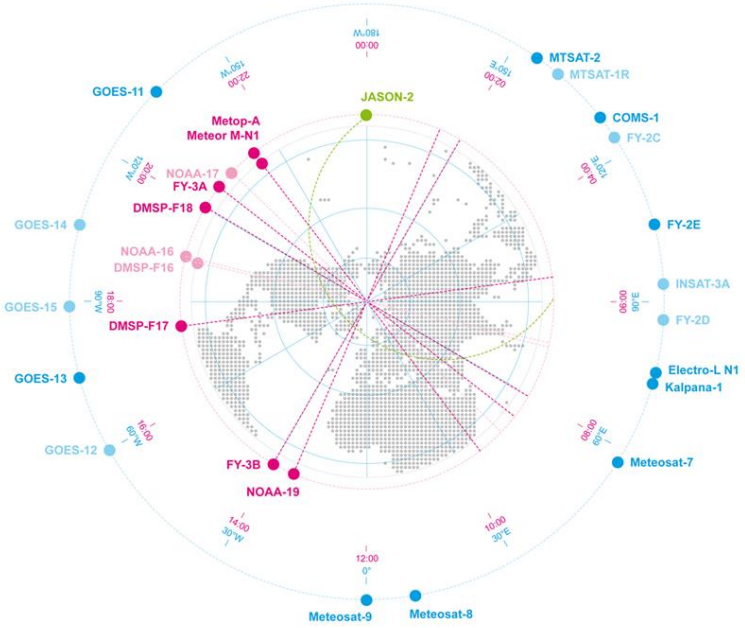

Status of the Second International Indian Ocean Expedition (IIOE-2) for enhanced data acquisition and management

Presented to CGMS-44 Plenary, agenda item C.7, 9 June 2016

IIOE-2 2nd International Indian Ocean Expedition

Presenter: Nick D'Adamo, UNESCO IOC Perth Programme Office; IOC IIOE-2 Coordinator

Co-authors: David Antoine, Curtin University, Western Australia; Peter Dexter, former Co-President JCOMM

Acknowledgement: Rajan Sivaramakrishan, Director, IIOE-2 Joint Project Office, India Node

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Historical context (original IIOE 1959-65)

IIOE-2 Genesis and planning phase (2012-2015)

Science Plan

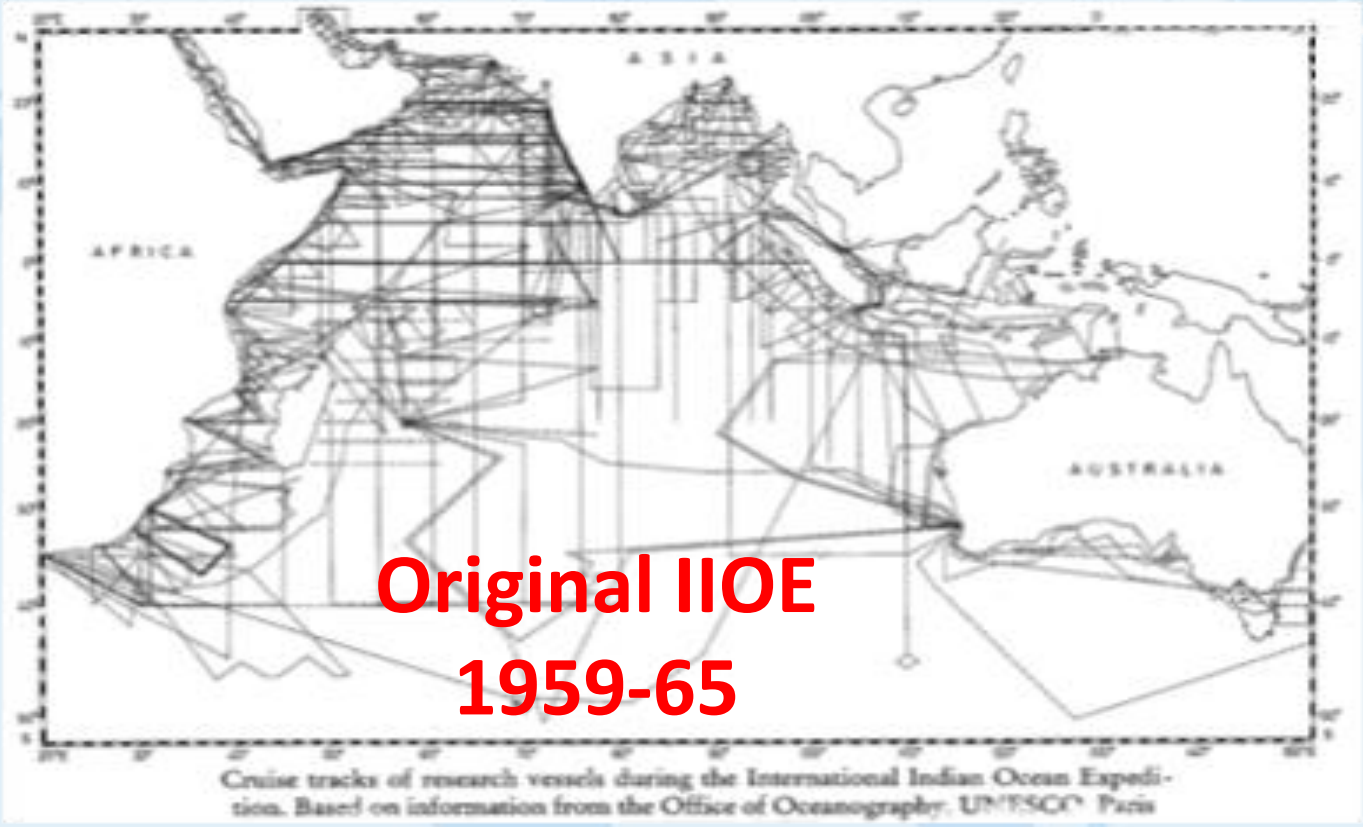
Status overview – engagement, activities, prospects

Implementation Plan

- **Governance, Steering Committee, Joint Project Office, Working Groups**

Areas for linkages: IIOE-2 + CGMS and its associated Remote Sensing community

'First' IIOE 1959-65 (Scientific Committee on Ocean Research + UNESCO IOC)



Cruise tracks of research vessels during the International Indian Ocean Expedition. Based on information from the Office of Oceanography, UNESCO, Paris

Total 323 ship months (approx.)

1) Australia → 37 months
2) France – 20
3) Germany – 7
4) India – 24
5) Indonesia – 3
6) Japan – 20
7) Pakistan – 8
8) Portugal – 3
9) South Africa – 13
10) Thailand – 2
11) USSR – 20
12) UK – 35
13) USA - 119

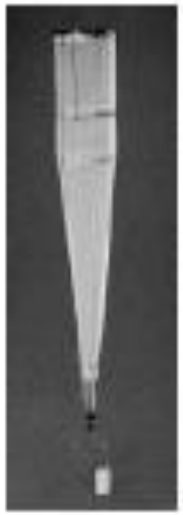
Hydrographic surveys (repeats)
Marine biology
Chemical oceanography
Marine geology
Meteorology
Geophysics

Legacy = New science, institutions, trained scientists, methodologies, literature

Courtesy: Satheesh Shenoi, INCOIS, India

Outputs included:

- 100s research papers (IOC published 8-volume set of reprints)
- Capacity building in the region
- Adoption of the Indian Ocean standard plankton net
- Establishment of reference stations, inter-calibration tests
- Ocean parameter atlases
- Establishment of the National Institute for Oceanography (NIO).



IIOE (1959-65)

products

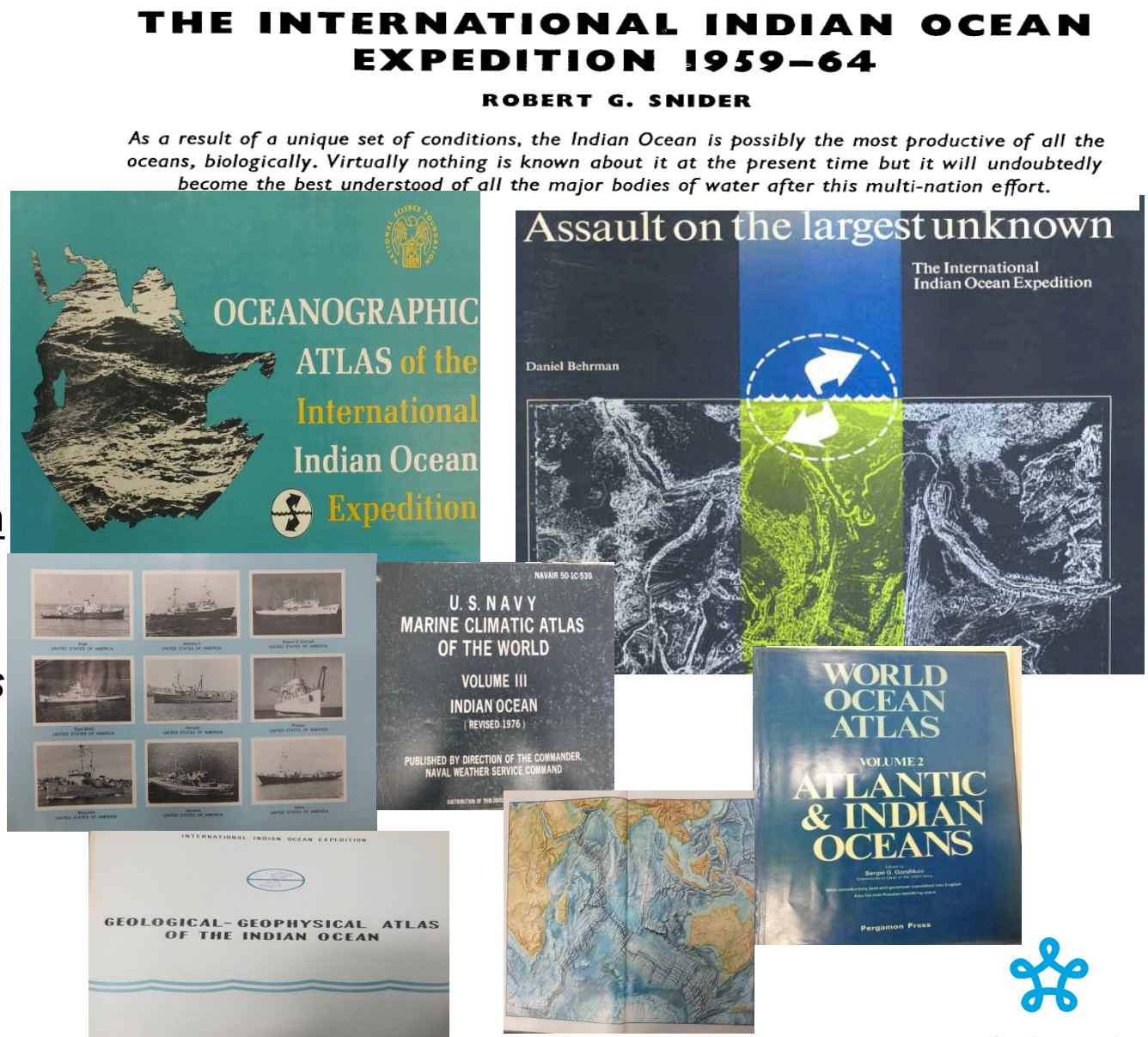
SCOR IIOE website

www.scor-int.org/IIOE_History.htm

IOC Library / archives

IIOE papers

Berhman (UNESCO; 1981)



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SINCE IIOE-1, A NUMBER OF MAJOR IO STUDIES, EG

WOCE – World Ocean Circulation Experiment (IOC)
JGOFS – Joint Global Ocean Flux Study (global carbon cycle) (IGBP)
GLOBEC – Global Ocean Ecosystem Dynamics Experiment (IGBP + IOC)
IndOOS - Indian Ocean Global Ocean Observing System (CLIVAR/IOGOOS)
GEOTRACES – Global Biogeochemical Cycles of Trace Elements and their Isotypes (SCOR + IOC)

…

SO WHY AN IIOE-2 ??

It has been half a century since the original IIOE
The Indian Ocean is still relatively poorly understood

Natural and human disasters in the IO highlight this point
Climate Change & Variability research needs, oceanographic, Sea Search and Rescue / recovery; Environmental problems; Climate Change; Food & Energy Security: Underpin sustainability for the Blue Economy

The planning for IIOE-2 has been undertaken under leadership of

- **Indian Ocean Global Ocean Observing System (IOGOOS)**
  - ***a GOOS 'Regional Alliance'***
    - ***Marine/Environment/Climate institutional reps – deriving from most IO countries.***

- **Scientific Committee on Ocean Research (SCOR)**
  - ***global = > 30 'national SCOR committees"***

- ***UNESCO Intergovernmental Oceanographic Commission (IOC)***
  - ***148 Member States – Intergovernmentally constituted***

An opportunity for IIOE-2 presented itself to examine contemporary issues

- *Linking & synergize individual programs*
- *Tackle truly basin-wide integrative issues*
- *Understand the anatomy of the IO and its climate to facilitate the maintenance of its health.*
- *Collaborative energies, synergies*
- *Issue that cannot be tackled by singular national approaches*
- *Provide for education, training (Capacity Building)*

IIOE-2 planning (2012-2015)

Genesis – early ideas germinated within SCOR, IOGOOS

then

A broad constituency created

regional + global

May IIOE-2 Reference / Focus Group meetings, both national and multi-national, including:

1: Hyderabad May 2013

2: Qingdao Nov 2013

3: Perth Dec 2013

WAGOOS

Institute of Marine Engineering, Science & Technology

IMarEST

4: **Mauritius** Mar 2014

Meteorological Satellites

5: Perth April 2014

Murdoch UNIVERSITY

SIBER + IOGOOS

6: Bangkok March 2015

BAY OF BENGAL LME

BOBLME

7: Nairobi April 2015

UNESCO/IOC Sub -Commission for Africa and the Adjacent Island States

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Planning meetings engaged a wide constituency

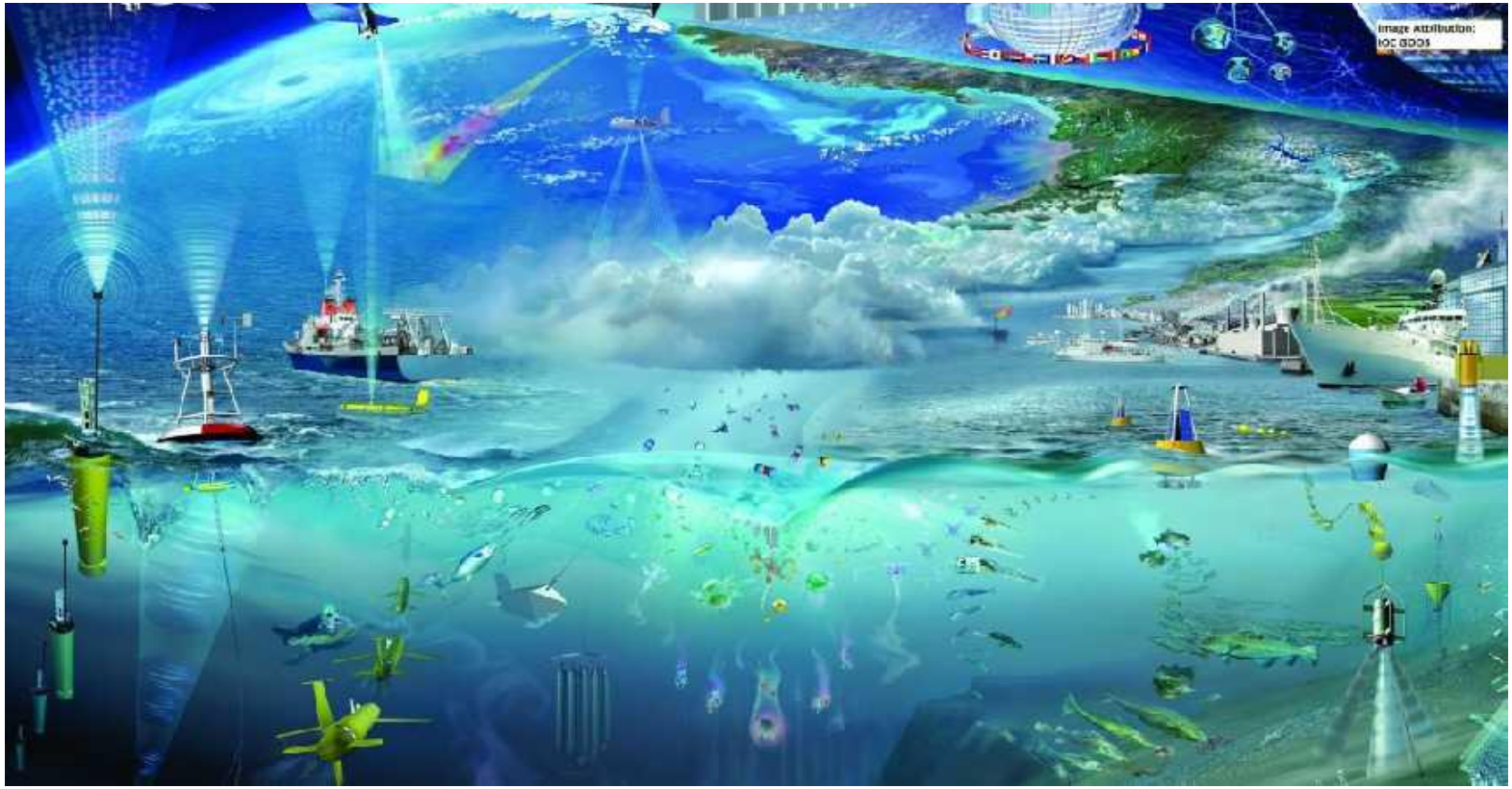
- *100 scientific/institutional leaders (derived globally)*
- *50 countries*
- *>55 institutions*
- *20 major national/regional/global oceanographic alliances (having multiple memberships)*

The constituency examined and confirmed the relevancy of an IIOE-2

… motivated by many drivers …

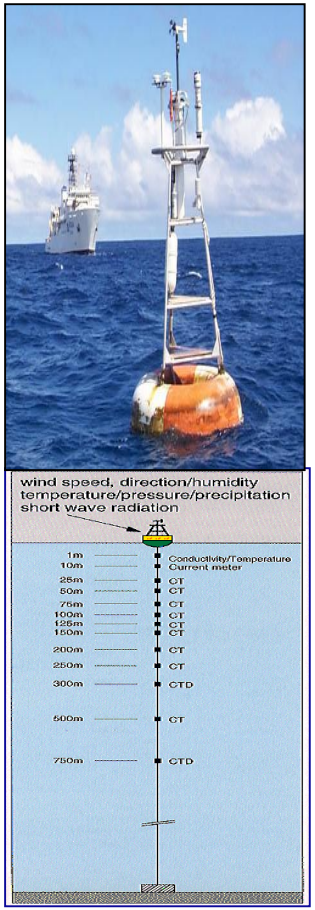
…a 'new world' in observational technology…

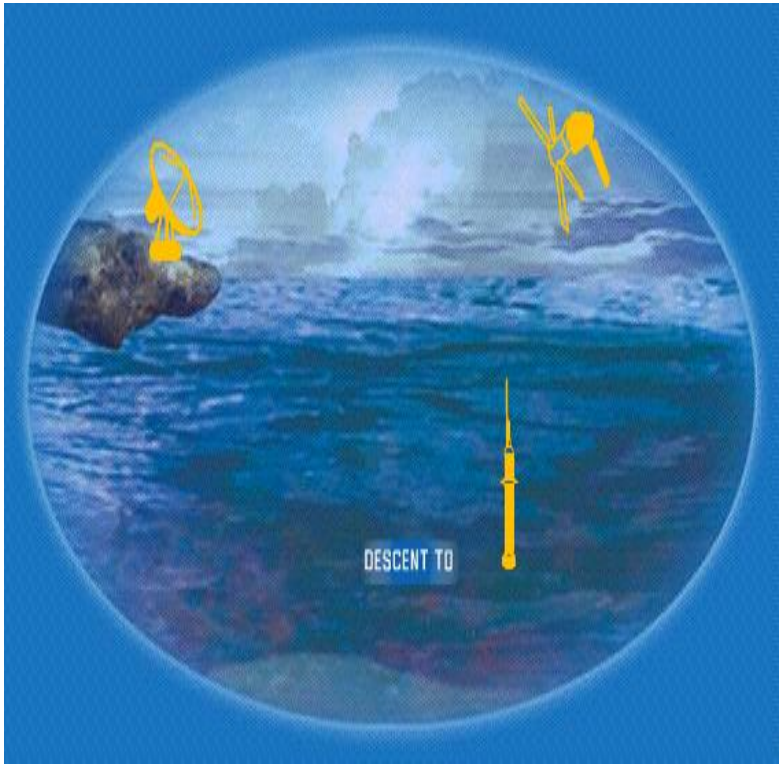
Contemporary techniques/technology, infrastructure → with advanced data transfer capacities→ give us an improved capacity to measure and characterize (processes)
Direct and robotically – gear, humans and animals - above, at and below the sea surface

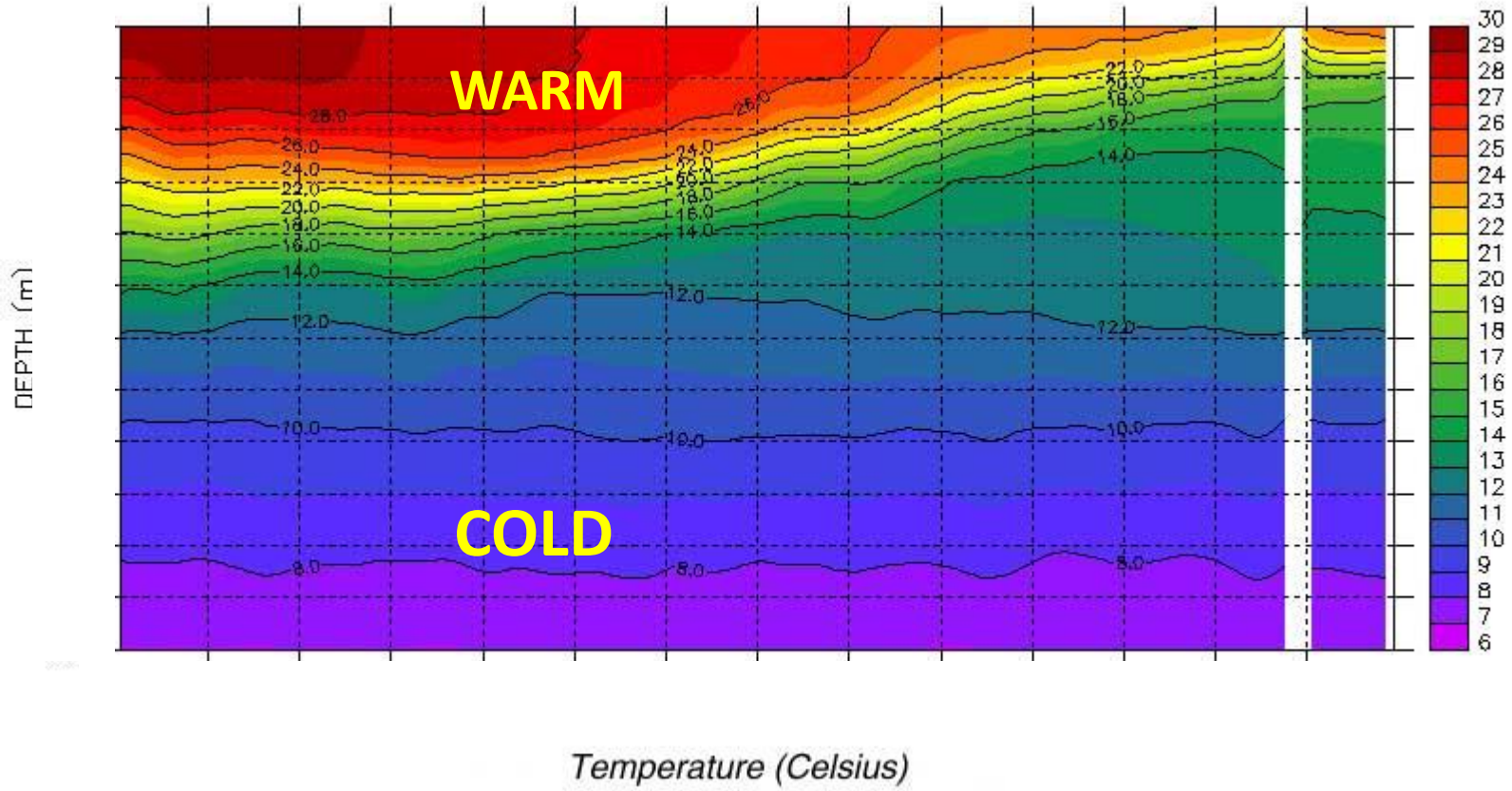


Robotics / remotely controlled equipment → driven via satellites

→ enhanced data transfer via satellites



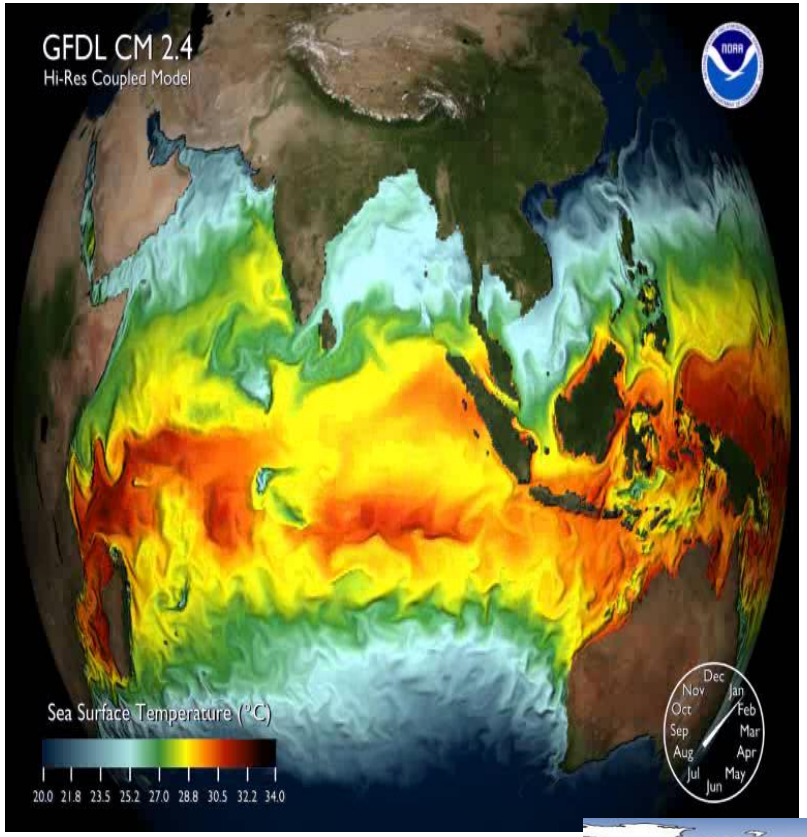




…contemporary ocean observing infrastructure → satellite comms → enables 'seeing' below the ocean's surface → including in 'real time'…

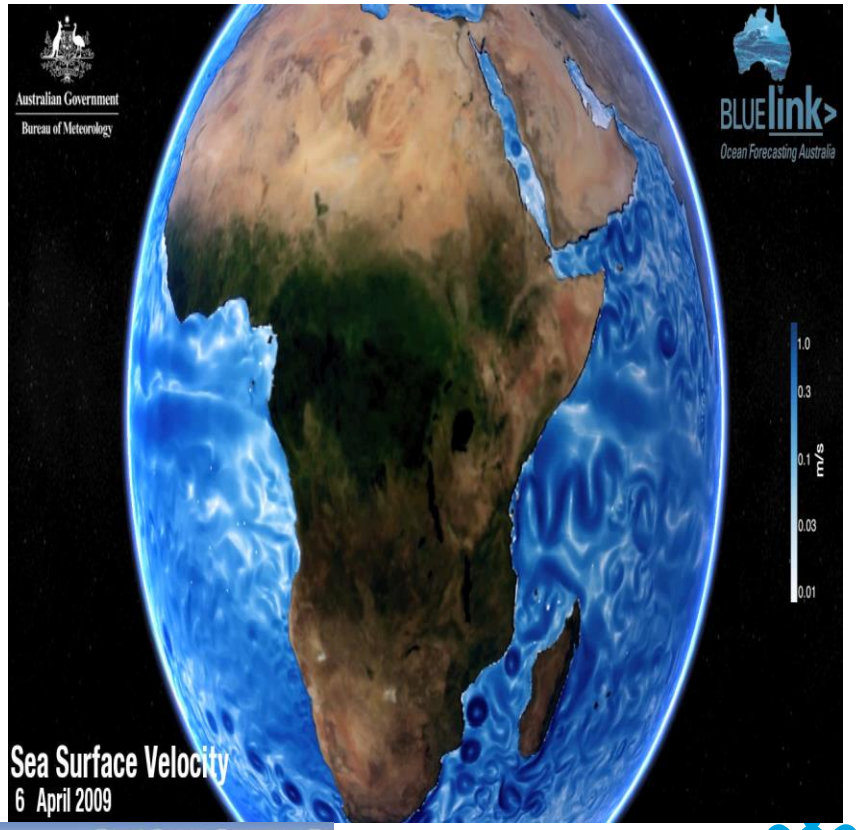
Characterizing the Cascade of Scales: intra & inter ocean connections
Observations→ characterization → modelling (satellites are critical)

IO Sea Surface Temperature



Courtesy: Gabe Vecchi, ex-IOP / GFDL USA

IO Sea Surface velocity



Courtesy: Garry Brassington, CAWCR, BLUElink, Australia

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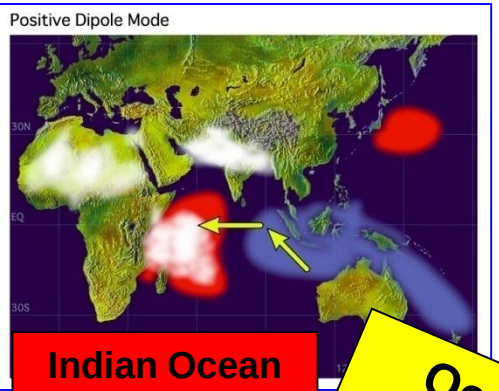
Exclusive Economic Zones

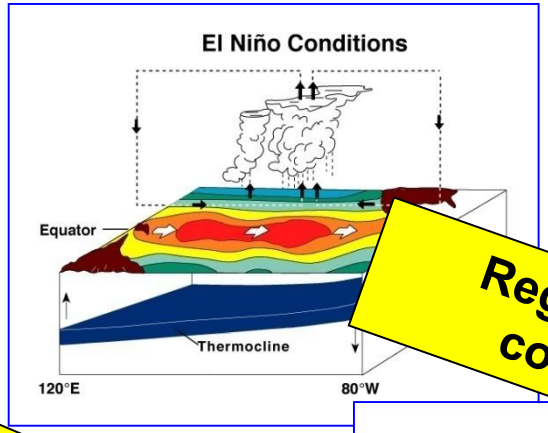
Much larger total EEZ network now
Sovereignty of access, data sharing restrictions
Therefore - need to collaborate under a collegial framework
Bi-, Tri-, Multi-lateral collaborations

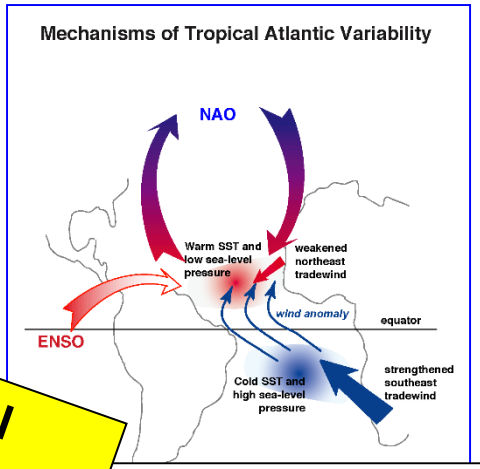
Large sovereign jurisdictions – need cost effective aerial coverage

Examples of broad-scale science/societal drivers motivating research in the IO



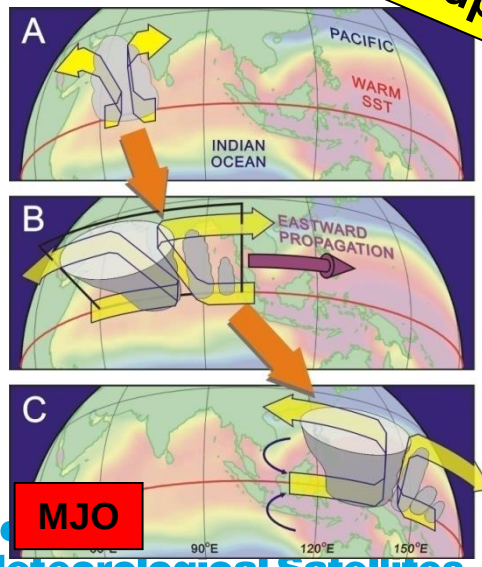
Indian Ocean Dipole



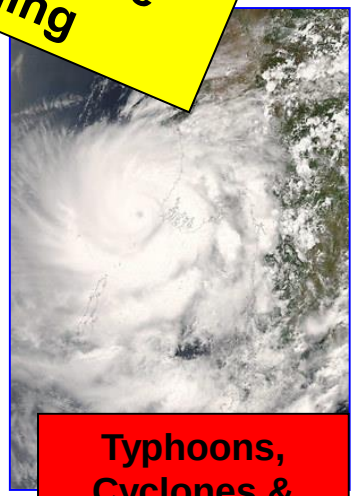


Regional/global connectivity

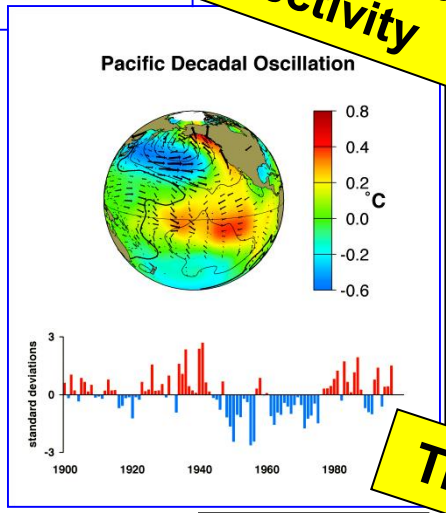
Ocean-climate coupling

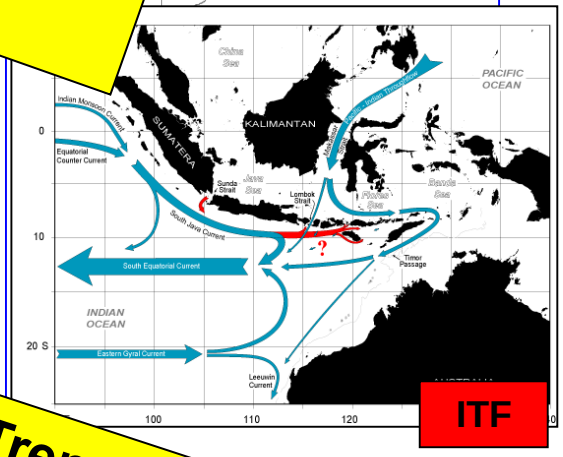


MJO



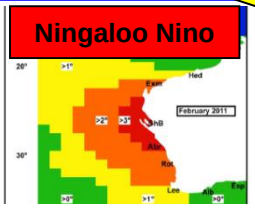
Typhoons, Cyclones & Hurricanes



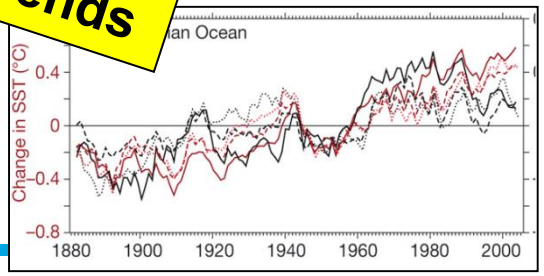


ITF

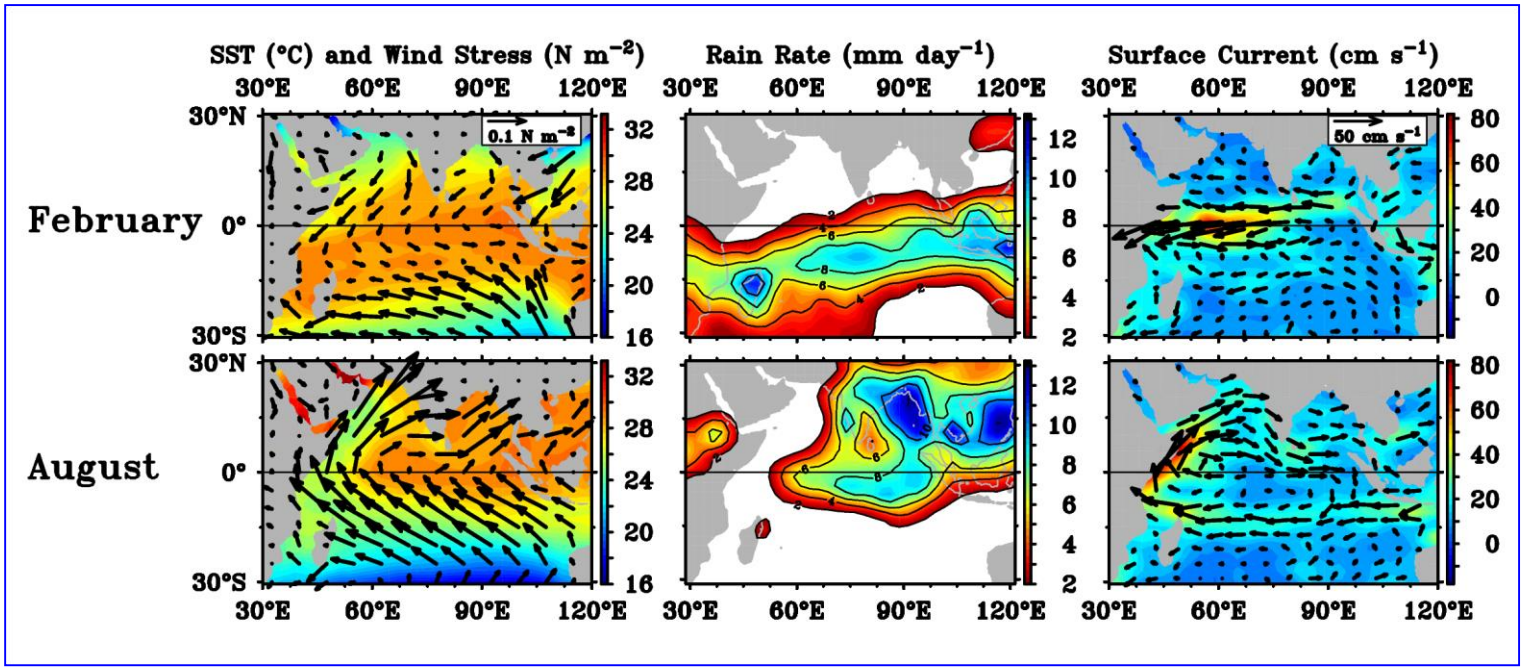
Trends



SST anomaly (Feb 2011)



Ocean related weather – monsoons etc – vital for the Indian Ocean



One third of the world's population depends on monsoon rainfall

W/N/E Indian Ocean strongly influenced - monsoons (floods, droughts), cyclones …

Courtesy: Mike McPhaden, IIOE-2 RG2 Qingdao Nov 2013

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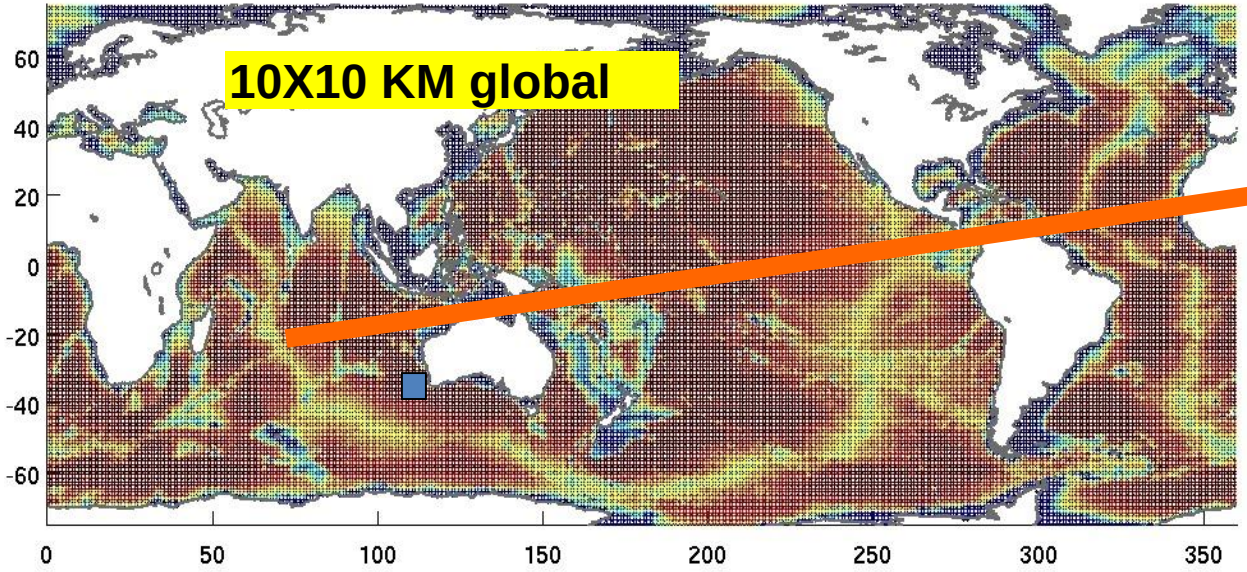
Data/info to support 'ocean forecasting'

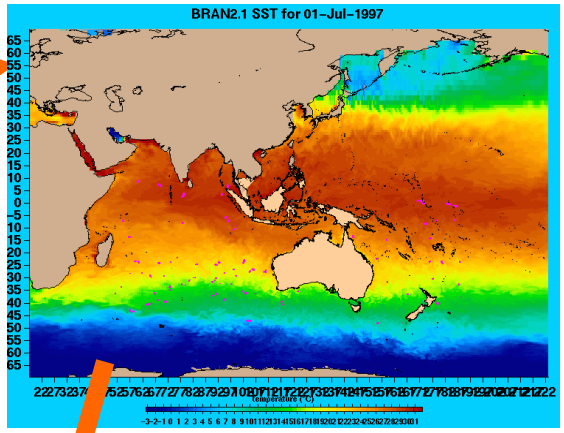
GLOBAL models and nesting (downscaling for bio-physical questions at relevant scales)

See GODAE OceanView



Courtesy BLUElink

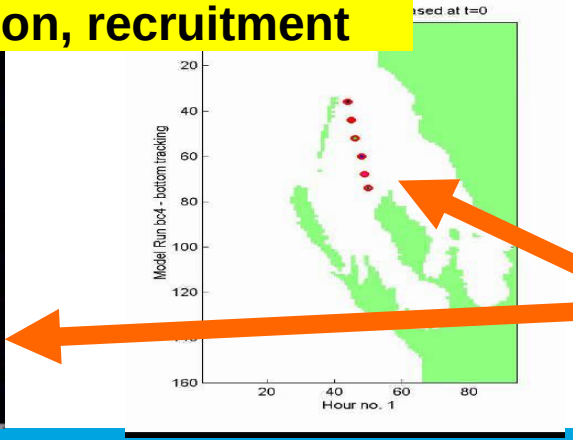
< 10km x 10km regional



Courtesy BLUElink

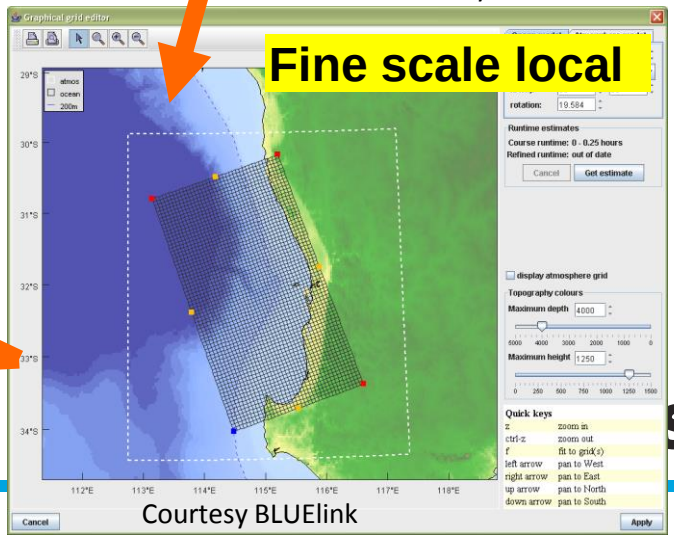
Eg larval dispersion, recruitment

Courtesy AIMS



Courtesy C Pattiaratchi

Fine scale local

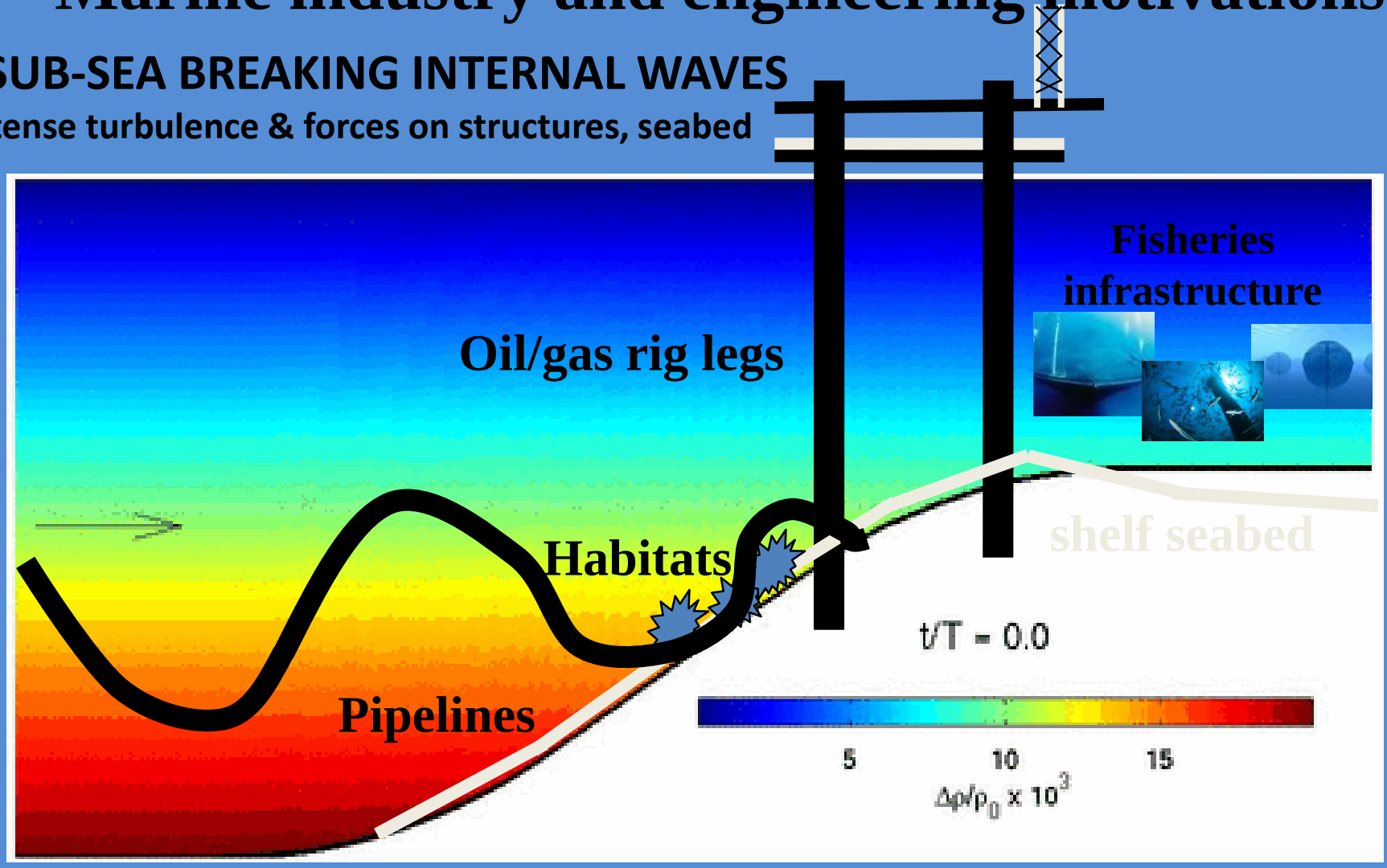


Courtesy BLUElink

Marine industry and engineering motivations

Eg SUB-SEA BREAKING INTERNAL WAVES

Intense turbulence & forces on structures, seabed



Currents (arrows) Vertical temp/density stratification (colour)

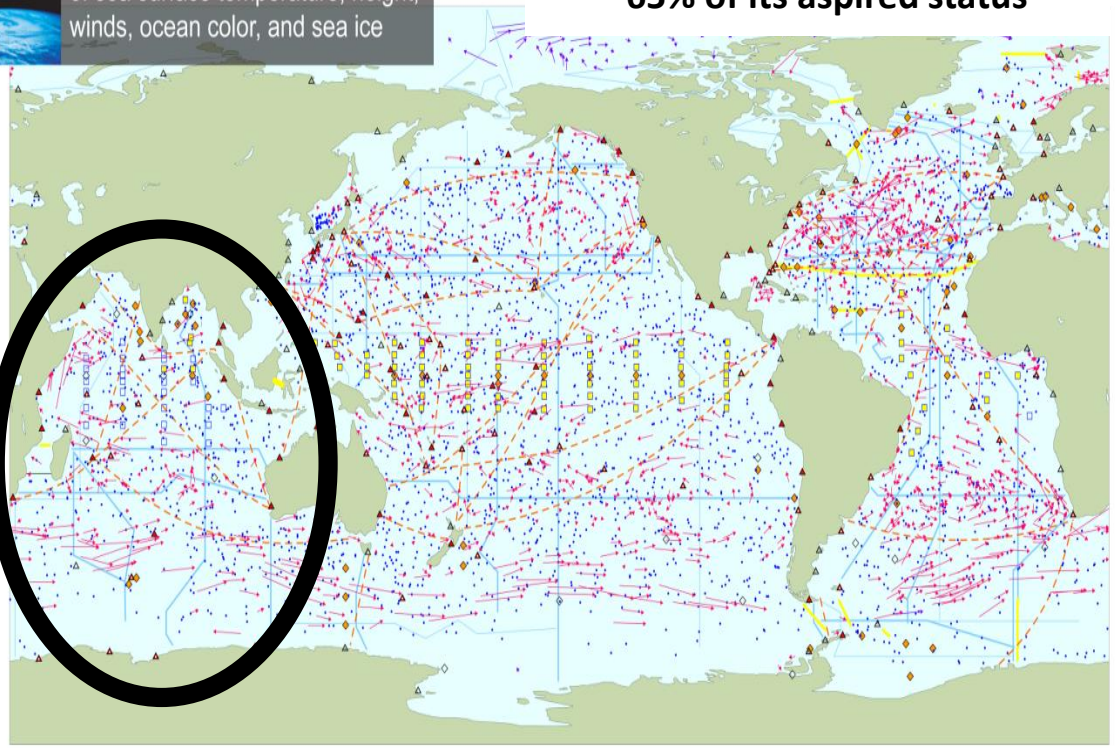
Bottom currents during internal wave breaking = 10-20 x stronger than ambient

(Venayagamoorthy & Fringer)

IIOE-2 will enhance the *Global Ocean Observing System* (GOOS)
Link to GOOS Steering Committee 'Panels' and GOOS global aspirations

continuous satellite measurements of sea surface temperature, height, winds, ocean color, and sea ice

Globally – GOOS is plateauing at ~65% of its aspired status



87% **Surface measurements** from volunteer ships (VOS)

250 ships in VOSclim pilot project

100% Global **drifting surface buoy** array

ice buoys

5° resolution array: 1250 floats

62% **Tide gauge** network (GCOS subset of GLOSS core network)

fast data, slow/no data, GPS

170 real-time reporting gauges

81% **XBT** sub-surface temperature section network

51 lines occupied

100% Argo **profiling float** network

3° resolution array: 3000 floats

Transport monitoring 24%

29 sites

48% Global **time series** network

58 moorings planned

74% Global tropical **moored buoy** network

119 moorings planned

43% Repeat **hydrography** and **carbon inventory**

(planned)

Full ocean survey in 10 years

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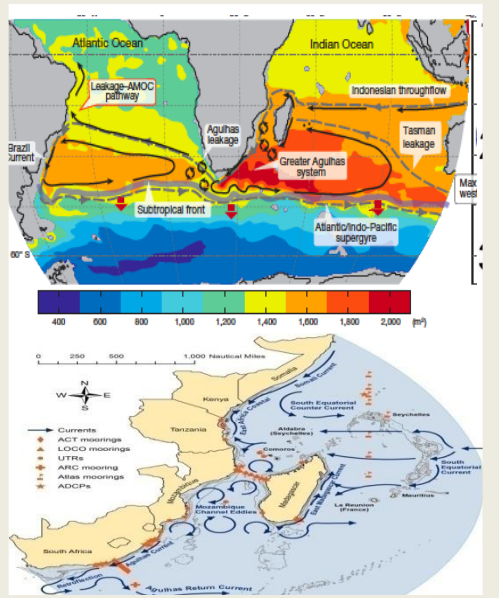
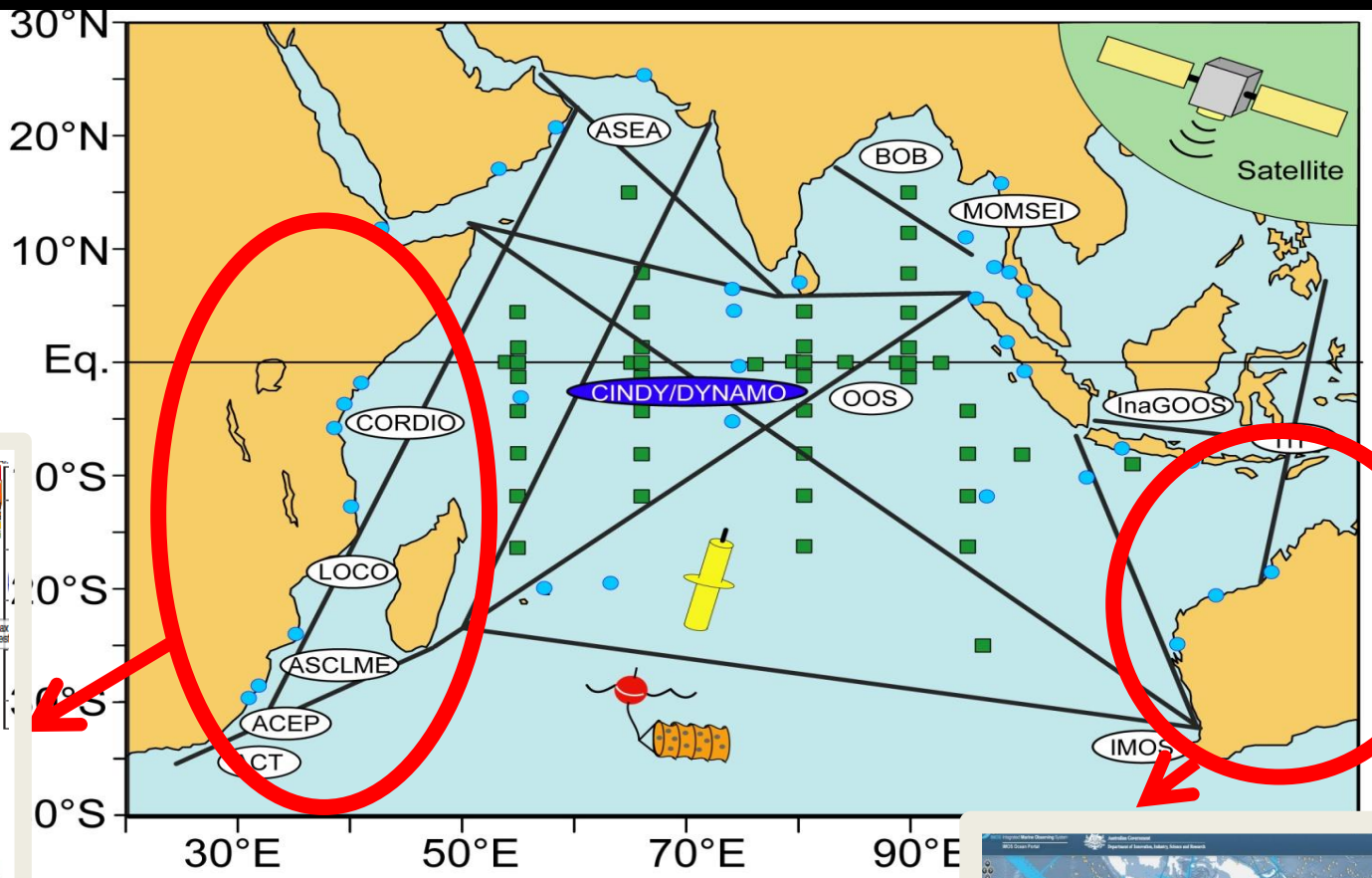
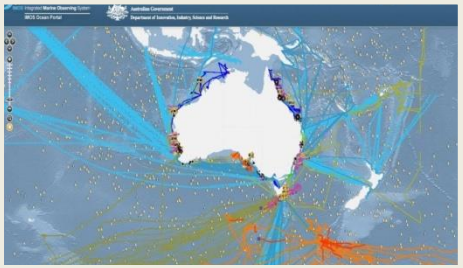
These IOGOOS entities are building and using the Indian Ocean Observing System (IndOOS)
IIOE-2 aims to enhance IndOOS – therefore directly relevant to sub-regional studies

Multi platform, long-term observational network. Under IOGOOS/CLIVAR/IMBER + IOC Perth support. Examples of major sub-regional foci are shown.



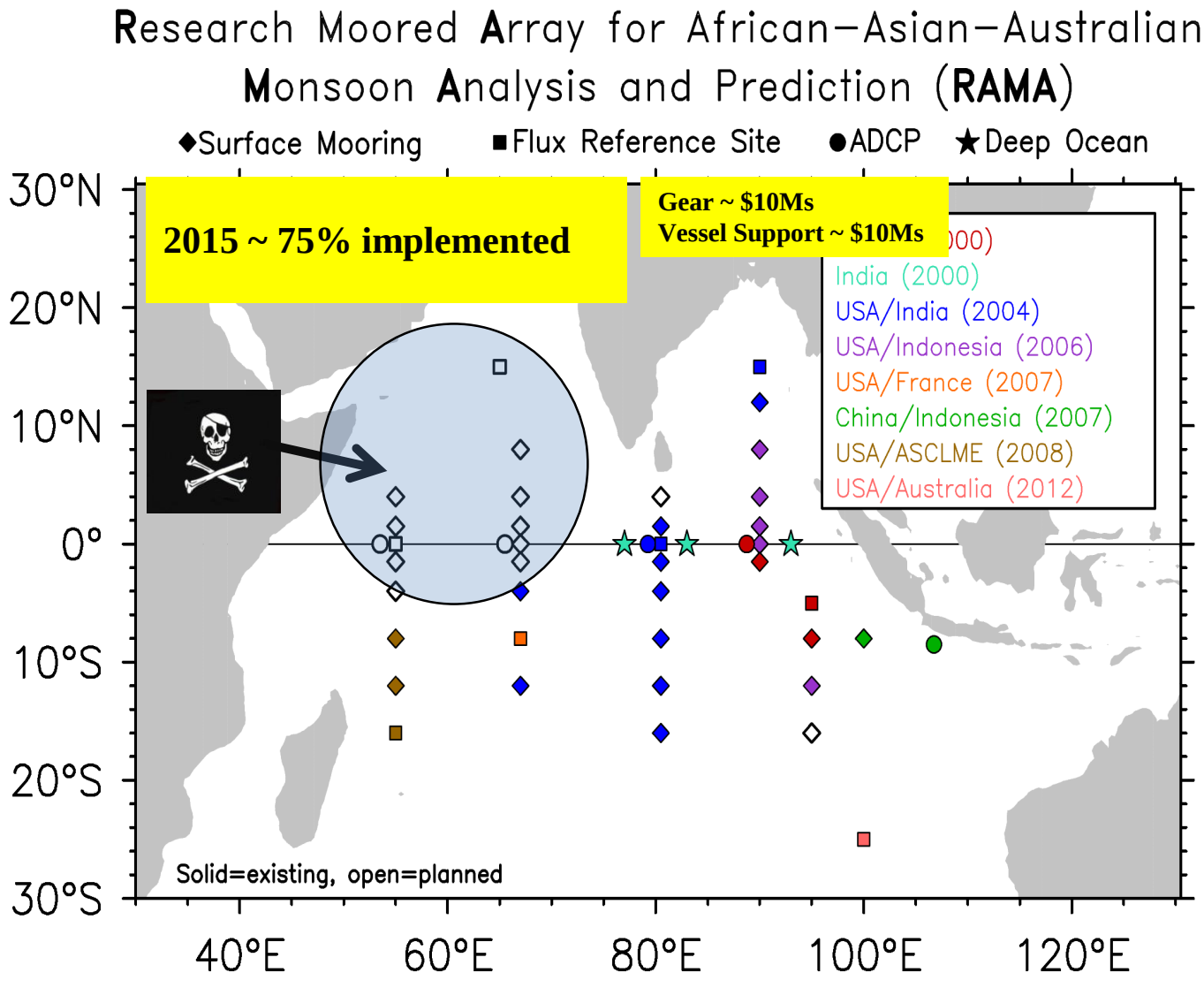
Emergent Agulhas System Study



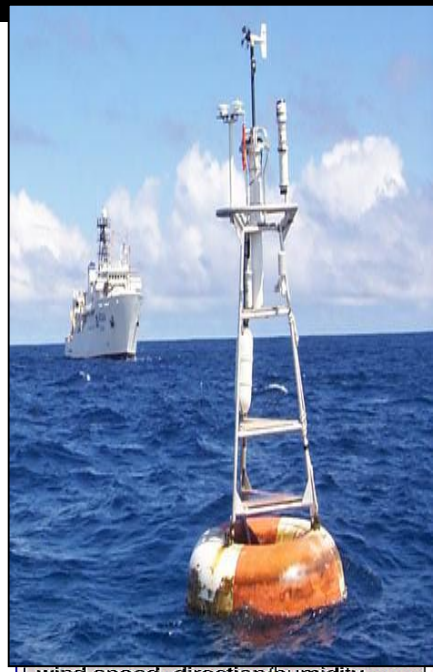


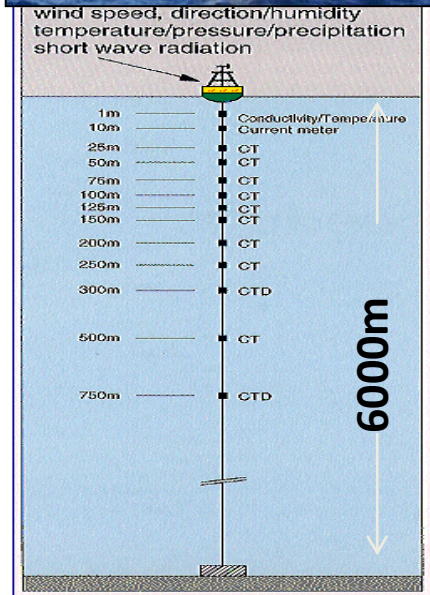
IMOS Australia

RAMA – Deep Ocean (up to 6000m) instrumentation



Courtesy M McPhaden and IOP





High level support obtained (IOC, SCOR, IOGOOS)

Eg

Formal imprimatur of UNESCO IOC

Achieved June 2015 - 148 Governments

Endorsed by IORA = Indian Ocean Rim Association (Ministerial Council at Foreign Affairs and Trade levels)

IORA = 20 Country Members, 6 Dialogue Partners & coordination groupings

Many reports, presentations

Identification of national, sub-regional and regional aspirations & priorities for science, capacity development

Underpinned guiding framework documents (at IOC, SCOR and IOGOOS levels) developed by representative expert groups

eg

IIOE-2 Science plan, IIOE-2 Implementation Strategy, institutional 'resolutions & decisions'

All collated, curated and easily accessible

IIOE-2 dedicated website

www.iioe-2.incois.gov.in

Reports, news, updates etc all freely available

IIOE-2 supported by a Joint Project office

Public focal points

Working with stakeholders and Steering Committee

Key Nodes

Perth, Australia (IOC PPO)

Principle IIOE-2 focal point, in close liaison/collaboration with Indian JPO Node Office

Links to IOC constituency (eg HQ, regions, Member States)

Includes IOC IIOE-2 Coordinator post

Hyderabad, India (ESSO-INCOIS)

Has an INCOIS based JPO Node Leader, plus all required resourcing (staff, budget)

Includes Regional Coordination Unit for Data/Info Management

Includes full hosting, maintenance, management of IIOE-2 website

IIOE-2 Launch

Goa, India
4 December 2015

Part of IO50 conference
(www.io50.incois.gov.in)

Launch also of

Science Plan

Implementation Strategy

Website

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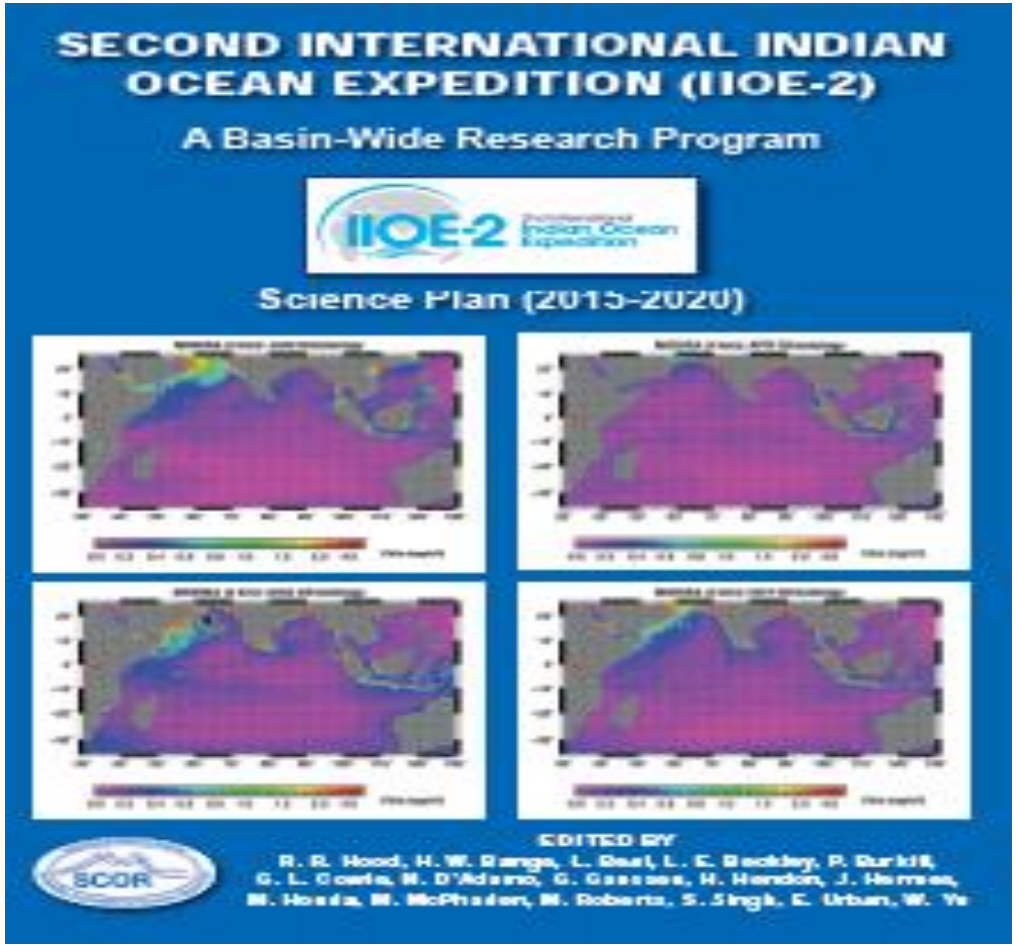
IIOE-2 Science Plan (Hood et al, 2015)

(developed by the SCOR Science Plan Development Committee, 2015)

(an international, interdisciplinary team of experts)



Science Plan for IIOE-2

Ed. Raleigh Hood (USA) … involved ~100 authors.

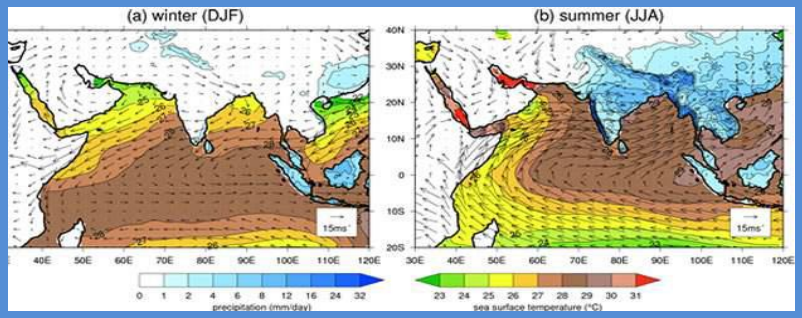
Reviewed widely by international community. Edited by scientists from Australia, China, Germany, India, Japan, Netherlands, UK and USA.

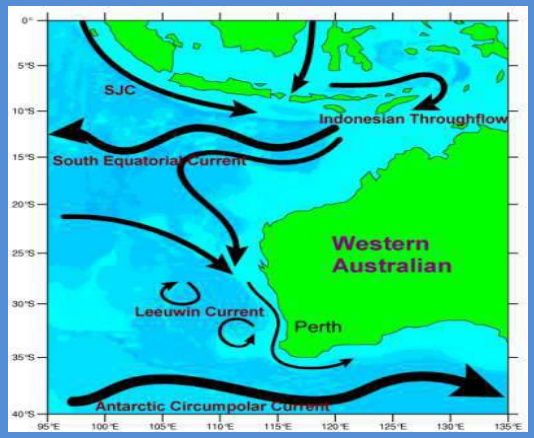
Six over-arching scientific Themes (with sub-themes)

1: Human induced stressors & their impacts

2: Boundary current dynamics, upwelling variability and ecosystem impacts

3: Monsoon variability & ecosystem response





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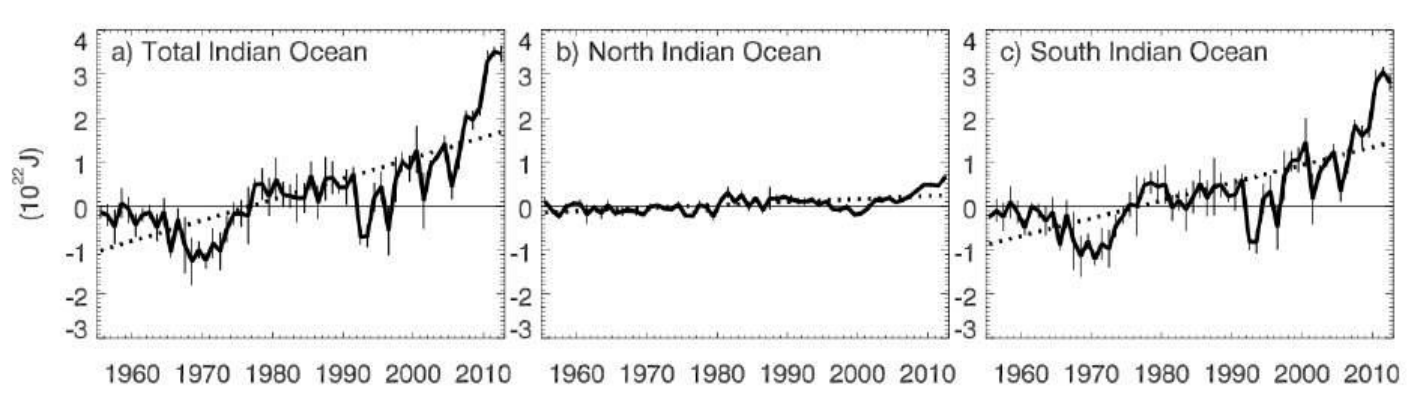
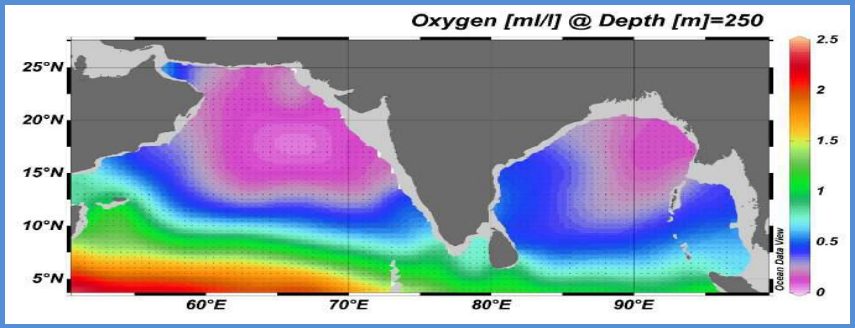
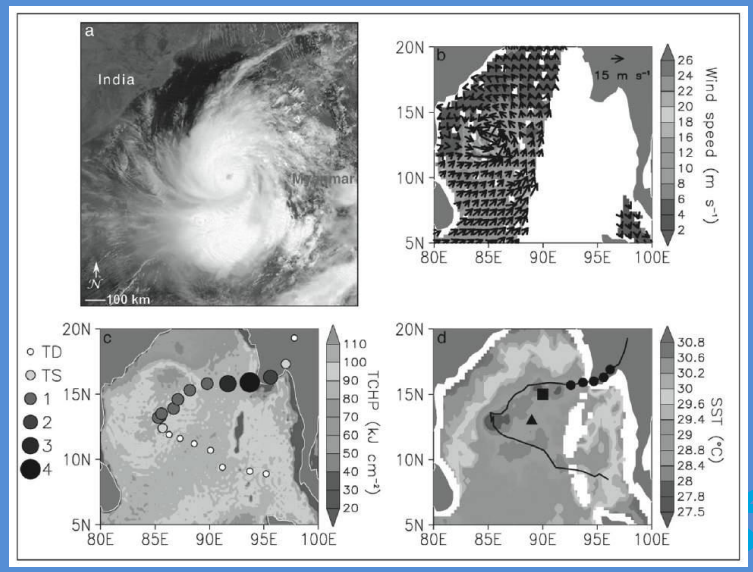
4: Circulation, climate variability and change



5: Extreme events and their impacts on ecosystems and human populations

6: Unique features of Indian Ocean





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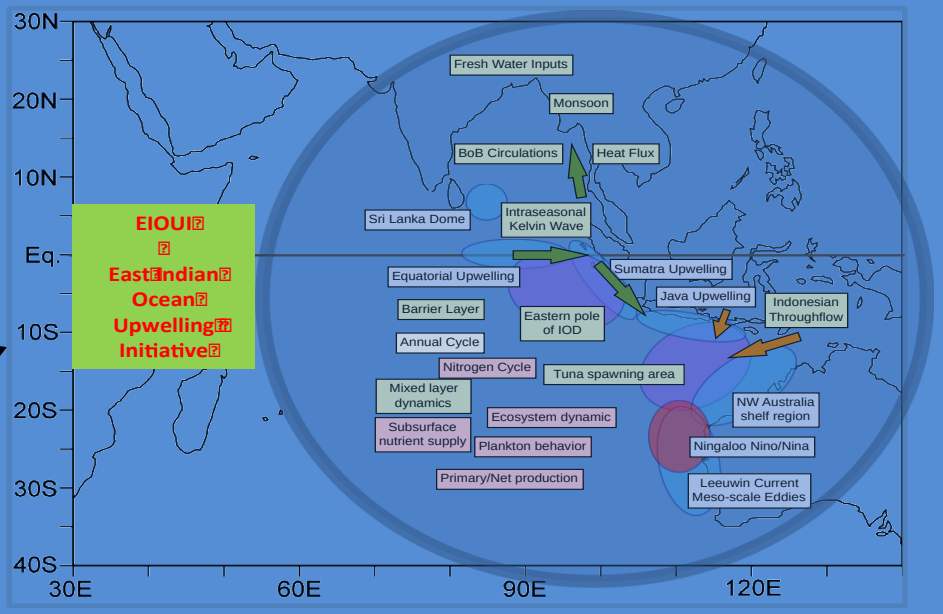
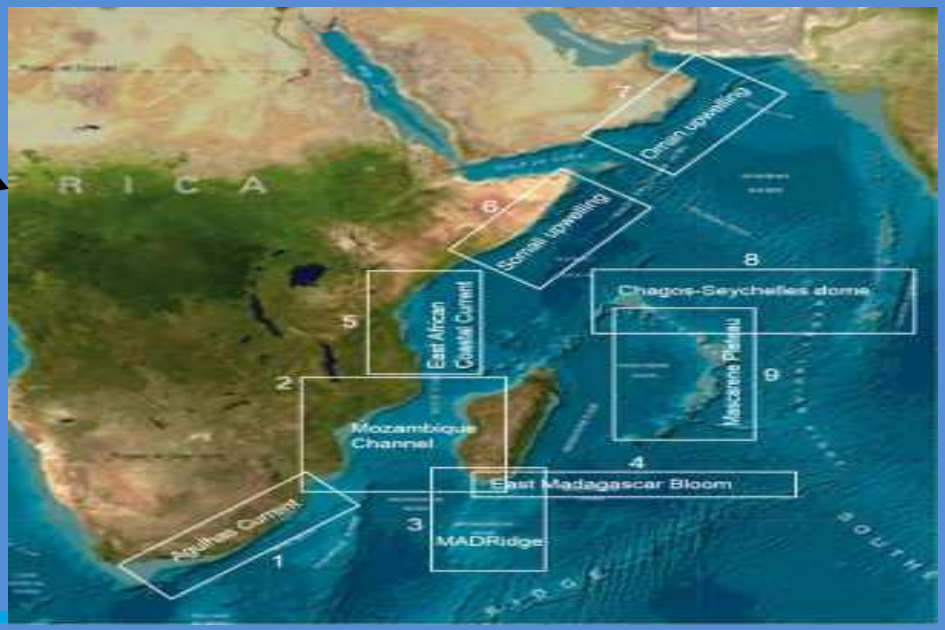
Science Plan refers to early specific committed & planned research

e.g. Eastern Indian Ocean Upwelling Research Initiative
(ref, more info: Weidong Yu, Yukio Masumoto et al)



***e.g. Emerging* Western Indian Ocean Upwelling Research Initiative**
(ref, more info: Mike Roberts et al)



- Agulhas Current driven upwelling
- Upwelling in the Mozambique Channel
- Madagascar Ridge and seamounts
- Upwelling in the East African Coastal Current (EACC)
- and influence of major islands (Mafia, Zanzibar, Pemba)
- Upwelling in the Somalia Current system
- Oman/Arabian Sea upwelling system
- Chagos-Seychelles upwelling dome and Chagos Ridge
- Mascarene Plateau induced upwelling
- Chagos-Laccadive Ridge-induced island wake effects

Even at this early stage, many major research cruises, research projects, training/education initiatives, etc – either done, committed or highly prospective … some highlights …

CRUISES (early, growing list)
India, South Africa, Kenya, FAO (RV F Nansen), Germany, UK, USA, Iran,, Indonesia, Japan, China

CAPACITY DEVELOPMENT (land, virtual & sea-based)
India, Iran, Indonesia, South Africa, Australia/Malaysia

SYMPOSIA
Perth 2017, IIOE-2 Science Symp within IAPSO-IAGA-IAMAS Cape Town 2017, Mauritius (TBA) with IODE 2017, AOGS 2016, CLIVAR OPS 2016 …

COMMS
www.iioe-2.incois.gov.in
IO Bubble Newsletter, IOC Perth comms program

ALLIANCES
…with IOC Regional bodies/committees/programmes (AFRICA, WESTPAC, IOCINDIO, IODE…

…developed/developing with GOOS Regional Alliances and the GOOS Regional Council and the GOOS Steering Committee

RESEARCH
EIOURI, WEIOURI, Bay of Bengal Acidification, Air-Sea Interaction, surface mico-layer

IIOE-2 governance

The steering committee and advisory elements

IIOE-2 Implementation Strategy (2015)

Written by the IOC IIOE-2 Interim Planning Committee (Group of Experts)

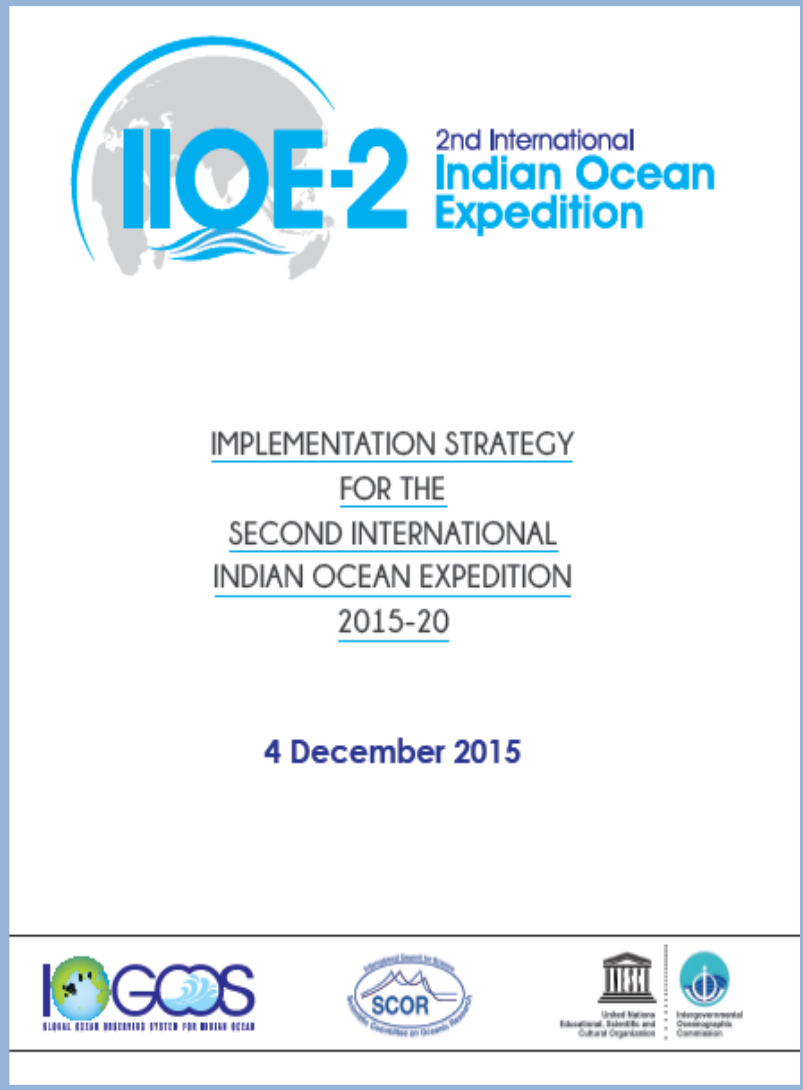
Chair, Satheesh Shenoi
Peter Burkill, Rana Fine, Birgit Gaye, Karen Heywood, Raleigh Hood, Ashley Johnson, Somkiat Khokiattiwong
Kenneth Lee, Charles Majori, Yukio Masumoto, S.W.A Naqvi, Andreas Schiller, Jerome Vialard, Nasser Zaker,
Haiwen Zhang (alternate Weidong Yu)

Editor, Nick D'Adamo (IOC IIOE-2 Coordinator)

Mathieu Belboech (JCOMMOPS), Cyndy Chandler (IODE), Jim Costopulos (Global Oceans), Peter Dexter (BoM Australia), Venu Ittekkot (University of Bremen), Martin Kramp (JCOMMOPS), Srinivasa Kumar (IOGOOS; INCOIS), Iouri Oliounine (IOC), Peter Pissierssens (IOC Oostende), Greg Reed (IODE), Mike Roberts (SIBER), Vladimir Ryabinin (Executive Secretary, IOC), Lucy Scott (Ocean Teacher Global Academy), Sivaramakrishnan Rajan (India), Ed Urban (SCOR)

Sponsorship and secretariat assistance

Government of India, IOGOOS, SCOR, UNESCO IOC



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IIOE-2 STEERING COMMITTEE

Co-Chairs (IOC, SCOR, IOGOOS)

STRATEGIC EXECUTIVE LEVEL

One representative per each of the six science themes from the SCOR SPDC IIOE-2 Science Plan

+

One representative per each of the seven operational divisions to be established as IIOE-2 Working Groups

+

One representative per each major IOC regional body/committee (e.g. IOCAFRICA, WESTPAC, IOCINDIO …)
Representing governments and institutions in IO sub-regions

REGIONAL COORDINATION LEVEL

One representative per each IIOE-2 'national committee'

SCIENCE DELIVERY LEVEL

One representative (i.e. Principal Investigator) per each 'major' IIOE-2 scientific research initiative, including a representative of the *Early Career Scientists Network* from the Capacity Building Working Group

Joint Project Office (JPO)

Australian (IOC PPO)
(Incl. IOC IIOE-2 Coordinator)

+

India (INCOIS)
(Incl. Data Coordination Unit + Website hosting)

(JPO leaders on Steering Committee as ex-officio)

IIOE-2 will have a Steering Committee, and within its Executive Level there will be leaders of:

Six Science Theme Divisions
and
Seven Working Groups

WG 1 Science and Research
Includes Task Team on Remote Sensing (currently championed by David Antoine, Curtin University, Western Australia; Perter Dexter past Co-President JCOMM)
WG 2 Data and Information Management
WG 3 Capacity Development
WG 4 Operational Coordination
WG 5 Outreach and Communication
WG 6 Translating Science for Society
WG 7 Resourcing and Sponsorship.

WGs to work as integrated set

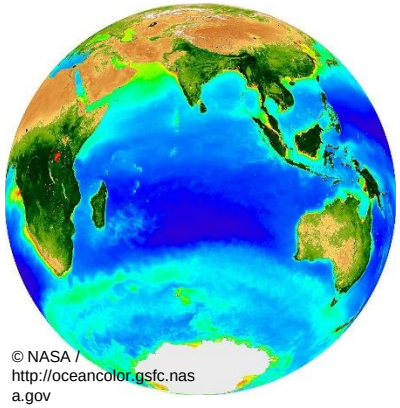
Annual planning meetings/symposia

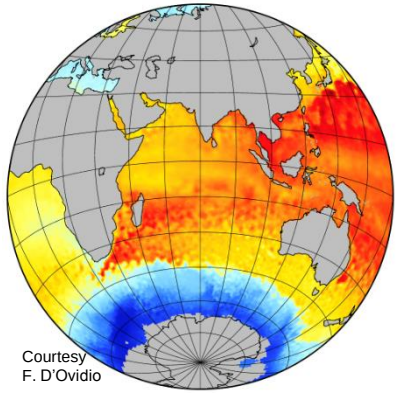
All IIOE-2 elements and constituents meet annually
- **Review, plan, collaborate**

Remote sensing provides the "big picture", allowing, e.g.:

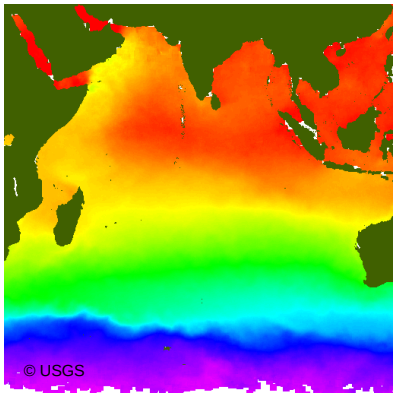
Integration of results from multiple research voyages and other initiatives at the scale of the Indian Ocean. Quantification of stocks, fluxes etc.. at basin scale

Meteorology Temperature



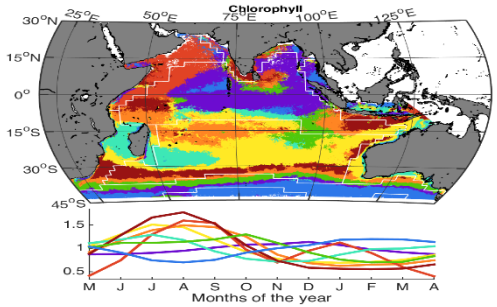


Ocean biology



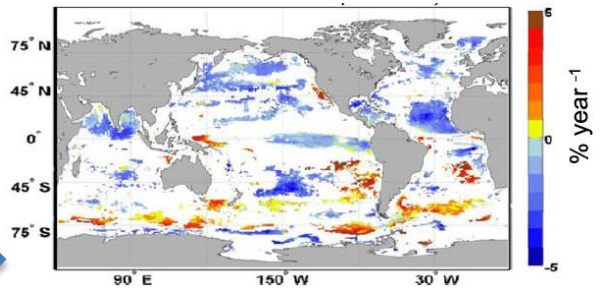
Ocean physics (Altimetry)

Cruise planning



Long-term studies, extending the IIOE-2 impact & legacy

Partitioning ("clustering") of the Indian ocean based on the annual cycle of phytoplankton chlorophyll ("phenology"). Figure courtesy Y. Huot, Univ. Sherbrooke



Chl decadal trends 1998-2012, From Gregg & Rousseaux, JGR, 2014

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How to make the best possible use of Earth satellite remote sensing in IIOE-2?

- Matching IIOE-2 objectives with concurrent satellite missions in order to identify the most suitable ones
- Organizing access to these data sets, so that the community does not wander randomly in search of data
- Evaluating the need for specific products that may not exist in Agencies portfolios (e.g., primary production)
- If such gaps exist, organizing (when feasible) collection of field measurements that could help developing these products
- Evaluating if and how the field data to be collected in IIOE-2 can be used in support to cal/val operations of international satellite missions
- If the answer to the above point is negative, engage a dialogue with space Agencies so that they can evaluate the support they would need to provide in order to take advantage of IIOE-2 operations for collection of cal/val information
- Having a forum to discuss RS-related issues connected to IIOE-2

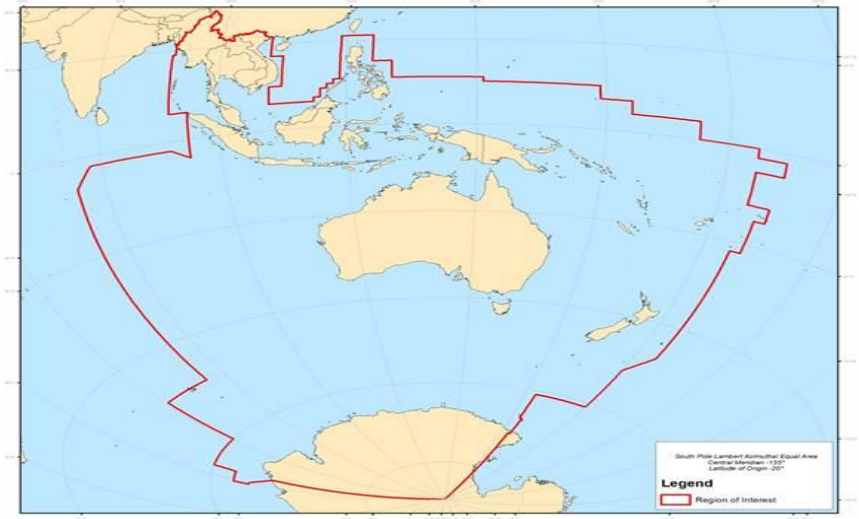
Taking advantage of the "Australian Copernicus data hub" to maximize the use of Earth satellite remote sensing in IIOE-2

Sentinel 1, 2 & 3 data sets should be available to the Australian & surrounding communities via the "Australian Copernicus data hub".

Should be ideally extended to the whole Indian ocean to serve IIOE-2 objectives.

Feasible?

Could, e.g., generate Indian-ocean scale Level-3 products (weekly, monthly, composites)



Current area for which the Australian Copernicus data hub is supposed to receive Sentinel data

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So….how best to achieve the above?

Extend today's collegial interaction

Remote Sensing community (CGMS, ESA …) establish a working alliance with IIOE-2

…within/through the IIOE-2 Steering Committee framework and/or the IIOE-2 Joint Project Office…

…we would welcome and appreciate the opportunity to work with you on this…

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thank you