Genesis of Hurricane Julia (2010) from an African Easterly Wave

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Motivation

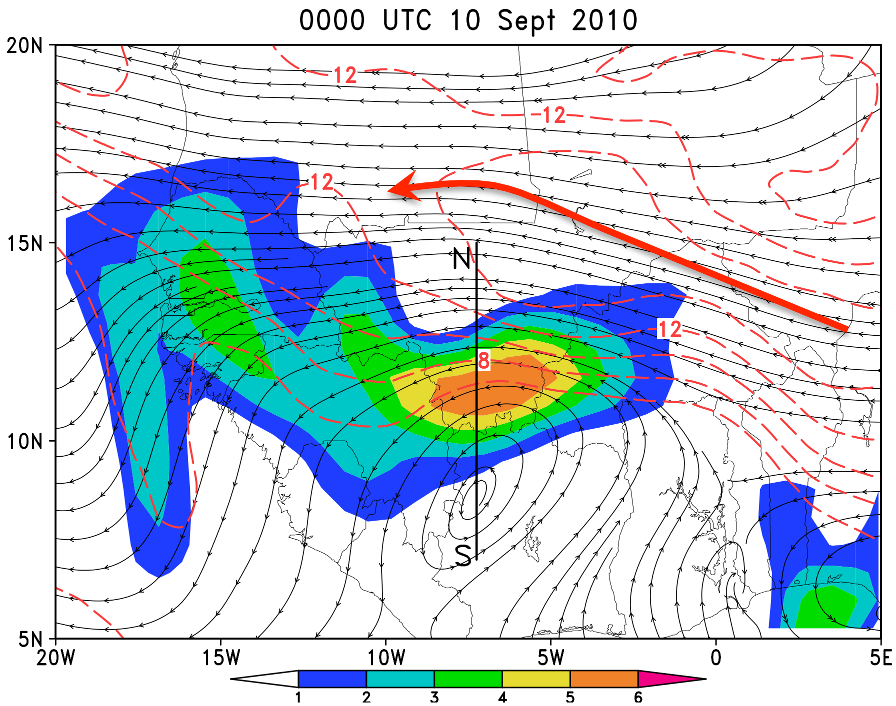
- The genesis of Julia (2010) was not well anticipated;
  - Introduced into the Tropical Weather Outlook (TWO) with a medium (30%) chance of formation only 18 h prior to transition to TD and a 70% chance of genesis 6 h prior to TCG (Tropcical Cyclone Report, Beven and Landsea);
- Explore the meso-β development (vorticity generation);
  - What role does convection play for the development within the AEW?

Objectives

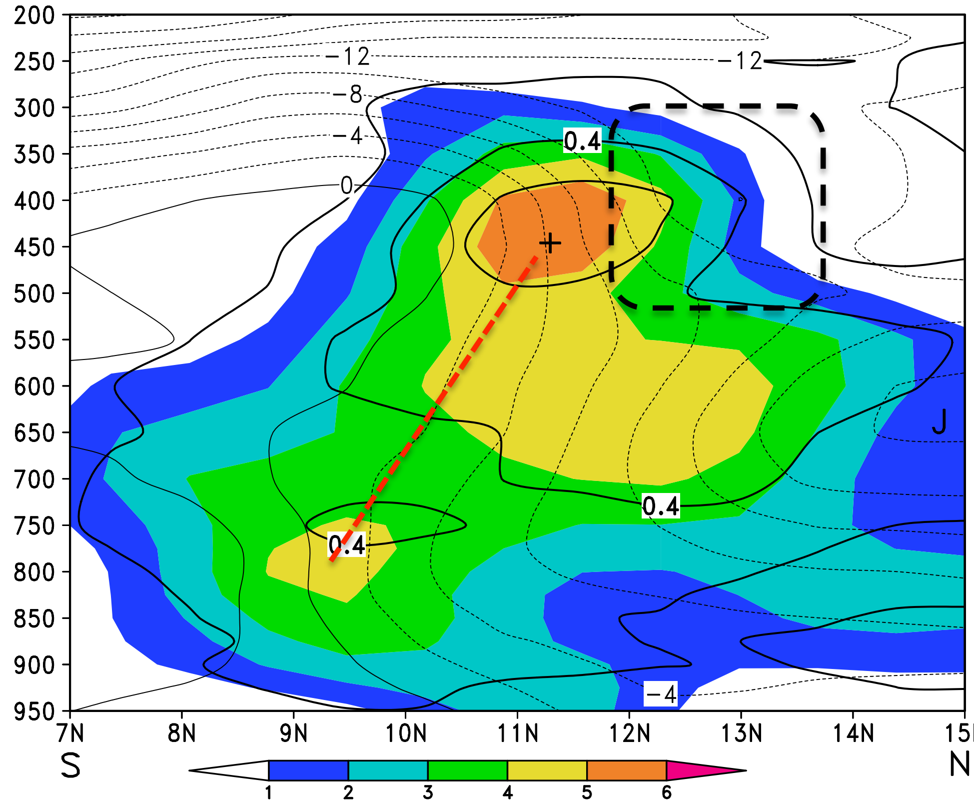
- Examine the genesis of Julia from the merging of several meso-β-scale vortices within the AEW;
- Study how deep convection, invigorated through a high θ_e and storm-relative helicity (SRH) environment, contributes to the development of the meso-β-scale vortices;
- Show that the vorticity maxima (and related convection) lies on the critical level (latitude) Dunkerton, et al. 2009, the latitude where the wind speed equals the phase speed of the AEW)

AEW and AEJ

450-hPa Relative Vorticity (shaded, 10^{-5} s^{-1}), 650-hPa Streamlines (resting frame) and Isotachs (red-dashed contours, m/s).



Relative vorticity (shaded), zonal wind (dashed/ solid thin line, m/s) and potential vorticity (thick solid line, contoured every .2 PVU).



J = Location of AEJ

\+ = Positive Upper-level PV

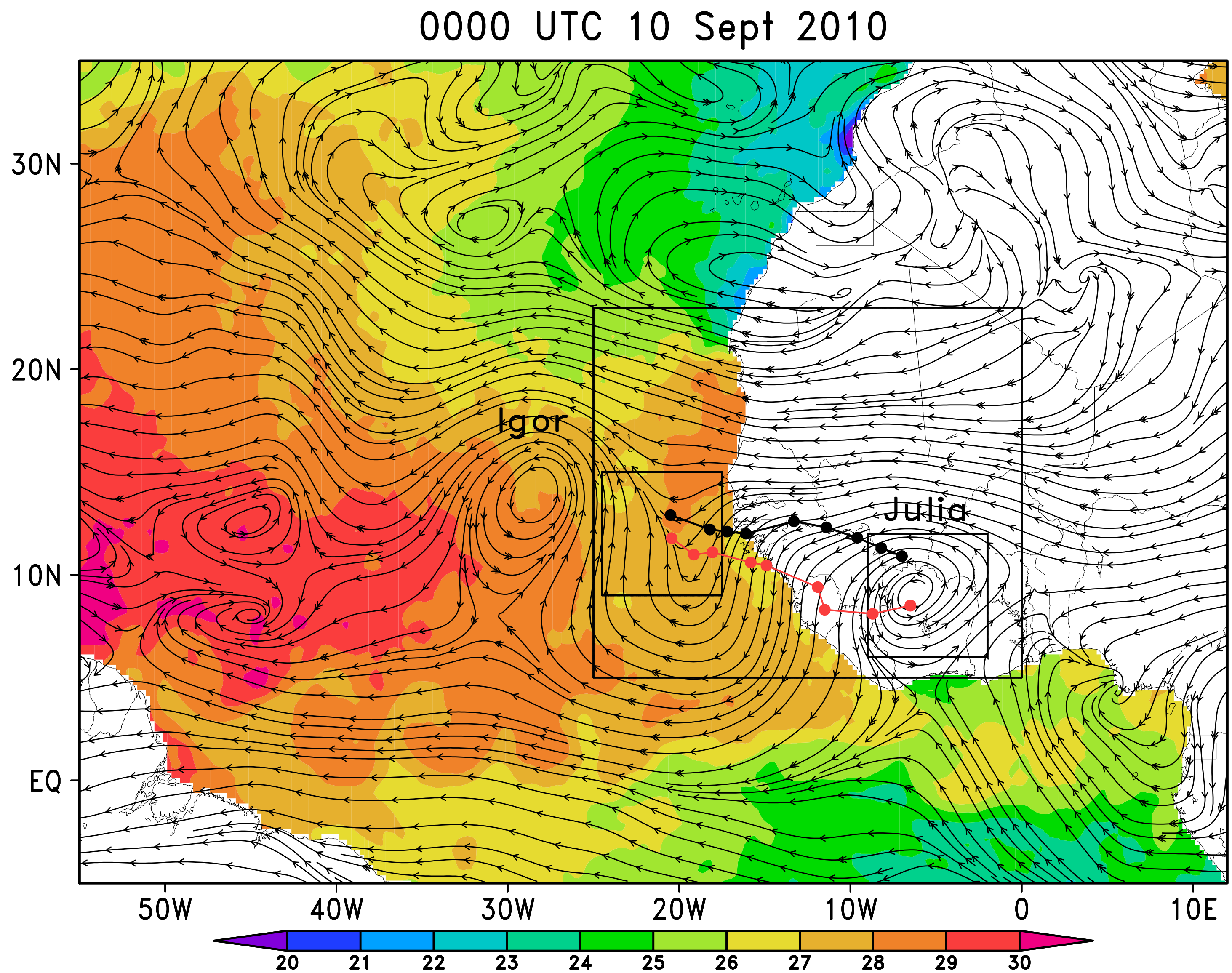
Box = Location where meridional PV gradient goes negative

WRF Simulation Set-up

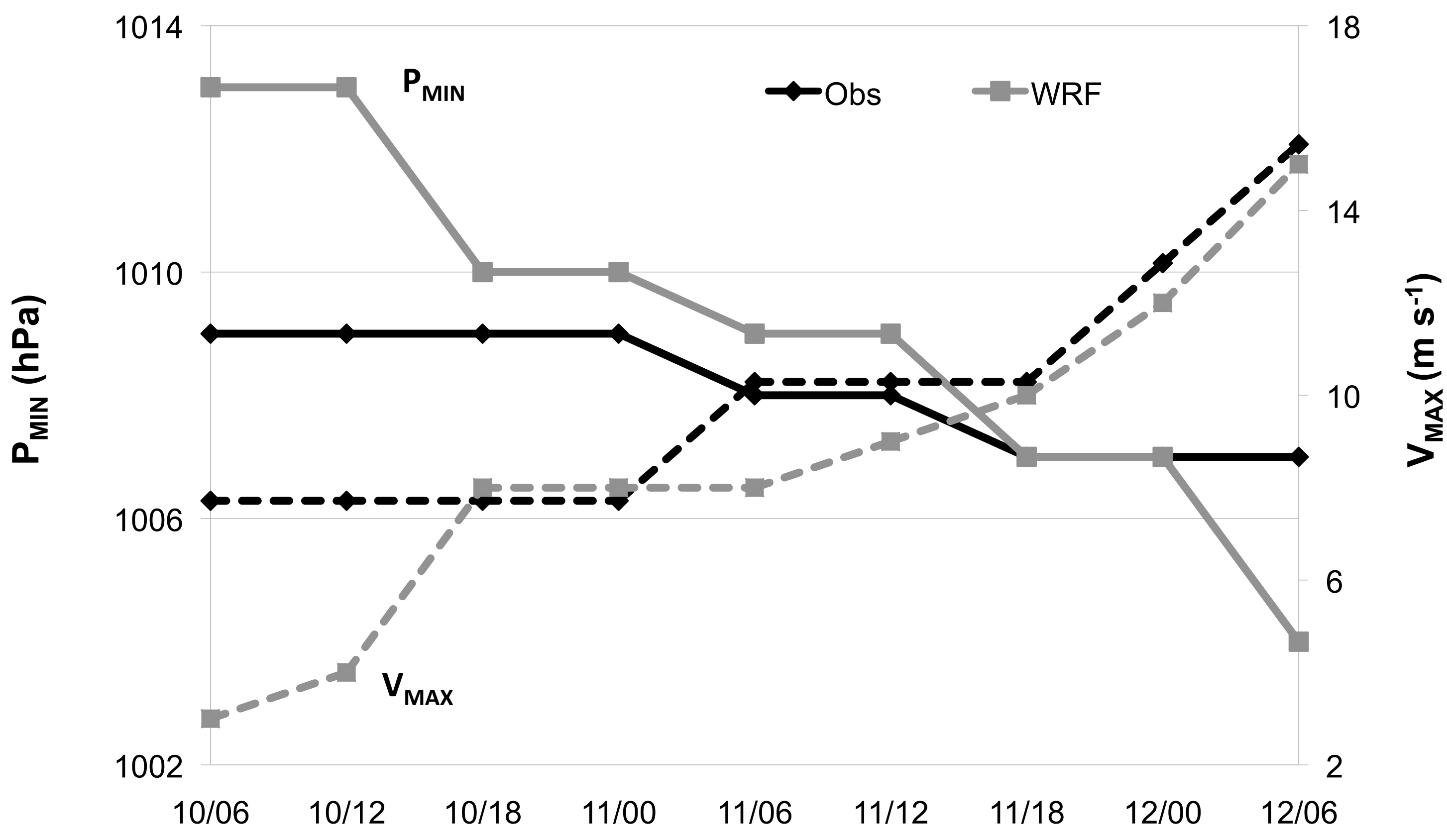
- Initialized 0000 UTC 10 Sept 2010
  - 78-hour integration
  - 12/4/1.33 km triple-nested simulation
- Used ERA-Interim for atmospheric IC and BCs and NOAA Optimal Interpolation SST data to initialize SSTs
- Used new Kain-Fritsch (KF) convective parameterization for 12 and 4 km domains

WRF Model Set-up

NOAA Optimal Interpolation SSTs (shaded, degrees C), 700-hPa Streamlines (resting frame) from ERA-Interim for the initialization time of the WRF simulation.



WRF Validation



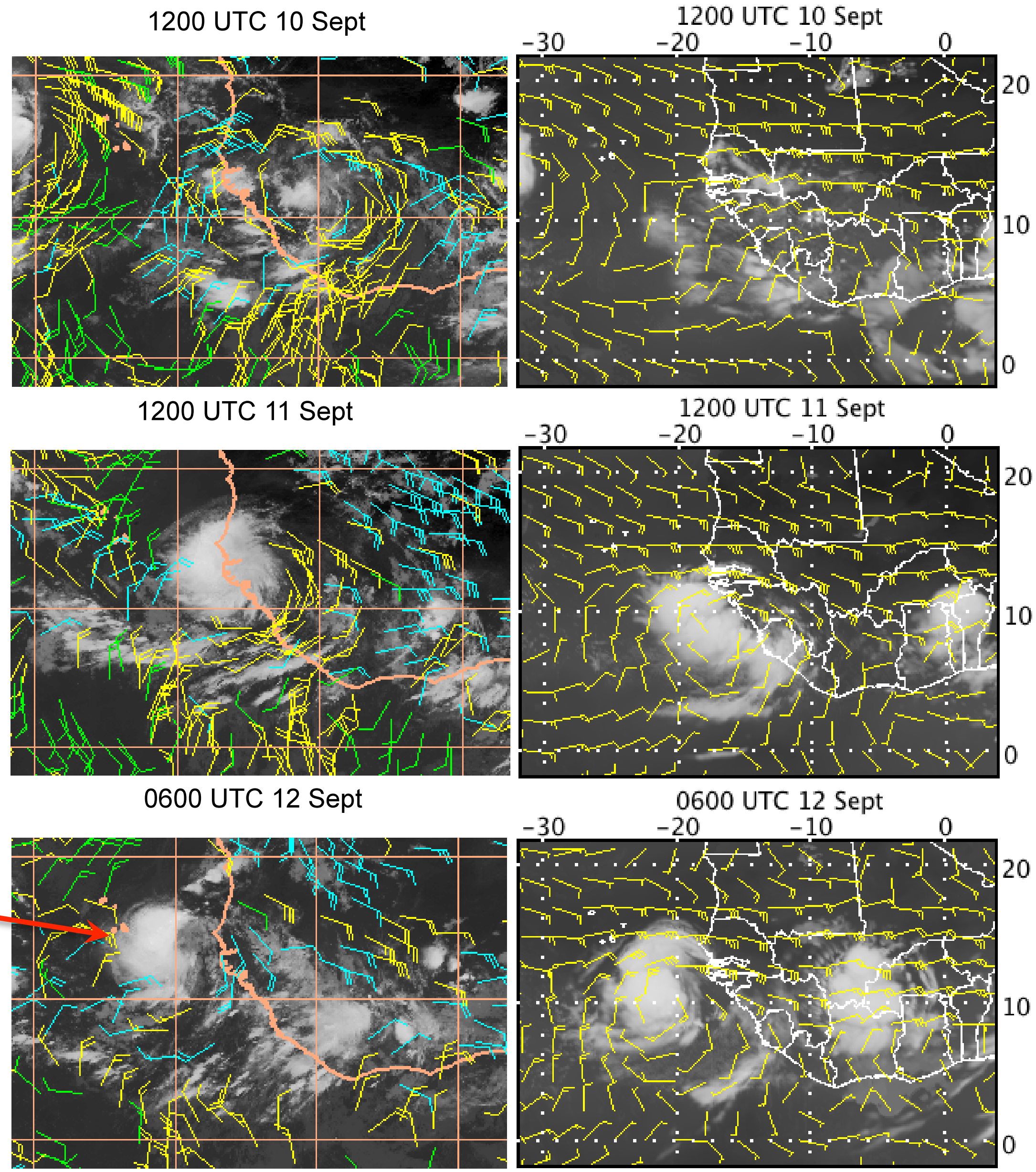
Average P_{MIN} error from observed was **1.67 hPa**. Track errors had substantial more latitudinal error than longitudinal.

METEOSAT-9 IR Imagery with satellite-derived winds

WRF Outgoing Longwave Radiation (OLR, shaded, white/ gray low OLR) and 700-hPa wind barbs

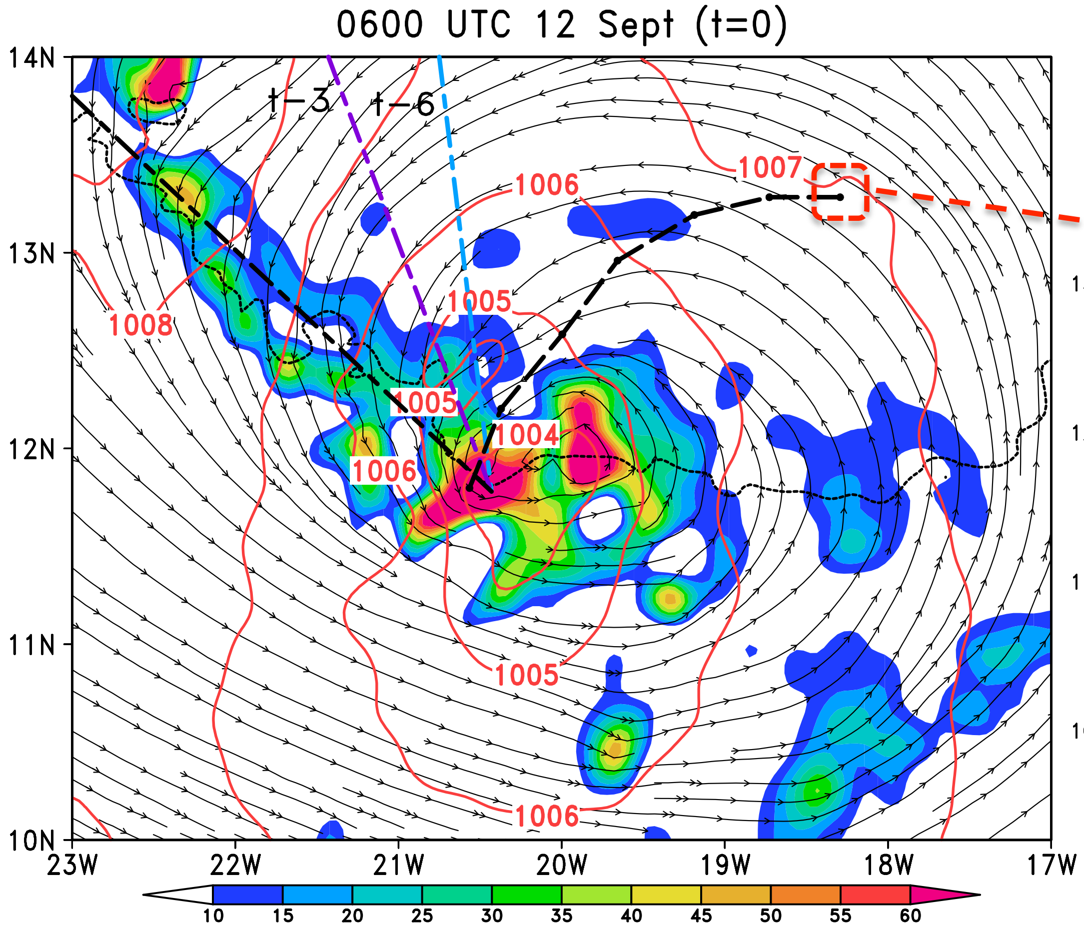
400-599 hPa (blue)
600-799 hPa (yellow)
800-950 hPa (green)

Julia

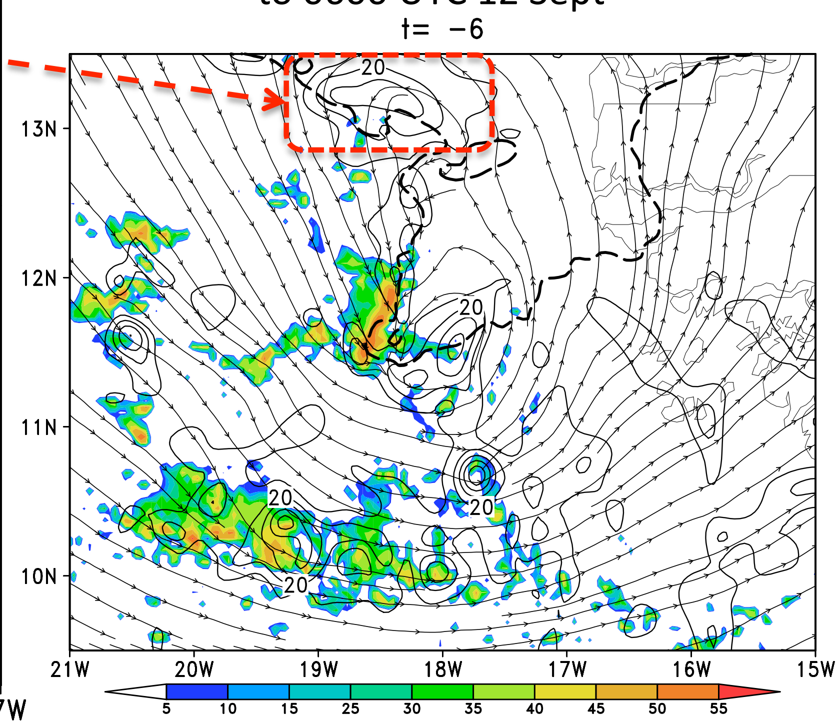


Transition from AEW to Julia

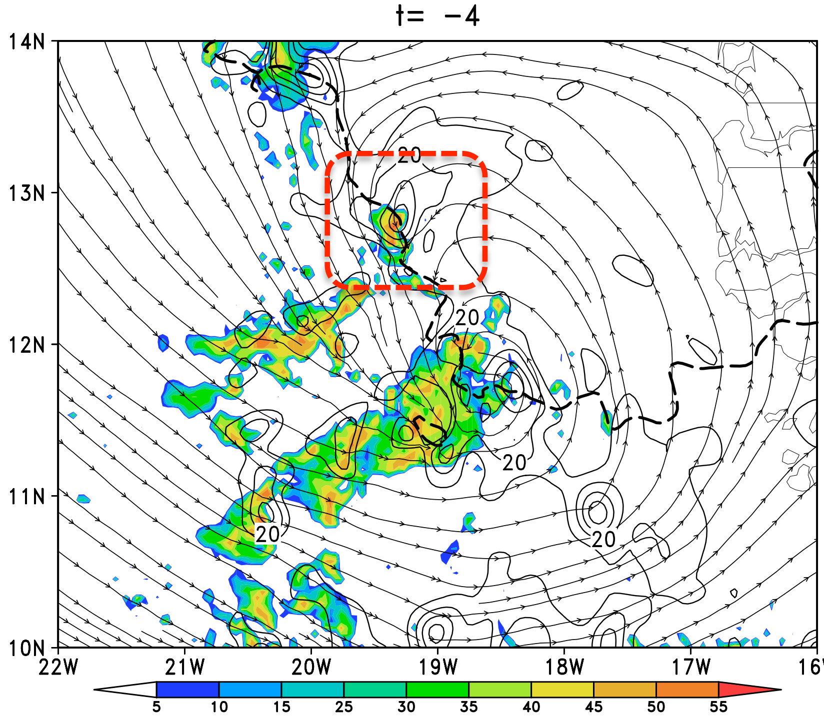
925-hPa co-moving streamlines, relative vorticity (shaded) and MSLP (red contours, every 1 hPa). Black line represents hourly-based back-trajectory of vorticity center that becomes co-located with the AEW circulation center. The AEW trough axis at 3 times is superimposed, with the black-dashed line being the current time trough axis. The critical latitude is shown with a dotted line.



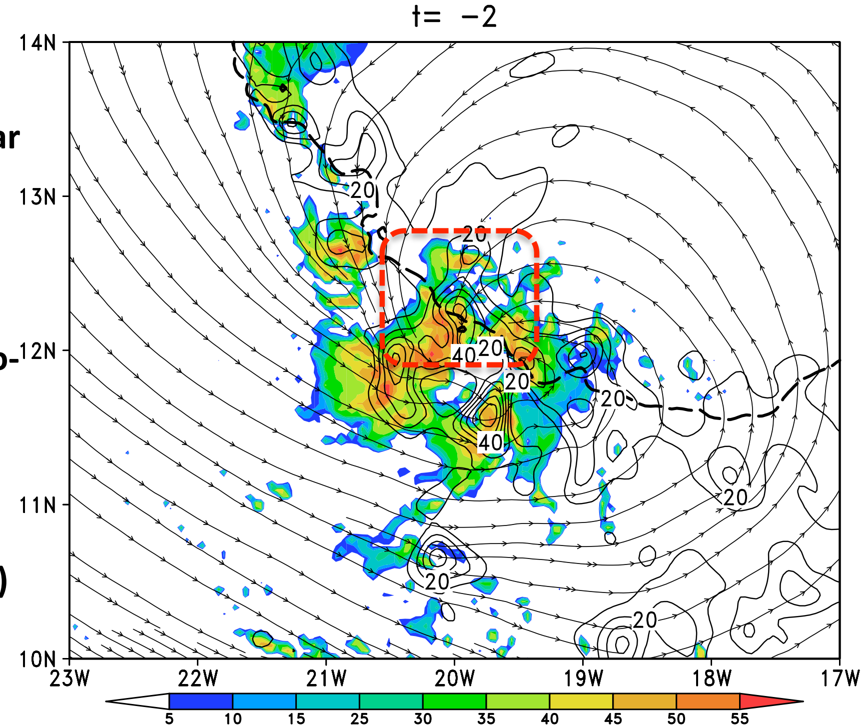
925-hPa Radar reflectivity (shaded) relative vorticity (contours), co-moving streamlines and the critical latitude (dashed line) 6 hours prior to 0600 UTC 12 Sept

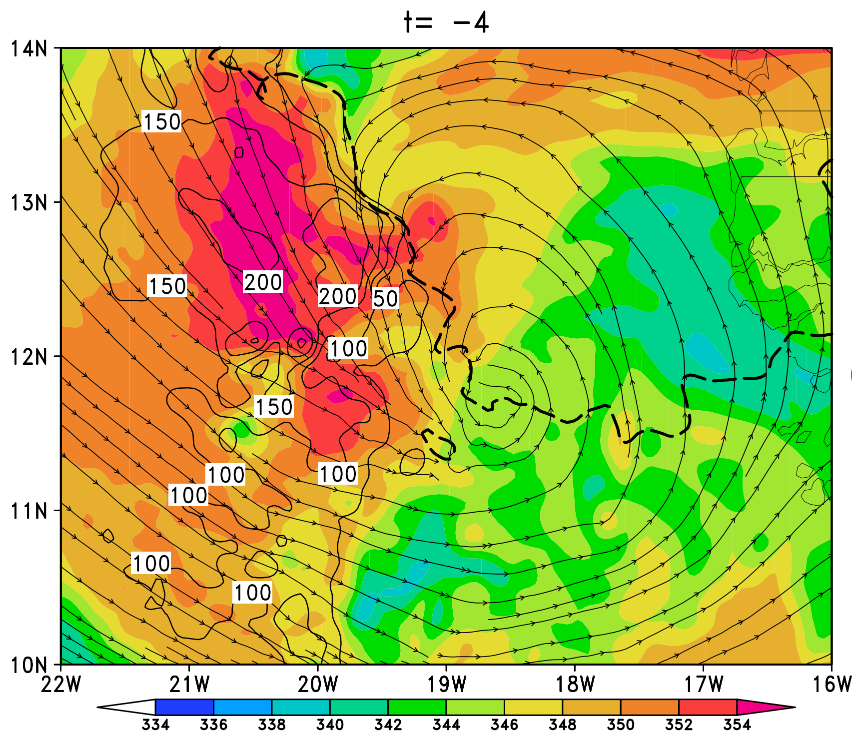


How did it strengthen over the 6-hour period?

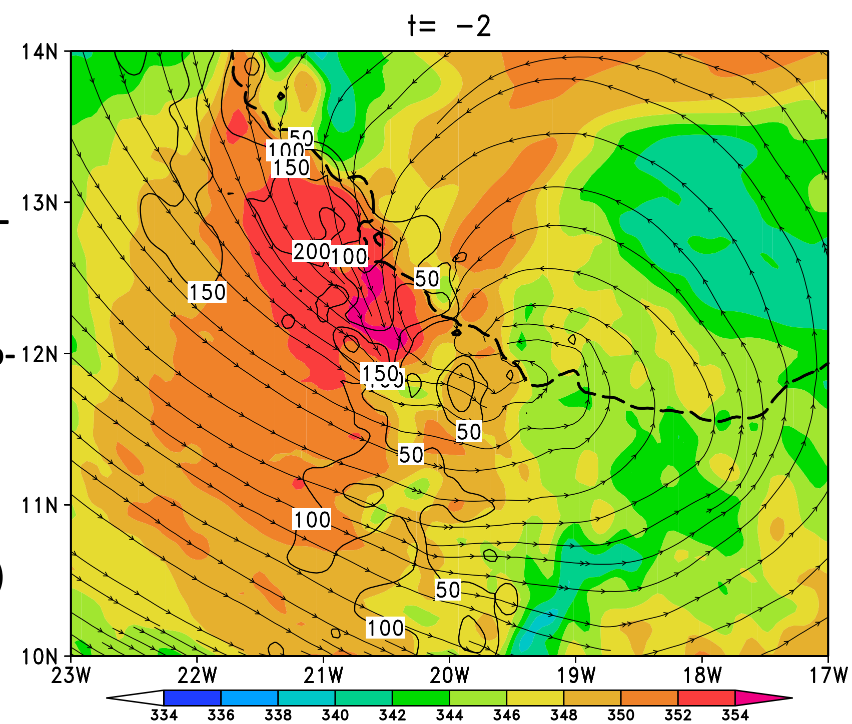


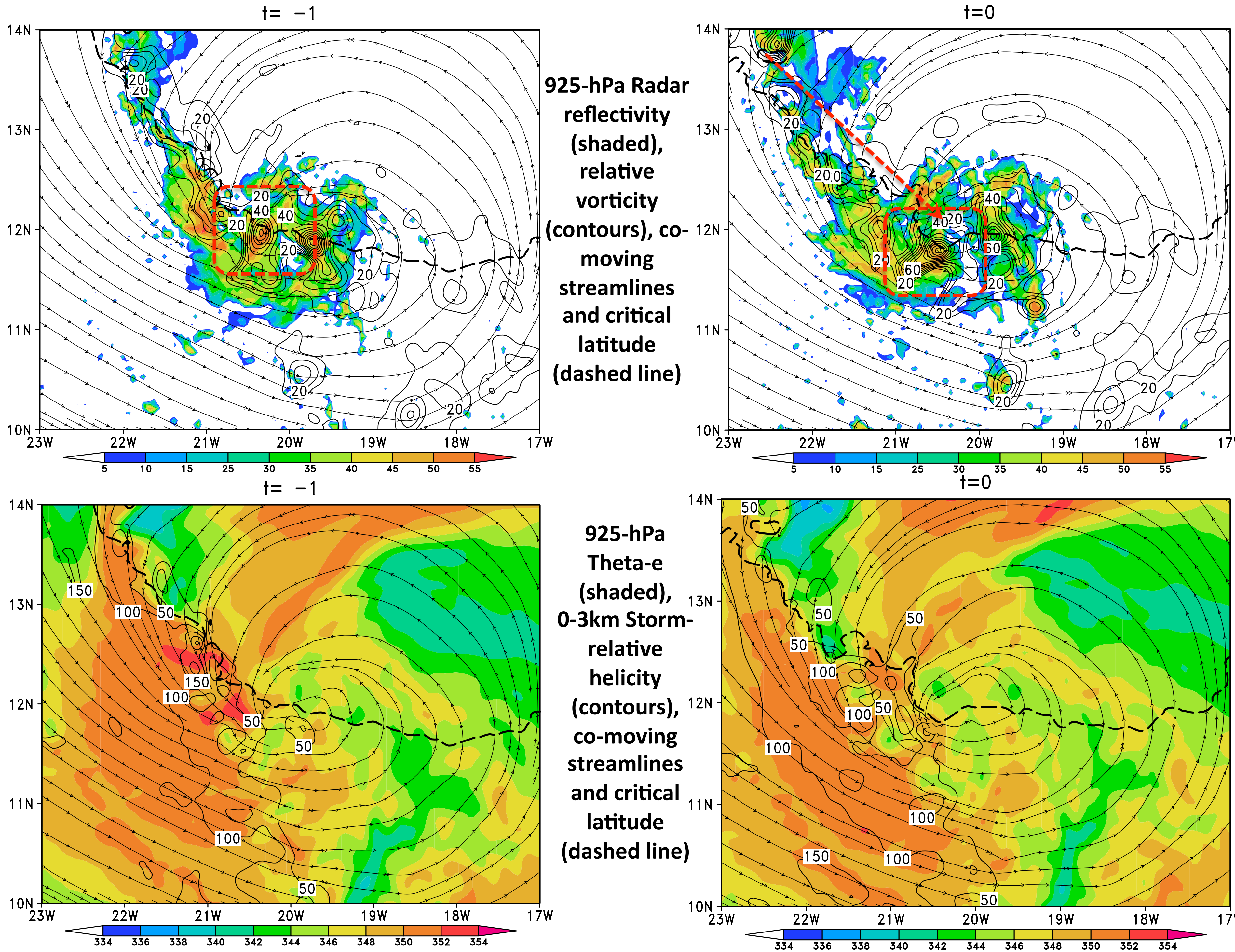
925-hPa Radar reflectivity (shaded), relative vorticity (contours), co-moving streamlines and critical latitude (dashed line)





925-hPa Theta-e (shaded), 0-3km Storm-relative helicity (contours), co-moving streamlines and critical latitude (dashed line)




t= -1
t=0
925-hPa Radar reflectivity (shaded), relative vorticity (contours), co-moving streamlines and critical latitude (dashed line)
t= -1
t=0
925-hPa Theta-e (shaded), 0-3km Storm-relative helicity (contours), co-moving streamlines and critical latitude (dashed line)
14N
13N
12N
11N
10N
23W
22W
21W
20W
19W
18W
17W
5 10 15 25 30 35 40 45 50 55
334 336 338 340 342 344 346 348 350 352 354

Concluding Remarks

- The genesis of Julia occurred from an initially unstable, vertically tilted AEW with a PV maxima around 450-hPa;
- While the AEW provides favorable forcing for convective development, merging of meso-β-scale vortices generated in rainbands accounts for the genesis of Julia;
  - High θ_e air to the north and west of the storm invigorates convection while ingestion of high sfc-3km SRH aids in cyclonic relative vorticity development at 925 hPa;
  - As hypothesized by Dunkerton, et al. 2009, the critical latitude provides a preferred region for amplification of meso-β development (their H1);
  - This low-level cyclonic vorticity development leads to genesis, both through convective enhancement and the critical latitude acting as an 'attractor' for meso-β cyclonic vortices