# Sea level and tides under climate change in the Pearl River Delta

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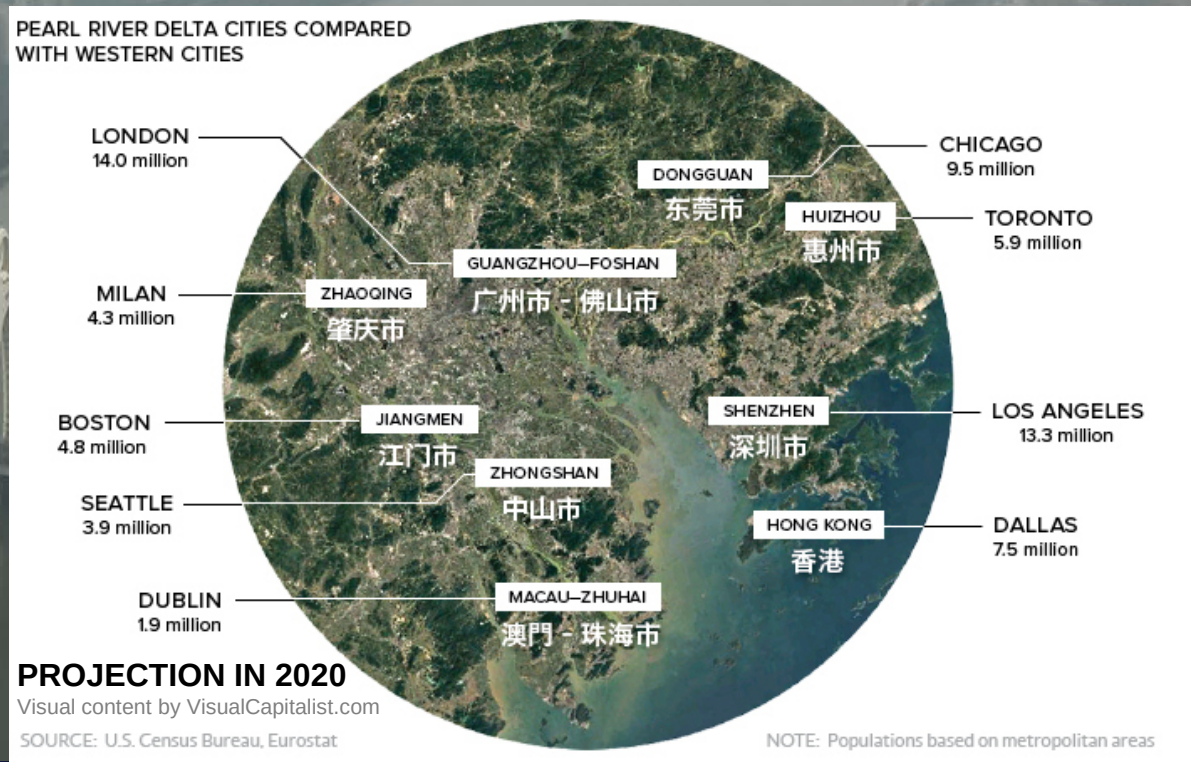
The Pearl River Delta is now the world's largest urbanized area in both size and population, and also the world's most vulnerable delta to flooding.

Since the 1980s, the Pearl River Delta has experienced rapid population and economic growth.

Guangzhou and Shenzhen, two main cities in the Pearl River Delta are ranked as number 1 and 9 cities in the world in terms of annual losses due to flooding.

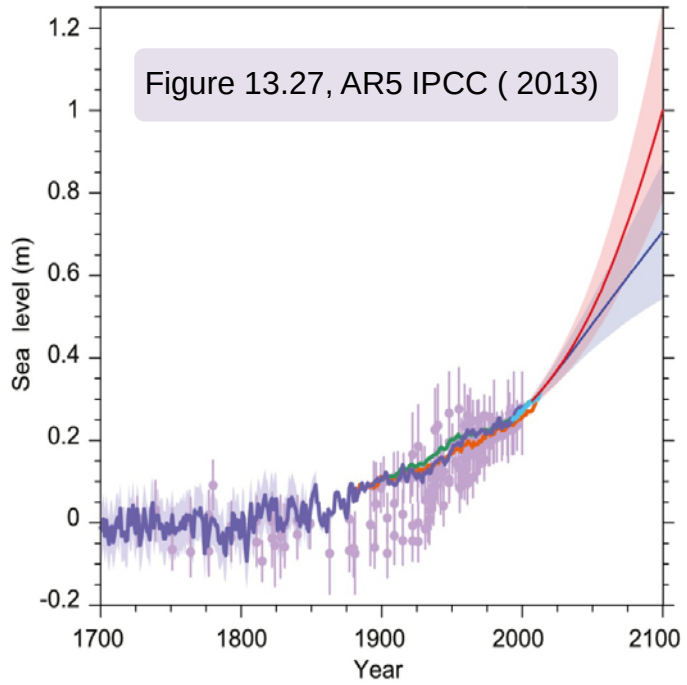
# Sea level rise today and by 2100

The changes in regional sea level are quantified in this work by using probabilistic regional sea level projections for selected scenarios of climate change.

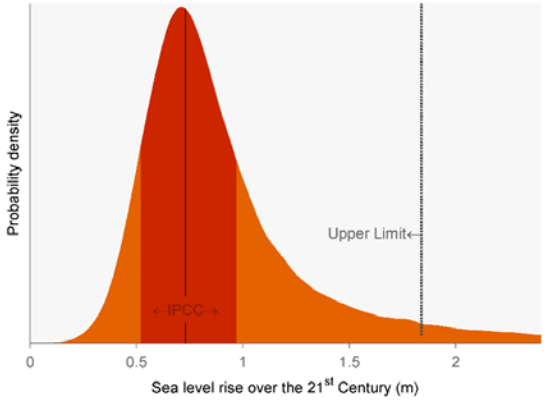
20th century rate for sea level rise: **1.7mm/yr**

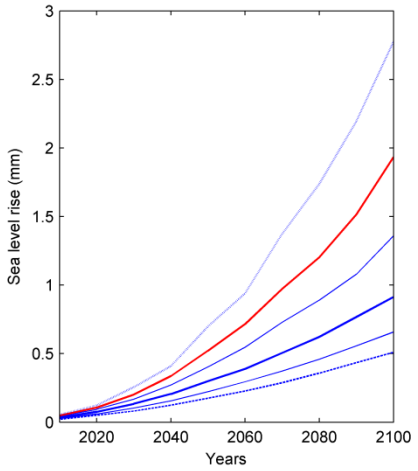
Since 1990s rate: **3.4 mm/yr**

Sea level rise by 2100 : **0.5-1.8 m**

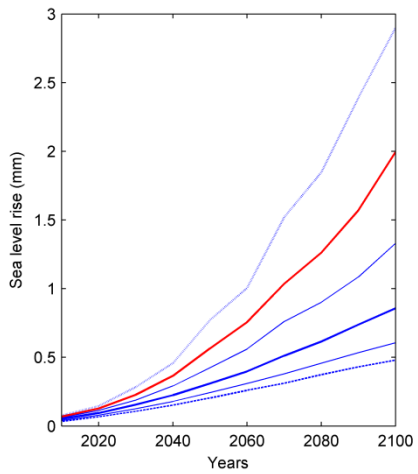



# Sea Level projections for China

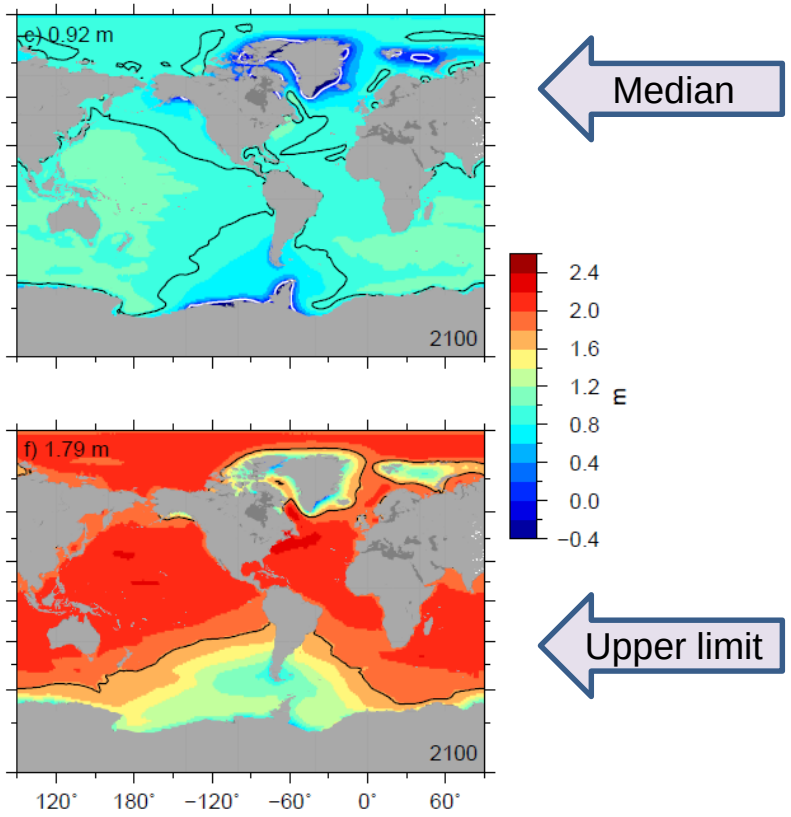



**GUANGZHOU**




**SHENZEN**



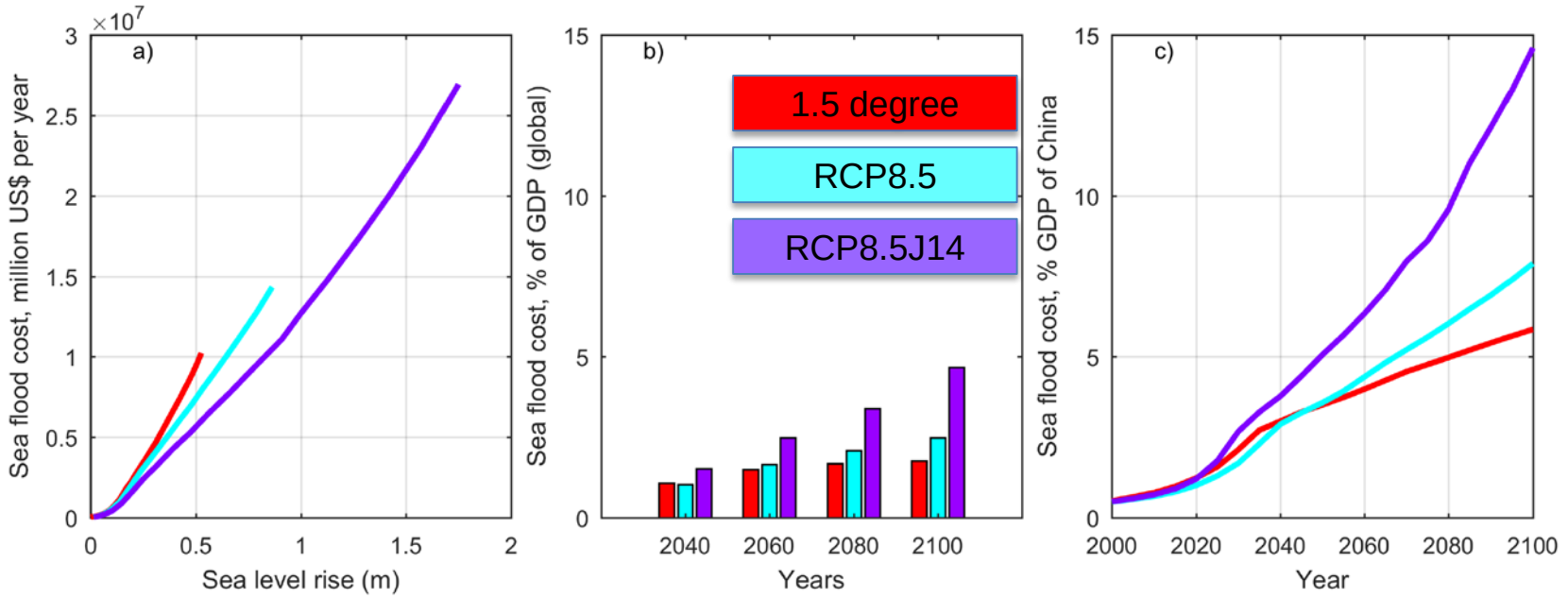

Jevrejeva et al, 2016

# Sea flood damage costs with the sea level rise by 2100

Global sea floods cost, Million US$ per year

Global sea floods cost, % of GDP (global)

Sea flood cost for China, % of GDP (China)




**China, flood cost in 2100**

US$ 3.4 trillion per year (5.8 % GDP) with warming of 1.5 degree (0.5 m sea level rise)
US$ 4.6 trillion per year (7.8% GDP) with RCP8.5 (0. 8 m sea level rise)
US$ 8.5 trillion per year (14 % GDP) with RCP8.5J14 (1.8 m sea level rise)

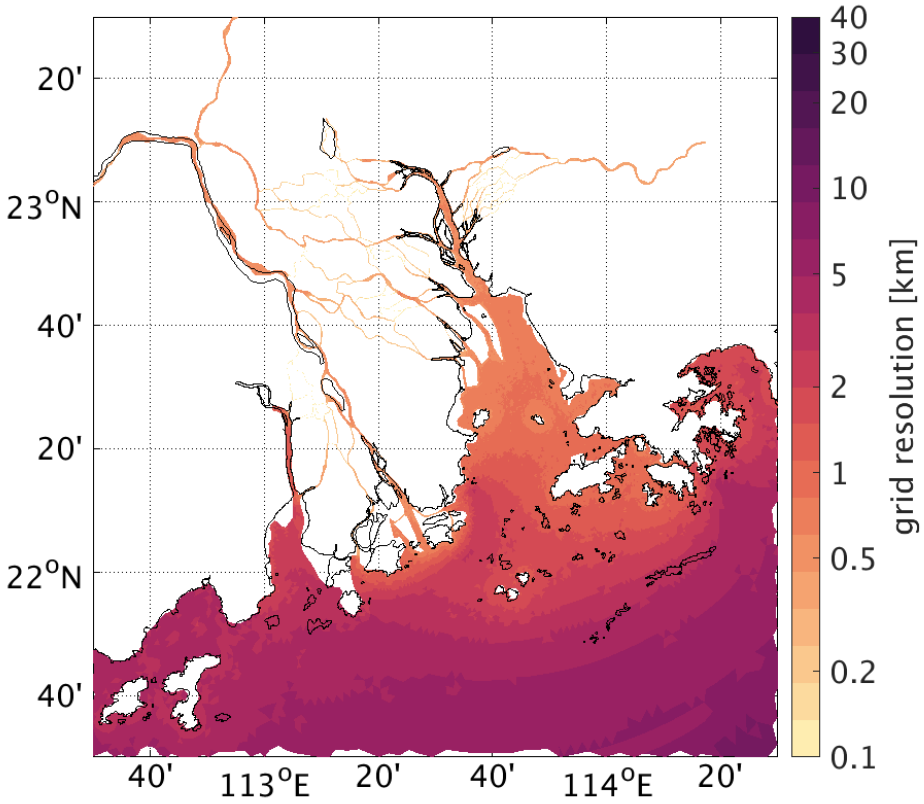
Jevrejeva et al., 2018

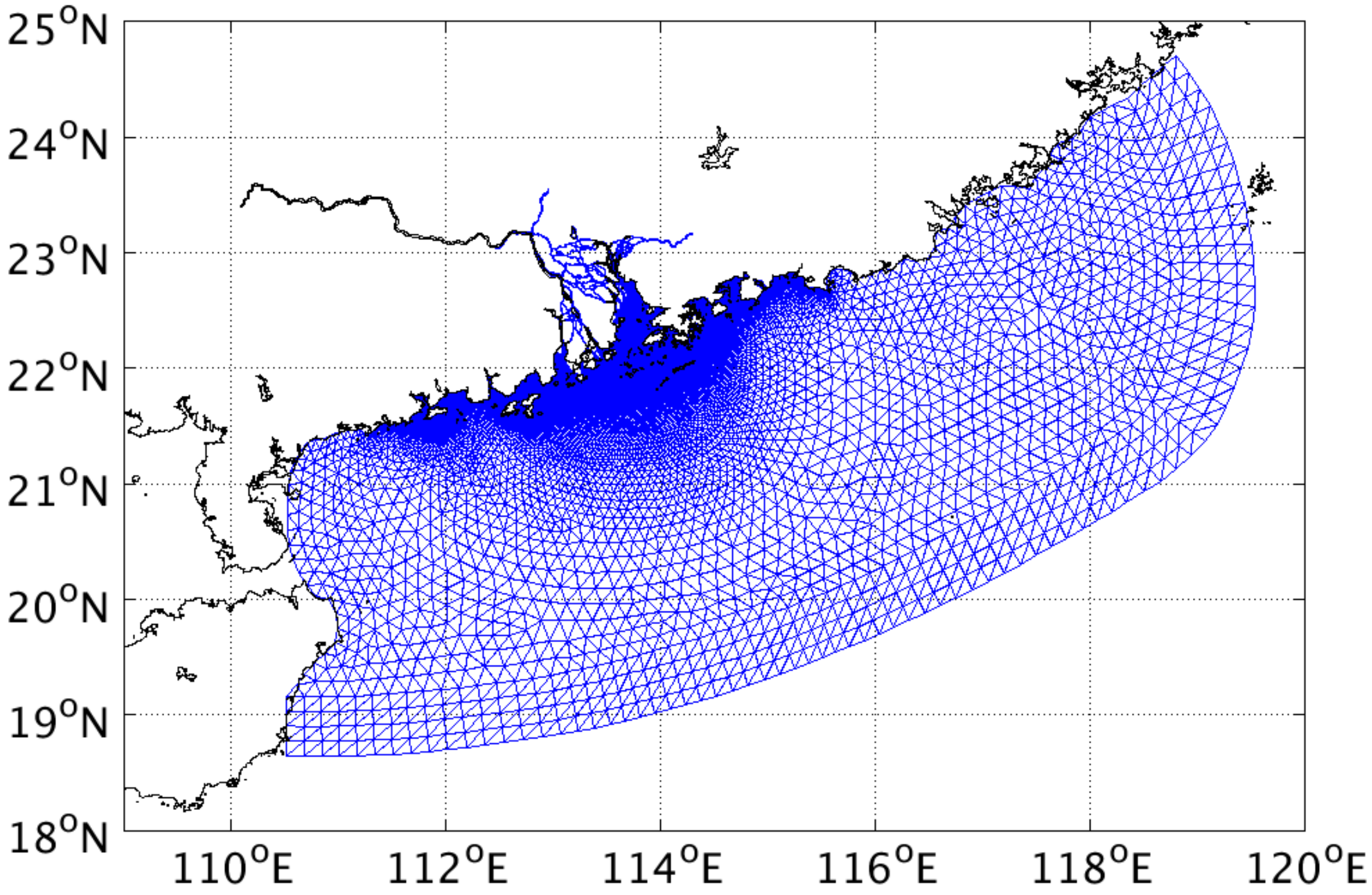
# Modelling the Pearl River Delta

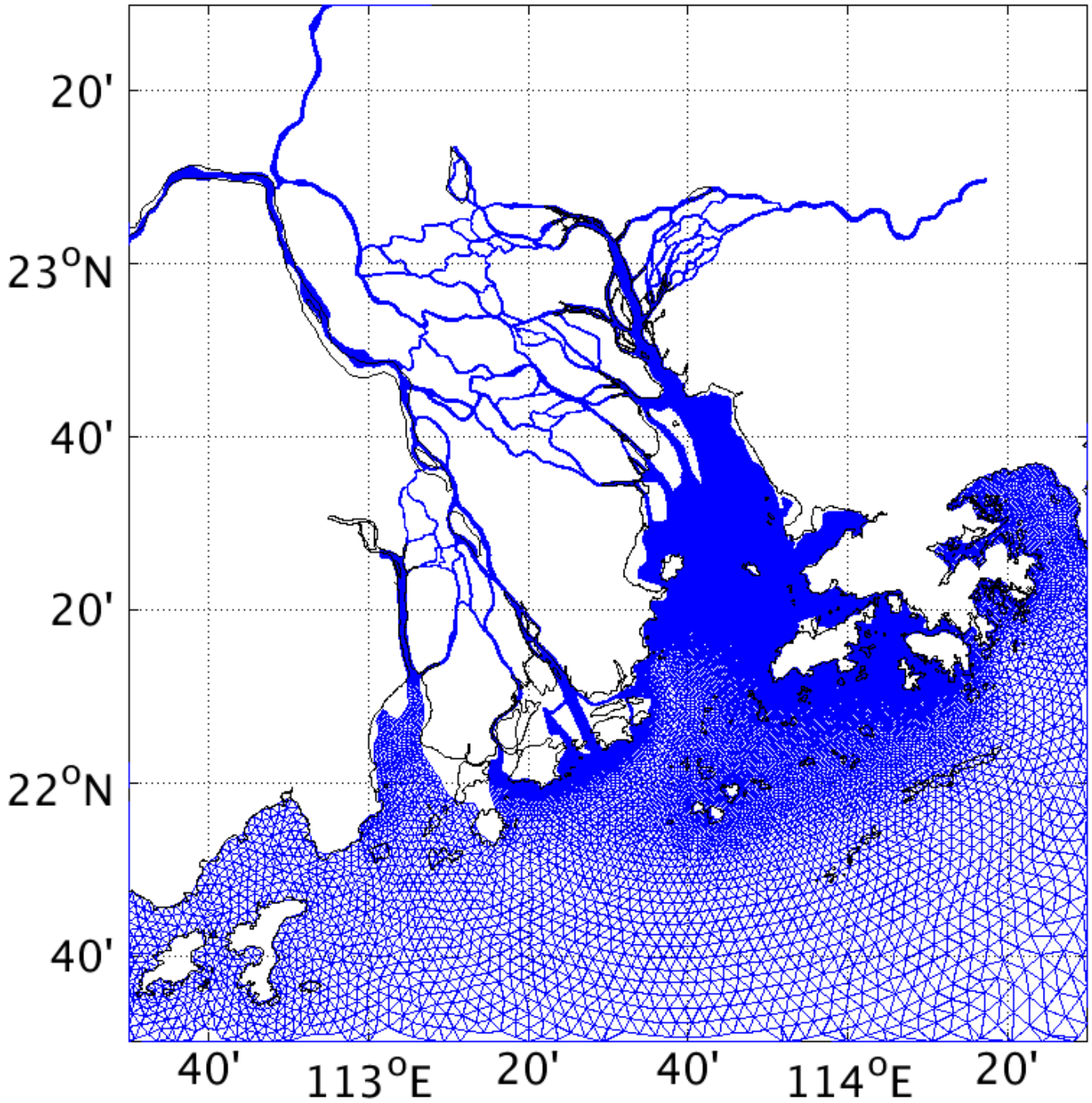
An FVCOM (Finite Volume Community Model) implementation for the South China Sea and Pearl River Delta is used to understand how the rising mean sea level and tides can interact and affect coastal inundation in the Pearl River Delta.

**Details…**

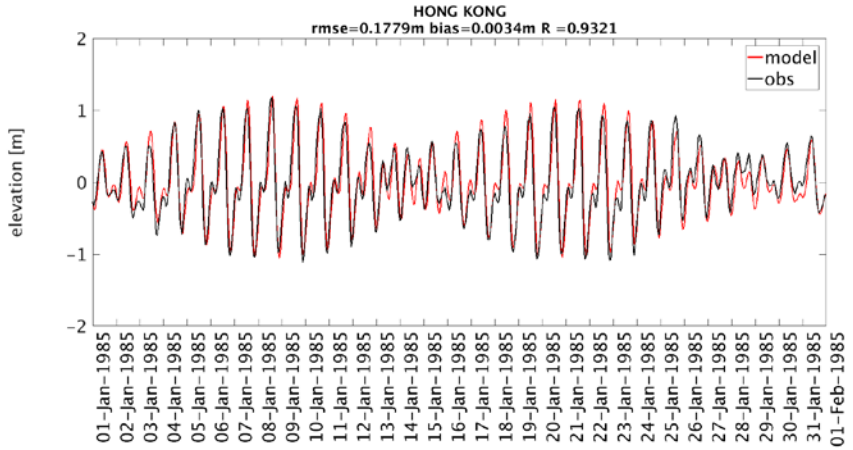
- **FVCOM 4.0**
- **25 vertical sigma layer, uniform**
- **Tide-only:** 8 components M2,S2,N2,K2,K1,O1,P1,Q1 - TPXO8.0
- **Bottom friction:** uniform roughness length (0.001 m) with minimum Cd=0.0025
- **Grid:** 85129 nodes - 140449 elements
- **Time step:** 0.25 s external mode (barotropic)/1.25 s internal mode (baroclinic)
- **River discharge:** annual average from Wu et al. 2016
- **Runtime (5 weeks model run):** 20 hours with 256 cpus

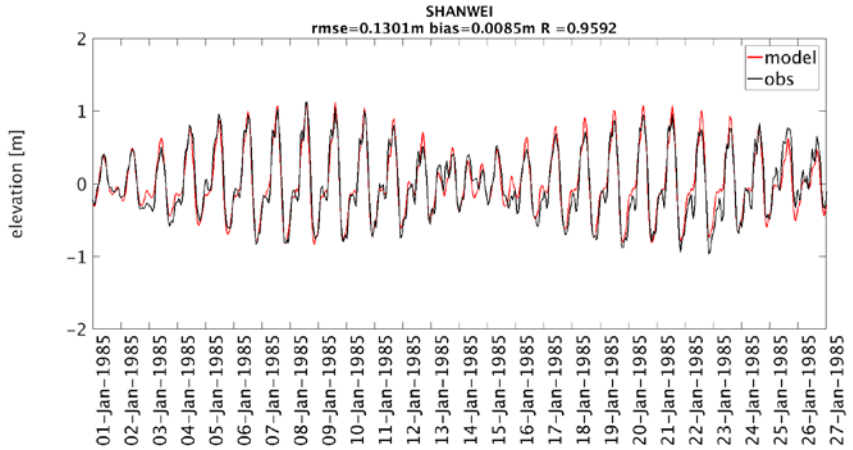


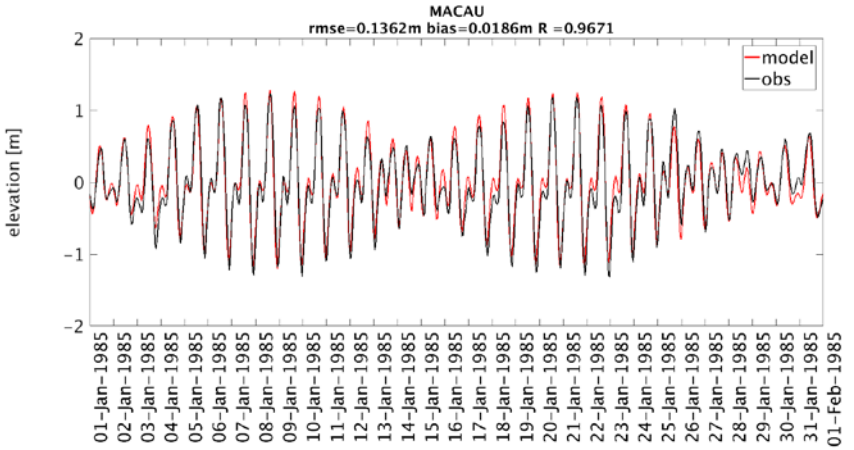

25°N
24°N
23°N
22°N
21°N
20°N
19°N
18°N
110°E
112°E
114°E
116°E
118°E
120°E

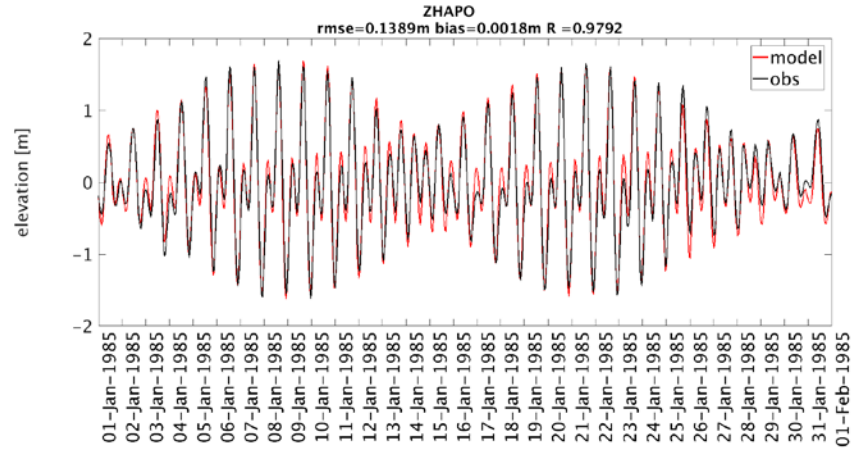

20'
23°N
40'
20'
22°N
40'
40'
113°E
20'
40'
114°E
20'

# Validation



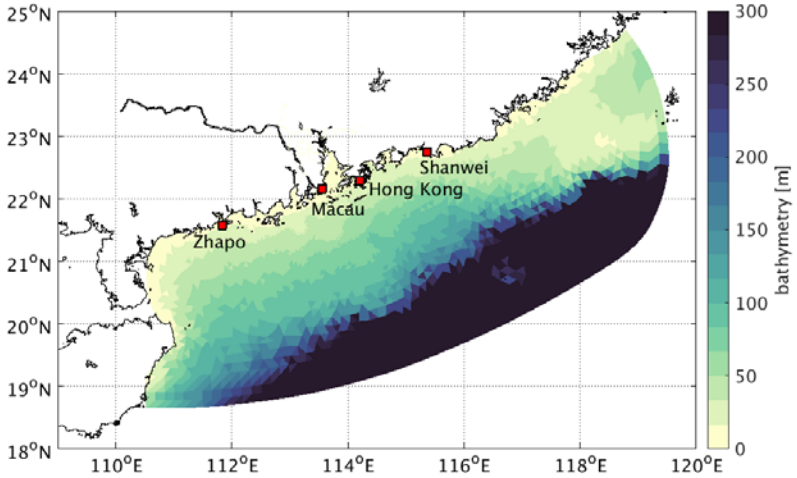



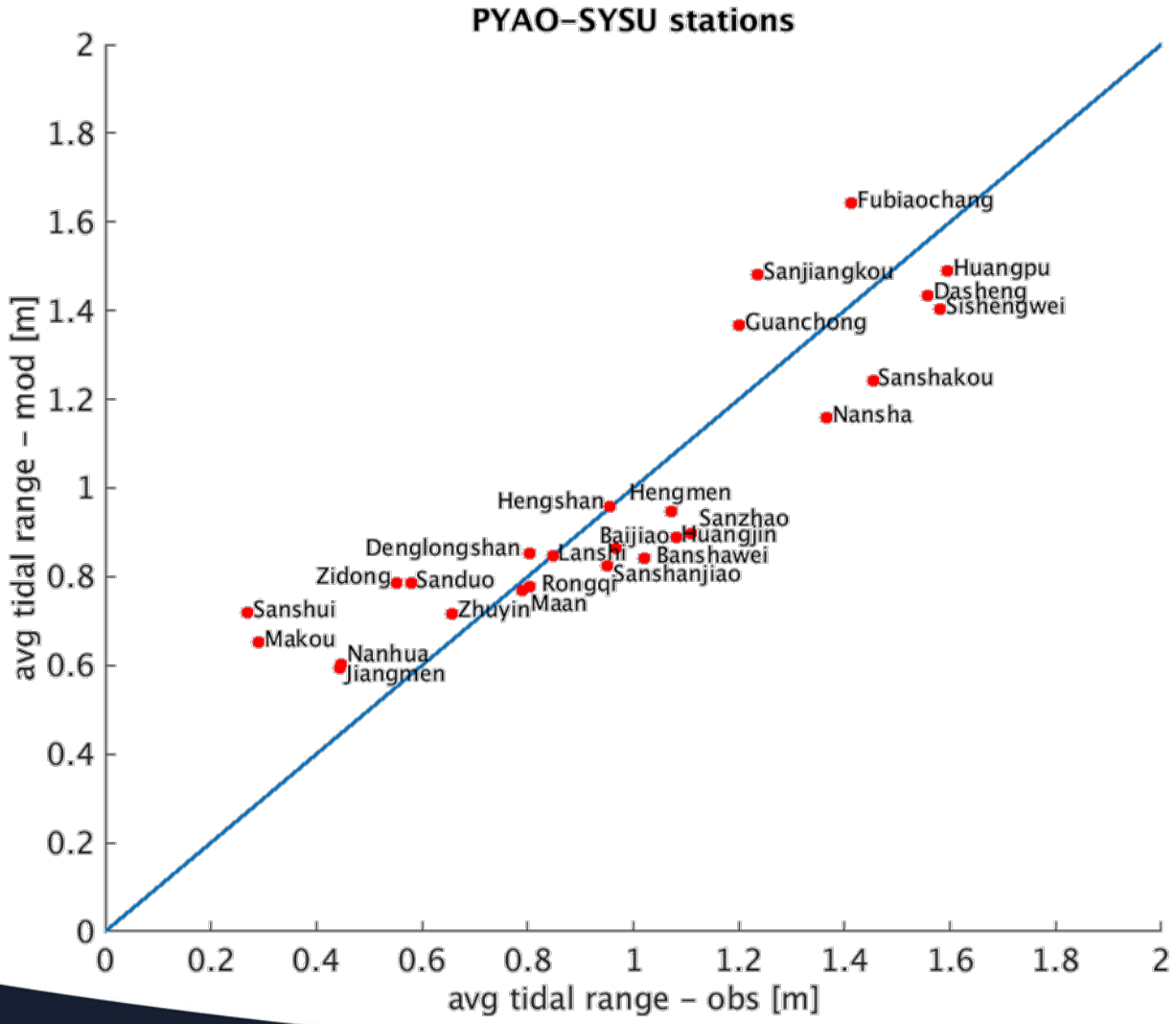



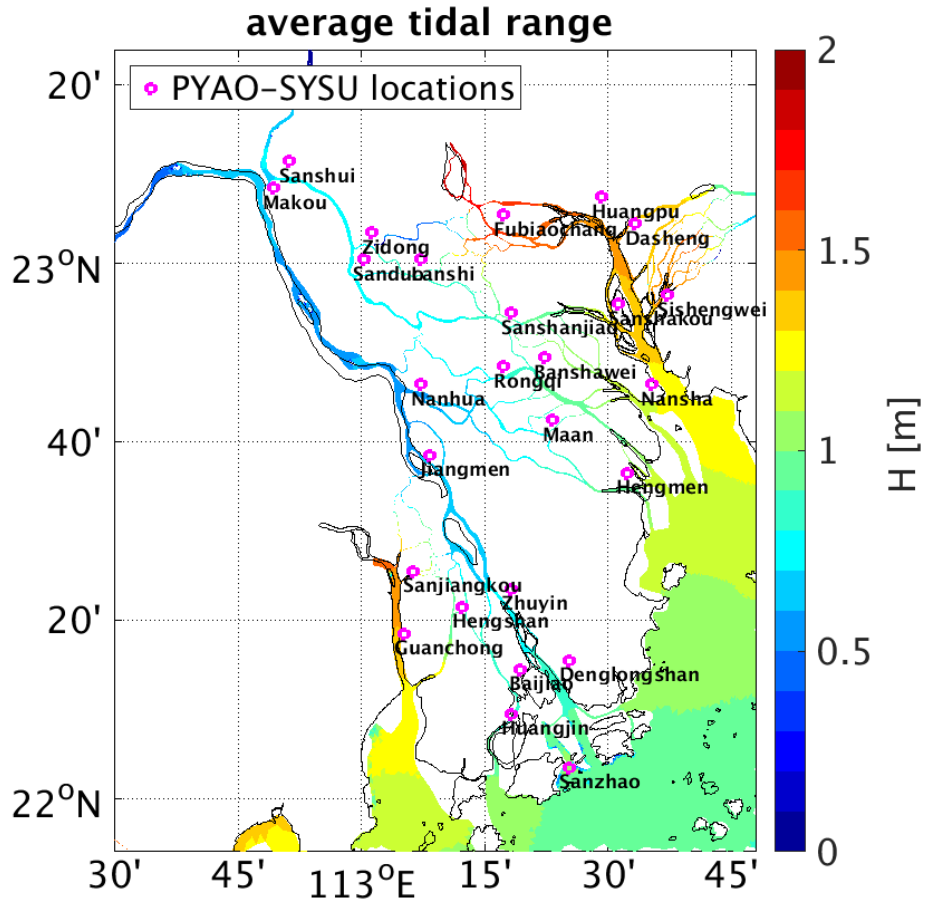

4 Tide Gauges available
with hourly resolution
from U Hawaii Sea Level Centre:

| | |
|---|---|
| Macau | 1978-01-01:1985-05-30 |
| Zhapo | 1975-01-01:1997-12-30 |
| Shanwei | 1975-01-01:1997-12-31 |
| Hong Kong | 1962-01-01:2016-12-30 |

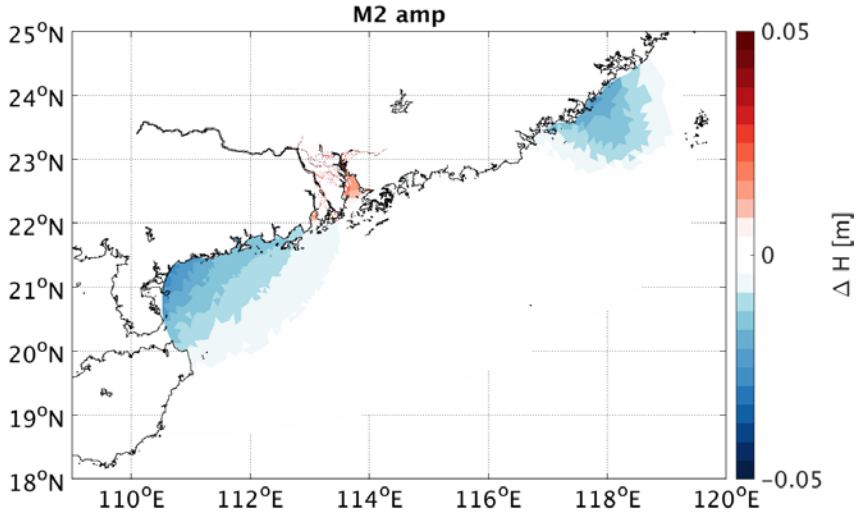


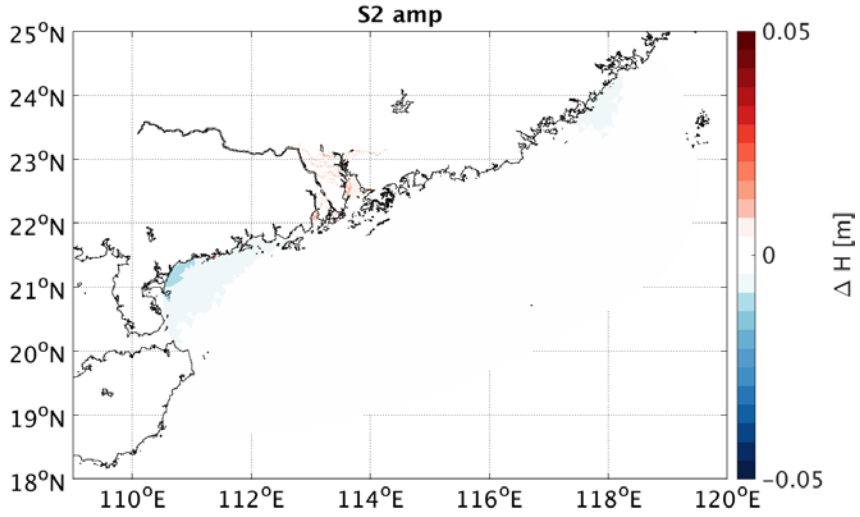
# Validation

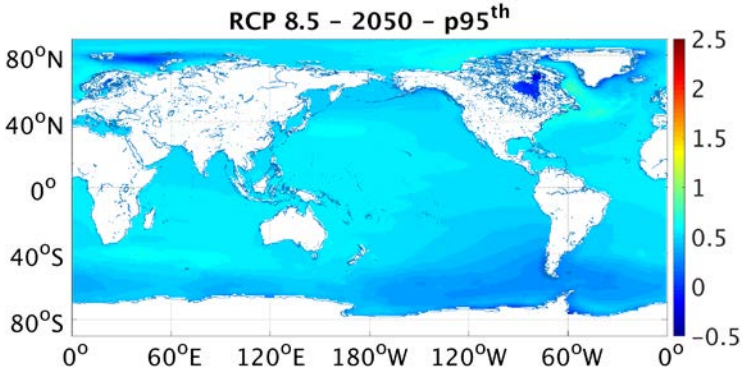

PYAO-SYSU stations
avg tidal range – mod [m]
avg tidal range – obs [m]
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
Fubiaochang
Sanjiangkou
Huangpu
Dasheng
Sishengwei
Guanchong
Sanshakou
Nansha
Hengshan
Hengmen
Sanzhao
Baijiao
Huangjin
Denglongshan
Lanshi
Banshawei
Zidong
Sanduo
Sanshanjiao
Rongqi
Maan
Sanshui
Zhuyin
Makou
Nanhua
Jiangmen

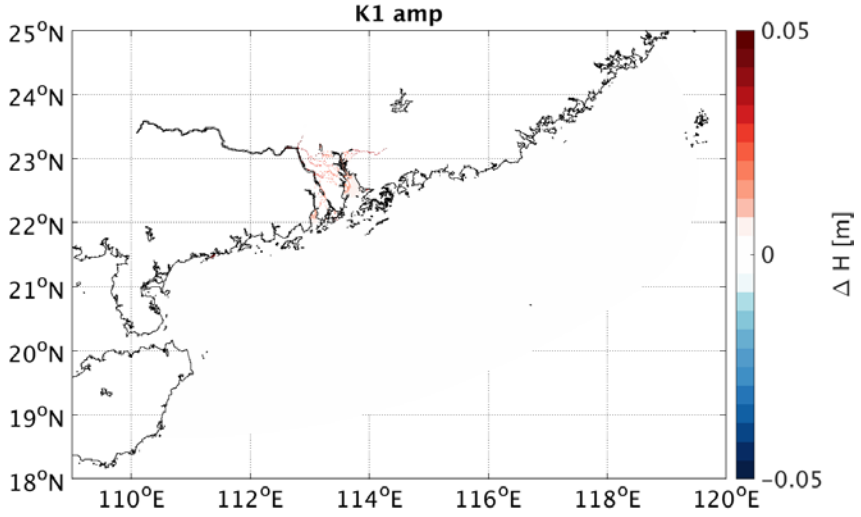

average tidal range
PYAO-SYSU locations
20'
23°N
40'
20'
22°N
30'
45'
113°E
15'
30'
45'
Sanshui
Makou
Zidong
Sandubanshi
Huangpu
Fubiaochang
Dasheng
Sishengwei
Sanshakou
Sanshanjiao
Banshawei
Rongqi
Nanhua
Nansha
Maan
Jiangmen
Hengmen
Sanjiangkou
Zhuyin
Hengshan
Guanchong
Denglongshan
Baijiao
Huangjin
Sanzhao
H [m]
0
0.5
1
1.5
2

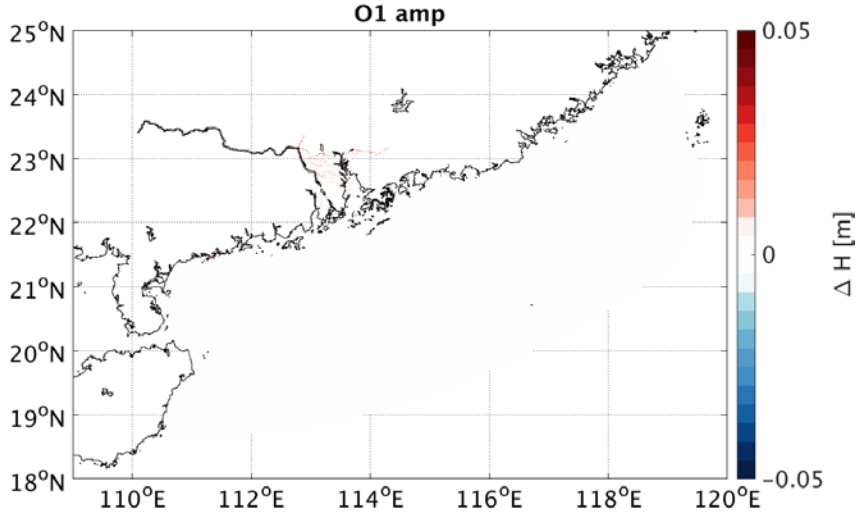
# Tidal amplitude changes due to Sea level rise in **2050**: RCP8.5 p95$^{th}$ scenario



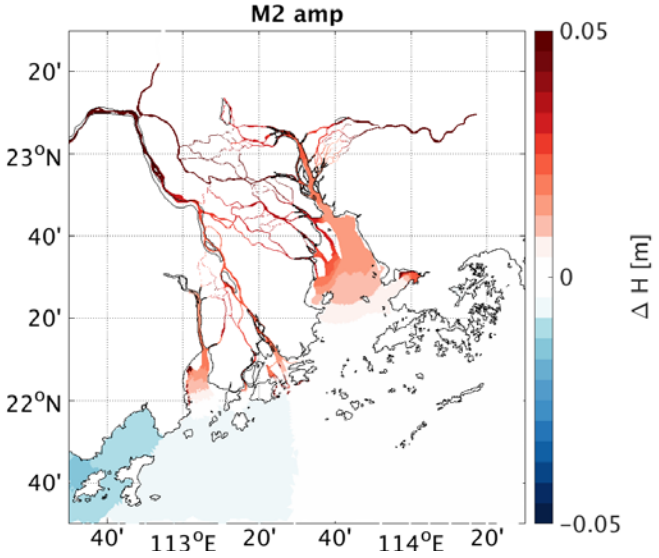



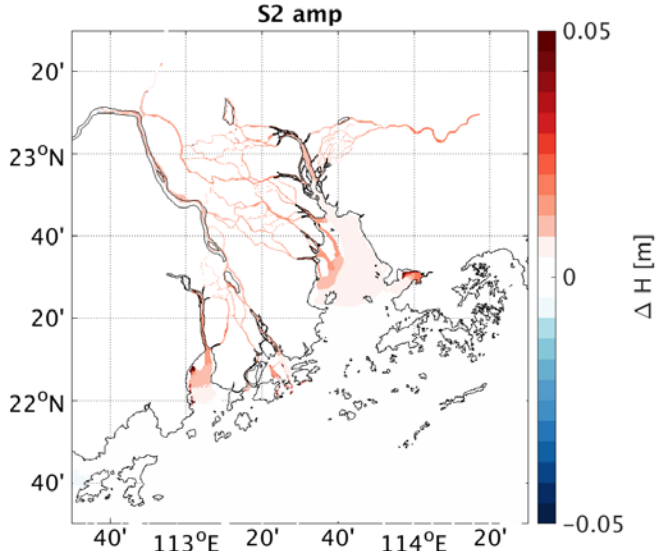



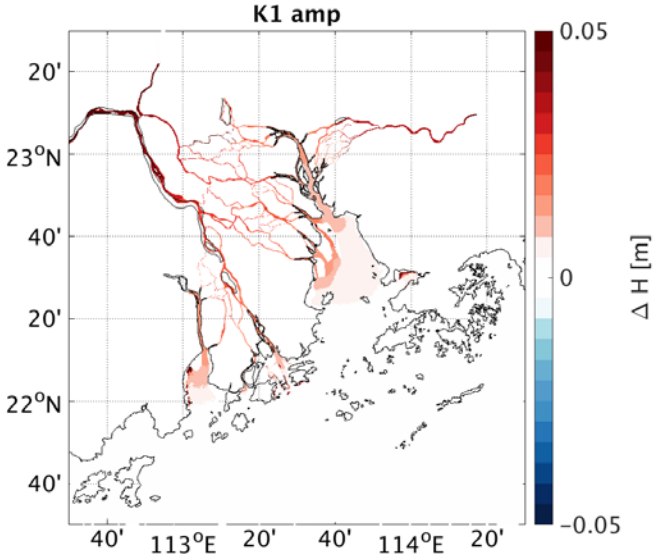



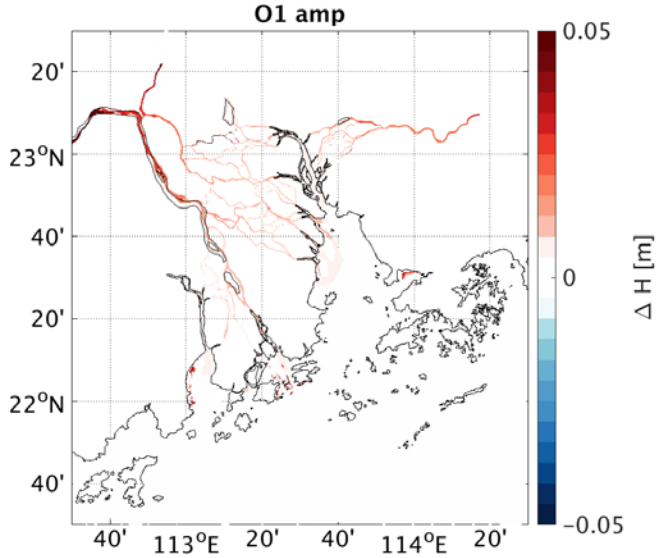



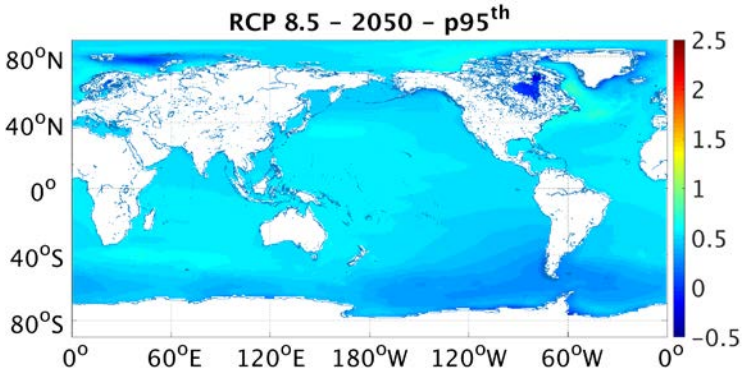
# Tidal amplitude changes due to Sea level rise in **2050**: RCP8.5 p95$^{th}$ scenario



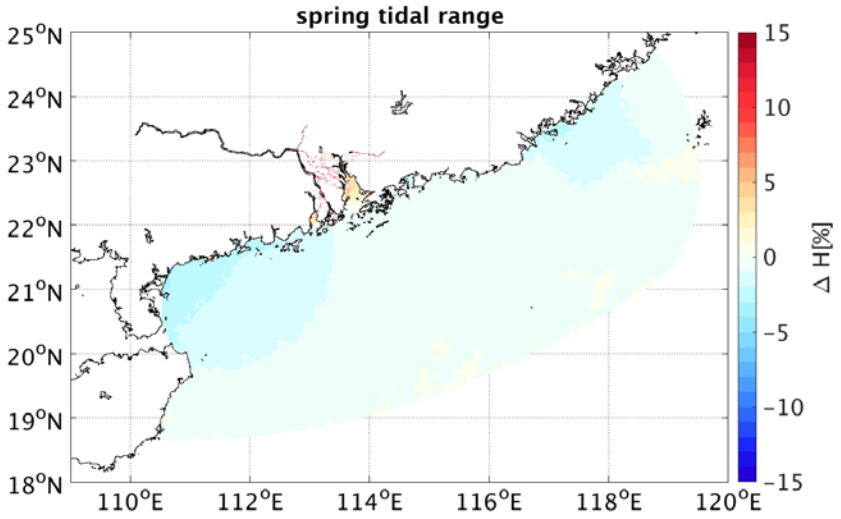



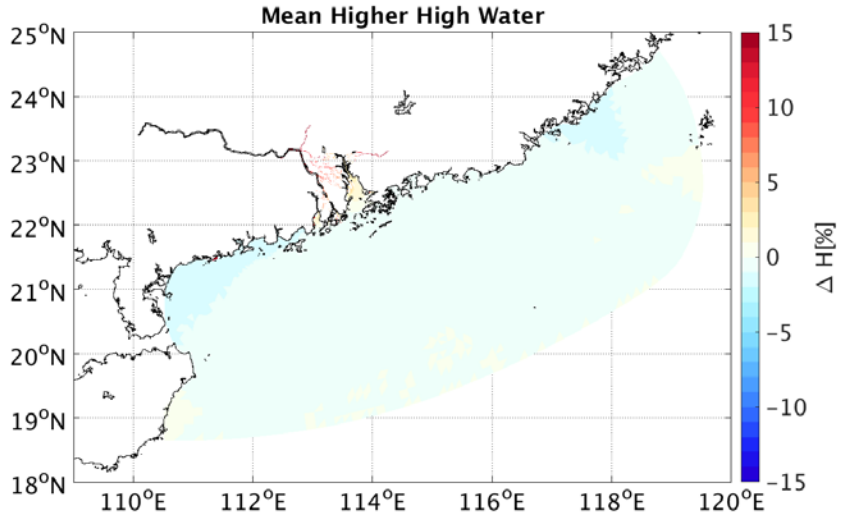



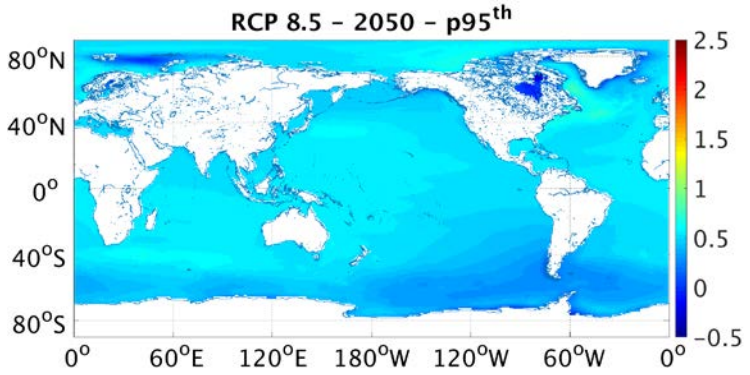



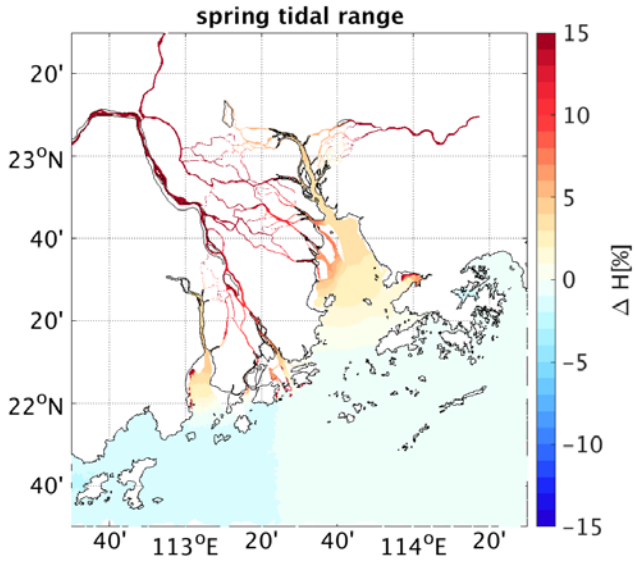



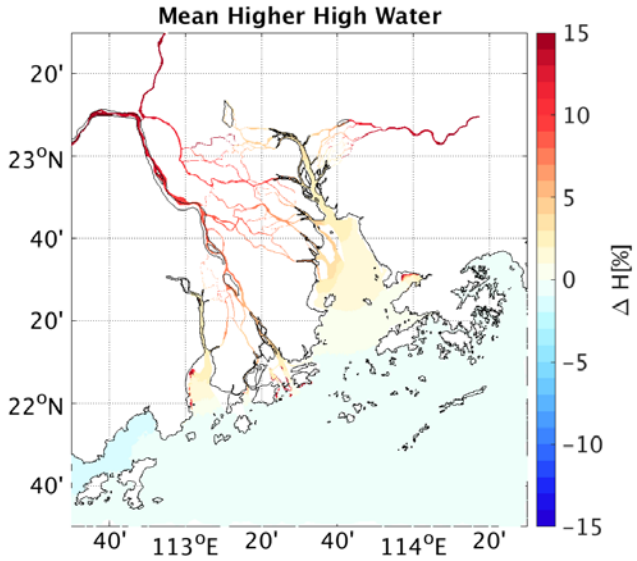
# Tidal amplitude changes due to Sea level rise in **2050**: RCP8.5 p95$^{th}$ scenario



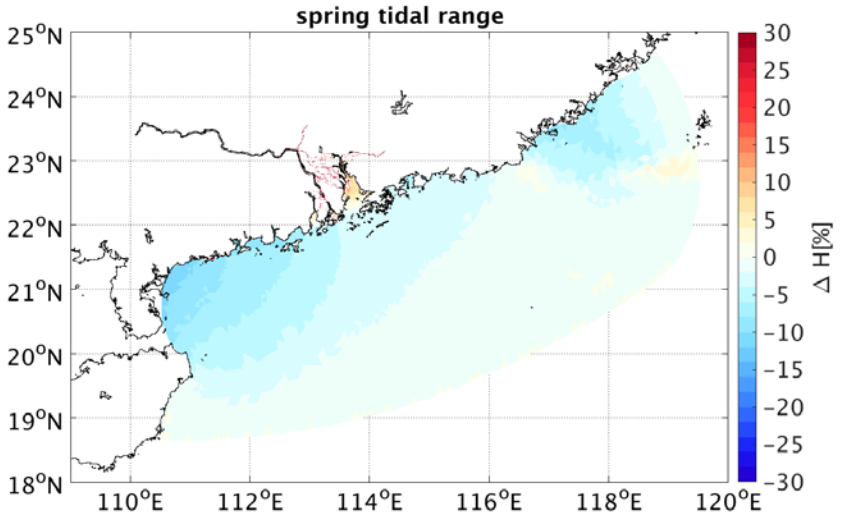



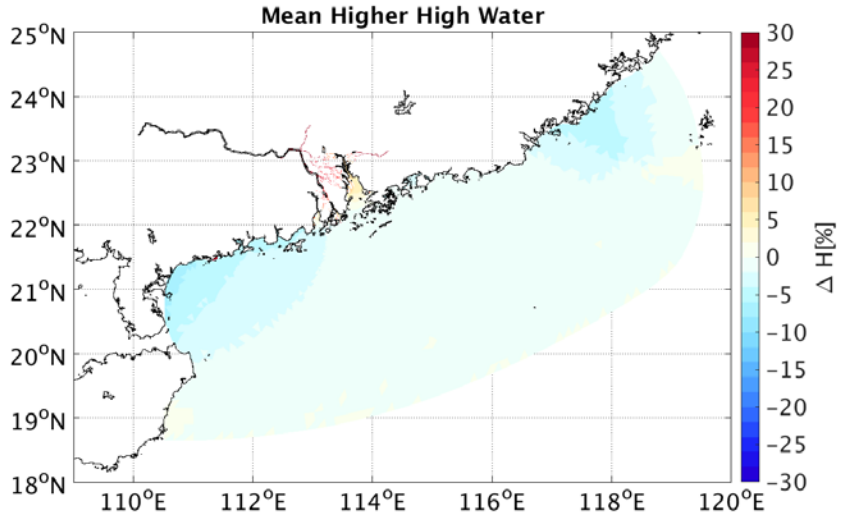



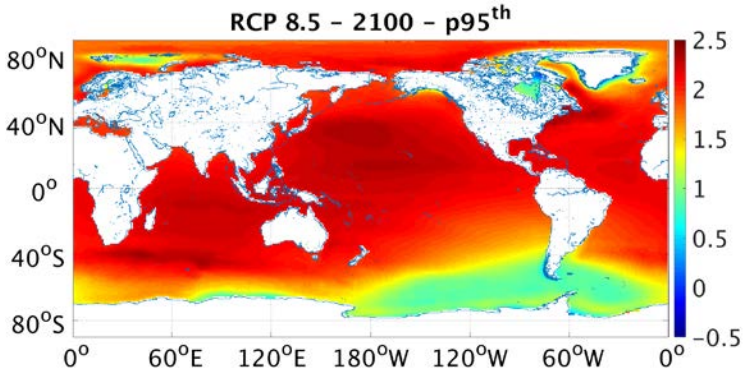

2(M2+S2)

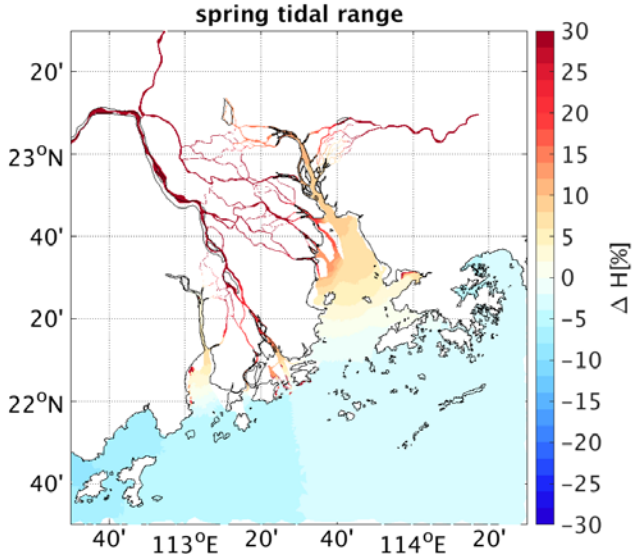
M2+O1+K1

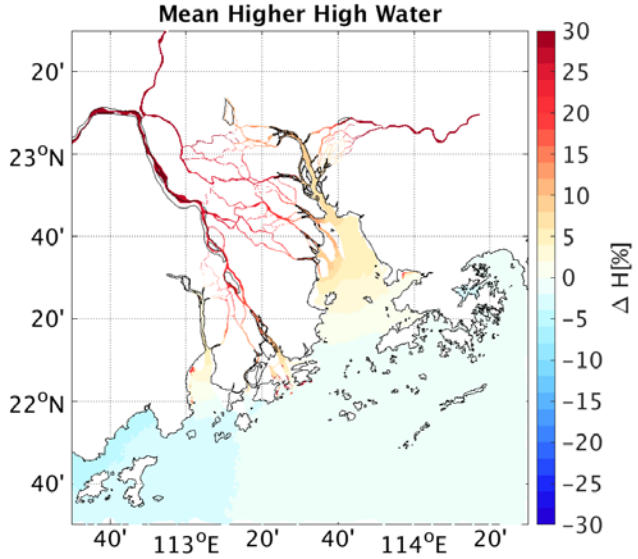
# Tidal amplitude changes due to Sea level rise in **2100**: RCP8.5 p95$^{th}$ scenario



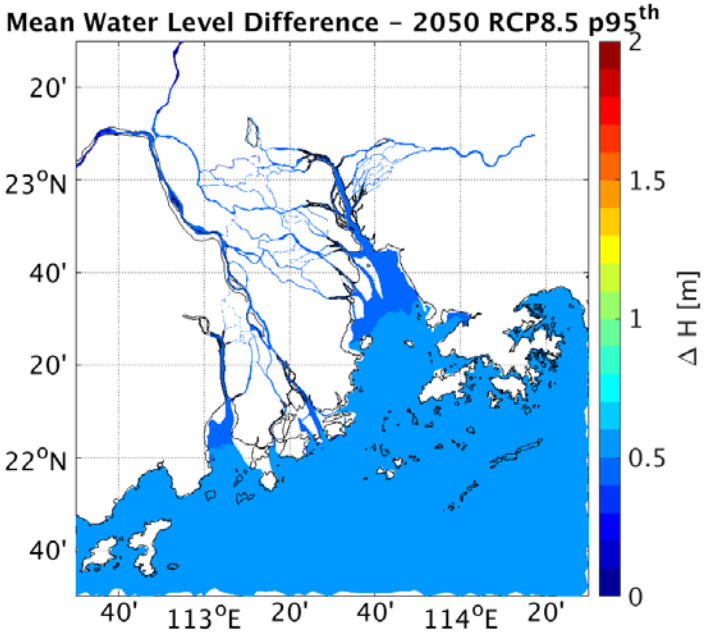



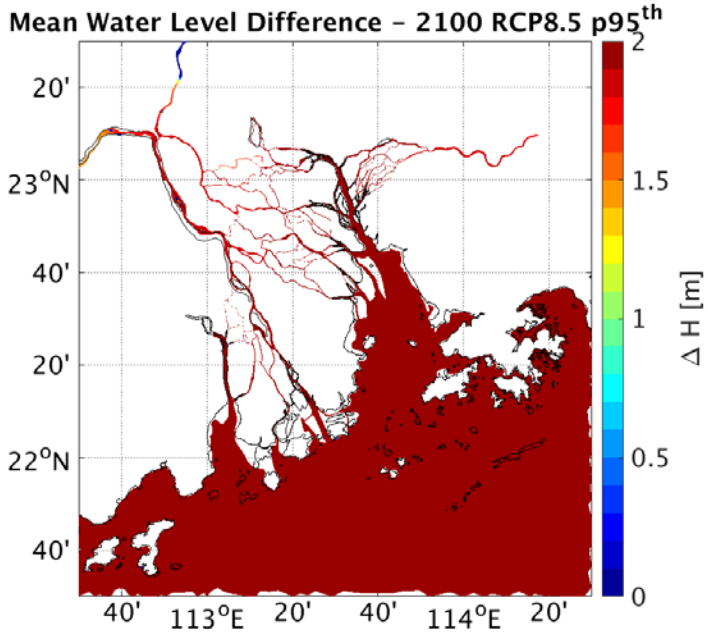



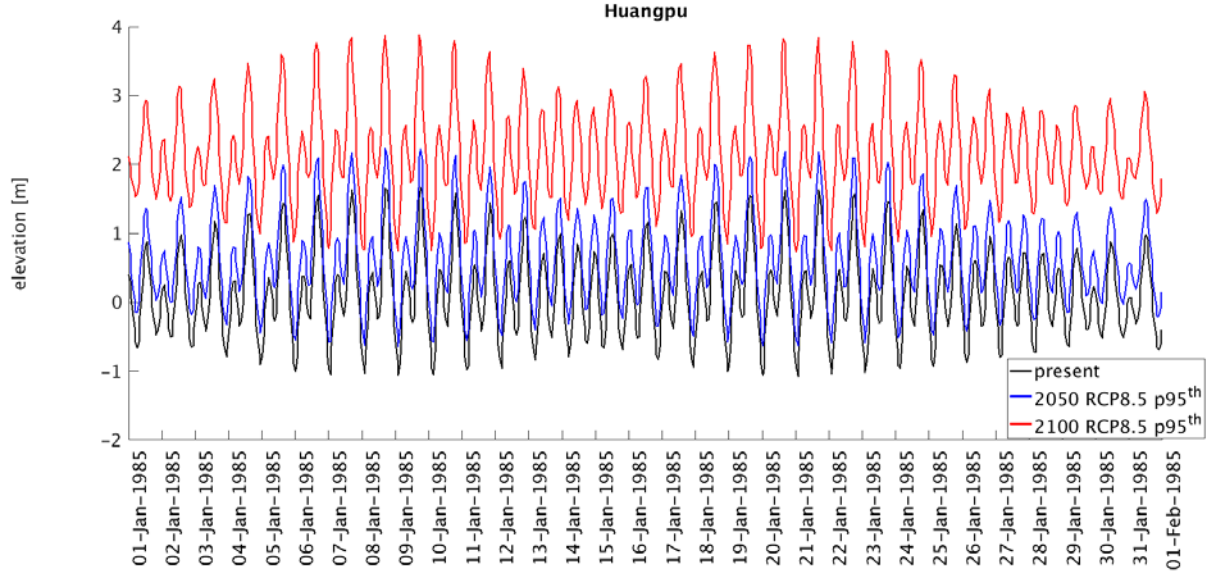

2(M2+S2)

M2+O1+K1

# Water level changes due to Sea level rise in 2050 and 2100: RCP8.5 p95th scenario

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NATURAL ENVIRONMENT RESEARCH COUNCIL

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# Conclusions & Future plans

- **Changes in spring tidal range with SLR scenarios of 0.5-2 m are of 5-30 cm, increasing going inland.**
- **The SLR signal is going to be the most relevant one for flooding, although changes in tides might become important in the smaller channels further inland.**
- **This work is the first step in the evaluation of the current defence system of the Pearl River Delta, which will also include the impacts of extreme water levels and waves associated with typhoons under future climate conditions.**

# Conclusions & Future plans

- **Our finail aim is to use the Pear River Delta FVCOM model to optimise the location of mangroves spaces for defence, under contrasting scenarios of climate change and land-reclamation.**

- **This work is part of the ANCODE project (Applying Nature-based COastal DEfence in the Pearl River Delta: the ANCODE project)**

Poster Session 2 - Themes C: People & D: Integration
Wednesday 5 September, 12:40-13:00 & Thursday 6 September, 13:10-14:00

**[P.D.004]** **Nature-based coastal protection in the Pearl River Delta: The ANCODE project**

J. Wolf*[1], T.J. Bouma[2,4], Z. Hu[3], S. Jevrejeva[1], M. De Dominicis[1], R. van Hespen[2,4], T. Ysebaert[2,4], P. Yao[3], C. Wang[5], M. Li[6], [1]*National Oceanography Centre, UK*, [2]*Royal Netherlands Institute for Sea Research, The Netherlands*, [3]*Sun Yat-sen University, China*, [4]*University of Utrecht, The Netherlands*, [5]*Satellite Environment Centre, China*, [6]*University of Liverpool, UK*

# QUESTIONS?
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**Acknowledgements**
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