Progress in the Dual-Frequency Scatterometer for GCOM-W2

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Talk Outline

- Where is the DFS programmatically?
- Where is the DFS technically?
- How can you help?

DFS Programmatic Progress

- Memorandum of understanding signed between Kicza (NOAA) and Horikawa (JAXA)
  - Agreement to work towards a potential flight of a scatterometer in GCOM-W2
- JAXA has baselined the DFS as part of the GCOM-W2 mission
  - Pending successful accommodation, funding of the DFS with a schedule compatible with GCOM-W2 needs, and successful review of the mission concept.
- A JAXA Mission Definition Review (MDR) is tentatively scheduled for December ‘09, with a US Mission Concept Review tentatively scheduled for September ‘09
- The nominal GCOM-W2 launch date is January, 2016

Research and Operations Users Working Group (ROUWG)

- A small working group with representatives from NOAA, JAXA, NASA, and the OVWST (M. Bourassa) has been selected to represent the requirements from the science and operations communities for the GCOM-W2 mission
  - Both AMSR3, DFS, and joint science goals are addressed
- The initial meeting of the ROUWG took place in Tokyo on April 20-21
- Meeting agenda concentrated on the science requirements documents for the GCOM-W2 mission
- The DFS draft science requirement document has been circulated to the OVWST for your comments
  - We also want your endorsement!

Orbit Issue

- The orbit for GCOM-W2 has not been finalized
  - Nodal crossing time is not yet defined
- We need inputs from the OVWST on the best configuration that will maximize science return
  - Coordination with ASCAT, Indian and Chinese scats
  - However, AMSR science goals and participation in other constellations must also be considered
- What metric maximizes science return?
  - Minimize average revisit time?

Summary of DFS Performance Requirements

Requirement	NOAA 2006 User Goals	Minimum Payload	Nominal DFS
WVC Size	**<5 km**	12.5 km	<10 km
Coastal Mask	**<5 km**	20 km	<10 km
Coverage	**90% of the ocean surface every 24 hours**	90% of the ocean surface every 24 hours	90% of the ocean surface every 24 hours
Wind Speed Accuracy (RMS)	**3-20 m/s: 2 m/s** **20-30 m/s: 10%** **30-80 m/s: 10%**	3-20 m/s: 2 m/s 20-30 m/s: 10% 30-80 m/s: not specified	3-20 m/s: 2 m/s 20-30 m/s: 10% 30-50 m/s: 10% 50-80 m/s: 20%goal
Wind Direction Accuracy (RMS)	**3-30 m/s: 10°** **30-80 m/s: 10°**	3-30 m/s: 20° 30-80 m/s: no requirement	3-30 m/s: 20° 30-50 m/s: 20° 50-80 m/s: 30° goal
Retrieval in Precipitation	**All-weather wind retrieval**	None in heavy precipitation	Near all-weather wind retrieval
Product Latency	**< 180 minutes for 85% of the data**	< 180 minutes for 85% of the data	< 180 minutes for 85% of the data

- The requirements are based on the 2006 NOAA users OSVW workshop report, but have been modified to align them with accommodation restrictions imposed by the GCOMW-2 mission
- These requirements have been discussed by the ROUWG

Core Data Products

Operational Merged Geophysical Data Records (OMGDR's): These data records will be produced in real time and used for operational weather applications. These records will be produced in Binary Universal Form for the Representation of meteorological data (BUFR), a binary data format maintained by the World Meteorological Organization and used widely by operational weather agencies. The OMGDR's will not be archived or reprocessed.

Fields contained in the OMGDR's shall include (but not be restricted to):

1. Backscatter coefficients with information needed for wind retrieval reorganized into WVC's. Backscatter coefficients may be composites of slices from a single pulse that fall within a WVC. Backscatter coefficients have clear sky absorption correction, rain contamination attenuation and scattering correction.
2. When collocated AMSR, or DFS, radiometer data are available, brightness temperatures are included.
3. Geolocated multiple (ambiguous) wind vectors in each ocean WVC with a flag for the selected vector. Wind vectors are retrieved from composite backscatter measurements in a WVC using the Geophysical Model Function.
4. Collocated wind error estimates and flags indicating data quality.

Science Merged Geophysical Data Records (SMGDR's): These data records contain the climate quality data records. They contain the same fields as the OMGDR's, but may have improved calibration, flagging, or geolocation relative to the OMGDR's. The SMGDR's will be stored in a data format widely used by the scientific and climate community, such as NetCDF or HDF5. These data are archived and reprocessed as improved calibration, geophysical model functions, flagging, or processing algorithms become available. The data set will form a consistent, uniformly calibrated and processed climate data record collected by the DFS for the entire GCOM-W2 mission.

Climate Requirements

[Goal] Climatological Wind Vector Biases

The biases on seasonally averaged winds will be less than TBD% of the seasonal mean in magnitude and TBD% of the seasonal mean in direction. The biases on seasonally averaged wind stress will be less than TBD% of the seasonal mean in magnitude and TBD% of the seasonal mean in direction. This climate goal is not easily verified on a global basis, and is therefore not levied as a requirement on the system.

[Requirement] Data Archiving

The data products for the entire mission, excluding the OMGDR's, shall be archived. The data to be archived include metadata required for reprocessing and calibration of the data.

[Requirement] Data Reprocessing

If significant changes (as determined by the science team) in the data product occur as a result of improved algorithms or calibration, the science data shall be reprocessed and made publicly available for the entire mission duration. A maximum of TBD reprocessing events shall occur during the nominal mission.

Question: are these requirements, in addition to the other performance and cal/val requirements, sufficient to capture the climate data record needs for the mission?

Additional Data Products

The project will produce the following data on a best effort basis:

- **Sea Ice Mask:** A geolocated mask of sea ice extent, classified into first year or multi-year ice. The sea ice mask will also include icebergs. This product is produced for each radar pass and as a weekly global mosaic.
- **Normalized Radar Cross Section Imagery:** Composite imagery for each radar polarization and frequency, including average cross-section and cross section variability. This product is produced for each radar pass and as a weekly global mosaic.
- **Higher Resolution Wind Vector Storm Sector Products:** For tropical cyclones and other storms, it is possible to generate useful winds information at higher resolution than the nominal data. These higher resolution data will be generated for all tracked cyclones and storms at a resolution of at least 5 km. The data will be available in near real time, and will be archived to facilitate climate studies.
- **Coastal wind data product:** Near the coasts, it is possible to produce a Ku-band only wind data product that rejects slices contaminated by land to produce wind estimates closer to the coast. This data product will not have the same performance characteristics as the nominal wind data product, may not be produced in regions of adverse geometry, and is not all-weather. Nevertheless, it may be of significant benefit for coastal warnings and shipping applications. The coastal data product will be reported on an irregular grid, which minimizes land contamination.

Cal/Val Requirements

1.1. [Requirement] Performance Validation

The DFS performance shall be validated independently during the validation phase. Validation shall include, but not be limited to:

- C omparison against available *in situ* wind measurements, such as those provided by ocean buoys or suitably instrumented ships.
- C omparison against *in situ* data collected by airborne sensors. These data are expected to be crucial for validation of performance for high winds and rainy conditions.
- S tatistical comparisons against regional or global numerical weather prediction model output, where these data are judged to be accurate enough to assess the mission performance.

In addition to validating the wind vector performance, the geophysical model function, data flags, and error estimates shall also be validated.

The validation results shall be presented at a validation meeting at the end of the validation phase and published in the refereed literature.

1.2. [Requirement] Engineering Checkout Phase

The mission shall support a 1-month engineering checkout phase during which no science or operational data are produced. The checkout phase is included in the total mission lifetime.

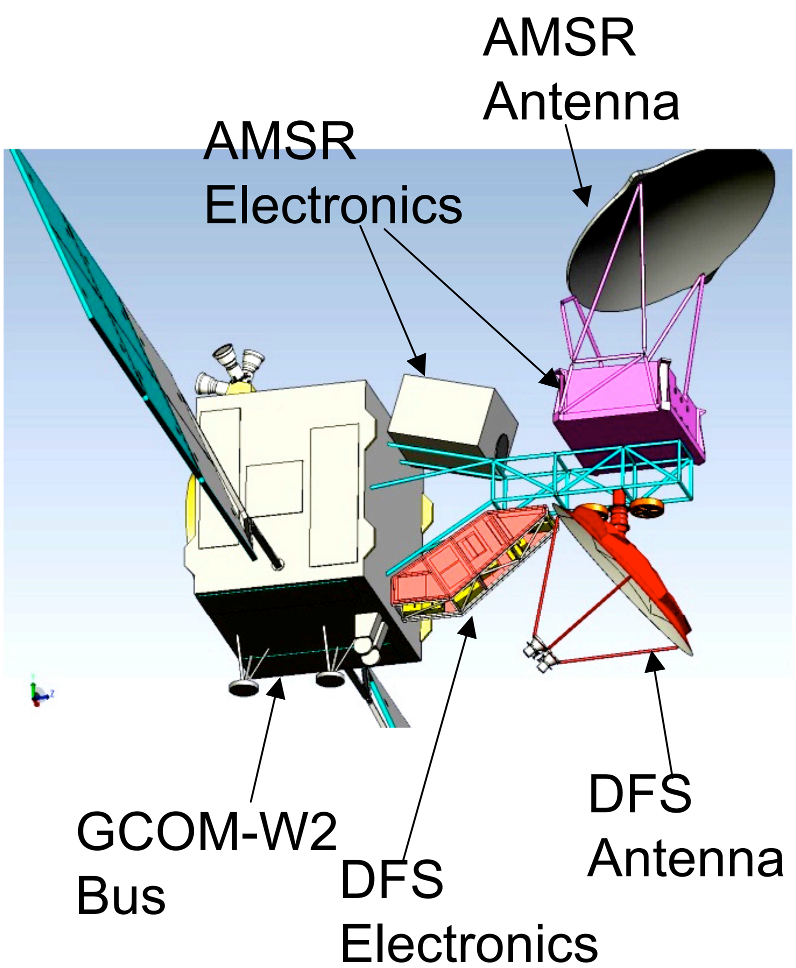
1.3. [Requirement] Calibration Phase

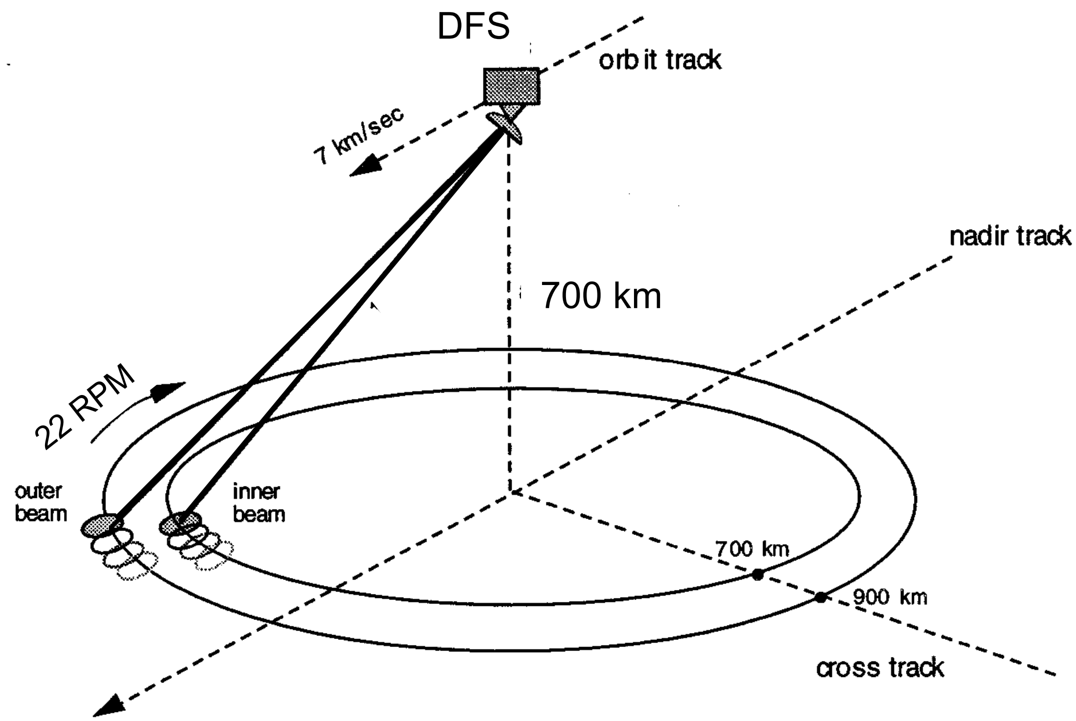
The mission shall support a 3-month calibration phase for determining unknown static system parameters. During this time, operational and science data products may be produced but need not meet the performance requirements. The calibration phase is included in the total mission lifetime.

1.4. [Requirement] Validation Phase

The mission shall support a 1-year phase for validating data product performance by the research and operations team. During this time, operational and research products are produced. A product upgrade and reprocessing of the science products may be required after the end of this phase. The validation phase is included in the total mission lifetime.

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

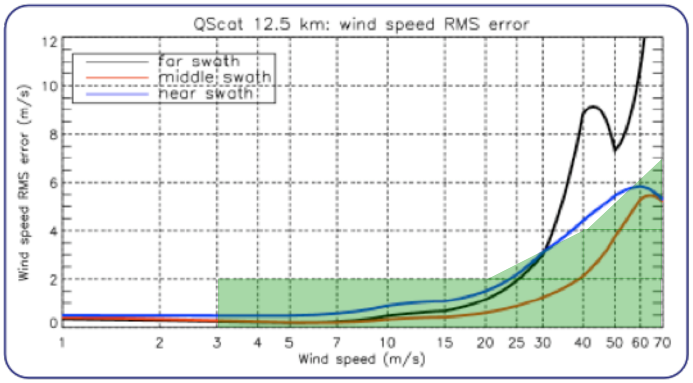
Parameter	QuikSCAT	DFS	XOVWM
Swath	1800 km	1800 km	1800 km
Channels	Ku HH & VV	Ku HH & VV C 2xHH	Ku HH & VV C 2xHH X radiometer
Peak Transmit Power	110W	220W	110W
Antenna Dimension	~1m	~2m	3.5m x 5m
Radar type	Real aperture	Real Aperture	Synthetic Aperture
C Azimuth Resolution	NA	~25 km Inner ~35 km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

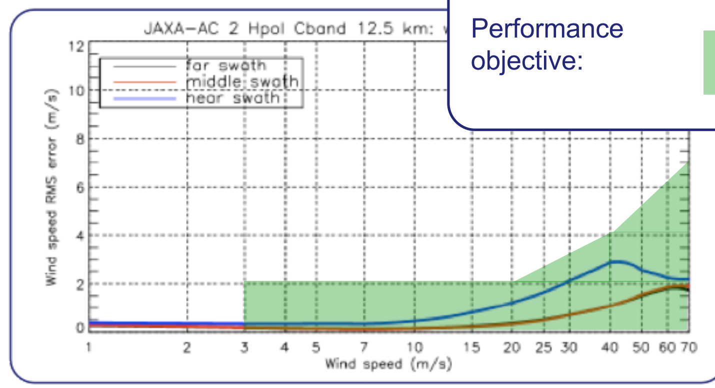
SeaWinds & Dual Frequency GCOM-W2 Scat Wind Speed and Direction Errors (12.5 km Resolution)

Nadir Swath
Middle Swath
Far Swath

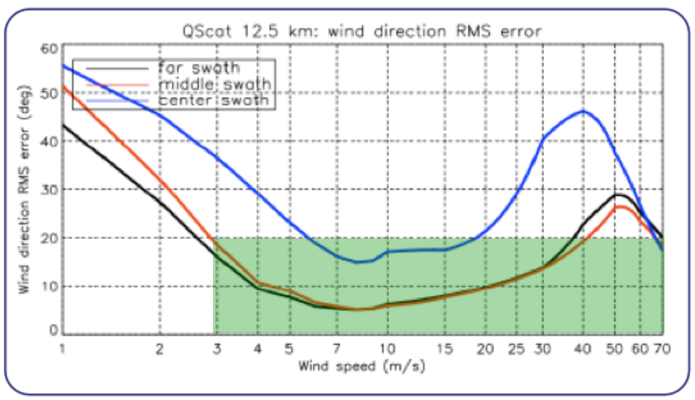
Performance objective:

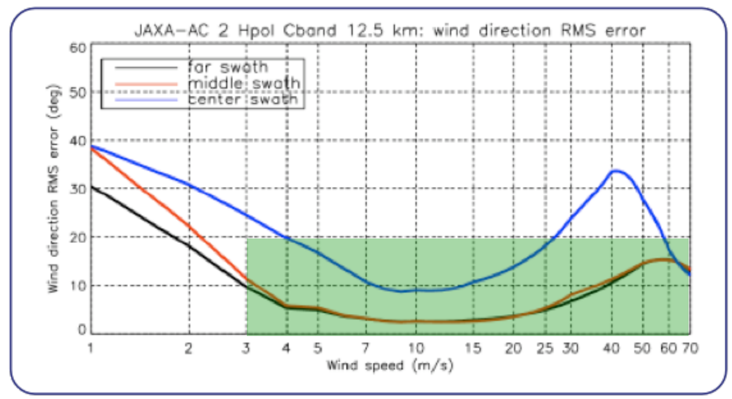
RMS Speed Error, m/s





RMS Direction Error, degrees





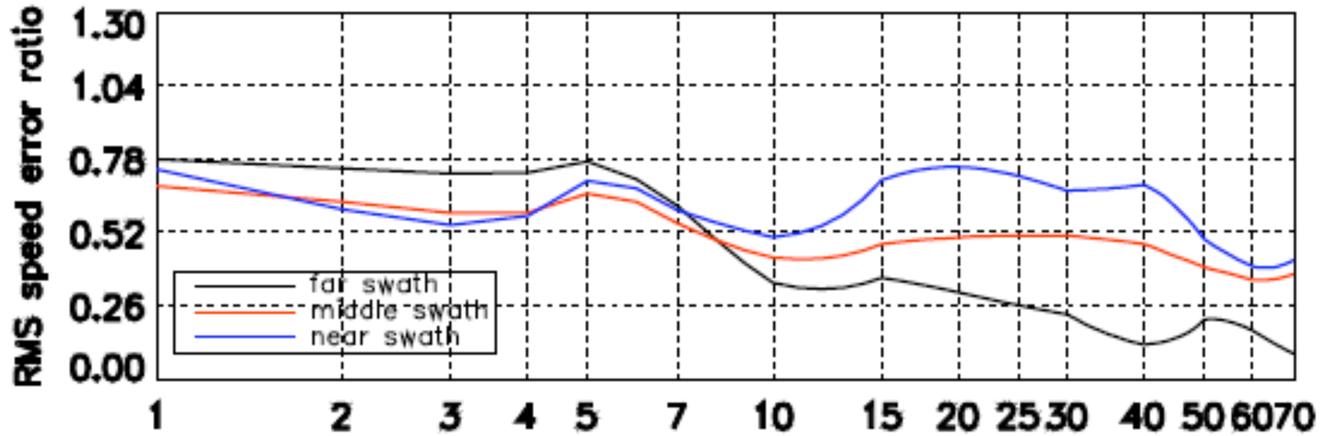
SeaWinds

Dual Frequency GCOM-W2 Scat

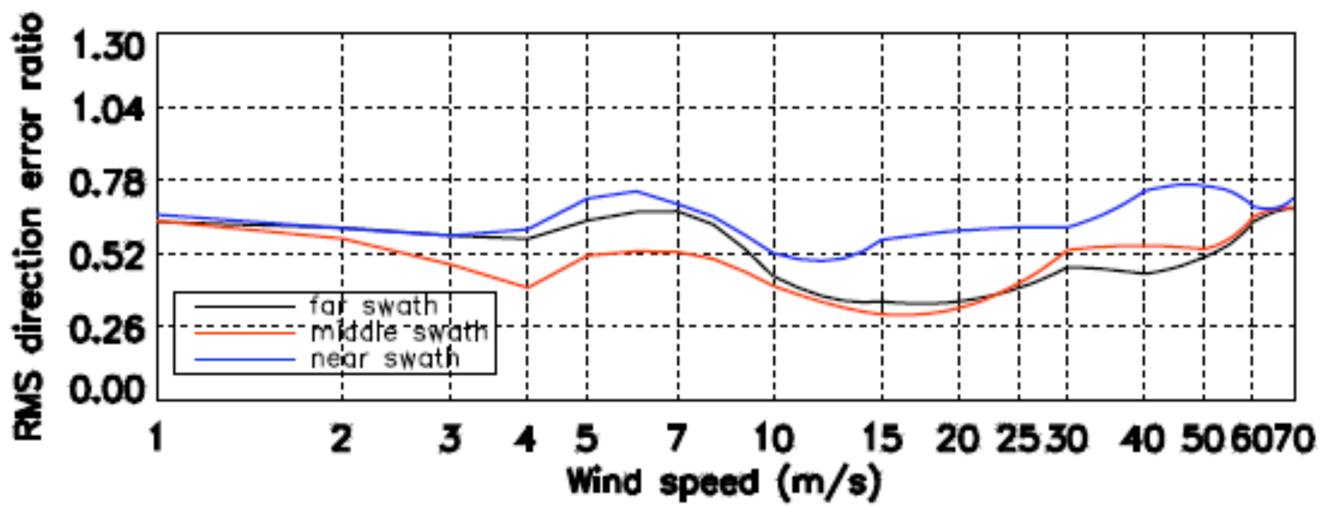
Note: The XOVWM high resolution instrument presented at the August meeting achieves similar speed and direction errors at 5 km resolution and would better these performance statistics by a factor of 2 at this resolution

Dual Frequency GCOM-W2 Scat Performance Ratios Relative to SeaWinds

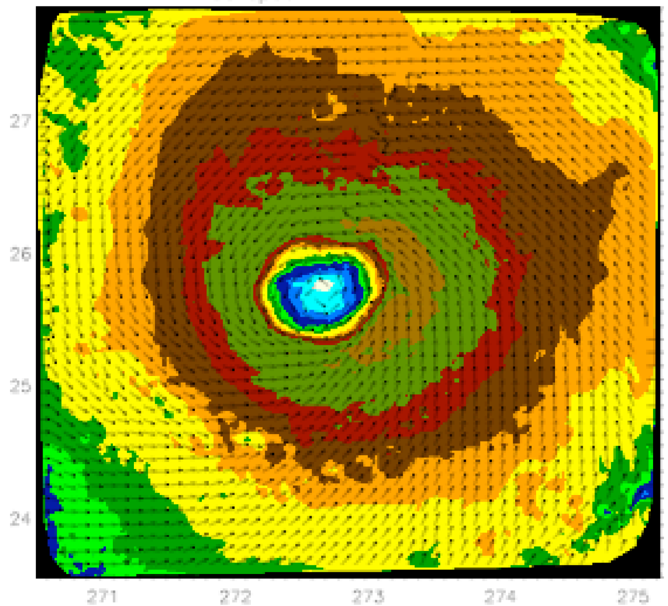
Nadir Swath
Middle Swath
Far Swath

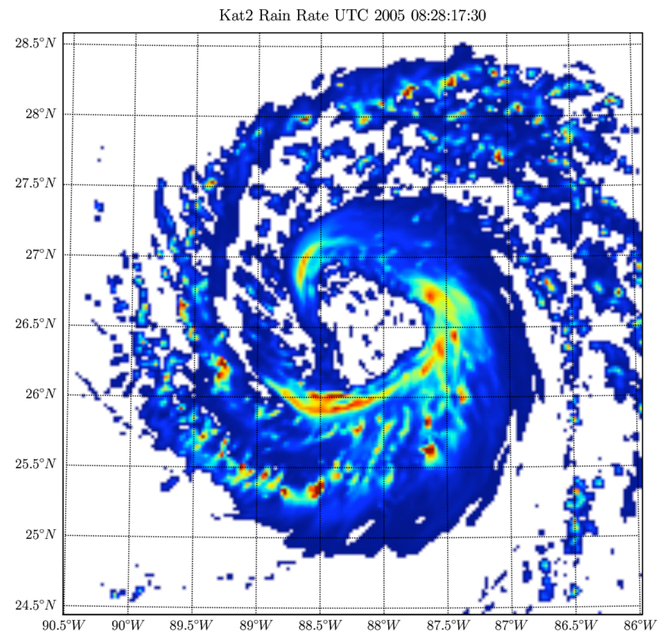


- Plots show the ratio relative to SeaWinds (RMS error)
- Values less than unity indicate improvements



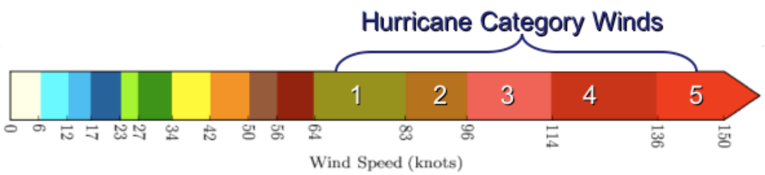
Katrina WRF Simulation

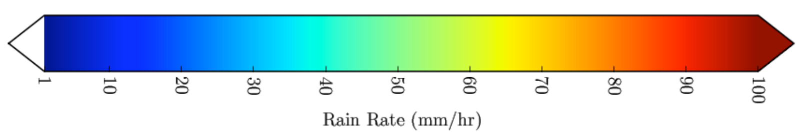




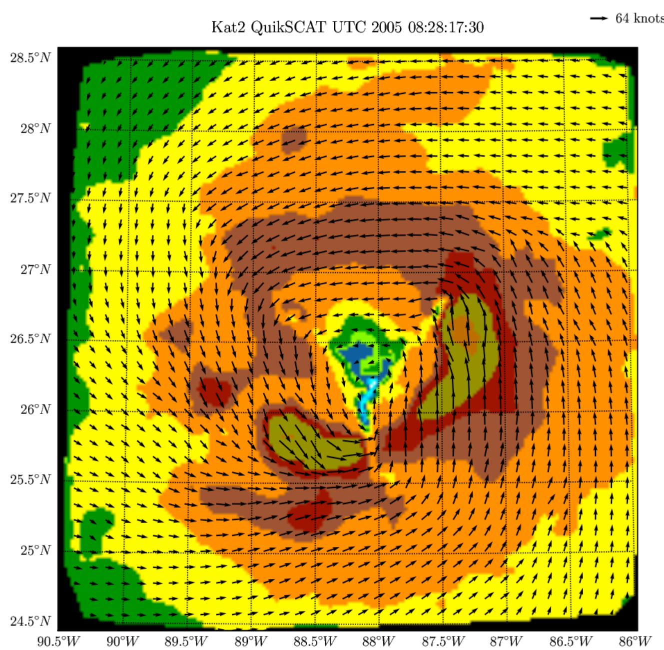
Weather Research and Forecasting Model (WRF) Surface Wind "Truth"

Weather Research and Forecasting Model (WRF) Rain Rate "Truth"

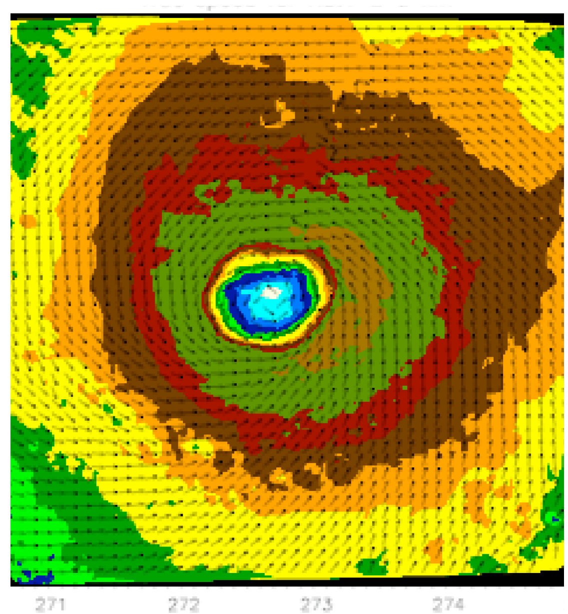




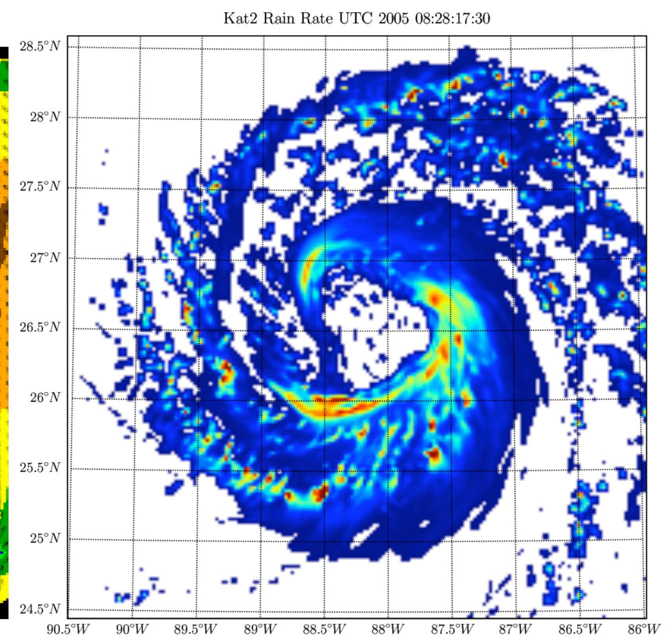
Katrina SeaWinds Performance



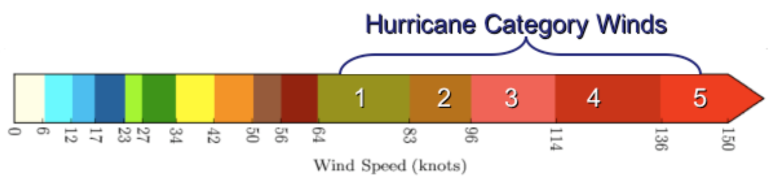
SeWinds Scatterometer Surface Winds

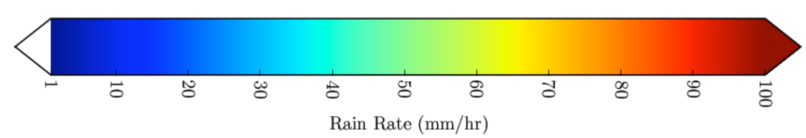


Weather Research and Forecasting Model (WRF) Surface Wind "Truth"



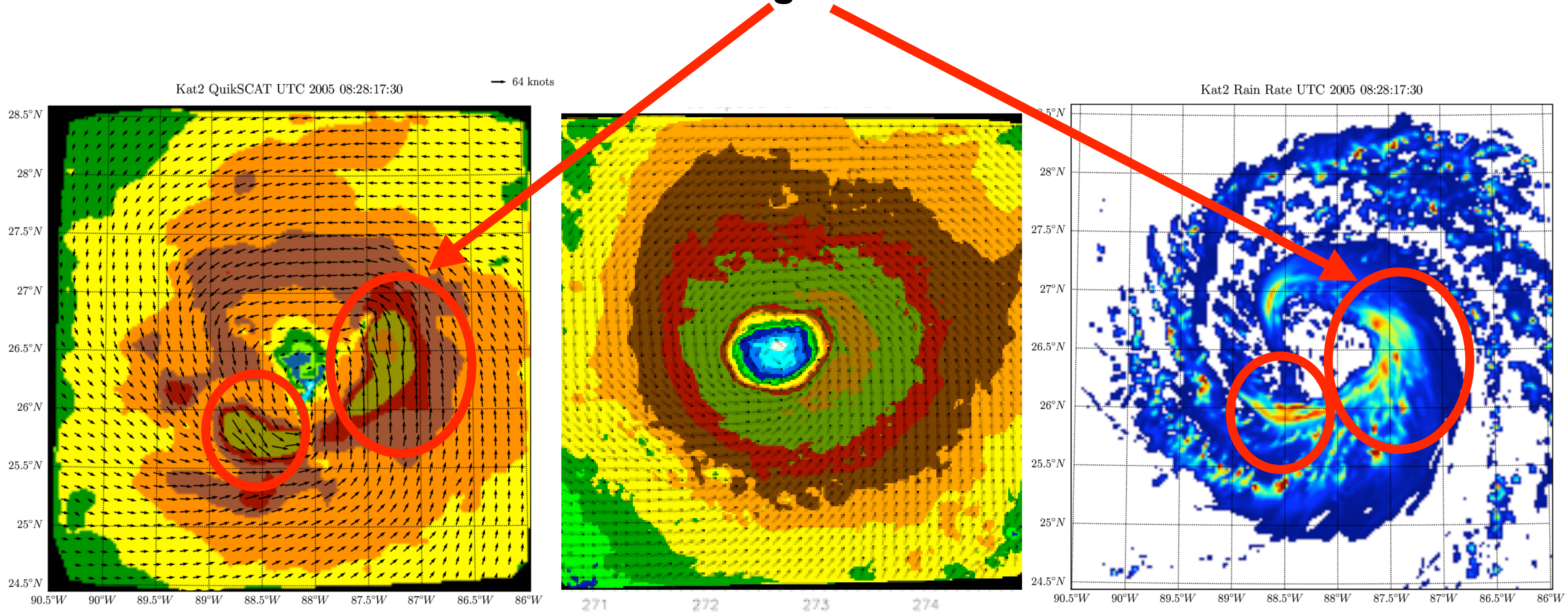
Weather Research and Forecasting Model (WRF) Rain Rate "Truth"





Katrina SeaWinds Performance

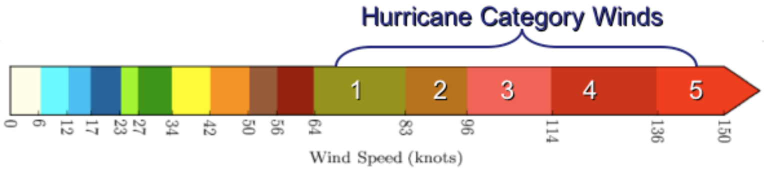
Measuring winds or rain?

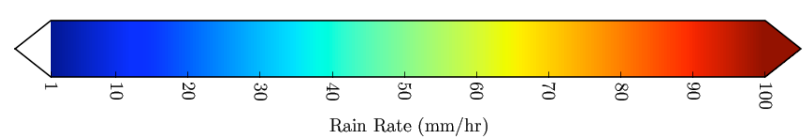


SeWinds Scatterometer Surface Winds

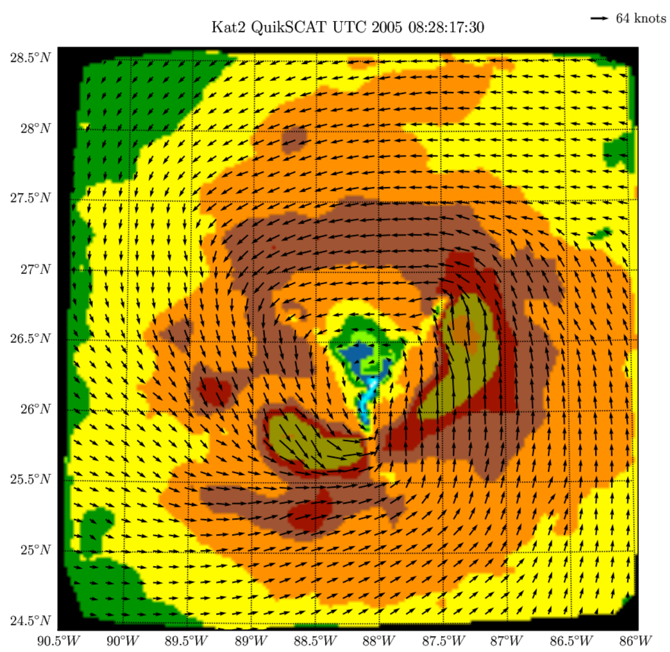
Weather Research and Forecasting Model (WRF) Surface Wind "Truth"

Weather Research and Forecasting Model (WRF) Rain Rate "Truth"

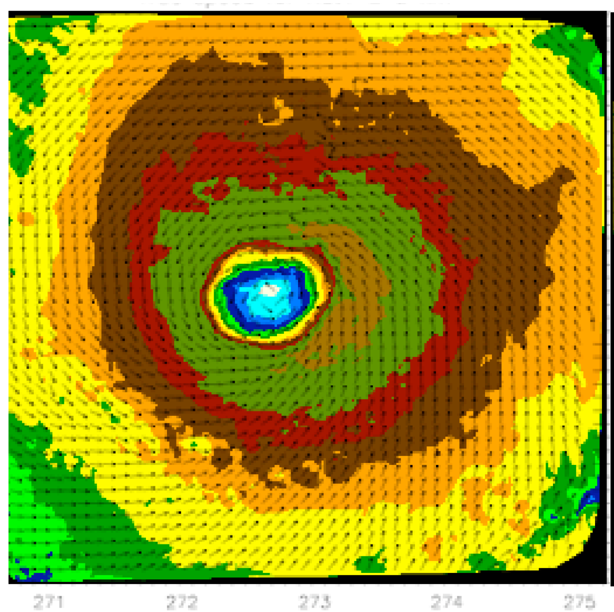




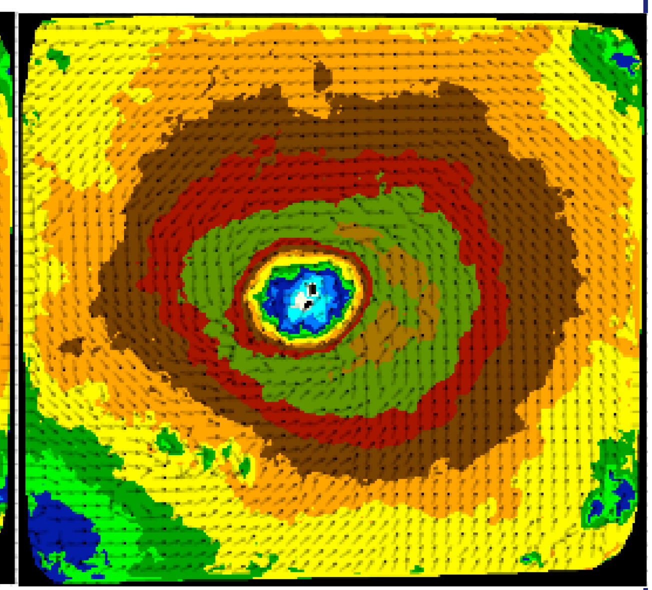
Katrina Performance Comparison



SeWinds Scatterometer Surface Winds

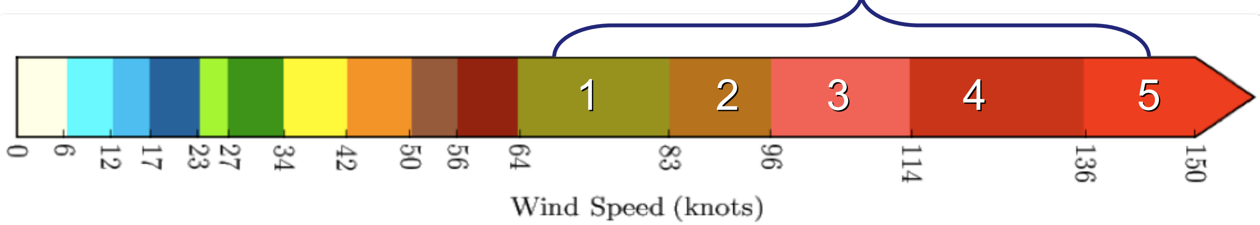


Weather Research and Forecasting Model (WRF) Surface Wind "Truth"

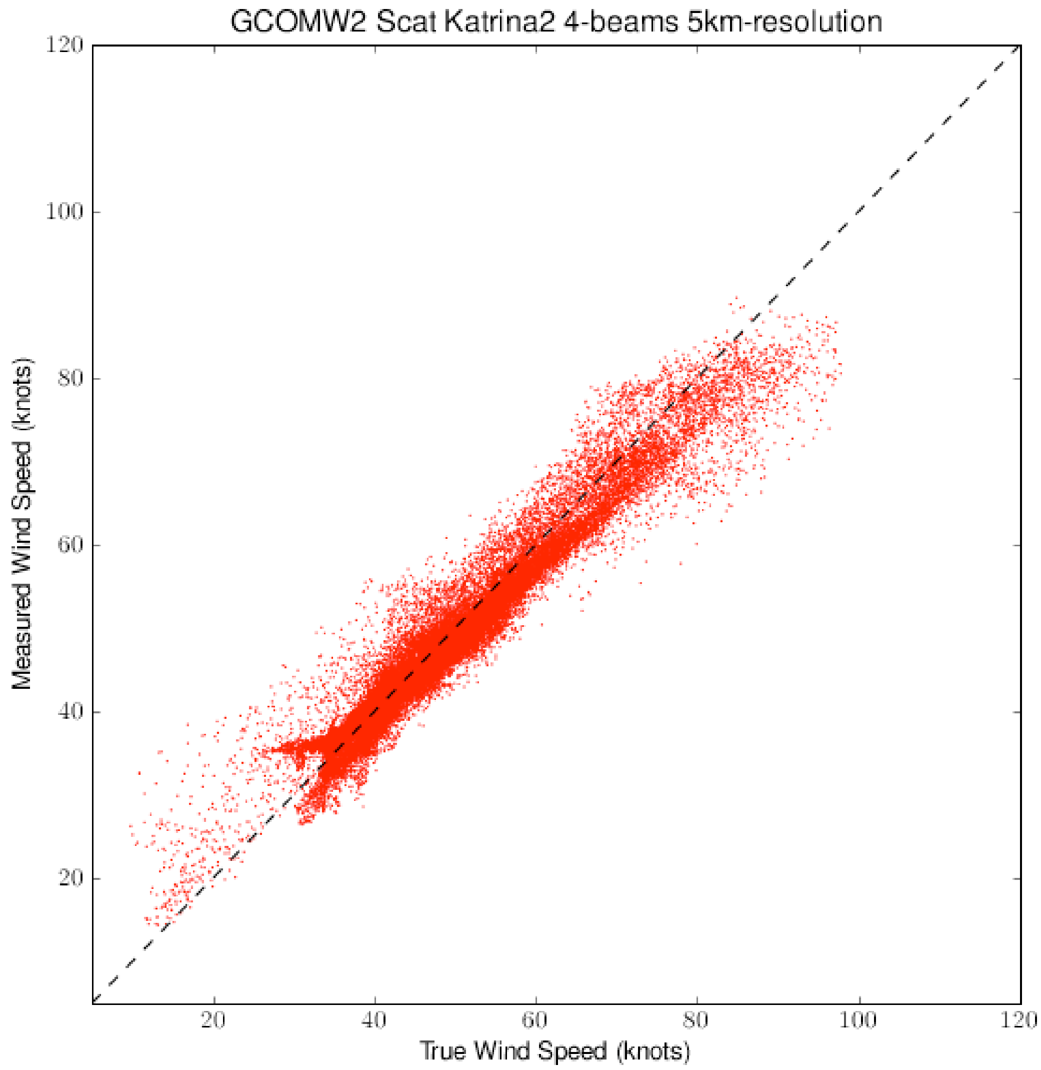


Dual Frequency GCOM-W2 Scatterometer Surface Winds

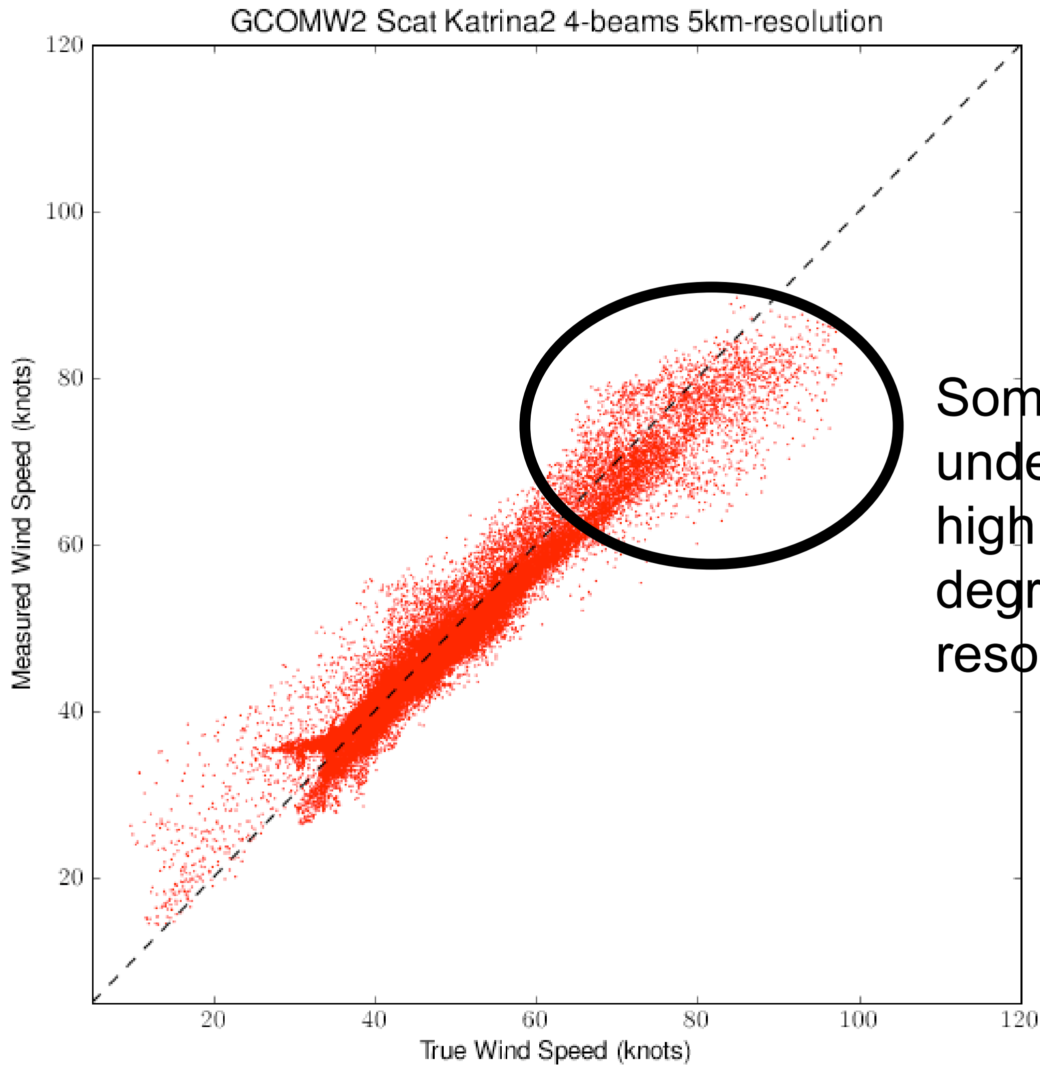
Hurricane Category Winds



GCOMW-2 DFS Wind Speed Performance

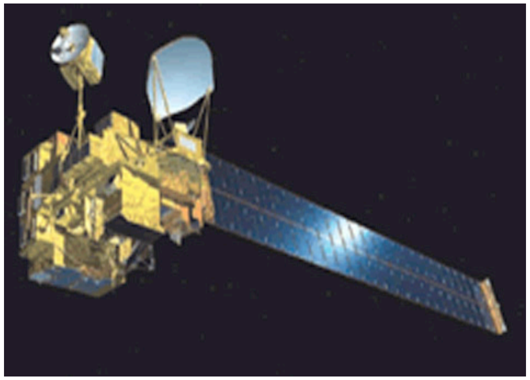


GCOMW-2 DFS Wind Speed Performance

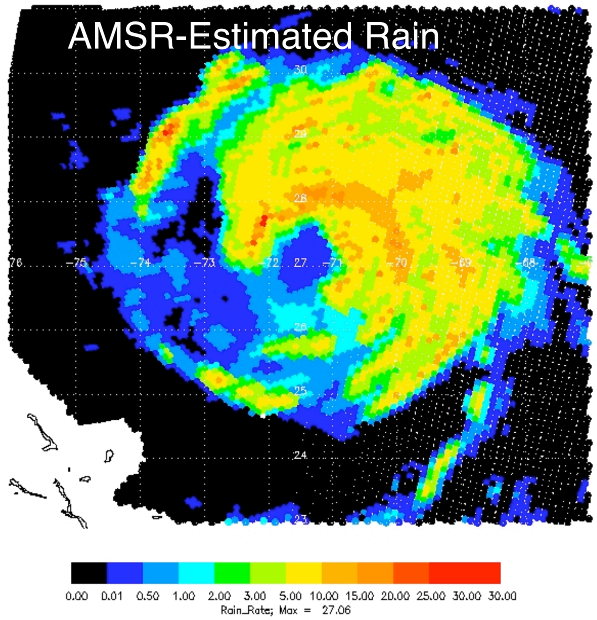


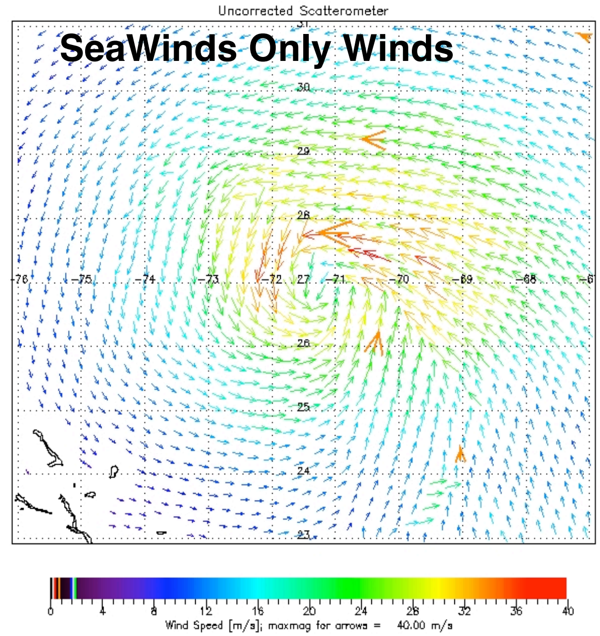
Some underprediction at high winds due to degraded spatial resolution

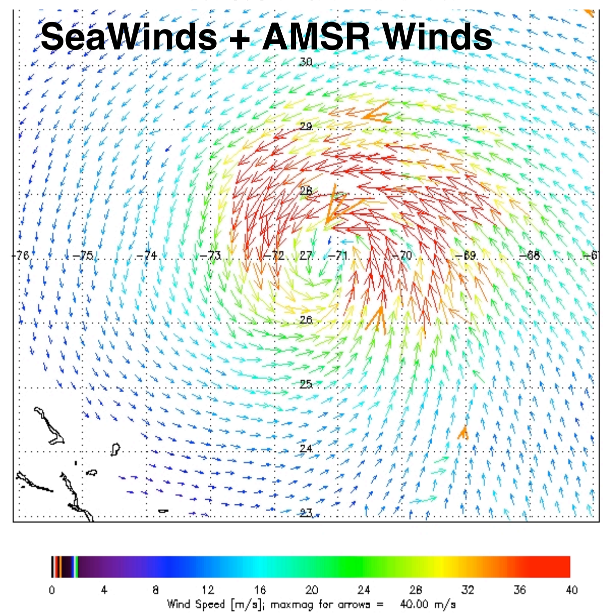
Improving Tropical Cyclone Winds in Rain using AMSR



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.

Scatterometry Climate Workshop

- Why is it needed?
  - Scatterometry has been viewed by many as a weather forecasting tool. This limited scope may not sufficient to provide wide support, even within NOAA
  - NOAA and the Obama administration have made a commitment to the monitoring of climate
  - The climate community has not yet articulated a comprehensive argument for the need of continued scatterometer data
- Why is it needed now?
  - A document with a community summary of the importance of scatterometry for climate must be in place before the MCR (September) and MDR (December).
- How can you help?
  - Please attend the workshop and/or help to write the document
  - Please let us know if you plan to attend ASAP

Suggested Support Statement from the OVWST

The Dual-Frequency Scatterometer (DFS), a NOAA/NASA advanced scatterometer instrument proposed to be flown together with an AMSR3 instrument as part of the JAXA GCOM-W2 mission, represents the most viable option to continue and enhance the climate data record started by the QuikSCAT mission, provide real time data required by NOAA for weather forecasting, and complement the coverage provided by the EUMETSAT's operational ASCAT scatterometer series. The Ocean Vector Winds Science Team (OVWST) has reviewed the science requirements for the DFS scatterometer. The OVWST endorses the scope of the DFS science and operational goals, and finds the required instrument performance, the space-time sampling, and the data throughput requirements as suitable to meet these goals.