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

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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

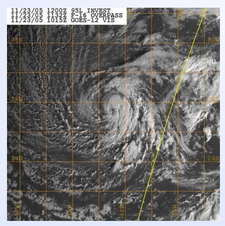
EXTRATROPICAL
- Variable cloud patterns
- Frontal or non-frontal
- Cold at upper-level center
- Maximum winds away from center
- Scale < 2000 km

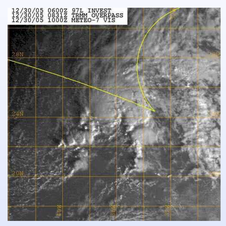
Figure 1. Diagram of three basic cyclone types. Tropical image is of Hurricane Katrina (2005). Subtropical imagery is of Subtropical Storm Andrea (2007). Extratropical system is from May 2003. Satellite imagery courtesy Earth Observatory, NASA GSFC.

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.



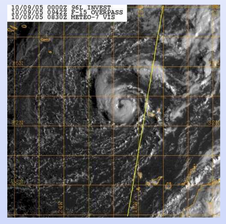


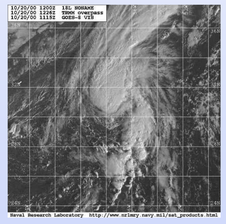
TYPE II (7)

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.

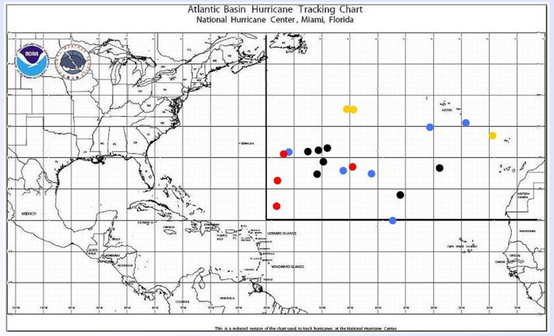


Figure 3. Position of each LSTC at time of genesis. Thick black lines demarcate spatial boundaries for the study.

Type I Type II Type III Type IV

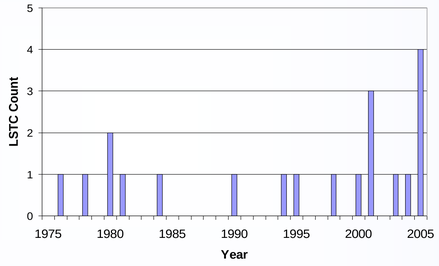


Figure 4. Histogram of LSTCs by year.

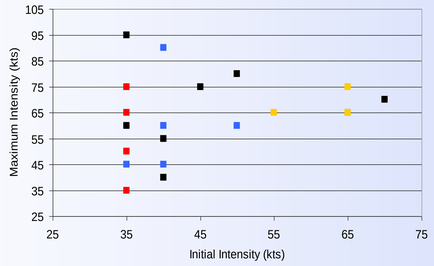
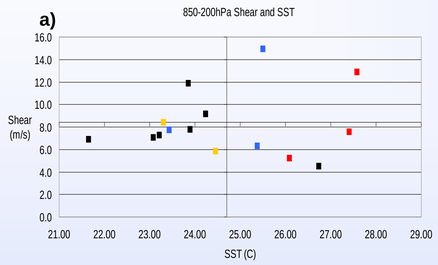


Figure 5. Graph of maximum intensity versus intensity at genesis.



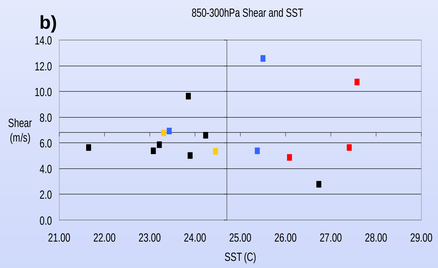
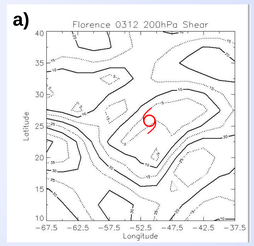


Figure 6. Graphs of shear and SST averaged over 24 hours prior to genesis for a) 850-200hPa and b) 850-300hPa layers. Shear and SST calculated on 5x5 grids centered on system.

Type I Type II Type III Type IV



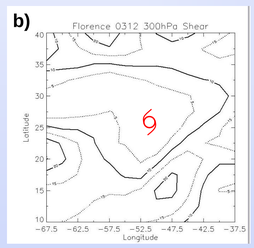


Figure 7. Shear contour plots for Florence 1994 (Type II). Note the increase in coverage of 5 m s^{-1} contour from 200hPa to 300hPa.

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.

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