Introduction

In 2011, the precipitation amounts during the summer season were much higher than usual in the northern and the central part of Thailand. Besides the moderate to rather active south-west monsoon, entering very moist air into the country, the remnants of several tropical storms contributed to the high precipitation totals. These caused severe flooding, leaving at least 596 people dead, according to the Department of Disaster Prevention and Mitigation from 17 November 2011 (http://www.thailandtip.net). Also parts of the capital Bangkok are under water. After trying to prevent the city from being flooded by closing the locks in the north, they had to be opened in the end due to the increasing water pressure.

Fig. 1: Left: General map of Thailand with detail of the map on the right. Right in red: Flooded regions in the catchment area of Chao Phraya from 12 to 21 October 2011 [source: Dartmouth Flood Observatory].
The left map in figure 1 shows a general map of Thailand, while the satellite data based map on the right, edited by the Dartmouth Flood Observatory, indicates in red the flooded regions in the catchment area of Chao Phraya during the period 12 to 21 October 2011. (Further maps dealing with the flooding in Thailand can be found on the internet pages of unitar.) The Chao Phraya is one of the most important rivers in Thailand, beginning in the north in Nak-hon Sawan at the junction of the rivers Ping and Yom, and flowing into the Gulf of Thailand south of Bangkok. Besides Bangkok, the old riverine capital Ayutthaya with its numerous sights is affected by the floods.

**Precipitation in Thailand**

The climate of Thailand is influenced by seasonal monsoonal winds. The southwest monsoon, usually blowing from mid-May to mid-October, brings warm, moist air masses from the Indian Ocean to Thailand and initiates the rainy season. The wettest period is mostly August to September (except for the east coast of southern Thailand). In addition to the southwest monsoon, tropical storms determine the monthly precipitation totals. The period May to October, during which the southwest monsoon prevails, is defined as main rainy season. However, it must be considered that in further months, especially in April and November, high monthly precipitation totals of partly more than 100 mm may be recorded. The dry period from December to February is influenced by the northwest monsoon.

In 2011, the southwest monsoon started in Thailand early in May and ended by mid-October. Partly, the monsoon was rather active causing above-average precipitation mainly in the northern and central parts of the country. Additionally, the remnants of several tropical storms on their tracks from the east, contributed to the monthly precipitation totals (e.g. HAIMA in June, NOCK-TEN in July, HAITANG and NESAT in September/October). All this resulted in high waters and extensive flooding.

Figure 2 shows the monthly precipitation totals of three representative stations in northern (Chiang Mai, Phitsanulok) and central (Bangkok) Thailand from September 2010 to October 2011 in comparison to the respective means of 1961-1990. Chiang Mai and Phitsanulok represent stations in the northern catchment area of Chao Phraya, while Bangkok exemplifies the situation at the lower section of the river. The figure displays the onset of the rainy season in May being much wetter than usual. Though September precipitation was below-average in Bangkok, October precipitation was well above-average. The figure also shows that there were already too wet conditions in northern and central Thailand in the pre-rainy season, i.e. in March and April.
**Fig. 2:** Monthly precipitation totals (red) of three Thai stations from September 2010 to October 2011 in comparison to the respective means of 1961-1990 (green).

Often more than 20 mm rain per day fell at the contemplated stations during the rainy season. Occasionally, even more than 70 mm was recorded, as in Chiang Mai (fig. 3) on 4 June (82 mm) and on 31 July (78 mm), and in Phitsanulok on 19 August (80 mm). A new record was set in Bangkok on 30 June with a daily precipitation total of 157 mm.
Fig. 3: Daily precipitation totals in Chiang Mai from May to October 2011.

Figure 4 shows the accumulated daily precipitation of the three stations since the beginning of the monsoon season, i.e. since May 2011. For comparison, the accumulated monthly means of the reference period 1961-1990 are plotted as step diagram. The difference indicates the precipitation surplus. The precipitation totals from May to October exceeded the averages by 247 mm in Chiang Mai, by 379 mm in Phitsanulok and even by 603 mm in Bangkok (see also tab. 2 below).
Fig. 4: Accumulated daily precipitation from May to October 2011 (red) as well as accumulated monthly means of the reference period 1961-1990 (green).

In table 1, the monthly precipitation totals (in mm) of selected Thai stations from May to October 2011 are opposed to the respective monthly means of the reference period 1961-1990. Summing up, table 2 displays the precipitation totals of the entire monsoon season May to October 2011 and their absolute (in mm) and relative (in %) deviations from the long-term
averages. The climate regions, as used by the Thai Meteorological Department, are given in column "reg." with the following abbreviations: C = central part; E = eastern part; N = northern part; NE = north-eastern part; SE = southern part / east coast; SW = southern part / west coast.

<table>
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Tab. 1: Precipitation totals of selected Thai stations from May to October 2011 ("rec.") and monthly means from 1961-1990 ("mean"). Above-average precipitation totals are marked blue.

<table>
<thead>
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<th>dev. MAY-OCT</th>
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Tab. 2: Precipitation totals ("sum") of selected Thai stations from May to October 2011 as well as their absolute and relative deviations ("dev.") from the long-term means.

The tables 1 and 2 show, that the precipitation surpluses from May to October 2011 were particularly high in northern and central regions of Thailand. In October, the precipitation decreased markedly in the north.

The Thai Meteorological Department edited the short report "Rainfall and severe flooding over Thailand in 2011" at the beginning of November 2011. It comprises a summary of the events and region-related precipitation data, referring to the long-term averages of the period 1971-2000.

Comparison with previous years

Figure 5 shows the precipitation totals from May to October (southwest monsoon season) of the years 1949 to 2011 for the stations from figures 2 and 4 above. For comparison, the station related mean of the May to October precipitation totals of the reference period 1961 to 1990 is also plotted in the diagrams.
Fig. 5: Precipitation totals from May to October of the years 1949 to 2011 (blue bars) and long-term mean of the years 1961-1990 (green line). Remark: Years with missing values are not considered.

Figure 5 exposes, that in 2011 the precipitation totals of the monsoon season were not the highest of the regarded time span, but that they were well above-average at all displayed stations. Just the concurrence of unusually high precipitation amounts in northern and central Thailand caused the widespread flooding.
Sources

- Dartmouth Flood Observatory: http://floodobservatory.colorado.edu/
- Deutscher Wetterdienst (DWD): Data archive.
- Global Disaster Alert and Coordination System (GDACS): http://www.gdacs.org/reports.asp?eventType=FL&ID=2011_3850&system=asgard&alertlevel=Orange&glide_no=0&location=&country=Thailand