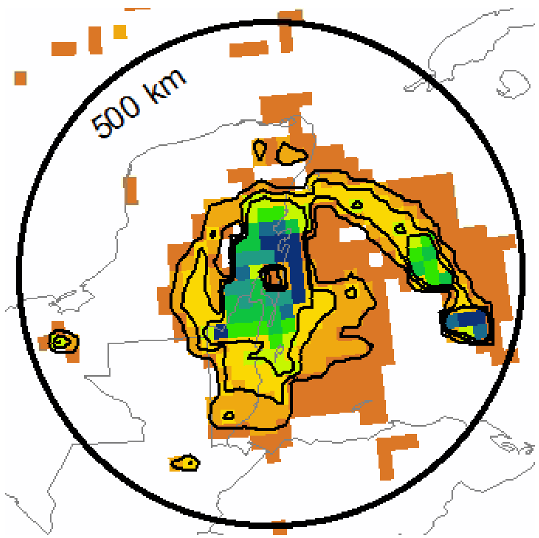
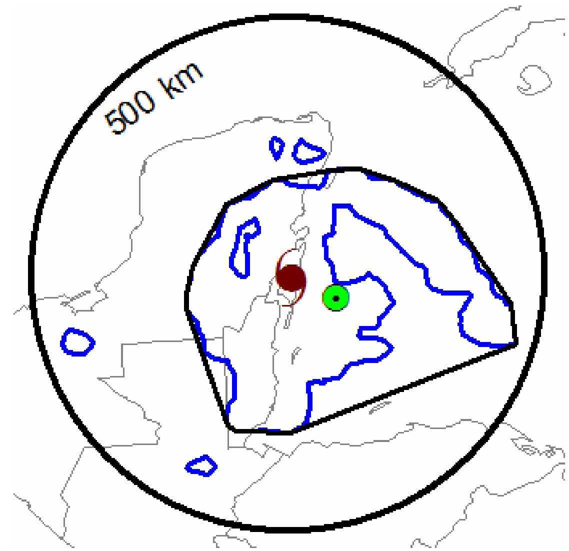
A GIS analysis of rain field size for tropical cyclones before and after landfall using data from TRMM





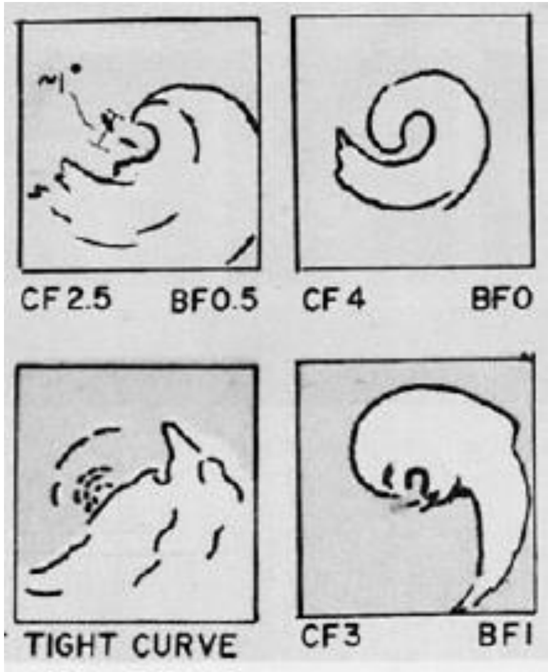
CAREER Award
BCS-1053864

Dr. Corene Matyas
Department of Geography
University of Florida

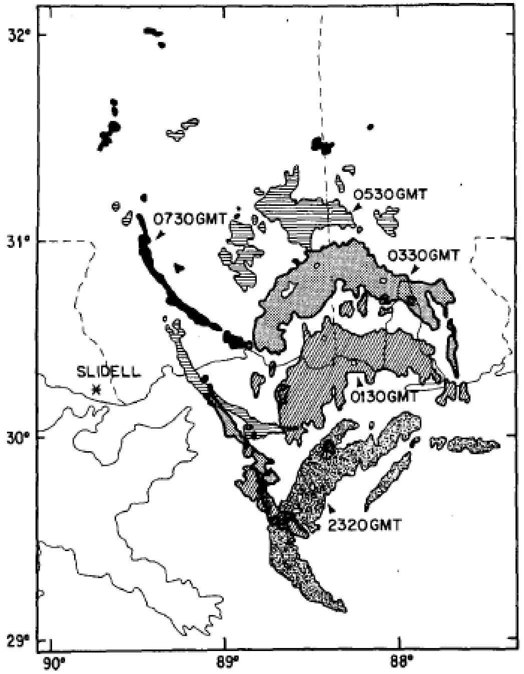
hurricane.geog.ufl.edu

Intensity: TC Shapes and Rain Rates

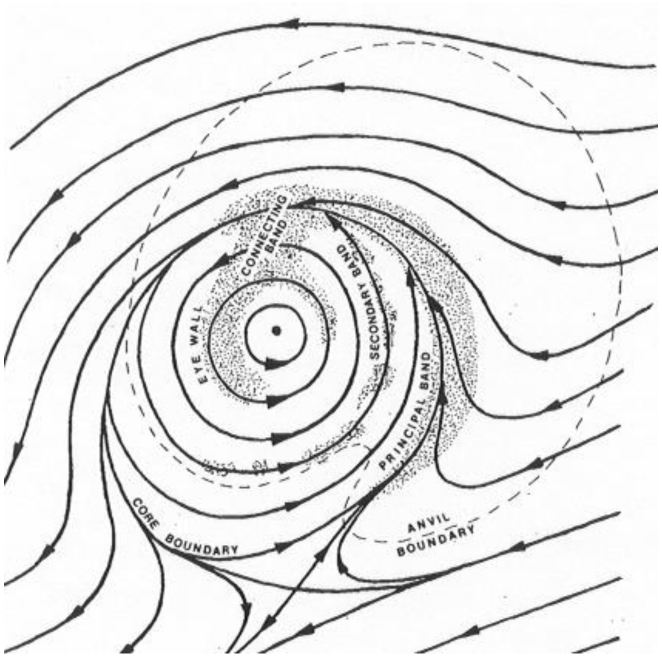
TC intensity analysis using satellites (Dvorak 1975)



Radar reflectivity (Parrish et al. 1982)



Rainband structures (Willoughby et al. 1984)

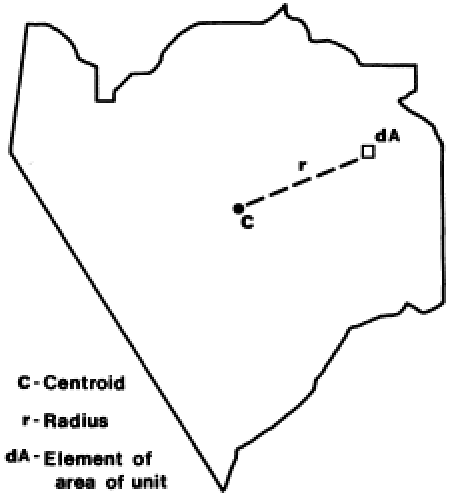


E.g., Rao and Macarthur 1994; Rodgers and Pierce 1995; Velden et al. 1998; Cerveny and Newman 2000; Lonfat et al. 2004; Cecil et al. 2005; Matyas 2007; Shepherd et al. 2007

Geographers Measure Space

Spatial Attributes: Location, symmetry, area, compactness, smoothness

E.g., Boyce and Clark 1964; Lee and Sallee 1970; Frolov 1975; Wentz 2000; Williams and Wentz 2008; Li et al. 2014

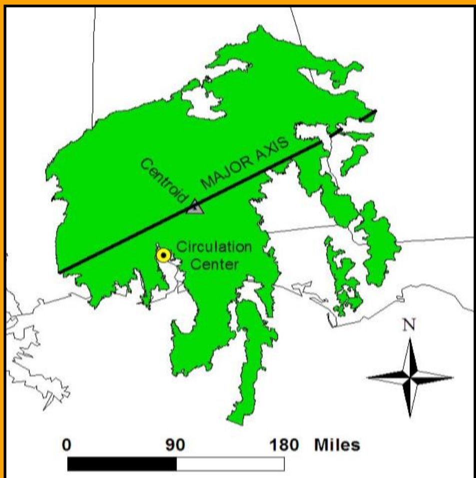


Dispersion about centroid (MacEachren 1985)

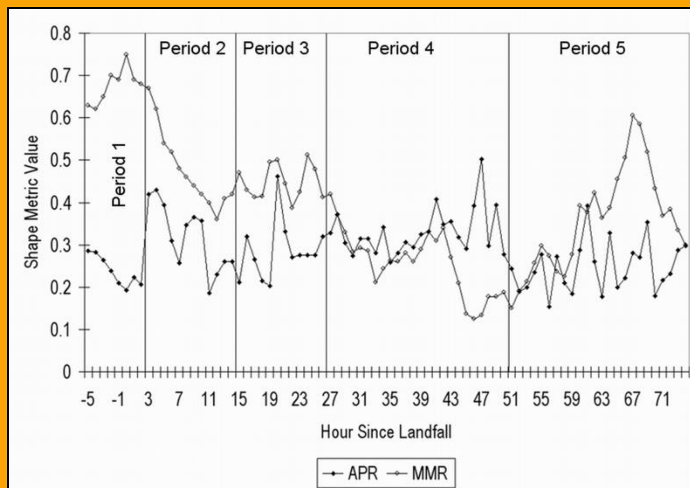
Applications to tropical cyclones

- Intensity
- Vertical wind shear
- Dry air entrainment

Previous Work

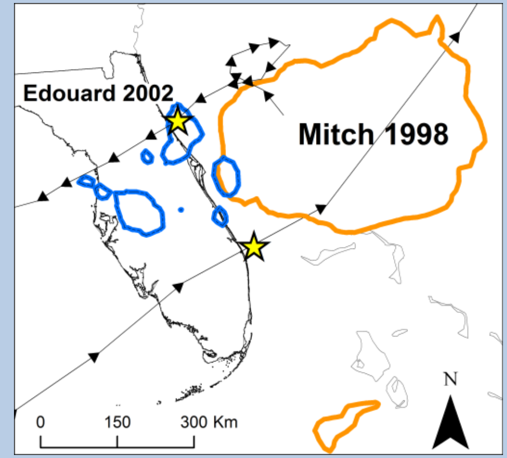


Matyas (2007)
Professional Geographer



Matyas (2008)
Meteorological Applications

- Level III Base Reflectivity Data
- Calculate measures of geometry
- Relate rain field shapes to environmental conditions



Matyas (2014)
Physical Geography

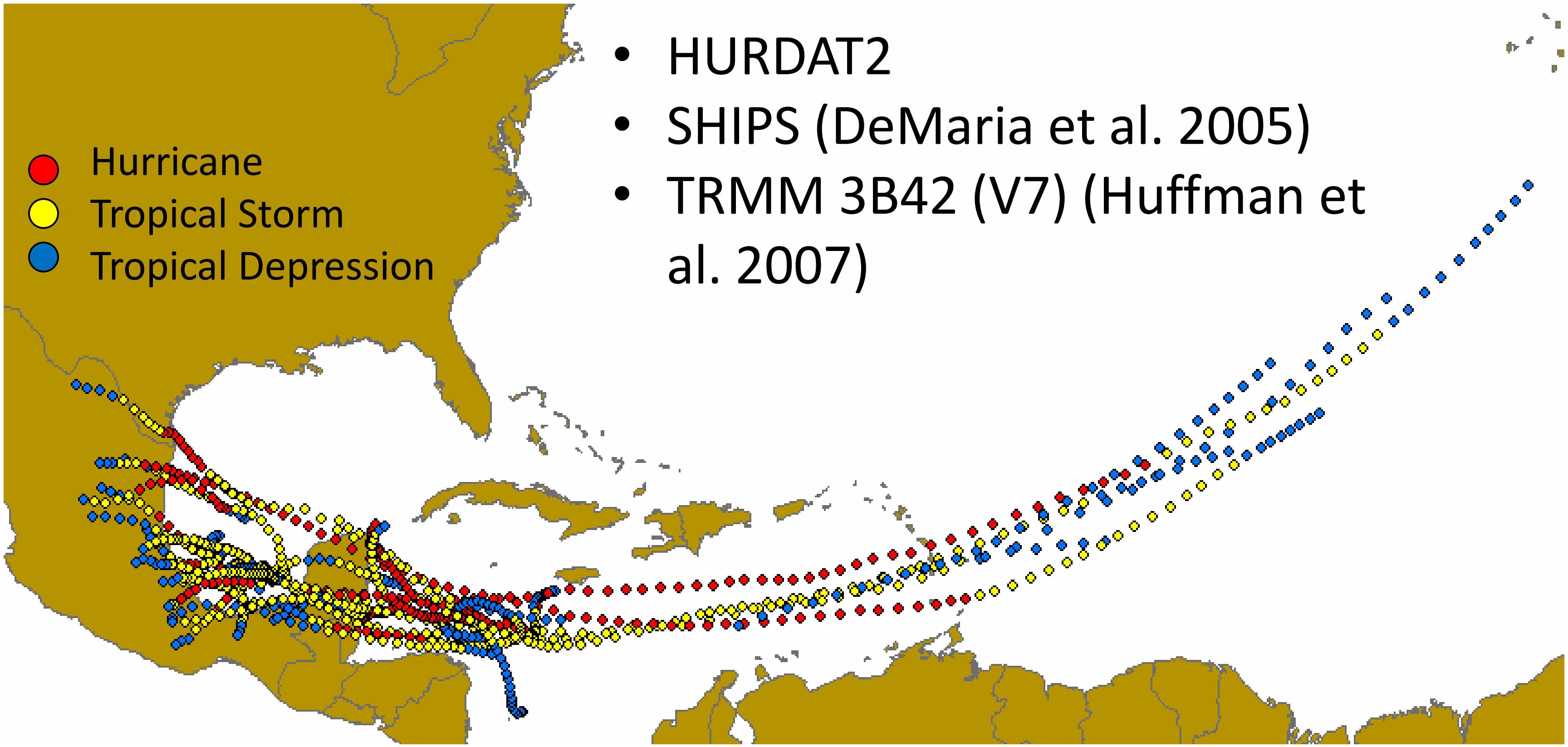
- TRMM 3B42
- 5 mm/hr areas
- Florida landfalls
- Largest areas:
ET conditions and intensity

Research Goals

Expand upon Matyas' (2014) TRMM analysis by

- Examine additional rain rate thresholds
- Omitting ET influence
- Calculating additional spatial metrics
- Examining entire TC lifecycle

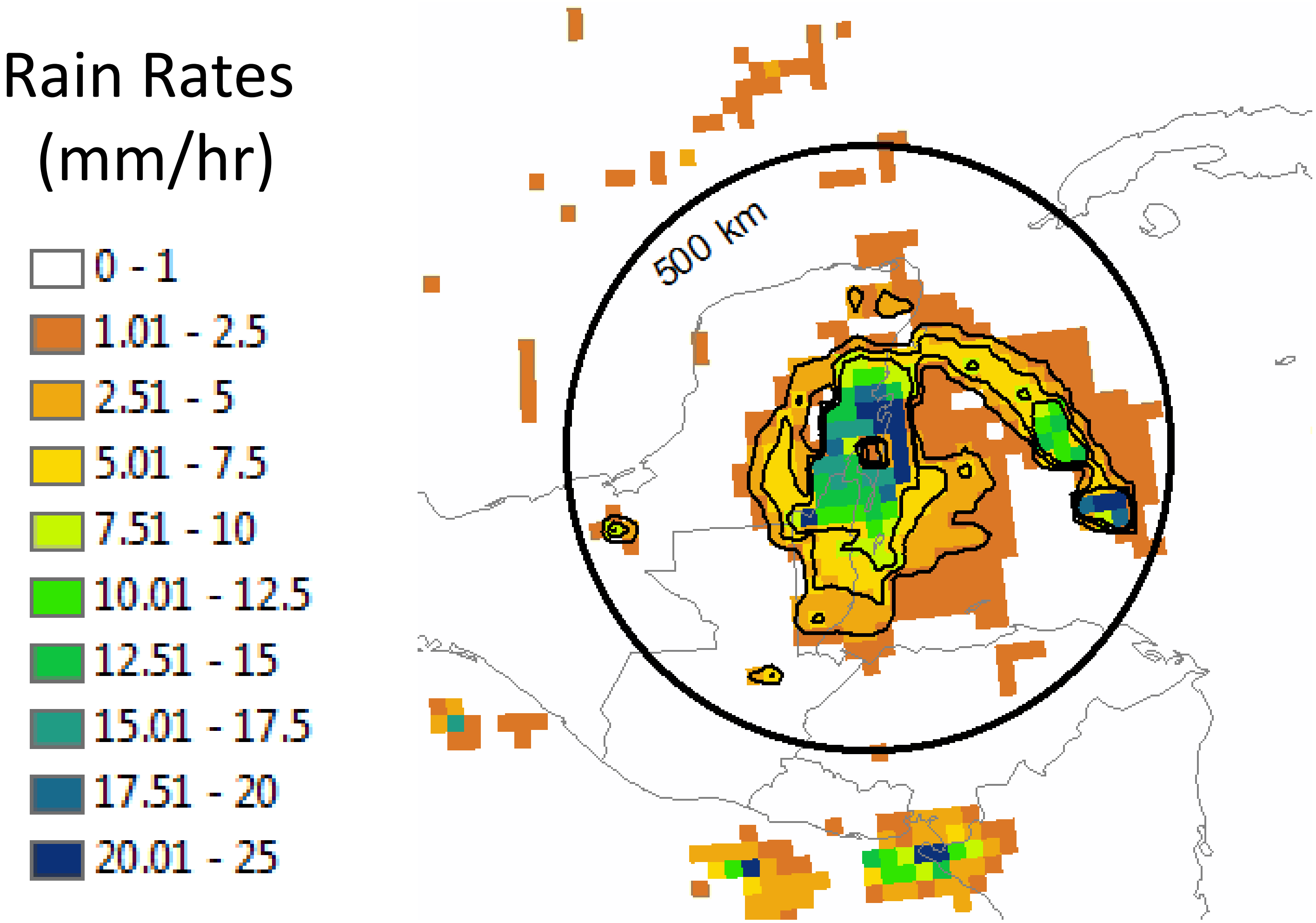
Data



- HURDAT2
- SHIPS (DeMaria et al. 2005)
- TRMM 3B42 (V7) (Huffman et al. 2007)

- 985 TRMM observations June – October 2000-2012
- Formation: Atlantic Ocean, Caribbean Sea, Gulf of Mexico
- Landfall: Mexico
- No extratropical storms

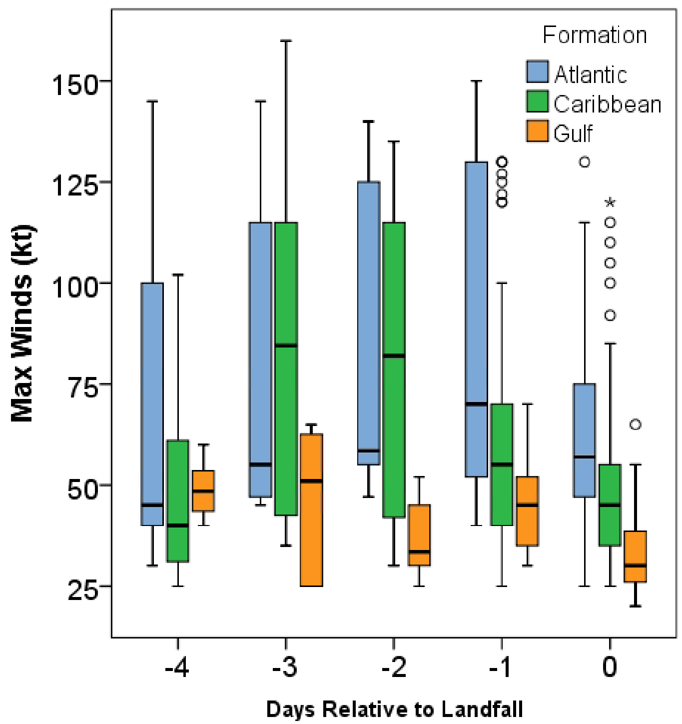
GIS Analysis Example: Dean 2007

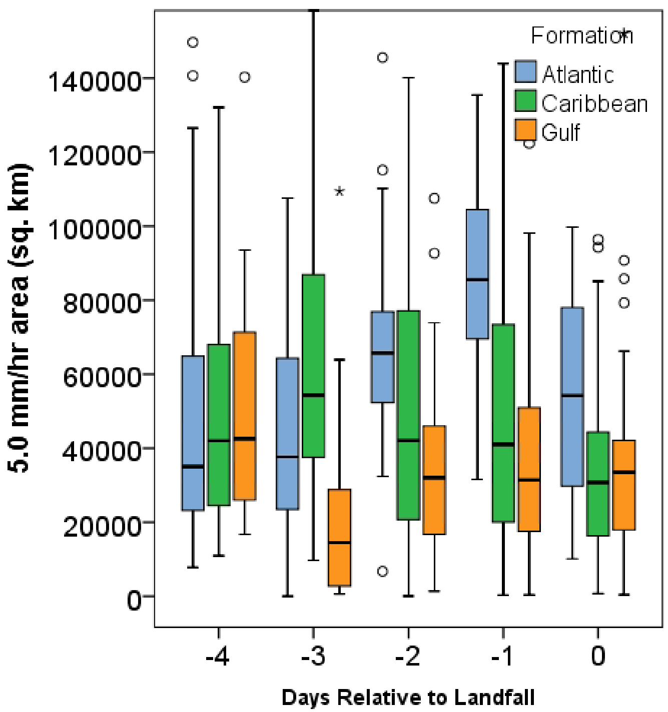


Polygons bounded by
2.5 mm/hr
5.0 mm/hr
7.5 mm/hr

Area Results: Intensity

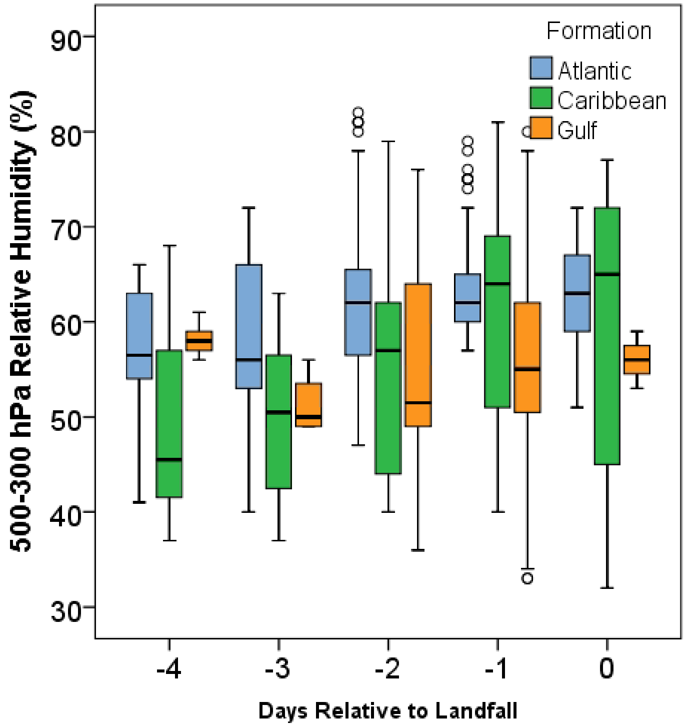
- Atlantic and Caribbean formation regions
- Spearman's Rank correlation coefficients 0.425 -0.620
- Peak in intensity and rainfall area 1-24 h before landfall Atlantic, 49-72 h Caribbean

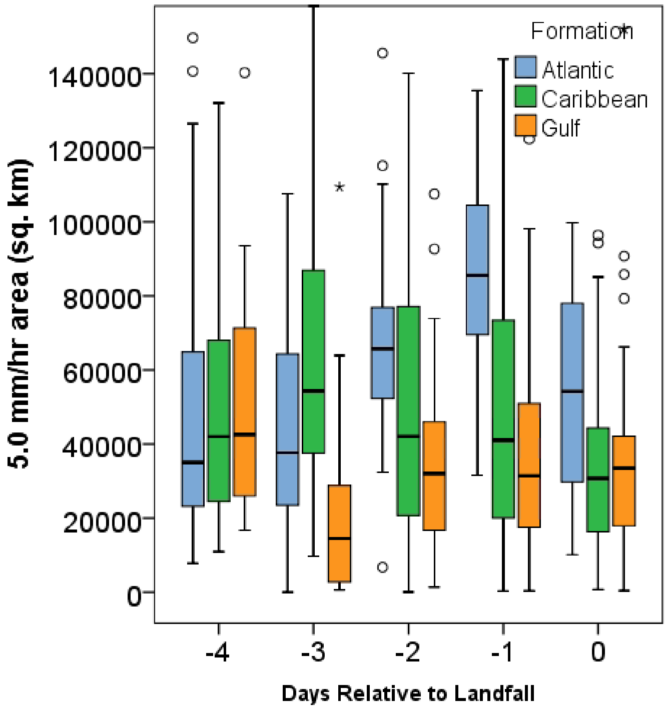




Area Results: Moisture

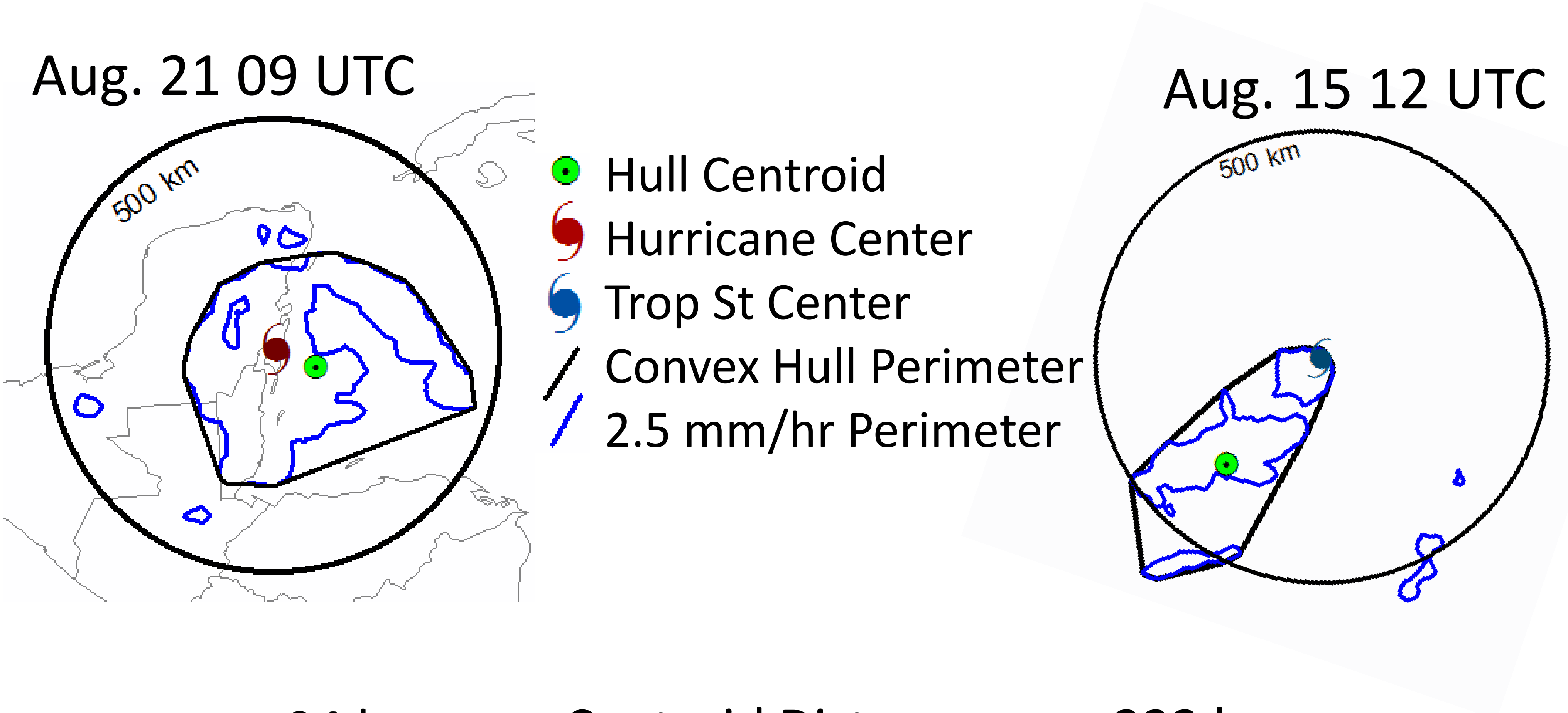
- Gulf formation region – highest correlation
- Some association: Atl and Carib regions
- SR Corr Coef: 0.330-0.599 with RH 850-700 hPa, 700-500 hPa, and 500-300 hPa





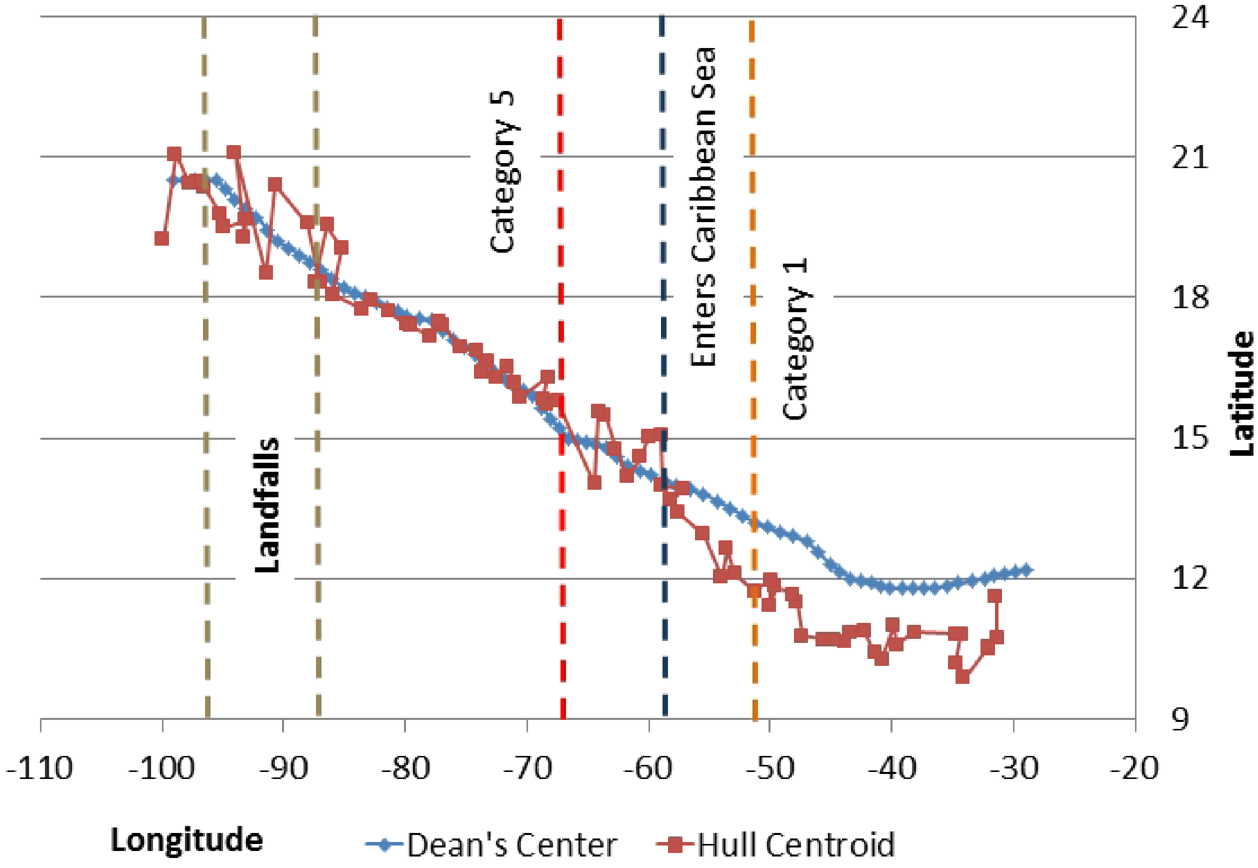
E.g., Rodgers et al. 1994; Jiang et al. 2008; Hill and Lackmann 2009; Konrad and Perry 2010; Matyas 2010, 2013

Convex Hull: Location, Symmetry, Compactness



94 km	Centroid Distance	323 km
117°	Centroid Direction	234°
0.77	Convex Hull MMR	0.41

Dean’s Center vs Convex Hull Centroid



Intensity is important but is not the only factor!

Spearman’s Rank correlation coefficents **<u>also</u>** above 0.500 for

Hull distance vs. low-level RH, storm speed, 850 hPa vorticity

Hull bearing vs. motion speed/ direction, shear speed/direction, 850 hPa vorticity

Conclusions and Future Research

- Shape metrics adequately represent relationship between TC rainbands and environmental conditions
- Intensity and moisture are key for raining areas
- Shear and storm motion important for centroid location/distance but not area

- Future work:
  – Incorporate results from shape metric calculations into predictive model for TC rainfall (e.g., TRaP)
  – Examine moisture budgets and storm structure in NARR/ compare with TRMM (Zick and Matyas, in preparation)
  – Quantify rainband spatial patterns over land using WSR-88D data (Tang and Matyas, in preparation)

Contact: matyas@ufl.edu

References (B-L)

- Boyce, R. R., and W. A. V. Clark, 1964: The concept of shape in geography. *Geographical Review*, **54,** 561-572.
- Cecil, D. J., S. J. Goodman, D. J. Boccippio, E. J. Zipser, and S. W. Nesbitt, 2005: Three years of TRMM precipitation features. Part I: Radar, radiometric, and lightning characteristics. *Mon. Wea. Rev.*, **133,** 543-566.
- Cerveny, R. S., and L. E. Newman, 2000: Climatological relationships between tropical cyclones and rainfall. *Mon. Wea. Rev.*, **128,** 3329-3336.
- DeMaria, M., M. Mainelli, L. K. Shay, J. A. Knaff, and J. Kaplan, 2005: Further improvements to the Statistical Hurricane Intensity Prediction Scheme (SHIPS). *Wea. Forecasting*, **20,** 531-543.
- Dvorak, V. F., 1975: Tropical cyclone intensity analysis and forecasting from satellite imagery. *Mon. Wea. Rev.*, **103,** 420-430.
- Frolov, Y., 1975: Measuring of shape of geographical phenomena: a history of the issue. *Soviet Geography: Review and Translation*, **16,** 676-687.
- Hill, K., and G. M. Lackmann, 2009: Influence of environmental humidity on tropical cyclone size. *Mon. Wea. Rev.*, **137,** 3294-3315.
- Huffman, G. J., and Coauthors, 2007: The TRMM multisatellite precipitation analysis (TMPA): Quasi-global, multiyear, combined-sensor precipitation estimates at fine scales. *Journal of Hydrometeorology*, **8,** 38-55.
- Jiang, H., C. Liu, and E. J. Zipser, 2011: A TRMM-based tropical cyclone cloud and precipitation feature database. *J. Appl. Meteorol. Climatol.*, **50,** 1255-1274.
- Jiang, H. Y., J. B. Halverson, and E. J. Zipser, 2008: Influence of environmental moisture on TRMM-derived tropical cyclone precipitation over land and ocean. *Geophys. Res. Lett.*, **35,** L17806.
- Konrad, C. E., and L. B. Perry, 2010: Relationships between tropical cyclones and heavy rainfall in the Carolina region of the USA. *Int. J. Climatol.*, **30,** 522-534.
- Lee, D. R., and G. T. Sallee, 1970: A method of measuring shape. *The Geographical Review*, **60,** 555-563.
- Li, W., T. Chen, E. A. Wentz, and C. Fan, 2014: NMMI: A mass compactness measure for spatial pattern analysis of areal features. *Annals of the Association of American Geographers*, **104,** 1116-1133.
- Lonfat, M., F. D. Marks, and S. Y. S. Chen, 2004: Precipitation distribution in tropical cyclones using the Tropical Rainfall Measuring Mission (TRMM) Microwave Imager: A global perspective. *Mon. Wea. Rev.*, **132,** 1645-1660.

References (M-W)

- MacEachren, A. M., 1985: Compactness of geographic shape: comparison and evaluation of measures. *Geografiska Annaler*, **67B,** 53-67.
- Matyas, C. J., 2007: Quantifying the shapes of US landfalling tropical cyclone rain shields. *The Professional Geographer*, **59,** 158-172.
- Matyas, C. J., 2008: Shape measures of rain shields as indicators of changing environmental conditions in a landfalling tropical storm. *Meteorological Applications*, **15,** 259-271.
- Matyas, C. J., 2010: Associations between the size of hurricane rain fields at landfall and their surrounding environments. *Meteorol. Atmos. Phys.*, **106,** 135-148.
- Matyas, C. J., 2013: Processes influencing rain-field growth and decay after tropical cyclone landfall in the United States. *J. Appl. Meteorol. Climatol.*, **52,** 1085-1096.
- Matyas, C. J., 2014: Conditions associated with large rain-field areas for tropical cyclones landfalling over Florida. *Phys Geogr*, **35,** 93-106.
- Parrish, J. R., R. W. Burpee, F. D. Marks, and R. Grebe, 1982: Rainfall patterns observed by digitized radar during the landfall of Hurricane Frederic (1979). *Mon. Wea. Rev.*, **110,** 1933-1944.
- Rao, G. V., and P. D. Macarthur, 1994: The SSM/I estimated rainfall amounts of tropical cyclones and their potential in predicting the cyclone intensity changes. *Mon. Wea. Rev.*, **122,** 1568-1574.
- Rodgers, E. B., and H. F. Pierce, 1995: A satellite observational study of precipitation characteristics in western North Pacific tropical cyclones. *J. Appl. Meteor.*, **34,** 2587-2599.
- Rodgers, E. B., J. J. Baik, and H. F. Pierce, 1994: The environmental influence on tropical cyclone precipitation. *J. Appl. Meteor.*, **33,** 573-593.
- Shepherd, J. M., A. Grundstein, and T. L. Mote, 2007: Quantifying the contribution of tropical cyclones to extreme rainfall along the coastal southeastern United States. *Geophys. Res. Lett.*, **34,** L23810.
- Velden, C. S., T. L. Olander, and R. M. Zehr, 1998: Development of an objective scheme to estimate tropical cyclone intensity from digital geostationary satellite infrared imagery. *Wea. Forecasting*, **13,** 172-186.
- Wentz, E. A., 2000: A shape definition for geographic applications based on edge, elongation, and perforation. *Geographical Analysis*, **32,** 95-112.
- Williams, E. A., and E. A. Wentz, 2008: Pattern analysis based on type, orientation, size, and shape. *Geographical Analysis*, **40,** 97-122.
- Willoughby, H. E., F. D. Marks, and R. J. Feinberg, 1984: Stationary and moving convective bands in hurricanes. *J. Atmos. Sci.*, **41,** 3189 - 3211.