GOOS – 210
GCOS – 192
WCRP – 16/2015

Report of the Eighteenth Session of the Ocean Observations Panel for Climate (OOPC-18)

14-17th April 2014

Tohoku University, Sendai, Japan.

www.ioc-goos.org/oopc18

The Ocean Observations panel for Physics and Climate is part of the Global Climate Observing System the Global Ocean Observing System and the World Climate Research Program. OOPC provides advice and guidance on observations to the Joint Commission for Oceanography and Marine Meteorology.

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1. Introduction

The Eighteenth session of the Ocean Observations Panel for Climate was held at Tohoku University, Sendai, Japan, hosted by OOPC Co-Chair, Toshio Suga. The meeting was held in parallel with the International Ocean Carbon Coordination Project (IOCCP) Scientific Steering Group/ GOOS Biogeochemistry Panel. The two panels were welcomed by Prof. Tadahiro Hayasaka, Dean of Science at Tohoku University, and Prof. Yutaka Michida, Vice President of the Intergovernmental Oceanographic Commision (IOC), Co-Chair of the International Ocean Data Exchange (IODE), and also former member of OOPC. In addition, Prof. Kimio Hanawa, Executive Vice President of Tohoku University and former Professor of Oceanography made a guest appearance during the second day of the meeting.

The meeting was attended by OOPC Members, 2 invited experts, and representatives of the CLIVAR basin Panels, and the co-chair of the Joint WMO-IOC Technical Commission for Oceanography and Marine Meteorology (JCOMM) Observations Coordination Group. The Chair of the Global Climate Observing System (GCOS) and the Director and Co-Chair of the Global Ocean Observing System (GOOS) were also in attendance. In addition, a Japanese workshop on coastal observations and modeling to give the panel an opportunity to hear about the range of science related to OOPC priority to expand towards the coast that was being carried out in Japan.

The agenda was structured around the OOPC work plan, and progress and priorities were considered in the context of reporting requirements to the GCOS, the GOOS as well as fostering connections with WCRP/CLIVAR and other stakeholders. As the panel was meeting in parallel with the International Ocean Carbon Coordination Project Scientific Steering Group/GOOS Biogeochemistry Panel, there was a strong focus on the development of variable and network specifications, and how to coordinate the development of the ocean component of the GCOS Implementation Plan.

All presentations from the meeting, including the workshop talks, are available at www.ioc-goos.org/oopc18

2. Communications and connections, reporting to GCOS and GOOS.

The Chairs of GCOS and GOOS presented overview talks and outlined the planning and reporting processes. The many connections that OOPC has to foster and facilitate continue to be a challenge, particularly in contributing to parallel reporting processes in GCOS and GOOS. The diagram below highlights the role OOPC plays in a GOOS and GCOS context. OOPC is the lead for Physical Variables for GOOS, and takes a lead in delivering to the Climate theme (through GCOS), drawing on the Biogeochemistry and Biology Panels of GOOS.

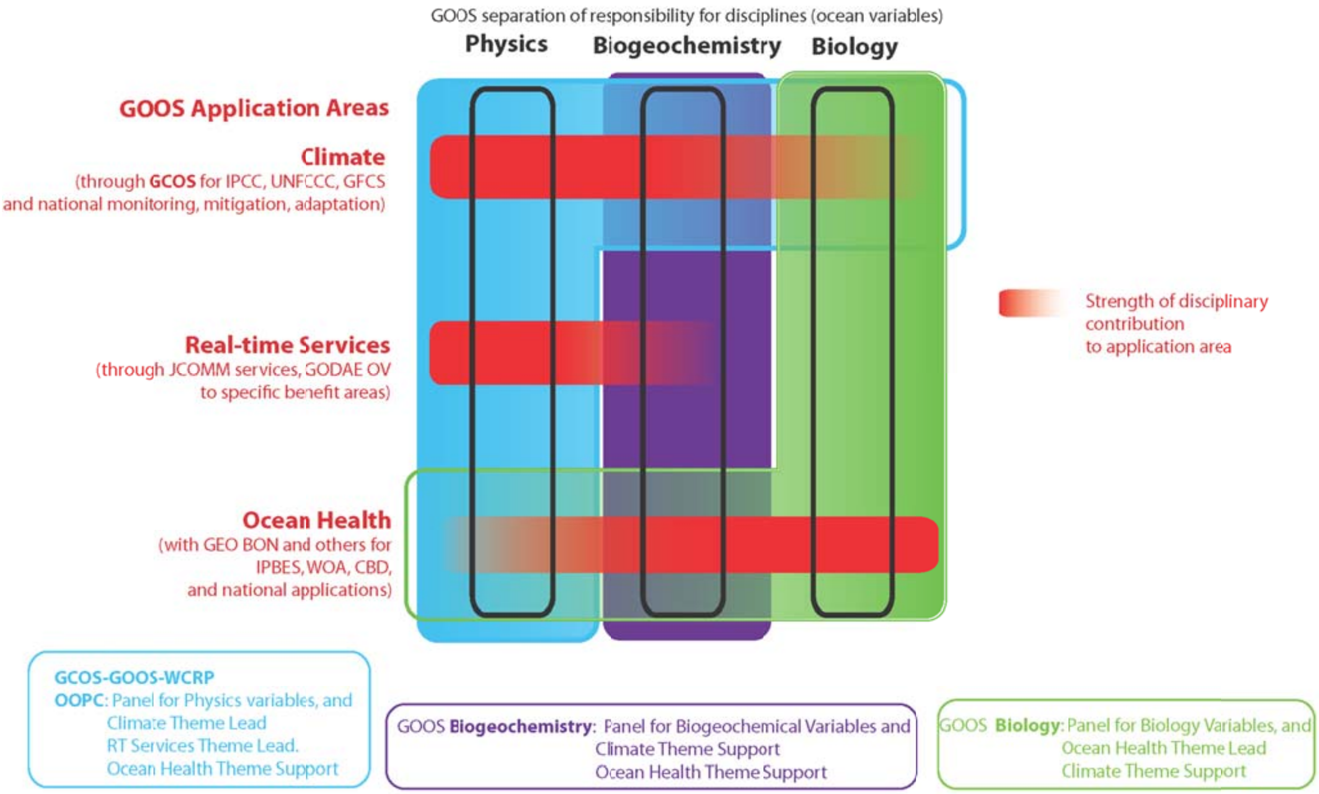


Figure 1: The role of GOOS Panels in delivering to key application areas.

OOPC manages connections to 2 sets of sibling panels in GCOS and GOOS, and to the JCOMM Observations Coordination Group in setting observing network targets. 2015 has been particularly busy, as the GCOS Status Report is being developed at the same time as establishing the GOOS Strategic Mapping, including the development of Variable and Network Specifications. It is hoped that in the future, OOPC will draw on the strategic mapping to report to GCOS. In addition, GOOS development projects will drive advances in the Global Ocean Observing System, and hence updates to network targets in the GCOS Implementation Plan.

The ambitious timeline for the next GCOS IP requires OOPC to forward plan how it will deliver to the GCOS IP, particularly in terms requirements for input from other panels. A preliminary timeline of activity is shown in figure 2.

A summary diagram illustrating the GOOS Strategic Mapping can be found here: http://lists-ioc-goos.org/goos-strategic-mapping-graphic/

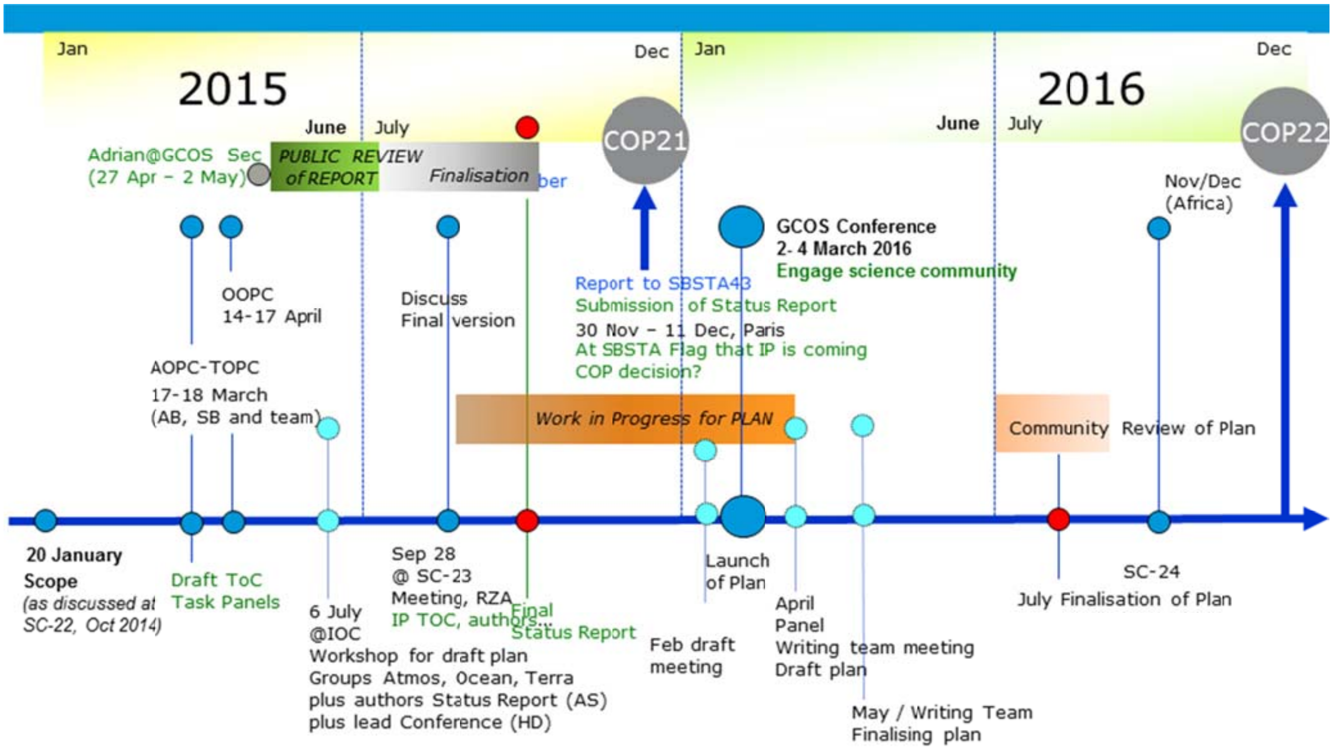


Figure 2. The timeline for the development of the 2016 GCOS Implementation Plan.

The GCOS IP will, at its core, be similar in structure to the previous one, with sections for each domain. In addition, there will be an overview section, focused on cross cutting issues such as:

- Relevance of ECVs to other UN Conventions (United Nations Convention on Combatting Desertification, UNCCD, and the Convention on Biodiversity, CBD)
- Use of ECVs for capturing the major climate budgets and cycles (Energy, Water, Carbon)
- Supporting Variables that underpin climate observations (e.g. Gravity).

A preliminary Timeline for the input from the panels into the GCOS IP includes:

1) Volunteers for Writing Team. (by September)
2) Confirm sub-structure for Ocean Section (by end of year)
3) Check for completeness of ECV List (additions, subtractions, reframing, specifications) (by end of the year)
4) Review ECV sections (from IP, SR) (from November to February)
5) Revise ECV Sections (from February to May)
6) Advise on combinations for climate system cycles, WCRP Grand Challenges, UN Sustainable Development Goals (From February to May)
7) Identify and propose supporting observations (from February to May)

Further work by the secretariat is required to finalise a timeline, identify tasks, and responsible panel members. Members of the panel agreed that the Status Report was largely written by the panel chairs. Given their academic commitments, they found it challenging. For the GCOS IP, it was agreed that panel members would be identified to take responsibility for delivering each ECV section.

3. Status of the Observing System (OOPC Only Session):

An overview of the key components of the Sustained Observing System was provided by David Legler, Co-Chair of the JCOMM Observations Coordination Group (JCOMM OCG). Motivations for the need for enhanced performance metrics were discussed, both by network and by variable. Draft enhanced metrics were presented by Network (developed by JCOMMOPS) and by Variable (developed through the NOAA Observing System Monitoring Center, OSMC). A framework for assessing risks to the observing system and mitigation approaches needs to be developed, and is on the agenda for discussion at the JCOMM OCG meeting which was held shortly after the OOPC meeting; Each OCG representative has been asked to provide guidance on key risks to the sustainability of their observing network.

4. Input on Requirements from CLIVAR Panels (OOPC Session)

At the OOPC-17 Session, the need to strengthen the feedback loop between OOPC and CLIVAR was identified. In response, the CLIVAR panels were given specific questions to answer in their talks.

While a large part of the original sustained observing system design has transitioned from a 'growth' phase to a sustain phase, we now need to move to a phase where the focus needs to be on strengthening, integrating and expanding the observing system; we need to continue to advocate for sustained observations, continually test and adjust the observing system to ensure it best meets requirements, and capitalises on technology development, while ensuring the necessary stability to meet climate requirements.

Such an process of ongoing evaluation requires a strong relationship between research and observing, and a good feedback loop of information which may include:

OOPC needs to

- Evaluate requirements for ocean observations, and set associated targets for ocean observing networks (i.e. seasonal and long term variability in upper ocean heat content and Argo array).
- Review and report observing system implementation status, risks and challenges (with JCOMM Observations Coordination Group)
- Evaluate performance of observing system against requirements.
- Evaluate areas of the observing system which require development (i.e Tropical Pacific, Deep Ocean, Boundary Currents)

OOPC needs CLIVAR to

- Articulate and advocate their requirements for sustained observing;
- Leverage observations to do good science, process studies, etc;
- Feed-back guidance into improving sustained observations, closing gaps, etc., which helps us improve the observing system for research.

In this context, the panels were asked to address the following questions, common themes are highlighted in the text below.

4.1. What are the current research priorities of the panel?

The Global Synthesis and Observations Panel (GSOP) activities are focused on the development of climate quality products, reanalysis and datasets, including the Reanalysis Intercomparison project, Coordination of the CLIVAR Research Focus on the Consistency Between Planetary Energy Balance and Ocean Heat Storage, and the International Quality Controlled Ocean Database (IQuOD) Project, which is focused on the international coordination of quality control and archival of climate data, starting with Temperature.

Atlantic Panel: Priorities include the Atlantic Meridional Overturning Circulation, seasonal to decadal climate prediction, support deep ocean observations, reducing tropical biases in models, and improve understanding of extremes.

Indian Ocean Panel: Priorities include circulation, especially Boundary Currents and interbasin exchanges, influence of meso-submesoscale variability on circulation, Indo-Pacific climate Interactions. In addition, the panel is promoting studies of teleconnections, cyclones, ocean component of the water cycle.

Pacific Ocean: Priorities include ENSO diversity, as well as western boundary region circulation and climate (through regional studies. The panel is involved in the ENSO Diversity Working Group, and also the Research Focus on ENSO in a changing climate.

Southern Ocean; Priorities include, eddies and mixing, Antarctic bottom water changes, under ice observations, air sea fluxes of heat, freshwater and carbon, carbon cycle and acidification, and decadal climate prediction.

4.2. How are sustained ocean observations being used to meet these priorities?

The datasets most consistently highlighted were

- Argo for ocean heat content estimates, providing context to historical observations, but also providing improved observations of upper ocean structure. .

- OceanSITEs; both flux moorings, and subsurface/deep ocean observations, primarily used for validation of mean fields and long term temporal variability (ocean reference sites).

- Tropical Moored Arrays are considered the cornerstone of basin scale observations, leveraged heavily for research activities.

In addition, the Atlantic Panel has a strong focus on the AMOC observing system, a series of arrays along zonal sections of the Atlantic. However, only one of these is sustained, the RAPID array in the North Atlantic. The GSOP panel also requires transport measurements to evaluate reanalyses. Further work is needed to articulate requirements for continuing other arrays in sustained mode.

4.3. What are the gaps or uncertainties in the observations?

Key gaps which were consistently highlighted were the need for improved air sea flux estimates, and observations of the ocean below 2000m. The need for observations under the ice was also highlighted by GSOP and the Southern Ocean Panel. These priorities are well represented in the OOPC Work Plan.

In addition, the need for improved understanding of the short term mesoscale variability in particular in the upper ocean structure, mixing and stratification, particularly in relation to extreme events (i.e. tropical cyclones) and strong Sea Surface Temperature gradients (e.g., those associated with boundary currents) and their impact on the large scale processes/phenomena was highlighted consistently by the panels.

It was noted that there are a number of process experiments and observing projects in boundary current regions and upwelling systems (eastern and western). OOPC can potentially draw on these activities as part of the planned evaluation on boundary currents and their interactions with the shelf (see section 8).

4.4. What modelling and process experiments are currently being conducted (how can/are they being used to inform the development of sustained observations)?

GSOP is focusing on climate modelling experiments that test upper versus deep ocean variability and trends, and implications for sampling designs; experiments are planned to use "pseudo profiles" from climate/ocean model simulations to test the effectiveness of the various off-the-shelf mapping methods currently used to estimate ocean heat uptake. The same framework could be used to test proposed deep ocean observing array designs, and they are initiating discussions with the international research community on experimental design.

In the Basin Panels, emerging foci appear to be on observing the eastern and western boundary regions; with both the Atlantic and the Indian Ocean establishing Upwelling Experiments (Eastern IO upwelling Research Initiative, EIOURI; and Enhancing PREdiction oF tropical Atlantic ClimatE & its impact, PREFACE) , and the Indian and the Pacific Panels have existing or emerging activities focussed on western boundary currents. The next challenge will be to determine what aspects of these will be required in sustained mode.

A focus on meso- to submesoscale variability, and its broader impacts was highlighted, including the Salinity Processes Upper Ocean Regional Study (SPURS) experiment focussed recently in the Atlantic and in the future the Pacific.

The Year of the Maritime Continent will drive a strong focus on convection and air sea interaction in the tropical Indian and Pacific Oceans.
The Atlantic Panel, with will have additional complementary small experiments focussed on enhanced flux measurements.

In the Pacific, the main activity is the TPOS 2020 Project (see section 7), which will refresh and optimize , redesign the Tropical Pacific Observing System. As part of this, the various process studies and observing system activities in the Western Pacific including SPICE and NPOCE, will be considered as an integrated whole, with a view to informing what observations will need to be part of a long term sustained system.

In the Southern Ocean, much of the process experiments are focussed on exploring under ice observing capability, including gliders under the ice, unmanned autonomous vehicles that can withstand freezing, and ice tethered profilers. There are also substantial testing efforts in the Southern Ocean for Biogeochemical Argo and Deep Argo.

4.5. What issues or would you like to table for discussion with OOPC?

While many panels did not address this question, GSOP called for an increased dialogue between OOPC and climate modelling groups on how best to use climate + ocean models as sources of hypothesised variability to then assess the adequacy of the current ocean observing system to detect or rule out such variability and to use such methods for helping to develop a quasi-optimal deep observing array.

A general discussion followed on the need to strengthen the connection to the modelling communities, and the issue was revisited in item 7 and 8 (below).

5. Setting requirements for observations by variable (Joint Session)

Upcoming priorities are driven by timelines for preparing the next GCOS Implementation Plan (2016), and GOOS Strategic Mapping process. Hence a strong focus is needed on finalising the specifications for observations by variable, as these will be drawn upon for the development of network specifications.

The development of Variable Specifications was presented by the panel chairs, and their role and uses was discussed. It was agreed that the physical specifications need to be looked across by a couple of panel members with an eye for the bigger picture, to make sure they are consistent, and extract detail on defining Societal Benefit Areas, Scientific Applications, and Processes/Phenomena to capture and to be used as generic descriptors. The biogeochemical specifications are already very consistent, and can be drawn upon in developing targets for networks.

The variable specifications can be drawn on to report on the observing system e.g. for the GCOS Implementation Plan. The panels discussed any modifications to the existing list of ECVs, and the Biogeochemistry Panel are advocating for a reframing of the biogeochemistry ECVs, based on the EOV specifications developed for: Oxygen, Macronutrients, Carbonate System, Transient Tracers, Suspended Particulates, Particulate Matter Export, Nitrous Oxide, Carbon Isotope C-13, and Dissolved Organic Matter.
The panels discussed what subset of the Biogeochemistry EOVs should become ECVs, and decided that 7 of the 9 would be put forward as ECVs. This was further discussed in the separate Biogeochemistry Panel session.

In preparation for the next GCOS IP, a big topic of discussion was the division of ECVs into surface/subsurface, precipitated by the Biogeochemistry Panel deciding to advocate for whole of water column variables. While for many in the room having whole of water column variables was more scientifically accurate, there were concerns about the impact of making such a change on, for instance, the engagement of Satellite Agencies and the content of The GCOS Satellite Supplement. In addition, there isn't a clear definition of 'surface'. For instance, ‘skin’ SST measurements from Satellite are generally calibrated using ‘bulk SST measurements from ship intakes, hull contact SST sensors, and drifters, which each measure temperature at a different point in the water column. In addition, it was noted that Sea Level is actually an integrative whole of water column variable, rather than a ‘surface’ variable. However, the benefit of splitting from surface to subsurface, also aids a specific focus on air sea fluxes. Hence, it was decided that a renaming of variables split into ‘interface’ (for those important for air sea interactions) and ‘water column’ ECVs.

During the session it was also advocated that from a GOOS point of view, the panels should be careful not to focus wholly on reporting responsibilities, and also need to initiate activities that will lead to real improvements in the observing system, such as pilot projects (perhaps for new biogeochemistry sensors or deployment plans and development projects (such as TPOS 2020; and Deep Ocean Observing Strategy, DOOS). Such activities are a strong focus of the OOPC work plan, and were discussed under item 7.

6. Articulating requirements and contributions of networks (Joint Session)

Complementary to the Variable Specifications, Network Specifications are under development. Firstly through members of the JCOMM Observations Coordination Group, but in future, the templates will be used by those proposing new networks into the system (see template in appendix 2 of the OOPC Work Plan). The Network Specifications should clearly articulate the potential role they play in the global framework of the sustained observing system. Network specific core science and related observing targets (i.e. seasonal and long term variability in upper ocean heat content and Argo array) should be formulated which will enable , and clear targets that completeness/performance can be measured against.

The Panels discussed approaches to setting targets for observing networks, and the panels discussed how best to establish initial targets for the biogeochemistry networks, drawing on the experience of OOPC and its predecessor, the Ocean Observing System Development Panel (OOSDP). There was an advocation for initial ‘no regrets’ targets, based on what was feasible (technically and in terms of resources, and impact; what the panel were confident would be broadly used and useful. Initial targets could then be revisited based on the resulting increase in system understanding. While there is a need to keep plans in the realms of feasibility, the panel were also encouraged to ‘dream a little’, and were reminded that the international Argo array of profiling floats only took 10 years to fully implement. The biogeochemistry panel agreed to identify a list of existing/potential Biogeochemical networks, and a contact point for each. The challenge will then be to develop these initial targets for core networks (e.g. Bio Argo, underway pPCO2).

The need to assess risks to the observing system was discussed briefly, and the JCOMM OCG chair invited input on the types of risks that should be considered.

7. Developing Improved Metrics for Observing Systems (Joint Session).

The need for observing system performance metrics was discussed, focusing on both network implementation, network based uptake and use, and performance/impact by variable. Initial proposed network metrics developed by JCOMMOPS were presented and feedback was provided, as input to the following JCOMM OCG meeting.

Observing system performance metrics by variable are complex, and will need to be the focuss of the panels. Such metrics can be at varying levels of complexity. Initial work through the NOAA Observing System Monitoring Centre has focused on identifying the number of measurements in each 5x5 degree box for different variables. Mark Bourassa is working with David Berry (JCOMM) to assess how observations contribute to reducing uncertainties; however this is considered a multi-year project.

Then the panels discussed a potential way forward evaluating the performance of the observing system by variable, engaging also GSOP and GODAE OceanView. See also discussions in session 8. OOPC will take this topic up for discussion following the GCOS IP process.

8. Observing System Evaluations (OOPC Session).

In parallel, the OOPC is coordinating systems based evaluations of observing requirements and their implementation, an early success was the evaluation of the Tropical Pacific Observing System, culminating in the TPOS 2020 Project (see www.tpos2020.org for more information).

Priorities for the next systems based evaluation were discussed by the panel based on the key areas identified in the Work Plan (see section 4). These include:

1) The Deep Ocean Observing system
2) Boundary Currents and Interbasin Flows
3) Observations for reducing uncertainties in air sea fFlux estimates
4) The upper ocean thermal observing system
5) Polar Seas
6) Regional and Coastal Seas

The work plan sets the background and context in each of these areas, including status of relevant activities to assist the panel in deciding how best to prioritise future activities.

As the Deep Ocean Observing Strategy (DOOS) is being coordinated through the GOOS Steering Committee, the next main focus for OOPC will be on Boundary Currents (see appendix 3 for full details). An Ocean Sciences Session is planned to assess the status of activities in observing and modelling Boundary Currents and furthermore their interaction with the shelf, which connects the open ocean to coastal requirements.

Smaller scale activities are likely to be focused on air-sea fluxes (in collaboration with AOPC) and observations at the ice-ocean Interface (in collaboration with TOPC), with a view to including targets in the next GCOS IP.

The challenge of engaging the modeling community in focused evaluation activities was raised by the TPOS 2020 presentation, as there are already many modeling panels and working groups across WCRP, GODAE OceanView, etc. GOOS Co-Chair Eric Lindstrom suggested a coordinated approach to engagement with the modeling community is needed across GOOS, and this should be a topic for the agenda at the next GOOS SC meeting.

9. Japanese workshop

On the 4th Day, a stimulating and informative workshop was held on “Future Prospects of Coastal Ocean Observations and Modeling in Japan”, which was attended by OOPC and over 20 local scientists from across Japan. See Appendix 1 for the agenda. OOPC member and coastal oceanographer, John Wilkin thanked the presenters for very stimulating talks, which gave an insight into the activities of a very active and innovative Japanese coastal oceanography community, which is less well known internationally, compared to their open ocean activities. John Wilkin encouraged the scientists at the workshop to engage in international fora and share their results.

10. Next steps including next OOPC Meeting

The OOPC continues to develop its panel membership to ensure it has the skills and connections needed to carry out the work plan. Following the OOPC-18 Meeting, OOPC would like to officially welcome Johannes Karstensen (GEOMAR, Germany) and Weidong Yu (SOA First Institute of Oceanography, China).

Johannes Karstensen is an observational physical oceanographer and his PhD in 1999 at the University of Hamburg, Germany. He did a Postdoc at Lamont Doherty Earth Observatory of Columbia University, USA, and at the University of Concepcion, Chile. Since 2002 Johannes is a Researcher at the GEOMAR Helmholtz Centre for Ocean Research Kiel, Germany. His research interests are in large-scale circulation of mass and heat and other properties in the ocean. Johannes is in particular interested to understanding the complexities of ocean transport and use a broad range of observations on scales from large- to sub-mesoscale. At the present time, the main emphasis of his research is on understanding the mechanisms responsible for changes in Subpolar North Atlantic properties and water masses in response to large-scale climate modes, such as the NAO and Atlantic Decadal Variability. Additionally Johannes is working on transport and mixing processes associated with ocean eddies, and feedback mechanism between physical and biogeochemical processes. Scientifically as well as strategically, he devote attention towards optimizing ocean observing – by contributing to the development of new ocean-observing techniques and by optimizing sustained and process based ocean-observing strategies.

Weidong Yu started his oceanography career in First Institute of Oceanography (FIO) in 1995 following his masters degree. Initially he worked on ocean surface wave modeling and then changed to climate research after he finished his PhD in 2005. Weidong's main focus is the Indian Ocean Observing System (IndOOS), and he was involved in the CLIVAR-GOOS Indian Ocean Panel (IOP) during 2006-2012. One of its key components to which China has contributed much, the Research Moored Array for African-Asian-Australian Monsoon Analysis and Prediction (RAMA) now comes as the corner stone for Indian Ocean climate studies. Along with this new data stream, Weidong's research focuses on several key climate processes over the tropical Indian Ocean, including the Indian Ocean Dipole (IOD), monsoon-ocean interaction, Asian Monsoon onset and its inter-annual variability, and cyclones in Bay of Bengal. Recently, Weidong is working with SCOR and IOC to promote the 2nd International Indian Ocean Expedition (IIOE-2), where he leads the development of one theme on equatorial and boundary currents and upwelling. Also Weidong is a member of the Tropical Pacific Ocean Observing System (TPOS) 2020 project Steering Committee, with the particular concerns on the surface flux and air-sea interaction over warm pool and its linkage with tropical Indian Ocean.

Welcome Johannes and Weidong!

We would also like to say thank you to Eric Lindstrom for his sterling support of OOPC. He has stayed on while we GOOS has reorganized its panel structure and we have revitalized the panel membership, despite having also becoming co-Chair of the GOOS Steering Committee. However, it is now time for him to focus on the GOOS SC; and the upcoming OceanObs19 conference.

Thank you, Eric!

The panel recognizes the need to bring new expertise onboard, including in the areas of ice-ocean interactions and coastal observational oceanography; and continue to foster diversity in membership.

Name	**Affiliation**	**Expertise**	**Year**	**Years**
Robert Weller	USA	Air-sea fluxes; upper ocean	1996	19
Johnny Johannessen	Norway	Remote sensing	1999	16
Toshio Suga (co-chair)	Japan	Hydrography, Argo	2007	8
Mark Bourassa (co-chair)	USA	Satellite winds, fluxes	2013	2
John Wilkin	USA	Coastal oceanography	2013	1.5
Bernadette Sloyan	Australia	Ocean Circulation, Climate	2014	1
Steve Worley	USA	Data and information	2014	1
Johannes Karstensen	Germany	Physics/Biogeochem, AtlantOS	2015	
Weidong Yu	China	Ocean Circulation, TPOS 2020	2015	

To feed into the GCOS Implementation Plan, the next OOPC Meeting is proposed for the week beginning the 11th April location to be determined. The TOPC panel have invited OOPC for a joint meeting to discuss ice-o/Ocean Interactions; however, OOPC felt this was best addressed by a focused workshop. Given the need to provide updated network targets and actions for the GCOS Implementation Plan, it was suggested that perhaps the next meeting should be associated with the JCOMM Observations Coordination Group. Further information will be provided shortly.

11. Summary of Actions (from Work Plan).

DRAFT ACTIONS AND RECOMMENDATIONS:

Joint Session.

- **A. ACTION: Develop mini-spec sheets upstream, of applications, and phenomena to control vocab, simplify EOV spec sheets, reduce duplication, and limit level of granularity. Johnny A. Johannessen, Bernadette Sloyan (by 15th June).**

- **B. ACTION: GOOS Director requests feedback from panel members regarding how strategic mapping, variable and network specifications could be of help in national roles and activity in addition to international roles (All)**

OOPC Session:

1. **ACTION: OOPC to discuss with OSEval TT and GSOP the potential to collaborate on how OSE experiments are designed with a view to improving utility for observing system design? (John Wilkin (OOPC), (another OOPC?), Gilles Larnicol/Peter Oke (OSEval TT), Keith Haines/Magdalena Balmaseda (GSOP)**

2. **ACTION: OOPC/GSOP to develop a strategy for engaging the climate model and forecast community in observing system design, through verifying and drawing on spatial/temporal variability in models. A 2 page scoping document will be developed (leads: Johannes Karstensen, OOPC; Matt Palmer, GSOP).**

3. **ACTION: OOPC/GSOP to discuss the potential to partner to assess observing system performance by variable (Mark Bourassa, Keith Haines, David Legler/OSMC, others?)**

4. **ACTION: JCOMM OCG to report to OOPC/GOOS SC on summary of risks to the observing system (GOOS SC: 24-27th May 2015)**

5. **Action: Improve linkages with groups interested in ocean impacts on weather and land applications by identifying good examples to highlight on the new GOOS website (Secretariat to coordinate: Katy Hill, Albert Fischer).**

6. **ACTION: OOPC members to provide comment on criteria for prioritizing timeseries sites to TPOS 2020. (By mid June)**

Joint Day

- **C. ACTION: A document to be written explaining the strategic mapping and particularly the use of the network templates (Albert Fischer, Katy Hill, by 24th April)**

- **D. ACTION Panel members to look at Network draft templates, feedback on clarity, utility, gaps, etc. as initial guidance into JCOMM OCG (by 24th April).**

- **E. ACTION: IOCCP/GOOS Biogeochemistry Panel to make a list of the key observing networks and their coordination mechanisms/contact points identified (where there is one) as an output from this meeting (including potential networks). (By 24th April)**

F. ACTION: OOPC to check granularity of existing Draft Network Specifications, and identify where they can be combined, and identify potential additional networks. (By 24th April).

G. ACTION: OOPC requests feedback from IOCCP/Biogeochemistry Panel on requirements for physical variables. Do current specifications meet needs? Can we articulate applications of physical variables for BGC applications? Coincident observation requirements, and latency of QC data delivery (by end of 2015, as input to GCOS IP).

H. ACTION: IOCCP/GOOS Biogeochemistry to scope a Workshop on BGC Network Specifications, Targets, Metrics (Funding permitting, early 2016).

I. DECISION: OOPC/GOOS Biogeochemistry agreed to recommend 7 of the 9 BGC EOVs as ECVs to GCOS (mostly a reframing of existing ECVs, all of which are whole of water column variables).

J. Recommendation to GCOS SC: IOCCP/GOOS Biogeochemistry Chair/Member be invited to the next GCOS SC to present case for changes to Ocean Biogeochemistry ECVs. (Update: Toste Tanhua will be invited to GCOS IP Planning Meeting, 6th July 2015, Paris).

K. ACTION: OOPC Members to take ownership of 1 or 2 ECVs and write sections to the GCOS Implementation Plan. Champions are already identified. (late 2015, early 2016).

L. Recommendation: Formation of GCOS IP Ocean Section Writing Team; OOPC CO-Chairs to lead on collating IP input and writing overview. Invite IOCCP/GOOS Biogeochemistry Chair/Member to join team for BGC, and explore whether an additional representative from GOOS Biogeochemistry/Biology is needed to cover all ECVs.

M. ACTION: OOPC and IOCCP/GOOS Biogeochemistry Panel to Coordinate an Ocean Sciences Town Hall on EOVs and ECVs

N. ACTION: Bernadette to report to OOPC-19 on outputs from Argo/GO-SHIP/IOCCP Conference (see www.gaic2015.org).

O. Recommendation to CLIVAR SSG: to revise Data Policy to request process studies align data management practices with relevant global sustained observing programmes, such as OceanSITES; and highlight policy when process studies are under development.

P. Action: OOPC/JCOMM OCG and GOOS Biogeochemistry Panel/IOCCP to work with OceanSITES through Network Specification Process to articulate requirements for moored timeseries and other OceanSITES components, and the design targets/specifications. (During 2015)

Q. Recommendation to JCOMM OCG to consider including additional network metrics in regular reporting (examples)
  - **a. Recruitment**
  - **b. Quality of data or data flow,**
  - **c. funding stability,**
  - **d. Age verses design age**
  - **e. deployment locations, or for sampling in specific regions.**
  - **f. Connections across networks**
  - **g. Number of EOVs measured.**
  - **h. Value for validation**
  - **i. Innovation in the network**

OOPC Only Day (Thursday)

7. **Action: Change names of Ocean ECVs to interfacial and ocean column: Justification needs to be drafted and presented to GCOS SC (Co-Chairs to lead, October 2015).**

8. **ACTION: OOPC/CLIVAR to coordinate a joint session on Observing and Modelling Boundary Currents and their interactions with the shelf at Ocean Sciences 2016 (Bernadette Sloyan, John Wilkin (OOPC), Alex Ganachaud (CLIVAR).**

9. **ACTION: Discuss potential for improved characterization of fluxes to be a highlight topic in the next GCOS IP (Mark Bourassa to discuss with AOPC/TOPC chairs, and make case at next GCOS SC in Sept)**

10. **ACTION: Develop case/requirements for wind stress (ocean vector surface stress) as an ECV. (Mark Bourassa, Bob Weller, Johnny A. Johannessen)**

11. **Recommendation to GOOS SC: Discuss coordination and oversight common approaches across regional activities, e.g. to engaging Modelling and DA community.**

12. **Recommendation to GCOS SC/Secretariat to provide further details for milestones regarding early preparation of the IP**

13. **ACTION: Develop detailed timeline for coordination/development of input to the GCOS IP, and expectations for input from GOOS Biogeochemistry and Biology Panels (OOPC Secretariat)**

14. **ACTION: Identify an OOPC panel member to take responsibility for coordinating/developing input for each ECV (OOPC Secretariat).**

15. **Recommendation to GCOS SC/GCOS Science Conference Organising Committee to provide Guidance on structure and expected contributions to GCOS Science Conference**

16. **ACTION: OOPC members to provide comment on criteria for prioritizing timeseries sites to TPOS 2020. (By mid June)**

17. **Recommendation: Development of requirements at the ice-ocean interface be discussed through a focused workshop, engaging SOOS, CliC, etc. communities.**

18. **Recommendation: TOPC send a representative to the next OOPC meeting to promote understanding across TOPC/OOPC activities.**

19. **ACTION: Identifying good examples of ocean products and applied applications to highlight on the new GOOS website (Secretariat to coordinate: Katy Hill, Albert Fischer).**

20. **ACTION: Highlight Sea Level as an exemplar of integrating open ocean and coastal requirements in the next GCOS IP. (John Wilkin to lead).**

Appendix 1: Agenda

18th Session of the Ocean Observations panel for Physics and Climate

Held in parallel with
A meeting of GOOS Biogeochemstry Panel and International Ocean Carbon Coordination Project (IOCCP) SC.

OOPC-18 Draft Agenda. v.3

14-17th April.

Tohoku University, 6-3, Aramaki Aza-Aoba, Aoba-ku, Sendai 980-8578
Room 1, Science Complex C, Graduate School of Science
Sendai, Japan.

Tuesday 14th April:

Plenary First Session with GOOS Biogeochemistry/International Ocean Carbon Coordination Project, IOCCP), Panel sessions rest of the day.

8.30-9.00: Registration

1. ***Joint Plenary. Introductions, overarching GCOS, GOOS talks. (Chairs: Toshio Suga, Toste Tanhua)***

9.00-9.30:	*Welcome from Chairs (Toshio, Mark, Toste),* *Welcome from Local Host (Dr. Tadahiro Hayasaka)* *A few words from Vice President of IOC (Dr. Yutaka Michida)* *Local Logistics (Toshio Suga, Katy Hill).*
9.30-10.00:	*GCOS Priorities, and process for Implementation Plan: focus, process, milestones. (Stephen Briggs)*
10.00-10.30:	*GOOS Strategic Mapping: status and next steps (Eric Lindstrom, Albert Fischer)*
10.30-11.00:	*DISCUSSION: contributions to planning processes, area of progress development in Ocean observing, work to do for deadlines.*

11.00-11.30: COFFEE BREAK. (then panels separate)

2. **Introduction: Ocean Observations panel for Physics and Climate (Chair: Mark Bourassa)**

11.30-12.00	Introduction and Update from the OOPC Co-Chairs: activities since OOPC-17, priorities going forward, meeting agenda (Mark, Toshio)
12.00-12.20	Discussion, questions, including discussion/approval of agenda.

3. **Status of the sustained observing system: (Chair: Mark Bourassa)**

12.20-12.50:	Observing System Status, risks, challenges, opportunities. (David Legler, OCG Co-Chair)
12.50-13.00:	Discussion:

13.00-14.00: LUNCH BREAK

4. **Feedback from CLIVAR Panels (Chair: Toshio Suga)**: Requirements for sustained observations, and status against requirements. Gaps, issues, development activities (i.e. Process Studies) to inform improvements

14.00-14.20: GSOP (Keith Haines)
14.20-14.40: Atlantic (Nico Caltabiano)
14.40-15.20: Indian Ocean Panel (Tomoki Tozuka)
15.20-15.30: Discussion

15.30-16.00: COFFEE BREAK

16.00-16.20: Pacific Panel (Alexandre Ganachaud)
16.20-16.40: Southern Ocean Panel (Katsuro Katsumata)
16.40-17.00: Discussion

Evening: OOPC Non-Hosted Dinner (details to follow

Wednesday 15th April: OOPC/GOOS Biogeochemistry Joint Day

5. ***Recap/input from separate panel sessions, focus of joint session. (Chair: Toste Tanhua)***

9.00-9.15: Agenda and aims of the joint session (Mark, Toshio, Toste)
9.15-9.30: Recap OOPC (Mark/Toshio)
9.30-9.45: Recap IOCCP/GOOS Biogeochemistry (Toste)

6. ***GCOS Implementation Plan/GOOS Strategic Mapping (more detail) (Chair: Mark Bourassa)***

10.00-10.30: GCOS IP. Priorities areas in new plan, and focus of Ocean Section/Input (Stephen Briggs)
10.30-11.00: GOOS Strategic Mapping (more detail), role of variable/Network Specifications (Eric Lindstrom, Albert Fischer)

11.00: COFFEE BREAK

11.30-12.00: Summary of existing Physics Variable specs, discussion common issues, areas for improvement etc (Mark, Toshio).
12.00-12.30 Summary of Biogeochemistry Specifications (Toste Tanhua).
12.30-13.00: Discussion of next steps: Public Presentation and Review of Variable Specs? proposing new variables (e.g. BGC variables to GCOS, interface variables)

Background Papers:

- *Current version of Physics and Biogeochemistry Variable Specifications (DONE)*
- *Justification/Strawman/pitch for any proposed new ECVs (Ocean Surface Vector Stress, Sensible/Latent Heat fluxes, Gas fluxes) (Mark)*

13.00-14.00: LUNCH BREAK

(Chair: Toste Tanhua)

14.00-14.20 Network specification sheets, (Katy Hill, David Legler).

14.20-15.00 Discussion: feedback on templates, next steps, process for proposing new networks (e.g. Global Glider network?) (Feedback to the JCOMM OCG, meeting at end of April)

Background Papers:

- *Current draft of Network Specifications (in process)*

- *Justification/Proposal for networks, or process for developing global mission (e.g. Ocean Gliders)*

7. *Quantitative targets for Observing Networks (Chair: Toshio Suga)*

15.00-15.30. *Process for developing targets for Physics/Climate Networks to date, lessons learnt by OOPC, next steps. (Eric, Johnny, others)*

15.30-16.00: *Discussion. Development of BGC Network Targets (and what should be in the next GCOS IP.*

16.00-16.30: COFFEE BREAK

16.30-17.00: *Observing System Metrics (by variable, network), assessment of risks to observing system. (David, Mark, output from OOPC discussions)*
17.00-17.30: *Discussion, feedback, next steps in developing Observing System Metrics.*

17.30-18.00: *Next steps for joint Physics/Biogeochemistry activities: Possible joint workshops/activities?(targets, GCOS IP, OceanObs19)*

Background Papers:
- *Draft Network Metrics Report.*

End of Day: 6pm.

EVENING: Joint Non-Hosted Dinner (details to be provided).

Thursday 16th April: Ocean Observations panel for Physics and Climate

8. Recap.

9.00-9.30: Recap/Discussion on outcomes of joint Day and Agenda for the day (Mark/Toshio)

9. Observing System Development Activities (Chair: Mark Bourassa) (connection to CLIVAR science, opportunities for inclusion in GCOS IP, development of GOOS Strategic Mapping).

09.30-09.50: TPOS 2020 (Weidong Yu, TPOS 2020 SC; Katy Hill project update),
09.50-10.10: Discussion: TPOS 2020 Timeseries activity.
10.10-10.30: AtlantOS (Johannes Karstensen, Albert Fischer).
10.30-10.50: Deep Ocean Observing Strategy, DOOS – (Eric Lindstrom, Bernadette Sloyan)
10.50-11.00: Discussion.

Background papers:

- Update on TPOS 2020
- Background Paper on AtlantOS (Johannes/Albert)

11.00-11.30. COFFEE BREAK

11.30-11.50: Boundary & BC/Shelf Evaluation (Bernadette Sloyan, John Wilkin).
11.50-12.10: Air Sea Fluxes – Update on for TPOS 2020 Planetary Boundary Layer TT, SOOS Fluxes, Potential/Need for fluxes ECVs, discussions with AOPC to date. (Mark Bourassa)
12.10-12.30: Polar oceans and cryosphere ECVs (sea ice, ice sheets,) and strategy for observing under ice. Potential for discussion with TOPC (future joint meeting/workshop?) (Johnny Johannesen, Mark Bourassa)
12.30-13.00: Discussion: Existing, future activities priorities, activity leads, etc.

Background papers:

- Scope of an Evaluation of Boundary Currents and their interactions with the shelf.

13.00-14.00 LUNCH BREAK

10. Discussion on way forward (Chair: Toshio Suga):

- OOPC Workplan and Progress against actions (Katy Hill)
- Discussion/Agreement on
    - Way forward for observing system evaluations (i.e. Boundary Currents and their interactions with the Shelf, Ice/Ocean Interactions)
    - Priorities/milestones for input to GCOS IP, GOOS Strategic Mapping, OceanObs 19
    - Other issues/opportunities?
- Next steps for variable specifications (Mark, Toshio, Katy)
    - Existing variable specs, improved consistency, gaps.
    - Expanding to include coastal requirements.
    - Expanding to include non-climate requirements.

16.00-16.30: COFFEE BREAK

- Developing Network Specifications (Katy, David, Albert):
    - Current draft templates: comments, any gaps, guidance to networks, anything missing.

- Future priorities (Discussion):
  - Priorities for development of existing/new variables and networks, tasking experts and subgroups.
  - Any opportunities arising from development projects (TPOS 2020, DOOS), coastal, review BGC ECVs (see BGC Variable Specs).
  - Planning for next meeting (GCOS would like us to meet in April next year)

Background Papers:

- OOPC Work Plan 2014 Update
- Summary of Actions status/progress
- Diagram of GOOS Structure.
- Variable Specifications
- Draft Network Specifications

18.00 (At Latest) Close for the Day.

Evening: Optional non hosted dinner with attendees of Japan workshop.

Friday 17th April:

Workshop: "Future Prospects of Coastal Ocean Observations and Modeling in Japan"

Opening Session Chair: Toshio Suga

9.00	Introduction (Toshio Suga)
9.05	JOS Vision for the future of coastal oceanography (Atsuhiko Isobe, Kyushu University)

Session 1: New approaches of coastal ocean observations Chair: Atsuhiko Isobe

9.15	Development and observation of oceanographic radar in Japan (Satoshi Fujii, University of Ryukyus)
9.35	COMPIRA concept, future operation of SSH observation with a fine resolution (Osamu Isoguchi, RESTEC)
9.55	High Density Satellite Observation (Kaoru Ichikawa, RIAM)

Session 2: Toward accurate data assimilation modeling in coastal oceans Chair: Naoki Hirose

10.15	APL/JAMSTEC (Yasumasa Miyazawa, JAMSTEC)
10.35	RIAM/Kyushu University (Naoki Hirose, RIAM)
10.55	AORI/University of Tokyo (Hiroyasu Hasumi, University of Tokyo)
11.15	MRI/JMA (Norihisa Usui, JMA)

11.35-12.20: COFFEE BREAK

Session 3: Biogeochemical observations and data products in the North Pacific Chair: Masao Ishii

12.20	Mapping of Sea Surface Nutrients in the North Pacific: Basin-wide Distribution and Seasonal to Interannual Variability (Sayaka Yasunaka, JAMSTEC)
12.40	Ocean acidification in the western North Pacific tropical and subtropical zone (Masao Ishii, JMA-MRI)

Session 4: Future view of coastal oceanography Chair: Toshio Suga

13.00	Present limitations and future prospects of coastal ocean forecasts (Atsuhiko Isobe)
13.20	Present limitations and future prospects of coastal ocean ecosystem modeling (Naoki Yoshie, CMES)
13.40	General discussion, feedback from panels
14.00	Closing

Appendix 2: TPOS Input Paper

The TPOS 2020 Project.

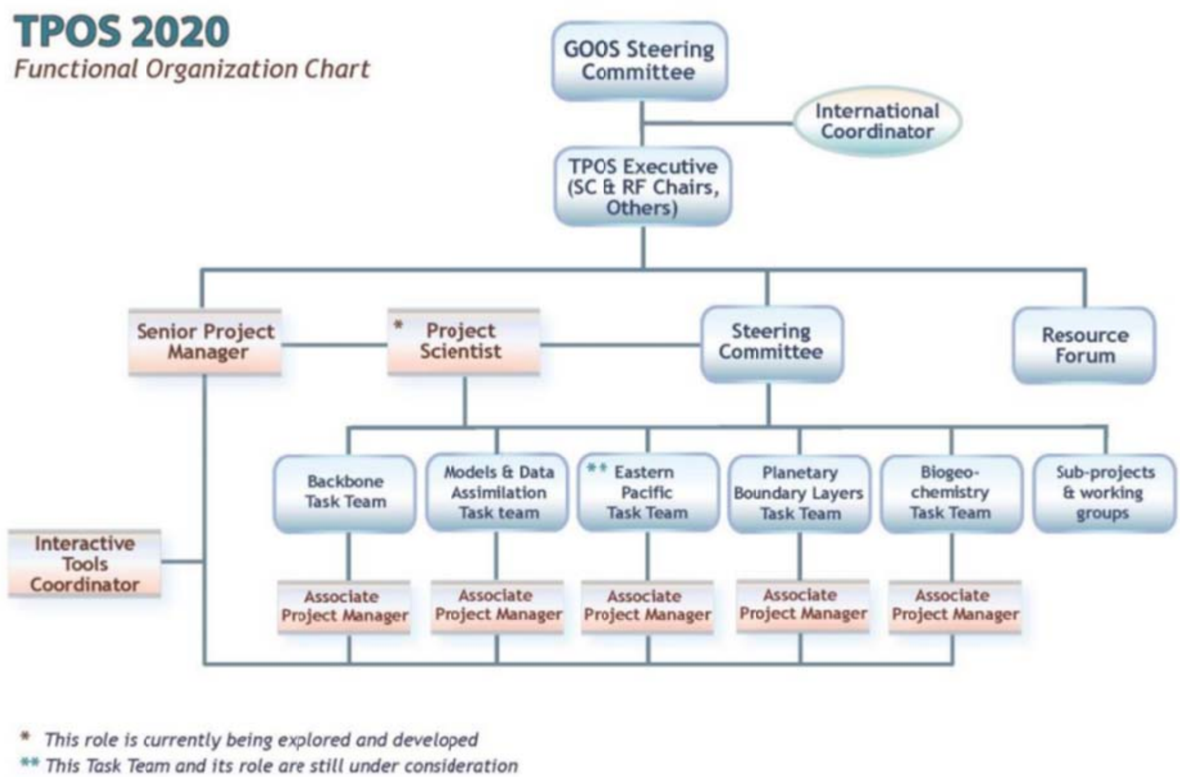
A Report to OOPC 18

Neville Smith (TPOS 2020 SC Co-Chair), Prof Weidong Yu (FIO/SOA; SC Member)

1. Background

The Tropical Pacific Observing System (TPOS) 2020 Project was an outcome of the TPOS 2020 Workshop[1] held from 27-30 January 2014 at Scripps Institution of Oceanography in La Jolla, for which OOPC was one of the sponsors (Prof Toshio Suga was the co-Chair). The workshop was attended by 65 invitees from 13 countries and 35 institutes. There were various invited talks based on 14 whitepapers and 9 agency presentations, together culminating in a number of recommendations including the establishment of the TPOS 2020 Project. The TPOS 2020 Project Steering Committee met for the first time at KIOST in Ansan, Korea 6-9 October 2014. The Report from that meeting can be found at the Project website http://tpos2020.org/ along with details of the Terms of Reference of the Project and its Steering Committee, and the initial membership of the SC.

2. Structure



The Figure above provides a summary of the Project structure, including Project Management perspectives. The structure is similar to that used for some earlier OOPC projects, like GODAE, Argo and OceanSites, where responsibility is vested in the project and its governance with a single line of reporting into the intergovernmental fabric for ocean observations, in this case via the GOOS SC. The Project has defined objectives and a finite lifetime. Like the other Projects, the agency sponsors (here represented by the Resources Forum compared

[1] See http://ioc-unesco.org/index.php?option=com_oe&task=viewEventRecord&eventID=1383 for details.

with, say, the Patrons of GODAE) are key and it those agencies that created and own the Project, as a contribution to GOOS and GCOS, among others. The International Coordinator (Katy Hill) assists with the important task of harmonising TPOS 2020 activities with bodies/panels in the intergovernmental world.

It is important to note that the TPOS 2020 Project does not itself interact with the international observing networks of GOOS, WIGOS, JCOMM or GCOS, even where those networks operate in the tropical Pacific Ocean. Those responsibilities remain with the standing panels and expert teams of the above. Any advice developed by TPOS 2020 will be communicated through the GOOS SC though in some cases we will likely harmonise such advice with the global perspectives of OOPC and others.

However, through the fact that agencies such as NOAA (USA) and SOA (China), and initiatives like IMOS (Australia) are part of the Project sponsorship and Resources Forum, TPOS 2020 does have a very direct interaction with relevant national initiatives and centres, such as the National Data Buoy Centre. TPOS 2020 is not setting standards or global designs but does need to road-test possible changes and to take account of the resource limitations and need for efficiencies of these bodies.

The TPOS 2020 management structure is much as you would find with any major Project, though we are endeavouring to keep project management light.

3. Progress

The TPOS 2020 Steering Committee had a very successful first meeting. The SC brings a broad mix of expertise and affiliations and the Committee were energetic and enthusiastic, and provide every indication they are prepared to work hard. The SC reviewed all recommendations from the TPOS 2020 Workshop and are well positioned for follow up in almost all cases.

Governance and process were agreed and, in particular, the intent to work in an orderly and purposeful manner aided by good project management practices.

The Steering Committee discussed 11 substantive potential lines or work, some delivering shorter term advice/outcomes, others on longer time frames. It is possible that for some sub-projects, in order to align with agency/national planning timelines, some phases may occur beyond the lifetime of TPOS 2020. In a number of cases decisions were taken to initiate this work (refer to the Figure above for a summary of the outcomes of these decisions).

A Resources Forum teleconference was held immediately after the Steering Committee Meeting. Around 15 organisations were represented, spanning operational and research agencies and Met Services, as well as satellite and modeling agencies.

4. Summary of activities

4.1. Short term actions

A Task Team has been formed to developing advice on the backbone TPOS[2]. The TT will initially advise on the elements of the backbone based on what we currently know and existing capabilities, making reasonable assumptions on the sustainability and risks to support. The Task Team has now been constituted and will begin work immediately. It may meet face-to-face later this year

Short-comings with El Nino/Southern Oscillation (ENSO) models were discussed at some length in La Jolla and again at the SC meeting. As much as 50% of the observed information is used to deal with bias in the models rather than initialising the climate modes known to be important for ENSO. This same bias limits the utility of forecast systems. The SC agreed to create a Modelling and Data Assimilation Task Team though this action has

[2] OOPC is probably more familiar with the term broadscale as used in the La Jolla Workshop and in TOGA and WOCE plans. The SC felt it was important to be more general and include all fundamental contributions, no matter the space scale being addressed.

encountered a number of issues. Several opportunities around the need to improve modelling and data assimilation were identified by the TPOS 2020 SC. A Workshop on systematic errors in tropical models and prediction systems has been discussed and the SC and/o r Task Team will conduct some assessment of when/how this might happen. TPOPS 2020 participated in the December 2014 OSEVal Workshop (as did a co-Chair of OOPC) and a number of these opportunities are raised in the Report of that Workshop.

4.2. The Tropical Pacific Ocean Climate Record

An important consideration for the Backbone Task Team and other parts of the TPOS design is the degree to which fixed-point mooring sites established during and after TOGA continue to play an important role (consistent with the recommendation from La Jolla workshop). Terms of Reference for a small study/audit were drafted and we appreciate feedback from OOPC/OceanSites on that draft, most of which was included in the final draft.

One point, however, on which the TPOS 2020 SC (and the Backbone TT) will take a different view concerns the definition of a Climate Record. Surprisingly, it would seem this term has not been defined by GCOS though we are aware that a definition provided by the US National Research Council (at the request of NOAA) for a Climate Data Record (in the context of satellite records) has been used: "a time series of measurements of sufficient length, consistency, and continuity to determine climate variability and change." The TPOS SC believes this definition is too narrow, even for a Climate Data Record, since it overly emphasises the time-series aspect compared with the other degrees of freedom of the climate system. In particular, we know from successive IPCC Working Group 1 Reports that networks such as Argo have been assessed as making valuable contributions to the detection of climate change (including long-term variability) and thus to the Climate Record. In essence if a data record resolves patterns of change and/or co-variance of essential climate variables, this may allow detection even when the temporal length of the record is limited.

The definition provided for detection by both Working Groups 1 and 2[3] suggests a more general interpretation for climate record that is not specific to time series:

“A climate record is (observed) evidence about climate, usually in some permanent form, with sufficient extent, quality, integrity and consistency to detect climate variability and change.”

The term ‘extent’ is used in place of ‘length’ and covers both temporal and space dimensions, and the degree to which more than one variable is being observed. The terms ‘quality’ and ‘integrity’ are used in place of ‘consistency’ since these are important criteria for detection, which in turn is a more appropriate term than ‘determine’.

The OOPC may wish to consider taking this matter up with the GCOS SC (it has been mentioned to the former GCOS SC Chair).

4.3. Longer term actions

The evolution of the TPOS will occur through design studies for the Backbone (by the Backbone Task Teams) and through a number of other studies that will guide enhancements and/or changes. There may be three or more stages in this process.

Task Teams were agreed for air-sea interaction and the ocean boundary layer (collectively referred to as the Planetary Boundary Layer), and for Biogeochemistry, respectively. The Terms of Reference have been finalised and Co-Chairs and membership have been agreed.

It is important that we initiate and support work to achieve change in the TPOS, involving partnerships within the research community and with operational groups involved in observation, modelling and prediction. Three areas have been identified.

[3] See, for example, http://www.ipcc.ch/pdf/assessment-report/ar5/wg2/WGIIAR5-AnnexII_FINAL.pdf.

The Western Pacific including the boundary layer regions and the source region of the equatorial undercurrent. The East Asian monsoon and convergence zones will also be foci. This project has great potential for most of the participants to work together on a Project that will guide significant change in the TPOS, again consistent with the guidance received from La Jolla. A team has been formed to deliver a project plan outline to the next SC.

The Eastern Pacific, including the coastal region. They key drivers here are the climate impacts experienced in southern and central America and again we hope to bring together a number of interests and participants. This sub-project will operate through a task team whose terms of reference will be agreed intersessionally.
Finally we have identified potential to conduct a significant process study in the central-to-eastern Pacific, focused on improving understanding of upwelling and the interaction with surface processes, to guide potential changes in our observing strategy and capability in this area and elsewhere.

5. Discussion

Though TPOS 2020 formally reports through the GOOS SC, it is of course part of the family of GOOS and GCOS activities and it is thus important that we coordinate with OOPC. Professor Yu is a member of the TPOS SC and Dr Katy Hill contributes to coordination in both cases. Some OOPC members (including ex-officio members) will participate in Task Team activities.

Along with AtlantOS, TPOS 2020 is likely to yield recommendations that have significant implications for the global observing system design and implementation, particularly around an integrated design taking account of modern satellite and in situ capabilities. Harmonisation for physical and climate aspects will ultimately rest with OOPC, and JCOMM for implementation.

TPOS 2020 is self-supporting and is grateful for the initial support of NASA and NOAA (through the US Not for Profit, the Consortium for Ocean Leadership) and the GCOS/GOOS Secretariat. IMOS (Australia) and the First Institute for Oceanography (SOA, China) have also confirmed their willingness to support TPOS activities, the latter through the Office created in support of CLIVAR at Qingdao. In both cases the support is in-kind and the Distributed Project Office will be working through the Resources Forum to develop needed operating funds. The TPOS website http://tpos2020.org/ contains the latest Monthly Status Report and further details on the Project.

9 April 2015

Appendix 3: Boundary Currents Input Paper.

OOPC Evaluation Activity: Boundary Currents, and their interactions with the shelf.

Bernadette Sloyan, John Wilkin, Katy Hill.

Background/Motivation.

Circulation in the coastal ocean and near shore zone influences a diverse range of human activities including maritime industry, recreation, and defense, and it plays a vital role in environmental health and productivity that deliver important ecosystem services. Coastal circulation is driven by local terrestrial influences at the land-shore boundary, coastal zone meteorology, tides, and equally importantly by remote forcing at the shelf-sea/open-ocean boundary. On coasts for which estimates exist, fluxes of nutrients and carbon across this boundary are leading order terms in the nitrogen and carbon budgets of shelf ecosystems.

In many coastal circulation regimes, the proximity of energetic boundary currents in deep water at the shelf edge is a key dynamic in mediating shelf-sea/deep-ocean exchange.

Mass, heat and salt transports within boundary currents are also of leading importance in basin-scale ocean budgets, yet direct observations of these transports have not been sustained to the extent required to fully complement observations within the ocean interior. In large part, this is due to the particular challenges of maintaining observing networks within energetic regimes, and capturing the significantly shorter time and space scales of variability there.

The long-term monitoring of boundary currents, at key locations, will provide a comprehensive reference data set that will measure mass, heat and salt transport, improve our understanding of the relationship of boundary currents and the basin-scale gyre forcing, and determine the impact of boundary current variability on coastal marine ecosystems. The observations will also be used to assess the simulation of boundary currents in various climate and ocean models. The continued monitoring of boundary currents is central to our understanding of how climate signals are communicated through the ocean.

Coastal ocean and shelf edge dynamics have immediate impact on ecosystem function and productivity on weekly to seasonal time scales, but can also drive multi-decadal changes in ecosystem structure through effects on habitat ranges and biodiversity. Changes in watershed land use and global weather will alter the net volume and characteristics of variability of river flows discharged into the coastal zone. At continental shelf scales, key areas of uncertainty of the oceanographic response to climate variability and change include sub-mesoscale processes and open ocean-shelf exchange.

While we have a broad understanding of the dynamics of upwelling in both western and eastern boundary current regimes, quantitative estimates of net shelf-sea/deep-ocean exchanges of freshwater and tracers are few globally. On narrow continental shelves adjacent to intense boundary currents (e.g. East Australia, the South Atlantic Bight) the impact of deep-ocean circulation on the shelf system is immediate, driving significant fluxes across the continental shelf edge through mesoscale and boundary layer dynamics. On broad continental shelves (e.g. the Scotian Shelf and Mid-Atlantic Bight) bathymetric constraints on cross-isobath flow can hamper exchange at the shelf edge, trapping terrestrial inflows and establishing appreciable across-shelf buoyancy gradients that in turn sustain shelf-edge fronts. But inevitably, terrestrial freshwater input must mix with the deep-ocean, and short length scale frontal variability at the margins of shallow coastal seas is undoubtedly a contributing dynamic.

With changing climate, ocean warming and a magnified hydrological cycle could drive significant changes in shelf ocean stratification, while changes to wind forcing will directly alter rates of upwelling. These ocean circulation processes, and meteorological forcing at the scales that impact upwelling, are poorly represented in climate models. Thus, we have little capability to predict how upwelling and other physical drivers of the ocean property exchange at the open ocean boundary will change in future climates. The impact these changes will wreak on coastal ecosystems is simply unknown.
Addressing these issues by downscaling coarse resolution climate model predictions through the application of higher resolution regional and coastal models has shown promise, but still faces research challenges.

Furthermore, a significant amount of physical and biological response on the continental shelf is due to episodic oceanic and atmospheric events at timescales of variability that are absent from coarse models and cannot be recovered locally. To be valid globally, the veracity of downscaled models needs to be appraised by supporting observations of shelf edge fluxes in a diversity of circulation regimes.

Coastal observing systems have now become sufficiently comprehensive that it is feasible to broadly measure these shelf-sea/deep-ocean exchange processes in conjunction with deep-ocean observing networks that capture variability within boundary current regimes, and the ocean interior, at increasingly fine scales.
Specific issues that a comprehensive (observations, and physical models) Boundary Current/Shelf Interaction study would address are:

- understanding the impacts and influences of large-scale remotely driven variability on boundary currents;
- understanding how variability of the strength and dynamics of the dominant boundary currents drive shelf-sea/deep-ocean exchange, including nutrient forcing, carbon export, and other aspects of productivity of shelf waters;
- understanding the response of coastal and boundary current dynamics to local and regional wind and buoyancy forcing fields, and the impact through teleconnections these have on dynamics at larger scales
- quantifying the resolution required for to adequately represent coastal and boundary current dynamics in models of global climate
- obtaining basin-wide estimates of meridional transports to consistent precision through a synthesis of coastal, boundary and deep ocean observations.

The provision of robust three-dimensional and time-varying ocean circulation estimates in boundary current regimes, resolving scales of a few kilometres, is seemingly within reach through advances in data-assimilative ocean models. However, development of integrated systems that could deliver the scope of observations required, and the models capable of fully utilizing them, is challenging. To succeed, this will require a coordinated international effort that brings together the expertise of the ocean modelling and observational communities.

Approach

1. **Session at Ocean Sciences 2016**
   Observing and modelling Boundary Currents, and their interactions with the continental shelf ocean.

- To review science questions and drivers, model requirements, uncertainties, observing requirements, gaps to address, etc.
- To review shelf and adjacent open ocean boundary observation and modelling activities to date (observations: both short term and sustained; models: both forecasts and reananlyses), and lessons learned from previous observing system designs
- To invite ideas on novel uses of new observing technologies to meet resolution and precision requirements

Outcome: whitepaper on status of observing and modelling boundary currents, as precursor document to a potential workshop/evaluation activity.

2. **Workshop on requirements for and approaches to monitoring and predicting boundary currents.**

GOALS OF A WORKSHOP

- Articulate requirements for shelf-open ocean monitoring i.e.
    - Scientific applications,
    - Societal relevant observing aspects,
    - Questions to be addressed,
    - phenomena/processes to capture,

    - variables to be measured, at what spatial and temporal scales
    - modelling approaches (forecast and reanalysis).
- Articulate the role and synergies of the range of networks and technologies in boundary current observations, including (but not limited to), satellite observations, deep and shelf moorings, XBT Lines, gliders, HF Radar.

OUTCOMES OF THE WORKSHOP

Design and implementations recommendations of targeted intensive international process experiments in specific shelf-sea/deep-ocean regimes that will guide the development of a sustained observation and modeling system to monitor and predict boundary current transports and support coastal ecosystem model prediction schemes.

Identify opportunities to leverage existing boundary current activities for process experiments that will lead to development of an efficient and cost-effective boundary current observing system required to address the questions related to the dynamical interactions of boundary-shelf circulation systems and required routine observations required for ocean forecasting systems (physics and ecosystems).
Improved techniques for downscaling temporally and spatially coarsely resolved climate prediction to include accurate representations of higher frequency and locally/regionally significant events and processes (e.g., local wind fields, tropical cyclones,) that drive persistent coast and shelf dynamics and ecosystem response.

Groups to Engage.

- P.I.’s undertaking boundary current/shelf observations
- GODAE OceanView (COSS TT, OSEval TT)
- GSOP, Decadal Prediction Community?
- Representatives from key observing networks (IOOS, IMOS, Copernicus)
- Those working on ecosystem indicators and range shifts (GODAE Ecosystem-TT,
- Agencies/Observing Programmes with relevant observing activities i.e. regional GOOS NOAA OCO, IMOS,

Appendix 4: Attendees

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against Actions from OOPC-17:

tions (agreed at OOPC-17,July 2014).

PC to provide information to CLIVAR Panels pportunities and issues in the observing each OOPC meeting, for discussion at js).		KH Discussed with CLIVAR Project office, and was raised/agreed at the CLIVAR SSG. However, focus this year will be on Research Opportunity/Grand Challenge meetings, rather than Panel meetings. How to engage with these projects?
VAR Panels (Basin Panels and GSOP) to PC on the use of the sustained observing dencies, inefficiencies, and gaps. (Each		KH Discussed with CLIVAR Project office, and was raised/agreed at the CLIVAR SSG. Next step: provide CLIVAR representatives for next OOPC meeting with these guidelines for input.
Secreratiat of OOPC, CLIVAR GSOP, AE Oceanview to have routine telecons etariat to coordinate)		First telecom completed in January 2015. Quarterly (with rotating chair) from now on.
s to read across Variable Specifications to ays to improve the template and next steps		Variable specifications discussed at the meeting, templates updated, and members have been engaged in discussions on revisions with experts.
societal drivers and general science ctions of specifications. Include climate, non- ers. Deadline: end September. (OOPC on with GOOS Office and co-chairs).		Drawing on drafted Variable specifications, overarching Societal Benefit Areas and Scientific Applications are being developed by the GOOS Secretariat. These will be presented at OOPC-18
ecretariat to improve templates, and ensure ifications (including with BGC). Seek eeded by end September. Responses November. (Co-chairs/Secretariat)		Complete. Now with GOOS Secretariat to ensure consistency across GOOS panels.
requirements to be included in each s/application area level: Secretariat/Co- n Wilkin to identify a team of experts to assist. December. Co-chairs and John Wilkin to rly September (Secretariat to coordinate). es).		Delayed to Post OOPC-18. Telecon with John Wilkin et. al. in late September re. setting requirements for coastal observations as part of Variable specification exersize. It was agreed that in most cases, the coastal requirements could be incorporated in the existing specification sheets, separated out at the processes/phenomena level. A list of experts for each variable has been proposed, and John has been testing the approach with coastal sea level. Now waiting to finalise open ocean specifications for the coastal experts to build on, post OOPC 18
: Final draft Specifications to be made ity for comment, SWOT analysis anels, CLIVAR Panels, GRAs, etc). Send out		Delayed to post 2018: Current draft specifications are being used to inform Ocean section of the GCOS status report. Also working on consistency across the package

and collate feedback).		
Recommendation : Develop a plan for advertising and socializing the Ocean ECVs/Physics EOVs. Including ▯ Presentation of a GOOS webinar ▯ Ocean Sciences, 2016: All EOVs (All 3 GOOS Panels).		Plans for an ECV/EOVs Ocean Sciences session in progress, in conjunction with GCOS/GOOS. Also, GOOS Science Conference (2-4th May)
Question to GOOS SC: What will the update and review process for GOOS EOVs be?		Decided that the EOV specifications will be 'living' documents. Evaluations (e.g. Boundary Currents) or development projects (TPOS 2020, DOOS) will likely be drivers to update these documents.
Recommendation to GCOS SC: Update the Biogeochemical Ocean ECVs to reflect the proposed EOVs as part of the next implementation plan: i.e. replace 'pCO2'/'Acidity' with 'Carbonate System'		Discussed at the GCOS SC meeting, and directly between GCOS and GOOS leadership. Process to be presented and discussed at OOPC-18.
Recommendation to GCOS SC: Consider the need for fluxes ECVs (Air-Sea, Land-Ocean) as part of the next GCOS implementation Plan.		Informal discussions commenced between OOPC and AOPC, . Deferred for future.
Action: Test Networks specification template with established observing networks. - Work with JCOMMOPS to pre-populate existing information gathered to date (gathered ahead of OCG-5, and as part of the variables exercise) through October 2014, - Seek input from network representatives (by February 2015) for discussion at OOPC-18.		Network Specs pre-filled by secretariat. Will be sent shortly to Network Reps for comment/input.
Action: Coordinate observing system implementation metrics by network with the JCOMM Observations Programme Area and JCOMMOPS (OOPC Secretariat to facilitate).		JCOMMOPS have developed a draft plan. To be discussed/presented at OOPC-18 and OCG-6 in April 2015
Recommendation to GOOS SC and JCOMM OCG: More pro-active approach to assessing risks and vulnerabilities to the observing system is needed, and how to mitigate it. i.e. Articulating ship time requirements to support the observing system.		On agenda for discussion at OCG-6, (27-29th April 2015) led by David Legler (Networks will report on risks to OCG). Recommendations to be presented to GOOS SC (24-27th May)
Action: JCOMM OCG to provide Network Status talk for each OOPC Meeting, highlighting issues and risks.		On the Agenda for OOPC-18
Action: OOPC to revisit existing GCOS Implementation plan network requirements and whether they should be tweaked ahead of the next IP (improving integration/optimization?). (To be addressed in the context of EOV/Network specification activity in coming 6/12 Months: for discussion at OOPC-18).		Precautionary approach recommended. Network Targets will be adjusted in the context of OOPC evaluation activities, and regional development projects
Recommendation: Ocean Indices should continue to be promoted by OOPC, but they should link to other groups who work on the applications/impacts activities. Strengthen connection to the observing system.		Further discussed at GOOS SC. Will be pursued through the development of the new GOOS Website
Recommendation for GOOS/GCOS SC: Highlight products, uses		Under discussion for the GOOS website. Limited staff

and applications of EOV/ECV observations on programme websites, including climate and ocean indices in the context of communications and outreach activities.		capability for a similar activity with the GCOS Website.
Action: Steve Worley/Co-Chairs Panel to discuss next steps based on the Keeley Data Report and role of OOPC, in consultation with OCG. Steve to present at the next OOPC Meeting (April 2015)		Discussions initiated with Steve.
Action: Steve Worley to attend JCOMM OCG, April 2015, Cape Town.		
Action: Update the paper on quantitative approaches to Observing System Evaluation based on feedback from OOPC-16, and engaging OSEval TT, GOOS Biogeochemistry Panel. (Mark Bourassa to coordinate with David Berry, Gilles Larnicol, Toste Tanhua) (By OOPC-18)		No progress. Mark et. al. focused on developing method and tools for statistical evalutations
Action: Develop guidelines and tool for variable based metrics against requirements, using statistics methods (Mark Bourassa in consultation with David Berry) (Priority activity for 2014-16) - Add more networks, sampling variability and the network specific sampling to the Berry et al. statistical tool. This action will require an assessment of what represents independent sampling (e.g., ship passages and satellite overpasses rather than the number of observations). (Mark Bourassa with David Berry) - Action: Longer term: update the tool to reflect how different observation networks interact. One obvious target is bias reduction through the use of a high quality network.		In progress ?
Recommendation: identify 1 surface and 1 subsurface variable to test the concepts of variable based metrics against requirements		
Action: Contact GHRSST re calculating the statistical performance of the SST observations to capture the (spatial/temporal) ENSO Signal, based on Bourassa/Berry guidelines. (Co-Chairs to write to GHRSST Chair/Office) (By end October, based on trial guidelines above)		Deferred until guidance on method/approach can be provided.
Action: Contact US AMOC Team re. calculating the statistical performance of the observing system to capture the (spatial/temporal) AMOC signal. (Co-Chairs to write to US AMOC Science Team, AtlantOS PIs) (by End of October).		Deferred until guidance on method/approach can be provided.
Action: Identify sampling requirements for measuring changes in extremes: initially test with surface winds and waves. This addresses the observing system's ability to identifying the distribution of values for an ECV, with a focus on the high impact events. (time line: one year)	?	Deferred until guidance on method/approach can be provided.
Recommendation: Consider TPOS 2020 SC and Task Team		Weidong Yu is attending the next meeting. We will follow

Members as future OOPC members to address OOPC expert gaps. (Weidong Yu will be attending the next OOPC meeting).		the development of Task Teams closely.
Recommendation: OOPC to work with DOOS to facilitate connections the observing community in the development of DOOS Implementation.		Bernadette Sloyan has joined the OOPC
Action: DOOS telecon to be organized between DOOS, GSOP, Interested basin reps, and GOV OSEval TT, Deep Argo, OceanSITES (DOOS Coordinator to organise)		DOOS requires intellectual leadership. GOOS Secretariat/Co-Chairs canvassing for potential leaders.
Action: DOOS Whitepaper to be sent to CLIVAR Basin Panels/GSOP (other groups? Decadal Prediction panel?) for comment. (OOPC secretariat to coordinate discussions)		Consultation process deferred until intellectual leadership in place.
Action: Strawman Locations for OceanSITES SBE 37 Temperature sensors will be discussed by the DOOS Physics TT, and then sent to CLIVAR Basin Panels/GSOP for input (Bob Weller/Bernadette Sloyan; OOPC Secretariat/DOOS Coordinator to coordinate distribution)		Discussions underway between Bob and Bernadette.
Action: Katy to draft a template for evaluation proposal and include background information to frame activity for discussion with community/seeking funding. (September)		Complete!
Action: Toshio (Broadscale), Bernadette (Boundary/Deep), John (Shelf/Coastal), Mark (fluxes), Gilles (OSEVal) to define scope, a possible activity strawman and groups/individuals to engage, etc., focusing on boundary currents/shelf interactions. Inc. Argo enhancement plans. (by end October)		A scope is under development. Possible outcomes have been drafted. Next steps need to be determined.
Action: Request CLIVAR Panels provide information on boundary current observations and process study activities (existing, historical, planned), approaches and underlying questions (concrete recommendations that would allow us to scope the resource requirements; Modelling challenges, phenomena you need to observe and what you might need to leave in place for modeling) to feed into proposed Boundary Currents evaluation. (Boundary Currents Scoping team).		In process. Nico Caltabiano is gathering information
Action: Write to the coordinators of the WGNE/OOPC SURFA project, requesting status report, and reiterating OOPC's support for this activity (contact names required)	?	Katy wrote to SURFA context, and an update was requested for OOPC-18
Action: Request an update on regional flux activities (TPOS and SOOS) for the OOPC-18 meeting (2015**)**		TPOS 2020 TT on the Planetary Boundary Layer is being chaired by Meghan Cronin and Tom Farrar. Mark is involved in the SOOS Fluxes activity.
Action: Discuss cross cutting activities on fluxes with AOPC chair/vice chair ahead of and in the sidelines of the GCOS SC meeting. (OOPC Co-chairs)		So far, we are not receiving a strong message that this is a priority for AOPC.
Recommendation: keep regional polar activities as watching brief,		Mark is on the organizing committee.

and engage as needed (i.e. SOOS Air Sea Fluxes Workshop)		
Action: request a webinar from the organizers of the SOOS under ice workshop (October 2014), once the report is available (mid 2014)		Proposed to GOOS Director
Recommendation : Coastal requirements to be considered as an integrated components of OOPC core activities, in developing variable specifications and the evaluation of boundary current-shelf interactions		Being implemented.

Appendix 6: Work Plan.

GOOS –
GCOS –
WCRP –

Work Plan 2013-2018

2015 Update

The Ocean Observations Panel for Climate is part of the Global Ocean Observing System the Global Climate Observing System and the World Climate Research Program. OOPC provides advice and guidance on observations to the Joint WMO-IOC Technical Commission for Oceanography and Marine Meteorology.

Contents

1. Introduction

1.1. Organizational context

The Ocean Observations panel for Physics and Climate had the role of providing scientific recommendations and reviewing 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). Traditionally, OOPC has focused on open ocean and physical variables. For climate relevant biogeochemical variables, OOPC has liaised with the International Ocean Carbon Coordination Programme. Following the development of the Framework for Ocean Observing[4], GOOS now has an expanded structure of 3 expert panels for physics (OOPC), biogeochemistry (an expansion on IOCCP) and biology and ecosystems.

OOPC therefore has subtly different but overlapping roles from the perspectives of its 3 main sponsors; delivering the requirements for sustained ocean observations to GCOS (which also has terrestrial and atmospheric components) and the physics component of the Global Ocean Observing System (connecting to the Biogeochemistry and Biology Panels), in addition to working with WCRP to define the ocean observing requirements for climate research.

Both GCOS and GOOS advocate a variables approach to defining observing system requirements, through Essential Climate Variables (ECV's) and Essential Ocean Variables (EOV's) respectively (see figure 1). OOPC will be responsible for defining and reviewing the implementation of Ocean based ECV's, and physics based EOVs. Current ECVs are listed in table 1, and the EOV/ECV space that OOPC is responsible for is illustrated in figure 2.

[4] **GOOS Framework for Ocean Observing** http://www.oceanobs09.net/foo/

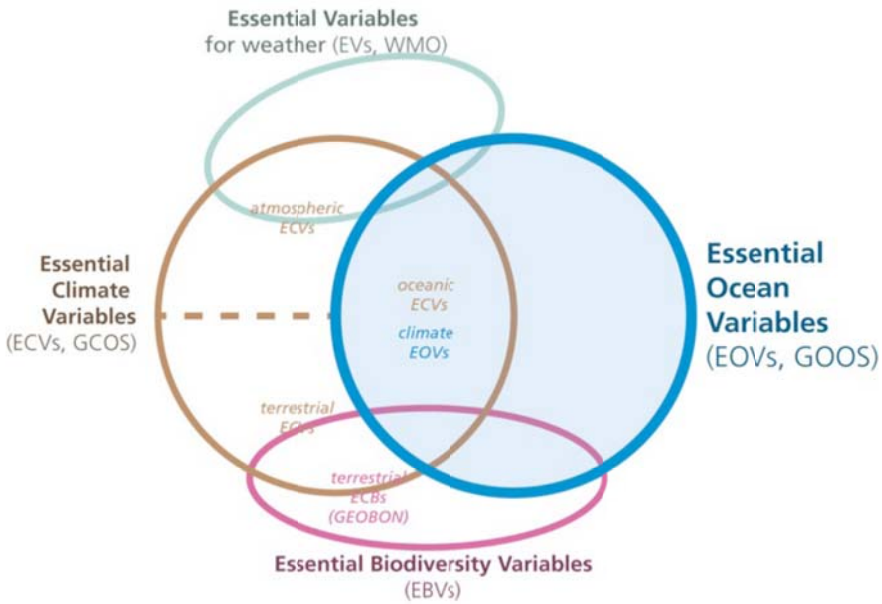

Figure 1. Applying the Essential Variables concept for different applications

Domain	GCOS Essential Climate Variables
Atmospheric (over land, sea and ice)	**Surface:**[1] Air temperature, Wind speed and direction, Water vapour, Pressure, Precipitation, Surface radiation budget. **Upper-air:**[2] Temperature, Wind speed and direction, Water vapour, Cloud properties, Earth radiation budget (including solar irradiance). **Composition:** Carbon dioxide, Methane, and other long-lived greenhouse gases[3], Ozone and Aerosol, supported by their precursors[4].
Oceanic	**Surface:**[5] Sea-surface temperature, Sea-surface salinity, Sea level, Sea state, Sea ice, Surface current, Ocean colour, Carbon dioxide partial pressure, Ocean acidity, Phytoplankton. **Sub-surface:** Temperature, Salinity, Current, Nutrients, Carbon dioxide partial pressure, Ocean acidity, Oxygen, Tracers.
Terrestrial	River discharge, Water use, Groundwater, Lakes, Snow cover, Glaciers and ice caps, Ice sheets, Permafrost, Albedo, Land cover (including vegetation type), Fraction of absorbed photosynthetically active radiation (FAPAR), Leaf area index (LAI), Above-ground biomass, Soil carbon, Fire disturbance, Soil moisture.

Table 1: Essential Climate Variables (*www.wmo.int/gcos*)
[1] Including measurements at standardized, but globally varying heights in close proximity to the surface, [2] Up to the stratopause, [3] Including nitrous oxide (N_2O), chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs), hydrofluorocarbons (HFCs), sulphur hexafluoride (SF_6), and perfluorocarbons (PFCs), [4] In particular nitrogen dioxide (NO_2), sulphur dioxide (SO_2), formaldehyde (HCHO) and carbon monoxide (CO), [5] Including measurements within the surface mixed layer, usually within the upper 15m.

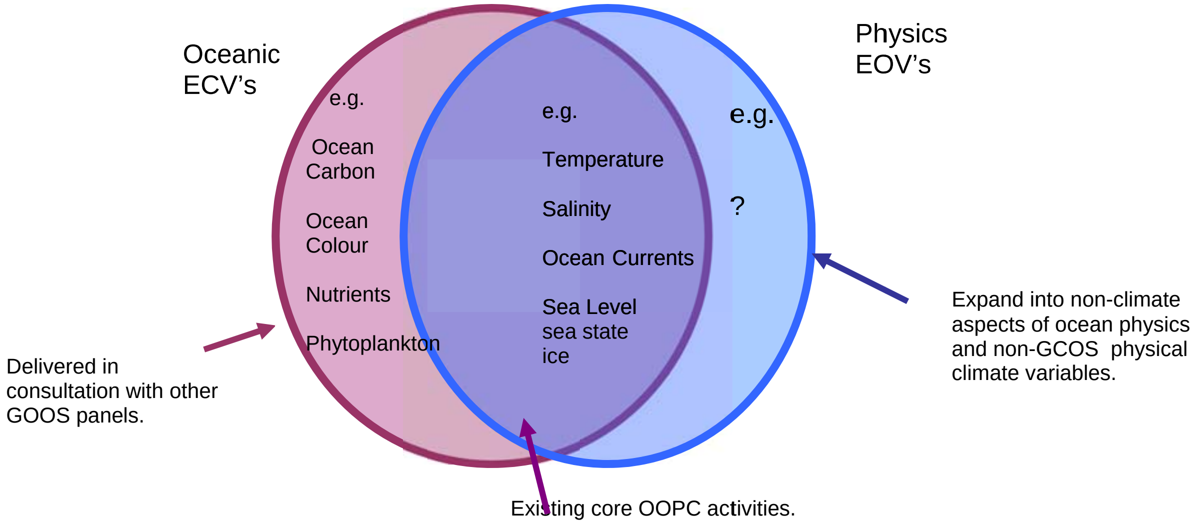

Figure 2. The domain of OOPC; delivering physics EOV's to GOOS and Oceanic ECV's to GCOS (* Potential Physics EOVs).

The priorities for OOPC have traditionally been delivered through the GCOS implementation plan[5] and to the UN Framework Convention on Climate Change. The GCOS Implementation Plan will be updated by 2016 with the bulk of the work being carried out in 2015. A GCOS Status Report was developed during 2014-2015. The implementation of GOOS will be guided by the GOOS Framework for Ocean Observing, with a decadal planning horizon via the OceanObs conference series; the next OceanObs conference will be in 2019.

In summary, the GCOS Implementation Plan update (2016) and OceanObs conference (2019) provide 2 deadlines for reviewing and updating recommendations for sustained ocean observations.

2015 Update.

In order to better articulate the role of OOPC in both GCOS and GOOS Contexts, a diagram was developed (Figure 3), which highlights the role OOPC has as being responsible for the Physical Variables for GOOS, and leading on delivering to the Climate Theme (through GCOS) and the Real-time Services theme (mostly through JCOMM), while supporting the Ocean Health Theme.

[5] GCOS Implementation Plan 2010

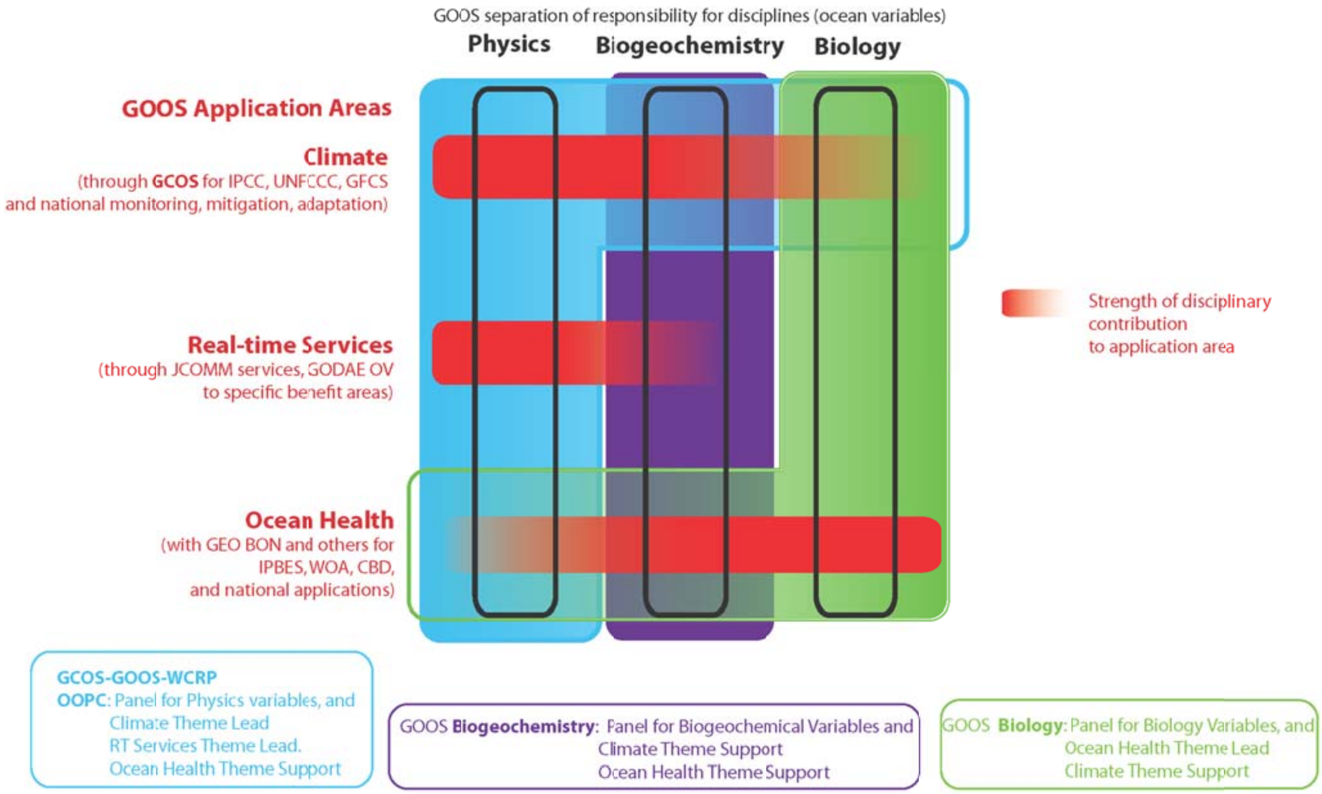

Figure 3: Articulating OOPC's role in GOOS as responsible for physics variables, and leading the delivery to Climate and Real-time Services Themes.

In 2015, OOPC met in parallel with the International Ocean Carbon Coordination Project (IOCCP) Scientific Steering Group/GOOS Biogeochemistry Panel to discuss requirements for variables, metrics, reporting and issues, and opportunities associated with the use of common observing platforms. The actions in this work plan relate to the OOPC sessions (numbered) in addition to the joint sessions (lettered).

2. Contributing to the GCOS and GOOS Assessment Processes

Below describes activities specifically related to developing input to the reporting processes for GOOS and GCOS. Activities in section 3 and 4 are development and evaluation activities in support of these deliverables.

2015 Update:

The different approaches to planning and coordination through both GCOS and GOOS; GCOS follows a more formal planning and assessment process; with a Status Report being released in 2015, and a new Implementation Plan in 2016. In parallel, a strategic map of the Global Ocean Observing System is being developed, which is a more dynamic/flexible process, but requires more detailed articulation of specifications for variables and networks. Trying to deliver to both processes in parallel presents a challenge for OOPC.

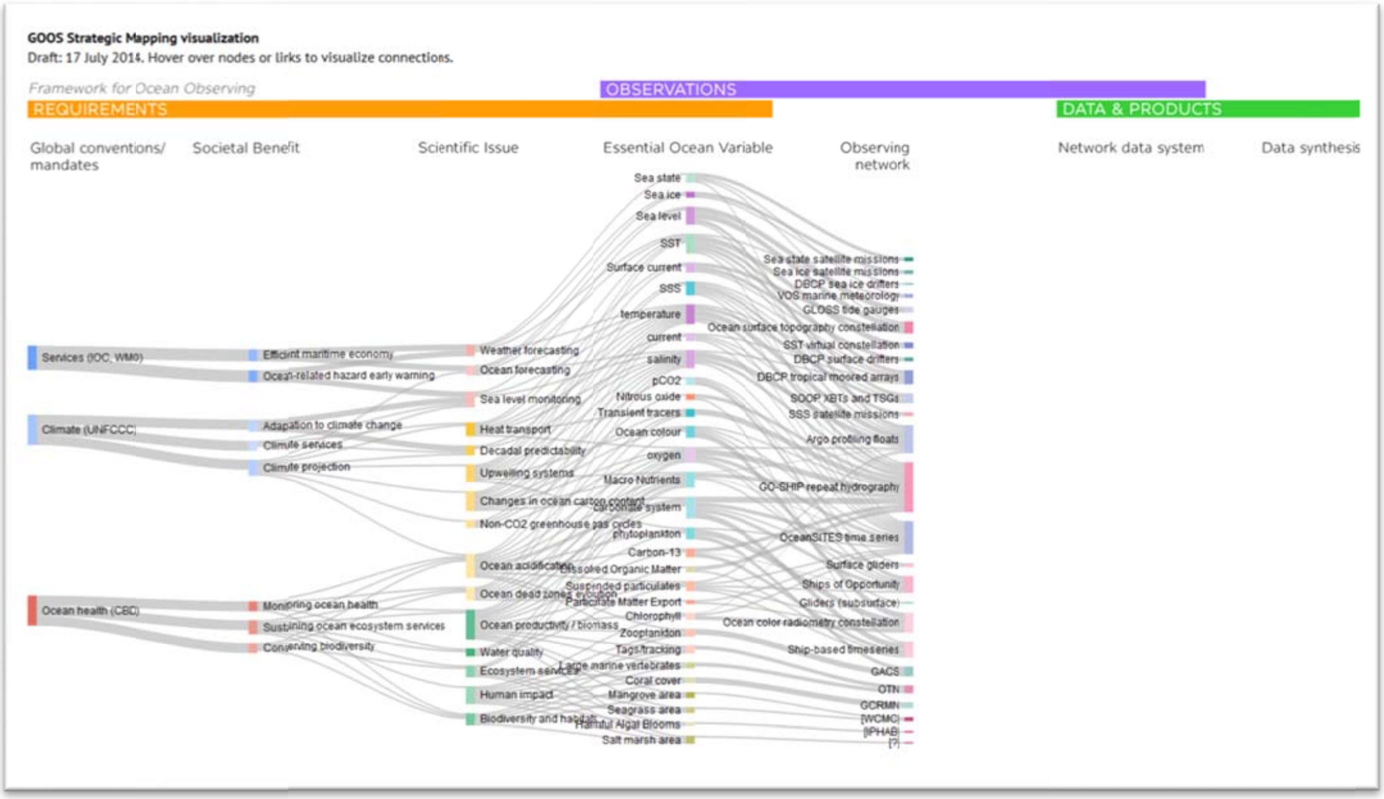

Figure 4: Screenshot of the GOOS Strategic Mapping Graphic (under development). http://lists-ioc-goos.org/goos-strategic-mapping-graphic/.

The GCOS process for developing the 2016 Implementation Plan is seen in Figure 5. OOPC will need to coordinate with the biogeochemistry and biology panels of GOOS, and with the JCOMM Observations Coordination Group to develop requirements for ECVs, and targets by network for the coming 5-6 years.

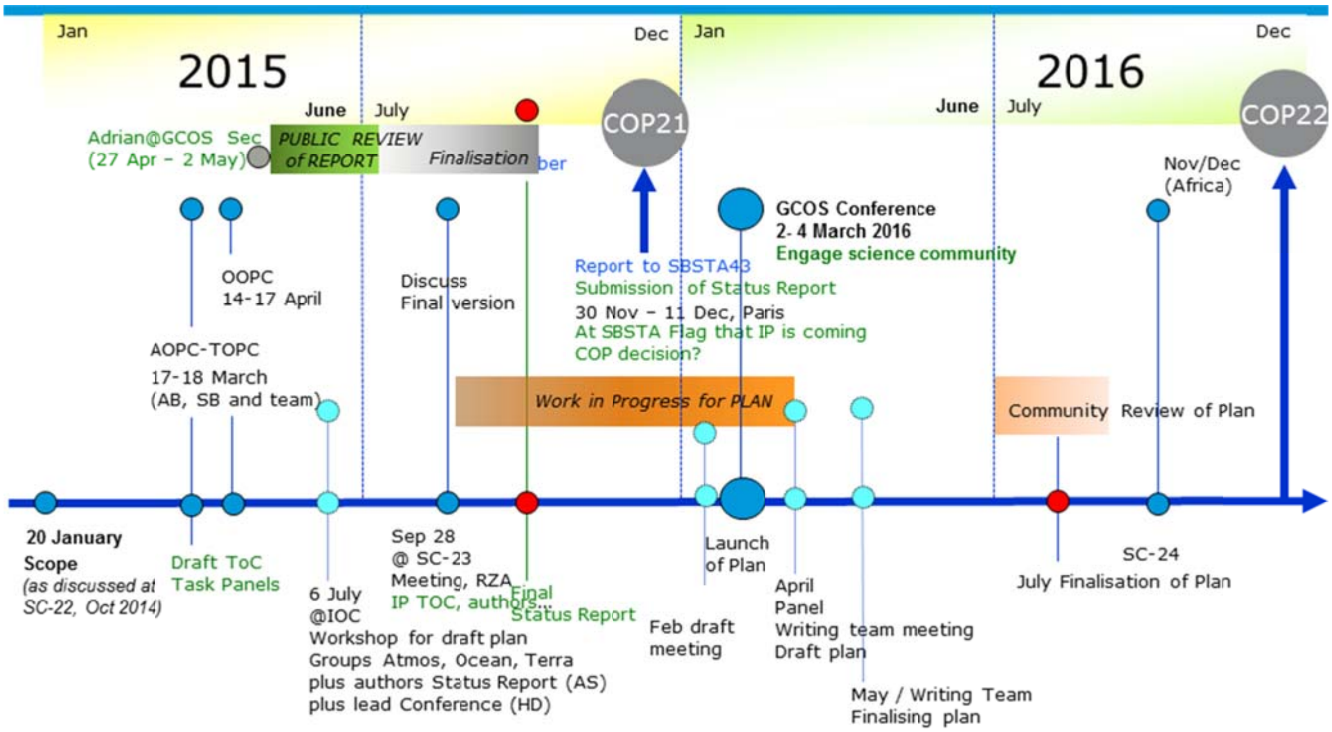

Figure 5: Roadmap for developing the 2016 GCOS Implementation Plan.

The GCOS IP will, at its core, be similar in structure to the previous one, with sections for each domain. In addition, there will be an overview section, focused on cross cutting issues such as:

- Relevance of ECVs to other UN Conventions (United Nations Convention on Combatting Desertification, UNCCD, and the Convention on Biodiversity, CBD)
- Use of ECVs for capturing the major climate budgets and cycles (Energy, Water, Carbon)
- Supporting variables that underpin climate observations (e.g. Gravity).

A preliminary timeline for the input from the panels into the GCOS IP includes:

1) Volunteers for Writing Team (by September)
2) Confirm sub-structure for Ocean Section (by end of year)
3) Check for completeness of ECV List (additions, subtractions, reframing, specifications) (by end of the year)
4) Review ECV sections (from IP, SR) (from November to February)
5) Revise ECV sections (from February to May)
6) Advise on combinations for climate system cycles, SDGs, WCRP GCs (From February to May)
7) Identify and propose supporting observations (from February to May)

Further work by the secretariat is required to finalise a timeline, identify tasks, and responsible panel members. Members of the panel agreed that the Status Report was largely written by the panel chairs. Given their academic commitments, they found it challenging to find the time. For the GCOS IP, it was agreed that panel members would be identified to take responsibility for delivering each ECV section.

B.. ACTION: GOOS Director requests feedback from panel members regarding how strategic mapping, variable and network specifications could be of help in national roles and activity in addition to international roles (All)

C.. ACTION: A document to be written explaining the strategic mapping and particularly the use of the

network templates (Albert Fischer, Katy Hill, by 24th April)

12.. Recommendation to GCOS SC/Secretariat to provide further details for milestones regarding early preparation of the IP

13.. ACTION: Develop detailed timeline for coordination/development of input to the GCOS IP, and expectations for input from GOOS Biogeochemistry and Biology Panels (OOPC Secretariat)

14.. ACTION: Identify an OOPC panel member to take responsibility for coordinating/developing input for each ECV (OOPC Secretariat).

15.. Recommendation to GCOS SC/GCOS Science Conference Organising Committee to provide Guidance on structure and expected contributions to GCOS Science Conference

2.1. Evaluating requirements for Essential Ocean/Climate Variables

Traditionally OOPC has developed requirements for ocean Essential Climate Variables (ECVs) to deliver into the Global Climate Observing System (as discussed in section 1). OOPC now has an expanded mandate, and a much bigger challenge in terms of connecting to various other groups. This now includes delivering requirements for physical variables for GOOS. While most of core variables considered essential will be the same for both GCOS and GOOS, the requirements may vary. For instance, the GOOS mandate is broader than climate, and reaches further into biogeochemistry and biology. In both contexts, we need to consider requirements for ocean variables to support the work of sibling panels. In GOOS, there are requirements for underpinning physical and environmental information to support biogeochemistry and biology; in GCOS, there are needs to connect up requirements across the interfaces with the land and atmosphere, in tracking the major budgets and cycles of the Global Climate Observing System. In both cases, the observations sometime share platforms and infrastructure, which can be linked to strengths and risks in the observation networks. With all these complexities in mind, OOPC would like to take a ‘collect once, serve many masters’ approach to defining and reporting requirements, and has drafted a template to use as a framework for developing EOV specifications.
Such a template is not without its challenges; OOPC is charged with developing a framework for ongoing evaluation of observing systems. To do this, we need to articulate the requirements to evaluate the observing system against. While we can identify space/time sampling and accuracy requirements for different applications in a simple table, it is harder to articulate regional variability in space time requirements. In addition, particularly for biology, there may be requirements for detecting specific thresholds, as opposed to accuracies; and we need a way also of articulating our confidence in the requirements: i.e. how well do we need to know what we need to know? (i.e. Estimate based on first principles, improved requirements based on process study, refined requirements based on X years of sustained observations) A draft template can be found in appendix 1. Following the Framework for Ocean Observations (FOO) we anticipate a cyclic process to refine these requirements.

2015 Update:

A lot of work has gone into the development of Variable Specifications for physical variables, with at least two rounds of iterations complete with experts. However, these documents are now very heterogeneous, and need to be more consistent, with an appropriate level of detail, to inform strategic mapping: Particularly in identifying societal benefit areas, scientific applications and phenomena to capture. They then need to be cross checked with the Biogeochemistry Specifications for consistency.

OOPC needs to work closely with the GOOS Biogeochemistry Panel in finalizing Variable Specifications, and drawing on them as input to the GCOS Implementation Plan.

A.. ACTION: OOPC Develop mini-spec sheets upstream, of applications, and phenomena to control vocab, simplify EOV spec sheets, reduce duplication, and limit level of granularity. Johnny Johannesen, Bernadette Sloyan (by 15th June).

M.. ACTION: OOPC and IOCCP/GOOS Biogeochemistry Panel to Coordinate an Ocean Sciences Town Hall on EOVs and ECVs.

G. ACTION: OOPC requests feedback from IOCCP/Biogeochemistry Panel on requirements for physical variables. Do current specifications meet needs? Can we articulate applications of physical variables for BGC applications? Coincident observation requirements, and latency of QC data delivery (by end of 2015, as input to GCOS IP).

I. DECISION: OOPC and IOCCP/GOOS Biogeochemistry agreed to recommend 7 of the 9 BGC EOVs as ECVs to GCOS (mostly a reframing of existing ECVs, all of which are whole of water column variables).

7.. Action: Change names of Ocean ECVs to interfacial and ocean column: Justification needs to be drafted and presented to GCOS SC (September 2015: OOPC Co-Chairs)

J.. Recommendation to GCOS SC: IOCCP/GOOS Biogeochemistry Chair/Member be invited to the next GCOS SC to present case for changes to Ocean Biogeochemistry ECVs. (Update: Toste Tanhua will be invited to the GCOS IP Planning meeting on the 6th July, Paris).

K.. ACTION: OOPC Members to take ownership of 1 or 2 ECVs and write sections to the GCOS Implementation Plan. Champions for each variable to be revisited to consider new members (end June). Assessment/Writing activity; late 2015, early 2016).

L.. Recommendation: Formation of GCOS IP Ocean Section Writing Team: OOPC CO-Chairs to lead on collating IP input and writing overview sections. Invite IOCCP Chair/Member to join team for BG, and explore whether an additional representative from GOOS Biogeochemistry/Biology is needed to cover all ECVs.

2.2. Articulating network contributions.

2015 Update:

Complementary to the Variable Specifications, a Network Specification template has been developed. Feedback on the template design has been sought from the OOPC and JCOMM OCG Co-Chairs, and JCOMMOPS. It is now being filled by the members of the JCOMM OCG, with a view to having final documents by the end of 2015, to inform targets for the 2016 GCOS Implementation Plan.

D. ACTION Panel members to look at Network draft templates, feedback on clarity, utility, gaps, etc. as initial guidance into JCOMM OCG (by 24th April).

E. ACTION: IOCCP/GOOS Biogeochemistry Panel to make a list of the key observing networks and their coordination mechanisms/contact points identified (where there is one) as an output from this meeting (including potential networks). (By 24th April)

F. ACTION: OOPC to check granularity of existing Draft Network Specifications, and identify where they can be combined, and identify potential additional networks. (By 24th April).

G. ACTION: IOCCP/GOOS Biogeochemistry Panel to scope a Workshop on BGC Network Specifications, Targets, Metrics (late 2015/early 2016?). (IOCCP to take into discussions in separate session on Thursday)

L. Action: Bernadette to report to OOPC-19 on outputs from Argo/GO-SHIP/IOCCP Conference (see www.gaic2015.org), 14-18 September 2015, Galway, Ireland.

M. Action: OOPC/JCOMM OCG and GOOS Biogeochemistry Panel/IOCCP to work with OceanSITES through Network Specification Process to articulate requirements for moored time series and other OceanSITES components, and the design targets/specifications. (During 2015)

2.3. Observing element/network status and metrics

To complement the requirements and status articulated by variable, we also need to continue to have a network based view of observing system contributions and status. Traditionally, we have assessed the status of the observing system in terms of a growth metric, % of design complete. However, this is no longer sufficient as a) it doesn't reflect the level of ongoing effort needed to keep the observing system static, and also b) it isn't clear what the contributions of the different observing networks are against requirements. Further work is needed to be able a) to articulate the contributions of observing networks and interdependencies, and b) to articulate the level of effort required. To assist in gathering the required information, OOPC has developed a template to complement the EOV Template, for developing specifications.

2015 Update:
There are two lines of work in the context of improved observing system metrics:

1) Implementation Metrics by network (based on targets articulated in Network Specifications), and
2) Performance metrics by variable (based on requirements articulated in Variable Specifications).

Implementation Metrics are being developed through the JCOMM OCG in collaboration with JCOMMOPS. Metrics being considered include:

- Number of platforms against target
- Coverage against target
- Annual level of effort against target
- Number of nations contributing
- Etc.

OOPC/GOOS Biogeochemistry provided feedback on additional metrics for JCOMM OCG to consider.

4.. ACTION: JCOMM OCG to report to OOPC/GOOS SC on summary of risks to the observing system (GOOS SC: 24-27th May 2015)

Q. Recommendation to JCOMM OCG to consider including additional network metrics in regular reporting (examples)

- **a. Recruitment**
- **b. Quality of data or data flow**
- **c. Funding stability**
- **d. Age verses design age**
- **e. Deployment locations, or for sampling in specific regions**
- **f. Connections across networks**

g. **Number of EOVs measured**
h. **Value for validation**
i. **Innovation in the network**

2.2. Developing approaches for assessing scales and accuracy requirements of observations

Quantitative approaches to observing system design and assessment through identifying the processes which need to be resolved, defining the spatial and temporal scales at which we require observations of variables and also defining accuracy requirements will enable the optimum combination of platforms to be determined for specific applications. The mostly linear link between spatial scales and temporal scales are well understood; where processes operating on long time scales also operate on broad spatial scales, i.e. changes in global ocean heat content; and processes on shorter timescales also operate on shorter space scales, such as surface waves. There can also be a relationship between scales and accuracy requirements. Long time scale, large spatial scale issues such as ocean heat content require either a relatively small number of highly accurate observations, or a larger number of observations with equally low bias and larger uncertainty. However, the shorter timescale and smaller spatial scale processes, particularly in the coastal zone, show such high variability that accuracy requirements are often less stringent.

A number of recent papers have tackled more quantitative approaches to observing system requirements, design and assessment (e.g. Bourassa et al., 2013[6]; Oke & Sakov 2012[7]; Berry and Kent 2009[8]). OOPC will explore approaches to date, and set out a plan for how this will be implemented in the context of the early priorities identified below.

2015 Update.

A paper was drafted ahead of the OOPC-16 meeting (September 2013), and discussed by panel members. There was a strong recommendation that the requirements setting needs to be informed by what can be actually achieved with the available observation technology and funding.

Since OOPC-16, OOPC Co-Chair is collaborating with David Berry (JCOMM) to develop the tool for applying the statistics provided in the templates with records of the actual sampling. The eventual goals are to complete the paper on the method and to make the information available on line through an interactive tool. Methodology has been discussed with David Berry; however, this is considered a long term research activity, and perhaps the OOPC should explore collaborations to consider a number of approaches.

The GSOP Panel has a mandate for evaluating products, and could contribute to such variable based evaluations. In addition, various modeling and statistical approaches to evaluating observing systems was presented at the joint GODAE OceanView Observing System Evaluation Task Team (OSEval TT)/CLIVAR GSOP Workshop in Toulouse in December 2014.

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[6] Bourassa, M.A., S.T. Gille, C. Bitz, D. Carlson, I. Cerovecki, C. Clayson, M.F. Cronin, W.M. Drennan, C.W. Fairall, R.N. Hoffman, G. Magnusdottir, R.T. Pinker, I.A. Renfrew, M. Serreze, K. Speer, L.D. Talley, G.A. Wick (2013) High-latitude ocean and sea ice surface fluxes: challenges for climate research. *Bulletin of the American Meteorological Society*, 94, 403-423. doi:10.1175/BAMS-D-11-00244.1.
[7] Oke, P. R., P. Sakov, 2012: Assessing the footprint of a regional ocean observing system. *Journal of Marine Systems,* 105-108, 30-51, doi:10.1016/j.jmarsys.2012.05.009.
[8] Berry, D.I. and E.C. Kent (2009) A new air-sea interaction gridded dataset from iCOADS with uncertainty estimates. Bulletin of the American Meteorological Society, 90, 645-656. DOI: 10.1175/2008BAMS2639.1.

The NOAA Observing System Monitoring Center (OSMC) is funded to work on more output focused observing system metrics, so there is an opportunity to connect OSMC to OOPC discussions and activities in this space. The discussion was initiated at a workshop in April 2014 in Toulouse which included OOPC, JCOMM OCG, JCOMMOPS and OSMC. Further discussion between OOPC, GSOP, and the GOV OSEval TT, and NOAA OSMC is needed on coordinating and evaluating approaches to assessing performance of the observing system, using a range of approaches.

1.. ACTION: OOPC to discuss with OSEval TT and GSOP the potential to collaborate on how OSE experiments are designed with a view to improving utility for observing system design? (John Wilkin, Johannes Karstensen, OOPC; Gilles Larnicol/Peter Oke (OSEval TT); Keith Haines/Magdalena Balmaseda, GSOP)

2.. ACTION: OOPC/GSOP to develop a strategy for engaging the climate model and forecast community in observing system design, through verifying and drawing on spatial/temporal variability in models. A 2 page scoping document will be developed (leads: Johannes Karstensen, OOPC; Matt Palmer, GSOP).

4.. ACTION: OOPC/GSOP to discuss the potential to partner to assess observing system performance by variable (Mark Bourassa, Johannes Karstensen, Keith Haynes, David Legler, Kevin O'brien)

11.. Recommendation to GOOS SC: Discuss coordination and oversight common approaches across regional activities, e.g. to engaging Modeling and DA community.

3. Developing and assessing products and information

3.1. Development and application of Ocean Indices

The coupled climate and ocean indices are tools to demonstrate how observations in the ocean can be used to deliver useful information on timescales which critical decisions are made. The development of the Global Framework for Climate Services and a mandate from GCOS to move towards delivering observations for assessing impacts and informing adaptation suggests that some focus in the climate indices space would be important. GCOS recently held a workshop on Climate Adaptation (Offenbach, February 2013), in which climate observation requirements for different sectors were discussed; including health, agriculture, forestry and coasts. Overwhelmingly the request was made for more local observations, and also the need to translate observations into information. OOPC can contribute by further working on demonstrating the link between ocean variability and regional climate. Previously, OOPC has developed case studies on the OOPC website of e.g. a farmer in California, or a Forestry Manager in Indonesia, describing what indices are relevant in their decision making, and how. There is potential to resurrect this activity and develop it further if the panel sees it as a priority.

2015 Update.

Examples of ocean observation applications for societal benefit will be identified as part of the GOOS website redesign, rather than developing an OOPC specific activity. OOPC can contribute by providing good exemplars, coordinated by GOOS Secretariat.

19.. Action: Identify good examples of ocean products and applied applications to highlight on the new GOOS website (Secretariat to coordinate: Katy Hill, Albert Fischer).

3.2. Other priorities

The Keeley report for JCOMM assesses the status and availability of observations by both variable and network. Further discussion is needed on the status of data availability by variable by the panel. Chapters by ECVs give a good and useful starting point in developing specification of EOVs and setting evaluation process for them.

2015 Update:

The Keeley Report was drawn on for the Data Management section of the GCOS Status Report. A forward strategy for improved data and information management will be developed during 2015, with a view to setting realistic targets in the 2016 GCOS IP. This discussion will be led by JCOMM OCG, with Steve Worley representing OOPC.
5.2. During discussions of CLIVAR activities, some concerns were raised that process study data was not being made available in a form that was consistent with the relevant sustained observing system data policies, e.g. OceanSITES for moorings.

O.. Recommendation to CLIVAR SSG: to revise Data Policy to request process studies align data management practices with relevant global sustained observing programmes, such as OceanSITES; and highlight policy when process studies are under development

4. Systems based Evaluations

In the section below, issues which have been identified as priority for OOPC are discussed, including a proposed priority/timeframe. It is acknowledged that OOPC cannot address everything at once; indeed, many groups in the community are working to address these issues. Therefore, the timeframes and priorities suggested are an indicator of when a focused OOPC activity or workshop may be timely and useful. In the meantime OOPC will continue to monitor the progress in these areas through WCRP and other programmes, encourage related activities, and engaging as needed and as practical.

4.1. Tropical Pacific Observing System

A workshop on the tropical Pacific Observing System has been proposed by NOAA and JAMSTEC, motivated by concerns about the sustainability of the TAO/TRITON mooring array. Since the development of the TAO/TRITON array in the 1980s, scientific requirements for observations have evolved, now spanning intra-seasonal to multi-decadal timescales; and also expanding from physics into biogeochemistry and biology. The available technology has also evolved, with routine observations from the Argo array, Altimeter and Scatterometer winds coming online more recently. In addition, new technologies such as ocean gliders, wave gliders and profiling moorings show potential. Following the successful implementation of its core mission, the International Argo programme is forging ahead with enhancements to the core array, including enhanced float deployments along equatorial regions.

OOPC has been invited to be involved in coordinating the workshop and has provided input on the scope, focus and process of the workshop, as well as suggested names for the scientific organizing committee. The workshop is likely to be in two parts; a science workshop, drawing on a whitepaper process and some commissioned design work (with stakeholders/funders also invited), and a follow up stakeholder workshop to discuss how best to collectively support the maintenance of the Tropical Pacific Observing System as a whole.

Some funds will be made available for attendance of OOPC members, and GCOS have offered sponsorship. The GODAE Oceanview Observing System Evaluation Task Team[9] is also likely to play a role in this workshop.

[9] **GODAE Ocean View Observing System Evaluation Task Team** https://www.godae-oceanview.org/science/task-teams/observing-system-evaluation-tt-oseval-tt/

The Tropical Pacific Workshop and review was successfully completed, chaired by David Anderson and Toshio Suga, and coordinated by the OOPC Secretariat. The review proposed the formation of a finite lifetime TPOS 2020 Project, to make the transition from the loosely coordinated set of observations to the observing system to be more robust, integrated and sustainable into the future. The final workshop report, recommendations and background is available at www.ioc-goos.org/tpos2020

2015 Update.

The TPOS 2020 Project has commenced in earnest, and held its first Steering Committee in October 2014 (Seoul, Korea). The Task Teams are currently being established. More details can be found at www.tpos2020.org, including a regular Monthly Status Report. TPOS 2020 Steering Committee Member, Weidong Yu has agreed to join OOPC, which strengthens the connection between OOPC and TPOS 2020.

A TPOS 2020 paper was provided to the OOPC meeting, asking for specific comment from OOPC, particularly on the criteria for prioritizing climate timeseries.

6.. ACTION: OOPC members to provide comment on criteria for prioritizing timeseries sites to TPOS 2020. (By mid June)

4.2. Deep Ocean Observing System

A strategy for a Deep Ocean Observing System is being coordinated by the GOOS Steering Committee to exercise the GOOS Framework for Ocean Observations in guiding the implementation of new components of the observing system. The Deep Ocean has also been identified as a priority for inclusion in the next version of the GCOS Implementation Plan (2016). The Deep Ocean Observing System will cover physics, chemistry and biology, and OOPC will be expected to take a lead on assessing requirements for physics variables, and connecting to the other panels as many platforms will be leveraged for particularly biogeochemistry.

There are key components that OOPC can initiate in preparation for this activity, such as defining the required scales, accuracies and regions of focus for observations in the deep ocean.

To track changes in deep ocean properties, highly accurate measurements of temperature and salinity will be needed below 2000m. A deep ocean pilot spin off of the Argo program called Deep Argo is under development. Floats will be equipped with accurate 'WOCE for life' CTD's. There is an initial plan to deploy deep Argo floats every 6x6 degrees in the South Pacific, with the potential, if successful, for this to be expanded into a global broad-scale array. Recent research on the warming and freshening of regions of deep water formation in the North Atlantic and around the Antarctic Continent provides a strong rationale for routine focused observations in regions of deep water formation and fate. Experience could be leveraged from the RAPID[10] project in North Atlantic, which now has a time series of 10 years.

OOPC should engage with Decadal Prediction groups to get inputs on observation requirements. In addition, Boundary currents/inter-basin exchanges (also an OOPC priority) have been identified as a potential region where decadal prediction systems could be validated. Groups working on sea level rise will also be interested in deep ocean observations, particularly as the deep ocean takes up more heat.

A good initial point of contact will be the WCRP Sub-group on Decadal Prediction[11]. An international workshop was held in May 2013 on Seasonal to Decadal Prediction hosted by Meteo France[12], which provided an opportunity to discuss observing system requirements.

[10] Rapid Climate Change (RAPID) http://www.rapid.ac.uk
[11] WCRP/CLIVAR/WGCM/WGSIP sub group on Decadal Prediction http://www.wcrp-climate.org/decadal/
[12] International Workshop on Seasonal to Decadal Prediction http://www.meteo.fr/cic/meetings/2013/s2d/

2015 Update:

Intellectual leadership of DOOS is currently being sought: the strategy will then go out to the community for consultation. That said, a number of activities are already underway, including the development of a Deep Argo Implementation Plan, Deep T/S Sensors on OceanSITES moorings, and discussions to instrument sea floor telecommunications cables, in addition to the existence of cabled observatories in some areas of the deep ocean. GO-SHIP is also considered a contribution to DOOS. It will be important that the development of these activities be considered in the light of the broader DOOS Strategy, rather than as isolated development activities. Further information was provided at OOPC-18.

4.3. Boundary Currents and Inter-basin flows, shelf interactions.

Boundary currents and inter-basin flows have an important role in our climate system by carrying heat and properties between the equator and poles, and between ocean basins. Western Boundary currents transport heat pole-wards, and regions of strong atmosphere ocean interactions. They are a source of uncertainty in climate models, and large uncertainties in air-sea flux estimates. Eastern Boundary Currents are associated with coastal upwelling zones, which have an important role in the ocean carbon budgets as regions of CO_2 out-gasing and biological uptake and support important fisheries.

However, particularly western boundary currents exhibit high variability, strong narrow flows and non-linear nature and can be difficult regions to measure. Inter-basin flows generally at ocean ‘chokepoints’ have the benefit of defined endpoints at each side of the current, and so estimates of their total flow is easier to constrain. Boundary currents are also regions of high uncertainty in climate models, and are a large source of uncertainty for air-sea flux estimate. Boundary currents are one of the next horizons for OOPC, as focus expands towards the coasts, and has also been identified for inclusion in the next GCOS Implementation Plan. It is likely that the impacts of western boundary currents are also of interest to AOPC, as WBCs make large contributions to vertical mixing between the boundary-layer and the free atmosphere. A co-investigation of fluxes in these areas could be of mutual interest.

Determining the drivers, fluxes (of heat, mass, salt and other properties) and dynamics of boundary currents requires observations at a large range of spatial and temporal scales. The optimal combination of observations required for sustained monitoring of western boundary currents will need to be drawn from a number of platforms, as no single platform can deliver all the information needed. There have been a number of efforts to observe both the Gulf Stream and Kuroshio Current in recent years and more recently mooring deployments have been carried out in the Agulhas and East Australian Currents. Following on from a successful process study in the Indonesian Throughflow (INSTANT), efforts to instrument key passages in sustained mode have been initiated. In the case of the Agulhas, the moorings were deployed along an altimeter track, and the aim was to see if a proxy for Agulhas strength could be determined from sea surface height anomaly data.

Accurate estimates of heat, mass and salt fluxes in boundary currents require accurate measurements of ocean velocity and surface relative vector winds. Assessing the requirements and approaches to observing boundary currents will contribute to defining approaches to measuring ocean velocity in general. The coupling between winds and SSTs suggests that there are large regional biases in winter season fluxes and Ekman upwelling. The spatial sampling requirements are yet to be determined for coupled wind and SST (including SST gradients) processes.

Technologically, while moorings are still the backbone of boundary current observations, high density XBT lines form the backbone to a global boundary current observing system, providing the long term geostrophic components of key currents. Altimetry is also effective on sufficient spatial/temporal scales. New technologies such as Pressure Inverting Echo Sounders (PIES) and ocean gliders also show potential. Sea floor cables could also be explored. Meanwhile, the Argo programme is planning to enhance float deployments in the western boundary current regions with the objective of maintaining double the ‘original Argo’ design density.

OceanObs09 whitepapers[13] form a sound basis, such as Send et al., (2009 ; Western Boundary Current observations) and Cronin et al., (2009; Air Sea Interactions). In addition, WCRP/CLIVAR held a Workshop on Boundary Currents Dynamics in July 2013.

Surface forcing for mid-latitudes changes rapidly in time and space, and requires satellite observations (in addition to the in situ observations) to adequately capture the spatial/temporal variability. The resolution, sampling and accuracy requirements must be better assessed for these regions and related applications.

2015 Update:

A 'boundary currents and their interactions with the shelf' proposal was presented at OOPC-18, led by Bernadette Sloyan and John Wilkin. CLIVAR Panels provided details of Boundary Currents activities. The boundary currents proposal recommended a session at Ocean Sciences on 'observing and modeling boundary currents'; to enable an assessment of the current status of activities, priorities, and inform a potential OOPC activity/workshop on observing boundary currents in the future. This was enthusiastically supported by the CLIVAR Panels.

8.. Action: OOPC/CLIVAR to coordinate a joint session on Observing and Modelling Boundary Currents and their interactions with the shelf at Ocean Sciences 2016 (Bernadette Sloyan, John Wilkin (OOPC), Alex Ganachaud (CLIVAR).

4.4. Observations for reducing uncertainties in Air Sea Flux Estimates

Models rely on air sea flux products to define the nature of the interaction between the ocean and the atmosphere; however, differences between air-sea flux products are often larger than the signal being estimated. OOPC has an ongoing Surface Flux Analysis Project (SURFA) with the WMO/WCRP Working Group Numerical Experimentation (WGNE), although it is not clear how active this project has been in recent years. Due to the many different sources of error in flux products, it is likely that incremental progress will also be made by focusing on observations linked to key sources of error in the coming years; many of which have been identified as priorities as part of other activities, such as upper ocean thermal observations, the Tropical Pacific, and boundary current observations (including heat, mass and salt fluxes).

2015 Update.

Fluxes were identified as a gap in all talks by CLIVAR panels. In addition, discussions have commenced with OOPC and AOPC regarding highlighting fluxes in the next GCOS Implementation Plan.

9.. ACTION: Discuss potential for improved characterization of fluxes to be a highlight topic in the next GCOS IP (Mark Bourassa to discuss with AOPC/TOPC chairs, and make case at next GCOS SC in Sept)

10.. ACTION: Develop case/requirements for wind stress (ocean vector surface stress) as an ECV. (Mark Bourassa, Bob Weller, Johnny Johannesen)

[13] OceanObs whitepaper series http://www.oceanobs09.net/proceedings/cwp/

4.5. Upper Ocean Thermal Review

An Upper Ocean Thermal Review has previously been identified as a priority for OOPC by GCOS due to the large differences in results people were getting from datasets of the same source. The issues around data accuracies have largely been resolved through work on the XBT fall rate error, Argo pressure corrections and the International Quality Controlled Ocean Database Project (IQuOD) [14]. A quantitative assessment of the correct balance between observing system components is still needed. However, this issue will likely be tackled (albeit not at a global level) as part the Tropical Pacific Workshop (see below) in the short term.

2014 Update:

Progress is being made on this topic incrementally, through e.g. a recommended TPOS 2020 Project Task Team on developing and improving the broad scale observing system. Other regional activities may also be working in this space. In addition the International Argo Programme is discussing the evolution of the Argo array design to enhance coverage in the Tropics, in western boundary currents, and expand observations in the polar oceans, and marginal seas. Discussion is needed with regard to these proposed enhancements in the context of the broader observing system. The Argo programme will likely move forward with their enhancement plans at a network level. OOPC should keep close communication with them and remind them to consider the enhancement of Argo in the context of the broader observing system. The same is true for other networks if they are considering revision of their design.

In addition, there have been calls for the design of the Drifter array to be revisited in light of the development of Argo and satellite observations. OOPC could provide guidance to each network for subsurface temperature/salinity regarding their enhancement/gap filling through development of EOV/ECV requirements, assessing implementation of EOVs/ECVs and the Status Report by network for GCOS. If it seems appropriate and effective, a focused activity may be led by OOPC during these processes. Broad scale observations TT of TPOS 2020 will provide a good practice for cross-platform coordination, including specification of different roles of different platforms. OOPC should make maximum use of their discussion and outcomes for guiding similar activities in other regions.

2015 (no update)

4.6. Polar Seas.

The Arctic and Southern Oceans are areas which are seeing some of the most rapid changes in the in the global ocean. As discussed in section 2.4., the warming and freshening of the regions of deep water formation in the North Atlantic and around the Antarctic continent is likely to have broad reaching impacts on deep ocean properties. However, there is a paucity of observations in polar ocean regions which has historically made it difficult to track and understand these changes. Technological advances in autonomous instrumentation and communications means that the polar oceans have recently become a strong focus for the observing community.

While technological challenges can be similar in the two regions, the coordination challenges are very different.

4.6.1. The Arctic Ocean

The prospect of ice free conditions in the Arctic and established interests of Northern Hemisphere countries means that the coordination of Arctic observations is a crowded space; including Arctic Regional Observing System (ROOS) as part of EuroGOOS and Sustaining Arctic Observing Networks (SAON), who recently held an Arctic Observing Summit in Vancouver in April 2013[15].

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[14] International Quality Controlled Ocean Database (IQuOD) Project http://www.iquod.org
[15] SAON Arctic Observing Summit http://www.arcticobservingsummit.org/

4.6.2. The Southern Ocean

The Southern Ocean research community have recently come together to develop a plan for a multidisciplinary observing system in the Southern Ocean, called the Southern Ocean Observing System (SOOS). SOOS has an implementation plan which identifies essential variables, and held a workshop on observations under the ice in Hobart in October 2012[16].

One area where OOPC coordination and connection to these activities may add value is in setting the requirements for observations for including ice-ocean interactions in data assimilating models. Surface energy fluxes remain an important issue in this region.

2015 Update

TOPC would like to meet with OOPC in 2016, with a specific focus on connecting up observations required for ice-ocean interactions. However, the panel felt that this was better addressed through a focused workshop, and that the panel will be busy focusing on delivering the ocean activities. With regard to general connections in the coastal space, OOPC sent a representative to the TOPC meeting in 2014, and concluded that in general the panels operate very differently, and connections are better fostered by cross representation in the short term, and identifying specific activities to progress through targeted workshops when ready. Given activities in CliC and SOOS in recent years, as well as under ice observations being highlighted as a specific gap by GCOS, an explicit focus on observing the ice-ocean interface ahead of the next GCOS IP would be timely.

18.. Recommendation: Development of requirements at the ice-ocean interface be discussed through a focused workshop, engaging SOOS, CliC, etc. communities.

19.. Recommendation: TOPC send a representative to the next OOPC meeting to promote understanding across TOPC/OOPC activities.

4.7. Regional and coastal seas

The activities and aspirations of OOPC sponsors point to a strengthened focus on coastal observations being timely. Previous GOOS planning activities in the coastal zone culminated in detailed reports by the Coastal Ocean Observation Panel (COOP)[17] in 2003, and the Panel for Integration Coastal Observations (PICO)[18] in 2012. Both grappled with how international coordination could add value in the coastal zone, and with how recommendations could be implemented. In addition, both groups suggested that coastal oceanography was effectively ‘done’ due to operational programmes for predicting extreme weather events and tsunamis, changes in the physical state of the upper ocean, and coastal flood monitoring; and largely focused on water quality and ecosystem services. The PICO plan updates the list of Essential Variables identified in the COOP plan (see text box below), - and considers spatial and temporal scales of processes/ecosystem responses, in addition to the timescale at which information needs to be delivered to inform decision making.

Essential Variables identified in the PICO Plan:

- External Pressures
  - Atmospheric (ocean surface vector winds, heat flux, precipitation, incident solar radiation);
  - Land-based inputs (freshwater, sediments, nutrients, pathogens, chemical contaminants);
  - Extraction of living marine resources (e.g. fishing);
  - Sea level rise, ocean warming and acidification;
  - Coastal flooding;
  - Natural ocean-atmospheric climate modes; and
  - Basin scale migrations of large pelagic predators.
- Ecosystem states (surface and subsurface)
  - Geophysical (fields of temperature, salinity, suspended matter, sea surface

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In the Framework for Ocean Observations, GOOS has reinforced that connecting open ocean and coastal activities is a priority for GOOS. GCOS is working to identify observation requirements that inform adaptation, and a recent workshop had a session on observations required for coastal zone management[19]. In addition, IOC leads activities in tsunami early warning systems and preparedness, coastal zone management related to short-term hazards and longer-term issues like coastal erosion, and JCOMM and WMO lead activities on coastal storm surge forecasting. All of these hazards related to sea level in the coastal zone, whatever their timescale, have some common observations requirements.

A focus on observations for climate adaptation related to sea level hazards in the coastal zone would benefit all these activities. However, this can be complex, as issues in the coastal zone potentially cut across the 3 GCOS panels (Ocean, Terrestrial and Atmosphere), but also need to consider socio-economic drivers. The GOOS regional alliances will also need to be engaged. For instance, uncertainties in runoff remain a substantial uncertainty for freshwater input and discussions need to continue with the TOPC panel on this topic.

The requirements in the coastal zone are likely to require the defining of new (non-climate but physical) Essential Ocean Variables such as bathymetry and topography, shoreline morphology and subsidence, wave swell, and saline intrusion.

A focus on the coastal zone would also potentially raise issues of the relationship of sea level hazards with other coastal issues, and may therefore cut across all 3 GOOS panels (physics, biogeochemistry, biology/ecosystems). This may raise new biogeochemical and biological variables in areas such as upwelling and fisheries, and ecosystems; and a series of socio-economic variables beyond the traditional reach of GOOS and GCOS related to population, demographics, poverty, hazard awareness and access to information, infrastructure density and coastal defenses, and land use.

Initially, ocean forecasting requirements may provide a useful framework in moving towards the coast. The GODAE Oceanview Task Team on Shelf and Coastal Seas would help provide the motivation for increased coordination of coastal data. A joint GRA/GODAE Oceanview activity would help build awareness of the utility of eddy resolving ocean reanalysis products in the shelf and coastal zone and the potential to improve the global reanalysis products in coastal regions through making coastal data-streams available. The decision by the International Argo Programme to enhance the global Argo mission to include deployments in marginal seas may also put the spotlight on regional data availability which will also be needed to validate Argo data.

In the open ocean, the coordination of observing priorities, data sharing and data standards are coordinated by platform based programmes and communities of practice, i.e. the Argo Steering Team, GO-SHIP, etc. In the coastal zone, groups using the same platforms would benefit from mechanisms to come together and discuss available technologies, data collection, quality control, data sharing and data management. Such Communities of Practice could potentially hosted by a GRA with a strong focus in that area. A priority for raising the profile of observations in the coastal zone is to ensure that existing data are made available to ocean reanalysis and forecasting groups, where possible in real time from a single point of access for each platform. However, it is not clear who would take on the management and distribution of these data for e.g. HF Radar, coastal moorings, and ocean gliders.

There is potential for ocean forecasting groups to use HF radar data for assimilation or validation. The establishment of a single source for data, with consistent QC would enable radar data to be routinely taken up by the ocean forecasting community. There was a GEO HF Radar Community of Practice, which was held a Global HF Radar Meeting at the MTS/IEEE Oceans '13 Conference[20]. Future candidate platforms for increased international collaboration include ocean gliders and coastal moorings.

[19] GCOS/IOC/UNEP Workshop on Observations for Adaptation, 26-28th February 2013. http://www.wmo.int/pages/prog/gcos/index.php?name=ObservationsforAdaptation
[20] IEEE/MTS Oceans 2013 Conference, 1-13 June 2013, Bergen, Norway http://www.oceans13mtsieeebergen.org/

In addition, there is a GEO Coastal Zone community of practice[21], which is co-chaired by Paul Di Giacomo and Hans-Peter Plag. Information should be requested on the status, plans and priorities of the GEO CZCP.

2015 Update:

OOPC has decide that the best approach to addressing coastal observation requirements is to integrate coastal activities into the broader OOPC activities; for instance;

- Variable Specifications with coastal requirements, articulated at the process/phenomena level.
- Highlighting the connection between the open ocean and cross shelf processes through the 'Boundary Currents and their interaction with the shelf' evaluation activity.

20. Action: Highlight Sea Level as an exemplar of integrating open ocean and coastal requirements in the next GCOS IP. (John Wilkin to lead).

[21] GEO Coastal Zone Community of Practice www.czcp.org

Summary and priorities

Based on the discussion of priorities and timeframes in previous sections, a summary timetable is provided below. The aim is to ensure the OOPC is equipped to provide input to key processes and reporting activities. While OOPC will continue to monitor a broad range of activities and connect to the various groups as needed, the timeframes suggested indicate when an OOPC led focused activity such as a workshop is likely on a particular topic, and will also inform the agenda of the OOPC meetings. Preparatory work is likely to be needed out of session and ahead of time.

	2013				2014				2015				2016				2017				2018				2019			
Meetings and deadlines			OOPC-16				OOPC-17			OOPC-18				OOPC-19				OOPC-20				OOPC-21					Oceanobs 19	
							GOOS SC	GCOS SC		OCG-6				GOOS SC		GCOS SC				GCOS SC				GCOS SC				GCOS SC
Approaches Observing system design and Eval			Draft paper on quantitative OS Design and Eval				Develop and test statistical tools for assessing observings system accuracy																					
Developing Observing System Metrics: Variable						Worksho	Improved Network metrics (with JCOMMOPS)				Developing metrics by Variable (OOPC, OSMC)																	
Evaluating ECVs and EOVs				Draft Specs for Ocean physics ECVs, with expert teams.					User feedback		Develop Specification for Ocean Surface Vector Stress,																	
Evaluating Observing Networks/Elements							Draft network/element Specs, consult with community				Update Network Specs, Develop clear network Targets.																	
GCOS Status Report and IP							Develop Status Report					Develop Implementation Plan																
Tropical Pacific Observing System			TPOS 2020 Review and Workshop				TPOS 2020 Project																					
Deep Ocean Observing System	Developing DOOS Strategy						Socialise DOOS Plan (Networks, Users,etc)				Identification of leadership, consultation of strategy				DOOS Project													
Upper Ocean thermal Observing System							Monitor Regional/Network activity (e.g. Argo, Drifters, TPOS) and persue through development of Variable specifications																					
Sea Level Observing System							Possible activity in conjunction with WCRP GC Sea Level, OCG/GLOSS																					
Observations for improving Air Sea Fluxes								Regional requirements (TPOS and SOOS)			Discuss Fluxes with AOPC for GCOS IP																	
Boundary Currents and Shelf interactions Observing System							Scope activity, consult			Plan Ocean Sciences Session			OS2016	Plan&/Run Workshop?														
Regional and coastal seas								Discussion of approach to coastal requirements,			Develop requirements for Sea Surface Height in Coastal Zone																	
Polar regions			Monitor, participate in regional activities,								Workshop: Observations at the Ice/Ocean Interface? (GCOS IP)																	

Activities coordinated outside OOPC

Formal reporting activities

OOPC Evaluation activities (intensity of colour = intensity of effort).

Table 2. OOPC Activity Timeline (Updated May 2015)

Appendix 1. Draft Variable specification template

Variable Specification Template
for Ocean Essential Climate Variable (ECV) and Physics Essential Ocean Variables (EOV)

Preamble/Introduction.

Variable Information	
Name of Variable (ECV and/or EOV)	e.g. Sea Surface Temperature
Sub-Variables[22]	e.g. Skin/Bulk SST, Irradiances
Derived Variables [23]	e.g Heat Flux
Supporting Variables [24]	
Contact/Lead Expert(s) [25]	Named contributors, and or expert team: e.g Group for High Resolution Sea Surface Temperature

[22] 'Sub-variables' are variables observed or known from instrumentation or metadata and used to calculate the desired EOV or ECV.
[23] 'Derived Variables' are variables derived from the EOV or ECV
[24] Supporting variables are those which are needed to deliver the EOV or ECV
[25] Contact experts should include experts or teams for platforms and for products

Requirements Settings					
ResponsibleGCOS/GOOS Panel **Reporting Mechanism**	OOPC GCOS Implementation Plan/Status Reporting to UNFCCC				
Readiness Level [26]	e.g.				
Societal Benefit Area (s)					
Scientific Questions/Applications to address					
Phenomena to capture.	e.g. Diurnal Cycle	e.g. Seasonal Cycle			
Temporal Scales of the Phenomena					
Spatial Scales of the Phenomena					
Magnitudes/range of the signal, thresholds to capture for the processes					

[26] See FOO readiness table on last page

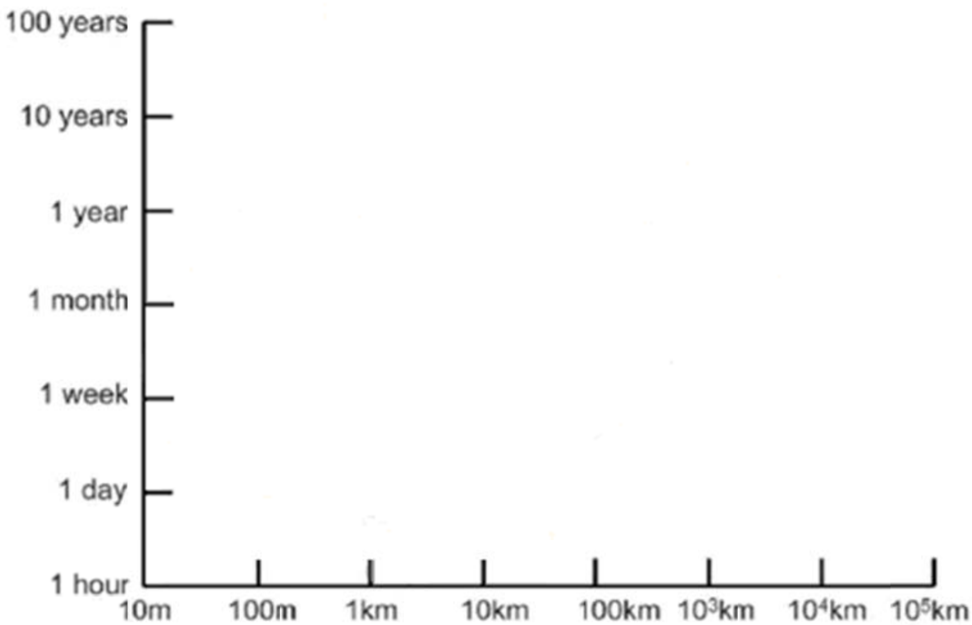

Figure 1: Draw Scales of processes[27] to be addressed, and fill in the magnitude of the signal to capture.

Figure 2: Map (optional)

[27] Processes refer to geophysical processes of interest (not space and time scales which can be seen in the plot). For example, western boundary currents or ENSO. The time scales refer to the geophysical processes rather than the scales needed to observed these processes. It is OK to include processes to which the EOV/ECV substantially contributes, but is not the sole variable.

Observation Deployment & Maintenance					
Observing Elements[28]					
Phenomena addressed					
Readiness Level $_1$					
Spatial sampling					
Temporal sampling					
Special Characteristics/ Contributions					
Relevant measured parameter(s)					
Sensor(s)/Technique					
Random Uncertainty estimate (units, one standard dev).					
Acceptable bias[29] **(units)**					
Uncertainty in the bias Units, one standard deviation)					

[28] If applicable, in a separate paragraph please describe how the networks interact with each other. For example, one network might be very sparse but it provides the most accurate data which are used to improve the calibration in other networks.
[29] In most cases, this information is equivalent to the required temporal stability in the bias

Future observing Elements					
Observing Elements					
Phenomena addressed					
Readiness Level [1]					
Spatial sampling					
Temporal sampling					
Special Characteristics or Contibution					
Estimated time when part of the observing system					
Relevant measured parameter(s)					
Sensor(s)/Technique					
Random Uncertainty estimate (units, 1 standard deviation).					

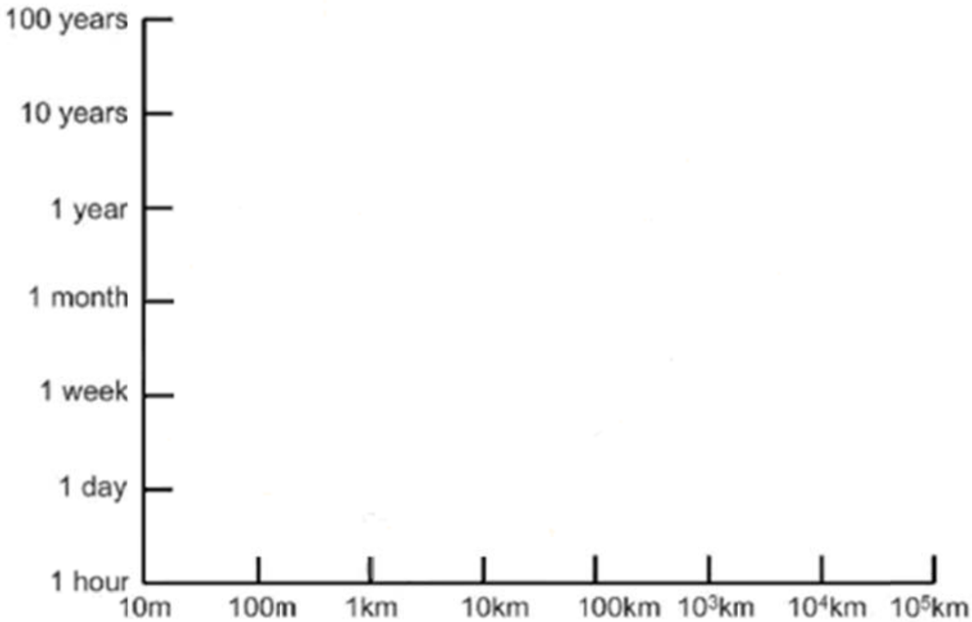

Figure 3. Draw in the well resolved observation scales of the component networks . If these scales are highly dependent on location or time, separate ovals could be drawn to capture this variability (e.g., one for the North Atlantic Ocean, and another for the Southern Ocean). If the capability changes greatly in recent times or will change in the near future (i.e., within five years), provide examples from two times.This refers to the scales that can be resolved, rather than the scales by the network, rather than for individual observations.

Figure 4: Map (optional)

Data & Information Creation[30]			
	e.g. Merged Satellite/In Situ SST	**e.g. Gridded in situ SST Product**	**Gridded in situ SST climatology**
Readiness Level $_1$			
Oversight & Coordination	e.g. GHRSST	e.g. HADSST	
Readiness status of Metadata			
Data Centre/repository			
Data Stream delivery and QC…			
Derived Products			

[30] If there are too many products (i.e. SST), describe each type of product.

Links & References	
Links (especially regarding Background & Justification)	
Links for Contributing Networks	
Data References	

[1] **Framework Processes and Readiness Levels** (from the Framework for Ocean Observing [FOO]).

FRAMEWORK PROCESSES BY READINESS LEVELS

Readiness Levels	Requirements Processes	Coordination of Observational Elements	Data Management & Information Products
Mature			
Level 9 "Sustained"	Essential Ocean Variable: • Adequate sampling specifications • Quality specifications	System in Place: • Globally • Sustained indefinitely • Periodic review	Information Products Routinely Available: • Product generation standardized • User groups routinely consulted
Level 8 "Mission qualified"	Requirements "Mission Qualified:" • Longevity/stability • Fully scalable	System "Mission Qualified:" • Regional implementation • Fully scalable • Available specifications and documentation	Data Availability: • Globally available • Evaluation of utility
Level 7 "Fitness for purpose"	Validation of Requirements: • Consensus on observation impact • Satisfaction of multiple user needs • Ongoing international community support	Fitness-for-Purpose of Observation: • Full-range of operational environments • Meet quality specifications • Peer review certified	Validation of Data Policy • Management • Distribution
Pilot			
Level 6 "Operational"	Requirement Refined: • Operational environment • Platform and sensor constraints	Implementation Plans Developed: • Maintenance schedule • Servicing logistics	Demonstrate: • System-wide availability • System-wide use • Interoperability
Level 5 "Verification"	Sampling Strategy Verified: • Spatial • Temporal	Establish: • International commitments and governance • Define standardized components	Verify and Validate Management Practices: • Draft data policy • Archival plan
Level 4 "Trial"	Measurement Strategy Verified at Sea	Pilot project in an operational environment	Agree to Management Practices: • Quality control • Quality assurance • Calibration • Provenance
Concept			
Level 3 "Proof of concept"	Proof of Concept via Feasibility Study: • Measurement strategy • Technology	Proof of Concept Validated: • Technical review • Concept of operations • Scalability (ocean basin)	Verification of Data Model with Actual Observational Unit
Level 2 "Documentation"	Measurement Strategy Described • Sensors • Sensitivity • Dependencies	Proof of Concept: • Technical capability • Feasibility testing • Documentation • Preliminary design	Socialization of Data Model • Interoperability strategy • Expert review
Level 1 "Idea"	Environment Information Need and Characteristics Identified: • Physical • Chemical • Biological	System Formulation: • Sensors • Platforms • Candidate technologies • Innovative approaches	Specify Data Model • Entities, Standards • Delivery latency • Processing flow

Figure 9. A Detailed View of Framework Processes for Varying Levels of Readiness.

Appendix 2: Network/Element Specification template

Specification of an observing system element (Template)

Introduction

Network Information	
Name of Network	
Description of Network[31]	
Oversight and Coordination[32]	
Process for community evaluation	

Network/Element Characteristics	
Phenomena Addressed[33]	
Spatial Sampling[34]	
Temporal Sampling	
Special characteristics or contribution.	e.g. multiple coincident parameters, complementarity with other networks, etc.

[31] Links to detailed descriptions/planning documents can be provided on last page.
[32] Links to key expert groups can be provided on the last page.
[33] See space for drawing stommel Diagram (figure 1)
[34] See space for drawing stommel diagram (figure 2)

Sensor Characteristics					
Sensors/Techniques					
Measured variables (sub variables[35])					
Random uncertainty estimates (one standard deviation).					
Uncertainty in bias (one standard deviation)					
Supporting variables[36]					
Derived products[37]			.		
Readiness: Observing Technique					
Readiness: Ability to scale globally					
Sustained in long term?[38]					

[35] Specific variables (for physical often the same as the ECV or EOV). For example seastate includes significant wave height, wave period and wave direction.
[36] 'Sub-variables' are variables observed or known from instrumentation or metadata and used to calculate the desired EOV or ECV. If data from another network is used to improve calibration (reduce random errors and uncertainty in biases) then provide a short note stating which data are used and estimate the impact.
[37] 'Derived Products' are value added products derived from the EOV or ECV. Derived products can include the use of other variables.
[38] Provide strengths, weaknesses, opportunities, and threats to sustainability

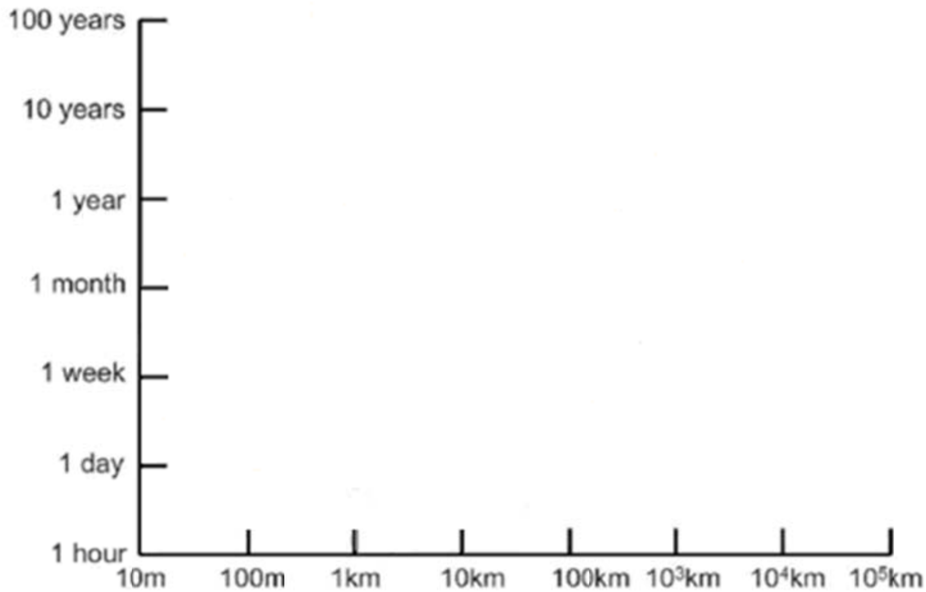

Figure 1: Draw Scales of phenomena to be addressed, and fill in the magnitude of the signal to capture. These are the scales that can be resolved by the network, rather than for individual observations.

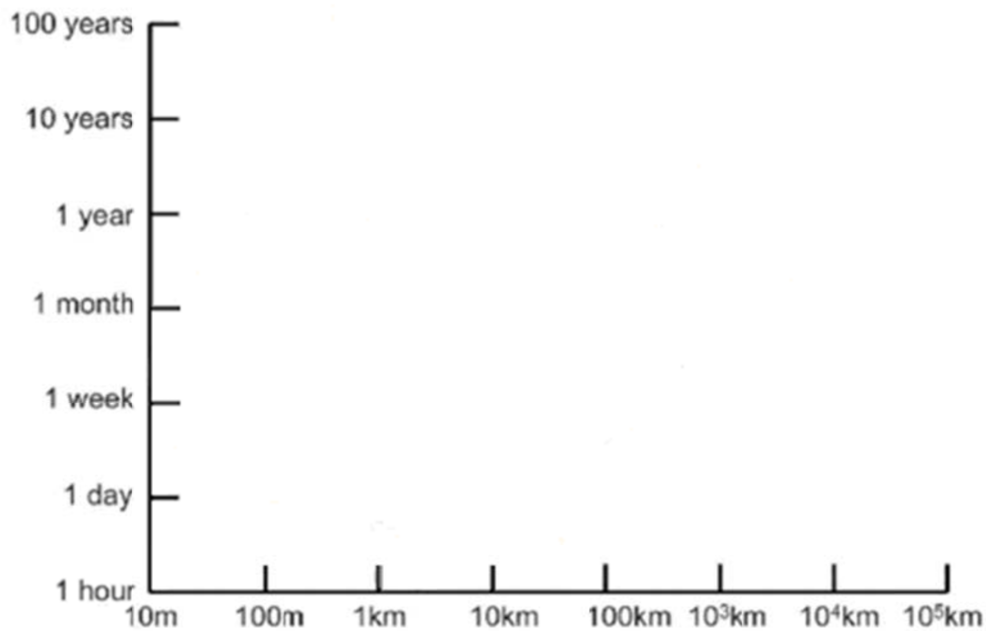

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Figure 3: Insert map (or maps) to illustrate sampling plan for network.

Data & Information Creation	
Readiness Level [1]	
Oversight & Coordination	
Readiness status of Metadata	
Data Centre/repository	
Data Stream delivery and QC…	
Derived Products	

Links & References	
Links* (especially regarding Background & Justification)	
Links for Contributing Networks	
Data References	

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Level 1 "Idea"	Environment Information Need and Characteristics Identified: • Physical • Chemical • Biological	System Formulation: • Sensors • Platforms • Candidate technologies • Innovative approaches	Specify Data Model • Entities, Standards • Delivery latency • Processing flow

Figure 9. A Detailed View of Framework Processes for Varying Levels of Readiness.

FIgure 4. Readiness levels from the Framework on Ocean Observations (FOO).

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GCOS • GOOS • WCRP

OOPC Ocean Observations Panel for Climate

http://www.oopc.info

GOOS, GCOS and WCRP are collectively sponsored by:

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