Factors Contributing to Sensitivity in the Observed Overland Reintensification of TC Erin (2007)

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Background

Relatively benign over open waters, TC Erin (2007) is noteworthy for a brief period of rapid intensification over Oklahoma on 19 August 2007, nearly 72 hours after landfall.
- Peak sustained winds increased from 20 to 50 kt (NHC 2009)
- System dissipated quickly thereafter on 19-20 August 2007.

Level II radar imagery from the Oklahoma City, OK (KTLX) radar provide a unique view of the reintensification period (Figure 1)
- New mesoscale area of low pressure formed early on 19 August
- Organization period between 0200-1000 UTC 19 August led to eye feature
- Significant mesovortex activity observed near and east of the center

Aim of the study: understand sensitivity in the evolution and support efforts toward understanding the cause of the unique reintensification.
- Emanuel (2008) hypothesis: soil moisture and surface flux driven
- Companion work: Galarneau et al. (2009), 13B.4 (Thursday, 9:45 am)

Simulation Verification and Vortex Resiliency

WRF model simulations were able to effectively, if somewhat understate, the observed reintensification process (Figures 2 and 3).
- Three of our four runs showed a notable reintensification on the morning of the 19th, approx. 5-6 hPa in magnitude (e.g. Figure 3b).
- Reintensification occurred despite track errors of several hundred km, with the simulated vortex reintensifying over Texas rather than Oklahoma.
- Reintensification occurred when mesovortices axisymmeterized about the remnant lower tropospheric vortex, similar to that observed in reality (Figure 2b-d).

Intensity at landfall did not negatively or positively affect the reintensification period (Figure 3b; also other results not shown).
- Perhaps significant decay time period negated these effects?
- Note that the presence of a weak vortex three days after landfall is not uncommon for landfalling TCs regardless of landfall location or intensity.
- Unknown: was there some other unique structure to the Erin vortex that helped enable the observed mode of redevelopment?

Conclusions

Model verification: WRF is able to simulate reintensification period
- Multiple runs with differing initializations and initial conditions
- Mode of reintensification seems to be similar to those of observations
- Reintensification occurred when axisymmeterization of vorticity about lower tropospheric vortex center was achieved

Sensitivity tests illuminate several key features...
- Evolution not sensitive to over water vortex strength or its overland decay
- Evolution not sensitive to underlying soil moisture profiles
- Reintensification occurs despite substantial track errors – is it right for the wrong reasons or is the evolution is somewhat geographically insensitive?

Ultimately, what caused the reintensification?
- Working hypothesis: dynamical contributions associated with the position of the vortex relative to the axis of the nocturnal LLJ (current work)
- Perhaps a small contribution from underlying soil conditions, but given uniqueness of the evolution we do not consider this the primary driver

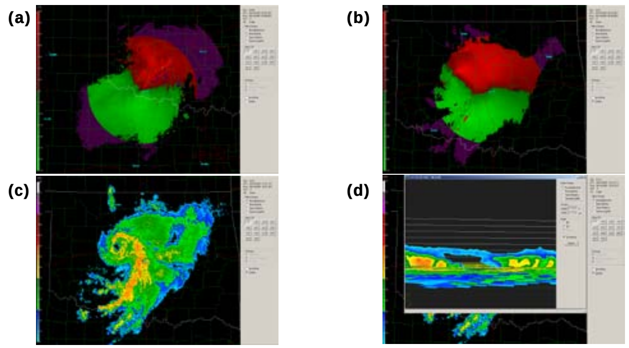

Figure 1: (a) Frederick, OK level II base velocity image at 0359 UTC 19 August; **(b)** Oklahoma City, OK (TLX) level II base velocity image at 0830 UTC 19 August; **(c)** TLX level II base reflectivity image at 1023 UTC 19 August; **(d)** vertical N-S cross-section about (c).

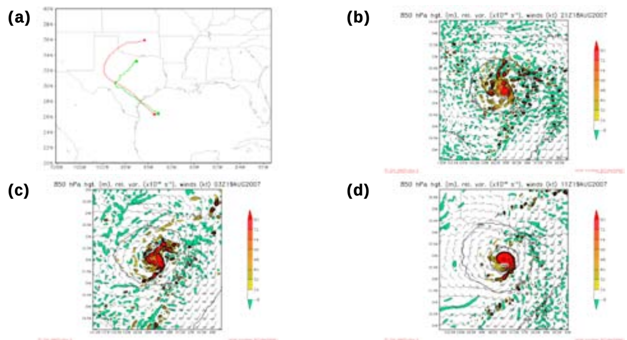

Figure 1: (a) Simulation 3 vortex track (green) versus NHC observed track (red) between 16-20 August; **(b)** simulation 3 850 hPa relative vorticity (10^{-5} s^{-1}) at 21 UTC 18 August; **(c)** as in (b), except at 03 UTC 19 August; **(d)** as in (b), except at 11 UTC 19 August.

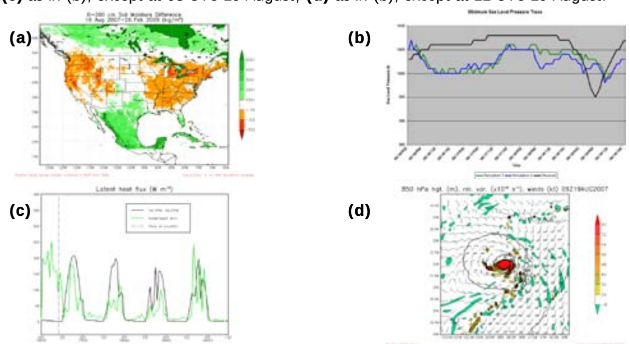

Figure 3: (a) Integrated soil moisture comparison between 16 August 2007 and 26 February 2009 as derived from 12 km NAM initializations; **(b)** minimum sea-level pressure trace from simulations 3 and 4 as compared to observations; **(c)** latent heat flux traces underneath the storm and over an open location in Oklahoma from simulation 4; **(d)** 850 hPa relative vorticity field centered on the storm at 0900 UTC 19 August 2007 from sim. 4.

Methodology

An array of mesoscale model simulations are performed as a part of this study, comparing the results to observations (in the form of synoptic analyses and radar data) and theory.
- Mesoscale model system: Advanced Research WRF (WRF-ARW) V3.0.1.1
- Horizontal resolution: 4 km
- Domain configuration: 560x536x30, centered near Little Rock, AR
- Initial/boundary conditions: 6-hrly NAM operational analyses
- Physics: Yonsei Univ. PBL, Lin et al. microphysics, explicit convection

Four simulations are performed, designed to gauge the sensitivity in the reintensification to vortex resiliency over land and soil moisture.
- Simulation #1: 1200 UTC 15 August-1200 UTC 20 August 2007
- Simulation #2: 1800 UTC 15 August-1200 UTC 20 August 2007
- Simulation #3: 0000 UTC 16 August-1200 UTC 20 August 2007
- Simulation #4: Same as simulation #3, except using drier soil moisture conditions from the 1200 UTC 26 February 2009 NAM initialization (Figure 3).

Soil Moisture Sensitivity

Why study soil moisture sensitivity?
- Was the atmosphere uniquely primed for such a reintensification to occur?
- Is the Emnauel (2008) hypothesis the main or a lesser determining factor?

Results (Figure 3)...
- Reintensification occurs whether over the moister or drier soil conditions.
- Latent heat flux values of 50-100 W m^{-2} prevalent underneath the storm over land as compared to 200-500 W m^{-2} over water.
- Reintensification occurs despite simulated location over Texas, where soil conditions were drier to begin with than in southwest Oklahoma.
- Mode of reintensification is identical between the simulations.

This all suggests that the reintensification was somewhat insensitive to the unique soil moisture conditions found in August 2007.
- Does not mean that they did not play a role, just that they perhaps were not the primary driver of the evolution.
- If not, then what was the primary driver of this evolution?

Acknowledgements & References

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