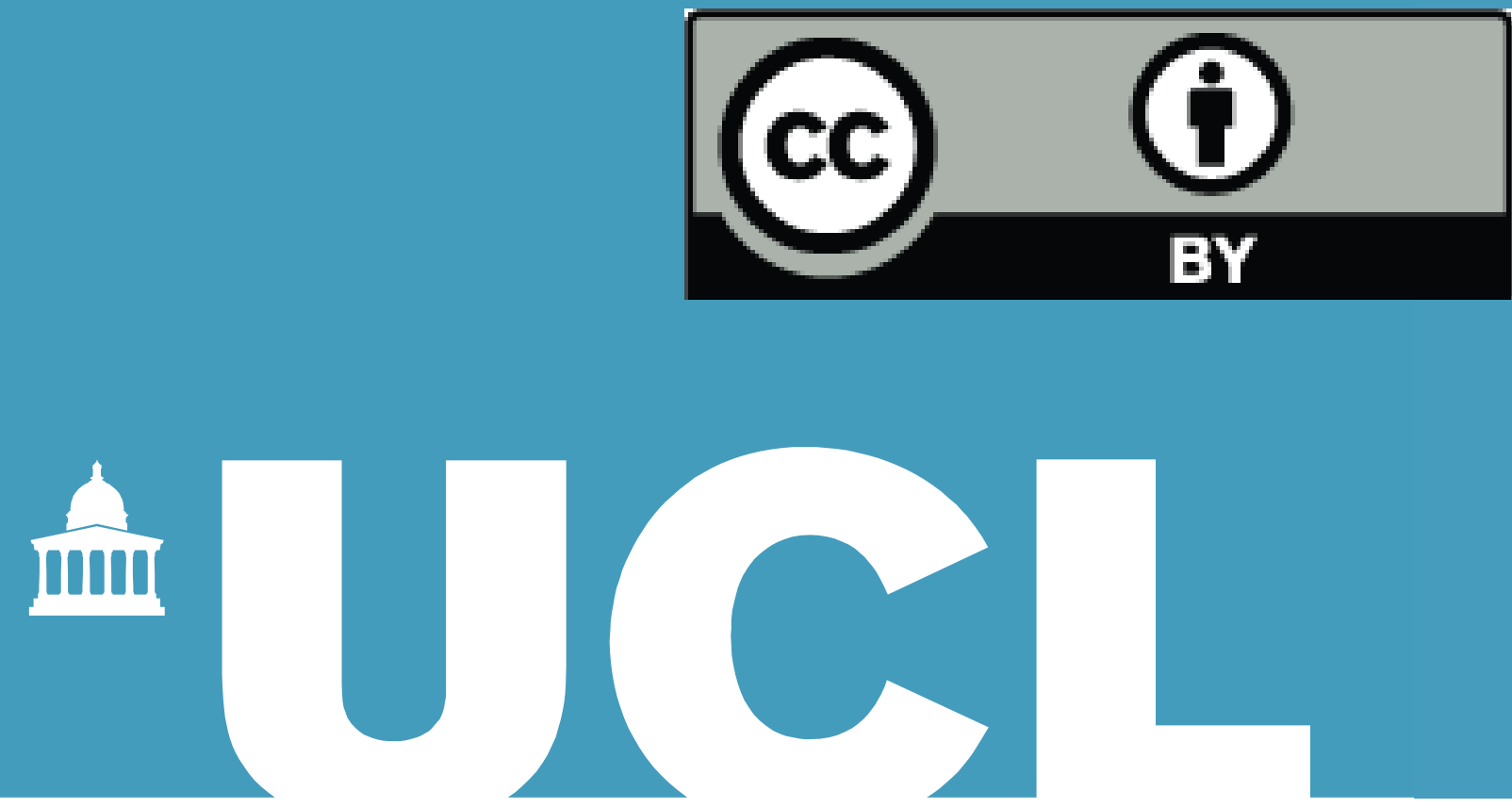


The 2011 Thailand flood: climate causes and return periods

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Introduction

- Thailand is one of the most developed and wealthiest countries in Southeast Asia. However, its tropical location, local topography and seasonal monsoon rains make it prone to floods.
- The insured loss from the 2011 Thailand flood (US \$12 billion) ranks as the highest ever from a freshwater flood disaster worldwide (Swiss Re, 2012).
- Here we provide an overview of the 2011 flood, discuss its climatic causes and estimate its return period using different techniques.

Flood overview & historical ranking

- During 2011 Thailand saw above average rainfall from the summer monsoon and from the remnants of four tropical storms in the country's north.
- Flooding was exacerbated by poor management of the country's main dams.
- An area of 30,000 km² was inundated, affecting 65 out of 77 provinces (Aon Benfield, 2012).
- The 2011 flood ranks 5th in terms of magnitude and 1st in terms of duration (Brakenridge, 2012).
- The return period for the 2011 flood (based on table below) is 5.6 years.

Top 10 Thailand flood events (1985-2012) (Brakenridge, 2012)				
Year	Dates	Magnitude	Duration (days)	Area Affected (km ²)
1995	1 Aug—9 Nov	7.9	101	444,000
2002	18 Aug—26 Nov	7.9	101	372,000
2006	20 Aug—13 Dec	7.7	116	213,000
2004	6 Aug—3 Oct	7.6	59	378,000
2011/12	5 Aug—9 Jan	7.5	158	97,000
2007	5 Sep—10 Nov	7.3	67	300,000
1994	3 Sep—18 Dec	7.1	107	65,000
2005	13 Aug—26 Sep	7.1	45	134,000
2003	12 Sep—12 Oct	7.0	31	315,000
1996	18 Jul—21 Aug	7.0	35	314,000

Flood magnitude = log (Duration × Severity × Area Affected).
Severity depends on the estimated recurrence interval of floods in the region affected and is defined on a scale between 1 and 2.

Climate causes

- Thailand precipitation in 2011 was 23% above normal.
- A strong Southeast Asian summer monsoon contributed to a rainfall anomaly of +246.1 mm for the May-October (MJJASO) period.
- A positive correlation exists between August-October (ASO) Southern Oscillation Index (SOI; Troup, 1965) and ASO precipitation (Singhrattna *et al.*, 2005). A moderately high SOI value of +7 for ASO 2011 (Australian Bureau of Meteorology, 2012) enhanced the summer monsoon.
- The remnants of four tropical storms brought high rainfall to northern Thailand between June and October - one third of the anomalously high rainfall in 2011.



Figure 1. (a) Aerial survey of the extensive flooding in Bangkok on 24 October 2011 and (b) the extent of the flood in 2011 with Switzerland shown for area-comparison. Images courtesy of Cpl. Robert J. Maurer, U.S. Marine Corps (a) and Swiss Re, Sigma No.2/2012 (b).

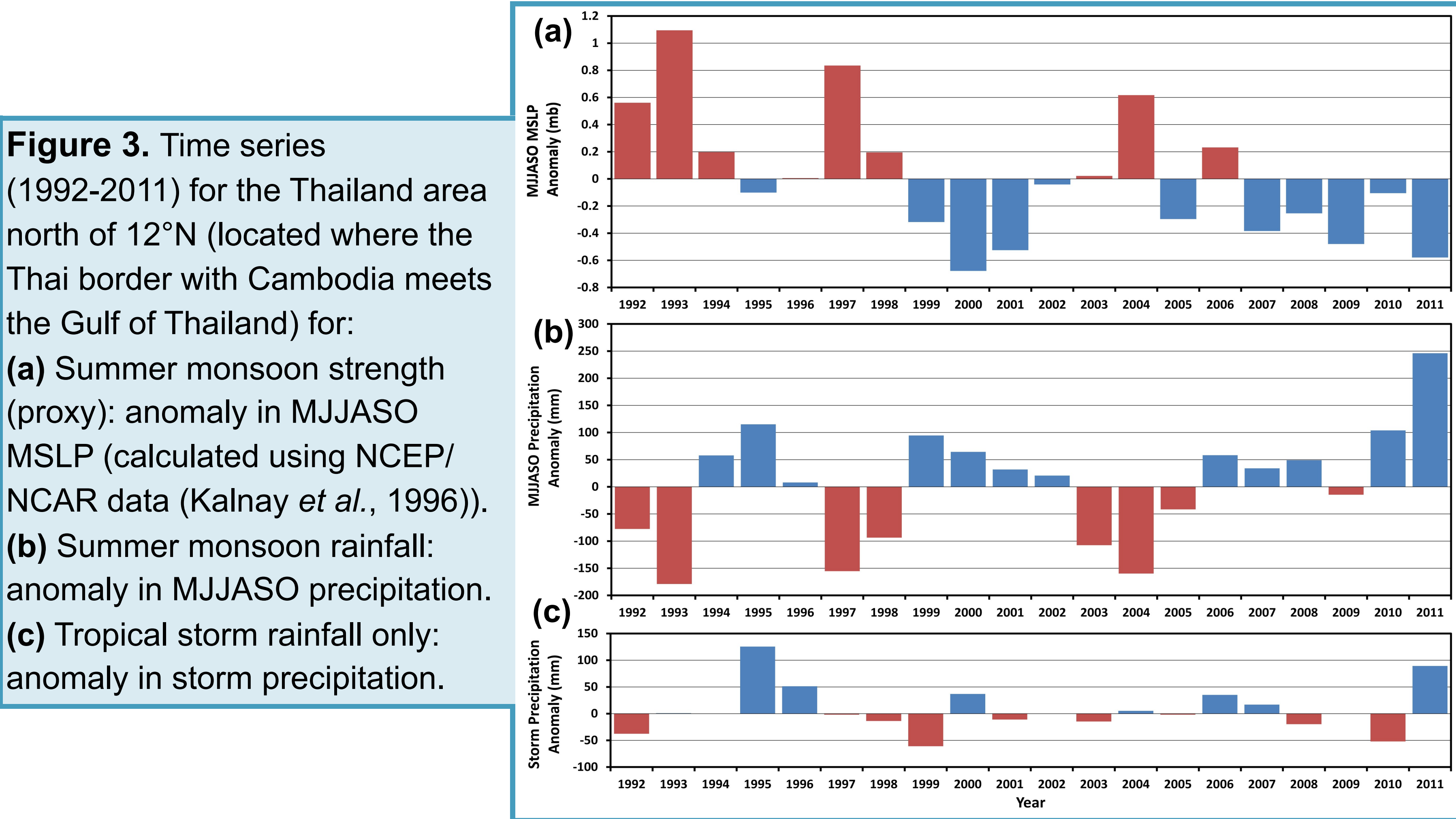


Figure 3. Time series (1992-2011) for the Thailand area north of 12°N (located where the Thai border with Cambodia meets the Gulf of Thailand) for:
(a) Summer monsoon strength (proxy): anomaly in MJJASO MSLP (calculated using NCEP/NCAR data (Kalnay *et al.*, 1996)).
(b) Summer monsoon rainfall: anomaly in MJJASO precipitation.
(c) Tropical storm rainfall only: anomaly in storm precipitation.

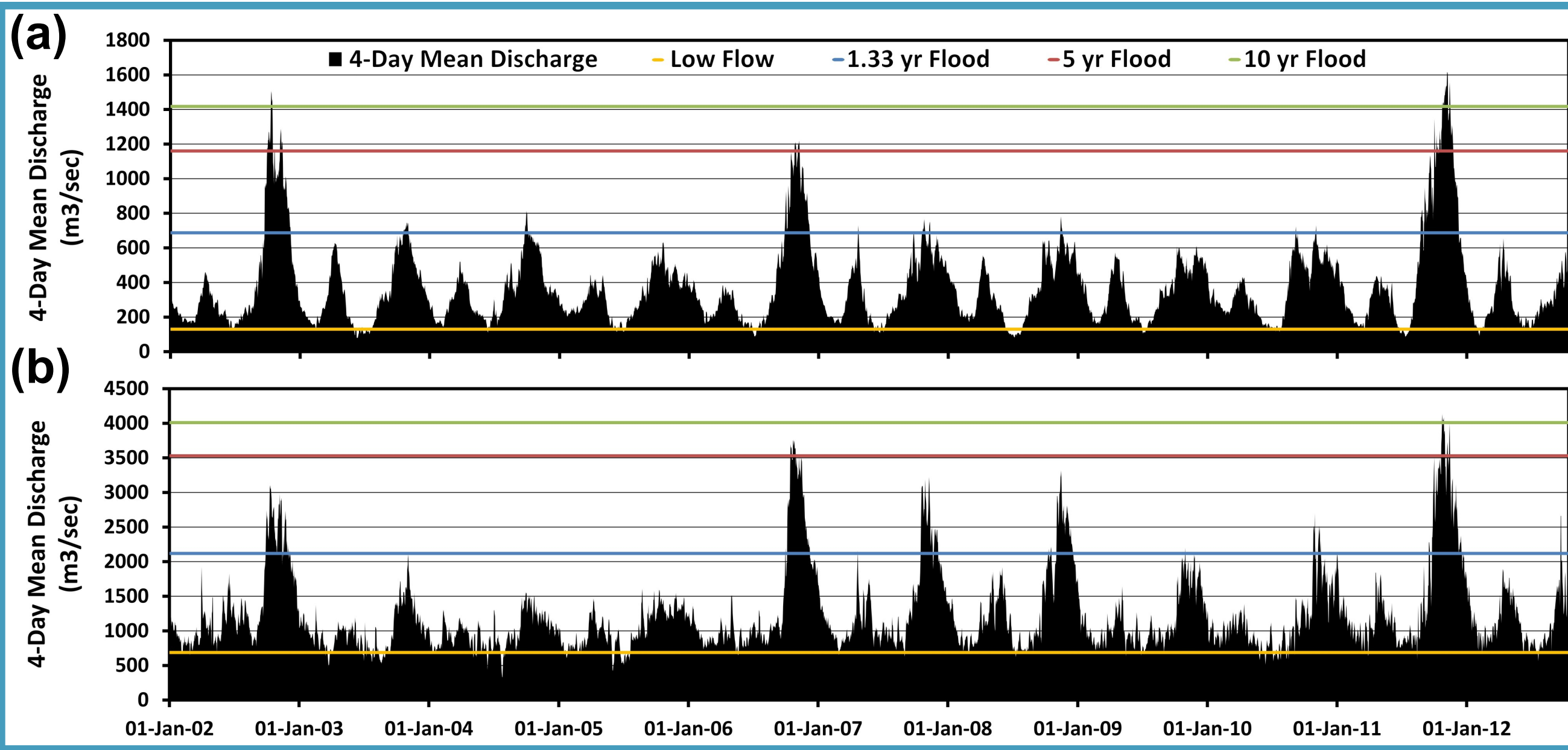


Figure 5. The 4-day mean satellite-derived river discharge data (2002-2012) are displayed for two locations on the Chao Phraya River basin (labelled (a) and (b) on Figure 4). The coloured lines show various flood amounts. (Adapted from Brakenridge *et al.*, 2012).

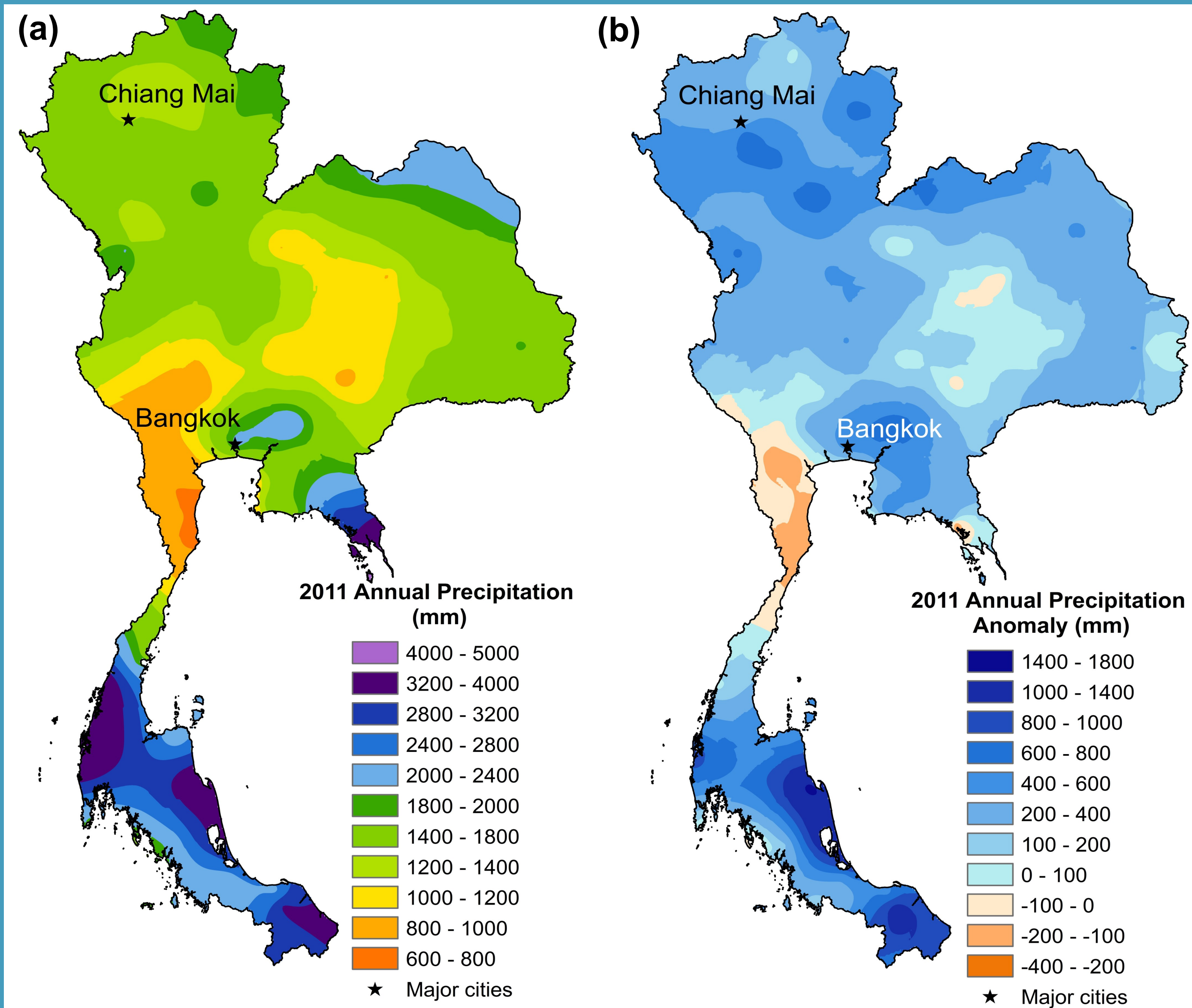
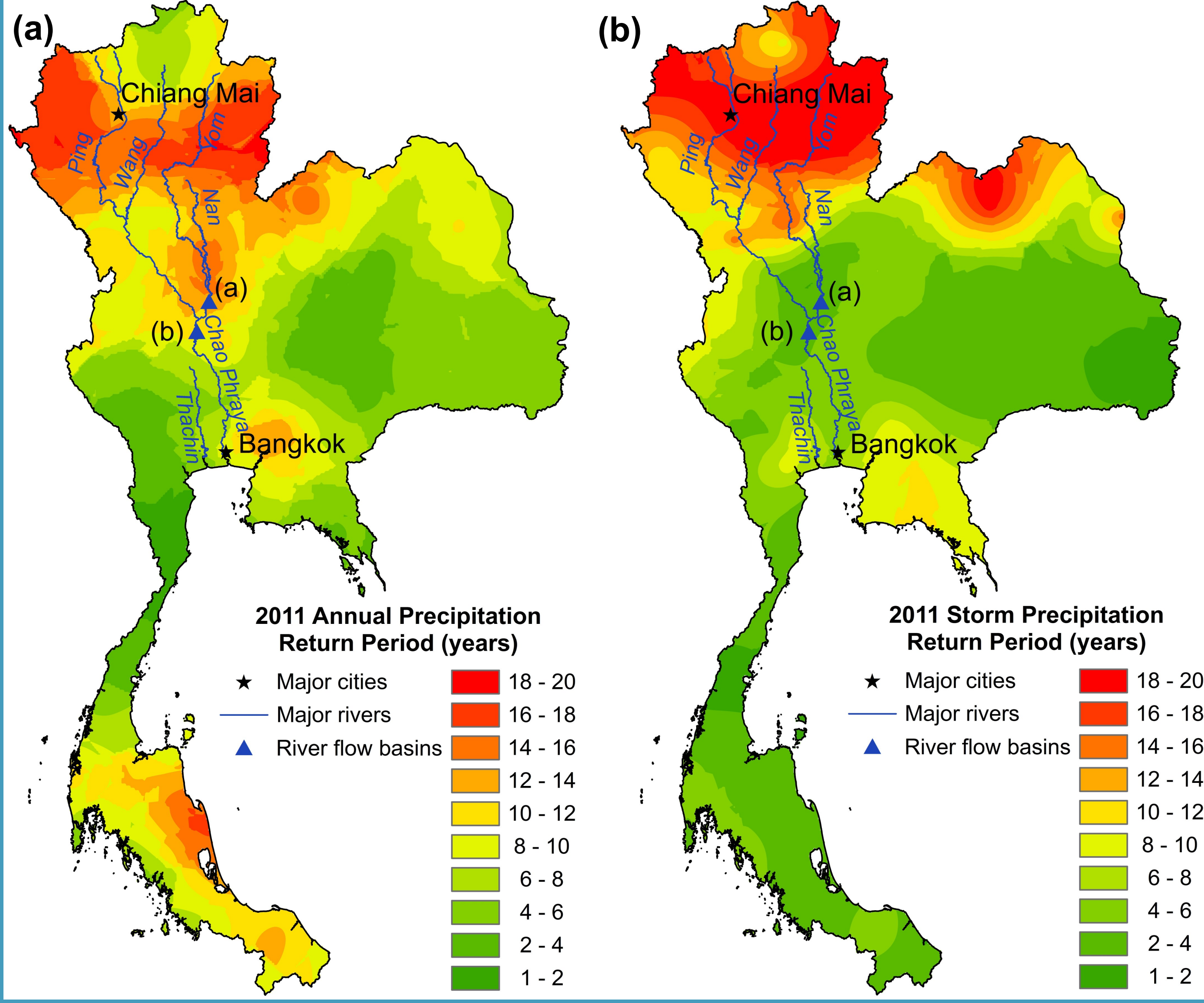


Figure 2. (a) Annual precipitation and (b) anomaly (cf 1992-2011 mean) for 2011. Rainfall data were provided by the Thailand Meteorological Dept.. The kriging spatial interpolation technique (Webster and Oliver, 2007) was used.

Figure 4. 2011 return period in years for (a) annual precipitation and (b) tropical storm precipitation. The major rivers in the Chao Phraya River basin are included together with the two sites used in Figure 5.



Return periods

- The 2011 flood return period may be estimated from pan-Thailand historical annual rainfall data and from satellite-derived river flows in the Chao Phraya River basin.
- The return periods for annual total and annual tropical storm rainfall in 2011 were computed for 100 weather stations across Thailand using 1992-2011 daily data and a standard return period method (NOAA, National Hurricane Center, 1987).
- The return period method divides the number of years with complete rainfall data by the number of years where the annual (or storm) rainfall total is greater than or equal to the observed value for 2011.
- Estimated return period for annual precipitation in 2011 is 6-10 years.
- Satellite-derived river flows from two sites on the Chao Phraya River were obtained from the Dartmouth Flood Observatory (Brakenridge *et al.*, 2012).
- The peak discharge in 2011 was the highest since January 2002 at both sites.
- The flood return periods estimated from the river data are:
Northern site = 10-20 years.
Southern site = 10 years.
- After bringing together the various different estimates, the “consensus” return period for the 2011 Thai flood is approximately 10-20 years, although this may be biased low.

Summary

- The 2011 Thailand flood ranks as the country's most damaging to date.
- It was caused by unusually high monsoonal rainfall (linked to a favourable SOI) and anomalously high rainfall from 4 tropical storm remnants crossing the north.
- The Chao Phraya River could not cope with the volume of water runoff and burst inundating an area the size of Switzerland. This river basin is home to 30% of the Thai population (DHI, 2012).
- A consensus of three different estimates suggests a return period for the 2011 Thailand flood of 10-20 years.

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Further Information

Gale E., Saunders M.A., 2013. The 2011 Thailand flood: climate causes and return periods. *Weather*, in press.