Production of Globally Uniform ISCCP Convection Tracking (CT) Dataset and Preliminary Analysis Results

Authors: Cindy Wang[1], Z. Johnny Luo[1], William B. Rossow[2], Cindy Pearl[3]

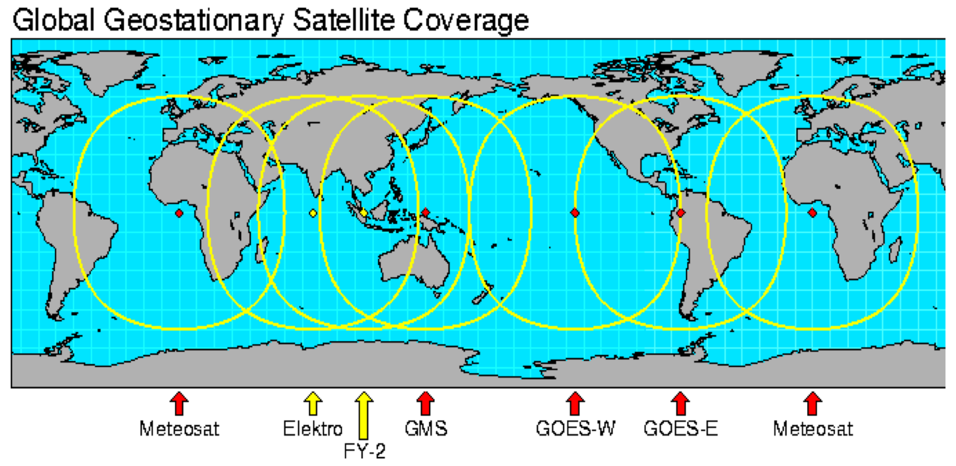
1. Department of Earth and Atmospheric Sciences – CCNY
2. NOAA-CREST – CCNY (Emeritus)
3. NOAA-CREST

Abstract

- The International Satellite Cloud Climatology Project (ISCCP)'s Convection Tracking (CT) database was designed to track the evolution of deep convective cloud systems throughout their life cycle.
- Previous version covered period from 1983-2008 and treated one geostationary satellite at a time.
- Recently, we started producing a new version of CT data that are built upon the new, H-version ISCCP data (HXG).
- Improvements from this new CT data include:
  1) globally uniform coverage
  2) higher spatial sampling/resolution (from 30 km down to 10 km)
  3) longer data record (1983-2012).

Introduction

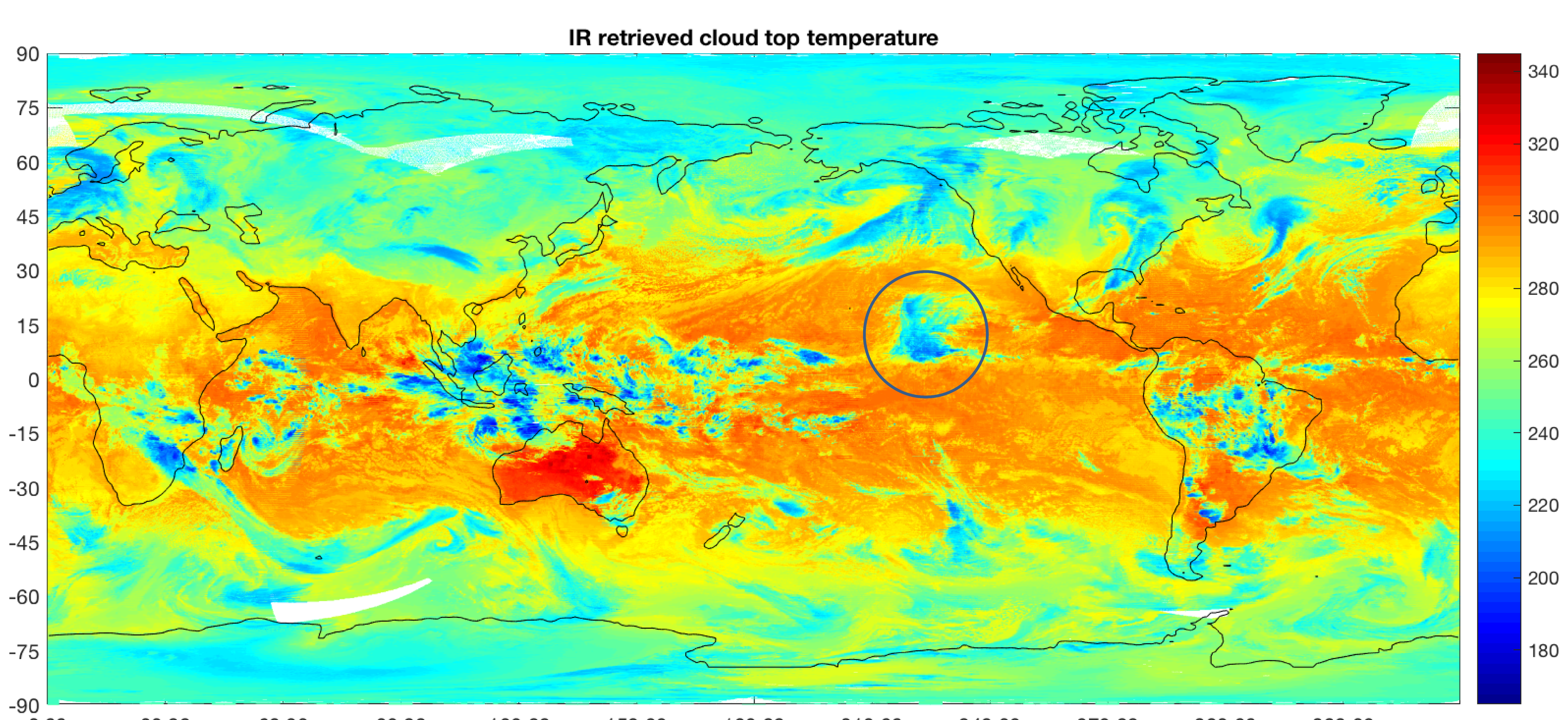
- In the old production of ISCCP, the CS are analyzed for 5 geostationary satellite data streams separately. However, new production merges the hierarchy into one global analysis.
- The new production of the dataset provides finer resolution of 10 km & 25 km in addition to providing a global analysis of CS.

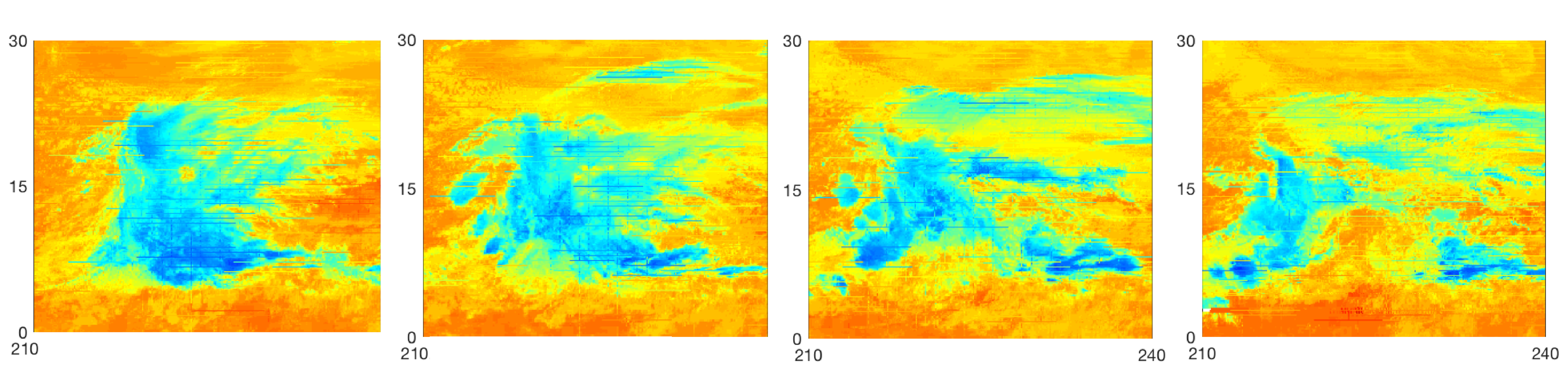


Methodology

- This analysis considers the global production of CS and CT and preliminary results including comparison with the old CS data.
- **Convective Systems (CS)** considers all high-level cloud systems and is described by its location, size and shape. They are defined as cloud systems with a cloud top temperature less than 245 K.
- **Convective Tracking (CT)** associates individual CS over time (minimum of 2 3-hr lifetime) into a family. CT is described by the motion, largest CS radius and minimum cloud top temperature in the family.

Determine	Determine whether a particular image pixel is cloudy and determines the cloud top temperature and optical thickness.
Cluster up	Cluster up all adjacent cold IR pixels with brightness temperature (TBIR)< 245 K and stores the summary information about cloud structural and radiative properties.
Track	Track each individual CS over time to form families and produces the CT database.



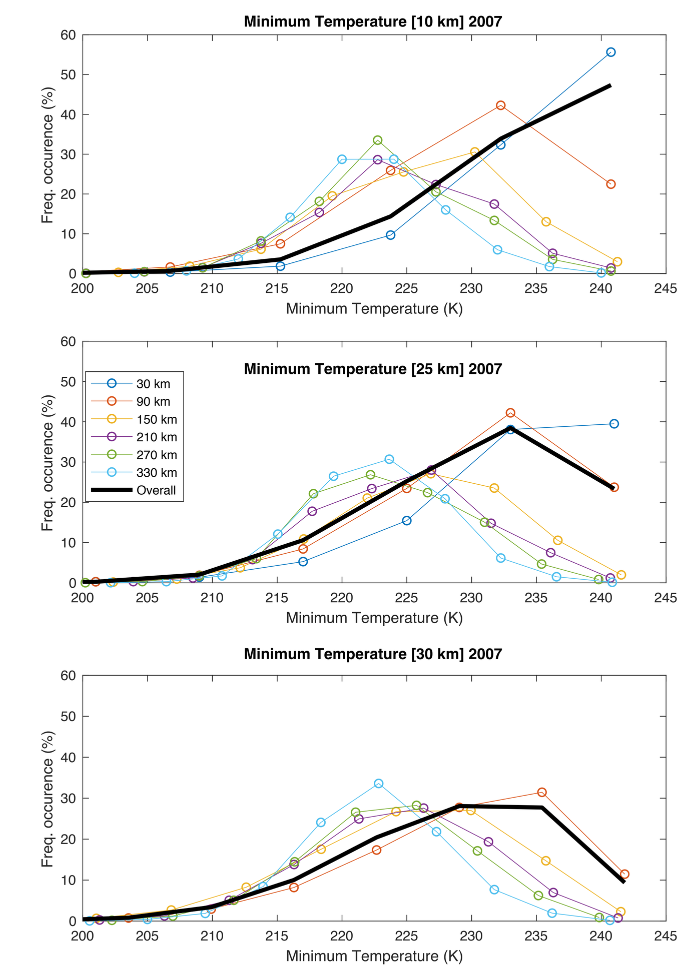


- The analysis of sampled weather satellite radiances is measured at infrared (11 microns) and visible (0.6 microns) wavelengths and determines if a image pixel is clear or cloudy. If it is cloudy, it determines the cloud top temperature (K) and optical thickness by comparing measured radiances of the output of the a radiative transfer model.
- The figure above shows the IR temperature from the H-version ISCCP data (HXG) used for the 10 km global production. The satellite tracks image pixels at a 3-hourly time interval and the algorithm calculates the progression of these pixels as a CS and (if longer than 3 hours), as a CS family.

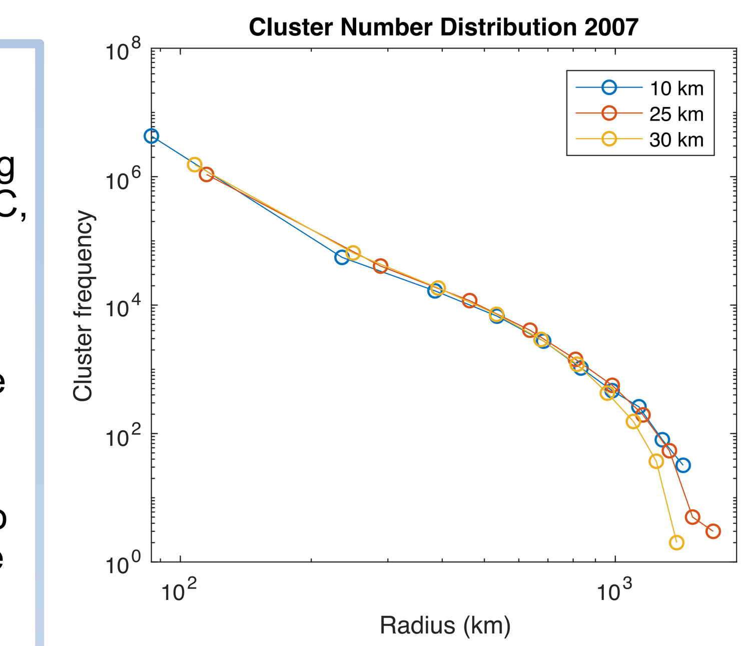
Properties of CS

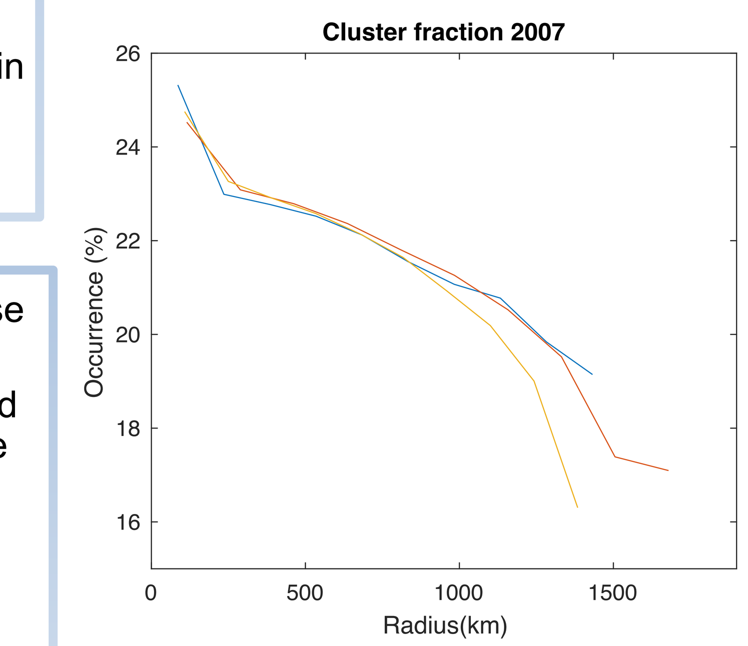
Parameters determined for each convective system

Parameters	Units
Date and time	(year, month, day, hour)
Location of CS center of mass	(longitude, latitude)
Radius of CS	(km)
Inclination of CS major axis	(degrees from north)
Eccentricity of CS	(0 to 1)
Convection fraction	
Number of CC	
Average radius of CC	(km)
Average T_{IR} of CS	(K)
Minimum T_{IR} of CS	(K)
Variance of T_{IR} of CS	(K)
Gradient of T_{IR} of CS	
Location of largest CC	(longitude, latitude)
Radius of largest CC	(km)
CS squared correlation of linear regression	



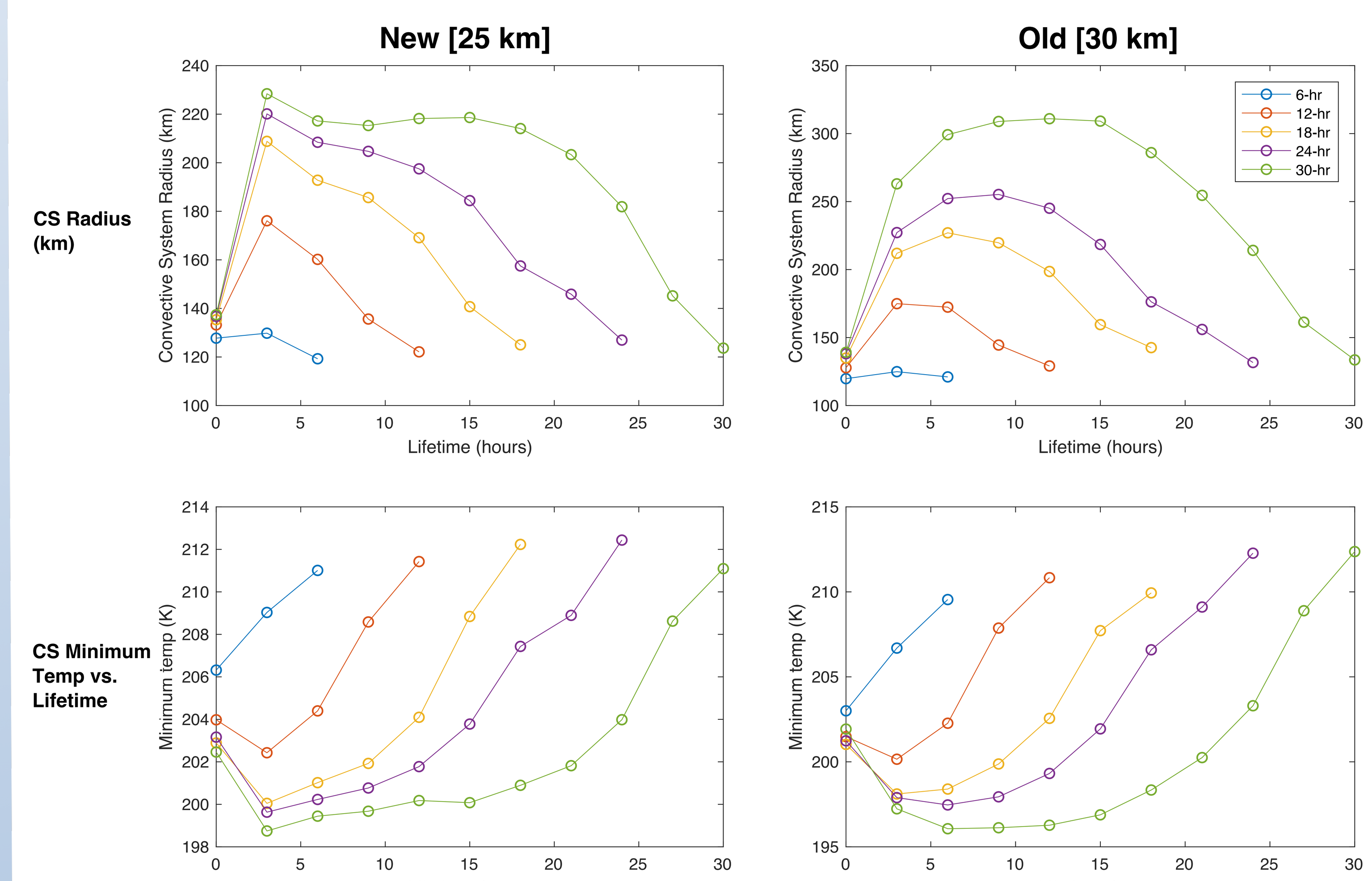
- The CS is described by its location, size, shape and the properties of its clouds, including whether there are embedded CC, their location and properties.
- The overall mean cloud top temperature peaks at higher temperatures because there are more CTs with smaller radiuses and higher temperatures.
- Typically, CS radius is related to the cloud top temperature of the system. As the radius of the system increases, the mean cloud top temperature decreases.
- However, there are differences in the CS radius and temperature based on the resolution of the dataset.





- Coarser resolution (30 km) captures more low minimum cloud top temperatures than in the finer resolution CS (10 & 25 km). This may be because a coarser resolution requires larger CS in order to overlap be observed.
- The old production also does not capture many large radius CS. This is due to spatial resolution between images that affects the captured CS and their respective radiuses. Additionally, large CS systems that propagate from one satellite region to another may be improperly represented in the dataset. This explains why the cluster frequency for the 30 km dataset drops off around 1500 km.
- The 30 km dataset captures the least amount of CS compared to the new production of CS.
- As the resolution increases from 25 km to 10 km, CS captures less large radius systems. This may be due to the coarser resolution clumping or aggregating smaller CS into larger ones.

Life Cycle View of CS



- The life cycle of a CS is based on three parameters: time of maximum extent, maximum extent (largest size) and duration of CS. The figure on the left shows these parameters averaged for 2007.
- The CS increase to peak size around 3-4 hours for the new global production but peak around 10-15 hours for the old production. The peak in CS radius corresponds with the minimum temperature for the CS at that time.

- Understanding the life cycles of these CS help us understand the variability of these systems at different time scales and their expected extent. This dataset tracks the CS using satellite infrared geostationary imagery as cloud clusters that evolve in time beginning as small systems to well-organized large patches of clouds before dissipating.

Select References

- Machado, L.A.T., and W.B. Rossow, 1993: Structural characteristics and radiative properties of tropical cloud clusters. *Mon. Weather Rev.*, **121**, 3234-3260, doi:10.1175/1520-0493(1993)121<3234:SCARPO>2.0.CO;2.
- Machado, L.A.T., W.B. Rossow, R.L. Guedes, and A.W. Walker, 1998: Life cycle variations of mesoscale convective systems over the Americas. *Mon. Weather Rev.*, **126**, 1630-1654, doi:10.1175/1520-0493(1998)126<1630:LCVOMC>2.0.CO;2.
- Rossow, W.B., and R.A. Schiffer, 1999: Advances in understanding clouds from ISCCP. Bull. Amer. Meteor. Soc., 80, 2261-2287.
- Vant-hull, Brian & Rossow, William & Pearl, Cindy. (2016). Global Comparisons of Regional Lifecycle Properties and Motion of Multi-day Convective Systems: Tropics, Mid-latitude, Land and Ocean. Journal of Climate. 29. 10.1175/JCLI-D-15-0698.1.

Ongoing Work

- Current available data include: 2007 (10 km and 25 km) CS and CT and 2008 (10 km) CS data. Future processing with focus on the production of 10 km from 2007-2012 onwards and backwards to 1983.
- The new production of the dataset provides finer resolution of 10 km and 25 km in addition to providing a global analysis of CS. Future research and work will focus on the improvements from this new dataset compared to the old production of CS which was coarser and produced regionally.
- Based on these preliminary analysis, it is observed that with the improved resolution, the amount of observed CS with higher CS radius and higher minimum temperature increases. This is due partially to a more global view of the CS. This accounts for the observed higher CS radius since long lifetime systems tend to propagate from one satellite observed region to another and therefore reported in parts. In addition, a finer grid is able to capture smaller systems which have higher minimum temperatures.
- For future analysis, other CS cloud properties should be considered including: mean, minimum cloud top temperatures, the spatial gradient of the cloud top temperatures, the number of image pixels with cloud top temperatures <200 K (convective cores) and the mean and maximum cloud optical thickness.
- Many previous observations and research on CS have been done (Dr. Vant-Hull and Dr. Rossow), for the old 30 km resolution production of ISCCP. Future analysis will use the new production (10 and 25 km) to affirm previous observations as well as assessing the global dynamics of CS.

Acknowledgements

Research support provided by NASA and the Department of Environmental and Atmospheric Science at the City College of New York. We would like to thank the technical support and the mentoring received from Dr. Luo, Cindy Pearl and Dr. Vant-Hull, among others. We would also like to thank the very supportive group of students at the atmospheric lab working with Dr. Luo and Dr. Booth.