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Tide Prediction for the Downstream Boundary Condition of the Chao-Phraya River Integrated River Model Using Harmonic Analysis

TIDE PREDICTION FOR THE DOWNSTREAM BOUNDARY CONDITION OF THE CHAO-PHRAYA RIVER INTEGRATED RIVER MODEL USING HARMONIC ANALYSIS

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Chao-Phraya river basin covers Thailand's land area of 20,125 sq.km and 372 km of length of Chao-Phraya river. It starts from the origin of the river in Nakhon Sawan to Gulf of Thailand in Samut Prakarn (Figure 1). The population living in the basin is approximately 23.0 million inhabitants. Chao Phraya River Basin has dynamically encountered severe flood inundation in the past such as in 1995, 2006 and 2011. The 2011 flood volume was 16 billion cubic meters. The flooding was caused by heavy rainfall, high tides, river overbank flow and breaching of flood control dikes. The flood damage cost in 2011 was dramatically US dollars 45.7 billion. Furthermore, there are enormous uncountable impacts on the well-being of suffering-flooded people.

Given these ever-lasting huge flood threats in these lower sections of the Chao-Phraya river basin, this author team initiated a project of developing an early flood warning system for possible flood mitigation. To that avail the river flood model HEC-RAS is employed. A review of the past flood events shows that about 85% of the total runoff occurs in the months of July to December; therefore, this period is also used in the calibration of HEC-RAS in both steady and transient mode. In the latter case the success of the calibration depends to a large extent on the downstream boundary condition of the river flow model which is located at the Fort Chula gauging station at the Chao-Phraya river mouth at the coast of the Gulf of Thailand. The water levels of this gauging station are influenced by both the upstream river water levels and the heights of the ocean tidal waves entering the Chao-Phraya river mouth.

Figure 1 Chao-Phraya river basin with Gulf of Thailand

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For the prediction of the tidal heights at the Fort Chula gauging station a harmonic tidal model of the Gulf of Thailand is applied to the Chao Phraya river mouth. The harmonic theory of tides stipulates that the tidal elevation η_r at an arbitrary ocean point of the earth is a weighted superposition of different harmonic lunar and solar constituents, each having its own amplitude, period and phase. Bases on this idea the tidal elevation η_r is written as

$$\eta_r(t) = a_0 + \sum_{i=1}^{N} a_i \sin\left[\frac{2\pi t}{T_i} + \delta_i\right] \tag{1}$$

where a_0 is the mean sea level, and a_i, T_i, and δ_i are the amplitude, period and phase of the i^{th} lunar and/or solar constituent. Each tidal cycle follows a simple recurring (harmonic) pattern with a fixed period. The parameters that vary from place to place are the amplitudes a_0, a_i and the time lag (phase) δ_i of each constituent. These values are determined for each corresponding value of T_i by least squares analysis using the data information that are obtained from the local tidal records (cf. Sun and Koch, 1998; Vongvisessomjai et al., 2000).

Using the expression (1) with the least-squares-computed coefficients, a seven-day-ahead tidal prediction for the Chula gauging station at the Chao-Phraya river mouth is done. The results are shown in Figure 2, where one can note a good agreement between predicted and observed tidal heights with a degree of explanation of 87%. Expectedly, as the forecasting period gets larger, the prediction errors increases, especially at the peaks and troughs of the tidal height fluctuation.

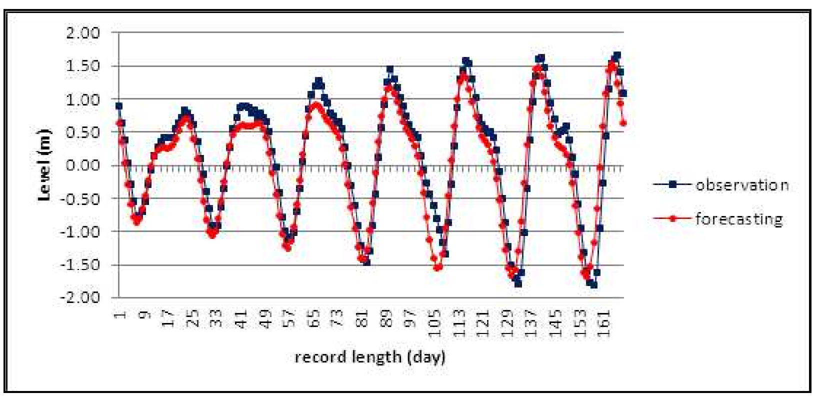

Figure 2 Forecasted and observed tidal elevations for the scheme of seven-day-ahead prediction

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