



India | SOLAS Open Science Conference 2024



2021 United Nations Decade  
2030 of Ocean Science  
for Sustainable Development

# Open Science Conference

10-14 November 2024

Hosted by CSIR - National Institute of  
Oceanography, Goa, India



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## Welcome for the 2024 SOLAS Open Science Conference!

Welcome to the 9<sup>th</sup> SOLAS Open Science Conference (OSC) at the National Institute of Oceanography in Goa, India! We have an exciting programme planned for the week to come, with opportunities for you to experience all that SOLAS has to offer, from established core themes to the emerging issues at the heart of our new SOLAS 3.0 science plan. As a bottom-up organisation, the energy and ideas generated at our Open Science Conferences create the momentum that shapes the SOLAS agenda and guides its future initiatives. We are very happy to welcome you to our scientific family. We hope the plenary lectures and poster sessions are interesting and informative, and that your thoughts will be shared with colleagues in our discussion sessions and throughout the meeting. Most of all, we hope you enjoy exchanging ideas, plans, and schemes with friends and colleagues, old and new, from around the world.

Goa is an ideal coastal destination to host the SOLAS OSC, offering a unique vantage point on India's western coast along the Arabian Sea. As India's smallest state, nestled in the Konkan region and bordered by Maharashtra and Karnataka, Goa is home to the renowned CSIR-National Institute of Oceanography (NIO). Situated in Dona Paula, Goa, NIO has a longstanding international reputation for its cutting-edge research on the North Indian basin's distinct oceanographic characteristics. This institute, an important part of the Council of Scientific & Industrial Research (CSIR), focuses on various oceanographic research areas, including biological, chemical, geological/geophysical, and physical studies, alongside specialised domains like marine instrumentation and marine archaeology. Goa's position on the Arabian Sea makes it a strategic gateway for marine research and environmental monitoring relevant to SOLAS' goals. With a rich tradition in basic and applied marine science, NIO has made significant contributions to the understanding of regional ocean circulation, marine ecosystems, and coastal and offshore environments. Additionally, the institute's efforts in oceanographic data collection and environmental impact modelling are critical for predicting and managing environmental change, echoing SOLAS' commitment to understanding the interaction between the ocean and atmosphere.

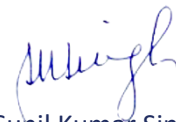
We want to thank all the sponsors and funders of this conference, as well as the sponsors of the International SOLAS program (SCOR, Future Earth, iCACGP, and WCRP) for all their support over the years. We also thank the SOLAS International Project Office and the Local Organising Committee for their hard work and dedication to assure that we have a fun and comfortable meeting this week. Finally, we thank you, the SOLAS community, for making SOLAS the productive, exciting, and important organisation that it is.



Christa Marandino  
Co-Chair, SOLAS Scientific  
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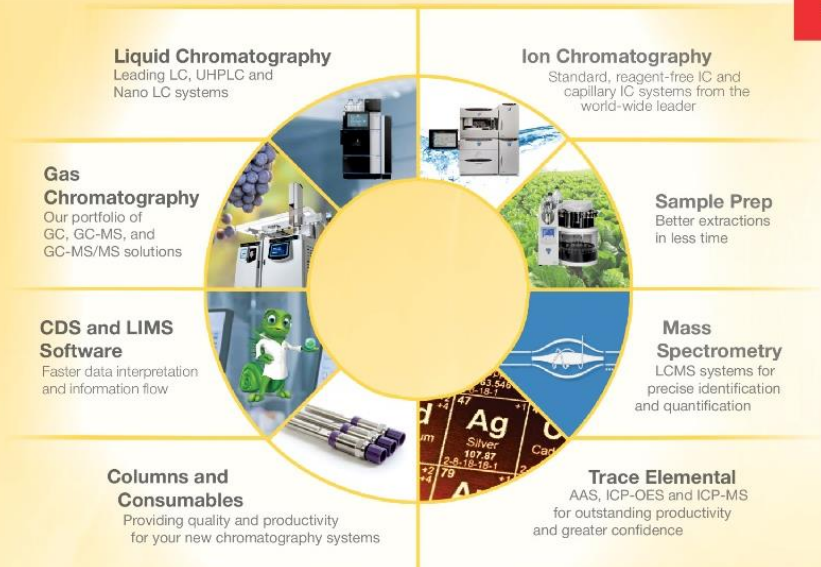

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# Programme overview

General

Time	Monday, 11 Nov	Time	Tuesday, 12 Nov
08:30	<b>Conference opening</b> Welcome / SOLAS introduction	08:30	<b>Integrate Topic: Upwelling system/Polar oceans and sea ice</b> Introduction by sessions chairs: <b>Arvind Singh, Daiki Nomura, Nadja Steiner</b>
09:30	<b>Theme 1: Greenhouse gases and the oceans</b> Introduction by session chair: <b>Karin Kvale</b>		
09:40	<b>Sam Dupont (Sweden):</b> The order of time – Bridging chemical changes with biological response to address ocean acidification	08:40	<b>Boris Dewitte (Chile):</b> ENSO-driven OMZ variability in the Pacific
10:10	<b>Sanjeev Kumar (India):</b> Dissolved trace gases in the open Arabian Sea - changed or remained similar since JGOFS	09:10	<b>Veronique Garçon (France):</b> Aquatic deoxygenation as a planetary boundary and key regulator of Earth System stability
10:30	<b>Jerry Tjiputra (Norway):</b> What goes in must come out: the oceanic outgassing of anthropogenic carbon	09:30	<b>Jessie Creamean (USA):</b> Snowcaps, lids, and lenses: The hurdles Arctic microbes must overcome to become airborne and form clouds
10:50	<b>Margaret Ogundare (Nigeria):</b> Seasonal and interannual variability in carbon dioxide fluxes in the tropical Atlantic: A critical review	10:00	<b>Asmita Singh (Norway):</b> The observational pyramid: Unravelling the physical and biogeochemical processes in the remote polar oceans
11:10	Coffee and tea break	10:20	Coffee and tea break
11:40	<b>Theme 2: Air-sea interface and fluxes of mass and energy</b> Introduction by session chairs: <b>Tom Bell</b> and <b>Peter Liss</b>	10:50	<b>Theme 3: Atmospheric deposition and ocean biogeochemistry</b> Introduction by session chair: <b>Joan Lloret</b>
11:50	<b>Shikha Singh (India):</b> Mixed layer depth: Key to understanding air-sea interactions in a changing climate	11:00	<b>Catarina Guerreiro (Portugal):</b> Aeolian dust deposition in the ocean: A calcifying phytoplankton perspective
12:20	<b>Ryo Dobashi (USA):</b> Air-sea gas exchange in the Baltic Sea	11:30	<b>Emtia Wium (South Africa):</b> The effect of dust and metal content on marine phytoplankton growth: A South African perspective
12:40	<b>Mingxi Yang (UK):</b> Deciphering the variability in air-sea gas transfer due to sea state and wind history	11:50	<b>Peter Liss (UK):</b> Microplastics: All up in the air?
13:00	<b>Leonie Jaeger (Germany):</b> Ocean's cool skin recovers within minutes: Observations from the autonomous surface vehicle HALOBATES	12:10	<b>Diksha Sharma (USA):</b> Dust into bloom: Understanding Arabian Sea phytoplankton community dynamics through atmospheric dust deposition
13:20	Lunch	12:30	Lunch
14:30	<b>Discussion sessions</b> <b>Session 1: Community feedback on launching a SOLAS mentorship program</b> - Douglas Hamilton, USA; Tanya Marshall, USA; Raquel Oliveira, Brazil <b>Session 2: SOLAS studied processes missing from coupled models</b> - Maria Kanakidou, Greece; Susann Tegtmeier, Canada; Boris Dewitte, Chile <b>Session 3: The coupling of ocean, sea-ice and atmospheric chemistry &amp; biogeochemistry: A cross-disciplinary research challenge</b> - Daiki Nomura, Japan; Sarat Chandra Tripathy, India; Anoop Mahajan, India; Lisa Miller, Canada; Nadja Steiner, Canada	14:00	<b>Discussion sessions</b> <b>Session 1: Exploring the nexus: Building capacity in understanding the impacts of atmospheric deposition on ocean biogeochemistry</b> - Semeena Shamsudheen, UK; Pallavi Saxena, India; Saurabh Sonwani, India; Douglas Hamilton, USA; Alessandro Tagliabue, UK; <b>Session 2: Impacts of biology in the Southern Ocean on cloud processes – upcoming collaborations and initiatives</b> - Jessie Creamean, USA; Marc Mallet, Australia; Manuela van Pinxteren, Germany <b>Session 3: Knowledge brokering for impact in marine governance</b> - Ellycia Harrould-Kolieb, Australia; Erik van Doorn, Australia
16:00	<b>Poster session (incl. coffee break)</b> Theme 1: Greenhouse gases and the oceans	15:30	<b>Poster session (incl. coffee break)</b> Integrate Topic: Upwelling system/Polar oceans and sea ice
17:00	Theme 2: Air-sea interface and fluxes of mass and energy	16:30	Theme 4: Interconnections between marine ecosystems, aerosols, and clouds
18:00	Theme 3: Atmospheric deposition and ocean biogeochemistry	17:30	Theme 5: Ocean biogeochemical control on atmospheric chemistry
19:30	<b>Nat/Reg Reps dinner</b> (invitation only)		

# Programme overview

General

Time	Wednesday, 13 Nov	Time	Thursday, 14 Nov
08:30	<b>Theme 4: Interconnections between marine ecosystems, aerosols, and clouds</b> Introduction by session chairs: <b>Maria Kanakidou and Jurgita Ovadnevaite</b>	08:30	<b>Science and Society / Climate Intervention</b>  Introduction by session chairs: <b>Ellycia Harrould-Kolieb, Christa Marandino, William Miller</b>
08:40	<b>Manuela van Pinxteren (Germany):</b> Oceans, aerosols, and clouds: An interplay in the climate system	08:40	<b>Erik van Doorn (Australia):</b> International law & policy concerning the air-sea interface
09:10	<b>Mishka Rawatlatl (South Africa):</b> Sources of water-soluble organic carbon in aerosols at the Cape Point GAW station	09:10	<b>Shubham Krishna (UK):</b> Climate warming masks de-eutrophication signal in coastal ecosystems
09:30	<b>Matti Rissanen (Finland):</b> Acid + SO <sub>3</sub> reactions as a source of nucleating precursors in marine boundary layer	09:30	<b>Doug Wallace (Canada):</b> Ocean-based climate intervention
09:50	<b>Rafel Simo (Spain):</b> Marine emissions of methanethiol increase aerosol cooling in the Southern Ocean	10:00	<b>Daniel Harrison (Australia):</b> Recent progress in the physical investigation of Marine Cloud Brightening
10:10	Group picture		
10:20	Coffee and tea break	10:20	Coffee and tea break
10:50	<b>Theme 5: Ocean biogeochemical control on atmospheric chemistry</b> Introduction by session chairs: <b>Nadja Steiner and Anoop Mahajan</b>	10:50	<b>Integrate Topic: Indian Ocean</b> Introduction by session chair: <b>Anoop Mahajan</b>
11:00	<b>Yee Jun Tham (China):</b> Heterogeneous recycling of reactive halogens in the marine atmosphere	11:00	<b>Tanya Marshall (USA):</b> Exploring the last oceanographic frontier: lessons from the Indian Ocean
11:30	<b>Sankirna Joge (India):</b> Dimethyl Sulfide (DMS) projections (past, present, future) using machine learning model	11:30	<b>Koji Hamasaki (Japan):</b> Profiling microbial community in sea surface microlayer and marine aerosols in the Bay of Bengal and the Southeast Indian Ocean
11:50	<b>Avinash Kumar (Finland):</b> Reactive Iodine oxides: A missing oxidant of SO <sub>2</sub> towards the formation of sulfuric acid in the marine environment	11:50	<b>S. Gopika (India):</b> Mechanisms of the tropical Indian Ocean surface warming patterns: Simulated by CMIP Models
12:10	<b>Rosie Chance (UK):</b> Ozone reactive organic compounds in the sea-surface microlayer	12:10	<b>Udisha Singh (India):</b> Geochemical tracing of atmospheric mineral dust over the North Indian Ocean
12:30	Lunch	12:30	Lunch
14:00	<b>Discussion sessions</b> <b>Session 1: Reducing uncertainties in soluble aerosol trace element deposition: a SCOR working group call to the community</b> - Morgane Perron, France; Akinori Ito, Japan, Douglas Hamilton, USA  <b>Session 2: SOLAS Science &amp; Society 3.0 the way forward</b> - Erik van Doorn, Australia; Ellycia Harrould-Kolieb, Australia  <b>Session 3: Coastal cities air quality under the influence from the ocean – shared common mission of IGAC and SOLAS</b> - Maria Kanankidou, Greece; Yee Jun Tham, China	14:00	<b>SOLAS 3.0</b> Introduction by session chairs: <b>Christa Marandino and William Miller</b>
		14:10	<b>Angela Landolfi (Italy):</b> Drivers and impacts of extreme events on air-sea interactions
		14:40	<b>Julie Dinasquet (USA):</b> Thriving through synergy: Fostering a SOLAS Community built on equity, international connections and early career scientists integration
		15:10	Discussion
15:30	<b>Poster session (incl. coffee break)</b> Integrated Topic: Indian Ocean	15:30	Coffee and tea break
17:00	Science and Society / Climate Intervention	16:00	SOLAS India meeting
18:30	Conference banquet		

## Venue information

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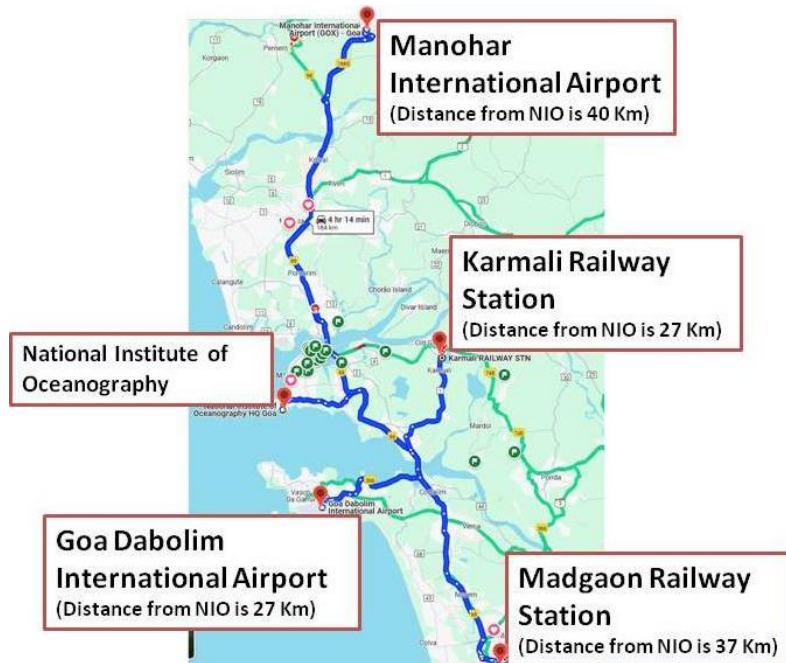
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Please regularly check the information board next to the desk which will display information about conference details, programme changes, and other announcements.

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# Venue information

Information

## Conference Venue Overview Map



**Plenary Meeting Venue:** SZ Qasim Auditorium (Cardium)

**Parallel Discussion Sessions Venue:**

SZ Qasim Auditorium (Cardium)

N.K. Panikkar Hall (Seminar Hall) on the ground floor of the NIO main building

H.N. Siddiquie Hall (Training Hall) on the 1st floor of the NIO main building

**Poster Session Venue:** VIP Guest House

**Lunch & Coffee and tea break:** Outside area of SZ Qasim Auditorium



## Direction and transport

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### Airport Transfer

Goa has two international airports, Goa Airport, Dabolim (GOI), located about 30 km from the capital, Panaji (also known as Panjim) & Manohar International Airport, MOPA (GOX), located about 35 km from the capital city.

#### Bus services

Take the shuttle bus from Goa Airport, Dabolim or Manohar International Airport, MOPA Airport to Panaji (check the timeline at <https://ktclgoa.com/> or book online at <https://goakadamba.com/>). The journey takes about 50 minutes from Dabolim Airport and 90 minutes from Mopa Airport to the Panaji KTC Bus Stand. From there, it's a 2-minute walk to the Panaji KTC City Bus Station, where you can take bus Y2 to the Dona Paula stop (~11 minutes). From Dona Paula, it's a 4-minute walk to NIO.  
Total Fare: 200-500 INR.

#### Taxi

Government-approved prepaid taxis, Goa Miles (counter, app-based service), and other private vehicle operator counters are available at the airports.  
Taxi charges range from ~2500 to 4000 INR.



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### Railway Station Transfer

Goa has several train stations. Convenient stations in Goa include Madgaon, Vasco, Karmali, and Thivim, with Madgaon being the main one.

#### Bus services

From Madgaon Railway Station to NIO Dona Paula, there are several bus routes. The route with the fewest transfers involves taking the MRG52 from Shirvodem Junction (a 20-minute walk from Madgaon Railway Station) to GMC Bambolim (31 minutes, 45 stops), followed by a 2-minute walk to Goa Medical College B, where you can catch bus Y1 to Dona Paula (9 minutes).  
Total Fare: 100-500 INR.

#### Taxi

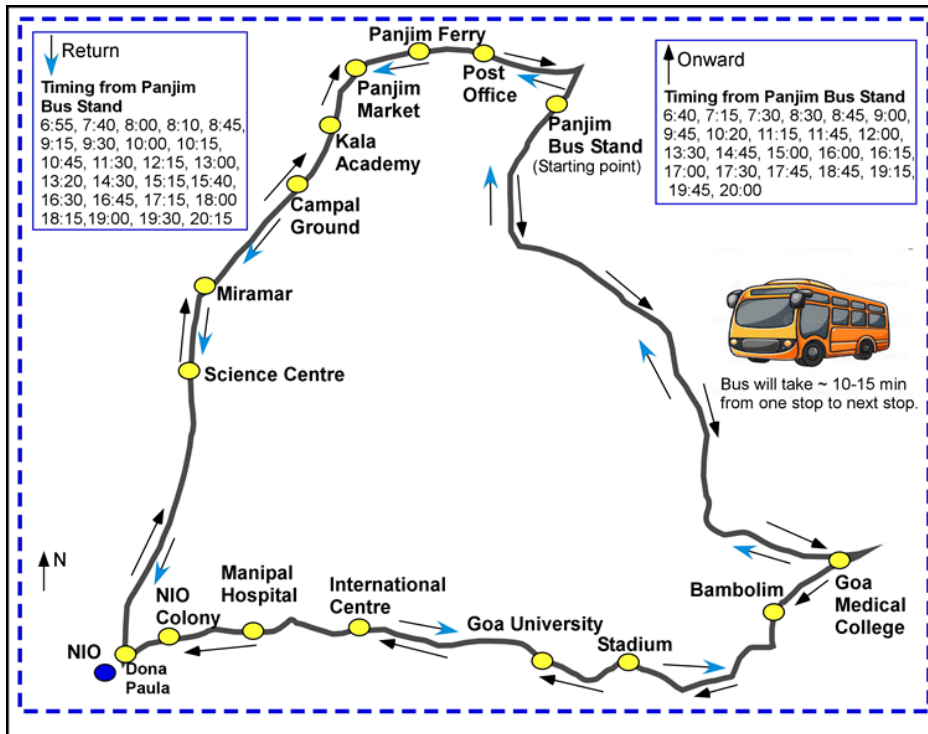
Government-approved prepaid taxis, Goa Miles (counter, app-based service), and other private vehicle operator counters are available at Margao and Vasco Railway Stations.  
Taxi charges range from ~2500 to 4000 INR.

\* **Please note!** It is not recommended to travel by bus, as the service is not frequent.

## Direction and transport

# Route and Timing of Electric Bus Operating from NIO to Panaji and Back

Information



## Shuttle Bus Arrangement

Pick-up (7:45 to 8:15 am) and drop-off (15 mins after conference activities) from the designated hotels (see the list at <https://solas-osc-2024.nio.res.in/accommodation/>) to the SZ Qasim Auditorium at NIO and back will be arranged. We will also provide this facility from the SZ Qasim Auditorium at NIO to the Banquet dinner venue and back to the hotel on 13 November. More details will be provided during the conference and will also be available at the respective hotel receptions.

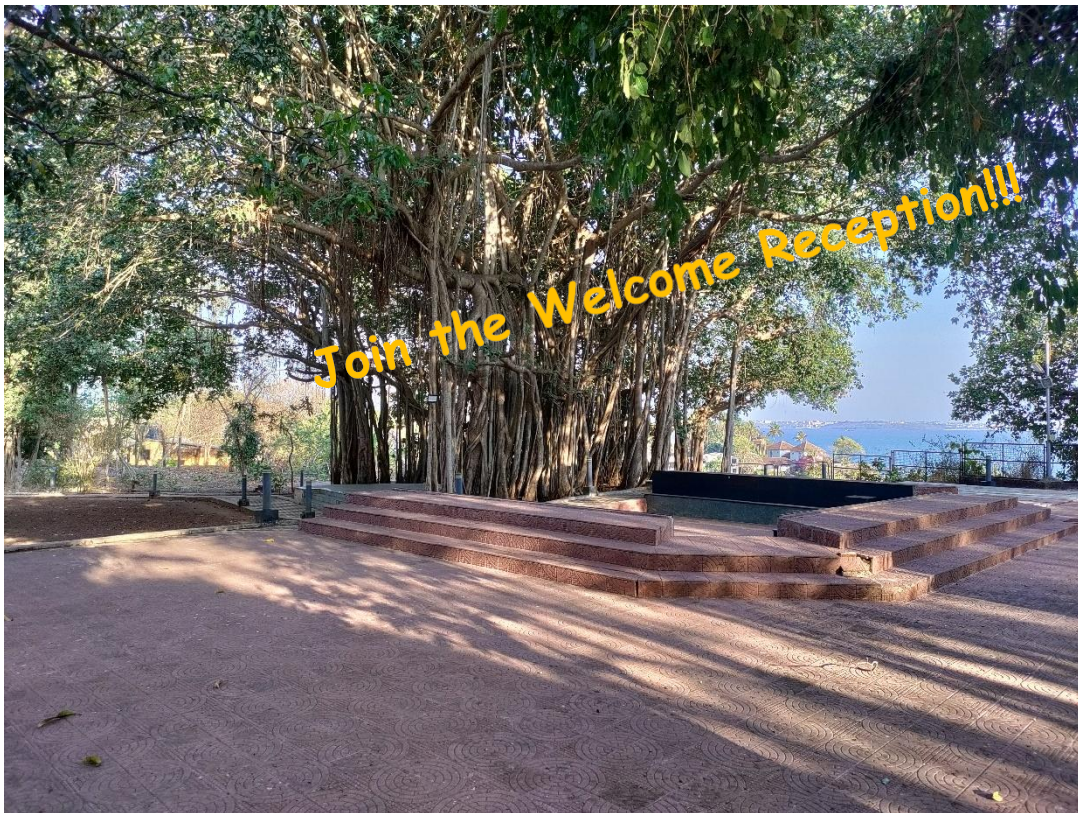
## Social events & Food

### Welcome reception

Sunday, 10 Nov, 18:00 pm  
 Lawn of the VIP Guest House,  
 CSIR-National Institute of Oceanography (NIO)  
 Dona Paula, Goa



**All conference participants are invited to this event!**

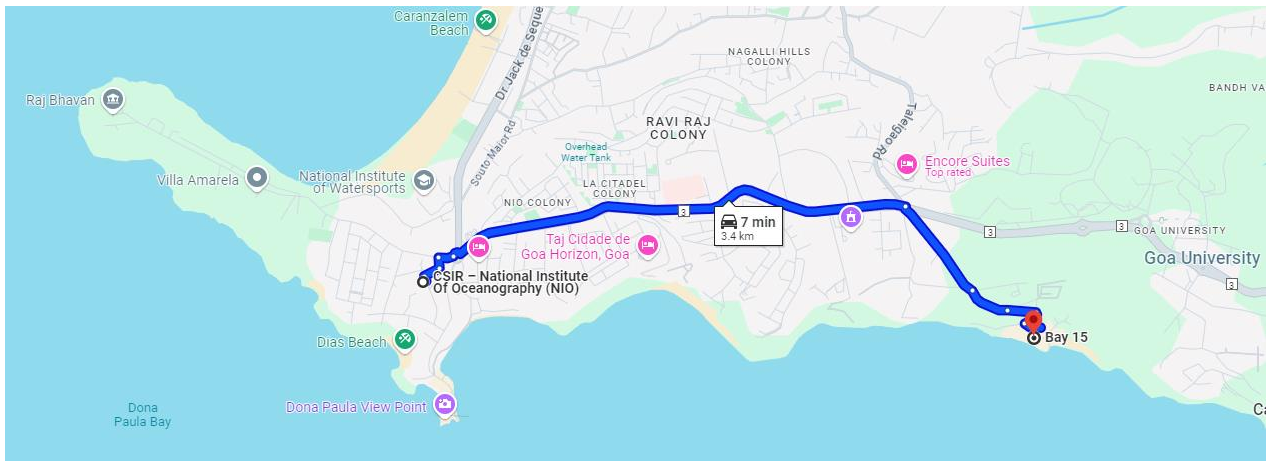


## Social events & Food

### Conference dinner

Wednesday, 13 Nov, 18:30 pm  
 Bay 15 - Odxel Beach, Dona Paula, Durgavado, Goa

The conference dinner includes a local cultural event followed by felicitation of important members in the SOLAS community and the poster award session.



## Social events & Food

### Dinning out in Dona Paula

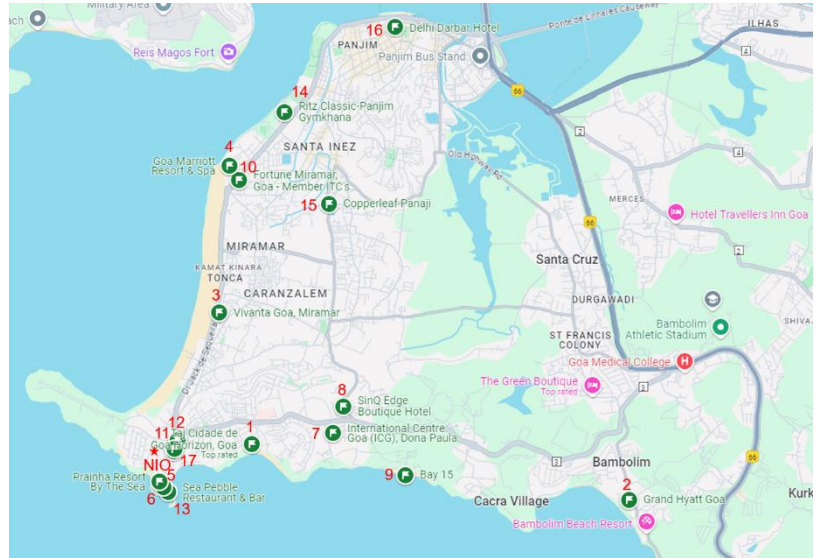
#### Hotel with Bars and Restaurants

— **High End**

1. Taj Cidade de Goa, Dona Paula
2. Grand Hyatt, Bombolin, Goa
3. Vivanta Goa, Miramar
4. Goa Marriott Resort & Spa

— **Medium Range**

5. Prainha Resort by The Sea
6. O Pescador An Indy Resort
7. International Centre Goa (ICG), Dona Paula
8. SinQ Edge Boutique Hotel
9. Bay 15
10. Fortune Miramar, Goa



#### Only Restaurants and Bars

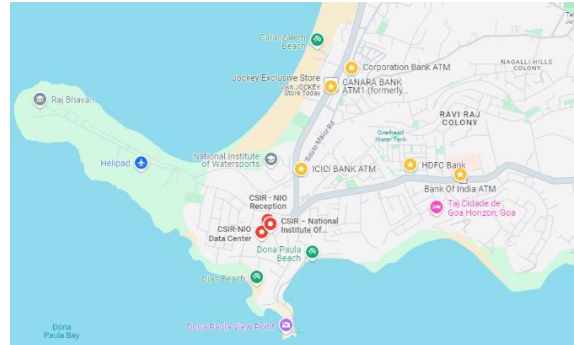
11. The Goan Room
12. Arcanjela Bar and Restaurant
13. Sea Pebble Restaurant & Bar
14. Ritz Classic-Panjim Gymkhana
15. Copperleaf Panaji
16. Delhi Darbar Hotel
17. Siddhi Pure Vegterian Udipi Restaurant



## Various useful information

### ATM

ICICI BANK  
 HDFC Bank  
 Bank of India  
 CANARA BANK (formerly Syndicate Bank)  
 Corporation Bank



### Foreign Currency Exchangers

Foreign currency can be exchanged at most of the banks and leading hotels, shops and travel agents, and other agencies who have been authorised by the Reserve Bank of India. Some of the full fledge money changers are as follows:

#### Thomas Cook India Ltd

8, Alcon Chambers, Dayanand Bandodkar Marg,  
 Panaji, Goa 403001  
 Tel: 08326639256

#### Trade Wings Ltd

1st Floor, Naik Building, MG Road,  
 Opp. Don Bosco School, Ozari, Panaji, Goa 403001  
 Tel: 08322430746

### Airlines Enquiry

- [Air India/ Indian Airlines](#): 0832-2542444
- [Indigo](#): 0124 6173838
- [Spice jet](#): 0832-2542708
- [Air Arabia Airlines](#): 0832-2229444
- [Oman AIR](#): 0832-2541875
- [Fly91](#): support@fly91.in
- [Saudi Arabian Airlines](#): 0832-2430830

### Hospitals & Medical Shops

- [Manipal Hospitals Goa](#): 0832-6632500
- [Goa Medical College](#): 0832-2458727
- [Marvel Medical Stores](#)
- [International Medical Stores](#): 098231 74005
- [United Chemist & Druggist](#): 0832-2453891

### Helpline Numbers in India

- [Police](#): 100 / 0832-2428482
- Fire: 101/ 0832-2225577
- Ambulance: 102 / +91-88887 02222
- Emergency service: 108 / 0832-2458725
- Hotline/Helpline: 1091

## Various useful information

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### Weather in Dona Paula

During the day, temperatures typically remain around 32°C, with a drop to approximately 25°C at night. Given the possibility of rain during the conference, it is advisable to carry an umbrella.

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### Children Day Care Facility

A children day care facility will be available during 8-14 November 2024 with a charge of 1500 INR per day. This facility is ~2 km from the CSIR-NIO campus and transportation for pickup/drop will be available during this period. Interested participants can contact [goa1148@bachpanglobal.com](mailto:goa1148@bachpanglobal.com) for more details.



### Hop on Hop off Goa – Bus Tour

Conducted sight-seeing tours by Hop On and Hop Off and other regular comfortable A.C. and Non A.C. coaches, accompanied by government approved tourist guides are organised by the Goa Tourism Development Corporation Ltd. and other private tour operators. These tours are generally from 9.00 hrs. to 18.00 hrs. covering the important tourist spots in North and South Goa.

#### Hop on Hop off Goa – Contact Details:

Phone Nos: 0832-2438311, +91 7447473495/98

Email ID: [hohogoa@prasannapurple.com](mailto:hohogoa@prasannapurple.com)

Website: [www.hohogoa.com](http://www.hohogoa.com)

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For further information, please visit the [SOLAS conference website](http://SOLAS conference website) as well as the Department of Tourism, Government of Goa website: <https://goatourism.gov.in/>

## Early Career Scientist Day (ECSD)

The SOLAS Early Career Scientist Day (ECSD) is an international event that brings together around 40 early career scientists and world-leading international experts for a day of skill development lectures and networking. During this day, the Local Organising Committee and the SOLAS Early Career Scientist Committee will welcome young researchers whom are not familiar with the SOLAS community. Guided visits to the National Centre for Polar and Ocean Research and sightseeing of Goa's Japanese Garden are included in the event. The event is free of charge and accessible upon registration. Coffee breaks and lunch are provided on the Sunday and a welcome dinner is offered to participants on the Saturday. Participants are responsible for airfare and registration for the SOLAS conference.

Sunday

### ECSD Programme - Saturday, 9 Nov 2024

Participant arrival

18:00 Welcome dinner at Sea Pebble Restaurant & Bar (H 15/155, Dona Paula Jetty, Goa)

### ECSD Programme - Sunday, 10 Nov 2024

08:45 Meet in the N. K. Panikkar Hall (Seminar Hall) on the ground floor of NIO main building

09:00 'Communication and multimedia' workshop (*Nidhi Gulati / Anoop Mahajan*)

10:20 Coffee break (provided)

10:40 'SOLAS Early Career Scientist Committee mentorship program' (*Douglas Hamilton*)

11:00 'Career development and mentorship' workshop (*Shikha Singh*)

12:30 Lunch break (Collect packets from NIO Canteen)

13:00 Visit of the National Centre for Polar and Ocean Research

16:00 Sightseeing at Japanese Garden and nearby beach

18:00 Return to CSIR-NIO before the SOLAS OSC ice breaker



NCPOR, Goa



Japanese Garden, Goa

## Daily overview - Monday

Times	Monday, 11 Nov
08:30	<b>Conference opening - Welcome &amp; SOLAS introduction</b>
09:30	<p align="center"><b>Theme 1: Greenhouse gases and the oceans</b> Introduction by session chair: <b>Karin Kvale</b></p>
09:40	<b>Sam Dupont (Sweden):</b> The order of time – Bridging chemical changes with biological response to address ocean acidification
10:10	<b>Sanjeev Kumar (India):</b> Dissolved trace gases in the open Arabian Sea - changed or remained similar since JGOFS
10:30	<b>Jerry Tjiputra (Norway):</b> What goes in must come out: the oceanic outgassing of anthropogenic carbon
10:50	<b>Margaret Ogundare (Nigeria):</b> Seasonal and interannual variability in carbon dioxide fluxes in the tropical Atlantic: A critical review
11:10	Coffee and tea break
11:40	<p align="center"><b>Theme 2: Air-sea interface and fluxes of mass and energy</b> Introduction by session chairs: <b>Tom Bell</b> and <b>Peter Liss</b></p>
11:50	<b>Shikha Singh (India):</b> Mixed layer depth: Key to understanding air-sea interactions in a changing climate
12:20	<b>Ryo Dobashi (USA):</b> Air-sea gas exchange in the Baltic Sea
12:40	<b>Mingxi Yang (UK):</b> Deciphering the variability in air-sea gas transfer due to sea state and wind history
13:00	<b>Leonie Jaeger (Germany):</b> Ocean's cool skin recovers within minutes: Observations from the autonomous surface vehicle HALOBATES
13:20	Lunch
14:30	<p align="center"><b>Discussion sessions:</b></p> <p><b>Session 1: Community feedback on launching a SOLAS mentorship program -</b> <i>Douglas Hamilton, USA; Tanya Marshall, USA; Raquel Oliveira, Brazil</i></p> <p><b>Session 2: SOLAS studied processes missing from coupled models -</b> <i>Maria Kanakidou, Greece; Susann Tegtmeier, Canada; Boris Dewitte, Chile</i></p> <p><b>Session 3: The coupling of ocean, sea-ice and atmospheric chemistry &amp; biogeochemistry: A cross-disciplinary research challenge -</b> <i>Daiki Nomura, Japan; Sarat Chandra Tripathy, India; Anoop Mahajan, India; Lisa Miller, Canada; Nadja Steiner, Canada</i></p>
16:00	<p align="center"><b>Poster session (incl. coffee break)</b></p> <p>Theme 1: Greenhouse gases and the oceans</p>
17:00	Theme 2: Air-sea interface and fluxes of mass and energy
18:00	Theme 3: Atmospheric deposition and ocean biogeochemistry
19:30	<b>Nat/Reg Reps dinner (invitation only)</b>

## Daily overview - Monday

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### Plenary sessions

#### Theme 1: Greenhouse gases and the oceans

Session chair: Karin Kvale

Keynote speaker: Sam Dupont

*University of Gothenburg, Sweden*



**Sam Dupont** is an Associate Professor and Senior Lecturer in Marine Eco-Physiology at the University of Gothenburg. His main research focus is the effect of global changes such as ocean acidification and warming on marine ecosystems. He has published more than 200 publications in journals including Nature, Science, PNAS and TREE. Sam is also working on the development of innovative science communication and education strategies to tackle global challenges. The third aspect of his work aims at evaluating and building capacities for marine science in developing countries.

Monday

#### **The order of time – Bridging chemical changes with biological response to address ocean acidification**

Addressing and minimising the impact of ocean acidification require an understanding of how the changes in the carbonate chemistry drives the biological responses. While significant progress has been made in each discipline from monitoring to modelling, there is still a need to improve the communication between the different fields. This presentation will focus on one of the keys allowing to bridge chemistry and biology: time. We will discuss how the dynamic of the carbonate chemistry at different temporal scales, from hours to years, is modulating the biological response and how this information can be used to design a biologically relevant monitoring program.

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## Daily overview - Monday

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### Dissolved trace gases in the open Arabian Sea - changed or remained similar since JGOFS

Mohammad Atif Khan<sup>1</sup>, Siddhartha Sarkar<sup>1</sup>, Himanshu Saxena<sup>1</sup>, Deepika Sahoo<sup>1</sup>, Arvind Singh<sup>1</sup>, **Sanjeev Kumar**<sup>1</sup>

<sup>1</sup>*Geosciences Division, Physical Research Laboratory, Ahmedabad, India*

The oxygen minimum zone (OMZ) of the Arabian Sea has expanded in recent decades. In light of this, the role of OMZ in modulating the dynamics of trace gases in the open Arabian Sea has not been abundantly investigated. In the present study, the vertical distribution of dissolved CO<sub>2</sub>, CH<sub>4</sub>, and N<sub>2</sub>O were measured from the surface to 3000 m at 14 stations during winter monsoon. Surface Arabian Sea provided mixed signal for CO<sub>2</sub>, where the northern part was largely undersaturated and southern region was oversaturated. N<sub>2</sub>O showed a typical double-peak structure at the northern stations. CH<sub>4</sub> in the surface layer of the open Arabian Sea, however, was considerably higher compared to studies conducted two decades ago. Taken together, it appeared that the N<sub>2</sub>O in the Arabian Sea has largely remained similar, whereas CH<sub>4</sub> dynamics has potentially changed in the last two decades.

Monday

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### What goes in must come out: the oceanic outgassing of anthropogenic carbon

**Jerry Tjiputra**<sup>1</sup>, Damien Couespel<sup>1</sup>

<sup>1</sup>*NORCE Norwegian Research Centre, Bergen, Norway*

About 25% of the emitted anthropogenic CO<sub>2</sub> is absorbed by the ocean and transported to the interior. Anthropogenic CO<sub>2</sub> is then redistributed by circulation and stored mostly in the upper layers of the subtropical gyres. Because of the combined effects of weakening buffering capacity, warming, changes in wind stress and ocean circulation, the ocean sink will weaken in the future. We use Earth System Model simulations to reveal that anthropogenic CO<sub>2</sub> begins to outgas in the subtropical gyres of both hemispheres during the summer of the 21st century. In 2100, about 53% of the surface ocean experience outgassing at least one month in a year in SSP1-2.6, against 37% in SSP5-8.5. After 2100, this fraction keeps increasing, reaching 63% by 2300 in SSP5-8.5. This outgassing pattern is driven by the rapid increase in oceanic *p*CO<sub>2</sub>, faster than atmospheric *p*CO<sub>2</sub>, due to warming and accumulation of anthropogenic carbon in these regions.

### Seasonal and interannual variability in carbon dioxide fluxes in the tropical Atlantic: A critical review

**Margaret Oione Ogundare**<sup>1</sup> & Falilu Olaiwola Adekunbi<sup>2</sup>

<sup>1</sup>Department of Marine Science and Technology, Federal University of Technology Akure, Nigeria, <sup>2</sup>Nigerian Institute for Oceanography and Marine Research, Victoria Island Lagos, Nigeria

Seasonal and interannual variability of carbon dioxide (CO<sub>2</sub>) fluxes within the tropical Atlantic Ocean significantly influences climate control and global carbon cycling. This study offers a comprehensive analysis of the causes, trends, drawing upon data from diverse observational investigations, modelling analyses, and biogeochemical research. The tropical Atlantic act as sink and source of CO<sub>2</sub> owing to variations in biological activity and physical processes that drive seasonal fluctuations in carbon uptake and release. The air-sea exchange rates and CO<sub>2</sub> solubility are influenced by changes in wind, precipitation, and sea surface temperature. Carbon fixation and remineralisation processes are influenced by nutrient availability and biological productivity. The interannual variability in ocean-atmosphere CO<sub>2</sub> exchange is a product of climate events such as El Niño-Southern Oscillation (ENSO) and Atlantic Meridional Mode (AMM) that substantially impact carbon fluxes. These variations have great impact on global carbon balances, ocean acidification, and the marine ecosystems.



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**@SOLAS\_IPO**

## Daily overview - Monday

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### Plenary session

## Theme 2: Air-sea interface and fluxes of mass and energy

Session chairs: Tom Bell and Peter Liss

Keynote speaker: Shikha Singh

*Indian Institute of Tropical Meteorology, India*



**Shikha Singh** is a scientist at the Indian Institute of Tropical Meteorology in Pune, India, as well as a Fulbright Scholar. She is an Early Career Researcher (ECR) member of the Indian Ocean Regional Panel for CLIVAR. Dr. Singh's research primarily focuses on ocean modelling, with an emphasis on resolving small-scale upper ocean processes within the models. Her areas of interest include investigating climate model biases, climate variability, and marine heatwaves. In addition to her research, she plays an active role in supporting the development of ECRs and has created the SDA2 framework for this purpose. This framework is designed to facilitate collaboration among ECRs around the world.

Monday

### Mixed layer depth: Key to understanding air-sea interactions in a changing climate

The mixed layer depth (MLD) is a pivotal parameter in oceanography that defines the uppermost oceanic layer where temperature, salinity, and other physical properties are homogenised through turbulent mixing driven by atmospheric and oceanic processes. This lecture will delve into the intricate role of MLD in mediating interactions between atmospheric and oceanic systems, highlighting its significance in modulating and being modulated by climate variability, weather dynamics, and marine ecological processes. The physical mechanisms of MLD variations, including wind-induced mixing, heat flux exchanges, and buoyancy-driven convection, and their repercussions for oceanic stratification, circulation patterns, and nutrient dynamics are also investigated. The session will also address the interaction between MLD and major climate phenomena such as El Niño and La Niña. This lecture seeks to offer a comprehensive understanding of how MLD serves as a crucial link between the atmosphere and ocean, affecting both regional and global environmental systems.

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## Daily overview - Monday

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### Air-sea gas exchange in the Baltic Sea

**Ryo Dobashi**<sup>1</sup>, David T. Ho<sup>1</sup>

<sup>1</sup>University of Hawaii at Mānoa, Hawaii, USA

Air-sea gas exchange influences the biogeochemical cycle of trace gases, such as CO<sub>2</sub> and dimethyl sulfide (DMS), which in turn impacts Earth's climate. The calculation of the air-sea gas fluxes requires gas transfer velocity ( $k$ ), often well-estimated from wind speed in coastal and open oceans under moderate wind speed. However, there are still topics that have not been thoroughly investigated, such as whether these parameterisations could be applied to inland seas such as the Baltic. In this study, we measured  $k$  in the Baltic Sea using the dual tracer technique. The observed  $k$  was lower compared to other coastal and offshore regions at the same wind speed, especially when wind speed was high. Most of the parameterisations proposed for the Baltic Sea were found to overestimate  $k$ . The lower  $k$  was likely due to wind fetch limitation and the presence of surfactants.

Monday

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### Deciphering the variability in air-sea gas transfer due to sea state and wind history

**Mingxi Yang**<sup>1</sup>, David Moffat<sup>1</sup>, Yuanxu Dong<sup>2,3</sup>, Jean-Raymond Bidlot<sup>4</sup>

<sup>1</sup>Plymouth Marine Laboratory, Plymouth, UK, <sup>2</sup>Marine Biogeochemistry Research Division, GEOMAR Helmholtz Centre for Ocean Research Kiel, Kiel, Germany, <sup>3</sup>Institute of Environmental Physics, Heidelberg University, Heidelberg, Germany, <sup>4</sup>European Centre for Medium-Range Weather Forecasts, Shinfield Park, Reading, UK

The air-sea gas transfer velocity ( $k$ ) is almost universally parameterised as a function of wind speed – an oversimplification that buries the mechanisms controlling  $k$  and neglects much natural variability. Sea state has long been speculated to affect  $k$ , but causal relationships from observations have been elusive. Here, using a Machine Learning technique we show that the inclusion of significant wave height improves the model simulation of observed CO<sub>2</sub> transfer velocity ( $k_{CO_2}$ ), while parameters such as wave age, steepness, and swell-wind directional difference have little influence. In high seas,  $k_{CO_2}$  during periods of falling winds exceed periods of rising winds by ~20%, consistent with the development of waves and whitecaps. A similar hysteresis is absent from DMS transfer, confirming that the sea state dependence in  $k_{CO_2}$  is primarily due to bubbles. We propose a new parametrisation of  $k_{CO_2}$  as a function of wind and waves, which outperforms previous parametrisations.

## Daily overview - Monday

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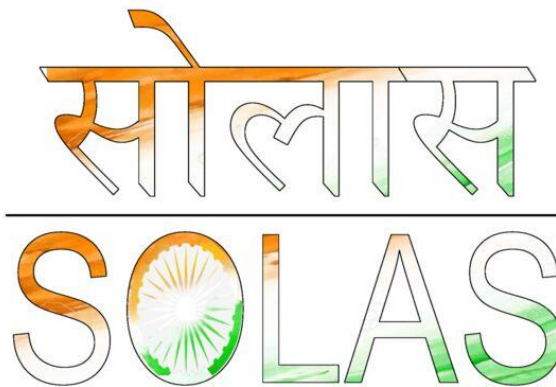
### Ocean's cool skin recovers within minutes: Observations from the autonomous surface vehicle HALOBATES

**Leonie Jaeger**<sup>1</sup>, Lisa Gassen<sup>1</sup>, Samuel Mintah Ayim<sup>1</sup>, Oliver Wurl<sup>1</sup>

<sup>1</sup>Center for Marine Sensors (ZfMarS), Institute for Chemistry and Biology of the Marine Environment (ICBM), School of Mathematics and Science, Carl von Ossietzky Universität Oldenburg, Oldenburg, Germany

Air-sea heat exchange exerts a significant influence on the sea surface temperatures across the ocean's skin layer. Due to the continuous heat loss at the skin layer, this uppermost millimetre of the ocean is generally cooler than the near-surface water. The oceanic skin temperature affects climate-relevant processes such as gas solubility and evaporative fluxes. Therefore, understanding the thermal dynamics of the skin layer after disturbances like wave breaking is crucial. However, obtaining field observations under typical oceanic conditions is hindered by observational challenges. Here, we present high-resolution temperature measurements of the skin and near-surface layer using the autonomous surface vehicle HALOBATES, which drifted within artificially disturbed water masses, enabling the observation and analysis of thermal recoveries. Our novel approach reveals that the complete recovery of the cool skin layer following an artificial disturbance takes up to three minutes, exceeding previous estimates.

Monday



India | SOLAS Open Science Conference 2024

## Daily overview - Monday

### Parallel discussion sessions

#### **Community feedback on launching a SOLAS mentorship program**

Convenors/Rapporteurs: Douglas Hamilton, USA; Tanya Marshall, USA; Raquel Oliveira, Brazil

SOLAS plans to launch a mentorship program in mid-2025 led by the Early Career Scientist (ECS) Committee. This is an initiative that the ECS community has asked for and will help shape SOLAS 3.0 as mentoring provides an intentional means of building community and sharing knowledge and experiences. The objective of the program is to facilitate strong mentorship links between established scientists and ECS members across multiple disciplines relevant to SOLAS. To launch a successful program, the ECS Committee proposes to host an open session at the OSC to brainstorm the design and implementation of the mentorship program and to assess interest among potential mentors and mentees. We will use feedback from both established and early career researchers to then shape the plan. The session will consist of a 10-15 min introduction on why SOLAS wants to implement a mentorship program, followed by discussion prompted by key questions. The long open discussion will allow for the attendees to contribute all their ideas.

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#### **SOLAS studied processes missing from coupled models**

Convenors/Rapporteurs: Maria Kanakidou, Greece; Susann Tegtmeier, Canada; Boris Dewitte, Chile

The number of atmosphere-ocean interface processes implemented in coupled global Earth system models to realistically simulate fluxes of momentum, heat, freshwater, gases, and aerosols is continuously increasing. While progress has been made in some areas, many of the key biogeochemical-physical interactions and feedbacks between the ocean and the atmosphere are still missing from these models. In this session, we will discuss the current status of SOLAS studied processes in coupled models, gaps, and scientific challenges as well as future directions.

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#### **The coupling of ocean, sea-ice and atmospheric chemistry & biogeochemistry: A cross-disciplinary research challenge**

Convenors/Rapporteurs: Daiki Nomura, Japan; Sarat Chandra Tripathy, India; Anoop Mahajan, India; Lisa Miller, Canada; Nadja Steiner, Canada

The ocean areas covered by sea ice are undergoing significant climate change, but many important chemical, biological, and physical processes and feedbacks in these areas are still poorly understood, particularly in the understudied Indian sector of the Southern Ocean. In this discussion session, we hope to foster new interactions among scientists working in the polar oceans and at lower latitudes in the Indian Ocean to explore ways we can help each other better understand both regions and the interactions between them. Through this discussion session, the SOLAS-related sea-ice research communities of BEPSII, CATCH, and Clce2Clouds hope to engage with more scientists who work in the Indian Ocean.

## Daily overview - Monday

### Poster sessions

Location: VIP Guest House

Poster presenters please come to the registration desk to pick up your individual poster board numbers and put up your posters.

Author	Title	No.
<b>Theme 1: Greenhouse gases and the oceans (16:00 – 17:00)</b>		
Prashant Narayan Vishwakarma	The impact of greenhouse gases on the sea surface temperature in the Indian Ocean	101
Ankit Swaraj	Primary productivity and respiration in the north east Atlantic Ocean – assessment across temporal and spatial scales by combining satellite ocean colour, in situ glider measurements and isotopic data	102
Karin Kvale	Reawakening the thermal-bipolar seesaw	103
Raquel Reno de Oliveira	Effects of increase of the CO <sub>2</sub> emissions on the biogeochemical of Tropical and Subtropical South Atlantic Ocean	104
Durgesh Bhati	Species-specific response of copepods to coastal acidification: A field-based approach.	105
Emma Huertas	Deception island: A source of CO <sub>2</sub> and CH <sub>4</sub> to the Southern Ocean	106
<b>Theme 2: Air-sea interface and fluxes of mass and energy (17:00 – 18:00)</b>		
Josefine Karnatz	Phytoplankton derived biopolymers in the Baltic Sea Surface Microlayer	201
Adith V B	Role of atmospheric heat-flux in the surface chlorophyll bloom over northern Arabian sea	202
Avijit Dey	The intraseasonal fluctuation of Indian summer monsoon rainfall and its relation with MISO and MJO	203
Anna Shestakova	Simulation of air-sea interactions during the Novaya Zemlya orographic winds (Russian Arctic) with the coupled model	204
Subhadeep Rakshit	Variable water column mixing influences oxygen and nitrogen cycling in a seasonally hypoxic fjord: inferred from observations and modelling	205
Vijay Kumar	Uncertainties in sea surface temperature and its implication on air-sea flux estimation	206
Falko Schäfer	Surfactant indices for sea surface microlayer characterisation: Comparison of sum-frequency generation, compression isotherm, and ac voltammetry methods	207
Shrivardhan Hulswar	Dimethyl sulfide (DMS) climatologies, fluxes, and trends	208

Author	Title	No.
Elena Päffgen	Turbulence-Based Description of the Air-Sea Gas Exchange	209
Raju Mandal	Understanding the role of ocean and atmosphere on the heat wave dynamics over India and real-time subseasonal prediction	210
<b>Theme 3: Atmospheric deposition and ocean biogeochemistry (18:00 – 19:00)</b>		
Haley Plaas	Investigating the resuspension of mineral dust in sea spray aerosol as a source of soluble iron	301
Akinori Ito	Strategy and protocol toward evaluating atmospheric Fe models using measurements	302
Minako Kurisu	Reconstruction of fluxes, solubilities, and chemical forms of atmospheric trace metals from the pre-industrial times to the present recorded in an SE-Dome II ice core, Greenland	303
Ankush Kaushik	Nano- and micro-plastics in the atmosphere: an analytical approach using Py-GC-MS	304
Morgane Perron	Atmospheric trace element deposition to the south-west Indian Ocean	305
Douglas Hamilton	Is fertiliser production also feeding the ocean?	306
Joan Llort	Evaluating the impact of an improved iron atmospheric cycle on marine primary production and subsurface iron stocks	307
Ravindra Sharma	Aerosol inorganic phosphorus over the Arabian Sea and Bay of Bengal	308
Marie Boye	Responses of phytoplankton to Patagonian dust input and anthropogenic changes in the future Southern Ocean	309
Natasha Majumder	Quantification of dry deposition fluxes of macro and micro-nutrients in the Bay of Bengal: Implication to surface water biogeochemical processes.	310
Chakradhar Reddy	Mercury in marine ecosystems: Bioaccumulation risks and mitigation	311
Aswini MA	Estimation of mineral dust fluxes to the Arabian Sea using the ground-based measurement and satellite based observations	312
Prema Piyusha Panda	Bioactive trace elements and their solubility over the Arabian Sea during the continental outflow	313

## Daily overview - Monday

Author	Title	No.
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## Daily overview - Tuesday

Time	Tuesday, 12 Nov
08:30	<p align="center"><b>Integrate Topic: Upwelling system/Polar oceans and sea ice</b></p> <p align="center">Introduction by sessions chairs: <b>Arvind Singh, Daiki Nomura and Nadja Steiner</b></p>
08:40	<b>Boris Dewitte (Chile):</b> ENSO-driven OMZ variability in the Pacific
09:10	<b>Veronique Garçon (France):</b> Aquatic deoxygenation as a planetary boundary and key regulator of Earth System stability
09:30	<b>Jessie Creamean (USA):</b> Snowcaps, lids, and lenses: The hurdles Arctic microbes must overcome to become airborne and form clouds
10:00	<b>Asmita Singh (Norway):</b> The observational pyramid: Unravelling the physical and biogeochemical processes in the remote polar oceans
10:20	Coffee and tea break
10:50	<p align="center"><b>Theme 3: Atmospheric deposition and ocean biogeochemistry</b></p> <p align="center">Introduction by session chair: <b>Joan Llort</b></p>
11:00	<b>Catarina Guerreiro (Portugal):</b> Aeolian dust deposition in the ocean: A calcifying phytoplankton perspective
11:30	<b>Emtia Wium (South Africa):</b> The effect of dust and metal content on marine phytoplankton growth: A South African perspective
11:50	<b>Peter Liss (UK):</b> Microplastics: All up in the air?
12:10	<b>Diksha Sharma (USA):</b> Dust into bloom: Understanding Arabian Sea phytoplankton community dynamics through atmospheric dust deposition
12:30	Lunch
14:00	<p align="center"><b>Discussion sessions:</b></p> <p><b>Session 1: Exploring the nexus: Building capacity in understanding the impacts of atmospheric deposition on ocean biogeochemistry –</b> <i>Semeena Shamsudheen, UK; Pallavi Saxena, India; Saurabh Sonwani, India; Douglas Hamilton, USA; Alessandro Tagliabue, UK</i></p> <p><b>Session 2: Impacts of biology in the Southern Ocean on cloud processes – upcoming collaborations and initiatives –</b> <i>Jessie Creamean, USA; Marc Mallet, Australia; Manuela van Pinxteren, Germany</i></p> <p><b>Session 3: Knowledge brokering for impact in marine governance –</b> <i>Ellycia Harrould-Kolieb, Australia; Erik van Doorn, Australia</i></p>
15:30	<b>Poster session (incl. coffee break)</b>
	Integrate Topic: Upwelling system/Polar oceans and sea ice
16:30	Theme 4: Interconnections between marine ecosystems, aerosols, and clouds
17:30	Theme 5: Ocean biogeochemical control on atmospheric chemistry

## Daily overview - Tuesday

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### Plenary session

## Integrate Topic: Upwelling system/Polar oceans and sea ice

Session chairs: Arvind Singh, Daiki Nomura and Nadja Steiner

### Keynote speaker: Boris Dewitte

*Center of Advanced Studies in Arid Zones (CEAZA), Coquimbo, Chile; CECI, Université de Toulouse, CNRS, Cerfacs, Toulouse, France; Center for Ecology and Sustainable Management of Oceanic Islands (ESMOI), Facultad de Ciencias del Mar, Departamento de Biología Marina, Universidad Católica del Norte, Chile*



**Boris Dewitte** graduated from University of Toulouse in 1998. His research areas include tropical climate variability, ocean and climate, climate change, air-sea interaction, multi-model analysis, regional biogeochemical coupled model development. While his early interest was on tropical Pacific climate dynamics (El Niño), his work has progressively evolved with a more regional focus, in particular in relation with eastern boundary upwelling systems. Over the past 15 years, he has been involved in various projects dedicated to the study of the Humboldt current system, dealing with regional air-sea interactions and the physical forcing of Oxygen Minimum Zone. He has been a member scientific committee of CLIVAR (2015-2019), co-chair of the Eastern Pacific Task Team of the TPOS2020 program (2019-2022), and currently a member of the Scientific Steering group of the WCRP Earth System Modelling and Observations (ESMO) Core Project. Since 2021 he is also the director of a project entitled CLAP (Research Program for Climate Action Planning) that investigates of how climate, environmental, biogeochemical and socio-economic drivers affect the coastal marine ecosystems in the central Chile region.

### ENSO-driven OMZ variability in the Pacific

The Oxygen Minimum Zones (OMZs), areas in the ocean where the concentration of dissolved oxygen is extremely low, not only influence the distribution and abundance of marine species but also play a significant role in the global carbon and nitrogen cycles. These OMZs are currently diversely simulated by state-of-the-art Earth System Models (ESM) challenging the interpretation of emission-driven climate simulations. They also experience fluctuations at interannual to decadal timescales tight to natural climate variability. Here I will review key physical processes connecting the El Niño Southern Oscillation (ENSO) to the Pacific OMZ emphasising differences between global and regional Earth System Models (ESMs) with a focus on the South Hemisphere. I will also illustrate how the ENSO-OMZ relationship can be used to reduce uncertainty in the future projections of the Pacific OMZs by the global ESMs and discuss the potential underlying mechanisms of this emergent constraint.

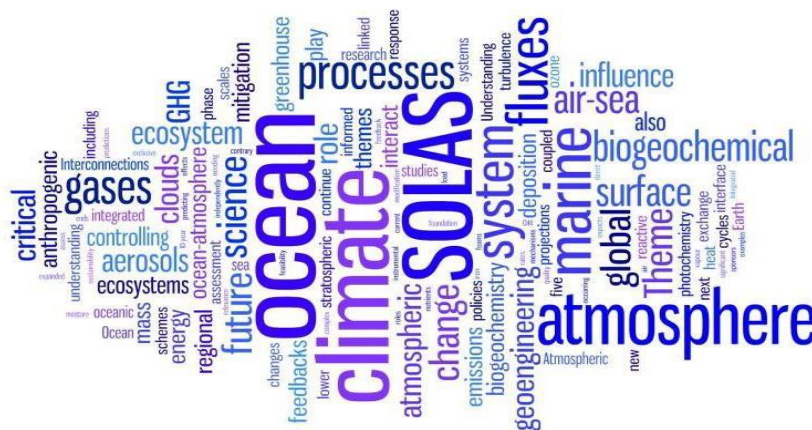
## Aquatic deoxygenation as a planetary boundary and key regulator of Earth System stability

Kevin C. Rose<sup>1</sup>, Erica M. Ferrer<sup>2</sup>, Stephen R. Carpenter<sup>3</sup>, Sean Crowe<sup>4</sup>, Sarah C. Donelan<sup>5</sup>, **Véronique C. Garçon**<sup>6</sup>, Marilaure Grégoire<sup>7</sup>, Stephen F. Jane<sup>8</sup>, Peter R. Leavitt<sup>9</sup>, Lisa A. Levin<sup>2</sup>, Andreas Oschlies<sup>10</sup>, Denise Breitburg<sup>5</sup>

<sup>1</sup>Department of Biological Sciences, Rensselaer Polytechnic Institute, Troy, USA, <sup>2</sup>Center for Marine Biodiversity and Conservation, Scripps Institution of Oceanography, UC San Diego, La Jolla, USA, <sup>3</sup>Center for Limnology, University of Wisconsin, Madison, USA, <sup>4</sup>Departments of Microbiology and Immunology and Earth, Ocean, and Atmospheric Sciences, University of British Columbia, Vancouver, Canada, <sup>5</sup>Smithsonian Environmental Research Center, Edgewater, USA, <sup>6</sup>CNRS - Institut de Physique du Globe de Paris, Paris, France, <sup>7</sup>MAST-FOCUS, Department of Astrophysics, Geophysics and Oceanography, University of Liège, Belgium, <sup>8</sup>Department of Natural Resources and the Environment, Cornell University, Ithaca, USA, <sup>9</sup>Institute of Environmental Change and Society, University of Regina, Saskatchewan, Canada, <sup>10</sup>GEOMAR Helmholtz-Centre for Ocean Research Kiel, Germany

Planetary boundaries represent thresholds in major Earth-system processes that are sensitive to human activity and control global-scale habitability and stability. These processes are inter-connected such that movement of one planetary boundary process can alter the likelihood of transgressing other boundaries. Here, we argue that the observed deoxygenation of the Earth’s freshwater and marine ecosystems represents an additional planetary boundary process that is critical to the integrity of Earth’s ecological and social systems, and both regulates and responds to ongoing changes in other planetary boundary processes. Research on the rapid and ongoing deoxygenation of Earth’s aquatic habitats indicates that relevant, critical oxygen thresholds are being approached at rates comparable to other planetary boundary processes. Concerted global monitoring, research, and policy efforts are needed to address the challenges brought on by rapid deoxygenation, and the expansion of the planetary boundaries framework to include deoxygenation as a boundary helps focus those efforts.

Tuesday



## Daily overview - Tuesday

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### Keynote speaker: Jessie Creamean

*Colorado State University, USA*



**Jessie Creamean** is an atmospheric research scientist at Colorado State University, Colorado, USA. Her research is focused on the systematic examination of aerosols originating from biogenic and geogenic sources such as vegetation, soils, and marine environments and how those particles facilitate the formation of ice in clouds, specifically the polar regions. Over the last 10 years, she has undertaken numerous field campaigns to the Arctic and recently has started working in the Southern Ocean region and Antarctica to develop a comprehensive dataset aimed at advancing our understanding of aerosol-cloud interactions in the high latitudes. When she is not traveling to the ends of the earth, she enjoys adventures in the Rocky Mountains with her two golden retrievers, Whiskey and Montana.

### **Snowcaps, lids, and lenses: The hurdles Arctic microbes must overcome to become airborne and form clouds**

Aerosols and clouds play critical roles in the Arctic energy budget. Specifically, aerosols from open water and sea ice surfaces remain poorly understood, yet could have significant impacts on ice nucleating particle (INP) concentrations, and thus, Arctic cloud formation. We highlight recent findings on aerosols from biological sources in the spring and summer melt periods in the central Arctic. However, the emission of aerosols is contingent on features like open leads and melt ponds, and whether they are covered by snow, freshwater melt layers, or ice lids. These aerosols become more complex near coastlines due to terrestrial influences, such as thawing permafrost. This integrative study involves the use of detailed aerosol, meteorological, oceanographic, and sea ice observations in the central Arctic and near Arctic coastlines. Overall, this work will enable us to assess local aerosol processes associated with cloud formation to better understand the Arctic system through a holistic approach.

## The observational pyramid: Unravelling the physical and biogeochemical processes in the remote polar oceans

**Asmita Singh**<sup>1</sup>, Nicolas Sanchez Puerto<sup>1</sup>, Glaucia Moreira Fragoso<sup>2</sup>, Joseph Landon Garrett<sup>3</sup>, Geir Johnsen<sup>2</sup>, Tor Arne Johansen<sup>3</sup>, Murat Van Ardelan<sup>1</sup>

<sup>1</sup>Department of Chemistry, Norwegian University of Science and Technology (NTNU), Trondheim, Norway,

<sup>2</sup>Department of Biology, Norwegian University of Science and Technology (NTNU), Trondheim, Norway,

<sup>3</sup>Department of Engineering Cybernetics, Norwegian University of Science and Technology (NTNU), Trondheim, Norway

Autonomous sampling platforms have transformed our knowledge and understanding of various physical and biogeochemical processes in the global oceans, offering high temporal and spatial resolution compared to traditional shipboard measurements. Moreover, the remote polar Arctic and Southern Ocean are difficult to access year-round due to seasonal constraints, resulting in limited studies. Thus, autonomous aerial and surface sampling platforms, such as the Autonaut, drones, PhytoPlankton Sampler and Remote Access Sampler, enable a wider observational window. When coupled with traditional in situ measurements and remote sensing observations using the NTNU hyperspectral nanosatellite, HYPSONO, these autonomous systems together form the 'Observational Pyramid'. This integration enhances the data accuracy for predictive models crucial for understanding future scenarios in a changing climate through real-time monitoring. While our research demonstrates the proof-of-concept with combined ecosystem data from fjord regions, both local and international collaboration will further expand our insights into unravelling the biogeochemistry of polar regions.



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## Daily overview - Tuesday

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### Plenary session

## Theme 3: Atmospheric deposition and ocean biogeochemistry

Session chair: Joan Llort

Keynote speaker: Catarina V. Guerreiro

*MARE (Marine and Environmental Sciences Centre)/ARNET (Aquatic Research Network), Ciências ULisboa, Portugal & IDL (Instituto Dom Luiz), Ciências ULisboa, Portugal*



**Catarina V. Guerreiro** is a marine biogeoscientist with expertise in coccolithophore (calcifying phytoplankton) signatures from sediments and water column in present-day marginal to open-ocean environments, its application as a tool to unravel (paleo)environmental variability, and its role in the organic and inorganic biological carbon pumps. Her first steps exploring the effects of Saharan dust in the Atlantic started in 2015, when she received a MSC COFUND Fellowship to work at the University of Bremen. She currently works as a Tenure Track Researcher and Lecturer at the University of Lisbon, leading her FCT-CEEC project CHASE ("CHASing the environmental Effects of dust deposition across the Atlantic and Southern Ocean: a coccolithophore perspective") at the University of Lisbon (<http://www.chase-dust.com>).

### Aeolian dust deposition in the ocean: a calcifying phytoplankton perspective

Aerosols have long been hypothesised to influence the climate system through the drawdown of CO<sub>2</sub> by providing a source of fertilising nutrients and mineral ballast to stimulate the phytoplankton-mediated biological carbon pump (BCP). Being adjacent to the largest source of mineral dust on a global scale, the NE Atlantic is a natural laboratory for assessing such ecological and biogeochemical effects. Coccolithophores, key phytoplankton living in Atlantic waters, are of biogeochemical importance due to their ability of calcifying an exoskeleton around their cell which is composed by multiple tiny calcite plates (coccoliths) synthesised intracellularly and routinely released into the surrounding ocean. Evidence from in-situ and remote sensing observations along two transects crossing – meridionally and longitudinally - the entire North Atlantic, support the hypothesis that Saharan dust stimulates the BCP by providing nutrients to fuel fast-blooming phytoplankton taxa and promoting the export of particulate organic carbon (POC) through dust and coccolith ballasting mechanisms.

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## The effect of dust and metal content on marine phytoplankton growth: A South African perspective

**Emtia Wium**<sup>1</sup>, Susanne Fietz<sup>1</sup>

<sup>1</sup>*Stellenbosch University, Stellenbosch, South Africa*

Phytoplankton play vital roles in the environment and require nutrients for growth. However, at and above threshold concentrations, nutrients and other metals may become toxic to phytoplankton. Dust can supply metals to open or coastal marine environments via wind and ocean circulation. We investigate the impact of dust and metal content on the growth of marine phytoplankton in coastal South Africa. A dataset on metal content in dust was compiled to compare to current concentrations in local coastal southern African waters to assess the extent of potential impact. Incubation experiments were conducted using local coastal phytoplankton and dust. The experiments are presented in which dust or individual metals in concentrations simulating the collected dust are added to a local phytoplankton community in natural seawater incubations. With this, we will know whether dust and its metal content in coastal southern Africa may have fertilising or toxic impacts on local phytoplankton.

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## Microplastics: All up in the air?

**Peter S. Liss**

*School of Environmental Sciences, University of East Anglia, Norwich, UK*

Microplastic particles are found in the remotest parts of the earth but how they get there is not well established. A major route for microplastics to enter the marine environment is via rivers. The possibility that microplastics are transported to the oceans through the atmosphere is a more recent idea. If correct, atmospheric transport presents a more credible way for microplastics to reach remote areas, rather than the much slower route of river input and subsequent transport by ocean currents. Initial calculations indicate that the riverine and atmospheric routes may be of similar magnitude, but there are many uncertainties mostly due to lack of measurements of microplastics in air over the open oceans. However, if the atmospheric route is significant then there are substantial implications for policies aimed at reducing plastics entering the marine environment and also for the upcoming UN Treaty on Plastic Pollution.

## Daily overview - Tuesday

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### Dust into bloom: Understanding Arabian Sea phytoplankton community dynamics through atmospheric dust deposition

**Diksha Sharma**<sup>1#</sup>, Haimanti Biswas<sup>1</sup>, Ashwini Kumar<sup>1</sup>

<sup>1</sup>CSIR-National Institute of Oceanography, Dona Paula, India

<sup>#</sup>Current affiliation: Dartmouth College, New Hampshire, USA

Atmospheric dust deposition significantly modulates nutrient availability and phytoplankton productivity in the Arabian Sea (AS), a region characterised by notable dust influxes, reaching up to  $50 \text{ g m}^{-2} \text{ year}^{-1}$  in its northernmost sector. While previous investigations predominantly utilised model simulations exploring the relationship between dust deposition and phytoplankton productivity in the AS, experimental studies are scarce. Here, we present the results of the first experiment conducted during winter and summer monsoons in the eastern AS, demonstrating elevated phytoplankton cell density and biomass (Chl *a*) in response to dust addition. Particularly noteworthy is the significant shift in phytoplankton community composition towards pennate diatoms (*Pseudo-nitzschia* sp. and *Cylindrotheca closterium*), attributed to external inputs of inorganic nitrogen and iron from dust. Our findings suggest that in future ocean scenarios characterised by heightened dust input, the proliferation of non-palatable phytoplankton taxa may ensue, potentially impacting critical ecological processes such as trophic transfer, carbon cycling, and fisheries.



## Daily overview - Tuesday

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### Parallel discussion sessions

#### **Exploring the nexus: Building capacity in understanding the impacts of atmospheric deposition on ocean biogeochemistry**

Convenors/Rapporteurs: Semeena Shamsudheen, UK; Pallavi Saxena, India; Saurabh Sonwani, India; Douglas Hamilton, USA; Alessandro Tagliabue, UK

The relationship between atmospheric chemistry, aerosol deposition, and ocean biogeochemistry is highly complex. This session focuses on how these processes affect global marine ecosystems, via modulating oceanic nutrient cycling, primary productivity, and ecosystem dynamics. To explore the nexus we propose establishing a new working group including iLEAPS, SOLAS, IGAC, GEIA and AIMES to answer:

1. What are the main sources and pathways of atmospheric deposition impacting ocean biogeochemistry? Are there emerging secondary sources that need attention?
  2. How do oceanic fluxes react with pollution in the marine boundary layer?
  3. How do pollutants such as heavy metals, persistent organic pollutants (POPs), and microplastics accumulate in marine organisms through processes like bioaccumulation and biomagnification?
  4. What are the long-term implications of anthropogenic activities on atmospheric deposition patterns and marine biogeochemical cycles?
- 

#### **Impacts of biology in the Southern Ocean on cloud processes – upcoming collaborations and initiatives**

Convenors/Rapporteurs: Jessie Creamean, USA; Marc Mallet, Australia; Manuela van Pinxteren, Germany

At this critical juncture, understanding the complex relationships between oceanic, cryospheric, and atmospheric processes in the Southern Ocean and Antarctica is imperative. Given their remoteness from major pollution sources, these regions serve as vital benchmarks for pre-industrial conditions. Challenges persist in unravelling the intricate dynamics among oceanic and ice biology, aerosols, clouds, precipitation, and radiation, impacting our ability to model past, present, and future climate change. To address these challenges, nations are launching large-scale field projects to collect essential data, underscoring the need for coordinated efforts to maximise resources and expertise. PICCAASO (Partnerships for Investigations of Clouds and the biogeoChemistry of the Atmosphere in Antarctica and the Southern Ocean) seeks to facilitate collaboration to extract insights from research before further changes occur. This session invites discussion across disciplines, focusing on recent or upcoming field campaigns and fostering interdisciplinary collaboration to address longstanding issues like the Southern Ocean's cloud-radiative bias.

## Daily overview - Tuesday

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### Knowledge brokering for impact in marine governance

Convenors/Rapporteurs: Ellycia Harrould-Kolieb, Australia; Erik van Doorn, Australia

Ensuring the effective interpretation, translation and communication of SOLAS research is critical for achieving impact. Knowledge brokering can be thought of as closing the gap between SOLAS research and practice and is critical to solving real world problems. So, how does one become a knowledge broker? and what skills are needed to do so?

This discussion session will explore the what, why, and how of knowledge brokering focussing on the experiences of scientists working at the science-policy interface of the air-sea interface. The session will begin with an initial lightning round of presentations and provocations of knowledge brokering in practice.

Questions that will be covered include the mechanics of knowledge brokering, such as: What is it? Why is it important? How is it done? And what skills, capacities and/or resources does one need to engage in knowledge brokering? Other themes to be covered will include: What role does knowledge brokering play in creating SOLAS research? and Do researchers have a responsibility to engage with knowledge brokering? How can SOLAS facilitate these topics?



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## Daily overview - Tuesday

### Poster session

Location: VIP Guest House

Author	Title	No.
<b>Integrate Topic: Upwelling system/Polar oceans and sea ice (15:30 – 16:30)</b>		
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Julie Dinasquet	Impact of atmospheric deposition during the 2023-2024 El Niño event in the California Current ecosystem	702
Haimanti Biswas	Phytoplankton community response to variable summer monsoon intensity along the southwest coast of India during 2017-2018.	703
Victor Aguilera	Oceanographic and biological effects of ENSO warming events over the 2022-2023 period in the Humboldt Current System	704
Boris Dewitte	Predictability in oxygen concentration in EBUS: insights from the CNRM-Cerfacs Climate Prediction System (C3PS)	705
Christina Breitenstein	Antarctic peninsula aerosol particle composition regarding free and combined amino acid influenced by the sea surface microlayer	801
Sebastian Zeppenfeld	Marine carbohydrates at high altitudes of the Arctic atmosphere	802
Odile Crabeck	The contribution of sea ice to CO <sub>2</sub> fluxes in polar oceans	803
Ajay B	Effect of strong wind events on the energy balance of Prydz Bay landfast ice	804
Soumyadeep Dutta	Effect of winds on the coastal polynyas in the eastern Antarctica	805
Nadja Steiner	Modelling past and future DMS emission from ice algae and pelagic phytoplankton in the Arctic	806
Daiki Nomura	Seasonal variation of the air–sea ice CO <sub>2</sub> flux during MOSAiC expedition in the Central Arctic Ocean	807
Vijay Prakash Kondeti	Quantification of ocean warming influence on sea ice melting in Arctic seas	808
George Manville	Sea ice meltwater release can explain high springtime seawater dimethylsulfide concentrations in the Antarctic marginal ice zone	809
Thomas Bell	Surface seawater pCO <sub>2</sub> dynamics in the partially ice-covered Weddell Sea, Antarctica	810

Author	Title	No.
<b>Theme 4: Interconnections between marine ecosystems, aerosols, and clouds (16:30 – 17:30)</b>		
Theresa Barthelmeß	Exploring hydrogel enrichment and composition in sea spray aerosols across diverse trophic regimes in the South Pacific Ocean	401
Marc Mallet	Multidisciplinary investigations of the Southern Ocean: A voyage to understand the large influence that marine biology has on clouds	402
Sneha Aggarwal	Can sea spray aerosol be a source of gas-phase perfluoroalkyl substances (PFAS)? A study in the Eastern North Atlantic Ocean	403
Eszter Kovacs	Factors controlling cloud droplet number concentrations over the Southern Ocean	404
Eszter Kovacs	Cloud response to emissions of missing aerosol source from melting sea ice around Antarctica	405
Harshbardhan Kumar	Satellite based observation of first aerosol indirect effect over Northern Indian Ocean	406
Yuzo Miyazaki	Origin of marine atmospheric organic aerosols during the spring phytoplankton bloom after sea ice melting in the Sea of Okhotsk	407
Aleksei Poliukhov	Improvement of sulfate aerosol emission in the INMCM5 model and its effect on cloud cover and radiation	408
Marie Boye	SOLAS-France: Activities and future projects	409
Damodar Shenoy	Establishing an international, multidisciplinary community of practice for the study of methylated sulfur compounds in the ocean: SCOR working group DMS-PRO	410
Bhagyashri Naik	Implications of nitrogen limitation on intracellular DMS/P release in <i>Gyrodinium instriatum</i>	411
Shailina Srivastava	Elucidating the complex interplay between aerosol, water-vapor, and UV radiation under subsaturated conditions using a Quartz Crystal Microbalance (QCM)	412
Ruchith R D	Exploring atmospheric boundary layer and cloud dynamics: Ceilometer lidar measurements in India's western coastal region of India	413

Tuesday

Author	Title	No.
<b>Theme 5: Ocean biogeochemical control on atmospheric chemistry (17:30 – 18:30)</b>		
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Siddharth Iyer	Marine derived aromatics lead efficiently to secondary organic aerosol	502
Dennis Booge	Influence of scrubber effluent on biogenic trace gas production	503
Liselotte Tinel	Shipping-related emissions of volatile organic compounds (VOCs)	504
Jerry Tjiputra	Regional responses of marine bromoform emissions to future climate change	505
George Manville	Analysis of atmospheric dimethylsulfide uncertainties using a global synthesis of ship and aircraft observations	506
Mansi Gupta	Role of air-sea exchange and atmospheric processes influencing the distributions of isoprene and dimethyl sulfide over the Bay of Bengal and Andaman Sea during post-monsoon season	507
Luana Pinho	Volatile Organic Carbon Fluxes (VOCs) in Brazilian coastal lagoons	508
Ankit Patel	Quantifying the effect of atmospheric chlorine chemistry on air quality over Indian subcontinent using GEOS-Chem model	509
Anoop Mahajan	Short Lived Halogens and their impact on the Climate System	510

## Daily overview - Wednesday

Time	Wednesday, 13 Nov
08:30	<b>Theme 4: Interconnections between marine ecosystems, aerosols, and clouds</b> Introduction by sessions chairs: <b>Maria Kanakidou</b> and <b>Jurgita Ovadnevaite</b>
08:40	<b>Manuela van Pinxteren (Germany)</b> : Oceans, aerosols, and clouds: An interplay in the climate system
09:10	<b>Mishka Rawatlal (South Africa)</b> : Sources of water-soluble organic carbon in aerosols at the Cape Point GAW station
09:30	<b>Matti Rissanen (Finland)</b> : Acid + SO <sub>3</sub> reactions as a source of nucleating precursors in marine boundary layer
09:50	<b>Rafel Simo (Spain)</b> : Marine emissions of methanethiol increase aerosol cooling in the Southern Ocean
10:10	Group picture
10:20	Coffee and tea break
10:50	<b>Theme 5: Ocean biogeochemical control on atmospheric chemistry</b> Introduction by session chairs: <b>Nadja Steiner</b> and <b>Anoop Mahajan</b>
11:00	<b>Yee Jun Tham (China)</b> : Heterogeneous recycling of reactive halogens in the marine atmosphere
11:30	<b>Sankirna Joge (India)</b> : Dimethyl Sulfide (DMS) projections (past, present, future) using machine learning model
11:50	<b>Avinash Kumar (Finland)</b> : Reactive Iodine oxides: A missing oxidant of SO <sub>2</sub> towards the formation of sulfuric acid in the marine environment
12:10	<b>Rosie Chance (UK)</b> : Ozone reactive organic compounds in the sea-surface microlayer
12:30	Lunch
14:00	<b>Discussion sessions:</b> <b>Session 1: Reducing uncertainties in soluble aerosol trace element deposition: a SCOR working group call to the community –</b> <i>Morgane Perron, France; Akinori Ito, Japan; Douglas Hamilton, USA</i> <b>Session 2: SOLAS Science &amp; Society 3.0 the way forward –</b> <i>Erik van Doorn, Australia; Ellycia Harrould-Kolieb, Australia</i> <b>Session 3: Coastal cities air quality under the influence from the ocean – shared common mission of IGAC and SOLAS –</b> <i>Maria Kanankidou, Greece; Yee Jun Tham, China</i>
15:30	<b>Poster session (incl. coffee break)</b> Integrated Topic: Indian Ocean
17:00	Science and Society / Climate Intervention
18:30	Conference banquet

## Daily overview - Wednesday

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### Plenary session

## Theme 4: Interconnections between marine ecosystems, aerosols, and clouds

Session chairs: Maria Kanakidou and Jurgita Ovadnevaite

Keynote speaker: Manuela van Pinxteren

*Leibniz Institute for Tropospheric Research, Germany*



**Manuela van Pinxteren** is a senior scientist at the Leibniz Institute for Tropospheric Research (TROPOS). Her research is dedicated to investigating interactions between the ocean and the atmosphere, with a particular focus on marine aerosol particles. The main aim is to identify the influence of the surface ocean on the composition and fate of atmospheric particles. To this end, Manuela is developing analytical methods to unravel the mysteries of organic matter in aerosol particles and in the sea surface microlayer. By coordinating various marine projects and field campaigns, Manuela has extended her expertise from the tropical oceans to the polar regions.

### Oceans, aerosols, and clouds: An interplay in the climate system

Marine aerosols significantly influence atmospheric processes and climate. This presentation explores the production of marine aerosols from the ocean's surface and their complex (organic) composition. Emphasising the need for good analytical methods, I will demonstrate how these techniques can help to characterise the diverse and detailed properties of aerosol particles and improve our understanding of their production and processing in the marine atmosphere. Additionally, I will discuss the sea surface microlayer, the ocean's "skin," and its role in connecting the marine atmosphere to aerosol formation, including the production of ice-nucleating particles (INPs). Finally, I will present how marine organics are linked to oceanic INPs and show their global contribution.

### Sources of water-soluble organic carbon in aerosols at the Cape Point GAW station

**Mishka Rawatlal**<sup>1</sup>, Kurt Spence<sup>1#</sup>, Casper Labuschagne<sup>2</sup>, Katye Altieri<sup>1</sup>

<sup>1</sup> University of Cape Town, South Africa, <sup>2</sup>South African Weather Service, Stellenbosch, South Africa

<sup>#</sup>Current affiliation: University of Helsinki, Finland

Marine aerosols impact atmospheric chemistry and climate by influencing cloud formation and the atmosphere's radiative balance. The sources and factors driving variability in marine organic aerosols remain under-examined. This study presents size-resolved water-soluble organic carbon (WSOC) aerosol concentrations collected weekly over eight months at the Cape Point Global Atmosphere Watch (GAW) station in South Africa. Drivers of fine-mode and coarse-mode variability in the WSOC aerosol concentrations are explored using air mass back trajectories, trace gas concentrations, and satellite observations of fires and chlorophyll-a. WSOC was predominantly found in the fine mode ( $< 1 \mu\text{m}$ ), particularly in marine air masses during spring and summer. Marine air masses displayed elevated WSOC concentrations from August to September, while continental air masses had higher concentrations from May to July due to increased biomass burning. This study advances our understanding of organic aerosols in a coastal region impacted by natural and anthropogenic factors.

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### Acid + SO<sub>3</sub> reactions as a source of nucleating precursors in marine boundary layer

**Matti Rissanen**<sup>1,2</sup>, Siddharth Iyer<sup>1</sup>, Shawon Barua<sup>1</sup>, Emin Besic<sup>1</sup>, Prasenjit Seal<sup>1</sup>, Avinash Kumar<sup>1</sup>

<sup>1</sup> Aerosol Physics Laboratory, Physics Unit, Tampere University, Tampere, Finland, <sup>2</sup> Department of Chemistry, University of Helsinki, Helsinki, Finland

Sulfur trioxide (SO<sub>3</sub>) is a key intermediate in the formation of atmospheric particulate matter. Its rapid water catalysed hydrolysis leads to sulfuric acid (H<sub>2</sub>SO<sub>4</sub>) production - the single most important compound initiating ambient new particle formation (NPF). Until very recently it was thought that SO<sub>3</sub> will not have a long enough lifetime for bimolecular reactions in the planetary boundary layer. However, Yao et al., ES&T Lett. 2020 were able to measure appreciable concentrations of SO<sub>3</sub> in megacity Beijing, illustrating that SO<sub>3</sub> bimolecular chemistry must be occurring notwithstanding the rapid hydrolysis rates. Now we have performed flow reactor experiments and detailed quantum chemical computations on acid + SO<sub>3</sub> reactions including iodic acid (HIO<sub>3</sub>) and sulfuric acid, and a collection of carboxylic acids. All the reactions are found to be very fast and produce acid sulfuric anhydrides that are likely contributors to atmospheric NPF events.

### Marine emissions of methanethiol increase aerosol cooling in the Southern Ocean

Charel Wohl<sup>1,2</sup>, Julián Villamayor<sup>3</sup>, Martí Galí<sup>1</sup>, Anoop S. Mahajan<sup>4</sup>, Rafael P. Fernández<sup>5</sup>, Carlos A. Cuevas<sup>3</sup>, Adriana Bossolasco<sup>3,6</sup>, Qinyi Li<sup>7</sup>, Anthony J. Kettle<sup>8</sup>, Tara Williams<sup>9</sup>, Roland Sarda-Esteve<sup>10</sup>, Valérie Gros<sup>10</sup>, **Rafel Simó**<sup>1</sup>, Alfonso Saiz-Lopez<sup>3</sup>

<sup>1</sup>Department of Marine Biology and Oceanography, Institut de Ciències del Mar, CSIC, Barcelona, Catalonia, Spain, <sup>2</sup>Centre of Ocean and Atmospheric Sciences, University of East Anglia, Norwich, UK, <sup>3</sup>Department of Atmospheric Chemistry and Climate, Institute of Physical Chemistry Blas Cabrera, CSIC, Madrid, Spain, <sup>4</sup>Centre for Climate Change Research, Indian Institute of Tropical Meteorology, Ministry of Earth Sciences, Pune, India, <sup>5</sup>Institute for Interdisciplinary Science (ICB), National Research Council (CONICET), FCEN-UNCuyo, Mendoza, Argentina, <sup>6</sup>Physics Institute of Northwest Argentina (INFINOA), National Research Council (CONICET), Tucumán, Argentina, <sup>7</sup>Environment Research Institute, Shandong University, Qingdao, China, <sup>8</sup>Météo France, Lannion, France, <sup>9</sup>Old Dominion University, Norfolk, VA, USA, <sup>10</sup>Laboratoire des Sciences du Climat et de l'Environnement (LSCE), CNRS-CEA-UVSQ, IPSL, Gif sur Yvette, France

Ocean-emitted dimethylsulfide (DMS) is a major source of climate-cooling aerosols. However, most of the marine biogenic sulfur cycling is not routed to DMS but to methanethiol (MeSH), another volatile whose reactivity has hitherto hampered measurements. Therefore, the global emissions and climate impact of MeSH remain unexplored. We compiled a database of seawater MeSH concentrations, identified their statistical predictors, and produced monthly fields of global marine MeSH emissions adding to DMS emissions. Implemented into a global chemistry-climate model, MeSH emissions increase the sulfate aerosol burden by 30-70% over the Southern Ocean and enhance the aerosol cooling effect while depleting atmospheric oxidants and increasing DMS lifetime and transport. Accounting for MeSH emissions reduces the radiative bias of current climate models in this climatically relevant region.

## Daily overview - Wednesday

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### Plenary session

## Theme 5: Ocean biogeochemical control on atmospheric chemistry

Session chairs: Nadja Steiner and Anoop Mahajan

Keynote speaker: Yee Jun Tham

*Sun Yat-sen University, China*



**Yee Jun Tham** received his PhD in atmospheric chemistry from The Hong Kong Polytechnic University, Hong Kong, China. After working as a postdoctoral researcher at the University of Helsinki, Finland, he has been working at the School of Marine Sciences, Sun Yat-sen University since 2021. He is interested in the cycles of halogens (Cl, Br, I) in the atmosphere and surface ocean. His research mainly focuses on the field observation and laboratory simulation of the emission of halogens, atmospheric processes of reactive halogens (including heterogeneous cycling), and their impacts in marine and coastal environment.

### Heterogeneous recycling of reactive halogens in the marine atmosphere

Halogens, including chlorine (Cl), bromine (Br) and iodine (I), are important elements in the ocean. The marine biological activities and air-sea interaction processes in the ocean provide a large source of reactive halogens to the atmosphere, which have significant influence on the biogeochemical processes, air quality and climate. Recent studies show that the oceanic emissions of reactive halogen have been increasing over the past decades due to global warming and elevated ozone. The halogen chemistry can be further enhanced in regions influenced by human activities (i.e., coastal pollutions, shipping emissions, etc.), for instance, via heterogeneous processes. In this talk, I will focus on the recent key findings on the atmospheric chemistry of reactive halogens (Cl, Br, I) with examples drawn from both the literature and my own research, centered mostly on the heterogeneous cycling of reactive halogens on aerosols and their impacts in the marine atmosphere. The talk will further discuss the challenges that still need to be addressed for better understanding of atmospheric heterogeneous recycling of reactive halogens in the changing world.

## Dimethyl Sulfide (DMS) projections (past, present, future) using machine learning model

**Sankirna D. Joge**<sup>1,2</sup>, Anoop S. Mahajan<sup>1</sup>

<sup>1</sup>Indian Institute of Tropical Meteorology, Pune, India, <sup>2</sup>Savitribai Phule Pune University, Pune, India

Dimethyl Sulfide (DMS) is a naturally emitted trace gas from the surface ocean and contributes to cloud formation and the Earth's radiation budget. Measurement of DMS in seawater is challenging, and hence, measurements are spatially and temporally inconsistent. In this work, in-situ DMS data points are used to train a machine learning model which uses predictors from CMIP6 models in order to predict seawater DMS concentrations from 1850-2100 for historical, ssp126, ssp245, ssp370, and ssp585 scenarios. The ML-based results show that the future seawater DMS concentrations are sensitive to the selection of the parameters used to train the model and the future scenarios considered. Most scenarios show a decrease in the DMS concentrations, which has implications on the future role of ocean emissions of cloud formation.

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## Reactive Iodine oxides: A missing oxidant of SO<sub>2</sub> towards the formation of sulfuric acid in the marine environment

**Avinash Kumar**<sup>1</sup>, Siddharth Iyer<sup>1</sup>, Shawon Barua<sup>1</sup>, Prasenjit Seal<sup>1</sup>, Matti Rissanen<sup>1,2</sup>

<sup>1</sup>Aerosol Physics Laboratory, Physics Unit, Faculty of Engineering and Natural Sciences, Tampere University, Tampere, Finland, <sup>2</sup>Department of Chemistry, University of Helsinki, Helsinki, Finland

Hydroxyl radicals (OH) are the main oxidants of SO<sub>2</sub> leading to the formation of sulfuric acid (SA) in the daytime. Measurement of ambient SA concentration in the suggests that other unaccounted oxidation pathways of SO<sub>2</sub> should exist. In marine environments, the reaction of nitrate radicals with the prevalent molecular iodine and iodocarbons are known sources of night time IO and OIO radicals.

Laboratory experiments for the reaction of in-situ generated iodine radicals and oxides with SO<sub>2</sub> were carried out using a flow reactor coupled with a nitrate-based chemical ionisation mass spectrometer (NO<sub>3</sub>--CIMS) and was observed to lead to the formation of SO<sub>3</sub>. High-level quantum chemical calculations were performed to get detailed insights into the mechanism and feasibility of the oxidation of SO<sub>2</sub> by iodine oxides to produce SA. This study suggests that I<sub>2</sub>O<sub>4</sub> may be one of the unidentified SO<sub>2</sub> oxidants responsible for significant production of SA, especially during night time.

### Ozone reactive organic compounds in the sea-surface microlayer

**Rosie Chance**<sup>1</sup>, Tom Bell<sup>2</sup>, Lucy Brown<sup>1</sup>, David Loades<sup>1</sup>, Liselotte Tinel<sup>1#</sup>, Katherine Weddell<sup>1</sup>, Lucy Carpenter<sup>1</sup>

<sup>1</sup>Wolfson Atmospheric Chemistry Laboratories, University of York, York, UK, <sup>2</sup>Plymouth Marine Laboratory, Prospect Place, Plymouth, UK

<sup>#</sup>Current affiliation: IMT Nord Europe, Institut Mines-Télécom, University of Lille, Centre for Energy and Environment, France

Dry deposition to the ocean surface is a major sink for tropospheric ozone, a pollutant gas. Oceanic deposition is driven by chemical reactions between ozone and compounds in the sea surface microlayer (SML), primarily iodide and components of marine organic matter. The nature and distribution of ozone reactive organic compounds in the SML are largely unknown. High-resolution mass spectrometry (HR-MS) has been used to probe the molecular composition of the SML and relate this to ozone reactivity. Ozonation experiments suggest that unsaturated fatty acids are dominant ozone reactants in fresh organic matter, while aromatic species are the main reactants in aged organic matter. Observations reveal these compounds are highly enriched in the SML and exhibit seasonal variation consistent with a biogenic source, but different to that of total dissolved organic carbon (DOC). This implies that DOC is a poor proxy for ozone reactive organic matter in ozone deposition models.



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## Daily overview - Wednesday

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### Parallel discussion sessions

#### **Reducing uncertainties in soluble aerosol trace element deposition: a SCOR working group call to the community**

Convenors/Rapporteurs: Morgane Perron, France; Akinori Ito, Japan, Douglas Hamilton, USA

Quantifying the transfer of micronutrient trace elements (TE) and pollutants across the air-sea interface is a current research priority of international research programs like SOLAS. However, large uncertainties remain on what fraction of the atmospheric input flux is soluble, hindering a good understanding of how atmospheric TE deposition modulates marine biological activity and, ultimately, the oceanic sequestration of atmospheric CO<sub>2</sub>. The SCOR Working Group 167 (RUSTED) brings together experts from ocean biogeochemistry, atmospheric chemistry and modelling communities, with the aim of assuring the quality and comparability of TE solubility data produced through laboratory leaching schemes and providing advice on the use of such data in Earth System models. RUSTED wishes to present its ongoing work. Including two intercomparison studies of 1) aerosol TE solubility laboratory leaching schemes and of 2) coupled atmosphere-ocean Fe solubility modelling estimates. Inputs and participation from the wider SOLAS community are sought.

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#### **SOLAS Science & Society 3.0 the way forward**

Convenors/Rapporteurs: Erik van Doorn, Australia; Ellycia Harrould-Kolieb, Australia

Since the Open Science Conference in Kiel in 2015, SOLAS Science & Society has worked on how to increase interaction between natural scientists and social scientists on the one hand and the interaction with society as a whole on the other. In this session, we would like to engage the SOLAS community in the work that has been done on the former. We will report on the efforts so far, especially the workshop on this topic held in Goa in November 2023 and aims for SOLAS Science & Society in the upcoming Science Plan. There is also ample opportunity to brainstorm about new topics that might need to be covered by SOLAS Science & Society in the future, both with our scientific efforts as well as our communication with stakeholders and local communities.

### **Coastal cities air quality under the influence from the ocean – shared common mission of IGAC and SOLAS**

Convenors/Rapporteurs: Maria Kanankidou, Greece; Yee Jun Tham, China

Coastal cities are located at the intersection between the ocean and the continent, and the alternating influence of sea and land air masses makes the formation, transfer and transformation processes of pollutants to present significant coastal characteristics. Marine emissions are affecting air quality in coastal cities and in turn the cities' emissions through changes in atmospheric composition affect the regional climate, contribute to deposition of pollutants/nutrients and thereby impact on the marine environments. Taking these interactions into account requires joint efforts by atmospheric and marine scientists. The regulation mechanism of air pollution in coastal cities and the health effects of emissions from marine source are still unclear, which is a major constraint to sustainable improvement of air quality in coastal areas. Located in both of the missions of IGAC and SOLAS, joint efforts have to be carried out to improve the air quality of coastal cities.

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## Daily overview - Wednesday

### Poster session

Location: VIP Guest House

Author	Title	No.
<b>Integrate Topic: Indian Ocean (15:30 – 17:00)</b>		
Sipai Nazirahmed	Distribution of picophytoplankton and its contribution in particulate organic carbon pool of the Arabian Sea	601
Deepak Kumar Rai	Glacial-Interglacial Oxygen Variability in the Northern Arabian Sea	602
Ina Stoltenberg	Characterising the distribution of nitrous oxide in the oxygen minimum zone of the Bay of Bengal	603
Abul Qasim	Seasonality in nutrient dynamics controls the C:N:P stoichiometry in the particulate organic matter of the northern Indian Ocean	604
Debarati Sengupta	Revisiting the concept of zooplankton diversity assessment: perspectives from carcasses	605
Hendrik Feil	Trace gas cycling in the Indian Ocean	606
Aditi Sharma	Modifications in silicate inputs may alter phytoplankton composition in the coastal Bay of Bengal	607
Sanjeev Kumar	Role of macro- and micro-nutrients on primary production and nitrogen fixation in the northern Indian Ocean	608
Sakshi Kanotra	Diving into the Phycosphere: Species-specific diatom-bacterial interactions in the eastern Arabian Sea Microenvironments	609
Ravi Bhushan	Deciphering processes regulating residence time and isotopic distribution of Be in the Indian Ocean	610
Rahul Khichi	Diatom assemblages in the surface sediments of the Eastern Arabian Sea	611
Md. Shahin Hossain Shuva	Daytime and night time sea surface temperature (SST) along with diurnal variability (D SST) in the northern Bay of Bengal: A remote sensing approach	612
Imsangla Imchen	Machine learning approaches for estimating subsurface oceanic parameters	613
Somdipta Sen	Submarine groundwater discharge derived carbon flux into a tidal estuary of the Bay of Bengal	614
Sohan Pm	Influence of tropical cyclone characteristics on the surface waves in the Bay of Bengal	615
Garima Shukla	Long term seasonal variability in the chemical composition of coarse and fine aerosols over the northeastern Arabian sea	616
Medhavi Pandey	Diatom response to variable atmospheric forcings in the recent past from the eastern Arabian Sea	617

## Daily overview - Wednesday

Author	Title	No.
Punya P	Spatial disaggregation and generation of high-resolution climate dataset (CMIP6) using machine learning techniques	618
Harithasree S	Variability in aerosols and related chemical species over the Indian Ocean	619
Jai Singh	Oceanographic surface monitoring & mooring tracking system	620
<b>Science and Society / Climate Intervention (17:00 – 18:00)</b>		
Shailendra Mandal	Climate intervention approaches for vulnerability assessment of coastal city to climate change and climate variability due to ocean-atmosphere interactions: Lessons from the metropolitan city of India	901
Jitender Kumar	Exploring the potential of various minerals for Ocean Alkalinity Enhancement (OAE)	902
Odile Crabeck	Introduction to marine CDR technologies, their potential risks and challenges.	903
Matthew Woodhouse	Simulating the effects of sea spray injection on aerosol and cloud	904
Shreya Mehta	Mineral based – OAE and its implications on the C and N biogeochemical cycling	905
Rebecca Jackson	Modelled impacts of marine cloud brightening in the Great Barrier Reef	906
Thomas Bell	The SeaCURE project: Diving into the details of a marine Carbon Dioxide Removal technology	907

## Daily overview - Thursday

Time	Thursday, 14 Nov
08:30	<p align="center"><b>Science and Society / Climate Intervention</b></p> <p align="center">Introduction by session chairs: <b>Ellycia Harrould-Kolieb, Christa Marandino, William Miller</b></p>
08:40	<b>Erik van Doorn (Australia):</b> International law & policy concerning the air-sea interface
09:10	<b>Shubham Krishna (UK):</b> Climate warming masks de-eutrophication signal in coastal ecosystems
09:30	<b>Doug Wallace (Canada):</b> Ocean-based climate intervention
10:00	<b>Daniel Harrison (Australia):</b> Recent progress in the physical investigation of Marine Cloud Brightening
10:20	Coffee and tea break
10:50	<p align="center"><b>Integrate Topic: Indian Ocean</b></p> <p align="center">Introduction by session chair: <b>Anoop Mahajan</b></p>
11:00	<b>Tanya Marshall (USA):</b> Exploring the last oceanographic frontier: lessons from the Indian Ocean
11:30	<b>Koji Hamasaki (Japan):</b> Profiling microbial community in sea surface microlayer and marine aerosols in the Bay of Bengal and the Southeast Indian Ocean
11:50	<b>S. Gopika (India):</b> Mechanisms of the tropical Indian Ocean surface warming patterns: Simulated by CMIP Models
12:10	<b>Udisha Singh (India):</b> Geochemical tracing of atmospheric mineral dust over the North Indian Ocean
12:30	Lunch
14:00	<p align="center"><b>SOLAS 3.0</b></p> <p align="center">Introduction by session chairs: <b>Christa Marandino</b> and <b>William Miller</b></p>
14:10	<b>Angela Landolfi (Italy):</b> Drivers and impacts of extreme events on air-sea interactions
14:40	<b>Julie Dinasquet (USA):</b> Thriving through Synergy: fostering a SOLAS Community built on equity, international connections and early career scientists integration
15:10	Discussion
15:30	Coffee and tea break
16:00	<b>SOLAS India meeting</b>

## Daily overview - Thursday

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### Plenary session

## SOLAS Science and Society & Climate Intervention

Session chairs: Ellycia Harrould-Kolieb, Christa Marandino and William Miller

Keynote speaker: Erik van Doorn

*Australian National Centre for Ocean Resources & Security, University of Wollongong, Australia*



**Erik van Doorn** is a lecturer at the Australian National Centre for Ocean Resources & Security (ANCORS) at the University of Wollongong. Before, he worked at the International Tribunal for the Law of the Sea, Kiel University as well as at the GEOMAR Helmholtz Centre for Ocean Research Kiel. Erik's fields of work are international law of the sea and international environmental law. His research has focused on marine resources, the marine uptake of carbon dioxide & ocean observing.

### International law & policy concerning the air-sea interface

Whereas SOLAS scientists traditionally dedicate their research to understand the interaction of processes between the lower atmosphere and the surface of the ocean, less attention is given to the work that they do in the social sciences and humanities. Yet there is an increasing need to address the air-sea interface interactions from a social science and humanities perspective, considering that anthropogenic climate change has been a driver in leading policy discussions regarding climate intervention. In addition, harmful algae blooms, ship emissions and marine plastics are topical issues that require interdisciplinary approaches to deliver implementable solutions. The international legal and policy framework has started to incorporate the air-sea interface issues but remains in its infancy. SOLAS is very well suited to raise awareness in this regard and more importantly, provide scientific input wherever necessary.



## Daily overview - Thursday

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### Keynote speaker: Doug Wallace

*Oceanography Department, Dalhousie University, Canada*



**Doug Wallace** is Canada Excellence Research Chair (CERC) Laureate and Canada Research Chair in Ocean Science and Technology at Dalhousie University in Halifax, Canada. He is also a Scientific Director of the Marine Environmental Observation Prediction and Response Network, a large Canadian network focused on marine risk. He is Co-Chair of DOTCAN (Development of Ocean Technical Capacity with Africa Nations): a not-for-profit that promotes grass-roots cooperation with West African countries. He is a Fellow of the Royal Society of Canada and has co-authored over 145 publications. Dr Wallace has contributed to building multidisciplinary research teams and programs in the USA, Germany, Europe, West Africa and Canada and is a former Chair of SOLAS.

### Ocean-based climate intervention

International negotiations to limit climate change have been ongoing for 35 years. Over that period, atmospheric CO<sub>2</sub> has increased by 80 μatm, with no sign of slowing down, and the ocean's heat content (0-2000 m) has increased steadily, on average, by 1.23 GJ m<sup>-2</sup>. Oxygen concentrations, pH and ice-cover have decreased and sea-level has risen. Commitments made under the Paris Agreement and subsequent negotiations imply a global temperature increase of 2.1 - 2.5 °C by the end of the century, if targets are met. Attaining the ambitious Paris goal of 1.5 °C, to limit dangerous climate change, will require negative carbon emissions using technologies that have not yet been proven at scale.

This context and awareness of a "climate emergency" has led to the ocean suddenly becoming the focus of a growing number of ideas for climate solutions or ocean-based climate intervention. These involve deliberate, large-scale manipulation of the ocean's physical, chemical and biological systems (including the cryosphere) under two main categories: a) Measures to mitigate climate change itself (e.g. marine carbon dioxide reduction (mCDR); deliberate climate modification); b) Measures to mitigate the impacts of climate-change (including restoration/ protection of ocean systems and/or biodiversity).

The address will present a brief horizon scan of the range of interventions currently under consideration. There will be a focus on ocean alkalinity enhancement for mCDR and use of oxygen produced during green hydrogen production to protect marine biodiversity from increasing hypoxia in coastal waters. Ethical, practical and funding challenges associated with this new area of research activity will be highlighted.

## Daily overview - Thursday

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### Recent progress in the physical investigation of Marine Cloud Brightening

**Daniel Patrick Harrison**<sup>1</sup>

<sup>1</sup> National Marine Science Centre, Southern Cross University, Australia

For over 30 years scientists and engineers have considered whether it was possible to mitigate global warming by atomising seawater over the ocean in a bid to favourably manipulate aerosol-cloud-radiation processes. In the Reef Restoration and Adaptation Program Marine Cloud Brightening (MCB) is being investigated as a regional strategy to reduce environmental stress on coral reefs during marine heatwaves. Atmospheric, biogeochemical and ecological modelling suggest that the potential exists to reduce light and thermal stress during marine heatwaves causing coral bleaching. In recent field campaigns, we have been able to for the first time empirically test the concepts underpinning MCB. From its inception the research program has involved consultation and participation of indigenous traditional custodians of the reef and has proceeded within the regulatory oversight of one of the world's most actively managed marine estates.

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## Daily overview - Thursday

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### Plenary session

### Integrate Topic: Indian Ocean

Session chair: Anoop Mahajan

Keynote speaker: Tanya Marshall

*Department of Geosciences, Princeton University, USA & Department of Oceanography, University of Cape Town, South Africa*



**Tanya Marshall**'s research explores nutrient supply and biogeochemical cycling in the modern ocean using geochemical tracers like nitrate isotopes and nutrient stoichiometry. She earned her PhD from the University of Cape Town, South Africa, where her research was focussed on characterising nitrogen cycling in the understudied South Atlantic and South Indian Oceans. More specifically, her work investigated how physical and biogeochemical processes that occur over multiple spatial scales impact surface ocean fertility, and carbon export potential. Tanya is currently a Presidential Postdoctoral Research Fellow in the Department of Geosciences at Princeton University, where she is working on developing a new quantitative framework for interpreting nitrate isotope ratios in the ocean.

### Exploring the last oceanographic frontier: lessons from the Indian Ocean

The Southern Ocean takes up over 40% of the ocean's anthropogenic CO<sub>2</sub>. The business-as-usual climate scenario projects a warmer climate, higher atmospheric CO<sub>2</sub> concentrations, and weakened ocean's CO<sub>2</sub> buffering capacity in the future. This study investigated how the Southern Ocean CO<sub>2</sub> sink will be affected by these conditions as simulated according to the socioeconomic pathway 585 climate scenario. We find that in addition to the increase in CO<sub>2</sub> uptake, the largest CO<sub>2</sub> sink region shifts from the Subtropical region (northern edge of the Southern Ocean) to the Antarctic region (southern edge) by the end of the century (2080 – 2099). In the future, CO<sub>2</sub> uptake is nearly double in the Antarctic region relative to the region between 30°S and north of the polar front; the present climate shows the opposite. Because CO<sub>2</sub> uptake is primarily regulated by temperature-driven solubility in the subtropical region, increased CO<sub>2</sub> uptake during cooler seasons (winter-autumn) due to higher atmospheric CO<sub>2</sub> in the future is nearly compensated by weakened CO<sub>2</sub> solubility in warmer seasons (summer-spring) due to warming. Two factors influence the CO<sub>2</sub> sink increase in the Antarctic region. First, warming-driven sea-ice melt enhances surface stratification and shoals ocean mixed layer depths, weakening subsurface DIC entrainment and enhancing seasonal surface cooling (& warming) rates; this strengthens solubility-driven CO<sub>2</sub> uptake. Secondly, consistent with previous studies, we find that the lower CO<sub>2</sub> buffering capacity strengthens biological-driven CO<sub>2</sub> uptake, although long-term changes in primary production are not significant. Collectively, these changes shift the Southern Ocean's dominant CO<sub>2</sub> sink from the subtropical region to the Antarctic region in the future.

### Profiling microbial community in sea surface microlayer and marine aerosols in the Bay of Bengal and the Southeast Indian Ocean

**Koji Hamasaki**<sup>1,3,4</sup>, Poonam Bikkina<sup>1</sup>, Md Mehedi Iqbal<sup>1</sup>, Yoko Makabe-Kobayashi<sup>1</sup>, Yoko Iwamoto<sup>2</sup>

<sup>1</sup>Atmosphere and Ocean Research Institute, University of Tokyo, Chiba, Japan, <sup>2</sup>Graduate School of Integrated Science for Life, Hiroshima University, Higashi-Hiroshima, Japan, <sup>3</sup>Department of Integrated Biosciences, Graduate School of Frontier Sciences, University of Tokyo, Chiba, Japan, <sup>4</sup>Collaborative Research Institute for Innovative Microbiology, University of Tokyo, Tokyo, Japan

To understand a role of microbes in air-sea interactive processes, we explored prokaryotic community structures in the sea surface microlayer, underlying water and sea spray aerosols during the KH18-6 cruise of R/V Hakuho-maru in late autumn in the Bay of Bengal and the southern Indian Ocean. Aerosol and seawater samples were collected, and bubble bursting experiments were performed on board. Microbial DNA was extracted and subjected to 16S rRNA gene amplicon sequencing for taxonomic profiling of prokaryotes. Distinct profiles between aerosol and surface water samples suggested preferential aerosolisation of some specific taxa of prokaryotes. Also, the results highlighted the dominance of land derived bacteria was controlled by prevailing surface winds, which led to the regional differences especially in coarse particles over distant oceanic atmosphere. Implications are the importance of particle association and constant mixing of aerosols in understanding aerial transport of microorganisms and its influences on cloud formation processes.

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### Mechanisms of the tropical Indian Ocean surface warming patterns: Simulated by CMIP Models

**S. Gopika**<sup>1,2</sup>, K. Sadhvi<sup>3</sup>, J. Vialard<sup>4</sup>, V. Danielli<sup>5</sup>, S. Neetu<sup>1</sup>, M. Lengaigne<sup>5</sup>

<sup>1</sup>CSIR- National Institute of Oceanography, Goa, India, <sup>2</sup>School of Earth, Ocean and Atmospheric Sciences, Goa University, Goa, India, <sup>3</sup>Digital University Kerala (DUK), Trivandrum, India, <sup>4</sup>LOCEAN/IPSL, Sorbonne Universités (UPMC, Univ Paris 06)-CNRS-IRD-MNHN, France, <sup>5</sup>MARBECC, University of Montpellier, IFREMER, IRD, France

Coupled Model Intercomparison Project (CMIP5/6) projects a warming pattern reminiscent of the Indian Ocean Dipole (IOD), with a reduction in the IO branch of the Walker Cell. In this study, we adapt and extend a simplified Sea Surface Temperature (SST) heat budget equation by Zhang and Li (2014, hereafter ZL14), across 46 CMIP5/6 simulations. Departing from the previous ZL14 methodology, our analysis incorporates feedback of downward longwave fluxes. While ZL14 emphasised downward longwave fluxes as the primary driver of IO average warming, our findings unveil the influence of changes in latent heat flux. These changes are closely associated with a basin-scale wind reduction, attributed to the weakening of monsoons and the Walker cell branch. Our results underscore the role of the Bjerknes feedback in driving the IOD-like pattern across both the MMM and inter-model diversity. In the Western Indian Ocean, enhanced warming is modulated by a seasonally fluctuating equilibrium.

### Geochemical tracing of atmospheric mineral dust over the North Indian Ocean

**Udisha Singh**<sup>1,2</sup>, Ashwini Kumar<sup>1,2</sup>

<sup>1</sup>Geological Oceanography Division, CSIR-National Institute of Oceanography, Goa, India, <sup>2</sup>Academy of Scientific and innovative research (AcSIR), Ghaziabad, India

The pivotal role of atmospheric mineral dust in altering Earth's radiation budget, influencing cloud formation and general atmospheric circulation, and modulating the biogeochemical cycle is well recognised. The North Indian Ocean (NIO), surrounded by various arid and semi-arid regions receives significant amount of dust annually. However, the level of uncertainty in understanding their impact over this marine region is high due to an inadequate investigation of their transport, sources, and sinks. Using isotopic (Sr-Nd) and mineralogical data, we made an attempt to characterise the mineral dust, identify their sources along with transport pathways over the NIO. The isotope analysis was carried out on samples collected during wet and dry season over the Arabian Sea and Bay of Bengal. Using radiogenic isotope ratio corroborated with air-mass back trajectories and aerosol index map, we recorded the role of different wind patterns impacting the temporal and spatial pattern of dust deposition over the NIO.

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## Daily overview - Thursday

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### SOLAS 3.0

Session chairs: Christa Marandino and William Miller

Keynote speaker: Angela Landolfi

*National Research Council, Institute of Marine Sciences CNR-ISMAR, Italy*



**Angela Landolfi** is a marine biogeochemist currently working at the Institute of Marine Sciences (ISMAR) at the Italian National Research Council (CNR) in Rome. During her PhD at the University of Southampton, she conducted experimental work related to regional nutrient budgets and the maintenance of primary productivity. She then spent over a decade in the biogeochemical modelling department at GEOMAR Helmholtz Centre for Ocean Research Kiel. Her research integrates observations and biogeochemical models to understand the cycling and maintenance of ocean reservoirs of carbon (C), nitrogen (N), and oxygen (O<sub>2</sub>), and

their interactions with other elements such as phosphorus (P) and iron (Fe). She is interested in how these cycles are affected and affect global climate, impacting on the storage and production of greenhouse gases like carbon dioxide (CO<sub>2</sub>) and nitrous oxide (N<sub>2</sub>O), under past, present and future climate conditions.

### Drivers and impacts of extreme events on air-sea interactions

Extreme conditions in ocean properties, such as temperature and acidity, have become more frequent in recent years, posing a threat to marine ecosystems and raising serious concerns about the disruption of key ecosystem services. The intensification of these extreme events is driven by a combination of increasing anthropogenic greenhouse gas emissions, which are expected to alter their frequency and severity, and natural climate variability. Often acting simultaneously, these extreme events can have additive effects but may also exhibit non-linear synergistic or antagonistic interactions, leading to difficult-to-predict impacts on marine ecosystems and air-sea interactions. Here, I will discuss both natural and anthropogenic drivers of extreme events and discuss the compounded effects of marine heat waves, ocean acidification extremes, and extreme wind conditions on air-sea interactions. Understanding these drivers and impacts is essential for predicting the ocean's mitigation capabilities.

## Daily overview - Thursday

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Keynote speaker: Julie Dinasquet

*Scripps Institution of Oceanography, USA*



**Julie Dinasquet** is a marine microbial ecologist at the Scripps Institution of Oceanography. Her research focuses on studying multiple interactions between ocean and atmosphere through the microbial lens. This includes investigating the cycling of volatile compounds by marine microbes, the impact of atmospheric deposition on microbial processes, or the role of the atmosphere in dispersal of marine microbes. Julie is the new director of SOLAS Summer School and co-coordinator of SOLAS 2026-2035 Science Plan section on "Scientific Community and Skill Development".

### **Thriving through synergy: Fostering a SOLAS Community built on equity, international connections and early career scientists integration**

A key component of the SOLAS 3.0 vision is fostering a thriving, diverse, and internationally connected community. Building on a legacy of capacity sharing and global collaboration such as the SOLAS summer school, the Open Science Conference and regional networks, this plan prioritises equity and early career scientists integration, incorporating lessons from past successes and challenges. We will strengthen scientific interactions through knowledge co-production, establish new working groups selected by the community, and empower national and regional committees. This synergistic approach will also expand initiatives for early career scientists' engagement and leadership through training, mentorship, skill enhancement, and equitable access to tools and resources. With the ultimate aspiration of establishing centers for observation, training, and solutions, SOLAS 3.0 envisions a future where the international community is equipped and inspired to work together to drive innovative and sustainable approaches to the complex challenges of ocean-atmosphere research.

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