CLIVAR-FIO Summer School

Report

GC Sea Level/CLIVAR-FIO Summer School

Past, Present and Future Sea Level Changes

25-30 June 2018, Qingdao-China

Background:

CLIVAR (Climate and Ocean: Variability, Predictability and Change) is one of the four core projects of the World Climate Research Programme (WCRP). The goal of CLIVAR is to improve understanding and prediction of ocean-atmosphere interactions and their influence on climate variability and change, to the benefit of society and the environment.

With the strong emphasis of CLIVAR on capacity building in particular geared towards Early Career Scientist, and thanks to the support from the First Institute of Oceanography (FIO), State Oceanic Administration of China, the hosting agency for both International CLIVAR Global Project Office and CLIVAR Summer School, the 1st CLIVAR-FIO Summer Course on "Past, Present and Future Sea Level Changes" was organized in Qingdao, China, from June 25 to 30, 2018, with the following Goal and Scope:

***Goal*:** The Summer School has the objective to provide early career scientists and engineers specializing in sea level research with an update in observations, knowledge, and understanding for the study of global and regional sea level change and their impacts in coastal areas.

***Scope*:** This Summer School covers a wide range of physical processes contributing to global and regional sea level change: from observations to modelling of the main physical processes of global and regional sea level rise and variability. In addition, there is a specific focus on impact studies in coastal areas.

Also, the CLIVAR Summer School is trying to establish a platform to foster international joint research among lectures and trainees, and to provide opportunities of exchanging visiting scholars and doctoral education. For more information, please visit: http://www.clivar.org/events/clivar-fio-joint-summer-school-2018.

The CLIVAR Summer Course was organized back to back with the eighth UNESCO/IOC Regional Training and Research Center on Ocean Dynamics and Climate (ODC) Training Course on Ocean Forecast System, which was held during 2-7 July, 2018.

Course Description:

A total of 202 applications coming from 39 countries for participation in the summer school had been received. During the selection process, the Organizing Committee assessed the relevance of the applicants' potential contributions to the summer school. Throughout the selection process, the Committee considered potential for future knowledge transfer an important factor, the education background as well as the scientific expertise was also considered.

We also aimed to achieve the widest possible geographical distribution of the trainees, and a gender balanced distribution. Improving and increasing the capability of developing countries was an additional aim of the summer school. With these considerations, 38 candidates from 25

countries (15 females and 23 males) were finally selected as trainees for the CLIVAR-FIO summer School in 2018. (See Figure 1 and Appendix 2 for details).

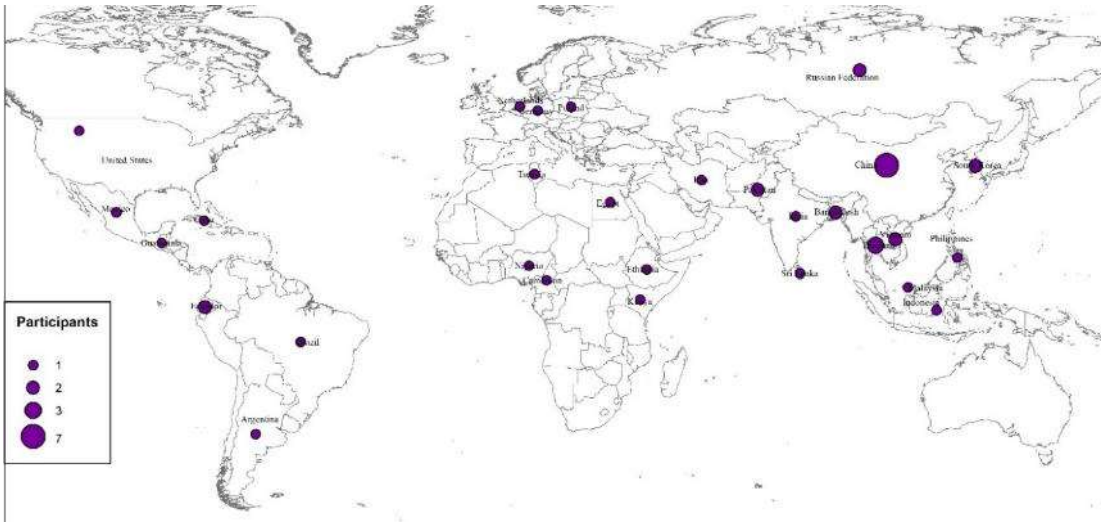

Figure1: Geographical Distribution of participants accepted to attend the Summer Course

The summer school included presentations from 10 lecturers from Europe, Australia, China and Thailand, and had the participation of supporting staff from the International CLIVAR Project Office (ICPO), the First Institute of Oceanography (FIO) and the UNESCO/IOC Regional Training and Research Center on Ocean Dynamics and Climate (ODC); see appendix 1.

The school offered 42 hours of academic activities including keynote lectures, practical applications and field visits, spread over 6 days; the Summer Course aimed to help establish research networks, and identify possible areas of cooperation among trainees and their institutions. To this end, each trainee was required to give a 10 minute presentation at the training course, which covered his/her main research focus, his/her institution's areas of work, and preliminary idea for cooperation with other countries in the region, for a detailed agenda see appendix 3.

The lecturers' and trainees' presentations are available in the program section of the summer school's homepage: http://www.clivar.org/events/clivar-fio-joint-summer-school-2018

In order to encourage team work, all trainees were divided into groups (of 5-6 participants) with a group coordinator elected by the members of each group with tasks to help organize their respective group discussions and prepare group reports. The group coordinator was required to chair one trainee report session. A **group report** was also required at the end of the training course, which summarizes the knowledge they have learnt from the training courses, results of their assignments, and suggestions to the cooperation in the future. The format of this report is the same as the trainee's report.

This activities provided a great environment for everyone in the classroom to know each other. It also enabled the lecturers to know better about their audience, and make necessary adjustment about their lectures to be more easily digested by the trainees. Also, good interaction between lecturers and trainees were observed both in the class and during the breaks. According to the feedback from trainees, the content, quality and arrangement of the lectures are well designed and delivered. There are interrelations among lectures, and the key concepts and messages on sea level changes have been reviewed and re-emphasized by several lecturers during their talks. However, more practice would be expected for the training courses in the future. By the end of the training course, new ideas for future cooperation emerged from some of the groups, which are strongly encouraged by CLIVAR.

Course Content

In what follows, we present short summaries of the contents of the presentations made by lectures on Sea Level:

Introduction to Sea Level Science. D. Stammer.

- The Earth System
- The sea level problem
- Components of sea level change
- Past, present and future sea level change
- Coastal aspects
- Sea Level Information
- GS Sea Level
- Modules taught

Past sea level changes. (geological scale briefly, tide gauge observations, observing systems, use of tide gauge data for climate research, use of altimeter data). S. Jevrejeva

- Sea level changes from geological records
- Instruments for the measurement of sea level
- Tide gauge records, Data Centres, Specific data sets
- Sea level observing systems (networks)
- Interpretation of observations, synthesis of the data- global sea level rise, reconstructions
- Sea level budget
- Short conclusion

Modern observations. (including satellite altimetry, GRACE and others, energy budget, sea level budget components, the role of the ocean component in sea level budget). D. Stammer

- Modern in situ observations
- Satellite altimetry
- Gravimetry
- Energy budget
- Sea level budget

Ocean observations, heat uptake, thermosphere sea level (including ocean in situ temperature, thermosteric sea level, observing systems: past, present and future, detection and attribution). K. von Schuckmann

Part I:

- Definitions and methods for estimating thermosteric sea level and ocean heat content
- Measurements of In Situ Ocean Temperature
- The Global Ocean Observing System: quality control, data processing
- Global Ocean Reanalysis
- Practical Exercise using Phyton notebook: Calculate Mean Sea Level: 2D maps and time series.

Part II:

- Earth Energy Imbalance
- Methods for Global Ocean Heat Content Estimates
- GOHC: Historical and Argo Era
- Role of the Deep Ocean
- Practical Exercise using Phyton notebook: Calculate Regional Trend for Ocean Heat Content

Observed and modelled Sea level variability: Observations (including role of climate modes, role of the ocean in SL variability, time series analysis, use of statistical methods for SL studies). D. Stammer

- Time series analysis
- Use of statistical methods for sea level studies
- Climate modes

- Role of the ocean in sea level variability
- Use of altimetry
- Coastal sea level

Observed and modelled sea level variability: Modelling (including global, regional and coastal), use of altimeter data. D. Stammer

- Computer simulations
- Regional simulations
- Global, regional, coastal projections

Vertical land movement. (GPS observations, observing systems for geophysical signals, including GIA and local subsidence, include GRACE here or in the next lecture). M. King

- A simple view of glacial isostatic adjustment (GIA). Modelling GIA
- How to measure a changing Ice sheet
- Elastic Deformation due to Centennial-scale glacier melt
- GIA and GRACE estimates of surface mass change (including ice)
- Vertical land movement, GIA and sea-level practical

Sea level components. Contribution from Glaciers, observations and modelling. Shiyin Liu

- Basic concepts
- Methods to estimate sea level equivalent of land ice mass
- The observations of recent glacier changes and the contribution to sea level rise
- Modeling glacier contribution to sea level change
- Recent progresses

Ice Sheet contributions: Introduction and Part I. G. Durand.

- Formation and evolution of ice sheets,
- Contemporary evolution of Greenland and Antarctic mass balance,
- Processes behind observed changes in the dynamics of outlet glaciers
- Brief history of ice-sheet modeling,

Ice Sheet contributions: Part II. G. Durand.

- Brief History of ice-sheet modeling
- Current challenges in numerical developments
- Projections of the evolution of ice sheets
- Next challenges

Global Sea Level Projections by 2100. S. Jevrejeva

- Cause of sea level rise/Sea level budget
- Global sea level projections by 2100:
- 1. Process based approach
- 2. Probabilistic approach
- 3. Semi-empirical approach
- Uncertainties in sea level projections
- Short conclusion

Sea Level Projections beyond 2100. S. Jevrejeva

- Sea level rise with warming of 1.5 and 2 °C (Paris agreement)
- Geoengineering and sea level
- Sea level projections beyond 2100
- Conclusion

Understanding and managing coastal hazards. Part I. G. Le Cozannet

- Coastal Hazards and Risks: Examples of events.
- Physical Phenomena driving coastal hazards:

  Coastal Flooding

  Coastal Erosion and Shoreline changes

  Saltwater Intrusion
- Current Management of Coastal Risks

Understanding and managing coastal hazards. Part II. G. Le Cozannet

- Detection and Attribution of Sea Level Rise Impacts
- Assessing Coastal Impacts of Sea Level Rise: From Global to local scales
- Assessing Future marine flooding and their uncertainties
- Uncertainties in future shoreline changes
- Future marine flooding: towards events that never happened before
- Research in support to coastal adaptation

Challenges in Sea Level Science. D. Stammer

- Accurately Estimate Ocean heat content/thermal expansion

  Critical element of keeping track of climate change and understanding the Earth's energy and sea level budgets

  Argo, repeat sections, deep Argo, marginal seas, under ice, continental shelves
- Robustly attribute response to GHG and aerosol forcing, constrain projections

  Observed changes, multi-model ensembles, accurate forcing estimates.
- Determine Threshold for melting of the Greenland Ice sheet

  Multi-model simulations, SMB and ice sheet dynamics, paleo observations
- Determine Antarctic Contribution

  Understanding, observations, high resolution ocean and ice sheet models
- High resolution models

  Representing climate processes, ocean-ice shelf/sheet interactions, understanding
- impacts, projection evaluation
- Extreme events

  Global storm surge changes, changes in climate variability, atmospheric forcing, Surface waves
- Support for mitigation of impacts

  Sea level forecasts, storm surge warning

Development of new climate model. F. Qiao

- Challenges faced by climate & Tropical Cyclone models
- Surface wave-circulation coupled model
- New Tropical Cyclone model
- New climate model
- Summary

Trainee Certificates. For evaluating the performance of trainees during the training course, a score was given to each trainee. The score was determined by attendance, motivation and activity performance during the training course and the quality of trainee report and group report. A certificate of accomplishment was issued to the trainees who complete at least 85% of the course. Four trainees were selected as the best trainees according to their training scores.

Chowdhury K M Azam	University of Dhaka	Bangladesh
Long Xiaoyu	University of Hawaii Sea Level Center	USA
Salama Amr	Institute of Graduate Studies and Research, Alexandria University	Egypt
Hermans Tim	NIOZ Royal Netherlands Institute for Sea Research	Dutch

Evaluation report

At the end of the training course an evaluation form was completed by all the trainees, in general all aspects of the course receive high scores average of 3.66/4.0, see appendix 4 for details.

The lowest scores correspond to:

- Hotel and meals arrangements were satisfactory (3.38)
- School helped me to learn how to work effectively with my peers in a workshop setting (3.36)

In the specific comments section, the most common suggestion was to provide more time for the practical applications, and the visibility of the screen if sitting too far in the back of the room.

Possible future activities:

During the final group reports, several suggestions were proposed as possible follow up activities for the future, which include:

1. New ideas for future research and cooperation:
    - Developing (or modifying the existing) Ocean Forecasting System (OFS) covering the Bay of Bengal and South China Sea. This will be important to mitigate hazards / disasters in the region;
    - Enhancing the observation system in the region to increase the accuracy of the OFS;
    - Close the surface wind fields on the ocean and run the ocean model to investigate the effects of wind on the western boundary currents in Western Pacific Ocean;
    - Set up the wave model for Hawaii in addition to the general atmospheric model;
    - Development or enhancement of ad hoc tools to produce a multi-hazards and risk assessment;
    - Assessment of economic impacts of coastal flood risk and sea level rise scenarios;
    - Preparation of a paper about long-term trends in sea level in each country of the group members, and their associated process that could explain this variation from a global and regional point of view.

2. Enhancing international networking and cooperation
    - Establish international networking to collaborate with other countries through South-south cooperation, regional cooperation, triangular/bilateral cooperation;
    - Share data and skills (e.g. data assimilation) among group members;
    - Capacity building;
    - Increased cooperation amongst science, civil protection, and decision-makers, favoring the creation of a cross-border network and introducing new practices to approach key actors, decision-makers, and stakeholders to the understanding and use of information and methods, normally restricted to the scientific community (development of current practices)

3. Share information learned at the summer school/training course with colleagues in home countries

- **Appendix 1: Lecturers and Supporting Staff**

Lecturers (By order of teaching)

Prof. Detlef STAMMER

Oceanography, Remote Sensing of the Earth System and Coupled Climate Assimilation, Universität Hamburg, Germany

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Dr Svetlana Jevrejeva

Marine Physics and Ocean Climate

The National Oceanography Centre (NOC), Liverpool, UK

Email: sveta@noc.ac.uk

Dr. Karina von Schuckmann

Mercator Ocean in Toulouse, France

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Prof. Matt King

School of Technology, Environments and Design, University of Tasmania, Hobart, Australia

Email: Matt.King@utas.edu.au

Prof. Shiyin Liu

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Dr. Gael Durand

CNRS - Institute of Geosciences and Environmental research (IGE), France

Email : gael.durand@univ-grenoble-alpes.fr

Dr. Gonéri Le Cozannet

Bureau de Recherches Géologiques et Minières (BRGM), Orléans, France

Email: G.LeCozannet@brgm.fr

Prof. Fangli Qiao

The First Institute of Oceanography, State Oceanic Administration, China

E-mail: qiaofl@fio.org.cn

Invited

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Head, IOC Sub-Commission for the Western Pacific, Intergovernmental Oceanographic Commission of UNESCO

c/o Department of Marine and Coastal Resources, Thailand

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Chair of IOC/WESTPAC

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Ms. Stefanny De Las Mercedes Quiroz Torres

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Appendix 2: List of Trainees

Family Name	First Name	Gender	Country	Email
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Li	Kai	M	China	haishanglai527@163.com
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Ren	Qiuping	F	China	renqiuping17@mails.ucas.ac.cn
Chen	Meixiang	F	China	chenmeixiang@hhu.edu.cn
Cabrales Infante	Javier	M	Cuba	javier.cabrales@insmet.cu
Cedeño	Jonathan	M	Ecuador	jcedeno@espol.edu.ec
Quiroz Torres	Stefanny	F	Ecuador	stedquir@espol.edu.ec
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Mulualem	Getachew Mehabie	M	Ethiopia	getch@aims.ac.za
Meyer	Elke	F	Germany	elke.meyer@hzg.de

Loarca	Andrea Lira	F	Guatemala	aliraloarca@ugr.es
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Appendix 3: Agenda- FIO-CLIVAR SUMMER SCHOOL

Time	Activity	Chair/Lecturer
25 June, 2018 (Monday)		
08:30-9:00	Registration in the meeting room	
09:00-10:00	Opening Ceremony	Jing Li
	1) Remark by SOA	
	2) Remark by Fangli Qiao	
	3) Remark by Detlef Stammer	
	4) Introduction of Summer Course by Jose Santos	
	5) Self-introduction by participants	
10:00-10:30	UN Decade of Ocean Science for Sustainable Development (2021-2030)	Wenxi Zhu
10:30-11:00	Break & Group photo	
11:00-12:30	Introduction to Sea Level Science	Detlef Stammer
12:30-14:00	Lunch	
14:00-15:30	Past sea level changes. (geological scale briefly, tide gauge observations, observing systems, use of tide gauge data for climate research, use of altimeter data)	S. Jevrejeva
15:30-16:00	break	
16:00-17:30	Modern observations. (including satellite altimetry, GRACE and others, energy budget, sea level budget components, the role of the ocean component in sea level budget)	Detlef Stammer
17:30-18:00	Delivering Ocean Services to Meet Societal Needs: Lessons and Experiences from SEAGOOS Ocean Forecasting System Development	Somkiat Khokiattiwong
18:00	End of activities	
26 June, 2018 (Tuesday)		

09:00-10:30	Ocean observations, heat uptake, thermosphere sea level (including ocean in situ temperature, thermosteric sea level, observing systems: past, present and future, detection and attribution). Part 1	Karina von Schuckmann
10:30-11:00	Break	
11:00-12:30	Ocean observations, heat uptake, thermosphere sea level (including ocean in situ temperature, thermosteric sea level, observing systems: past, present and future, detection and attribution). Part 2	Karina von Schuckmann
12:30-14:00	Lunch	
14:00-15:30	Observed and modelled Sea level variability: Observations (including role of climate modes, role of the ocean in SL variability, time series analysis, use of statistical methods for SL studies)	Detlef Stammer
15:30-16:00	Break	
16:00-17:30	Observed and modelled sea level variability: Modelling (including global, regional and coastal), use of altimeter data	Detlef Stammer
17:30-18:30	Trainee reports (1)	Coordinator Group 1
18:30	End of activities	
27 June, 2018 (Wednesday)		
09:00-10:30	Vertical land movement. (GPS observations, observing systems for geophysical signals, including GIA and local subsidence, include GRACE here or in the next lecture)	Matt King
10:30-11:00	Break	
11:00-12:30	Practical Applications: GIA model corrections to tide gauges, computing trends from individual gauges, sea-level fingerprints etc. Observed contributions from ice sheets	Matt King
12:30-14:00	Lunch	
14:00-17:30	Site visiting of FIO: 1) Key Lab of Marine Science and Numerical Modeling; 2) China Ocean Sample Repository; 3) Marine Information Center	Local organizers

17:30	End of activities	
28 June, 2018 (Thursday)		
09:00-10:30	Sea level components. Contribution from Glaciers, observations and modelling	Shiyin Liu
10:30-11:00	Break	
11:00-12:30	Ice sheet contributions – dynamics. (Formation and evolution of ice sheets, contemporary evolution of Greenland and Antarctic mass balance, processes behind observed changes in the dynamics of outlet glaciers)	Gael Durand
12:30-14:00	Lunch	
14:00-15:30	Ice sheet contributions – modelling and projections (Brief history of ice sheet modelling, current challenges in numerical developments, projections of ice sheets' evolution)	Gael Durand
15:30-16:00	Break	
16:00-17:30	Sea level projections. (Global & regional, local approaches, comparison with 20th century observations/modelling; introduction to fingerprints, patterns, e.g. the role of land water, glaciers)	S. Jevrejeva
17:30-18:30	Trainee reports (2)	Coordinator Group 2
18:30	End of activities	
29 June, 2018 (Friday)		
09:00-10:30	Projections for the 21st century and beyond	S. Jevrejeva
10:30-11:00	Break	
11:00-12:30	Understanding and managing coastal hazards (including flooding, erosion with references to groundwater salinization): (1) examples of impacts from current events; (2) the physical phenomena driving the hazards; (3) current management of coastal risks (prevention, preparedness, crisis management, response, adaptation)	Gonéri Le Cozannet
12:30-14:00	Lunch	

14:00-15:30	Coastal impacts of sea level rise (shoreline changes, extreme water levels and flooding): (1) impacts from sea level rise from a global to local perspective; (2) managing uncertainties in sea level rise impact assessments; (3) evaluating the expected benefits of adaptation and mitigation; (4) services to support adaptation in coastal areas	Gonéri Le Cozannet
15:30-16:00	Break	
16:00-16:45	Challenges for sea level science	Detlef Stammer
16:45-17:30	Presentation on WCRP	
17:30-18:30	Trainee reports (3)	Coordinator Group 3
18:30	End of activities	
30 June, 2018 (Saturday)		
09:00-10:30	Development of new climate model	Fangli Qiao
10:30-11:00	Break	
11:00-12:00	Closing Ceremony	Local organizers
12:00-15:00	Farewell lunch	

Appendix 4: Evaluation results

Summer Course Evaluation Results

Trainees were asked to respond to the following statements by using the 4-point rating scale to indicate the extent to which He/She agrees or disagrees with each statement.

4 = Strongly Agree 3 = Agree 2 = Disagree 1 = Strongly Disagree

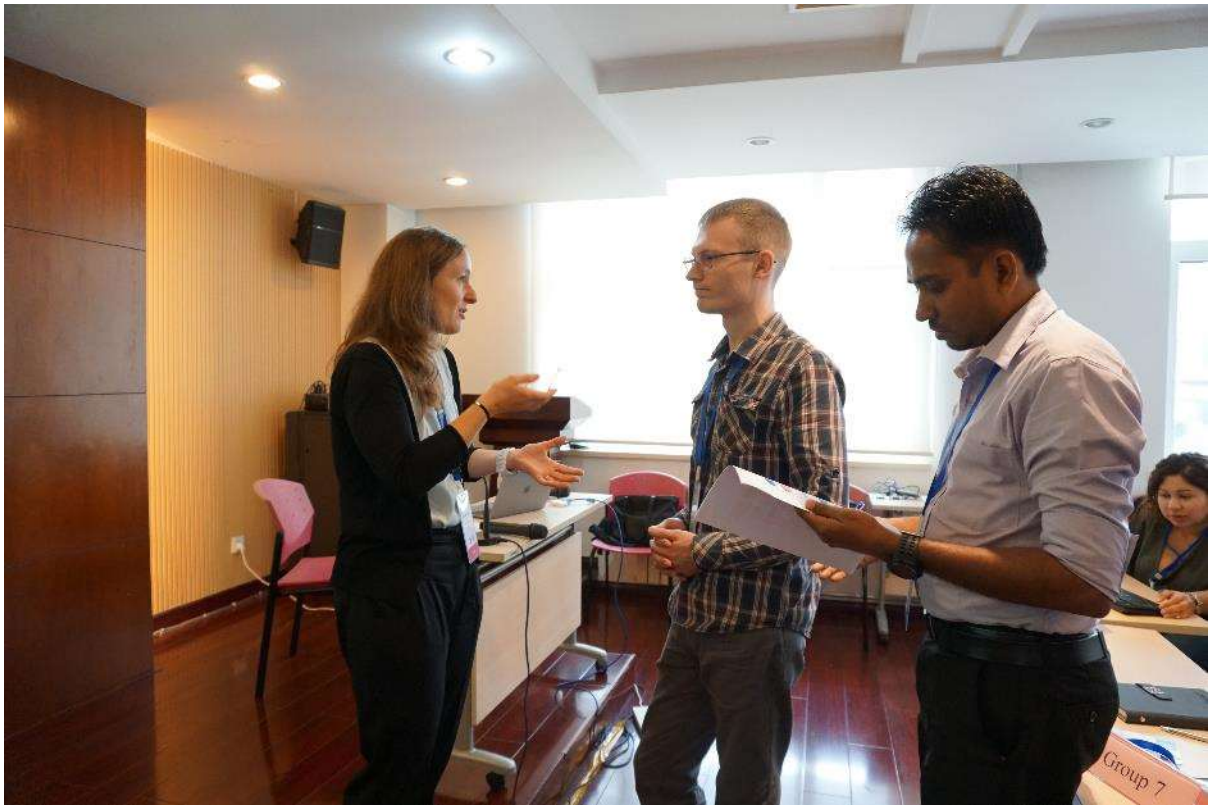
Average Score based on 39 replies	
1. Summer School objectives were stated clearly and met	3.90
2. Summer School was well organized	3.82
3. School helped me to learn how to work effectively with my peers in a workshop setting	3.36
4. The information and/or skills presented were relevant and useful	3.67
5. The lecturers provided adequate time for questions and answered the satisfactorily	3.79
6. The lecturers modeled student-centered learning strategies and techniques	3.46
7. This Summer Course increased my knowledge and skills in Sea Level Science	3.87
8. The Summer course as presented was congruent with the Summer course description	3.64
9. The presenters allowed me to work with and learn from others	3.59
10. The meeting room and other facilities were appropriate	3.69
11. Hotel and meals arrangements were satisfactory	3.38
12. Instructions provided before/during the summer course was clear and timely	3.72

Specific comments:

more time for practical exercises
Excellent
Thank you

I've learned a lot from this course, Thank you for giving me an opportunity participating in the class
some classes are a little repetitive
Reduce learning time 9:00-15 or 16:00; add drinks to lunch
there should be more time for lecture-student interaction, like a mentoring night/day
they could arrange a socials night/dinner together to talk with everyone and lectures
please give more practical exercises
provided warm water
This school was really excellence but I feel one drawback that we could not get enough time for practical sessions
This summer school provided me the opportunity to learn and gain new experience. It will be better if you could dedicate mire time for practical, specially how accurately we can interpret the results
we need more practical works
When I sat at back room, I could not saw presentation clearly. Microphone has sometimes low voice
Congratulations! For helping ECS
give more opportunity to Chinese Students
Setting all group members in a place every day hindered to discuss or talk with all, I mean trainees from other group members. So I think if it is better to sit in the classroom during lectures mixing up with trainees from all group
Really focus on practice. Allow us to have access to update data and help us to work on it according to the current scientific motivation. Lectures are good but with real practice it would be better. Think about vegan vegetarian. It is not easy to feed sometimes ourselves
1)-hotel notice could be earlier, I already booked. Same for invitation letter for China 2)-bottom of the screen could not be read from back of the class 3)-lecturers not present during some student presentations 4)-outstanding point for falling a teen; quite childish. may be award for best presentation and attendance list only to get certificate 5)-very good and interesting lectures 6)-add title of trainee &photo to program book-nice for networking and future reference 7)-maybe require English level for admittance, hard to communicate with some people

Opening Ceremony of the Summer Course



Trainees interacted with lecturer

Group discussions during the course

Visiting FIO High Performance Computing Center