Measuring the width of rainfall swaths produced by landfalling tropical cyclones over the northeastern U.S.

University of Florida
Tropical Cyclone Rainfall Group

Yao Zhou, Corene J. Matyas
Department of Geography, University of Florida
Contact: yaozhou@ufl.edu, hurricane.geog.ufl.edu

National Science Foundation
WHERE DISCOVERIES BEGIN
Funded by CAREER Award Grant: BCS 1053864

Introduction

Rainfall from tropical cyclones (TCs) can induce freshwater flooding that leads to loss of life. An improved understanding of the spatial distribution of rainfall associated with TCs as they move over land could help to identify which flood-prone regions should be warned in advance of the TC's arrival. Many TCs tracking northward over the northeastern U.S. have produced heavy rainfall that caused flooding due to their interaction with elevated terrain and/or their transition into extratropical cyclones. This process is generally referred to as extratropical transition (ET). About 45% TCs of North Atlantic basin undergo ET (Hart and Evans, 2001). Previous research has found that as ET proceeds, the distribution of heavy precipitation appear to the left of track (Jones et al., 2003). Yet few studies have quantified how wide the area receiving TC rainfall is and how this width changes as the TC moves inland. This study explores the spatial patterns of rainfall produced by TCs tracking northward over the eastern U.S. and making transition to extratropical cyclones using a Geographic Information System (GIS). The results include the average width of the rainfall swaths and characteristics of width change as these TCs move inland.

Data

- 55 TCs tracking northward over the eastern U.S. and making ET during 1948-2011
- TC positions obtained from IBTrACs from National Climate Data Center (NCDC)
- Daily precipitation totals on 0.25°× 0.25° latitude-longitude grid from the National Centers for Environmental Prediction (NCEP) - Climate Prediction Center Unified Precipitation Dataset (UPD)

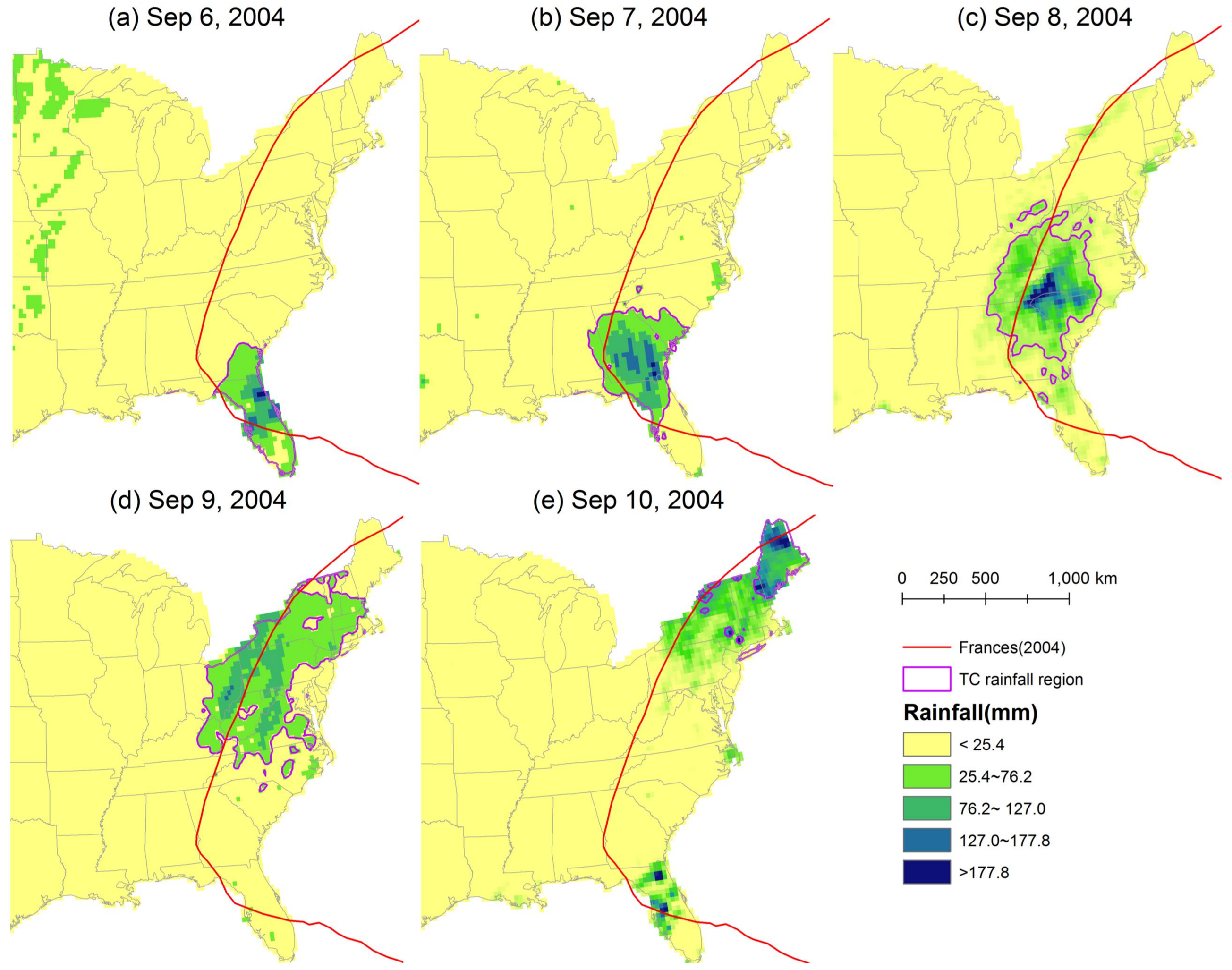

Figure 1 Daily rainfall of Frances (2004)

Method

- TC rainfall totals are calculated by summation of daily precipitation beginning 24 hours before the storm's first U.S. landfall, and ending 24 hours after the storm left the U.S or dissipated over land. Most TCs spent parts of 4 days producing rainfall over the U.S.
- A contour method is utilized to generate TC rainfall regions. For each day and total period, all contour polygons that are over a threshold value of 25 mm and within 500 km of track are selected as potential TC rainfall regions (Figure 1 a:e).
- All selected daily rainfall regions in TC period are merged (area surrounded by purple line). The potential TC total rainfall regions (shaded area) which have overlapping area with merged daily region are defined as the TC rainfall region. This method excludes rainfall produced by other weather systems (Figure 2).
- The widths of rainfall swath on left side of the track are calculated every 50 km along the track beginning at the point of landfall (Figure 3).
- A moving average of 3 points is calculated to smooth the distance measurements.
- Classify trend in change of width as increasing, decreasing, or no change overall and relative to the time that the TC is defined as extratropical cyclone by National Hurricane Center (NHC).

Results

- The average distance from track to TC rainfall edge is 290 km on left side. Maximum widths neared 960 km (e.g. Juan (1985)).
- Average distance of left side of rainfall is 280 km before ET, and 342 km after ET.
- 41 of 55 TCs expanded their rainfall swaths before or immediately after being defined as extratropical cyclone. Average increased width of left side is 237 km. Range of increased width of left side is 75km - 548 km (Audrey (1957)) (Table 1).

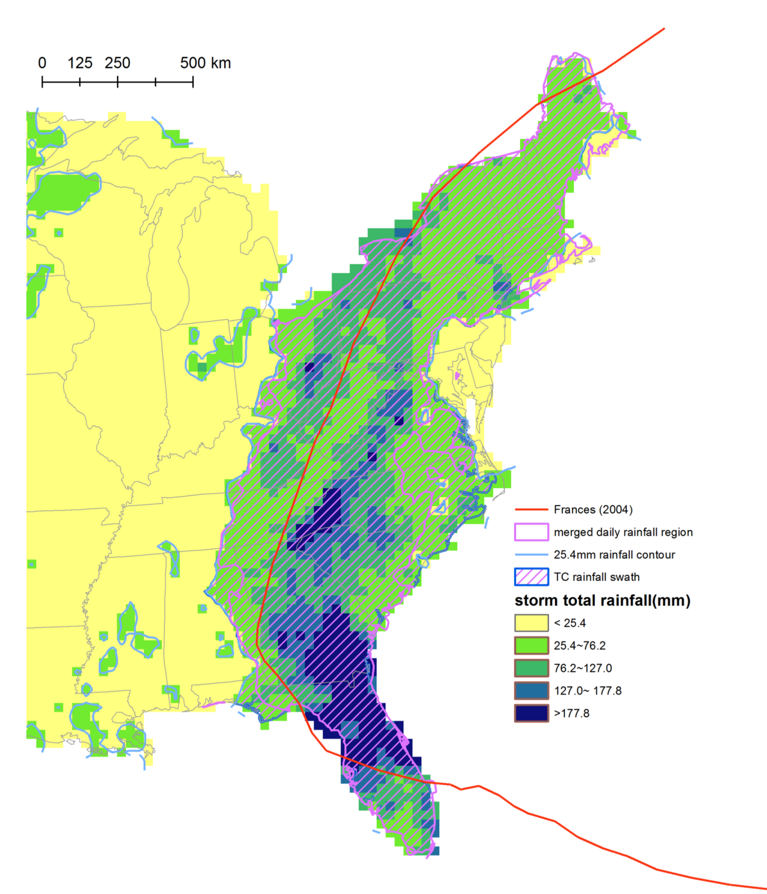

Figure 2 Storm total rainfall of Frances (2004)

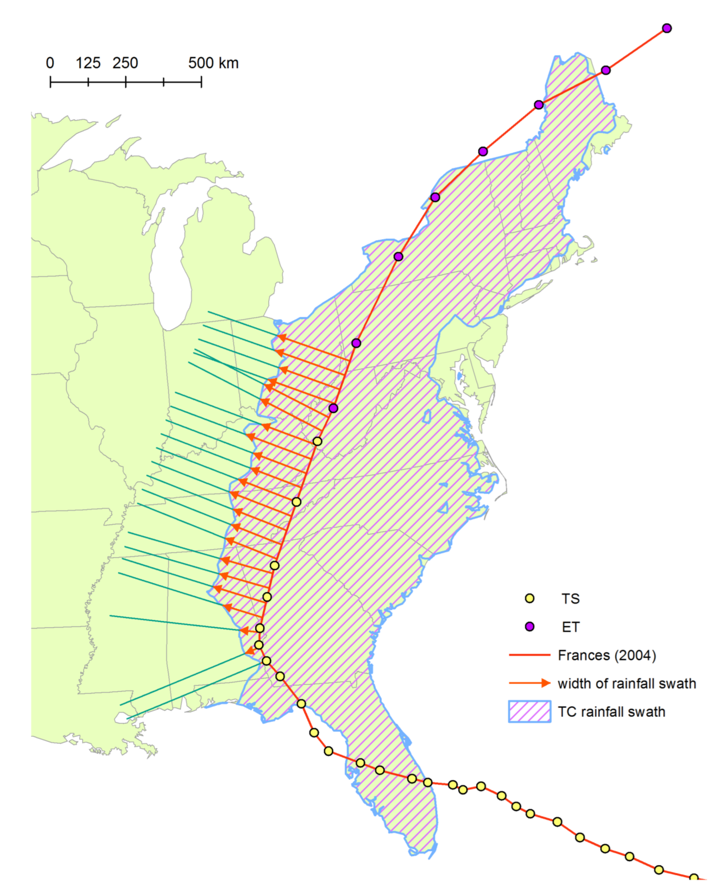

Figure 3 Measuring distances from track to left edge of rainfall swath

Discussions

- UPD is suitable for spatial analysis of moderate rainfall (25.4 mm)in this study.
- Most TCs expand rainfall swaths on left side of tracks. TCs with similar tracks have more possibility in having similar rainfall pattern (e.g. Gloria (1985), Floyd (1999) and Irene (2011)). But not all TCs with similar tracks had the same patterns of rainfall.
- Because UPD is over U.S. mainland, rainfall swath could not be measured after ET for most TCs that complete ET north to 40 ° N. It is the reason that only 13 TCs expand rainfall swath both before and after ET in this study (Table 1).

Future Work

- Examine other factors that might impact on change of widths of rainfall swaths.
- Utilize the same spatial analysis technique to define the widths of all TCs affecting the U.S. and compare right and left sides of the track when possible.

References

- Hart, R. E., and J. L. Evans, 2001: A climatology of the extratropical transition of Atlantic tropical cyclones. J. Climate, 14, 546–564.
- Jones, S. C., and Coauthors, 2003: The extratropical transition of tropical cyclones: Forecast challenges, current understanding, and future directions. Wea. Forecasting, 18, 1052–1092.

Table 1 Change of left side of rainfall swath for 55 TCs

Change of rainfall swath	TCs Name	
Increasing (41/55)	Before ET	No name (1949), Carol (1954), Florence (1953), Diane (1955) , Donna (1960), Dora (1964), Alma (1966), Gladys (1968), Doria (1971) , Eloise (1975), David (1979), Frederic (1979), Danny (1985), Gloria (1985), Allison (1995), Fran (1996), Bertha (1996), Danny (1997), Floyd (1999), Frances (2004), Gaston (2004), Ivan (2004), Wilma (2005) , Gustav (2008), Ike (2008).
	After ET	Audrey (1957), Gracie (1959), Cindy (2005).
	Both before and after ET	Hazel (1954), Floss (1956), Carla (1961), Hilda (1964), Opal (1995), Josephine (1996), Earl (1998), Gordon (2000), Allison (2001), Jeanne (2004), Alberto (2006), Barry (2007), Hanna (2008).
Decreasing (8/55)	Betsy (1965), Alicia (1983), Gilbert (1988), Hugo (1989), Isabel (2003), Arlene (2005), Ernesto (2006), Fay (2008).	
No change (6/55)	David (1979), Dennis (1999), Bill (2003), Matthew (2004) , Katrina (2005), Irene (2011) .	