



The Effects of Dry Air Ridging on the Rainfall Distribution of

Tropical Storm Hanna

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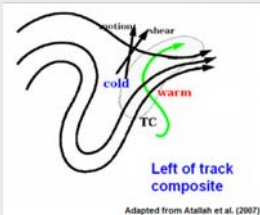
Raleigh, North Carolina



Introduction:

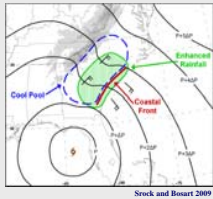
Rainfall distribution in landfalling tropical cyclones is known to be driven by:

- 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:

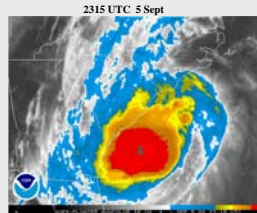
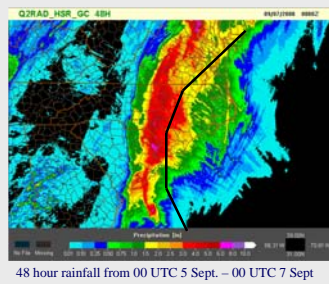
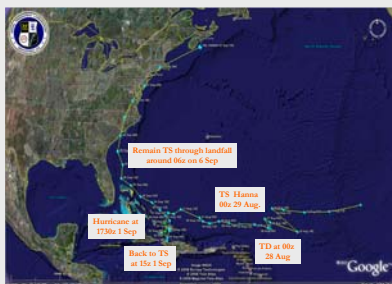
- Orographically forced ascent
- Coastal frontogenesis
- Cold air damming



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.

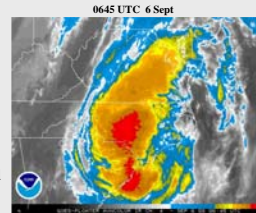
Track and Rainfall:

- Annotated track of TS Hanna



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



Track and Rainfall:

- Annotated track of TS Hanna

Remains TS through landfall around 06c on 6 Sep

Hurricane at 1730c 1 Sep

TS Hanna 00z 29 Aug

Back to TS at 15z 1 Sep

TD at 06z 28 Aug

Google

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

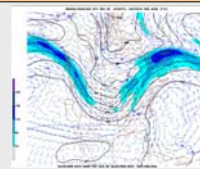
This is indicative of extra-tropical transition and increased baroclinity

0645 UTC 6 Sept

Acknowledgments

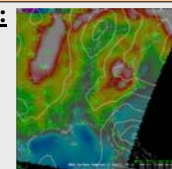
The authors would like to thank forecasters at the NWS in Raleigh, NC, Dr. Gary Lackmann at North Carolina State University, and NWS Eastern Region Headquarters for their assistance and input on this work.

Upper Air:



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:



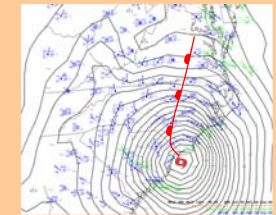
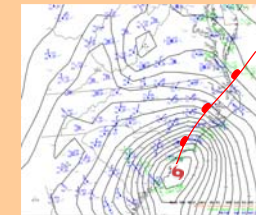
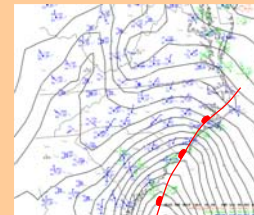
On the morning before Hanna made landfall, a strong, dry high pressure ridge extended from the Mid-Atlantic into the Southeast U.S.

Radar:

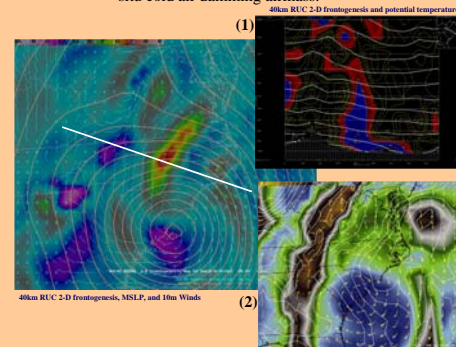


- Rainbands ahead of TS Hanna cooled portions of central and western NC through evaporational cooling as rain fell into the dry air ridge
- A large, north-south oriented band of heavy rainfall became nearly stationary over central North Carolina as the center of TS Hanna moved inland.

Surface:



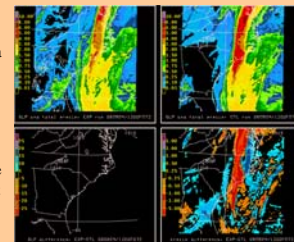
- The cooling from pre-storm rainbands produced in-situ cold air damming along the eastern slopes of the Appalachians, as well as contributed to a diabatically enhanced thermal gradient (weak coastal front) along the NC coast.
- As TS Hanna approached from the south, strengthening easterly winds and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



- 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.

- 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.

WRF Simulations



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.