A Climatology of Warm Season Cold Air Damming and Tropical Cyclones in the Southeast U.S.

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Motivation

- It is known that cold air damming (CAD) can occur while tropical cyclones (TC) are impacting the southeast and Mid-Atlantic states, and that CAD can have an impact on rainfall distribution by enhancing mesoscale lift Srock and Bosart (2009).
- What was not known is how often CAD occurs during these events. This project attempts to objectively quantify how often CAD occurs as tropical cyclones passed through or close to the southeast U.S.
- A climatology of CAD events will enhance situational awareness of forecasters in the days and hours preceding landfall.

Background

- Srock and Bosart (2009) outlined mesoscale features that enhance precipitation associated with TCs making landfall over the southeast U.S., including CAD (Fig. 1).
- While typically a cool season phenomenon, it has been shown that CAD can enhance lift via isentropic ascent as warm, tropical air ascends the more dense cool pool, as well as strengthening frontogenesis along the CAD/wedge airmass.

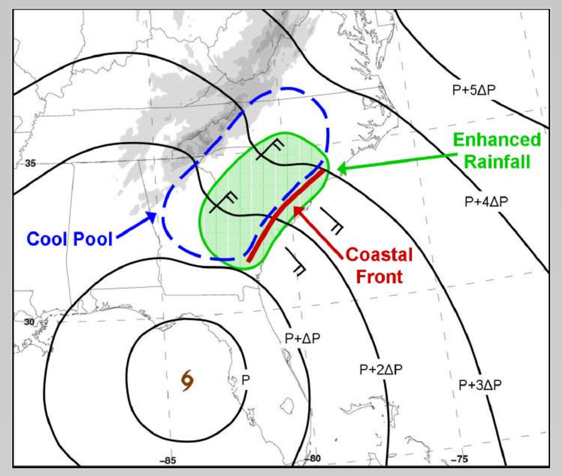

Fig. 1 Schematic of the influence of CAD and the coastal front on TC related precipitation . From Srock and Bosart (2009)

Methodology and Event Identification

- All TCs passing through the southeast U. S. and Mid-Atlantic region between 1995-2012 were evaluated for CAD occurrence during the lifespan of the TC.
  - Used a technique outlined by Bailey et al. (2003).
  - If observed mean sea-level pressure and potential temperature criteria were met along with at least one of three cross-sections in Figure 3 for six consecutive hours, then CAD occurred.
  - If the criteria was met along multiple cross-sections, then the CAD was considered "Strong."
- 54 TCs were identified.
  - 27 with CAD
  - 14 with Strong CAD
  - 27 with No CAD


Fig. 2. Domain chosen for selecting TC cases.

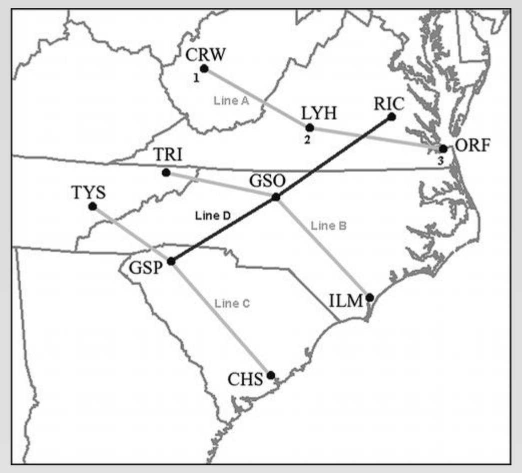

Fig. 3. Line segments used for CAD occurrence calculations, from Bailey et al. (2003).

TC Tracks

- Tracks for both CAD and No-CAD cases typically originated in the sub-tropical Atlantic, Caribbean or Gulf of Mexico.
- TCs for the CAD cases typically moved northeast through the study domain, generally between the Appalachians and the Gulf Stream.
- No-CAD TCs typically moved west of the Appalachians or along the Southeast coast.

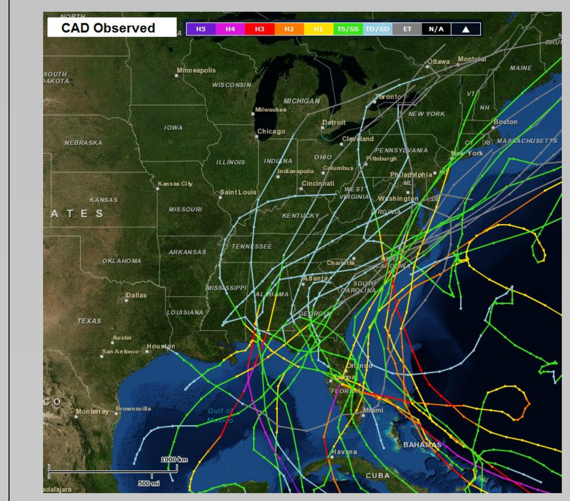
Fig. 4. Track map for 27 CAD cases.

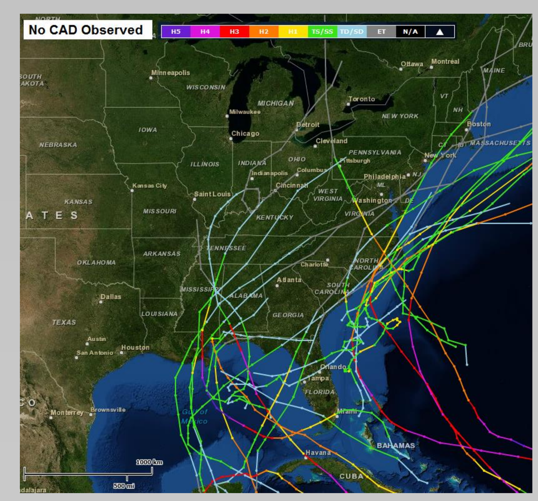
Fig. 5. Track map for 27 No CAD cases.

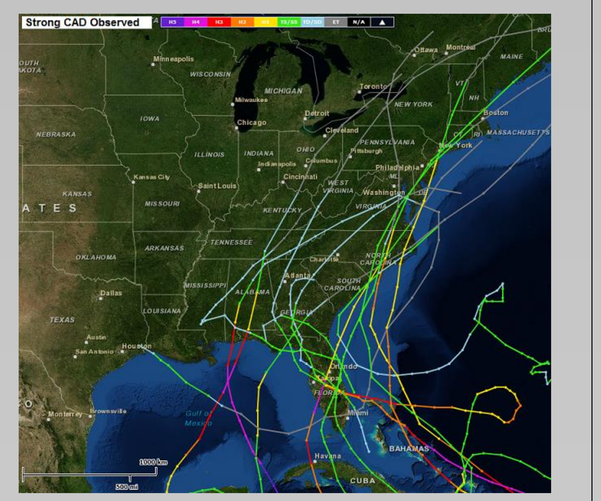
Fig. 6. Track map for 14 Strong CAD cases.

CAD Onset and Surface Maps

- A plot of the location of each TC at the onset of CAD shows a large majority of the TCs were located over Florida, southern Georgia, southern Alabama, or the northeast Gulf of Mexico.

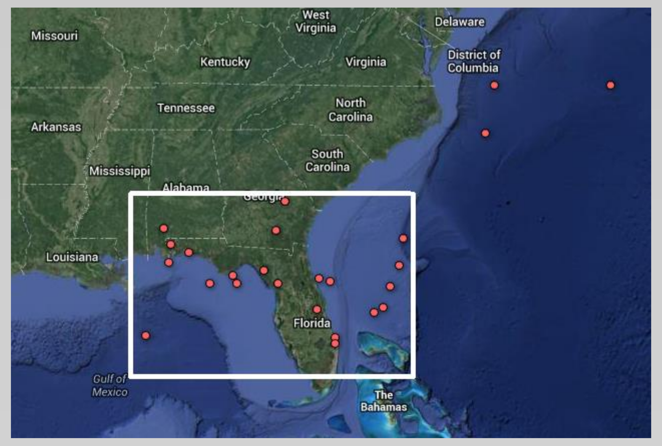
Fig. 7. Track map for 27 CAD cases.

CAD Cases

- In classic CAD cases, the presence of a strong surface high pressure system over New England is critical for the development of CAD.
- Surface map analyses indicate a pattern of moderately strong high pressure systems near the Great Lakes, New England, or Mid-Atlantic coast at the onset of CAD.

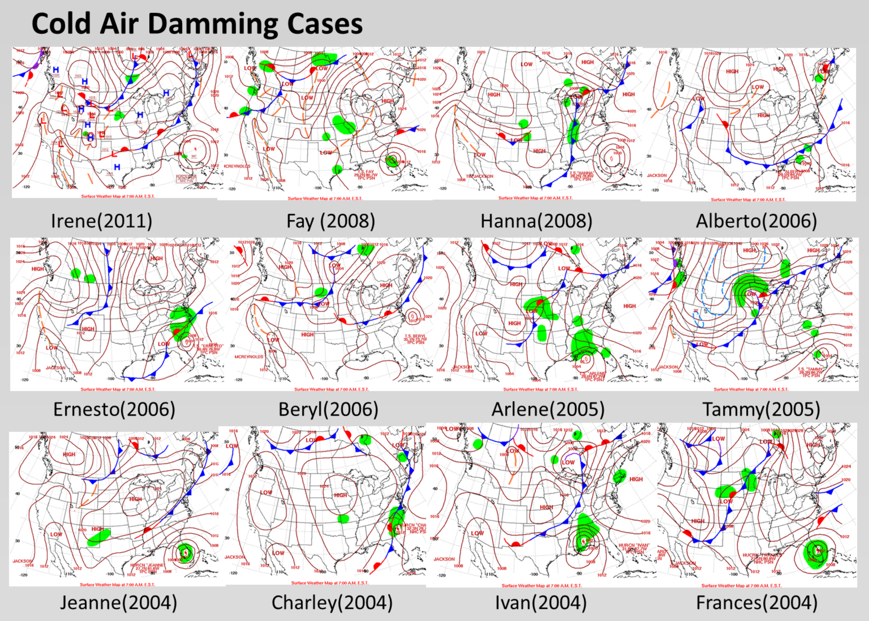

Fig. 8. Surface map analysis at the time of CAD onset for each CAD case.

No-CAD Cases

- A surface high is present near the East Coast in No-CAD cases, but it appears to be weaker and not located in the preferred location over New England.
- In many cases, the surface high is located well offshore of the Mid-Atlantic states.

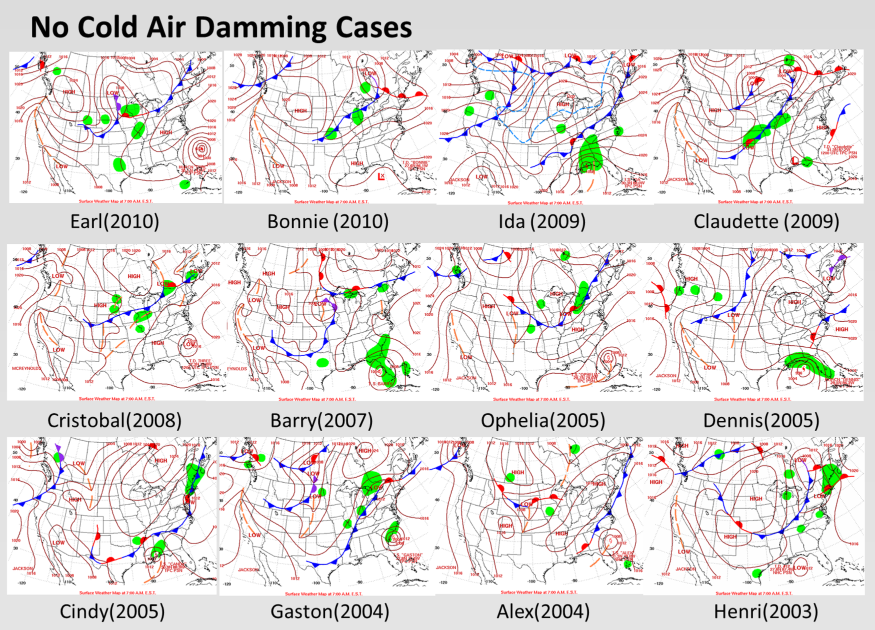

Fig. 9. Surface map analysis when each NO CAD storm crossed 29° N.

Composite Maps

- Using the cluster of TC locations within the domain in Figure 7, composites were created from the NCEP/NCAR reanalysis dataset, including the following:
  - –MSLP Mean and Anomaly
  - –500 hPa Mean and Anomaly
- Because the No-CAD cases do not have an onset time, the average latitude for the onset of CAD cases of 29° N was used as the input time for the No-CAD composites.
- Mean and anomaly composite plots were created using NCEP/NCAR Reanalysis data for 500 hPa heights and sea-level pressure.
- The mean 500 hPa geopotential heights for both the CAD and No-CAD cases depict a zonal pattern though the No-CAD composites show some slight troughing in the eastern Great Lakes.
- There is a much larger positive height anomaly over eastern Canada and New England in the CAD cases compared to the No-CAD cases.
- A larger positive mean sea-level pressure anomaly is present over the northeastern U.S. in the CAD cases.

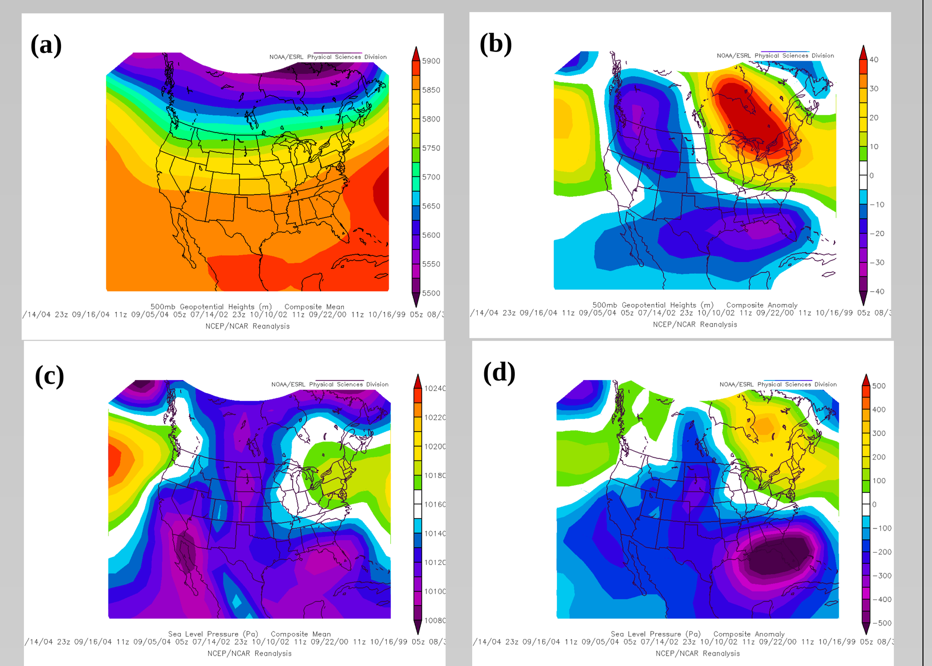
Fig. 10. For CAD cases, composite plots of a) 500 hPa geopotential height, b) geopotential height anomaly, c) mean sea-level pressure, and d) sea-level pressure anomaly

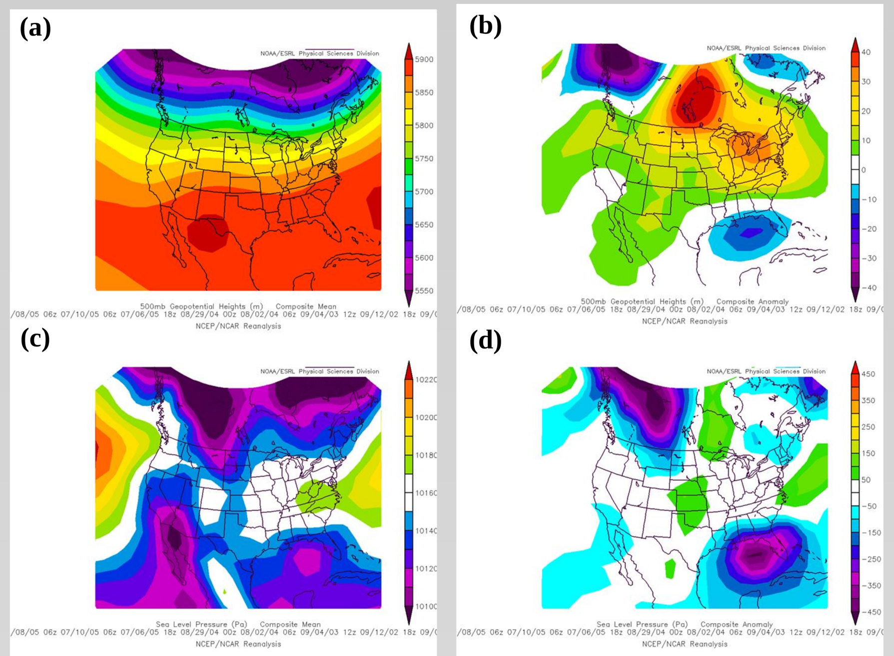
Fig. 11. Same as in Figure 10, but for NO CAD cases

Conclusions

- Cold air damming was found to have occurred during the lifespan of half (27 of 54) of the TCs passing near or across the southeast U.S. between 1995-2012.
- Of the 27 CAD cases, 14 were considered strong CAD cases.
- Most TCs were located near northern Florida at the onset of CAD.
- For the CAD cases, the surface high pressure system was stronger and more often located in a more favorable position over New England.
- For the No-CAD cases, the surface high pressure was typically weaker and centered either well to the west of the region or off the Mid-Atlantic coast.