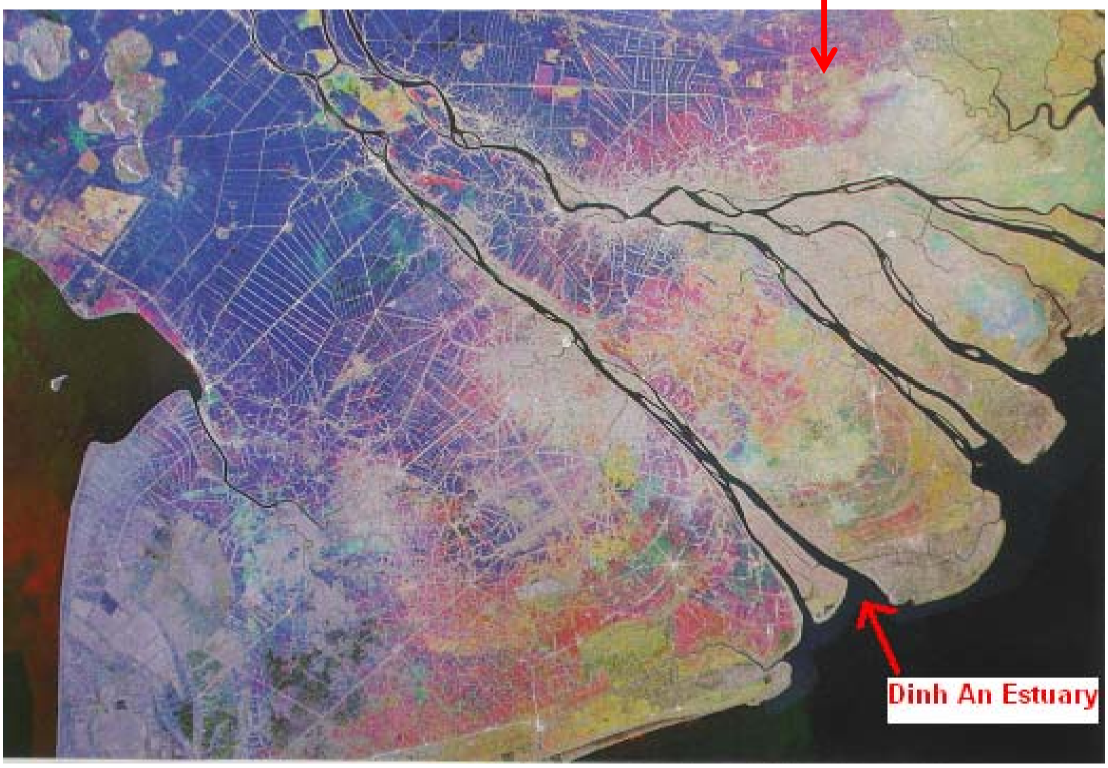
Interaction between morphology change & salinity distribution in the Dinh An Estuary, Vietnam

The Mekong River with its length of 4800km starts from Tibet Highland (China), flows through Myanmar, Thailand, Laos, Cambodia then finally into South Vietnam then to sea by 9 river mouths. The Mekong estuary morphology needs much research work. This below article is a contribution to analysis of the Dinh An Estuary.



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INTERACTION BETWEEN MORPHOLOGY CHANGE AND SALINITY DISTRIBUTION IN THE DINH AN ESTUARY, VIETNAM

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Abstract

Salinity intrusion into estuaries, in general, is mostly affected by river discharge and tidal level. Furthermore, the change of salinity can also be attributed to other external forces such as wave height and river mouth morphology. However, there has not any investigation been conducted so far taking into account this kind of aspect. The question should be paid attention here is: how is the interaction between morphology change and salinity distribution in the Dinh An estuary? In this paper, a three-dimensional model has been used to consider the above mentioned parameter.

Keywords: Dinh An estuary, morphology, numerical model, salinity intrusion

1. INTRODUCTION

The Mekong River starts at an elevation of about 5,000m in the Tanghla Shua on the Tibetan Plateau. From this source, the river goes through six countries: China, Myanmar, Lao PDR, Thailand, Cambodia and Vietnam. Before flowing out into the South China Sea, the Mekong River splits into two branches, the Mekong (known as Tien River) and the Bassac (known as Hau River). Tran De and Dinh An are two branches of the Hau River.

The economy of Mekong Delta, which is the major agricultural production area of Vietnam, has responded quickly to the government's "open door" policy and been oriented towards the primary sector. The delta shares 27% to the total GDP of Vietnam, some 40% of agricultural production, and a half of rice production in the country (MRC, 2004).

Accoding to MRC (2004), during the dry season saline water from the South China Sea and the Gulf of Thailand moves upstream along the rivers and canals of the Mekong Delta. The salinity intrusion into the Mekong Delta is very complicated. The highest salinity is usually observed in April. Currently, 1.77 million ha of delta lands are affected by saltwater intrusion, which affects not only irrigation development but also domestic water supply. Salinity worsens water quality and damages crop-lands. The most severe situations occur during the low flow season when there is insufficient flow to prevent seawater intrusion. Strong tidal waters encroach up to 50-70 km. The existing engineering infrastructure will be inadequate for coping with salinity intrusion, if water abstraction increases in the delta. The area affected to increase to 2.2 million ha, if no preventive measures are taken up.

According to Le (2003), tides in the South China Sea are predominantly semi-diurnal with non-uniform amplitude. Each day the tide has two crests and two troughs, the height of each crest and trough varies from day to day during about 15 days periods. Two troughs more significantly change as compare with the change of two crests during each half of a month's tide period. The amplitude can be up to 2 m, with a phase lag of the borderline of two troughs being half of the tide period. When one trough decreases down, the other trough increases gradually from day to day, and vice versa.

Salinity intrusion into estuaries, in general, is mostly affected by river discharge and tidal level. Furthermore, the change of salinity can also be attributed to other external forces such as wave height, river mouth morphology. There has not been any investigation, however, studied up to now taking into account this kind of aspect. In this study, a three-dimensional model has been used to consider the effect of morphology change on salinity distribution.

2. STUDY AREA AND DATA INVESTIGATION

The Hau River ($9^0 33'$-10^0 46'N, 105^0 00'- 106^0 42'E) is a part of the Lower Mekong Delta as shown in Fig. 1. The total catchment area of the study site is about 490 km^2. The Hau River located in the monsoon tropical semi-equatorial climate zone, and the climatic regime in the Hau River is dominated by the two monsoon seasons: the north-east (dry season, from December to April) and the south-west (rainy season, from May to November) (Nguyen and Nguyen, 1999).

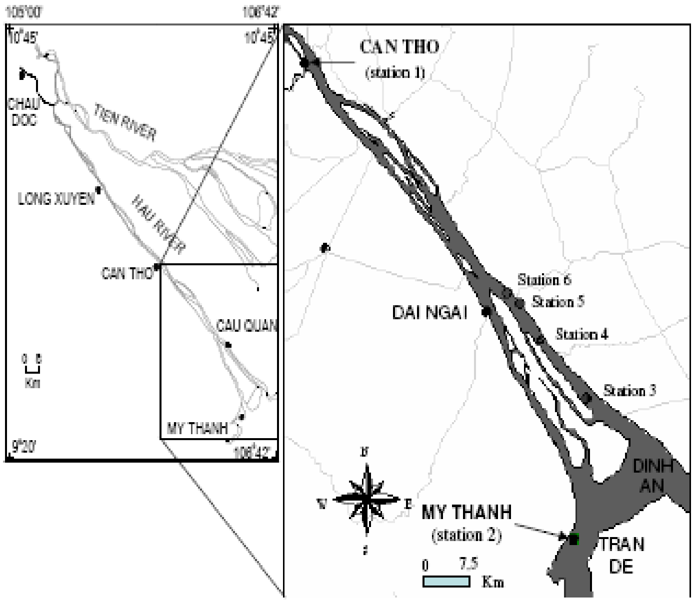

Fig. 1 Study area and surveying stations

Water quality parameters were measured by using TPM Chlorotec (ALEC Electronics Co., Ltd.), and the measurement of flow velocity and bathymetry near river mouth area were carried out by the use of Acoustic Doppler Current Profiler (ADCP) in both longitudinal and cross-sectional transects for two main surveying campaigns, April 2005 and March 2006, respectively.

Futhermore, four stations (station 3, 4, 5, and 6 using COMPACT-CT sensors) were installed along the river to obtain contiuous salinity and temperature data (time interval is 10 minutes) through out the dry season in 2005 as seen in Fig. 1. Nevertheless, tidal level at the river mouth can be measured in My Thanh station (station 2), and the upstream river discharge can be observed in Can Tho station (station 1).

3. MODEL SET-UP

3.1 Hydrodynamic Module

The hydrodynamic module used in the present study, named Estuarine Coastal Ocean Model (ECOM), is a three-dimensional, time-dependent, finite difference, developed by Blumberg and Mellor (1987). The model has a long history of successful applications to oceanic, coastal, and estuarine waters (Blumberg et al., 1999). The model incorporates the Mellor and Yamada (1982) level 2.5 turbulent closure model to provide for a realistic parameterization of vertical mixing. A system of curvilinear coordinates is used in the horizontal direction, which allows for a smooth and accurate representation of variable shoreline geometry. In the vertical scale, the model uses a transformed coordinate system known as the σ coordinate transformation to permit better representation of bottom topography and flow near the bottom (Ahsan, Q.P.E et al., 2005). The mode split technique allows the 2D calculation of the free surface elevation and the velocity transport in barotropic approximation separately from the 3D calculation of velocity and thermodynamics (Blumberg, 1977).

Detailed description on the numerical model can be found elsewhere (Blumberg, 1977; Blumberg and Mellor, 1987; Blumberg et al., 1999; Nguyen and Tanaka, 2006). It will not be shown here. The model configuration, open boundary conditions and initilisation will be briefly illustrated in the next sections.

3.2 Model configuration

The grid sytem used in the model is an orthogonal curvilinear grid. The computational domain consists of 400x16 segment grids in horizontal plane and 11 equally spaced sigma levels in vertical plane. The internal mode time step, Δt_i=40s and number of time steps between the internal and external modes, Isplit=10. In undertaking the modelling study, we have concentrated on determining how river bathymetry effect on salinity based on two main data sets of morphological change on April 2005 and March 2006.

3.3 Boundary conditions

A description of boundary conditions has been elucidatedly introduced in the above mentioned references. Open lateral boundary conditions are presented here. Tidal at My Thanh station is given as downstream boundary, whereas river discharge at Can Tho station is used as upstream boundary condition. For salinity at the river mouth, the observed data is input and salinity at Can Tho station setup with zero values. For temperature at both the river mouth and upstream, measured values are used.

4. RESULTS AND DISCUSSIONS

4.1. Time variation of salinity

Figures 2 and 3 reveal the calibrated results of the time variation of salinity on 3 days (11, 12, and 13 April 2005) and 1 day (1 May 2005) at four stations (3,4,5, 6) respectively as seen in Fig. 1. It can be seen that the caculated results correspond very well to observed data. Additionally, the variation of salinity are in phase with tidal level.

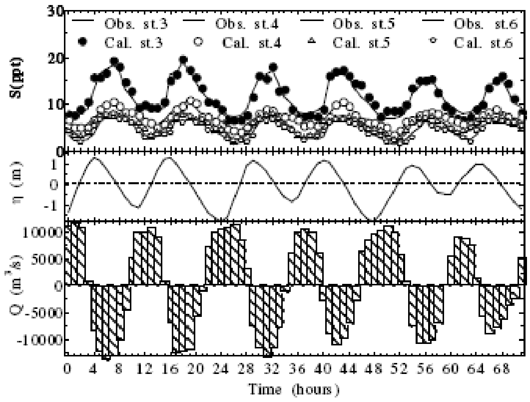

Fig. 2 Time variation of salinity on 11, 12 and 13 April 2005 (calibration)

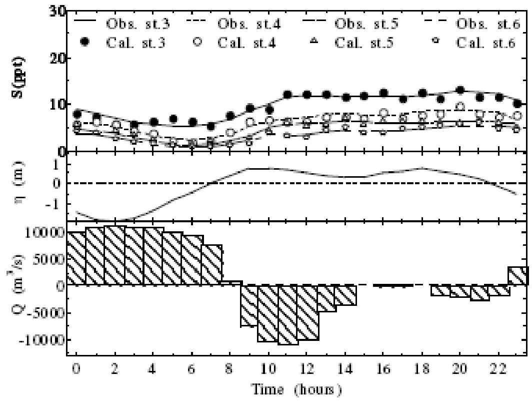

Fig. 3 Time variation of salinity on 1 May 2005 (calibration)

4.2 Salinity intrusion length

The variation of salinity intrusion lengths are shown in Figs. 4, 5 corresponding to 11 April and 1 May 2005, respectively.

Even though salinity values were not those at high water slack and low water slack, the intrusion process in the Dinh An estuary can be well reflected. In connection with practical view point, probably intrusion length could be considered to be the most important parameter in predictiting the intrusion of saltwater further upstream.

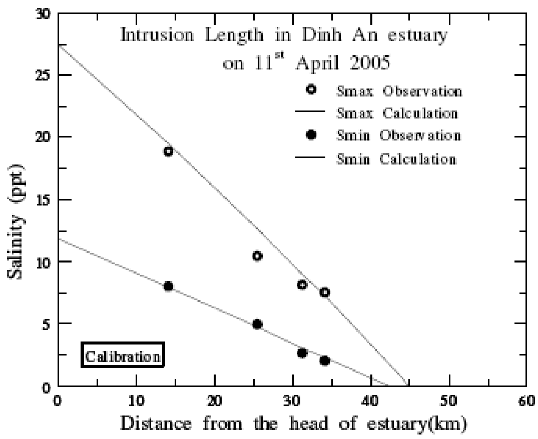

Fig. 4 Simulated intrusion length versus observed one (on 11 April 2005)

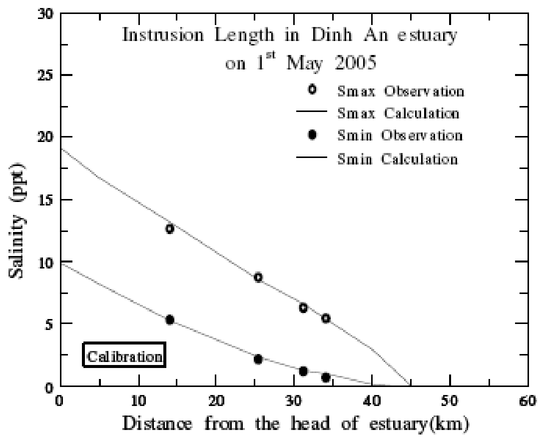

Fig. 5 Simulated intrusion length verus observed one (on 1 May 2005)

4.3 Effect of morphlogy on salinity

Figure 6 shows a distinct difference between two river transects of 2005 and 2006's measuring data. It can be seen that the latter morphology data is deeper than the former. Therefore, it may affect the salinity distribution. Now, we will determine the effect of morphology change on salinity distribution by considering different morphology patterns.

Figure 7 compares the observed and calculated contours of the streamwise vertical salinity along the river on 6 April 2005, whereas similarity of salinity distribution on 28 March 2006 is rendered Fig. 8. The horizontal axis indicates the distance from the head of the Dinh An estuary, meanwhile the vertical axis reveals the water depth. These figures clearly display how the salinity concentration distributed along the Dinh An estuary from downstream to upstream. It is undertandabe that the salinity distribution can be well reproduced to represent the real phenomena in an estuary. Moreover, significant difference in terms of salinity due to the such change of morpholgy has been confirmed by both observation data and simulation results. It clearly appeared that the salinity regime in the Dinh An estuary is well-mixed.

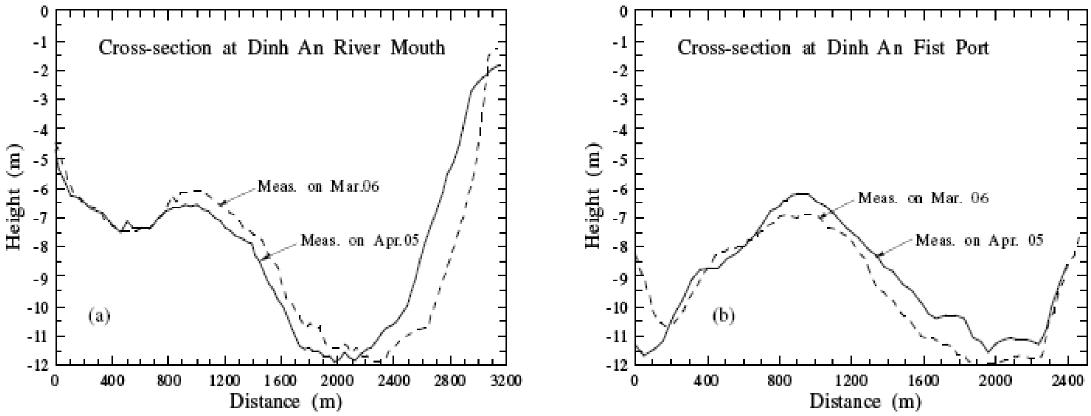

Fig. 6 Cross-sectional profiles regarding to morphology data set of 2005 & 2006

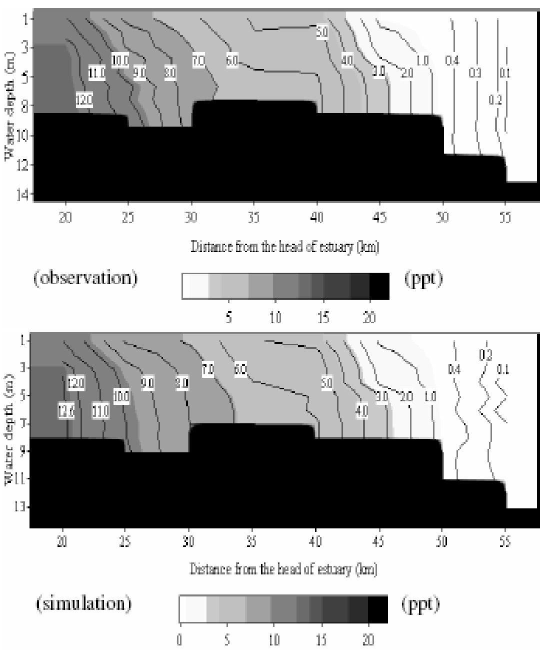

Fig. 7 Salinity distribution patterns regarding to morphology data on 6 Apr. 2005 (verification)

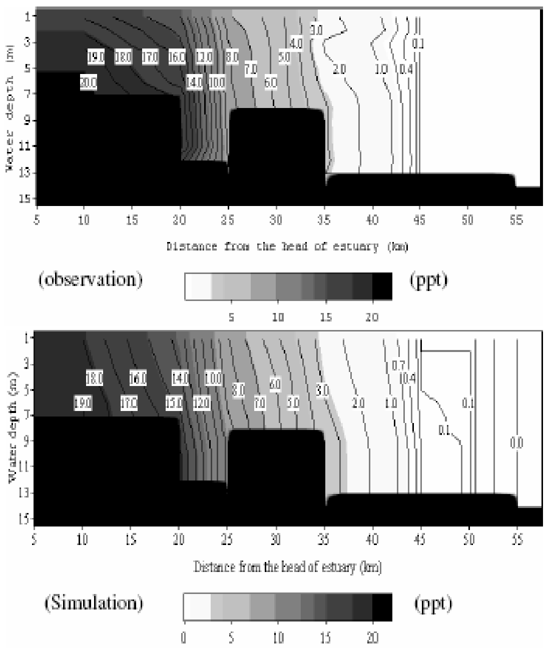

Fig. 8 Salinity distribution patterns regarding to morphology data on 28 Mar. 2006 (verification)

From Figs. 7 and 8, it can be clearly seen that the salinity distibution on 6 April 2005 is smaller than one on 28 March 2006, although in the measuring period the tidal level of the latter is a little lower than one of the former, whereas river discharge was almost the same. The reason might be caused by significant change of morphology as the above mentioned. Due to the limitation of budget and time, we have just carried out two morphology data sets and that data covered only the area near the coastal region and river mouth.

For further study, hythepotical assumption of morphology data based on the 2005 and 2006's data will be used to make clarification of the distinct influence of morphology on salinity distribution in the Dinh An estuary.

More detailed influences of not only morphology change, but also wave set-up on salininity concentration can be seen in Nguyen et al. (2006a,b).

5. CONCLUSIONS

The ECOM model was applied to simulate salinity ditribution in the Dinh An estuary taking into account the influence of morphology change on salinity distribution. The major results of this study can be summarized as follows:

(1) This paper applied a three-dimensional model to deal with phenomena of salinity distribution in the Dinh An estuary, Vietnam. It can be regconised that the model results are in good agreement with the measurement data. Both calibration and verification proceseses indicate that the model is able to predict the saltwater intrusion into the river with a reasonable accuracy. Additionally, it can be clearly seen that the salinity regime in the dry season is well-mixed.

(2) Interaction between morphology change and salinity distribution has been elucidated. It has been confirmed that the change of salinity is not only influenced by usual parameters (river discharge and tidal level), but also another external force such as morphology change.

6. ACKNOWLEDGEMENTS

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