CHAPTER 1 INTRODUCTION

1.1 Rational/Problem

The sea level rise is one of many problems of the global warming effects. The long term sea level changes in each area are different. Some regions show that sea level rise are greater than the global average sea level rise. Sea level rise has two main processes: thermal expansion of sea water and widespread melting of land ice. It impacts on coastal erosion, land loss, increase salinity, increase flooding and storm events, fishery communities, environments in coastlines and many coastal applications. Many researches (IPCC, 2007; Dasgupta, et al., 2007; White, 2011) concern on how sea level rise and its impacts. A report of the Commonwealth Scientific and Industrial Research Organization (CSIRO) studied global warming in the Asia Pacific region and predicted that the sea level will rise up to 0.16 - 0.50 m in year 2030 - 2070 with the sea level rise of 0.30 - 0.50 m would affect more than 100,000 km along coasts, especially China's Pearl Delta and Bangladesh's Delta (Michael, 2006). The National Aeronautics and Space Administration (NASA) reported that the trends of long term sea level are rise using the linear regression method (NASA, 2010). This report revealed historical trends of global mean sea level from tide gauge records (left panel) and the average sea level from global satellite measurements (right panel), see Figure 1.1. Niemnil and Trisirisatayawong (2006) reported that long term sea level in the Gulf of Thailand of Sattahip, Ko Mattaphon and Ko Sichang stations are rising rates of 0.22, 0.51 and 0.81 mm/yr, respectively while a falling rate of 0.52 mm/yr at Ko Lak station. However, Vongvisessomjai (2006) reported that sea level fall in the Gulf of Thailand region using tide gauge records at Ko Lak station, Prachuap Khirikhan province and Sattahip station, Chonburi province.
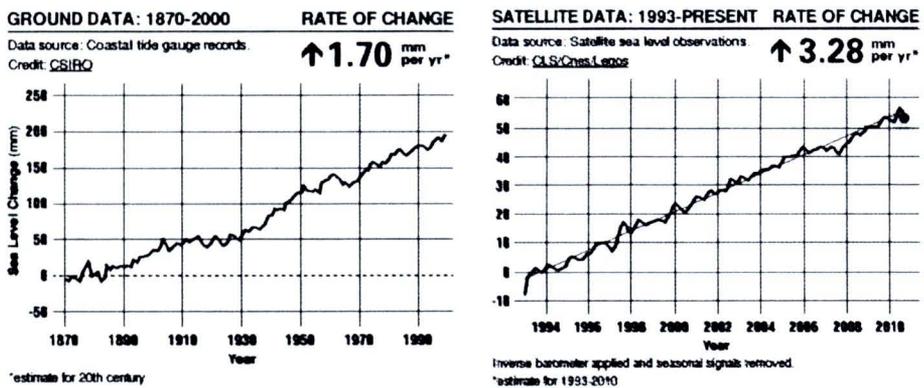

Figure 1.1 The global mean sea level data derived from coastal tide gauge records (left panel) and the average sea level since 1993 derived from global satellite measurements (right panel) by NASA, 2010.

1.2 Literature Review

Yanagi and Akaki (1994) investigated mean sea level variations in the Eastern Asia using observed sea level data of 16 stations from the Permanent Service for Mean Sea Level (PSMSL) during 1950 to 1991. The future global sea level rise show that the mean sea level rise in year 2030 would be 0.18 m as reported by Intergovernmental Panel of Climate Change, IPCC. On the other hand, the result of research showed the mean sea level will rise more than 0.22 m in the year 2030 along the eastern coasts of Japan and the Philippines but the mean sea level rise would be below 13 cm along the coasts of the Yellow/East China Seas, South China Sea and the Gulf of Thailand.

Ebuchi and Hanawa (1995) compared surface current velocity variations derived by the TOPEX altimeter with data from Tokyo-Ogasawara Line Experiment (TOLEX)-Acoustic Doppler Current Profiler (ADCP) monitoring during October 1992 to July 1993. Firstly, the interpolated TOPEX SSH is compared with sea level data at Chichijima in the Ogasawara Islands. It can be concluded that the tidal error aliasing in the sea surface heights from TOPEX is not negligible in the TOLEX region. Thus, comparison of the TOPEX data with the TOLEX-ADCP data is decided to be made by using cross-track velocity components of the surface current, which are considered to be relatively less affected by the tidal errors. The cross-track velocity variations derived from the TOPEX agree well with sea level of the ADCP observations. The root mean square (RMS) difference and correlation coefficient are 5.63 cm and 0.67 respectively.

Ebuchi and Hanawa (1996) presented the comparison of sea surface heights (SSH) from TOPEX altimeter with sea level data from tide gauge at Chichijima in Oga-sawara (Bonin) Islands and hydrographic data around the Islands. The performance of three new oceanic tide models such as CR model, RSC model and MSET model showed good agreement with RMS differences less than 4 cm. The RSC model gave the smallest RMS difference, 2.61 cm. The results of these models by using SSHs from TOPEX were also compared with sea level data at Chichijima. A long-term variation of one year period was found in the residual between the SSHs and the sea levels at Chichijima. This variation was also found in the difference between the dynamic height anomalies calculated from hydrographic data around the Islands and sea levels at Chichijima. The residual showed variation alias caused by incompleteness of the ocean tide correction with the repeat cycle of the altimeter observation.

Nerem, et al. (1997) used Empirical Orthogonal Functions (EOFs) to analyze the observed sea level variations from Topex/Poseidon. The spatial characteristics of the first mode is weakly related to the El Nino Southern Oscillation (ENSO).

Swathi and Yajnik (1997) compared SSHs obtained from Modular Ocean Model (MOM) with Topex/Poseidon data in the Indian Ocean. In this research, the SSH in the Indian Ocean obtained from a global simulation of MOM with a resolution of $1°$ in the longitude, $1/3°$ in the latitude between $30°S$ to $30°N$ and 20 levels in the vertical with climatological wind forcing and restoring conditions on temperature and salinity. The correlation between the two data sets in the northern Indian Ocean, especially the Arabian Sea is better than in the southern Indian Ocean.

Torrence and Webster (1999) applied wavelet analysis to indexes of equatorial Pacific sea surface temperature (Niño3 SST), the Southern Oscillation Index (SOI) and all Indian rainfall. The wavelet coherence is applied to the ENSO and monsoon index. The results showed that the Niño3 SST and Indian rainfall were found to be highly coherent.

Kim, et al. (2001) compared the SSH from Topex/Poseidon MGDR radar altimeter data in the East Sea (Japan Sea) with the SSH from in-situ tide gauges at Ulleungdo, Pohang and Sockcho/Mucko. The correlation coefficients of SSHs between the Topex/Poseidon altimeter and the tide gauges were 0.42, 0.26 and 0.25, respectively.

Ding, et al. (2002) analyzed the future sea level change in Hong Kong using data from the tide gauges and sea surface atmospheric pressures recorded over the year 1954 - 1999, as well as data sets of the global sea surface atmospheric pressures, Southern Oscillation Index (SOI) and SST in the eastern equatorial Pacific to analyze the basic features in the sea level change for this region. Results showed that there is a rising trend of 1.9 ± 0.4 mm/yr in the sea level of Hong Kong and the interannual variations are related to El Niño and La Niña events that occur frequently in the tropical Pacific.

Chu, et al. (2003) used EOFs to investigate the spatial and temporal variability of monthly mean sea surface height anomaly from Topex/Poseidon data in the South China Sea. The results showed that the existence of multi-time scale variability: seasonal, interannual and intraseasonal indicated to the dominant modes of EOFs.

Wong, et al. (2003) studied the annual mean sea level measured at various tide gauge stations along the eastern and western coasts of Hong Kong and determined the long term sea level change in Hong Kong for the year 1954 - 2003. During the 50 years, the annual mean sea level at the North Point/ Quarry Bay rose at a rate of 2.3 mm/yr. This is similar to the rate of sea level rise of 2.3 mm/yr in the South China Sea as reported by State Oceanic Administration of China and slightly higher than the global mean sea level rise of 1.0 to 2.0 mm/yr for the 20th century as reported by Inter-governmental Panel on Climate Change (IPCC).

Tiwari, et al. (2004) investigated the dominant mode of interannual change and its correlation with ENSO by using sea level variations from Topex/Poseidon along the Indian Ocean. The results showed significant correlation of sea level changed in the Indian Ocean with ENSO events.

Vongvisessomjai (2006) analyzed sea level in Gulf of Thailand using 56 years of tide gauge records at Ko Lak, Prachuap Khirikhan province and Sattahip, Chonburi province. The results showed that sea level are falling slowly, which is consistent with results of Gregory (1993) who reported sea level falls in the low latitudes and the Gulf of Thailand of 0 - 0.05 m, using U.K. Meteorological Offices Coupled Ocean-atmosphere General Circulation Model. However, IPCC found future sea level rise in 100 years. The result showed that the sea level in the Gulf of Thailand was found preliminarily to be slightly falling or not changing, contradict to the assumption that sea level is rising in the Gulf of Thailand at the same rate as that in the high and middle latitudes.

Niemnil and Trisirisatayawong (2006) determined the rate of sea level change in the Gulf of Thailand using annual sea level data from tide gauge stations of Hydrographic Department, Royal Thai Navy and Port Authority of Thailand such as Sattahip station in Chonburi province, Ko Lak station in Prachuap Khiri Khan province, Ko Mattaphon station in Chumporn province and Ko Sichang in Chonburi province. The results showed that sea level of Sattahip station, Ko Mattaphon and Ko Sichang rising at rates of 0.22, 0.51 and 0.81 mm/yr, respectively while Ko Lak station gives a falling rate of 0.52 mm/yr.

Cheng and Qi (2007) analyzed the trends of 13 year sea level anomalies in the South China Sea using three-month moving average method. The mean sea level had a rising rate of 11.3 mm/yr during 1993 - 2000 and a falling rate of 11.8 mm/yr during 2001 - 2005. The trends of thermosteric sea level variations were calculated using Ishii data and MIT General Circulation Model assimilation data.

Sea level rise is a major effect of climate change and it is likely to affect millions of people by the year 2100. The IPCC (2007) found that sea level had changed dramatically in the past and the rate of sea level rise had increased. However, sea level is very difficult to predict, because the melting of the Greenland and Antarctica ice sheets will react to global warming. Moreover, local sea level is affected by tides, ocean currents, and geographically-varying land movements. Recently, scientists discussed and investigated sea level and its impacts using numerical ocean models for prediction and prevention effects of sea level rise.

In this research, the long term sea level in the Gulf of Thailand and the South China Sea are investigated by comparing observations and results from numerical ocean models. The consideration area is between 90°E to 130°E and 5°S to 30°N, see Figure 1.2. The trends of sea level are calculated using data records from tide gauge stations. The EOF is applied to investigate the dominant modes of variabilities. The wavelet analysis then used to analyze, especially in wavelet coherence.
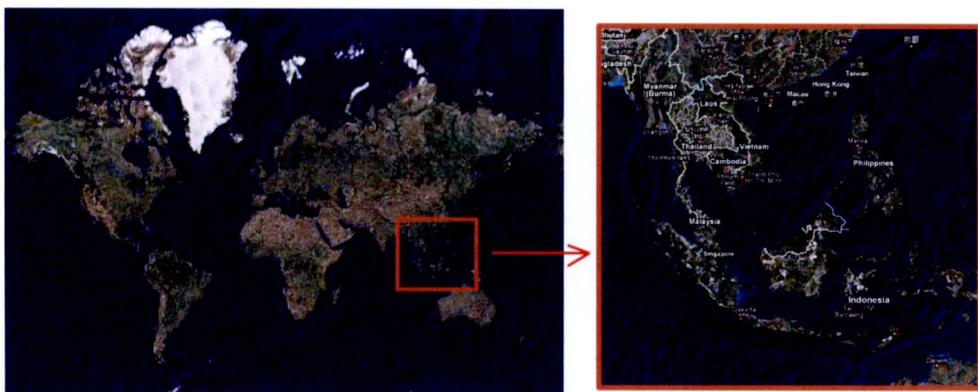

Figure 1.2 The studied area which covers the Gulf of Thailand and the South China Sea (Google, 2008).

1.3 Objectives

The objectives of this research are follow:

1. To analyze the sea level observation data in the Gulf of Thailand and the South China Sea.

2. To compare the sea level between the observation data and results from numerical ocean models in the Gulf of Thailand and the South China Sea.

3. To modify a numerical ocean model for the Gulf of Thailand.

4. To evaluate the results of the modified model.