Tropical Cyclogenesis from an African Easterly Wave: Hurricane Julia (2010)

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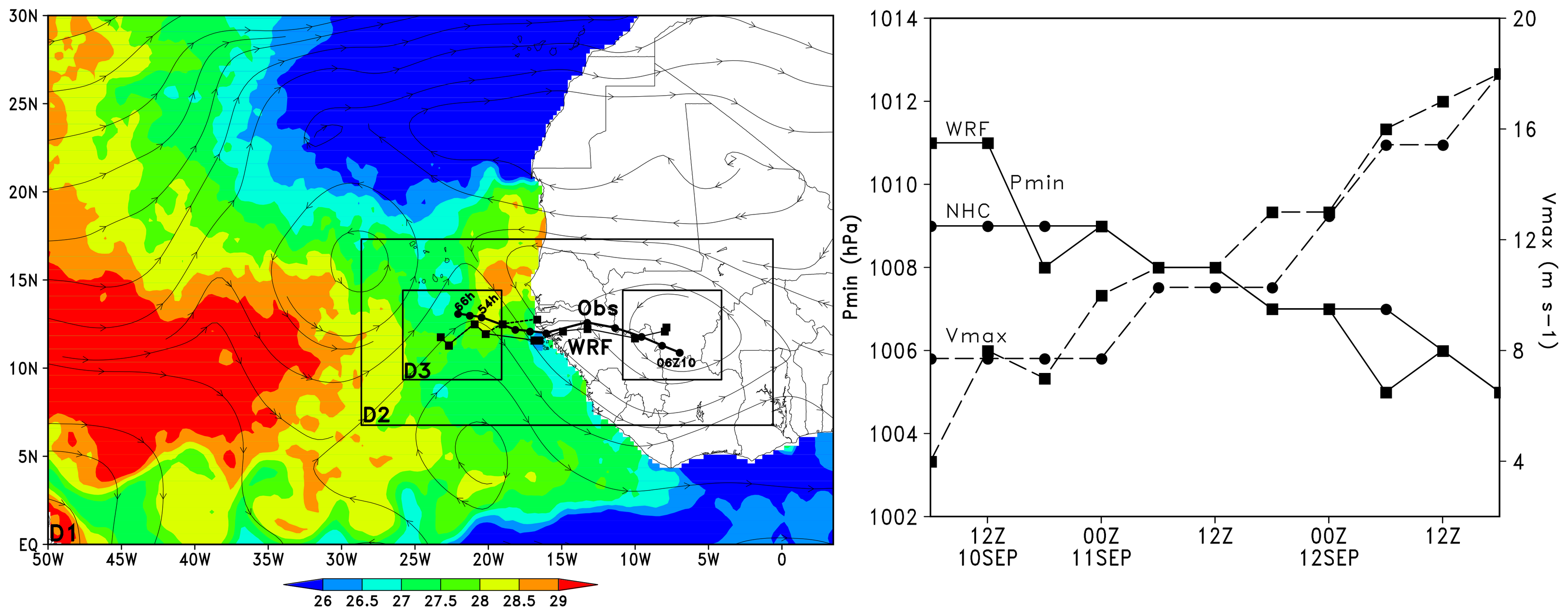
The Weather Research and Forecasting (WRF) Model



To ensure the simulation of the storm is realistic, we validate it against the limited number of observations we have. Observations used are track and intensity estimates from the NHC.

The above figures show the validation of the track (**left**) and intensity (minimum central pressure and 10 m max wind speed, **right**). Sea-surface temperatures are shaded with ERA-Interim 600 hPa co-moving streamlines (**left**).

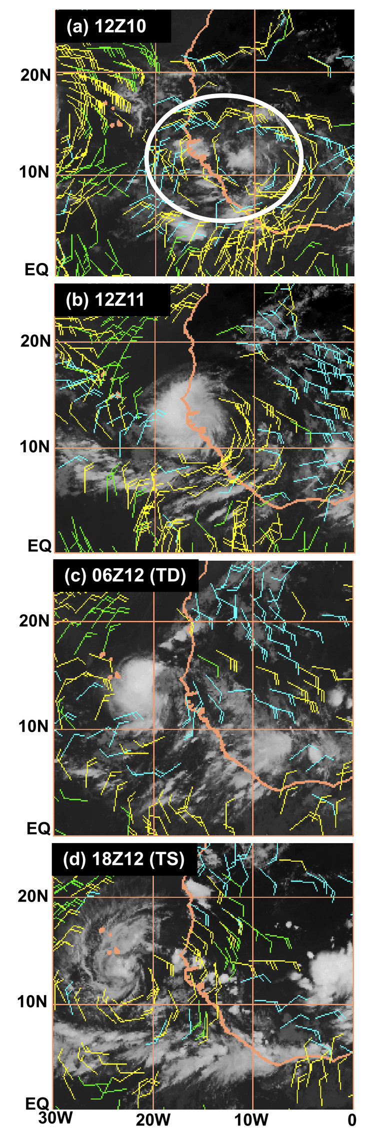
Introduction and Objectives

Tropical cyclogenesis (TCG) is defined as the process by which a non-developing tropical disturbance becomes a self-sustaining disturbance. This transition is one of the least understood processes in tropical meteorology today since it involves a plethora of interacting processes across multiple spatial scales. To investigate processes related to TCG, a high-resolution numerical weather simulation is conducted on Hurricane Julia.

The work presented here will:

i) Illustrate the genesis of Hurricane Julia;
ii) Describe the role of the African Easterly Wave in TCG;
iii) Show the development of the low-level vortex (LLV) within the AEW;
iv) Demonstrate the importance of upper-tropospheric processes in TCG

An Overview of Hurricane Julia (2010)

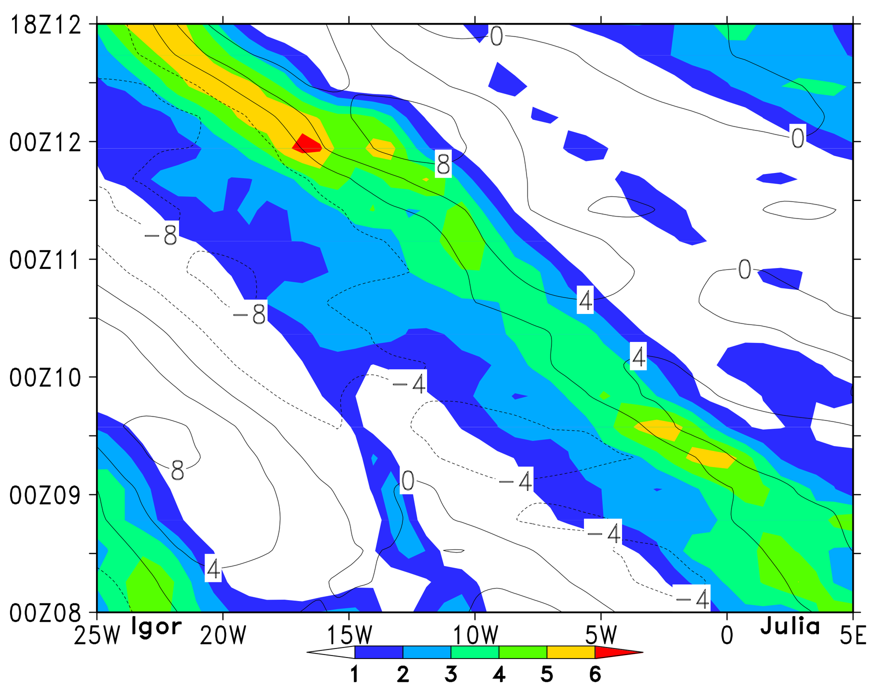


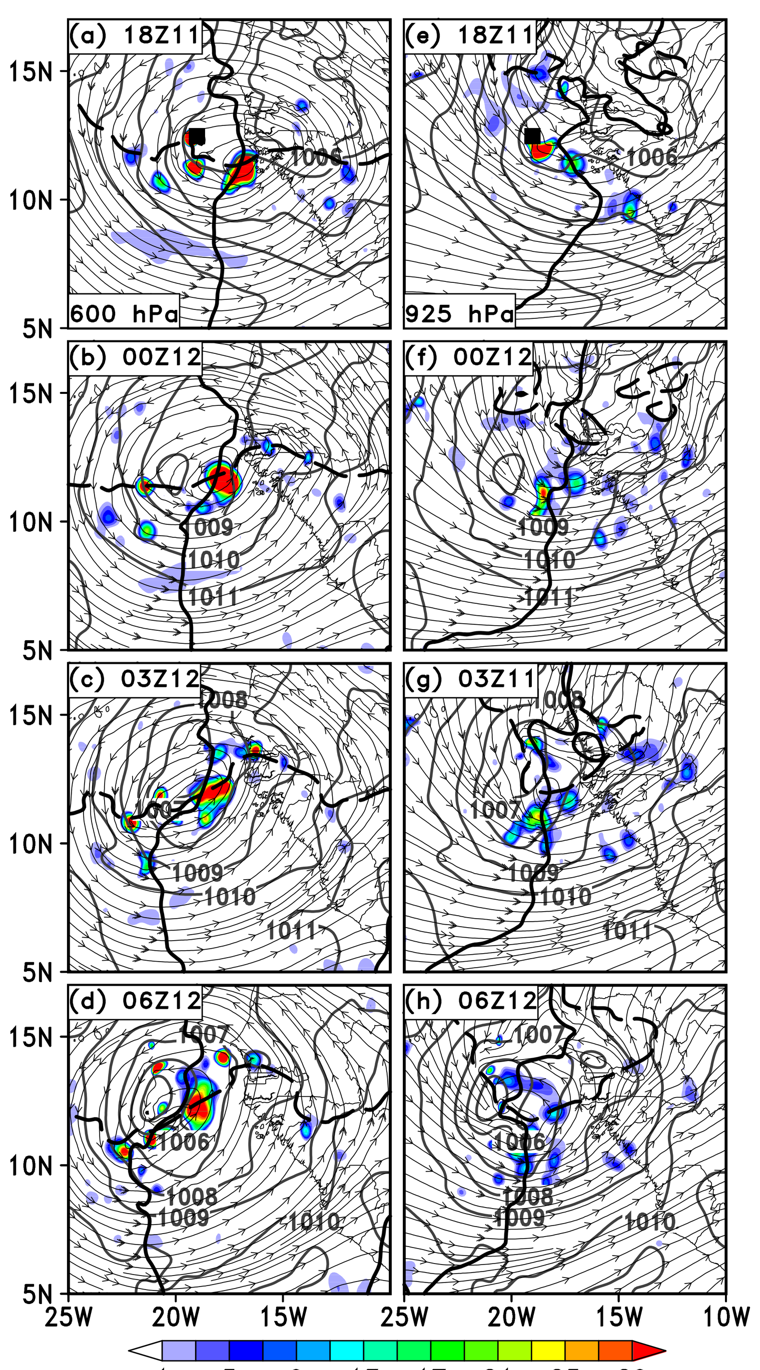
Hurricane Julia Facts:

- Was declared a Tropical Depression (TD) 0600 UTC 12 September 2010
- Became a Tropical Storm (TS) 1800 UTC 12 September 2010
- Was **not** well forecasted by the National Hurricane Center even with significant weather model guidance
- Formed within a strong African Easterly Wave which was traceable back 5 days before TCG

Left: Infrared (IR) imagery from the METEOSAT-9 satellite. The disturbance of interest is shown in the white oval in (a). Satellite-derived winds are shown as wind barbs for various layers.

The African Easterly Wave (AEW)





Above: Hovmoller diagram of relative vorticity (shaded) and meridional wind at 600 hPa. AEW motion(C_p) is 8.0 m s^{-1} westward.

Right: Evolution of the AEW and LLV at various times. The Okubo-Weiss (OW) parameter (shaded), MSLP (contours) and streamlines are shown. The OW parameter marks favorable formation locations within the AEW.

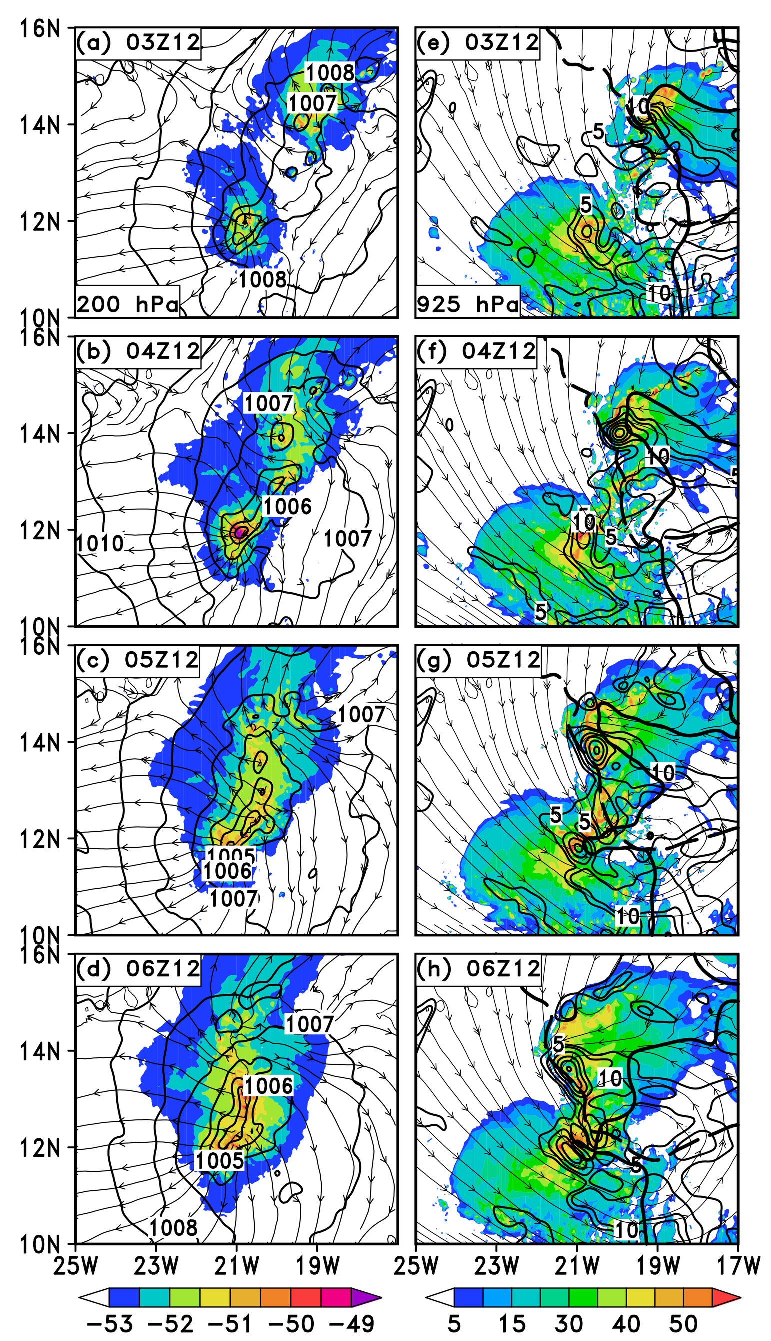
Conclusions and Future Work

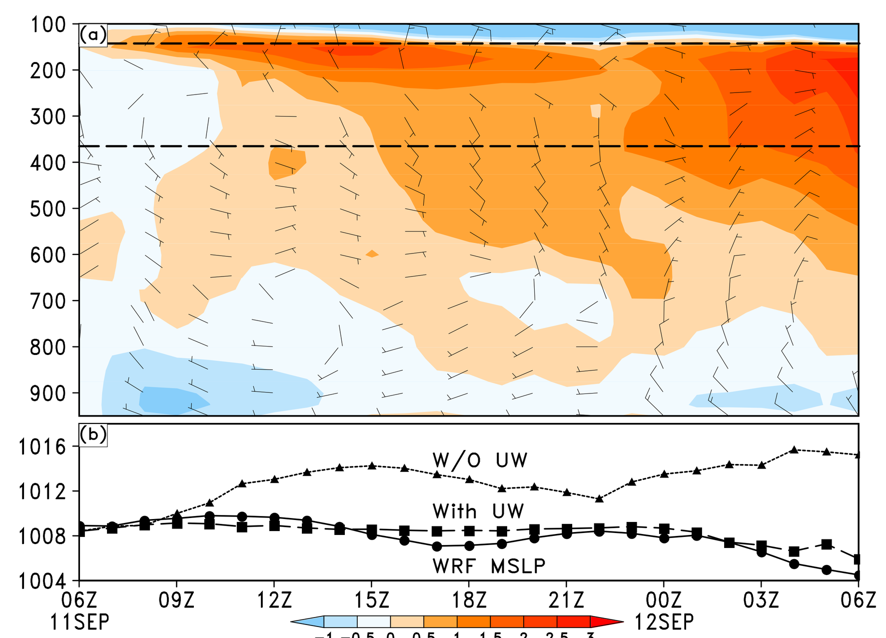
1) The WRF simulation is able to successfully reproduce the genesis of Hurricane Julia;
2) The LLV vortex forms on the western portion of the AEW, entering the AEW circulation center by TCG time;
3) The LLV vortex forms beneath upper-tropospheric warming, which is maximized near 200 hPa;
4) Upper-tropospheric warming forms partly due to deep convection detraining near the tropopause;
5) Without the upper-tropospheric warming, calculations of MSLP demonstrate that the LVV would not deepen into TD Julia;
6) Low-level vorticity generation is enhanced along the critical latitude of the AEW, conglomerating into a coherent vortex by TCG time;

Future work:

- Investigate the role of convection and low-level vertical wind shear in low-level vorticity generation;
- Assess the dynamics of TCG via differences in WRF ensemble simulations;

Low-level Vortex Formation and Upper-level Warming





Left: Temperature and co-moving streamlines at 200 hPa (shaded) with MSLP (contours) in (a)-(d). Composite radar reflectivity (shaded) with 925 hPa relative vorticity (contours) and co-moving streamlines in (e)-(h).

Above: (a) Time-series of temperature difference from 0600 UTC 11 Sept. and wind barbs. (b) Time-series of hydrostatic MSLP calculations with and without warming seen between dashed lines in (a) as compared with the WRF-estimated MSLP.