SHORT REPORTS

J.Sci.Soc. Thailand 11 (1985) 121-127

A MEAN SEA LEVEL EVENT IN THE GULF OF THAILAND

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(Received 18 June 1985)

Abstract

In March, 1985, a change in the instantaneous mean sea level of about 0.5 m caused floods at Songkhla and Bangkok, some 1000 Km apart. This event demonstrated clearly the role of the instantaneous mean sea level in the end of year floods occurring in Bangkok at the end of the wet season.

It is well known that the tides in the Gulf of Thailand and in the Chao Phya River may tend to rise in September of each year, reaching a maximum during November, and returning to their "normal levels" during December[1]. Tidal theory makes a strict distinction between astronomical and meteorological/oceanological tides. The former are determined by the gravitational attraction of the Moon and the Sun the periodic nature of which is well understood and accurately predictable. The latter, like weather, are stochastic in nature and therefore cannot be predicted. The sea level changes referred to above belong to the second category of tides. Fig. 1 shows the records for March, 1985 from tide gauges operated at Songkhla by the Harbour Department and in the Chao Phya River by the Hydrographic Office of the Royal Thai Navy. Note that the regularity of the tidal pattern in these records is severely disturbed; in the middle of the month, the lowest tides are higher than those two weeks earlier and two weeks later.

In general, to achieve the most accurate tide predictions, the non-astronomical tides should be removed from tidal records before the records are harmonically analyzed. Day by day, predictions would then have to be corrected on the basis of observations at selected control tide gauges. Instead, it is common practice to disregard this state of affairs and analyze harmonically the raw records. In that case, seasonal tidal height variations of the type occurring in the Gulf of Thailand are included in the semi-annual

and annual harmonic constants. This is the reason why each year in October or November announcements are made to forewarn the Bangkok public of high tides which then may or may not occur. Any improvement in the accuracy and reliability of water level predictions, especially for the Bangkok area, would be of great importance.

However, in the Gulf of Thailand and elsewhere, major meteorological tides are not confined to certain periods of the year. Fig. 1 shows that during March 1985, the tides became higher all around by about half a metre. This development reduced gravity drainage, and, as a consequence, floods occurred in the Bangkok and Songkhla areas. This event is of great importance for the study of Bangkok's end of the year floods. In this paper, we present the results of an analysis of the floods of March, 1985, which was conducted as part of an overall study of Bangkok's floods.

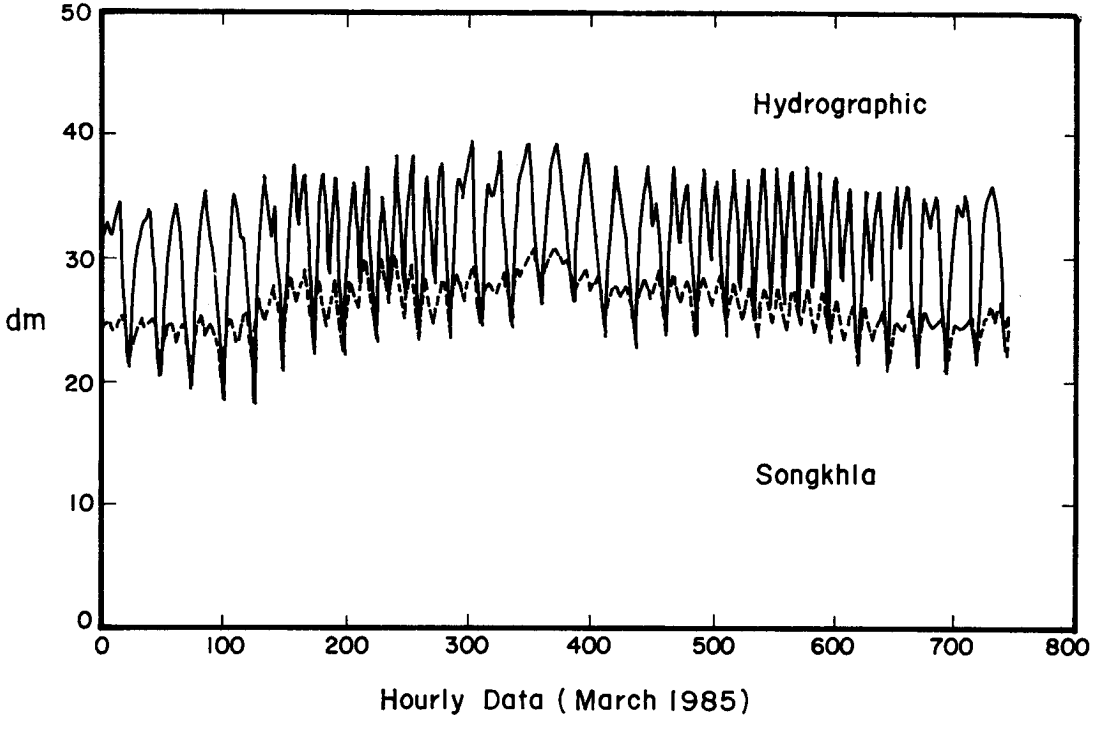

Fig. 1 Raw Tidal Data

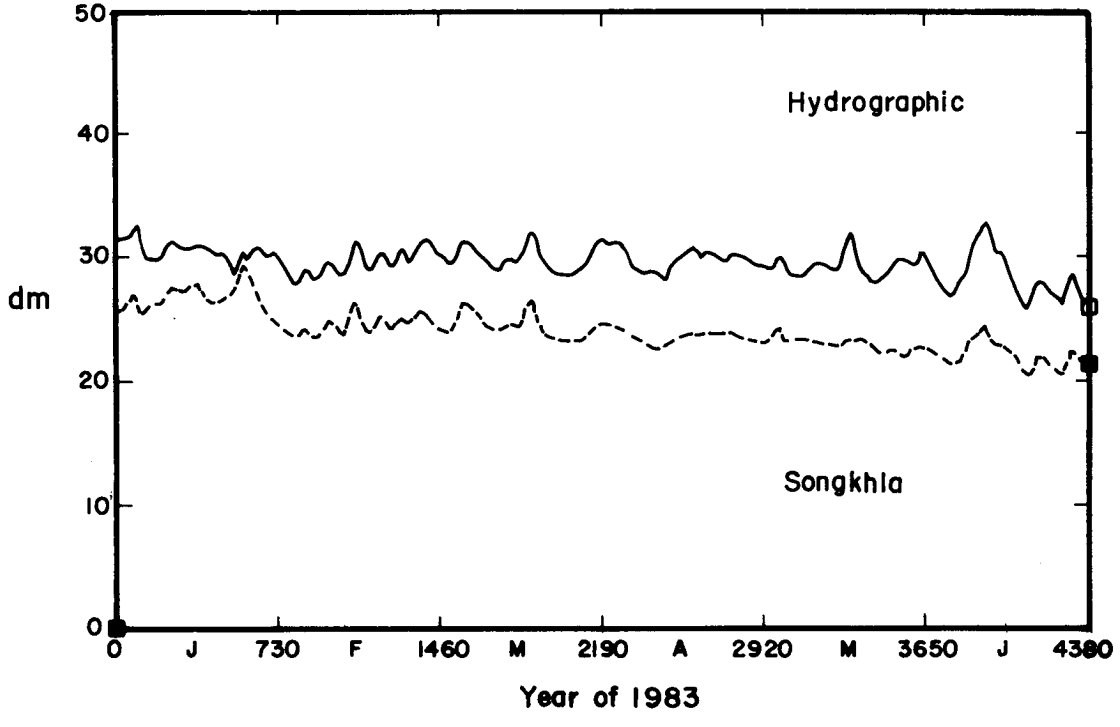

Fig. 2 A Low Pass Filtered Water Levels. Running Mean : 25,25,23,673

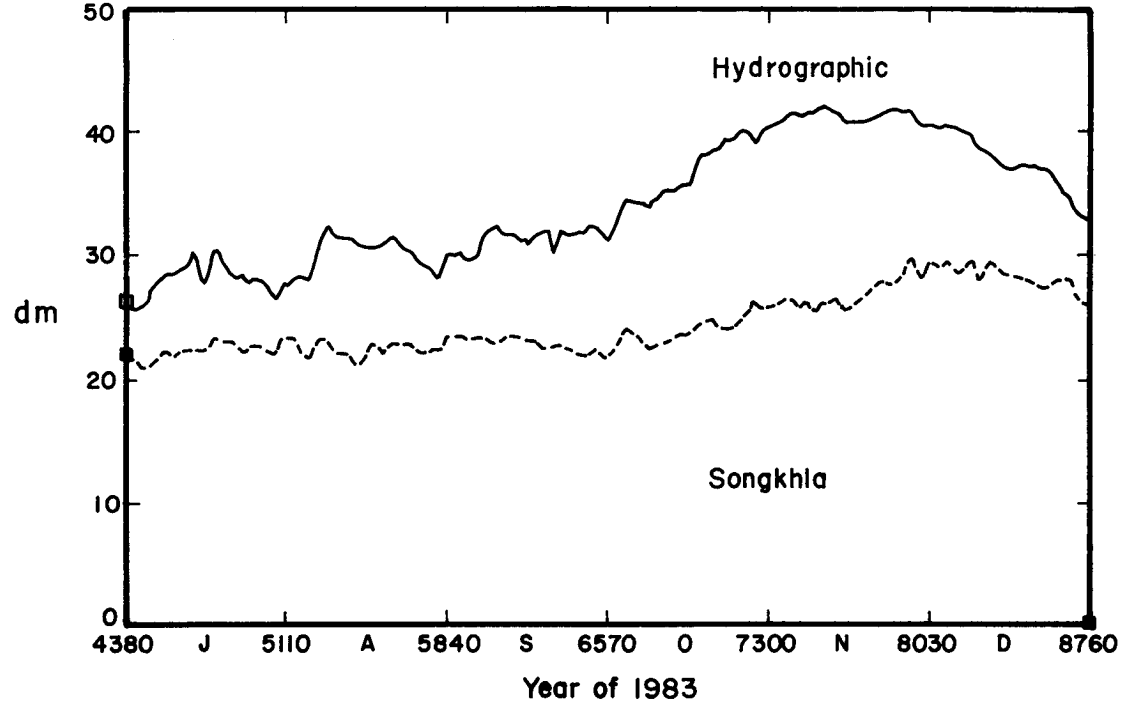

Fig. 2 B Low Pass Filtered Water Levels. Running Mean : 25,25,23,673.

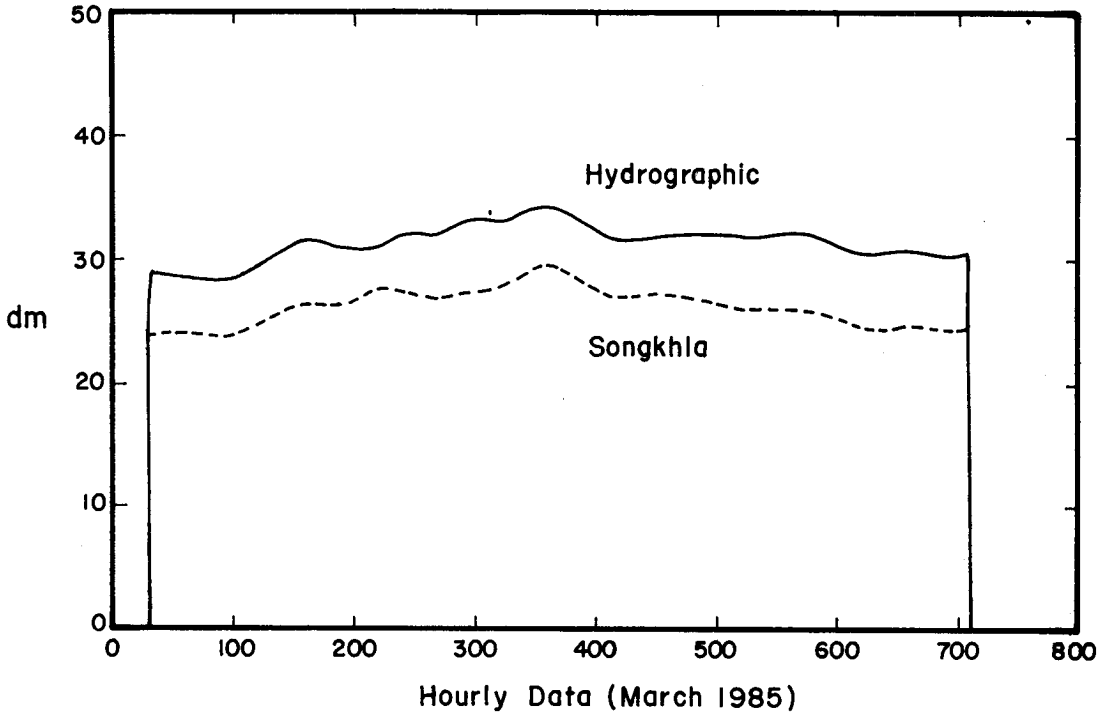

Fig. 3 Low Pass Filtered Tidal Data. Running Mean : 25,25,23.

The basic idea of harmonic analysis, first proposed by William Thomson, later Lord Kelvin, in 1872, is to analyze harmonically hourly tidal heights recorded at a station in terms of periods which are determined by the orbits of the Sun and the Moon. The most important periods derived from these orbits and supplementary considerations are about 12 and 24 hours long. Since the periods relating to the Moon are longer than those relating to the Sun, one obtains on superposition the beat effect, commonly known as the Neap and Spring Tides. When the 12 hourly periods dominate, one speaks of semi-diurnal tides, otherwise of diurnal tides. In the Gulf of Thailand, both types of tides occur.

In addition to the harmonic components, harmonic analysis yields a quantity called the mean sea level which is used by marine surveyors to establish a reference datum for charting, shipping and construction of coastal installations. It is the average value of all hourly tidal heights included in a harmonic analysis. This term is apt to cause confusion, since many people will be inclined to accept it as an absolute quantity, while in actual fact its value depends on the time covered by the record. Furthermore,

its value is also linked to the datum of a given tide gauge which may be affected by the sinking of Bangkok.

Theoretically, tidal predictions based on harmonic analysis of at least a year's data should be accurate, apart from minor variations with periods in excess of one month for any time selected, so that one could, for example, compute the tide levels at Ayuthaya at the time of its destruction by the Burmese. In practice, the meteorological, and therefore unpredictable, tides interfere, or, as it is convenient to argue, "modify the mean sea level". Such instantaneous mean sea levels can be computed by low pass filtering of the raw data before harmonic analysis, i.e., by removing all contributions with periods below a set value, for example, 25 hours, etc. This objective is achieved most simply by computing sequentially running means over a number of hours equal to the largest period to be filtered. Since 12 and 24 hourly components dominate tidal records, it is an established procedure to compute the running means successively for 23, 25 and 25 hours. Monthly variations are filtered by averaging subsequently over 673 hours. Once the results of its low pass filtering have been subtracted from a tidal record, its harmonic analysis will yield a good approximation to its astronomical tide constants below the filter cutoff; these constants can then be employed to predict tidal heights, times of low and high waters, etc. However, these predictions will refer to an, in general, unknown datum, the instantaneous mean sea level.

An additional complication arises in the presence of runoff floods when the downstream current impedes the progress of the tide radiating from the Gulf upstream into the river. As a result, prediction of the astronomical tide becomes more difficult. Nevertheless, instantaneous "mean river levels" can still be computed, but only with a lag of up to 35 hours. However, since the mean level does not vary quickly, it can be used as a predictor for assessing the likelihood of municipal flooding. As a first approximation, half the range of the preceding day's astronomical tide can be added to the mean level.

Around the world, many smaller and larger towns have been constructed at what amount to mean sea levels. As a rule, such towns are characterized by an abundance of canals and waterways. Venice, Leningrad and Bangkok are the most illustrious examples which come immediately to mind. Among other less obvious locations one finds London, Port Adelaide in South Australia, and even large sections of countries such as North Holland and Bangladesh. Simply as a consequence of their location, these population centres are flooded for shorter or longer time intervals when mean sea levels in the sense defined earlier rise for a wide range of reasons, not all of which are as yet understood.

When persistent winds blow from Africa along the Adriatic Sea, from Denmark across the Baltic Sea, from Spitzbergen over the North Sea, mean sea levels rise and stay high for several days, and population centres experience floods. When cyclones form

over the Gulf of Bengal or over the seas surrounding the Philippines, long period, storm-generated waves, on entering shallow water, raise mean sea levels for very brief periods with disastrous consequences for populations living in low lying areas. When submarine earthquakes occur in the Northern Pacific, tidal waves or Tsunamis (a Japanese term) are generated; these solitary waves have in the past killed thousands and even hundred thousands of people. Most of these phenomena are characterized by their relatively short durations.

Along the South Coast of Australia, mean sea levels can rise by up to 2 metres when the ever present surf and storm waves wash away coastal dunes and the sea creates lagoons inland. At Port Adelaide, a suburb of Adelaide on the Gulf of St. Vincent, streets will flood under such conditions; this occurs a number of times each year. On the Gulf of Thailand, the mean sea level often rises from September until November and returns to its more or less steady height in December. Since at the same time, the wet season sends flood water down the Chao Phya River, the role of the mean sea level in the flooding of Bangkok has become obscured. Both in Southern Australia and in the Gulf of Thailand, the changes of mean sea level are caused by mechanisms which are not as yet understood, although there can be no doubt that their origin is not local. However, while these variations tend to exhibit preference for certain times of the year, this is not always the case.

In particular, during March of 1985, a mean sea level rise of half a metre in the Gulf of Thailand led to flooding in as far apart localities as Bangkok and Songkhla. This event made it possible to separate the two mechanisms which take part in the flooding of Bangkok, namely the seasonal flood wave descending the Chao Phya River and the variation in mean sea level, as will be shown below.

A simple argument establishes beyond doubt the fact that hourly mean sea level changes actually play a role in Bangkok's floods. One need only compare instantaneous mean sea levels, i.e., low pass filtered sea level records from locations on the Chao Phaya River near Bangkok and somewhere reasonably far way on the Gulf of Thailand, for example, Songkhla. Fig. 2 shows such hourly mean sea level records for 1983. Allowing for the fact that the absolute values of the hourly mean sea levels must differ since the reference levels of the two tide gauges do not refer to a common datum, it is seen that these curves exhibit a remarkable similarity for a large part of the year. From the beginning of October onwards, the mean level at Songkhla also begins to rise, but more slowly than at Bangkok, where the flood water from upstream begins to make the larger contribution. However, even before that time, the Bangkok hourly mean level exhibits excursions which are not matched by the Songkhla record.

The instantaneous mean level records of March, 1985 confirm this conclusion. At that time, the sea level offered the only possible explanation of the floods at Songkhla and Bangkok. It is seen from Fig. 3 that indeed the two curves are very similar. Long

waves with periods of about two days entered the Gulf from the South China Sea and eventually induced a maximum mean level change of about half a metre on 16th March, the date when at both locations floods began and continued for several days.

Since the actual water levels at any locations in the Gulf of Thailand and in the lower reaches of the Chao Phya River are subject to astronomical semi-diurnal or diurnal tides, the instananeous mean sea level determines the amount of gravity drainage which can occur in any system of canals or lakes which are connected to the River or the Gulf. During most of the year, this exchange with what amounts to an infinite reservoir maintains acceptable levels, which do not interfere with the lives of the inhabitants. However, when the mean sea level rises, and/or the river flow increases, the drainage times are reduced and water will enter the city through canals which do not have gates.

A first step towards safeguarding Bangkok against disastrous floods must introduce a planned control of the inflow through the canals. In other words, sluice gates must be constructed on all canals leading directly or indirectly into the metropolitan area. The opening and closing of these gates must be effected systematically under a centralized agency with reference to actual levels occurring at control gauge sites.

The sinking of Bangkok is a recent development following in the wake of adoption of Dutch practices of pumping fresh water from the ground water table beneath the city. In the first place, this affects the levelling of tide gauges, and introduces an uncertainty into comparisons of levels measured at different localities.

Reference

1. Punpruk, V. (1981) Sea Level Variations in Gulf of Thailand. *Master Thesis, Naval Postgraduate School,* Monterey, California, USA.

บทคัดย่อ

ในเดือนมีนาคม 2528 ระดับน้ำทะเลเฉลี่ยที่เพิ่มระดับขึ้น 0.5 เมตร ทำให้เกิดน้ำท่วมที่จังหวัดสงขลากับกรุงเทพฯ ซึ่งอยู่ห่างกันตั้งร่วม 1000 กิโลเมตรทันที เหตุการณ์นี้แสดงให้เห็นอย่างชัดเจนถึงบทบาทของระดับน้ำทะเลเฉลี่ยที่จะมีต่อการท่วมของกรุงเทพฯ ในปลายฤดูฝน.