EGU General Assembly 2020
Online | 4–8 May 2020
ABOUT | ABSTRACTS & PROGRAMME | SHARING GEOSCIENCE ONLINE | REGISTRATION FEES | MEDIA | GUIDELINES

OS2.1
Open session on coastal and shelf seas
Convener: Johan van der Molen | Co-conveners: Huib E. de Swart, Andreas Lehmann, Alexander Osadchiev, Julie D. Pietrzak
Displays | Chat Wed, 06 May, 14:00–18:00

Variation behavior of tidal dynamics in the Yangtze Estuary: implying the amplification of hydrodynamics and sediment dynamics by the human intervention

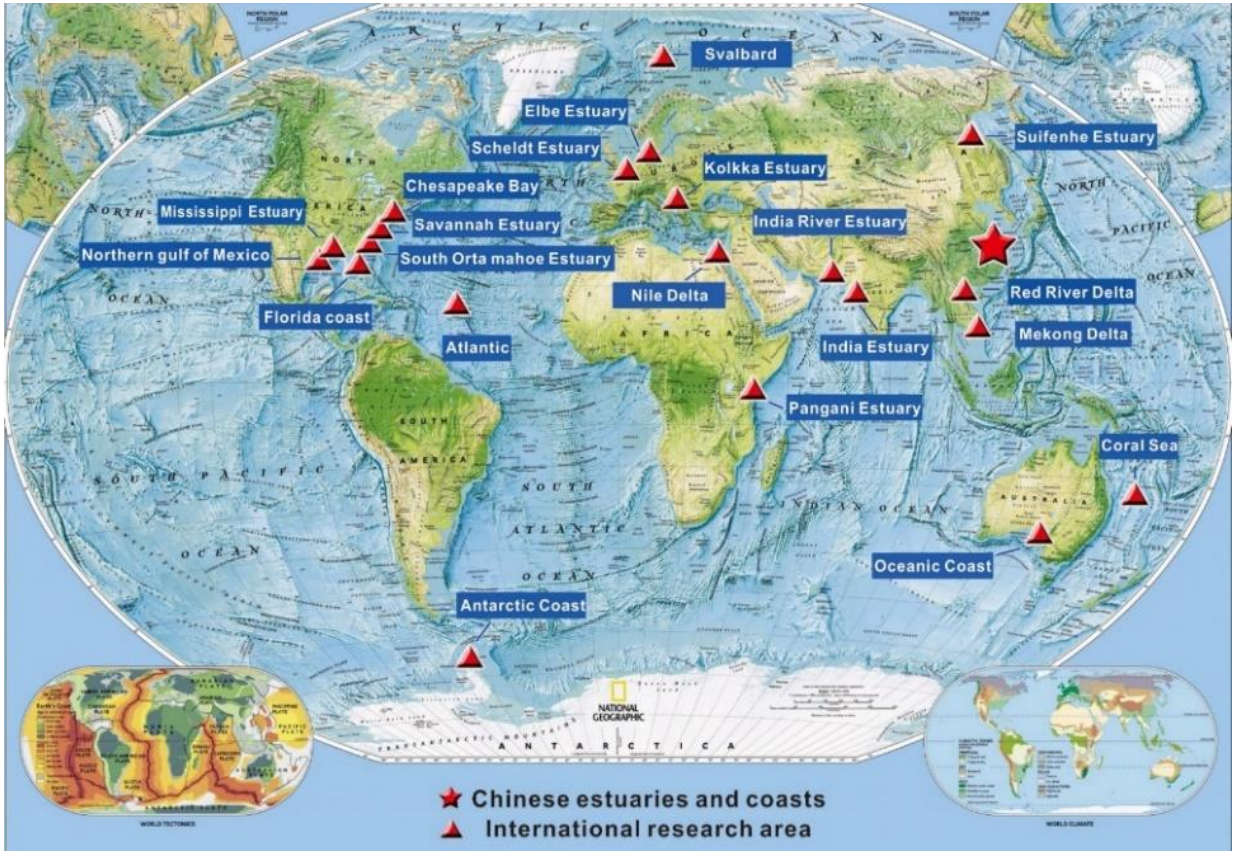
CHENG Heqin[1], Chen Wei[2], Teng Lizhi[1], Yuan Xiaoting[1]

[1]State Key Laboratory of Estuarine and Coastal Research
East China Normal University , Minghan District, 200142, Shanghai, China
[2]Helmholtz-Zentrum Geesthacht, Max-Planck-Straße 1, 21502 Geesthacht, Germany

2020-05-06, Shanghai

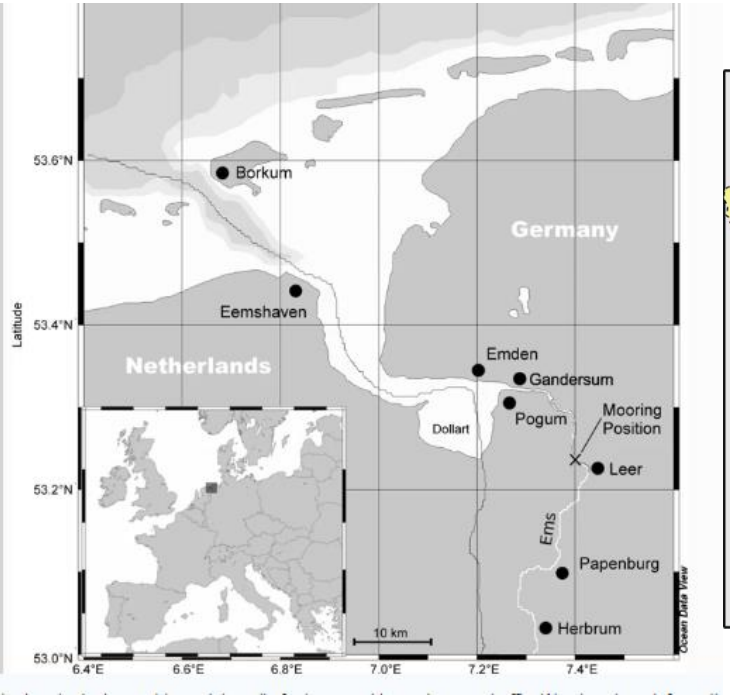
Introduction

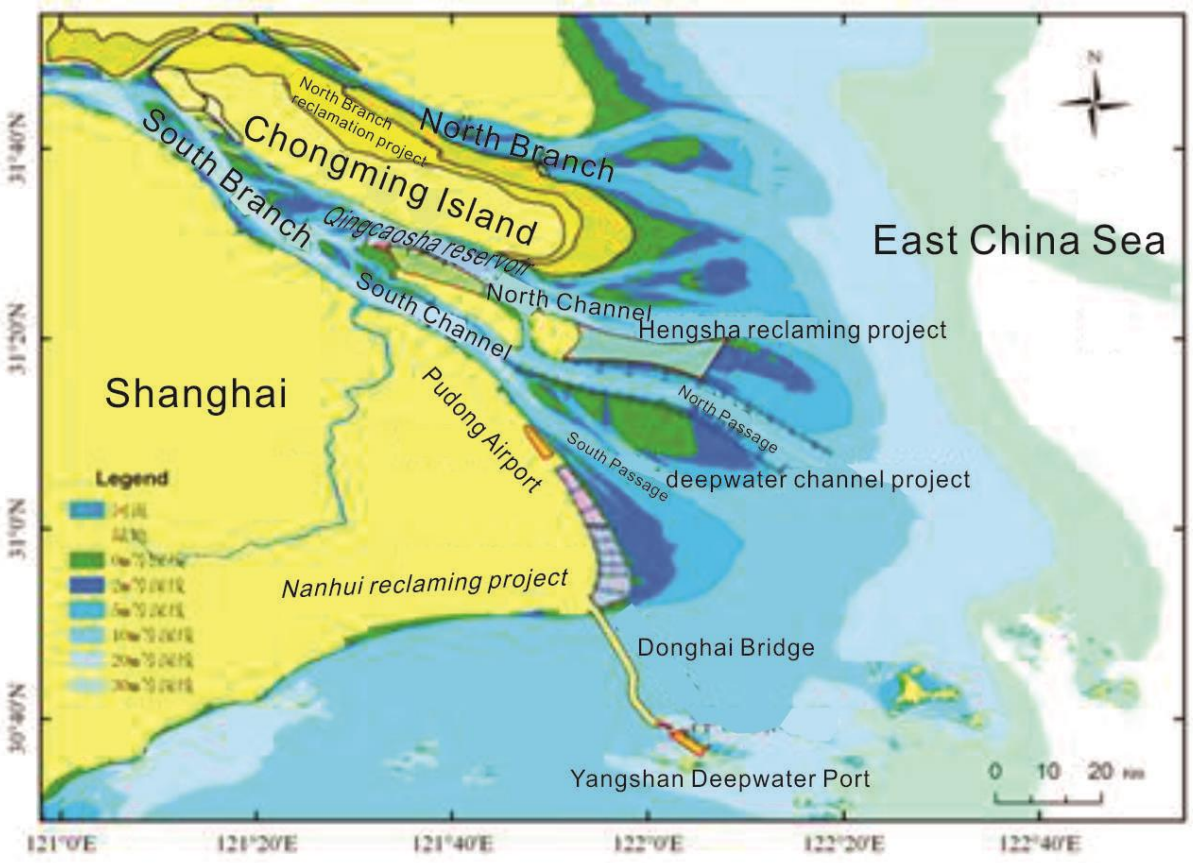
During the last decades, many estuarine systems in Europe (e.g. the Elbe, Ems, Loire) have shown increases in tidal range and in turbidity, which are linked to local human activity (e.g., deepening).



Winterwerp, J.C., Wang, Z., van Braeckel, A.,. Ocean Dyn., 63, 1293-1306.

Compared to these European estuaries, the Yangtze Estuary is much larger in scales, experiences much stronger river discharge, and it is subject to a strong seasonal variation in freshwater and sediment supply from the drainage area.





Moreover, the Yangtze estuary is a complex network with several branches, connecting channels.

Question: Tidal amplification ?

Despite the intense research efforts over the past two decades, it is still unclear which impact (local or nonlocal) is responsible for the changing flow and sediment characteristics in the estuary.

Dam construction (more thank 50000)

South-to-North Water Diversion Project

Water pumping and diversion project along the river

Land reclamation

Deep waterway project

Bridge engineering across river and sea

Human interventions (local and unlocal) ?

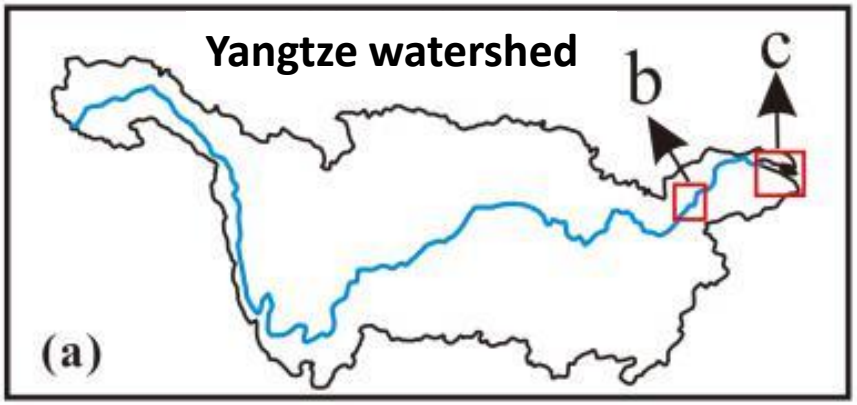
Our deep investigation of tidal characteristic quantities such as extreme tidal level, tidal range, amplitude of tidal constituents, tidal characteristic coefficient is performed in a systematic manner.

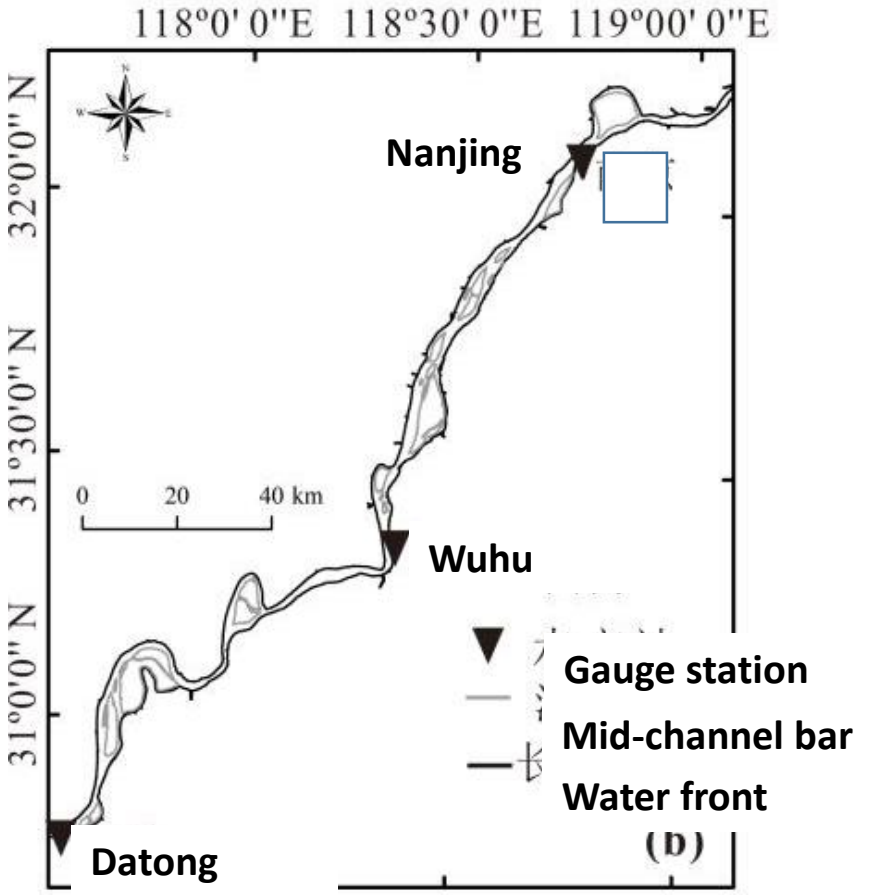
Spectral analysis

Wavelet analysis

Data and analysis

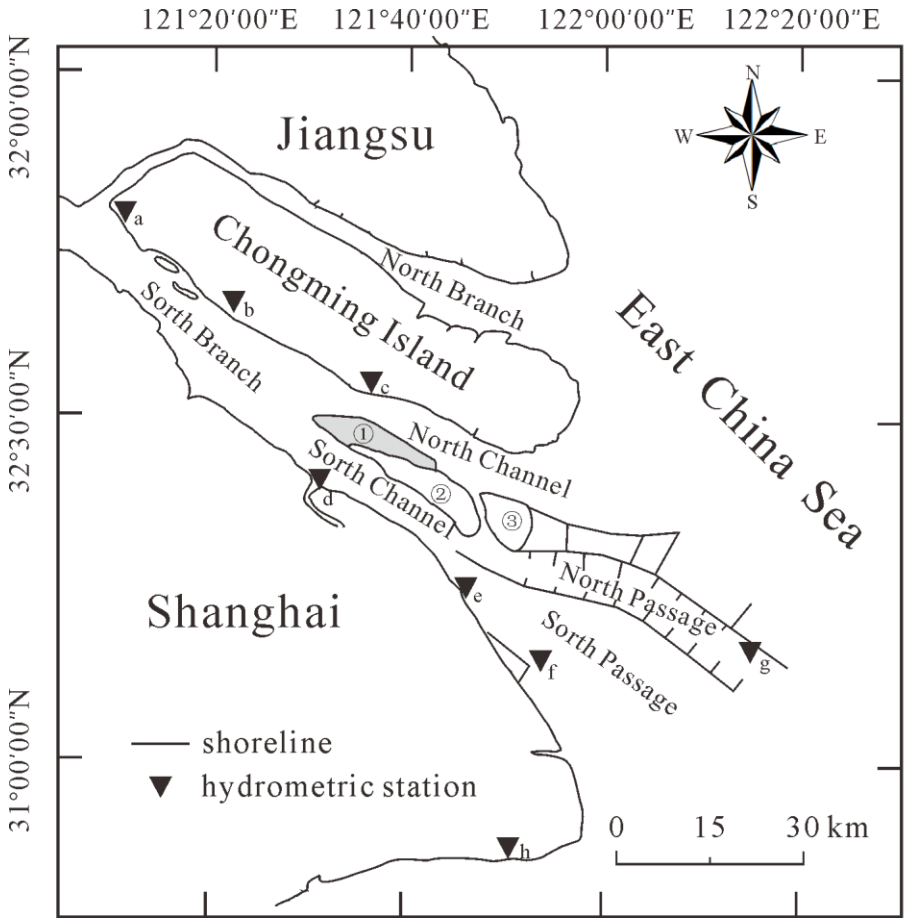
Tidal river channel of the upper estuary





- Hourly averaged water level, tidal range at Datong, Wuhu and Nanjing gauge stations during 1978-1983 and daily average water discharge at Datong station during 1978-1983 and 2008-2016
- Subaqueous bathymetry data along the main channel from Datong to Nanjing during 1998-2013

Data and analysis

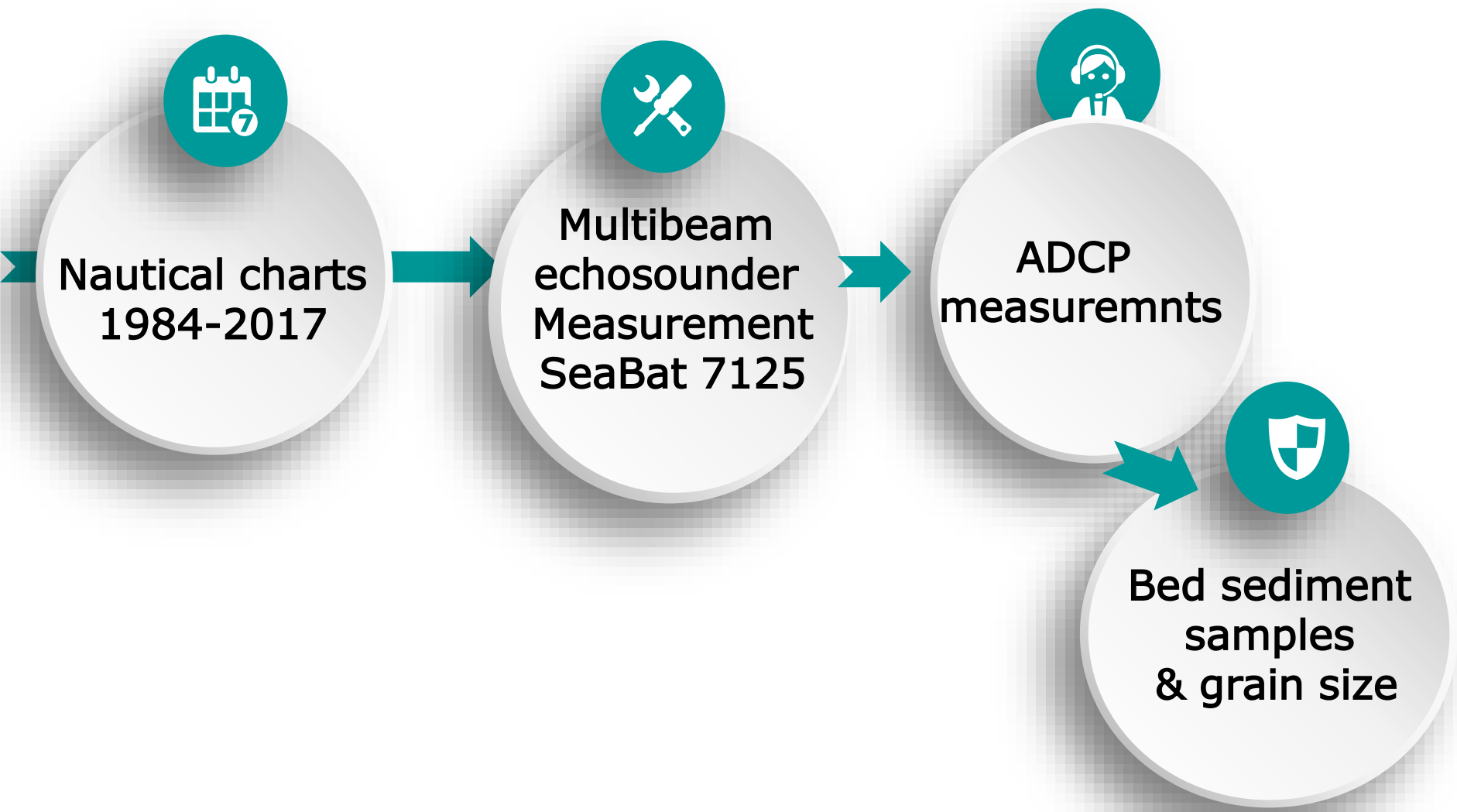


① Qingcaosha Reservoir
② Changxing Island
③ Hengsha Island
a. Chongxi Station
b. Nanmen Station
c. Baozhen Station
d. Wusong Station
e. Sanjiagang Station
f. Zhongjun Station
g. Niupijiao Station
h. Luchaogang Station

- Extreme water level and annual average tidal range at 5 gauged stations in the estuary during 1965-1978 and tidal constituents in 1970s

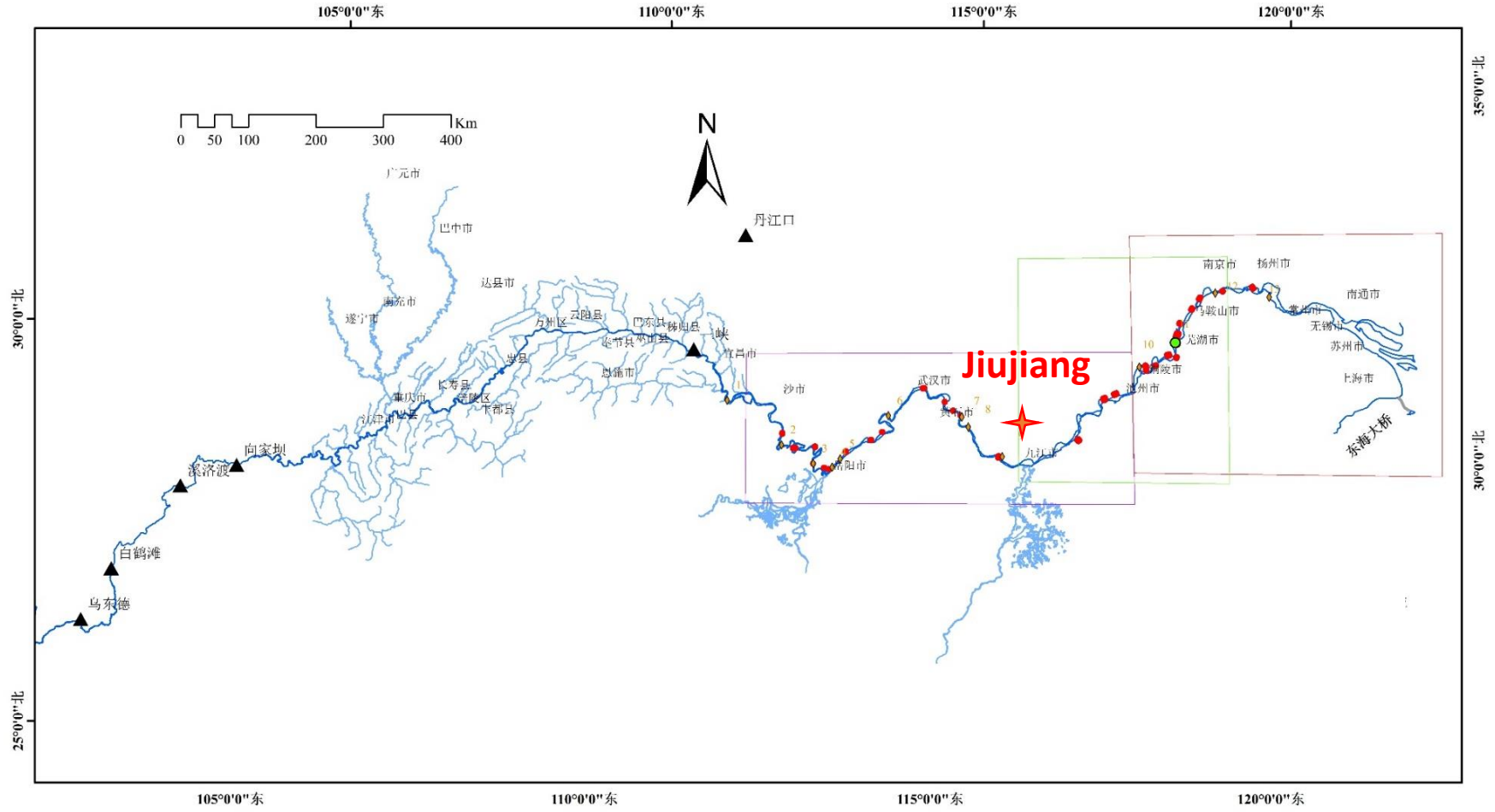
- Hourly averaged tidal level at 8 gauge stations in the estuary during 2010-2016
- Annually averaged tidal range at 3 gauge stations during 1979-2009 and other 3 stations during 1996-2009
- Historical subaqueous bathymetric data in 1986, 1998, 2000, 2007, 2008, 2011, 2017 and 2018

Data and analysis



Results

In the upper estuary



Shi S.Y. and Cheng H.Q., et al., 2018. Fluctuations in the tidal limit of the Yangtze River estuary in the last decade[J]. Science China Earth Science

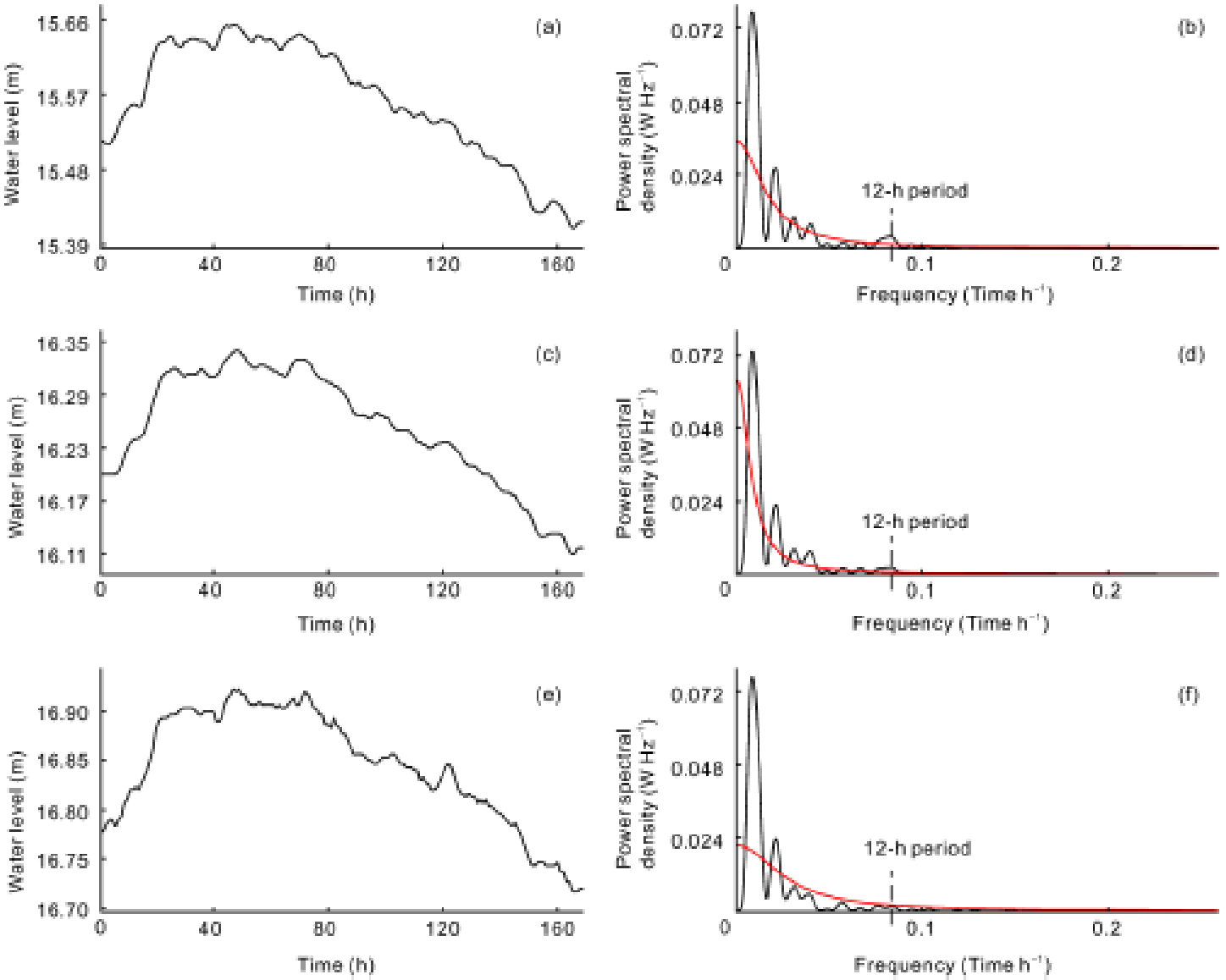


Figure 4 Water level spectrum analysis during the extreme flood period at Datong station ((a), (b)), Chikou station ((c), (d)), Zongyang Sluice station ((e) and (f)).

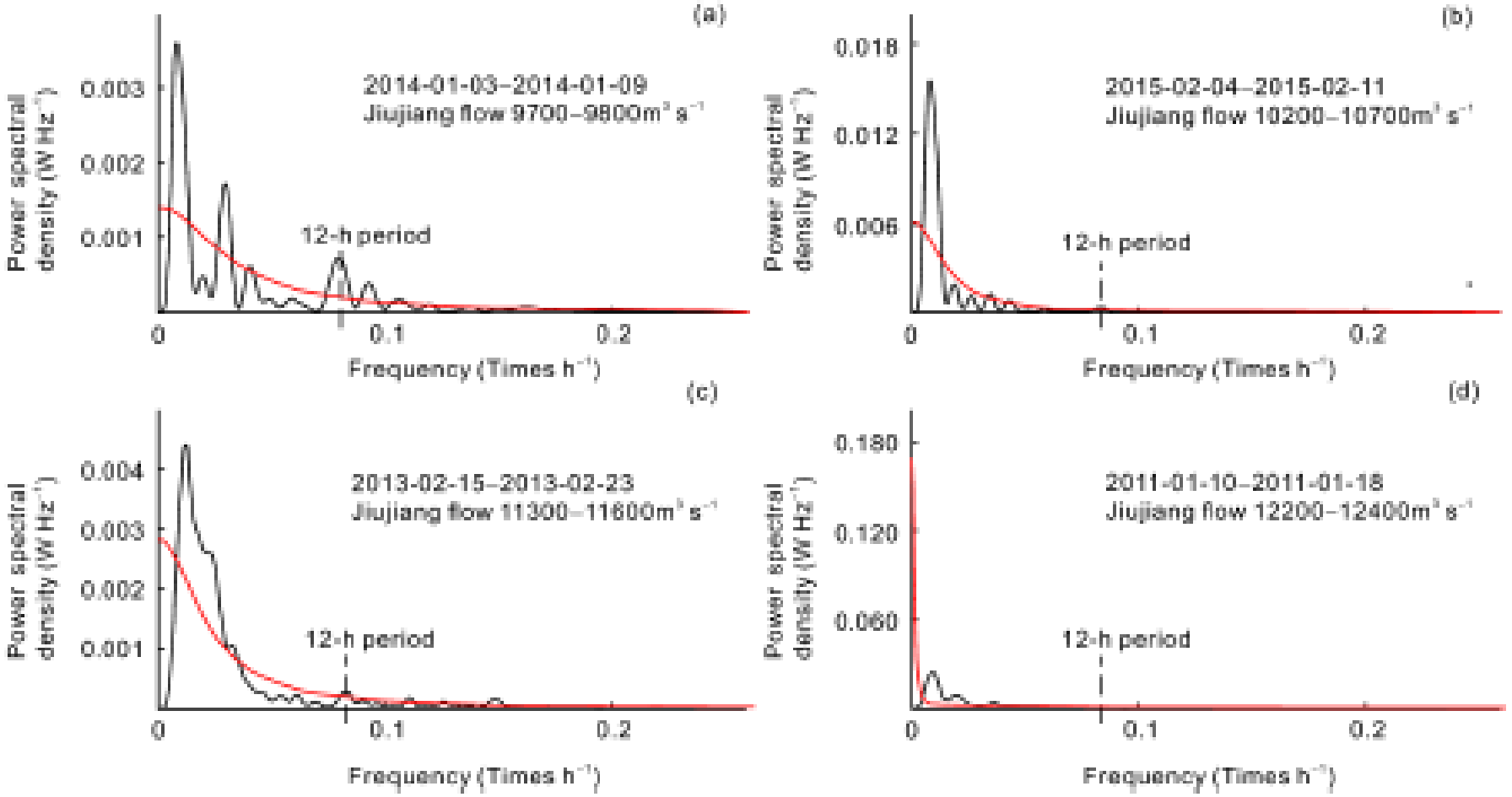


Figure 5 Water level spectrum analysis at Jiujiang station for different flow rates.

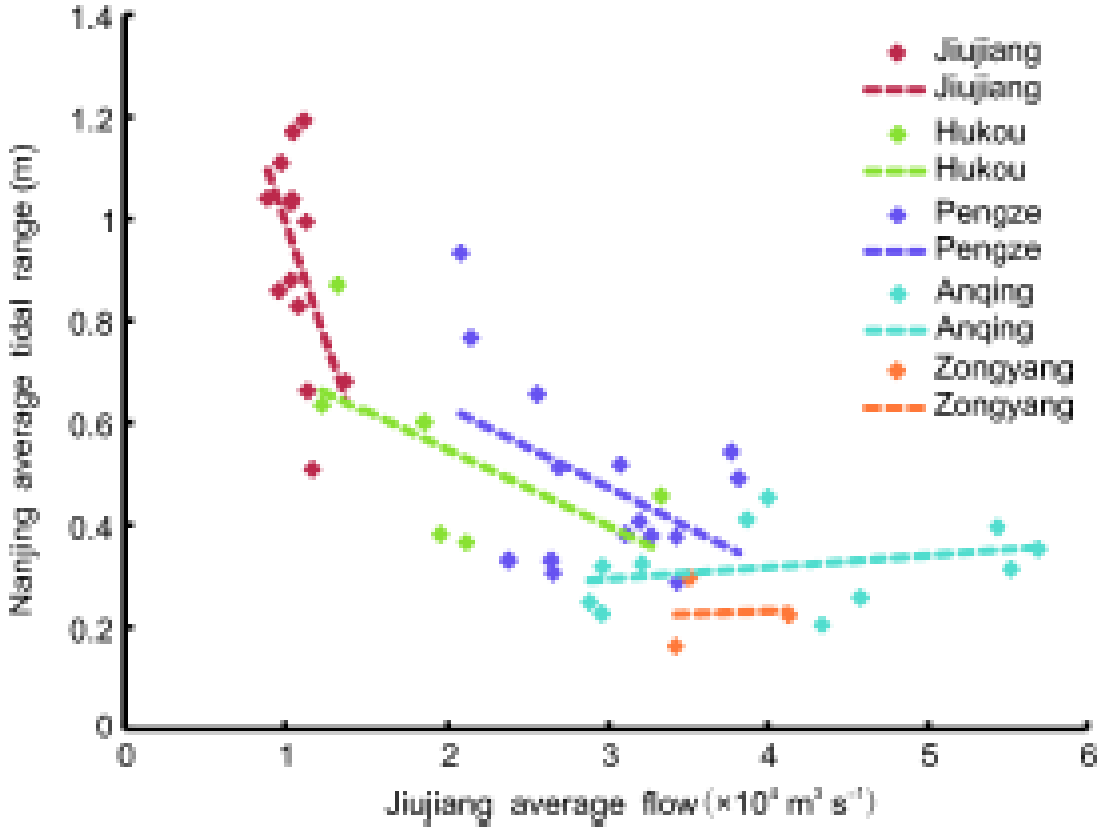


Figure 11 Relationship between Jiujiang flow rate, Nanjing tidal range, and the tidal limit.

Shi S.Y. and Cheng H.Q., et al., 2018. Science China Earth Science

Significant upstream migration of tidal limit

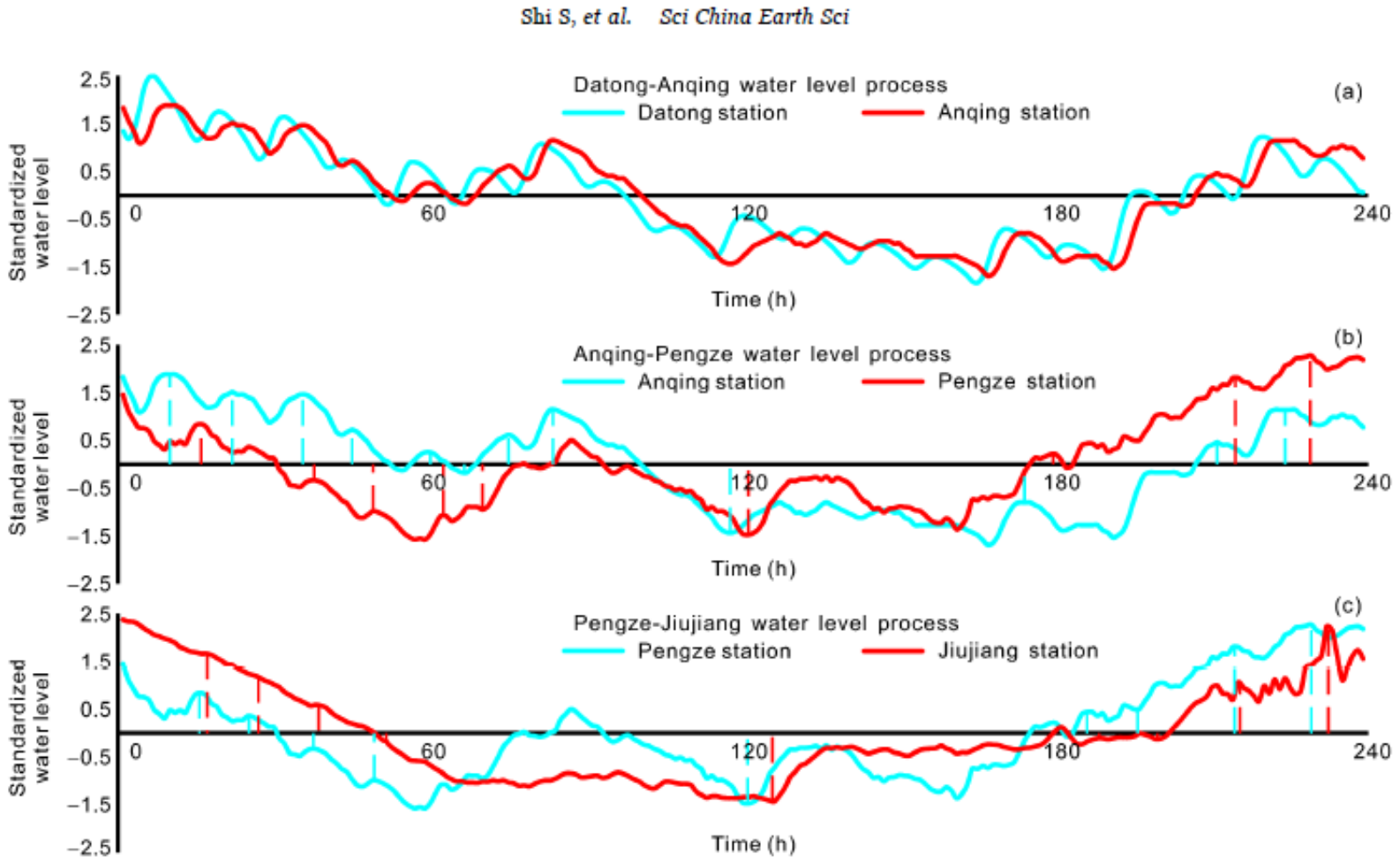


Figure 12 Standardized water levels along the Jiujiang-Datong reach, 18–27 December 2007.

Shi & Cheng, et al., 2018

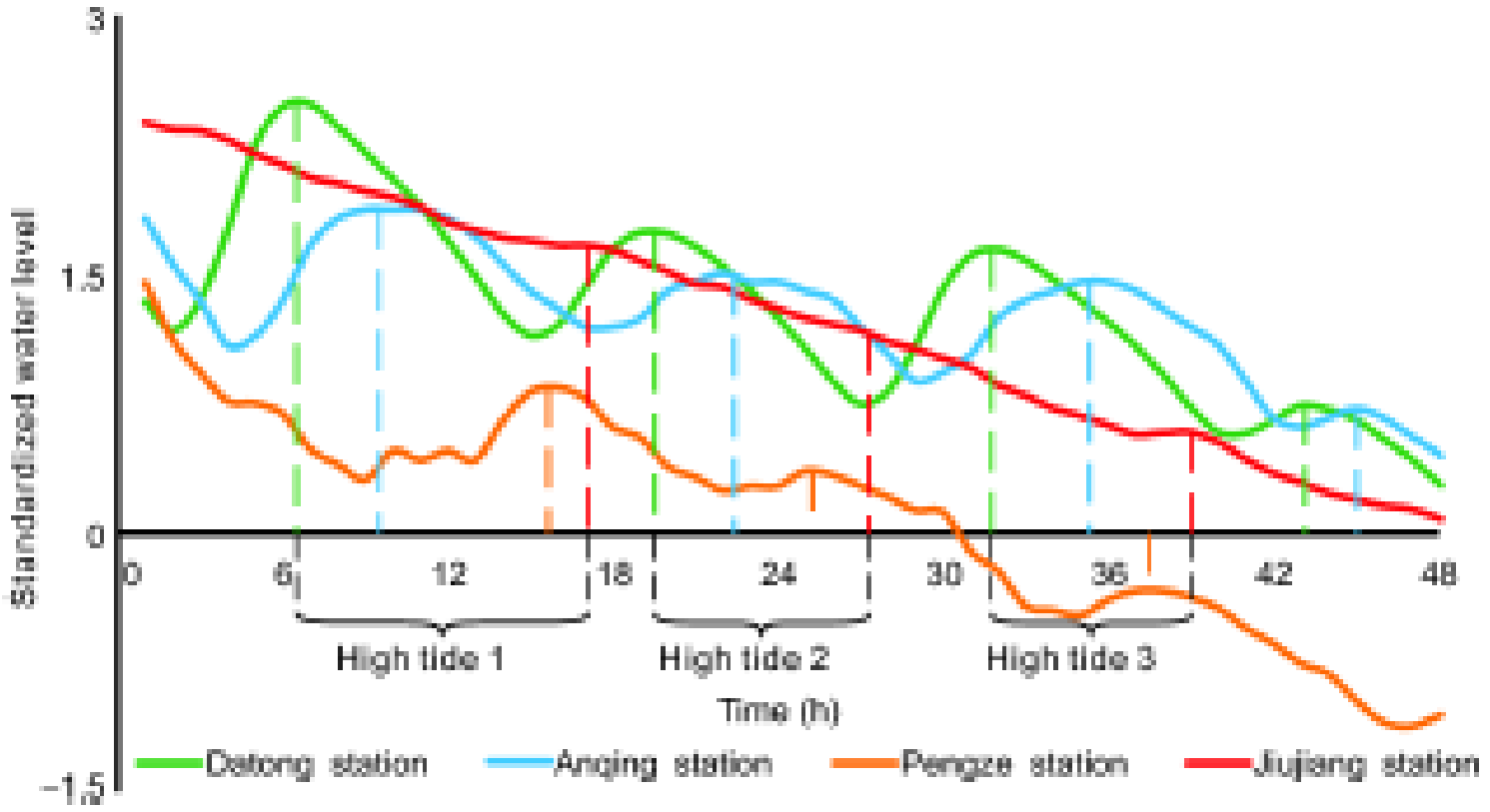


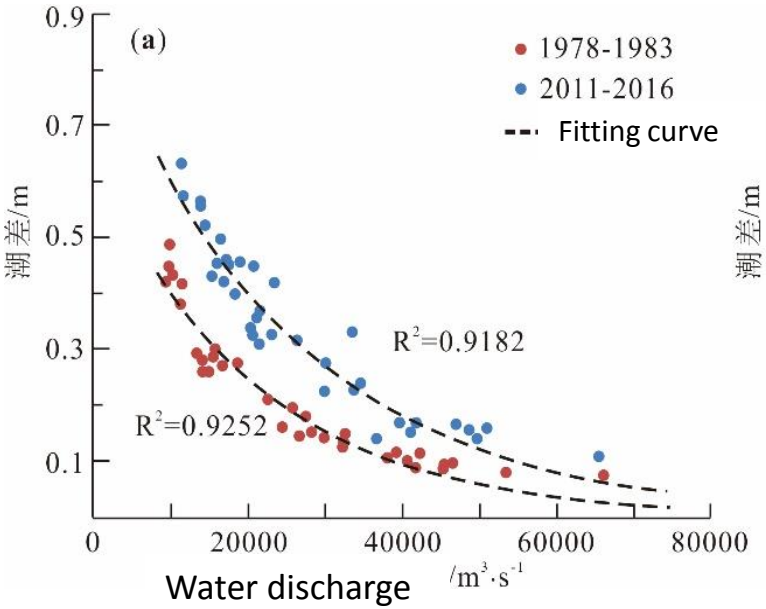
Figure 13 Tidal wave propagation along the Jiujiang-Datong reach, 18–19 December 2007.

Tidal limit migrated upwards 200 km in dry system and 82 km in flood season

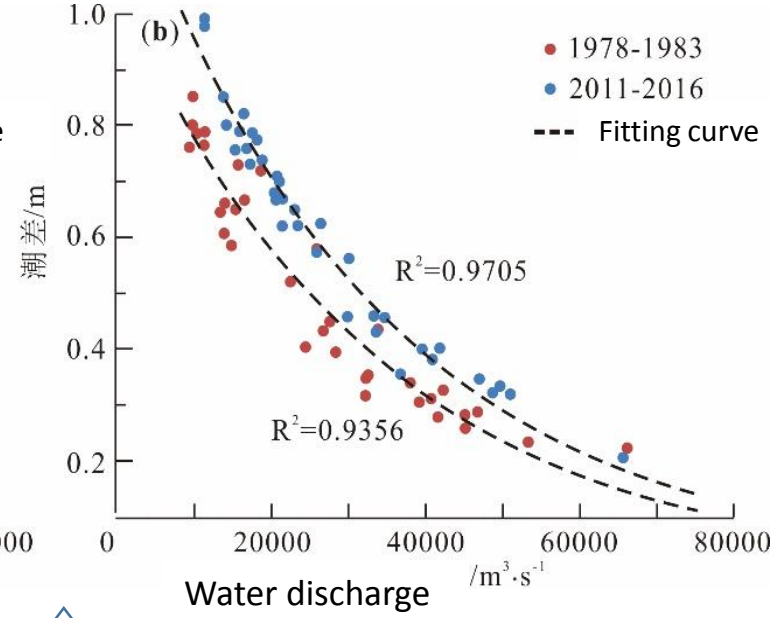
Shi S.Y. and Cheng H.Q., et al., 2018. Science China Earth Science

In the upper estuary

Datong



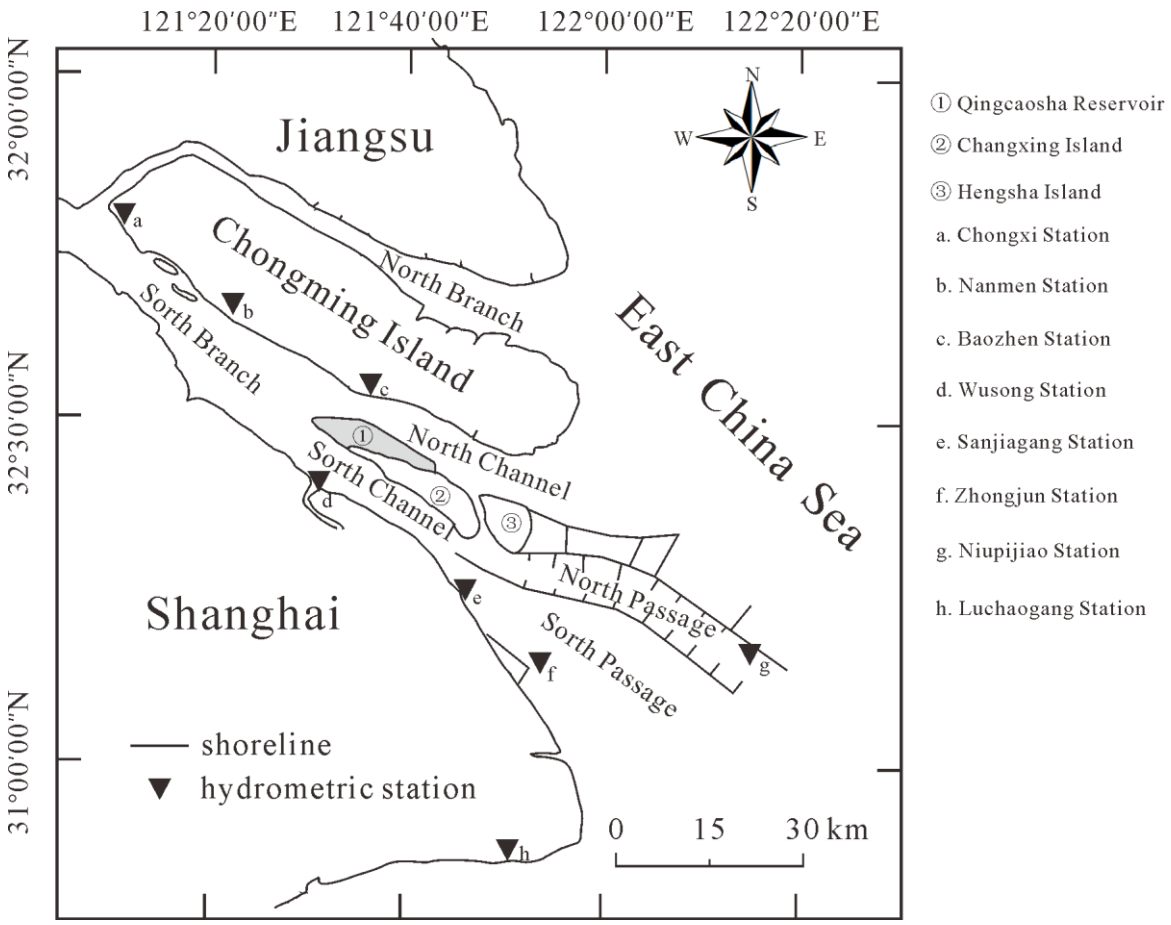
Nanjing



Monthly averaged tidal range increased 10 cm at similar runoff

Yuan X.T., Cheng H.Q., et al., 2019. Marine Science Bulletin

Highest and lowest tidal level in the Estuary



Figures with data will be shown during the presentation

N: Nanmen station; B: Baozhen station; W: Wusong station; Z: Zhongjun station

Yuan X.T. Dissertation 2019

Figures will be shown during the presentation

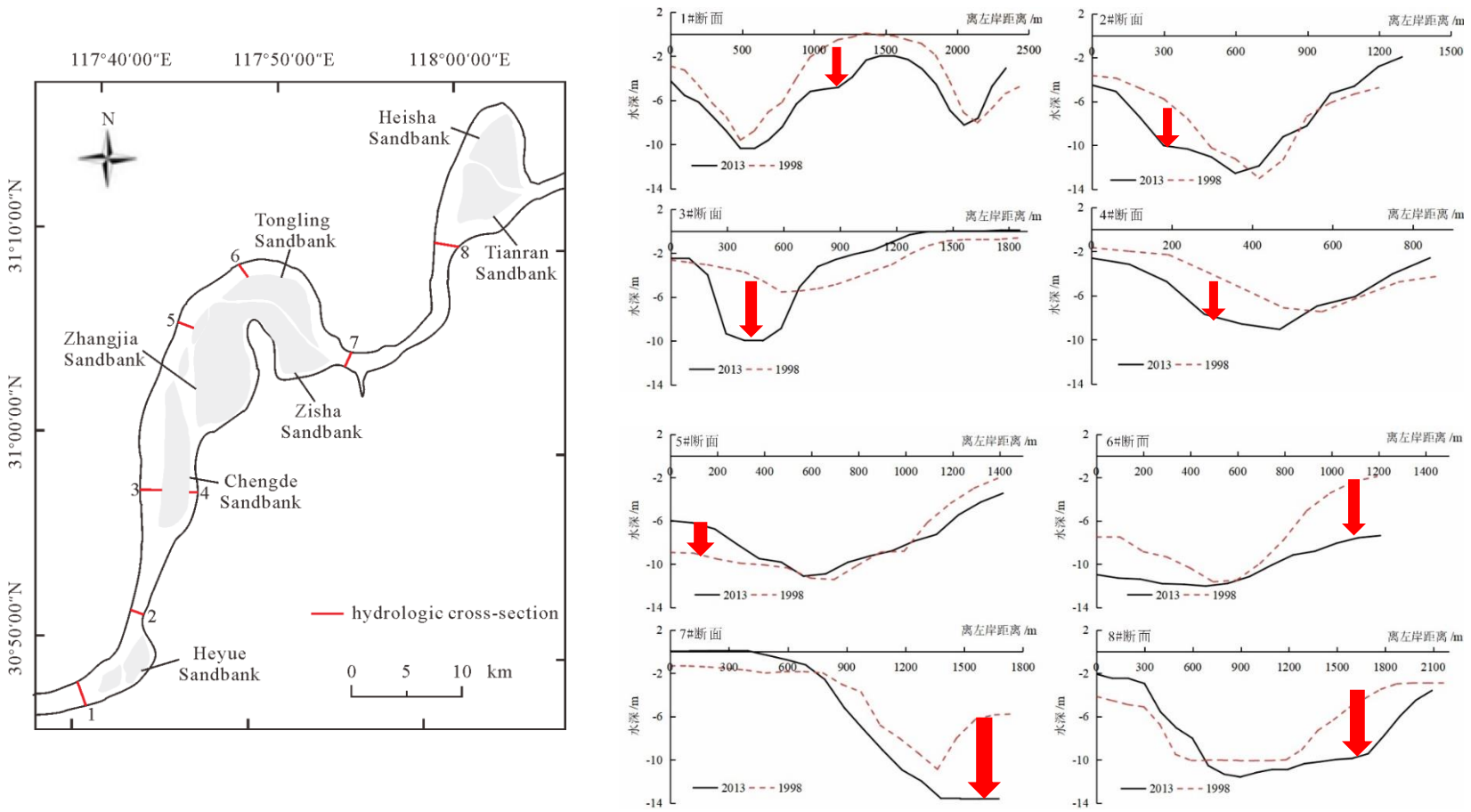
Monthly averaged tidal range in the Yangtze Estuary

Tidal constituents M2, M4, K1, O1, MS4, significant increase of M2 and M4 at Nanjing station

Increase in M2 and M4 during 2011-2016 in the estuary

Local deposition/erosion along the tidal river channel of the upper estuary

Yuan 2019 Dissertation

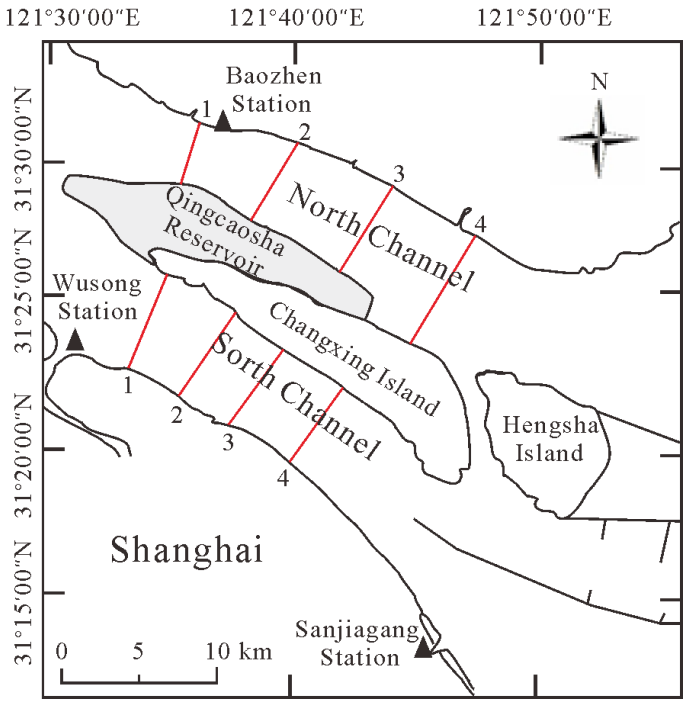


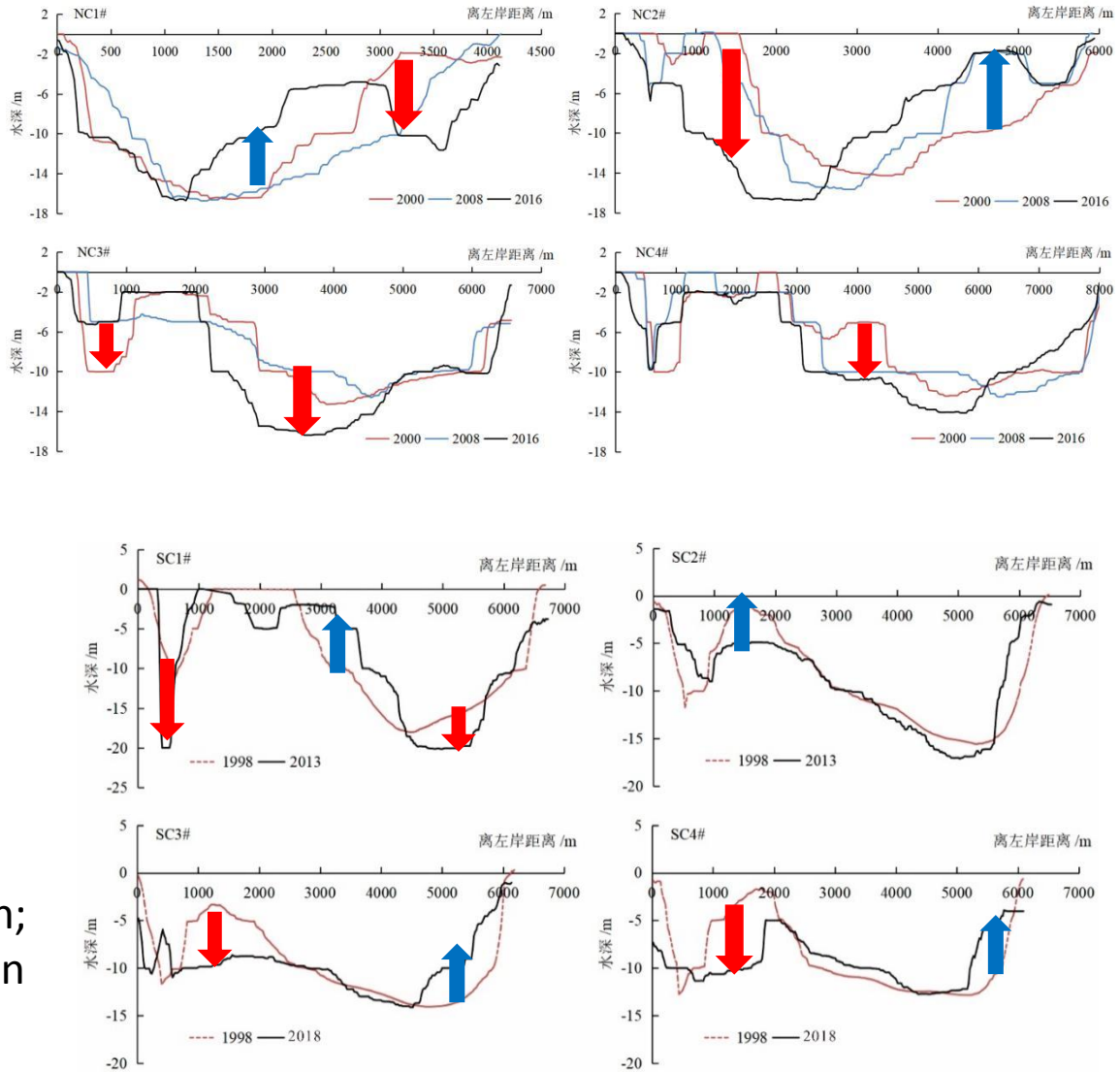
Left: location map of 8 cross section; Right: water depth of 8 cross section profiles

Coincidence of change in tidal range, tidal constituents, etc. with the local channel geometry change by the local engineering works

Local deposton/erosion in the estuary

Yuan 2019 Dissertation





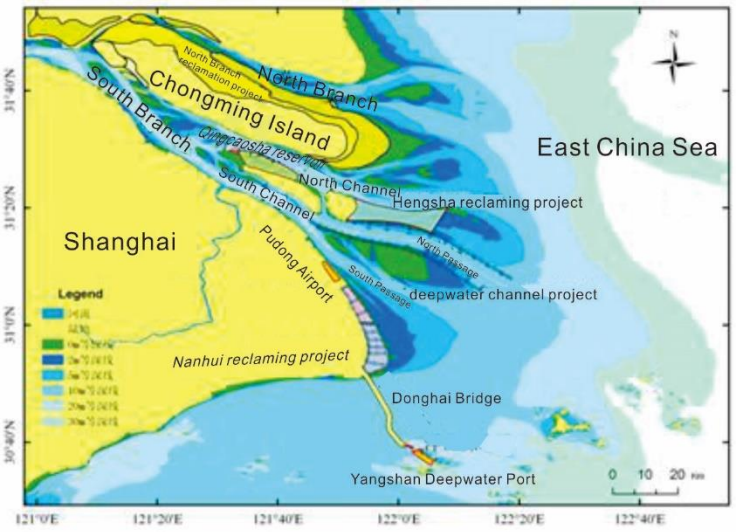
Left: location map of 8 cross section;
Right: water depth of 8 cross section profiles

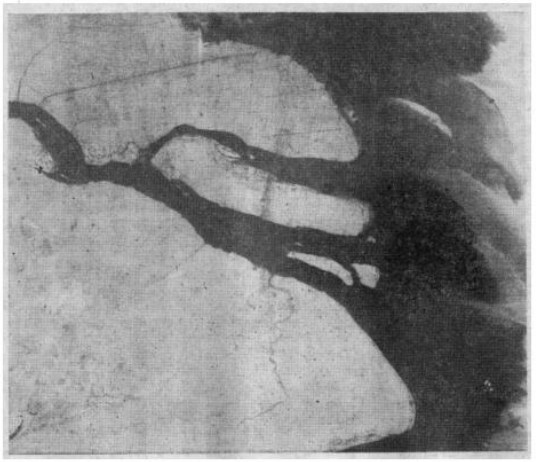
Coincidence of change in tidal range, tidal constituents, etc. with the local channel geometry change by the local engineering works

Local impact

Channel geometry change

Channel deepening





Situation of YE in 1970s

Situation of YE in 2004

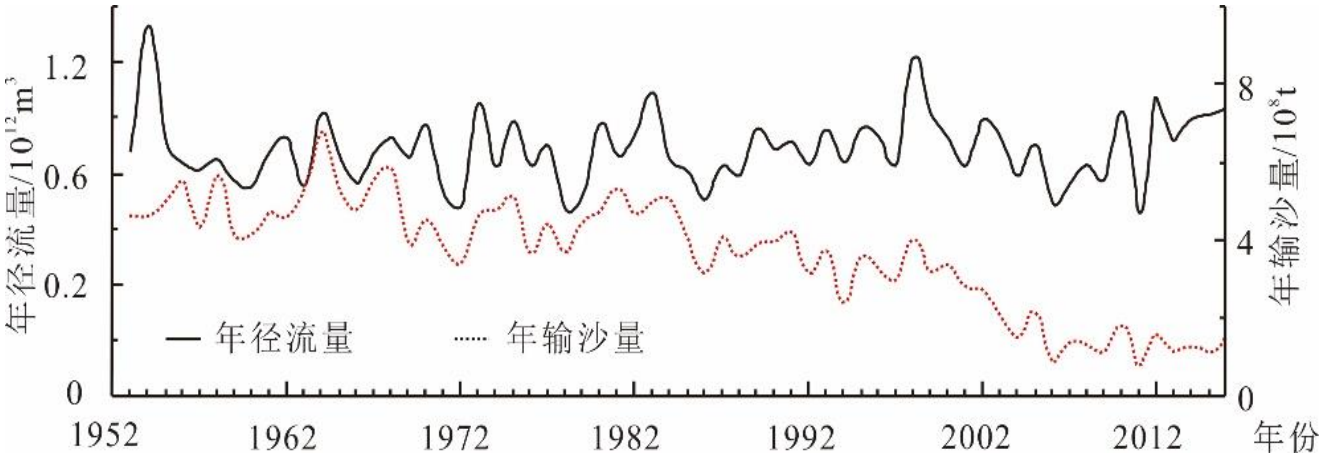
Situation of YE in 2017

Nonlocal

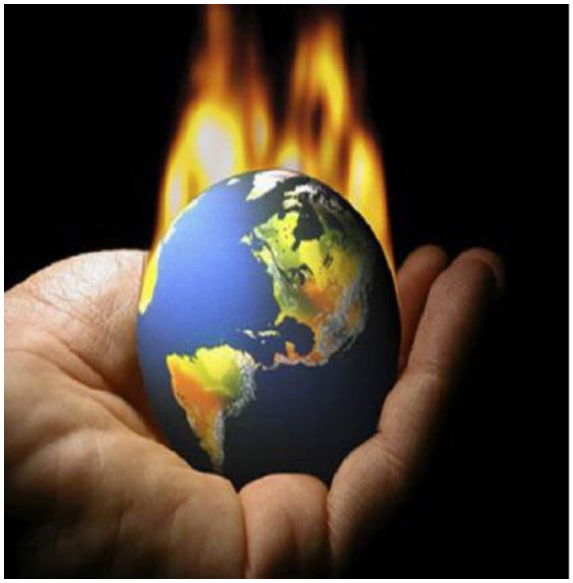
Three Gorges Dam

Nonlocal human interventions

runoff and sediment decline

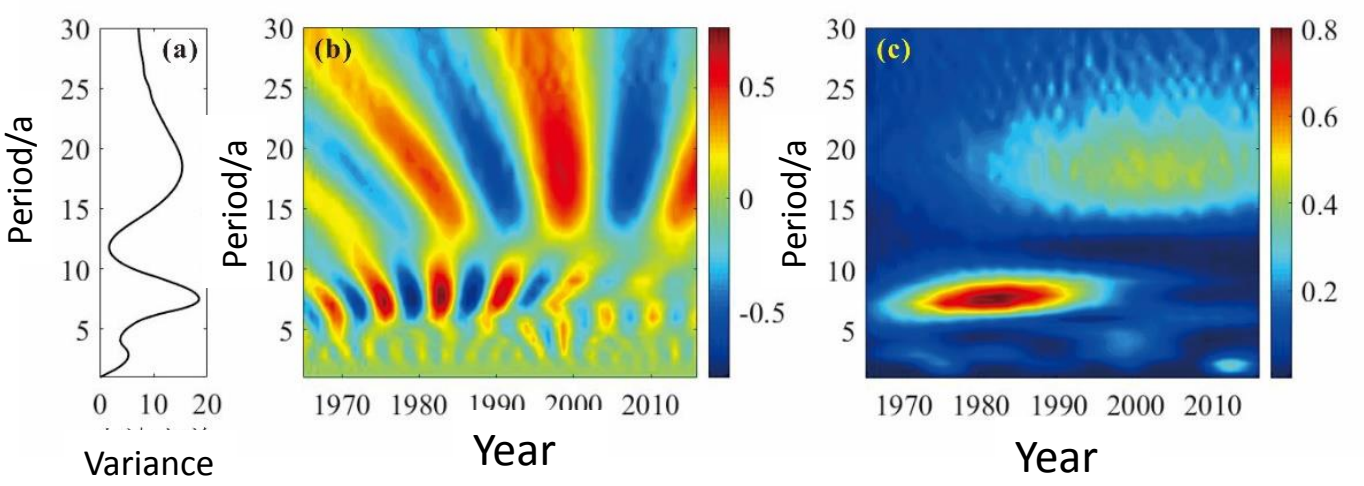


Climate warming



Nonlocal natural behaviors

Effect of runoff and climate on the tidal level



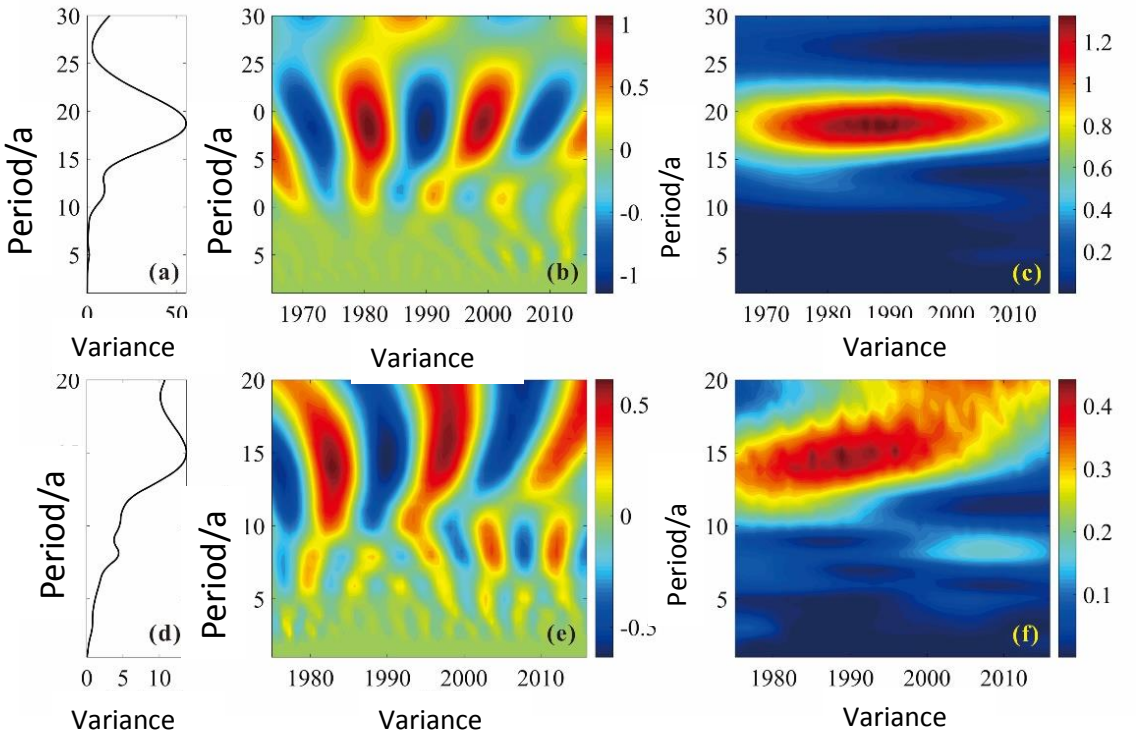
- Periods of runoff changed in 2-3 a， 6-7 a and 6-17 a at Datong station
- Periods of extreme water level changed in 3 a and 7 a, and then periods of lowest tidal level changed in 2-3 a, 5 a and 11 a at Nanjing and Wuhu stations

Yuan X.T., Cheng H.Q., et al., 2019. Marine Science Bulletin

Nonlocal natural behaviors

Impact of climate change on the tidal range

Periods of annually averaged tidal range changed in 10 a, 18.6 a， 11 a and 7 a.



Sea level rise

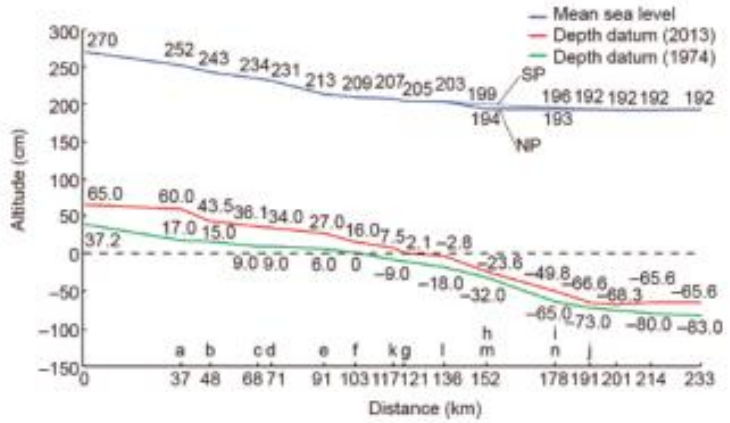


Fig. 8. Variations in the theoretical tidal datum in 1974 and 2013 at 14 tidal stations: a. Xuliujing, b. Baimaozha, c. Qiyakou, d. Yanglinzha, e. Shidongkou, f. Wusong, g. Wuhaogou, h. Zhongjun, i. Nancaodong, j. Dajishan, k. Changxing, l. Hengsha, m. Beicaozhong, n. Niupijiao. The distance starts from Tianshenggang, which is located upstream in Nantong, Jiangsu Province.

Cheng HQ, et al. Mapping Sea Level Rise Behavior in an Estuarine Delta System: A Case Study along the Shanghai Coast. Engineering, 2018, https://doi.org/10.1016/j.eng.2018.02.002.

Cheng HQ, Chen J.Y. Adapting cities to sea level rise: A perspective from Chinese deltas. Advances in Climate Change Research, 2017, 1-7, http://dx.doi.org/10.1016/j.accre.2017.05.006.

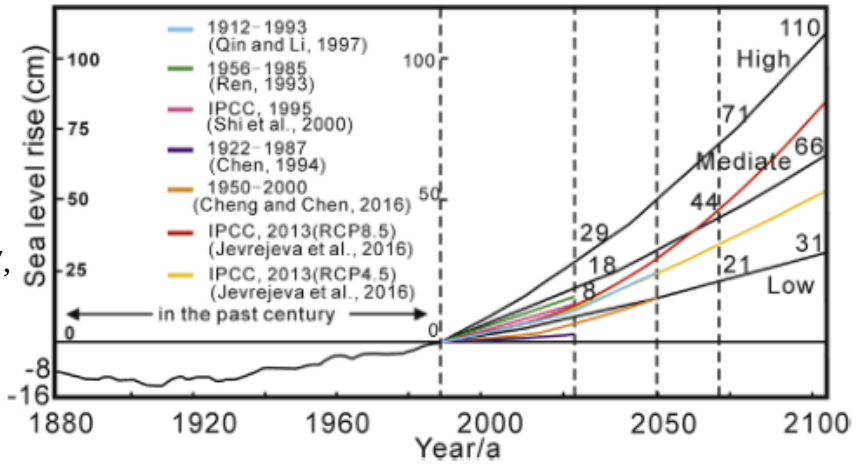


Fig. 3. Measured and predicted sea level rises from various research (combined from Cheng and Chen (2016) and Jevrejeva et al. (2016)).

Conlusions

- An obvious tidal amplification existed for last four decades attributed to combined impacts of short term local human intervention of channel geometry, e.g. land reclamation, waterway regulation and long-term climate change.
- Tidal range and lowest tidal level had been significantly raised by the local engineering works.

Thank you for

your attention, help and collaboration!