Global Tracking and Life Cycle Analysis of Storms using a Decade of Satellite Observations

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Motivation

- Lagrangian storm tracking and life cycle of storms on the globe helps to
  - Study whole evolution of storm
  - Determine transport of moisture
  - Learn how individual storms form and decay
- Goal: develop a comprehensive global picture of storm tracks, types, characteristics, and life cycles using satellite measurements
- Applications
  - Improve meteorological forecasts
  - Quantify individual storm water cycle contributions
  - Assess/validate current and future satellite missions

Data and Methods

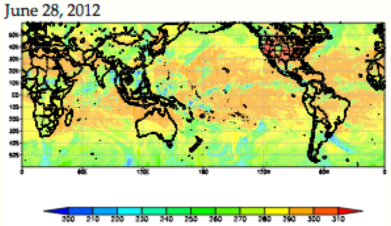

Figure 1 - IR dataset NCEP-CPC 4km Cloud Top Temperature

- 30 min brightness temp.
- GOES, METOSAT, GMS
- Interpolation used to fill in satellite coverage gaps
- Examined DJF 2001-2011

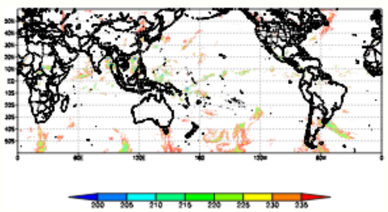

Figure 2 - Cloud clusters using ForTraCC tracking technique (Vila et. al, 2008)

Capture thresholds:

- Temperature < 235 K
- Area > 100 pixels

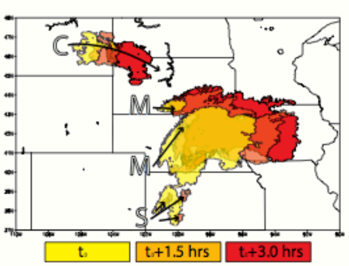

Figure 3 - Tracking

- Uses area overlap, both forward and backward in time
- Continuous systems ("C") have a single overlap
- Smaller splits ("S") and merges ("M") treated as new systems
- Centroid of cluster used to mark storm tracks

Results

Storm Trajectories

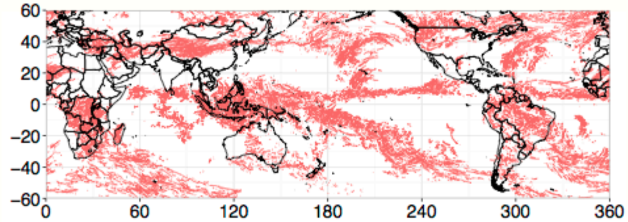

Figure 4 - Storm trajectories from Dec 1-4, 2001.

- A few days of tracking yields a large number of storms
- Traces out DJF atmospheric patterns, e.g. Midlatitude storm tracks across North America, ITCZ close to equator

Global Storm Climatology and Variability

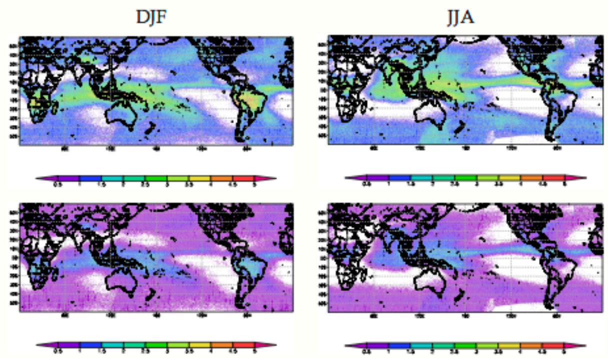

Figure 5 - Storm climatology and variability, 2001-2012, 0.25° at maturity (min. temperature).

- Strongest activity over continents, esp. West Pacific islands
- Large variability over in atmospheric rivers, N. American hurricane and storm tracks, and the West Pacific

Lifetime and Size Distributions

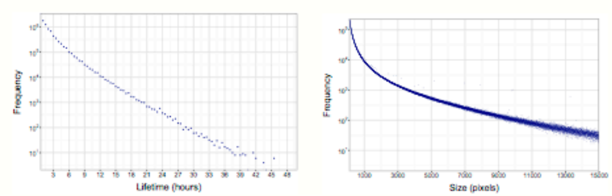

Figure 6 - Count of storm lifetimes and sizes. 83% of storms live < 3 hours, high resolution data needed to track storms

Results

Life Cycle Evolution

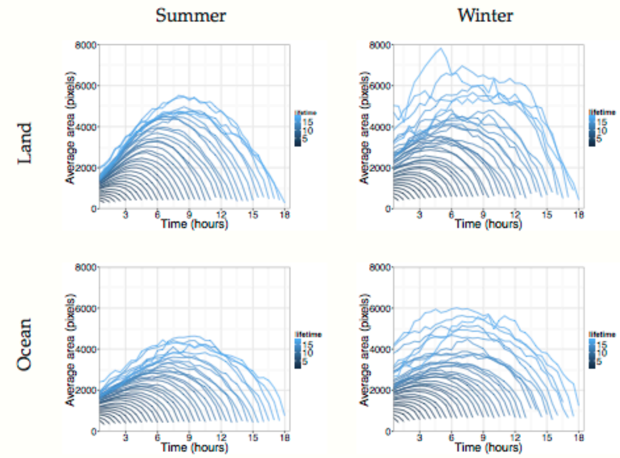

Figure 7 - The average life cycle evolution for storms of varying life times Summer: JJA (North) and DJF (South). Winter: DJF (North) and JJA (South)

- Each curve represents the average properties of millions of storms grouped by life span
- Shows how the size changes as a function of the storms' lifetime
- Evolution non-linear; varies by season, location, and storm classes

Conclusions

- Lagrangian analysis coupled with satellite IR yields global storm tracks
- Storm initiation higher over convergence zones, rainforest, Pacific islands
- Enhanced variability over wintertime storm tracks and atmospheric rivers
- Lifetime occurrence follows log-linear scale, while size appears to have a lognormal distribution
- High frequency of small, short-lived storms emphasizes continued reliance on high resolution data
- Life cycle shows regularity, can develop model to estimate storm duration
- Data will be available soon: http://stormtracks.umd.edu

References and Affiliations

- Vila, D. A., Machado, L. A. T., Laurent, H. and Velasco, I., 2008: Forecast and Tracking the Evolution of Cloud Clusters (ForTraCC) Using Satellite Infrared Imagery: Methodology and Validation. Weather and Forecasting 23, 233-245.
- Machado, L.A.T., Rossow, W.B., Guedes, R.L., Walker, A.W., 1998. Life Cycle Variations of Mesoscale Convective Systems over the Americas. Monthly Weather Review 126, 1630-1654.
- Houze, R.A., 1993. Cloud Dynamics. Academic Press, San Diego.

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