Precipitation Structure and Distribution in Landfalling and Transitioning Tropical Cyclones

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Purpose:

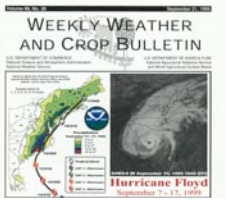
- Determine what dynamical process control whether rainfall occurs to the left of center (LOC) or right of center (ROC) in landfalling tropical cyclones (TCs).
- Build composites of LOC vs. ROC landfalling TCs and back out governing dynamics.
- Build composites of landfalling TCs based on whether they experience extratropical transition (ET) and back out rainfall relative to TC track.
- Illustrate important mesoscale rainfall features in landfalling TCs that undergo ET.

Outline:

- Example of LOC rainfall with ET (Floyd 1999).
- Composite LOC vs. ROC rainfall and governing dynamics.
- Composite strong ET vs. non-ET composites and rainfall distribution.
- Mesoscale precipitation features associated with landfalling TCs.

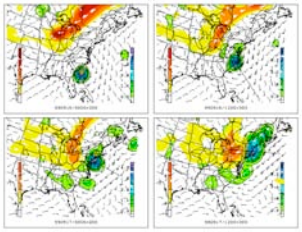
Extratropical Transitions:

- Pacific typhoons: Sekioka (1956, 1957).
- Hurricane Hazel (1954): Palmén (1958), Anthes (1990).
- Hurricane Agnes (1972): The "lonely" years.
- The 1995-1996 Hurricane Seasons: ET goes on the front burner.
- ET Review: Jones et al. (2003).

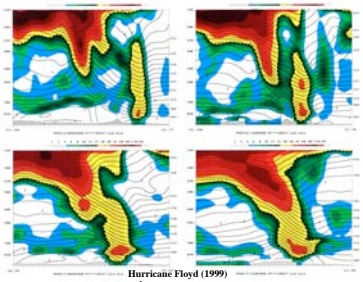


Track and storm total precipitation associated with Hurricane Floyd as reproduced from the Weekly Weather and Crop Bulletin (volume 86, No. 38).

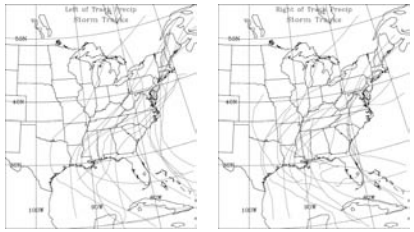
Floyd (1999) PV fields
300-200 hPa (warm colors), 850-700 hPa (cool colors)



Source: Atallah and Bosart (2003)

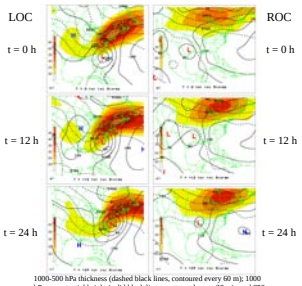


Hurricane Floyd (1999)
θ (K), PV (shaded)



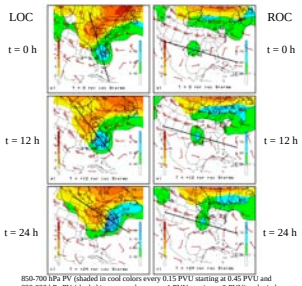
LOC Tracks of the tropical cyclones (based on the National Hurricane Center Best Track Data) for a) storms with precipitation to the left of track (LOC) and b) storms with precipitation to the right of track (ROC). ROC

Source: Atallah et al. (2006)



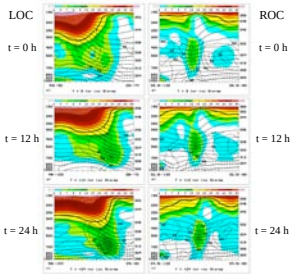
1000-500 hPa thickness (dashed black lines, contoured every 60 m); 1000 hPa geopotential height (solid black lines, contoured every 30 m) ; and 850-200 hPa wind shear (shaded, contoured every 5 m s^{-1}, starting at 20 m s^{-1}

Source: Atallah et al. (2006)



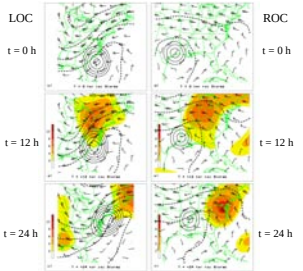
850-700 hPa PV (shaded in cool colors every 0.15 PVU starting at 0.45 PVU and 300-200 hPa PV (shaded in warm colors every 1 PVU starting at 2 PVU) and wind (barbs, knots convention). Thick dashed contours indicate areas of positive PV advection in the 300-200 hPa layer starting at 1x10^{-5} PVU s^{-1}, and contoured every 2x10^{-5} PVU s^{-1}.

Source: Atallah et al. (2006)



Cross sections of PVU (shaded, starting at 0.4 PVU), isentropes (thin solid lines, contoured every 3 K), and relative humidity (dashed lines, contoured every 10 %). The thick black line denotes the 1.5 PVU surface, taken to be the Dynamic Tropopause (DT). Thick solid lines indicate the position of the warm core associated with the TC.

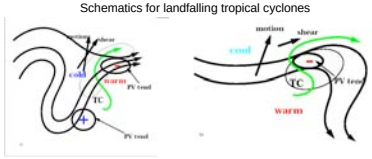
Source: Atallah et al. (2006)



Potential temperature (dashed black lines, contoured every 10 K) and wind (barbs, knots) on the DT along with the 850 hPa relative vorticity (contoured every 2 x 10^{-5} s^{-1}, starting at 2 x 10^{-5} s^{-1}), and diabatic residual ridging (shaded in degrees K with intervals given by the color bars)

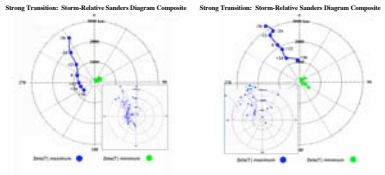
Source: Atallah et al. (2006)

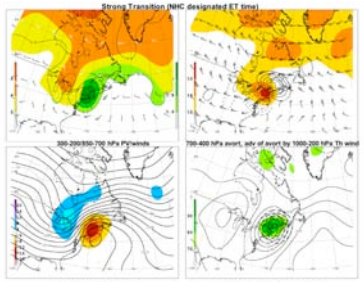
Schematics for landfalling tropical cyclones

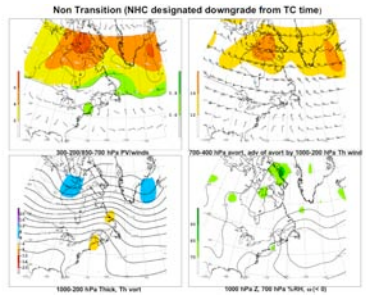


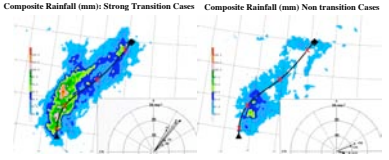
- The curved black lines represent streamlines of the upper-tropospheric flow.
- Arrows represent motion and deep tropospheric shear with the relative magnitudes given by the length of the arrow.
- The curved green line represents the trajectory of a parcel starting near the surface in the warm sector and ending in the mid to upper-troposphere in the cool sector.
- The gray shaded area represents regions of precipitation and pluses and minuses represent the local PV tendency resulting form a combination of advection and diabatic redistribution of PV.

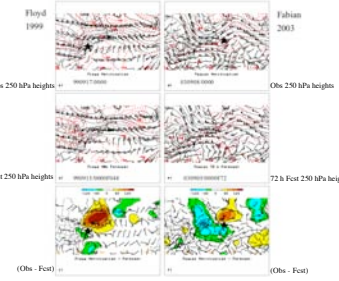
Source: Atallah et al. (2006)











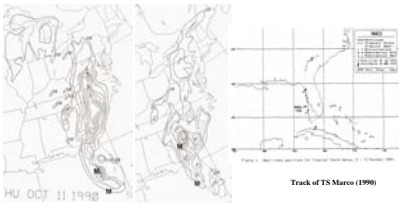
Source: Atallah et al. (2006)

a) 200 hPa geopotential heights (solid lines, contoured every 12 dam) and winds (one barb = 5 m s^{-1}) for 00 UTC 17 September 1999; b) The GFS 48 h forecast of the 200 hPa geopotential heights and wind verifying at 00 UTC 17 September 1999; and c) The difference (a – b) in the 200 hPa geopotential height (shaded every 30 dam) and wind.

d) As in a except for 00 UTC 08 September 2003. e) The GFS 72 h forecast of the 200 hPa geopotential heights and wind verifying at 00 UTC 08 September 2003. f) The difference (d – e) in the 200 hPa geopotential height (shaded every 30 dam; dark to light for negative errors and dark to light for positive errors) and wind.

ET: Science Issues:

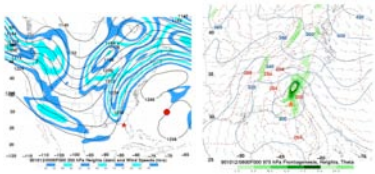
- What are the predictability uncertainties that govern TC/trough/jet interactions during ET?
- What are the bulk upscale effects of deep convection on downstream development during ET?
- What are the differences between ET events with no EC reintensification and ET events where the EC undergoes explosive reintensification?
- What physical processes govern precipitation distribution, amount and location during ET?



24 h precip (in) ending 12Z 11 Oct'90 24 h precip (in) ending 12Z 12 Oct'90

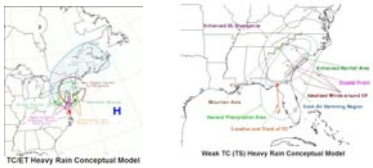
Tropical Cyclone Marco (1990)

200 hPa 0000 UTC 12 Oct'90 975 hPa 0600 UTC 12 Oct'90



Source: Srock (2005)

Source: DeLuca (2004) Source: Srock (2005)



TC Mesoscale Science Issues:

- What determines precipitation evolution during TS/TC/jet interactions?
- How do microphysical processes influence the precipitation efficiency of heavy rain generation in deep, moist tropical air masses?
- What physical processes govern the formation and evolution of mesoscale surface boundaries in quasi-uniform tropical air masses?
- How does atmospheric stability impact the nature of TC-mountain interactions in heavy rain regions?
- How do high-shear and low-CAPE environments contribute to severe weather formation in conjunction with landfalling and transitioning TCs?

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