

SFMR Performance During the 2005 Hurricane Season

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60th Interdepartmental Hurricane Conference
Mobile, Alabama
March 20-24, 2006

2005 SFMR Performance

- Flown in 9 storms, 7 landfall situations
 - Arlene Cindy Dennis
 - Emily Irene Katrina
 - Ophelia Rita Wilma
- 34 total SFMR missions, 23 tasked
 - 16 total, 8 tasked for NOAA42
 - 18 total, 14 tasked for NOAA43

2005 SFMR Performance (cont'd)

- SFMR used in 23 advisories, prompted 2 special advisories
- All cases played decisive role in an important decision on current intensity or estimates of intensity change
- Especially crucial for landfall intensity estimates for Dennis, Katrina, Rita and Wilma
- Mentioned prominently in Katrina, Rita and Ophelia NHC storm reports

SFMR Use Points to Key Deficit

- **Difficult for forecasters to transition from routine AFRC flight level reco data to SFMR surface data, especially in landfall situations like Katrina**
- **Extensive use of SFMR in 2004-2005 illustrates the urgent need for SFMR installation on WC-130J aircraft as soon as possible- especially critical in current era of enhanced TC activity**

SFMR Updates

- From HRD projects:
 - <http://www.aoml.noaa.gov/hrd/project2005/sfmr.html>
- From NHC storm reports:
 - <http://www.nhc.noaa.gov/2005atlan.shtml>

Key SFMR Issues

- **Calibration vs. Model Development**
- **Averaging Considerations**
- **Real-Time Quality Control**
- **Future Interpretation Issues**

SFMR Calibration Procedure

- Single “pre-season” laboratory calibration by ProSensing

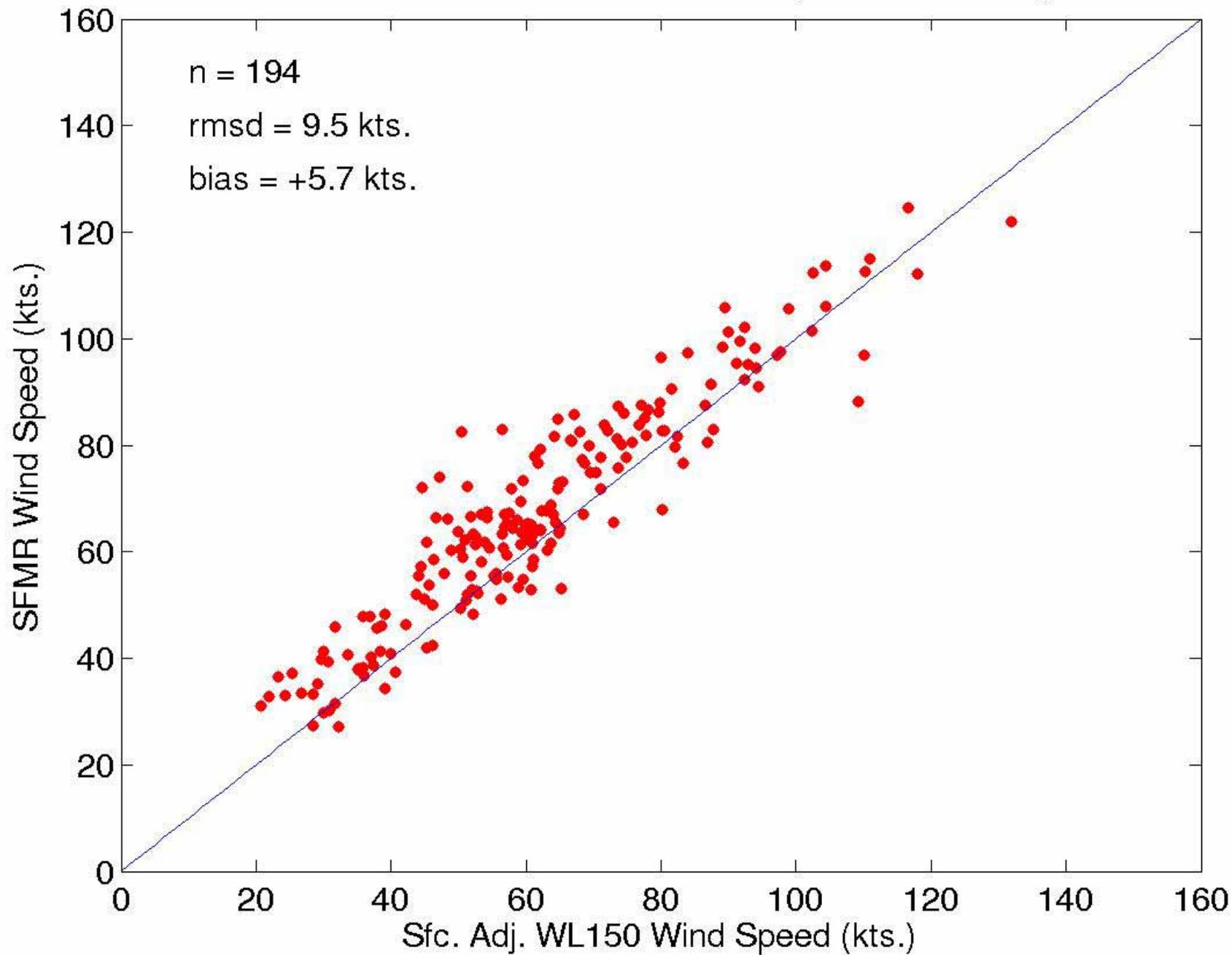
$$T_B = a_0 + a_1\gamma + \dots$$

- Single “pre-season” airborne ‘calibration adjustment’ of a_0 for in-flight configuration
 - Flight in weak winds over known surface conditions (U10, SST) from redundant surface observation sources: buoy, GPS sonde, AXBT’s
 - Adjustment to theoretically-based T_B
 - In practice, should be performed annually

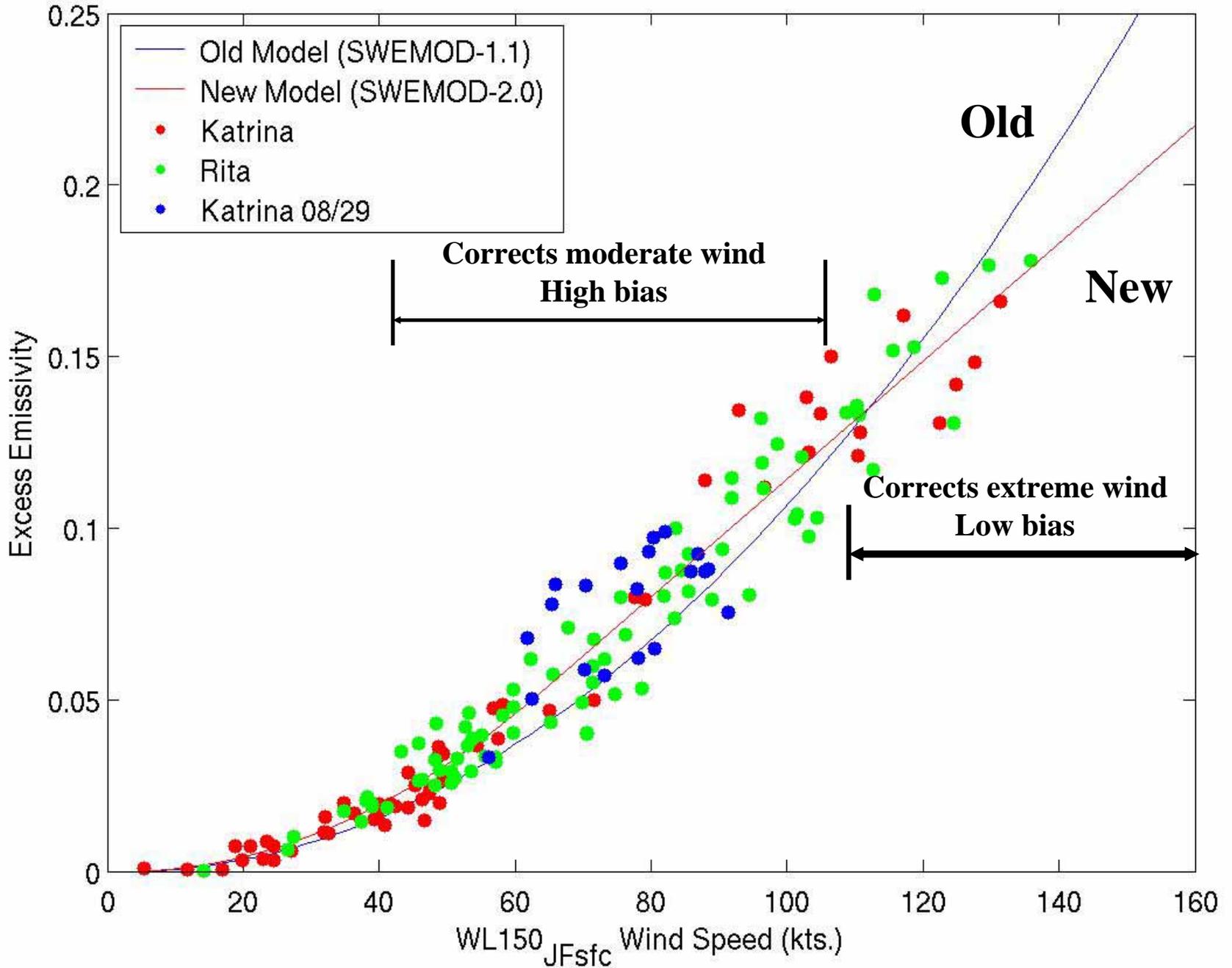
SFMR Model Development

- Empirically-based wind/emissivity (T_B) model function
- Statistical correlation of surface wind estimates with calibrated SFMR measurements
 - Early model function related emissivity to surface adjusted flight-level winds
 - Since 2003, related to GPS sonde near-surface winds
 - Updated 2005 function based on larger data base of GPS near-surface winds
- New model function corrects previously observed biases (e.g. moderate wind “high bias” & extreme wind “low bias” noted in 2004 data)

2004 HRD SFMR -- Old Model (SWEMOD-1.1)



Sfc. Adj. (JF) WL150-Based SFMR Wind/Emissivity Model (SWEMOD)



New SFMR Wind/Emissivity Model

Function

$$\begin{aligned}\Delta e_w &= c_0 + c_1(w - w_b) + c_2(w - w_b)^2, & w \leq w_b \\ &= c_0 + c_1(w - w_b), & w > w_b\end{aligned}$$

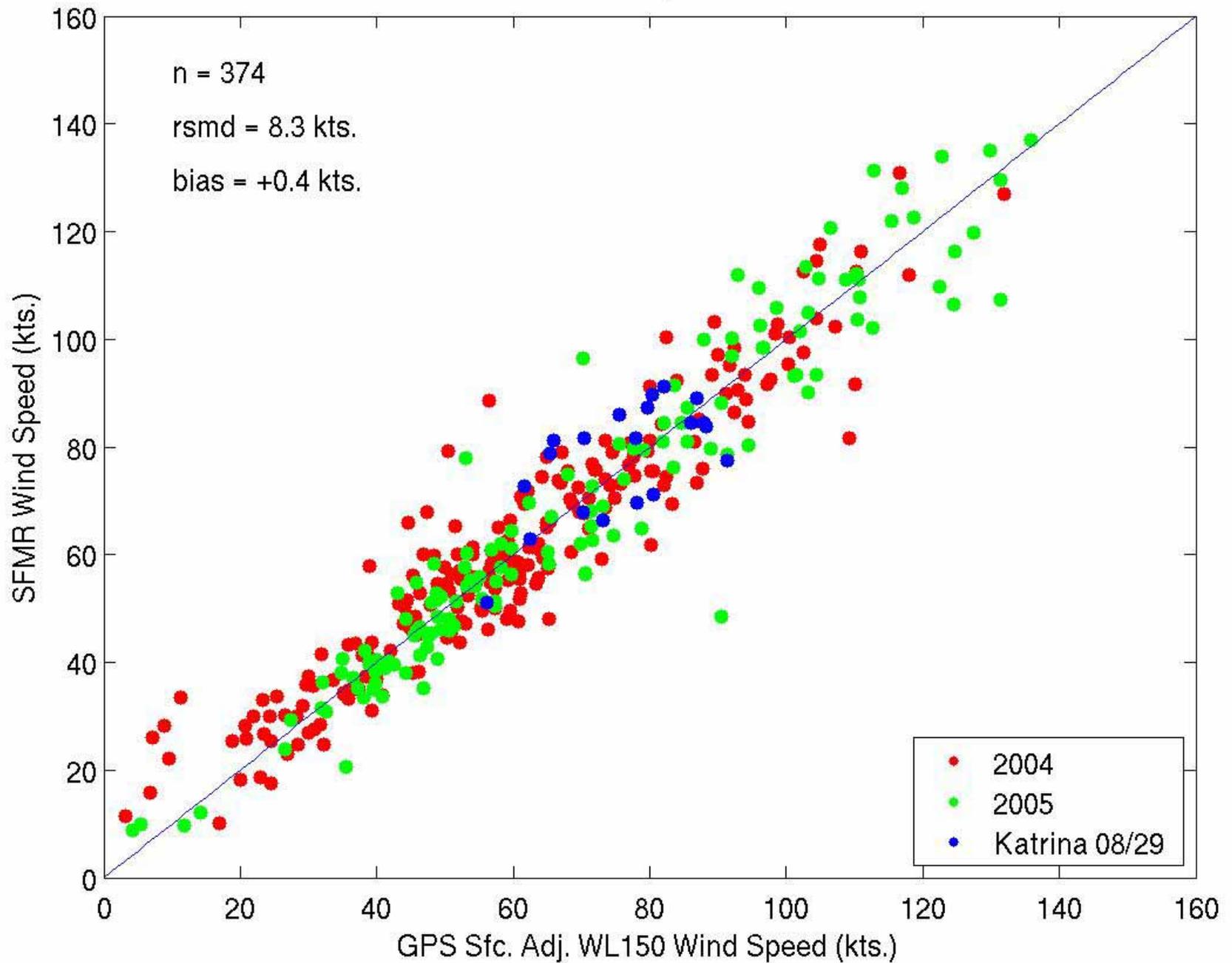
$$w_b = 33.2 \text{ m/s}$$

$$c_0 = 5.3058 \cdot 10^{-2}$$

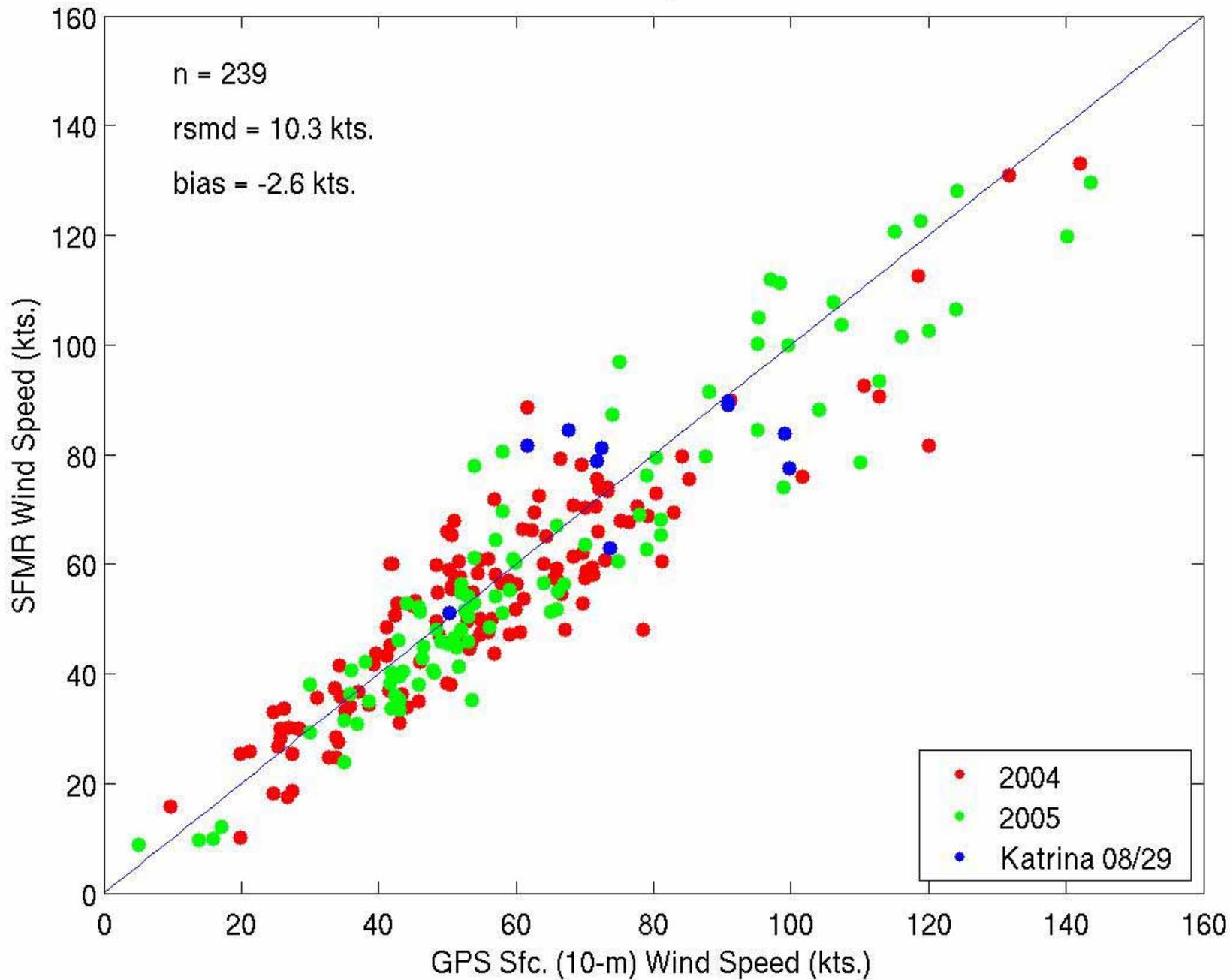
$$c_1 = 3.3313 \cdot 10^{-3}$$

$$c_2 = 5.22101 \cdot 10^{-5}$$

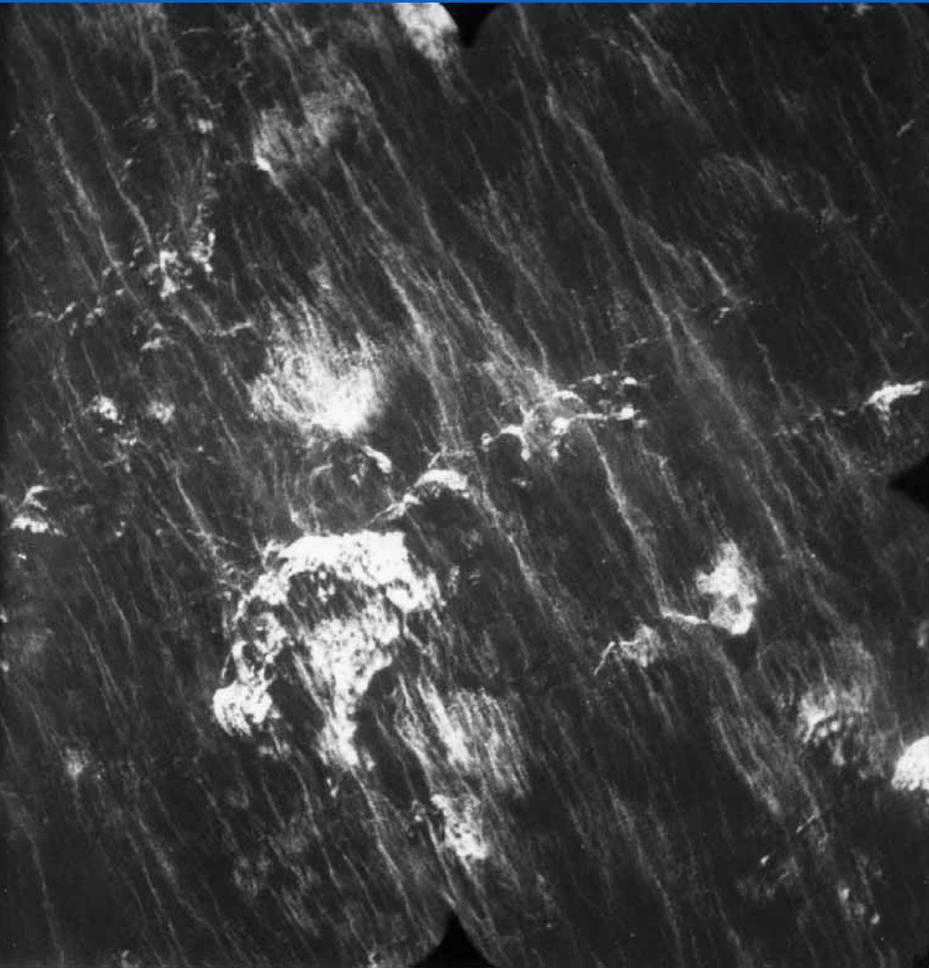
SFMR/GPS 2004/2005 Comparisons -- SWEMOD-2.0



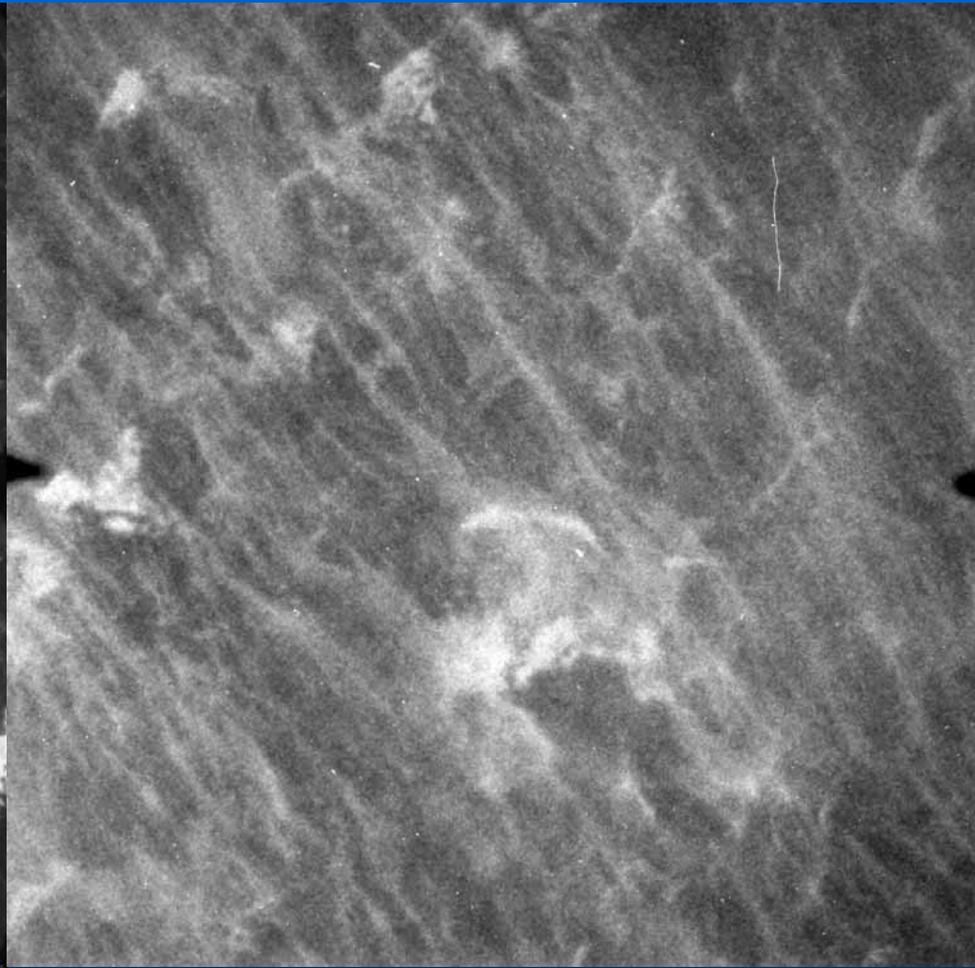
SFMR/GPS 2004/2005 Comparisons -- SWEMOD-2.0



Ocean Surface Whitecaps and Foam Streaks in a Hurricane



200 m
Wind speed ~28m/s



200 m
Wind Speed ~ 46 m/s

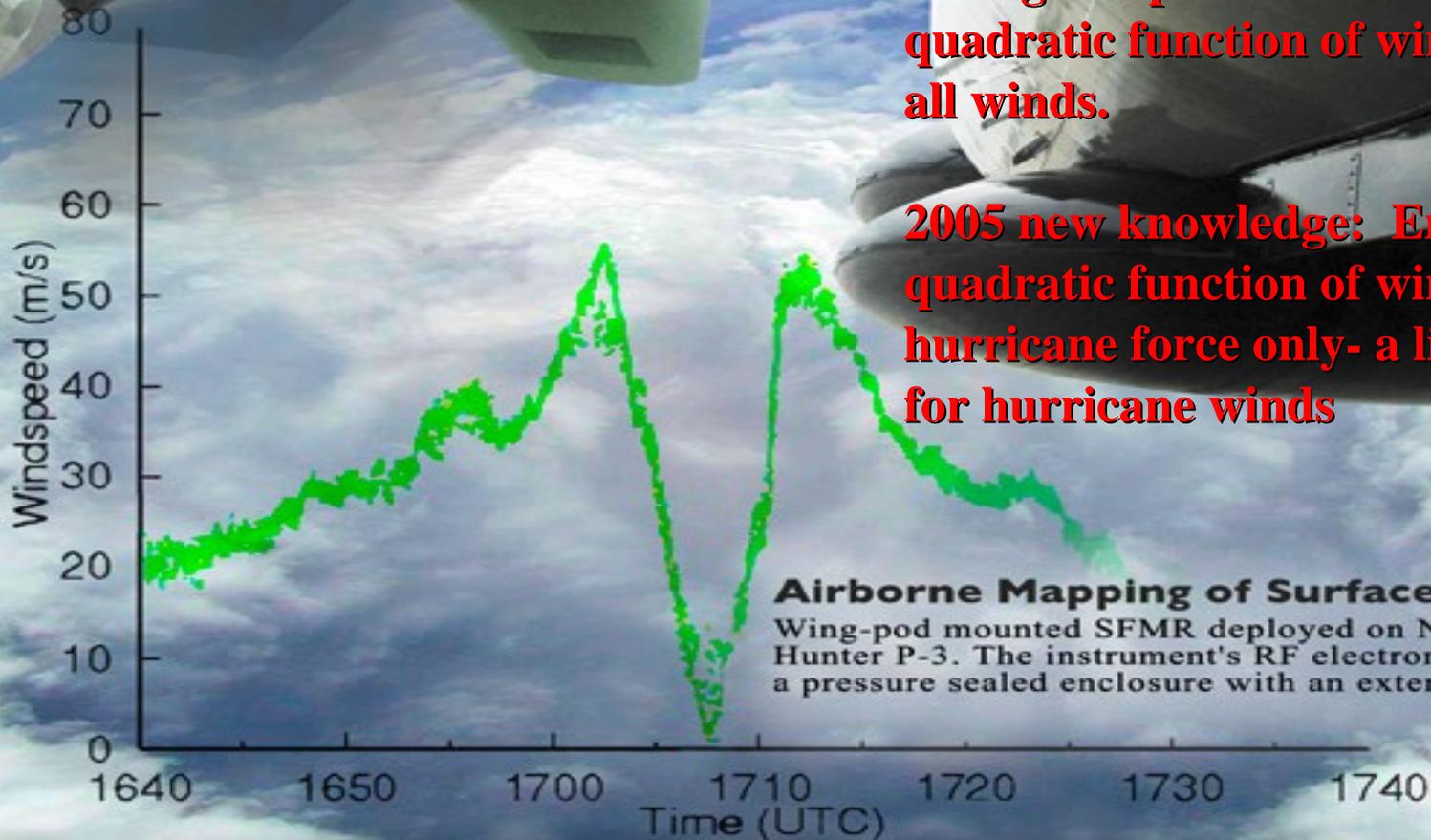
STEPPED FREQUENCY MICROWAVE RADIOMETER

Impacts National Hurricane Center forecast during the 2004 hurricane season

SFMR measures C-band microwave emission from foam (air bubbles in the ocean)

First guess pre-2005: Emissivity a quadratic function of wind speed for all winds.

2005 new knowledge: Emissivity a quadratic function of wind up to hurricane force only- a linear function for hurricane winds



Airborne Mapping of Surface Wind Speed

Wing-pod mounted SFMR deployed on NOAA's Hurricane Hunter P-3. The instrument's RF electronics are housed in a pressure sealed enclosure with an external antenna.

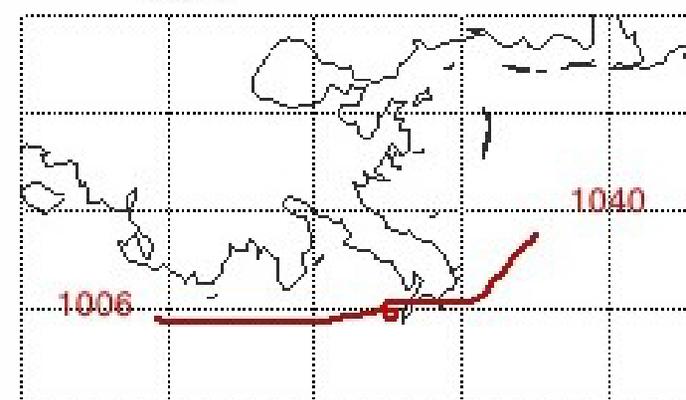
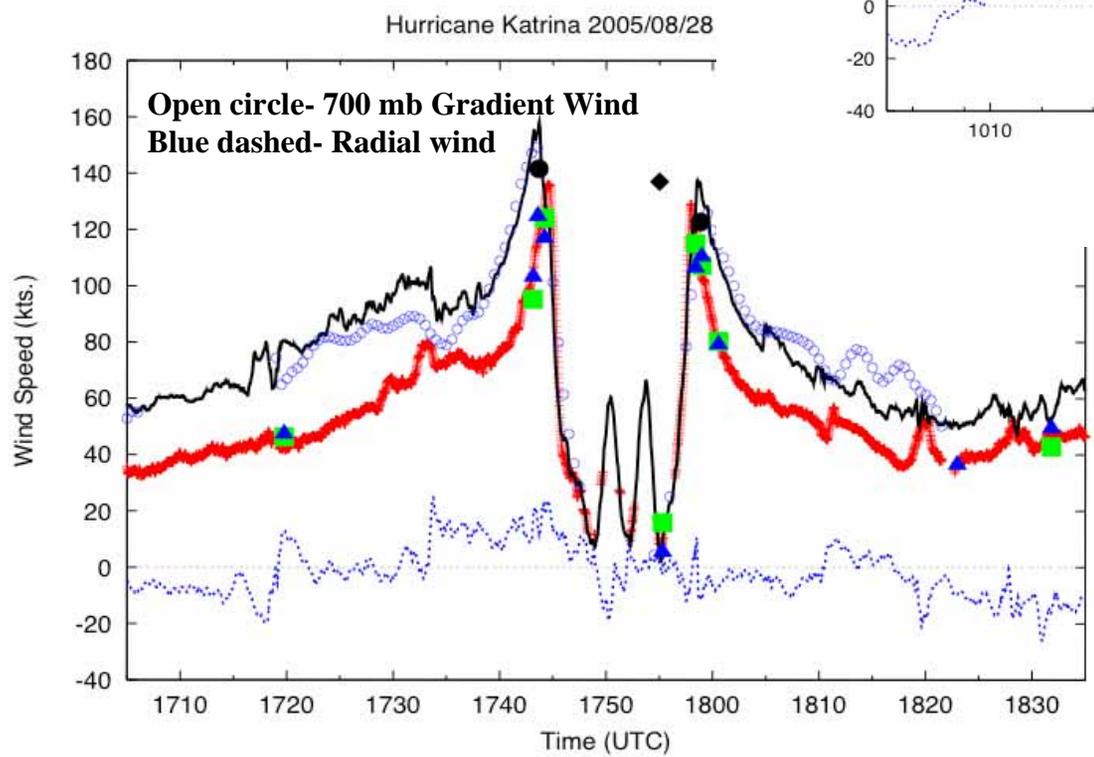
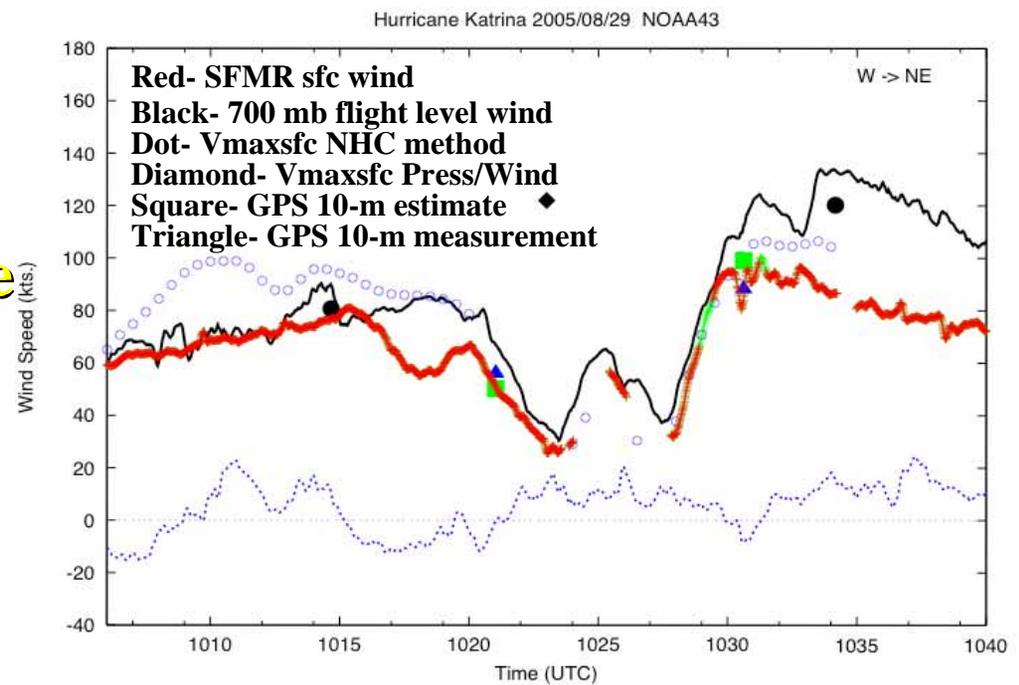
Hurricane Katrina- SFMR

29 Aug

Flat profile: $V_{maxsfc}=100$ kt

28 Aug- Sharply peaked profile

$V_{maxsfc}=142$ kt



Averaging Considerations

- **Model function**

- All SFMR channels update several times (~3s) over a 10s period
- Correlate surface-adjusted WL150 wind speed (avg time = ??) with 10-s average SFMR (frequency-independent) emissivity
- Cross-track footprint (22 deg) vs along-track footprint for 10, 30, 60 s avg time @ 110 m/s (220 kt) GS:
 - RA = 330m (1500'): 0.2x1.3 km, 0.2x3.9 km, 0.2x7.8 km
 - RA = 1500m (5000'): 0.6x1.7 km, 0.6x5.1 km, 0.6x 10.2 km
 - RA = 3000m (10000'): 1.3x2.4 km, 1.3x7.2 km, 1.3x14.4 km
- Reference: Swell wavelength ~ 200m; local sea ~ 75m
- Issue: time required for air parcel at different wind speed to travel across one beamwidth on the surface
- OR: time required for foam coverage to respond to changes in the wind
- Consideration: since all waves from cm-scale capillaries up to the peak are likely breaking in hurricane conditions, time scale likely small~ minutes??

Averaging Considerations (Cont'd)

- **Real time wind retrieval**
 - Transmitted retrieval averaging tied to data rate in past
 - Need to be made consistent across all aircraft, i.e. IHC06 Agenda item proposal for 30-s average

Quality Control

- **Basic QC checks**
 - Outlier TB measurements
 - Aircraft pitch, rolls (> 6 deg)
 - Over-land measurements (Tb > 270K)
- **External QC**
 - Landmasking
 - Bathymetry
 - Improved SST
- **NOAA flight director's discretion (yes/no decision on data transmission)**
- **Many issues are to be addressed by JHT**

Other SFMR Issues

(for SFMR JHT, YR 2)

- **Bathymetry**

- SFMR issues in shallow water are still merely anecdotal, theory suggests that winds may be overestimated in ‘surf zone’ where swell breaking in shallow conditions
- ‘Sheltered’ shallow water (offshore flow, Bahama Banks, Lake Ponchartrain) wind retrievals ‘look good’
- To be addressed by excluding near-coastline “shallow-water” retrievals; extensive shallow-water dropsonde obs
- Similar issue with wind/current interactions (no quantitative info), i.e. Gulf Stream, Loop Current boundaries

- **Rain**

- Has little effect on results at high (> 50 kt) winds, even in extreme rainrates (~ 50 mm/hr)
- Weaker winds have tendency to be overestimated in heavy rain (e.g. in an outer rainband) – Issue is due to emissivity-rain model bias

WC-130J SFMR Installation Status

- Dec., 2004- \$10.5M supplemental to DoD for SFMR on AFRC WC-130J's
- 26 July, 2005- first Technical Interchange Meeting (TIM) at Wright-Paterson to define project scope- delivery of first SFMR set for Sept, 2006
- Oct., 2005- Lockheed (LM) under contract
- 17 Nov., 2005- Second TIM at LM/Dobbins
- Feb, 2006- Air Force purchasing office announces slippage in delivery to Jan, 2007
- Mar, 2006- ProSensing under subcontract
- Mar, 2006- With NOAA concurrence, G-IV SFMR to LM moves delivery to Nov, 2006
- Mar, 2006- still no contract for delivery of remaining 9 SFMR units to operational WC-130J's.