ICCE 2018
36TH INTERNATIONAL CONFERENCE ON COASTAL ENGINEERING 2018
Baltimore, Maryland | July 30 – August 3, 2018
The State of the Art and Science of Coastal Engineering

BEACH RESPONSE TO EXPOSED RIVERINE SEDIMENT AND BEACH NOURISHMENT

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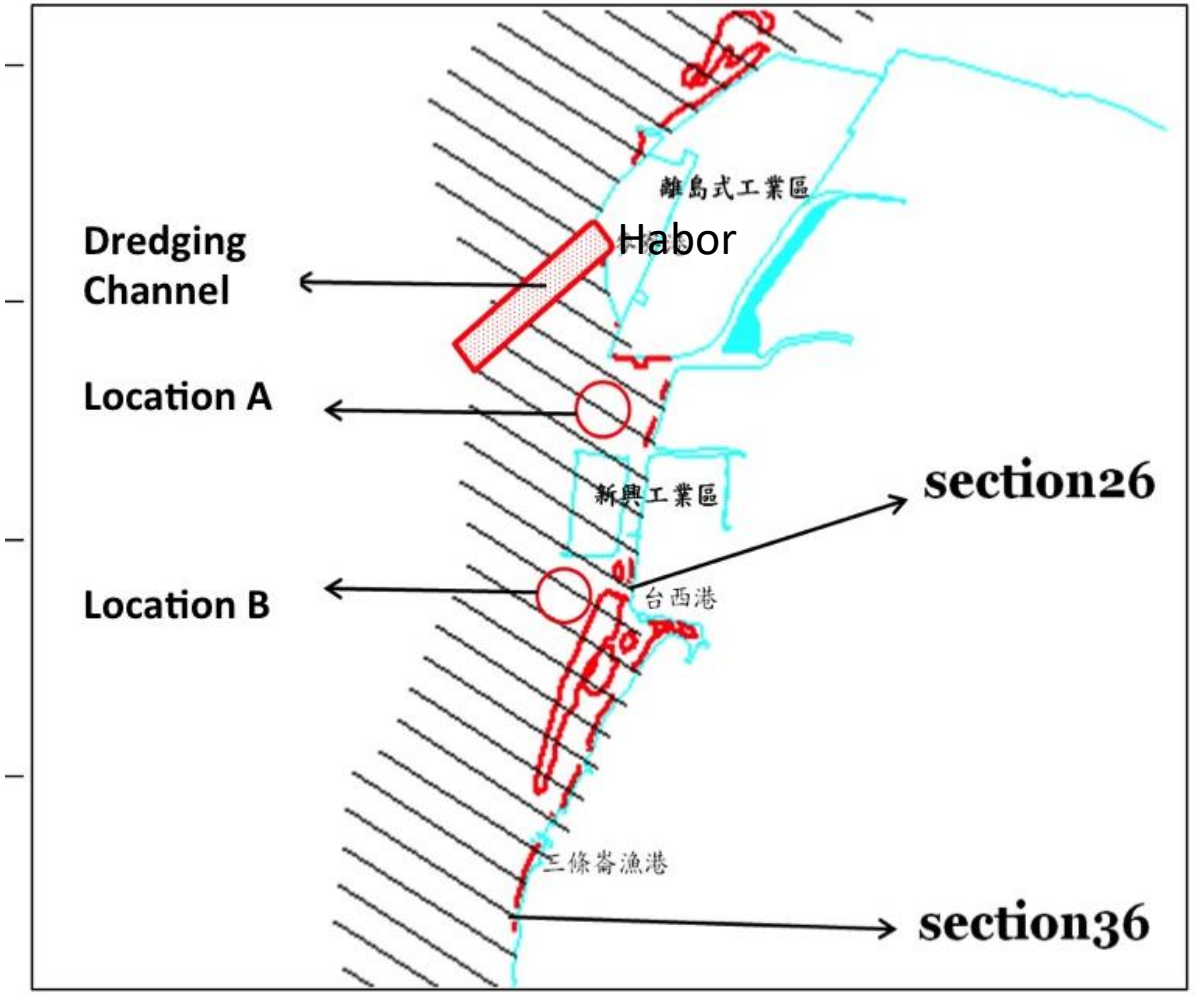
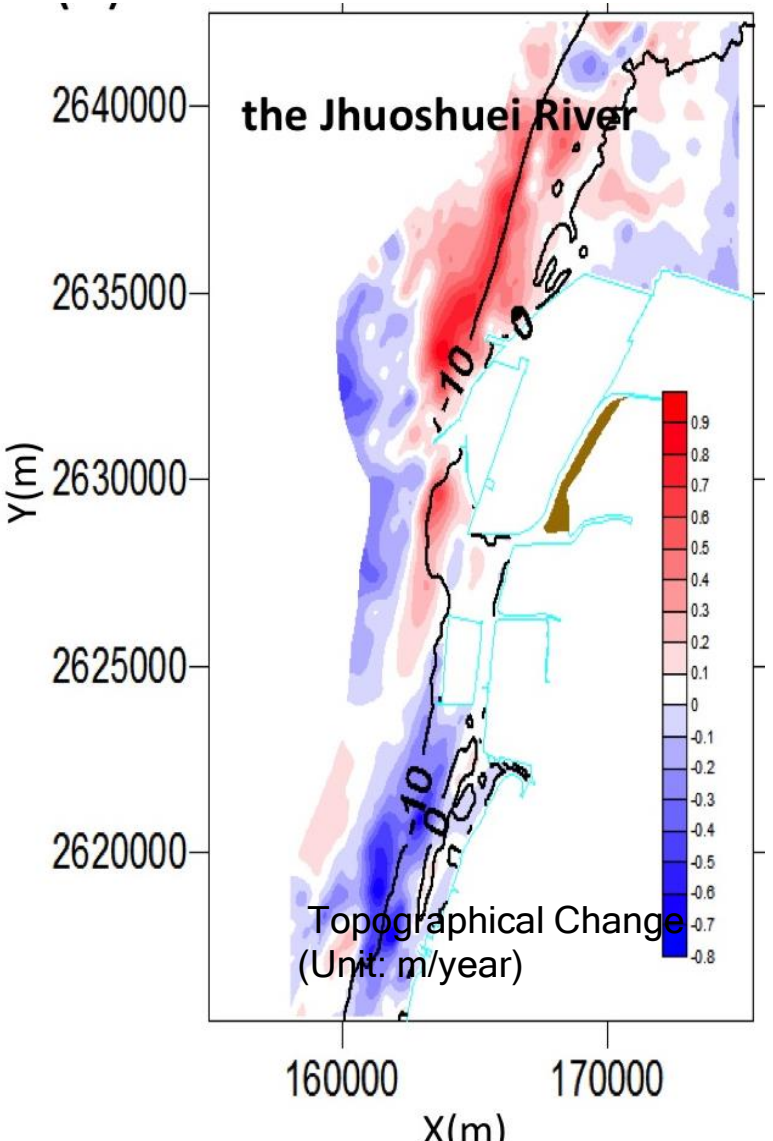
Introduction

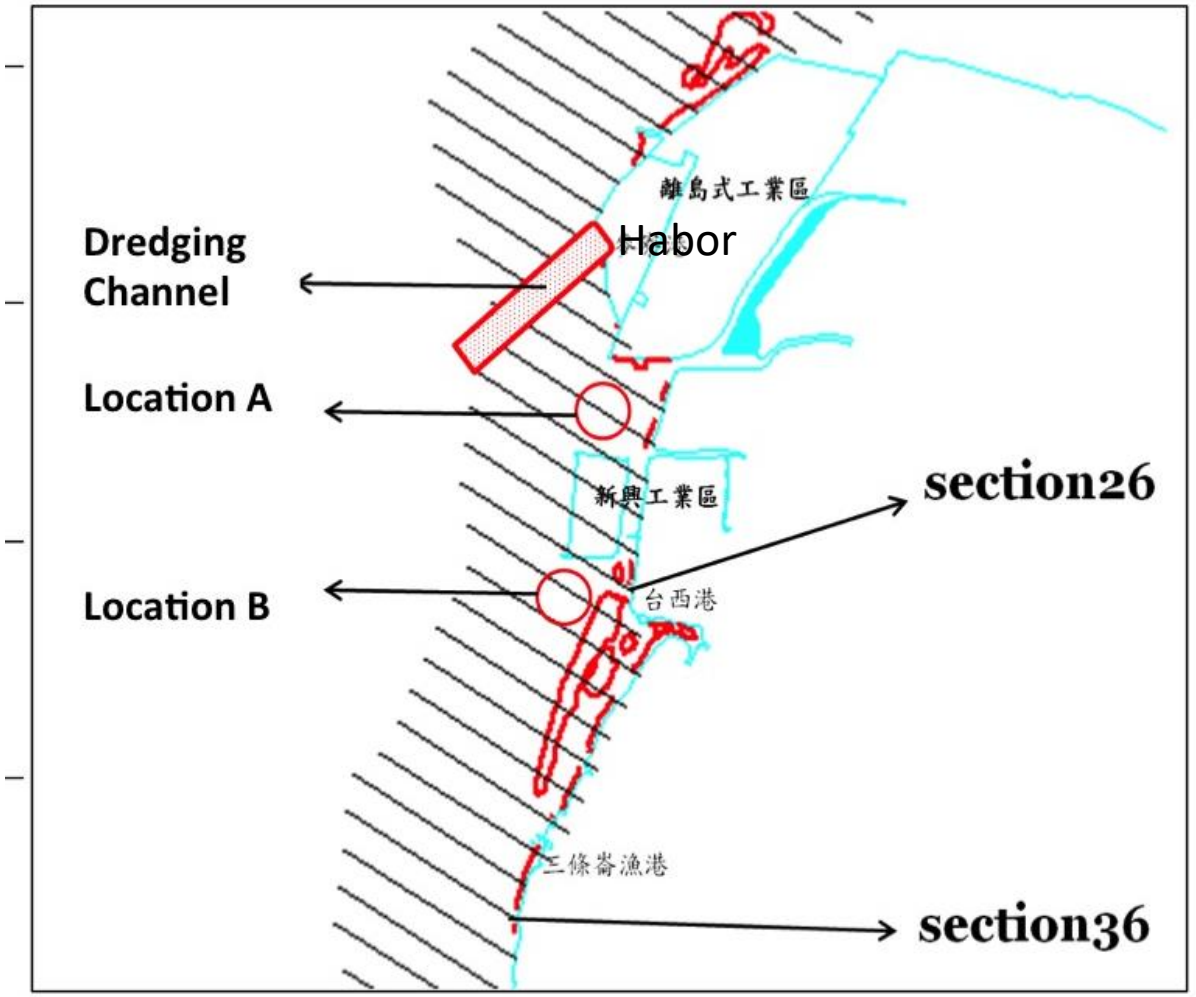
In the past decade, the evidence of severe seabed erosion (up to 1m/year) along the sandy coast has raised concerns regarding the sustainability of coastal structures in the Yunlin County, western of Taiwan.

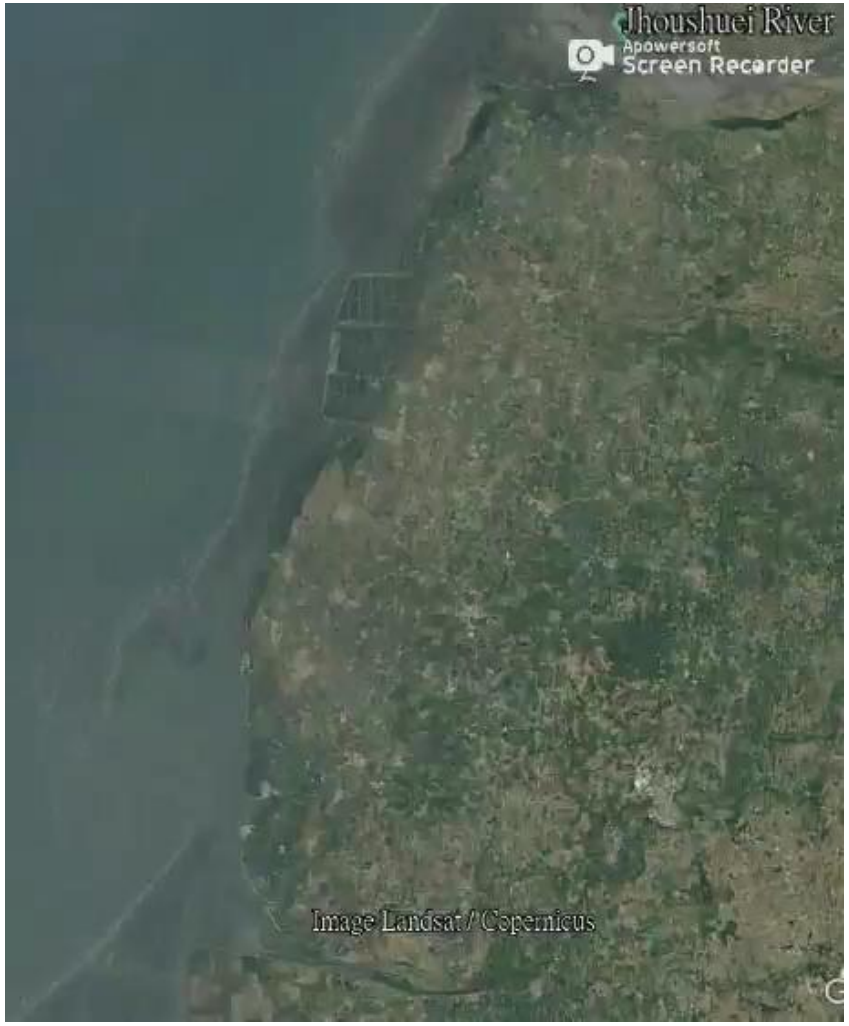




Topographical Change
(Unit: m/year)

Introduction





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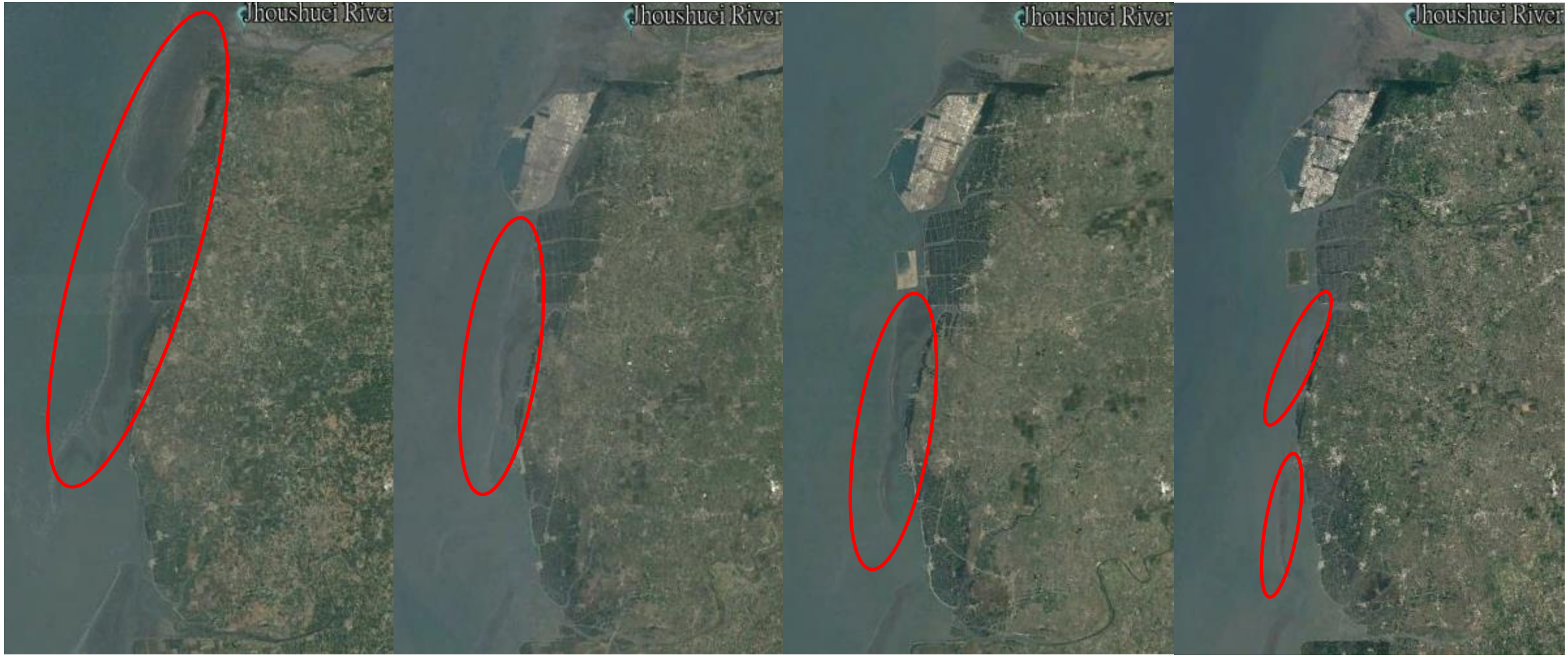
Introduction

1987 1998 2002 2016



Introduction

The potential mechanisms for sediment transport may include:

- Fresh water discharge
  (Typhoon)
- Wave and wave-driven current
  (Northeast Monsoon)
- Tide-driven circulation
- Coastal Structure
- Human Activities
  (Dredging/Beach Nourishment)

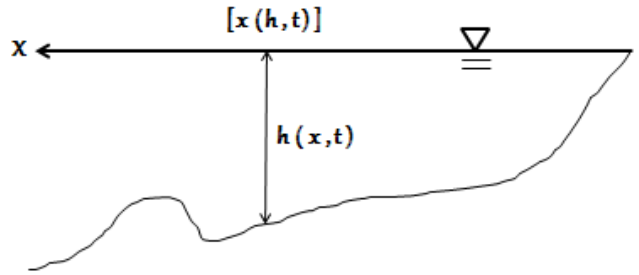
Scientific Objectives:

- Understanding the dominant mechanisms using empirical orthogonal function (EOF) and numerical models.
- Studying the consequences of hydrodynamics on sediment transport and morphological evolution using numerical model.

SAR image of Jhoushui river mouth courtesy of Dr. Chang at Center for Space & Remote Sensing Research, National Central Univ., Taiwan.

Methodology (I) 2D Empirical Orthogonal Function (EOF) Analysis

$$M = [h(x,y,t)]_{mn} = e_{mk}(x,y)e^{T}_{nk}$$



$$M = \begin{bmatrix} S_{11} & \cdots & S_{m'1} \\ \vdots & \ddots & \vdots \\ S_{1n} & \cdots & S_{m'n} \end{bmatrix}_{m\ n}$$

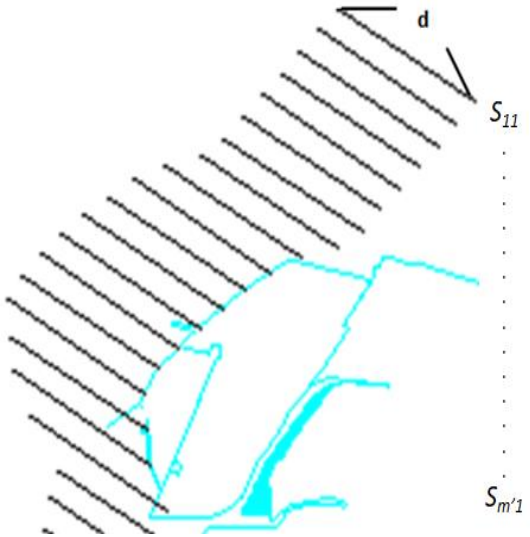
m : Number of data in the study area.
n : Years of data.

Spatial Eigenvectors *Temporal* Eigenvectors

$$M = [h(x,y,t)]_{mn} = e_{mk}(h)e^{T}{}_{nk}(t)$$

↓ *Deducted average*

$$M = [h(x,y,t) - \bar{h}(x,y,t)]_{mn} = [\tilde{h}(x,y,t)]_{mn} = \tilde{e}_{mk}(h)\tilde{e}^{T}{}_{nk}(t)$$



$$A = MM^{T} = [\tilde{h}(x,y,t)]_{mn}[\tilde{h}(x,y,t)]_{mn}{}^{T} = [a_{ij}]_{mn}$$

$$Ae_{mk}(h) = \lambda_i e_{mk}(h)$$

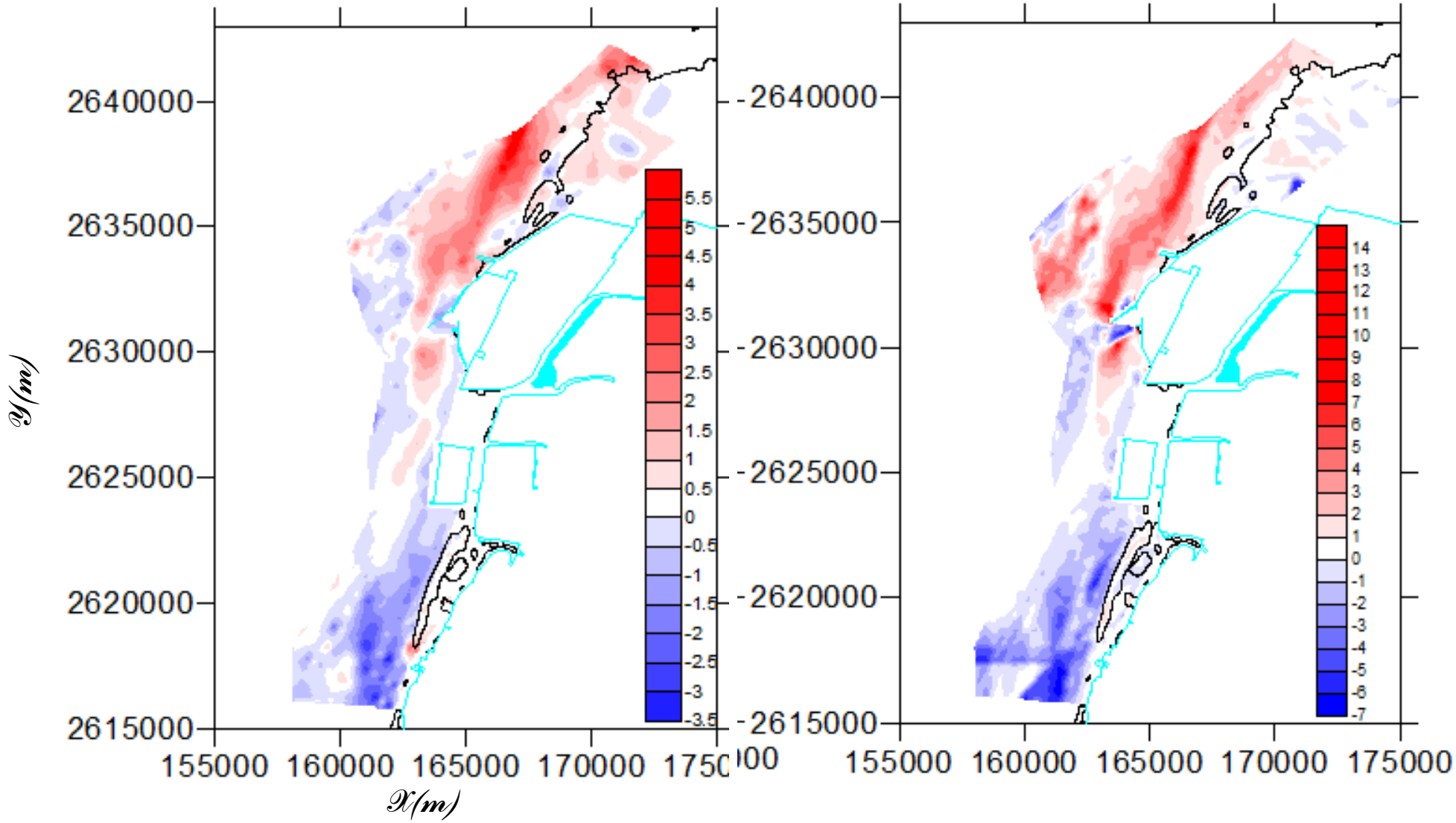
Eigenvalues

$$e_{nk}(t) = [\tilde{h}(x,y,t)]_{mn}{}^{T} e_{nk}(t) \xrightarrow{\textit{Solve Characteristic equation}} e^{*}{}_{nk}(t) = \frac{e_{nk(t)}}{a_k} \qquad -1 < e^{*}{}_{nk}(t) < 1$$

Result: 2D EOF Analysis (The 1st Mode: 63%)

The 1st Mode (Spatial)

Topographical Change (Unit: m)



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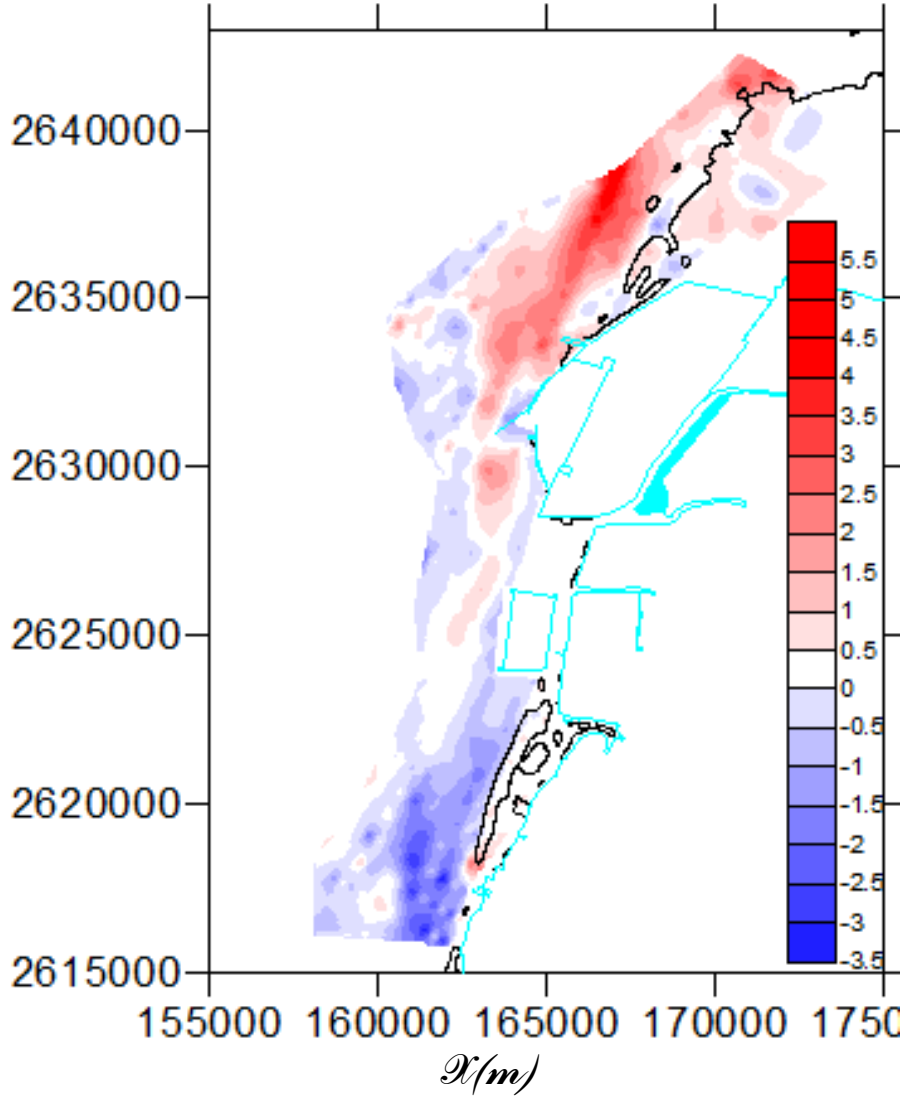
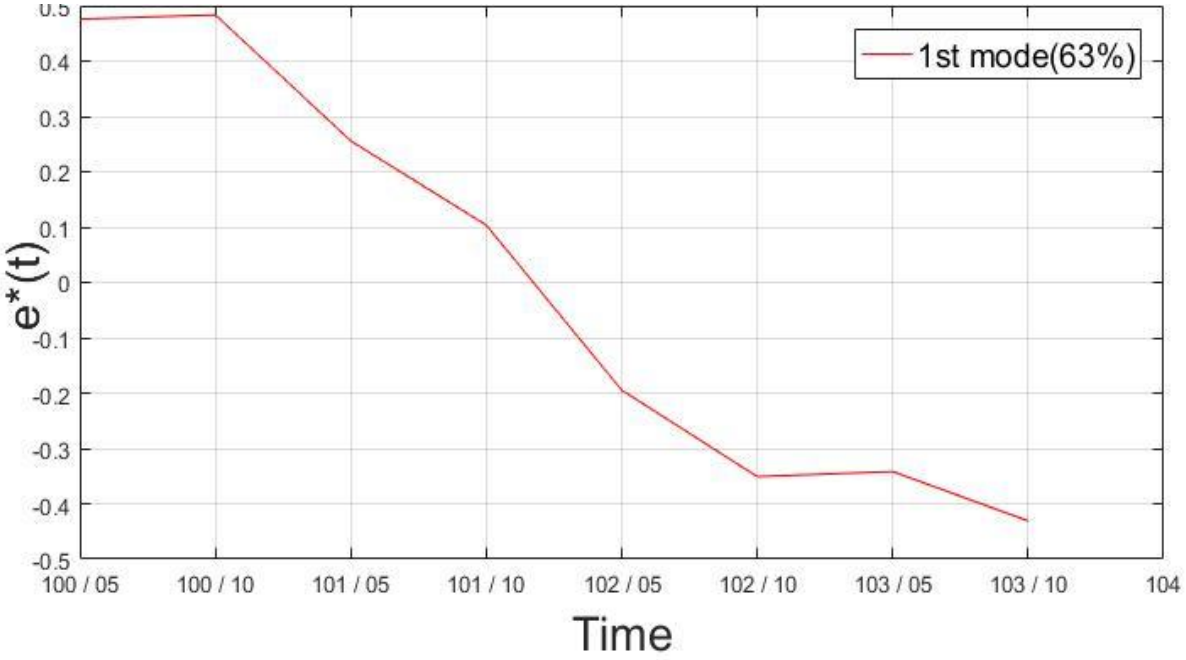
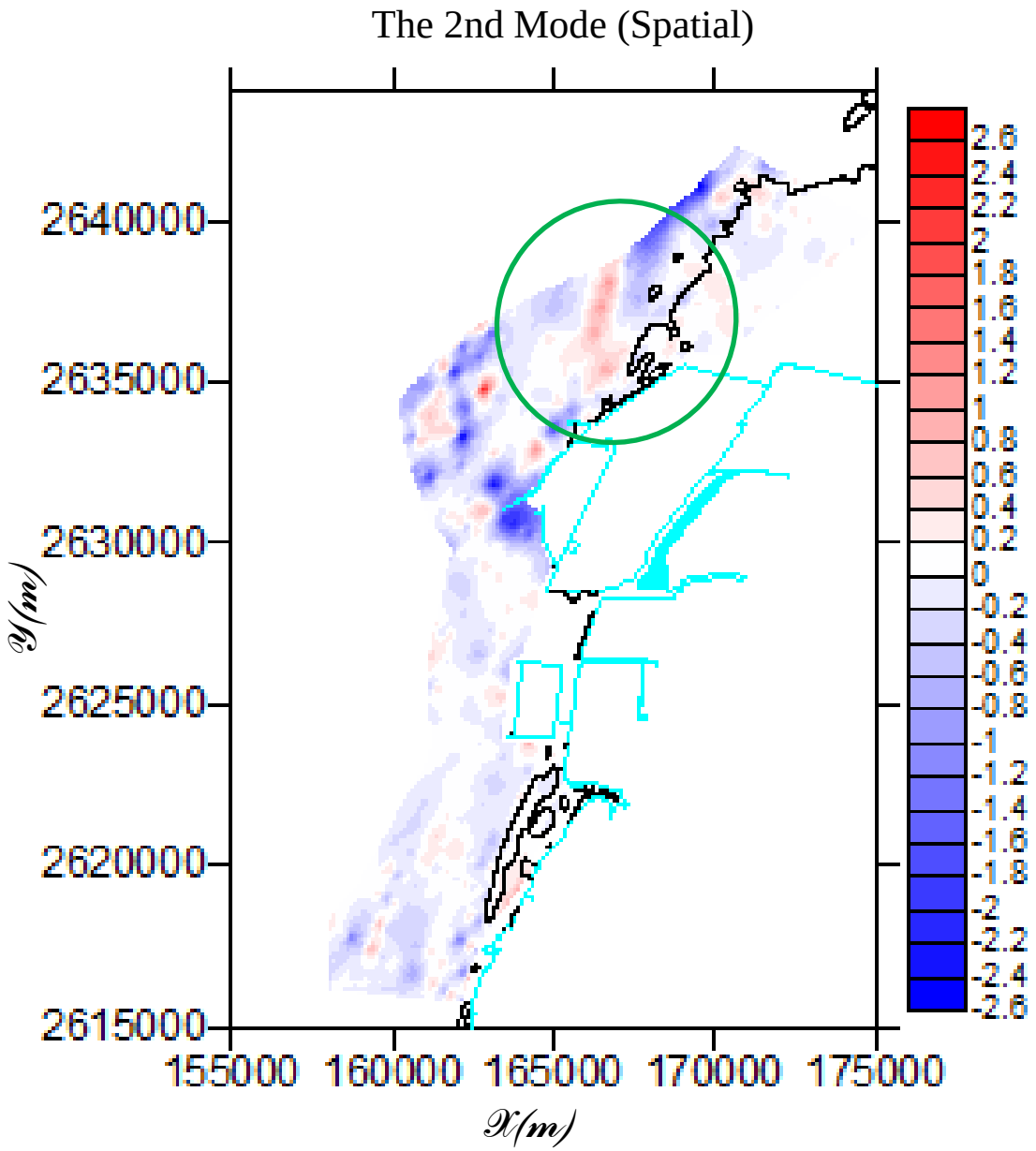
The 1st Mode (Spatial)

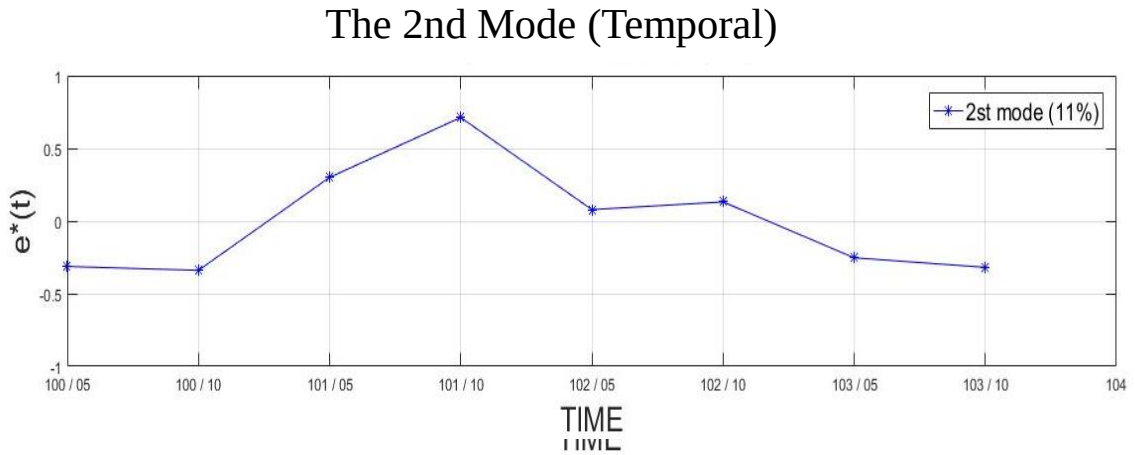


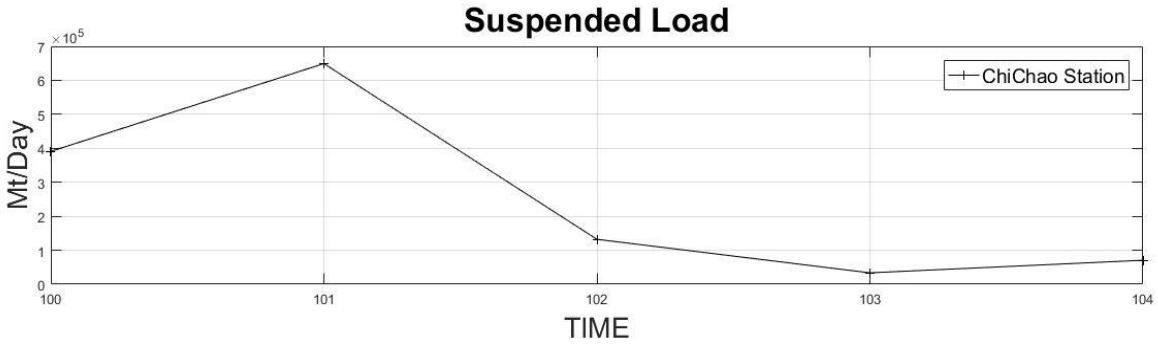
The first Mode (Temporal)



Result: 2D EOF Analysis (The 2nd Mode: 11%)







- EOF decomposition separates the observed variability of bathymetry into independent spatial and temporal modes.
- The 1st mode (63%) -> wave, tide, and coastal structure
- The 2nd mode (11%)-> riverine sediment

Methodology (II): Numerical Model (NearCoM-TVD)

NearCoM-TVD (Shi et al., 2012; Chen et al. 2014)– a quasi-3D nearshore circulation model coupled with spectral wave model SWAN, along with a couple of sediment transport formulation: Soulsby (1997); Kobayashi et al. (2008); van Rijn et al. (2011).

***WHY** NearCoM-TVD?*

Couples SHORECIRC and SWAN to model nonlinear wave-current interactions.

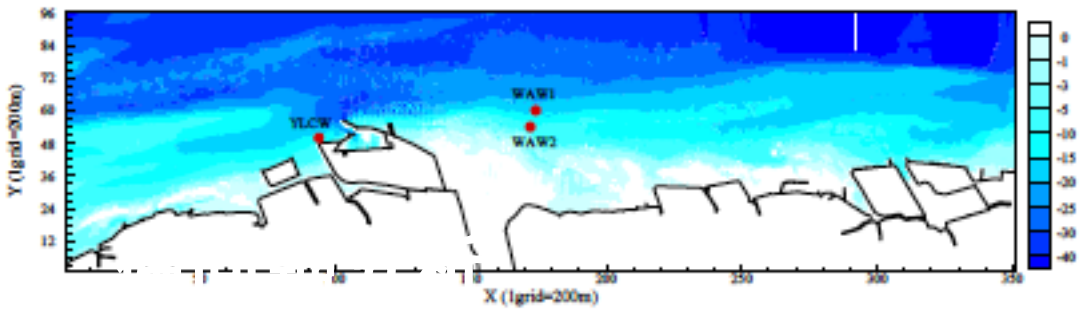
SHORECIRC is a quasi-3D circulation model that incorporates the effect of wave on the vertical structure of currents [Svendsen et al. 1994] and compares well with a full-3D circulation model [Haas and Warner, 2009].

The quasi-3D model is computationally efficient, allowing modeling of large scale sediment transport and long term morphological evolution. (domain>50km^2)

NearCoM-TVD is used widely for studies of wave-current interaction

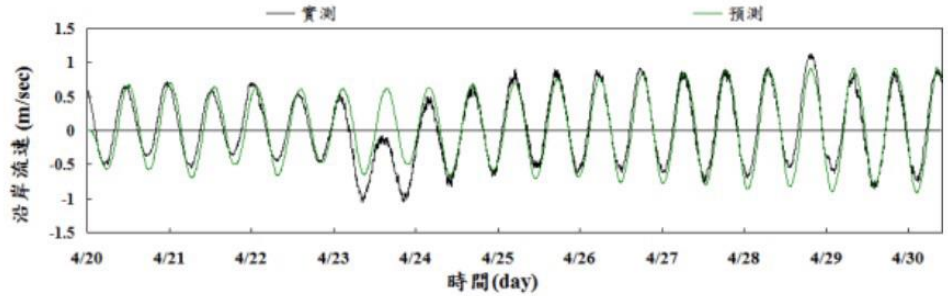
-> 1182 Anna Wargula, Time-varying wave effects on flows and dynamics at an unstratified inlet.

Result: Model Validation (2010/4/20~4/30, toward spring tide, offshore wave =1m)

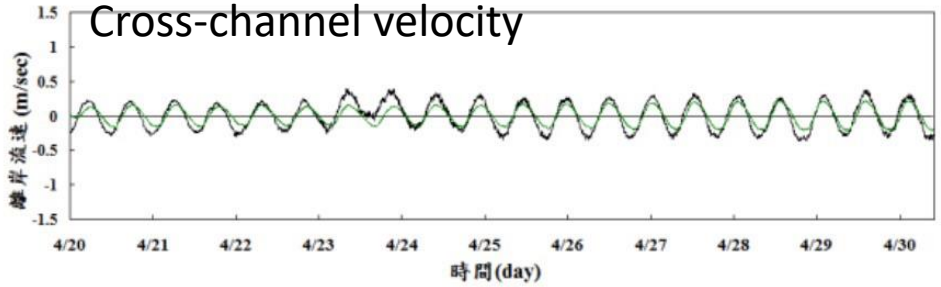


Grid Size: 200 (m)
Origin: E=162000 N=2608000 (TWD67)
Angle of Rotation: 60 degree (clockwise from the north)
Area: 70*19.6 Km
Total Grid: 350*96

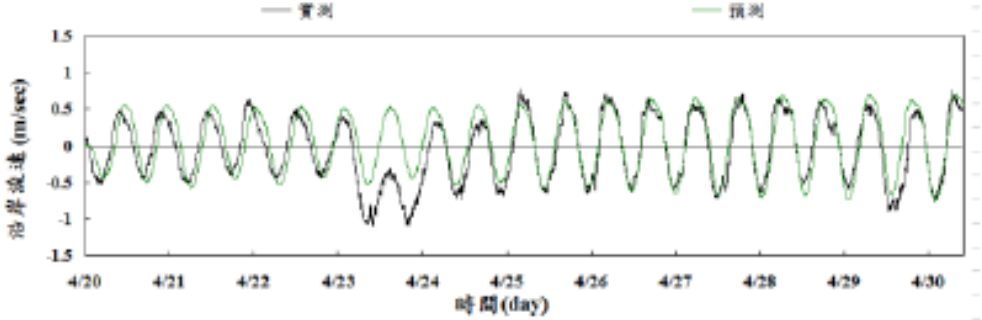
Along-channel velocity



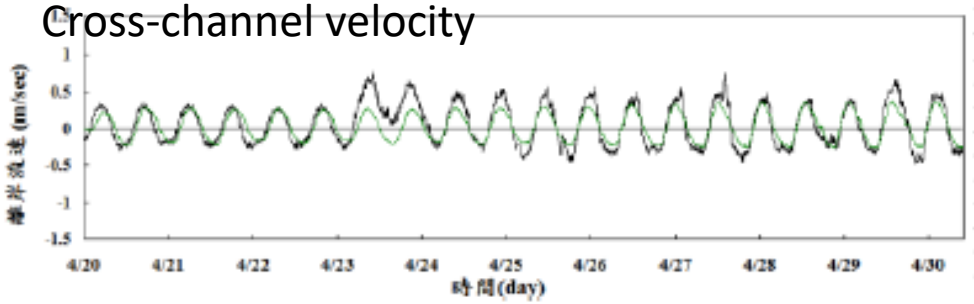
Cross-channel velocity



Along-channel velocity

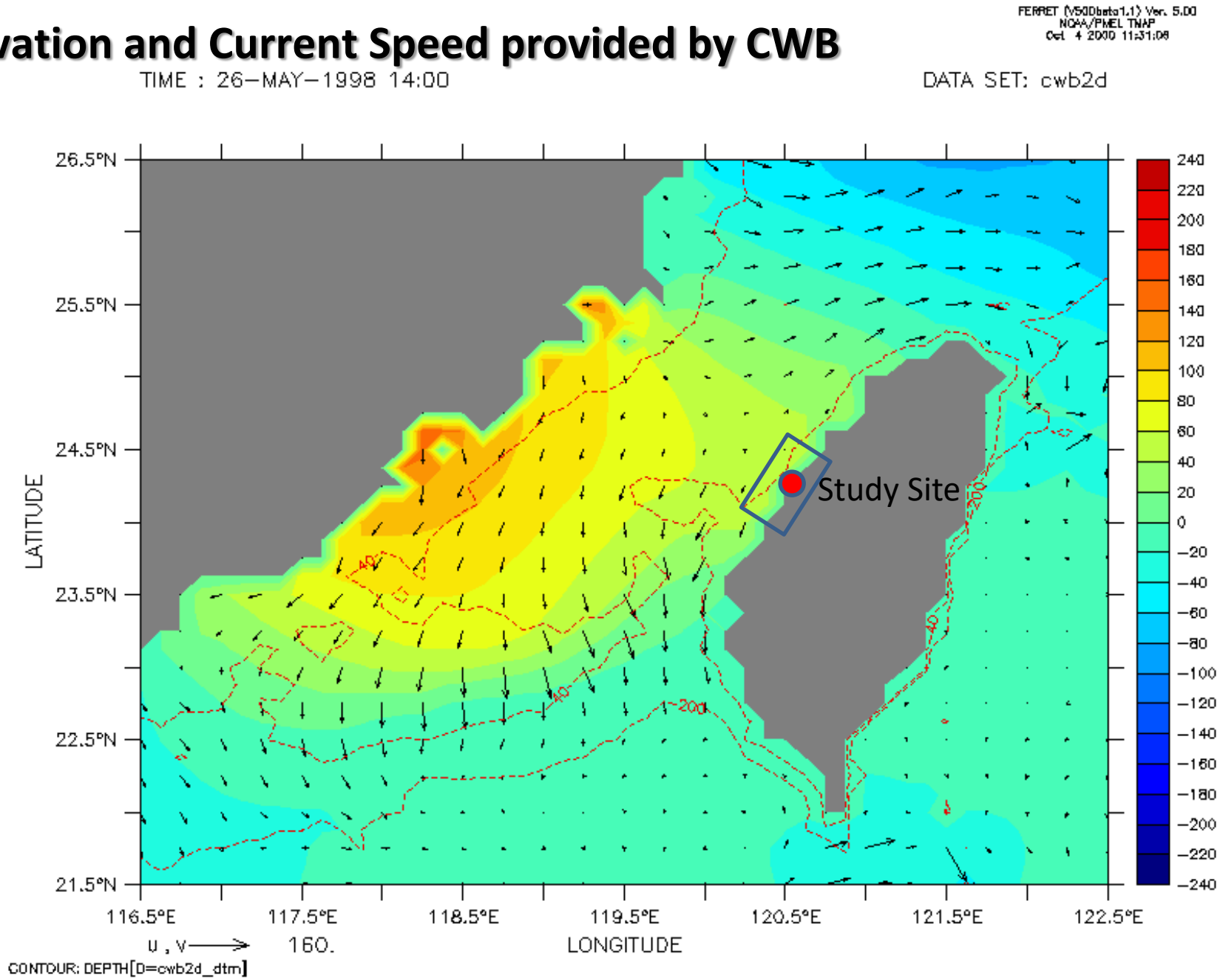


Cross-channel velocity

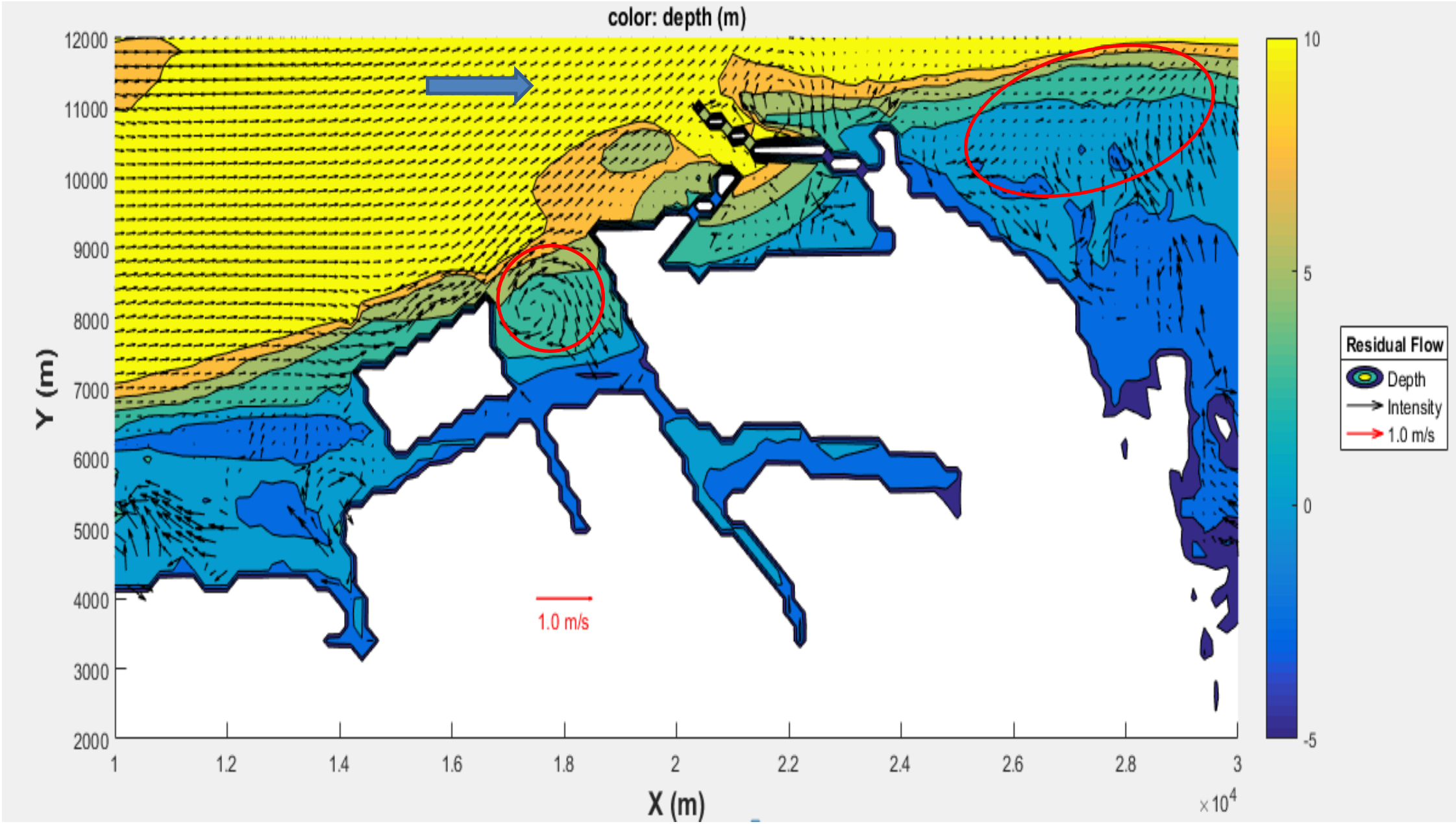


[Hsu et al., 2013]

Surface Elevation and Current Speed provided by CWB



Result: Residual Flow Field



Summary

- EOF decomposition separates the observed variability of bathymetry into independent spatial and temporal modes:
  - the 1st mode (63%): wave, tide, coastal structure
  - the 2nd mode (11%): riverine sediment

- NearCoM-TVD is validated with measured current velocities. Simulation results reveal that tidal currents may play an important role in
  - transport processes of the riverine sediment near the river mouth
  - circulation patterns near the spot of beach nourishment

Ongoing work:

The prediction of sediment transport and morphological evolution

Ongoing work:

Solution for mitigating seabed erosion?

THANK YOU!

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