Late Season Tropical Cyclogenesis in the Northeastern Atlantic Ocean: 1975-2005

Rachel Grant Mauk
Department of Geography, The Ohio State University, Columbus OH 43210

An Atypical Area

- Late season tropical cyclones (LSTCs) not uncommon
- Twenty LSTCs formed in NE Atlantic from Oct-Dec in 1975-2005 seasons
- Ten formed from 2000-2005
- Nine tropical storms, eleven hurricanes, no major hurricanes
- High wind shear, low sea surface temperatures (SSTs) common
- Environment usually unfavorable for tropical cyclone development

Why Study LSTCS?

- Tropical cyclogenesis in any environment not completely understood
- Transition from extratropical or subtropical to tropical cyclone not understood
- "Hybrid" systems (between subtropical and tropical) also not understood
- Affect shipping, occasionally land
  - US, Canada, Bermuda, Caribbean, Azores, Europe
- Destructive: 1991 "Perfect Storm", Noel 2007
- Ten LSTCs since 2000: influence of climate change?

Project Details

Systems selected for:

- Location: north of 20ºN, east of 60ºW
- Time: after 1 Oct. from 1975-2005
  - Consistent satellite classification after 1975
- National Hurricane Center (NHC) designation:
  - Tropical **AND**
  - Maximum wind ≥34 knots **FOR**
  - ≥6 hours
- Wind data from NCEP/NCAR Reanalysis II (Kalnay et al. 1996)
- SST data from Reynolds Weekly SST fields v. 2 (Reynolds et al. 2002)

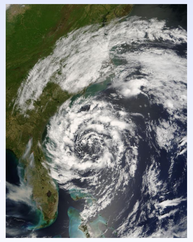
Basic Types of Cyclones

TROPICAL

- Organized clouds at center
- Non-frontal
- Warm at upper-level center
- Maximum winds close to center
- Scale < 500 km

SUBTROPICAL

- Limited clouds at center
- Non-frontal
- Cold at upper-level center
- Maximum winds away from center
- Scale < 750 km



EXTRATROPICAL

- Variable cloud patterns
- Frontal or non-frontal
- Cold at upper-level center
- Maximum winds away from center
- Scale < 2000 km

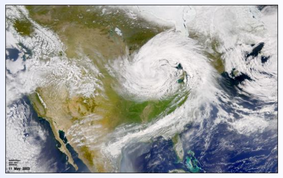


Figure 1. Diagram of three basic cyclone types. Tropical image is of Hurricane Katrina (2005). Subtropical imagery is of Subtropical Storm Andrea (2007). Extratropical system is from May 2003. Satellite imagery courtesy Earth Observatory, NASA GSFC.

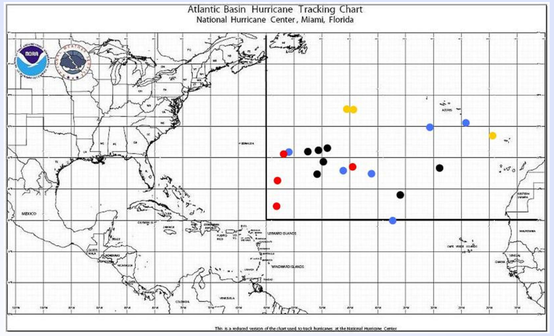


Figure 3. Position of each LSTC at time of genesis. Thick black lines demarcate spatial boundaries for the study.
Type I Type II Type III Type IV

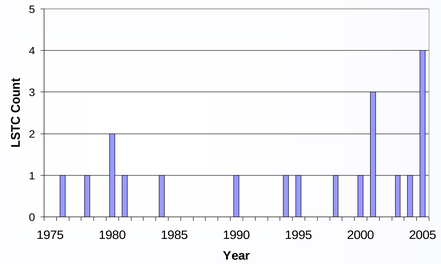


Figure 4. Histogram of LSTCs by year.

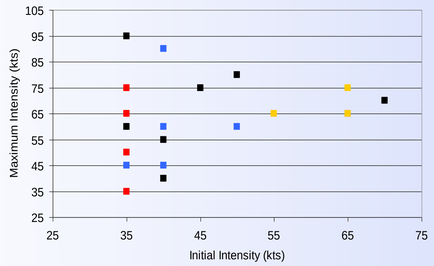
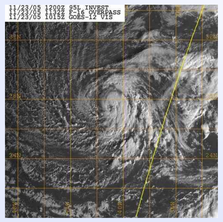


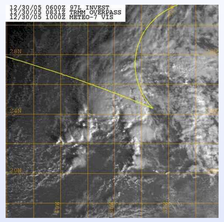
Figure 5. Graph of maximum intensity versus intensity at genesis.

Classification of LSTCs

TYPE I (6)

Initial system is non-tropical, non-frontal, and pre-existing. Convection fires near center of system, wind radii contract.



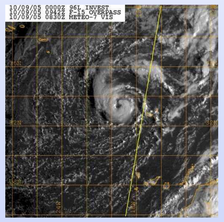


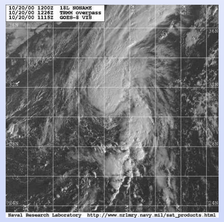
TYPE II (7)

Initial system is a frontal low. Front stalls in central Atlantic, low spins up as frontal structure dissipates.

TYPE III (3)

Initial system is an occluded extratropical cyclone. Frontal structure dissipates, convection fires around low.





TYPE IV (4)

Initial system is tropical wave or circulation. Development occurs by typical tropical process.

Figure 2. Visible satellite images and genesis descriptions of one system from each LSTC type. Number in parentheses is number of systems matching each type. Images are taken from the Naval Research Labs' Tropical Cyclone Page, Marine Meteorology Division, Monterey, California.

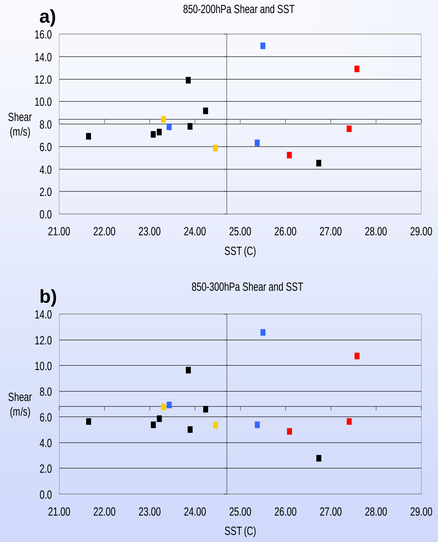


Figure 6. Graphs of shear and SST averaged over 24 hours prior to genesis for a) 850-200hPa and b) 850-300hPa layers. Shear and SST calculated on 5x5 grids centered on system.
Type I Type II Type III Type IV

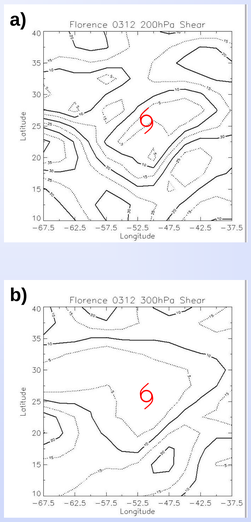


Figure 7. Shear contour plots for Florence 1994 (Type II). Note the increase in coverage of 5 m s^{-1} contour from 200hPa to 300hPa.

Conclusions

- LSTCs develop from four unique origins
- Spatial correlation with type
  - Type II near (30N,50W)
  - Type III in high latitudes
  - Type IV in SW sector
- Average SST is 24.7C
  - Tropical development threshold 26.5C (Bosart and Bartlo 1991)
- Wind shear highly variable within types
  - Area of lower shear co-located with Type I, II, III genesis location

Future Work

- Project will be continued as Master's thesis
- Continue analysis of local environment
  - Vertical temperature gradients
  - Horizontal vorticity (tendency to rotate) anomalies
- Move from genesis to persistence
  - How do LSTCs survive in low SST/high shear environments?

References

Bosart, L. F., and J. Bartlo, 1991: Tropical cyclone formation in a baroclinic environment. *Mon. Wea. Rev.*, **119**, 1979-2013.

Kalnay et al.,1996. The NCEP/NCAR 40-year reanalysis project. *Bull. Amer. Meteor. Soc.*, **77**, 437-470.

Reynolds, R.W., et al., 2002: An Improved In Situ and Satellite SST Analysis for Climate. *J. Climate*, **15**, 1609-1625.

Acknowledgments

This project was funded by an Undergraduate Research Scholarship from the Colleges of the Arts and Sciences. Their generosity is greatly appreciated.

I would like to thank the Honors College for all the opportunities they have provided during my time here. I also thank my Honors adviser, Joanna Spanos, and my thesis adviser, Dr. Jay Hobgood, for supporting me in academics and in life. I would not be what I am without your guidance.