Global Coordination of Ocean Observations.

Progress, Challenges and Opportunities.

Katy Hill (GOOS/GCOS @WMO).

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GCOS GLOBAL CLIMATE OBSERVING SYSTEM
The Global Ocean Observing System GOOS
WCRP World Climate Research Programme
jcomm OCEANOGRAPHY & MARINE METEOROLOGY

Outline

- How we got to here…
- Where are we now?
  – the Global Ocean Observing System (GOOS)
  – Global Climate Observing System (GCOS)
  – Ocean Observations Physics and Climate panel (OOPC)
  – Ocean Observing Networks
- Where next? Challenges and Opportunities.

Global coordination of ocean observations

WHY INTERNATIONAL COORDINATION?

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Why do we need international coordination?

- 1873s: International Meteorological Organisation (IMO) Formed.
  - To facilitate the exchange of weather information across national borders

  'It is elementary to have a worldwide network of meteorological observations, free exchange of observations between nations and international agreement on standardized observation methods and units in order to be able to compare these observations.' - Professor Buys Ballot
  - Non-governmental (e.g. 'informal club'), voluntary collaboration
- 1950: World Meteorological Organisation
  - Intergovernmental mechanism, bound by a convention. (formal mechanism, representative membership, 1 member 1 vote)
  - Decisions are binding.

WORLD METEOROLOGICAL ORGANIZATION

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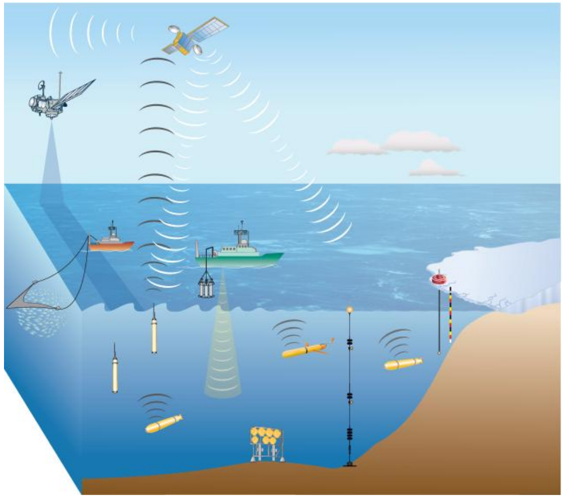
Why do we need international coordination?

- Why do we need global coordination of ocean observations.
  - Similarly recognise the need to collaborate.
  - Challenge in that the ocean is a ‘global commons’.
  - Global collaboration, consensus planning essential.
- Intergovernmental frameworks (sometimes) useful
  - WMO Decisions for motivating engagement from Met Services, Data Transmission, Sharing, etc.
  - IOC Decisions for e.g. addressing EEZ/Law of the Sea Issues.
  - Some parts of the countries place great value on working within formal multilateral frameworks.
  - Downside: can be cumbersome, slow moving.
- Solution: Hybrid approach.
  - Spin up programmes, projects aloof from, but with access to, the Intergovernmental frameworks.
  - Can stay agile, while connecting in as useful (e.g. Argo, TPOS 2020)



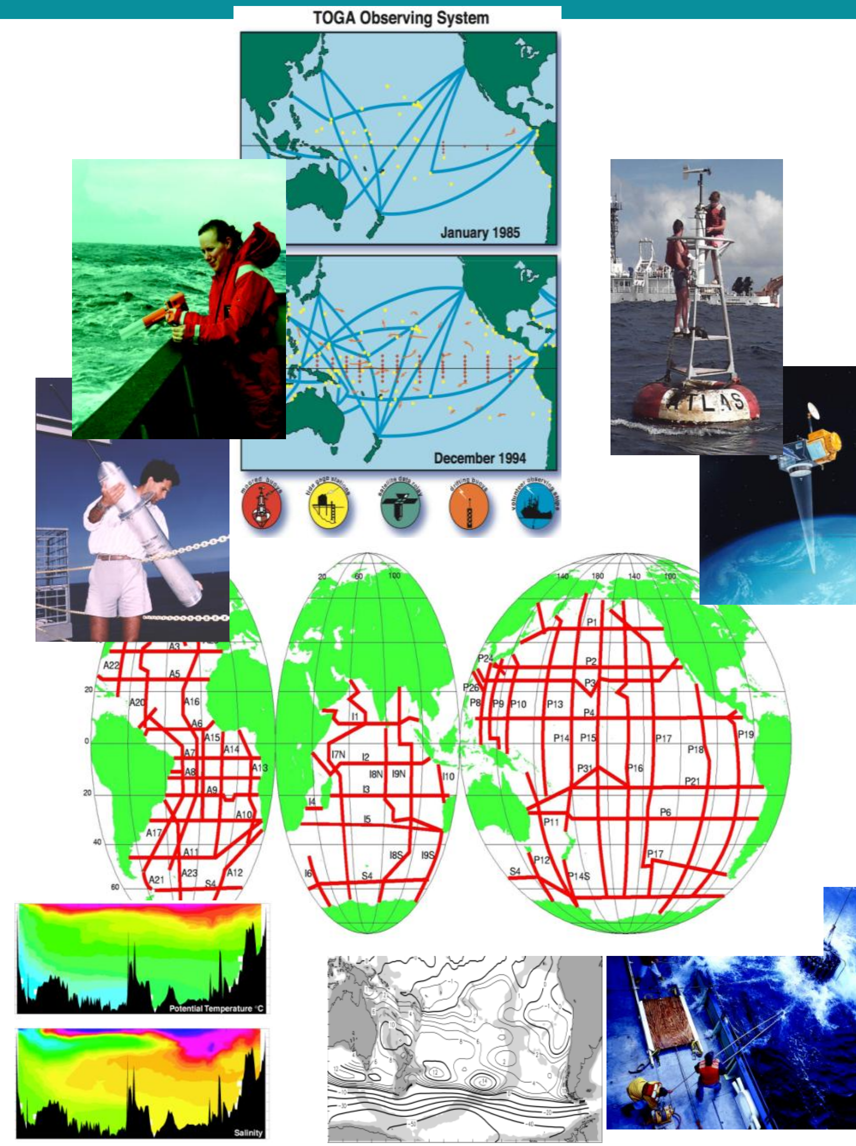
Global coordination of ocean observations

HOW WE GOT TO HERE..

Major global experiments laid the foundations

- The Tropical Ocean Global Atmosphere, TOGA Experiment (1985-1994).
- The World Ocean Circulation Experiment, WOCE (1983-2002).

- *Ocean Observing System Development panel (1990-1995).*
- *GCOS-GOOS-WCRP Ocean Observations Panel Climate (1996-)*



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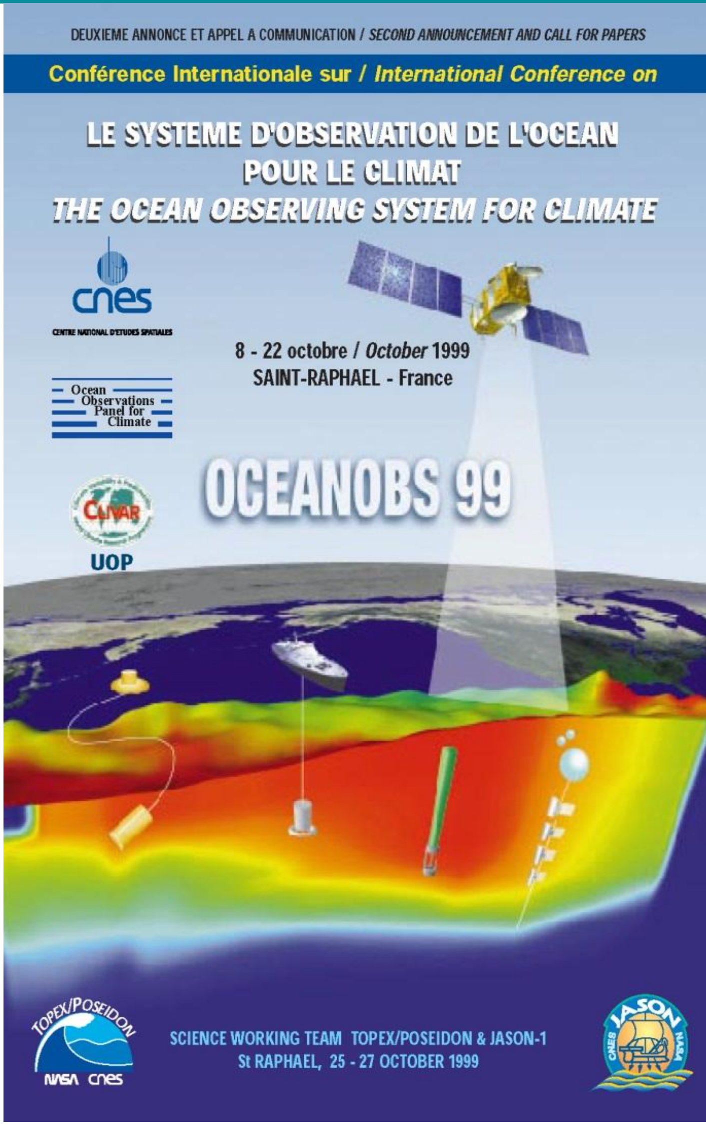
OceanObs'99

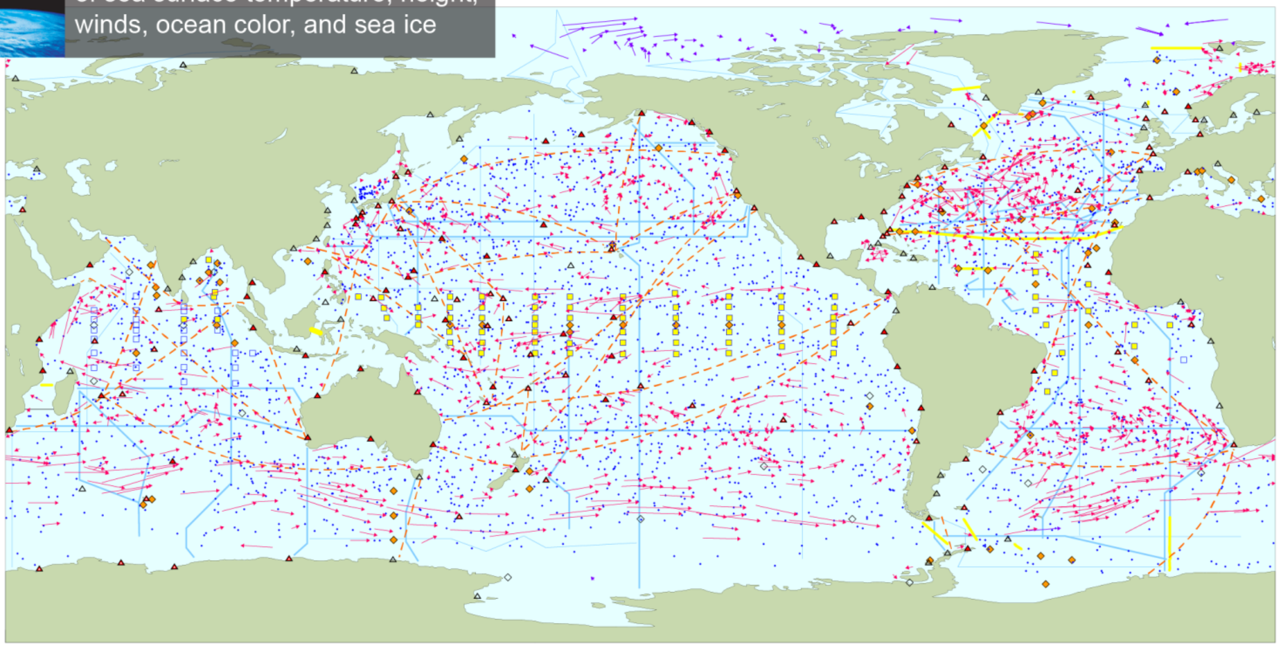
- Led by OOPC and CLIVAR
- 450 people gathered in San Rafael, France to discuss the observing system
- fostered a consensus to undertake an internationally coordinated sustained global ocean observing system for physical climate and ocean carbon,
- Decisions were made on the future observing networks, e.g. Argo (✓), ocean tomography (👎)
- Real targets were set →
- Subsequently agreed and presented in the first GCOS Implementation Plan.

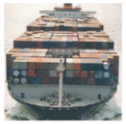


Implementation following OceanObs'99 Conference

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

Total in situ networks **61%** September 2013





100% **Surface measurements** from volunteer ships (VOS)

250 ships in VOSclim pilot project

75% Global **drifting surface buoy** array

ice buoys

5° resolution array: 1250 floats

66% **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

62% Repeat **hydrography** and **carbon inventory**

(planned)

Full ocean survey in 10 years

Transport monitoring 48%

29 sites

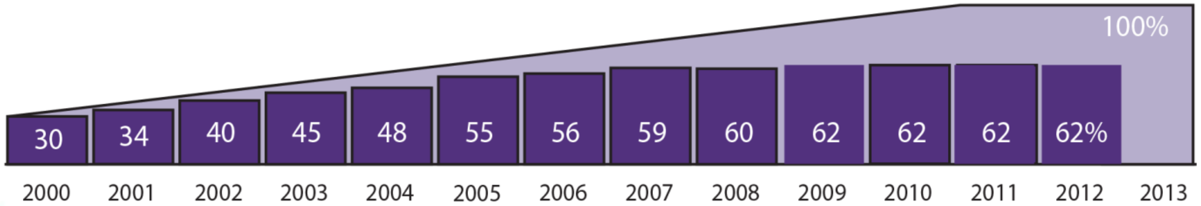
34% Global **time series** network

58 moorings planned

56% Global tropical **moored buoy** network

119 moorings planned

Representative milestones



original goal for full implementation by 2010

System % sustained, of initial goals

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OceanObs'09

- Led by OOPC, CLIVAR and IMBER
- 680 people gathered in Venice, Italy.
- Demonstrated the scientific and societal benefits of the sustained ocean observing system
- Began the process of expanding the range of communities working together
- Work towards integrated-multidisciplinary observing system from the open ocean to the coast.
- Led to development of the Framework for Ocean Observing to guide the selection and implementation of new EOVs.

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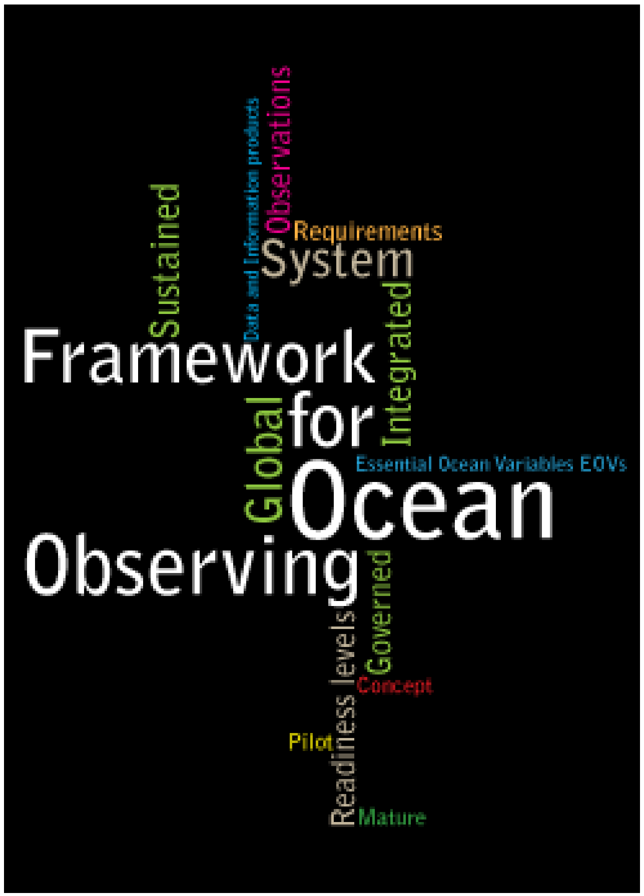
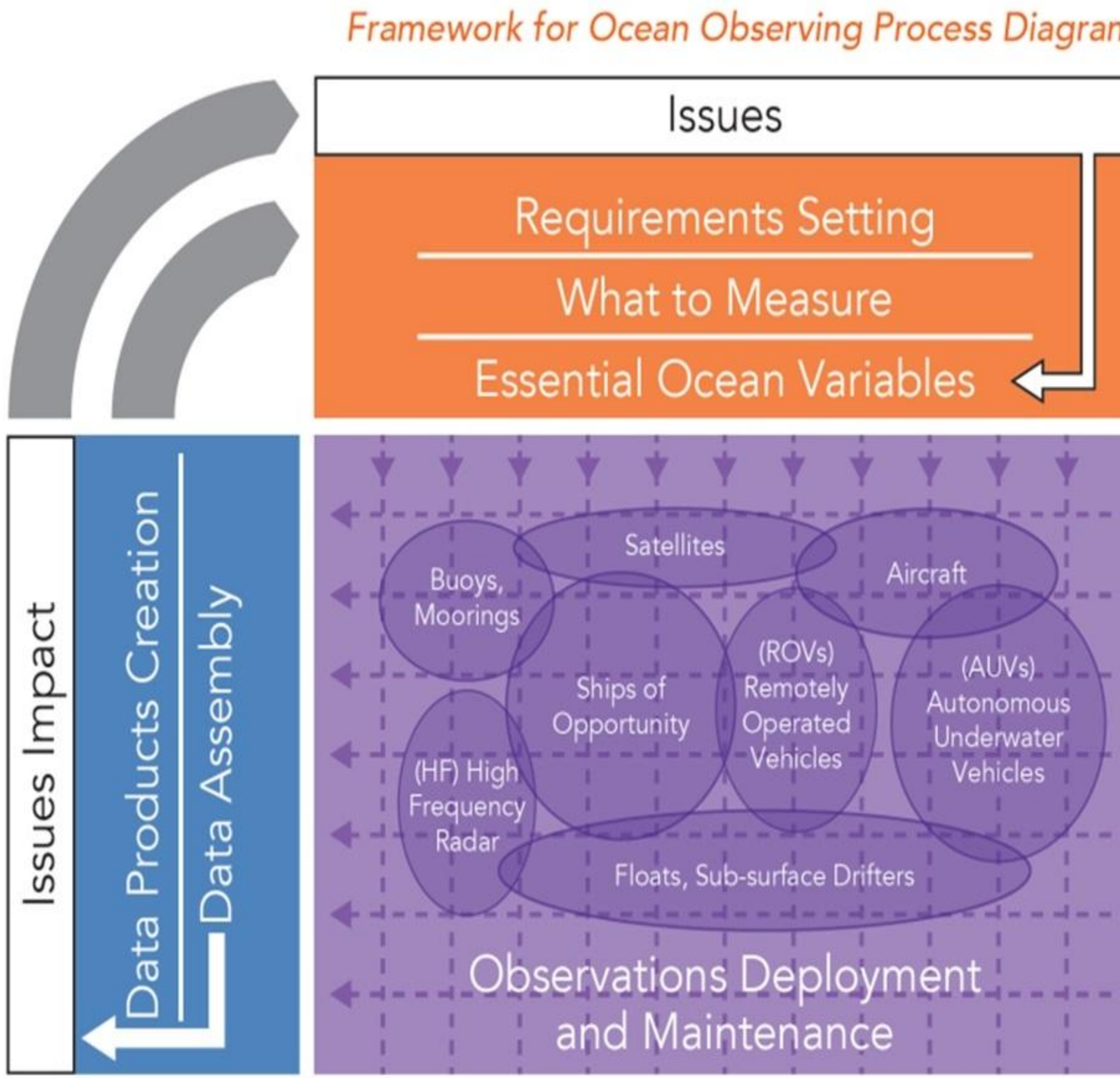
The Framework for Ocean Observing (FOO)





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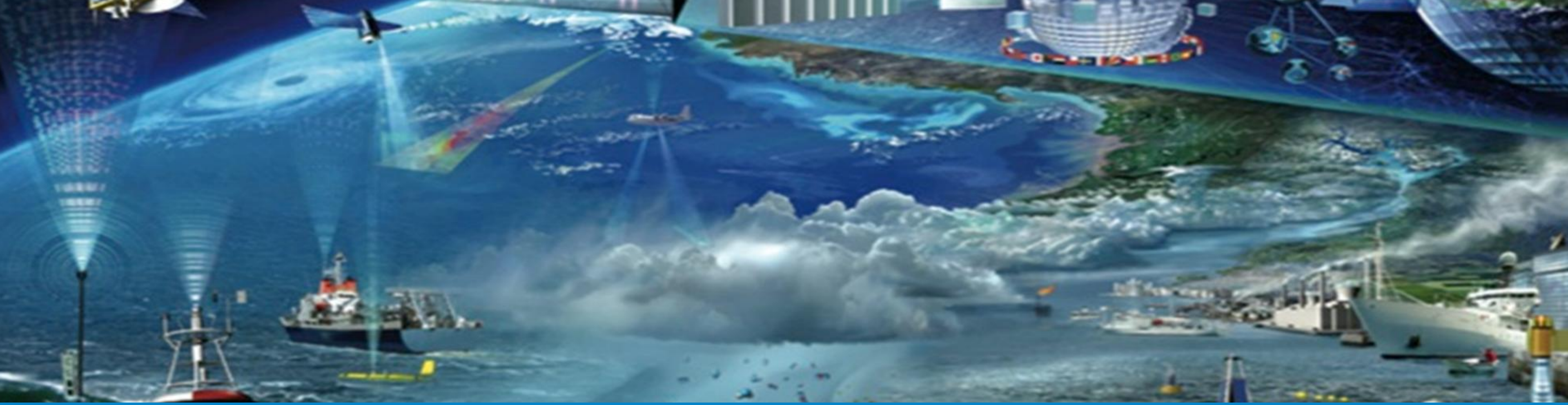

Global coordination of ocean observations

WHERE ARE WE NOW?

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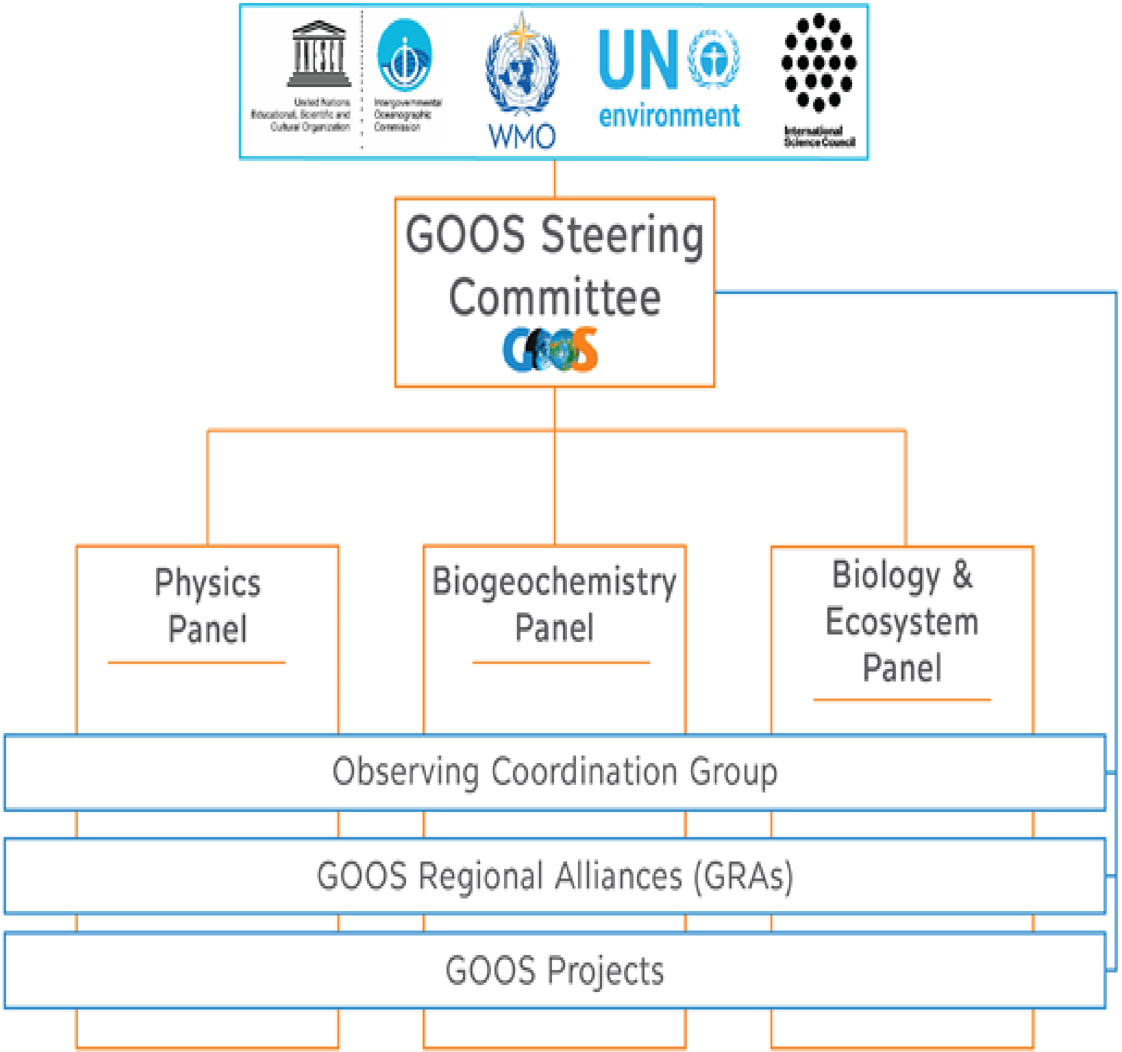
Global Ocean Observing System



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GOOS

Vision
A fully implemented global ocean observing system will provide the critical ocean information needed to address climate change, generate forecasts, and protect ocean health.

Mission
To lead the ocean observing community and create the partnerships to grow an integrated, responsive and sustained global observing system.

For
- Climate
- Ocean health
- Operational services

Strategic Goals & Objectives

Deepening Engagement & Impact

1 Strengthen partnerships, to improve delivery to end users from observations through forecasts, services, and scientific assessments.

2 Build advocacy and visibility for the sustained observing system with stakeholders, communicating with key users and national funders.

3 Regularly evaluate system impact, to assess fit for purpose.

4 Strengthen knowledge and exchange around services and products, empowering the spread of end user applications at a local level.

System Integration & Delivery

5 Provide authoritative guidance on integrated observing system design, synthesizing across evolving requirements.

6 Sustain, strengthen and expand observing system implementation through GOOS and partner communities, promoting standards and best practice, and developing metrics to measure success.

7 Ensure GOOS ocean observing data and information are findable, accessible, interoperable, and reusable, with appropriate quality and latency.

Building for the Future

8 Support innovation in observing technologies and networks.

9 Develop capacity to ensure a broader range of stakeholders participate in, and benefit from, GOOS.

10 Extend systematic observations to understand human impacts on the ocean.

11 Champion effective governance for global in situ and satellite observing, together with partners and stakeholders.

Essential Ocean Variables (EOVs)

Physics

- Sea State
- Ocean surface stress
- Ocean Heat Fluxes
- Sea Ice
- Sea level
- SST
- Subsurface temperature
- Surface currents
- Subsurface currents
- Sea Surface Salinity
- Subsurface salinity

Biogeochemistry

- Oxygen
- Nutrients
- Inorganic Carbon
- Tracers
- Suspended particulates
- Nitrous oxide
- Carbon isotope (^{13}C)
- Dissolved organic carbon
- Ocean Colour

Biology and Ecosystems

- Phytoplankton biomass and diversity
- Zooplankton biomass and diversity
- Fish abundance and distribution
- Marine turtles birds and mammals abundance and distribution
- Live coral
- Seagrass cover
- Mangrove cover
- Microalgal canopy
- Microbe biomass and diversity (*emerging)
- Benthic invertebrate abundance and distribution (*emerging)

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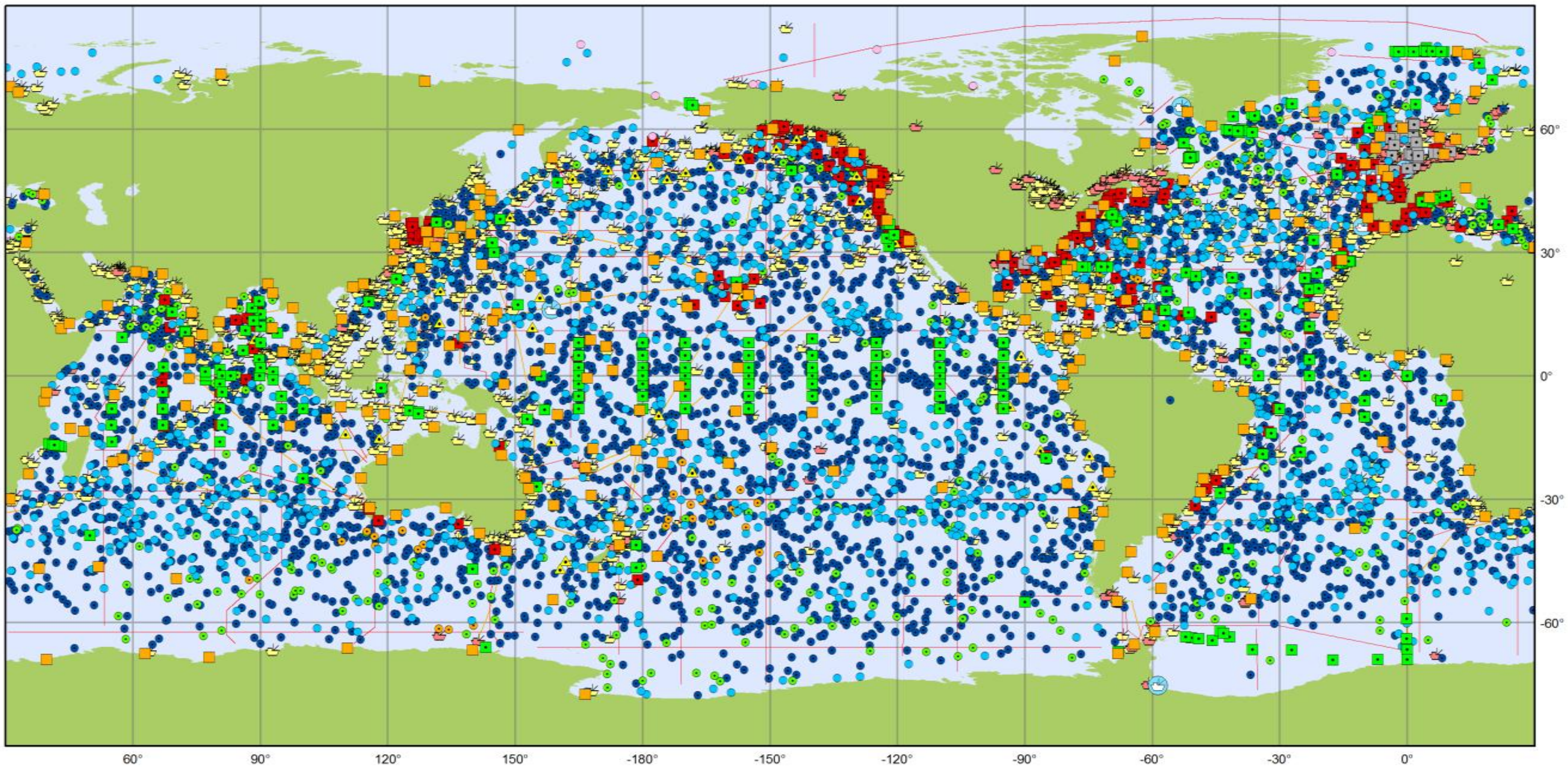
Observing System Status



Main in situ Elements of the Global Ocean Observing System

January 2018

Profiling Floats (Argo)
- Core (3895)
- Deep (44)
- BioGeoChemical (314)

Data Buoys (DBCP)
- Surface Drifters (1410)
- Offshore Platforms (102)
- Ice Buoys (12)
- Moored Buoys (370)
- Tsunameters (33)

Timeseries (OceanSITES)
- Interdisciplinary Moorings (333)

Repeated Hydrography (GO-SHIP)
- Research Vessel Lines (61)

Sea Level (GLOSS)
- Tide Gauges (252)

Ship based Measurements (SOT)
- Automated Weather Stations (261)
- Manned Weather Stations (1745)
- Radiosondes (14)
- eXpendable BathyThermographs (37)

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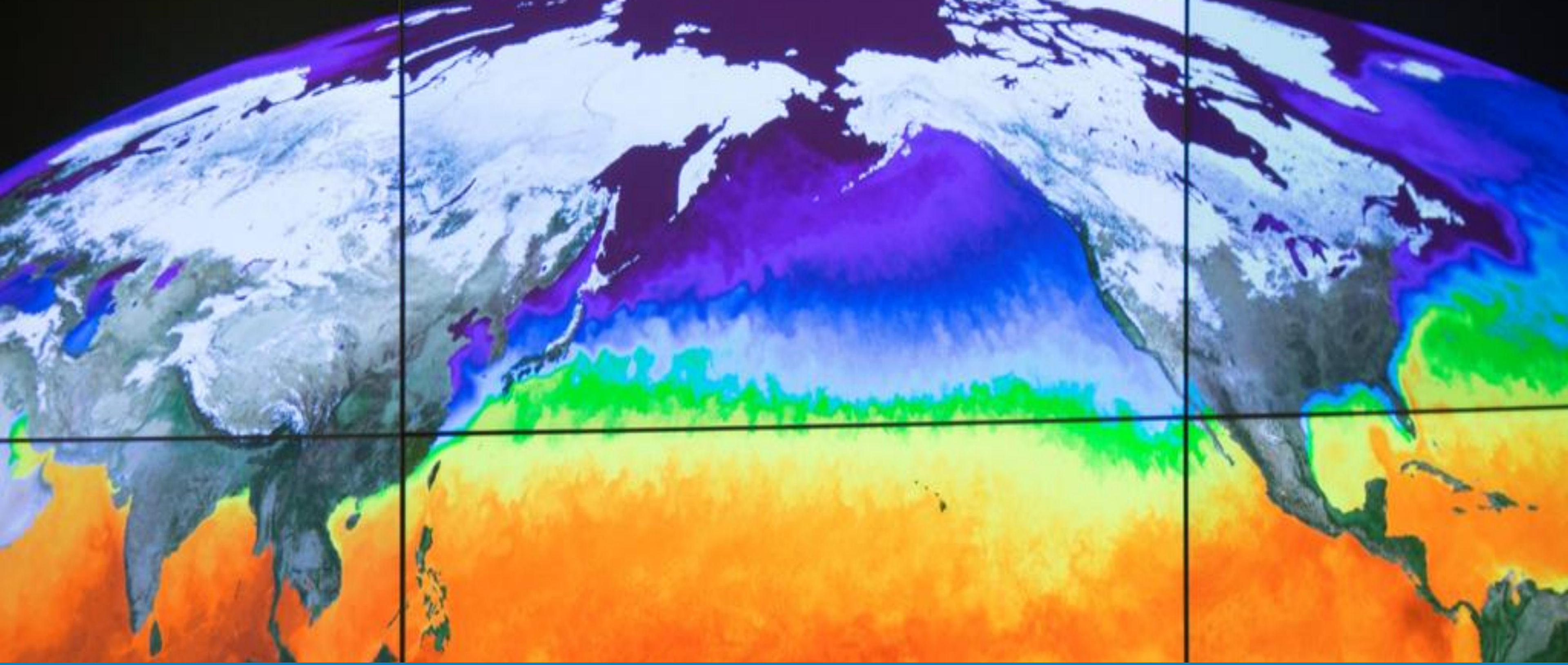

Delivering to

THE GLOBAL CLIMATE OBSERVING SYSTEM

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GCOS GLOBAL CLIMATE OBSERVING SYSTEM

WCRP World Climate Research Programme

ipcc INTERGOVERNMENTAL PANEL ON climate change

United Nations Framework Convention on Climate Change

Essential Climate Variables (ECVs)

Atmospheric

Surface

Precipitation; Pressure; Radiation budget; Temperature; Water vapour; Wind speed and direction

Upper-air

Earth radiation budget; Lightning; Temperature; Water vapor; Wind speed and direction

Composition

Aerosol and ozone precursors; Aerosols properties; Carbon dioxide, Methane and other greenhouse gases;

Oceanic

Physical

Ocean surface heat flux; Sea ice; Sea level; Sea state; Sea surface Salinity; Sea surface temperature Subsurface currents; Subsurface salinity; Subsurface temperature

Biogeochemical

Inorganic carbon; Nitrous oxide; Nutrients; Ocean colour; Oxygen; Transient tracers

Biological/ecosystems

Terrestrial

Hydrosphere

Groundwater; Lakes; River discharge

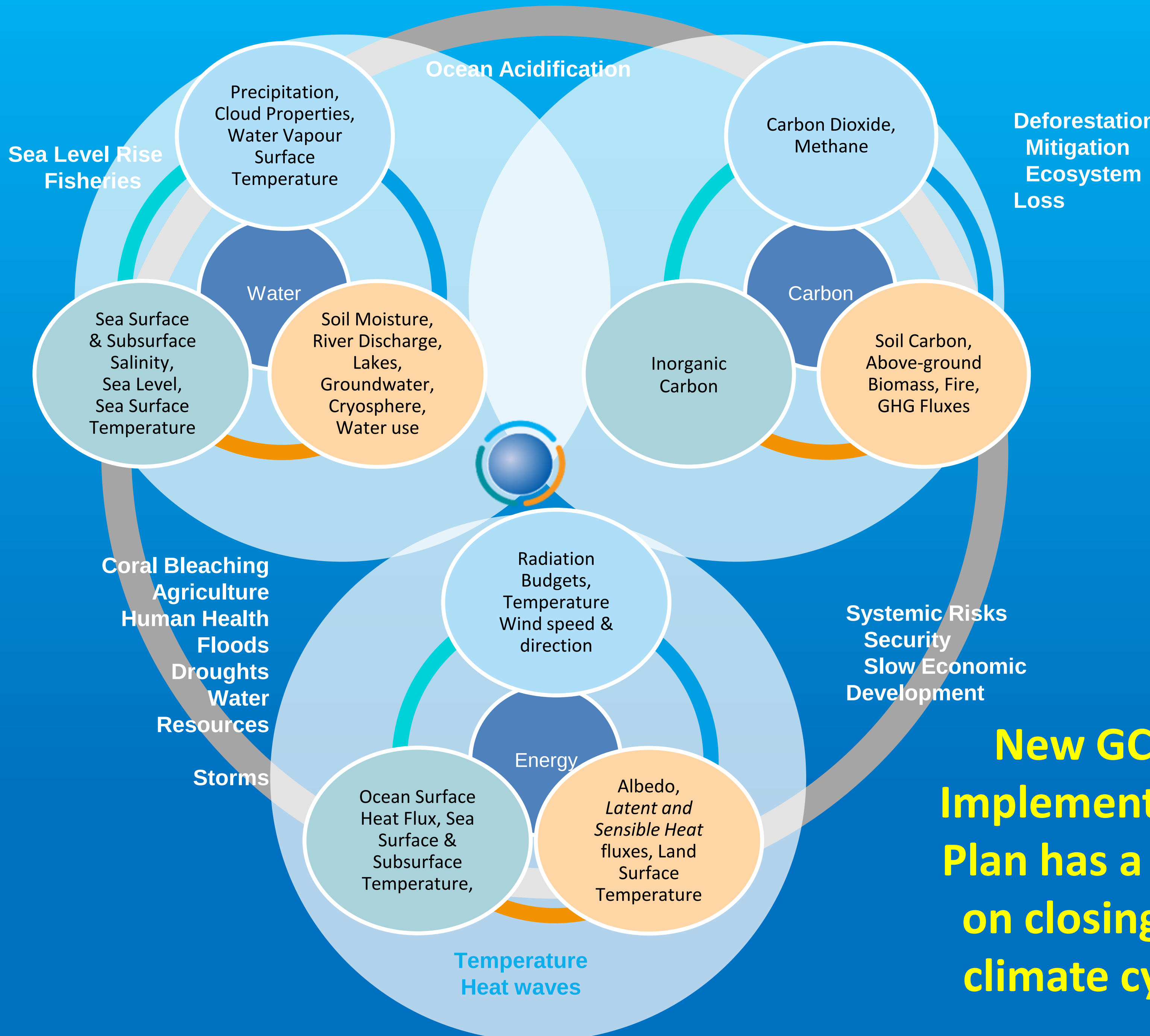
Cryosphere

Glaciers; Ice sheets and ice shelves; Permafrost; Snow

Biosphere:

Above-ground biomass; Albedo; Fire; Fraction of absorbed photosynthetically active radiation; Land cover; Land surface temperature; Latent and sensible heat fluxes; Leaf area index; Soil carbon; Soil moisture

Human use of natural



New GCOS Implementation Plan has a focus on closing the climate cycles

IPCC Special Report 1.5 degrees C

- **Oceans**. Limiting warming to 1.5°C compared to 2°C: substantially reduce risks to marine biodiversity, ecosystems and their ecological functions and services to humans in ocean and coastal areas, especially Arctic sea-ice ecosystems and warm water coral reefs.
- a. With 2°C of global warming, it is very likely that there will be at least one sea ice-free Arctic summer per decade. This is reduced to one per century with 1.5°C global warming.
- b. Ocean ecosystems are experiencing large-scale changes with critical thresholds being exceeded at 1.5°C and above. Crossing these thresholds may have irreversible effects.
- c. The majority of warm water coral reefs are already experiencing the large-scale loss of coral abundance (cover) today and would lose a further 70-90% of cover at 1.5°C.
- d. Ocean acidification at 1.5°C is expected to amplify the adverse effects of warming, impacting the survival, calcification, growth, development, and abundance of a broad range of taxonomic groups (i.e. from algae to fish)
- e. The risk of declining ocean productivity, distributional shifts (to higher latitudes), damage to ecosystems (e.g. coral reefs, wetlands), loss of fisheries productivity (at low latitudes), and changing ocean chemistry (e.g., acidification, hypoxia) are projected to be substantially lower at 1.5°C compared to 2°C

ipcc WMO UNEP
INTERGOVERNMENTAL PANEL ON climate change

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Introducing the

OCEAN OBSERVATIONS, PHYSICS AND CLIMATE PANEL,

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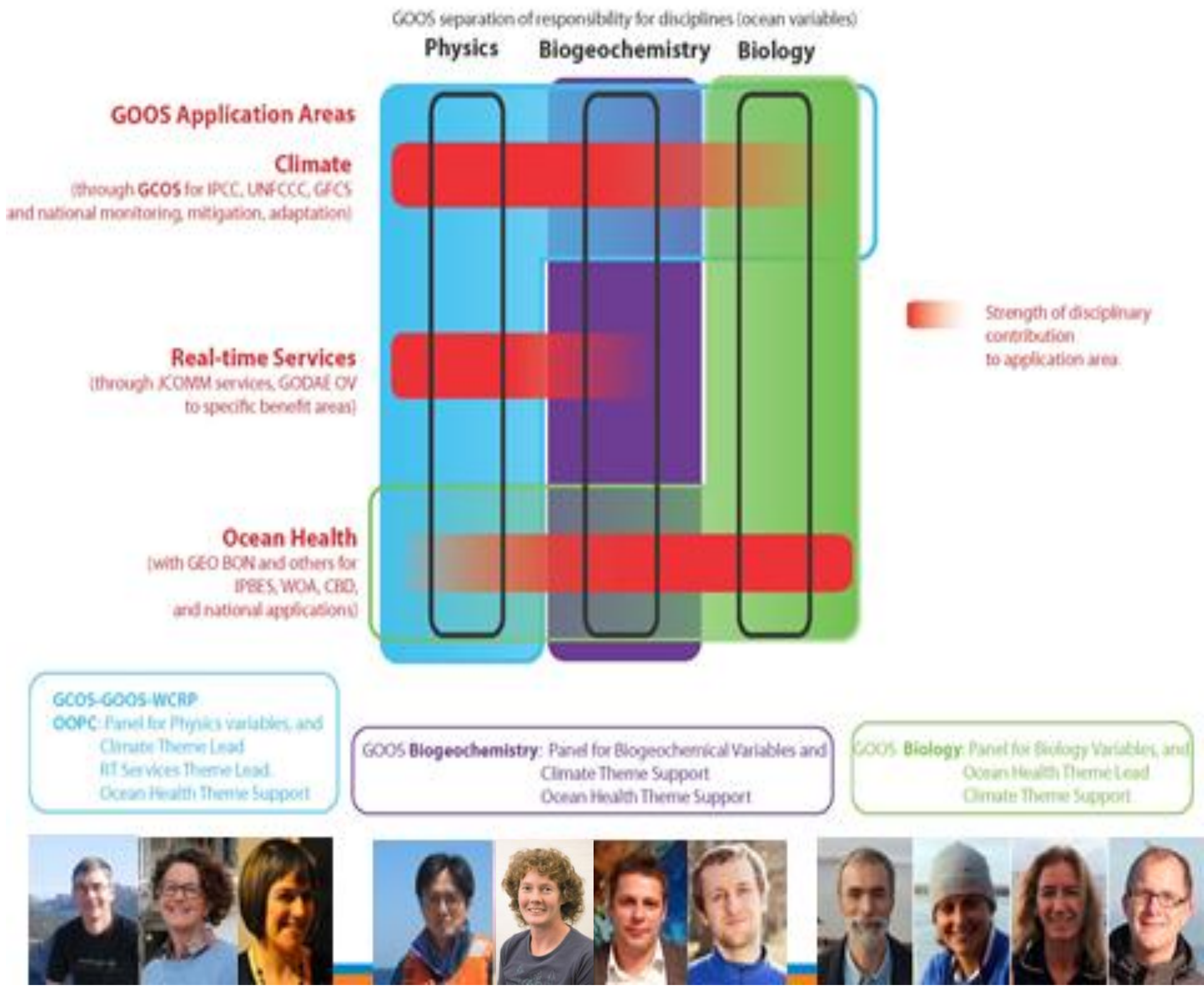
The Ocean Observations Physics and Climate panel

- The Panel's mandate is to provide scientific recommendations and to review the implementation of the ocean observations required for climate in support of its 3 sponsors,
  - the [Global Climate Observing System](#) (GCOS),
  - the Global Ocean Observing System (GOOS), and
  - the [World Climate Research Programme](#) (WCRP).
- Responsible for Physics Essential Ocean Variables for GOOS
- Responsible for Ocean Essential Climate Variables for GCOS (in liason with other GOOS panels).



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OOPC Focus

- **Assess, review and prioritize requirements** for Essential Ocean Variables, **EOVs** and Essential Climate Variables, **ECVs**
- Work with JCOMM OCG and regional bodies to **coordinate observing networks**
- **Review** the status of and **requirements** for **data and information management**
- Develop a **process for ongoing evaluation** of the observing system
- **Liaison and advocacy** for agreed plans
- Report to sponsors

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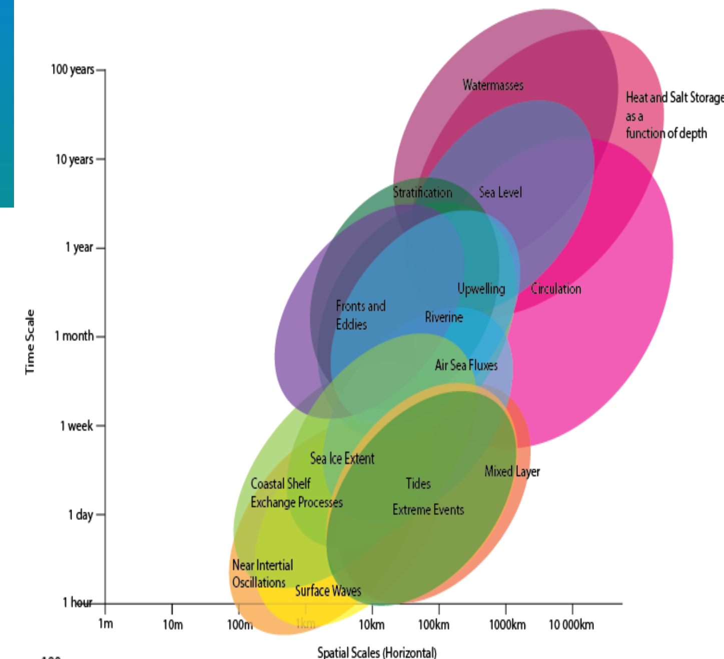
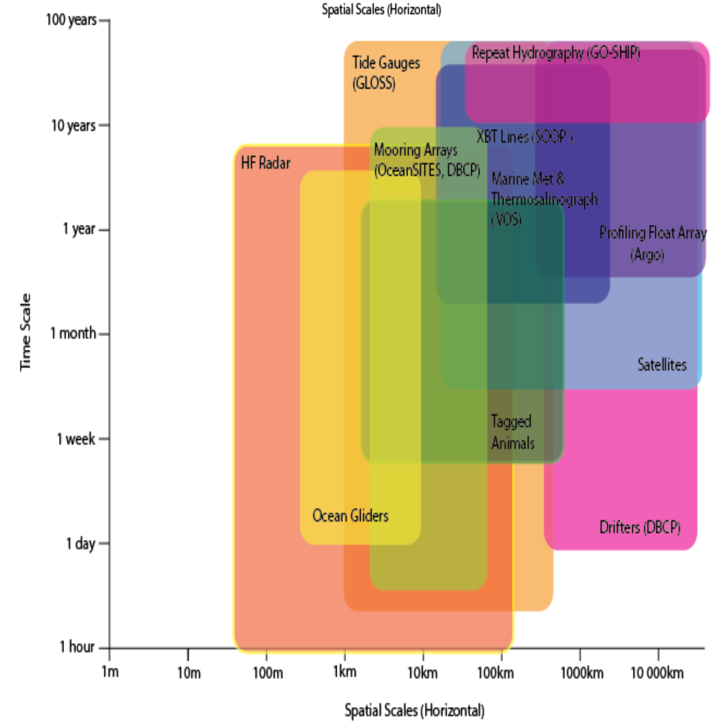
Developing requirements for Essential Ocean Variables

- EOV Specifications
  - Detailed documents explaining rationale, observing components, data streams.
  - Phenomena approach; so easy to draw out requirements for different applications (e.g. climate relevant phenomena)
  - Waiting on developments of Strategic mapping to update.





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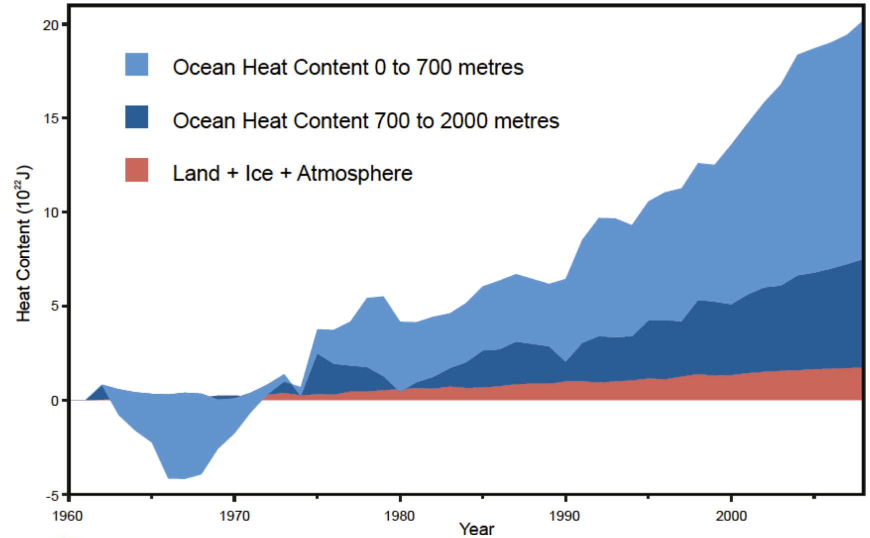
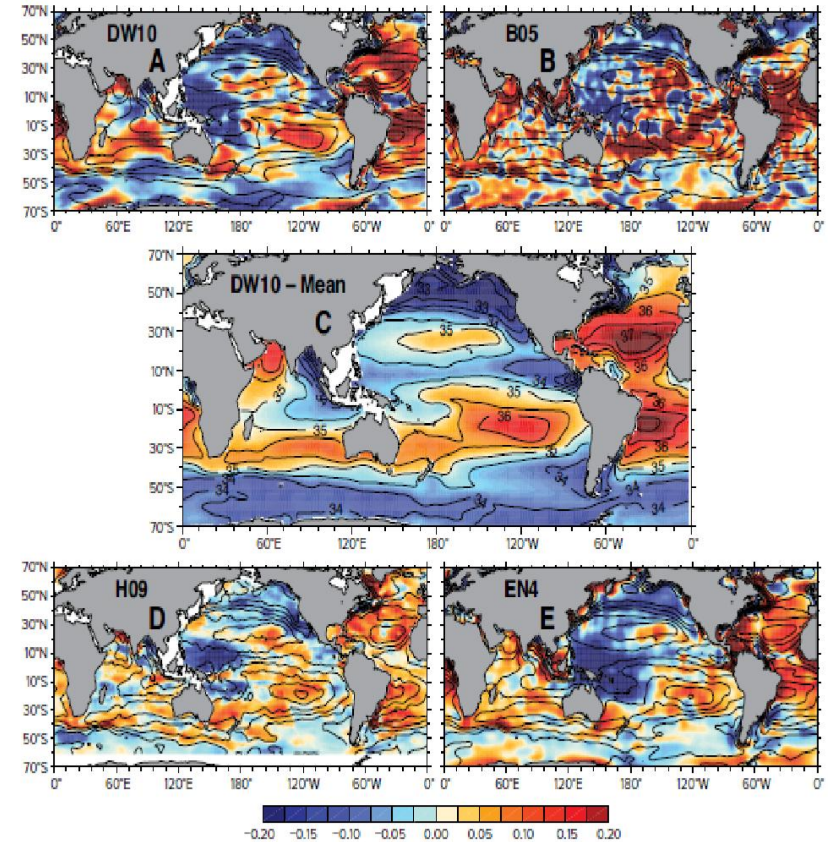
Review: Ocean Heat and Freshwater Storage
(Leads: Matt Palmer, Paul Durack).

- Around 20 Experts invited to engage.
- Aim: undertake a review of the observing system for capturing changes in Heat and Freshwater Storage:
  - Review drivers, requirements (space/time scales.
  - Agree on set of global/regional analyses.
  - Workshop to review analyses, agree on drafting of review paper.
- Outcomes: recommendations on observing system gaps, adjustments; improve integration, products.
- Proposed workshop: late 2018 or early 2019, UK Met Office.
- OO’19 Community Whitepaper outlining approach





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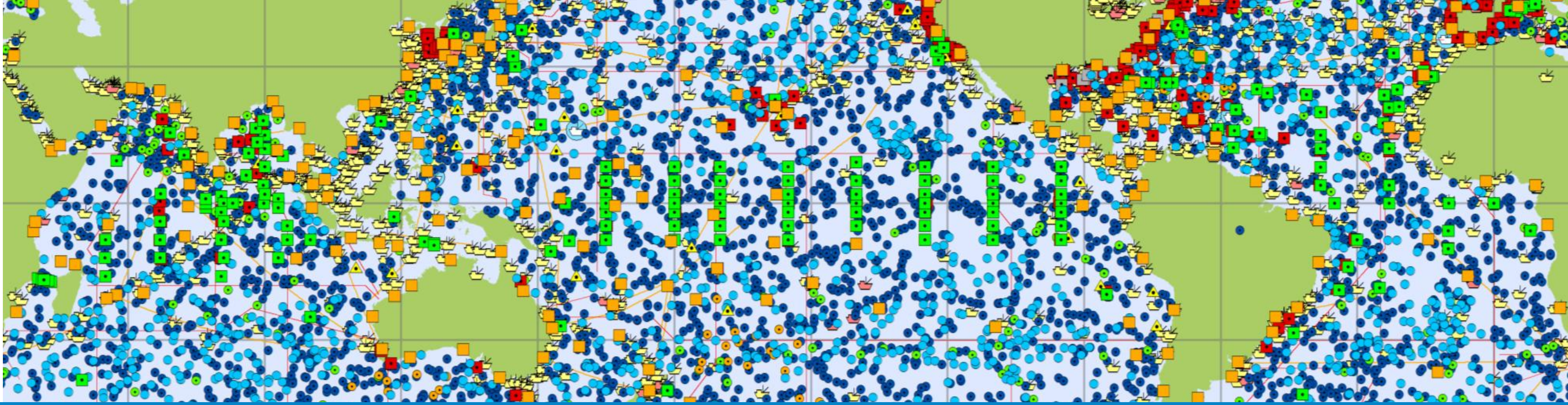


Working with

THE OBSERVING NETWORKS (JCOMM OBSERVATIONS COORDINATION GROUP)

Who is the Observations Coordination Group?

Regional Marine Instrument Centre (RMIC)

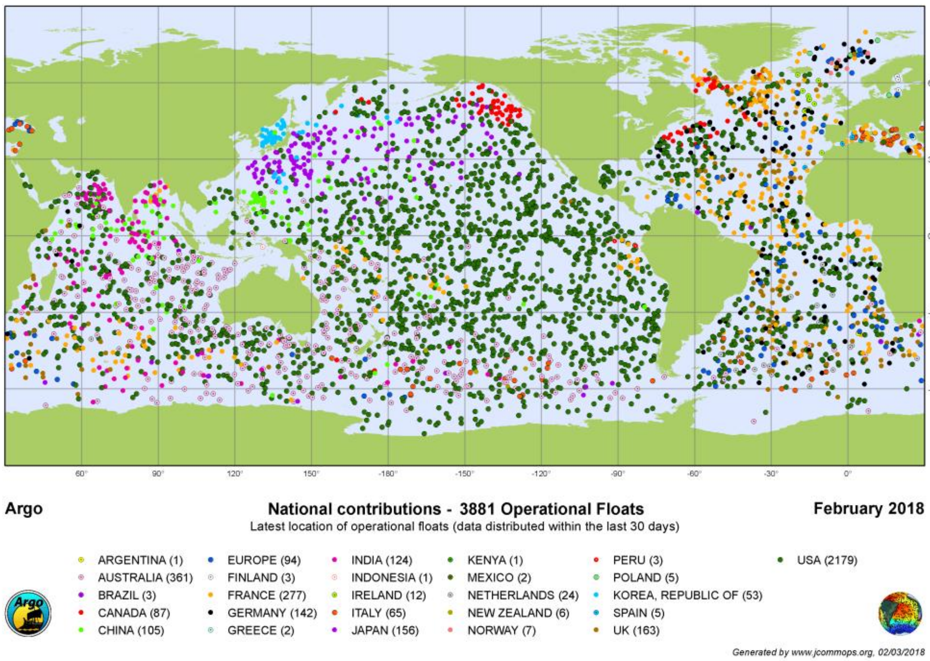
OSMC Observing System Monitoring Center

OceanGlider

HF Radar
GOOS Regional Alliance
Animal Profiling Networks

Recent Interaction with JCOMM OCG

Argo



Status (March 2018)

- 3849 Operational Floats
- 29 active countries
- Some flat/declining national contributions
- Core Argo 15% underfunded
- Southern Ocean 40% implemented - BGC contribution tangible.
- North Atlantic oversampled (to be redirected in SO)
- Spatial coverage still improving (good coordination)
- 96% obs. within 24h

Recent Achievements

- Design reviewed (initial 3200 to global 3800) (+Polar/Marginal)
- Good coverage (~70%) P.O. getting old, and on decrease.
- 1+ paper per day logged
- Global ocean heat gain observed with unprecedented accuracy

Foci for the Next Year

- EEZ permissions remain a challenge
- IOC proposal: add BGC sensors to std payload
- Proj: max to 4000 then degradation
- BGC (900) full array still to be funded
- Deep Array and regional enhancements piloted
- Technology progressing
- Charters crucial for sustained coverage4

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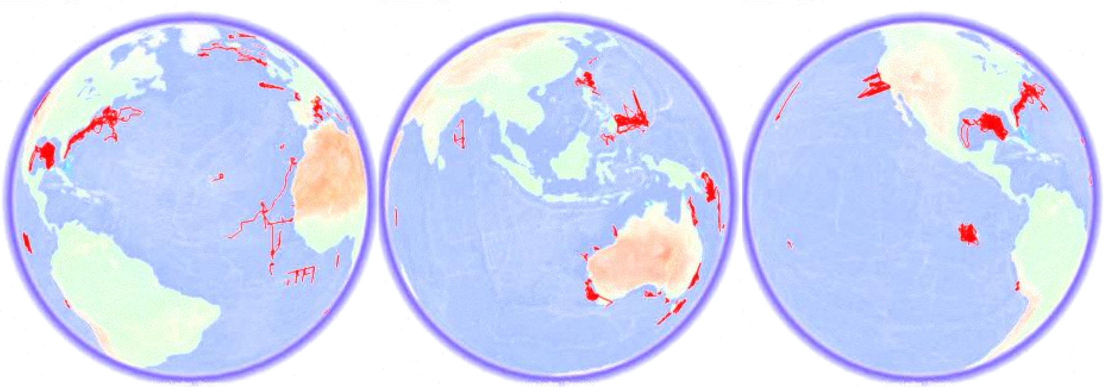
OceanGliders



Recent Achievements

- Commenced Sept. 2016, governance model and task teams, Boundary currents, Storms, Water transformation, Data management
- Aim to support long term (sustained) glider observations with a focus on scientific & societal issues
- Research: ~100 yearly publications

Status

- ~30 active gliders in the water at any time providing ~50,000-100,000 profiles/year (BGC) in regions not well covered by other components
- 18 countries

Foci for the next year

- Engage new communities
- New TTs: Polar, Biogeochemistry
- Inclusion of gliders in JCOMMOPS
- Maintain existing lines and initiate new (capacity building)
- Metrics for network performance
- Contribute to a multi-platform strategy
- Best practices
- OceanObs'19 contributions

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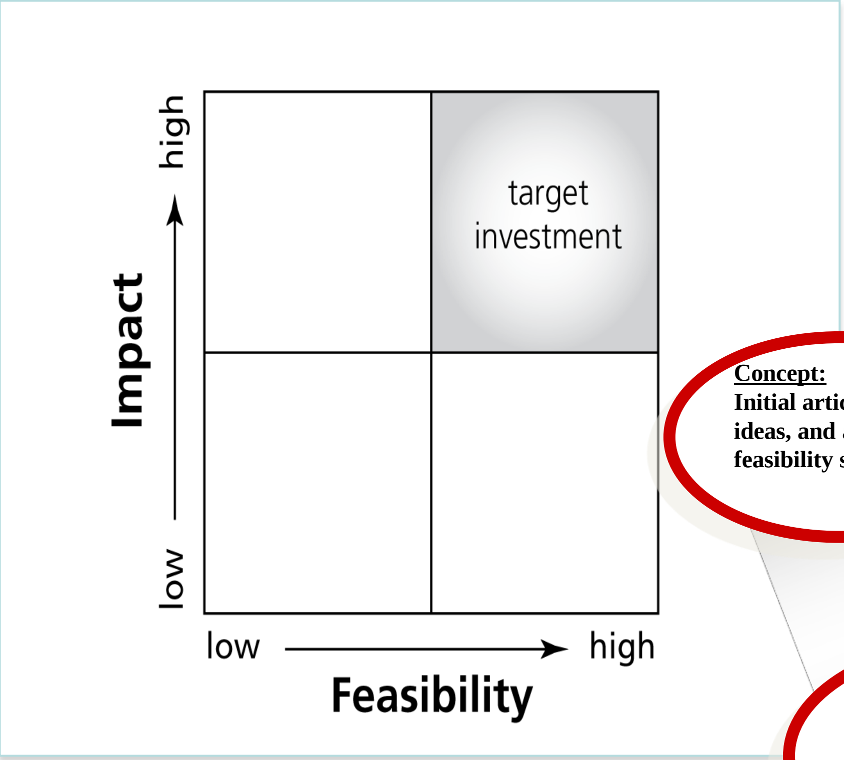
The Framework for Ocean Observing (FOO)



Close gaps

Lower cost per obs

Deliver to new applications

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Global coordination of ocean observations

CHALLENGES AND OPPORTUNITIES

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Challenges Check list..

- How do we evolve the observing system to meet a broader range of applications, from hurricane forecasting, to supporting ecosystem services?
  - The Framework for Ocean Observing provides (some) guidance here.
  - Phenomena approach to observing system design.

- How do we maintain the interest and momentum for sustaining observations, when funding is on short term funding cycles?
  - Keep exercising the system through reviews; engaging users, innovation, broadening participation.

- How do we continually evaluate and innovate the observing system to meet evolving needs?
  - Keep exercising the system through reviews; engaging users, agency funders.

- How do we foster the next generation of leaders for the next charge forward for sustained observing?
  - A challenge for OceanObs'19 and the decadal agenda.

- How do we evolve our coordination activities to meet future needs?
  - Will be discussed at OceanObs'19

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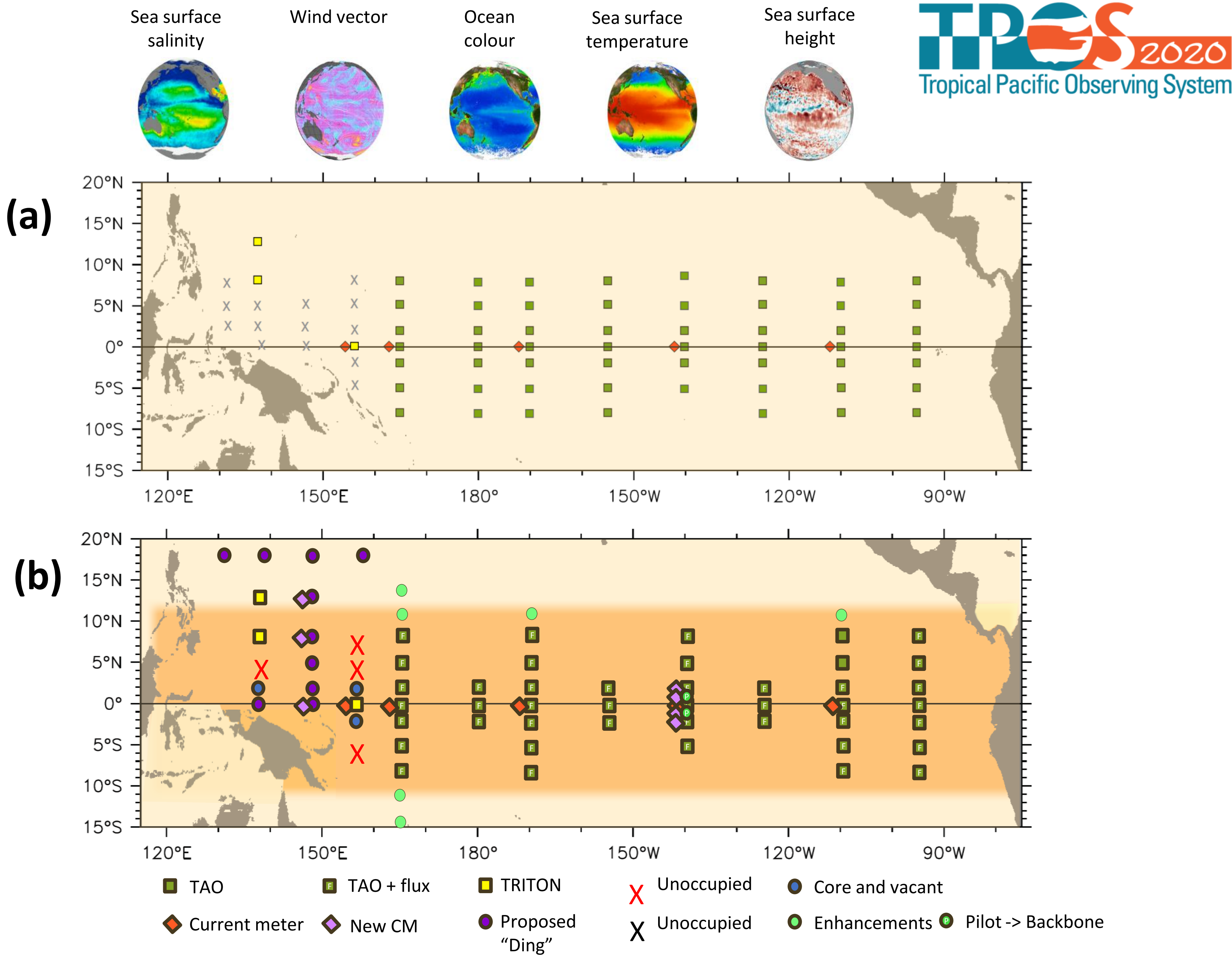
Sea surface salinity
Wind vector
Ocean colour
Sea surface temperature
Sea surface height
TPOS 2020
Tropical Pacific Observing System
(a)
(b)
20°N
15°N
10°N
5°N
0°
5°S
10°S
15°S
120°E
150°E
180°
150°W
120°W
90°W
TAO
TAO + flux
TRITON
Unoccupied
Core and vacant
Current meter
New CM
Proposed "Ding"
Unoccupied
Enhancements
Pilot -> Backbone

OceanObs'19

- 2 panel members are co-chairs of the Programme Committee.
- 1 panel member co-chair of the sponsors committee.
- OOPC Secretariat supported establishing committees, project office, and coordinated initial sponsorship engagement.

- Panel members strongly engaged in Whitepapers, including key papers which align with OOPC Work Plan priorities.
- OOPC Overarching paper on ocean observations for physics/climate (possible merger with WCRP Ocean Obs requirements for Climate)

UN Decade of Ocean Science for Sustainable Development

2021 2030 United Nations Decade of Ocean Science for Sustainable Development

- A major opportunity to advance Ocean Sciences.

- Potentially an 'Innovation Incubator' for the Ocean Observing System.

- Aim to position outcomes of OceanObs to be taken up by the Decade.

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UN Decade of Ocean Science for Sustainable Development

2021 2030 United Nations Decade of Ocean Science for Sustainable Development

A Decade to...

BOLSTER

ocean observing and data systems

Potential activities ...

- An Ocean Observing System for All Major Ocean Basins
- Sustained Deep Ocean Observing System
- Open access, data portal for all
- Social science metrics