Applying Nature-based COastal DEfence in the Pearl River Delta: the ANCODE project

*Judith Wolf *[1], Tjeerd J. Bouma[2,4], Zhan Hu[3], Svetlana Jevrejeva[1], Michela De Dominicis[1], Rosanna van Hespen[2,4], Maarten Kleinhans[4], Klaas Timmermans[2,4], Tom Ysebaert[2,4], Peng Yao[3], Chen Wang[5], Ming Li[6], Peng Zheng[6]*

[1]National Oceanography Centre (NOC), UK
[2]Royal Netherlands Institute for Sea Research (NIOZ), Netherlands
[3]Sun Yat-sen University (SYSU), China
[4]University of Utrecht, Netherlands
[5]Satellite Environment Centre, China
[6]University of Liverpool, UK

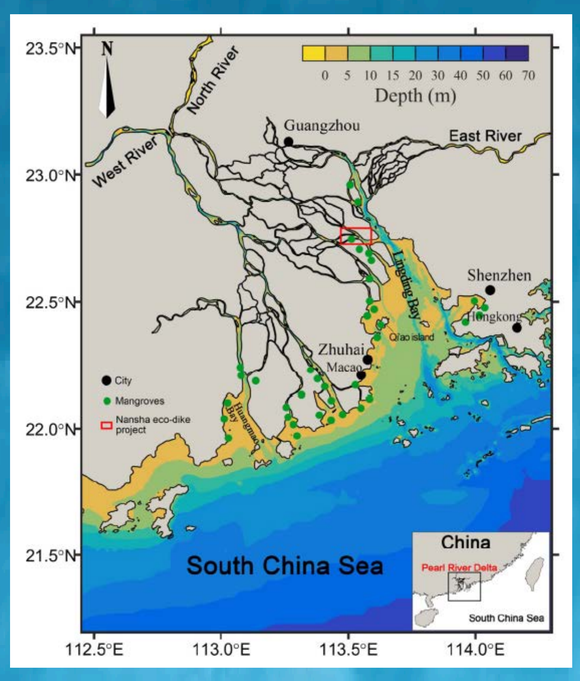
Introduction

Coastal cities worldwide are at increasing risk of coastal flooding due to increasing populations and assets as well as sea level rise and subsidence. The estimated average annual losses (AAL) were US$6 billion in 2005, and this figure is expected to grow by a factor of 10 up to 2050[1], assuming continuing improvement of existing sea defences (if existing defences are not upgraded the estimated annual losses could exceed US$1trn). Guangzhou, in the Pearl River Delta (PRD) in China, is the city most at risk globally and may be exposed to increased flooding due to more extreme winds, rising water levels and waves associated with typhoons.

Nature-based coastal defence solutions are recognised as more sustainable alternatives or additions to conventional hard engineering approaches[2]. In tropical and sub-tropical regions, these may include using mangroves and oyster reefs as a buffer zone, which can attenuate waves and trap sediment.

There are challenges in the implementation of such schemes and many attempts to re-establish mangroves have failed, because the plantation may be exposed to inundation and other stresses such as waves, lack of sediment or inappropriate conditions such as salinity. A useful approach for identifying periods when mangroves may be established involves identifying Windows of Opportunity (WoO) when conditions are favourable[3].

The Zhu Jiang (Pearl River) basin including its 3 tributaries (West, North and East rivers)

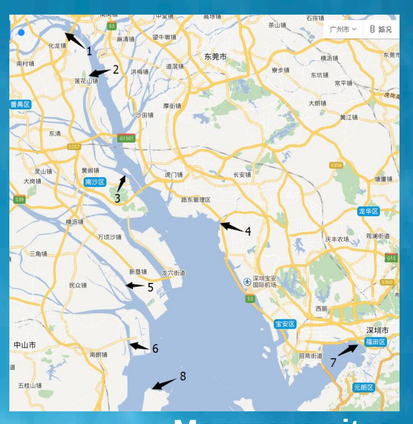


Establishment of Mangroves and Oyster Reefs

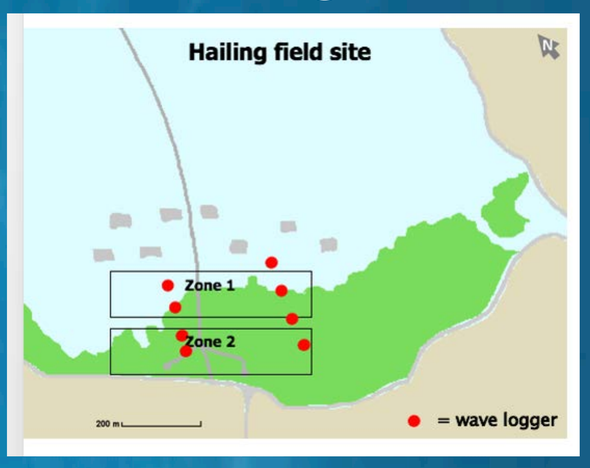
Key questions (for effectiveness & resilience) :

1. How wide should the nature-based coastal defence be?
   a. vegetation patch scale ➔ wave attenuating capacity affected by repeated storms
   b. tidal flat scale ➔ long-term stability of the ecosystem (lateral expansion and retreat)
   c. Delta scale ➔ Optimizing ecosystem sizes on a delta-scale (where should we put natural defenses?)
2. How to create the ecosystems where they are needed?
   a. First measure ➔ integrating nature-based coastal defence with reclamations
   b. Second measure ➔ use dredged sediment to create Windows of Opportunity (WoO)
   c. Third measure ➔ build oyster reefs in front of mangroves for WoO

Fieldwork in PRD and Hailing Island



Mangrove sites



METHODOLOGY

Assess mangrove area through time & reasons for loss

Apply ecosystem to locations with: 1. high risk of flooding; 2. important to the entire PRD system

WT1 Large-scale monitoring & modelling

- **WT1.1** Mangrove area monitoring — Remote sensing
- **WT1.2** SLR and storminess scenarios — Climate model
- **WT1.3** Evaluate defense effect of mangroves in PRD under climate change — FVCOM model
- **WT1.4** optimizing ecosystem distribution

Wind, SLP, SLR

Water level, Waves, Currents, Salinity, SSC

Location of mangrove wetland or oyster reefs

WT3 Local-scale modelling

- **WT3.1** Repeated storms on mangroves & oyster reefs — Delft3D-SWAN modeling
- **WT3.2** WoO by dredging sediment & oyster reefs — DET-ESTMORF modeling
- **WT3.3** Long-term stability of ecosystem, dynamic VEG and Morphology — DET-ESTMORF modeling
- **WT3.4** Synthetic case study — Integrated modeling

Mechanical properties, Wave force

Morphodynamics, Sediment dynamics, Waves, Plant response

Cliff erosion, uprooting

WT2 Experimental study

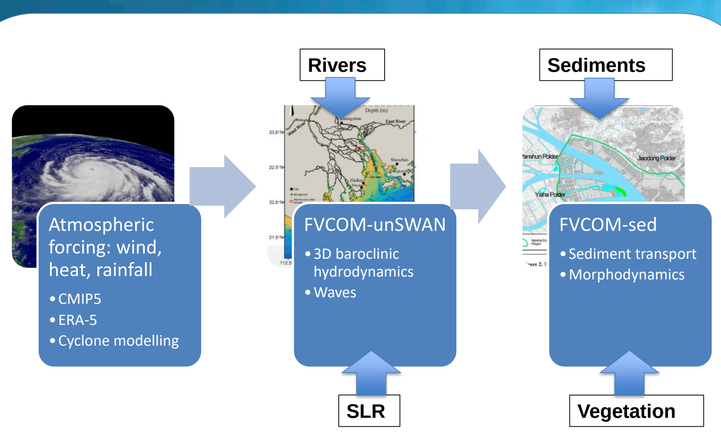
- **WT2.1** Repeated storms on mangroves
- **WT2.2** Create WoO by oyster reefs
- **WT2.3** Create WoO by dredging sediment
- **WT2.4** mangrove lateral erosion

Salinity experiments

SSC measured by 1. OBS 2. Bottle 3. sediment traps

Applying nature-based defence with global change & anthropogenic drivers

External influences on delta



The ANCODE project:

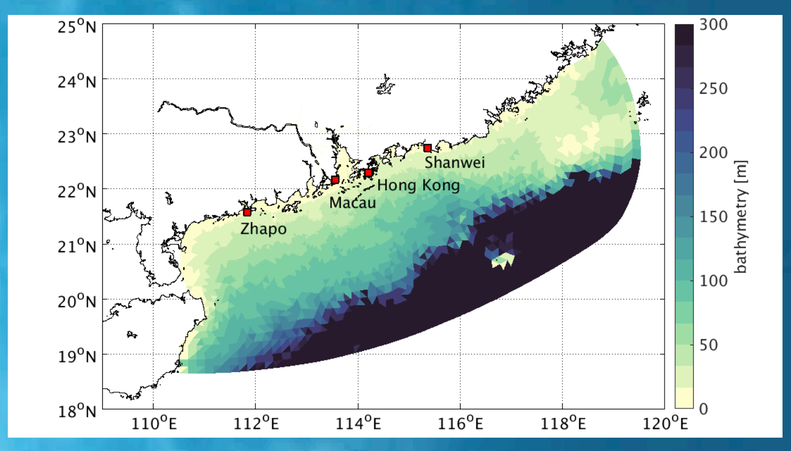
aims to develop:

- new process-based understanding
- predictive models of ecosystem size requirements

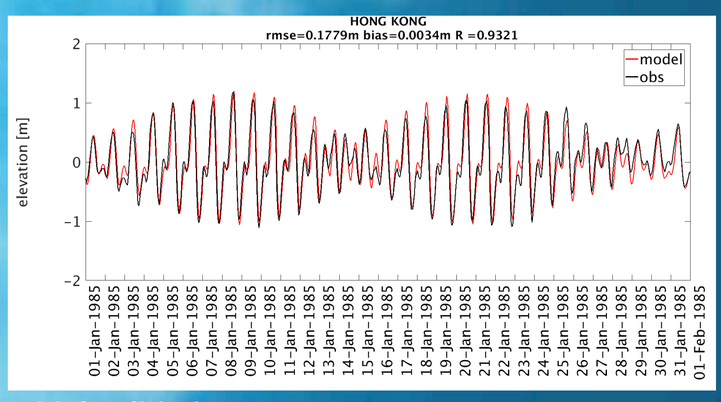
by using field experiments, remote sensing and numerical modelling in the PRD and the coastline of the South China Sea.

- **WT1:** Delta-scale mangrove area monitoring by remote sensing and modelling of the delta and adjacent South China Sea
- **WT2:** Experiments using novel methods to study mangrove resilience in PRD and Hailing Island, as well as testing WoO creation using dredged sediment and oyster reefs
- **WT3:** Local-scale modelling using high-resolution dynamic and equilibrium models to examine the vegetation patch and tidal flat scale
- We will interact with stakeholders to address resilient urban planning and management, to provide opportunities for nature as part of the urban development process.

FVCOM Modelling



The FVCOM model uses an unstructured triangular grid which allows good coastal resolution while not requiring high resolution everywhere[4].



Tidal validation

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*Contact for more information: jaw@noc.ac.uk

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