The Effects of Dry Air Ridging on the Rainfall Distribution of Tropical Storm Hanna

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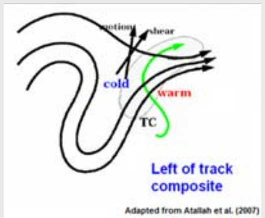
Introduction:

Rainfall distribution in landfalling tropical cyclones is known to be driven by:

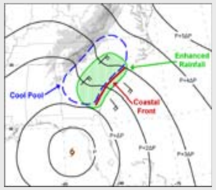
•Track •Speed •*External Forcing*

- Maximum rainfall shifted to left of track in systems undergoing extra-tropical transition and interacting with an approaching upper-level trough (Atallah et al. 2007)
- Interaction with a down stream ridge or low-level boundary can shift heaviest rainfall to right of track



Mesoscale effects on rainfall distribution:

- Orographically forced ascent
- Coastal frontogenesis
- Cold air damming

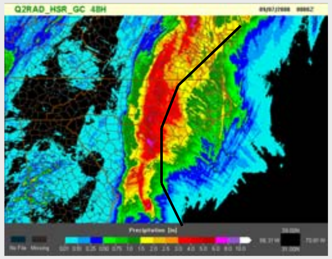


Srock and Bosart 2009

Hypothesis: Interaction of in-situ cold air damming, which formed from rainbands ahead of TS Hanna moving over a dry surface high pressure ridge, and an inland moving coastal front, enhanced rainfall to the left of the storm track.

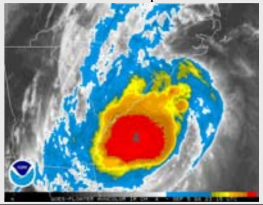
Track and Rainfall:

- Annotated track of TS Hanna



48 hour rainfall from 00 UTC 5 Sept. – 00 UTC 7 Sept

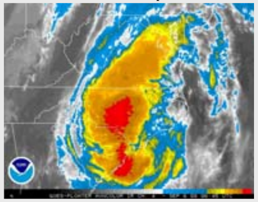
2315 UTC 5 Sept



Infrared images showing the transition from a symmetric to and asymmetric cloud structure left of track rainfall enhancement

This is indicative of extra-tropical transition and increased baroclinity

0645 UTC 6 Sept



Acknowledgments

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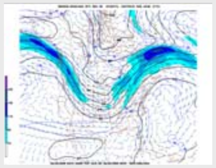
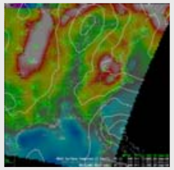
Upper Air:



00 UTC 6 Sept. GFS 300mb Analysis

An upper level trough was located over the Central U.S., but the main jet core was located north of New England, separated from TS Hanna as it made landfall.

Surface:



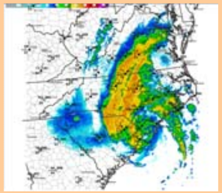
12 UTC 5 Sept. Surface Obs and MSAS SLP

On the morning before Hanna made landfall, a strong, dry high pressure ridge extended from the Mid-Atlantic into the Southeast U.S.

Radar:

18 UTC 5 Sept

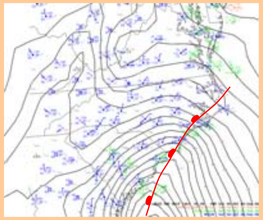
23 UTC 5 Sept



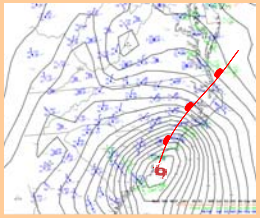
07 UTC 5 Sept

• Rainbands ahead of TS Hanna cooled portions of central and western NC through evaporational cooling as rain fell into the dry air ridge
• A large, north-south oriented band of heavy rainfall became nearly stationary over central North Carolina as the center of TS Hanna moved inland.

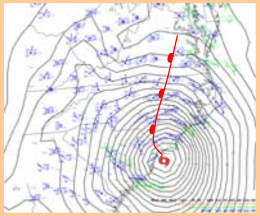
Surface:



00 UTC 6 Sept



03 UTC 6 Sept

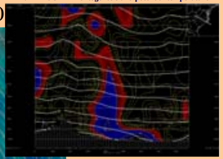


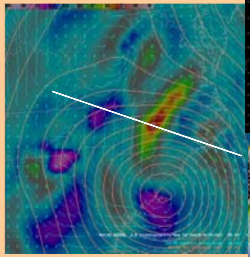
06 UTC 6 Sept

• The cooling from pre-storm rainbands produced in-situ cold air damming along the eastern slopes of the Appalachians, as well as contributed to a diabatically enhanced thermal gradient (weak coastal front) along the NC coast.
• As TS Hanna approached from the south, strengthening easterly winds and moisture flux pushed the coastal front inland toward the in-situ cold air damming airmass.

40km RUC 2-D frontogenesis and potential temperature

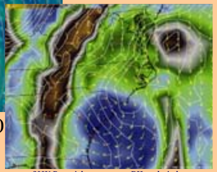
(1)





40km RUC 2-D frontogenesis, MSLP, and 10m Winds

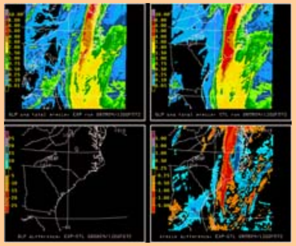
(2)



300K Potential temperature, RH, and wind

•The interaction of the westward moving coastal front and the residual cool, stable layer caused increasing frontogenesis (1) and enhanced isentropic lift (2) as air ascended the stable layer.

WRF Simulations



•Removing the effects of terrain from a WRF (Version 3) control simulation caused a noticeable reduction and eastward shift in areal extent of the heaviest rainfall associated with TS Hanna.
•Because there is little difference in the track in the CTRL and NOTER runs, it appears the heaviest rain fell more along track than in the CTRL run.

Conclusions:

• The interaction of an inland moving coastal front and in-situ cold air damming caused enhanced frontogenesis and isentropic lift to the left of the track of TS Hanna.
• WRF model simulations reveal the importance of the local terrain in the formation of in-situ cold air damming and LOT rainfall shift. Without the mountains, rainfall was reduced and shifted closer to the track of the storm.
• Based on analysis of other events, this type of mesoscale interaction has occurred with other tropical systems and coastal troughs/fronts.