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Active-Passive Microwave Remote Sensing With SeaWinds and AMSR on Midori-2

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Thank you to JAXA for
Level 1A AMSR on Midori-2 data

JAXA
Japan Aerospace Exploration Agency

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23 March 2005

Basic Model

$$\sigma_{0,meas} = \tau^2 \left(\sigma_{0,wind} + \Delta\sigma_{0,rain} \right) + \sigma_{0,vbs}$$

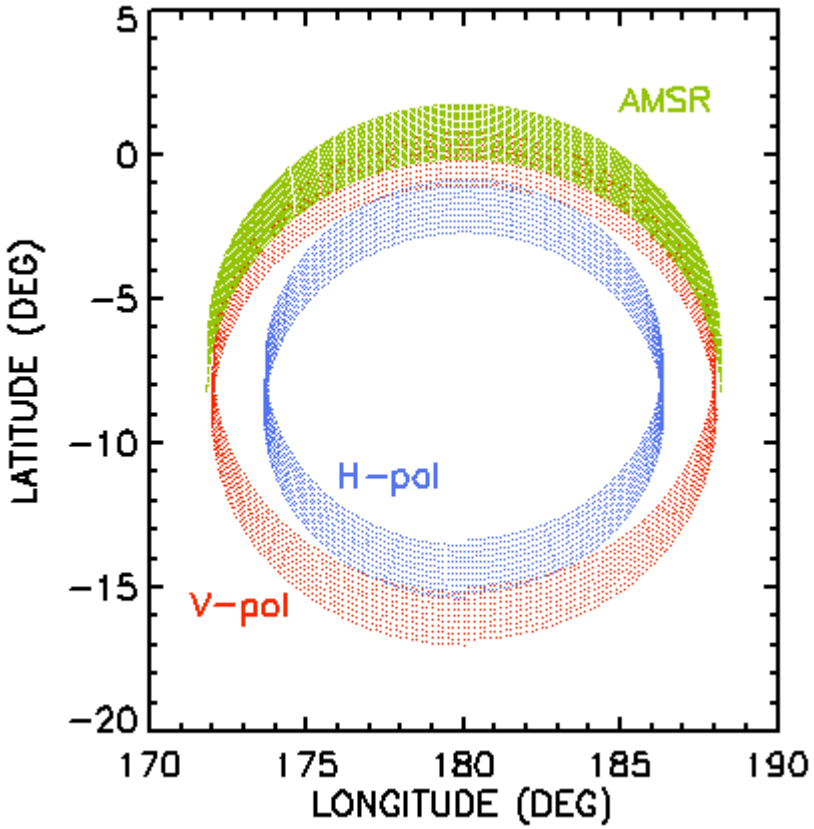
surface signal

transmission

volumetric rain backscatter

atmospheric signal

Sampling Geometry



Differences

1) Look Direction
2) Incidence Angle
3) Footprint Size
4) Exact collocation

Complete Model

$$\left[\sigma_{0,meas} - \tau^2 \sigma_{0,wind}\right] = \left(\tau^2\right)\Delta\sigma_{0,rain} + \left(1-\tau^2\right)\omega$$

$$\Delta\sigma_{0,rain} = f_1\left(R\right)$$

$$\omega = f_2\left(\Delta T_e\right) \quad \text{(37 GHz)}$$

Get coefficients of f_1 and f_2 using NCEP winds

see: Hilburn et al., 2005, *Journal Applied Meteorology* (submitted)

Estimating Transmission

- Radiometer provides direct estimate of τ^2 , the footprint average transmission:

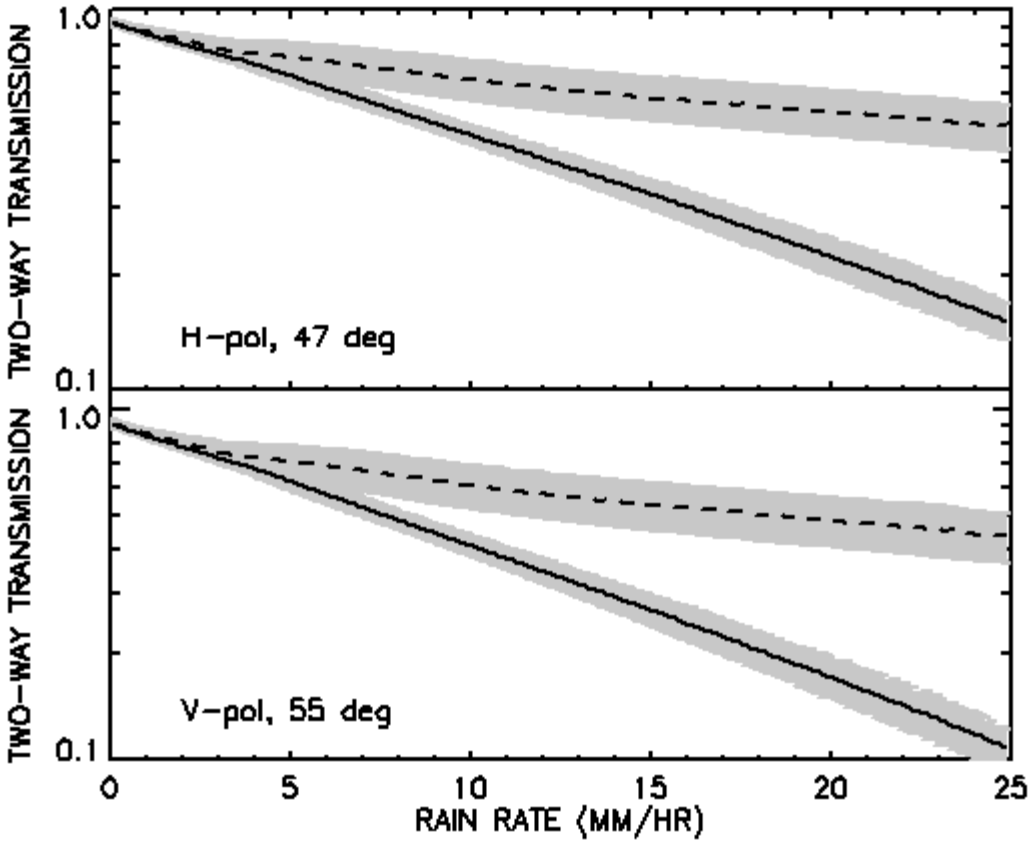
$$T_B = T_E\left(1-\tau^2\rho\right)$$

- Not hard to adjust to proper frequency and incidence angle

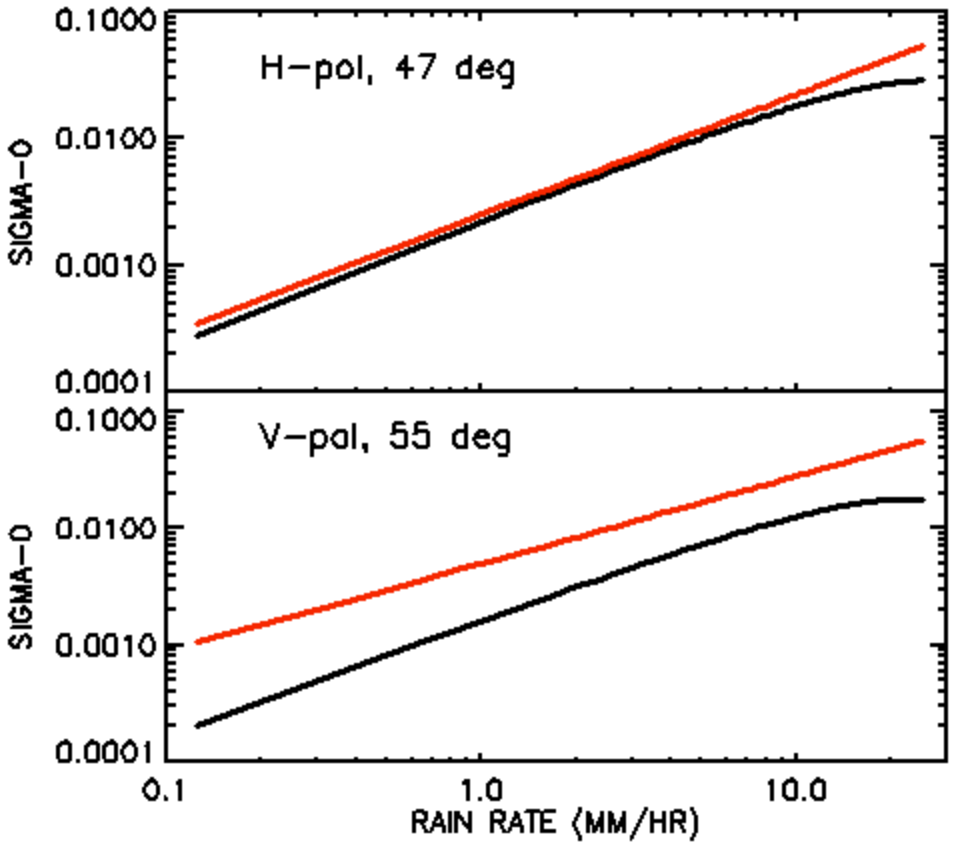
- Estimating τ^2 from the "footprint average rain rate" gives far too small τ^2 and consequently much ***too high*** "corrected winds". The beamfilling effect:

$$\left[\tau^2\right]=\left[e^{tA}\right]=e^{t\hat{A}}\geq e^{t[A]},\quad \hat{A}\leq[A]$$

Estimating Transmission



Estimating Rain Roughening



Contreras et al., 2003

Estimating Rain Backscatter

- Well known that radar reflectivity varies greatly with rain rate
- Need to account for drop size distribution variability
- Ku is “attenuating frequency”, so need to account for vertical profile as well
- DSD and profile both related to type of precipitation
- Convective/Stratiform partitioning reduces a spectrum of variability into binary classification
- Instead, use radiometric scattering information to characterize spectrum of variability

Drop Size Distribution Variability

- Radiometer provides two signals
  - Attenuation signal (τ^2)
  - Scattering signal (ΔT_e)

Effective Temperature Depression (ΔT_e)

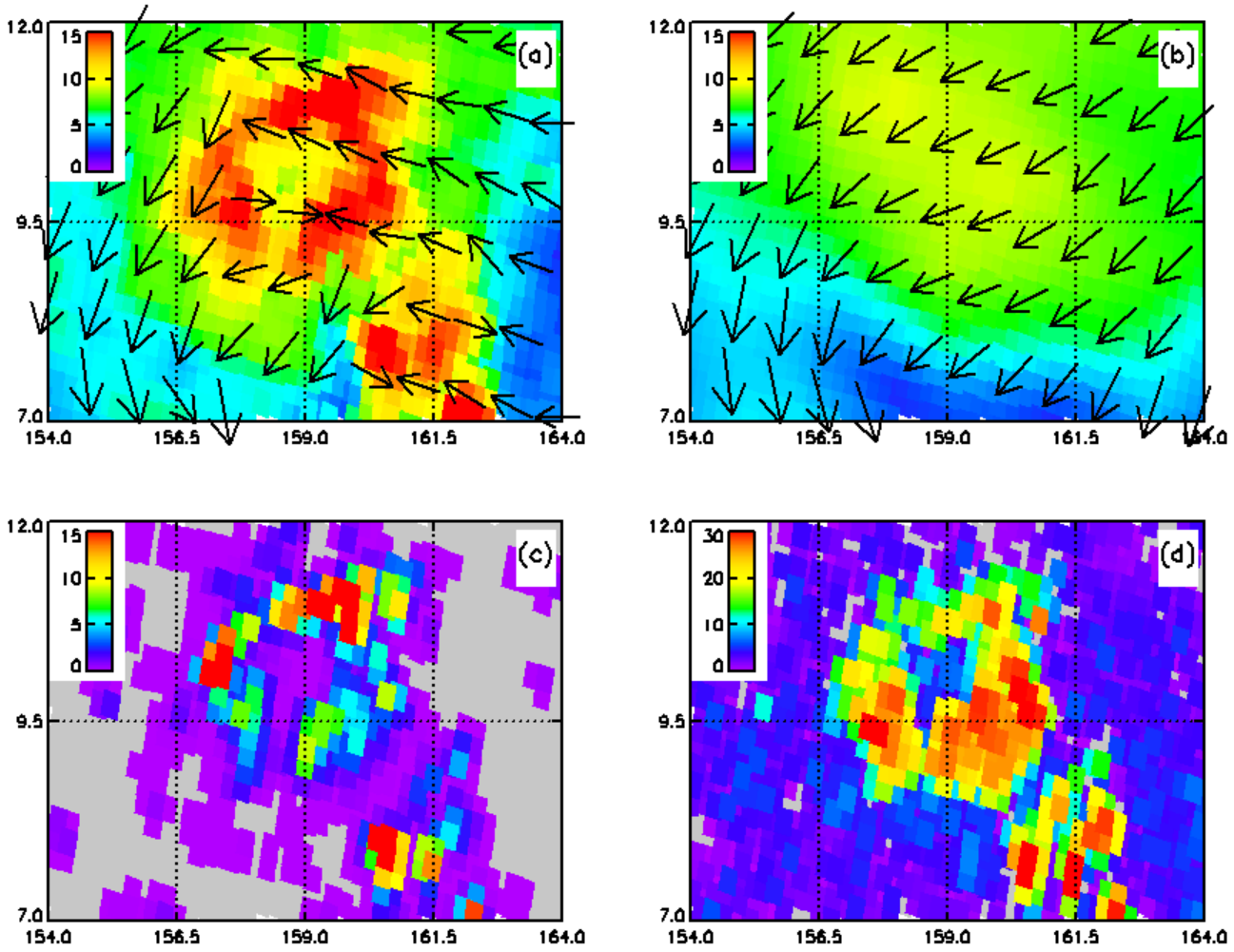
↓

Single Scatter Albedo ($a \sim \omega$)

↕

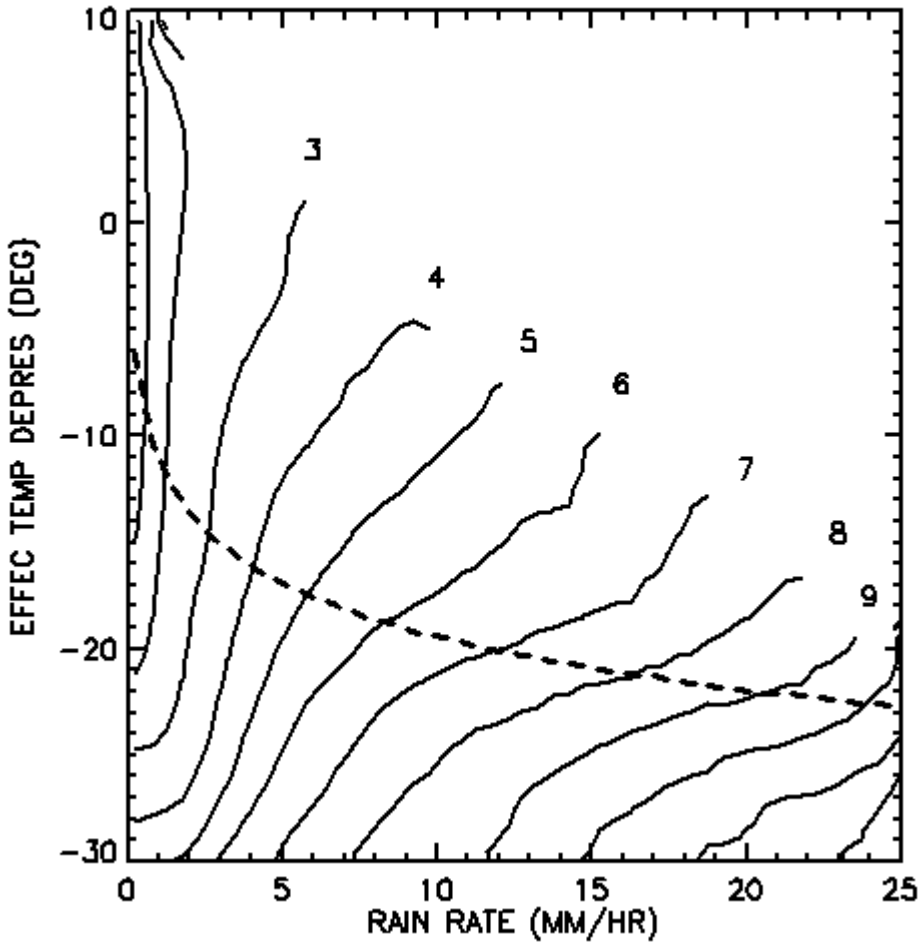
DSD Variability ($\eta = 2\omega k_{abs}$)

Need More Than Just Rain Rate

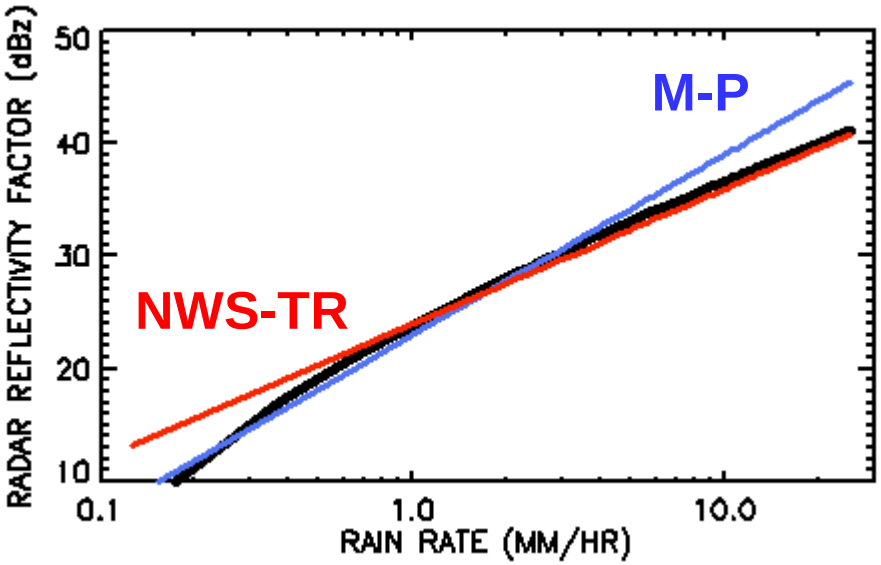


28 June 03, West of the Marshall Islands, Rev 2806

Need More Than Just Rain Rate



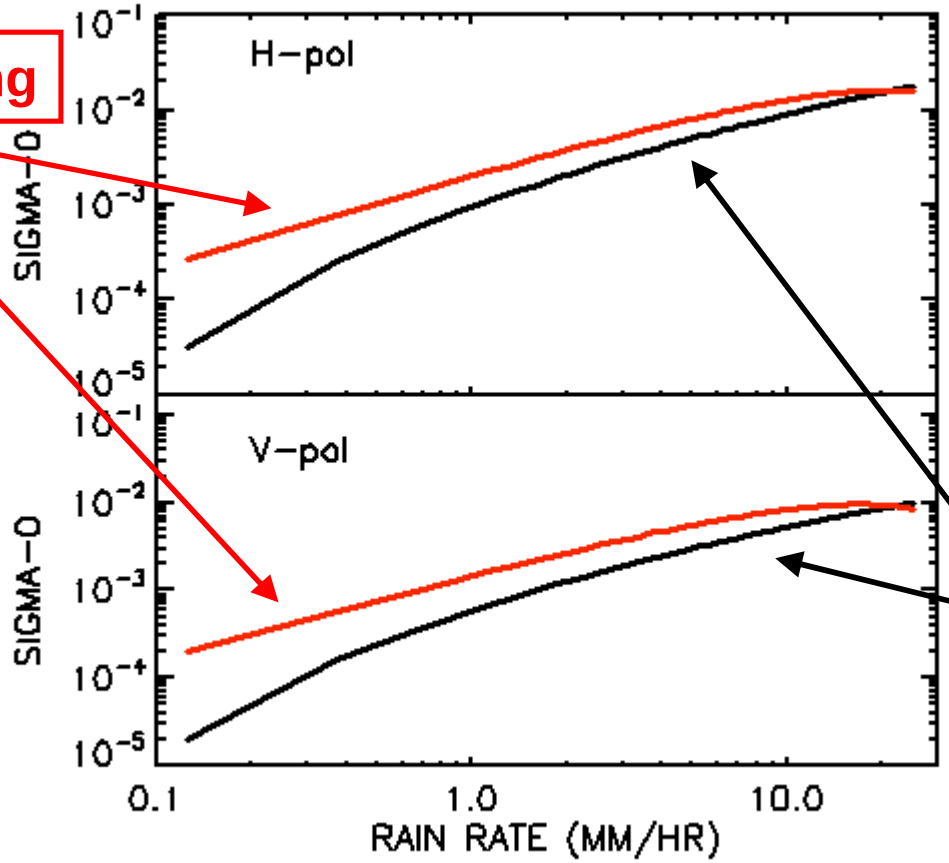
Vertical Profile Variability



$$\sigma_{0,vbs} = \underbrace{\left(1-\overline{\tau}^2\right)\overline{\omega}}_{\text{Mean Response}} + \underbrace{\left(1+\overline{\tau}^2\right)\omega'}_{\text{“Top/Bottom Heavy” Stratiform/Convective}} - \underbrace{2\overline{\tau}\left(\omega'\tau'\right)}_{\text{Abs/Sca Covar (DSD/Phase)}}$$

Relative Contributions

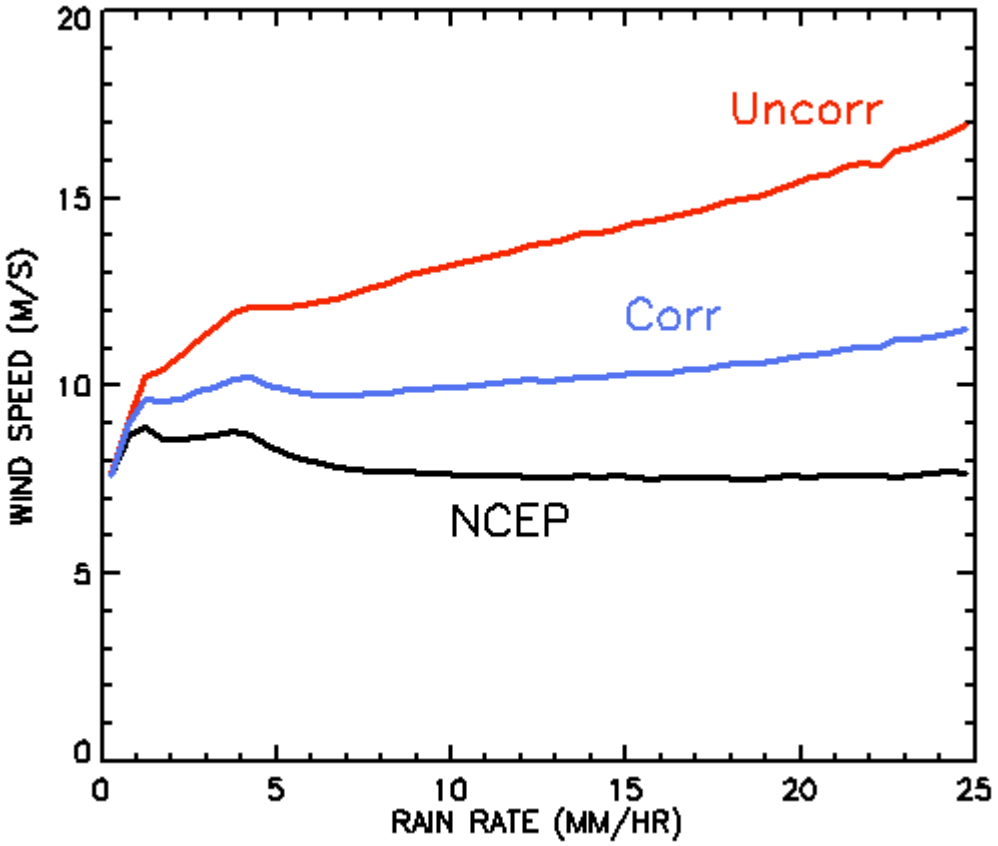
rain roughening



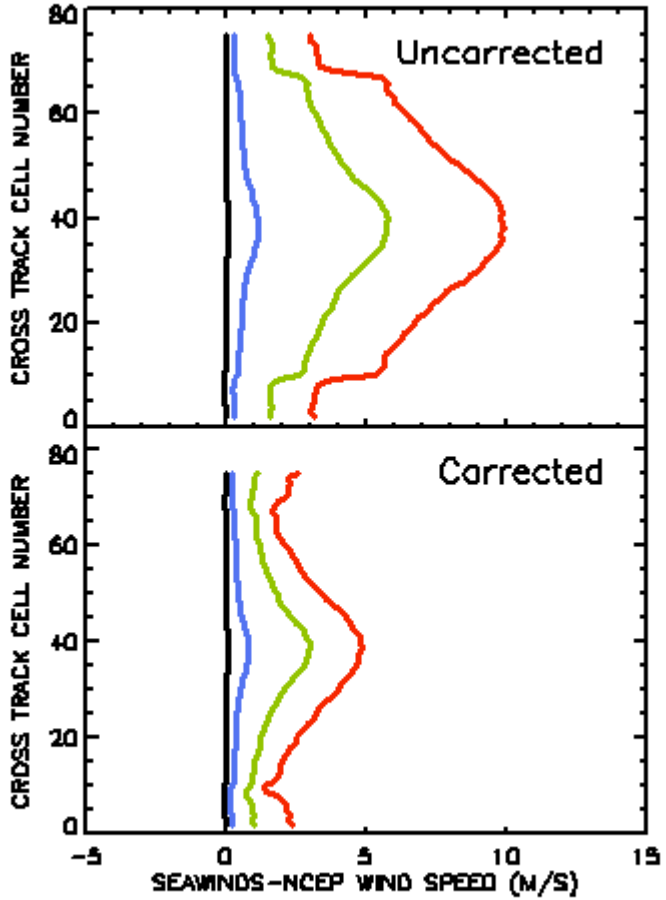
volumetric backscatter

Results consistent with Draper and Long (2004)

Average Wind Speed Improved

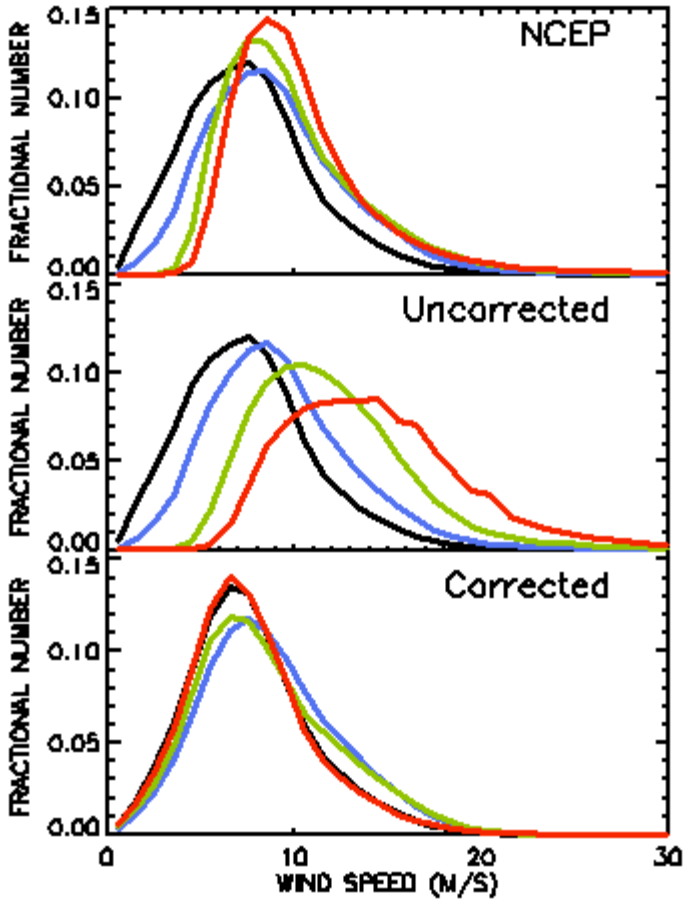


Cross-Track Biases Reduced



NO-RAIN, LOW, MODERATE, HEAVY

Histograms Better Aligned



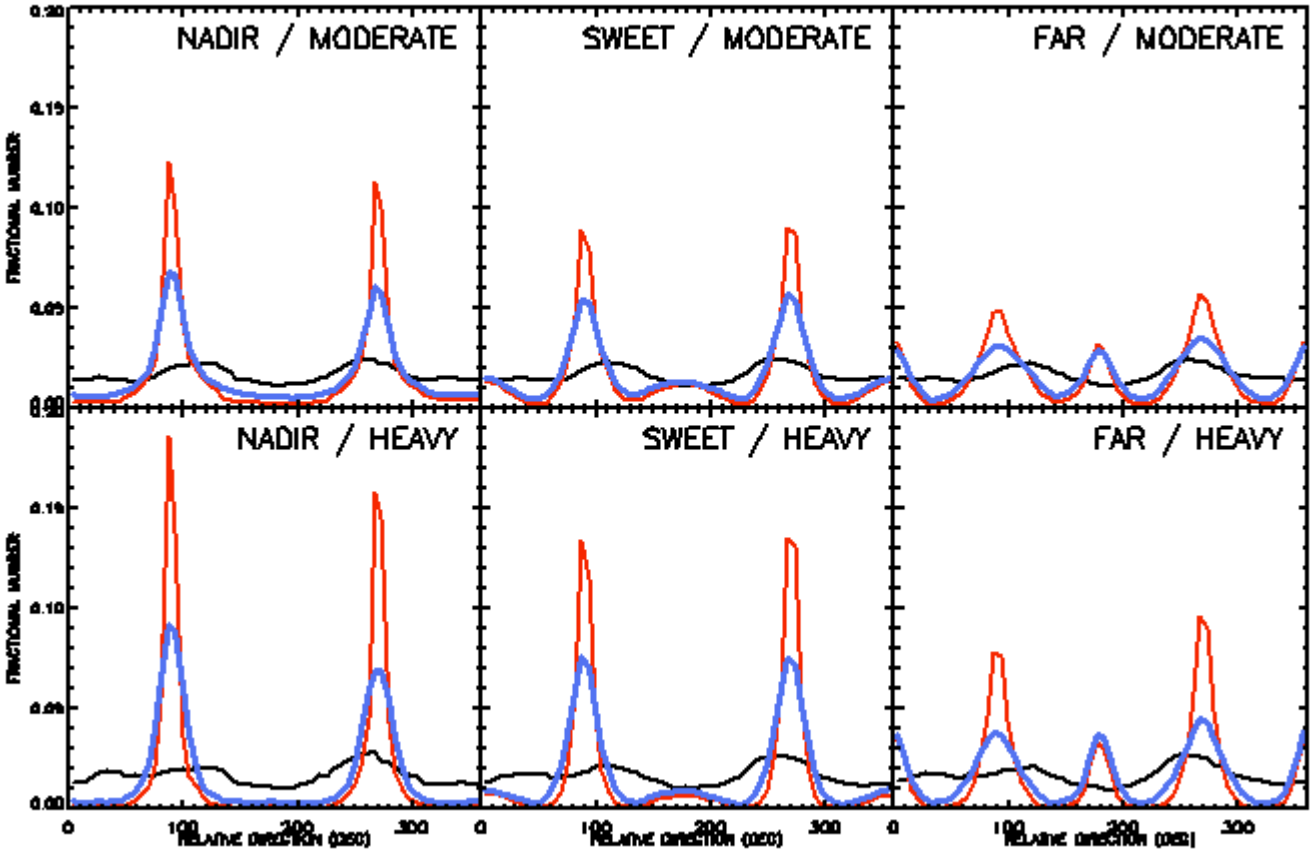
NO-RAIN, LOW, MODERATE, HEAVY

Cross-Track Directions Reduced

NCEP, UNCORRECTED, CORRECTED

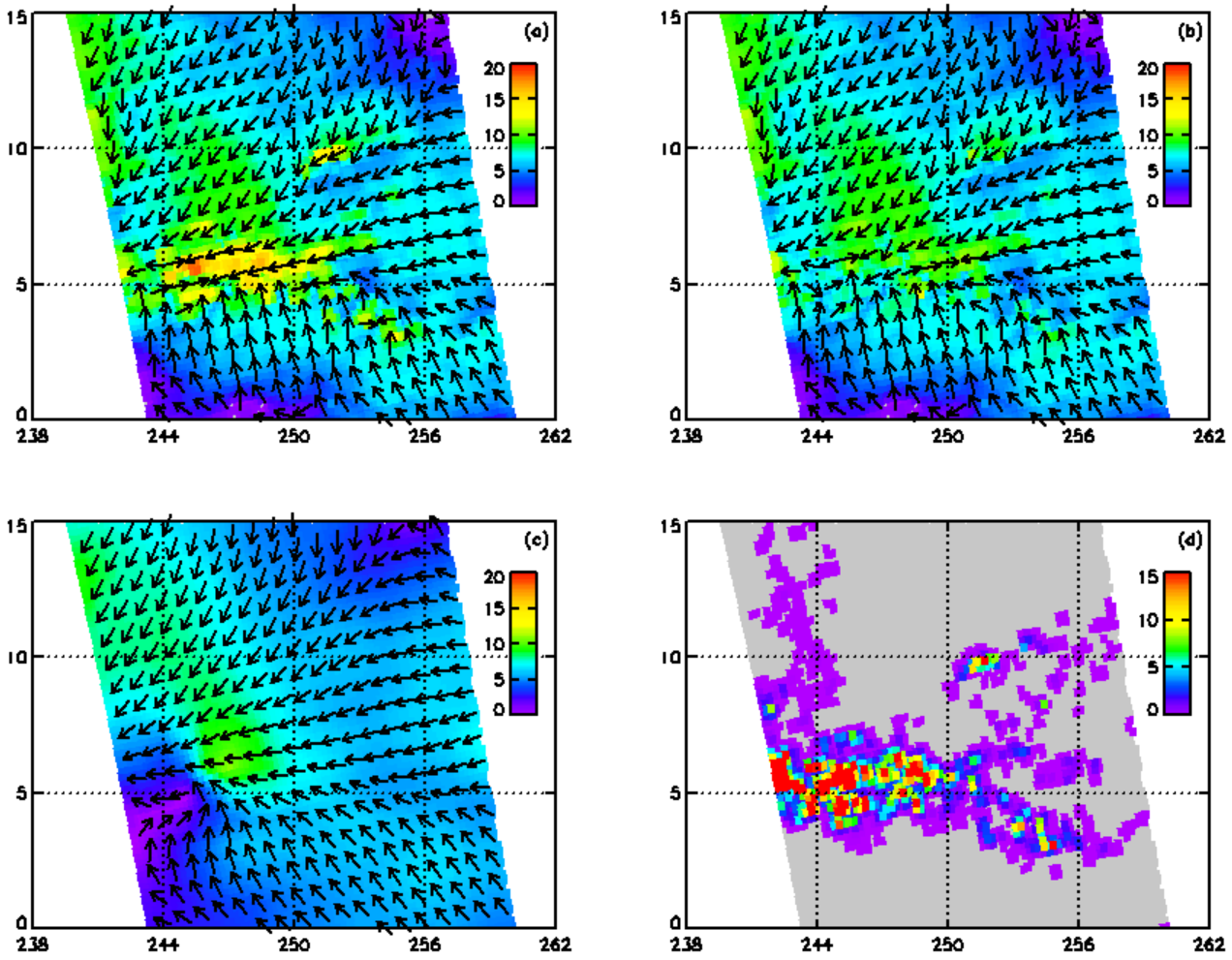
MODERATE

HEAVY



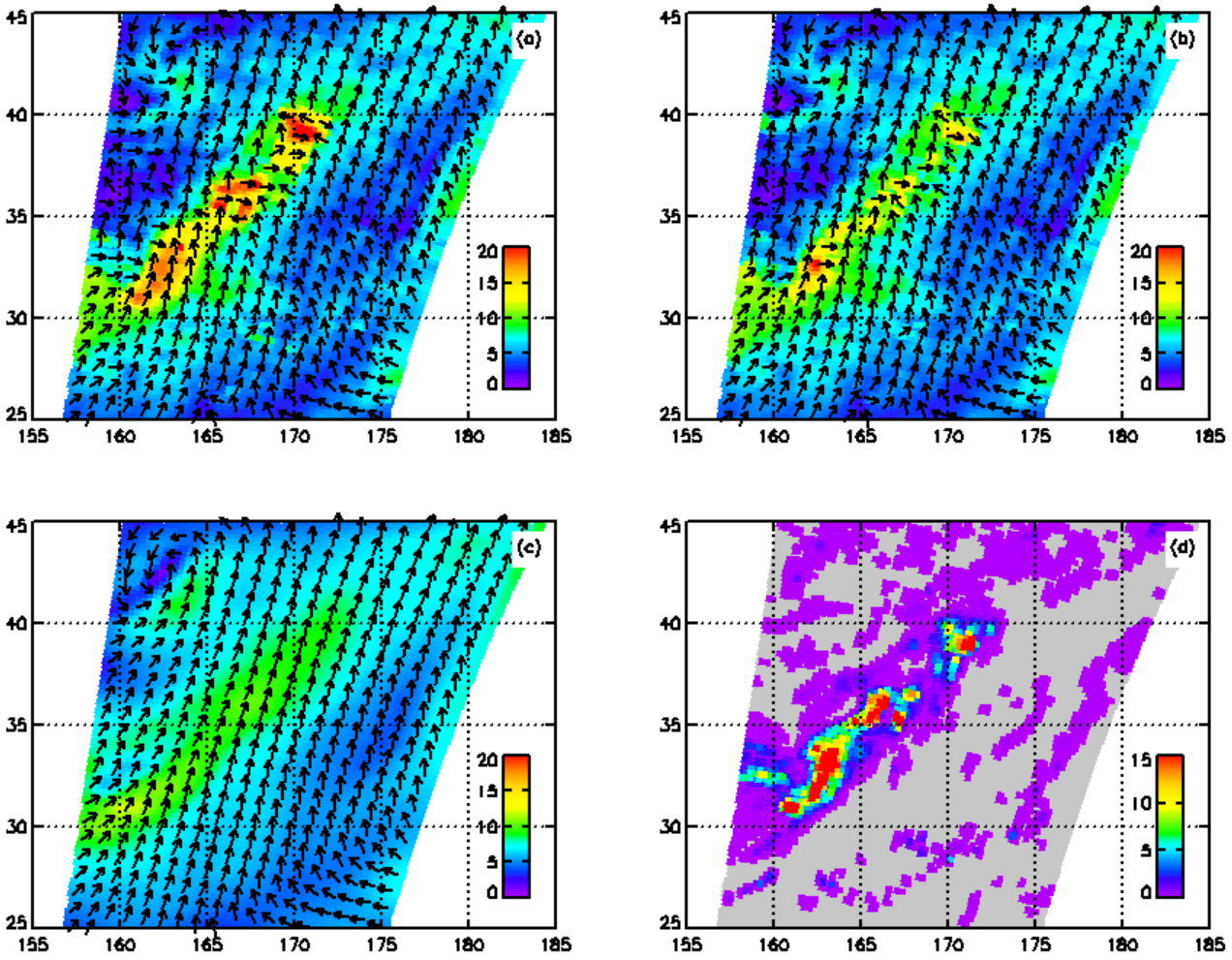
NADIR SWEET FAR

Tropics



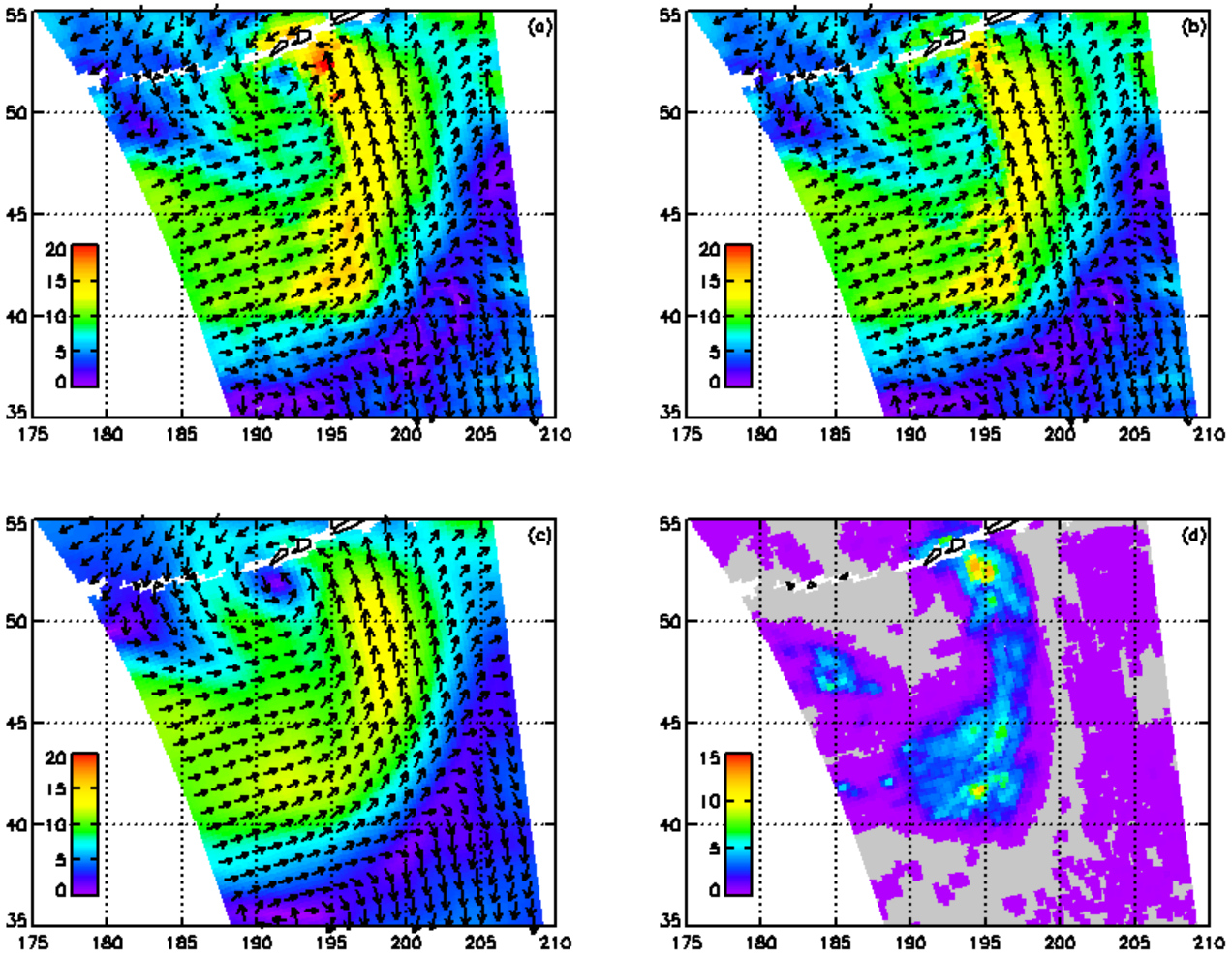
10 Apr 03: Western Central American Coast, Rev 1670

Mid-Latitude



28 June 03, Northwest of Hawaiian Islands, Rev 2806

High Latitude



16 July 03, South of Aleutian Islands, Rev 3054

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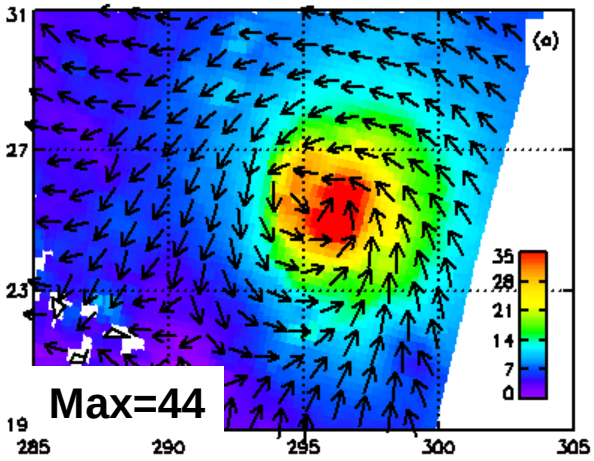
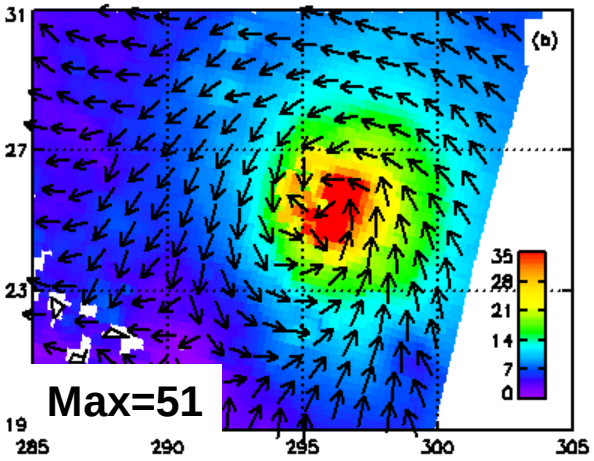
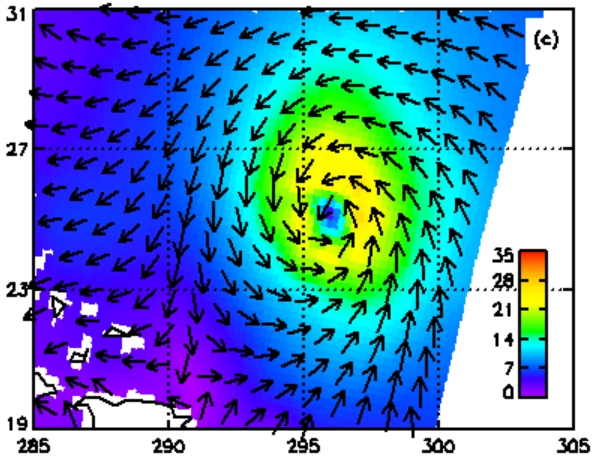
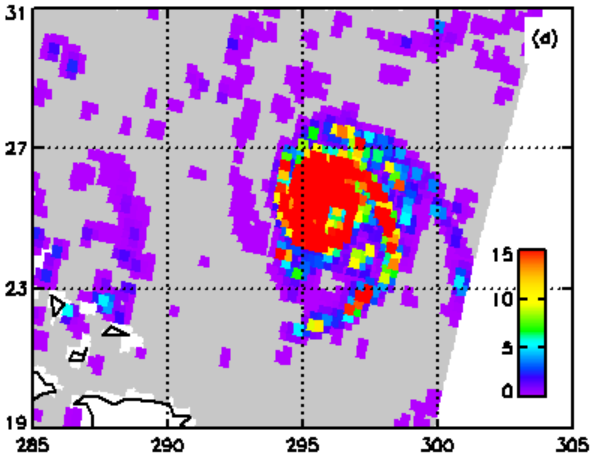
Hurricane Fabian

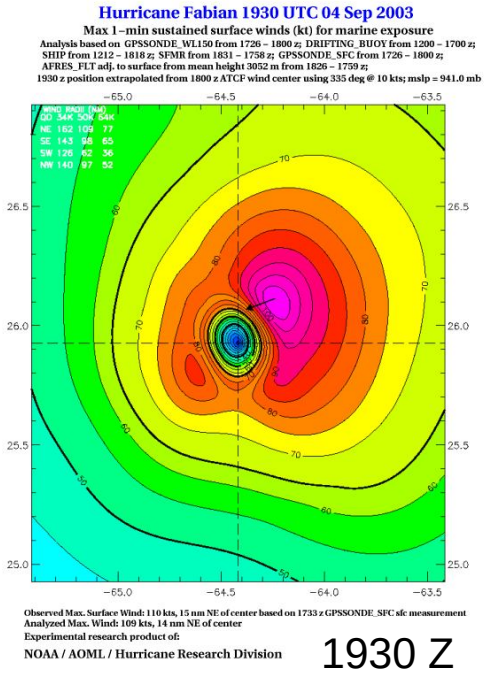
1500 Z











1930 Z

No scat in H-wind

Max = 110 kts = 57 m/s
= **<u>50 m/s</u>** (10-MM)

US NAVY:
0.88 x 1-min mean = 10-min mean

04 Sep 03, Rev 3770

Conclusions

- AMSR radiometer data can successfully be used to correct SeaWinds scatterometer data
- Mismatch issues: need to do full footprint matching scheme for best results
- For further details:
  - Hilburn et al., 2005, Journal Applied Meteorology (submitted)

Midori-2 Clearly Demonstrates the Advantages of Active-Passive Microwave Remote Sensing