Relationship Between Core Convective Structure and Intensity Change in Tropical Cyclones

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DATA SOURCES

Cloud-to-ground lightning from the National Lightning Detection Network

Storm intensity and motion from TPC best-track data

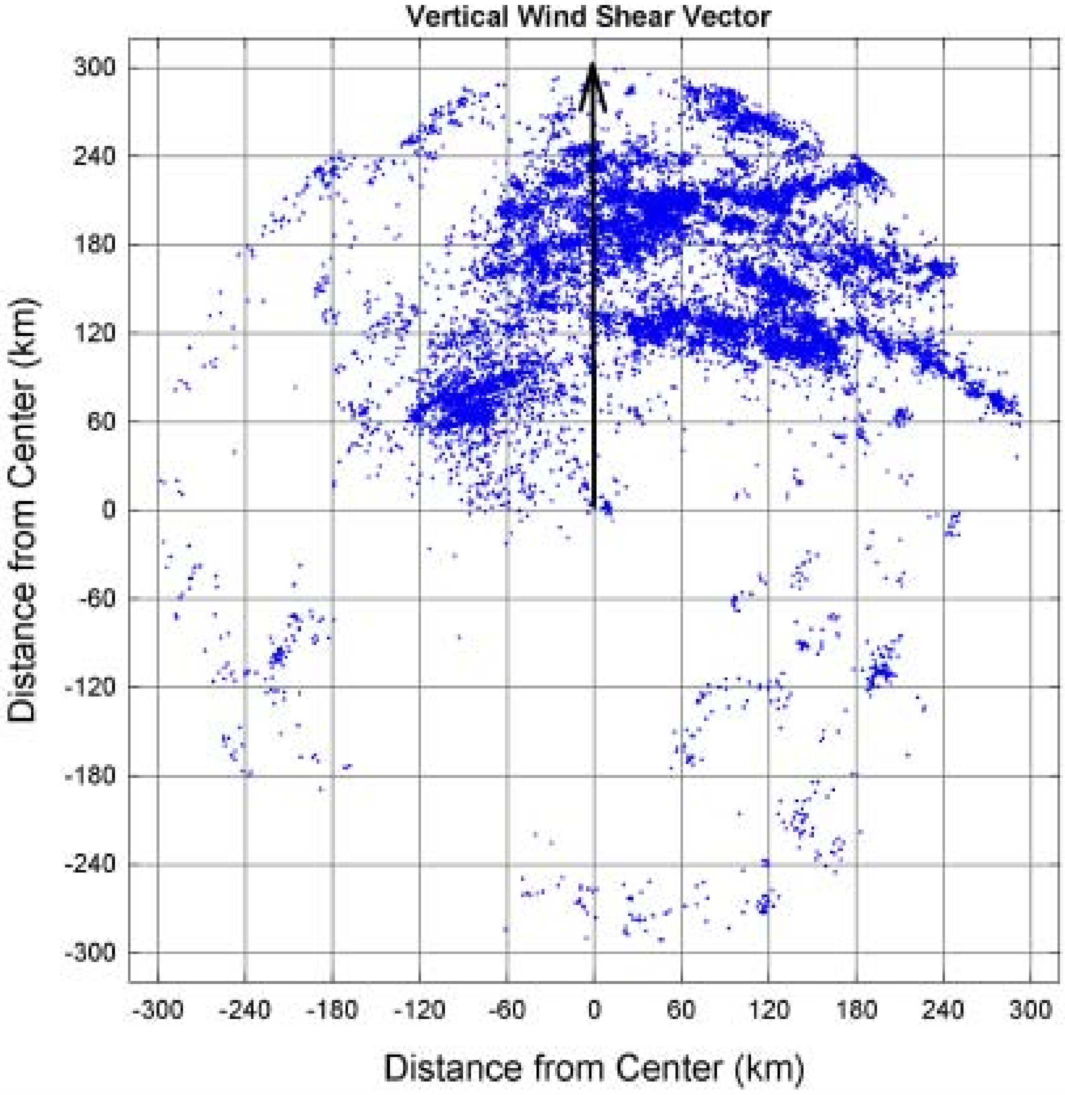
Vertical wind shear from ECMWF gridded analyses

Lightning grouped into 12-hour periods centered on

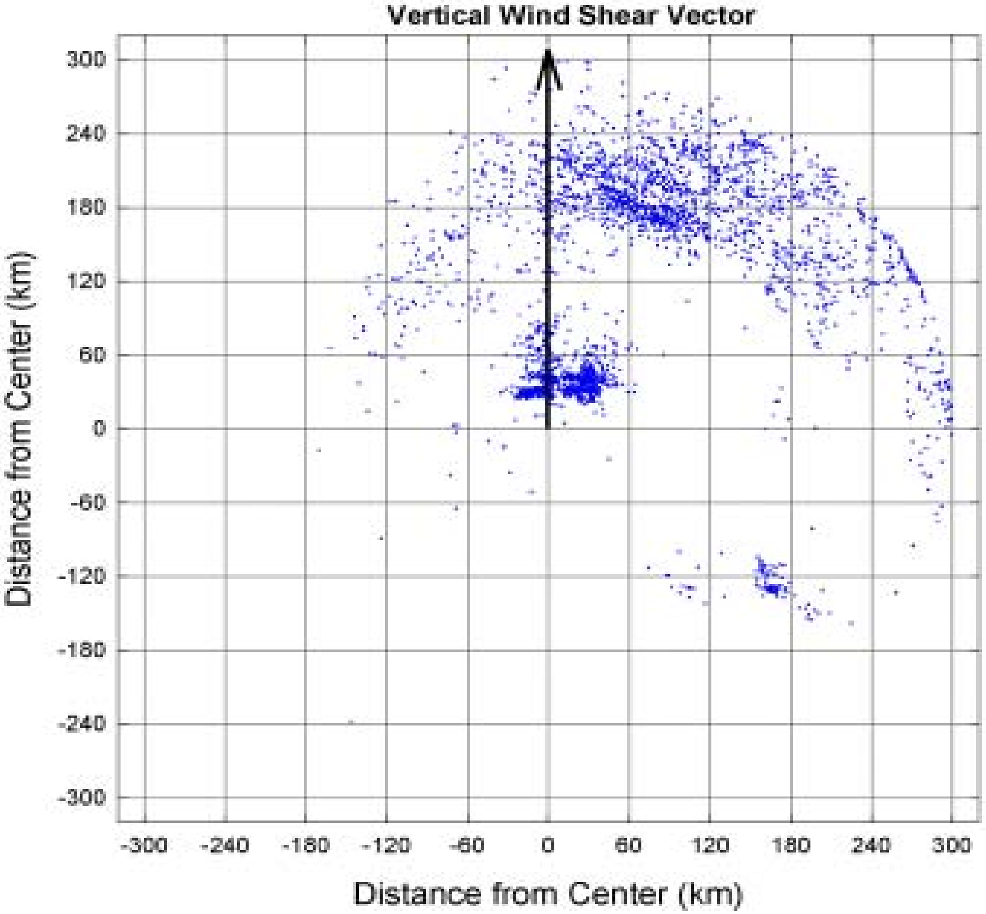
0000 and 1200 UTC

Only 12-hour periods meeting minimum flash criteria are kept

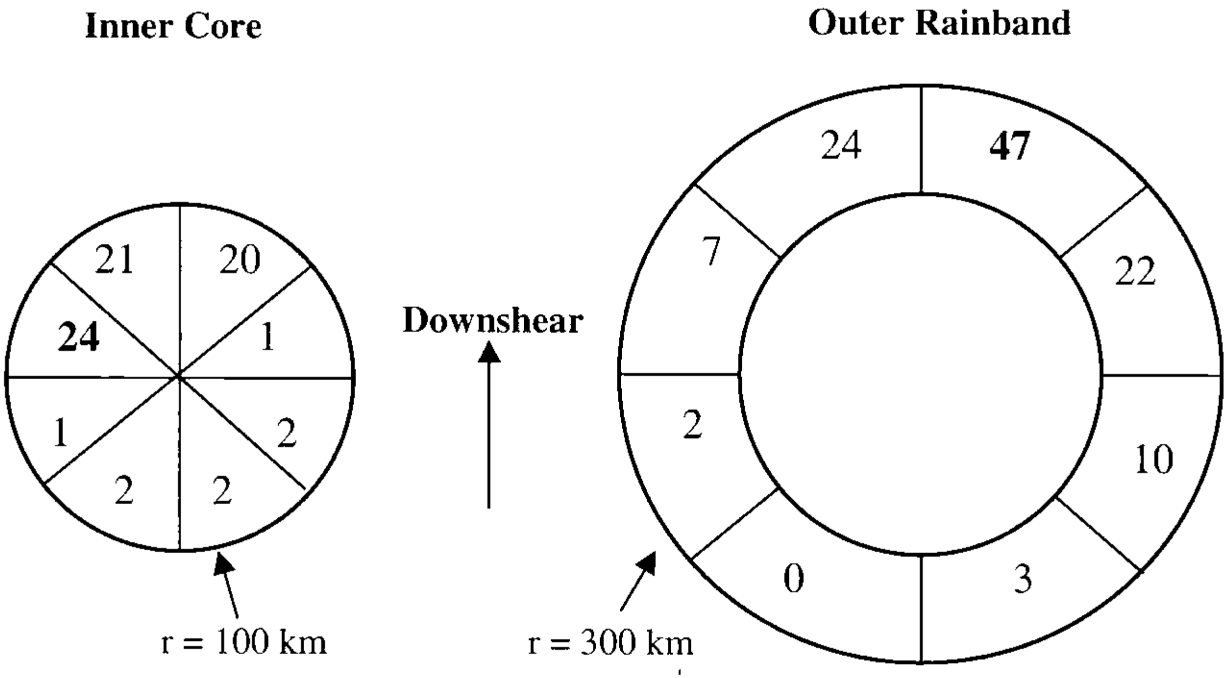
All flashes are rotated with respect to either the wind shear or storm motion vectors



Composite of lightning in TS/TD Alberto (1997)



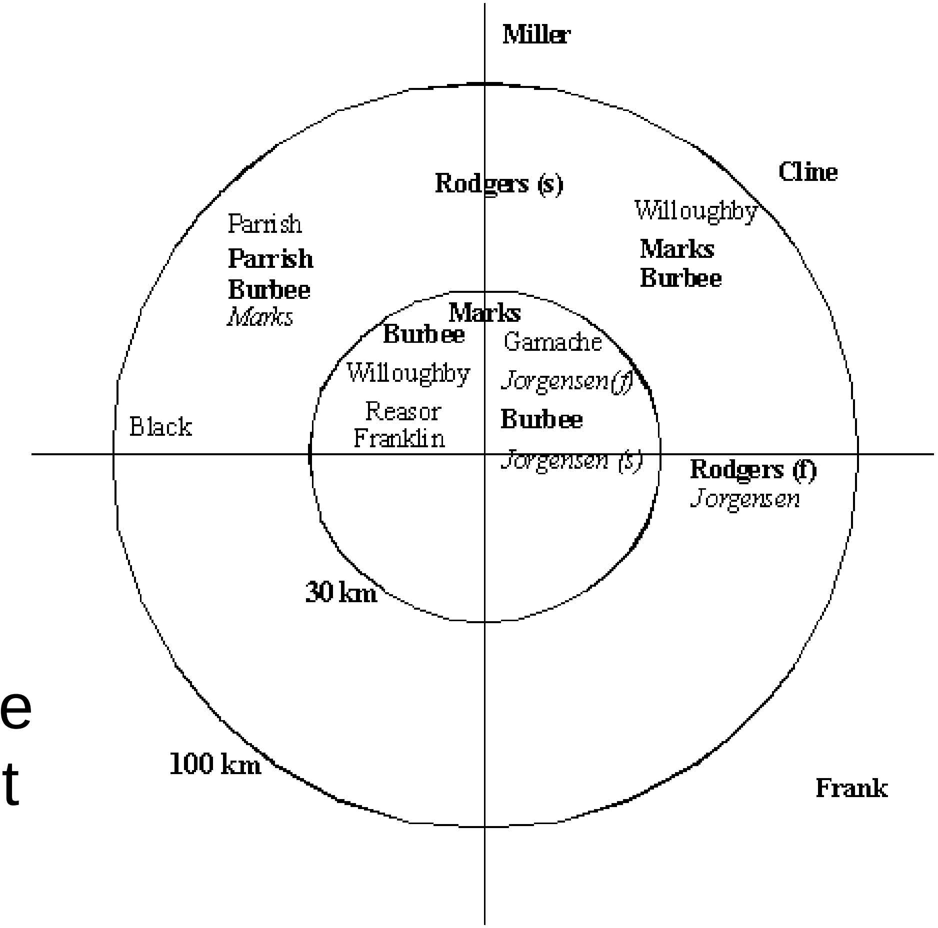
Composite lightning in Hurricane Bertha (1996)



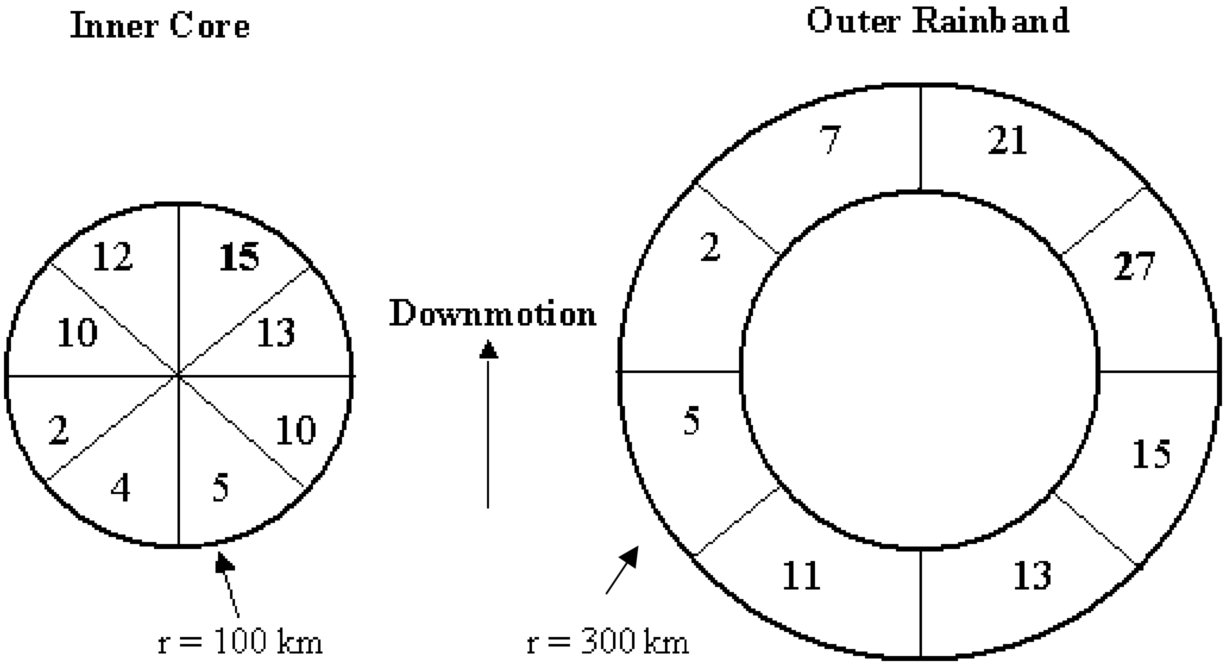
Distribution with respect to the vertical wind shear vector of the occurrences of maximum lightning by octant.

MOTION

↑



Observed convective maxima with respect to storm motion in tropical cyclones



Distribution with respect to the storm motion vector of the occurrences of maximum lightning by octant.

SUMMARY OF HURRICANE MOTION EFFECTS:

Maximum convection in the inner core lies in the front quadrant.

Maximum convection outside the 100 km radius lies to the right of motion.

Both results match previous studies using vertical motion, reflectivity, and precipitation.

Are motion and shear both important, or does their systematic relationship create an artifact?

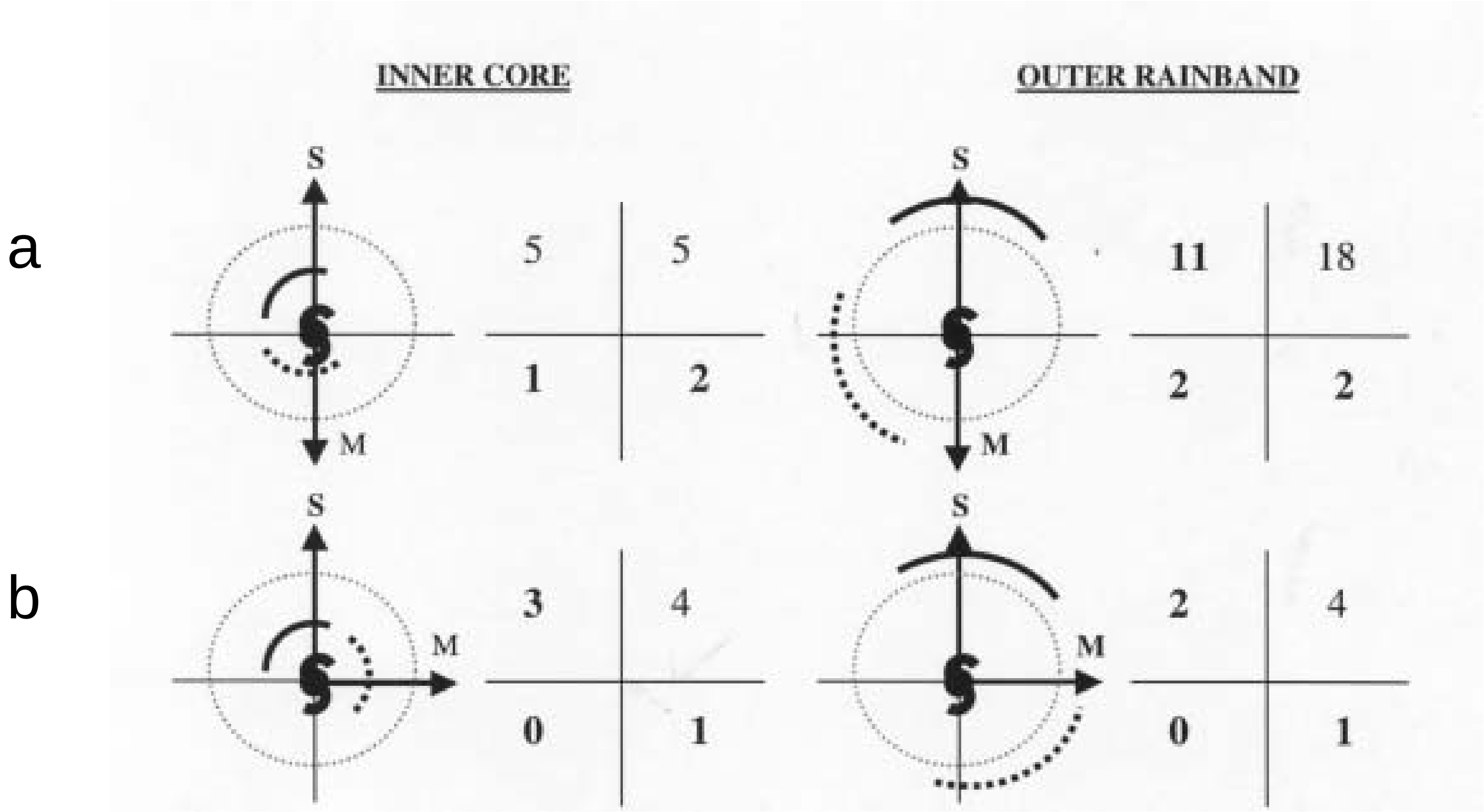
To address this, choose circumstances in which shear and motion vectors put the convective maxima in differing quadrants.

Possible outcomes

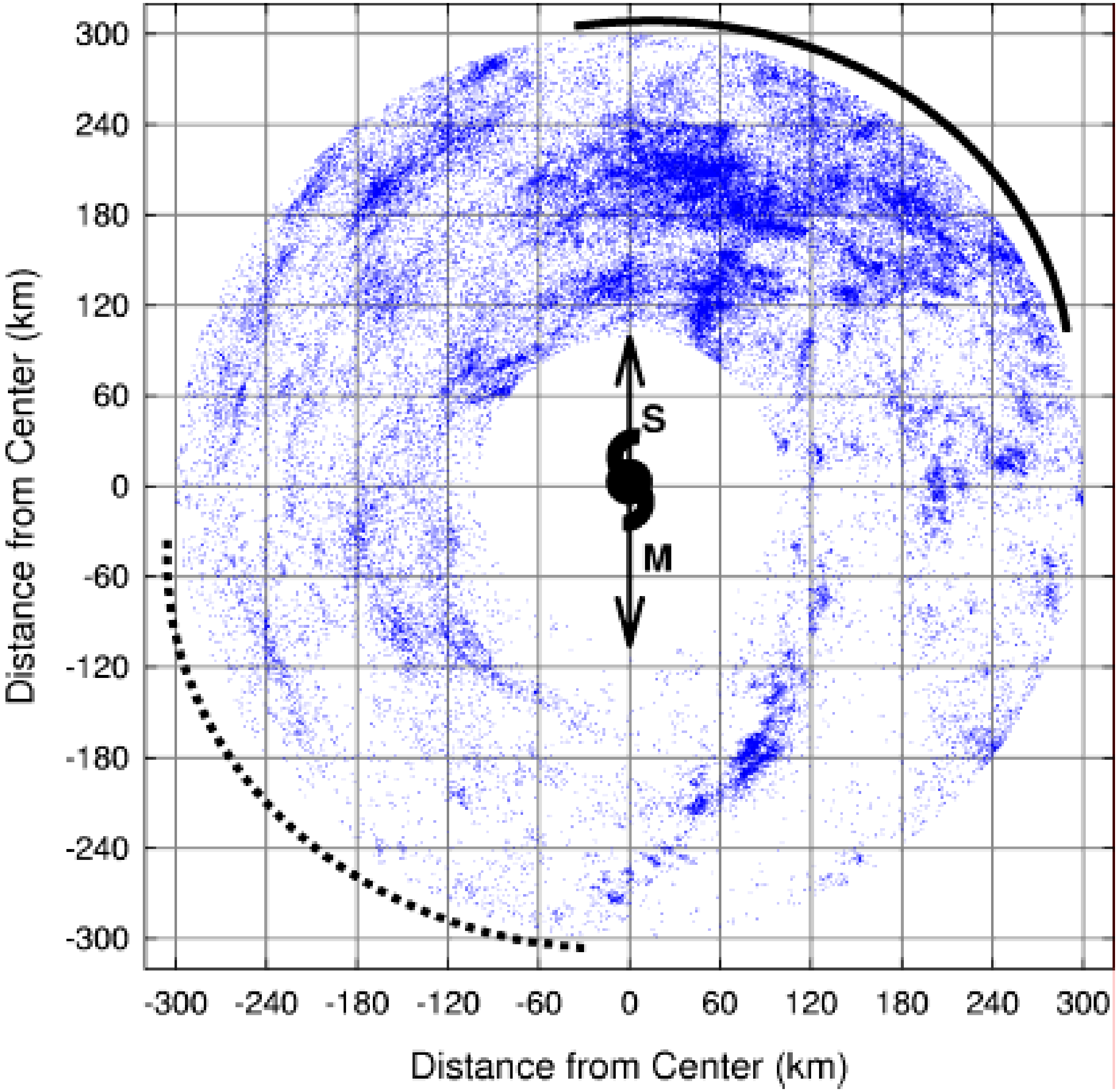
Dual maxima in lightning, showing that both shear and motion are important

Single maximum, showing that one effect dominates the other.

Latter case: one signature would be an artifact



Lightning distribution for shear and motion opposite (a) and motion 90º right of shear (b).



Distribution of ground flashes (r > 100 km) composited for all 12-hour periods with shear and motion vectors 180º ± 45º.

SUMMARY

Lightning distribution shows the same influence of storm motion on convective asymmetries as seen in previous studies

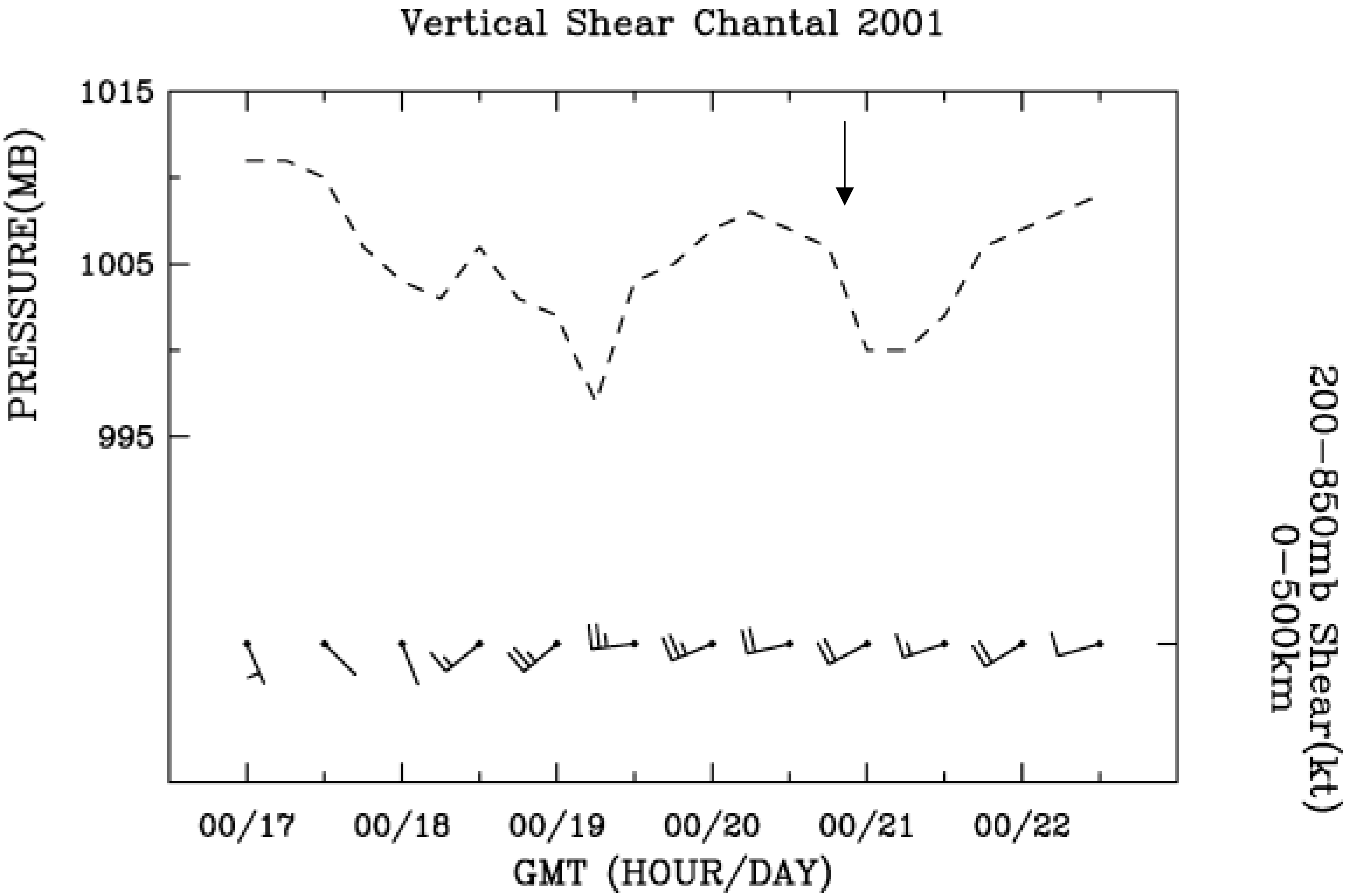
But further breakdown into various shear/motion regimes shows that the motion influence is largely an artifact of a much stronger vertical wind shear influence.

Motion influence (asymmetric friction) is real (see Shapiro 1983), but free-atmosphere subsidence from shear stabilizes the column and restricts the upward motion from asymmetric friction to the top of the boundary layer.

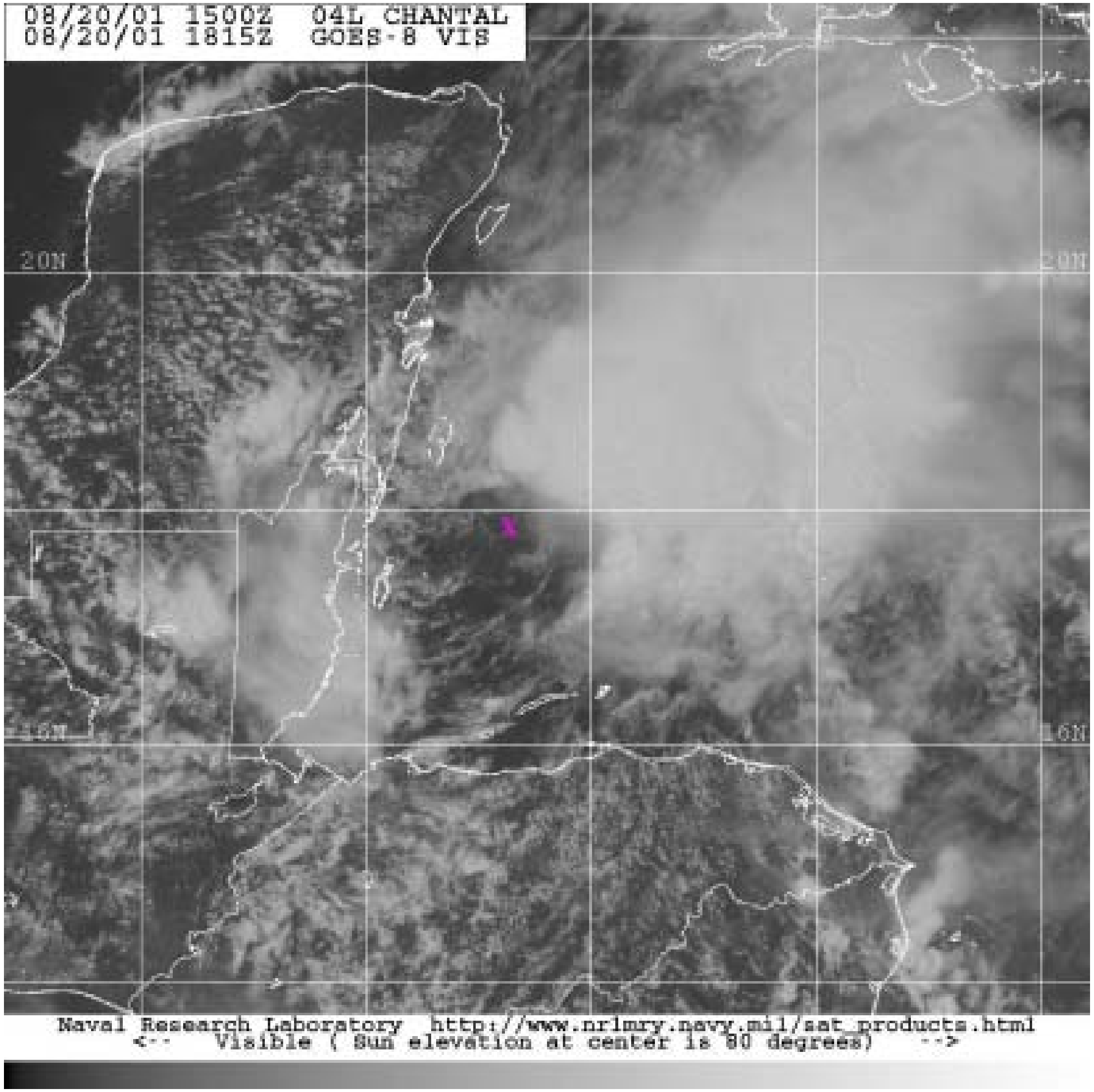
Idealized numerical studies should choose vertical shear/motion relationships like those in nature. Most commonly used idealized angles between motion and shear in models (0º and 180º) are rare in nature.

PRIMARY SCIENTIFIC QUESTIONS

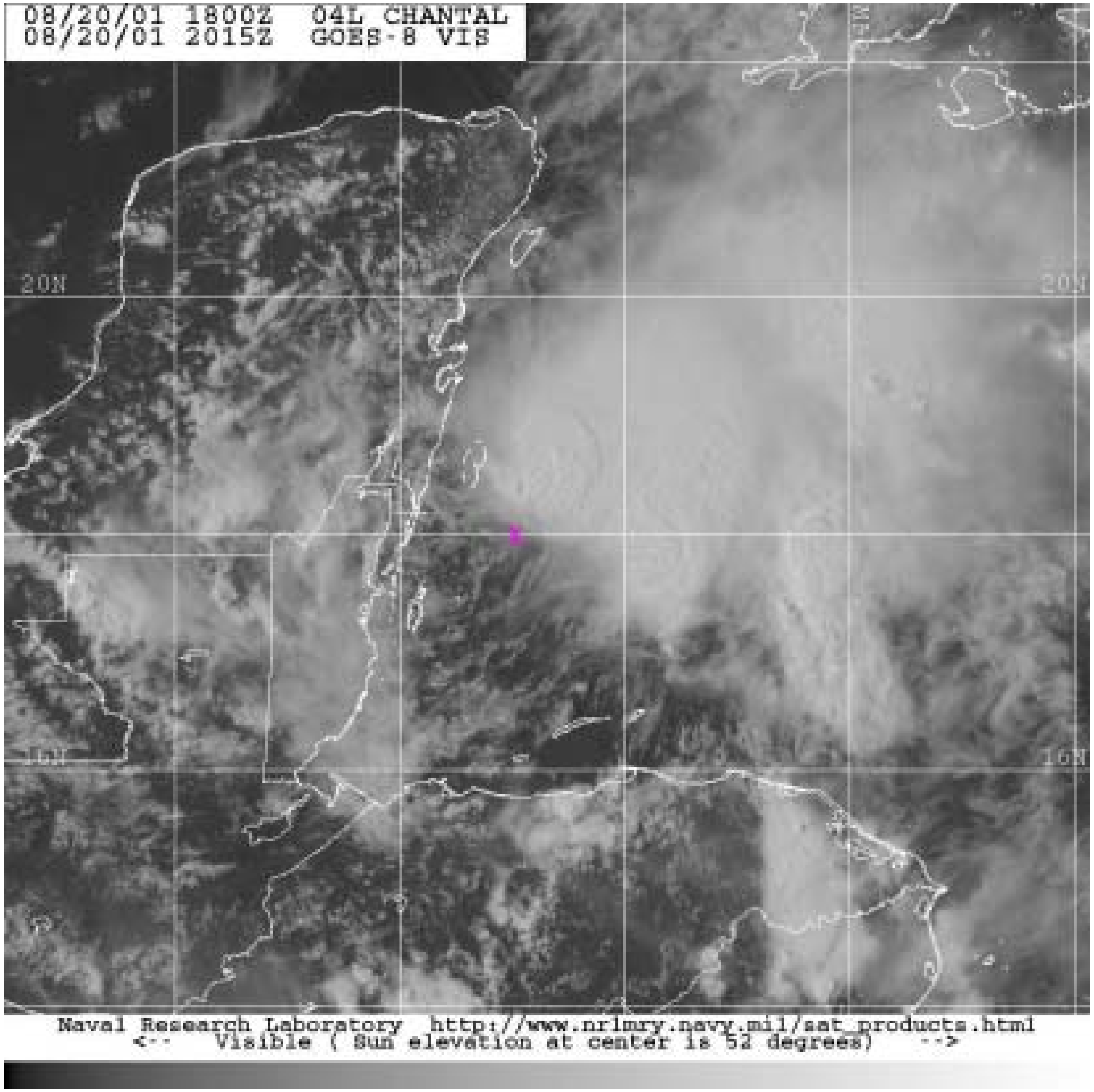
- Dynamics of vertically sheared tropical cyclones
- Mechanisms of intensification of tropical cyclones, especially asymmetric storms
- Structure of hurricane “supercells” and their influence on intensity change.



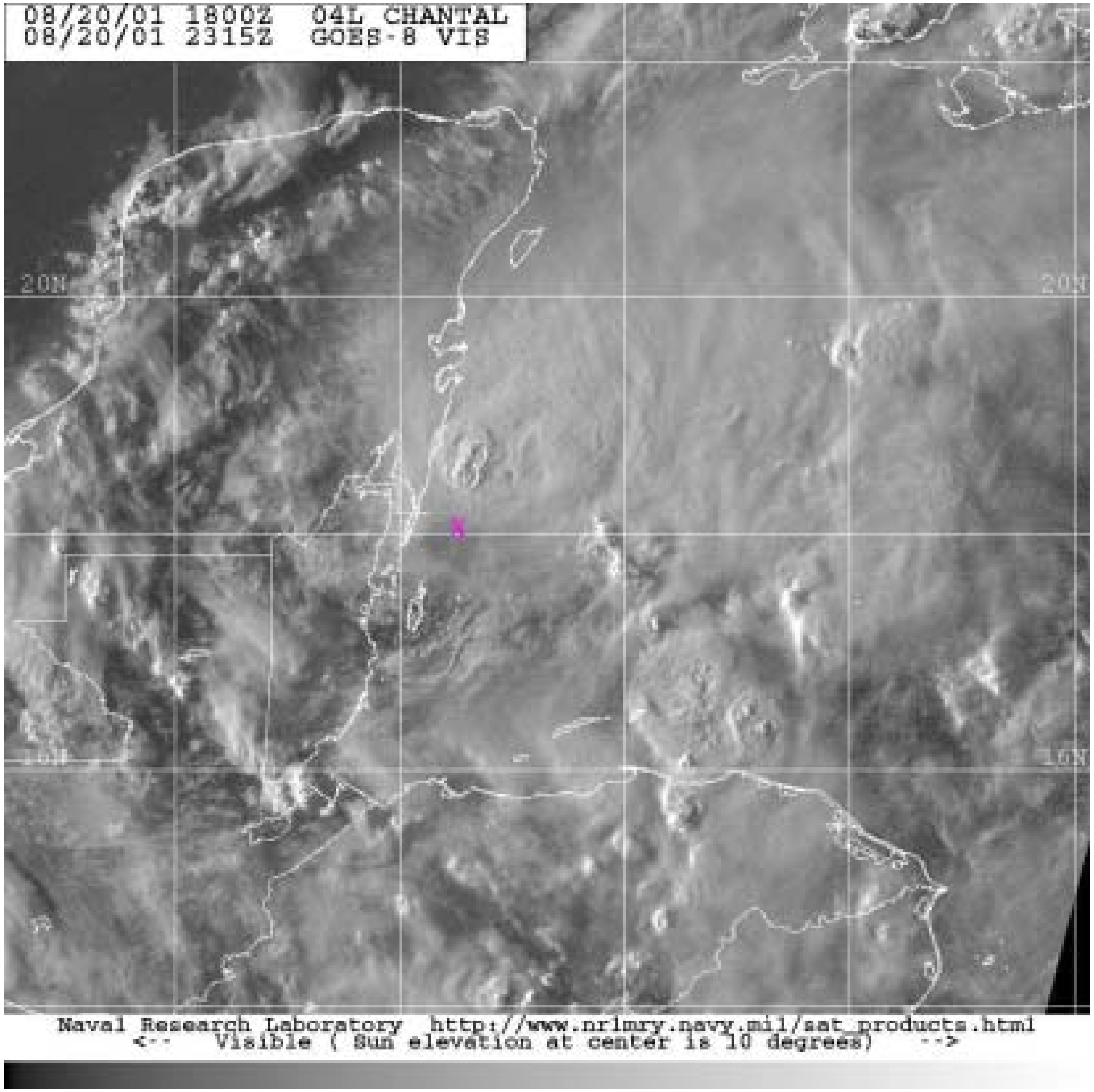
Central pressure (dashed) and 850-200 mb wind shear vector (long barb = 5 ms^{-1}). Arrow indicates approximate flight time.



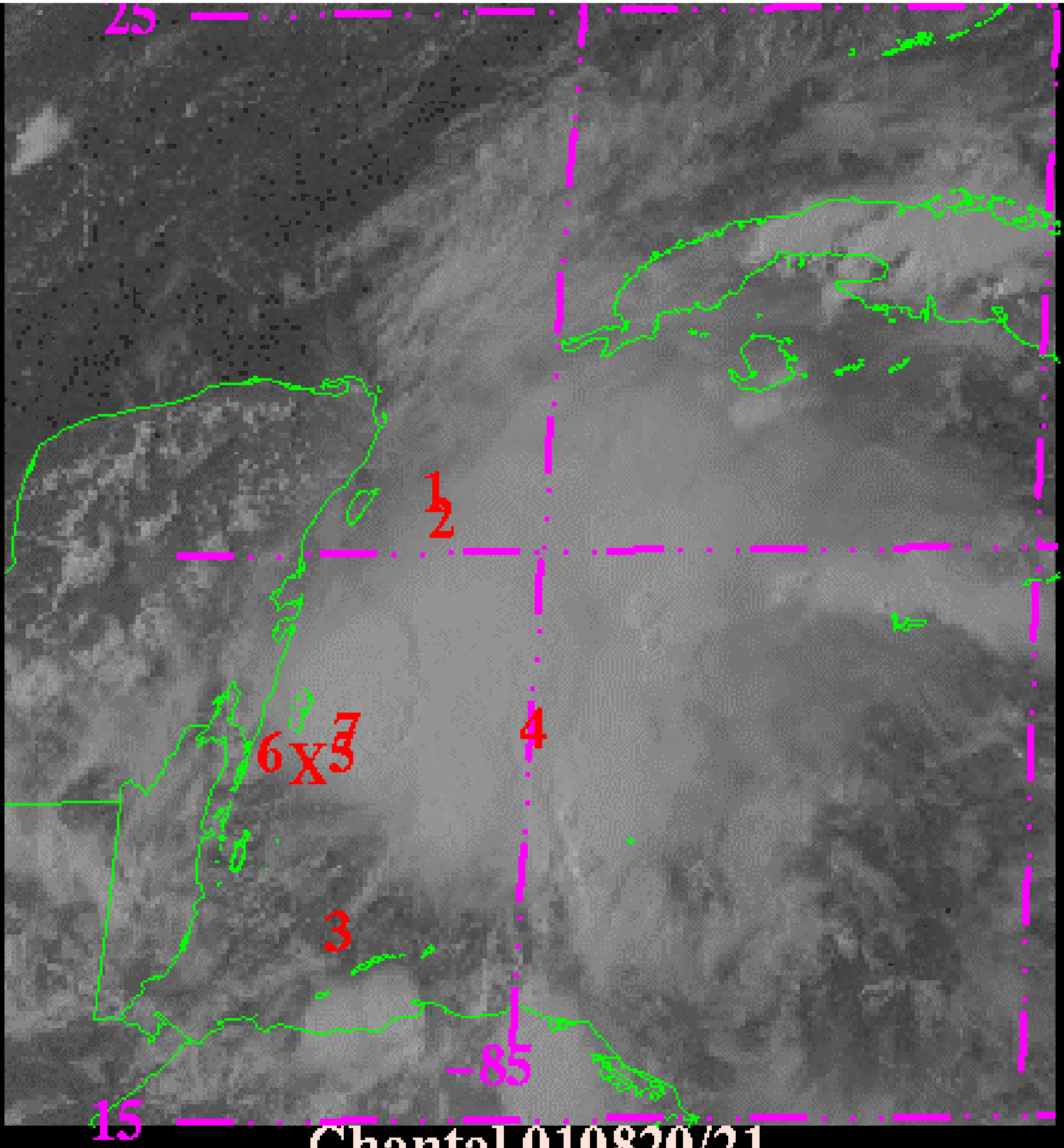
Visible image of Chantal at 1815 UTC 20 August 2001. X shows the interpolated best-track center.



Visible image of Chantal at 2015 UTC 20 August 2001. X shows the interpolated best-track center.



Visible image of Chantal at 2315 UTC 20 August 2001. X shows the interpolated best-track center.



Chantal 010820/21

SUMMARY

Chantal: bulk Richardson number suggests hurricane supercells resemble those from higher latitudes.

Location of supercells: downshear left quadrant

Chantal, Gabrielle, and Humberto provide excellent case studies of the dynamics of sheared tropical cyclones.