



The Ocean Observations Physics and Climate panel

A panel of the Global Climate Observing System (GCOS), the Global Ocean Observing System (GOOS), and the World Climate Research Programme (WCRP)

Provides scientific advice to the GOOS/Ocean Coordination Group (OCG)

Chair: Bernadette Sloyan

Secretariat: Katy Hill (GCOS/GOOS)

*Intergovernmental Oceanographic Commission – World Meteorological Organisation

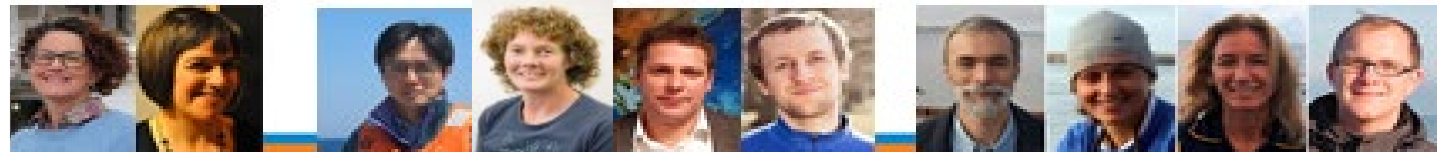
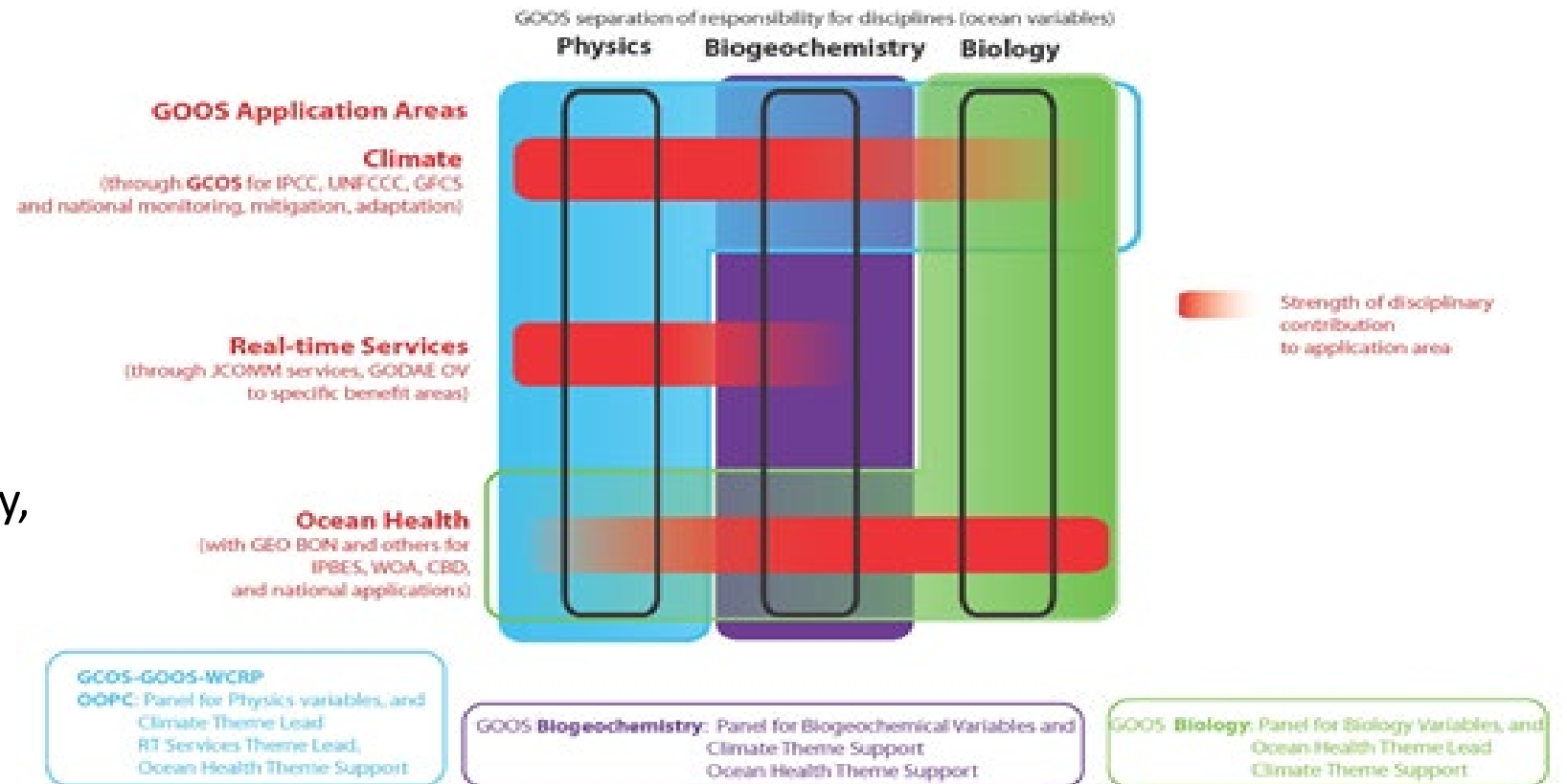
GCOS • GOOS • WCRP



OOPC, IOCCP and Bio/Eco

OOPC conduit for GCOS Ocean concerns including:

- Physics
- With IOCCP – carbon and biogeochemistry
- With Bio/Eco – biology and ecosystems
- With Ocean Coordination Panel – track data availability, implementation
- Evaluate GCOS IP Action Items
- Observing System review/developments





OOPC, IOCCP, and BIO/ECO

ACTIONS FOR THE NEXT 1-2 YEARS

EOVs and Essential Climate Variables (ECVs)

Physics

- Sea state
- Ocean surface stress
- Ocean surface heat flux
- Sea ice
- Sea level
- Sea surface temperature
- Subsurface temperature
- Surface currents
- Subsurface currents
- Sea surface salinity
- Subsurface salinity

Biogeochemistry

- Oxygen
- Nutrients
- Inorganic carbon
- Transient tracers
- Particulate matter
- Nitrous oxide
- Stable carbon isotopes
- Dissolved organic carbon

Cross-disciplinary

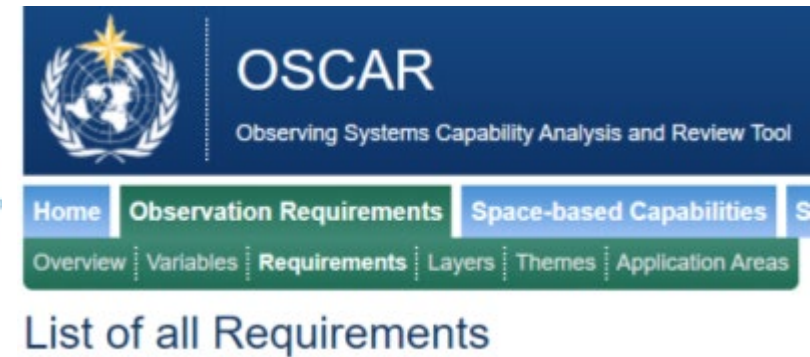
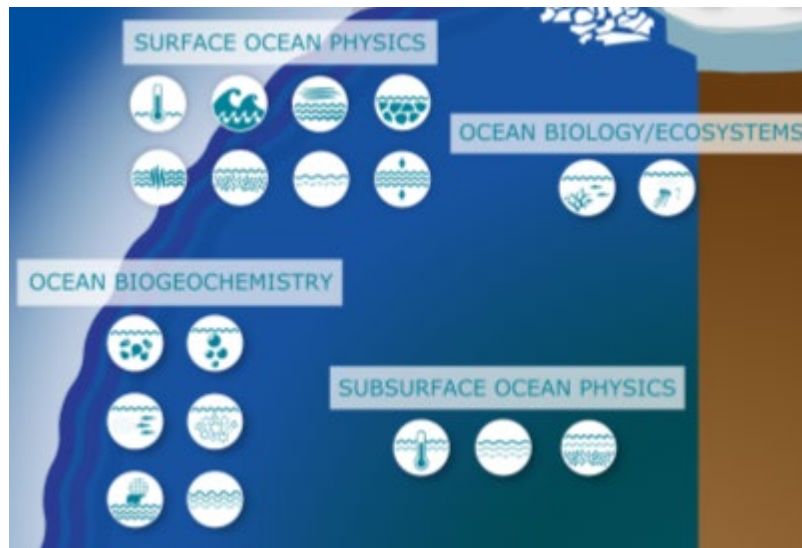
- Ocean colour
- Ocean sound

Biology and Ecosystems

- Phytoplankton biomass and diversity
- Zooplankton Planktons and diversity
- Fish abundance and distribution
- Marine turtles birds and mammals abundance and distribution
- Hard coral cover and composition
- Seagrass cover and composition
- Mangrove cover and composition
Marine habitat properties
- Microalgal canopy cover and composition
- Microbe biomass and diversity (*emerging)
- Invertebrate abundance and distribution (*emerging)

Harmonization of requirements for EOV & ECV observations

- Clear articulation from GCOS of their reporting needs and the move towards strengthened engagement with WMO (which also means engaging in the Rolling Review of Requirements) brought about a need to better integrate the process of setting requirements for EOVs (GOOS) and ECVs (GCOS).
- Current discrepancies between how requirements are set (products vs phenomena) and communicated through GCOS IP, ECV factsheets and EOV Specification Sheets.

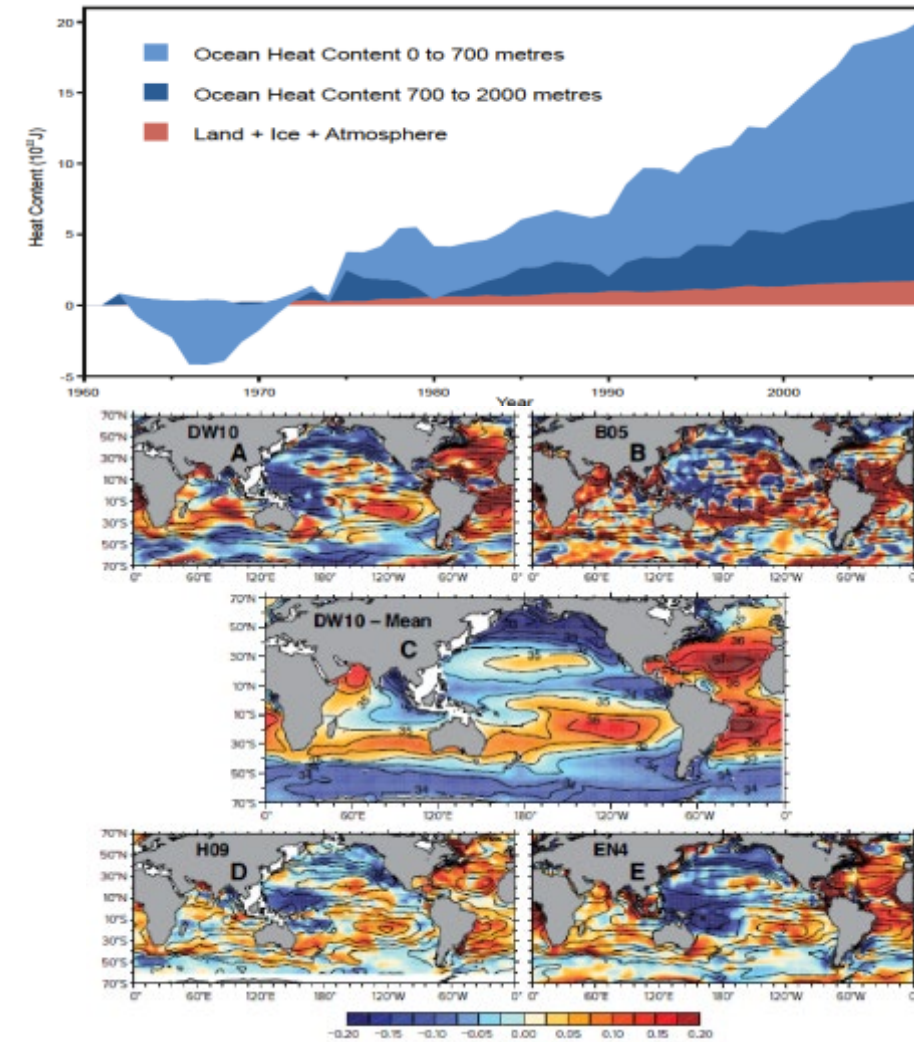


- Progress towards harmonization of EOV/ECV requirements. 30 Jul-1 Aug at WMO HQs, meeting involving GOOS & GCOS secretariat staff under the guidance of OOPC Chair.
- **Outcome: new, coherent requirements table developed for EOV Specification Sheets, compatible with both GCOS reporting needs and WMO RRR.**
- Focus on specifying **threshold** and **target** resolution, frequency and uncertainty.

Review: Ocean Heat and Freshwater Storage

(Leads: Matt Palmer, Karina von Schuckmann)

- Ongoing activity led by OOPC with initial time horizon of 3-5 years
- Aims to bring together modeling and observational communities to promote evaluation/development of modelling capability and ocean observing system
- Building on legacy of CLIVAR/WCRP CONCEPT-HEAT project on Earth's energy imbalance
- Forward-looking review paper published as part of Ocean Obs'19 (20 invited experts)
- First workshop: UK Met Office, 28 Apr – 1 May 2020. Heat/Freshwater Transport and Storage in Observations and Climate Models
- Link to OceanPredict through: OSSEs; “synthetic profiles”; heat/freshwater transport estimates



GCOS IP 2016: Action 09, 10, 11, 31, 32

Strategy: Air-Sea Heat Fluxes

Meghan Cronin & Bob Weller (OOPC)

Marjolaine Krug (OOPC - link to boundary currents)

Liz Kent (AOPC)

Motivation

- Air Sea Fluxes are key to understanding and predicting climate from days to decades.
- Large uncertainties in flux products
- New techniques and technologies bring opportunity for progress

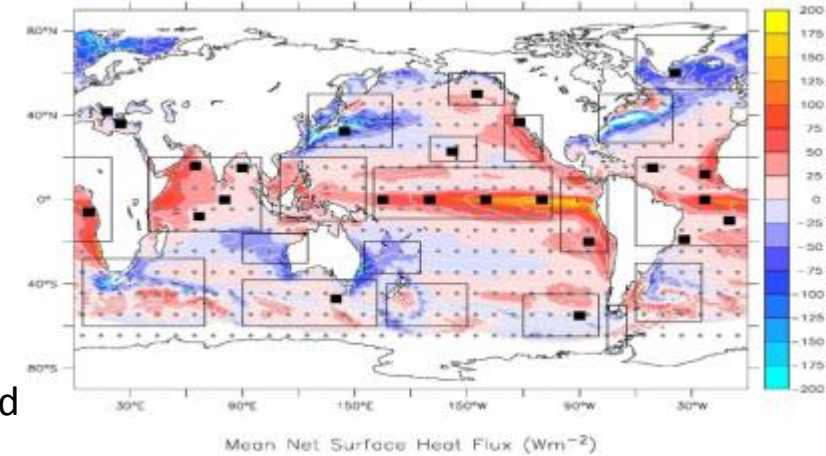
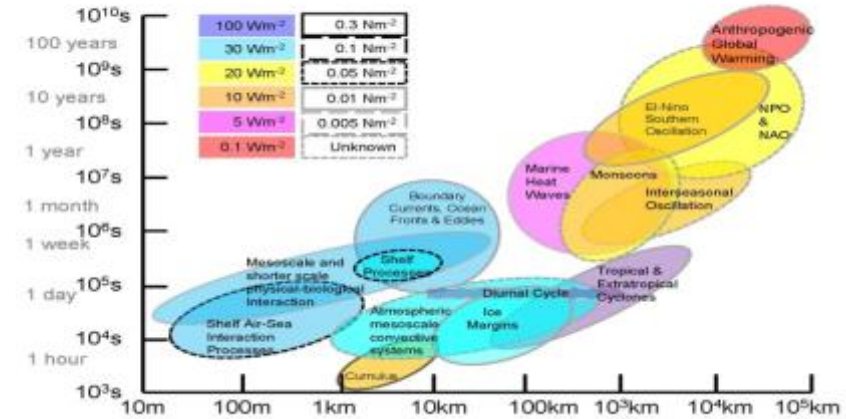
Ambitious 10-year Goal (OO'19 Community Whitepaper)

- Gridded 25 km @ 3 hourly (aspirational 10 km @ hourly) Air-Sea Fluxes with 1-day random uncertainties of:
 15 W m⁻² (5%) for heat flux & 0.01 N m⁻² (5%) for wind stress and biases less than 5 W m⁻² & 0.005 N m⁻²

Two Major Recommendations

- Optimize satellite-based retrievals for boundary layer measurements of air temperature and humidity, sea surface temperature, and ocean wind stress.
- Create a global *in situ* array of flux observing platforms, built around an expanded OceanSITES network of time series reference station moorings.

Flux Accuracies and Processes



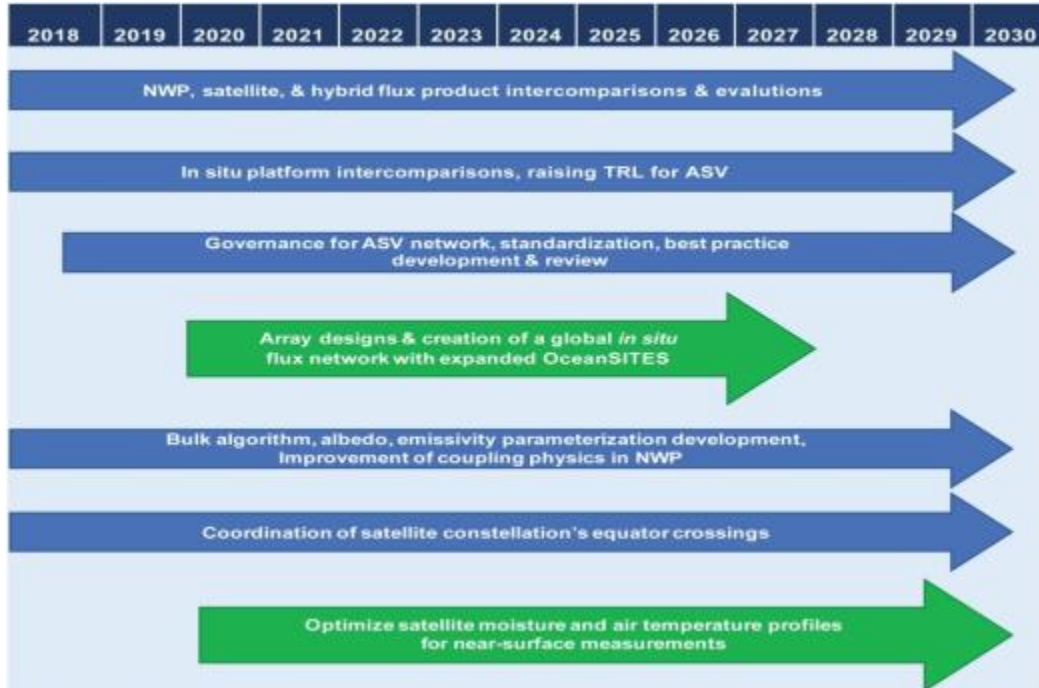
Strategy: Air-Sea Heat Fluxes

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Flux EO/ECV	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Bulk SST	Partially met												Adequate
Skin Temperature	Partially met												Adequate
Wind Speed and Direction	Partially met												Adequate
Air Temperature	Not met												Adequate
Humidity	Not met												Adequate
Bulk Surface Currents	Partially met												Adequate
Skin Surface Currents	Not met												Adequate
Surface Solar Radiation	Partially met												Adequate
Surface Longwave Radiation	Partially met												Adequate
Albedo	Partially met												Met
Sea State	Requirement Unknown											Requirement Known	



Roadmap for Expansion of *in situ* Array

- Evaluate cross-platform, cross-product, & ocean vs. land-based comparisons to quantify uncertainties and improve best practices and model physics and parameterizations.
 - Ocean & Land Baseline Surface Radiation Network?
- Form an international Autonomous Surface Vehicles (ASV) expert group to coordinate data stream, evaluate data, and develop best practices and standardizations.
- Perform array design studies and pilot studies to raise Technical Readiness Levels for new flux platforms.
- Improve bulk algorithm, including role of sea state, and parameterizations of albedo and emissivity.
- Improve coupling physics in NWP.

Roadmap for Optimization of Satellite Retrievals

- Improve resolution of satellite retrievals, time coincidence of remotely-sensed flux EOVs/ECVs, and algorithms relating retrievals to near-surface conditions.
- Improve parameterizations for transforming bulk EO/ECV into bulk algorithm state variables.

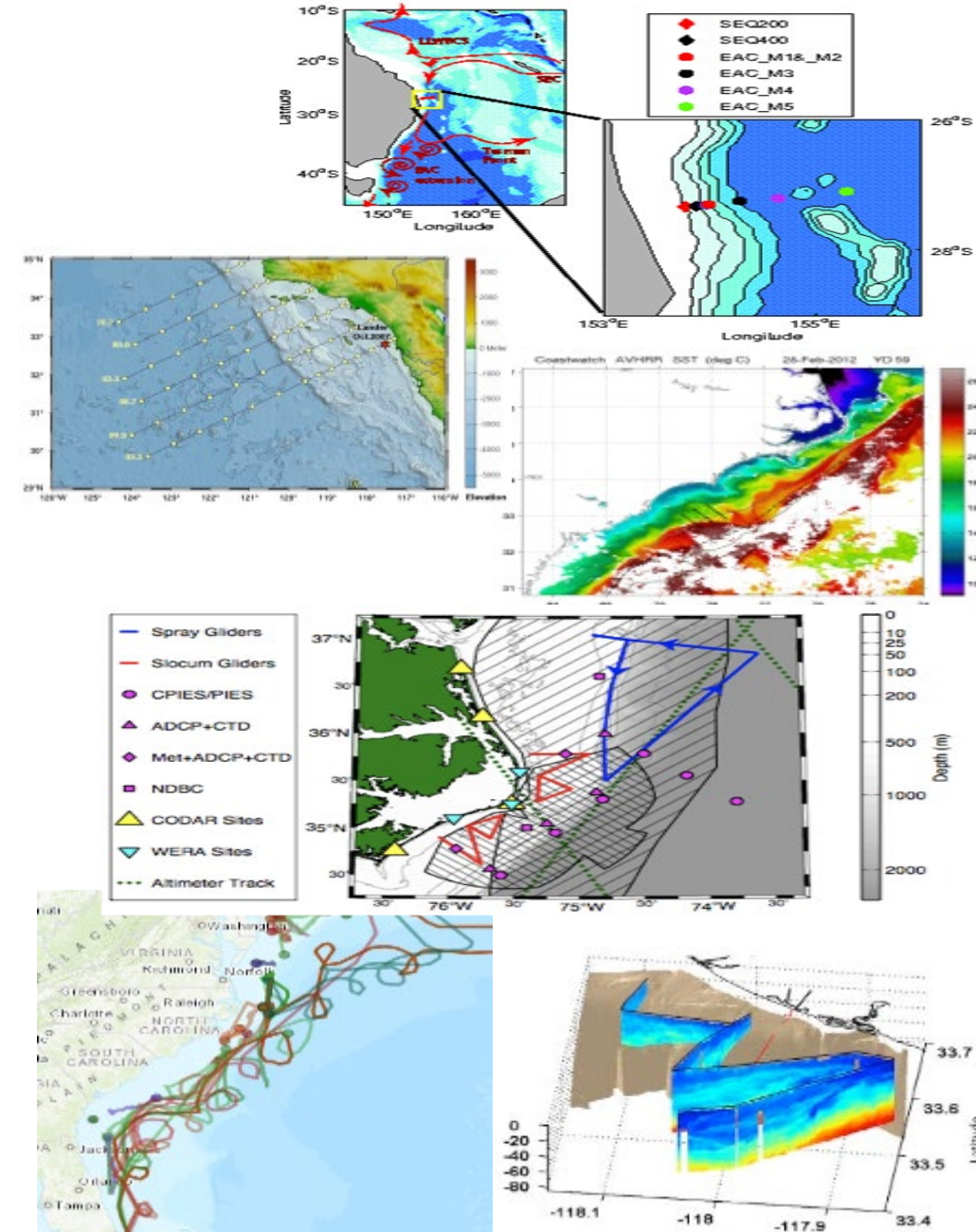
Project: Boundary Systems

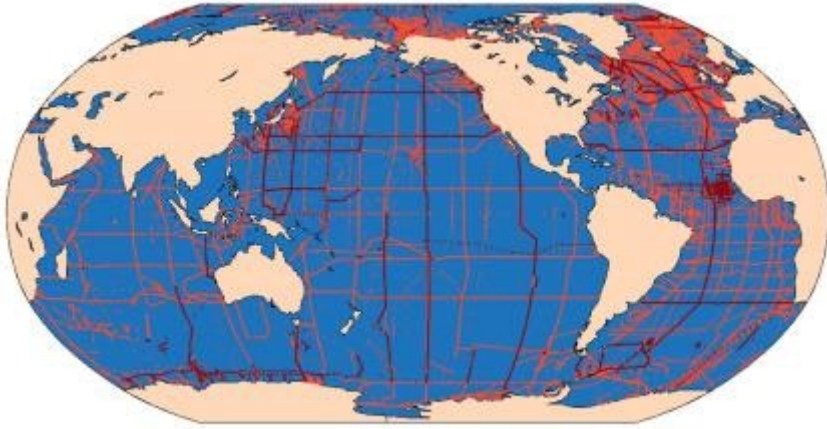
GCOS IP 2016: Action 01, 7, 19

Leads: Maria Paz Chidichimo, Marjolaine Krug, John Wilkin

The wider task team of 11 International experts has been established

- AIM: Establish an ongoing project to guide, support the development of boundary current observing systems
 - Leveraging OO'19 Whitepapers (Boundary Currents 'super' paper; Coastal BGC/Eco papers; Network based papers; New technologies)
 - Reviews of mature Boundary System observations and process studies.
 - Collaboration with OceanPredict through observing system design studies.
 - Engage GOOS Regional Alliances on capacity development, open data, collaboration/access to coasts; articulate societal impacts
 - Work with observing networks to coordinate multi-platform approaches and model synthesis
- Progress:
 - Communiqué in early 2018 gathered input on framing the priorities and objectives of the review, and expressions of interest in participating
 - A charge to the Task Team has been drafted to frame initial steps
- Next Steps:
 - Developing expanded prospectus for project including coordination with other groups (WCRP, CLIVAR, Regional and National Programs)
 - Work toward a community workshop around pilot project themes





Location of samples include in GLODAPv2.2019

Global Ocean Data Assimilation Project (GLODAP)

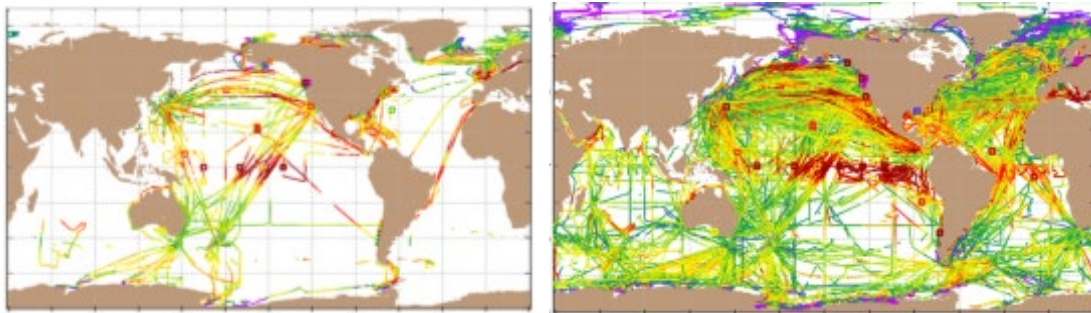
- Release of GLODAPv2.2019 during 1st AtlantOS International Symposium
- Data from 116 new cruises have been added and small errors in the previous GLODAPv2 data product have been corrected.
- 840 cruises, > 1.1 million Niskin bottle sample analyses, from 1972 through 2017
- More at www.glodap.info

Surface Ocean CO₂ Atlas (SOCAT)

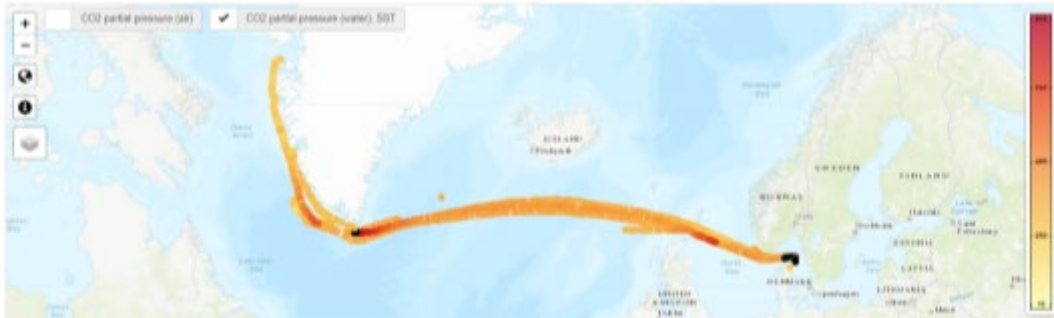
- Release of SOCAT version 2019 in June 2019.
- 25.7 million QC surface ocean fCO₂ data from 1957 to 2018.
- Still without sustained funding
- More at www.socat.info

First Near-Real Time pCO₂ data available from EU Research Infrastructure Integrated Carbon Observing System (ICOS) - Ocean Thematic Centre (OTC)

- ICOS Carbon Portal: <https://www.icos-cp.eu/>
- More at: <https://tinyurl.com/y5qv7mnj>



Data included in SOCAT version 2019 from 2018 (left) and all years (right).



ICOS OTC NRT Product from M/S Nuka Arctica, 2019-04-24 – 2019-09-26

Phenomena-based data products

Global Ocean Acidification Observing Network Data Portal

GCOS IP 2016: Action O19

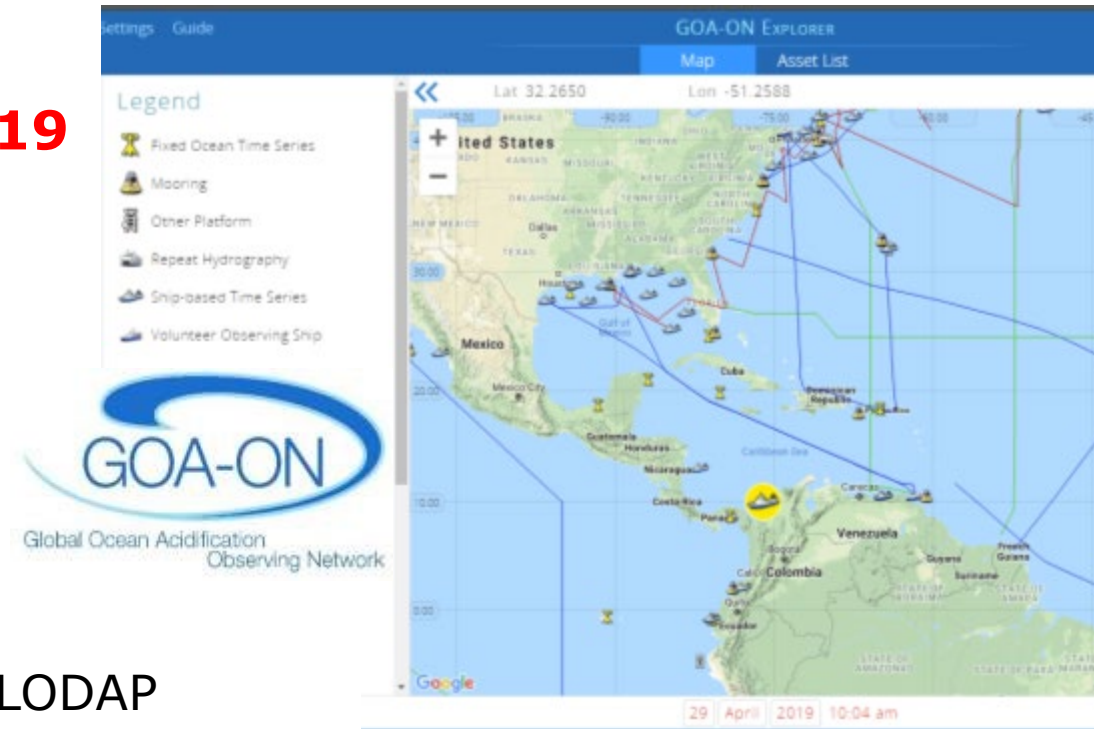
<http://portal.goa-on.org/Explorer>

- Metadata on OA-relevant observations
- Filter by region, platform, EOY, etc.
- Visualize available time series data
- Contact data providers

Oxygen Data Portal / Synthesis Product

(Scoping and design phase)

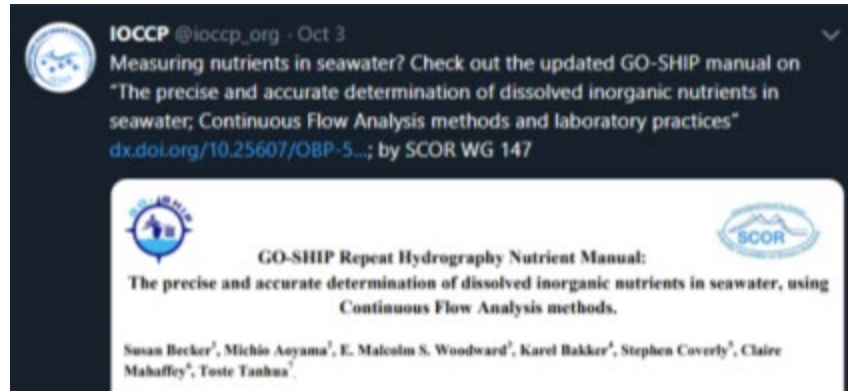
- Joint effort by IOCCP, GO2NE, IOC, NOAA NCEI & GLODAP
- Aim to include all oxygen data from all relevant platforms
- Like GOA-ON Portal, it will be a phenomenon-oriented product (i.e. Deoxygenation).
- GOOS Biogeochemistry Panel engaged in building the framework in terms of aims, end users, structure, funding sources, community coordination, etc.
- Scoping workshop in Sopot, Poland, on 11-13 November 2019



Nutrients ECV

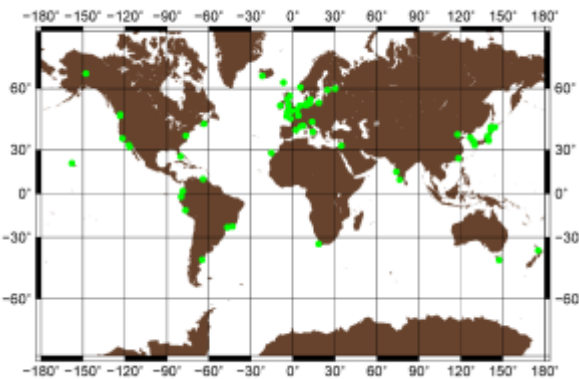
**GCOS IP 2016:
Action O20**

Revised GO-SHIP Repeat Hydro Nutrient Manual



Download from: <http://dx.doi.org/10.25607/OBP-555>

IOCCP-JAMSTEC 2018 Inter-laboratory Comparison Exercise of a Certified Reference Material (CRM) for Nutrients in Seawater



Global map showing the distribution of 69 laboratories from 30 countries/territories participating in the IOCCP-JAMSTEC 2018 Inter-laboratory Calibration Exercise of a Certified Reference Material of Nutrients in Seawater.



<http://www.ioccp.org/index.php/nutrients>

Tracers ECV

**GCOS IP 2016:
Action O21**

Jenkins et al. (2019): **A comprehensive global oceanic dataset of helium isotope and tritium measurements**, Earth Syst. Sci. Data, 11, 441–454, <https://doi.org/10.5194/essd-11-441-2019> Also transient tracers data in GLODAPv2.2019

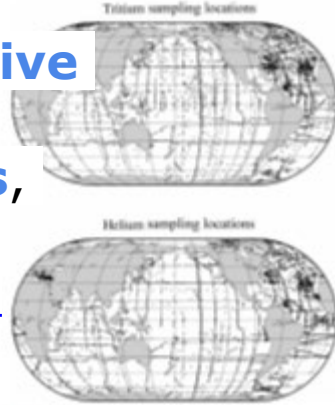


Figure 3. Tritium and helium sample locations.

Nitrous Oxide ECV

**GCOS IP 2016:
Action O22**

Bange et al. (2019): **A Harmonized Nitrous Oxide (N₂O) Ocean Observation Network for the 21st Century**. Front. Mar. Sci. 6:157. doi: 10.3389/fmars.2019.00157

- Proposed the establishment of a harmonized N₂O Observation Network (N₂O-ON) combining data from various platforms.
- Establish central calibration facilities in selected international laboratories to improve accuracy, and ensure standardization and comparability of N₂O measurements.
- Final data products to include a harmonized global N₂O concentration and emission fields for use in model validation and projections of future oceanic N₂O emissions, to inform the global research community and policy makers.

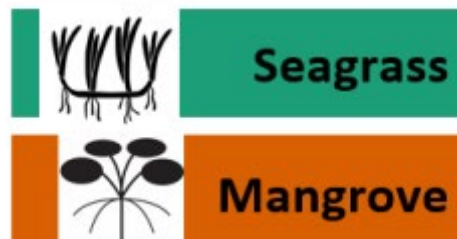
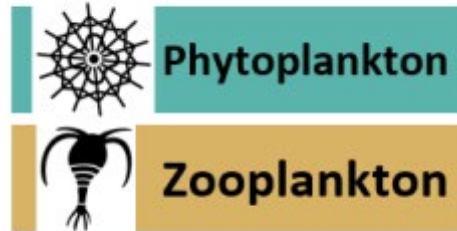
Planning the implementation of biological EOVs: bringing together the networks

GCOS IP 2016: Action 07, 25, 26, 27



EOV Workshops

- Vision and mission
- Needs and requirements
- Capabilities
- Impact - capacity development
- Funding
- Governance



Other biological EOVs to follow.....

Engaging Modelling Community

OceanPredict (Successor to GODAE OceanView), WCRP/WWRP, Operational systems (NWP, Seasonal-Near term)



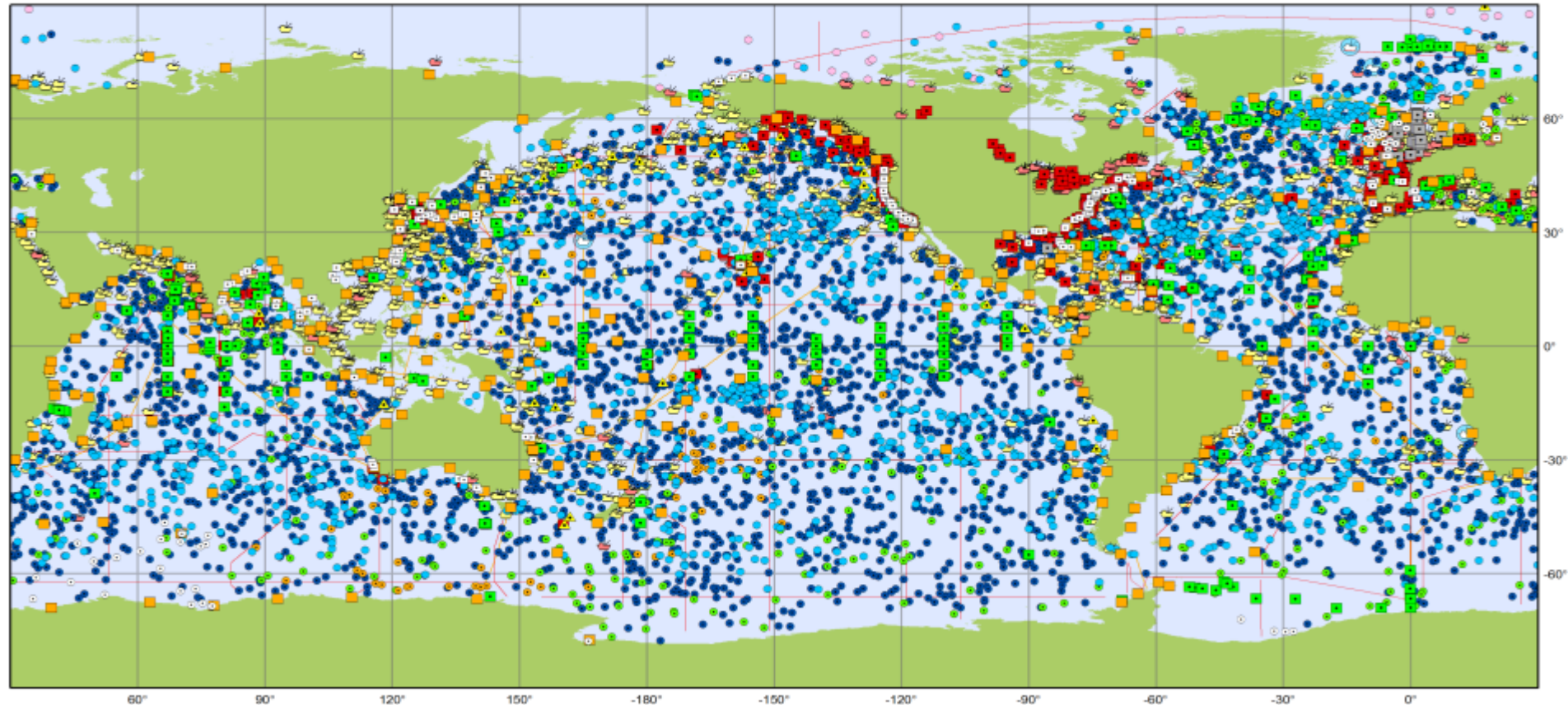
- Improving global & regional analysis and forecast systems internationally
- Task Teams on ...
 - Observing System Evaluation, Data Assimilation, Coastal Ocean and Shelf Seas, Marine Ecosystem Analysis and Prediction
- Collaboration
 - Using model-based tools to contribute to testing obs network (gaps, impact, resilience)
 - Modeling systems are key link to end users, products that rely on/add value to Observations
- OceanPredict'19 conference
 - 3 OOPC related talks (1 keynote)
- OOPC to consider engaging key modelling and forecasting groups in OOPC-23.

OOPC-OceanPredict Collaborations:

- Ocean Predict Co-Chair Eric Chassignet attended OOPC-21.
- Coastal Ocean and Shelf Sea-TT (and Observing System Evaluation TT) representatives to engage in OOPC Boundary Current Project.
- IOCCP to engage with Marine Ecosystem Analysis and Prediction TT
- OceanPredict consider how to engage in the Heat and Freshwater review.
- OOPC to review GODAE OceanView Operational Oceanography Metrics.
- OOPC/OceanPredict to consider broader collaboration for the co-design of Observing System evaluation experiments in the future; to inform developments in both models and observations.

GCOS IP 2016: Action 04, 07, 14,

Monitoring Networks - OCG/ JCOMMOPS, Observing Platforms



**GCOS IP 2016:
Action 02, 3, 37-57**

Main in situ Elements of the Global Ocean Observing System

September 2019

Profiling Floats (Argo)

- Core (3869)
- Deep (96)
- BioGeoChemical (367)

Data Buoys (DBCP)

- Surface Drifters (1491)
- Offshore Platforms (92)
- Ice Buoys (23)
- Moored Buoys (358)
- ▲ Tsunameters (35)

Timeseries (OceanSITES)

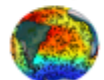
- Interdisciplinary Moorings (345)
- Repeated Hydrography (GO-SHIP)
 - Research Vessel Lines (63)
- Sea Level (GLOSS)
 - Tide Gauges (290)

Ship based Measurements (SOT)

- Automated Weather Stations (265)
- Manned Weather Stations (1386)
- Radiosondes (13)
- eXpendable BathyThermographs (34)

Other Networks

- HF Radars (270)
- Animal Borne Sensors (53)



Monitoring Networks - OCG/ JCOMMOPS, Observing Platforms

	Argo				DBCP				SOT	
	Argo Core	Argo Global	Argo BioGeoChemical	Argo Deep	Global Drifter Array	Global Tropical Moored Buoy Array	Coastal/National Moored Buoys	Tsunami Buoys	VOS	SOOP XBT
Implementation										
Activity Global Ocean	85.04% 9/2019 ↓	98.16% 9/2019 ↓	38.93% 9/2019 ↗	8.98% 9/2019 ↗	101.1% 9/2019 ↓	48.74% 9/2019 ↓	99.67% 9/2019 ↓	50% 9/2019 ↓	80.75% 9/2019	
Density Pacific Ocean					76.67% 10/2019 ↓					
Density Indian Ocean					82.67% 10/2019 ↗					
Density Atlantic Ocean					86.67% 10/2019 ↗					
Density Global Ocean	86.52% 9/2019 ↗	88.47% 9/2019 ↗	46.83% 9/2019 ↗		80.33% 10/2019 ↓					
Intensity Global Ocean	48.14% 9/2019 ↓	65.46% 9/2019 ↓	40.99% 9/2019 ↓	13.08% 9/2019 ↓	75.52% 9/2019 ↓					
Data Flow										
Delivery Global Ocean	97.35% 9/2019 ↗	96.44% 9/2019 ↗	92.42% 9/2019 ↗						50.56% 9/2019	
Metadata Quality - Sensor Global Ocean		98.9% 9/2019 ↗			85.15% 9/2019 ↗	81.03% 9/2019 ↗	29.1% 9/2019 ↗	100% 9/2019 ↗	80.62% 9/2019 ↓	
Timeliness (GTS FR) Global Ocean	98.59% 9/2019 ↗	98.64% 9/2019 ↗	99.22% 9/2019		90.34% 9/2019 ↓					
Data Uptake										
Data Use (Research) Global Ocean		398 2017 →								
International										
Diversity (National) Global Ocean	26 2018 ↓	26 2018 ↓	16 2018 →	7 2018 ↗	10 9/2019 ↗	1 9/2019 ↓	15 9/2019 →	5 9/2019 ↗	24 2018	8 2018

GCOS IP 2016: Action 02, 3, 37-57



OOPC, IOCCP and Bio/Eco

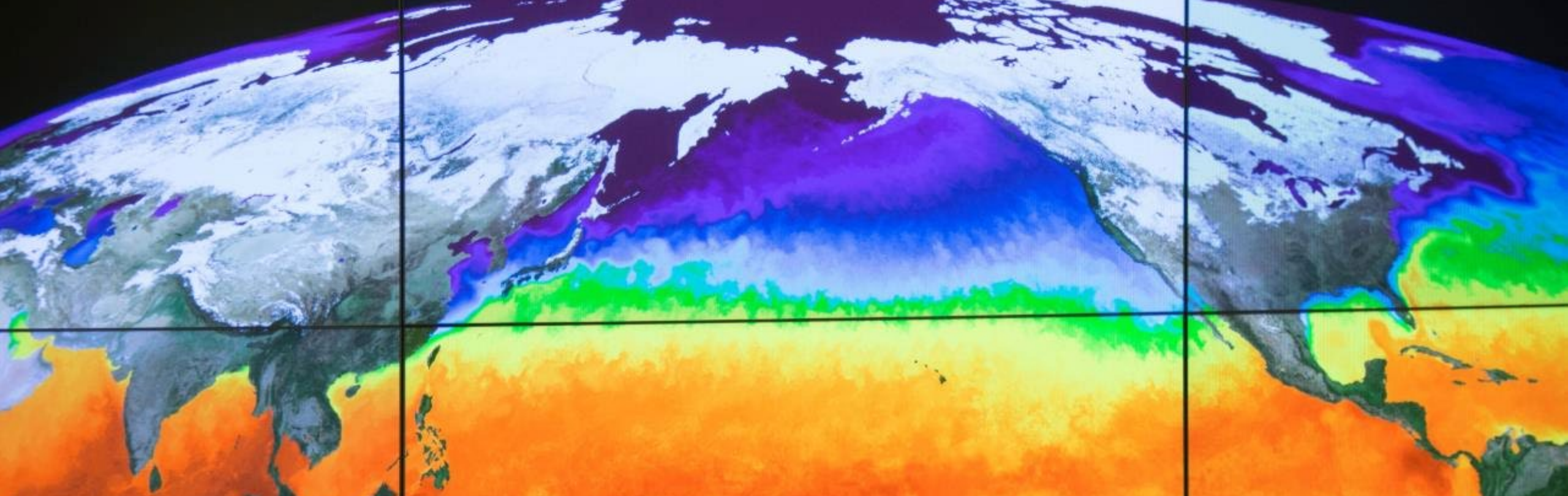
CHALLENGES AND OPPORTUNITIES

Opportunities

- Integration of technological developments.
- Managing the evolution of the observing system with the Observations Coordination Group (physics and geochemical) and partners in Bio/Eco systems.
- Emerging Focii:
 - Fostering the partnership with model groups Observing System Evaluation, Design and development.
 - The Ocean Decade opportunities for a period of sustaining and potential expansion of observations and bolstering ocean modelling.
 - Leveraging focus on ‘earth system approaches’, in expanding users groups of the heterogeneous (aims, funding, platforms, ownership) observation system.

Challenges

- Securing funding for end-to-end Ocean Observing system – design, engineering, implementation, data QC/QA, interoperability, access
- Setting requirements for EOVs/ECVs for various users is complex. Additional effort with operational services (e.g WMO/RRR).
- Leveraging focus on ‘earth system approaches’, in expanding users groups of the heterogeneous (aims, funding, platforms, ownership) observation system.
- OOPC coordination role, within GOOS, to meet GCOS planning and reporting processes is a challenge
- Juggling role and responsibility of OOPC from both GCOS and OOPC.



OOPC

RESOURCING

Resources

- Overseeing GOOS physics, as well as delivery into Climate (through GCOS), Operational services (through WMO), research applications (through WCRP) requires appropriate secretariat support.
- The current allocation of one OOPC secretariat is not adequate; we have requested additional secretariat support.

As a results

Given limited resources, we are prioritising effort. In this situation “business as usual” tasks (requirements, action tracking, communications) are not given adequate attention.



OOPC: 9-13th March 2020, Cape Town
IOCCP (Biogeochemistry), Bio/Eco will also meet

[GOOS: SC-9 30 March- 3 April, East Africa](#)

www.goosocean.org

GCOS Reporting Timeline

