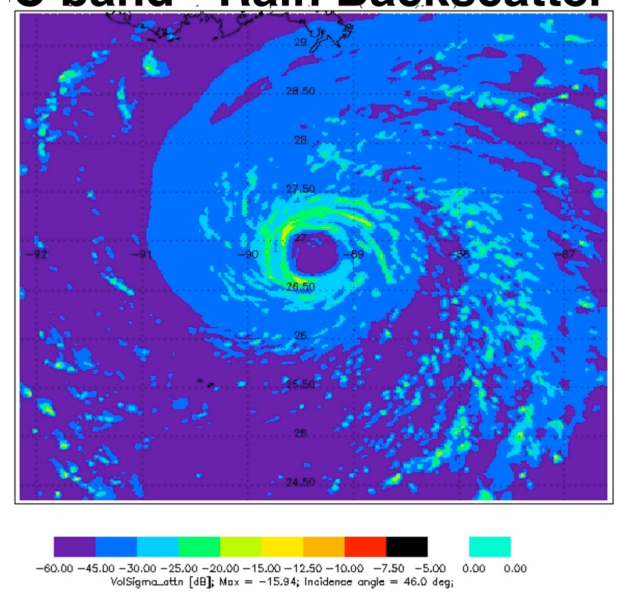
Rain Rate



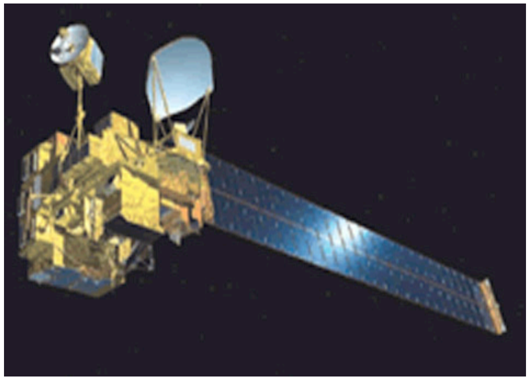
KU band - Rain Backscatter



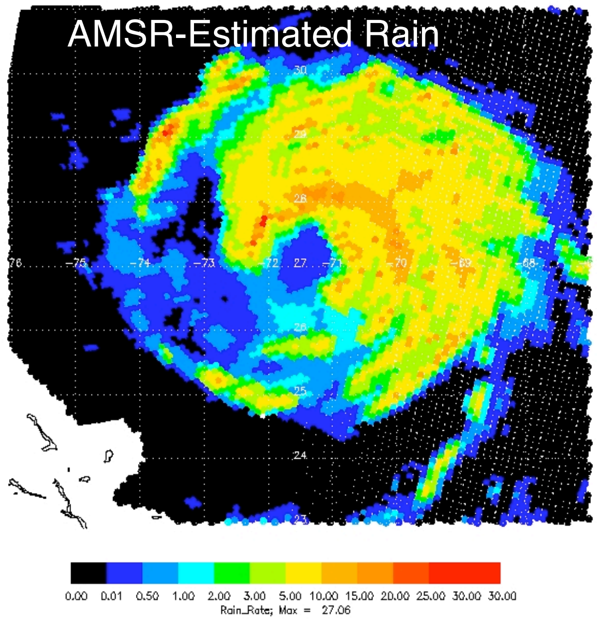
C band - Rain Backscatter

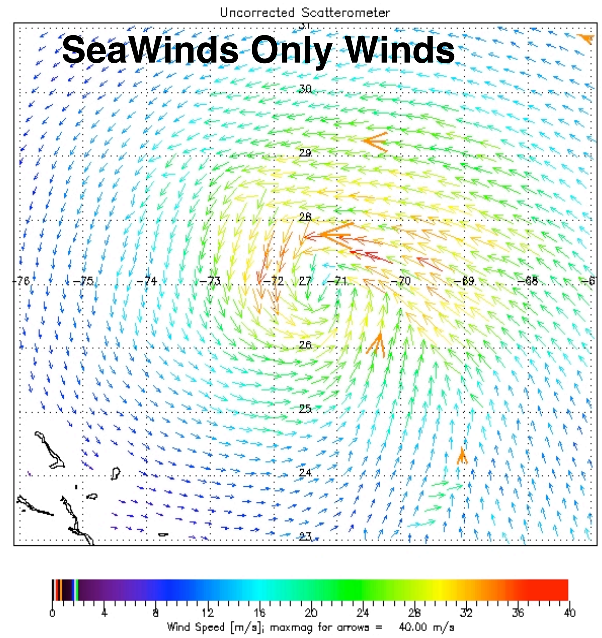


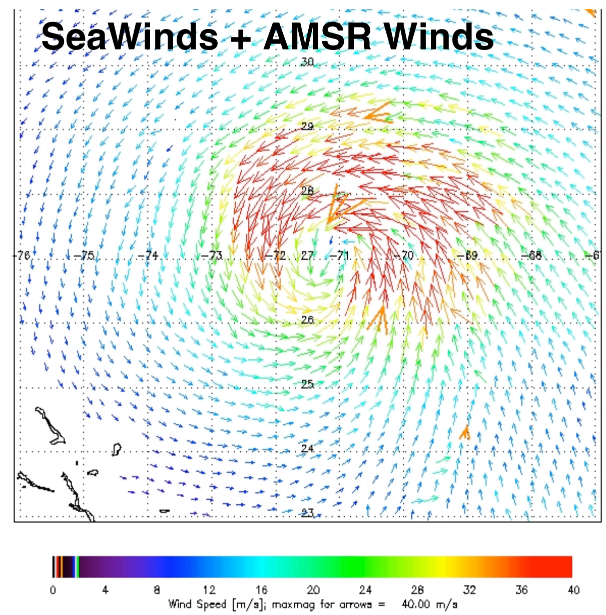
Improving Tropical Cyclone Winds in Rain using AMSR



SeaWinds and AMSR on Adeos-II



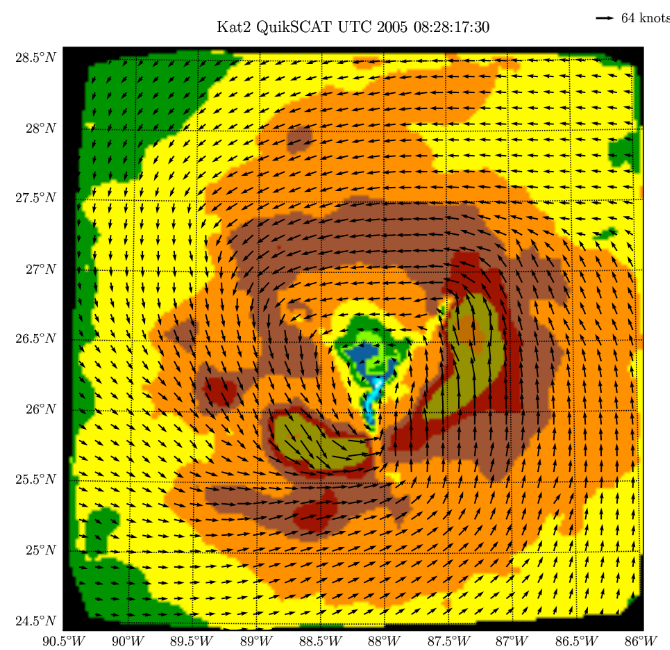




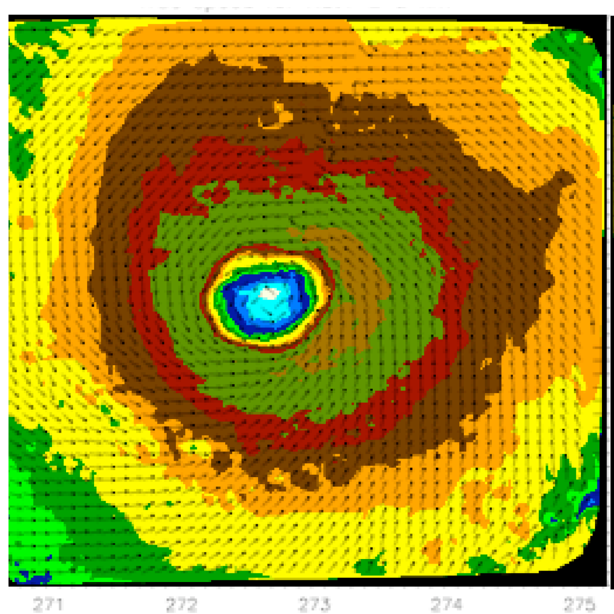
The combination of AMSR and the SeaWinds scatterometer on Adeos-II was a unique opportunity to demonstrate the usefulness of combined measurements.

AMSR estimated rain can be used to retrieve better winds under rainy conditions, aiding the study of tropical cyclones, in this example.

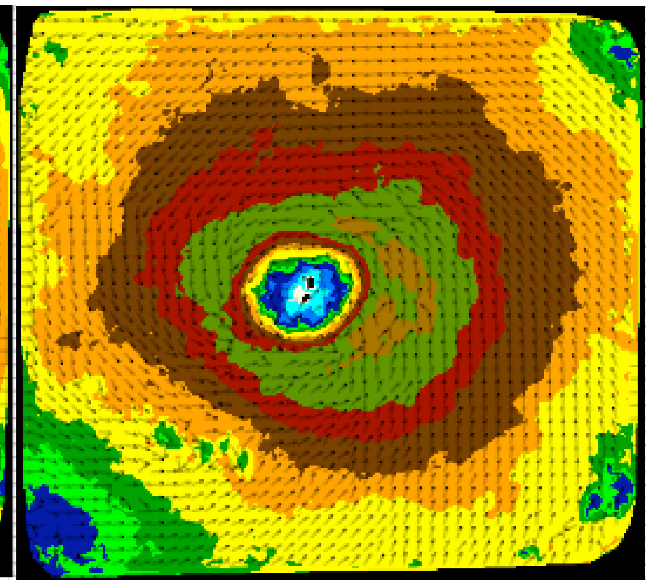
Katrina Performance Comparison



SeWinds Scatterometer Surface Winds

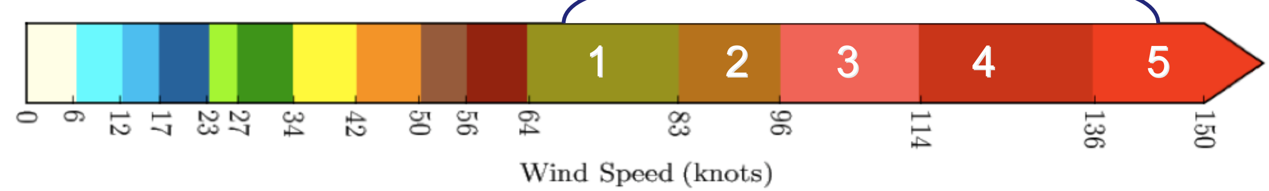


Weather Research and Forecasting Model (WRF) Surface Wind “Truth”

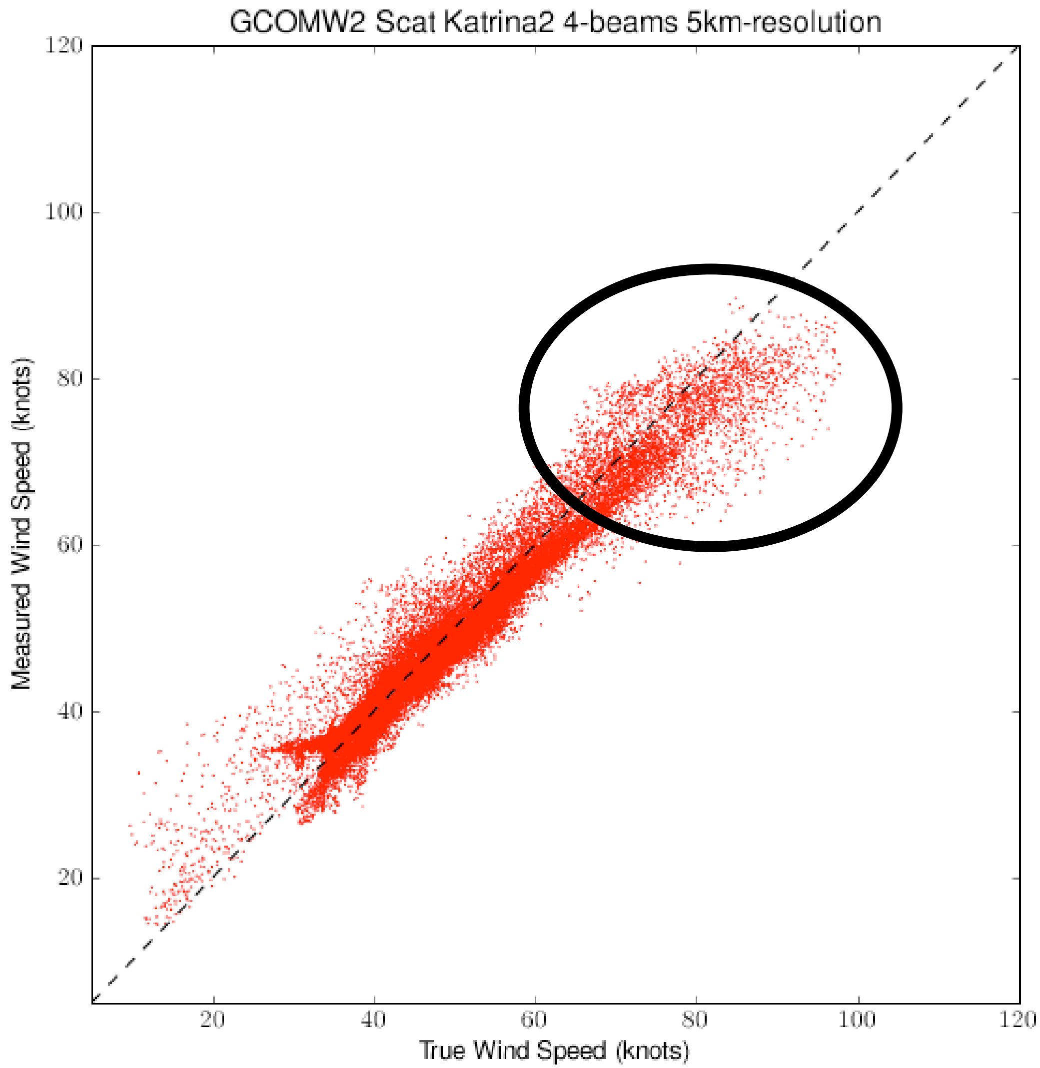


Dual Frequency GCOM-W2 Scatterometer Surface Winds

Hurricane Category Winds



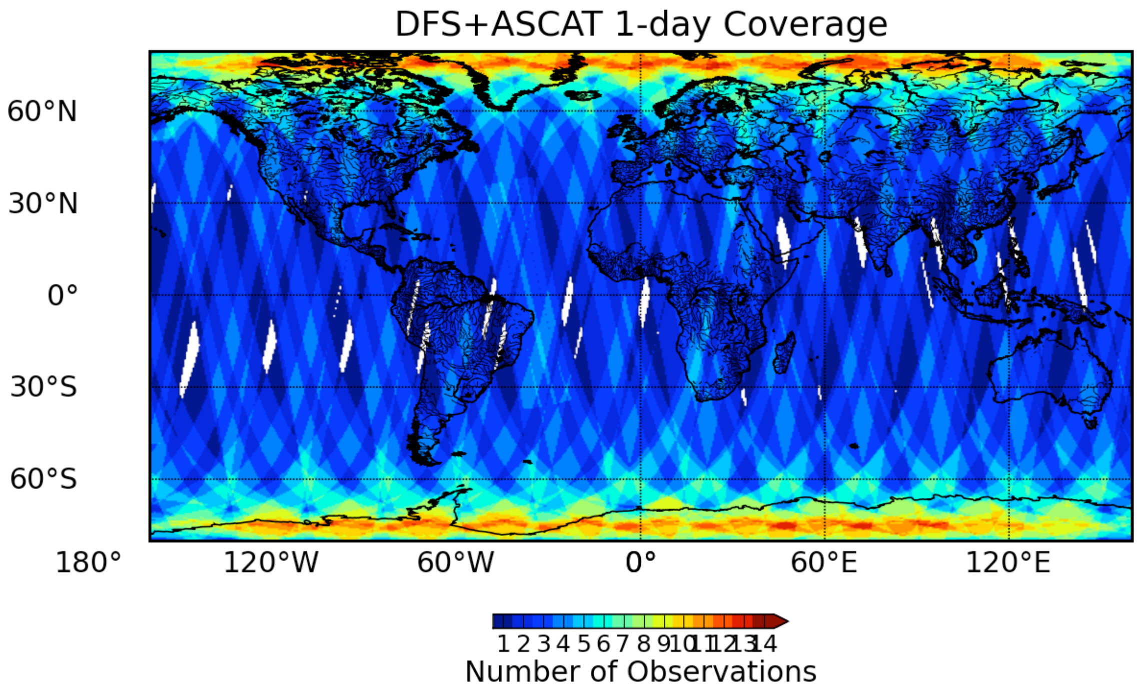
GCOMW-2 DFS Wind Speed Performance

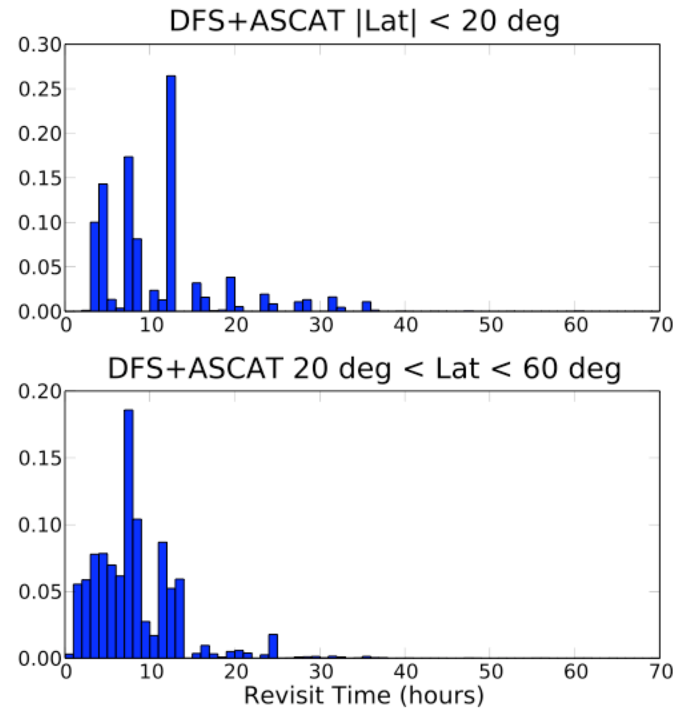


DFS winds have high correlation with true winds.

Some underprediction at high winds due to spatial resolution

DFS (on A-train) + ASCAT Coverage





QuikSCAT+ASCAT Coverage