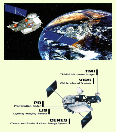
Detecting Climate Signals in Precipitation Extremes using TRMM Data

Increasing Contrast between Wet and Dry Extremes during the Past 16 Years



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1. Motivation and Key Question

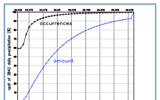
- Previous studies suggest increasing precipitation extremes in a warming climate
- The so-called "global warming hiatus" period (1998–2013)
- Reported Increased frequency of precipitation extreme around the world
- The state-of-the-art TRMM precipitation data products

→ Can we detect signals of changing precipitation extremes, including intense precipitation and prolonged droughts, using TRMM data?

2. Data and analysis procedures

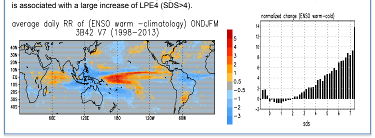
- TRMM Multi-satellite Precipitation Analysis (TMPA) 3B42 (version-7), a satellite merged-infrared-microwave-radar precipitation dataset with 0.25° x 0.25° and 3-hourly resolution covering 50°S–50°N [Huffman and Bolvin, 2014]. For comparison, CPC unified gauge-based data.
- Convert daily precipitation rates (RR) to SDS values, where

  SDS (x,y,day)=(RR(x,y,day) – mean)/SD ← standard deviation
- Construct probability distribution function (pdf) of local precipitation event (LPE) based on SDS
- Examine changes in pdf of LPE for ocean, land, wet, and dry seasons respectively
- Minimize impact of ENSO on the calculation of trend, based on linear regression

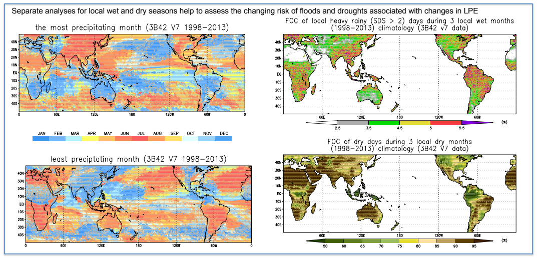


LPE (40°S–40°N) climatology indicates the corresponding [FOC, amount] of LPE2 (SDS>2) = [3.4%, 42.8%]

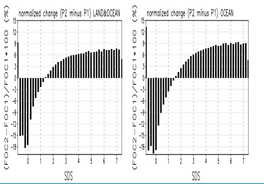
ENSO events have strong impacts on the geographic redistribution of LPE. ENSO warm phase is associated with a large increase of LPE4 (SDS>4).



Separate analyses for local wet and dry seasons help to assess the changing risk of floods and droughts associated with changes in LPE

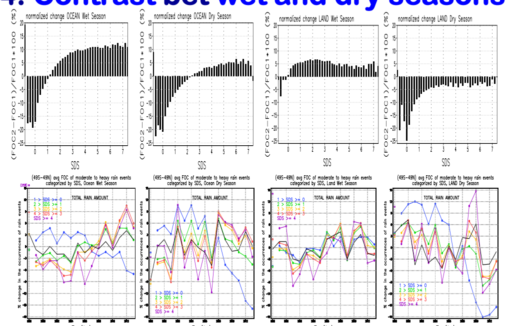


3. Detecting a structural change in global LPE pdf



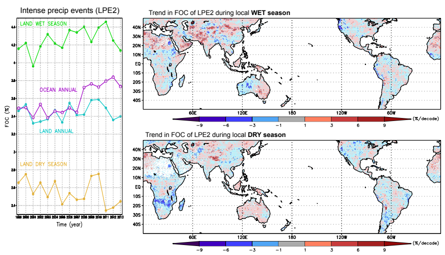
The normalized change in the frequency of occurrences (FOC) of LPE binned by SDS values for the entire (land & ocean) domain, and ocean only. Normalized change is defined by the FOC difference between P1 (1999–2005) and P2 (2006–2012) divided by FOC value of P1 at each SDS bin.

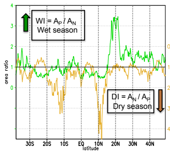
4. Contrast bet wet and dry seasons



Changes in FOC of LPE for ocean wet season, ocean dry season, land wet season, land dry season, and the corresponding time series for moderate to intense LPE.

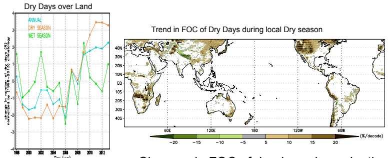
5. Increasing/decreasing intense precipitation events (LPE2) during local wet/dry season





Changes in FOC of LPE2 shown by time series, trend pattern, and the ratio of grid points with positive trend and negative trends.

6. Increasing dry days during local dry season



Changes in FOC of dry days shown by time series and geographic distribution of trend

7. Trend of LPE2 and dry days

Table 1. Trend Estimate of LPE2 and Dry Days for 1998–2013⁺

Region a. (40S-40N); b. (20N-40N)	Annual	Wet season	Dry season
Ocean + Land (LPE2)	a. **<u>4.1</u>** b. ***8.4**	a. **<u>5.9</u>** b. ***12.4**	a. -1.0 b. -1.8
Ocean only (LPE2)	a. **<u>5.5</u>** b. ***8.1**	a. **<u>7.6</u>** b. ***12.7**	a. 0.5 b. -2.8
Land only (LPE2)	a. -0.2 b. ***9.0**	a. 1.4 b. ***12.0**	a. **<u>-6.6</u>** b. 0.1
Land only (Dry Days)	a. ***1.7**	a. -0.8	a. ***3.2**

⁺Trend in FOC of intense local precipitation events (LPE2) and in FOC of the dry days, estimated by linear regression expressed in unit of % change per decade. Calculation of LPE2 trend is based on adjusted data with ENSO signals removed by regression using Nino3.4 sea surface temperature. Significance level exceeding confidence level of 90%, 95% and 99% are shown respectively in bold, underlined, and with asterisk

Summary

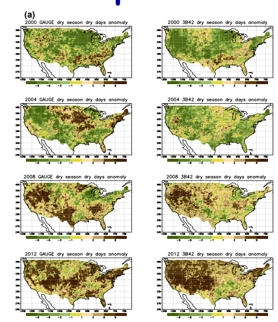
We investigate changes in daily local precipitation events (LPE) using TMPA 3B42 data (1998–2013), which coincides with the "global warming hiatus".

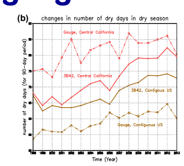
Results show a structural change in probability distribution functions (pdf) of LPE, signaling more intense LPE, less moderate LPE, and more dry days globally.

Analyses for land, ocean, wet and dry seasons separately reveal more complex and nuanced changes over land, characterized by a strong positive trend (+12.0% per decade, 99% confidence level (c.l.)) in frequency of extreme precipitation (LPE2) over the Northern Hemisphere extratropics during the wet season, but a negative global trend (-6.6% per decade, 95% c.l.) during the dry season.

Analyses of the risk of drought based on the number of dry days show a significant global drying trend (3.2% per decade, 99% c.l.) over land during the dry season. Regions of pronounced increased drought include western and central US, northeastern Asia and southern Europe/Mediterranean.

8. Increasing dry days in CONUS - comparison with gauge data





3B42 vs. Gauge data in the observed changes in number of dry days during local dry season shown in (a) evolution of the geographic patterns (every 4 years, from year 2000 through 2012) over contiguous United States (CONUS), and (b) time series of the observed mean changes of contiguous US, and of central California.

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