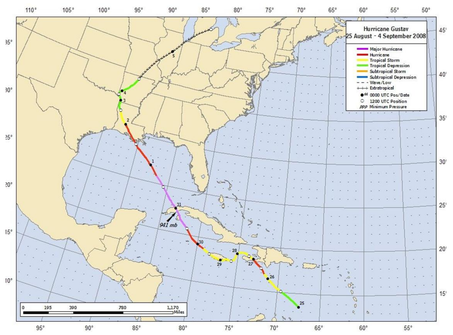
The Rapid Intensification of Hurricane Gustav (2008)

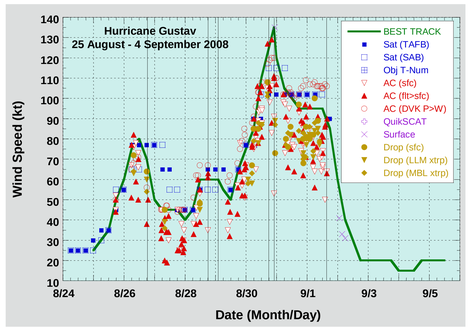
Jason H. Keefer

Department of Atmospheric and Environmental Sciences, University at Albany, State University of New York, Albany, NY

Background on Gustav (2008)



Best track positions for Tropical Cyclone (TC) Gustav from 25 August to 4 September 2008 from the National Hurricane Center. Track during the extratropical stage is based on analyses from the National Oceanic and Atmospheric Administration (NOAA) Hydrometeorological Prediction Center. (Beven and Kimberlain 2009)



Maximum sustained wind speeds for TC Gustav from 24 August to 5 September 2008 from the National Hurricane Center. (Beven and Kimberlain 2009)

References

Beven, J. L., and T. B. Kimberlain, 2009: Tropical Cyclone Report. Hurricane Gustav (AL072008). [Available online at www.nhc.noaa.gov/pdf/TCR-AL072008_Gustav.pdf.]

Kaplan, J. and M. DeMaria, 2003: Large-scale characteristics of rapidly intensifying tropical cyclones in the North Atlantic basin. *Wea. Forecasting*, **18**, 1093-1108.

Kaplan, J., M. DeMaria, and J. A. Knaff, 2010: A revised tropical cyclone rapid intensification index for the Atlantic and Eastern North Pacific basins. *Wea. Forecasting*, **25**, 220-241.

Acknowledgments

This project derived from a research project for Professor Kristen Corbosiero's Synoptic Meteorology I course. Professor Corbosiero created the Hovmöller diagram, and provided assistance and direction on this project.

Professors Ross Lazear and Kevin Tyle are thanked for assistance in using GEMPAK to create the wind shear and divergence plots, along with plots that are not shown on this poster.

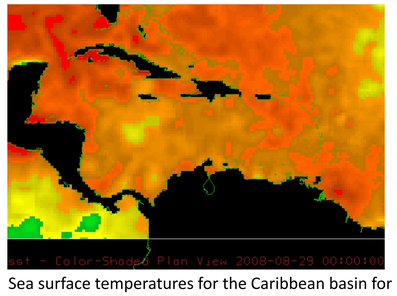
What is Rapid Intensification?

Rapid intensification (RI) of a tropical cyclone is defined as an event of maximum sustained winds increasing greater than 15 m s^{-1} (approx. 30 kt) in a 24 h period (Kaplan and DeMaria 2003).

From 1200 UTC 29 August to 2200 UTC 30 August 2008, TC Gustav rapidly intensified from a tropical storm, with a minimum pressure of 989 hPa and 50 kt maximum sustained winds, to a category 4 hurricane, with a minimum pressure of 941 hPa and 135 kt maximum sustained winds.

Several studies (Kaplan and DeMaria 2003, Kaplan et al. 2010) have defined a number of oceanic and synoptic-scale atmospheric parameters that distinguish RI events in tropical cyclones. The most important are:

- Sea surface temperature / ocean heat content
- 850–200-hPa vertical wind shear
- 850–700-hPa relative humidity
- 200-hPa divergence



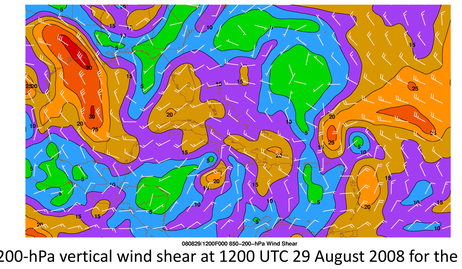
Legend:
- greens: > 26°C
- yellows : > 27°C
- yellow-oranges: > 28°C
- red-oranges: > 29°C
- reds: > 30°C

Sea surface temperatures for the Caribbean basin for 29 August 2008. Data from the National Oceanic and Atmospheric Administration Optimum Interpolation 1/4° Daily Sea Surface Temperature Analysis dataset.

For a number of the important parameters, the environment near TC Gustav was conducive for RI at the onset of RI:

- Sea surface temperatures > 29°C
- Low level relative humidity > 70%
- Broad area of 200-hPa divergence over convective core

However, the amount of **vertical wind shear** in the vicinity of the storm at the onset of RI (> 15 m s^{-1} in several areas) is not typically conducive for RI (< 5 m s^{-1}).



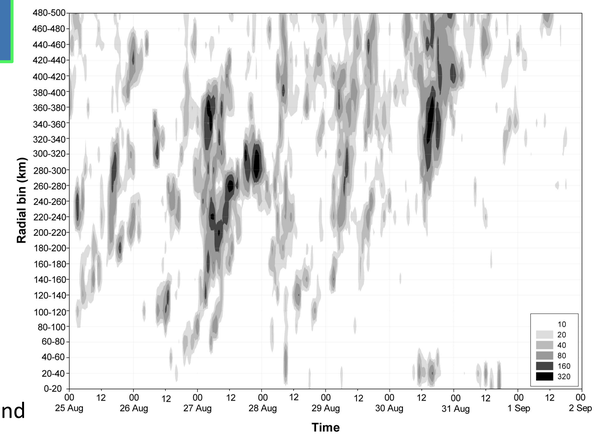
850–200-hPa vertical wind shear at 1200 UTC 29 August 2008 for the Caribbean and Western North Atlantic basin. Data from the Global Forecasting System (GFS) 1° initialization dataset.

Mesoscale Analysis from Lightning Data

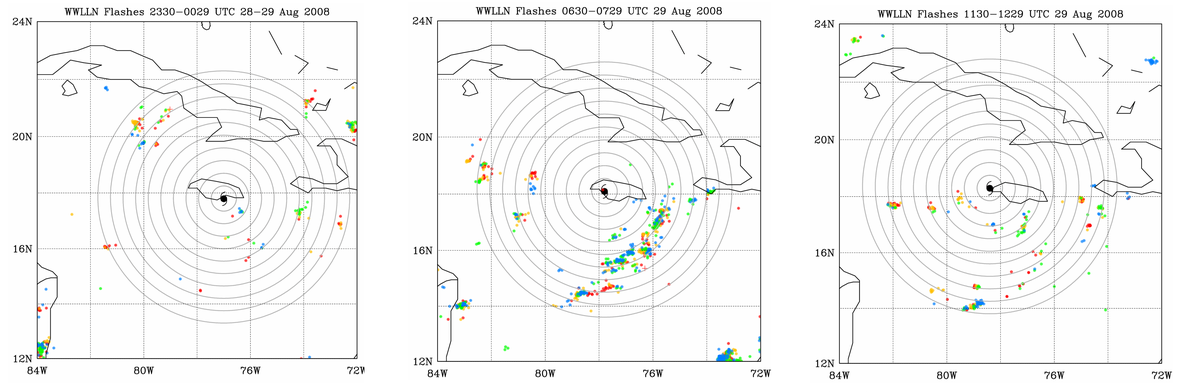
A mesoscale analysis is performed using lightning flash data from the **World Wide Lightning Location Network (WWLLN)**. This data is used in this study as an analog of convection. Radar and National Lightning Detection Network (NLDN) data could not be used because of limitations in the spatial range of such data sources.

The lightning plots below show the evolution of convection in the 12 hr prior to the onset of RI. A significant rainband formed downshear a few hours before the onset of RI. Several clusters of flashes developed near the center of the storm near the onset of RI.

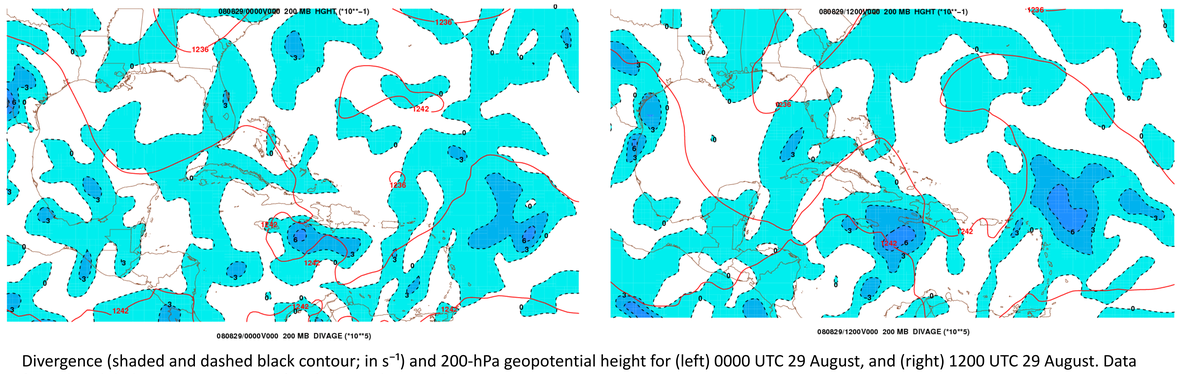
The convection acts to increase divergence aloft (i.e. 200 hPa) and increase low-level winds due to increased vertical motion. The WISHE process (diabatic heating from sea surface evaporation from low-level winds) is enhanced as a result. A positive feedback between the convection and WISHE is established. This feedback is crucial to the RI of Hurricane Gustav.



Hovmöller diagram of WWLLN flashes in 20 km radial bins from the center to 500 km of the storm from 0000 UTC 25 August to 0000 UTC 2 September.



WWLLN flashes for (left) 2330 UTC 28 August – 0029 UTC 29 August, (center) 0630 – 0729 UTC 29 August, and (right) 1130 – 1229 UTC 29 August



Divergence (shaded and dashed black contour; in s^{-1}) and 200-hPa geopotential height for (left) 0000 UTC 29 August, and (right) 1200 UTC 29 August. Data from the Global Forecasting System (GFS) 1° initialization dataset.

Future Work

- Model simulation of hypothetical situation where vertical wind shear is weaker than observed in TC Gustav.
- Look at other cases of rapid intensification using WWLLN data.