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An Observational and Modeling Study of Tropical Cyclone Outer Rainbands

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Motivation and Purpose: When a region is threatened with a tropical cyclone, it is generally true that general aviation (GA) aircraft that are evacuating must depart prior to the arrival of the first outer rainbands . This is done to avoid potential flying hazards associated with the rainbands. Having an understanding of the development and evolution of these outer bands is crucial to forecasting their behavior. The purpose of this preliminary study is to begin to develop this understanding.

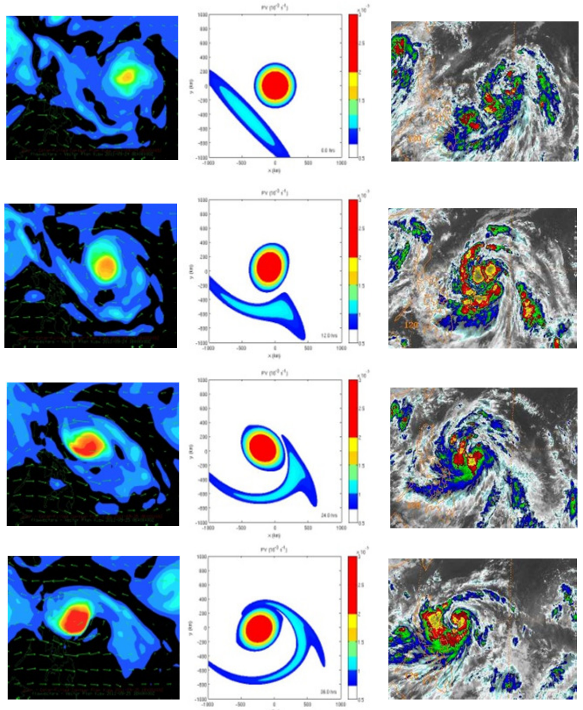
Hypothesis: Using shallow water model simulations, Guinn and Schubert (1993) showed that a strong potential vorticity (PV) maximum (i.e., a vortex) and a weaker PV maximum can interact in a way to produce PV structures that strongly resemble rainbands. This was referred to as ***vortex merger***. We hypothesize that the vortex merger process can, in fact, be responsible for the development and evolution of outer convective rainbands in nature.

Method: GFS 0.5° initial and 3 hour forecast grids were obtained for the period 1 July 2011 00 UTC to 31 October 2011 21 UTC. Using these data the IDV data visualization tool was then used to plot PV and other meteorological parameters at the 700 hPa level. Possible cases of vortex merger leading to outer rainband formation were then identified using these plots. This was done for tropical cyclones within the Atlantic and Pacific (East and West) Ocean basins.

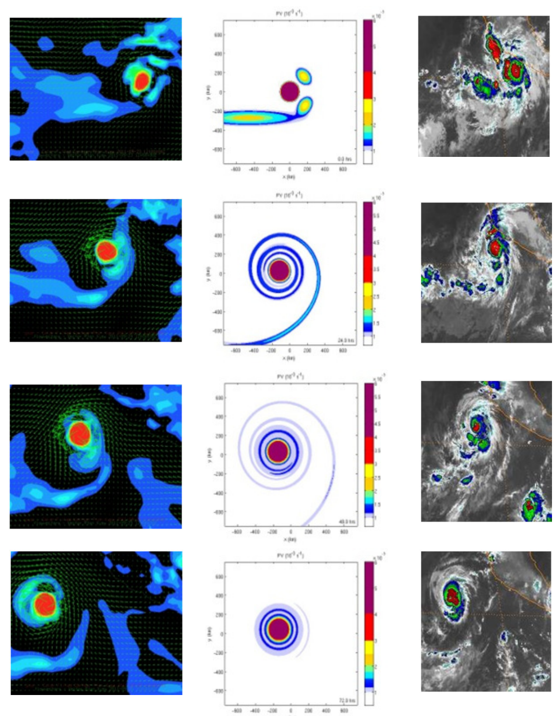
Method (cont.): Selected cases were then simulated using a shallow water model with idealized PV structures for model initialization. The evolution of the PV structure in the shallow water model simulations and that observed in the GFS grids were then compared. GFS grid analyses and shallow water model simulation results were also compared to satellite imagery.

Results: Analysis of PV at 700 hPa derived from GFS grids during portions of three tropical cyclone events shows that the vortex merger process is taking place and PV structures resembling rainbands do result. Idealized simulations of these cases using a shallow water model also supports the idea that vortex merger is leading to outer rainband formation. Comparison of the resulting PV structures to satellite imagery shows that these structures seem to play a role in organizing convection although convection is not always seen in these areas of high PV.

Typhoon Nesat every 12 hours from 24 Sep 06 UTC to 25 Sep 18 UTC. Column 1: PV (K m^2 kg^{-1} s^{-1}) and wind vectors at 700 hPa derived from GFS 0.5° grids. Column 2: PV (s^{-1}) from the shallow water model simulation. Column 3: IR satellite imagery.



Hurricane Hilary every 24 hours from 23 Sep 12 UTC to 26 Sep 12 UTC. Column 1: PV (K m^2 kg^{-1} s^{-1}) and wind vectors at 700 hPa derived from GFS 0.5° grids. Column 2: PV (s^{-1}) from the shallow water model simulation. Column 3: IR satellite imagery.



Hurricane Irene every 9 hours from 21 Aug 12 UTC to 22 Aug 06 UTC. Column 1: PV (K m^2 kg^{-1} s^{-1}) and wind vectors at 700 hPa derived from GFS 0.5° grids. Column 2: PV (s^{-1}) from the shallow water model simulation. Column 3: High Cloud/Convective Diagnostic satellite imagery.