IMPROVING QSCAT RETRIEVALS OF HIGH WINDS

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Outline:

- **Challenges of high wind retrievals**
- **Development of the new GMF Ku2009**
- **Validation of Ku2009 winds**
- **Storm examples**
- **Impact of rain on wind retrievals**
- **Future plans**

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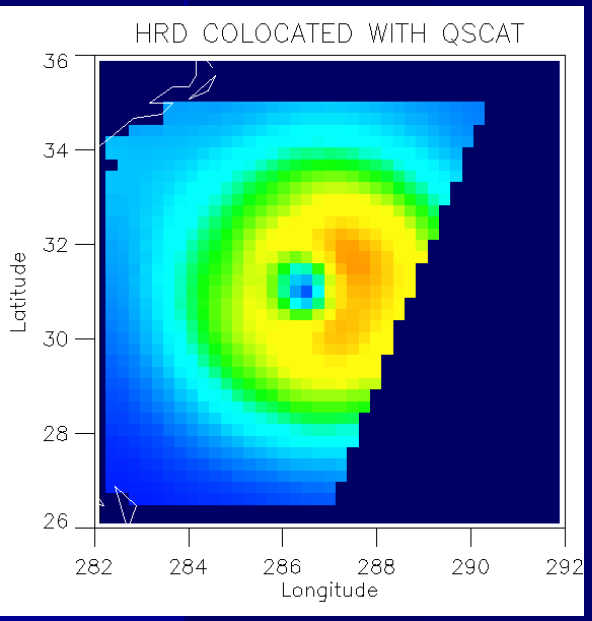
CHALLENGES OF SATELLITE HIGH WINDS RETRIEVALS

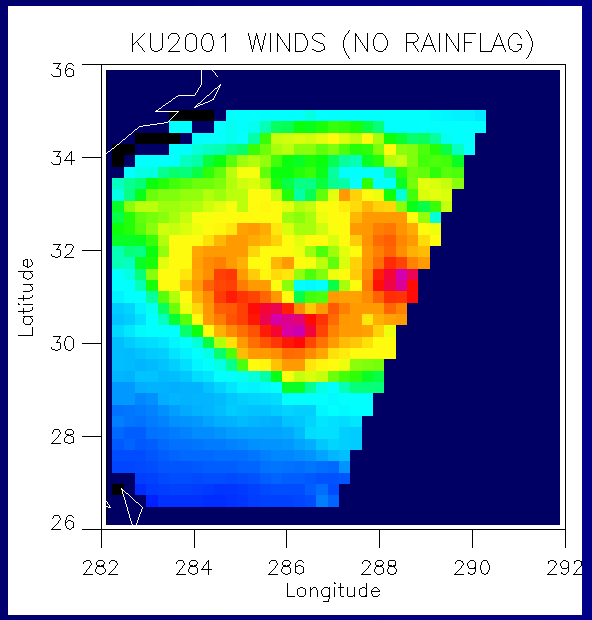
- Satellite sensors retrieve a physical property (QSCAT=surface backscatter ratio) that needs to be calibrated to a reliable observed “ground truth” (buoy wind, NCEP wind, other satellite data, etc..)
- When methodology and retrieval algorithms for QSCAT were developed at Remote Sensing Systems, there was a lack of in situ validation data at high winds (wind > 20 m/s)
- Geophysical Model Function Ku2001: Assumptions and extrapolations were made, also based on feedback from researchers using hurricane data.
- Now we have 10 yrs of scatterometer wind data that can be validated, together with an extensive buoy dataset, and additional wind observations.

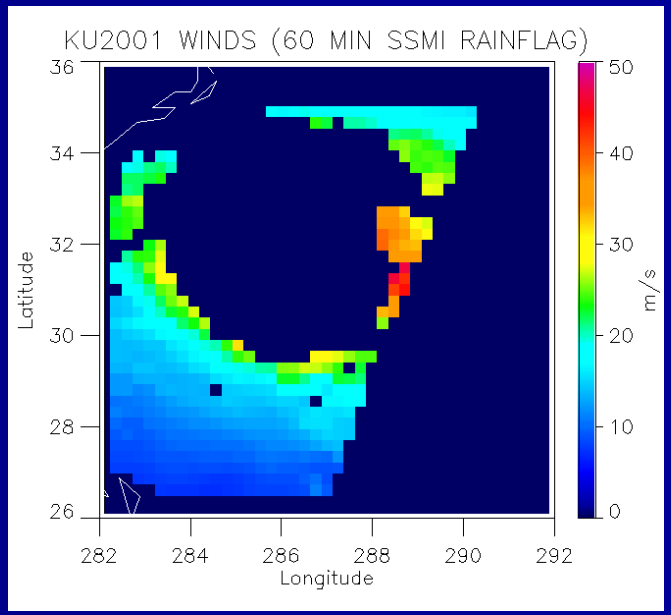
WHAT DO WE USE FOR CALIBRATION OF HIGH WINDS?

- Hurricane Research Division wind analyses (HRD)
- Problem: Most of the colocated QSCAT-HRD observations coexist with rain, which makes QSCAT unusable.

Example: ATLANTIC STORM ISABEL, SEP 2003







HRD

QSCAT, NO RAINFLAG

QSCAT, 1 HR RAINFLAG

HOW DO WE SEPARATE RAIN FROM THE WIND SIGNAL?

- Rain affects the scatterometer winds.

- Best way to separate wind-rain effects is to use radiometer observations with multiple channels: low frequency (C and X-band) is less sensitive to rain than high frequency (K-band). WINDSAT has this capability.

WINDSAT

- WINDSAT V7 data recently processed at RSS.
- They are global, therefore they include many rain-free high wind cases from extratropical storms
- WINDSAT has been validated at high winds using HRD.
- WINDSAT includes algorithms capable of measuring wind under rain or hurricane conditions (***Meissner and Wentz, 2009;*** *Meissner's presentation on Tuesday*).

THE NEW QSCAT GMF: KU2009

- Goal: use Windsat V7 to redevelop RSS QSCAT GMF.
- As a preliminary step, we used 9 yrs of SSMI V6 data to calibrate QSCAT to develop the methodology for the new Geophysical Model Function (GMF).
- The GMF relates the radar backscatter cross section σ_0 to wind speed w and wind direction Φ_R relative to the satellite look angle.
- We only use the best rain-free retrievals to develop the GMF

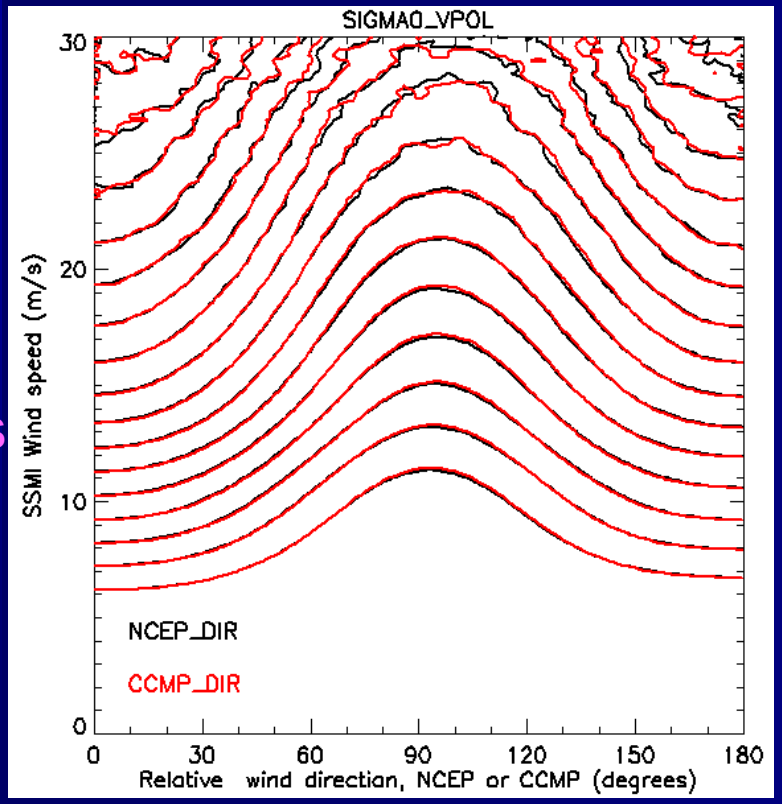
$$\sigma_0 = f(w, \varphi_R)_{pol} = \sum_{i=0}^{N} A_i(w) \cos(i\varphi_R)$$

- Step 1: Build a table of observed σ_0 binned for wind speed and wind direction using a calibration "ground truth"

BINNING σ_0 FOR WIND DIRECTION: NCEP OR CCMP?

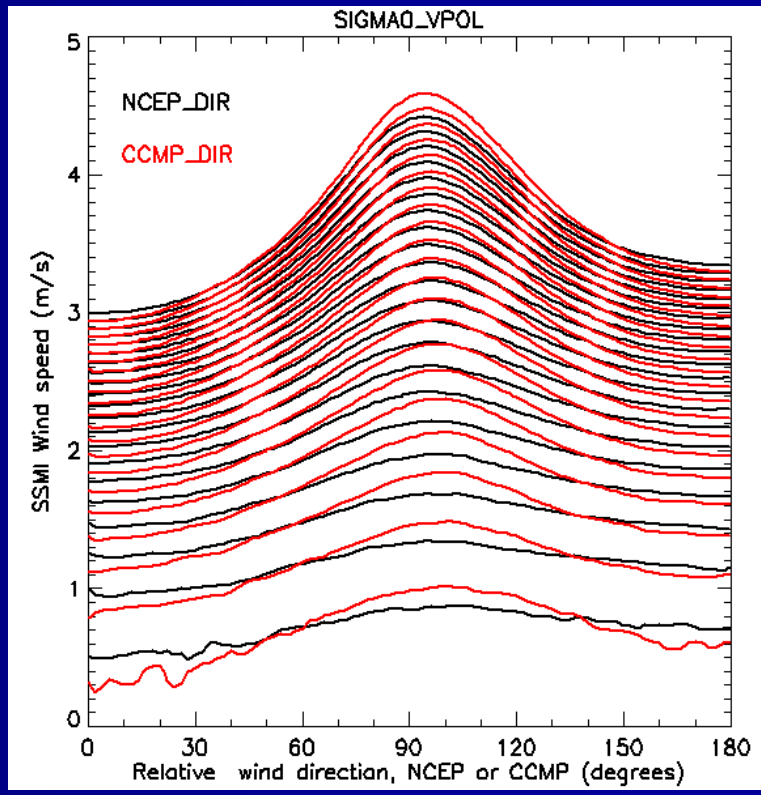
σ_0 CONTOUR PLOT USING NCEP OR CCMP WIND DIRECTION

WIND SPEED 0-30 M/S



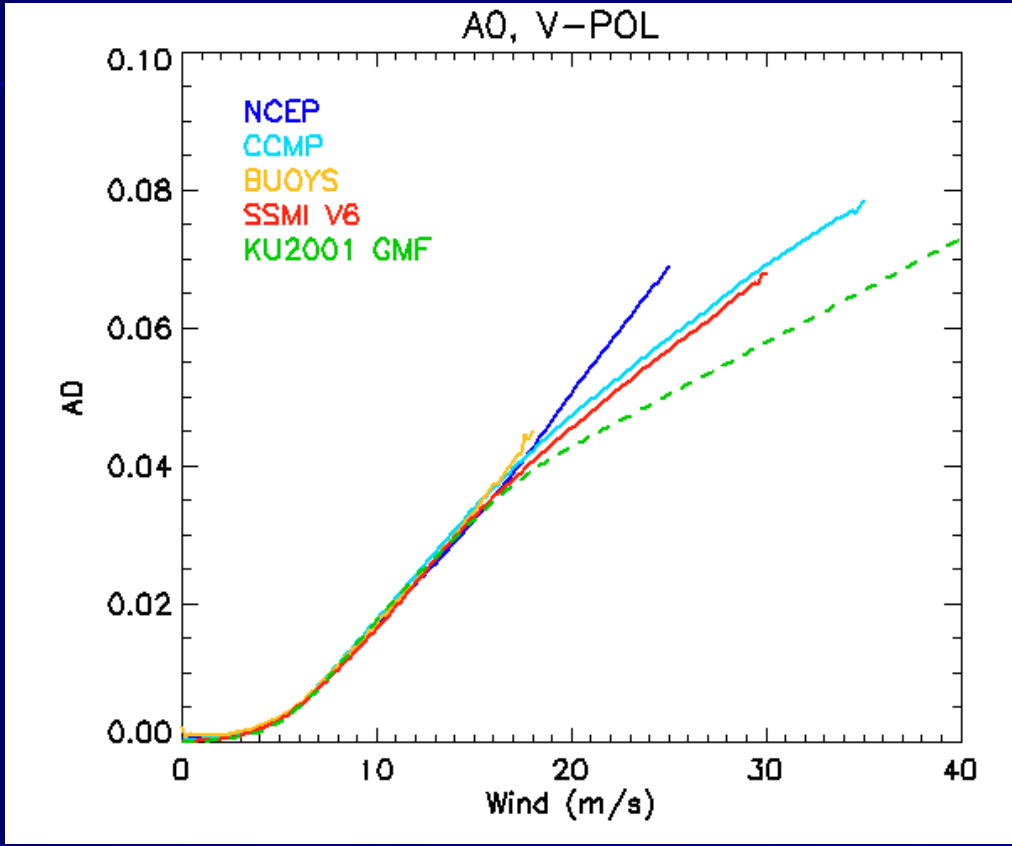
WIND DIRECTION

WIND SPEEDS 0-5 m/s



WIND DIRECTION

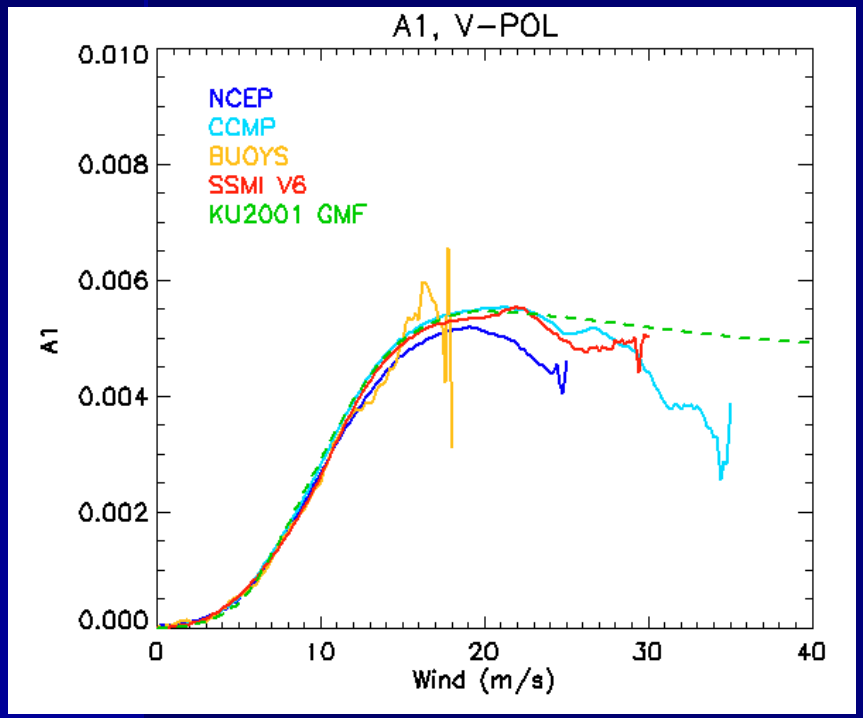
BINNING σ_0 FOR WIND SPEED: THE NON-DIRECTIONAL COEFFICIENT A_0



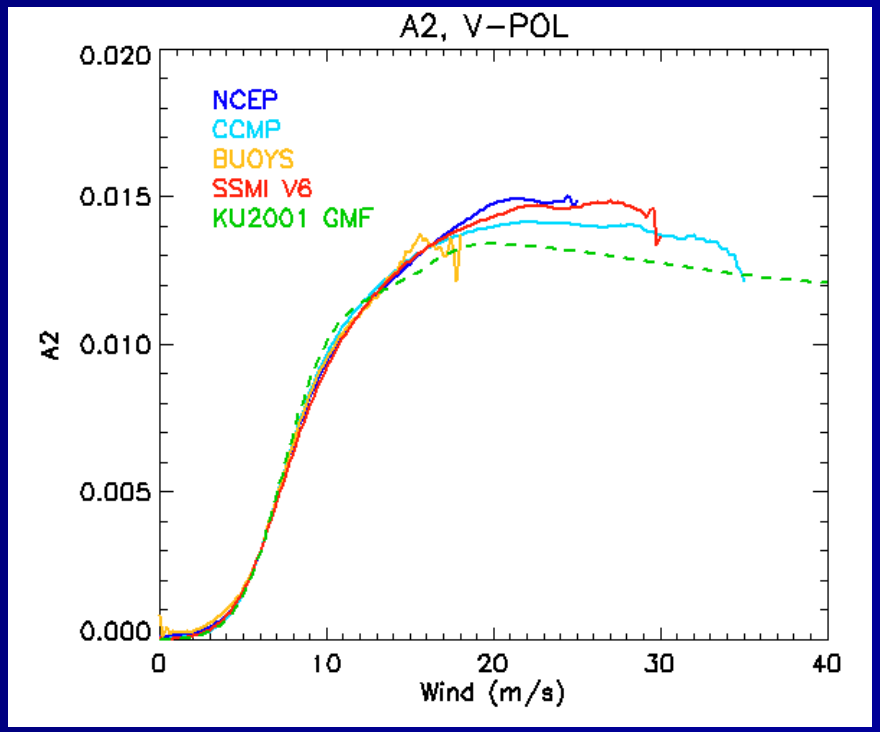
Flagging for rain at colocation site and surrounding area is essential. The A1coefficients are largely underestimated at high winds if area-rain flagging is not performed (not shown).

BINNING σ_0 FOR WIND SPEED: THE DIRECTIONAL COEFFICIENTS

A_1 UPWIND-DOWNWIND INFO

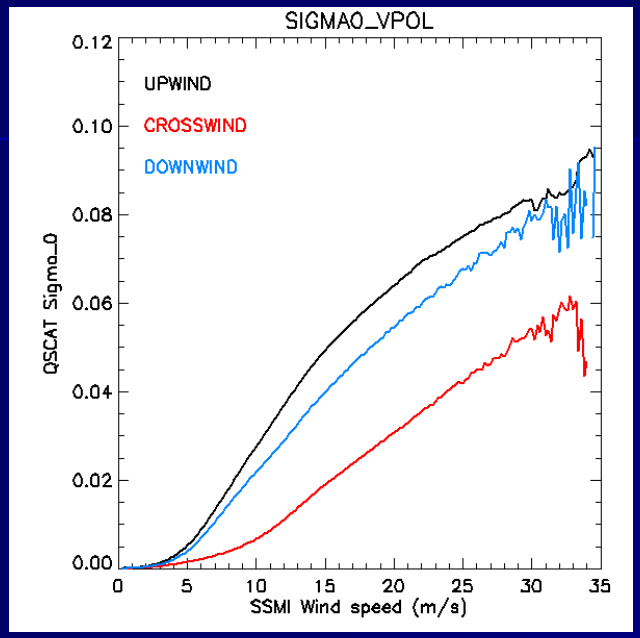


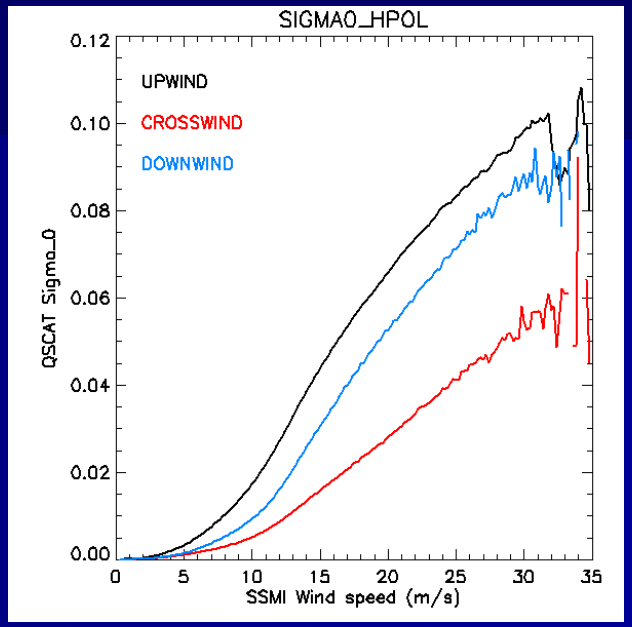
A_2 UPWIND-CROSSWIND INFO



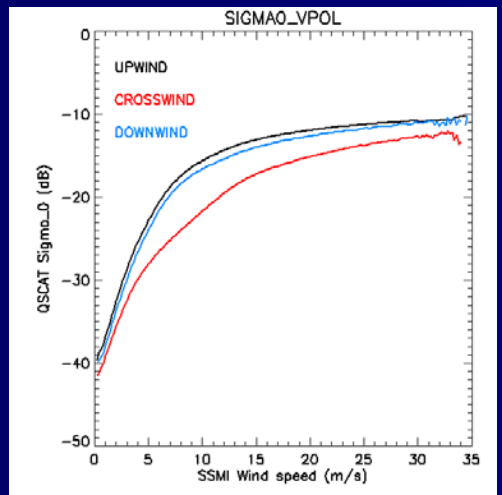
SATURATION AT HIGH WINDS?

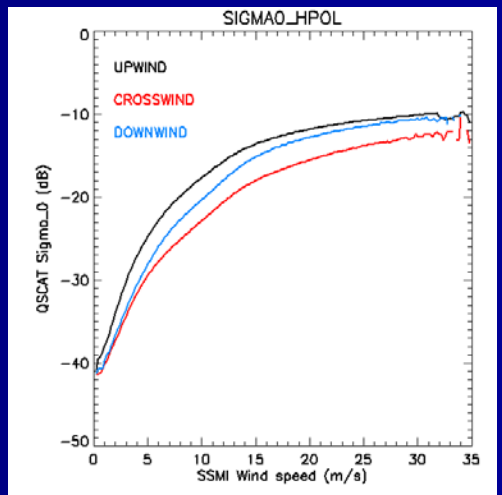
BACKSCATTER RATIO (linear)





dB units (logarithmic)

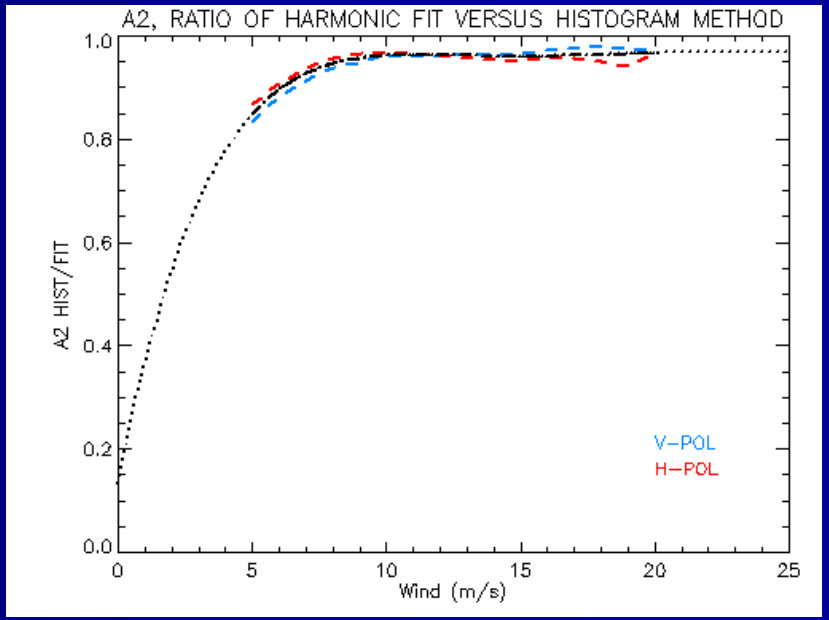




CORRECTION FOR UNCERTAINTY IN NCEP/CCMP WIND DIRECTION

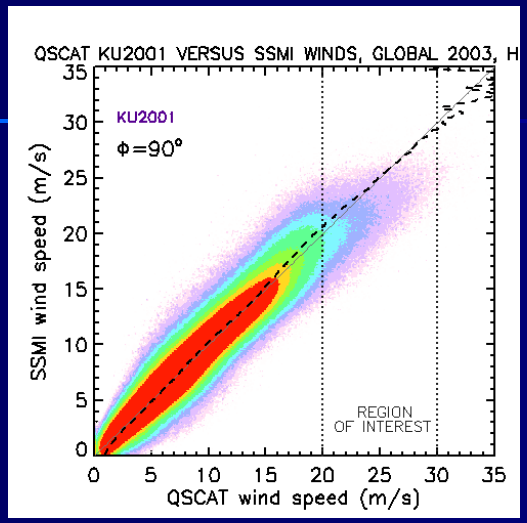
- Uncertainty in NCEP/CCMP wind direction leads to underestimation of A_i from harmonic fit
- We used an alternative method to estimate A_1 and A_2 (described in *Wentz et al, 1999*), based on the statistical distribution of upwind-downwind or upwind-crosswind sigma0 retrievals.
- Does not use ancillary wind direction.
- It needs many colocations to be reliable (9 yrs of SSMI)

▪With this method, we estimated a correction (in the figure) to be applied to the harmonic coefficients Ai (i=1,5) to account for uncertainty in NCEP/CCMP wind direction



DIRECTIONAL BIAS:

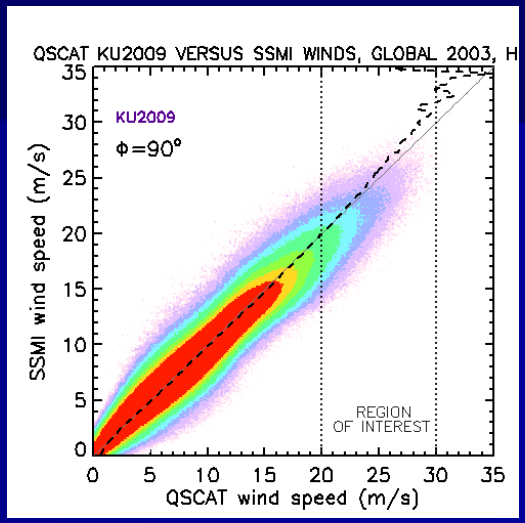
KU2001



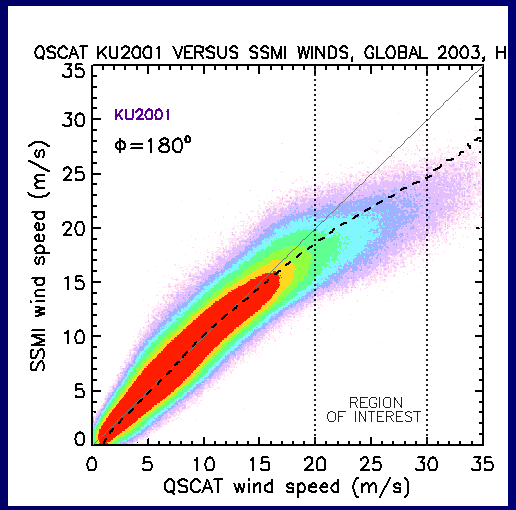
SSMI

Crosswind
Φ=90

KU2009



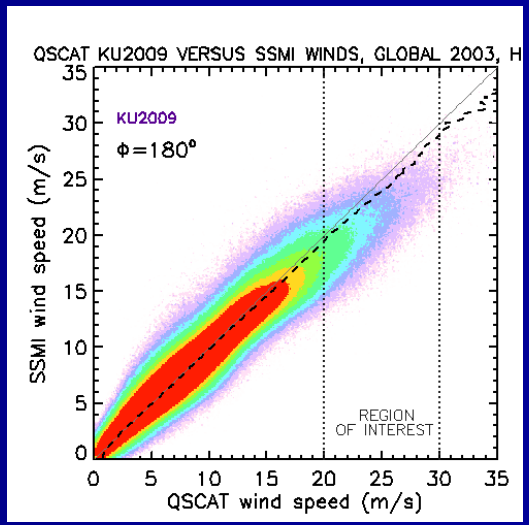
SSMI



SSMI

Downwind
Φ=180

SSMI

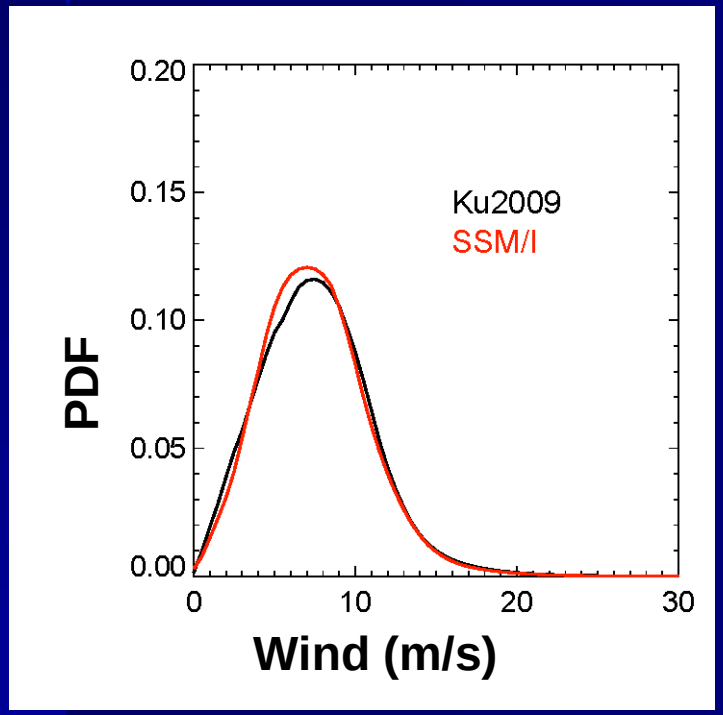


QSCAT

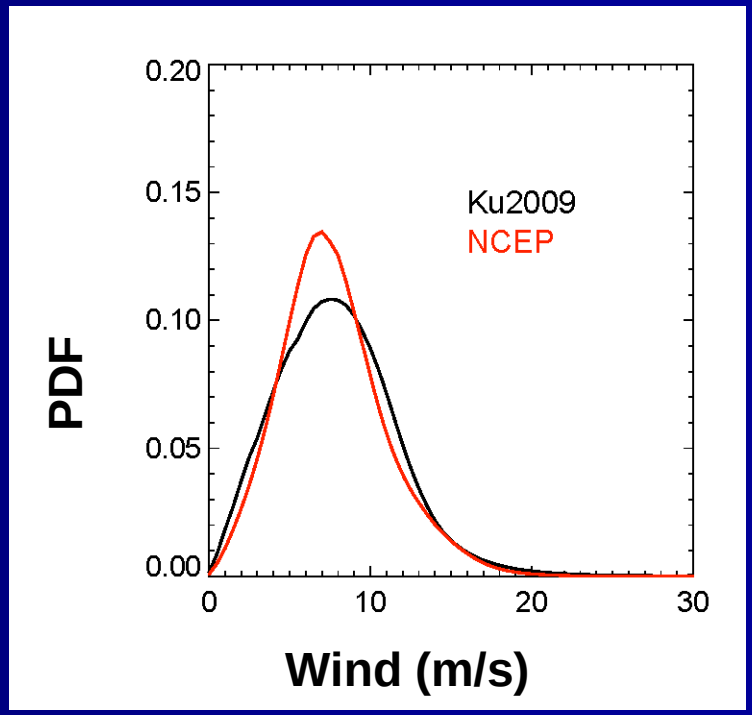
QSCAT

STATISTICS OF KU2009: WIND SPEED PDFs

QSCAT VERSUS SSMI

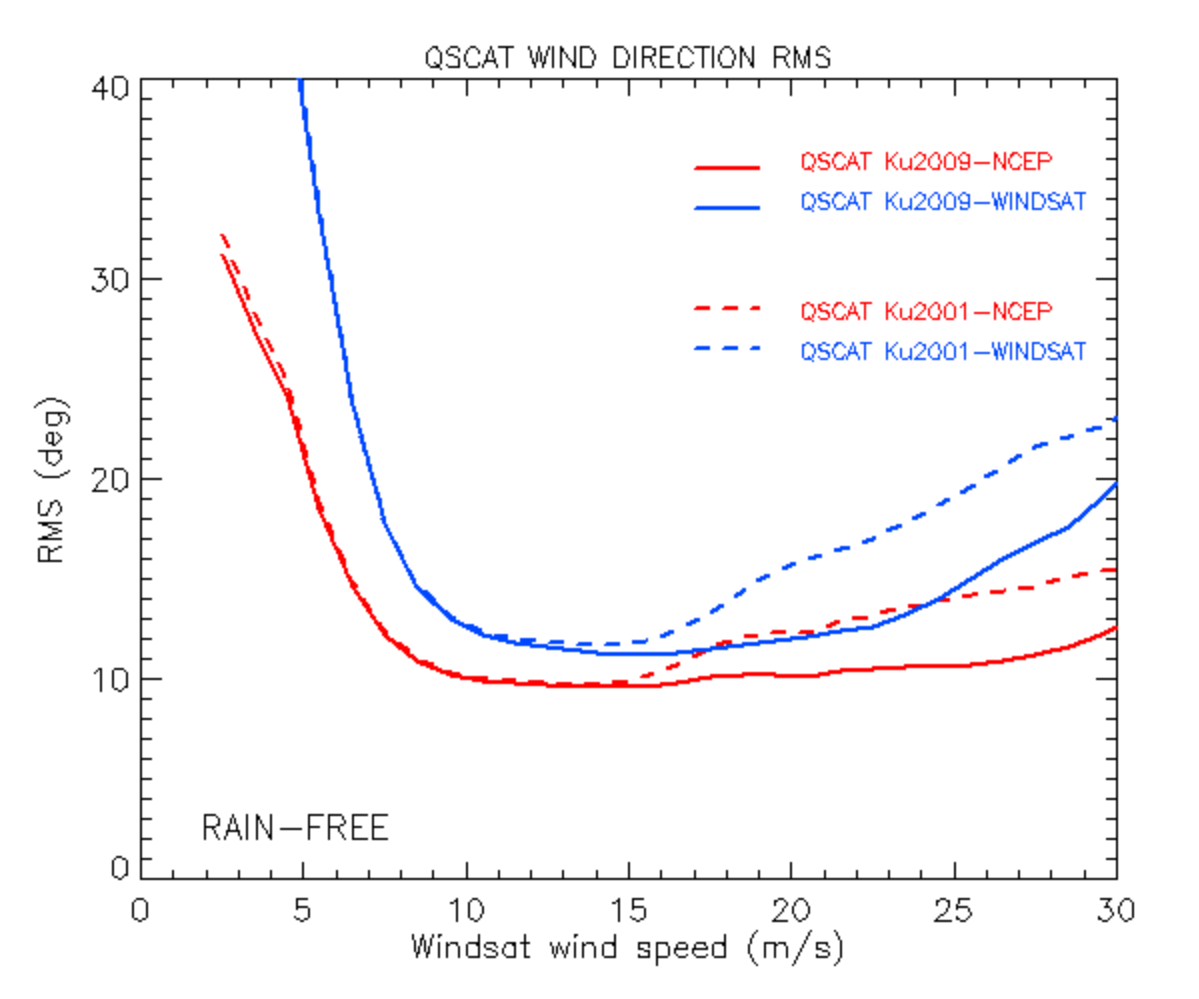


QSCAT VERSUS NCEP



1 FULL YEAR OF COLOCATIONS

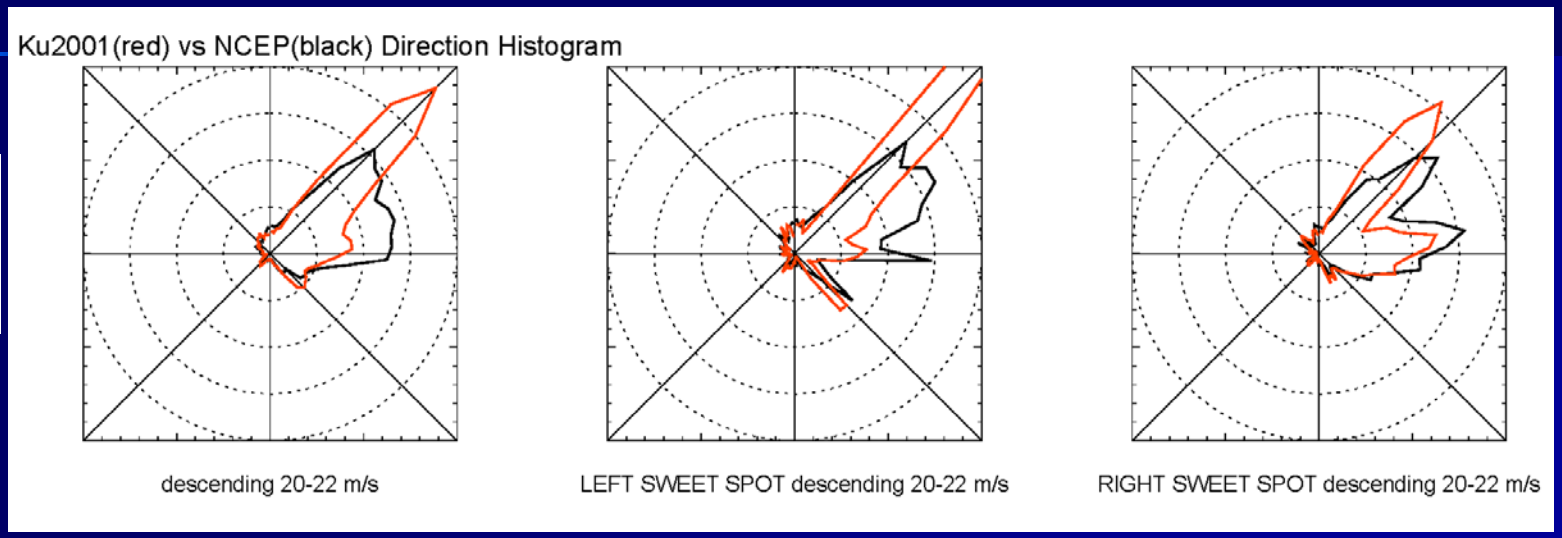
QSCAT WIND DIRECTION RMS: Ku2001 versus Ku2009



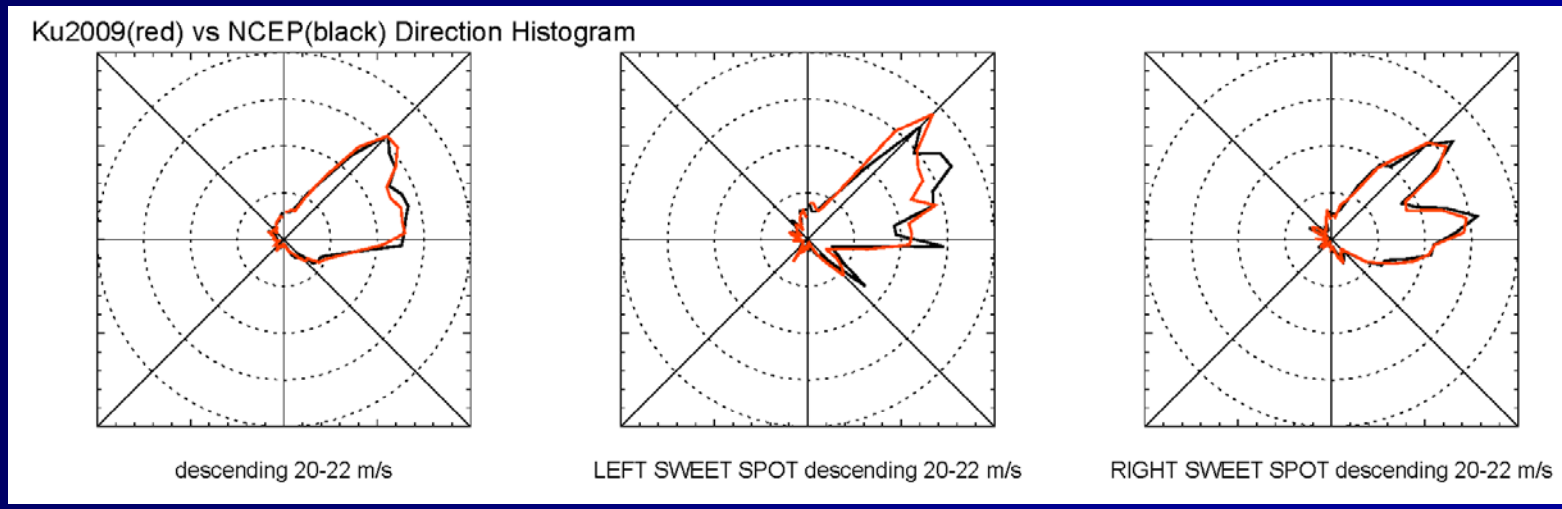
WIND DIRECTION STATISTICS KU2009:

- Good improvement at high winds with Ku2009 versus Ku2001

Ku2001
NCEP
(20-22 M/S)



Ku2009
NCEP
(20-22 M/S)

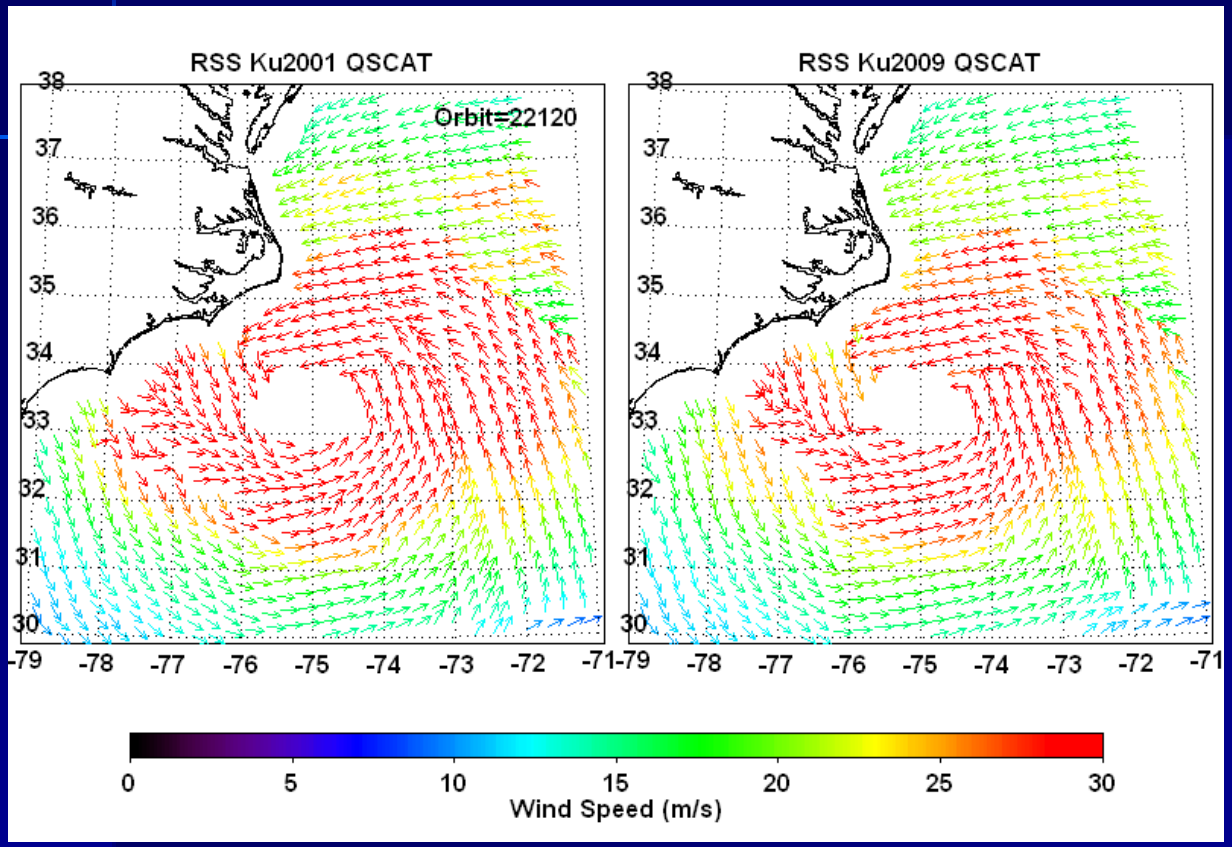


HURRICANE ISABEL

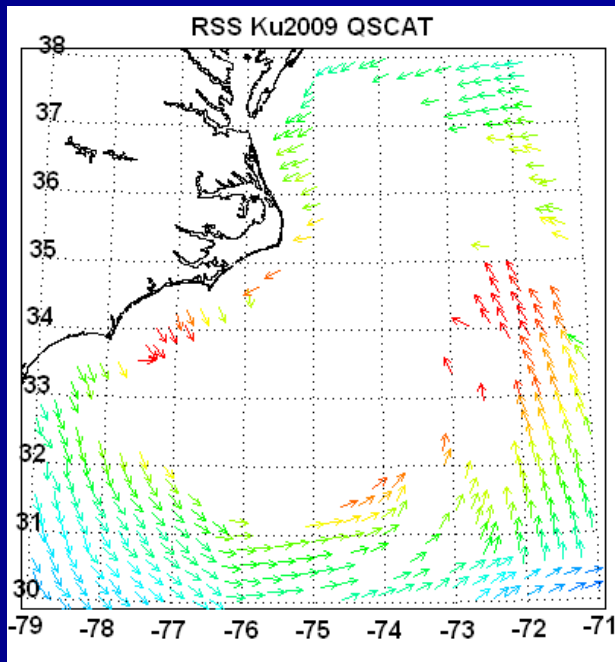
September 18, 2003

KU2001

KU2009



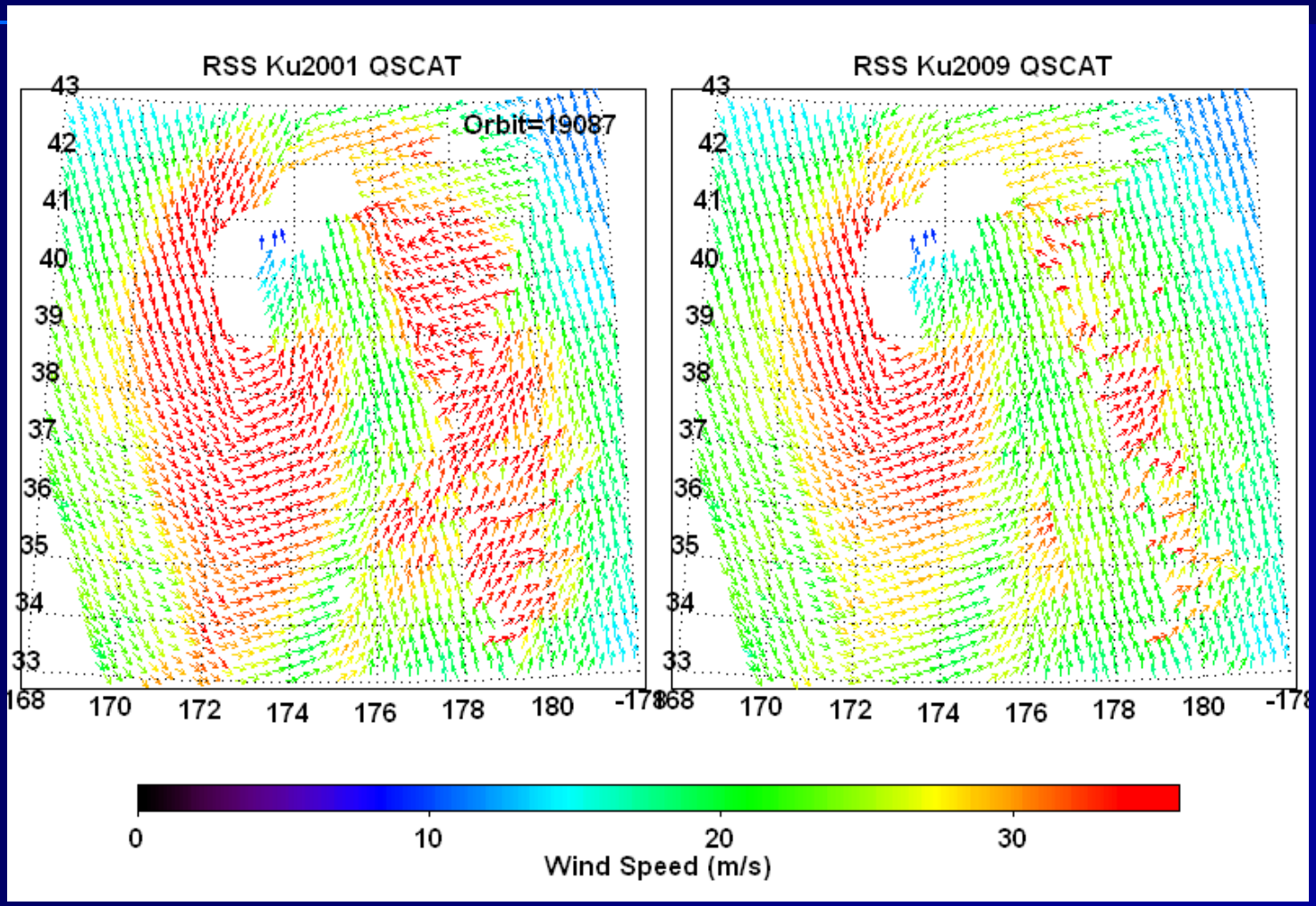
ALL RETRIEVALS,
QSCAT rain flag on



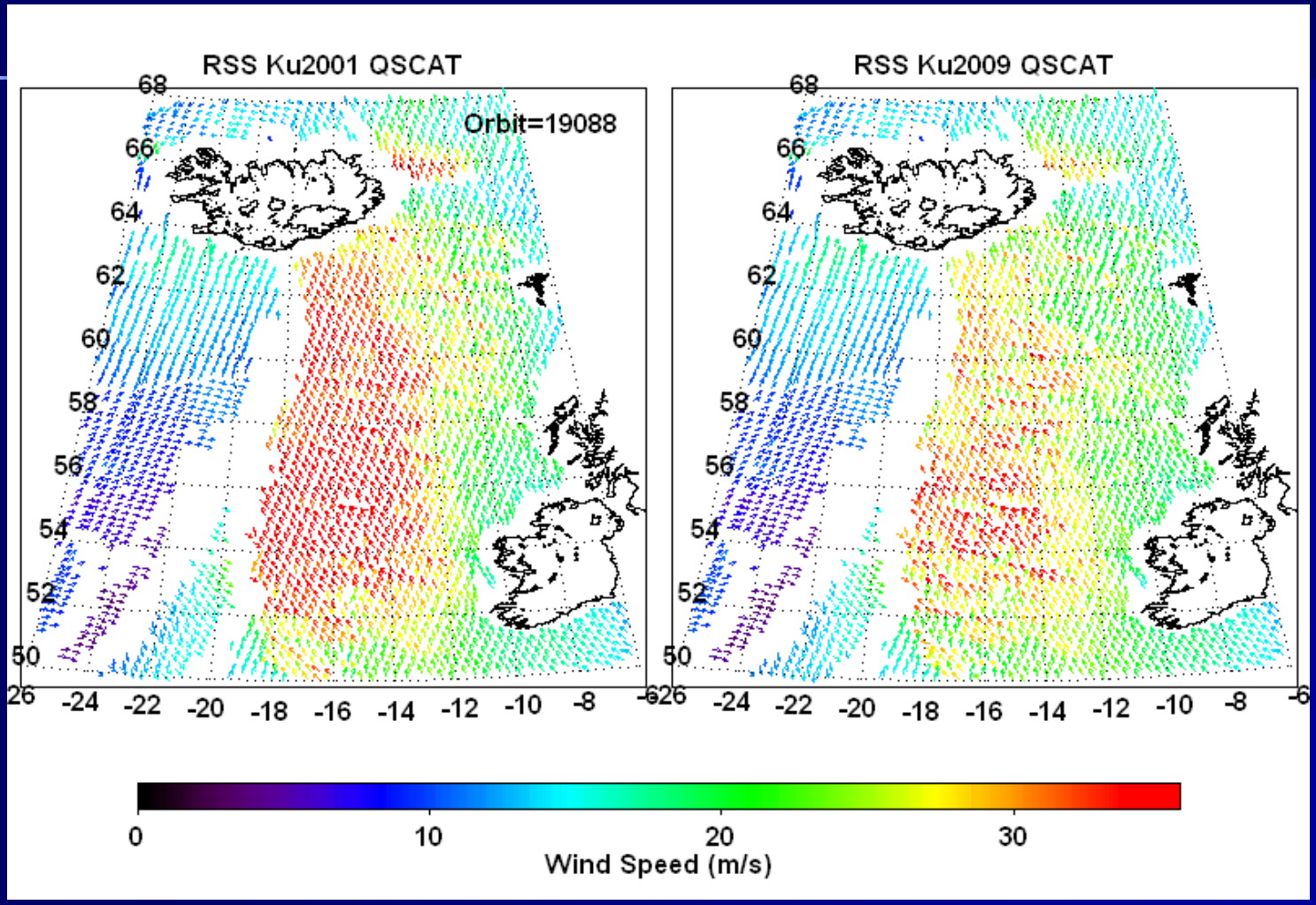
RETRIEVALS colocated with SSMI radiometer
Only rain-free (rad rain < 0.15 mm/hr)

No data left !

Extratropical storm, Pacific: Feb 17, 2003

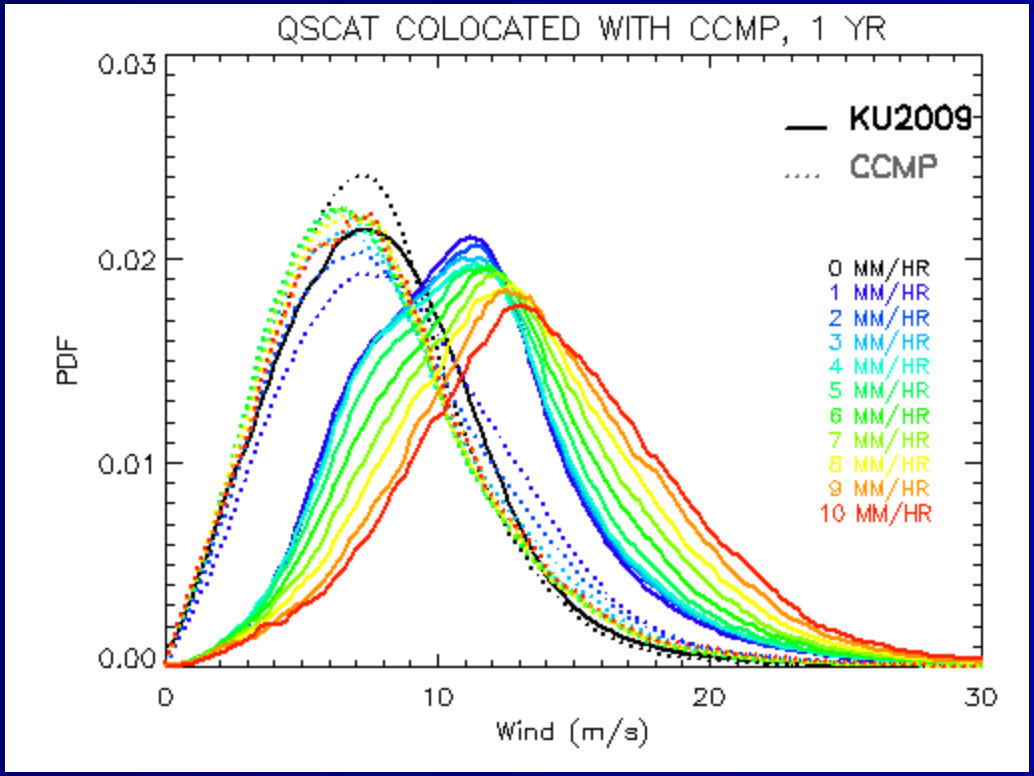


Extratropical storm, Atlantic: Feb 17, 2003



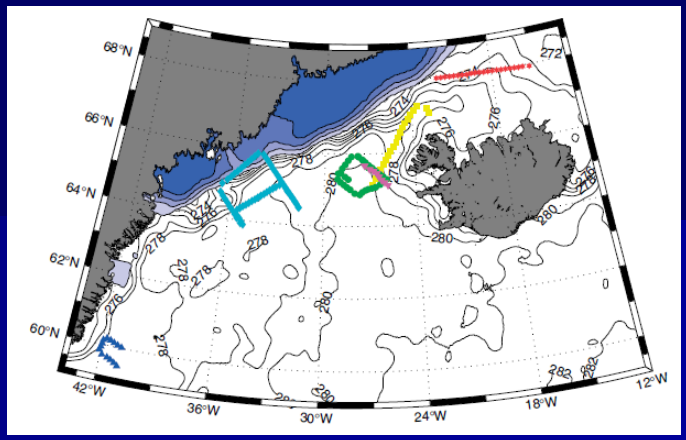
RAIN EFFECTS ON QSCAT RETRIEVALS

- Rain produces a positive bias in wind speed proportional to the rain intensity. The bias is significant even for the lightest rain (0.1 mm/hr, not shown).
- For the GMF development we need to flag all retrievals with rain > 0 (determined by colocating with radiometer rain retrievals).

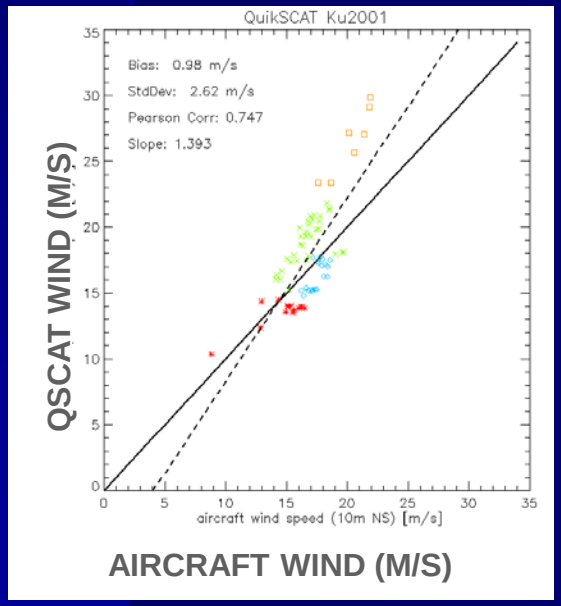


AIRCRAFT DATA VALIDATION (T. Meissner, D. Smith)

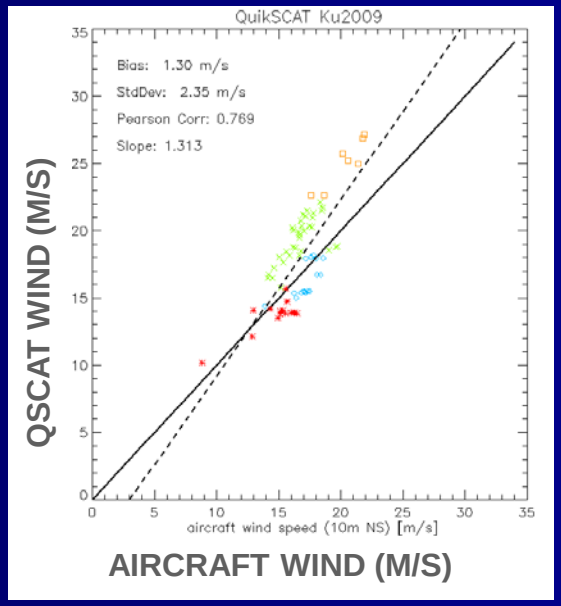
- Aircraft observations taken during the Greenland Flow Distortion Experiment (GFDex), Feb and Mar 2007 (Renfrew et al, QJRMS 2009).
- 150 data points spread over 6 days with each data point equivalent to a 12 km spatial average. Possible sea ice contamination
- Observations taken at 30-50 m above sea level and adjusted to standard 10m height



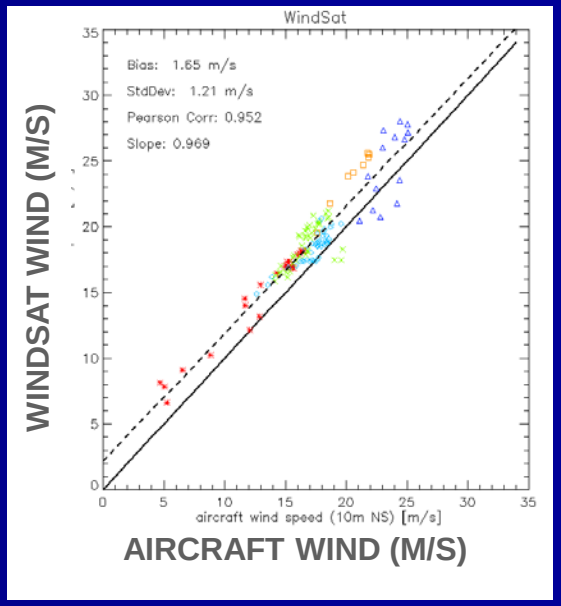
KU2001 (Rain-free)



KU2009 (Rain-free)



WINDSAT (all weather)



SUMMARY

- We developed an interim GMF (Ku2009) using 9 years of colocated SSMI winds to calibrate high wind retrievals.
- The new GMF has lower high winds compared to Ku2001.
- Rain flagging is very important for studies that require accuracy (climate, calibration, intercomparisons).
- The final GMF will be developed using the same methodology presented here but using Windsat winds (and possibly wind direction) for calibration.

NEAR-FUTURE WORKPLAN

We just finished validating WindSat V7 retrievals. The radiometer high winds (WindSat and SSMI) are reliable at least up to 40 m/s. WindSat also detects rain.

1. Redevelop the GMF by using rain-free WindSat for calibration (7 years). Many rain-free high wind retrievals in extratropics.
2. Develop a GMF for wind stress (Bourassa; Rodriguez)
3. Develop a physically based rain correction algorithm (Kyle Hilburn at RSS).
4. Develop GMF for ASCAT/ERS: use of consistent methodology is important when creating climate data record

Thank you