Assessing the relationship between the large-scale and inner-core estimates of vertical shear

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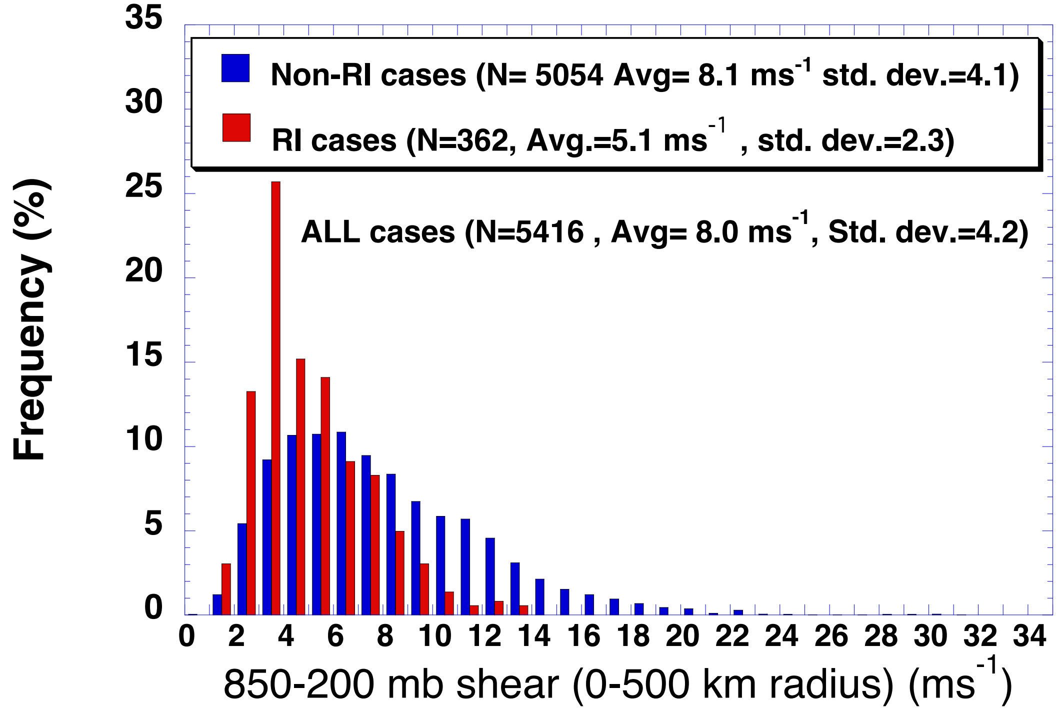
Background

- **Many previous observational (e.g., Reasor et al. 2000, Black et al. 2002, Corbosiero and Molinari (2002), Molinari and Vollaro (2010)) and modeling (e.g., Jones (1995), DeMaria 1996, Frank and Ritchie (2001), Riemer et al. (2010)) studies have examined the impact of vertical shear on tropical cyclone (TC) structure. However, few of these studies included a systematic evaluation of the relationship between the environmental and local inner-core vertical shear.**
- **In a more recent study by Reasor et al. (2013), the relationship between the local (5-80 km radius) 2-9 km and environmental (0-500 km radius) 850-200-mb shear were evaluated mostly by using the singular metric of the difference in the shear vectors computed between the above two areas and levels.**
- **Present study seeks to build upon Reasor et al. (2013) and perform a more comprehensive analysis of the relationship between the local and environmental shear by comparing the mean flow and vertical shear within both regions throughout the depth of the entire 850-200mb layer.**
- **Overarching study goals are to:**
  - **Improve our understanding of the relationship between the local and environmental vertical shear and their impact on TC intensity change.**
  - **Document the radial variation in mean flow and shear from scales ranging from environmental to local for use in comparisons with numerical models.**

Distribution of GFS-derived 850-200-mb (0-500 km) SHIPS-derived 24-h mean Atlantic basin vertical shear for RI and non-RI cases (1989-2012)

RI- Maximum wind increase $\geq$ 15.4 m/s in 24-h (Kaplan and DeMaria 2003)



Methodology

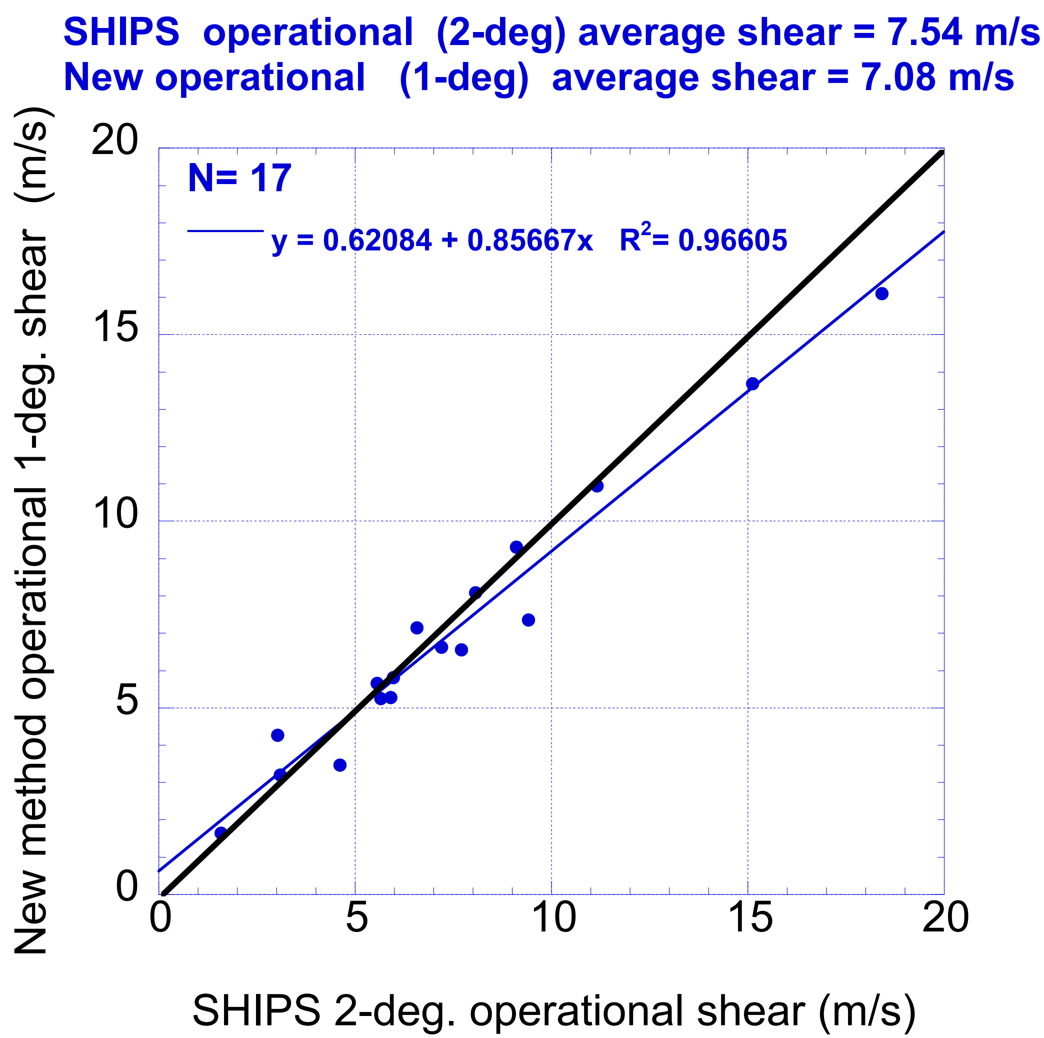
- **NOAA WP-3D Doppler-deduced horizontal (earth-relative) winds on cylindrical grid with 2-km radial and 5° azimuthal spacing from 2-9 km with 0.5 km vertical resolution were obtained from 5 km <radius < 80 km using methodology discussed in Reasor et al. (2013).**

- **Doppler winds were then area-averaged to compute local wind flow and vertical shear for 15 different tropical cyclones from 2003-2010 for 40 different time periods for systems with 23 ms^{-1} <Vmax <77 ms^{-1} .**
  - **Note: A minimum radial spacing of ≥ 20 km and maximum azimuthal gap ≤ 35° were required to compute area-averaged Doppler-winds.**

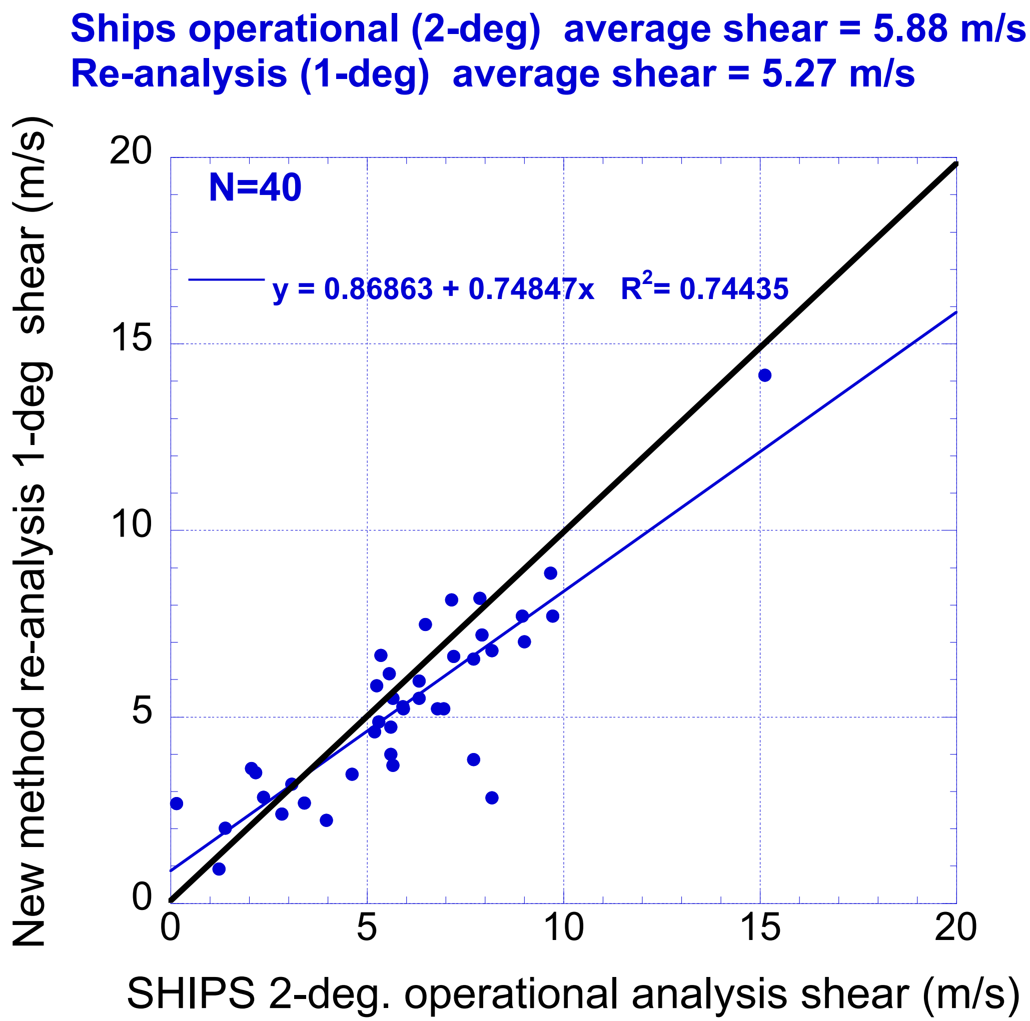
- **NCEP/GFS CFSR data at the mandatory levels sampled on 1°X1° Lat./Lon. grid were interpolated to a cylindrical grid with 50 km radial and 30° azimuthal spacing for the 6-h time period closest to the time of Doppler analysis.**

- **The mean vortex was then subtracted from the gridded winds following the methodology of Knaff et al. (2007) and the resultant winds were used to compute the NCEP/GFS area-averaged earth-relative flow and vertical shear within 500 km radius.**

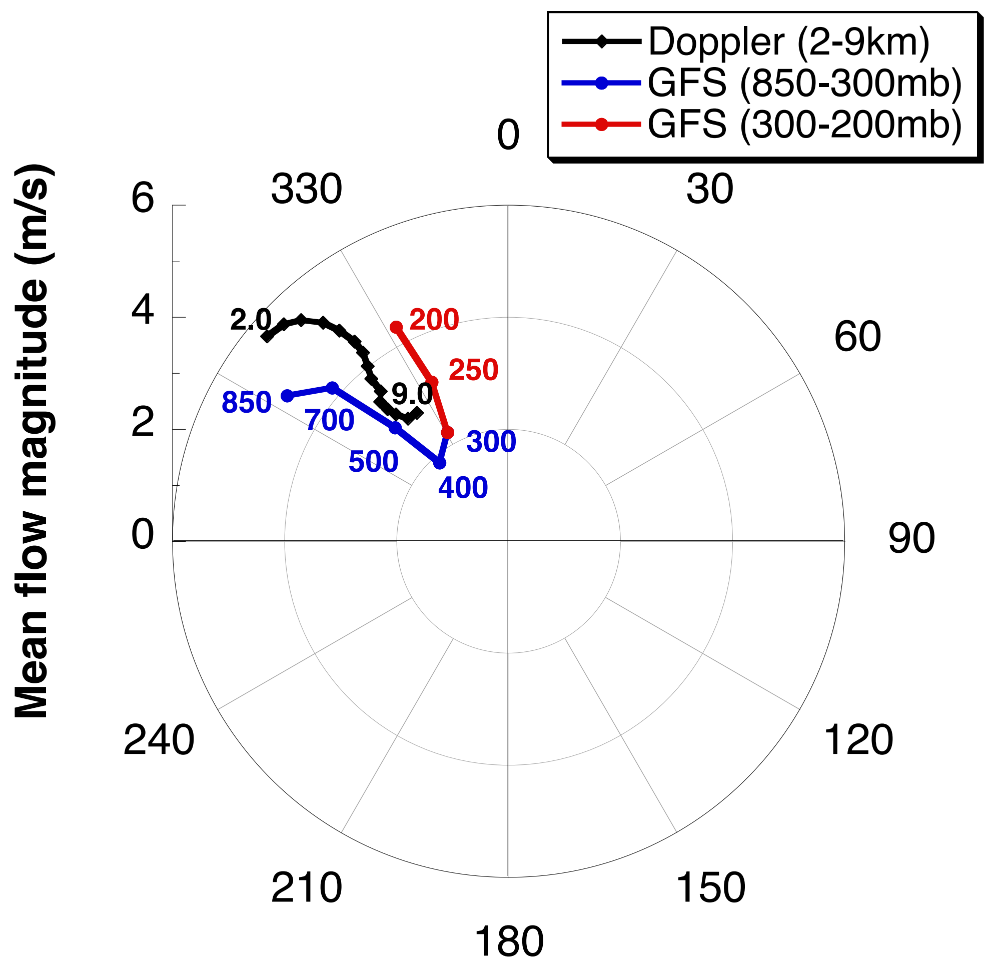
Comparison of 850-200 mb SHIPS-2-deg. vs. new method 1-deg NCEP/GFS operational analysis 0-500 km shear estimates



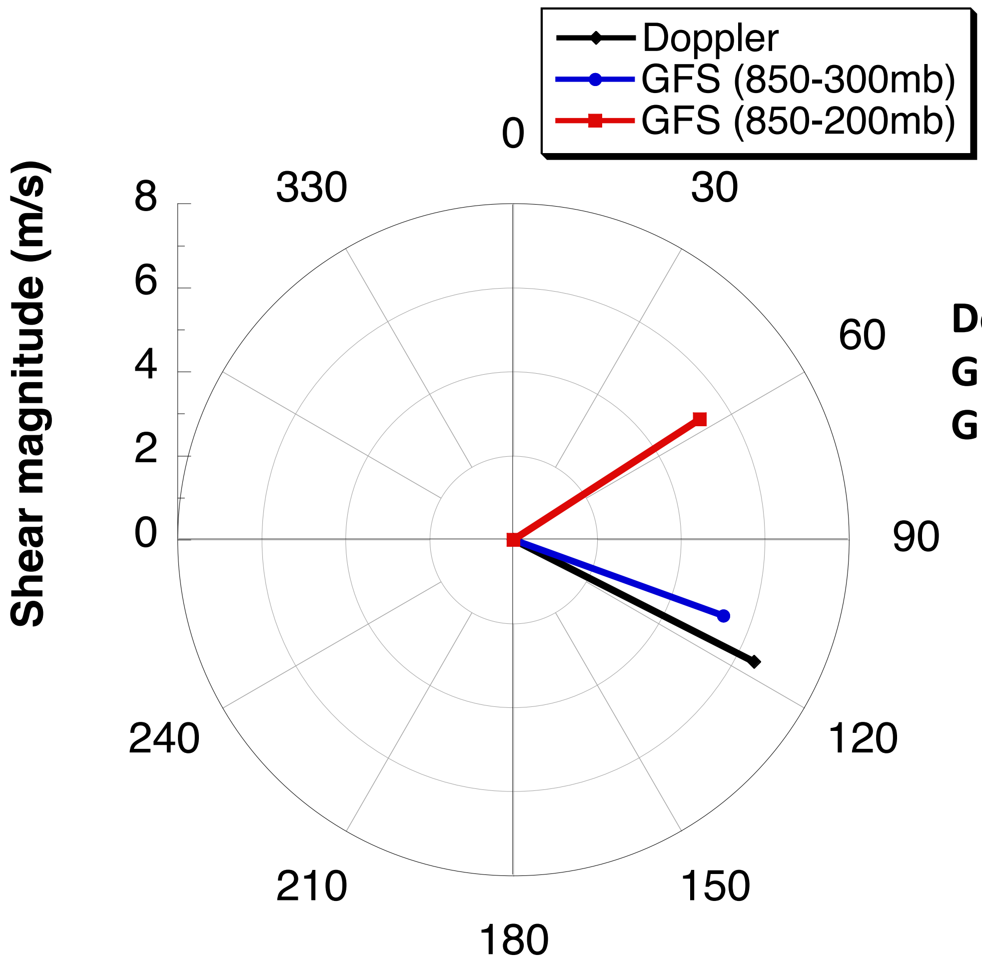
Comparison of SHIPS 2-deg. GFS operational vs. new NCEP/GFS-CFSR 1-deg 0-500-km radius shear estimates



Hodograph depicting sample averaged local (Doppler) and environmental (GFS) 0-500-km radius earth-relative flow (N=40)



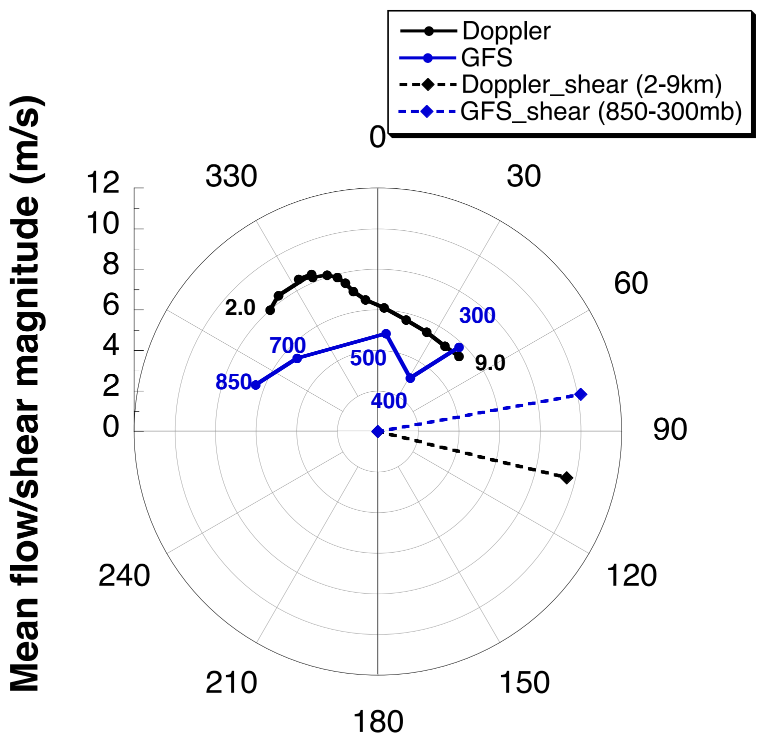
Sample-averaged local (Doppler) and environmental (GFS) 0-500 km shear (N=40)



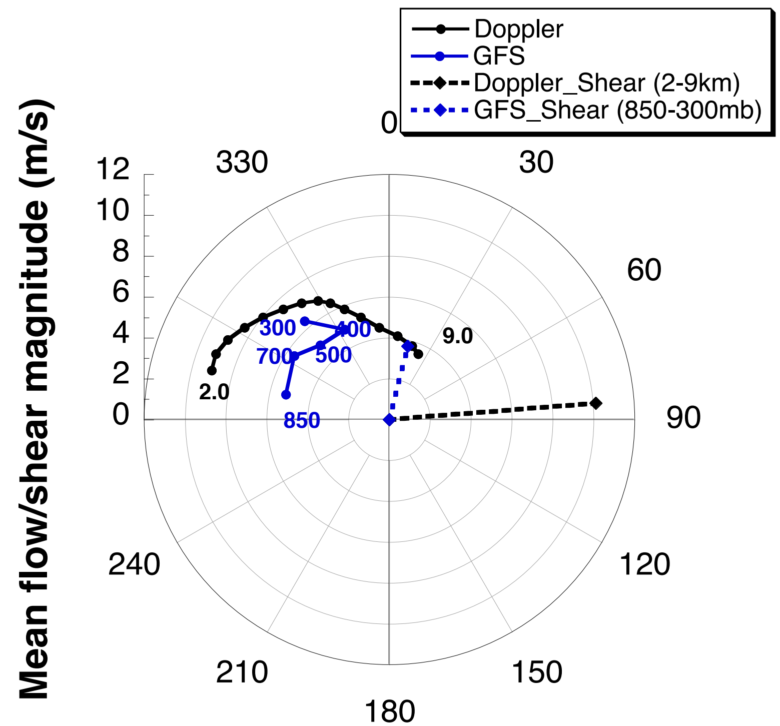
Doppler : Shear=6.4 m/s, θ =116°
GFS(850-200mb): Shear=5.3 m/s, θ=57°
GFS(850-300mb): Shear=5.3 m/s, θ=110°

Hodographs depicting local (Doppler) vs. environmental (GFS) 0-500-km radius earth-relative flow and 850-300 mb vertical shear

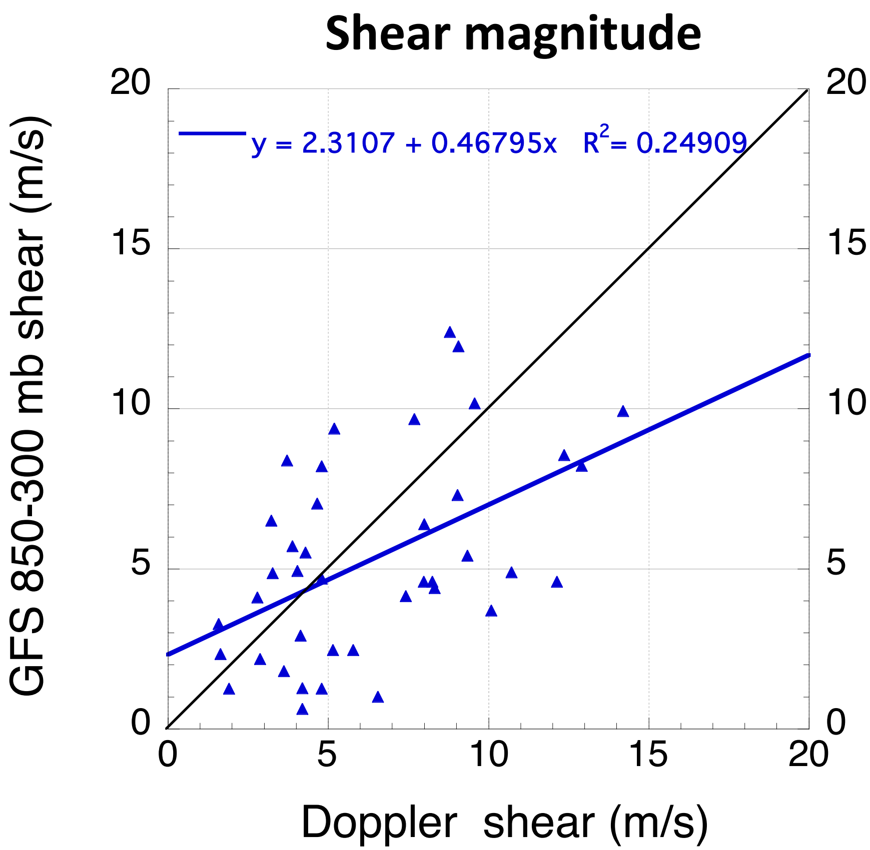
Ivan: 040915 00 UTC
Vmax = 56.5 m/s

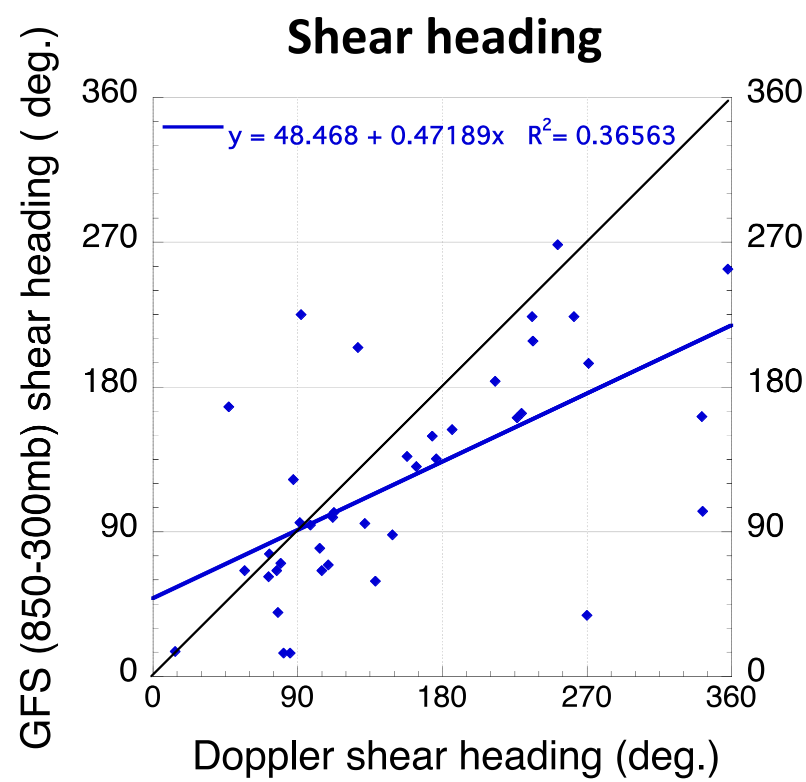


Ivan: 040909 18 UTC
Vmax= 66.8 m/s

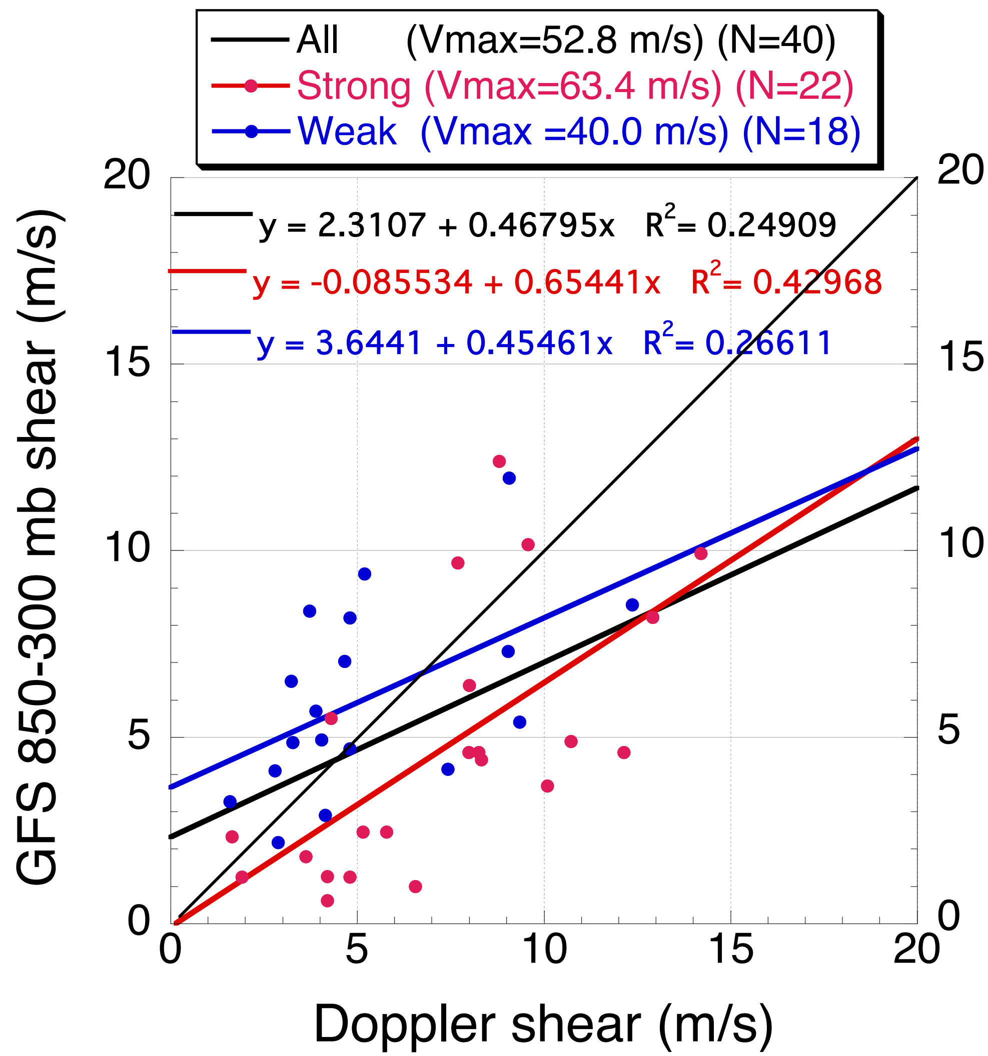


Comparison of local (Doppler) vs. environmental (GFS) 850-300-shear magnitude and heading from 0-500-km radius of all cases in study sample (N=40)

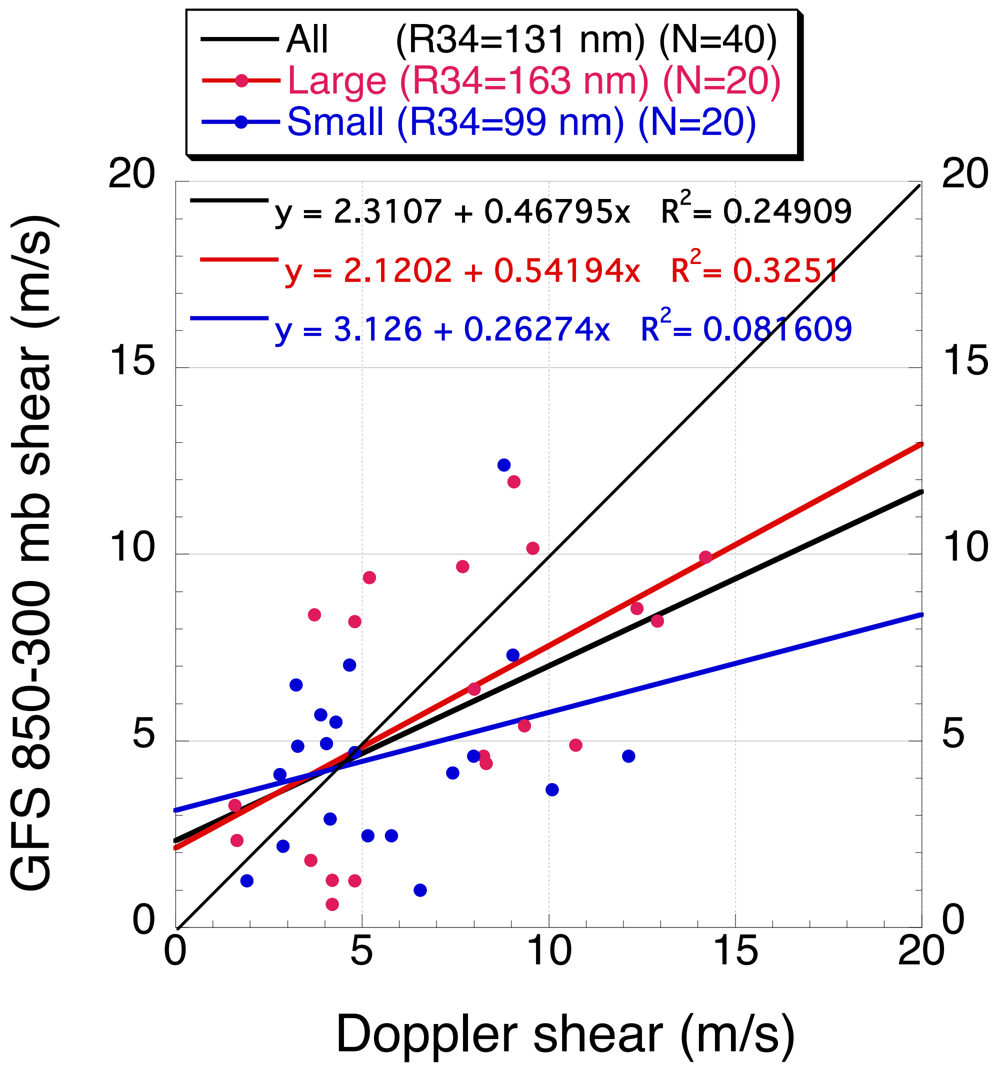




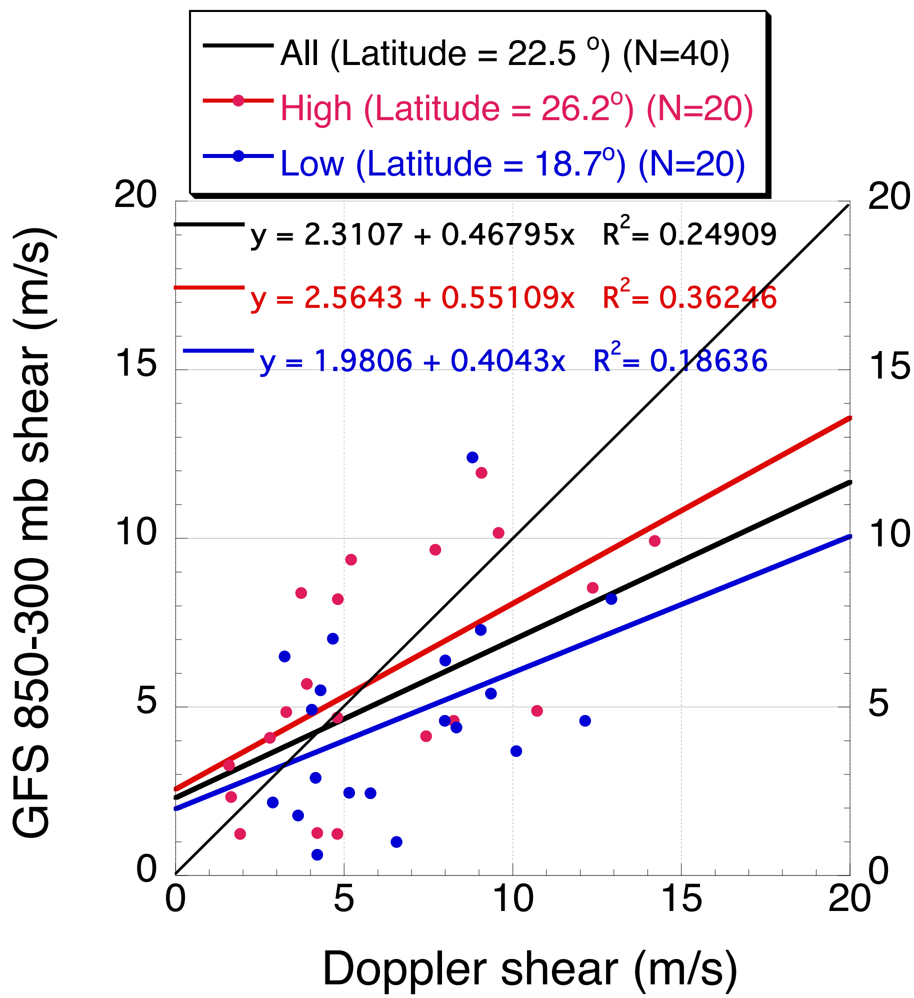
Comparison of local (Doppler) vs. environmental (GFS) 0-500-km radius shear stratified by maximum wind (Vmax)



Comparison of local (Doppler) vs. environmental (GFS) 0-500-km radius shear stratified by mean radius of 34-kt wind (R34)



Comparison of local (Doppler) vs. environmental (GFS) 0-500-km radius shear stratified by storm latitude



Summary

- Doppler-deduced local shear was compared to NCEP/GFS-CFSR deduced environmental shear for a total of 40 cases.
- Results of comparisons showed that sample mean local (Doppler-deduced) flow and vertical shear between (2-9 km) were in fairly good agreement with the corresponding environmental GFS estimates from 850-300 mb although Doppler shear had larger magnitude and was to right of GFS shear vector.
- Agreement between local and environmental flow/vertical shear on an individual case by case basis was not nearly as good, however, and exhibited considerable scatter.
- An increase in the existing sample mean bias between the local and environmental shear was found for stronger storms perhaps reflecting a higher likelihood for such systems to produce increased local shear due to larger convectively-induced asymmetries.
- Larger and higher latitude systems showed a reduction in the overall sample-mean bias between the local and environmental shear perhaps suggesting an enhanced resiliency to shear for such systems.

Future work

- Extend Doppler wind analyses out to ~120 km (whenever possible) to help better understand/document the degree to which environmental vertical shear is modified by storm vortex.
- Increase study sample size.
- Explore additional methods for compositing Doppler and GFS results.
- Employ more sophisticated metrics to evaluate vortex resiliency to shear

Questions/Suggestions?