

Annual Report 2020, CLIVAR/IOC-GOOS Indian Ocean Region Panel

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The panel acknowledges the work force behind IORP activities— who have selflessly taken time off from their daily work and life to support Indian Ocean science (photo taken during IORP telecon in November 2020)

Panel overview

After finalizing and publishing the Indian Ocean Observation System (IndOOS) Decadal Review in 2019, IORP focused on disseminating and implementing the recommendations in 2020. An article summarizing the scientific drivers discussed in the review and key recommendations, is now published in the Bulletin of the American Meteorological Society [Beal et al. 2020, [link](#)]. Also, IORP coordinated a special issue in CLIVAR Exchanges elaborating on the chapters presented in the IndOOS Review Report [CLIVAR Exchanges Vol.78/Feb 2020, [link](#)]. IORP, along with IIOE-2 members, led/assisted the reconstitution of the IndOOS Resource Forum (IRF), for an effective implementation of IndOOS-2.

During this time, IORP had its annual meeting and quarterly teleconferences, focusing on IndOOS, UN Decade of Ocean Science, WCRP LightHouse Activities (LHA). Juliet Hermes is leading a Task Team for tracking the IndOOS-2 Recommendations, with the help of the IndOOS Resource Forum. Roxy Koll, Lisa Beal, Jing Li and Juliet Hermes met with IRF during their quarterly meetings this year. IRF is reactivating ocean observations and making the top recommendations from IndOOS-2 on board. The IRF will facilitate the implementation of IndOOS-2 recommendations, maximize the use of the existing resources and make IRF also as an 'IndOOS Coordination Forum'. Juliet Hermes and Roxy Koll are interacting with the regional teams

(north/central Indian Ocean and Africa) of the UN Decade of Ocean Science program. Roxy Koll is involved in the WCRP LHA and restructuring, representing the South Asian domain.

IORP had an interactive session with GOOS (Emma Heslop) on the recent initiative by the GOOS Observations Coordination Group (OCG) on the impacts of COVID-19 on ocean observations.

Two new members joined IORP this year: *Dwi Susanto (University of Maryland, USA/Indonesia)* and *Birgit Gaye (University of Hamburg, Germany)*, both of whom are also members of the Sustained Indian Ocean Biogeochemistry and Ecosystem Research (SIBER) panel, a regional programme of IMBeR, for a better linkage of CLIVAR with biogeochemical (BGC) and biological community. IORP is optimistic in having at least one member from the WIO region (east Africa / small island / Middle East) from next year.

IORP Achievements during 2019-20

1. Workshops and Conferences

- a. 16th Session of CLIVAR/IOC-GOOS Indian Ocean Region Panel meeting, 24 March 2020, via Telecon [[Report](#)].

The 16th Session of Indian Ocean Region Panel (IORP-16), originally planned on March 24, 2020 in Goa, India, was convened virtually due to the global COVID-19 pandemic. The meeting began by reviewing the progress of the IORP-15 action items and the IORP annual report to the SSG-25. The panel then had a joint discussion on the following issues: 1) prioritised actionable recommendations for IndOOS Resource Forum (IRF); 2) establishment of a Task Team to record new contributions to IndOOS-2; 3) ideas to develop transformational projects in Indian Ocean for the UN Ocean Decade; 4) strengthening the linkage with CLIVAR panels/RFs and WCRP Grand Challenges; and 5) membership recommendations. More details in the [report](#).

- b. Session at EGU 2020 Annual Meeting.

An interdisciplinary session on “The Indian Ocean’s past, present, and future” was convened for the 2020 Annual Meeting by the European Geophysical Union (EGU) to be held in Vienna (Austria) by Caroline Ummenhofer (WHOI), Yan Du (SCSIO), Alejandra Sanchez-Franks (NOC), and Jérôme Vialard (IRD). Due to COVID-19 the EGU Meeting was held virtually in May 2020 and the scheduled oral session was converted to a virtual online chat session, with prior submission of online material by session participants.

It was a successful session with 30 submitted abstracts, 14 of them by early-career scientists. In a lively online chat with 86 participants, 13 abstracts, including the invited presentation on nitrogen fixation in the Bay of Bengal, were presented and discussed with online attendees. The session covered a wide spectrum of topics ranging from biogeochemistry and oxygen minimum zones, biophysical interactions and fisheries, sea level and circulation variability, interactions with the monsoon circulation, and Agulhas leakage. It also included a presentation on IndOOS-2, a roadmap to better observations for the rapidly warming Indian Ocean, that summarized findings from the IndOOS-2 report published in late 2019. Topics spanned from (intra)seasonal, interannual to (multi)decadal, and millennial time scales, combining observations, theory, modeling, and paleo proxy records.

c. IndOOS-2 Town Hall at AGU OSM 2020

A Town Hall titled 'IndOOS-2: A Roadmap to Better Observations and Predictions of the Rapidly Warming Indian Ocean' was organized by Lisa, Roxy, and Caroline on 20 February 2020, at the AGU Ocean Sciences Meeting in San Diego. The Town Hall aimed to spread the word about the outcomes of a recent [review of the Indian Ocean Observing System \(IndOOS\)](#) that provides a roadmap to an improved observing network: IndOOS-2. A [postcard](#) highlighting the IndOOS review was shared among the OSM participants. The Town Hall provided a forum to receive input from the community regarding (a) implementation of the IndOOS-2 roadmap and (b) improvement of end-user products and services, including models and predictions. The Indian Ocean research community was encouraged to help spread the word to the broader community: i.e. to facilitate new ideas and partnerships among nations and institutions, as well as among observers, modelers, and developers of products and services in order to implement an IndOOS-2 that can meet future societal need for predictability of Indian Ocean climate and ecosystems across time scales from sub seasonal to decadal and beyond ([news](#)).

2. Scientific results from activities

The *Executive Summary* (<https://doi.org/10.36071/clivar.rp.4-1.2019>) of the 'IndOOS-2: A roadmap to sustained observations of the Indian Ocean for 2020-2030' was launched during the OceanObs'19, which was organised from 16 to 20 September 2019 in Hawaii, USA. Juliet Hermes from IORP presented a poster titled 'A Sustained Ocean Observing System in the Indian Ocean for Climate Related Scientific Knowledge and Societal Needs'. The *Full Report* (<https://doi.org/10.36071/clivar.rp.4.2019>) of the IndOOS-2 was launched during the WCRP Climate Science Week, which was organised during the 2019 AGU Fall Meeting in San Francisco, USA from 9-13 December 2019 ([news](#)).

The IndOOS-2 article (<https://doi.org/10.1175/BAMS-D-19-0209.1>) published in BAMS consolidates the state-of-the-science reviews on most aspects of Indian Ocean oceanography, including monsoons, ecosystems, oxygen minimum zones, Indian Ocean heat content, interannual and decadal variability, and climate change. Based on these scientific drivers, it provides a roadmap to an improved Indian Ocean observing system for 2020-2030. Related articles published are listed at the end of the report.

3. Scientific capacity building and career support

In July 2018, the Secretary of India's Ministry of Earth Sciences (MoES) announced a new open data policy for the Ocean Moored buoy Network in the northern Indian ocean (OMNI) moored buoys in international waters. This announcement paves the way for a new partnership between NOAA and MoES to more closely coordinate OMNI and the Research Moored Array for African-Asian-Australian Monsoon Analysis and Prediction (RAMA). The objective of the RAMA-OMNI partnership is to improve access to high-quality moored time series data from in the Indian Ocean and to better coordinate field work to maintain the arrays. Improving data access will stimulate broader utilization of the data for scientific research and applications and coordinating field work will allow for a more efficient use of resources (particularly ship time) for regular servicing of the buoys.

To advance this initiative, the NOAA-MoES RAMA Implementing Arrangement (IA), which will expire in November 2020, is under revision and close to being signed for another five years. The new IA highlights the RAMA-OMNI initiative and includes additional MoES ship time for RAMA-OMNI mooring operations. In addition, NOAA and MoES are developing a RAMA-OMNI data delivery web portal to be hosted by NIOT and INCOIS.

Development of the portal, originally planned for launch in July 2020, has been delayed because of the COVID pandemic; however, its inauguration is imminent. PMEL and NIOT are also leading the development of a manuscript describing the RAMA-OMNI partnership for publication in a refereed journal sometime in 2021.

With the funding support of National Natural Science Foundation of China (NSFC) and Chinese Academy of Sciences (CAS), China promises to maintain eight subsurface moorings in the Indian Ocean, of which, three have been deployed in the equator, two in the south Bay of Bengal, one in the southern tropical Indian Ocean, and are already providing 4-year historical data. Two additional buoys will be deployed in the southern tropical Indian Ocean. The Indian Ocean cruises funded by NSFC welcomes scientists from other countries to participate and observed data can be obtained by contacting PI of the cruises. China is interested in water vapor transport of the North Indian Ocean to the Tibetan Plateau. Biological and geological components are included in the proposed project in addition to the physical oceanographic part, and the project is foreseen to be funded in 2021.

4. Knowledge exchange

- a. INCOIS is hosting capacity building programmes on operational oceanography for Africa, which are open to the island states in WIO to join. Two programmes are linked with the INCOIS capacity building programme: one is the [Ocean Teacher Global Academy \(OTGA\)](#) of IODE of IOC, that can support the travel and other expenses for the selected candidates; another programme is just open to anybody to sponsor the accommodation in the guesthouse in INCOIS.
- b. Roxy Koll presented a webinar talk on "[Climate Change in the Indian Ocean and its Impacts](#)" to the Young Earth System Scientists (YESS) community on 5th November 2020.
- c. Roxy Koll contributed as a Lead Author to the IPCC SROCC and as a Contributing Author to IPCC AR6.
- d. Roxy Koll is a Governing Council member of the Ocean Society of India, and organizes/convenes conferences focusing on the Indian Ocean, encouraging the participation of young researchers and students.
- e. Lisa Beal talked at a US CLIVAR Phenomena, Observations, and Synthesis Panel (POS) webinar on 'IndOOS-2: A roadmap to better observations of the rapidly warming Indian Ocean' on 4 June 2020, and the recording for the webinar is available.
- f. The panel co-chairs assisted Nick D'Adamo to prepare the input to IOC Executive Council Session No. 53 on the IndOOS-2. Nick suggested to the IOC Secretariat to make the links for IndOOS-2 Executive Summary and Full Report available to all the 150 member states of IOC, as it is one of the most important and outstanding assessments and strategic reviews, with well considered and prioritised recommendations for action, of a major element of 'global' GOOS.
- g. Motoki Nagura submitted an abstract for the JpGU-AGU Joint Meeting 2020 (virtual) entitled 'IndOOS-2: A Roadmap to Better Observations of the Rapidly Warming Indian Ocean' for a poster.
- h. Roxy and Jing on behalf of CLIVAR attended the SOLAS Indian Ocean Meeting on 28 September 2020. During the Meeting, Roxy made a presentation on "Indian Ocean Warming and Monsoon Extremes", highlighting how the monsoon has changed during the past six decades, and the factors that intensify the monsoon variability and increase extreme rains and floods in the Indian Ocean. A poster was submitted by ICPO and presented by Jing Li, introducing the work of CLIVAR in the Indian Ocean, as well as the

potential cooperation opportunities with SOLAS, in particular on the implementation of IndOOS-2 (news).

Plans for 2021 and beyond

- a. IORP considers the new WCRP LHAs and Homes as a priority and recognizes that particularly LHA1 (Explaining and Predicting Earth System Change), LH2 (My Climate Risk) and LHA5 (WCRP Academy) fits well with the IORP/IndOOS recommendations. We also see that the WCRP Home on linking the observational and modeling communities is important for the IORP goals. We plan to work closely with CLIVAR/WCRP on the LHAs/Homes.
- b. IORP will be actively involved with the UN Decade of Ocean Science through IOC/IndOOS Resource Forum in the next several years as their goals overlap with that of IORP/CLIVAR.
- c. IORP hopes to work with the WIO region and the Young Earth System Scientists (YESS) community in order to nurture capacity building and future leaders.
- d. An Indian Ocean-themed session proposal for the next EGU Meeting in Vienna, Austria, for April 2021 has also been submitted.
 - [Understanding the Indian Ocean's past, present, and future](#), EGU Meeting, Vienna, Austria, April 2021, Conveners: Caroline Ummenhofer, Yan Du, Alejandra Sanchez-Franks, and Jérôme Vialard
- e. A multi-region-panel meeting and two-day workshop is being planned by IORP (Lisa Beal) and is originally planned in May 2021 in Trieste, Italy, now postponed to 2022 due to COVID-19 pandemic. The workshop is to discuss the common issues faced by all basins in sustained ocean observations, e.g. data sharing, best practices, expanding to coast and partnership on Ocean Observations, etc.

Articles published in 2019/20 related to panel activities (if any)

1. Beal, L. M., J. Vialard, M. K. Roxy and Coauthors, 2020, A roadmap to IndOOS-2: Better observations of the rapidly-warming Indian Ocean. *Bull. Amer. Meteor. Soc.*, doi: 10.1175/BAMS-D-19-0209.1 [\[link\]](#).
2. **CLIVAR Exchanges special issue:**
The Recent Decadal Review (2020-2030) of the Indian Ocean Observing System (IndOOS-2) and its Outcomes. CLIVAR Exchanges special issue No.78, Eds. L. Yu. Doi: <https://doi.org/10.36071/clivar.78.2020>
 - a. Beal et al. IndOOS-2: A Consolidated and Enhanced Indian Ocean Observing System for the Next Decade.
 - b. McDonagh et al.. Natural and Anthropogenic Warming of the IO Waters.
 - c. Lengaigne et al. Monsoon and Regional Air-Sea Interaction.
 - d. Feng et al. Ocean Processes and Modelling.
 - e. Hood et al. Physical and Biogeochemical Processes and Interactions in the Indian Ocean.
 - f. Tozuka et al. Climate Information and Prediction across Timescales.
 - g. Hermes et al. IndOOS, the Indian Ocean Region Panel and OceanObs'19.
 - h. McPhaden et al. Reflections on the Origins of the Indian Ocean Observing System (IndOOS).
3. Roxy M. K., C. Gnanaseelan, A. Parekh, J. S. Chowdary, S. Singh, A. Modi, R. Kakatkar, S. Mohapatra, C. Dhara, S. C. Shenoi, M. Rajeevan, 2020, Indian Ocean warming, in Krishnan et al. (eds.), *Assessment of Climate Change over the Indian Region*, Springer, Singapore [\[link\]](#).

4. Wirasatriya, A., J. D. Setiawan, D. N. Sugianto, I. A. Rosyadi, Haryadi, G. Winarso, R. Y. Setiawan, R. D. Susanto, Ekman dynamics variability along the southern coast of Java revealed by satellite data, *International Journal of Remote Sensing*, 2020. doi:10.1080/01431161.2020.1797215
5. Hamzah, F., T. Agustiadi, R. Dwi Susanto, Z. Wei, L. Guo, M. Dai, Dynamics of the carbonate system in the western Indonesian seas during Southeast Monsoon, *J. Geophys. Res. Oceans*, 2020 <https://doi.org/10.1029/2018JC014912>.
6. Eko Siswanto, Takanori Horii, Iskhaq Iskandar, Jonson Lumban Gaol, Riza Yuliratno Setiawan, R. Dwi Susanto, Impacts of climate changes on the phytoplankton biomass of the Indonesian Maritime Continent, *Journal of Marine Systems*, 2020, 103451, ISSN 0924-7963, <https://doi.org/10.1016/j.jmarsys.2020.103451>.
7. J. Kim, Y. Kim, H.-W. Kang, S.H. Kim, T.Rho, D.-J. Kang, Tracing water mass fractions in the deep western Indian Ocean using fluorescent dissolved organic matter, *Marine Chemistry*, 218 103720, <https://doi.org/10.1016/j.marchem.2019.103720>

Budget and other needs for 2021

Budget requirements for 2021 is unclear as of now, considering the COVID situation and travel restrictions globally. In case travel resumes and an IORP-related meeting is scheduled, 4,000 CHF is anticipated from WCRP/CLIVAR to support the travel of about 2 international IORP members for the IORP meeting. It is anticipated that US members will be funded by US CLIVAR.

IORP proposes to have an additional Early Career member (eg. from [YESS community](#)) in all CLIVAR panels including IORP, other than the current set of regular members who are mid-to-senior career researchers. At present CLIVAR panels lack strong communication and feedback with the young scientific community. Having a YESS member would mean that we would be able to communicate the science and operational insights to the young community. They have a lot many young members from across the globe, and we will be able to utilize their workforce also. The benefits are many, if we think about it. This will also bring diversity in terms of age and career in the panels, and we will be nurturing future leaders for these panels and the science community. Similar positions are now nurtured in GOOS, WWRP, IIOE2, etc. For IORP and IndOOS, having an YESS member would mean cooperating with the YESS platform to conduct the capacity building activities in the Indian Ocean rim countries. It will also foster interpanel activities and networking between YESS members of various CLIVAR panels.

Other papers published relative to Indian Ocean work

- Mawren et al (accepted corrections, GRL), Exceptional TC Kenneth in the far northern Mozambique Channel and ocean eddy influences
- Dilmahamod, A. et al (accepted, JGR), A model investigation of the influences of the South-East Madagascar Current on the South-East Madagascar Bloom
- Rapolaki et al (2020, Moisture sources associated with heavy rainfall over the Limpopo River Basin, southern Africa, *Climate dynamics*. DOI 10.1007/s00382-020-05336-w
- McGraph, Hermes et al (2020), Investigating connectivity between two sardine stocks off South Africa using a high-resolution IBM. *Fisheries oceanography*, <https://doi.org/10.1111/fog.12460>
- Morris, T. et al, (2019) Lagrangian evolution of two Madagascar cyclonic eddies: vertical structure, eddy properties and fluxes, *Journal of Geophysical Research: Oceans*, 124, 8193–8218. <https://doi.org/10.1029/2019JC015090>

- Pfaff, MC, Logston, RC, Raemaekers, SJP, Hermes, J et al (2019). A synthesis of three decades of socio-ecological change in False Bay, South Africa: setting the scene for multidisciplinary research and management. *Elem Sci Anth*, 7: 32. DOI:10.1525/elementa.367
- Nagura, M. (2020). Variability in meridional transport of the subtropical circulation in the south Indian Ocean for the period from 2006 to 2017. *Journal of Geophysical Research:Oceans*, 124, e2019JC015874. <https://doi.org/10.1029/2019JC015874>
- Ryan S, Ummenhofer CC, Gawarkiewicz G, Wagner P, Scheinert M, Biastoch A, and Böning CW (2020). Depth structure of Ningaloo Niño/Niña events and associated drivers. *Journal of Climate*, doi:10.1175/JCLI-D-19-1020.1.
- Abram NJ, Hargreaves JA, Wright NM, Thirumalai K, Ummenhofer CC, and England MH (2020). Paleoclimate perspectives on the Indian Ocean Dipole. *Quaternary Science Reviews*, 237, doi: 10.1016/j.quascirev.2020.106302.
- Abram NJ, Wright NM, Ellis B, Dixon BC, Wurtzel JB, England MH, Ummenhofer CC, Philibosian B, Cahyarini SY, Hantoro W, Shen C-C, Cheng H, and Heslop D. (2020) Tight coupling of tropical Indian and Pacific climate variability through the last millennium. *Nature*, 579, 385-392.
- Ummenhofer CC, Ryan S, England MH, Scheinert M, Wagner P, Biastoch A, and Böning CW (2020). Late 20th Century Indian Ocean heat content gain masked by wind forcing. *Geophysical Research Letters*, doi:10.1029/2020GL088692.

Annex A

Proforma for CLIVAR Panel requests for SSG approval for meetings

New request:

1. **Panel name:** CLIVAR/IOC-GOOS Indian Ocean Region Panel (IORP)
2. **Title of meeting or workshop:** 17th session of the IORP meeting
3. **Proposed venue (Or indicate if online):** TBC (Goa, India??)
4. **Proposed dates:** TBC
5. **Proposed attendees, including likely number:** IORP members + 5 invitees (~20 people)
6. **Rationale, motivation and justification, including: relevance to CLIVAR science & WCRP Grand Challenges, and any cross-panel/research foci links and interactions involved:**

It is possible that if situation ease up in 2021, that International Indian Ocean Science Conference (IIOSC) will be held in late 2021 (which was postponed from 2020 due to COVID-19 pandemics), and IORP meeting with IRF/SIBER/IOGOOS could be carried out. It could be a hybrid meeting also.

7. **Specific objectives and key agenda items:** IndOOS-2 Implementation; Linking to IIOE-2 and IOGOOS; IORP interested researches in collaboration with SIBER; preparation of the pan-CLIVAR workshop on ocean observations in 2022, Italy; contribution to UN Ocean Decade and WCRP implementation; IORP membership; and etc.
8. **Anticipated outcomes (deliverables):**
9. **Format:** TBC
10. **Science Organizing Committee (if relevant)**
11. **Local Organizing Committee (if relevant)**
12. **Proposed funding sources and anticipated funding requested from WCRP:**
4,000 CHF (travel expenses for 2 IORP members, if the meeting can be organised in person.)