EXTENDED ABSTRACT TEMPLATE

(not to exceed 4 pages including references and figures)
(Times Roman type font; font size =12; single or 1.5 spacing; justified with default margins)

Title of the paper[i] **:** Convective Cloud Towers and Precipitation Initiation, Frequency and Intensity; *Hydrology and Flood Forecasting*

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ABSTRACT: Geosynchronous satellite retrieval of precipitation is desirable because it would provide continuous observation throughout most of the globe in regions where radar data is not available. In the current work the distribution of precipitation rates is examined as a function of cloud tower area and cloud top temperature. A thunderstorm tracking algorithm developed at Meteo-France is used to track cumulus towers that are matched up with radar data at 5 minute 1 km resolution. It is found that roughly of the precipitation occurs in the cloud mass that surrounds the towers, and when a tower is first detected the precipitation is already in progress 50% of the time. The average density of precipitation per area is greater as the towers become smaller and colder, yet the averaged shape of the precipitation intensity distribution is remarkably constant in all convective situations with cloud tops warmer than 220 K. This suggests that on average all convective precipitation events look the same, unaffected by the higher frequency of occurrence per area inside the convective towers.   Only once the cloud tops are colder than 220 K does the precipitation intensity distribution become weighted towards higher instantaneous intensities.

Keywords: precipitation, convection, thunderstorms

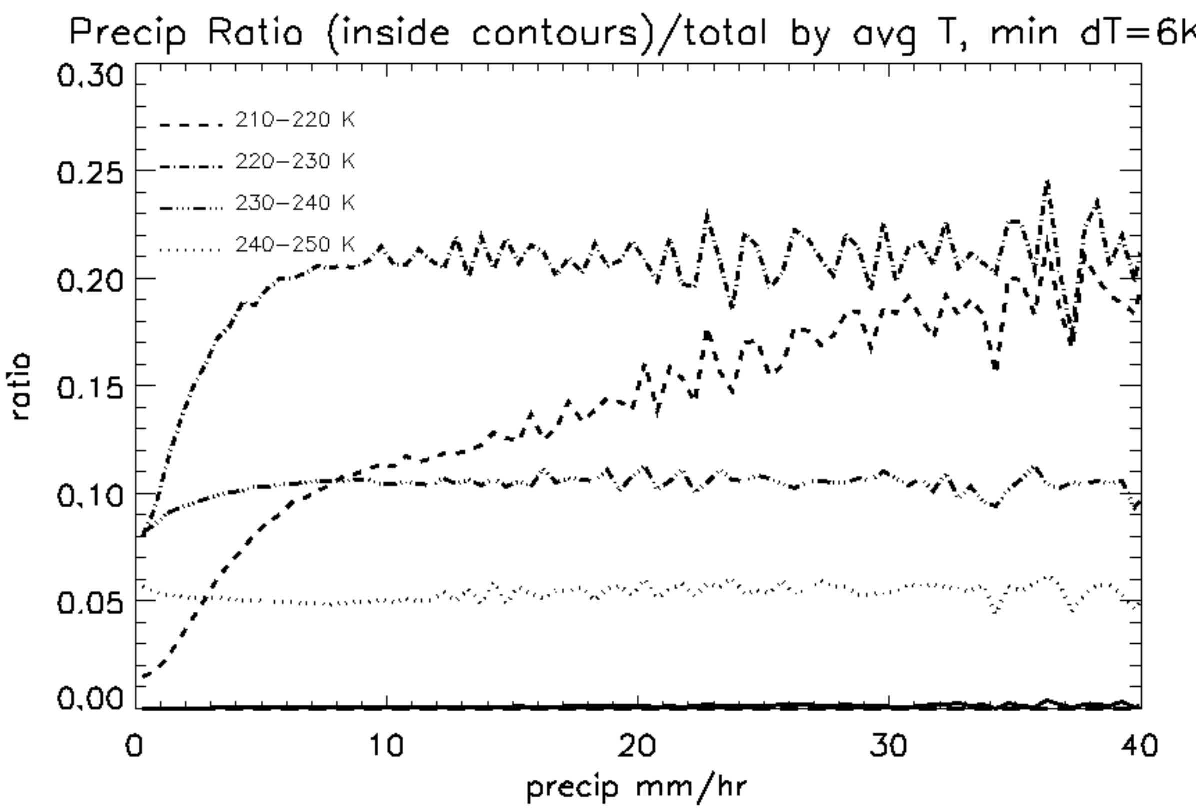
Introduction: Geosynchronous satellite retrieval of precipitation is desirable because it would provide continuous observation throughout most of the globe in regions where radar data is not available. But this limits us to infrared techniques, which are not as reliable as direct droplet scattering techniques such as radar and microwave. Improvement is needed. Most IR techniques use pixel based retrievals, perhaps with local texture included; but recent work has had success using characteristics of the entire cloud cell.

In an effort to extend IR precipitation estimation techniques, the density distribution of precipitation rate is examined as a function of cloud tower area and average cloud top temperature, de-emphasizing individual pixels in favor of geometrical aspects of the cloud.

Methodology: The national radar mosaic from Ohio State University was used, providing precipitation information at 1 km 5 minute resolution. This was matched with 15 minute GOES satellite IR data at 4 km resolution. Data from the entire month of May 2009 was tabulated, an unusually active period for thunderstorms in the mid atlantic east coast study area (37 to 44 N and 72 to 81 W).

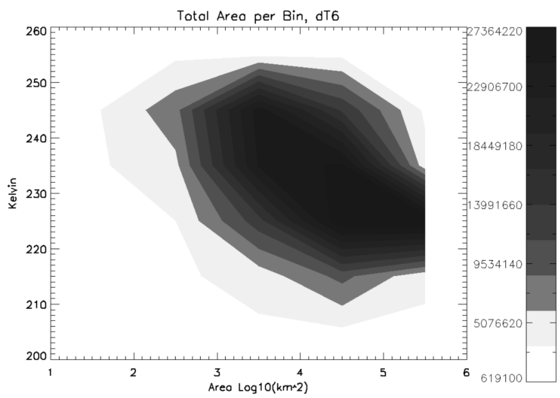
A cloud tower detection and tracking algorithm developed by Meteo-France was used to identify cloud towers and follow them throughout their lifecycle. For each satellite image the radar echoes that fell within the towers were sorted into bins defined by tower area and average cloud top temperature. The lifecycle statistics of each cell were also tabulated. It should be noted that for small geometrically simple clouds the algorithm will select the entire cloud as a tower; but for large cloud masses each turret will be selected as a tower, leaving much of the cloud between the towers unclassified by the study.

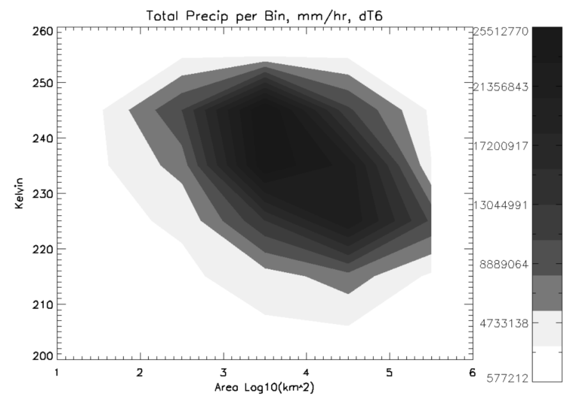
Results & Observations:
Histograms can be formed of number of pixels of a given radar echo intensity for all cases and compared to histograms formed of pixels inside the cloud towers. The ratio of these histograms shows the relative frequency of occurrence of precipitation intensity for various cloud tower parameters. Such a ratio plot is shown for cloud towers with average cloud top temperatures in 10-degree bins ranging from 210 to 250 K:



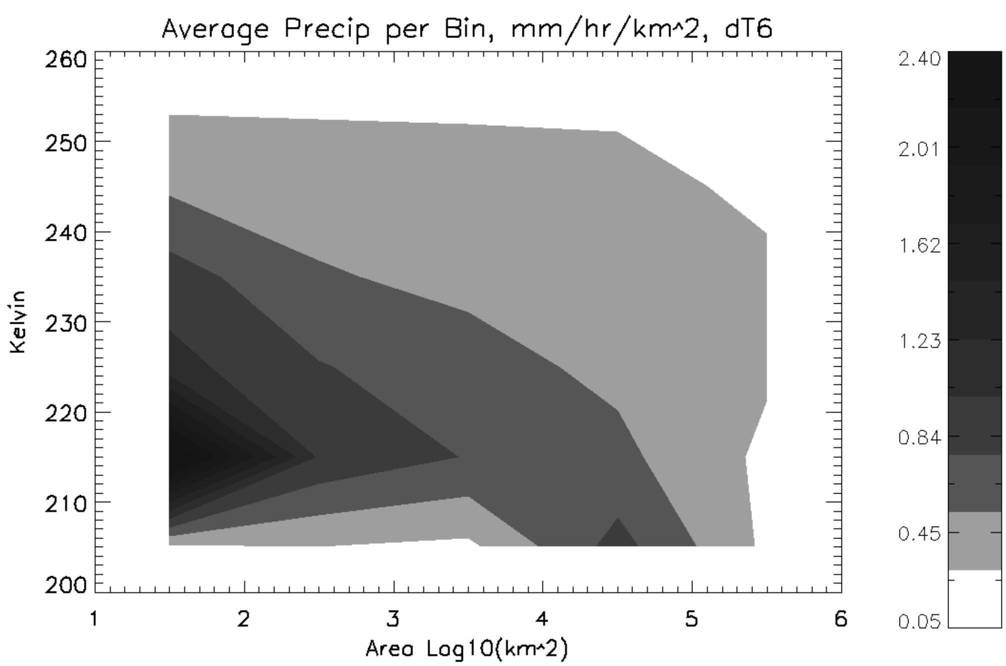
These results show that once the rain rate is above about 5 mm/hr (pure convective) the shape of the intensity distribution is unchanged (the ratio is flat) regardless of what the cloud top temperature is. The exception is for cloud top temperatures colder than 220 K, for which the intensity distribution inside the towers increases with rain rate.

The dependence of the total precipitation on area and average cloud top temperature of the cloud towers can be studied by binning the towers by these two variables as done below, with log(area) on the horizontal and average temperature on the vertical.





The total area per bin is on the left, and the total precipitation per bin is on the right. Clearly the total precipitation tracks closely with the total cloud area per bin. But when the precipitation per area is calculated (by dividing the graph on the right by the left), the true dependence of precipitation per pixel is demonstrated:



This plot shows that average precipitation not only increases as cloud top temperature decreases, but it also increases as cloud tower area decreases. This is most likely linked to the tendency of precipitation to occur during the growing phase of a storm when there are strong updrafts. This relationship was used by Delgado et al (2008) as one of the factors in an improved IR rainfall estimation. We should emphasize that the previous plot shows that unless the average cloud top temperatures are colder than 220 K, the increase in precipitation per area is due to increased frequency of occurrence, not increased instantaneous rain rates.

Conclusions: This work demonstrates that the distribution of precipitation intensity doesn't change with the convective structure, only the frequency of occurrence. Though nearly all IR precipitation estimation algorithms use cloud top temperature as an indicator, we see here that cloud cell size is an equally viable indicator. As cloud cells become colder and smaller, the precipitation frequency increases.

References:

Delgado, G., L. Machado, C. Angelis, M. Bottino, A. Redano, J. Lorente, L. Gimeno, R. Nieto, 2008: Basis for a Rainfall Estimation Technique Using IR-VIS Cloud Classification and Parameters over the Lifecycle of Mesoscale Convective Systems, *J. Appl. Met. Clim*,. **47**, 1500-1517.

Morel, C., S. Senesi, F. Autones, 2002: "Building Upon SAF-NWC Products: use of the Rapidly Developing Thunderstoms (RDT) Product in Meteo-France Nowcasting Tools". Report to EuMetSat, available via http://www.meteorologie.eu.org/RDT/doc/Morel2002.pdf

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The statements contained within the manuscript/research article are not the opinions of the funding agency or the U.S. government, but reflect the author's opinions.

[i] Indicate the appropriate technical session