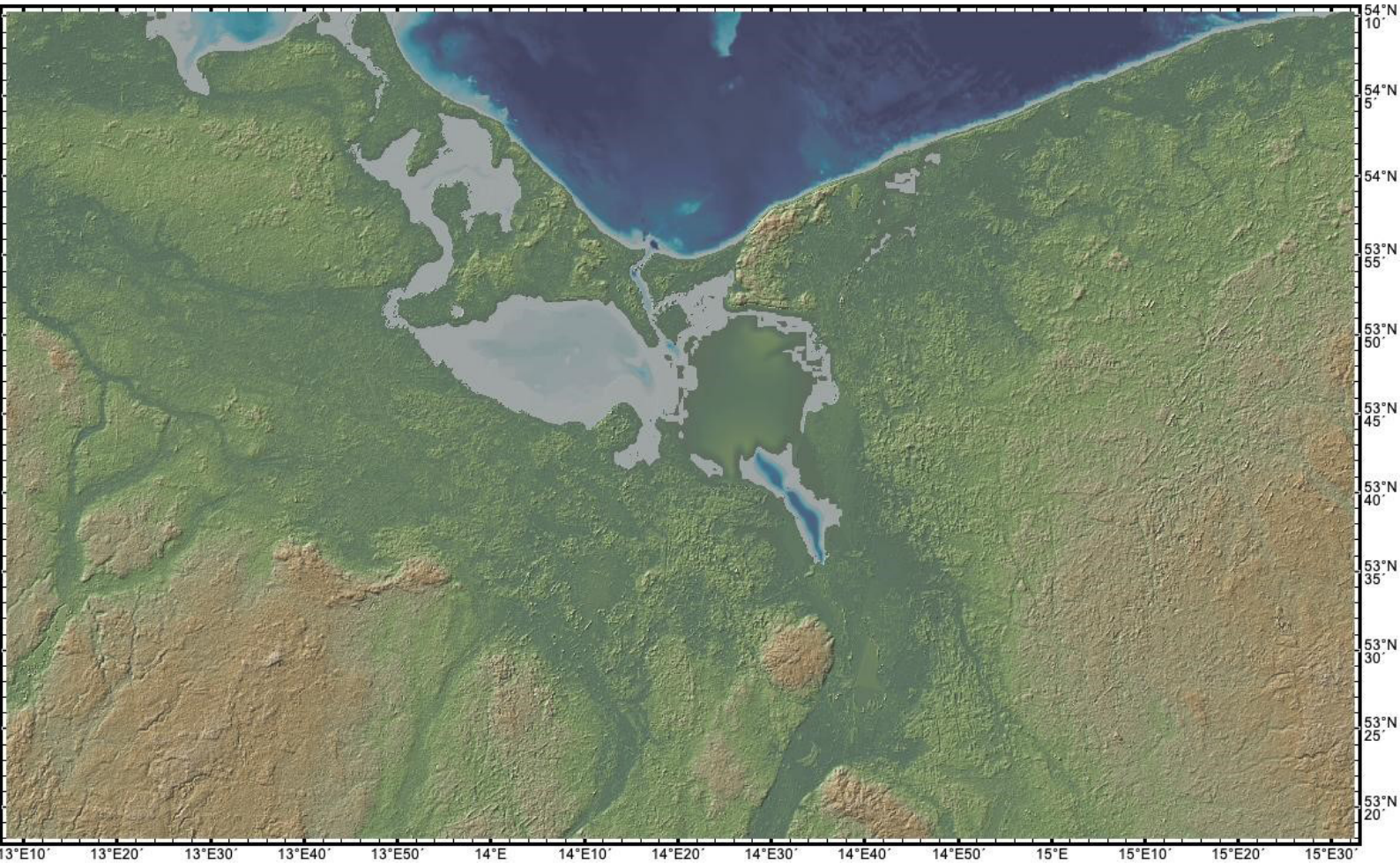


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Online Conference

# River Mouth Systems and Marginal Seas - Natural drivers and human impacts

Online, 5 - 7 December 2022

## Programme, Abstracts, Participants

Edited by
Marcus Reckermann, Jan Harff, Joanna Dudzińska-Nowak,
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Cover image: Oder river mouth system, southern Baltic Sea (courtesy of Peter D. Clift)

# River Mouth Systems and Marginal Seas - Natural drivers and human impacts

Online Conference, 5 - 7 December 2022

**Organized by**

UNIVERSITY OF SZCZECIN
Institute of Marine and Environmental Sciences

MUZEUM NARODOWE w Szczecinie

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Deep-time Digital Earth
IUGS Big Science Program

DDE Marginal Seas Task Group

**Preface**

River mouths such as deltas, coastal embayments and estuaries form the gateways from the continents to the oceans, which have been attractive for people to settle along the coastal zones over the long period of human settlement history. The natural environment of marginal seas and their coastal zones are increasingly threatened by climate change induced rising sea-level, floods, storms, tsunamis, coastal erosion and anthropogenically induced environmental hazards. To mitigate the threats effective strategies for sustainable development of the coastal zones have to be elaborated.

Since 2020, an international inititive promoting Marginal Seas Research has been launched within the frame of the Deep-time Digital Earth Program (DDE) of the IUGS. The mission of the intitiative is the development of a general strategy for describing the processes in marginal seas holistically as an interaction between geo-, ecosystem, climate and socioeconomic systems at the zone of transition between continents and oceans. Within the frame of this initiative, comparative studies of marginal seas' functionality are fostered in order to contribute to generalized concepts of sustainable management of the marine and coastal environment of marginal seas in different climatic zones and geological-tectonic settings.

To study the interrelation between natural and anthropogenic drivers exemplarily it is planned to promote targeted research for a deeper understanding of the river mouth systems' development from the pristine past to the anthropogenically dominated present.

The complexity of the processes to be studied requires research teams made up of earth and life scientists, climatologists, archaeologists, historians, socio-economists, modelers and IT specialists. Representatives of these disciplines are invited to the conference to jointly discuss the effects of climate change and anthropogenic activities in the area of densely populated river mouth systems on the marine and coastal environment. Thus, the time span of the processes to be examined must range from the pristine status through early human settlements to the industrialized epoch of the present day of the river estuary systems. From this discussion, recommendations for the development of general numerical models to manage river mouth systems for their sustainable development are expected.

Session 1

**Climate change and River mouth systems**

In this session, general questions about the role of climate change and related sea level rise, frequency and direction of storm events and their role as driver of the dynamics of the river mouths and related coastal systems shall be discussed. To what extent can climate models help for future projections of this dynamics and the frequency of coastal hazards? Theoretical approaches and practical experiences to answer these and related questions are welcome.

Session 2

**Human activities and environmental impacts from the past to the future**

The socio-economic conditions of the gateways between continents and oceans have always attracted people to use and shape these habitats. The historical reconstruction of these processes and the description of their current dynamics are irreplaceable for the design of future balancing economic use and preservation of natural environment. The participation of geoscientists and life-scientists, historians and archaeologists, socio-economists, engineers and modelers in the discussion of these questions is expressly encouraged.

Session 3

**Proxy-records and modern observations**

Data sets need to describe not only the current functionality of river mouth systems but have to include the history from the pristine paleo-environment to the current anthropogenically impacted regime. The time spans to be represented by data are trending from millennial to the seasonal scale. The records include paleo-data - derived by "decoding" of sedimentary proxies - to current monitoring and data measured in real-time. The interpretation of proxy data demands a cooperation between geoscientists, climatologists, historians and archaeologists. The identification of the onset of human effects on the environment and its future projection are needed preconditions to foster strategies for sustainable development of industrialized coastal embayments and estuaries to be discussed.

Session 4

**Advanced data management and modeling**

One target of the conference is to contribute to the comparison of river mouth systems on the global scale based on standardized data, numerical models and methods of AI and ML. This standardization can help to provide generalized concepts for sustainable development of river mouth systems to balance the protection of their environment and the economic use of their resources. The focus on harmonizing and processing of interdisciplinary data on the disciplinary scale between natural sciences, socioeconomics, archaeology and technical sciences requires transdisciplinary data management and modeling approaches. This data integration based on the FAIR principle (Findable, Accessible, Interoperable and Reusable) will be discussed in this session.

*Jan Harff, University of Szczecin and Chairman of the Scientific Conference Committee*



We thank Rachel Jankowski for assistance in putting this booklet together.

**International Online Conference on**

# River Mouth Systems and Marginal Seas - Natural drivers and human impacts

**5 - 7 December 2022**
**All times in Central European Time (CET)**
Seattle: -9h; Baton Rouge: -7h; India: +4h 30min; China: +7h
**Check your local time difference!**

## Day 1: Monday, 5 December 2022

### Opening Session

Chair: Jan Harff

12:00 **Welcome adresses**
Waldemar Tarczyński, Rector of the University of Szczecin;
Patron of the Conference
and representatives of the conference organizers

12:20 **Introduction to the conference**
Jan Harff

12:30 Conference Keynote

**Holocene, modern and future sediment transport through the mouths of the Pearl and Indus rivers**
Peter D. Clift

**Scientific Sessions**

## Session 1
## Climate change and River mouth systems

Chair: Peter D. Clift, Marcus Reckermann

13:00 **Impact of extreme events on material transfers and ecosystem functioning at the mouth of the Rhone River: floods and storms** *(Session 1 Keynote)*
Catherine Rabouille, B. Lansard, C. Cathalot, F. Toussaint, B. Bombled, O. Aouji, E. Viollier

13:20 **Characterization of the biogeochemistry of sediments after flood events in the Rhône River prodelta**
E. Ferreira, C. Rabouille, B. Bombled, E. Regnier, B. Lansard, S. Nmor, M. Manoux, E. Viollier, N. Verpy, L. Papillon, D. Malengros, G. Monvoisin, C. Gauthier, P. Van Beek, M. Souhaut, T. Zambardi

**13:35 Break**

13:50 **Evidences of Sea Level Change from marginal sea areas of Northern East Coast of India**
Subhasis Roychaudhuri, Avik Manna, Bhaskar Mazumder

14:05 **Evolution of the Han River Delta Coastline over the last 40 years and beyond**
Xiu Juan Liu, Zi Qian Wei, Albert J. Kettner, Yang Wang, Jia Ji Yi

14:20 **Holocene sedimentary distribution and morphological characteristics reworded by East Asian monsoon hydrodynamics in the Mekong River area, South Vietnam shelf**
Xiao Wang, Xinong Xie, Wenyan Zhang

14:35 **The Pearl River Estuary system evolution in Late Quaternary: Sea-Level, Climate, Paleogeography change**
Jinpeng Zhang , Yufeng Wang, Shiming Dong, Jianmei Hou, Pingyuan Li, Chixin Chen and Zhen Xia

14:50 **Remote sensing monitoring of seawater intrusion in the background of Yellow River Delta erosion**
Wenbo Zhang, Hongyu Li, Xiaohuang Liu

15:05 **Fluctuating sedimentation dynamics of the Rewa Group of rocks, Rewa District, Madhya Pradesh**
Sibabrat Nayak, Ajay Shankar Pandey, Hemant Kumar, and Joyesh Bagch

**15:20 Break**

15:35 **On several hydrological and biogeochemical aspects of the Mekong River delta functioning**
Andrzej Górniak, Tran Xuan Dung, Vo Luong Hong Phuoc

15:50 **Session 1 Open Discussion**
Moderation: Peter D. Clift, Marcus Reckermann

## Session 2
## Human activities and environmental impacts from the past to the future

Chair: Niels Hovius, Anna B. Kowalska

16:00 **Rivers of the submerged Palaeo-Agulhas Plain, and implications for early human use on this landscape** *(Session 2 Keynote)*
Hayley C. Cawthra

16:20 **Urban Seas as Part of River Mouth Systems – Western Coast U.S. and Canada Examples**
Gary H. Greene, John R. Delaney

16:35 **Causes and effects of engineered river diversion in channel dynamics and deltaic development: A story of the largest distributary of the Mississippi River**
Y. Jun Xu, Bo Wang, Ming Tang

16:50 **End of day 1**

# Day 2: Tuesday, 6 December 2022

12:00 **Spatial Distribution and Pollution Characteristics of Heavy Metals in Surface Sediments of Lingshui, Xinying Mangrove and Seagrass Wetlands**
Kaizhe Fu, Long Junqiao, Zhen Zeheng, Ding Weipin, Huang Zanhui

12:15 **Terrestrial carbon storage and its environmental responses in the Yellow River Delta**
Hongyu Li, Dou Wenjun, Xu Zhen, Liu Xiaohuang and Li Renqiang

12:30 **Impacts of morphological change and sea-level rise on stratification in the Pearl River Estuary**
Mengyao Ma, Wenyan Zhang, Wei Chen, Junjie Deng, Corinna Schrum

12:45 **Study on Hydrodynamic Characteristics and Environmental Response in Shantou Offshore Area**
Yuezhao Tang , Yang Wang , Enjin Zhao, Jiaji Yi

13:00 **The role of natural resources monitoring and investigation system in the economic development and ecological protection of the estuary delta**
Maoqiu Xiong and Xiaohuang Liu

13:15 **Variation of sediment flux from the Hanjiang River and the Rongjiang River into the sea and its effect on deposition of Hanjiang River Subaqueous Delta over the recent 60 years**
Yufei Wang, Yang Wang, Xiu Juan Liu

**13:30 Break**

13:45 **The impact of human activities on the estuary of Zhifu Island and its surrounding small watershed based on remote sensing image data analysis**
Kuanle Bao, Hongsong Wang , Kun Yan, Qingzheng Yuan

14:00 **The influence of Caofeidian Project on the evolution of deep groove landform in Bohai Sea**
Hongxian Chu, Jiang Wenqin,Feng Yongcai, Yuan Jidong, Chen Yuhai, Feng Binghui

14:15 **Influence of regional tectonics, sedimentation and human intervention in smaller seabound river systems: A case study from Subarnarekha River**
Mriganka Ghatak, Srirupa Gupta, Sandeep Thakur

14:30 **The Lower Oder and Pomeranian Bay in Archaeological Record**
Michał Adamczyk, Anna B. Kowalska, Krzysztof Kowalski

14:45 **The East Gotland Basin (Baltic Sea) as a candidate Global Boundary Stratotype Section and Point for the Anthropocene series**
Jérôme Kaiser, Serena Abel, Helge W. Arz, Andrew B. Cundy, Olaf Dellwig, Pawel Gaca, Gunnar Gerdts, Irka Hajdas, Matthias Labrenz, James A. Milton, Matthias Moros, Sebastian Primpke, Sarah L. Roberts, Neil L. Rose, Simon D. Turner, Maren Voss, Juliana A. Ivar do Sul

**15:00 Break**

15:15 **Indigenous knowledge systems informing an adaptive estuary management: The socio-cultural dynamics of the Sundays River Estuary**
Athabile Xuba

15:30 **Living with the river: Strategies of anthropogenic use of the Lower Elbe estuarine floodplain**
Stefan Krabath, Martina Karle

15:45 **People and the Sea in Mpondoland: An analysis of Culture, Provisioning and Accessibility to Ocean and Coastal Services**
Bayanda B. Laqwela

16:00 **Zooplankton communities in the Lower Saxony Wadden Sea experience strong changes in composition and structure in response to stressors induced by the major river systems and marine hydrographical processes**
A.B. Ndah, L. Roenn, J. Goebel, M. Boersma

16:15 **Session 2 Open Discussion**
Moderation: Niels Hovius, Anna B. Kowalska

16:25 **Break**

16:30 **Virtual excursion to the Oder river mouth system and City of Szczecin**
Anna B. Kowalska

16:50 **End of Day 2**

# Day 3: Wednesday, 7 December 2022

## Session 3
## Proxy-records and modern observations

Chair: Gary H. Greene, Xinong Xie

12:00 **Tectonic anabranching of River Brahmaputra: implications on survival of cultural and biodiversity hotspots beside world's largest river island Majuli** *(Session 3 Keynote)*
Bashab N. Mahanta, Mansoom P. Kashyap, Baba M. Mahapatra

12:20 **Deterioration in the subaqueous Mekong Delta, Vietnam**
Karl Stattegger, Daniel Unverricht, Witold Szczucinski, Klaus Schwarzer

12:35 **Late Holocene Vistula River floods recorded in grain size distributions and diatom assemblages of marine sediments of the Gulf of Gdańsk (Baltic Sea)**
Marta Szcześniak, Mikołaj Kokociński, Robert Jagodziński, Krzysztof Pleskota, Marek Zajączkowski, Witold Szczuciński

12:50 **Morphological evolution of bayhead delta within a tide-dominated embayment, case studies at the Lingding Bay, South China Sea**
Junjie Deng, Congrui Chen, Hongze Yu

13:05 **Analysis of Quaternary sequence development in the Pearl River Estuary, North South China Sea with single-channel seismic profiles data**
Shiming Dong, Jinpeng Zhang, Yufeng Wang

13:20 **Evolution of sedimentary environments and source-to-sink transport processes off the eastern Wanquan Estuary since the Holocene**
Xinjie Wu, Kun Yuanb, Yanwei Songb, Yu Caia, Feng Panc, Zhanrong Guo

**13:35 Break**

13:50 **Three stage paleochannels identification and main resource analysis from Middle Pleistocene in the Western Bohai Sea**
Shuyu Wu, Hongxian Chu, Kuanle Bao

14:05 **Fine-grained turbidites in the southern Okinawa Trough and its implication for earthquakes activity over the past 700 years**
Yamin Yang, Lizhong Zhang, Reiwen Shen, Zhigang Zeng, Xiting Liu

14:20 **Grain size characteristics and sedimentary environment response of different sedimentary facies in ZK-XH01 borehole at the entrance of Hanjiang River**
Guanzhong Zeng, Jiaqi Xu, Rui Xia

14:35 **A downcore calibration of the $TEX_{86}^{L}$ temperature proxy for the Baltic Sea**
Anna K. Wittenborn, Helge W. Arz, Thorsten Bauersachs, Cyril Dutheil, Christiane Hassenrück, Klaus Jürgens, Hagen Radtke, Janine Wäge-Recchioni, Jérôme Kaiser

14:50 **Postglacial evolution and present stage of the Odra River mouth development (the southern Baltic Sea)**
Andrzej Osadczuk, Ryszard K. Borówka, Krystyna Osadczuk, Andrzej Witkowski, Artur Skowronek, Łukasz Maciąg Małgorzata Latałowa, Kamila Mianowicz, Brygida Wawrzyniak-Wydrowska

15:05 **Session 3 Open Discussion**
Moderation: Gary H. Greene, Xinong Xie

15:15 **Break**

## Session 4
## Advanced data management and modeling

Chair: Joanna Dudzińska -Nowak, Federica Foglini

15:30 **High-resolution mapping of Underwater Cultural Heritage in shallow coastal areas: case study from the Venice Lagoon** *(Session 4 Keynote)*
F. Madricardo, M. Bassani, G. D'Acunto, A. Calandriello, A. Petrizzo, F. Foglini

15:50 **Long-term simulation of the development dynamics of the Vistula delta in the Holocene through the 4F model adjustment**
Jerzy Jan Frydel

16:05 **Physical-biogeochemical transformation of DOC in the river-estuary-ocean continuum: a modeling perspective**
Jialing Yao, Jianzhong Ge

16:20 **High-resolution seafloor models from Disko Bay, central West Greenland – A pioneer study**
Diana Krawczyk, Chris Yesson, Paul Knutz

16:35 **The "Hainan Delta", Beibu Gulf, South China Sea - model and paleoenvironmental interpretation**
Jakub Miluch, Helge Arz, Ryszard Krzysztof, Hongjun Chen, Joanna Dudzińska-Nowak, Peter Feldens, Jan Harff, Tao Jiang, Jerome Kaiser, Łukasz Maciąg, Andrzej Osadczuk, Krystyna Osadczuk, Michał Tomczak, Andrzej Witkowski, Xie Xionong, Ping Xiong, Jinpeng Zhang, Wenyan Zhang, Eduardo Zorita

16:50 **Session 4 Open Discussion**
Moderation: Joanna Dudzińska-Nowak, Federica Foglini

17:00 **Closing Discussion and Wrap-Up**
Moderation: Jan Harff

17:20 **End of day 3 and farewell**

**Conference website:**

**https://baltic.earth/rivermouthsystems2022**

# Conference Keynote

# Holocene, Modern and Future Sediment Transport through the Mouths of the Pearl and Indus Rivers

Peter D Clift

Department of Geology and Geophysics, Louisiana State University, Baton Rouge, LA, USA (pclift@lsu.edu)

The Pearl River of southern China and the Indus River in SW Asia, with its delta in Pakistan are both large monsoon-fed rivers that are home to significant human populations. Sealevel and monsoon controlled discharge have controlled the flux of sediment through the river mouths in the last several thousand years. Zircon U-Pb dating shows that sandy sediment in the Indus travels slowly and is mostly deposited near the river mouth during the Holocene, with limited supply to offshore shelf clinoforms and almost nothing to deeper waters. Deep-water sand sedimentation only occurs during sea-level low-stands. In contrast, silt and clay have more readily been transported into the submarine canyon, as well as the clinoforms and this transport is largely unbuffered from the river mouth. The silt is however strongly advected to the east by long-shore currents. Smectite clay is preferentially deposited in the river mouth rather than transported far offshore relative to other clays, although the proportion of smectite is also seen to increase after 5 ka, probably because of reworking of smectite-rich soils in the flood plains driven by the establishment of agriculture in this area around that time. Damming of the Indus during the 20$^{th}$ Century has dramatically reduced the flow of water and sediment to the river mouth and resulting in salinization of the farm lands and retreat of the coast due to subsidence and sea-level rise.

In contrast, the Pearl River presently carries little sand but its dominantly muddy load is not delivered into deep water because of the modest discharge and very wide continental shelf, combined with a strong west-flowing coastal current. The onshore delta is heavily settled and developed compared with the Indus and is vulnerable to future sealevel rise. Like many deltas it has advanced seawards since the stabilization of sealevel at ~6 ka. The source of sediment has been mostly stable through time but also shows the impact of the start of agriculture, at around 2.7 ka in this region, and mature, weathered, soil material was reworked into the river. Prior to this time enhanced recycling from the flood plains is associated with times of strong monsoon rains. Again, damming has sharply reduced sediment flux to the ocean over the past 40 years from >100 Mt/yr to ~20 Mt/yr. Nonetheless, sedimentation in the coastal zone is seen as a carbon-neutral method for protecting the coasts and their populations from rising sea levels but would require management of the river basin. A combination of offshore artificial reefs to reduce wave-recycling and mangrove plantations to capture sediment near the coast is a potentially effective combination to secure the region's future but would require increasing sediment supply and the redirecting of sediment to the northeastern distributaries and away from those that are directing sediment more directly out into the South China Sea. Preserving the sediment within the bay that is formed between the delta front, and the coastline to the east is critical for the long-term stability of the area.

## Session 1

# Climate change
# and river mouth systems

# Characterization of the biogeochemistry of sediments after flood events in the Rhône River prodelta

E. Ferreira[1], C. Rabouille[1], B. Bombled[1], E. Regnier[1], B. Lansard[1], S. Nmor[1], M. Manoux[1], E. Viollier[1], N. Verpy[2], L. Papillon[2], D. Malengros[2], G. Monvoisin[3], C. Gauthier[1], P. Van Beek[4], M. Souhaut[4], T. Zambardi[4]

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[2]Aix Marseille Univ., Université de Toulon, CNRS, IRD, MOI UM 110, 13288, Marseille, France
[3]GEOPS : Géosciences Paris Sud (GEOPS), Université Paris-Sud – CNRS – Université Paris-Saclay, 91400 Orsay, France
[4]LEGOS : Laboratoire d'Etudes en Géophysique et Océanographie Spatiales, Observatoire Midi Pyrénées, 31400 Toulouse/ LAFARA

Coastal sediments are key areas in the study of the carbon cycle, as they can be both burial (carbon sink) and mineralization (carbon source) areas. In deltaic sediments, deposition, erosion and mineralization processes are influenced by the input of organic matter from rivers, which is intensified during flood and storm periods. In the context of climate change, these events should intensify and be more frequent. It is thus important to understand the dynamics of flood deposits on the biogeochemistry coastal sediments. A bi-monthly winter cruise was conducted from November 2021 to March 2022 on three stations located on a transect offshore in the Rhone River mouth. Sediment cores were sampled to analyse solid phases (OC, $^{7}Be$) and liquid phases (DIC, $SO_4^{2-}$ $CH_4$) by taking pore water samples. Following a flood that took place at the end of December a strong deposition event was observed (about 24 cm); that leads to a homogenization of the surface layer with a lower impact of the deposition offshore. We documented the reorganization of biogeochemical processes after the flood period, with an intensification of sulfato-reduction below the sediment surface. Anaerobic oxidation of methane intensified at depth below the former buried interface. This first monitoring allowed to characterize the biogeochemical reorganization after flood deposition. The use of numerical model of early diagenetic processes in the surface sediment could help to quantify the effect of flood deposit on net $CO_2$ fluxes from the sediment to the water column.

# On several hydrological and biogeochemical aspects of the Mekong River delta functioning

Andrzej Górniak [1], Tran Xuan Dung[2] and Vo Luong Hong Phuoc[2]

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[2] National University of Ho Chi Minh City, University of Science, Ho Chi Minh, Vietnam (txdung@hcmus.edu.vn, vlhphuoc@hcmus.edu.vn)

Mekong River has a one of largest delta in the eastern part of Asia with high tides activity, occurring in lower 500 km river length. The water outflow from the delta takes place through 9 estuaries up to 2-3 km wide, with maximum depths up to 30-35 m. Climate create a simple river hydrological regime with dry and wet periods. Climate change and water management intensification in Mekong River basin affected on changes in delta functioning. Results of recent evaluation shows decrease of sediments load, increase of water use for irrigation and much stronger influence of ocean/salt water on delta functioning. El Nino and La Nino events are strongly marked in hydrological processes also. Significant effects of changes in delta hydrology are seen in near 65 % of erosional costal shoreline.

We present results of hydrological and biogeochemical field investigations in dry period of year (October 2019-February 2020), provided along a Vietnamese, northern branch of Mekong River - Tien River with higher discharge and more natural riverbed than second main Branch – Bassac River. Analysis of diurnal cycles in Mekong River were done during stationary measurement in My Tho and Cai Be.

Besides cycle of flood and ebb tides, we have found also specific hydrological rhythm of water movement in nearshore part of riverbed. Changes of water movement direction had a place not in moment of extremal river level, but ca. 20-30 minutes after level extremum. Three phases of each tide event of lower Mekong River were documented: initial backflow of nearshore stream with oppositive flow direction, stage of whirling river without evident flow and period of total change of water direction movement. The occurrence of a back stream of water contributes to the formation of a friction zone on the contact with the main current of the water mass and becomes a source of additional sedimentation of the suspension carried by the river. Such a friction zone appears at each tide occurrence, i.e. 4-5 times per day, and increases the sedimentation rate of river sediments.

Another effect of tides in the estuary arms of the Mekong delta are short-term changes in oxygen concentrations in the water. The existence of a 20–30-minute spinning phase, without a significant water flow in the riverbed. It is also a period of a slight increase in the oxygen concentration by 0.3 - 0.6 mg $dm^{-3}$, with an average value of 5-6 mg $dm^{-3}$. This is due to the higher photosynthetic activity of phytoplankton during the vortex motion of algae cells than during unidirectional motion, when part of sand and silt of suspension partially descends towards the bottom. The activity of tides influences the daily variation in the rate of $CO_2$ emission from river waters to the atmosphere, which there are confirmed by the results obtained during direct measurements.

The presented results of research in the dry season in the lower part of the Mekong River delta show significant modifications of sedimentation processes in the river where tides occur. The role of tides in shaping the water environment of the delta's waters will increase in the situation of the forecasted increase in the level of the oceans in the future. These changes will therefore entail the necessity of changes in the management of the delta areas and the necessity to undertake adjustments.

Research was financed by Polish National Agency for Academic Exchange (NAWA) and cooperation with a National University of Ho Chi Minh City, University of Science (HCMUS), Vietnam.

# Evolution of the Han River Delta Coastline over the last 40 years and beyond

Xiu Juan Liu[1,2], Zi Qian Wei[1], Albert J. Kettner[3], Yang Wang[2], Jia Ji Yi[2]

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[2.] Haikou Marine Geological Survey Center, China Geological Survey, Haikou 570100, China
[3.] Community Surface Dynamics Modeling System CSDMS, at INSTAAR, University of Colorado, Boulder, CO 80309, USA

As one of Chinese large deltas, the Han River Delta has been facing the challenge of decreasing fluvial sediment supply over the last decades. Here, we use six Landsat images for 1980-2020 and a conceptual geometric model to investigate the recent evolution process of the delta coastline and the effect of sediment reduction on the coastline evolution. The research results show that the main coastline type has changed from the sandy to the artificial since 2015 and most coastlines have been stable over the study period, different from long-term advance before 1980s. The significant reduction of fluvial sediment flux plays a key role in the status shift of the delta shoreline from advance to stability. The future evolution of the delta coastline will not depend on further decrease of riverine sediment flux, but on the relative sea level rise rate. These findings can support delta evolution prediction and coastal management.

# Fluctuating sedimentation dynamics of the Rewa Group of rocks, Rewa District, Madhya Pradesh

Sibabrat Nayak, Ajay Shankar Pandey, Hemant Kumar, and Joyesh Bagch

Geological Survey of India, Northern Region, Lucknow, India (hemant.kumar@gsi.gov.in)

The Vindhyan Supergroup is the thickest sedimentary succession of India and its importance lies in its vastness in time and space with an emphasis on atmosphere, climate, sedimentary cover, and life. The Sohagi Ghat section in the Rewa district of Madhya Pradesh exposes the topmost part of the Kaimur Group represented by the white to buff-colored Dhandraul Quartzite (sandstone) Formation. The overlying Rewa Group is differentiated into Panna shale, Lower Rewa sandstone, Jhiri shale, and Upper Rewa sandstone formations. The cyclicity of the thick sequence of arenaceous sediments interbedded with the argillaceous sediments at different levels indicates the fan delta and braided deposits as the regressive strand of sea changes.

In the Sohagi Ghat section, the Panna Formation shows three major lithofacies, identified as, Thinly bedded siltstone facies (TBSF), Silty-shaly facies (SSF), and Interbedded sandstone-siltstone facies (ISSF). It is characterized by an interbedded sequence of very thin to thinly laminated shale and very fine-grained sandstone with thick beds of siltstone/shale. At places, the shales are calcareous in nature.

The Lower Rewa sandstone (=Asan sandstone) is sandwiched between the Panna shale below and the Jhiri shale above in the area. The shaly, shelfal succession of the Rewa shale as a deep-water succession punctuated by wedge-shaped sandstone and/or conglomerate bodies occurring at multiple stratigraphic levels. These wedge-shaped sandstone and/or conglomerate units as regressive wedges with varying depositional environments. The lithofacies associations of the heterolithic Lower Rewa Sandstone can be classified as *i) Sandstone lithofacies association ii) Siltstone lithofacies association and iii) Shale lithofacies association. Sandstone lithofacies association* consists of fine to very-fine-grained sandstone with an average thickness of about 55 cm (maximum 3 m thick). The sedimentary structure viz. planar cross-bedding, trough cross-bedding with mud drapes low angle discordances, interference ripples, current ripple, cuspate ripple, flute cast, furrow & ridge etc. present in the sandstone lithofacies association is indicative of sand flat environment of deposition within upper subtidal to intertidal domain. The syn-sedimentary deformation structures observed at places within the sandstone are due to the quick deposition of water-saturated sediments that expel water causing liquefaction and deformation. Flute casts occur abundantly in shallow water marine as well as in the non-marine environment. Groove casts form when high-velocity flows scour the underlying sediment and create asymmetrical grooves to be filled by the overlying sediments.

Jhiri shale Formation is classified as (i) S*ilty-Sandy facies (SStF) and (ii), Silty-Shaly facies (SShF),* The *SStF* litho-facies association comprises of an interbedded sequence of silty and sandy component, silty component is more, the sequence is very thinly laminated to thinly bedded in nature, having thickness more than 10-12 m. with fining upward sequence and the sandstone-silt stone hetrolithic units are the most common characteristic features signifying intermediate fluctuation of flow. The s*ilty-shaly facies (SShF)* assemblage consists primarily of silty and, to a lesser degree, shaly sequences. Clastic dykes and gutter casts are also observed in this lithofacies at the Sohagi ghat section suggesting high energy conditions for the formation of gutter casts and penecontemporaneous seismic activities are responsible for the formation of clastic dikes. The overall sequence comprises of silty sand in the lower part followed upward by the silty shaly facies. The overall depositional environment for Jhiri shale is shelfal type with areal exposure.

The Upper Rewa sandstone is medium to fine-grained sandstone succession. The Upper Rewa Sandstone, forming upward coarsening succession, consists of channelized sand bodies, which are constituted of fining upward (FU) erosional cycles, made up of large to small-scale cross-bedding. The presence of large-scale planar and trough cross-bedding, small-scale planar cross-bedding with double mud drapes, parallel lamination with low angle discordance, wave ripples, palaeocurrent reversal, and tidal bundles with double mud drapes indicate the marine environment of deposition under subtidal to intertidal conditions. Five major lithofacies divisible into sub-facies were identified and interpreted for their depositional environments (i) *Liquefied* Sandstone *(LSt*) (ii) Low Angle Parallel Bedded Sandstone (*LAPBSt*), (iii) Fine-grained Sandstone (*FSt*), (iv) Cross-bedded Sandstone *(CBSt)*, (Large-scale Planar Cross-bedded Sandstone, Herringbone Cross-bedded Sandstone, Large-scale Trough Cross-bedded Sandstone), (v) Ripple Laminated Silt-mudstone. (*RLSiM*)

The Rewa succession, exposed at the Sohagi ghat section, is composed of shale and sandstone interbeds with the wave and sole features representing a storm-dominated shelf succession. The lithological characters, facies associated with them and sedimentary structures indicate that Panna Formation is of foreshore to shoreface depositional environment. Lower Rewa sandstone (=Asan Formation) suggests a tidal flat environment of deposition. Jhiri Formation suggests an outer shelf environment of a deposition while that of the Upper Rewa Sandstone Formation indicates tide and wave-dominated shore-face environment of deposition.

# Impact of extreme events on material transfers and ecosystem functioning at the mouth of the Rhone River: floods and storms

*Session 1 Keynote*

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River dominated Ocean Margins (RiOMar) are prone to multiple abrupt forcings such as floods that deliver tremendous amount of water, nutrients and particles and storms that redistribute this material over the shelf and to the deep-sea. These intense events have a very important impact on the marine environment and ecosystems especially in river deltas. The Mediterranean Sea is one of the most vulnerable regions to climate change: in addition to expected global warming, climate models simulate an intensification of the frequency and intensity of storms, floods and heat waves. Several studies were undertaken over the last decades in the Rhone River prodelta sediments using oceanographic transects based on *in situ* oxygen microprofiling and core sampling. With this combination of tools, we were able to show that floods have a large impact on the river prodelta which vanishes on the shelf. We were also able to show that this impact is modulated by the flood solid load and its origin and reactivity. In addition to the sea expeditions, long-term moorings of a newly design benthic station were conducted at a single point near the river mouth to produce time series of high frequency oxygen microprofiles in sediments. Using these time series coupled to the measurement of sediment height, we show that large storms resuspend centimetre-thick layers of sediment which increases oxygen consumption temporally due to re-oxidation of exposed reduced species. Overall, the budget between deposition and resuspension is largely favourable to deposition, but the fate of organic carbon deposited during the floods between recycling and preservation is still uncertain.

# Evidences of Sea Level Change from marginal sea areas of Northern East Coast of India

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The coastal belt of West Bengal and Northern Odisha experienced repeated rise and fall of sea level during glaciation and deglaciation at different times of the Quaternary period. In response, a variety of landforms have been developed like mudflats, back swamps, dune ridges and beach face evolved through dynamic interaction of both fluvial and marine processes. Successive rows of dune ridge subparallel to present day coastline intervened by tidal flats represent gradual regression of Holocene sea. During the last glacial maxima (LGM) the Ganges River with the tributaries were flowing through the delta region and the sediments were deposited during the lowest sea level stands. Evidences of coastline retreat are quite clear from the present study reflected by the sediment type, facies variation and geomorphological features.

Global warming is projected to be the major cause of sea-level rise over the next 100 years. Geoscientific investigations carried out in Ganges-Brahamaputra deltaic system and offshore since 1997 by Geological Survey of India reflects i) shore line changes, ii) shifting of islands with movement of sediments towards north and iii) changes in offshore bathymetry depicting seal level rise phenomena. Further, the postulated down throw to the east of Calcutta –Maymensigh ridge or tilting to the east caused decrease of freshwater flow to the western Gangetic delta. This has resulted in deepening of the eastern channels in the Sundarbans Region. Measurement of changes in shorelines from various Navigational Charts, Toposheets and Satellite Images (false colour composite) reveals that since 1770, the southern boundary of Sagar Island has shifted around 3.7 km to 4.5 km north.

The erosion to the delta front is not only localized along the land –sea boundary but also within the delta front zone in the marine domain too. Comparison of the location of the 5 and 10 m isobaths from NHO Chart No. 351 (1985) and the isobaths computed from bathymetric survey conducted by GSI in 1999-2000 indicates significant erosion at the delta-front zone and the 10m contour has advanced towards north for 3 to 8 km approximately, though the rate of erosion is not uniform everywhere. Changes in configuration of the islands, viz., Ghoramara Island which was much larger in 1951, Jumbodwip Island which is constantly shifting towards north since 1951 is also indicative of delta front degradation.

Though the northern Bay of Bengal region is experiencing overall erosion indicating sea level rise, yet in contrast, the coastlines west of Hooghly River, exhibits signature of shoreline progradation of around 3.5 km around Subarnarekha and 2.5 km around Dhamara Rivers since 1940. Comparison of the disposition of 10m and 20m isobaths from NHO-351 of 1985 and bathymetric data collected by GSI indicates shifting of bathymetric contours towards east off Dhamara for around 600 m to 1.2 km which is indicative of aggradation. Tilting of the underlying formations of Bengal Basin towards east aided by higher degree of erosion in the upper reaches of Subarnarekha and Dhamara rivers is presumed to be responsible for the deltaic progradation.

Study of foraminiferal population density and their species diversity also indicate a higher rate of sedimentation in the Hoogly River Estuary and deltaic front area compared to the south.

Although sea level has been fluctuating during geological times, the rate of shoreline erosion is indicative of relative sea level fluctuations rather than global sea level rise in this part of the coastline.

# Holocene sedimentary distribution and morphological characteristics reworded by East Asian monsoon hydrodynamics in the Mekong River area, South Vietnam shelf

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Based on shallow seismic and core evidence, the distribution of the Holocene sediments in the Mekong River shelf area was investigated. The results show that the depocenter of Holocene sediments in the southern Vietnam shelf is located mostly within the Mekong estuary, Cape Ca Mau, and incised-valleys. The Holocene sediments in the Mekong estuary and the Cape Ca Mau are mainly distributed along the coast line, extending a short seaward distance. The thickest area is in Cape Ca Mau, with a thickness of more than 30 m, and the thicker Holocene sediments in the Mekong estuary are about 20 m, and there are less sediments between the two depocenters. The Holocene sediments in the incised-valley are greatly affected by the morphology of the valley, which is strip-shaped along the valley with the thickest part reaching 20 meters. In order to unravel possible driving mechanisms of the sedimentary distribution, 3-Dimensional numerical modeling was applied to investigate oceanographic and morphodynamic on the South Vietnam Shelf. Results indicate that besides sediment supply and sea level changes, the East Asian monsoon also has a significant effect on sediments redistribution in the Mekong river shelf area. During the rainy season, a large amount of sediments delivered by the Mekong River were deposited in the estuary, and some of them migrated to the northeast part under the influence of the East Asian summer monsoon. In the dry season, part of previously deposited sediments were resuspended by waves and tides, and were transported to the southwest part under the influence of the East Asian winter monsoon. When these sediments reaching Cape Ca Mau, they were redeposited here due to the greatly weakened hydrodynamic conditions, which led to developed the sediments depocenter in Cape Ca Ma u, away from the Mekong river mouth.

# The Pearl River Estuary system evolution in Late Quaternary: Sea-Level, Climate, Paleogeography change

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Due to the Tibet and Yungui plateaus uplift and South China Sea basin subsidence in Cenozoic, the topographic structure promotes series of big rivers formation in East and Southeast Asia, for instance the Pearl River formation since ca. 30 Ma (Jin et al., 2022). As the second larger river in China and top twenty large rivers in the world, the Pearl River in South China has a long length (over 2300 km) and big size catchment area (over $0.45\times10^6$ $km^2$), and discharges fresh water over $330\times10^9$ $m^3$/year, carrying about $92\times10^6$ tons terrestrial matters/sediments to the northern South China Sea (SCS) in annual mean level.

The Pearl River mouth system has trickled on land area and a wide shelf of the SCS over 300 km in low latitude zone (~20 - ~23°N) with strong interaction of land-sea occurring at there within a climate transition zone from tropical to subtropical. In the coastal zone, the sedimentary and geographic system was shifting among bay-estuary-delta following the global sea-level adjustment during the Late Quaternary, in term of delta and estuary deposition was created or submerged or destroyed. On the basic of geological investigation in latest years, some new progresses are approaching.

The newly geological data from drilling cores revealed three transgression and regression cycles/changes in the Lingding Bay of Pearl River Estuary at least in Late Quaternary, compared with the geological data from sea areas off Hongkong and Macao, and land area of the Pearl River Delta. The evolution of the ancient Pearl River Delta and estuary was controlled by regional tectonic activities and global sea level changes. The new stratigraphy work through OSL age dating (around 200 kyr. BP in MIS 7) defined the marine stratigraphy of Baini Formation (local unit name from land area without precise age dating in history) genesis in the Pearl River Estuary for the first time. This progress distinguished the Quaternary transgression/seawater invasion event to the Middle Pleistocene, which made the geochronology more advanced compared to previous work's results in Pearl River mouth system. In additionally, this new knowledge makes the debate on stratigraphy, paleo-climate, -sea-level and -geography in Pearl River mouth area more clearly that the second marine stratum in Pearl River delta and estuary area was performing in MIS 5/ last interglacial stage with high sea-level stand, instead of MIS 3 as previous research results.

The modern Pearl River Delta was formed following the sea-level regression in the Holocene, after the deglacial with fast sea-level rising. The recent research has shown the head area of Pearl River Delta has brackish water diatom species occurred at ca. 9500 cal. yr. BP. This set a valuable definition of Holocene transgression at 9500-7500 cal. yr. BP in the delta head area (Fu et al., 2020). Meanwhile, the geological record in Pearl River Estuary shown a fast sediment accumulation with valley infilled and marine sediment facies happened. These indicated the big shift of paleoenvironment in the early Holocene, which was driven by the strong summer monsoon and heavily precipitation effective to bring terrestrial matters deposition and plenty of nutrient's supply (as fossil diatom record) as well. This new knowledge makes sense to understand the tip point of Holocene transgression and regression in Pearl River Estuary area.

In order to understand the paleo-Pearl River Mouth system (delta-estuary-shelf) evolution and its response to past global change and local constrain e.g., tectonic movement in the Quaternary scale, we promote the deep core drilling campaign on the shelf of North SCS.

# Remote sensing monitoring of seawater intrusion in the background of Yellow River Delta erosion

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Under the double influence of global climate change and human factors, coastal zone has become the most active and vulnerable area on earth. Especially since 1998, the Yellow River Delta has experienced total erosion. Seawater intrusion and soil salinization have become major geological disasters in coastal areas, threatening ecological security and human living environment. These two kinds of disasters occur successively and are related to each other, which constitute the disaster chain of seawater intrusion and soil salinization. The traditional salinization detection method is a single point measurement based on sample points. Although it can provide relatively accurate salinization degree, it is difficult to meet the needs of regional monitoring. Based on multi-source satellite data such as TM, GF-1 and Sentinel, this study established a remote sensing inversion model of seawater intrusion and soil salinization by monitoring the difference of spectral characteristics on the surface of salinized soil and the change of surface vegetation cover, and evaluated the development process and influence of seawater intrusion and soil salinization in the Yellow River Delta region from 1998 to 2020. The results show that since 1998, due to the terrestrial erosion, the decrease of groundwater level and the increase of coastal aquaculture area in the Yellow River Delta, the seawater intrusion has been aggravated in some areas of the Yellow River Delta, and the soil salinization control situation is still serious.

# Session 2

# Human activities and environmental impacts from the past to the future

## The Lower Oder and Pomeranian Bay in Archaeological Record

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The paper presents the archaeological record of the Lower Oder, the Szczecin Lagoon and the Pomeranian Bay. A selection of artefacts and written sources concerning a cultural heritage is surprisingly large and includes a vast period at least since the Late Pleistocene up to the modern times. Many of them are known only from archival record or literature due to loses during World War 2. Nonetheless, a mere presence of this record indicates a potential for archaeological research in Oder River and around its estuary. Due to a good preservation the available sources include rare categories of organic finds, such as Stone Age art pieces, which among others, will be presented here in details.

# The impact of human activities on the estuary of Zhifu Island and its surrounding small watershed based on remote sensing image data analysis

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The northern sea area of Yantai, located in the southwest of the North Yellow Sea, is a typical coastal zone where small drainage basins merge into the ocean in northern China. In the east of the mouth of the major drainage basin Dagujia River, there is the largest Continent Island in China, Zhifu Island. In the last 40 years, due to the combined effects of human activities and climate change, the estuary of small basins in this region has undergone great changes.

This study mainly used remote sensing images of a resolution of 30 meters (Landsat4/5/8) and machine learning algorithm (ExtraTreesClassifier) to classify the land cover within a small watershed in this region from 1984 to 2021. Based on these data, the InVEST model is used to analyze the annual water yield, sediment migration and the exposure of some shoreline in a small watershed. Multi-spectral remote sensing images with 10-meter resolution (Sentinel-2) were used to calculate various remote sensing indexes based on water indexes in the coastal zone, and the silt changes of the coastal estuary region were obtained since 2016. The deformation of the coastal zone region since 2016 was analyzed by microwave remote sensing images. Two periods of beach profile monitoring were carried out, and corresponding particle size analysis samples were collected on the monitoring profile for analysis.

The results: 1. The microwave remote sensing data show that there is no obvious subsidence change in the coastal zone area due to the type of coastline dominated by bedrock and stable geological characteristics. 2. Sediment migration from Dagujia River in the study area and sediments from the Bohai Sea contributed greatly to the formation of Continent Island. The data onto grain size analysis show that the east and west sides with Zhifu Island exhibit different hydrodynamic characteristics, which is one of the main factors.

# Rivers of the submerged Palaeo-Agulhas Plain, and implications for early human use on this landscape

*Session 2 Keynote*

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The coastal plain and continental shelf are one continuous geomorphic feature, separated only by relative sea level at any point in geological time. South Africa is a far-field site with respect to global ice sheets, and as such, has remained unglaciated through the Quaternary glacial-interglacial cycles. This spatial setting means that geological deposits within the range of these sea-level fluctuations may be better preserved than other regions globally that were scoured by shifting ice sheets. As sea level fell in response to glacial cycles such as the regression towards the Last Glacial Maximum, the continental shelf was exposed as a terrestrial landscape. In the Cape and on the Palaeo-Agulhas Plain submerged landscape, this corresponds to an area the size of the country of Ireland.

Across the present-day continental shelf, there are remnants of aeolianite and cemented beach deposits that illuminate the nature of past coastlines adjacent to palaeo river mouths, and estuarine and lacustrine environments have been mapped with hydroacoustic methods, scuba diving and sediment coring. Mesozoic sedimentary deposits crop out near the surface of the seafloor and soils derived from siltstone and shale bedrock are prominent when the coast is up to ~60 km distant from the modern shoreline at its maximum point. This stands in strong contrast to the modern-day dissected coast adjacent to the steeply dipping quartzite Cape Fold Belt rocks and fostered a savanna-type of vegetation on riparian floodplains: a remarkably different palaeoenvironment to that of the present. The submerged landscape was a unique terrestrial environment and there is no exact modern-day analogue in the region other than a small (~70 km2) area located near Cape Agulhas. The expansion of this plain during changing sea levels was coupled with exaggerated floodplains, meandering shallowly incised rivers and wetlands. The low gradient of the continental shelf in this area implies that estuaries may have had a far inland reach, and although this landscape may have had abundant water resources, they were not necessarily potable to early humans occupying the area.

This talk discusses the character of fluvial and estuarine seismic facies that were identified on hydroacoustic profiles, as well as the relationship between coastal dunes and river mouths as sources of sediment supply, and finally the relationship between humans and this environment through time. Specifically, this work demonstrates how the rivers and river mouths may have changed in their morphology during different sea-level regimes and the potential impact or implication of this to inhabitants of the Palaeo-Agulhas Plain.

# The influence of Caofeidian Project on the evolution of deep groove landform in Bohai Sea

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The dynamic conditions and geomorphological evolution of the Caofeidian area in the Bohai Sea have changed considerably due to enhanced human activities. Especially in the local shoreline, human activities have become the dominant factor controlling the environmental evolution of the coastal zone area. The coastline length in Caofeidian area changed from 244.51 km in 2001 to 403.42 km in 2020, an increase of 65%.

The shallow stratigraphic structure of the seafloor in the deep groove is finely delineated by the measured data in 2021 in Caofeidian area and compared with the historical data in 2004, 2008 and 2013. The sedimentary layers on both sides of the deep groove were relatively continuous while the deep groove seafloor was depressed and rugged, the top was missing the Holocene marine sedimentary layers. The deep groove seafloor was mainly eroded and scoured, and the maximum local erosion was more than 4 meters between 2013 and 2021. Moreover, new submarine landslides and erosion depressions have appeared in the deep channel in recent years, which can be bring certain safety hazards to Caofeidian Port. However, these also can be beneficial to maintain the water depth of the deep channel, but we should pay more attentions to whether the submarine landslide has a trend to move to the front edge of Caofeidian head, take timely engineering measures to strengthen the submarine shore slope, and further strengthen the monitoring and warning of marine geohazards in the deep groove.

# Influence of regional tectonics, sedimentation and human intervention in smaller seabound river systems: A case study from Subarnarekha River

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While the bigger river systems with large catchment areas and substantial sediment package for study, emerging from mountain fronts have attracted attention from various research groups, the smaller, independent seabound peninsular basins with limited sediment packages and with subdued paleoclimate signatures have received lesser attention. Subarnarekha basin with an area of 18951 km2 originates from lower level plateau, drains over varied lithology and major shear zones for a length of 400 km and meets Bay of Bengal in the eastern coast of India. Subarnarekha is a unique sea bound river mouth system; it originates from the lower level plateau in Peninsular India and has a much smaller basin area. The basin is also unique in the sense that it passes over various landforms- lower level plateau at its source, structurally influenced terrain, urban and engineered landscape in the middle course, low lying flood plain and coastal landform at its mouth.

The basin shows a mixed influence of tectonic and human interference. The profile of the river is marked by break in slope at a few places. Majority of the basin shows low relief which is supported by the average relief ratio (0.003) suggesting of a basin with gradual slope and low relief and also a high value of length of overland flow (0.84) with gentle slopes, long flow paths, more infiltration and reduced runoff.

Subarnarekha basin bears influence of structural elements. :Three major shear zones namely North Purulia shear zone, South Purulia Shear Zone and Singbhum Shear Zone corss the basin and near these zones, the river courses follow these structural trends. Further, close to the shear zones the rocks show signatures of shearing and deformation. Application of basin morphological factors and geomorphic indices shows good correlation with ground situation. The basin is elongated with an elongation ratio less than 0.7 and asymmetric in nature. The asymmetry factor of the basin is high, showing a tilt towards left margin. Tilted nature of the basin is also supported by the fact that the right bank tributaries are more in number and flowing for longer distances as against the left bank tributaries which are fewer in number and have a relatively steeper gradient.

This river basin has seen many human interventions. Between 1978 and 2016, 28 dams have been constructed on the trunk channel and its tributaries which have significantly reduced sediment load distribution in the river. Landuse pattern in the basin has changed over past five decades especially near river mouth. The coastal part is under intense anthropogenic interference. The coastline is a major tourist attraction and also is under erosion as evident from recent studies. Aquaculture has emerged as a major livelihood practice in a large part parallel to the coastline as it is being claimed for fish farming. The river has changed its course very frequently in its lower stretch as apparent from a series of abandoned meander scrolls, ox bow lakes etc. However, these abandoned courses also play a role in distribution of excess water flow in the river during high discharge. The river basin has strong historical imprint too and the identified historical sites provide critical insight into the contribution of this river in cultural evolution of the area.

Smaller seabound basins like Subarnarekha have played an important role in landscape evolution, inland and coastal sedimentation in the proximity of marginal seas. It is important to develop a detailed understanding for sustainable utilization the resources of such basins.

# Urban Seas as Part of River Mouth Systems – Western Coast U.S. and Canada Examples

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We define "Urban Sea Systems" as the entire drainage basin and adjacent marine sectors associated with major port cities. An urban sea is industrialized, a distribution hub, densely populated, and culturally diverse with a dominant economy based on transportation, manufacturing, food and materials production, and tourism. An "UrbSea" can be an inland or marginal sea, an estuary, bay, or river mouth all connected to the global ocean. We compare three major urban sea systems along the west coast of North America that are defined by their proximity to river mouths, global trade, and environment. From south to north, from the Mexican Border to Canada these port cities consist of Los Angeles-Long Beach, San Francisco, and the Salish Sea (Puget Sound to Vancouver, B.C.).

The ports of Los Angeles-Long Beach are situated within the small San Pedro embayment that is open to the Pacific Ocean and near the mouth of the Los Angeles River, the largest river in the area having a drainage basin of 2,134 km2 (824 $mi^2$) but is intermittent or seasonal in flow. It is one of the largest shipping hubs along the North American west coast. The marine environments in and around the ports are highly contaminated from radioactive materials and chemicals dumped offshore in the past.

The ports of Oakland and San Francisco are in San Francisco Bay. This bay and its tributaries constitute the largest estuary along the California coast and opens to the Pacific Ocean through the narrow Golden Gate. It is a Type B (well-mixed) estuary resulting from saltwater and freshwater mixing by strong tidal currents and continuous, periodically intense, river flow. Much of the freshwater contribution to the Bay is from the interior drainage basin of the Great Central Valley of California and fed by the San Joaquin and Sacramento rivers, perennial flow from a 152, 291 $km^2$ (58, 800 $mi^2$) drainage basin. The strong tidal currents scour and erode, as well as transport sediment along the Bay floor. Although little coarse-grain fluvial sediment is presently being supplied to the Bay, extensive coarse-grain deposits exist as relict sediment, the result of hydraulic gold mining in the mid- to late-1800s. The marine environments in the southern part of the bay including saltwater marshes have been altered for salt evaporation ponds and salt harvesting facilities.

The Salish Sea is an inland estuarine sea that is perennial fed by fresh water from over 20 major rivers including the Fraser River of B.C. Canada and the Skagit and Snohomish rivers of Washington State, having a combined water shed of ~320,000 $km^2$ (124,000 $mi^2$). It's major opening to the Pacific Ocean is through the Strait of Juan de Fuca, one of the busiest Pacific Rim trade shipping routes in the world. Ports of Tacoma, Seattle, Everett, Bellingham, and Vancouver are all transshipment points for container and bulk cargo ships and tankers. A near pristine marine environment exists locally while the more urbanized areas have been subjected to pollution during the past 200 years. The many waterways and fiords of the region are attractive to tourist and recreational fishers. This urban sea appears to be an ideal region for the instrumentation and studies that would benefit many problems confronting urban seas worldwide.

# Spatial Distribution and Pollution Characteristics of Heavy Metals in Surface Sediments of Lingshui, Xinying Mangrove and Seagrass Wetlands

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In order to study the risk status of the two typical ecosystems of Lingshui and Xinying in Hainan Island, 70 sets of sediment samples collected from study area mangrove and seagrass wetlands were collected for physical and chemical analysis, and mathematical statistics such as difference analysis, geoaccumulation index analysis, ecological risk analysis, correlation analysis and principal component analysis were used. Methods The characteristics of heavy metal pollution were analyzed and evaluated, and the heavy metal content and pollution characteristics of surface sediments of different types of wetlands were studied. The results showed that the accumulation index of heavy metal As in mangrove and seagrass wetland sediments in the study area was significantly higher than that of Cr, Cu and Pb, indicating moderate pollution and moderate ecological risk, while Cr, Cu and Pb had less ecological risk. The sources of Cr, Cu, As and Pb in mangrove sediments in Lingshui and Xinying have similar sources, that is, mainly from the natural environment, and secondly from human activities. The excess of As is related to the existence of large-scale fish and shrimp aquaculture and docks around the study area. Parking and other human activity factors.

# The East Gotland Basin (Baltic Sea) as a candidate Global Boundary Stratotype Section and Point for the Anthropocene series

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The short sediment core EMB201/7-4 retrieved from the East Gotland Basin, central Baltic Sea, is explored here as a candidate to host the stratigraphical basis for the Anthropocene series and its equivalent Anthropocene epoch, still to be formalized in the Geological Time Scale. The core has been accurately dated back to 1840 CE using a well-established event stratigraphy approach. A pronounced and significant change occurs at 26.5 cm (dated 1956 ± 4 CE) for a range of geochemical markers including $^{239+240}$Pu, $^{241}$Am, fly-ash particles, DDT (organochlorine insecticide), total organic carbon, and bulk organic carbon stable isotopes. This stratigraphic level, which corresponds to a change in both lithology and sediment colour related to early anthropogenic-triggered eutrophication of the central Baltic Sea, is proposed as a Global Boundary Stratotype Section and Point for the Anthropocene series.

# Living with the river: Strategies of anthropogenic use of the Lower Elbe estuarine floodplain

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As an announcement of a planned interdisciplinary research project for the area of the Lower Elbe estuary, we will give an overview of effects resulting from the transformation from a natural landscape to a fluvial anthroposphere. The Elbe estuarine floodplains, influenced by tides, storm surges, and inland floods, had been cultivated since the beginning of the 1st century A.D., but their intensified use did not occur until the High Middle Ages, when they became the target of systematic inland colonization along with reclamation of new land. Therefore, the investigations focus on the period from the beginning of the medieval land development in the 11th century to the first dredging of the Elbe in the early 19th century. The beginning of the study period is marked by a change in the relationship between environment and society. Whereas life in the first millennium was characterised by adjusting to the existing conditions, in the second millennium people began to actively intervene in the landscape. During this time, the investigation area was not only subject to strong natural morphological changes, but was also highly influenced by dike construction and hydraulic engineering measures with significant consequences for biodiversity. Dutch migrants brought with them the necessary hydraulic engineering expertise and mentality to transform the areas into fertile agricultural land. In addition, water transport and inland navigation became an increasingly important factor of the regional and over-regional economy. Hot spots of trade and exchange emerged especially near river crossings but also at the confluence with other rivers or land roads. These diverse activities at the river led to the development of a "fluvial culture" and a regional identity, the expression of which can still be seen in the landscape and society today. The interventions in the natural balance had far-reaching effects on the geogenic and ecological systems, which repeatedly forced socio-economic adjustments. Due to the complexity of the interactions of natural and settlement processes, a bundle of interdisciplinary methods from archaeology, medieval and modern history, historical geography, geology, soil science as well as archaeobiology will be applied in the project. Based on the current state of research, the study area can be divided into seven regions, in which the development of environmental and landscape changes as well as the history of settlement and economy are to be comparatively analysed and reconstructed. The aim of the planned project is to reconstruct diachronically the pre-industrial development of settlements and agricultural areas, of dike construction and water management, as well as that of trade and production and of biodiversity.

## People and the Sea in Mpondoland: An analysis of Culture, Provisioning and Accessibility to Ocean and Coastal Services

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South Africa is positioned at the interface of three oceans, namely Indian, Atlantic and Southern/Antarctic Ocean. It has about 3100km coastline which runs from Northern Cape boarder with Namibia Side to SA boarder with Mozambique. Along these coastlines there are different indigenous/local communities with different ocean cultures and knowledges.

This research using a selected Mpondoland coastal communities as a field, is interested in examining the cultural, provisioning and accessibility of services provided by the ocean in the region. It is a multi-sited ethnographic study, and seeks to engage with elders, youth, and different government and non-governmental institutions regarding the local coasts.

# Terrestrial carbon storage and its environmental responses in the Yellow River Delta

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River deltas are not only major coastal landforms on our planet but also provide abundant and important land resources for countries. The modern Yellow River Delta (YRD), which is the youngest and fastest-forming land in China, is under intensive land-ocean interactions controlled by multiple natural and anthropogenic drivers. YRD has experienced complicated and unique changing patterns affected by the land cover/vegetation change as well as the recent decline in upstream water and sand inflows and saltwater intrusion. Predicting the quantity of carbon (C) stored in this new-forming and highly-dynamic land is crucial for the assessment of terrestrial and oceanic carbon cycling. However, terrestrial C storage and how it varied with environmental conditions, especially the soil salinity, time of formation and vegetation properties, still remains unclear. In this study, we predicted the spatial distribution of terrestrial C storage and its components in YRD using a Random Forest algorithm, supported by meteorological, remote sensing and our own field investigation data. The results showed that YRD stored about 2.8 Tg C (with C density of 4.39 kg $m^{-2}$), of which 86.6% was in the top 1 m soil, 7.8% in the biomass of vegetation, and 5.6% in the ground layer. The terrestrial C storage as well as the C density decreased from inland to coastal direction. Soil salinity indexes were positively correlated with vegetation C storage while negatively correlated with soil C storage. Notably, Soil C storage increased with time of soil formation. We also found the plant species richness and biomass increased significantly with increasing time of soil formation, and the distribution area of the low salinity indicator species advanced towards the coast. Our results highlighted the strong effects of soil salinity and time of formation on terrestrial C storage in YRD. The information gained in this study will facilitate policy decisions concerning the preservation of natural environment in river deltas worldwide that are subject to intensive land-ocean interactions and human interventions.

# Impacts of morphological change and sea-level rise on stratification in the Pearl River Estuary

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The Pearl River Delta (PRD), where several megacities are located, has undergone drastic morphological changes caused by anthropogenic impact during the past few decades. In its main estuary, the water area has been reduced by 21% whilst the average water depth has increased by 2.24 m from 1970s to 2010s. The mainly human-induced morphological change together with sea level rise has jointly led to a remarkable change in the water stratification. However, the spatial and temporal variability of stratification in the estuary and associated driving mechanisms remain less understood. In this study, stratification in the Pearl River Estuary (PRE) in response to morphological change and external forcing is investigated by 3-dimensional numerical modeling. Simulation results indicate that stratification in the PRE exhibits distinct spatial and temporal variabilities. At a tidal-to-monthly time scale, variation of stratification is mainly driven by advection and straining through tidal forcing. At a monthly-to-seasonal scale, monsoon-driven river runoff and associated plume and fronts dominate the variation of stratification. Human-induced morphological change leads to an enhancement of stratification by up to four times in the PRE. Compared to an overwhelming human impact in the past few decades, future sea level rise would further enhance stratification, but to a much lesser extent than past human impacts. On the other hand, stratification in different areas of the estuary also responds differently to the driving factors. The western shoal of the estuary is most sensitive to changes in morphology and sea level due to its shallowness, followed by the channels and other parts of the estuary, which are less sensitive.

# Zooplankton communities in the Lower Saxony Wadden Sea experience strong changes in composition and structure in response to stressors induced by the major river systems and marine hydrographical processes

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The southern Wadden Sea has been a center of attraction for many decades for its diverse marine ecosystems, spectacular landforms, and biodiversity, earning the status of a UNESCO World Heritage Site. However, in recent decades, the sea's eutrophication status and biodiversity loss have become an issue of great concern. We aimed to assess the zooplankton community structure in response to environmental and anthropogenic stressors in the Lower Saxony Wadden Sea using data provided by the Lower Saxony Water Management, Coastal Protection and Nature Conservation Agency (NLWKN) collected since 2015 from the mouth of the Ems River in the west to the Weser estuary in the east. Additional time series datasets of riverine loads from the major German rivers (1977 – 2017: Paetsch & Lenhart, 2019) were also analyzed. The data were analyzed according to three main objectives: 1) to determine whether the ecological characteristics of diversity, richness, dominance, and community structure reflected qualitative perceptions of ecosystem quality, 2) to compare ecological characteristics across the six stations (BorkW1, BorkW2, WukuW1, JadeW1, NneyW1, and SpogW1), based on the zooplankton communities encountered, and 3) to determine the response of the key zooplankton community traits (such as abundance, biomass, and bio-volume) to abiotic parameters, and to the influence of the three major river systems: Ems, Weser, and Elbe. The results revealed distinct spatial patterns in the zooplankton community structure. Nutrient concentrations and stoichiometry, as well as climate-related hydrographic parameters: temperature, salinity, and Secchi depth, strongly constrained zooplankton communities and body size. We estimated that stations with relatively high concentrations of P and N, and low N:P ratios including BorkW1 and WukuW1 had a high eutrophication potential because of their location in the inner estuaries and potentially on the paths of coastal residual currents. Relatively large and primarily herbivorous zooplankton taxa, lower overall abundances, and low diversities characterized these stations. Stations with lower nutrient concentrations and higher N:P ratios including JadeW1, BorkW2, and NneyW1 were located in the outer estuaries and barrier islands. The station with the lowest eutrophication potential was SpogW1 characterized by the lowest salinity (<28 PSU), the highest N:P ratio, and the predominance of the relatively small-bodied, primarily carnivorous copepods (Oithona spp., and Corycaeus anglicus). We demonstrated that riverine input is still an important contributor to nutrient enrichment in the Lower Saxony Wadden Sea. Overall, the total bio-volume decreased significantly across all stations, indicating that species were also responding to prevailing stressors by reducing their body sizes. Among the major river systems, the Ems had the lowest nutrient loads, followed by the Weser, and the Elbe, with the highest loads. Hence, the Lower Saxony Wadden Sea continues to face two major challenges: riverine N-enrichment and offshore/transboundary nutrient enrichment likely contributing to the low zooplankton diversity. However, the significant decrease in nutrient loads (P decreased rapidly while N remained relatively stable) from the major rivers since the mid-1987, and the resultant increase in the N:P ratio led us to suggest tentatively that offshore transboundary sources were also contributing significantly to the nutrient dynamics and the dynamic eutrophication potential of the area.

# Study on Hydrodynamic Characteristics and Environmental Response in Shantou Offshore Area

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As a coastal trading city in China, Shantou has complex terrain and changeable sea conditions in its coastal waters. In order to better protect the coastal engineering and social property along the coast, based on the numerical simulation method, this paper constructed a detailed hydrodynamic model of the Shantou sea area, and the measured tide elevation and tidal current were used to verify the accuracy of the model. Based on the simulation results, the tide elevation and current in the study area were analyzed, including the flood and ebb tides of astronomical spring tide, the flood and ebb tides of astronomical neap tide, the high tide, and the low tide. In order to find the main tidal constituent types in this sea, the influence of different tidal constituents on tide elevation and tidal current in the study area was analyzed. At the same time, the storm surge model of the study area was constructed, and the flow field under Typhoon “Mangkhut” in the study area was simulated by using the real recorded data. Typhoon wind fields with different recurrence periods and intensities were constructed to simulate the change in the flow field, the sea water level, and the disaster situation along the coast. The results showed that under normal sea conditions, the sea water flows from southwest to northeast at flood tide and the flow direction is opposite at ebb tide. The tidal range is large in the northwest and small in the southeast of the study area. The tides in the study area are mainly controlled by M2, S2, K1, and O1 tidal constituents, but N2, K2, P1, and Q1 tidal constituents have significant effects on the high water level. The water level caused by typhoons increases significantly along the coast of Shantou City. In the west area of the Rong River estuary, a typhoon with a lower central pressure than 910 hPa may induce a water increase of more than 2 m.

# Variation of sediment flux from the Hanjiang River and the Rongjiang River into the sea and its effect on deposition of Hanjiang River Subaqueous Delta over the recent 60 years

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Hanjiang River Delta has rich land, large population and developed economy. Hanjiang River and Rongjiang River are also facing the problem of continuous reduction of sediment flux into the sea. Based on the water and sediment flux into the sea of Hanjiang River and Rongjiang River and the multi-year marine charts and columnar samples of Hanjiang River Subaqueous Delta, this thesis studies the variation characteristics and main controlling factors of runoff and sediment flux into the sea of Hanjiang River and Rongjiang River over the recent 60 years by using the methods of water and sediment data analysis, marine chart erosion and deposition evolution analysis and sediment sample analysis, and studies the influence of water and sediment changes into the sea of Hanjiang River and Rongjiang River on the deposition of Hanjiang River Subaqueous Delta.

The annual runoff into the sea of Hanjiang River and Rongjiang river has no significant change trend, but the annual sediment flux into the sea of Hanjiang River and Rongjiang River shows a significant decrease trend as a whole. The sediment flux into the sea of Hanjiang River began to decrease significantly and sharply in 1998 and 2001 respectively. The construction of large reservoir is the main controlling factor causing the significant reduction of sediment fluxes into the sea. Human activities in the basin (construction of a large number of reservoirs and water and soil conservation) have a slight impact on the seasonality of runoff and sediment fluxes into the sea of the Hanjiang River. The significant reduction of sediment flux into the sea of Hanjiang River and Rongjiang river has obvious spatial differentiation on the sedimentation of Hanjiang River Subaqueous Delta: the significant reduction of sediment flux into the sea of Hanjiang River and Rongjiang River leads to the radial coarsening of columnar sediment particles in the near estuary area of subaqueous delta, the reduction of sedimentation rate or the transformation from deposition to erosion. In the area far away from the estuary, the particle size of columnar sediment has no obvious change in the vertical direction, and the deposition rate does not decrease significantly. In the area between the two, since the sediments discharged into the sea after the impoundment of the reservoir are mainly fine-grained suspended sediments, the source of coarse-grained sediments in the subaqueous delta sediments of Hanjiang River is reduced, resulting in the upward refinement of columnar samples. The spatial response model of Hanjiang River Subaqueous Delta to the sharp decrease of sediment flux into the sea is significantly different from that of the Yangtze River Subaqueous Delta and the Yellow River Subaqueous Delta.

# The role of natural resources monitoring and investigation system in the economic development and ecological protection of the estuary delta

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China's marginal seas mainly include the Yellow Sea, the East China Sea and the South China Sea. As the frontier between land and sea, they are of great strategic significance in safeguarding China's sovereignty and territorial integrity, developing the marine economy, safeguarding national defense and military security, and promoting resource development and protection. However, with the economic development and irrational human activities, the marginal seas and estuarine deltas have generally seen the trend of resource degradation, environmental degradation and disaster intensification, and the ecological environment has been seriously damaged, which has become one of the important factors restricting the sustainable development of regional social economy.
In order to respond to the concept of a life community, gradually realize the overall protection, systematic restoration and comprehensive management of the estuarine system and marginal seas, and ensure the ecological security of coastal areas, it is necessary to establish a natural resources survey and monitoring standard system with the natural resources classification standard as the core, based on the theory of natural resources science and earth system science, and advanced technologies such as spatial information, artificial intelligence, big data, Build an efficient technical system for natural resource survey and monitoring, and find out the natural resource status of China's estuary delta, with the Yellow River Delta, the Pearl River Delta and the Yangtze River Delta as the main survey and monitoring areas. According to the dynamic zoning of China's natural resources, a national comprehensive observation and research station network of natural resource elements is established. Through systematic investigation, observation test, prediction simulation, monitoring and evaluation, the existing wetland resource survey, water resource survey and other data results are integrated to systematically grasp the dynamic change and trend prediction of land, water, wetland, ocean and other natural resources in the estuary delta system, and reveal the relationship and succession law of natural resources, Scientifically evaluate the key supporting and restricting role of natural resources in the economic and social development and ecological civilization construction of the delta.

# Causes and effects of engineered river diversion in channel dynamics and deltaic development: A story of the largest distributary of the Mississippi River

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The Mississippi River enters the northern Gulf of Mexico through two outlets: the Mississippi River mainstem of 500 km long and its distributary, the Atchafalaya River of 220 km long (Figure 1 left). Before the 20th century, less than 10% of the Mississippi flow went into the Atchafalaya. Since the early 20th century, the Atchafalaya began to form a steeper gradient and a well-defined channel; Consequently, the discharge from the Mississippi entering the Atchafalaya was rapidly increasing during the 1930s and 1940s. In 1942, a 40-km long diversion channel was created 60 km upstream of the Atchafalaya River mouth to divert 30% of the river flow (blue channel in Figure 1 right), in order to prevent a major city (Morgan City, Figure 1 right) downstream from flooding. In the 1950s, the flow of the Mississippi into the Atchafalaya increased to more than 40%. With the fear of the Atchafalaya soon capturing the entire Mississippi River, a complex of hydraulic structures was built in 1963 to control the intake of the Atchafalaya from the Mississippi. Since then, the structures maintained approximately 25% of the discharge of the Mississippi River going into the Atchafalaya River. The increased discharge before the completion of the control structures caused many of the open water areas in the Atchafalaya River basin to accumulate sediments. With sediment filled in these open water areas, subaerial land in the Atchafalaya Bay started forming in 1972 and was accelerated by large floods that occurred from 1973 to 1975, building the Atchafalaya River subdelta (ARSD) and Wax Lake Outlet subdelta (WLSD) (Figure 1 right). Today, the mouth of the Atchafalaya River is the only location that is still gaining new land along the sinking Mississippi River Delta, which has attracted international attention in recent years as a model for promoting channelized river sediment diversions to protect and/or restore river deltas. Here, we present the morphologic changes in the Atchafalaya River main channel from 1967 to 2006 (i.e., after the hydraulic structures were built), as well as the two outlet channels from 1977 to 2006 (i.e., following the emergence of the ARSD and WLSD). We will discuss how river engineering has altered riverine sediment transport and delivery from the upper Atchafalaya to the river mouth over the past four decades. As many of the world's deltas are losing land, these findings have crucial research and management implications.

## Indigenous knowledge systems informing an adaptive estuary management: The socio-cultural dynamics of the Sundays River Estuary

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Although there has been research conducted on estuary management and the ecological dynamics of estuaries in South Africa, there is less of a focus on the socio-cultural dynamics of estuaries which informs strategies of sustainable adaptive management. That is, only a few, and far between, studies have attempted to highlight how estuary users are (or could be) involved in the management of estuaries. Therefore, this research aims to cover the primary socio-cultural dynamics of the estuaries in terms of its uses and management by making use of the Sunday's River Estuary in the Eastern Cape, South Africa as a case study.

This study employs an embedded, qualitative research approach to explore experiences, values and knowledge systems around the Sunday's River Estuary by using semi-structured interviews. The use of this approach allows for both a complex and holistic understanding of the perceptions of estuarine management and governance and how they community plays a role in such. The study illustrates that community involvement in the management of estuaries and an indigenous knowledge systems-based policy are required for the sustainable use and management of these socio-ecological systems.

## Session 3

# Proxy-records
# and modern observations

# Morphological evolution of bayhead delta within a tide-dominated embayment, case studies at the Lingding Bay, South China Sea

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Bayhead delta is common at wave-dominated estuaries. Here, taking the example of the Lingding Bay, South China Sea, we present an evolutional study of bayhead delta in the tide-dominated embayment. The eastern three Pearl River Distributary channel mouths discharge flow and sediment with an angle into the estuarine embayment (i.e. the Lingding Bay). The estuarine shoals in front of the eastern three distributary channel mouths elongated, and deflected when they approached the primary deep trough in the estuary. Based on the quantitative and geostatistical analysis of chart data in the past 120 years, this paper analyzed the elongation and deflection of estuarine shoals in front of the eastern three distributary channel mouths in the Lingding Bay. Furthermore, we apply processed-based morphodynamical models to investigate the processes responsible for the elongation and deflection. Lastly, we will present scenarios of the simulation based on different rates of global sea-level rise and reduction of riverine sediment supply. Based on the presented results, we will give some suggestions for increasing estuarine sustainability at this unique topographic and dynamic setting of the Pearl River Estuary. This study shall also improve our understanding of river mouth fluvial-dominated depositional processes within tide-dominated estuarine embayments, which could serve as scientific base for estuarine sustainable management and planning.

# Analysis of Quaternary sequence development in the Pearl River Estuary, North South China Sea with single-channel seismic profiles data

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To investigate the sedimentary development and stages of transgression in the PRE in greater detail. We acquired about 500 km seismic reflection profiles reprocessing the data in 2020. In this study, the existing data and newly collected single-channel seismic data in the Lingding bay area of the PRE are co-interpreted.

Interpretation and analysis of the 2D seismic reflection data make us to identify the typical seismic reflection interface, divide the seismic sequences, and then determine the seismic facies – sedimentary facies features, shallow strata features and submarine geomorphology features of this area. Four reflection interfaces were identified which called $R_0$, $R_1$, $R_2$, $R_3$ and Rg. $R_0$ is the seafloor of the marine and the Rg is the bed rock. Most of the paleochannels and shallow gas were recognized between the reflection $R_1$ and $R_2$.

According to the distribution of the reflection interface and the structural characteristics of the layers, the strata above the basement can be divided into four seismic sequences from top to bottom, namely A, B, C and D. According to the reflection characteristics of seismic profiles combined with the data of existing boreholes, the two layers of sequence A and sequence B have the characteristics of good reflection continuity, dense layers, stable thickness and horizontal occurrence, indicating a stable sedimentary environment, which is consistent with the sedimentary environment of Lingding bay area in the Pearl River Estuary during the Holocene. The continuity, amplitude intensity, thickness and internal structure of the second layer of sequence C and sequence D have great changes, indicating that the sedimentary environment has great changes and is deposited in the late Pleistocene. There is an obvious unconformity relationship between sequence B and sequence C, and the discontinuity reflection $R_2$ is undulating, and has obvious characteristics of overcomplex in the upper layer and erosion in the lower layer. The strata below Rg are prequaternary basement. Each sequence has different reflection characteristics, lithology and geological age.

The characteristics of four sequences in Quaternary are revealed; seismic facies such as paleochannels, sand waves, shallow gas, and bedrock outcropping are recognized. Through the comparison of the borehole and seismic data in the sea areas of Hong Kong and Macao, and the Pearl River Delta, the evolution of the ancient Pearl River Delta and estuarine is analyzed, The Quaternary transgression started during the Middle Pleistocene. The PRE has undergone at least four stages of transgression, in the Middle and Late Pleistocene (Baini Formation), Late Pleistocene (may in debate) and Holocene, respectively.

# Tectonic anabranching of River Brahmaputra: implications on survival of cultural and biodiversity hotspots beside world's largest river island Majuli

*Session 3 Keynote*

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Brahmaputra, is a large, tropical, trans-boundary river with high sediment load having the unique distinction of possessing both largest and smallest inhabited river islands. Majuli is the largest inhabited river island situated in the Indian state of Assam and bounded by Brahmaputra on the south, Subansiri River on the northwest, and the Kherkatia River (anabranch of Brahmaputra) on the northeast. The island was formed during a flooding event in 1750 with a sudden change of Brahmaputra from a low energy meandering to a high energy braided river and subsequent capture of one of its tributary. The island is a part of the Brahmaputra alluvium squeezed between active Himalayan and Indo-Burmese orogenic belts in a complicated tectonic regime. The main flow path of Brahmaputra is controlled by the crustal scale reorganization continuing in this part of the world. Due to which, Brahmaputra manifests a channel width range of 1.2 to 18 kms causing choked flow at places. Due to the choked flow, the channel area increases upstream causing floods during monsoon in biodiversity hotspots like Kaziranga National Park. Formation of newer islands with area of 300 $km^2$ (Dibru-Saikhowa National Park) has also been observed due to very fast avulsion of Lohit River which is also considered as a paleo-path of Brahmaputra.

Geotectonically, Majuli island is bounded by the E-W Jorhat Fault, NE-SW Dibrugarh lineament and Simen fault. There are Himalayan cross faults traversing the island too along NW-SE and NE-SW trends. During the piracy event forming Majuli, Brahmaputra flowed southwesterly along the Dibrugarh lineament for 25 kms leaving its westerly flowing trail and again took the path governed by Jorhat fault. Due to the uplifting block of Mikir Hills for which the Jorhat fault acts as the northern boundary, the river had to restrict itself along the westerly path. The island which is home for approximate 160000 people and the main seat of Vaishnavite religion of this part of India is basically a part of the main land. The tectonic controlled anabranching process which has created the island is at present acting as the destroyer of the same by the means of unabated erosion. The island area has been reduced to 352 sq km on date from 880 sq km at the beginning due to erosion.

The erosion pattern of the two rivers viz. Brahmaputra and Subansiri was studied and areas with marked selective erosion has been found. It was observed that the eastern end of the island is more prone to weathering than the western end. From a combined study of satellite imaging, bathymetric survey and mapping, it was found that the lobate shaped erosions in the study areas are restricted to traces of the active cross faults related to the Himalayan thrust system through which the rivers are trying to anabranch.

The study indicates towards tectonic control of anabranching of the river at regional to local scale. Similar situation is observed all along the river within Assam plains, where development as well as destruction is in progress. Considering the riverine population, their culture and the biodiversity hosted in those areas, protection measures are being undertaken regularly. However, proper understanding of the behavior of the underlying tectonic elements is required for appropriate hazard management plans.

# Postglacial evolution and present stage of the Odra River mouth development (the southern Baltic Sea)

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Multidisciplinary research that has been conducted over the past dozen or so years by multi-person team has revealed that the Odra River mouth area was evolving during the Late Glacial and Holocene in several stages. This area has evolved from glacio-fluvial to fluvio-limnic to marine through to the present lagoonal stage.

In the Late Pleistocene, the pre-Odra River was rolling westward along the Toruń-Eberswalde ice-marginal valley to discharge, farther away and like the rivers Elbe and Rhine, to the Atlantic. After the Scandinavian icesheet retreat (ca. 14.5 ky BP), the ancient river was flowing north-west to discharge to the Baltic Sea, most likely close to the eastern part of today's Island of Rügen. Initially, the Odra was a braided river of a type, with many wandering channels and sandbanks, which then probably turned into an anastomosing, with channels stabilized by vegetation. In the mid-Holocene, the river was most likely meandering through swamps and bogs.

During the Littorina transgression (ca. 7 ky BP), the river valley was invaded by the sea water and was transformed into a marine embayment extending southward down to today's city of Szczecin, becoming an estuary. Processes of coastal erosion and longshore transport of eroded sediments produced two sandy spits which grew in size and gradually blocked the estuary, turning it into a lagoonal river mouth. The growth of these spits was accompanied by the development of a sequence of many dune ridges. Most probably, relatively soon the back delta began forming on the land side of the spit barrier.

One of the key elements of the present-day Odra river mouth system is the Szczecin Lagoon, a shallow water body isolated from the open Baltic Sea by two islands: the Wolin and the Usedom, built partly by morainic deposits and partly by spit barrier. The Szczecin Lagoon's natural depth does not exceed 8.5 m, and about 96% of the area being shallower than 6 m. Shallows (areas less than 2 m deep) occupy more than 25% of the lagoon

Separation of the lagoon from the direct influence of the Baltic Sea resulted in alteration of the sedimentation nature. A contribution of organic matter began to increase, the marine malacofauna being replaced by freshwater species. Organic-mineral sediments of gyttja type have been accumulating in the lagoon until today. Nevertheless, in the most shallow-water areas there are also sandy or silt-sandy deposits. In sediments with a high content of organic matter, an increased concentration of some heavy metals is observed, even down to 50 cm depth in the sediment, which is associated with environmental pollution in the 20th century. In some parts of the Szczecin Lagoon, a sequence of sediments representing all phases of the development of the Odra river mouth can be seen in the vertical profile of several meters.

# Deterioration in the subaqueous Mekong Delta, Vietnam

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The interplay of river, tide and wave forcing controls shape and sedimentation at the front of the Mekong Delta. Specific hydro- and morphodynamic conditions in the western subaqueous part of the asymmetric Mekong Delta generate a sand ridge - channel system (SRCS) which is unique in subaqueous delta formation. This large-scale morphological element extends 130 km along the delta front consisting of two sand ridges and two erosional channels.

Three different zones within SRCS can be distinguished. The eastern initial zone extends along delta slope and inner shelf platform southwest of the Bassac river mouth, the largest and westernmost distributary of the Mekong Delta. In the central zone SRCS covers the outer part of the subaqueous delta platform with a pronounced sand-ridge and erosional channel morphology. Cross-sections of the SRCS reveal an asymmetric shape including steeper ridge flanks facing into offshore direction. Channels incise down to 18.2 m water depth (wd) and 10.5 down the ridge top at the outer subaqueous delta platform, respectively. Towards the west the sand ridges pinch out while the two channels merge into one and form a giant erosional scour of up to 33 m wd within the shallow subaqueous delta platform. In the western zone, this channel gets shallower and vanishes along the south-western edge of the subaqueous delta platform around Ca Mau Cape.

Sediment transport from the Mekong River nourishes the sand ridges. In contrast, tide and wind-driven currents cut the erosional channels, which act also as fine-sediment conveyor from eroding headlands between the Bassac river mouth and Cape Ca Mau with a costal retreat of 2.5 cm/day. SRCS in the subaqueous Mekong Delta is a relevant indicator of delta-front instability and erosion. Westward sediment transport is intensified during the winter-monsoon period. Active sedimentation varies greatly and reaches sediment accumulation rates of up to 10 cm/yr in the western depocenter near Ca Mau.

Westward and southward from the Camau Peninsula, the subaqueous prodelta appears as a mud-dominated, organic-rich, high-accumulation (up to 1.5 cm yr−1) zone. South of the river mouths, a wide zone is dominated by terrigenous sands, which most likely represent the sink for river-supplied bedload sediments. The third and most offshore located zone of moderate-accumulation (0.3–0.4 cm yr−1) is dominated by muddy sands that are rich in biogenic carbonate. Evidence of redeposition, event deposition and changing sedimentary conditions is found in each of these zones reflecting the combined effects of tides, the changing monsoonal current and wind regimes and episodic tropical storms.

The subaqueous delta front stores approximately 50% of the fine-grained sediments supplied by the Mekong River. Roughly one-fourth of the sediments are retained in the subaerial region of the delta (including the Tonle Sap Lake), and approximately 25% accumulates on the inner shelf around the Camau Peninsula, primarily in the form of prodelta deposits. No significant amounts of fine-grained sediments are exported across the shelf into the deep South China Sea.

In the larger regional context, sediment plumes and shelf clinoforms can be traced almost continuously from the Yangtse until the Mekong Delta as a unique morphodynamics feature of the northern and western marginal parts of the South China Sea. Major sediment plumes originate at the mouths of large rivers, namely the Yangtse, Pearl, Red and Mekong Rivers and extend several hundred kilometers in downdrift direction, governed mainly by the monsoonal system with prevailing winter-monsoon winds from NE.

# Late Holocene Vistula River floods recorded in grain size distributions and diatom assemblages of marine sediments of the Gulf of Gdańsk (Baltic Sea)

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During the large flood of the Vistula River in 2010, the riverine brackish water surface plume extended up to 70 km into the Gulf of Gdańsk (Baltic Sea), whereas the seafloor was covered with a thin layer of the flood deposits. It inspired a search for older palaeoflood records in marine sediments, which may be helpful in reconstructions of past climate extremes. Thus, the present work aimed to identify the most useful flood indicators and apply them to identify palaeoflood records in sediment cores from the Gulf of Gdańsk. Particularly, the usefulness of grain size distributions and diatoms as potential flood indicators was tested. The study is based on analyses of surface samples collected during and one year after the 2010 flood and two long sediment cores which were subjected to high-resolution grain size, diatom, and geochemical analyses, while chronology was based on the combined AMS$^{14}$C, $^{210}$Pb, and $^{137}$Cs dating. It was found that modern large flood deposits were relatively thin (subcentimeter), medium-grained sands, and within a year, they were removed from a water depth of less than 30 m. Thus, the palaeoflood record was searched in sediment cores retrieved from water depths over 60 m, and composed mainly of sandy mud. Most of the 1 cm thick sediment samples were characterized by unimodal distribution, however, some of them were bimodal, with the additional mode in fine-grained fractions, which is interpreted to be the result of direct deposition from riverine flood surface water plume. The diatom assemblages revealed a moderate downcore variability, and consisted of euhalobous, mesohalobous, oligohalobous, halophilus and indifferent taxa. The intervals characterized by bimodal grain size distributions were often characterized by an elevated amount of benthic oligohalobous (freshwater), as well as decreased euhalobous and mesohalobous taxa supporting the likely interpretation of these layers as deposited during river flood events. During the last c. 4 ka a dozen of major flood events were identified, however, their applications to the flood climate reconstruction were difficult because of relatively frequent, and partly unknown, changes in major river mouth positions in the past. The present work suggests that thin deposits of major floods left on the seafloor and subjected to further mixing maybe still recognized using a combination of detailed grain size distribution analysis with diatom analysis supplemented by basic geochemistry and a good understanding of the depositional system.

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# A downcore calibration of the [Równanie] temperature proxy for the Baltic Sea

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$TEX_{86}$ proxies based on glycerol dialkyl glycerol tetraether (GDGT) membrane lipids from ammonia-oxidizing Archaea (Crenarchaeota) provide unique tools to reconstruct paleo-water temperatures. Different parameters such as the distribution and community composition of Crenarchaeota in the water column and the seasonality of archaeal production may, among others, bias the $TEX_{86}$ relationship with water temperature. Thus, many $TEX_{86}$-based calibrations for various environmental settings exist.

In the brackish Baltic Sea, temperature proxies are restricted to the western Baltic Sea or not applicable at all except for the $TEX_{86}$ proxies. Since surface sediments used to establish temperature calibrations are restricted in time, a downcore calibration approach is proposed here, which consists of comparing values of three different iterations of GDGT-based indices ($TEX_{86}$,$TEX_{H86}$ *TEX86H*, $TEX_{L86}$ *TEX86L*,) from a well-dated sediment core from the Fårö Basin with measured water temperatures in the central Baltic Sea over the last 45 years. Instrumental temperature data were selected for different depths and seasons from the ICES Dataset on Ocean Hydrography.

Our results show that water temperatures between 80–120 m and > 120 m are best correlated with $TEX_{L86}$ *TEX86L* for almost all months of the year. As the highest correlation coefficients (up to $r^2 = 0.7$) are found for water depths between 80–120 m, a linear regression model of $TEX_{L86}$ *TEX86L* with the 80–120 m *in situ* water temperatures was established. The significant correlation between $TEX_{L86}$ *TEX86L* and water temperature is explained by genetic and lipid data (e.g. intact GDGTs), showing that *Candidatus Nitrosopumilus*, thriving near the redoxcline and in bottom waters, represents the dominant biological source of GDGTs.

Applying the subsurface temperature calibration to a Holocene sediment core from the East Gotland Basin Sea suggests that the water temperature between 80–120 m was 1°C lower during the Medieval Climate Anomaly, and similar to modern values during the Holocene Thermal Optimum. The present study provides a robust regional subsurface temperature calibration that allows high-resolution reconstructions of paleotemperatures in the Baltic Sea.

# Three stage paleochannels identification and main resource analysis from Middle Pleistocene in the Western Bohai Sea

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Large worldwide sea regressions and transgressions, as well as sea surface oscillations, have altered river history in the continental shelf since the Quaternary in China. A variety of sizes of rivers and lakes were formed on the continental shelf during the Quaternary glacial stage, when the sea level generally dropped, the ancient shoreline receded, and massive rivers imported significant amounts of material into the shallow marine environment. Early rivers fell into the sea floor during the interglacial period when the glacier melted and the sea level rose significantly, the majority of these early rivers were covered by the sediments, creating buried paleochannels.

The offshore area in the western of Bohai, has experienced interglacial-ice-postglacial climate change since the Pleistocene, and fluvial and marine deposits interacted, showing a good periodic change pattern. The distribution of largely buried paleochannels in this area is very concentrated, which is the most ideal area to study the paleochannels and paleoclimate change. The prerequisite for the formation of paleochannels is adequate material transport, which river system is the source of the paleochannels? Yellow River? Luan River? Hai River? Or Liao River?

In recent years, a large amount of high-resolution single-channel seismic data have been acquired and two boreholes (hole TJC-1 and hole H6) totaling more than 200m in depth have been drilled by Yantai Center of Coastal Zone Geological Survey (YCCZGS) and Qingdao Institute of Marine Geology (QIMG) in this region, and these core data were examined for date, grain size and clay mineral testing.

According to the high-resolution seismic data, identified three stage paleochannels, $SU_2$ stage-, $SU_4$ stage- and $SU_6$ stage paleo-river channel. At the $SU_2$ stage, when at the low sea level period during the Last Ice Age, distributed two large pale-river channels, were with NNW-SSE direction in the western and NW-SE direction and N-S direction eastern respectively, with great variation in cutting depth, longitudinal and transverse. At the $SU_4$ stage, when in the middle of the Late Pleistocene (MIS 4 stage), distributed three different sizes of paleochannels, with NW-SE direction in the western and NWW-SEE direction in the northern, with a larger scale in the middle. At the $SU_6$ stage, when in the Middle Pleistocene, distributed three different sizes of paleochannels, with N-S direction in the eastern and NWW-SEE direction in the western, and a non-complete N-S direction paleo-river channel is revealed in the northeastern. Based on the grain size analysis of two holes, coarser grain size, well sorting, positively skewed, normal shape and very sharp kurtosis in the hole TJC-1, and fine size, poor sorting, positively skewed, bimodal structure kurtosis in the hole H6.

From clay minerals analysis, the main clay minerals of two boreholes are four kinds, including illite, montmorillonite, kaolinite, and chlorite, among which illite has the highest component, the clay mineral assemblage is illite-montmorillonite-chlorite-kaolinite. The resource of sediment in the $SU_2$ stage and $SU_4$ stage is mainly from the Yellow River and Luan River, followed by the Hai River, $SU_6$ stage is a mixture of the Yellow River, Luan River, and Liao River.

# Evolution of sedimentary environments and source-to-sink transport processes off the eastern Wanquan Estuary since the Holocene

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Mineralogy, grain size and $^{14}C$ dating were surveyed in a 22.8-meter-long core (ZK16) off the eastern Wanquan Estuary of Hainan Island on the western margin of the South China Sea (SCS). The Holocene paleoenvironments were reconstructed into 4 distinct stages based on significant variations in mineralogy and grain size. The clay mineral assemblages from stage 1 to early stage 3 are similar and show features related to physical erosion. The clay mineral assemblages show a change from physical to chemical erosion on a centennial scale at the end of stage 3, which is identified as evidence of a change in provenance. Source-to-sink transport processes off the eastern Wanquan Estuary and the Wanquan River in the Holocene are investigated. The results first show that fluvial sediment transport from the river mouth to the near-shore continental shelf was completely different ~7 ka ago. The sedimentary regime reached a similar pattern to that of the modern regime at approximately 5 ka. Although grain size shows invariant characteristics during the modern transport process, clay mineral assemblages still show high-frequency oscillations. By combining clay mineralogical distributions along the eastern coast of Hainan Island, we suggest that the major force of the variations in clay mineral assemblages during the modern transport process was contributed by surface currents controlled by the East Asian Monsoon (EAM).

# Fine-grained turbidites in the southern Okinawa Trough and its implication for earthquakes activity over the past 700 years

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Understanding recurrence intervals of earthquakes is an essential prerequisite for improving seismic hazard assessment (Moernaut et al., 2018; Satake and Atwater, 2007). Due to the short time span of earthquake time, it is difficult to record the time and constrain the average recurrence rates. However, turbidite deposits may potentially provide valuable complementary records and reliable constrain on the recurrence intervals and frequency of large earthquakes. And this method has been widely applied along the tectonic activity plate margin such as the Chile (Bernhardt et al., 2015), Japan (Nakajima and Kanai, 2000), New Zealand (Pouderoux et al., 2012), the Cascadia margin of North America (Goldfinger et al., 2003), Alaska (Williams et al., 2019). The southern Okinawa Trough (SOT) near Taiwan is one of the most seismically active areas in the world and features well-developed turbidite deposits. To better evaluate the coupling be-tween the turbidite deposits and the paleo-seismological activity in this area, we investigate a high temporal resolution sediment core HOBAB4-S2, retrieved from the SOT off eastern Taiwan. Based on core photographs, core descriptions, grain size analysis, elemental ratios, and coarse-grained composition analysis, a total of 15 turbidite events (T1-T15) between 1445 AD and 2003 AD were identified in this core (Fig.1), including 3 types of turbidite facies (TI-TIII): thin clay-medium silt turbidites (TI), thick coarse silt turbidites (TII) and fine sand turbidites (TIII). Most of these turbidite events can be correlated with contemporary turbidite events recorded in previously reported sediment cores and/or can be directly related to instrumental and historical earthquake records, indicating that earthquakes are likely the dominant triggering mechanisms for these turbidite events. However, our new sediment core shows an increase in the thickness and occurrence frequency of turbidites during the Little Ice Age (LIA) compared to post-1950 AD. We suggest that the formation of turbidity currents was favored by an enhanced sediment supply due to frequent typhoon-induced heavy rainfalls during the LIA, leading to elevated sensitivity of the source region to earthquakes. This study supports the conclusion that turbidite records from seismically active areas can be used to reconstruct the history of local paleo-earthquakes with the caveat that such studies should be placed in a well-considered climatic context.

# Grain size characteristics and sedimentary environment response of different sedimentary facies in ZK-XH01 borehole at the entrance of Hanjiang River

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Relying on the Han River, Jianghan Plain has been an important granary in China for its fertile soil and dense population since ancient times. The analysis of the sedimentary environment of the estuary is helpful to clarify the evolution of human history and climate environment in the region. Taking ZK-XH01 borehole sediment in entrance of Hanjiang River basin as the research object, the evolution of the sedimentary environment at the estuary was analyzed in combination with the lithology and grain size composition of the sediments. Through sediment property discrimination, average particle size comparison, sorting analysis, sedimentary scatter map, comprehensive C-M map and sedimentary discrimination parameter Y. It was founded that the grain size characteristics of the sediments in entrance can effectively distinguish the sedimentary environment and dynamic process, and there were three kinds of sedimentary environments in the study area: paludal facies, lacustrine facies and fluvial facies. At 26.7-33m, it was deposit of paludal facies, the sediment was transported by still water suspension, mainly containing organic sludge, and small sand ripple bedding was occasionally seen. At 6.9-26.7m, it was deposit of lacustrine facies, It was an incomplete hydrostatic suspension transport, with a layered cycle generated by hydrodynamic action. The main sediments were brown yellow clay and silty clay. The sand content, average particle size and numerical value of the sediments tended to decrease from bottom to top, reflecting the gradual shrinkage of the lake and the transformation of the climate from warm and humid to dry. By comparing other borehole data in the region, this change indicated the gradual disappearance of the ancient Yun-meng Lakes. At 0-6.9m, it was deposit of fluvial facies, It was mainly transported by rolling, and the sediment was yellow black silt, which indicated that the area would usher in a warm and humid climate after the lake dries up, and the rainfall would increase. The analysis of the sedimentary environment in entrance provided a reference for the further reconstruction of the ancient environment in Jianghan Plain.

# Session 4

# Advanced data management and modeling

# Long-term simulation of the development dynamics of the Vistula delta in the Holocene through the 4F model adjustment

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The role of climate change and related sea level rise, frequency and direction of storm events and their role as driver of the dynamics of the river mouths and related coastal systems are apparent. Nevertheless, coastal zones of the seas and oceans still pose a major challenge to Quaternary researchers because of their particular vulnerability to short-term changes. Especially, in a world shaped by extreme phenomena, the course of these changes may have a substantial impact on the environment, population and infrastructure.

During the last 24k years, the area of Poland was subjected to a series of geological processes developing the landscape into its present form. In the late Pleistocene, during the decline of glaciation, the ice sheet gradually disappeared and waters flowing from its melting front filled the basin in its foreland forming the Baltic Ice Lake, which imprints an early stage in the development of today's Baltic Sea. As a result of glacio-isostatic adjustment (GIA) in the Holocene and eustatic sea level variations, latitudinal extent of the Baltic Sea at that time underwent significant changes: regression – retreat towards the North and transgression – increase of the latitudinal extent towards the South.

Reconstruction of the development of the southern Baltic Sea shoreline was possible owing to application of alongshore quasi-continuous explorations based on an infinite number of virtual averaged n-profiles within the 4F model (unlike coastal monitoring and behaviour predicting across the shore via a limited number of transects). This model (at 1:2,000,000) is 2haracterized by high accuracy and precision of mapping, resulting in cloud-based computations and simulations running in a coherent spatial and temporal environment combining past, present and future.

Shift dynamics is defined as a chartable change of the rate of the process over time. These processes subject to numerical modelling include: ice sheet advance and retreat, marine transgression and regression, coastal erosion and accumulation. Due to the scaling possibilities of the 4F model, its application upon the Vistula delta area requires only minor adjustments, allowing for both long-term hindcasting and forecasting of the coastal development extent and dynamics. Since the model consists of formulae defined as variables instead of constants, preferred due to their flexibility of use in further simulations, simple on-line modification of only upper and lower limits of integration within the Desmos environment is sufficient for the specified task.

# High-resolution seafloor models from Disko Bay, central West Greenland – pioneer study

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We have modelled seafloor terrain of nearly the entire Disko Bay region providing scientific baseline information about surface geology and sedimentary environments that can support the Seafloor Management Plan in Greenland. Disko Bay is a large marine bay in central West Greenland with a complex topography, largely modified by glacial processes. Oceanographic conditions are governed by seasonal sea ice, Atlantic-sourced water mass and freshwater input from the Greenland Ice Sheet. This area is also known for its biodiversity hotspots and rich fishing grounds.

Our study utilized multiple datasets of multibeam bathymetry and backscatter, seismic profiles and ground-truthing consisting of video footage from drop camera and benthic video sled, as well as sediment samples from grab and corers. Our models show that the key geological units in Disko Bay characterize the scale of geomorphic features, which in turn affects the distribution and complexity of habitat zones. The NE sub-region is underlain by Cretaceous sandstone and characterized by large-scale landforms, mainly vast flat areas, such as sandy and muddy plains. The SW sub-region is characterized by Precambrian Gneiss and Paleoproterozoic metasedimentary rocks with complex system of small-scale geomorphic features, resulting in topographically complex habitats in the area. Two distinctive habitats were discovered at the geological boundary separating the two sub-regions and associated with potential gas seeps: i) southern pockmark field and ii) western zoanthid-sponge wall. Our study highlights that areas of conservation interest and those of commercial interest are necessary to be delineated in such high-resolution habitat maps, to better identify conflicting seabed areas in the overall scope of sustainable use of the oceans and marine resources in Greenland.

# High-resolution mapping of Underwater Cultural Heritage in shallow coastal areas: case study from the Venice Lagoon

*Session 4 Keynote*

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Although Underwater Cultural Heritage (UCH) sites represent highly valuable common resources for scientific, historical, ecological, educational, and recreational purposes, our knowledge of UCH is still very limited. These resources are fragile and non-renewable, often non-accessible, being submerged or buried under the sea floor. For this reason, UCH sites are generally hard and costly to identify and study, and difficult to preserve, and, in most of the cases, rarely visible by the public.

Global sea level rise, consequences of climate change and ecosystem degradation due to human activities are threatening the future conservation of UCH sites. At the same time the general lack of funding devoted to UCH, protection and preservation imply that in the long term these resources could be destroyed. Coastal, transitional and lagoon environments, in particular, offer a variety of submerged cultural archaeological sites, given that humankind has populated these areas for millennia for their high productivity. However, very shallow water, heavy silt suspension and very low visibility often limit the access to these important archaeological resources.

In this contribution, we show how acoustic remote sensing by means of high resolution multibeam echosounder and sub-bottom profiler together with selective video inspections, can help in mapping and preserving the UCH. The collected acoustic data not only help to reconstruct the palaeoenvironments over the centuries, but, in some cases, it also can provide new evidence of the presence of archaeological structures both over and within the seafloor. We present here a case study in the Lagoon of Venice (Italy) that, together with the historical city of Venice, is a UNESCO World Cultural and Natural Heritage. In the Venice Lagoon, UCH research done so far often lacks large-scale high-resolution mapping and positioning. The new data collected supports a new interpretation and quantitative description of the mapped structures shedding new light on the significance of the Roman occupation of the Venice Lagoon. In the attempt to preserve this precious underwater cultural heritage, we presented a reconstructive hypothesis and a 3D digitization of the mapped structures that are currently endangered by erosion and subsidence processes. This work represents a starting point for a renovated effort of discovering, documenting, and preserving the highly valuable UCH in the Venice Lagoon, the methodology could then easily being transferred in other coastal areas to preserve UCH around the world.

# The “Hainan Delta”, Beibu Gulf, South China Sea - model and paleoenvironmental interpretation

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A paleodelta (“Hainan Delta”) was discovered in the Beibu Gulf, located at the northern continental shelf of the South China Sea southwest of the Island of Hainan, by the interpretation of seismic survey data. An interdisciplinary and unique data-set was acquired by studying a sediment core ZBW drilled by the China Geological Survey at a position suggested by our team (northern shelf of the SCS), which penetrated the sediments of the Hainan paleo-delta. Obtained data allowed to describe marine sedimentary facies (including sedimentology, geochemistry, mineralogy and biofacies) that contain almost a complete geochronological sedimentary sequence from MIS 5 to MIS 2. An age model was developed using results of OSL and AMS dated sediments. According to this model, the delta was formed between 65 ky BP (MIS 4) and 56 ky BP (MIS 3). Our sequence-stratigraphic model bases on the assumption that the global sea-level curve (Waelbroeck et al. 2002) can serve as a relative sea-level (rsl) curve for regional and even local studies during the last glacial period at the northern margin of the South China Sea (SCS). Two seismic reflectors, R2 and R1 mark unconformities and display together with the sea bottom (R0) the Late Pleistocene to Holocene shelf sediment architecture. These reflectors confine seismic units (R0-R1), and (R1-R2) to be studied. The Hainan Delta was formed in a process of “Normal Regression” which means in a time of sea-level rise (MIS 3) an outpacing by sediment supply. A reconstruction of the paleorelief of the northern shelf of the SCS was accomplished by applying a method of “back-stripping” known from sedimentary basin analysis for three scenarios as a base for paleo-hydrological studies 56 ky BP (MIS 3: falling rsl and truncation of the delta’s top layers), 60.5 ky BP (MIS 3: rsl-highstand), 65 ky BP (MIS 4: rsl- lowstand and onset of the paleodelta-formation). A 3D delta model of the Hainan Delta (part of the unit (R2-R1) and its internal structure (clinoforms, paleodistributaries) were generated by interpolation of seismic-derived datapoints. The complex interpretation of clinoform strike and dip angles, and the direction of paleodistributary channels point at Hainan Island as the main sediment source of the Hainan delta sediments. These findings are supported by the results of mineralogical provenance analyses comparing ZWB samples with corresponding surface samples from Hainan Island. Sediment mass calculation showed a 4 times larger contribution of Hainan Island to the Seismic Unit (R1-R2) than from the paleo-Red River. The high accumulation rate of delta sediments is explained preliminarily by precipitation anomalies enhancing erosion and discharge of the Hainan rivers compared to those surrounding the Beibu Gulf in the North (including the paleo-Red River) and West. The delta formation took place during a “Failed Glacial Termination” linked to rsl-rise, but weak summer monsoon and precipitation minima in Southern Asia. Our interpretation of biomarker and oxygen isotopes of ZBW core approves this assumption and shows a temperature minimum correlated with Heinrich Event H6 in the Northern Atlantic Ocean.

Our re-analyses of precipitation data of the last century discovered that Hainan Island correlates negatively with the rest of Asia, so that high precipitation at Hainan Island can go along with weak Asian Summer Monsoon periods and may explain high sediment transport rates from Hainan Island to the Beibu Gulf ruling the accumulation of the Paleo-Hainan Delta. Numerical simulation of riverine sediment accumulation in the Beibu Gulf support this interpretation.

# Physical-biogeochemical transformation of DOC in the river-estuary-ocean continuum: a modeling perspective

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Dissolved organic carbon (DOC) is an important part of costal marine ecosystem. Estuary is a key interface for terrigenous and marine DOC transport and dynamic transformation, which is affected by a variety of physical and biogeochemical processes such as photo-oxidation, phytoplankton photosynthesis, salinity-induced flocculation, and microbial decomposition, etc. However, most of the modeling studies do not explicitly represent the transformation processes of DOC and its driving factors throughout the river-estuary-ocean continuum.

Therefore, to better understand the dynamics of DOC cycling in the Changjiang Estuary, this study combine field observation and physics-biogeochemistry model to derive a more complete picture of the DOC transport processes. The unstructured grid, Finite-Volume Coastal Ocean Model (FVCOM), coupled with the European regional seas ecosystem model (ERSEM), is applied to study the DOC cycling in the Changjiang Estuary. Considering photo-oxidation is one of the main sinks of terrigenous DOC, the model divides the DOC as two components, terrigenous DOC and marine DOC. In the terrigenous component, the processes of photo-oxidation, flocculation and microbial decomposition consumption are mainly considered. In the marine component, the processes of microbial decomposition, biological cycle of zooplankton and phytoplankton are primarily concerned.

According to the observation data over the years, there is a high-DOC area in the south branch of Changjiang Estuary in summer. Model result shows DOC is removed rapidly as it transports from river to estuary. Terrigenous DOC is the main source inside the river mouth, while marine DOC is the main source outside the river mouth. The DOC in the offshore area showed significant seasonal variations, with the maximum concentration around July and low in February. It mainly results from the fact that terrigenous DOC is easily consumed by photodegradation. As terrigenous DOC transports to river mouth, the degree of DOC removal increases with its longer residence time. While marine DOC will be supplemented by phytoplankton and zooplankton.

Our results support prior studies of DOC distribution characteristics in the Changjiang Estuary, and will be used to analyze the mechanism of DOC transport in the estuary.

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No. 12 Programme, Abstracts, Participants. MedCORDEX-Baltic Earth-COST Workshop ”Regional Climate System Modelling for the European Sea Regions”. Universitat de les Illes Baleares, Palma de Mallorca, Spain, 14 - 16 March 2018, International Baltic Earth Secretariat Publication No. 12, 96 pp, March 2018

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