A Novel Hurricane OVW Retrieval Technique for QuikSCAT

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Ocean Vector Winds Science Team Meeting
Annapolis, MD
May 9-11, 2011

Outline

- SeaWinds OVW measurements in hurricanes
- Radar backscatter geophysical model function
- X-Winds OVW retrieval algorithm
  - wind direction retrieval
  - wind speed retrieval
- X-Wind Comparisons with H*Wind

SeaWinds Hurricane OVW Measurements

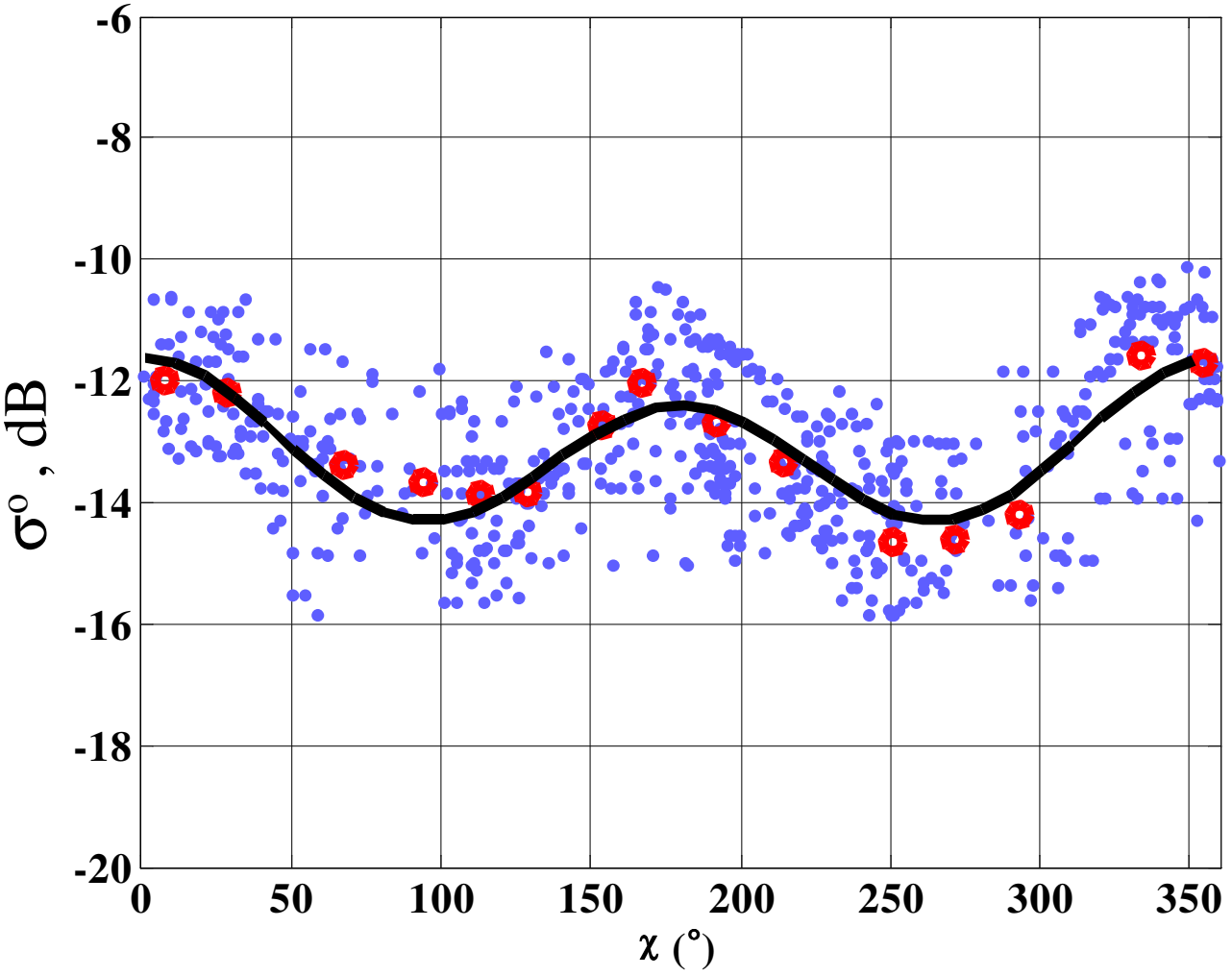
- Historically Ku-band scatterometers have consistently under estimated hurricane wind speeds
- Issues
  - Inadequate spatial resolution
  - Rain contamination
  - Geophysical OVW algorithms
    - GMF – relationship between radar backscatter and surface wind speed
    - Rain correction

Extreme Winds Sigma-0 Geophys Model Function (XW-GMF)

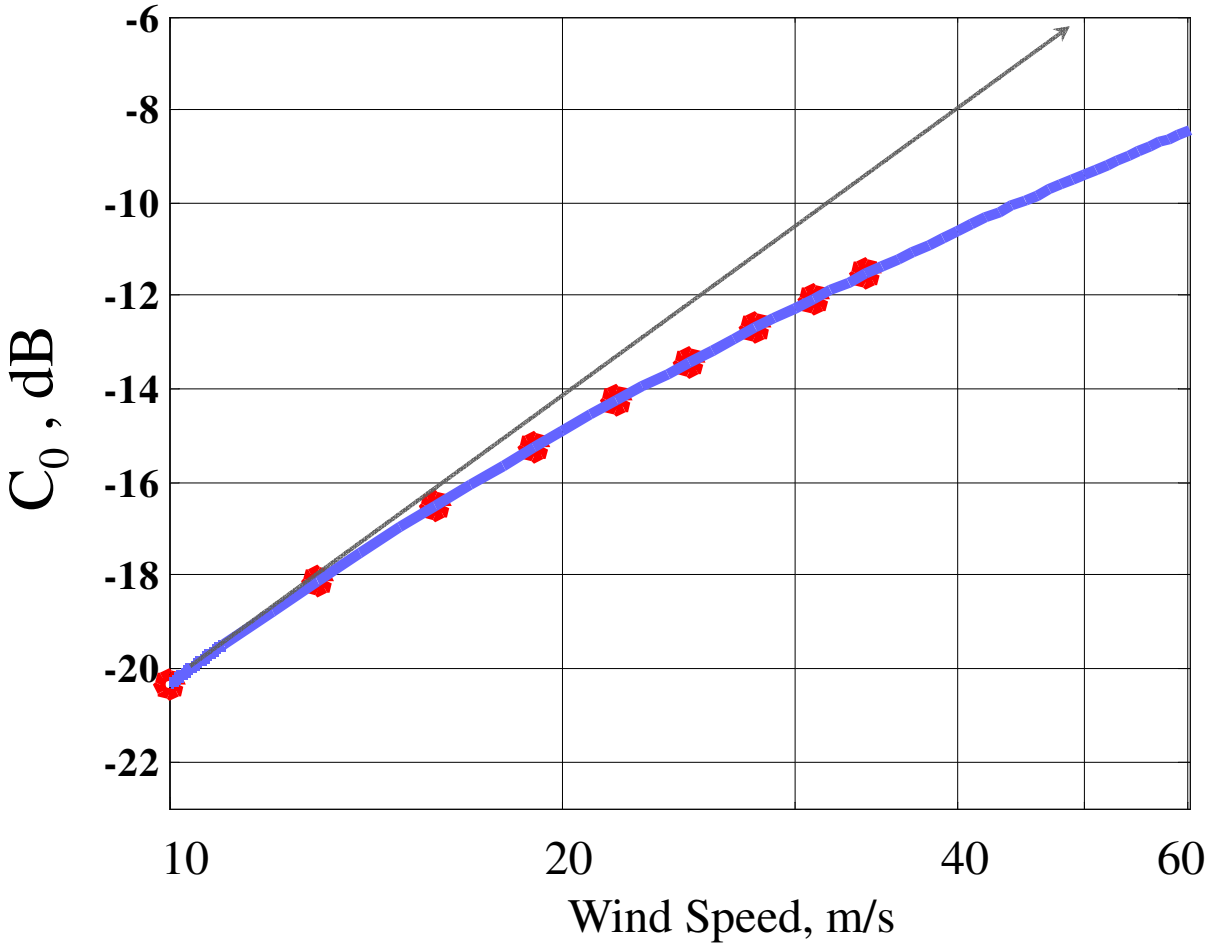
- Special GMF developed for hurricanes
  - Training dataset of 35 QScat hurricane overpasses
  - 3-D GMF: $\sigma^o = f(ws, relative\ wdir, atmos\ transmis)$
    - WS: one-minute sustained 10m wind speeds from NOAA HRD H*Wind surface wind analysis
    - Relative wind direction χ: from multi-radar az looks and from H*Wind analysis
    - Atmos transmissivity: inferred from simultaneous observations of QRad H-pol brightness temperatures

Hurricane Geophysical Model Function (GMF)
QuikSCAT H-pol, 30 m/s

$$\sigma^o = C_0(ws) + C_1(ws) * \cos\chi + C_2(ws) * \cos 2\chi$$

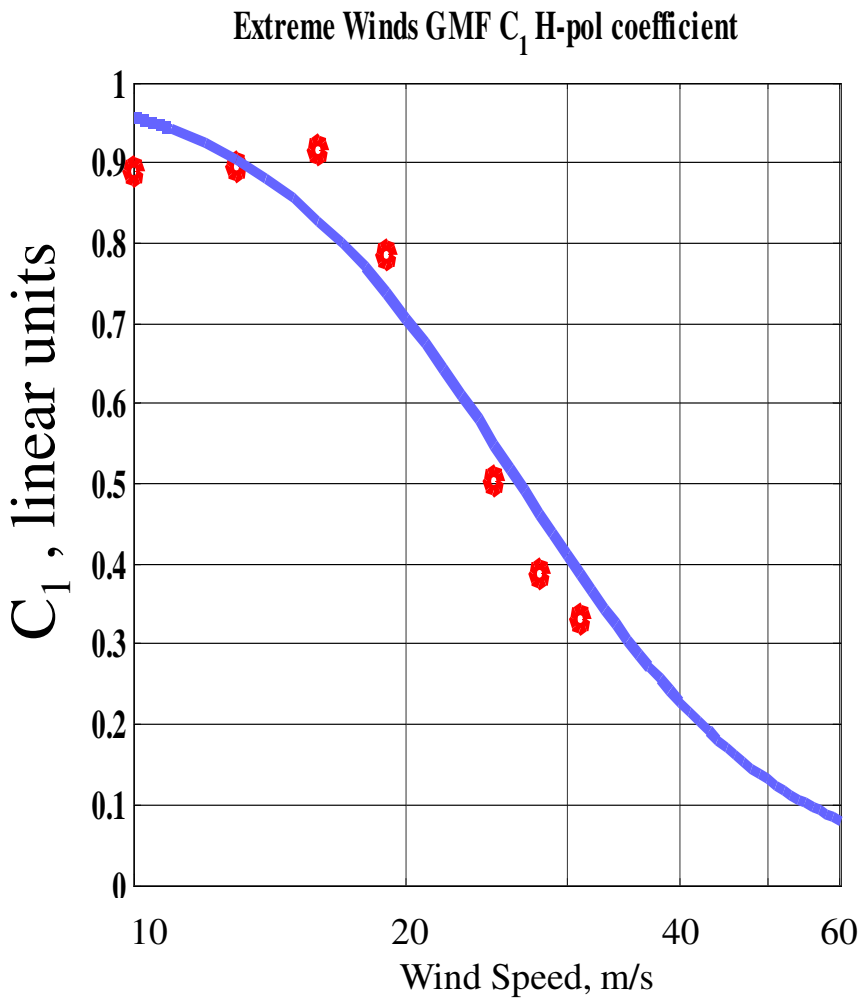


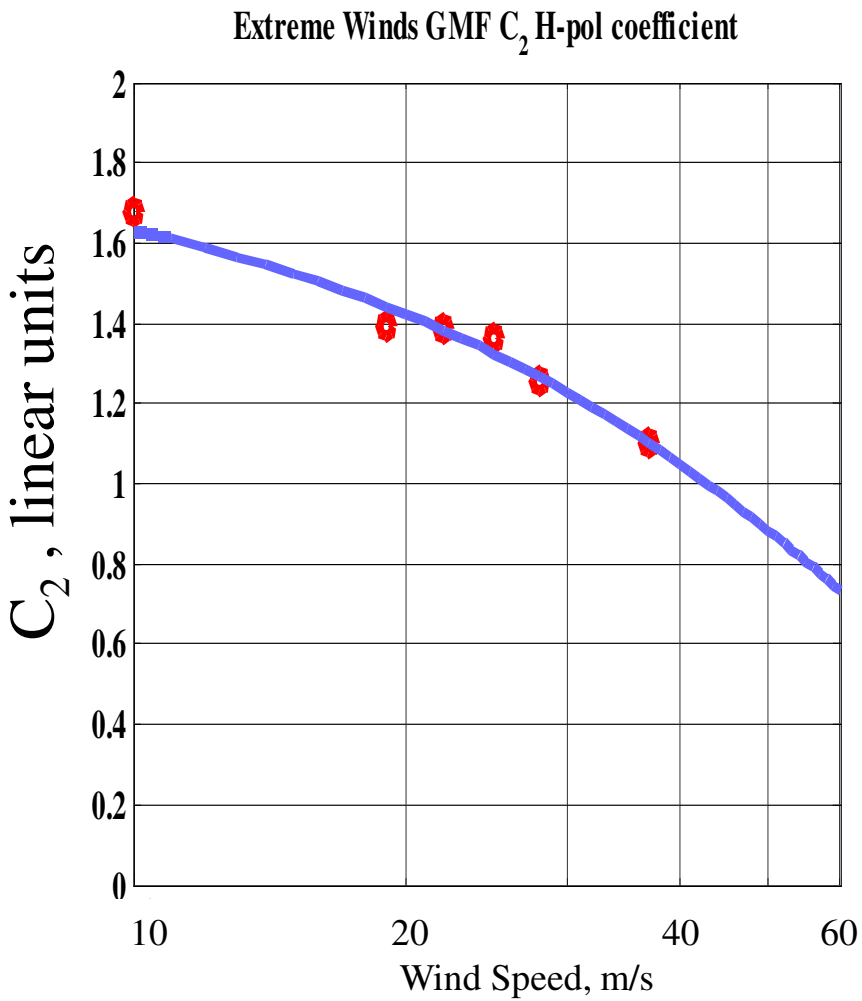
GMF C_0 Coeff Dependence on Wind Speed



GMF Anisotropy with Wind Speed

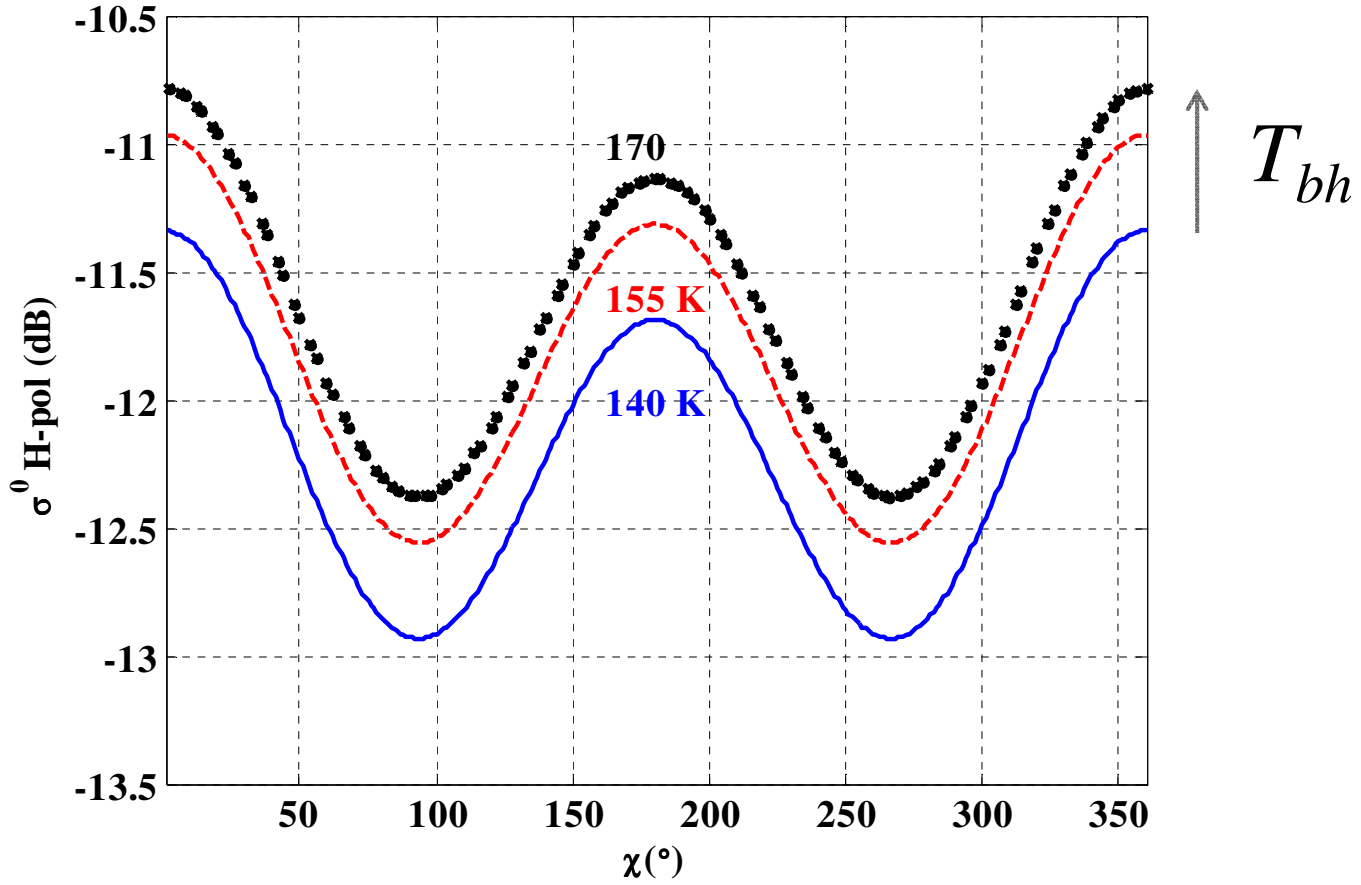
$$\Delta\sigma^{o} = C_1(ws) * \cos\chi + C_2(ws) * \cos 2\chi$$





XW-GMF Atmospheric Transmissivity

- Rain attenuation is corrected implicitly through use of the QRad H-pol brightness temperature T_{bh}
  - GMF = $f(ws, rel\_wdir, T_{bh})$



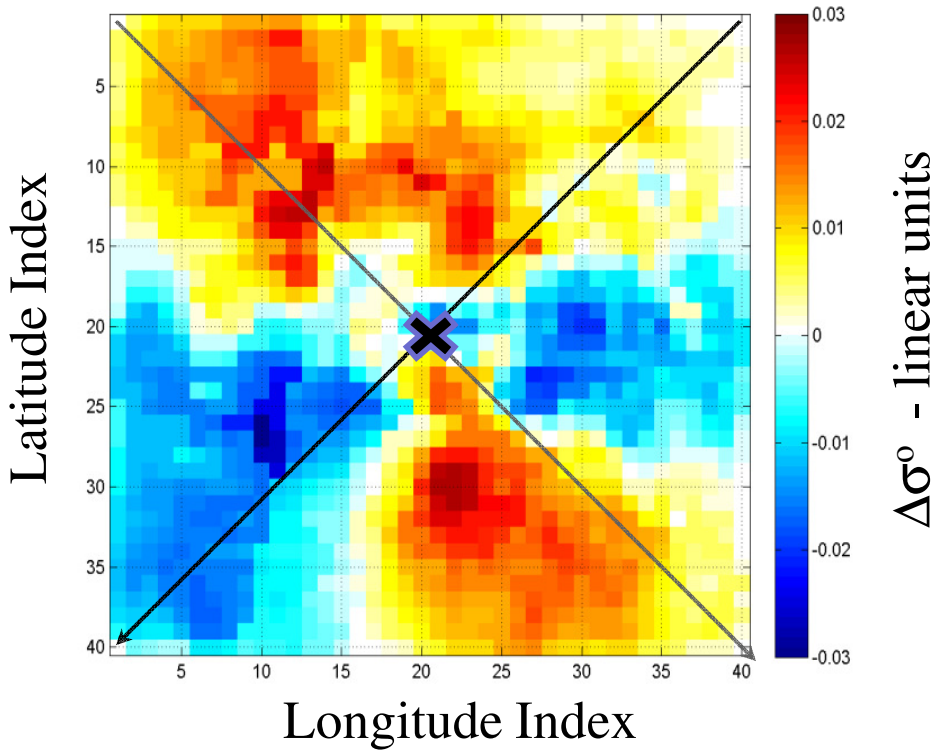
X-Winds OVW retrieval Algorithm

- Attributes
  - Assumes cyclonic wind direction rotation about TC center
  - Assumes rain effects are primarily absorptive
    - Rain volume backscatter is neglected
  - Empirical 3-D XW-GMF accounts for backscatter saturation with wind speed & rain absorption
  - Uses scalar wind direction and wind speed estimation
    - Not traditional maximum likelihood estimation

Scalar Wind Direction Estimation

- Relies on anisotropy of measured difference between forward and aft looking backscatter measurements

$\Delta\sigma^{o}_{meas} = (\sigma^{o}_{fore} - \sigma^{o}_{aft})$ @ top-of-the-atmos



Wind Direction Modeling of $\Delta\sigma^o$

Sigma-0 anisotropy model for single radar azimuth look

$$\Delta\sigma^o = C_1(ws) * \cos\chi + C_2(ws) * \cos 2\chi$$

Taking the difference between fore & aft radar looks yields

$$\Delta\sigma^o_{\text{mod}} = \left(cos\chi_{fore} - \cos\chi_{aft}\right) + C_2\left(cos2\chi_{fore} - \cos 2\chi_{aft}\right)$$

Wind direction solutions (aliases) are roots of

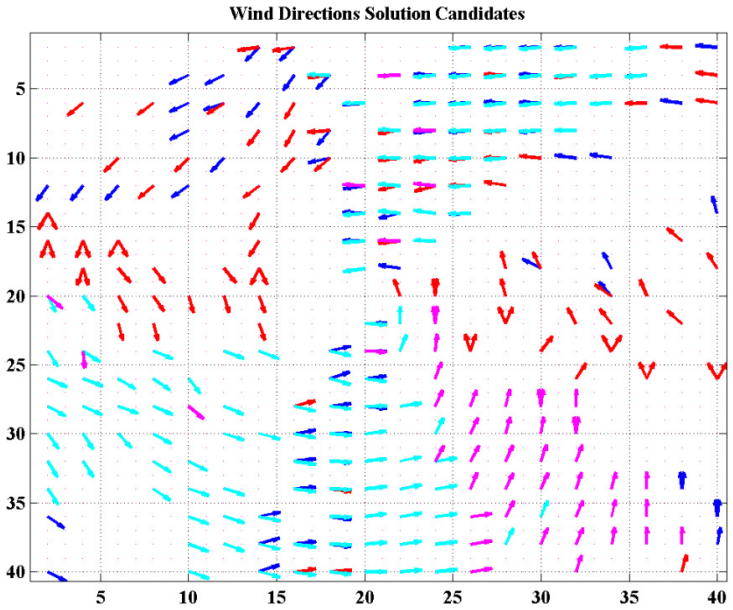
$$\left(\Delta\sigma^o_{\text{m}eas} - \Delta\sigma^o_{\text{mod}}\right) = 0$$

Yields ambiguous wind direction solutions

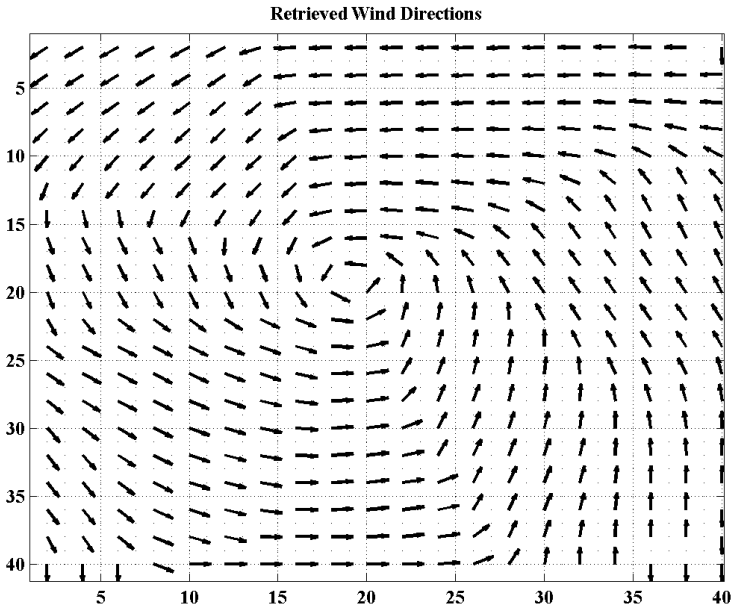
typically ~ 6 – 8

Wind Direction Alias Removal

- Keep ambiguities within window ±30° from CCW spiral
- Multi-pass median filter and populate missing pixels through interpolation
- Use smoothed TC wind field for wind speed estimation



Wind Directions Ambiguities



Initial Wind Direction Field

X-Winds Scalar Wind Speed Estimation

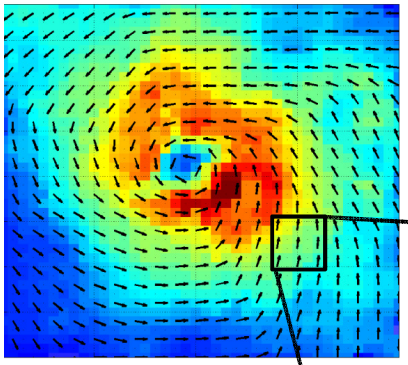
- Use smooth TC wind field as "estimated true" wind direction and calculate relative wind direction

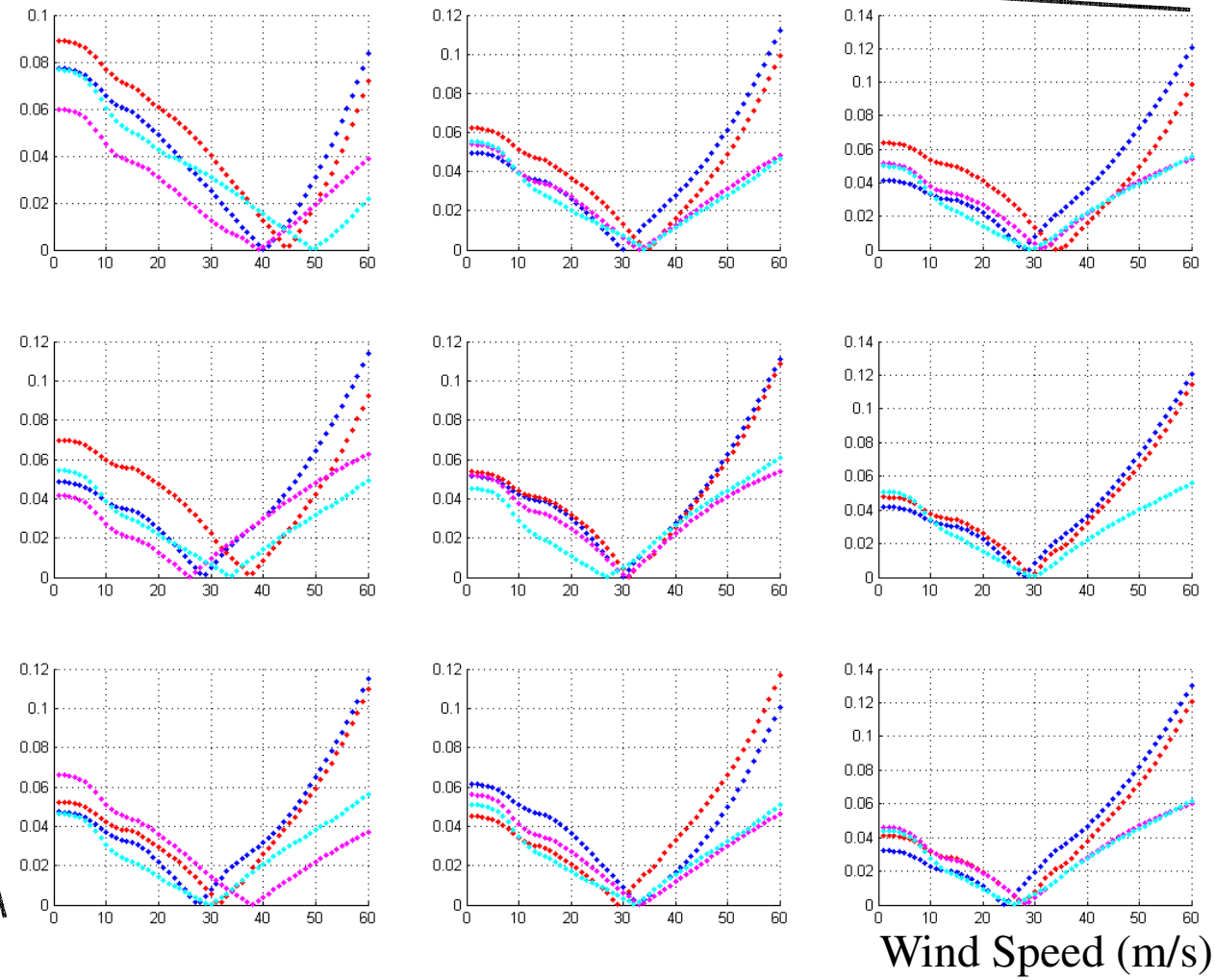
  χ = (radar az – "est-wind dir")

  Find 1-D wind speed solution for each σ^o flavor (pol & direction) that satisfies this relationship

$$\left(\sigma^{o}_{meas} - (XW - GMF)\right) = 0$$

X-Winds Wind Speeds Retrievals (4- σ^o flavors)

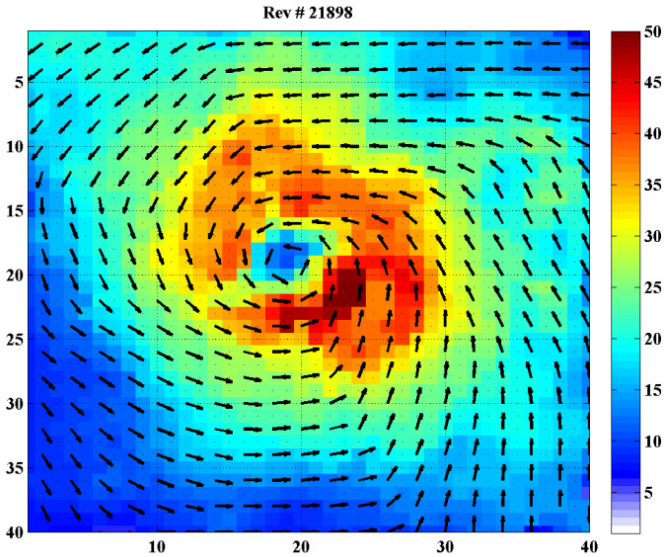




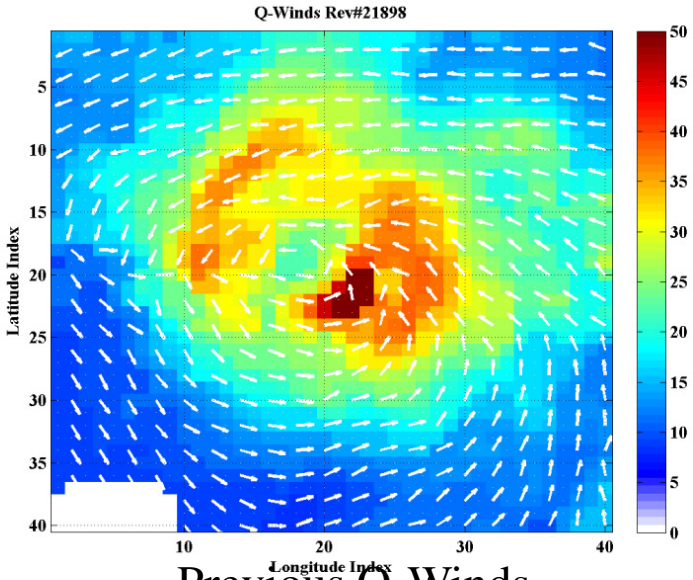
X-Winds Comparisons

- L2B-12.5km OVW product
- H*Wind surface wind analysis

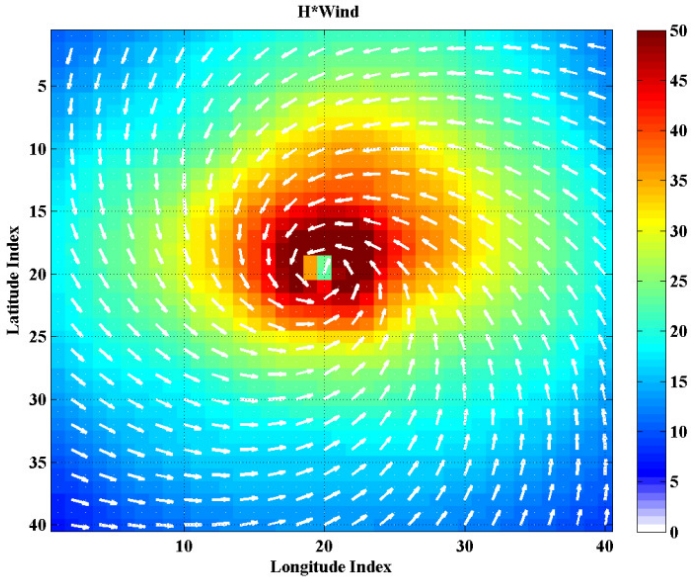
Hurricane Fabian Rev#21898



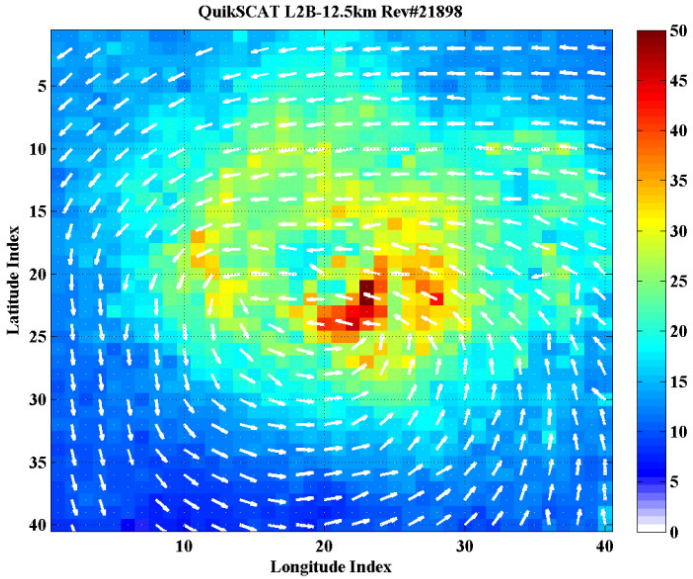
X-Winds



Previous Q-Winds

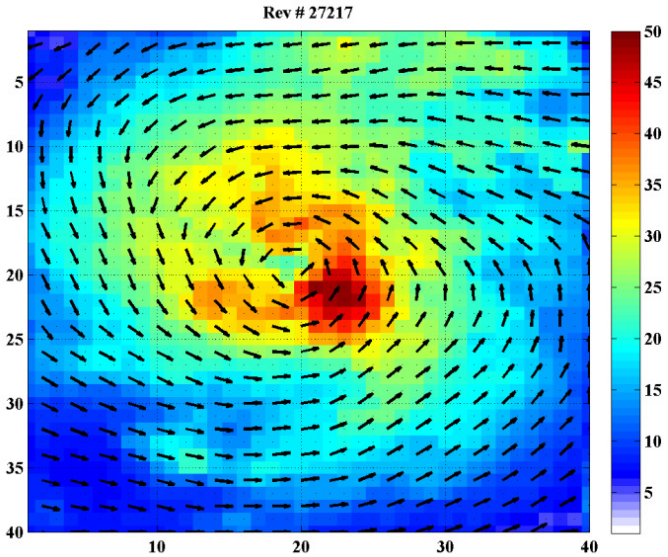


H*Wind

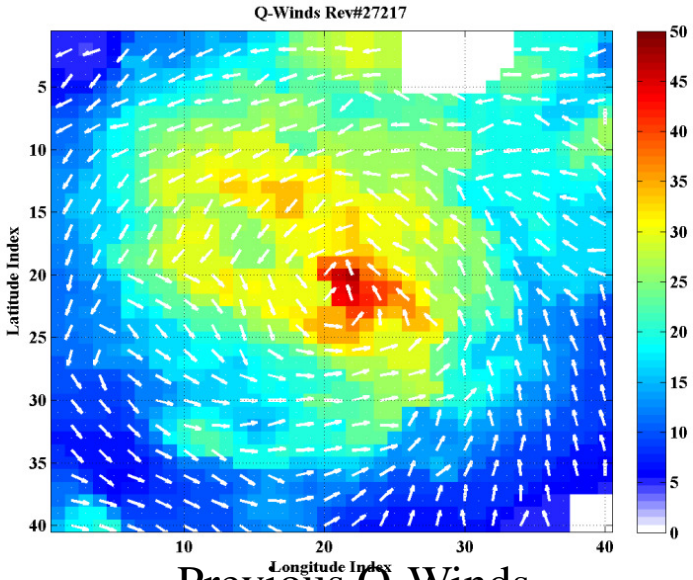


L2B-WS 12.5km

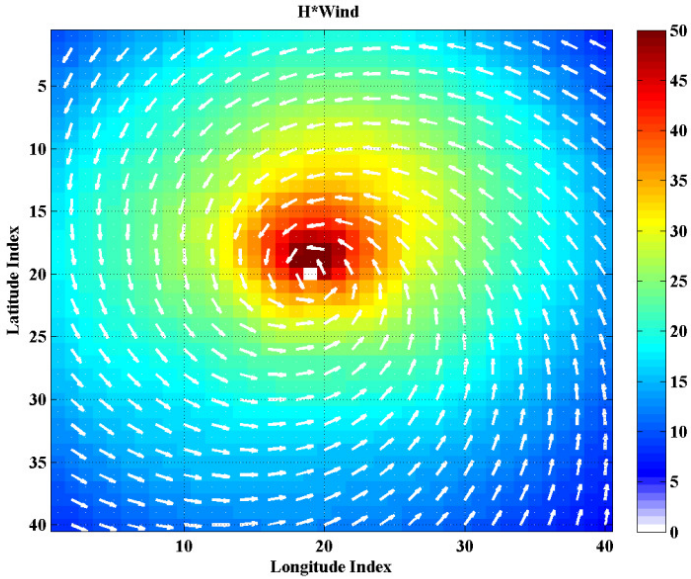
Hurricane Ivan Rev#27217



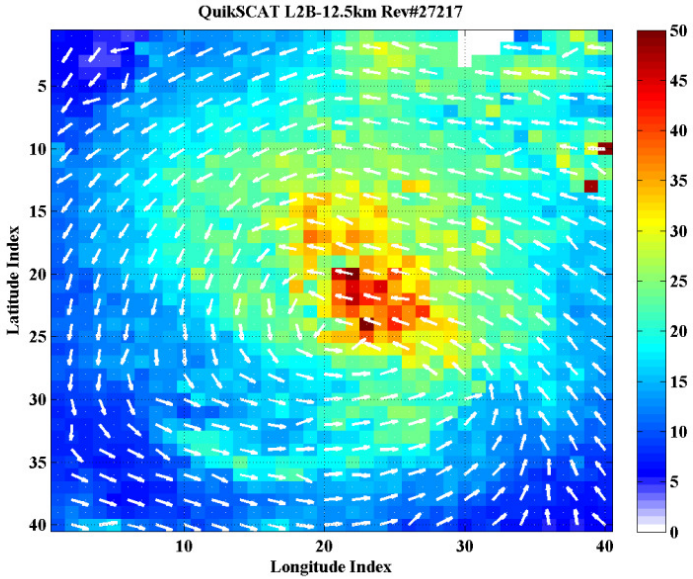
X-Winds



Previous Q-Winds



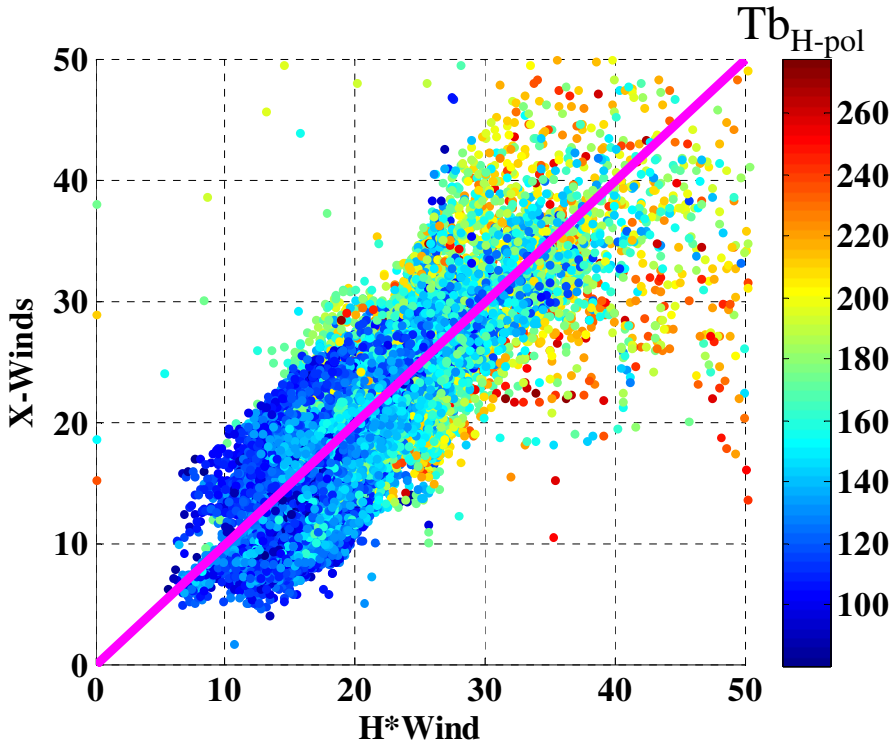
H*Wind



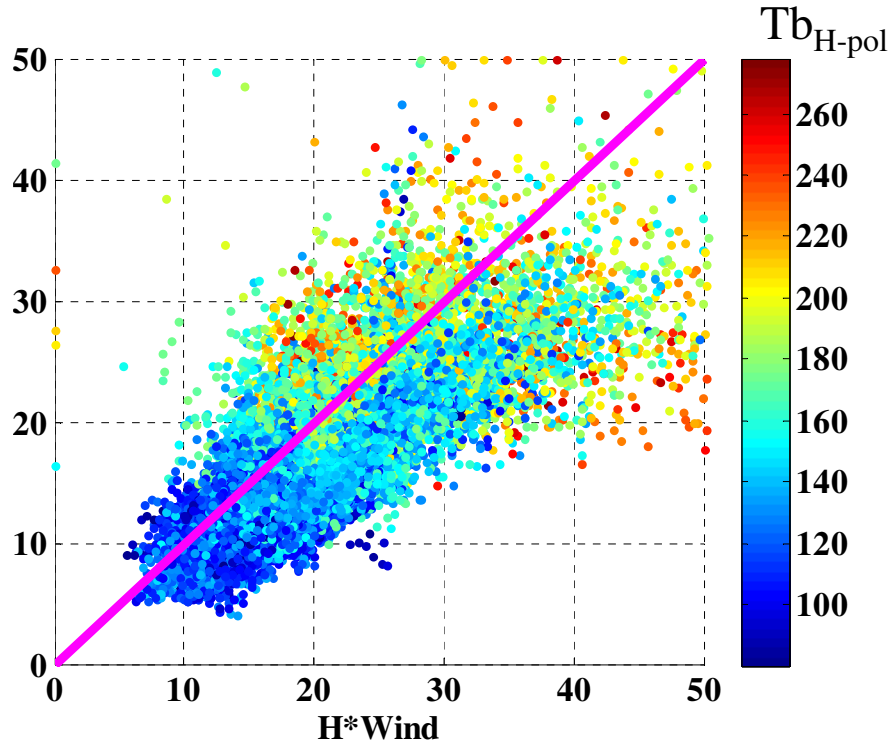
L2B-WS 12.5km

Wind Speeds Comparison (10 revs)

X-Winds

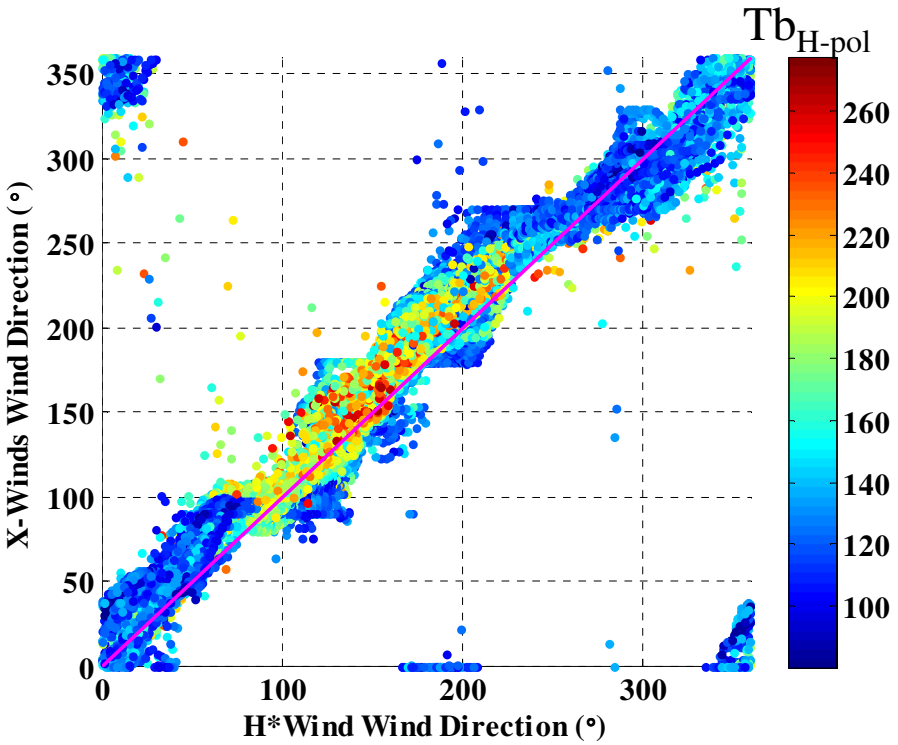


QuikSCAT L2B-12.5km

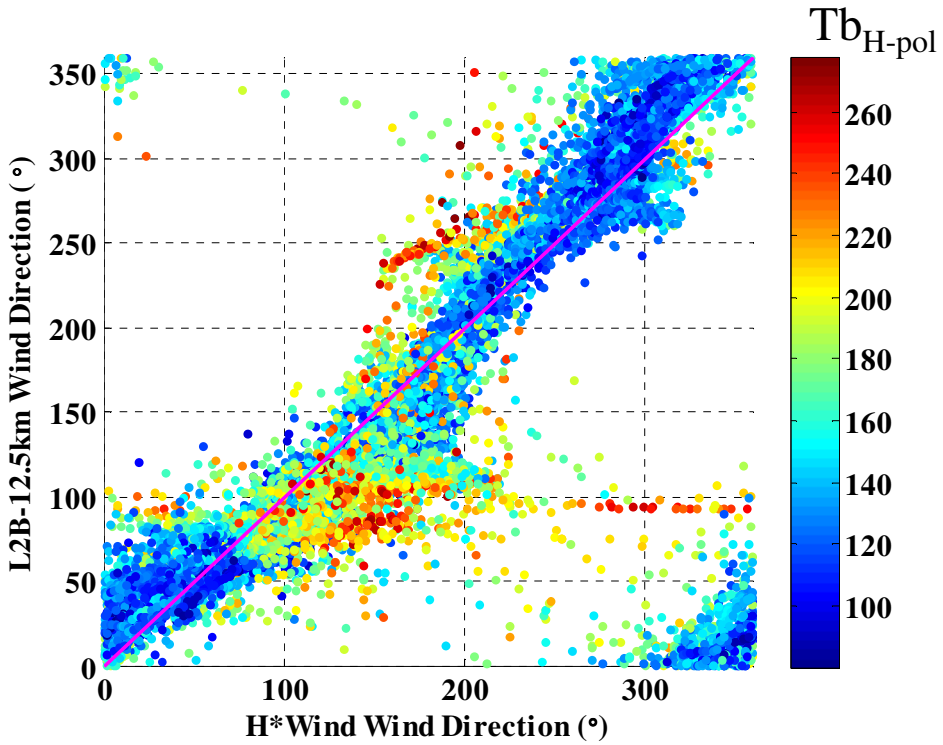


Wind Direction Comparison (10 revs)

X-Winds



QuikSCAT L2B-12.5km



Conclusion

- A new OVW retrieval algorithm has been developed for SeaWinds
  - Specifically tailored to to tropical and extra-tropical cyclones
  - Retrieves wind speeds that are approx 10 m/s higher than the standard L2B-12.5km OVW product
    - Performs better in comparison with H*Wind surface wind analyses
- A new L-3 SeaWinds TC OVW data set will be produced starting this summer 2011