CAS-EurASc Frontier Forum on Marine Science and Technologies

Shanghai | Online via Zoom

18-19 November 2024

Sponsors

European Academy of Sciences, Chinese Academy of Sciences

Organizer

East China Normal University

CAS-EurASc Frontier Forum on Marine Science and Technology

Dates and place

18-19 November 2024

Forum held in Shanghai and on-line via Zoom.

Forum link (for audience):

https://us02web.zoom.us/j/86410274649

Meeting ID: 86410274649

Password: 651740

Chairs

Prof. Paul Tréguer, University of Western Brittany, France

Prof. Jing Zhang, East China Normal University/Shanghai Jiao Tong University, China

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European Academy of Sciences, Chinese Academy of Sciences

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Description

The CAS-EurASc Frontier Forum on Marine Science and Technology co-sponsored by the Earth Sciences Divisions of the Chinese Academy of Sciences (CAS) and the European Academy of Sciences (EurASc) aims to provide a platform for marine scientists and engineers in China and Europe to share their knowledge and experience of frontier research methods and results, and to foster international and interdisciplinary collaboration.

The Forum dedicates special focus of a dialogue between scientists from China and Europe, which will be also delivered online and open to the general public. The keynote speakers are all scientists who are actively engaged in state-of-the-art research in various aspects of this field.

In order to synthesize an understanding of progress in marine science and technology, and determine priority areas for cooperation that will provide a basis for a future research agenda, the Forum consists of interactive sessions that include different aspects of oceanography, in particular multidisciplinary topics, as well as presentations that reflect new and emerging research on the ocean and society.

The themes of the four sessions are:

- **Session One:** AI and Twin Oceans
- **Session Two:** Ocean Ecosystems and Carbon Cycle
- **Session Three:** Coastal Ocean and Sustainability of Society
- **Session Four:** Ocean Technology and Observations

The Forum will be held online from 8:30 to 14:30 (CEST) to accommodate the time difference between China and Europe.

Program

2024/11/18, Monday			
08:00-08:30 (CET)	15:00-15:30 (Beijing)	**Opening ceremony & Group photo**	
Theme1. AI and Twin Oceans: Co-Chair: Yan Du, Pierre Tandeo			
08:30-08:50 (CET)	15:30-15:50 (Beijing)	The digital twin ocean: new advances for a wide range of user applications	Alain Arnaud
08:50-09:10 (CET)	15:50-16:10 (Beijing)	Developing a regional digital-twin-ocean system	Dake Chen
09:10-09:30 (CET)	16:10-16:30 (Beijing)	Applying deep learning for satellite altimetry mapping	Quentin Febvre
09:30-09:50 (CET)	16:30-16:50 (Beijing)	AI applications in the reconstruction of muti-scale ocean structure	Yan Du
09:50-10:10 (CET)	16:50-17:10 (Beijing)	Interpretable regression from the physics to the biogeochemistry in order to emulate regional indicators for unseen climate scenarios	Erwan Le Roux
10:10-10:30 (CET)	17:10-17:30 (Beijing)	AI Applications in Oceanography	Changming Dong
10:30-11:00 (CET)	17:30-18:00 (Beijing)	Discussion	
11:00-12:00 (CET)	18:00-19:00 (Beijing)	Break	
Theme 2. Ocean Ecosystems and Carbon Cycle Co-Chair: Yuntao Zhou, Louis Legendre			
12:00-12:20 (CET)	19:00-19:20 (Beijing)	Research Progress in Carbon Sink Fisheries in China Coastal Ocean	Qisheng Tang
12:20-12:40 (CET)	19:20-19:40 (Beijing)	Negative feedbacks of the Earth System to carbon dioxide removal and sequestration	Louis Legendre
12:40-13:00 (CET)	19:40-20:00 (Beijing)	Expanding global oxygen minimum zones restrict marine habitats under climate change	Yuntao Zhou
13:00-13:20 (CET)	20:00-20:20 (Beijing)	Role of ecosystem structure in shaping carbon dynamics in the ocean	Corinne Le Quéré
13:20-13:40 (CET)	20:20-20:40 (Beijing)	Progress of siliceous radiolarian observation in the Indo-Pacific Ocean and its application prospects	Lanlan Zhang
13:40-14:00 (CET)	20:40-21:00 (Beijing)	Outcomes and challenges of the active restoration of coastal ecosystems	Laura Airoldi
14:00-14:30 (CET)	21:00-21:30 (Beijing)	Discussion	

2024/11/19, Tuesday			
Theme 3. Coastal Ocean and Sustainability of Society Co-chair: Qing He, Anny Cazenave			
08:30-08:50 (CET)	15:30-15:50 (Beijing)	Sea Level Rise and its impact on coastal areas	Svetlana Jevrejeva
08:50-09:10 (CET)	15:50-16:10 (Beijing)	Big Remote sensing data for costal environmental research	Chenghu Zhou
09:10-09:30 (CET)	16:10-16:30 (Beijing)	Tropical Indian and Pacific Interbasin interactions enhance coastal sea level variability and extreme events in Recent Decades	Weiqing Han (pre-recorded)
09:30-09:50 (CET)	16:30-16:50 (Beijing)	Human-driven sediment regime shift processes in the turbid estuary system	Qing He
09:50-10:10 (CET)	16:50-17:10 (Beijing)	Sea-Level Science in Singapore and Southeast Asia	Benjamin P. Horton
10:10-10:30 (CET)	17:10-17:30 (Beijing)	Reducing the carbon footprint of aquaculture towards the carbon negative vision	Hui Liu
10:30-11:00 (CET)	17:30-18:00 (Beijing)	Discussion	
11:00-12:00 (CET)	18:00-19:00 (Beijing)	Break	
Theme 4. Ocean Technology and Observations Co-chair: Xinyuan Diao, Hervé Claustre			
12:00-12:20 (CET)	19:00-19:20 (Beijing)	The Large-scale Scientific Facility of Cold-seep Ecosystem	Si Zhang
12:20-12:40 (CET)	19:20-19:40 (Beijing)	Enhanced BGC-Argo Floats: New Scientific Applications and Response to Societal Needs	Hervé Claustre
12:40-13:00 (CET)	19:40-20:00 (Beijing)	Modular ocean trace elements sampling for the international GEOTRACES studies	Xinyuan Diao
13:00-13:20 (CET)	20:00-20:20 (Beijing)	Observing particle size at global scale using Biogeochemical Argo	Nathan Briggs
13:20-13:40 (CET)	20:20-20:40 (Beijing)	The Development and Application of China's Marine Satellites	Mingsen Lin
13:40-14:00 (CET)	20:40-21:00 (Beijing)	Towards autonomous observations of the ocean's carbonate pump	Griet Neukermanns
14:00-14:30 (CET)	21:00-21:30 (Beijing)	General Discussion	
14:30-14:50 (CET)	21:30-21:50 (Beijing)	Synthetic conclusions by sessions co-chairs, and general conclusions by Jing Zhang and Paul Tréguer	

Chairs

Paul J. Tréguer

Paul J. Tréguer is emeritus professor at the University of Brest (France). He is a marine biogeochemist who has expertise in nutrient cycles in coastal and open oceans, and in polar ecosystems. He is at the initiative of the SILICA International School (open in October 2020) and of the SILICAMICS network (third conference, Hangzhou, October 2021). From 2000 to 2008, he chaired/co-chaired/directed different international programs, including: the Southern Ocean – Joint Global Flux Study (SO-JGOFS) appointed by the International Geosphere Biosphere Programme (IGBP), and the Scientific Committee on Oceanic Research (SCOR), and the EUR-OCEANS Network of Excellence (NoE) on the impacts of global change on marine ecosystems. From 1991 to 2012, he founded and directed the "European Institute for Marine Studies" (IUEM), and the consortium Europôle Mer. Since 2000, he has been developing cooperative actions with Chinese universities or marine institutes, including: the Ocean University of China (Qingdao) and the Second Institute of Oceanography (Hangzhou). Paul J. Tréguer has received numerous prizes and honours, including: fellow of the American Geophysical Union AGU (2016), fellow of the Association for the Sciences of Limnology and Oceanography ASLO (2016), fellow of the European Academy of Sciences EurASc (2015), Honorary Doctorate from the University of Québec-Canada (2014), Georges Millot medal of the French Academy of Sciences (2013). Paul J. Tréguer is officer of the Legion of Honour (2017). He has published more than 150 refereed papers and several books. His book entitled "Oceans – evolving concepts" was published in 2020.

Jing Zhang

Jing Zhang, professor at Shanghai Jiao Tong University and East China Normal University, teaching chemical oceanography and biogeochemistry. His research work focuses on the behavior and the circulation of trace elements and biogenic elements in the ocean. His early work has concentrated on biogeochemical processes in estuaries and coastal waters, including the behavior and destination of chemical elements. Recently, he has attended many cruises in the tropical Western Pacific and equatorial Eastern Indian Ocean, focusing on the research about the distribution pattern, migration and transformation of trace elements and nutrients at different depth and in different sea areas, and understanding the intersection problems with different disciplines such as physics, biology.

Abstracts

Alain Arnaud

Alain Arnaud, head of the Digital Ocean department at Mercator Ocean international is a EurASc invited speaker. Karina von Schuckmann is a EurASc fellow.

Abstract

The digital twin ocean: new advances for a wide range of user applications

Alain Arnaud[1*] & Karina Von Schuckmann[1]

1 Mercator Ocean International, France

*** Corresponding author (email: aarnaud@mercator-ocean.fr)**

The Digital Twin Ocean (DTO) will give governments, researchers, businesses, activists, and citizens alike the power to make informed decisions, backed by science and data, to restore marine and coastal habitats, support a sustainable blue economy and mitigate and adapt to climate change. This will allow a wide range of users to interactively access comprehensive information to assess the impact of potential interventions in different ocean-based scenarios, help design the most effective ways to restore and protect marine and coastal habitats, support sustainable development, and foster climate resilience and adaptation. The European DTO's ambition is to make ocean knowledge, backed by science and data, readily available to all, to citizens, scientists and policymakers around the world, and as a platform for global cooperation. Mercator Ocean International (MOi) leader in the field of operational oceanography, is playing a leading role in the development of the European DTO. Federating partners and initiatives on the EU and international level, MOi ensures an inclusive and collaborative approach in building the digital framework, core model suite and virtual environment for the DTO. In this presentation, most recent developments and new advancements will be presented on the European DTO, including the integration of research project, thematic applications and local twins, or on the advancements for generating information tailored to specific needs, crucial in helping scientists, policy makers, national authorities, private industries and the public at large, understand the role humans and nature play in shaping the ocean's, and ultimately our planet's future.

Dake Chen

Dake Chen is a physical oceanographer and a member of Chinese Academy of Sciences. He worked as a professor at Columbia University and served as the director of the State Key Laboratory of Satellite Ocean Environment Dynamics for many years. Presently he is the director of the Southern Marine Science and Engineering Guangdong Laboratory (Zhuhai). His academic career has been devoted to oceanographic and climate research, with significant achievements in the areas of coastal ocean dynamics, large-scale ocean circulation, as well as climate variability. His current research interest includes tropical ocean-atmosphere interaction, theories of general ocean circulation, as well as polar ocean and climate. He is also serving in many scientific organizations and editorial boards, and playing an instrumental role in promoting programs of oceanic and polar research.

Abstract

Developing a regional digital-twin-ocean system

Dake Chen[1*]

1 Southern Marine Laboratory, Zhuhai, 519000, China

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For marine disaster prevention, environment protection and ecosystem-based management, a digital-twin-ocean (DTO) system is very much needed for coastal regions. Such a system, using a variety of cutting-edge technologies and integrating data and models, is being developed for the Guangdong-Hong Kong-Macao Greater Bay Area (GBA), which is an economic powerhouse in China and is one of the most prosperous bay areas in the world. Here we describe the smart observing/monitoring platforms and modeling/forecasting techniques used for our DTO construction, outline the structure and function of our DTO engine, and demonstrate the usability of our DTO system with a number of applications. The GBA DTO sets an example for the further development of DTO systems in China.

Quentin Febvre

Quentin Febvre is a research engineer at IFREMER Brest, the main oceanographic center in France. He is part of the Laboratory for Ocean Physics and Satellite remote sensing. He is a EueASc invited speaker.

Abstract

Applying deep learning for satellite altimetry mapping

Quentin Febvre[1*], Ronan Fablet[2], Julien Le Sommer[3] & Cément Ubelmann[4]

1 Laboratoire d'Océanographie Physique et Spatiale, Centre National de la Recherche Scientifique – Ifremer, Plouzané, France;

2 IMT Atlantique, Lab-STICC, UMR CNRS 6285, 29238, Brest, France;

3 Université Grenoble Alpes, CNRS, IRD, IGE, Grenoble, France;

4 DATLAS, Grenoble, France

*** Corresponding author (email: quentin.febvre@ifremer.fr)**

We present how advancements in deep learning can aid in the analysis of satellite measurements of sea surface height (SSH). Current altimeters provide data sampled in an irregular manner, limiting the observation of finer processes. Pushing this limit would enhance our climate monitoring capabilities. Exciting opportunities have emerged with the SWOT mission. Learning approaches have shown remarkable capabilities in many areas and this we discuss how they can be mobilized for altimetry data. We specifically address the scarcity of ground truth data when learning altimetry data interpolation methods. We illustrate how ocean model simulations and observation systems can overcome this challenge by providing supervised training environments that generalize to real data.

Yan Du

Dr. Yan Du is a senior scientist at the South China Sea Institute of Oceanology, Chinese Academy of Sciences, and a professor at the University of Chinese Academy of Sciences. His scientific interests include multi-scale dynamics of the ocean and climate, air-sea interaction, ocean circulation, and extreme weather/climate events. He has published ~200 SCI papers with more than 9,000 citations. He was listed in Elsevier's Highly Cited Chinese Researchers and The Reuters TOP 1,000 most influential climatologists in the world. He is serving as co-editor-in-chief of DAO and an editorial board member for six other international journals. He was awarded the Special Government Allowance of the China State Council, the Young Science and Technology Innovation Leaders from the MOST, the National Natural Science Foundation of China for Distinguished Young Scholars, and the Science and Technology Award for Chinese Youth. He is also a Chief Scientist of the new Doppler Satellite (prototype), leading the Ocean Surface Current multi-scale Observation Mission (OSCOM).

Abstract

AI applications in the reconstruction of muti-scale ocean structure

Yan DU[1*], Yuhong ZHANG[1], Mingyang WANG[1], Yating OUYANG[2] & Qin DUAN[2], Yineng LI[1], Shilin TANG[1], Xinwei, JIANG[3]

1 Guangdong Key Laboratory of Ocean Remote Sensing, State Key Laboratory of Tropical Oceanography, South China Sea Institute of Oceanology, Chinese Academy of Sciences, 510301, Guangzhou, China;

2 University of Chinese Academy of Sciences, 266400, Qingdao, China;

3 National Satellite Ocean Application Service, Beijing, China

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Ocean near-surface current has enormous energy, involving processes in multiple spatial and temporal scales. To date, in situ measurements of ocean current velocities are limited and sparse, and direct satellite measurements of the global ocean surface currents have not been realized. The widely used current data are the

geostrophic currents inverted from satellite sea surface heights and the currents back-calculated from the trajectories of surface drifters. These data sets do not meet the requirements for the study of non-equilibrium processes in the ocean, which may dominate over 50% of the heat flux in the upper ocean and 20-50% of the primary production. The emergence of AI and the age of “big data” presents significant opportunities for the study of oceanic non-equilibrium processes. In this talk, the possible applications of the reconstruction of multi-scale ocean structure are discussed in two aspects: ① High-resolution sea surface data obtaining, including temperature and chlorophyll inversions and diagnostics of the ocean surface current, etc; ② Sub-surface temperature, salinity, and current inversion based on surface satellite data.

Erwan Le Roux

Erwan Le Roux is a postdoc at IMT Atlantique in the Mathematical and Electric Engineering department. He is a EurASc invited speaker.

Abstract

Interpretable regression from the physics to the biogeochemistry in order to emulate regional indicators for unseen climate scenarios

Erwan Le Roux[1*], Pierre Tandeo[1], Carlos Granero Belinchon[1], Melika Baklouti[2], Julien Le Sommer[3], Romaric Verney[4], Florence Sevault[5] & Samuel Somot[5]

1 IMT Atlantique, Lab-STICC, UMR CNRS 6285, Brest, 29238, France;

2 Aix-Marseille Université, Université de Toulon, CNRS, IRD, MIO UM 110, 13288, Marseille, France;

3 Univ. Grenoble Alpes, CNRS, IRD, Grenoble INP, INRAE, IGE, Grenoble, 38058, France;

4 Ifremer, DYNECO, Hydrosedimentary Dynamics Laboratory (DHYSED), Brest, 29238, France;

5 CNRM, Université de Toulouse, Météo-France, CNRS, Toulouse, 31400, France

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Digital twins of the ocean are near real-time virtual representations of the ocean, combining artificial intelligence and advanced modeling. In this context, climate change risks are generally assessed with impact indicators provided for each climate scenario. These indicators, often defined as spatio-temporal average, are computed from impact models driven by existing climate data. However, computation costs of impact models can sometimes limit the number of explored scenario. We address this problem with a statistical approach that infers impact indicators for unexplored scenarios. Specifically, using explored scenarios, we estimate an interpretable equation that maps each year climate indicators to an impact indicator. This estimation can be decomposed in three steps: i) identification of groups of climate indicators ii) search of an

optimal set of equations for each group iii) selection of a single equation from all optimal sets. Our application is based on a biogeochemical model driven by a regional climate model (RCM) for two scenarios (RCP 4.5 and RCP 8.5). In the Gulf of Lion, we search for an equation that maps RCM variables averaged monthly to annual mean Net Primary Production (NPP).

Changming Dong

Dr. Changming Dong is the professor at School of Marine Sciences, Nanjing University of Information Science and Technology and also serves the school as the dean. Prof. Dong has broad research interests including oceanic dynamics, numerical modeling, laboratory GFD and AI oceanography. As the primary PI, Prof. Dong proposed to build the largest rotating tank in the world for the GFD study and it has been implemented this month. Prof. Dong has set up the first AI Oceanography Association in China in 2022 and serves as the chairman of the association. He has published over 190 peer-reviewed papers and 6 books.

Abstract

AI Applications in Oceanography

Changming Dong[1*]

1 School of Marine Sciences, Nanjing University of Information Science and Technology, Nanjing, China

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With the availability of petabytes of oceanographic observations and numerical model simulations, artificial intelligence (AI) tools are being increasingly leveraged in a variety of applications in oceanography. In this talk, these applications are reviewed from the perspectives of identifying, forecasting, parameterizing ocean phenomena and AI-based methods to solve N-S equations. Specifically, the usage of AI algorithms for the identification of mesoscale eddies, internal waves, oil spills, sea ice, and marine algae are discussed in this talk. Additionally, AI-based forecasting of surface waves, sea surface temperature, the El Niño Southern Oscillation, and storm surges is presented. This is followed by a discussion on the usage of these schemes to parameterize oceanic turbulence. Moreover, physics-informed deep learning and neural networks are discussed within an oceanographic context, and further applications with ocean digital twins and physics-constrained AI algorithms are described.

Qisheng Tang

Qisheng TANG is a fellow of the Chinese Academy of Engineering, and the incumbent Honorary President/Director and Chief Scientist of the Chinese Academy of Fishery Sciences/ Yellow Sea Fisheries Research Institute. With long-term engagement in research on the sustainable development and utilization of living marine resources, he pioneered the exploration of China's marine ecosystems (including Marine Ecosystem Dynamics and Large Marine Ecosystems) studies, and has conducted a number of innovative researches in fishery biology, stock enhancement and management, and aquaculture ecology. Focusing more on strategic consultation and studies in recent years, he has proposed new sustainable development concepts such as "Carbon Sink Fisheries", "Environmentally Friendly Aquaculture", "Resource Conservation Fishing Industry", and "Green Development of Aquaculture". He has published more than 350 peer-reviewed papers.

Abstract

Research Progress in Carbon Sink Fisheries in China Coastal Ocean

Qisheng TANG[1*]

1 Yellow Sea Fisheries Research Institute, Chinese Academy of Fishery Sciences, Qingdao 266071; State Key Laboratory of Mariculture Breeding and Sustainable Goods, Qingdao 266071 China;

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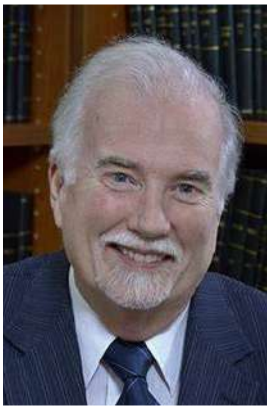
Since the significant carbon sink functions in shellfish and algae farming were discovered, study on carbon budget and ecology of major aquaculture species in China coastal ocean has received attention and gained new results (e.g., the second special issue on fisheries carbon sink, Progress in Fishery Sciences，2022，43 (5): 1-159). Major new achievements include: (A) The stock carbon budget model and new carbon sink terms were created. For example, the shellfish stock carbon budget model: total carbon sink (used carbon, 100%) = removed

carbon 21.5% + stored carbon 41.8% + released carbon 36.7%, net carbon sink 63.3% = total carbon sink 100% - released carbon 36.7%. (B) According to the stock carbon budget model and individual carbon content, the fisheries carbon sink measurement methods (including algae, shellfish and capture stock) were clarified. (C) The total carbon sink and net carbon sink in China coastal ocean fisheries were assessed. In 2020, the total carbon sink and net carbon sink of shellfish and algae aquaculture were 6.59 million t (equivalent to 885,000 hectares of compulsory afforestation per year) and 4.3 million t, and the total carbon sink and net carbon sink of capture fisheries were 49.83 million t (equivalent to 6.66 million hectares of compulsory afforestation per year) and 17.44 million t, respectively. Fisheries carbon sink has become the largest blue carbon in China coastal ocean. These new achievements provide an important scientific basis for promoting the development of carbon sink fisheries and carbon trading.



Louis Legendre

Louis Legendre is a fellow of the European Academy of Sciences, the Royal Society of Canada, Academia European and the Chinese Academy of Sciences (foreign member).

Abstract

Negative feedbacks of the Earth System to carbon dioxide removal and sequestration

Legendre, Louis[1*]

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Atmospheric CO_2 continues to rise by ~3 ppm annually. This increase has continued to enhance ongoing global warming, which should be limited to a global average of 1.5°C according to the 2015 Paris agreement. The only way to avoid crossing the 1.5°C global warming limit is to implement rapid, deep and sustained reductions of global emissions of CO_2 and other greenhouse gases. However, there will be residual CO_2 emissions from sectors that are difficult or costly to decarbonize, which, may be between 5 and 10 Gt CO_2/year when global energy and industrial CO_2 emissions reach net-zero. Compensating for residual emissions is the main target of carbon dioxide removal (CDR), i.e. removal of CO_2 from the atmosphere (capture) and durable storage it in Earth's reservoirs (sequestration).

Yuntao Zhou

Dr. Yuntao Zhou is an Associate Professor of School of Oceanography, Shanghai Jiao Tong University. She has investigated extreme environmental events including low dissolved oxygen levels, heatwaves, and cold spells in the open ocean over recent decades. Additionally, she has explored the historical habitat restrictions of marine species due to climate warming and deoxygenation. As the leading author, she has published approximately 20 papers in prestigious journals such as Geophysical Research Letters, Limnology & Oceanography, Limnology and Oceanography Letters, and Environmental Science & Technology.

Abstract

Expanding global oxygen minimum zones restrict marine habitats under climate change

Yuntao Zhou[1*], Hongjing Gong[1]

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*** Corresponding author (email: ytzhou@sjtu.edu.cn)**

Oxygen minimum zones (OMZs) are regions of the ocean where dissolved oxygen levels are extremely low, significantly affecting marine ecosystems with their expansion. Despite their significance, long-term dynamics of OMZ volumes across different depths and regions remain poorly understood due to limited observations. Moreover, the impact of OMZ expansion on the compression of marine animal habitats remains significantly underexplored. Addressing these gaps, we quantify the expansion and interannual changes of OMZs in horizontal and vertical directions from 1960 to 2022, using comprehensive multi-source observations. We demonstrate that the volume of global OMZ60 (i.e., dissolved oxygen < 60 μmol/kg) expanded by as much as 10 million km3, approximately comparable to two thirds of the volume of the Arctic Ocean. This expansion rate exceeds previous estimates by a factor of 10, highlighting a critical underestimation in current biogeochemical model predictions. Furthermore, our analysis indicates that the OMZs limit suitable habitats for most marine

species. This study not only contributes to our understanding of marine biogeography under changing climatic conditions but also underscores the critical need for conservation strategies that account for how shifts in oxygen levels due to climate change could fundamentally reshape marine ecosystems.

Corrine Le Quéré

Corrine Le Quéré is a fellow of the European Academy of Sciences and the Royal Society.

Abstract

Role of ecosystem structure in shaping carbon dynamics in the ocean

Le Quéré, Corrine[1]*

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Understanding how climate variability and climate change affects marine ecosystem dynamics and its cascading implications for the carbon cycle is a "known-unknown" that was highlighted in the past four Assessment reports of the IPCC. We present an overview of insights that have arisen from the development of global marine ecosystem models based on the representation of diverse organisms into Plankton Functional Types (PFTs). PFTs are represented in those models when they have an explicit biogeochemical role, distinct physiological, environmental, or nutrient requirements, and when they influence other organisms at scale. Increasing the number and diversity in PFTs in global models has, for example, helped identify the importance of slow growing zooplankton (e.g. krill) for maintaining a low chlorophyll concentration in the Southern Ocean summer and hence a good North/South chlorophyll ratio. Likewise, incorporating zooplankton calcifiers (e.g. pteropods) in models has helped show that CaCO3 dissolution above the lysocline was necessary to reproduce both biomass and production observations. This presentation will show how the representation of ecosystem structure in models shapes carbon dynamics at the global and regional scale.

Lanlan Zhang

Lanlan Zhang is a professor of South China Sea Institute of Oceanology, Chinese Academy of Sciences, and a member of Plaeontogical Society of China. She focus on interdisciplinary research on marine microorganism, marine ecology and paleoclimate and paleoenvironment. BS, Department of Biology, Qufu Normal University, China. PhD and MS, Marine Geology, South China Sea Institute of Oceanology, Chinese Academy of Sciences. Visiting scholar in Tohoku University, Japan. More than 50 papers published in Nature Communications, Marine Geology, Global Planetary Change, Deep Sea Research, and Continental Shelf Research and so on. Two monograph books published by Science Press, China. She has participated in more than ten oceangoing/offshore scientific research and observation voyages.

Abstract

Progress of siliceous radiolarian observation in the Indo-Pacific Ocean and its application prospects

Lanlan Zhang[1*], Xiawen Cheng[1] & Rong Xiang[1]

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As an important key functional group of the ocean, Marine micropaleontology not only plays an important role as a biological pump in the Marine biogeochemical cycle, but also a good carrier and recorder of important climate and Marine environment changes. Although the modern knowledge is very necessary and important for improving our recognition and explanation to disclose the sedimentary radiolarians and their relationship with environments. But lots of knowledge of the spatial distribution and their relationship with kinds of environmental factors are unknown yet. So, it seems that increasing the modern study is becoming more and more urgent.

Based on the above study background, we provided three questions: what are modern shallow radiolarians in the western North Pacific? How are their distributions and relationship with environments? How are their probable photosynthetic microbiota by focusing on fluorescence from radiolarian cells and their associations under epi-fluorescence microscopes?

It was found that radiolaria silicae species had different symbionts and zonal differences, reflecting their specific interspecific differences and survival strategies.

This study provided the depth distribution pattern of different species in the East Equatorial Indian Ocean. Temperature dominated the species variation from surface to deep layer. The abundance of species corresponded with controlling factors at each depth. The taxa were similar in the euphotic and deep layer at both stations, indicating their consistent hydrologic properties of high chlorophyll in the euphotic layer and high silicate in the deep layer. Water masses with different salinities led to differences in intermediate species composition at each station. Taxa corresponding to different water masses can apply as indicators of the water masses evolution.

Significance: This study improved understanding of the diversity of species in the deep sea, provide data support for deep sea silicon flux, and found an index for the evolution of water masses.

Breadth: The scientific interest of our work is across marine biology, biogeochemical cycles, paleoecology and oceanography.

• Radiolarians indicate a two-layer water structure in the Okinawa Trough, consisting of shallow water (0-200 m) and intermediate water (200-1600 m).

• This two-layer water structure is influenced by the Kuroshio Current (KC) and North Pacific Intermediate Water (NPIW).

• The KC strengthened in the early Holocene, weakened in the middle Holocene, was the weakest during 4-2 ka, and has strengthened since 2 ka.

• The NPIW was extremely strong during Heinrich Stadial 1 (HS1) and Younger Dryas (YD), and was the weakest during 4-2 ka like the KC.

• Weak low-latitude KC signal, Radiolarian Minimum Event, may have influenced the NPIW at high latitudes.

• In the North Pacific, variations in the northward circulation in the upper ocean and southward transport of intermediate water critically alter the vertical stratification of the ocean at the basin scale. The radiolarian assemblages in a sediment core from the Okinawa Trough presented here indicate a two-layer water structures influenced by the KC and NPIW. The KC strengthened at ~11.7-8.2 ka, weakened at 8.2-2 ka, and strengthened after 2 ka. In contrast, the NPIW was strongest during the HS1 and YD. The abundances of shallow-water and intermediate-water assemblages both show low-value anomalies during 4-2 ka, reflecting a weak KC and weak NPIW. Based on the available data, we conclude that the weakening of the KC during 4-2 ka reduced northward salt transport, resulting in decreased salinity, decreased density, and enhanced water stratification in the high-latitude northwest Pacific Ocean, thus the weakening NPIW.

Laura Airoldi

Laura Airoldi is a fellow of the European Academy of Sciences and a member of the Academy of Sciences of Bologna Institute, Italy.

Abstract

Outcomes and challenges of the active restoration of coastal ecosystems

Airoldi Laura[1,2*]

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Coastal human population and demand for resources is rising rapidly, and so is the human footprint on the global ocean. Against this background of profound and rapid deterioration, ecosystem restoration is emerging as a management strategy that can provide realistic, context-specific trajectories to combat and reverse habitat and biodiversity loss, as encouraged by the UN Decade on Ecosystem Restoration (2021–2030). I will introduce a conceptual framework for designing restoration as a "nature-based" approach to pressing societal challenges, such as climate mitigation and adaptation. Using the extensive restoration actions carried out in Venice lagoon over the past 40 years as a case study system as well as other restoration efforts globally, I will show how restoration can provide desirable (yet perfectible) outcomes in terms of spatial quality, biodiversity values, and ecosystem functioning. I will also explore what factors can maximise the effectiveness and predictability of restoration outcomes, and highlight research gaps and challenges to increase the short-and long-term success of conservation and rehabilitation efforts in increasingly urbanised marine areas.

Svetlana Jevrejeva

Svetlana Jevrejeva is a sea level scientist working at the Marine Systems Modelling group, National Oceanography Centre (NOC), UK. She is an internationally acknowledged sea level expert, a Lead Author of Chapter 13 (Sea Level Change), Working group 1, Fifth Assessment report of Intergovernmental Panel on Climate Change (AR5 IPCC). Svetlana Jevrejeva is a Member of the World Climate Research Programme (WCRP), contributing to the Safe Landing Climates Lighthouse Activity as a Member of Sea level group. She is a member of the Intergovernmental Oceanographic Commission (IOC) Global Observing Sea Level System (GLOSS) Group of Experts.

Svetlana specializes in the synthesis of observations and models for advanced understanding of physical mechanisms for global and regional sea level rise and variability, their impact in coastal areas, changes in tropical cyclones in warming climate and extreme sea levels. With her research and publications Svetlana Jevrejeva has made a distinct contribution to sea level science, with more than 90 papers published in high impact journals, reflected in high number of citations (>20000). Svetlana Jevrejeva engages with stakeholders, policy makers and the international scientific community to translate advances in sea level science into impact and bring societal benefit.

She is a EurASc invited speaker.

Abstract

Sea Level Rise and its impact on coastal areas

Svetlana Jevrejeva[1*]

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Coastal zones contain large human populations, significant socio-economic activities and fragile ecosystems. With climate change and sea level rise coastal communities, infrastructure and services are particularly exposed to rising sea levels, facing increasing risk of more frequent and severe coastal inundation, leading to huge economic losses. Up to 90% of increases in magnitude of extreme sea levels are driven by future sea level rise. In tropical areas the present-day 100-year return period for extreme sea levels would be experienced at least once a year by 2030-2040.

In my presentation I will provide estimates of economic costs due to flooding for global coastline and World Bank income groups. If warming is not kept to 1.5 °C, but follows a high emissions scenario, global annual flood costs without additional adaptation could increase to US$ 27 trillion per year for global sea level rise by 2100. Countries in South East Asia are particularly vulnerable, and projected to experience the largest increase in annual flood costs. Adaptation could potentially reduce sea level induced flood costs by a factor of 10.

Future sea level rise, and changes in magnitude and frequency of extreme sea levels undermine the resilience of coastal communities and ecosystems and reduce the time for post-event recovery. Scientific evidence is critical to underpin the decisions about adaptation options.

Chenghu Zhou

Chenghu Zhou is a professor at the Institute of Geographic Sciences and Natural Resources, Chinese Academy of Sciences (CAS), and an Academician of the Chinese Academy of Engineering.

He is mainly engaged in the research of remote sensing and GIS and its connection with geoscience, including knowledge mining of spatial data, geological intelligent computing, numerical simulation analysis and evaluation of information systems of flood disaster, geological analysis and application of remote sensing images.

He has established a quantitative remote sensing analysis model of geomorphic entities and a digital geomorphic mapping technology. Furthermore, he has established a global discrete geographic grid model for hydrological spatial and temporal data, developed application models such as river hydrological process simulation and risk assessment.

He has published more than 300 academic papers, including more than 70 SCI papers, 19 academic monographs and atlases, and more than 7,300 citations by domestic and foreign peers.

He has won 15 national and provincial science and technology awards, including 5 national science and technology progress awards and 4 provincial and ministerial science and technology awards.

Abstract

Big Remote sensing data for costal environmental research

Chenghu ZHOU[1*]

1 State Key Lab for Resource and Environmental Information System, Institute of Geographical Science and Natural Resources Research of CAS, Beijing

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As a critical belt, coastal zone plays a key role in global change and regional sustainable development. It is urban agglomeration area, economic prosperity area and social developed area, also environmental sensitive area. Therefore, utilization of huge amounts of remote sensing data to monitor environmental change, assess environmental impact become the frontier and important topics in coastal zone studies. We choose the

Guangdong-Hong Kong-Macao Greater Bay area as the study area and applied multi-sources remote sensing images to monitor the changes of urban development, near ocean environmental pollution, et al. The results show that large synchronous coverage of remote sensing data can be effectively used in revealing coastal change characteristics and prefeatures.

Weiqing Han

Weiqing Han is an EurASc invited speaker. She is a professor in the Department of Atmospheric and Oceanic Sciences, the University of Colorado at Boulder, USA.

Abstract

Tropical Indian and Pacific Interbasin interactions enhance coastal sea level variability and extreme events in Recent Decades

Weiqing Han[1*] & coauthors

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Sea surface High EXtreme (HEX) events and marine heatwaves (MHW) have increasing impacts on human society and marine ecosystems in a changing climate. By analyzing in situ and satellite observations, reanalysis data, CMIP6 model simulations and performing climate model Pacemaker experiments, we detected intensified decadal variability of sea level and sea surface temperature (SST) in the eastern Indian and western tropical Pacific Oceans - where coasts and multitude islands exist - since the mid-1980s and understand their causes. While greenhouse gas warming increased SST over the Indo-Pacific warm pool, we find that tropical Indian Ocean SST anomalies (SSTA) induced by volcanic eruptions intertwin with the Interdecadal Pacific Oscillation (IPO) to enhance/weaken the easterly trade winds in the western tropical Pacific, causing intensified decadal sea level anomalies (SLA) and SSTA over the western tropical Pacific, which subsequently induce enhanced SLA and SSTA in the southeast Indian Ocean near the west Australian coast via both atmospheric bridge and oceanic connection. While the interplay between global sea level rise and interannual-to-decadal climate variability caused the increased no. of HEXs along the Indonesian coasts of the Indian Ocean in the past decade, the interbasin interaction intensified the interannual SLA and SSTA amplitudes in the southeast Indian Ocean off the west coast of Australia in recent decades, causing enhanced the Ningaloo Nino events – MHWs that occur near the west Australian coast.

Qing He

He Qing is a professor at East China Normal University and the Director of the State Key Laboratory of Estuarine and Coastal Research. She has long been engaged in basic research on estuarine and coastal sediment dynamics, specializing in the water-sediment transport and morphological changes in estuaries and deltas and their engineering applications. She has led numerous national and provincial projects, including key projects funded by the National Natural Science Foundation of China (NSFC), major international cooperation research projects of NSFC, and major projects of the Shanghai Science and Technology Commission. Under her leadership, the research team has made innovative achievements in understanding the mechanisms of sediment dynamics and geomorphic evolution in the Yangtze river basin–estuary–nearshore driven by human activities and in applying these findings to national deep-water channel engineering. She currently serves as the chief scientist of the United Nations "Ocean Decade" Mega-Delta Program and is the president of the Coastal and Estuarine Branch of the Chinese Society of Oceanography and the Chinese Association for Oceanography and Limnology. She is also the director of the Yangtze River Delta Protection and Development Committee of the Yangtze River Economic Technical Society, deputy director of the Estuarine Professional Committee of the Chinese Hydraulic Engineering Society, and deputy director of the Estuarine Management and Protection Professional Committee of the Chinese Hydraulic Engineering Society. She is a member of the World Association for Sedimentation and Erosion Research (WASER) and the Scientific Steering Committee of the International Conference on Cohesive Sediment Transport Processes (INTERCOH), as well as an associate editor of the International Journal of Sediment Research (IJSR).

Abstract

Title Human-driven sediment regime shift processes in turbid estuary system

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Fluvial sediment supply has been decreasing significantly in estuaries worldwide, leading to sinking deltas, wetland loss, and navigational and ecological problems. The Yangtze Estuary has experienced a gradual decline in riverine sediment supply since the mid-1980s, followed by an accelerated decline to the present-day amount of 75% since 2003. Consequently, the hydro- morphodynamic changes in the estuary have raised much concern. To understand the hydro-morphodynamic response systematically, we have collected the long-term water and sediment discharges, suspended sediment concentrations (SSC), satellite images, and bathymetry maps. We also set up numerical models to understand the mechanisms behind. The results suggest that the hydro-morphodynamic response varies in different parts of the estuary. The inner estuary responds much faster than the mouth zone, with a decline in SSC by 70% since 2003 accompanied by erosion. In contrast, the mouth zone shows high SSC with a decline in SSC of 50% since 2013 and sustains accretion on higher tidal flats for a long term. We quantify a morphological time lag of ~30 years in the mouth zone in response to the rapid sediment decline. Especially in the navigation channel (North passage) in the mouth zone, the surface SSC decreases whereas the near-bed SSC increases, leading to enhanced vertical sediment-induced density gradients, which may even be larger than the vertical salinity-induced density gradients. Such a large vertical sediment-induced density gradient enhances stratification and causes a reduced hydraulic drag by 60% with SSC of 10-80 g/L, resulting in turbulence damping and then tidal amplification, which further favors sediment import with higher SSCs. This positive feedback between sediment-induced density gradient and hydrodynamics is mainly triggered by the channel deepening and diking, which play an important role in the intensive siltation in the navigation channel. Overall, the hydro-morphodynamic response to reduced sediment supply in the Yangtze Estuary suggests significant time lag effects, which should be considered in a systematic way, and future work still needs further close monitoring.

Benjamin P. Horton

Professor Benjamin Horton EurASc invited speaker. Professor Benjamin Horton is the Director of the Earth Observatory of Singapore and a professor at the Asian School of the Environment in Nanyang Technological University (NTU). He is lead Principal Investigator of the Climate Transformation Program of Singapore. He has been appointed the AXA-Nanyang Professor in Natural Hazards.

Prior to joining NTU, Professor Horton was Professor at Rutgers University and Associate Professor at the University of Pennsylvania. Professor Horton obtained his BA from the University of Liverpool, UK, and PhD from the University of Durham, UK.

Professor Horton has received a number of awards in his career. In 2019, he was appointed the President's Chair in Earth Sciences at NTU for outstanding achievement. For excellence in research he received the Plinius Medal from the European Geosciences Union, the Voyager Award from the American Geophysical Union, and the W. Storrs Cole Award from the Geological Society of America. He was elected Fellow of the Geological Society of America and the American Geophysical Union.

He was a Review Editor for the Intergovernmental Panel on Climate Change (IPCC) 6th Assessment Report and was an author of the 5th Assessment Report. Professor Horton's research was cited by President Obama in his 2015 State of the Union Address at the United States Capitol on January 20th 2015. He also actively contributed to the COP26 conference: he led the COP26 report on managing disaster risks from natural hazards in ASEAN. He was also appointed Mentor for the Commonwealth Futures Climate Research Cohort to guide a group of researchers working towards solutions for climate-vulnerable communities in the lead-up to COP26.

Professor Horton has published over 260 articles in peer-reviewed journals, including 40 articles in high profile journals such as Science, Nature, and Proceedings of the National Academy of Sciences. Professor Horton is supervising or has supervised 28 students to the degree of PhD and 24 postdoctoral scientists, of which 20 now have permanent academic positions. His H-index is 80 and he has >19,000 citations.

Professor Horton's research concerns sea-level change, with the aim of understanding and integrating the external and internal mechanisms that have determined sea-level changes in the past, and which will shape such changes in the future. His research impacts upon important ecological, ethical, social, economic and political problems specifically facing coastal regions.

Abstract

Sea-Level Science in Singapore and Southeast Asia

Benjamin P. Horton[1,2*], Emma Hill[1,2], David Lallemant[1,2], Aron Meltzner[1,2], Adam Switzer[1,2].

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Sea-level rise through to 2050 is fixed. Singapore is looking at 14 to 35 centimeters of sea-level rise through the middle of the century, given the long-drawn impact of global warming on the oceans and ice sheets. Beyond 2050, sea-level rise becomes increasingly susceptible to the world's emission choices. If countries choose to continue their current paths, greenhouse gas emissions will likely result in ~3°C of warming by 2100, and a sea-level rise of up to 1.15 metres in Singapore. Rapid ice sheet loss from Greenland and Antarctica could lead to a sea-level rise approaching 2.12 metres by 2150.

Using case studies from the Southeast Asia Sea Level (SEA2) program from Singapore and Southeast Asia, we illustrate the ways in which current methodologies and historical and geological data sources can constrain future projections, and how accurate projections can motivate the development of new sea-level research questions to mitigate and adapt to climate change. For example, we estimate the influences of vertical land motion on sea-level projections for major cities. We show that cities experiencing the fastest rates of land subsidence are concentrated in Asia and these cities also have more variable VLM than assumed by the IPCC. Further, we project the impacts of tropical cyclones in a warming climate. We project the cities of Hai Phong (Vietnam), Yangon (Myanmar), and Bangkok (Thailand) will have increases in peak tropical cyclone intensity and durations. And finally, we focus on the implications of rising sea levels to coastal ecosystems. With 3°C of warming, nearly all the mangrove forests and coral reef islands would be beyond their sea-level rise tipping point for survival.

Hui Liu

Hui Liu, Ph.D. in Aquatic Biology from Ocean University of China; Senior Scientist of Yellow Sea Fisheries Research Institute, Chinese Academy of Fishery Sciences; European Union Marie Curie Fellow, and member of the Working Group on Environmental Impact of Aquaculture - International Council for the Exploration of the Sea (ICES-WGEIA). Having been engaged in research on marine aquaculture and aquaculture ecology for over 30 years, I have chaired more than 20 projects of the national and provincial level, incl. Key International Scientific and Technological Innovation Cooperation Programme of the Ministry of Science and Technology, and general project of National Natural Science Foundation of China. I have also jointly led or participated in more than 40 international and domestic research projects, such as the 6th and 7th Framework Programme of the European Union and the Horizon 2020 Programme. I have participated in a large number of policy and strategic studies, including those commissioned by the China Council for International Cooperation on Environment and Development (CCICED), the Chinese Academy of Sciences and the Chinese Academy of Engineering, the State Oceanic Administration and the Ministry of Agriculture, etc. I have published over 80 books/book-chapters and peer-reviewed papers, received 9 Chinese invention patents, and 5 scientific and technological awards including the first prize of Shandong Province Marine Science and Technology Innovation Award and the second prize of Science and Technology of China Academy of Fishery Sciences.

Abstract

Reducing the carbon footprint of aquaculture towards the carbon negative vision

Hui Liu[1*]
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The ocean offers a wide array of potential climate mitigation options that can contribute to carbon neutrality goals, including, but not limited to, the grooming of carbon efficient ecosystems (“blue forests”), the use of the

ocean's inherent energy potential, minimizing the carbon footprint of ocean-based activities such as marine fisheries.

Capture fisheries and aquaculture in the oceans are indispensable pillars of global food security and nutrition security, and these activities also emit significant amounts of GHGs. However, marine aquatic foods generally have lower GHG emission intensity per unit compared to terrestrial animal protein sources. The carbon footprint of mariculture is more complex and includes three components: on-farm, upstream (represented by feed production), and downstream (represented by processing and transport), where the upstream and downstream emissions are often greater than the farming process itself. For a more systematic view of the carbon footprint of mariculture, the loss of carbon sinks due to the encroachment of farming practices on typical coastal blue carbon ecosystems such as mangroves and salt marshes should also be considered. An inventory study shows that the global carbon footprint of aquaculture (both marine and freshwater) is 263 million tonnes of CO2 equivalent per year, which is the same magnitude as that of capture fisheries, with feed use and energy consumption being the largest source of carbon footprint; however, this statistic only account for fish, shellfish and shrimp farming, not including emissions downstream of the industry.

Carbon accounting for marine fisheries faces a variety of challenges, including data acquisition and accuracy issues, complexity of accounting methods, and technical and policy barriers. In terms of data acquisition, the difficulty, cost and lack of data precision directly affect the accuracy of the accounting results; carbon accounting is usually complex, and requires different methods for different stages, such as LCA and carbon footprint calculation, while indirect carbon emissions should also be considered. The challenges presently include inconsistent accounting boundaries, lack of unified standards and norms etc., making it difficult to compare and synthesize the results of different studies.

Reducing the carbon footprint of marine food production has become a hot topic for sustainable development, and is key to forming a climate-smart global food production sector. In the field of mariculture, the biggest opportunity lies in strengthening research on the potential for macroalgae and shellfish farms to act as carbon sinks and accelerating the implementation of incentive policies such as fisheries carbon trading, so as to further promote farming practices with carbon sequestration and ecosystem restoration functions. In addition, promoting the development and application of alternative feeds to reduce the upstream carbon footprint of fed mariculture, and building supporting processing and distribution networks in aquaculture clusters to reduce the downstream carbon footprint of the whole industry are both highly operational carbon reduction initiatives.

Si Zhang

Prof. Zhang Si is a member of the Chinese Academy of Engineering and Director of the Southern Marine Science and Engineering Guangdong Laboratory (Guangzhou). He is a distinguished scientist in the field of marine ecological engineering.

He focuses on the core scientific and technological issues of “eco-environmental effects of the active compositions of tropical marine organisms and its utilization” and “ecological security of the reef islands in the South China Sea and the Guangdong-Hong Kong-Macao Greater Bay Area”. He has created the ecological engineering theory of the chemical ecology of tropical marine life and developed key technologies for the green utilization of bioactive substances from tropical marine life. These achievements have reduced the sources of marine pollution and promoted the green utilization of marine bio-resources.

He has made significant theoretical and technical achievements in the development of the ecological coast (biological coast) of the reef islands in the South China Sea. Furthermore, he has made outstanding contributions to revealing the land-ocean interaction in the GHM Greater Bay Area and the material evolution in the deep sea. These achievements have provided an irreplaceable technological basis to support the secondary natural development of reef islands and laid a solid foundation for ecological security and sustainable development in the South China Sea. In addition to the above theoretical and technical achievements, he has constructed an innovation platform for tropical sea ecological engineering, which is the key foundation for promoting the sustainable development of engineering technology.

He has published 400 journal papers (300 papers published in SCI journals) and 3 books, acquired 100 authorized patents (including 20 PCT patents). The scientific research team led by him received the top commendation from the CPC Central Committee and the State Council in 2018. He has also received the Award for Outstanding Contribution to Science and Technology in Guangdong Province, the National Award for Excellence in Innovation, the National Technological Invention Award, the National Science and Technology Progress Award, the 15th China Patent Excellence Award and the Ho Leung Ho Lee Prize for Science and Technology Innovation, among others.

Abstract

Cold Seep Ecosystem Large Research Infrastructure

Zhang Si[1*]

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The Cold Seep Ecosystem Large Research Infrastructure, is a major national science and technology infrastructure of the “14th Five-Year Plan”, consisting of three main components: the Seafloor Laboratory, High-Fidelity Simulator, and Supporting Center. The Seafloor Laboratory operates at a maximum depth of 2,000 meters, accommodates up to six crew members, and has a displacement of approximately 600 tons. It can remain on the seafloor for up to 30 consecutive days, allowing for comprehensive, in-situ ecological precision monitoring and sampling, as well as biological and ecological experiments under original and gradient pressures in the cold seep areas. The High-Fidelity Simulator comprises a cold seep–natural gas hydrate coupling evolution simulation system, a control and support system, and a scientific research system. It operates at a maximum pressure of 20 MPa, with the spherical chamber of the cold seep module having an inner diameter of 5 meters, the cylindrical chamber having an inner diameter of 3 meters, and the total water height being 15 meters. The natural gas hydrate module has an inner diameter of 3 meters and a height of 3.6 meters. This system enables high-fidelity simulation of the full range of eco-environmental factors in cold seep ecosystems and the natural gas hydrate extraction processes. The Supporting Center mainly consists of a surface support mother ship as well as a research and intelligent management center. Its primary function is to support the routine operation, maintenance, and scientific research activities of the cold seep facilities. The surface support mother ship has a displacement of approximately 9,500 tons, with an overall length of around 130 meters. It features DP2-class dynamic positioning, a lift deck area of 320 square meters, and an open deck area of around 550 square meters. It is the first vessel in China capable of providing operational support for a 600-ton-class seafloor laboratory, primarily serving the transportation, deployment, retrieval, surface monitoring, energy and material resupply, and personnel rotation needs of the Seafloor Laboratory.

Cold seeps are fluid systems formed by methane leakage from the decomposition of natural gas hydrates on the deep seafloor, serving as a crucial window into the transformation of methane phases and ecosystem evolution. The cold seep ecosystem, often referred to as an “oasis in the deep-sea desert”, offers a critical breakthrough in frontier life science revealing the food webs and metabolic patterns of life in extreme deep-sea environments. It is featured by the chemosynthetic processes and biological carbon fixation that occur in the high-pressure, dark, methane-rich conditions of the deep sea, making it a key system for deep-sea biological carbon sequestration. Methane plays a vital role in linking the deep-sea carbon cycle, and the deep ocean is the largest methane reservoir across the globe, playing a significant role in the global carbon cycle and its ecological

effects. The carbon sources for free methane primarily include deep thermogenic and biogenic processes, known as the “two sources”. Methane’s carbon sinks—biological, chemical, and physical fixation—are referred to as the “three sinks”. Therefore, it is essential to understand the “two sources and three sinks” of deep-sea methane and the mechanisms of chemosynthetic carbon fixation. Furthermore, it is urgent to comprehend the state and trends of methane before and during the extraction of hydrocarbon resources, such as natural gas hydrates, from the seafloor!

The cold seep ecosystem exhibits distinctive characteristics known as the “Three Rapid and One Indigenous” traits. These include: the rapid decomposition of natural gas hydrates when removed from their in-situ phase equilibrium environment, the rapid response of deep-sea microorganisms to environmental changes through gene expression regulation, the rapid genomic changes of microorganisms like ammonia-oxidizing archaea in non-in-situ environments, and the pronounced indigenous nature of organisms inhabiting cold seep areas. Long-term in-situ research at designated plots is a crucial and reliable method for exploring deep-sea cold seep life and the ecological effects of deep-sea methane. Based on in-situ quantitative monitoring and on-site experimental studies, High-Fidelity Simulation is a crucial tool for studying the evolution of cold seeps and the phase transformation of deep-sea methane. The Cold Seep Ecosystem Large Research Infrastructure focus on major scientific questions, such as the life strategies driven by chemosynthesis under high-pressure, methane-rich conditions, the formation and evolution of deep-sea hydrocarbon resources, and their ecological and environmental effects. The Large Research Infrastructure is designed with an approach of “field experiments + land-based simulation, with sea-land coordination and spatiotemporal interchange”. This functions as powerful research means that integrates long-term in-situ seafloor experimentation with high-fidelity land-based simulation to study the deep-sea cold seep ecosystem.

Hervé Claustre

Hervé Claustre is CNRS Senior Scientist at LOV. His research is dedicated to the development of interdisciplinary approaches at the frontiers of marine biology, chemistry and optics for the study and understanding of biogeochemical processes ranging from small to global scales. For more than 20 years a large part of his efforts has been dedicated to the development of new observational approaches, largely based profiling floats. He is presently the co-chair of the BGC-Argo program.

He is a EurASc invited speaker.

Abstract

Enhanced BGC-Argo Floats: New Scientific Applications and Response to Societal Needs

Hervé Claustre[1*]

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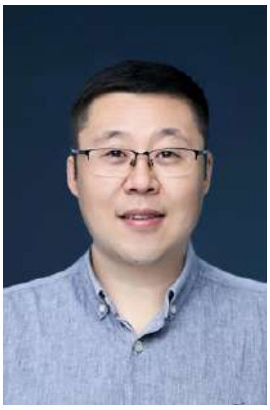
The BGC-Argo mission broadens the scope of the OneArgo program by enabling global monitoring of key biogeochemical processes and their evolution in response to climate change. This is achieved through the measurement of six variables in the 0-2000 oceanic layer: oxygen, nitrate, pH, irradiance, chlorophyll-a and suspended particles.

Through several EU-funded projects, our group has progressively enhanced the capabilities of BGC-Argo floats that now provide more energy and support additional sensors. To date, over 20 of such floats have been deployed across various open-ocean regions. This presentation will highlight some initial results, focusing on: (1) the Underwater Vision Profiler (UVP), which quantifies particle size distribution; (2) a transmissometer, acting as an optical sediment trap; and (3) a dual hyperspectral sensor, measuring both downwelling irradiance and upwelling

radiance within the ocean's illuminated layer. The potential of these enhanced BGC-Argo floats is clear, opening new pathways for better understanding and quantifying the biological carbon pump and its connection to subsurface ecosystem drivers.

These floats also hold the potential to integrate additional sensors, such as passive acoustic sensors (for monitoring marine mammals and meteorological conditions) and active acoustic sensors (for studying macroplankton and small fish). In the future, such multidisciplinary platforms could become crucial for supporting science-based governance of open-ocean regions, especially in relation to marine carbon dioxide removal (mCDR) strategies or the management of high seas marine protected areas.



Xinyuan Diao

Dr. Diao xinyuan, Researcher of The Key Laboratory of Ocean Circulation and Waves, Institute of Oceanology, Chinese Academy of Sciences, has been engaged in Ocean circulation of Coastal China Sea and the Investigation Technology.

He focuses on the typical phenomena of the Coastal China Sea. Using the new observing methods or facility, he and his team reveal the formation, development and evolution of the Yellow Sea Cold Water mass and the Yellow Sea Warm Current, especially in the spring and autumn. He is very familiar with the development of the investigate instrument, and conduct the development of several new observing system.

He presided many national key research and development projects, National Natural Science Foundation, and the Strategic Priority Research Program of the Chinese Academy of Sciences. As the chief scientist, he conducts dozens of marine survey and over 1000 days at sea. He has published more than 70 academic papers and patents.

Abstract

Modular ocean trace elements sampling for the international GEOTRACES studies

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Zhang and a group of engineers and researchers from Shanghai and Qingdao are presenting the modular trace element sampling facility that they have developed (MOTES). Vertical profiles of lead and iron, two trace metals particularly prone to contamination, are also shown to attest the reliability of MOTES.

The advantages of MOTES are that the improved Niskin-X sampling bottles could remain closed on the deck and open underneath the sea surface, and there is no need to remove and assemble the samplers during the whole process of sampling and filtration. Above the titanium CTD frame the Niskin-X bottles installed on, there is only a plastic-coated coaxial communication cable (12000 m) to minimize disturbance to the water column and potential contamination in the up-cast lift. There are three modular components in the facility, the winch system, the clean room and the L frame. The stainless-steel winch system and the clean room dedicated to sampling, and sample transfer and filtration are both installed in the standard-sized clean container which are very convenient to move. The hub part of winch system which contact with cable is cladded by nylon to avoid potential contaminations. The L frame system is installed in the 10 ft standard-sized container base. Last but not least, the three modular components can be detached for land transportation and reassembled on the deck of research vessels for sea-going cruises. Note also that the design concept can be adapted for other types of applications in a sea-going voyage, such as ships/cargo vessels and observational platforms, which require clean working conditions and must be self-sustaining in remote areas/situations.

Nathan Briggs

Nathan Briggs is a senior Researcher at the National Oceanographic center in Southampton in UK. He is a biological oceanographer and biogeochemist whose work primarily focuses on the uptake of carbon by ocean life and its fate in the mesopelagic zone. The main tools he uses for his research are robotic underwater “floats” and “gliders” equipped with bio-optical and biogeochemical sensors.

He is a EurASc invited speaker.

Abstract

Observing particle size at global scale using Biogeochemical Argo

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Marine particles play a central role in the ocean carbon cycle, as a large fraction of the ocean’s organic matter, both living and dead, is in particulate form. Global-scale, continuous observations optical backscattering, from both satellites and, more recently, Biogeochemical Argo, have greatly increased our ability to study marine particles and their role in global ocean processes. Optical backscattering measurements provide information on bulk particle concentration, but correspond primarily to “small” (<100 µm), suspended particles. Here use high-frequency fluctuations in the in-situ optical backscattering measurements to partition the Biogeochemical Argo particle dataset into multiple, quantitative size classes, ranging from 200-1000 µm. These larger particles play a critical role in global carbon cycle, as they can sink much more rapidly, driving long-term carbon storage in the deep ocean. We also present independent validation of this new particle size dataset using floats equipped with both optical backscattering sensors and particle imaging cameras.

Mingsen Lin

Dr. Mingsen Lin, Director, Researcher of the Key Laboratory of Space Ocean Remote Sensing and Applications of the Ministry of Natural Resources, Academician of the International Academy of Astronautics, Chair Professor at Tianjin University, Outstanding Visiting Scholar at Xiamen University, Vice Chairman/Secretary General of the Chinese Ocean Society, has been engaged in ocean remote sensing research and ocean satellite engineering construction. He has led the team to overcome the technical difficulties of China's ocean microwave remote sensing ocean dynamic environment parameter algorithm model, presided over more than 80 national key research and development projects, National Natural Science Foundation, National 863 Program, manned spaceflight, and ocean satellite ground system projects, and has achieved outstanding academic results in the research of microwave remote sensing sea surface wind field inversion mechanism, satellite data processing technology, and ocean satellite ground processing system construction. He has published more than 260 academic papers and monographs. 25 units. Received 1 second prize of National Science and Technology Progress Award, 1 special prize of provincial and ministerial level scientific and technological achievements, 9 first prizes, 8 second prizes, and 18 patents. Selected as a first level talent in the national "Hundred, Thousand, Thousand, and Ten Thousand Talents Project", awarded the title of National Excellent Science and Technology Worker, government special allowance, and first class merit once.

Abstract

The Development and Application of China's Marine Satellites

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This report will share that after more than 20 years of development, China's marine satellites have made great progress. Currently, there are 11 satellites in orbit, which have played an important role in China's marine disaster prevention and reduction, marine economy, marine ecological civilization construction, and marine security; In the operational application of ocean satellites, the focus will be on showcasing the application effects in ocean environment forecasting, ocean disaster warning, ocean ecological environment monitoring, global climate change, ocean resource investigation, and ocean spatial planning; Finally, introduce China's future marine development plan.

Griet Neukermans

Griet Neukermans is an Associate Research Professor and head of the Marine Optics and Remote Sensing Group within the Biology Department of Ghent University in Belgium. She is an oceanographer with fundamental and applied expertise in remote and in situ optical sensing of marine particles – the living and the non-living, the organic and the inorganic, from submicron to centimeter-size. Her research is situated at the interface of marine optics, biogeochemistry, and ecology.

She is a EurASc invited speaker.

Abstract

Towards autonomous observations of the ocean's carbonate pump

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The ocean's carbonate pump is a component of the biological carbon pump that concerns the transport of Particulate Inorganic Carbon (PIC) formed by calcifying plankton from the surface to deep ocean. Whereas recent technological advances are enabling observations and improved understanding of the organic carbon pump from BioGeoChemical-Argo floats, similar advances in the carbonate pump are limited by a lack of autonomous device to estimate PIC.

Here, we present first critical steps into the development of an autonomous PIC sensor, conceptualized as a submersible cross-polarized transmissometer. The operating principle is that PIC can be detected based on the depolarization of forward-scattered light induced by the birefringence of PIC. Laboratory calibrations with PIC from cultured calcifying phytoplankton reveals that the sensor can detect PIC in seawater across the oceanic

concentration range, as low as 0.06 µg PIC/L. We show linearity in the relationship between PIC and depolarization over three orders of magnitude.

A first prototype of the PIC sensor was integrated in a ship-based underway optical flow-through system on board the RRS Discovery in May-June 2024 in the Icelandic Basin. We conducted cross-comparisons with discrete water samples of PIC determined from the ICP-OES technique and present first field results including continuous underway PIC measurements in- and outside the annually recurring spring-summer coccolithophore bloom. Further developments are ongoing to make the PIC sensor suitable for vertical profiling on autonomous platforms.

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