Global Storm Tracking, Characterization, and Analysis with Satellite-based Observations

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Motivation

Purpose - Develop a comprehensive global picture of storms to identify types and quantify lifetime characteristics and water cycle contributions

- **Lagrangian storm tracking** helps understand where and how storms form/decay in context of atmospheric circulation (fig. 1), surface features
- **Using satellite infrared data** is advantageous: has fine time/space scales; produces global (not regional) results from observations (not models)

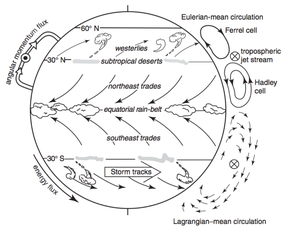

Figure 1 - Large-Scale circulation

Source: Encyclopedia of Atmospheric Sciences

- Atmosphere driven by pole/equator temperature gradient (from solar heating), the Coriolis effect (from earth's rotation)
- Deep convection occurs at the ITCZ, from trade wind convergence

- Applications
  - Assess/validate current and future satellite missions
  - Improve meteorological forecasts
  - Quantify storm water cycle contributions
  - Enhance natural hazard predictive capacity

Data and Methods

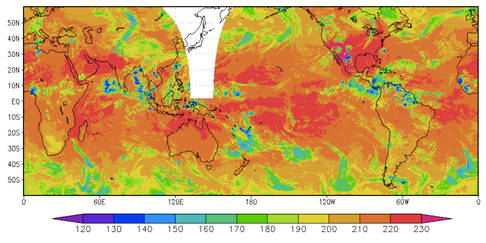

Figure 2 - IR dataset
NCEP-CPC 4km Cloud Top Temperature

- 30 min brightness temp.
- GOES, METOSAT, GMS
- June 1 - August 30, 2011

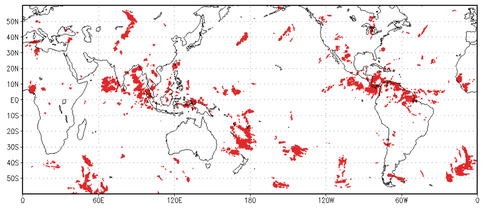

Figure 3 - Cloud clusters using ForTraCC tracking technique (Vila et. al, 2008)

- Capture when T < 235 K, cluster size > 1600 km^2

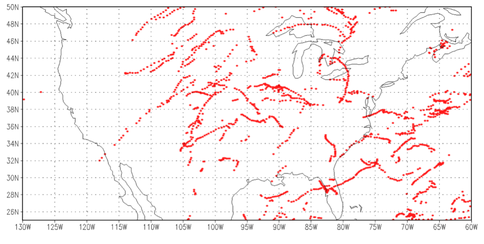

Figure 4 - Tracking storms
June 2011, lifetime > 12 hrs

- Detection by area overlap, both forward and backward in time
- Clusters that split or merge treated as a new system

Results - Spatial Analysis

Are there preferred regions of storm formation?

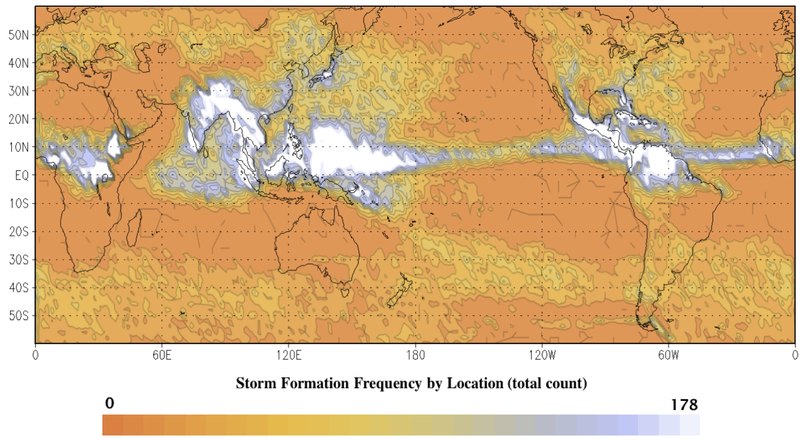

Figure 5 - Count of storm formation at a given location (Jun-Aug, 2011)

- Peak activity along the ITCZ (8 N), associated with Hadley Cell ascent in the N.H. summer season
- Other favorable regions - S.E. Asia (from summer monsoon), N.W. Pacific (from warm ocean waters), N.E. Atlantic (from Azores High)
- S.H. less active because it is the winter hemisphere

What is the global lifetime distribution of storms?

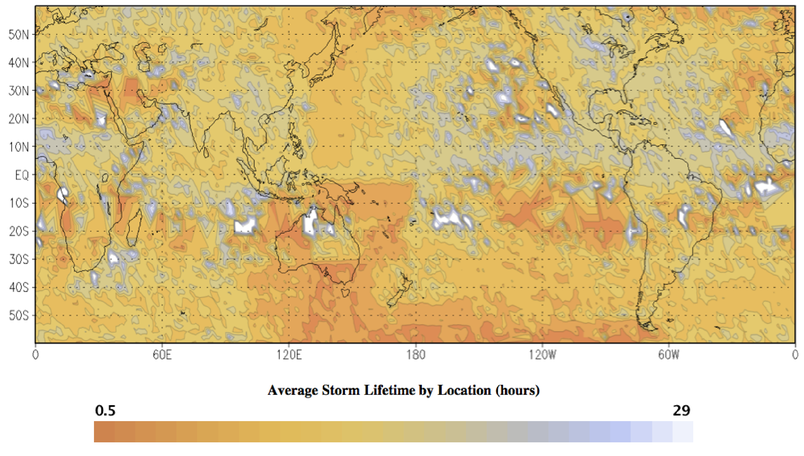

Figure 6 - Average storm lifetime at a given location (Jun-Aug, 2011)

- Longer average lifetimes of storms are in the N. H. (summer), over regions with warmer oceanic waters
- Long-lived coastal storms are possibly result of frontal or stationary clouds
- Low average lifetimes can indicate regions of high convection - ex. isolated thunderstorms live < 1 hour
- Few but long lived storms passed near the California coast, leading to high average lifetimes - needs to be examined using longer time scales

Results - Lifetime Characterization

How long do most storms live?

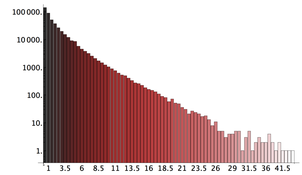

Figure 7 - Count of storm lifetimes

- Majority of storms live < 3 hours
- Short-lived events (ex. single-cell thunderstorms) go undetected when using 3-hourly datasets

What are the temperature and size properties?

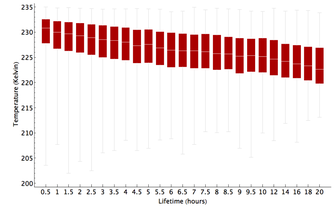

Figure 8 - Average cloud top temperature by lifetime

- Short-lived storms were warmer, but coldest thunderstorms reach the upper troposphere

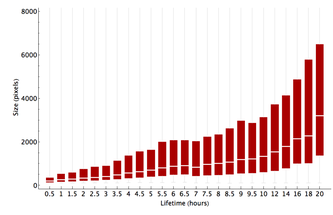

Figure 9 - Average cloud size by lifetime

- Long-lived storms tend to enlarge and change to stratiform rainfall
- Temperature, size characteristics could be used in the future to classify storms

Conclusions

- Variety of storms captured using IR satellite observations/storm tracking
- Large scale atmospheric circulation influences where storms form, ex. peak activity along ITCZ and monsoon regions
- Majority of storms have lifetimes < 3 hrs, fine time scales needed for capture
- Shorter lived storms tend to be warmer, smaller than longer lived ones
- Future work: Develop classification scheme to objectively stratify storms

References

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