A TRMM-based Tropical Cyclone Precipitation Feature Database and Its Usage on Intensification Study

Haiyan Jiang and Edward Zipser
Department of Meteorology, University of Utah

Hurricane Science Research Program Science Team Meeting
Florida State University, Tallahassee FL
April 6-8, 2009

TCPF Database is a subset of the UU TRMM PF database. About 0.2 million PFs over 837 TCs during 1998-2007. TRMM PR, TMI, LIS, VIRS, 3B42, NCEP reanalysis /NOGAPS analysis; will add TMI SST, QuikScat winds, NASA MERRA reanalysis data

Will be online soon. Will provide data to the science team members based on request.
TC Best Track
*TC Locations and Maximum Wind, etc.*

TRMM PF Level-2
TRMM statistical parameters
(See Liu et al. 2008)

If (distance between TC center and PF center less than 500-km)

TRMM TCPF Level-1 (Pixel)

Yes

TRMM TCPF Level-2 (PFs)

Statistics Calculation Combination

TRMM TCPF Level-3 (Grid)

No

TRMM non-TCPF Level-1 (Pixel)

TRMM non-TCPF Level-2 (PFs)

Statistics Calculation Combination

TRMM non-TCPF Level-3 (Grid)
Motivation of This Study

- Early studies suggest that hot towers (---Simpson et al. 1998, Meteorology and Atmospheric Physics) and convective bursts (---Steranka et al. 1986, Monthly Weather Review) near the eye can be related to TC intensity change.

- Hot towers: tall cumulonimbus towers which reach or penetrate the tropopause. --Malkus and Riehl 1960, Tellus.

Heymsfield et al. (2003) Journal of Applied Meteorology
Objectives

- Evaluate the probability of RI/IN when the TC’s eyewall (EW) contains one or more hot towers or a closed ring of precipitation exists surrounding the eye.

- Rank the strength of TC’s convection in the eyewall (EW) in terms of the TC’s maximum wind speed intensity.

- Rank the strength of TC’s convection in the eyewall (EW) stratified by the TC’s intensity change: i.e., non-intensifying (NonIN) and intensifying (IN) including rapid intensifying (RI, 24-h maximum wind speed increase 30 kt or greater) and slow intensifying (SI, 24-h maximum wind speed increase 30 kt or less) stages.

- Evaluate the probability of RI/IN when the TC’s eyewall (EW) contains one or more hot towers or a closed ring of precipitation exists surrounding the eye.
9 years (1998-2006) of UU TRMM TCPF data

Manually select TRMM orbits in which TC EW is well-observed. For multiple EWPFs per orbit, we only select the strongest EWPF in terms of PR Max 20 dBZ height.

<table>
<thead>
<tr>
<th>Intensity</th>
<th>CAT35</th>
<th>CAT12</th>
<th>TS</th>
<th>TD</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>EWPFs</td>
<td>74</td>
<td>162</td>
<td>448</td>
<td>54</td>
<td>1233</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Intensity Change</th>
<th>RI</th>
<th>SI</th>
<th>IN</th>
<th>NonIN</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>EWPFs</td>
<td>58</td>
<td>532</td>
<td>590</td>
<td>475</td>
<td>1065</td>
</tr>
</tbody>
</table>
Mean and Median Profiles of Maximum Reflectivity for Different TC Intensities

**Mean**

**Median**
CDFs of Min. 85GHz PCT, Min. 37GHz PCT, Min. Tb11, and Max. 20 dBZ Echo Height for Different Intensities
Mean and Median Profiles of Maximum Reflectivity for Different Future 24-h Intensity Change Stages

![Graphs showing mean and median profiles of maximum reflectivity for different future 24-h intensity change stages. The graphs display data for different intensification stages: Rapid Intensifying, Slow Intensifying, Intensifying, and Non Intensifying.]
CDFs of Other Convective Properties for Different Future 24-h Intensity Change Stages

- **Minimum 85 GHz PCT**:
  - Rapid Intensifying
  - Slow Intensifying
  - Intensifying
  - Non Intensifying

- **Minimum 37 GHz PCT**:

- **Minimum 11 Micron Tb**:

- **Maximum 20 dBZ Echo height**:

---

**Axes:**
- **CDF (%)**
- **Minimum 85 GHz PCT (K)**: 50 to 300
- **Minimum 37 GHz PCT (K)**: 200 to 300
- **Minimum 11 Micron Tb (K)**: 150 to 300
- **Maximum 20 dBZ Echo height (km)**: 0 to 20
Chance of RI/IN When Hot Tower (HT) or Closed Ring Eyewall Exists

- Define HT: Maximum 20 dBZ echo height > 14.5 km (same as Kelley et al. 2004)
- Define closed EW: From the EWPF dataset, we select those with a feature of closed ring of precipitation surrounding the eye in terms of TMI 37 GHz PCT (polarization corrected brightness temperature) and attribute these subset of EWPFs as closed EWPFs.

<table>
<thead>
<tr>
<th></th>
<th>EWPFs with HT</th>
<th>Closed EWPFs</th>
<th>Total EWPFs</th>
</tr>
</thead>
<tbody>
<tr>
<td>RI</td>
<td>20</td>
<td>14</td>
<td>58</td>
</tr>
<tr>
<td>SI</td>
<td>154</td>
<td>51</td>
<td>532</td>
</tr>
<tr>
<td>IN</td>
<td>174</td>
<td>65</td>
<td>590</td>
</tr>
<tr>
<td>NonIN</td>
<td>90</td>
<td>51</td>
<td>475</td>
</tr>
<tr>
<td>Total</td>
<td>264</td>
<td>116</td>
<td>1065</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Chance of RI</th>
<th></th>
<th>Chance of IN</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>RI</td>
<td>8%</td>
<td>13%</td>
<td>55%</td>
<td></td>
</tr>
<tr>
<td>IN</td>
<td>66%</td>
<td>56%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Summary

- A relationship does exist between TC intensity/intensity change and the strength of convection in the eyewall based on analyzing 9 years of TRMM observed convective proxies.

- The chance of RI/IN increases when a hot tower exists, but not substantially. A hot tower is neither a necessary nor a sufficient condition for RI. The role of hot tower on TC intensification needs to be further examined.

- The chance of RI/IN increases when a closed precipitation ring exists surrounding the eye.
Future Work

- Complete the TCPF database and put it online
- Select a larger subset in terms of TMI and VIRS observations to analyze hot towers and convective bursts; lightning data
- Examine the role the environmental factors such as SST, shear, total precipitable water, horizontal moisture convergence, etc.
- Combined effects of convective intensity and environmental factors on rapid intensification
- Case studies
My Wish List for the Field Program

- RI cases with/without hot towers/convective bursts
- RI cases with/without closed eyewall feature
- Hot tower/convective burst cases without RI
- Closed eyewall cases without RI

- Radar and radiometer measurements
- Dropsonde data to obtain large scale environment factors
- Microphysics measurements inside the eyewall
Contact: hjiang@utah.edu
Webpage: http://trmm.chpc.utah.edu
Accepted EWPF Example: TRMM Observations of Atlantic Hurricane Karl (2004)
Accepted Closed EWPF Example: TRMM Observations of Atlantic Hurricane Cindy (1999)
CFADs of Maximum Reflectivity Profiles in EWPFs for Different TC Intensities
CFADs of Maximum Reflectivity Profiles for Different Future 24-h Intensity Change Stages

Intensifying CFAD (590 samples)

24h

Rapid Intensifying CFAD (58 samples)

Non-Intensifying CFAD (475 samples)

Slow Intensifying CFAD (532 samples)