The Relationship between Storm Motion, Vertical Wind Shear and Convective Asymmetries in Tropical Cyclones

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* Talk was recreated from original transparencies

Previous Work

- Lightning flashes from the National Lightning Detection Network (NLDN) in 35 Atlantic basin tropical storms from 1985-1999

- Quantify the asymmetric lightning signatures in tropical cyclones associated with vertical wind shear and storm motion

- Is the vertical shear or storm motion signature dominant?

- What is the relationship between vertical wind shear and storm motion?

Data and Methodology

- Separate inner 100 km (eyewall and inner rainbands) and 100-300 km ring (outer rainbands) regions

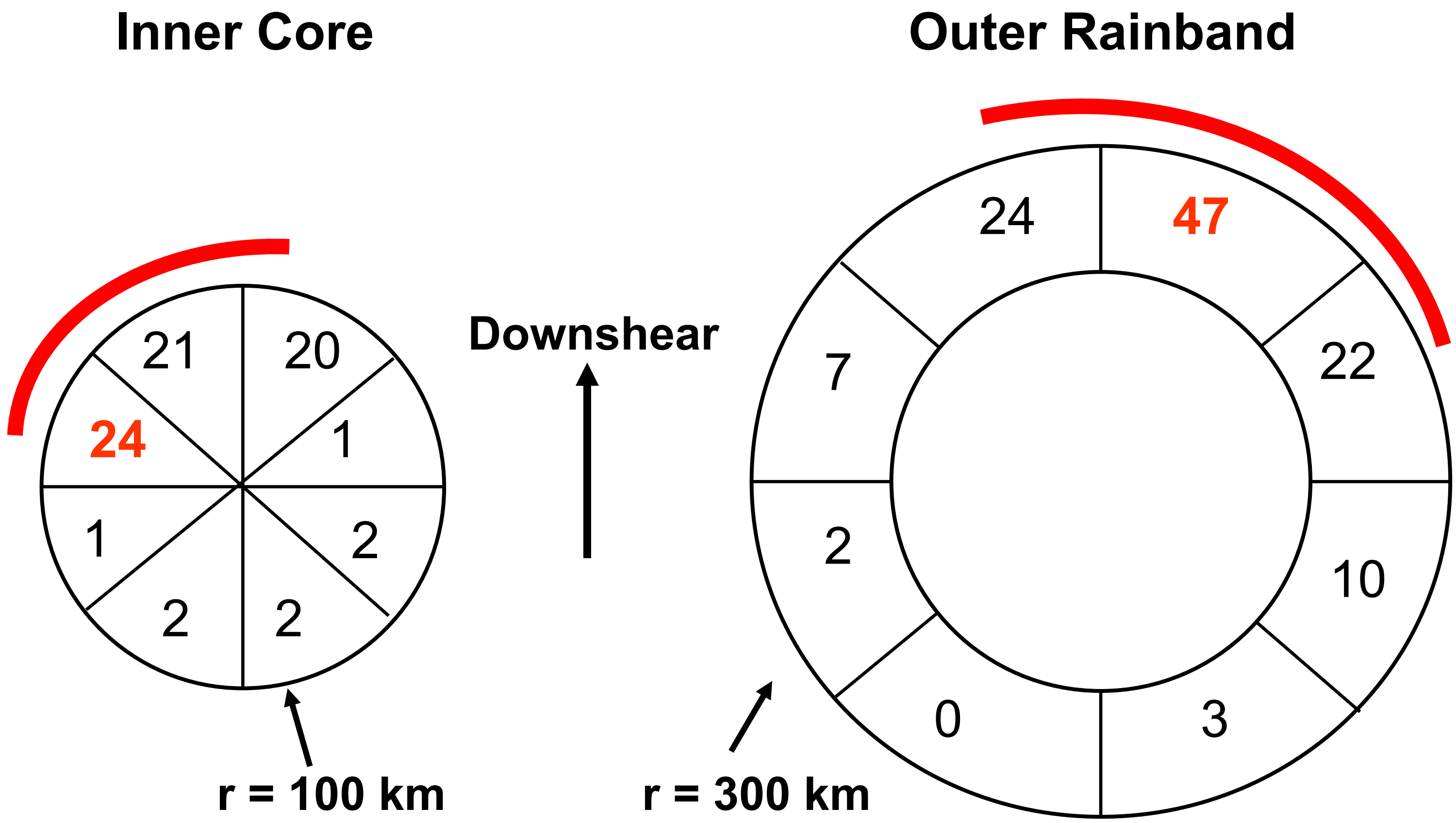
- Flashes occurring in the 12 hour period centered on 00 and 12 UTC were plotted with respect to the storm center

- Minimum flash counts per 12 hour period were imposed to restrict the number of periods examined

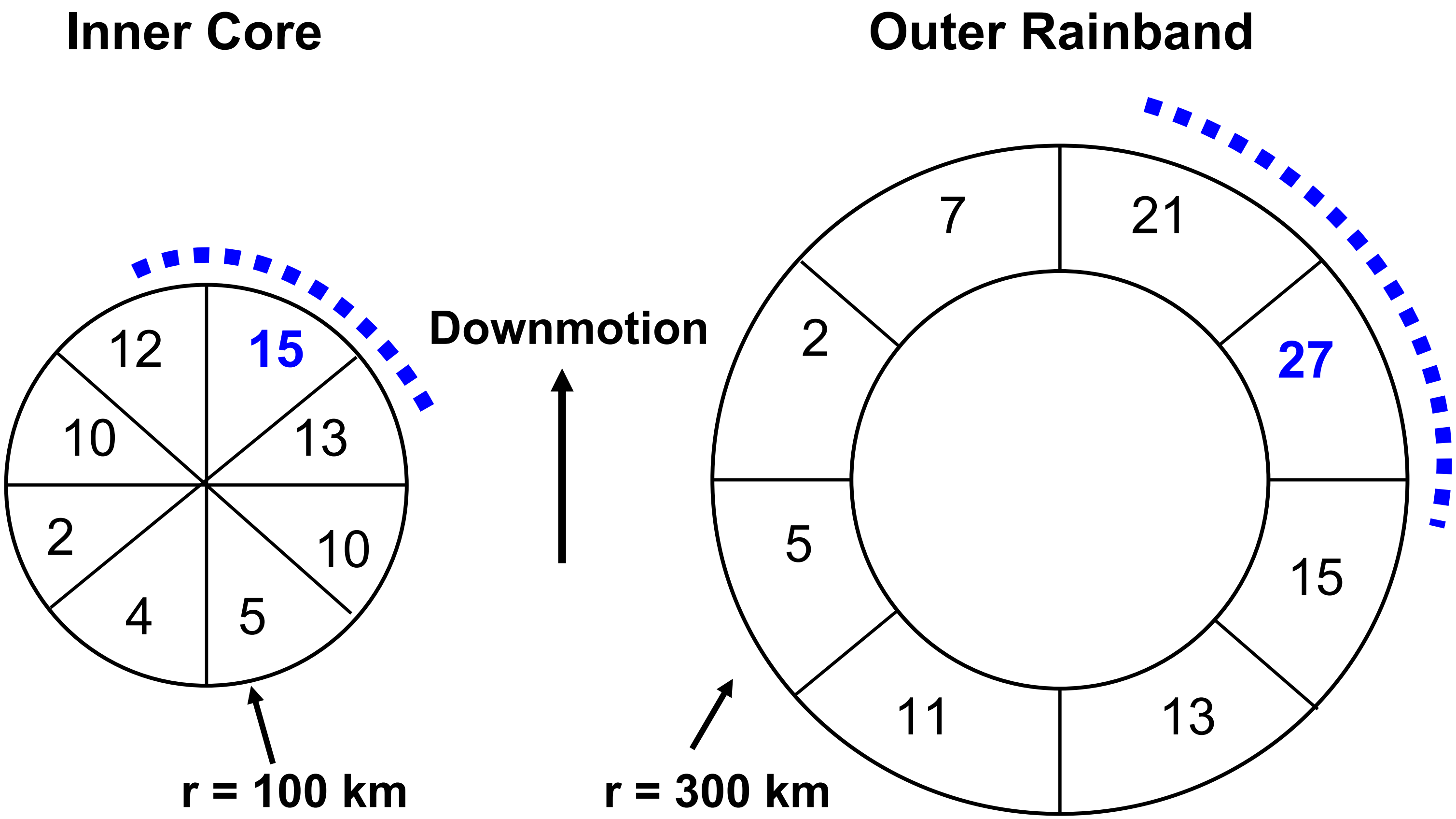
- Each flash was rotated around the storm center through an angle equal to that required to align the shear/motion vector for that 12 hour period with due north

- Determine which quadrant or octant had the highest flash count

Vertical Wind Shear Signal

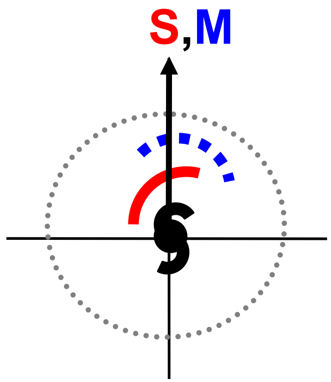


Storm Motion Signal

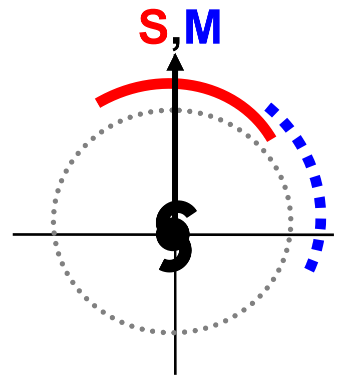


Inner Core

Outer Band



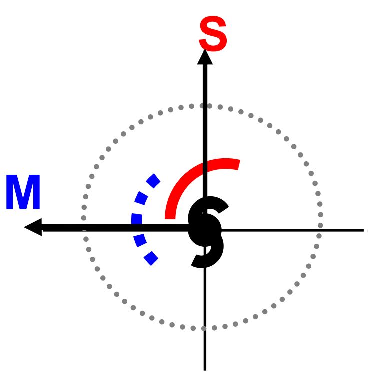
19	14
3	1



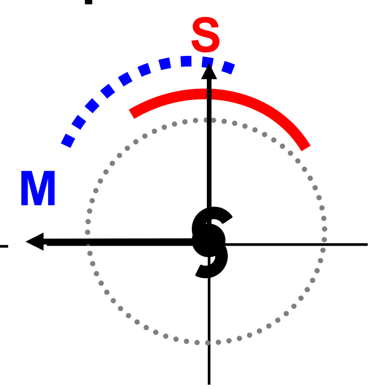
13	**30**
3	**6**

0° Angle Separation

90° Angle Separation

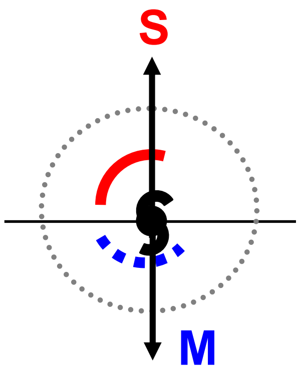


25	**16**
3	4



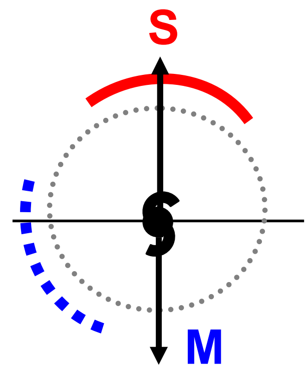
20	**32**
3	7

Inner Core



5	5
1	2

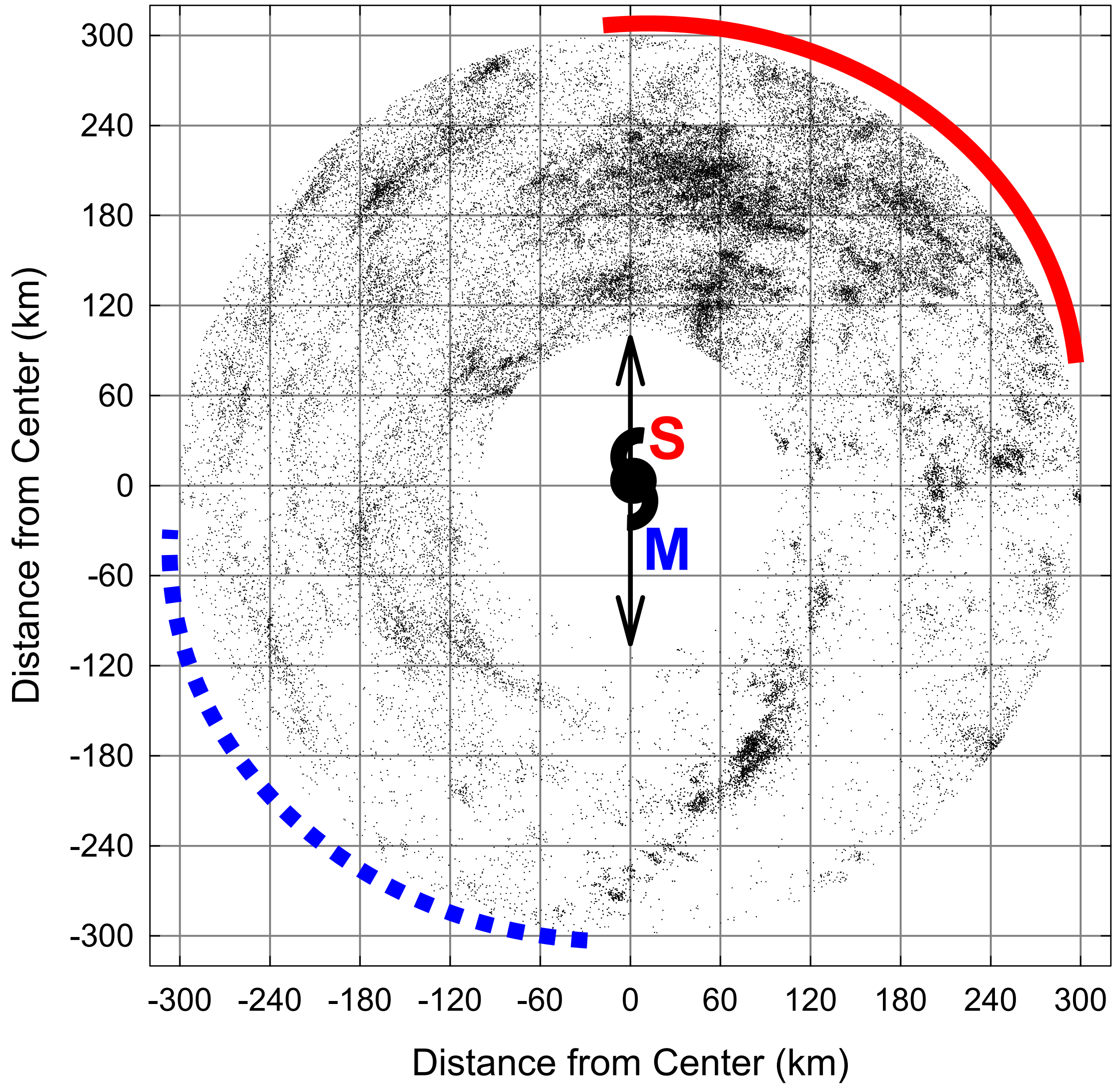
Outer Band



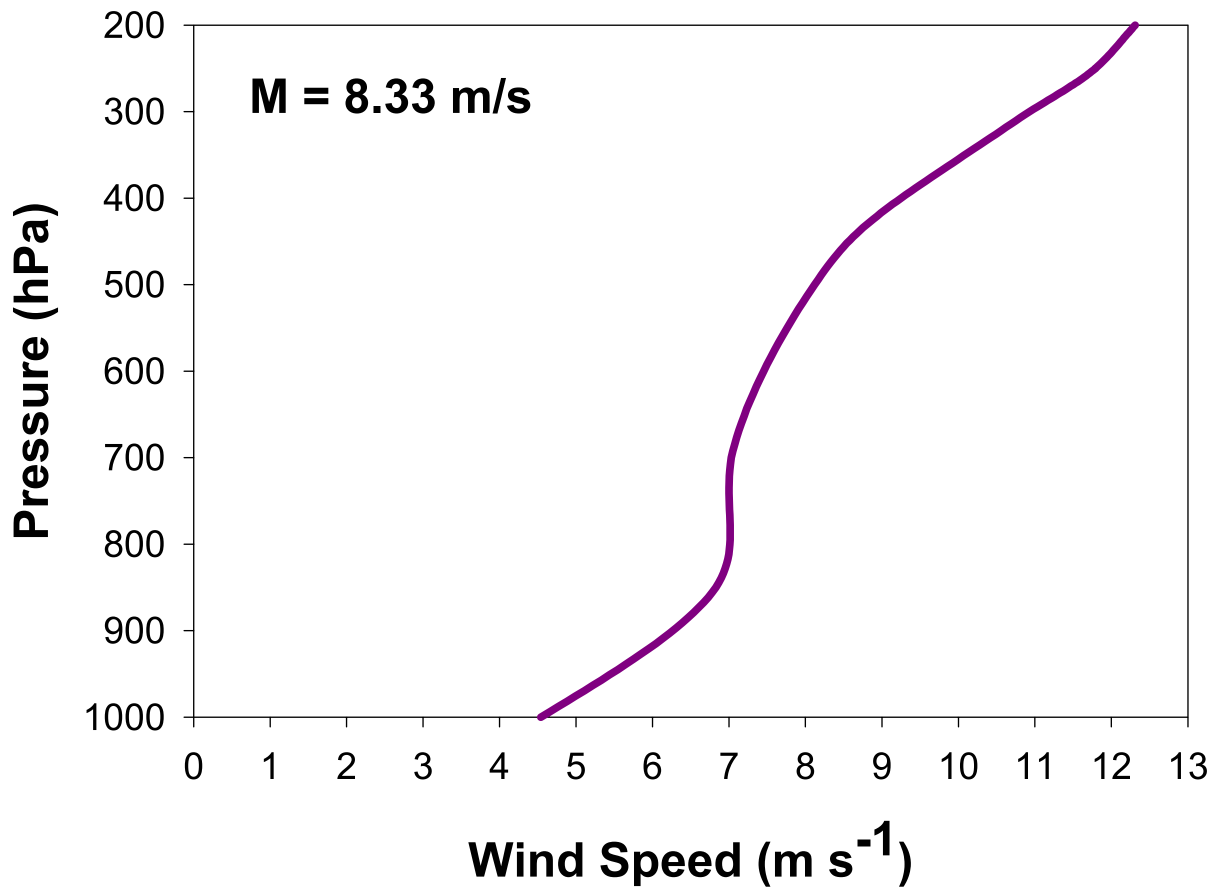
11	**18**
2	2

180° Angle Separation

All outer band flashes where the shear and storm motion vectors where 180°± 45° apart



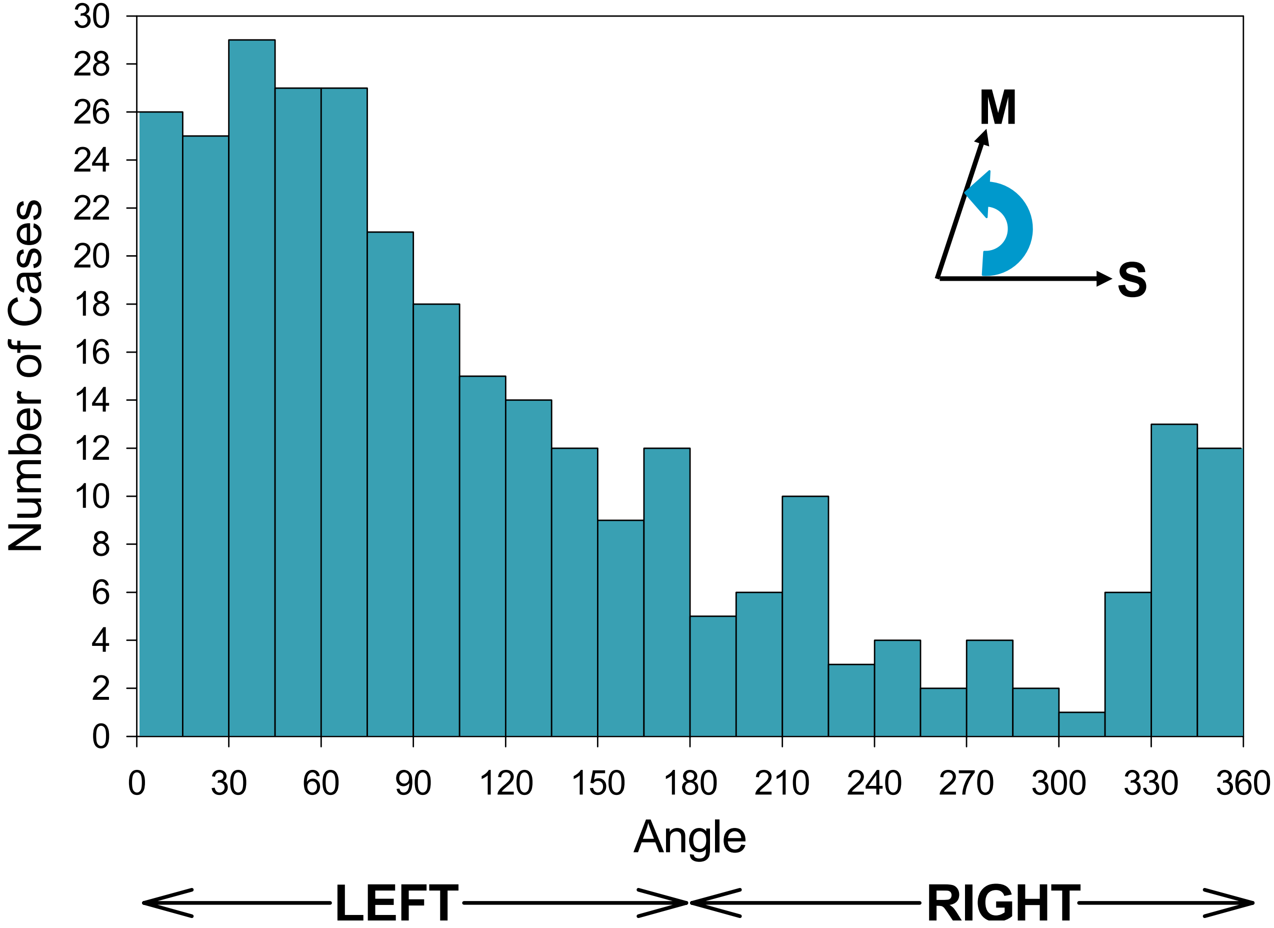
Why is the storm motion signal so weak?



Average wind profile of the fast motion cases

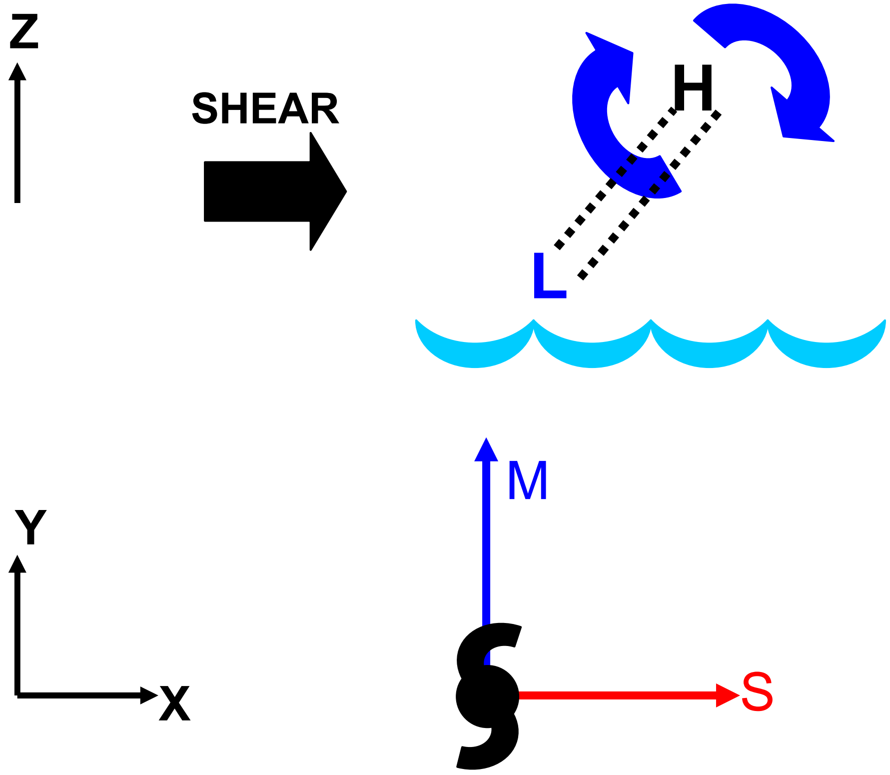
The mean motion is 8.33 m/s, but in the boundary layer the flow is only 5-6 m/s

The relationship between the vertical wind shear and storm motion vectors



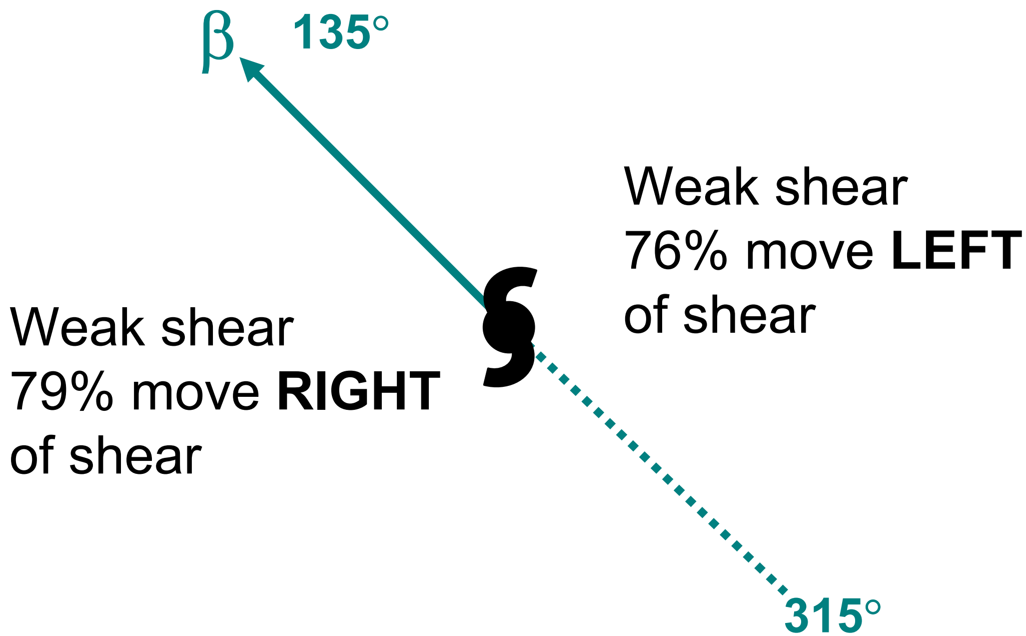
Why is motion LEFT of shear?

1.) Downshear shift of upper level negative PV anomaly



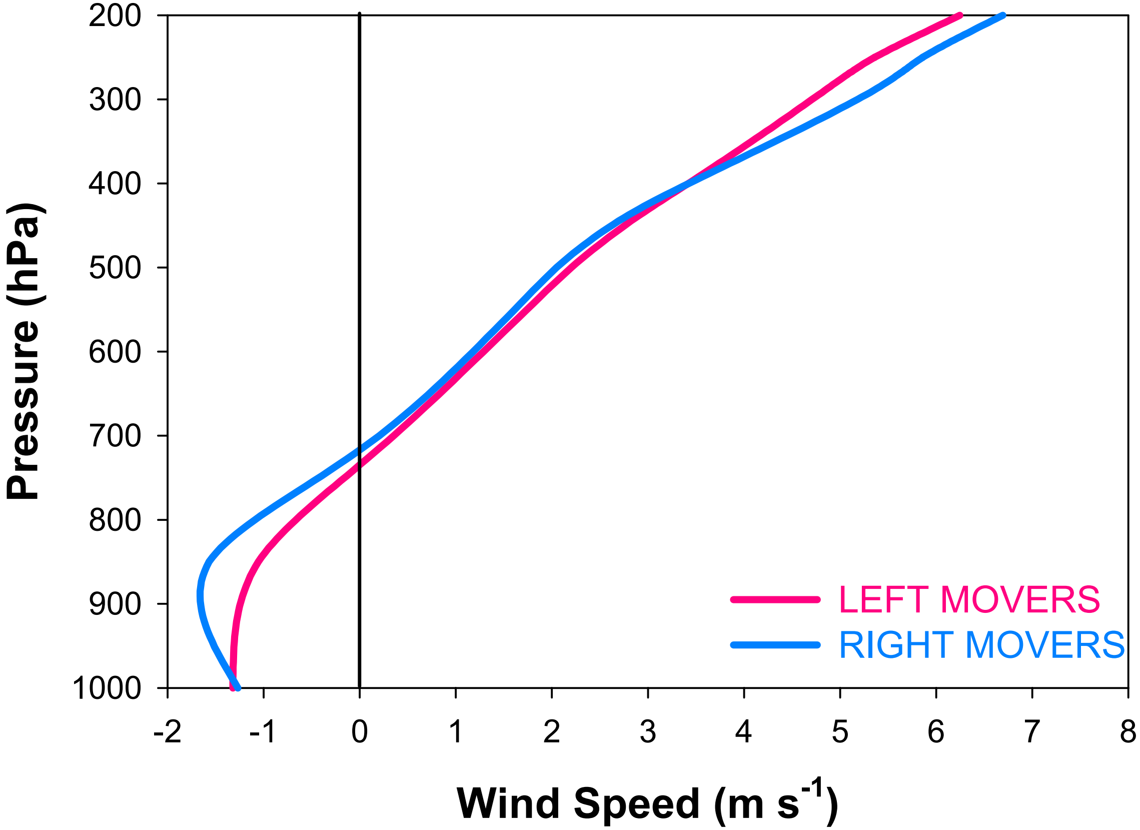
ALWAYS
induces motion
LEFT of shear

2.) Beta effect → always towards the northwest



3.) Background PV gradient

$$\partial q / \partial y \sim f \; \partial / \partial z (\partial \Theta / \partial y) \sim -\partial^2 u_g / \partial z^2$$



Summary

- Inner core flash maxima: Downshear left & Front quadrants

- Outer rainband flash maxima: Downshear right & Right of motion

- The storm motion signature may be an artifact of the much stronger vertical wind shear effect
  - ~ BL friction may produce only shallow upward motion
  - ~ Mean current in the boundary layer may be less than the environmental steering flow, thus asymmetric friction will be less than predicted from motion alone

- Motion is predominantly left of shear
  - ~ Downshear tilt of the upper level anticyclone is dominant for shear greater than 5 m s-1
  - ~ For weak shear, the β effect plays a significant role

- It is important to note that a downshear tilt of the *CYCLONIC* part of the vortex would result in motion to the *RIGHT* of shear

- Since this rarely occurs, it would seem that the vertical tilt must remain small in the cyclonic part of convectively active storms