IndOOS-2

A Roadmap to Sustained Observations of the Indian Ocean for 2020-2030

Coordinating lead authors

Lisa M. Beal[1], Jerome Vialard[2], Mathew K. Roxy[3]

Dec 2019

doi.org/10.36071/clivar.rp.4.2019

Sponsored by

The Global Ocean Observing System

International Review Board

Jay McCreary
University of Hawaii

Coleen Moloney
University of Cape Town

Susan Wijffels
WHOI, USA

Marjolaine Krug

CSIR, South Africa

Richard Matear
CSIRO, Australia

Peter Dexter, BOM, Australia

Numbers of IndOOS-2

2000 + EMAILS

60 AUTHORS

35 MONTHS

25 CHAPTERS

6 REVIEWERS

3 EDITORS

3 WORKSHOPS

= **136 ACTIONABLE RECOMMENDATIONS**

GOOS•GOOS•WCRP OOPC

IOGOOS GLOBAL OCEAN OBSERVING SYSTEM FOR INDIAN OCEAN

United Nations Educational, Scientific and Cultural Organization

Intergovernmental Oceanographic Commission

GOOS The Global Ocean Observing System

IndOOS-2

CLIVAR

NOAA National Oceanic and Atmospheric Administration U.S. Department of Commerce

IMBeR

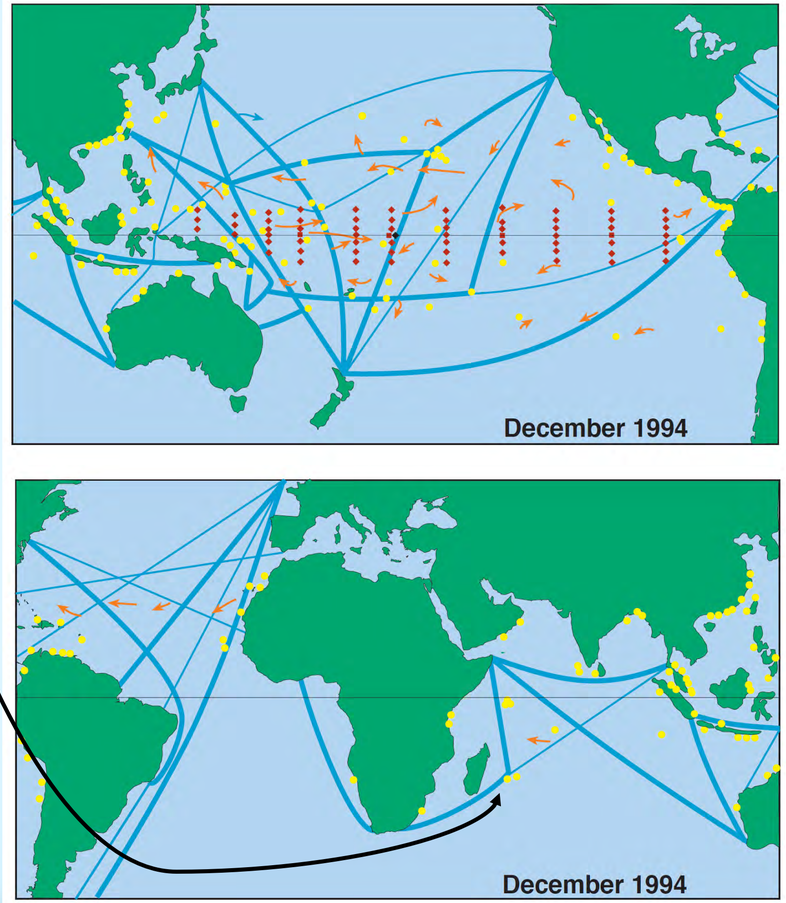
WCRP World Climate Research Programme

IUGG

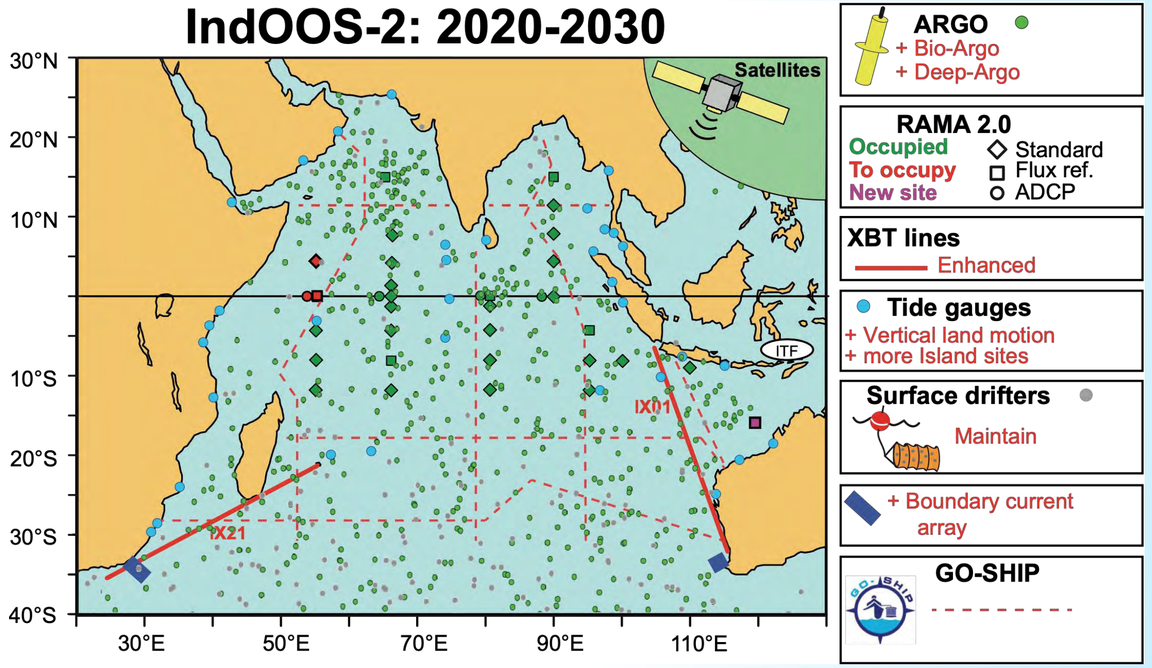
IAPSO International Association for the Physical Sciences of the Oceans

IndOOS-2 Roadmap

From a least observed Indian Ocean in the 1990s



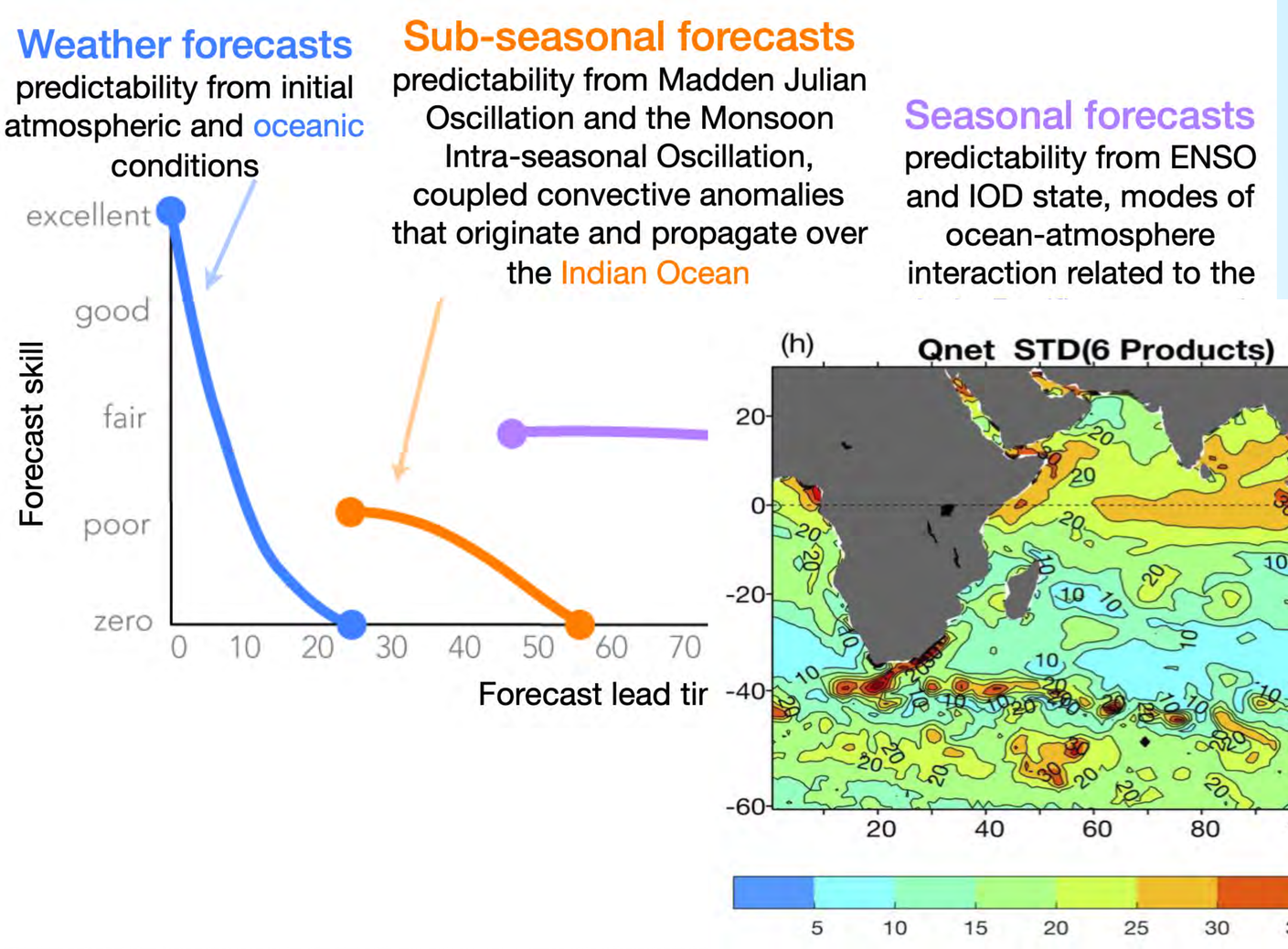
To one of the best observed Indian Ocean in the 2020s



GOOS • GOOS • WCRP
OOPC
IOGOOS
GLOBAL OCEAN OBSERVING SYSTEM FOR INDIAN OCEAN
United Nations Educational, Scientific and Cultural Organization
Intergovernmental Oceanographic Commission
GOOS
The Global Ocean Observing System
IndOOS-2
CLIVAR
NOAA
IMBeR
WCRP
World Climate Research Programme
IUGG
IAPSO
International Association for the Physical Sciences of the Oceans

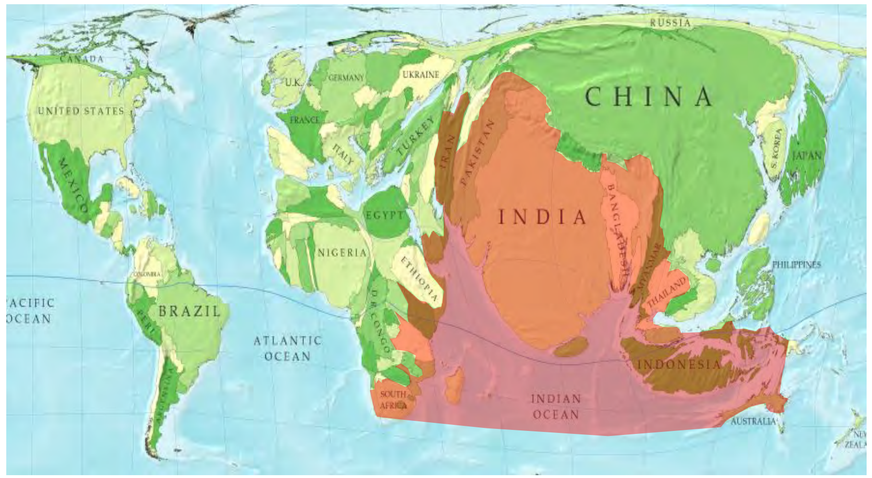
Review: Remaining gaps

- Low prediction skill of sub-seasonal to seasonal forecasts
- Large discrepancies in climatologies of heat exchange at the air-sea interface
- Lack of observations in western equatorial Indian Ocean (piracy and vandalism) and boundary currents
- No sustained ecosystem measures

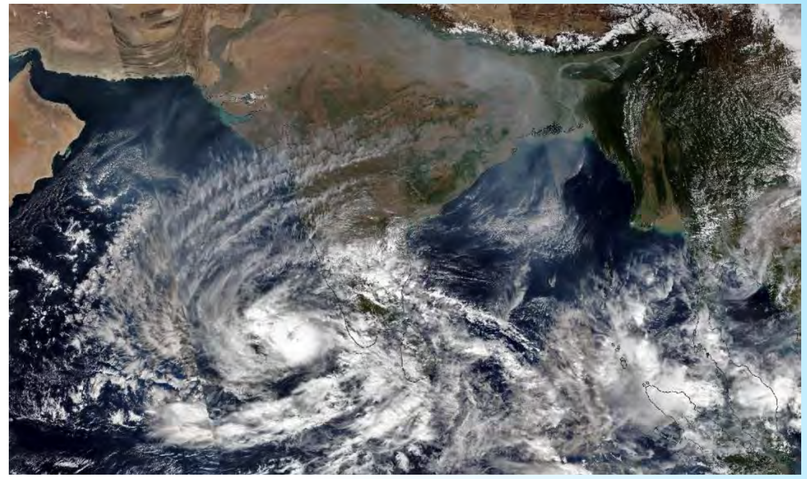


Why do we need the IndOOS-2? Increased vulnerability

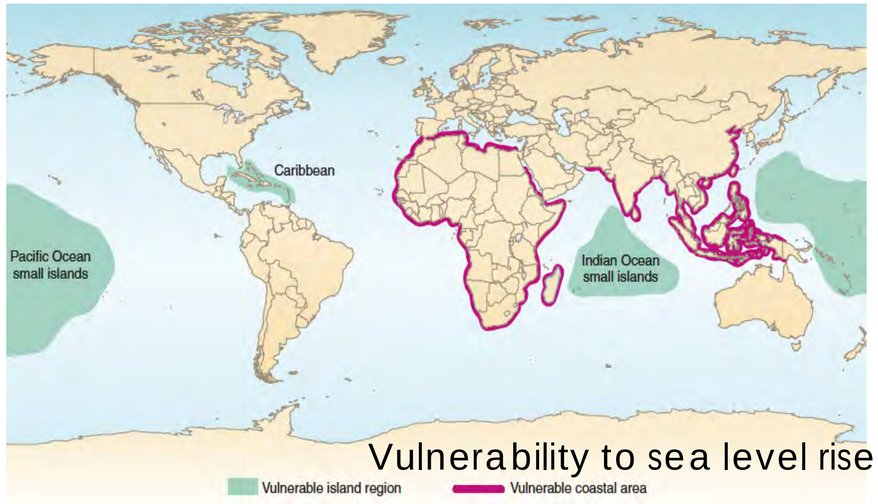
- Indian Ocean rim countries are increasingly vulnerable due to rises in population, sea level, and cyclone intensity.
- There are many small island developing states and least developed countries dependent on fisheries.
- The Bay of Bengal sees 5% of global cyclones, but 80% of global casualties. Cyclone Nargis in 2008: 140,000 dead, 1 million homeless, and $10 billion damages.



One third global population

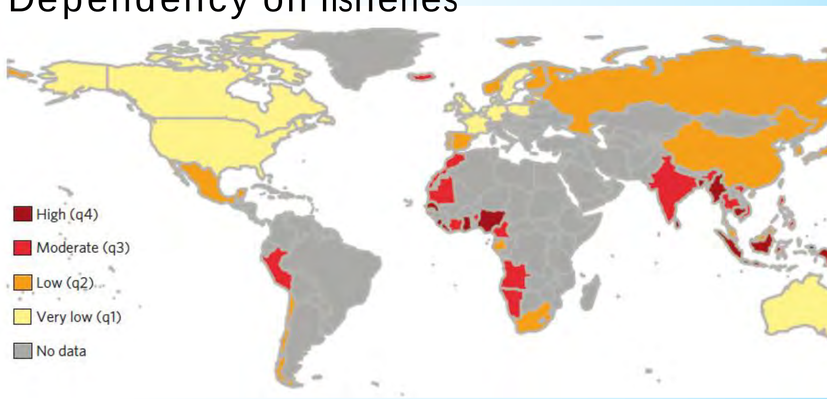


Arabian Sea cyclones are increasing



Vulnerability to sea level rise

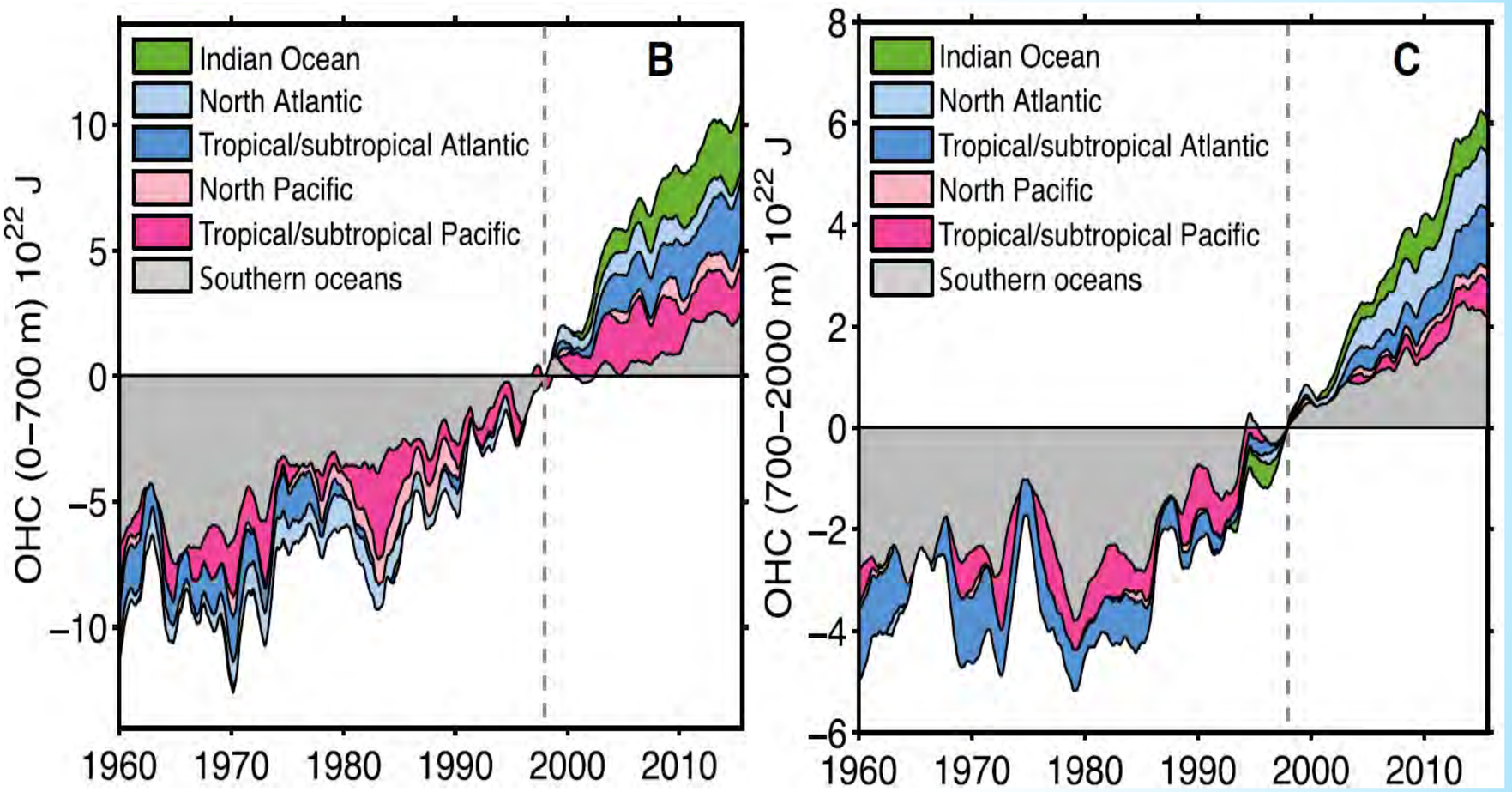
Dependency on fisheries



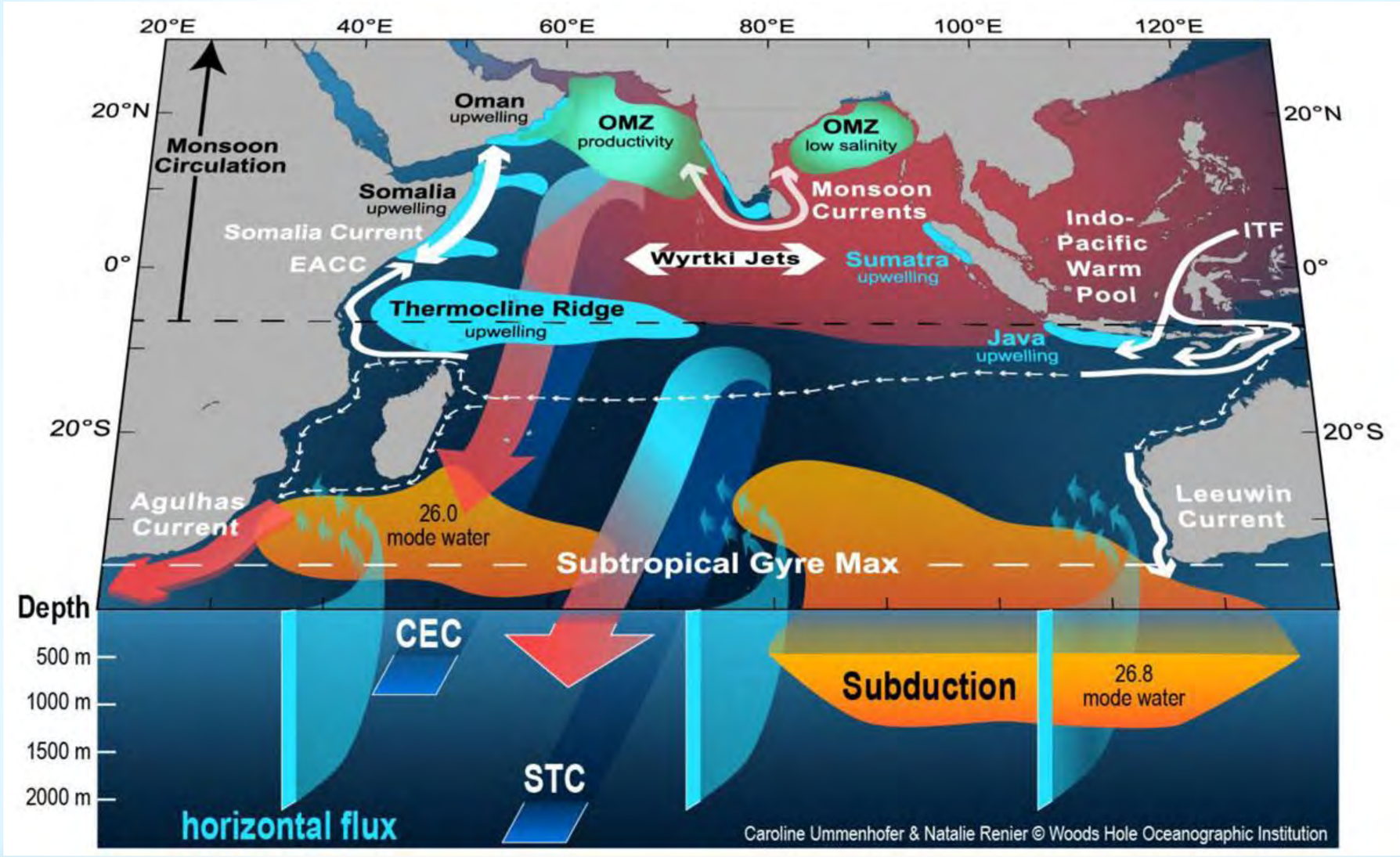
Murakami et al (2017), Paul et al. (2009), Nicholls and Cazenave (2010), Barange et al (2014)

Why do we need the IndOOS-2? Rapid warming

- Despite its small size, the Indian Ocean has accounted for 30% of the global oceanic heat content increase over the last decade
- Largest heat content changes occurred in the southern subtropics.
- Decadal increase in Indonesian Throughflow while Agulhas Current may be weakening?
- Where will the heat go?



Why do we need the IndOOS-2?



Meteorology and Atmospheric Physics
https://doi.org/10.1007/s00703-021-00792-3

ORIGINAL PAPER

Check for updates

Are ocean-moored buoys redundant for prediction of Indian monsoon?

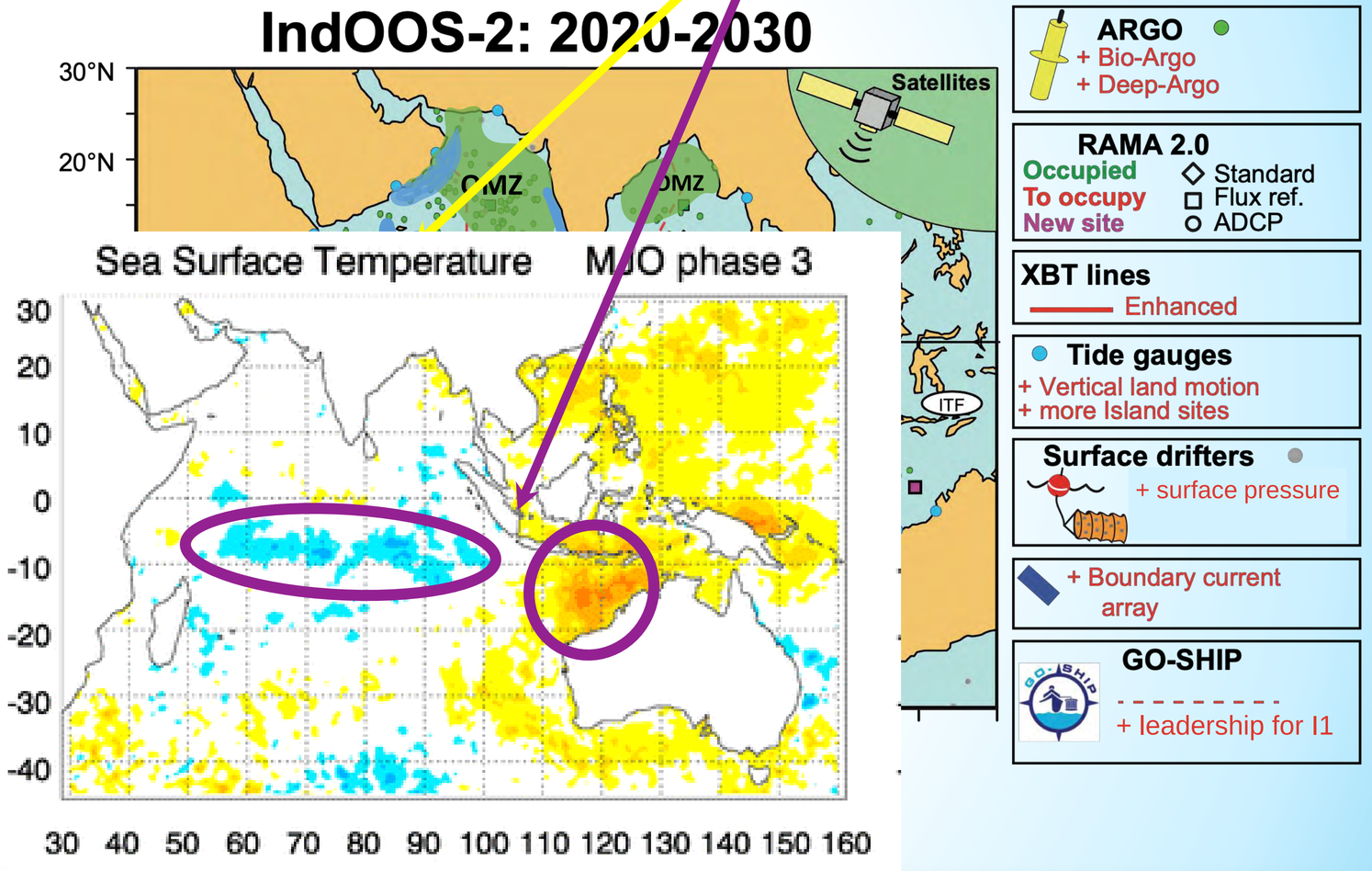
Maheswar Pradhan[1] · Ankur Srivastava[1] · Suryachandra A. Rao[1] · Deep Sankar Banerjee[2] · Abhisek Chatterjee[2] · P. A. Francis[2] · O. P. Sreejith[3] · M. Das Gupta[4] · V. S. Prasad[4]

Abstract

The Tropical Atmosphere Ocean (TAO) and Triangle Trans-Ocean Buoy Network (TRITON) buoys deployed in the tropical Pacific play a significant role in monitoring tropical Pacific conditions such as El-Niño/La-Niña in real-time. Earlier studies have illustrated the importance as well as irrelevance of moored buoy observations towards the prediction of sea surface temperature in the tropical Pacific Ocean. With the advent of Argo floats, have these moored buoy observations become redundant? In the present study, we address this question in the context of Indian summer monsoon rainfall (ISMR) prediction. The extreme monsoon year of 2018 was selected to test the above hypothesis. Without moored buoy observations being assimilated, the oceanic initial conditions and the seasonal forecasts had large oceanic temperature errors and forecasted a normal monsoon instead of a below-normal monsoon during 2018. Therefore, moored buoy observations are essential and

Roadmap for IndOOS-2: Core Findings

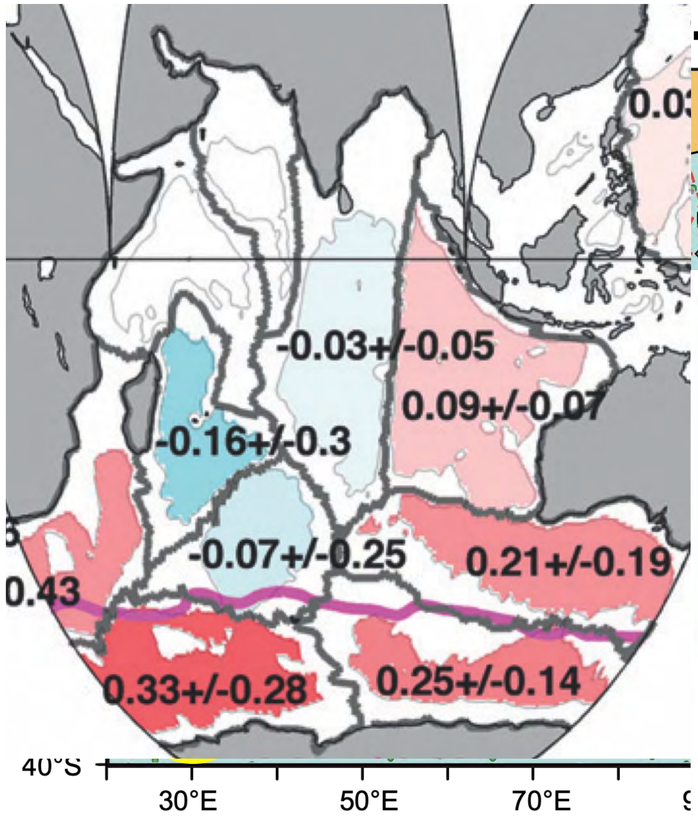
- Coverage of the **western equatorial Indian Ocean** needs to be completed.
- **Biogeochemical measurements must be collected alongside physical parameters**, initially targeted to regions of high variability and change, such as the OMZs and upwelling systems.
- **Enhanced vertical and temporal resolution of upper-ocean measurements** are needed in tropical regions strongly coupled to MJO and MISO development.



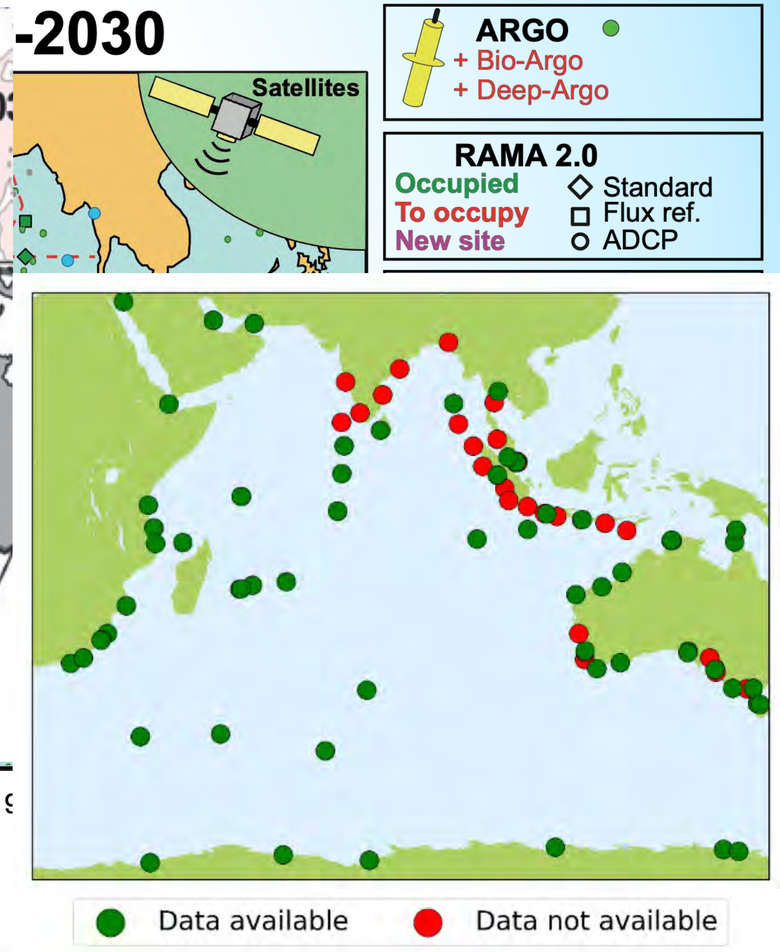
Roadmap for IndOOS-2: Core Findings

- **Boundary flux arrays** in the Agulhas and Leeuwin Currents are needed alongside an **enhancement of Indonesian Throughflow monitoring.**
- More **observations of the deep ocean below 2000 m** are needed to capture circulation, heat content, and sea level change. Initially targeted to subtropics.
- More land motion sites are needed alongside tide gauges, as well as additional island sites.

Warming below 4000 m, W/m2,
Purkey & Johnson (2010).



EOVs: T, S
EOVs: sea surface height
EOVs: T, S, u(z), O2



Core Findings: Beyond *in situ* Observations

- Continuous, overlapping **satellite measurements are central** to the IndOOS.
- There is urgent need for **advancements in data assemblage and coupled data assimilation** techniques
- There is a need for increased investment and **stronger partnerships with Indian Ocean rim countries and end-users,** along with improved data sharing and commitments to best practices.

Capacity building and training for the western Indian Ocean

Proposal for IORP coastal and marginal seas hybrid workshop

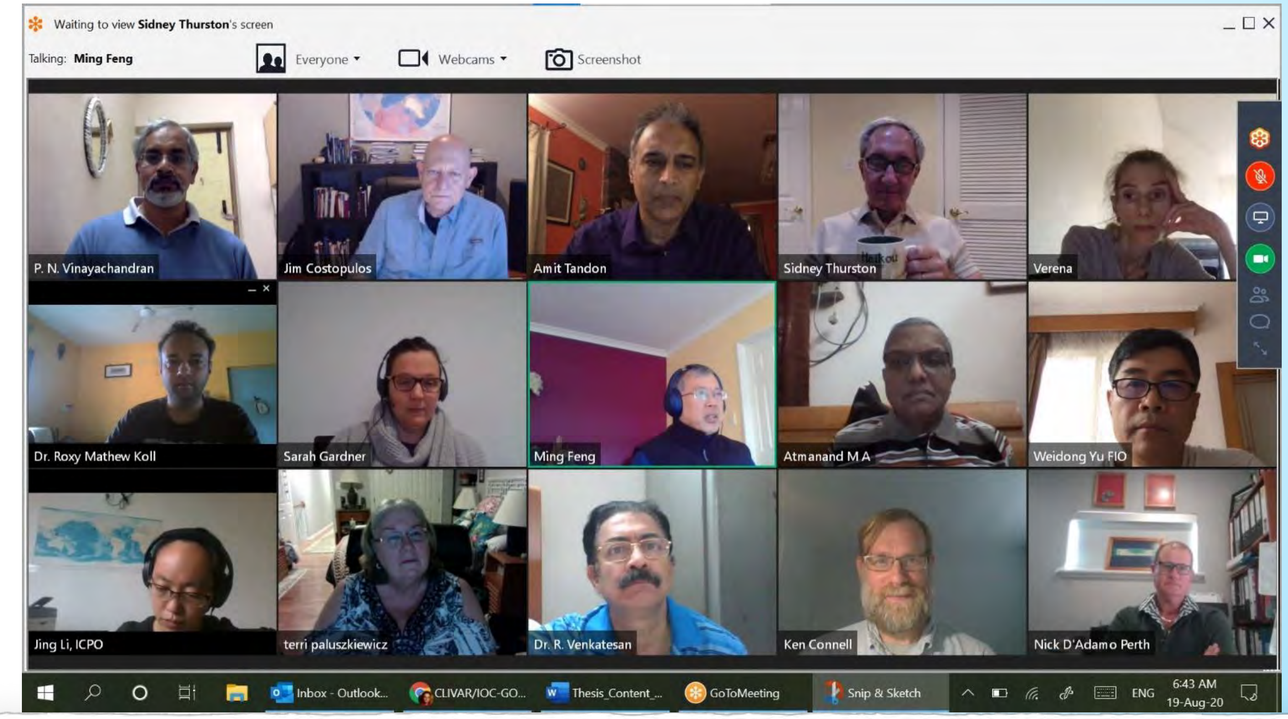
1. **Panel name:** CLIVAR/IOC-GOOS Indian Ocean Region Panel
2. **Title of meeting or workshop:** Training workshop on observing the coastal and marginal seas in the western Indian Ocean.
3. **Proposed venue (Or indicate if online):** Hybrid meeting with physical locations in Mozambique and Kuwait and global virtual attendance
4. **Proposed dates:** Winter 2021 or Spring 2022
5. **Proposed attendees, including likely number:** 10-15 in Mozambique and 10-15 in Kuwait; 50-75 globally

(a)Capacity building in the WIO region - specifically targeted at supporting ocean observing systems and utilizing global data sets.

(b)Training manual/report/website on ocean observations that can be used by other panels and the WCRP Academy

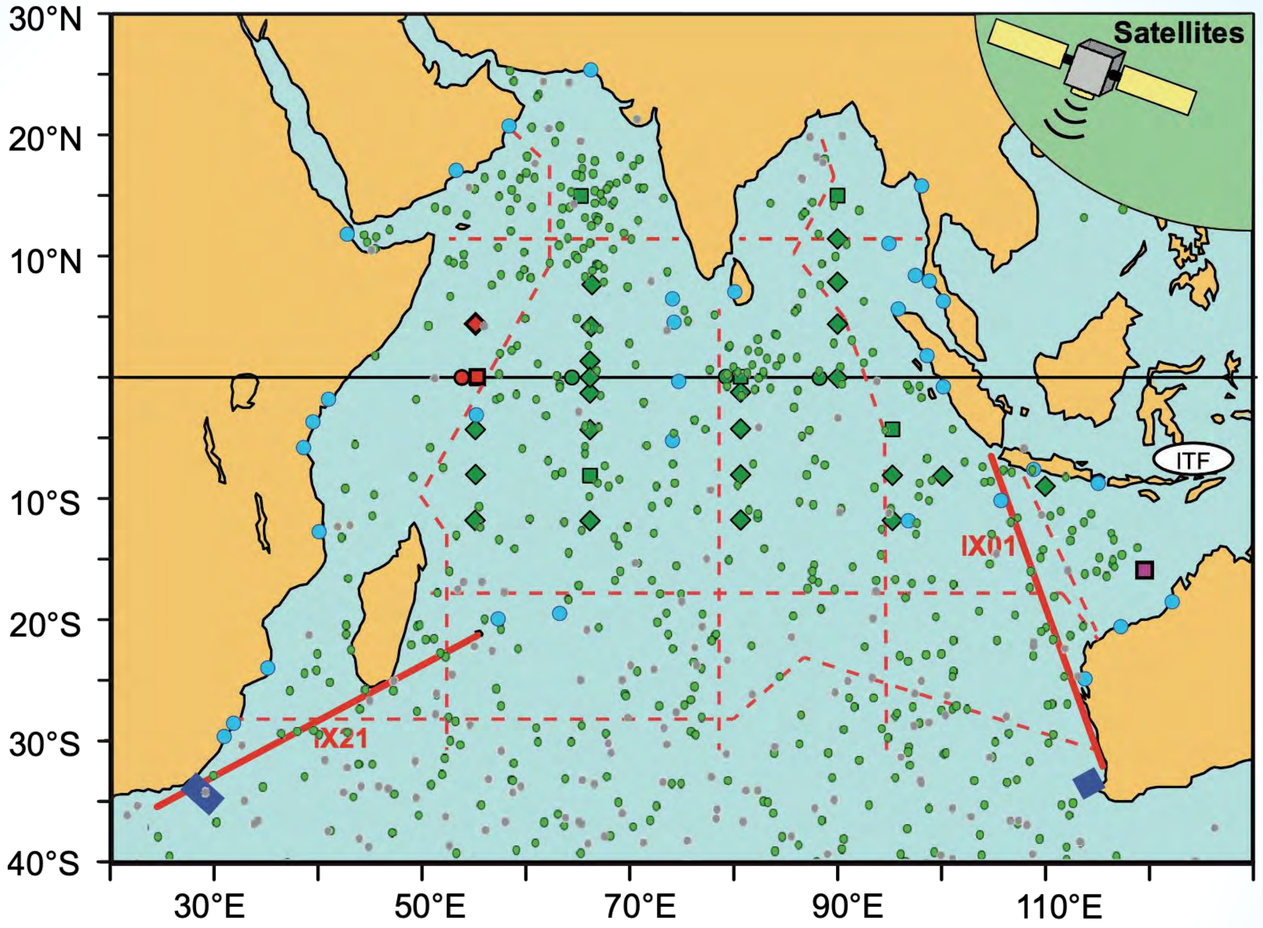
IndOOS Resource Forum, for implementing IndOOS-2

IndOOS Resource Forum (IRF) and IIOE2 can facilitate the implementation of IndOOS-2 recommendations, and maximize the use of the existing resources



- IndOOS-2 can provide a fit-for-purpose observing system that leads to improved weather forecasts and climate predictions for the benefit of all

IndOOS-2: 2020-2030



ARGO
+ Bio-Argo
+ Deep-Argo

RAMA 2.0
Occupied
To occupy
New site
Standard
Flux ref.
ADCP

XBT lines
Enhanced

Tide gauges
+ Vertical land motion
+ more Island sites

Surface drifters
Maintain

+ Boundary current array

GO-SHIP

IndOOS-2 roadmap: doi.org/10.36071/clivar.rp.4.2019

GCOS•GOOS•WCRP OOPC
IOGOOS GLOBAL OCEAN OBSERVING SYSTEM FOR INDIAN OCEAN
United Nations Educational, Scientific and Cultural Organization
Intergovernmental Oceanographic Commission
GOOS The Global Ocean Observing System
IndOOS-2
CLIVAR
NOAA
IMBeR
WCRP World Climate Research Programme
IUGG
IAPSO International Association for the Physical Sciences of the Oceans