THE ABSENCE OF A ROLE OF CLIMATE CHANGE IN THE 2011 THAILAND FLOODS

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Thailand experienced severe flooding in 2011. During and after an unusually wet monsoon (July–September) in northern Thailand, rivers on the flood plains in the center and the south flooded their banks and inundated large parts of the country, including the former capital Ayuttha and neighborhoods of the present capital Bangkok. Large-scale industrial estates were submerged by 2.5 m of water for nearly 2 months and the economic damage was considerable. The reinsurer SwissRe estimated an insured damage between 8 and 11 billion U.S. dollars (USD) (SwissRe 2011). The total damage is much more uncertain, the World Bank estimates a value of 45 billion USD (World Bank 2011).

Flooding events are not uncommon in Thailand. However, the scale of the 2011 event was unprecedented. In this article we perform a first analysis of the meteorological component of the flood: how unusual was the rainfall in the catchment of the Chao Phraya river in northwestern Thailand, and are future monsoon rainfall trends expected due to climate change? It should be emphasized, however, that nonmeteorological factors were much more important in setting the scale of the disaster. Examples are the changing hydrography of the river (the levels of the Chao Phraya were in some places more than 0.5 m higher than in 1995 for even a slightly lower discharge), conversion of agricultural land to much more vulnerable industrial usage, and reservoir operation policies.

Observed rainfall anomaly and return time. We use the Global Precipitation Climatology Centre (GPCC) V5 1° rainfall analyzes (Schneider et al. 2011) to estimate historical rainfall over Thailand. This dataset nominally starts in 1901, but up to 1915 there are very few reporting stations in Thailand. The number of stations included rises from 35 in 1915 to 80 in recent years (A. Becker 2011, personal communication). We therefore start our analysis in 1915. For 2010 and 2011 the dataset was extended using the GPCC monitoring product. On the overlap period 1986–2010 the correlation is 0.99 but the monitoring dataset has a slightly lower mean and variability. A linear correction for the mismatch leads to a 2.7% increase in the values for 2010 and 2011.

Figure 4a shows the time series of rainfall in the middle and upper Chao Phraya basin, approximated by the region 15°–20°N, 99°–101°E, which is shown by the box in Fig 5. In this estimate the monsoon season 2011 is the wettest in the record, but comparable to 1995. To estimate the return time we fitted a

generalized Pareto distribution (GPD; Coles 2001) to the highest 80% of the distribution before 2011. This gives a central estimate of a return value of 140 years although the 95% confidence interval encompasses a range from 50 to several thousand years. In terms of large-scale meteorology, the 2011 monsoon was not very different from previously observed seasons.

La Niña has a statistically significant but small effect of rainfall in the area: the linear correlation coefficient with the Hadley Centre Global Sea Ice and Sea Surface Temperature (HadISST1) Niño-3.4 index is about −0.25 (between −0.07 and −0.39 with 95% confidence), slightly weaker than the spring teleconnection to the Netherlands (van Oldenborgh et al. 2000). Under the assumption that the empirical distribution shifts linearly with the Niño-3.4 index, the observed weak La Niña (Niño-3.4 = −0.5) implies an increase of the probability of "above-normal" precipitation from 33% to 45% in July–September 2011. From the scatterplot Fig. 4b one can see that all extreme rainfall events in the past occurred at neutral or La Niña conditions. However, the return time of the 2011 event was not lower relative to the regression line than the 140 years quoted above. The extra 17 ± 13 mm (2σ error) explained by the weak La Niña is counteracted by other changes in the tail within the large uncertainties of the empirical distribution function.

Have Thailand rainfall extremes become more likely due to climate change? One method to answer this question is to analyze the observations only. Given the intrinsic rarity of extreme events, this implies that one has to make statistical assumptions on the distribution of the data. One possibility is the assumption that the probability distribution function of monsoon rainfall does not change shape but is shifted to higher or lower values by the changing climate (van Oldenborgh 2007). The trend of the time series in Fig. 4 is not significantly different from zero: the mean precipitation has not changed beyond the natural variability. The 20-yr running mean and standard deviation also do not show significant variations.

The second method is to use climate models rather than statistical models, which in principle can give a physics-based estimate of the change in PDF. A full analysis would have to involve a validation of the representation of the Southeast Asian monsoon in these models. Here we simply note that the 17 climate models available in the CMIP5 archive (Taylor et al. 2012) at the time of writing

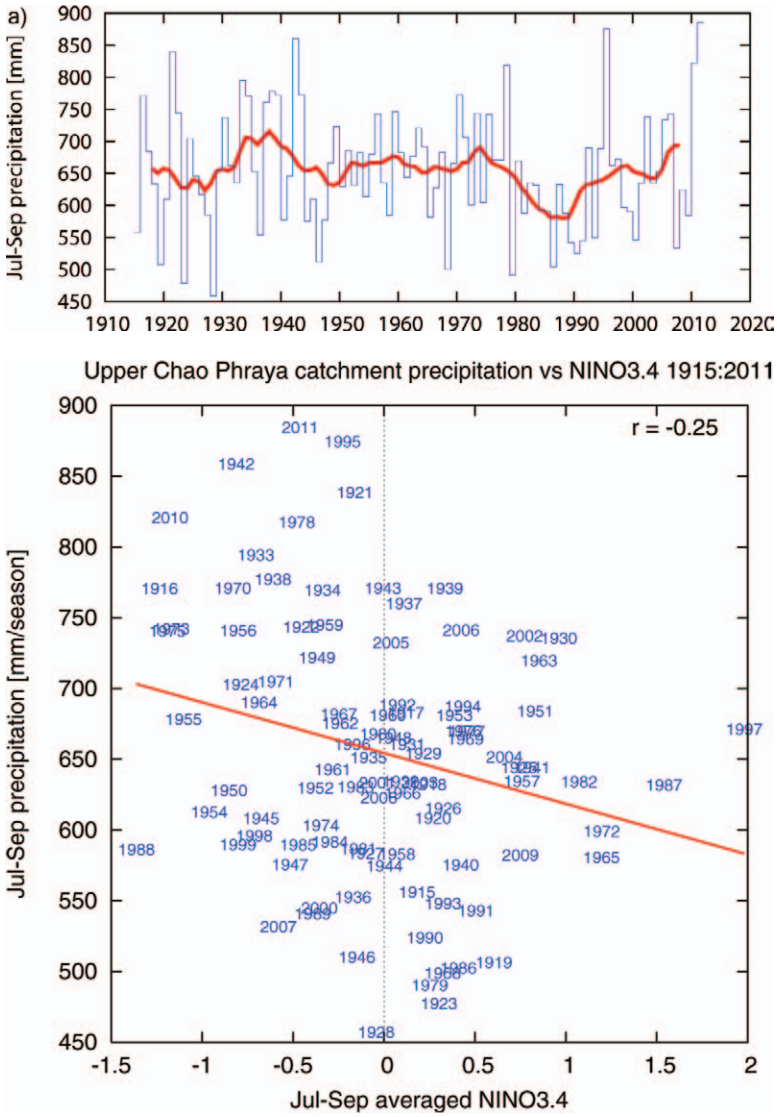

Fig. 4. (a) July–September precipitation (mm) in the upper catchment of the Chao Phraya river that flooded in 2011. The rainfall has been approximated by the 10 grid boxes in 15°–20°N, 99°–101°E in the GPCC V5 1° analysis 1915–2009, extended with the GPCC monitoring analysis linearly adjusted to agree on the overlap period. The red line denotes a 10-yr running mean. (b) Scatterplot of this precipitation against the HadISST1 Niño-3.4 index. The least squares regression line has been drawn red.

show no trend in the region of the catchment of the Chao Phraya up to 2011 in either mean or variability. They do show an increase of 10%–20% in both mean and standard deviation by 2100, indicating that the frequency of very active monsoons is projected to increase in the future by these models. We again stress that the credibility of any projected change depends on the simulation of climatology of the Asian monsoon, which is as yet untested in this ensemble and has been shown to be highly variable across models (Kim et al. 2008).

Conclusions. Although the damage caused by the 2011 floods on the Chao Phraya river in Thailand was unprecedented, the available data show that the amount of rain that fell in the catchment area was not very unusual. Other factors such as changes in the hydrography and increased vulnerability were therefore more important in setting the scale of the disaster. Neither in the precipitation observations nor in climate models is there a trend in mean or variability up to now, so climate change cannot be shown to have played any role in this event. Current models do project increases in both mean and variability in the future that would increase the probability of extremes. It may be advisable to take this into account when addressing current vulnerabilities.

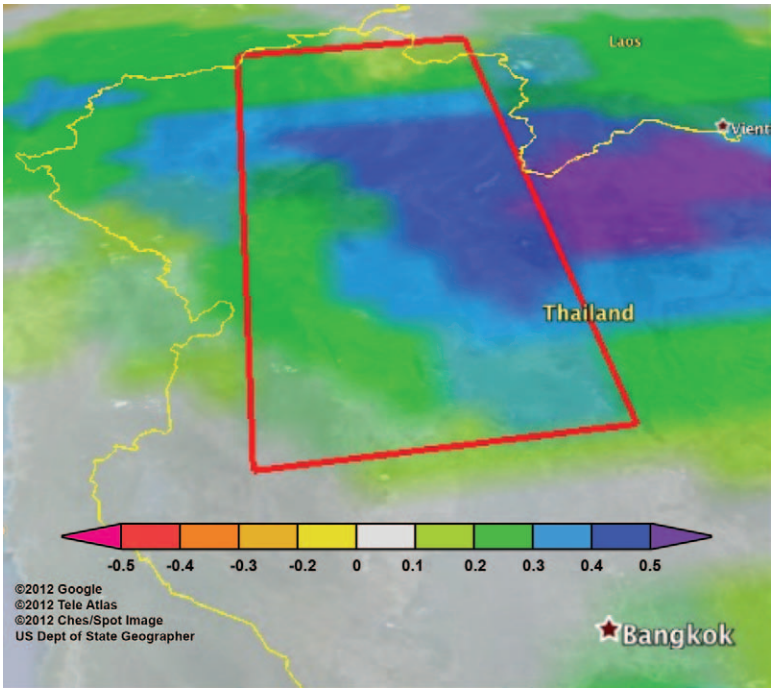

Fig. 5. Relative precipitation anomalies in Southeast Asia during July–September 2011. The value 0.5 means 50% more precipitation than normal in this season. The red box denotes our approximation of the middle and upper catchment basin of the Chao Phraya River, which runs south through Bangkok to the Gulf of Thailand. Data: GPCC V5 plus monitoring datasets at 1° resolution.

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