Report of the 1st Meeting of the TPOS 2020 Steering Committee

6-9th October, 2014,
Korea Institute of Ocean Science and Technology (KIOST),
Ansan, Korea

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1. Opening and introductions

The co-chairs welcomed attendees to the inaugural session of the TPOS 2020 Steering Committee (SC), and thanked everyone for being able to attend and, in particular thanked the Korea Institute of Ocean Science and Technology (KIOST) for hosting the meeting at relatively short notice.

Dr Dosoo Jang, Head of the International Cooperation department at KIOST, extended his welcome to the members of the SC, on behalf of the KIOST director. Dr Jang noted that KIOST will move to Busan by 2016, so the senior management are busy planning this move. Dr Jang also noted the international interest in the TPOS 2020 activity, which was discussed at the recent meeting of the Partnership for Observation of the Global Oceans (POGO). KIOST representatives attended the TPOS 2020 Workshop (La Jolla, January 2014), and reported issues and challenges to KIOST staff.

Dr Dongchull Jeon also added his welcome. The main projects being developed by KIOST of relevance to TPOS 2020 are “GAIA” and “Blue Ocean”. Dr Jang noted that the GAIA project is funded through the Ministry of Science and Technology, while Blue Ocean planned through the Ministry of Oceans and Fisheries, which is the parent of KIOST. The Blue Oceans project is not yet funded.

KIOST have a new research vessel under construction, which should be fully commissioned in late 2016, and will be used for implementation of the Blue Ocean project. KIOST invites international partnerships to collaborate as part of Blue Ocean. Dr Jang also noted that KIOST will soon launch a new geostationary ocean colour satellite, which will cover the western Pacific.

Dr Dongchull Jeon added that he hoped that the new 5000 tonne research vessel can contribute to TPOS in the future. He also offered to provide a tour of the Lab and satellite base.

The Steering Committee members then briefly introduced themselves. While the TPOS 2020 Workshop recommended the SC not exceed 10 (or 12) members, it was decided that the breadth of science challenges within TPOS 2020 meant that a larger membership was needed to ensure that the SC had the required balance of expertise. The membership now totals 15 (see Appendix 2 for full membership details).

2. Agenda

The co-chairs summarised the agenda and expected outcomes. The meeting was structured around three science talks plus shorter presentations focused on specific topics, with time for SC discussion designed to foster the settlements of strategy going forward. The main aims of the meeting were to agree on the Terms of Reference for several Task Teams, and to identify short term and longer term activities. The Co-Chairs also needed to be prepared to brief the TPOS 2020 Resources Forum, which met by Teleconference on the 10th October, immediately after the SC meeting. Some additional items were added to the agenda (6f) before the Agenda was adopted by the SC, and the timing of some items was altered to allow relevant members to participate before departing (see Appendix 1).

Further details of the meeting, including powerpoint presentations and background documents, can be found at www.tpos2020.org.

3. Background and SC Terms of Reference

The co-chairs presented background to the TPOS 2020 Project, including the motivation for the January 2014 TPOS 2020 Workshop, Workshop outcomes and the Terms of Reference (ToR) for the TPOS 2020 Project were also presented (see Appendix 3). The co-chairs emphasised the opportunity to build on momentum from the Workshop.

The TPOS 2020 connections to other panels and activities were discussed, in particular, the connection to observing activities in other basins through, for example, the CLIVAR Basin Panels. There is a strong connection to the Indian Ocean Observing System through SC members Yukio Masumoto and Weidong Yu, and there are common scientific and logistic issues with existing outside groups. In addition, links to the PIRATA programme and the European proposal for a systems based evaluation of the Atlantic observing system (AtlantOS) should be fostered. (AtlantOS has similar aims as TPOS 2020.)

Action 1: Explore the possibility for a future meeting joint with the IndOOS SC. (TPOS Co-Chairs, Weidong Yu and Yukio Masumoto to discuss).

Action 2: Brief the AtlantOS Executive on outcomes from 1st TPOS SC (Katy Hill to discuss with Martin Visbeck and Albert Fischer).

4. Selected scientific presentations

Three invited presentations were solicited, to 'deep dive' into key scientific issues, and motivate/focus discussions. These were scheduled where relevant in the agenda:

- Scientific presentation #1: ENSO and its diversity – what we do/do not know (Harry Hendon) (Presented under 6a, Modelling)
- Presentation #2: Integration of remote sensing and approach to cal/val (Tom F) (Presented under 6b, broadscale)
- Scientific presentation #3: 2016 GOE : PIONEER (Pacific and Indian Ocean Network Establishment for global Environment Research) (DongChull Jeon) (Presented ender 6e, Boundary Regions.)

5. Overview of scientific issues/questions

The scientific context for TPOS was introduced by Co-Chair Billy Kessler. The main aim of the project was to build a robust TPOS, this robustness comes from observing and understanding the physical processes. Long climate records are required, to detect small background changes, which can drive surprises. Hence evolution of the observing system requires careful

oversight, with sufficient technology overlap and variety to allow for calibration of the climate record.

A round table was then conducted, whereby each of the SC members were asked to identify one issue and one opportunity. This information then informed the discussion for the remainder of the agenda.

6. Key science challenges

a. ENSO Modelling and assimilation challenges

The modelling and assimilation challenges were framed by Harry Hendon, who gave the science talk on ENSO and its diversity. Arun Kumar reviewed the status of operational seasonal forecasts, now coordinated under the World Meteorological Organisation and the Global Framework for Climate Services, including use and requirements for observations. Bill Large presented the fundamentals of model parameterisation, where effort is currently focussed, and what questions can now be addressed. Yukio Masumoto discussed ocean model development and current problems and limitations.

It was agreed that Ocean/Climate Models have persistent problems and "improving the forward model" must be a priority. ENSO (and intraseasonal) prediction systems have skill that appears to vary by epoch, but also large systematic errors that can impede the models' ability to make good use of in situ data. Thus TPOS 2020 must be vitally concerned with their progress and contribute to it, e.g., by process studies.

Systematic errors also cloud interpretation of studies on the impact of ocean data in prediction models; some results suggested the skill of models and the spread of model ensembles are not impacted by the increased quantity of data in the last decade. This suggests we need a nuanced approach to sensitivity studies and their communication to users and managers.

The diversity among El Niño events, and the changed skill between different epochs (especially pre and post-1998), underline a need for improved understanding, based on existing and enhanced observations and models. Processes in the fresh pool region of the western tropical Pacific, including moist convection in the vicinity of the ITCZ on timescales ranging across diurnal, intraseasonal, interannual to decadal are not well understood. The SC discussed where TPOS observations could make a difference.

There are some indications that improved representation of salinity in models might matter for forecast skill. The role of salinity variations in predictability and prediction on intraseasonal to interannual timescales should be better understood.

There is an opportunity to collaborate with and, perhaps, contribute to the WCRP "Grand Challenge" on Clouds Convection and Climate Sensitivity, especially their activity focused on improved model representation of convection and the ITCZ.

Action 3: Discuss potential TPOS-2020 modelling contribution to the WCRP/GEWEX "Grand Challenge" on Clouds, Convection and Climate Sensitivity. Seek interest and opportunities to engage in these convection and ITCZ issues (Harry Hendon and Neville Smith; Dec 2014)

The Salinity Processes in the Upper Ocean Regional Study (SPURS)[1] is likely to contribute to TPOS objectives. Similarly, engagement with the proposed "Year of the Maritime Continent[2]" the proposed Chinese Western Pacific effort, and SPICE[3]-related activities, also would be timely. They are also likely to deliver model improvement and improved knowledge of E Asian monsoon.

Improved understanding of coupling between the surface and the thermocline (leading to improved ocean models) might be achieved through an observational and modelling experiment on upper ocean physics and upwelling, including high-vertical resolution explicit modelling of vertical eddies (so-called Large Eddy Simulations; LES).

Action 4: Consider the development of an equatorial upwelling and mixing process studies. SC Subgroup to determine next steps. (The SC formed a small sub-group comprising Dongchull Jeon, Ken Takahashi, Arun Kumar, Sophie Cravatte, Tom Farrar and Billy Kessler to develop a proposal for such a study by Feb 2015).

The question mark around the role of salinity (see above) raised the option of drawing on expertise from the ocean observing system evaluation scientific community to assess the efficacy of salinity assimilation in the Tropical Pacific, using the upcoming OSEVal workshop 10-12 December, 2014 in Toulouse, France as a way of engagement. . A further challenge is to develop an improved framework for OS sensitivity studies, one that draws more widely on the accrued knowledge of observations and variability as well as targeted OSE/OSSEs.

Action 5: Draft abstract for OSEval Workshop: Salinity, observing system sensitivity studies and lessons to be drawn from model innovation tendencies. (Neville; by end of October). Need to identify SC member to attend.

Action 6: Seek information on meeting of French P.I's interested in TPOS and modelling issues, attached to the OSEval Workshop (Katy Hill to contact Alex Ganachaud; Oct 2014)

The presence of large systematic errors casts significant doubt on the direct use of OSE/OSSEs with seasonal prediction class models. Indeed, reference to systematic errors through much of the La Jolla Workshop and this meeting suggests a workshop on systematic errors in tropical Pacific model and prediction systems should be considered (it might make sense to cover all basins since this is not unique to the Pacific), with one objective being to develop recommendations for specific modelling/prediction experiments or campaigns. The SC was informed about soon to be published work led by Steve Griffies that will assess systematic errors in fundamental features of the tropics in stand-alone ocean models.

[1] Salinity in the Upper Ocean Regional Study (SPURS) http://spurs.jpl.nasa.gov/

[2] Year of the Maritime Continent https://usclivar.org/sites/default/files/meetings/2014/summit-presentations/Zhang_Summit2014.pdf

[3] Southwest Pacific Circulation and Climate Experiment (SPICE) http://spice.legos.obs-mip.fr/

Action 7: Check with WWRP/WCRP Subseasonal to Seasonal Steering Group and WGNE regarding workshop plans and connections. (Neville, Harry)

Action 8: Develop plans/work together on a systematic errors workshop, covering the tropical oceans, roughly 18-24 month horizon (Co-Chairs; Co-Chairs M&DA TT; proposition by 31 March 2015).

TPOS 2020 should focus on a small number of activities that are worth doing (deliver value), doable, and that will impact the evolution of the TPOS. Looking at the observing system through the lens of coupled model prediction systems is one possibility, but there are few low hanging fruit and the routes to improving these systems are not obvious. Focussing on the stand-alone components (atmosphere or ocean) would seem to offer better chances of success, at least initially.

The talks and discussion in this session helped clarify the Terms of Reference for a Modelling and Data Assimilation Task Team, following initial scoping in the TPOS 2020 Workshop Report (updated draft TORs can be found in Appendix 4), and additional actions that will contribute (see above).

Decision 1. The Steering Committee agreed to form a Modelling and Data Assimilation Task Team, with Terms of Reference as given in Appendix 4.

Action 9: Redraft Modelling and Data Assimilation TT Scope and TORs for SC approval out of session (Neville Smith; by end of October).

Arun Kumar agreed to be a Co-Chair for the Task Team and several other SC members agreed to participate.

b. Broadscale sampling

To motivate the Broadscale session, Tom Farrar gave a presentation emphasizing the value added by designing the in situ array in the context of remote sensing, and the approach to calibration and validation in TPOS. Subsequent discussions focused on clarifying the scope and purpose of a broadscale observing system, building on the Task Team terms of Reference in the TPOS 2020 Workshop Final Report.

There was a lot of discussion about what should be considered in this context, and it was decided that this should include all sustained aspects of the observing system. Therefore, broadscale was not the best terminology since it restricted the scope to “broad” spatial scales. The SC decided that ‘Backbone’ was most appropriate, giving the connotation that it supported or underpinned a range of activities and enhancements, and that it was the core element on which most of the rest of our activities would rely on.

The SC agreed that the Backbone observing system should be a comprehensive and integrated solution serving multiple uses, limiting standalone elements; most will have utility on top of their ‘backbone’ function. Initially the task team will need to consider requirements. The approach should be to build a system starting from expected-to-be sustained global components, such as satellites, and then add ‘legacy’ elements for which there is a compelling case for continuity. Enhancements will be considered where a strong

case can be mounted. There may be proposals which are subject to further testing through and beyond 2020.

Decision 2. The Steering Committee agreed to form a Backbone tropical Pacific Observing System Task Team with terms of Reference as given in Appendix 4.

The TORs were updated to provide clarity around scope, and the consideration of existing carbon observing activities. It was decided that the Task Team should form immediately, and deliver the first set of recommendations on changes to the Backbone observing system design by mid-2016. The TT would report to the SC annually. Sophie Cravatte agreed to co-Chair the Task Team and several other SC members agreed to participate.

Action 10: Complete revisions to Backbone TT terms of reference and confirm nominated second co-Chair (Co-Chairs; Oct 2014).

c. Biogeochemistry and biology

The Biogeochemistry and Biology Whitepapers from the TPOS Workshop outlined current and future issues quite well, and provided a good starting point. Pete Strutton introduced the topic and discussed the parameters to measure, the time and space scales that need to be resolved, some of the specific issues around CO_2, and the existing and emerging technology that may be available.

The Steering Committee supported the suggestion that a Task Team would be the most effective option for taking this topic forward, noting that a scope and terms of reference of a Task Team had not been an outcome from the La Jolla Workshop.

Pete Strutton outlined possible tasks for such a team including to:

1. Clearly articulate the motivating science questions, drawing on the whitepapers
2. Decide on variables that would be in and out of the core sampling.
3. Provide guidance for the Backbone Observing System Task Team on which variables should be part of the Backbone.
4. Identify which time and space scales are well resolved by the Backbone observing system (including satellites).
5. Identify the variables, space and time scales that are not well resolved by the Backbone observing system
6. Identify the platforms that can resolve these processes
7. Prioritise variables
8. Create a prioritised list of instruments and platforms that should be included in TPOS.
9. Identify/prioritise process studies
10. Maintain communication with the GOOS Biogeochemistry and Biology Panels, and the Backbone tropical Pacific Observing System Task Team.

The Task Team TORs will be developed based on these points, and including the context/scope of the activity. It was agreed that the Backbone Task Team would also consider biogeochemical observations where there was clear evidence to support such an action, and based on advice from the Biogeochemistry TT.

Action 11: Pete Strutton to lead development of scope of a Biogeochemistry TT, including identification of deliverables and TT membership. The Terms of Reference would be considered and agreed out of session (Draft by end November 2014).

d. Diurnal variability, air-sea fluxes and near-surface dynamics

Bill Large presented the context for this session, arguing that the complex of processes connecting the atmosphere and subsurface ocean at large scale fundamentally involved high frequencies, especially the diurnal cycle. The TPOS 2020 Workshop Whitepaper number 11 remains a sound basis. The discussion pointed to a relatively greater focus on the boundary layers as a whole (beyond flux measurements) compared with the La Jolla Workshop.

It was decided that TPOS 2020 should form a Task Team to develop advice on surface and ocean boundary layer observations and associated studies. There were some early ideas on possible experiments, including convection and rainfall in the Western Pacific, and on upwelling and mixing in the central/eastern Pacific, as discussed in section 6a. Further elaboration of the scope of the Task Team, and its name were discussed and agreed during the meeting. Further work is needed to develop an observing strategy: some may be campaign based, some part of the sustained (backbone) system. This area in particular might provide opportunities for piloting new technology or technology development. Tom Farrar from the SC agreed to co-Chair the task Team several SC members agreed to participate.

Decision 3. It was agreed to form a Task Team on the Planetary Boundary Layers, to include air-sea interaction and fluxes and the ocean boundary layer (mixing and upwelling). (See Appendix 4 for Task Team scope, key issues and TORs)

Action 12: Finalise TORs of Planetary Boundary Layer Task Team, including Co-Chairs and possible team members (Tom Farrar, with co-Chairs, by end October)

e. Approaches to observation of boundary regions

Western Boundary

Several large regional observing activities or finite lifetime process studies, already exist or are planned in the Western Pacific. These include:

Existing:

- Regional circulation observing activities north and south of the Equator:
  - The North Pacific Ocean Circulation and Climate Experiment (NPOCE)[4]
  - The Southwest Pacific Ocean Circulation and Climate Experiment (SPICE)[5]
- Indonesian Throughflow observations
  - The Integrated Marine Observing System (IMOS; sustained)[6]
  - The Chinese Academy of Sciences (CAS) Project, 2014-2018.

Planned:

In the North Pacific, a group of Chinese scientists have proposed a 10 year western Pacific observation proposal (led by Dake Chen and Weidong Yu) to the Ministry of Science and Technology (MOST) , which mainly consists of a "big cross" of moorings; meridionally near 135E (from TAO/TRITON to 24N), and zonally at 19N (150E and westward). The motivation for the activity is focussed on the Western Pacific ocean circulation, the East Asia monsoon, typhoons and ENSO. It is hoped that, if successful, there is potential for SOA to take it on as a sustained activity.

China also has 12 ocean satellite missions planned over the timeframe of the Western Pacific observation experiment.

With several substantial activities by different national groupings in the Western Pacific, TPOS 2020 should seek coordination so that the whole can be more than the sum of the individual pieces, and there would be benefit to all by joining these activities together as an integrated whole, including connecting up the science rationale. Such integration may raise opportunities for greater collaboration, and could also lead to discussions about what a sustained regional observing system for the Western Pacific could look like post 2020. Putting regional and national activities into the bigger picture may also help strengthen data sharing and regional agreements on data policy in line with international guidelines.

Action 13: Form a Drafting Group to gather information on existing and planned activities and, subject to the Steering Committee's consideration of the Group's assessment of the above, begin drafting of instructions for a Task Team or other mechanism to oversee development of a project in the Western Pacific (Ken Ando, by end of February 2015).

The Steering Committee noted that such an initiative is likely to have two phases, one coinciding with the TPOS 2020 timeline, the other post-2020.

Ken Ando agreed to lead the Drafting Group, with Dake Chen, Weidong Yu, Dongchull Jeon, Sophie Cravatte and Billy Kessler agreeing to assist. Several other regional experts were identified as potential contributors to the draft.

[4] North Pacific Ocean Circulation and Climate Experiment: http://npoce.qdio.ac.cn/

[5] Southwest Pacific Ocean Circulation and Climate Experiment : http://www.clivar.org/panels-and-working-groups/pacific/spice

[6] IMOS Deep Water Arrays http://imos.org.au/da.html

Eastern Pacific Boundary

There is strong potential to strengthen regional collaboration by bringing together a core group of researchers across regional agencies. Persistent serious errors in representing the thermocline in models may make the eastern Pacific a good focus for a systematic errors workshop, which may also bring benefits to the region.

The importance of re-implementing the 95°W line of TAO was discussed at length, noting that in the past, high levels of vandalism has made sustaining these moorings extremely difficult; new technologies such as gliders and wavegliders may make observing this region more achievable in future but demonstrations of feasibility have yet to occur. As with other regional activities, any focused regional work around the far eastern Pacific boundary will inform requirements and options for the Backbone. IMARPE (Peru) currently runs ship board time-series sections (frequency depending on ENSO status) in the region. Additional suggestions include taking advantage of the IMARPE ship (Peru) for the maintenance of the TAO line at 95°W and sampling under the seasonal southern ITCZ, and leveraging regular offshore coastal sections/stations by countries in western South America (issues with data availability).

The need to improve data sharing in near real time was also noted. TPOS 2020 has no mechanism to facilitate discussions on data sharing, but it could be part of a change project in concert with others. The Permanent Commission for the South Pacific (CPPS) should also be engaged. The potential for a coastal air-sea interaction process study was also discussed.

Ken Takahashi agreed to take responsibility for drafting the terms of reference and, subject to their agreement by the SC, to co-Chair the TT. Potential members for the initial task were identified.

Decision 4. The Steering Committee agreed to form a Task Team for the eastern tropical Pacific boundary region, subject to inter-sessional agreement on the Terms of Reference.

Action 14: Develop TORs for a Task Team to focus on the eastern Tropical Pacific boundary region, giving priority to engaging regional experts and institutions (Ken Takahashi/Billy Kessler; deadline: end November). In addition to defining needed observational, goals of the TT could include: (a) Capacity build for improved sustained observing capability; and (b) Facilitate the development of a regional research project, which may contribute guidance for a sustained observing system.

f. Other Issues for Discussion

Time-series criteria

As part of the Backbone observing system discussion, the ongoing role and value of time-series as contributions to the climate record will need to be considered. OceanSITES has established criteria for fixed-point time-series but, to the knowledge of the SC, no attempt has been made to define the value delivered by fixed-point time series in the tropical Pacific.

Action 15: Draft criteria for evaluating fixed-point time-series and circulate for final agreement by SC members (deadline: 17th October; see Appendix 5), and circulate to OOPC and OceanSites for comment and feedback (deadline 24th October 2014).

Action 16: Identify a small group from the SC (with other participants, as appropriate) to document existing fixed-point time-series in the tropical Pacific and to provide recommendations on their priority to the Backbone tropical Pacific Observing System TT and to the SC (Co-Chairs, Jan 2015)

Deep Ocean

Some members of the SC raised the need to consider the deep ocean requirements. There is an existing Deep Ocean Observing Strategy (DOOS) being developed under GOOS, and it would be appropriate for TPOS 2020 to consider this plan in the context of Tropical Pacific requirements. An agenda item will be included in the agenda for SC-2 to consider this strategy further.

Action 17: SC members to consider TPOS needs in the context of DOOS Strategy (www.ioc-goos.org/doos).

Action 18: Deep ocean observations (below 500 m) to be an agenda item for next meeting (TPOS2020 Project Office).

Data Management

Recommendations from the TPOS 2020 Workshop emphasized the need to increase investment in data management, particularly to support enhancements, with an indicative level being 10% of the overall investment.

There is potential for consolidation of data-streams in general, moving away from platform specific data management systems, and to integrated approaches. Kevin O'Brien et al (NOAA/PMEL) are working on an integrated data prototype. TPOS 2020 could champion consolidation and integration (See also paper 13 from La Jolla).

In addition, some data policy (access, exchange, etc.) issues were mentioned during the meeting that will need attention.

It was decided that it is premature to define a TPOS data and information activity at this time, but the SC supports the idea of a TPOS data integration pilot project.

Decision 5. Data and information management discussions to be taken offline with relevant groups (Neville Smith, David Legler)

Societal Impacts

The Steering Committee agreed that if they advocate large changes to the observing system, they need to be able to articulate the societal benefits. A first step will be to articulate the benefits of TPOS for prediction systems and research, and indirectly for climate and ecosystem services.

However, formal societal impact case studies are few in number, and rarely make a direct connection to the observing system. It is not at all clear how to make this association

quantitative. A suite of case studies would assist in articulating the link between the observations and societal benefit, and also help in connecting to the Global Framework for Climate Services (GFCS).

Possible ways forward include scheduling a session at a future meeting, drawing on the activities of the Working Group for Seasonal to Interannual Prediction and the GFCS, or working with key agencies around the Pacific to collect good case studies.

The need to demonstrate the benefits of the observing system highlights the need for good communications.

> ***Action 19: Recommendation: identify good case studies/exemplars of the societal relevance/impact of Tropical Pacific observations. Work with researchers working in climate impacts, and also agencies who are taking up and using data for societal applications (all SC; by SC meeting 2).***

Data assimilation and sensitivity experiments

It was noted that there was no specific agenda item/input on data assimilation. While it is generally accepted that prediction of ENSO and, more recently the Madden-Julian Oscillation evolution requires a coupled ocean and hence initial ocean data, there is diversity in the approach and in the 'skill' of assimilation systems. Forecasts are generally shown to have sensitivity to the initial ocean state, but there is ambiguity and uncertainty around the level of sensitivity. Given the resources and time horizon of TPOS, the Steering Committee formed an initial view that improvement in DA is not yet at the same level of priority as (forward) model improvement.

Not all available data are assimilated, and questions were raised about the assimilation of salinity and currents, among other issues. The SC noted the need for an improved OSE/OSSE strategy (See actions in Modelling section (6a)).

> ***Action 20: An agenda item on data assimilation issues should be included for SC 2 (TPOS 2020 Project Office).***

New Technology

The Whitepaper from the TPOS 2020 Workshop provides a good foundation. However, new technology requirements will be raised in the context of closing gaps, delivering new observations, or lowering the costs per observation, and recommendations on new technology will be a natural output of all the Task Teams. The SC decided that there was enough expertise on the panel to consider new technology issues and opportunities, without having to develop an additional activity.

7. Discussion of Big Challenges and Priorities

Actions and timelines were discussed to ensure that TPOS 2020 delivers in the agreed timeframe. In summary, about 11 separate new activities will be worked on through TPOS 2020. However, they will deliver on different timescales, and have been prioritised accordingly as short term actions, longer term actions, and 'other' actions. All actions have been detailed against the previous agenda item.

8. Review of Actions from the TPOS 2020 Workshop

The Steering committee reviewed the actions from the La Jolla meeting, and noted that the vast majority were in hand through the Steering Committee activities. Some needed to be raised at the Resources Forum, and the co-chairs will ensure this is on the agenda for the next RF meeting. One particular activity which needs to be raised to the RF by the SC is the importance of ships as an integrated component of the observing system.

Action 21: SC to draft a short note on the role of ships as a component of the Observing System, including example actions to improve the role/contribution (e.g., Transmit underway CTD Data on GTS; ancillary observations; and engineering tests). (Co-Chairs; By February: proposed timing for next RF)

Further details of the actions can be found in Appendix 6.

9. Approach to TPOS 2020 Project

With a six year timeline, TPOS 2020 and associated task team activities will need to be actively project managed to ensure projects remain focused and outcomes are delivered on time. Therefore, a project plan is being developed for TPOS, using a 'lite' approach to project management.

In addition, communications and engagement activities will be critical to TPOS 2020 success, as there are many relationships to manage at both national and international levels. A powerpoint outline of a possible approach to project management, and communications and engagement, can be found in Appendix 7. A Project Plan and a communications and engagement plan will be developed by the Project Office. In the short term, a general presentation, project prospectus and other tools will be developed to aid SC members in promoting TPOS 2020 within their communities.

Action 22: Update the TPOS 2020 draft prospectus, which was written at the end of the TPOS 2020 Workshop, for use in promotion/engagement activities (Billy Kessler to redraft, Project Office to coordinate layout/printing).

Decision 6. The Steering Committee agreed to focus its energy on regular reporting of TPOS activities and progress, and associated outreach. The SC members agreed to act as advocates for the project.

Action 23: Develop a Communications and Engagement Plan for the TPOS 2020 Project. (Project Office, N Smith)

Action 24: TPOS Paper to be developed and presented at the 3rd ENSO Conference in Guayaquil, Ecuador, 12-14th November (Ken Takahashi, Project Office to coordinate development).

Action 25: Develop TPOS 2020 slides set. High level summary for SC members to use to promote TPOS 2020 (Project Office/Co-Chairs)

10. Action plan for 2014-15 (summary)

Under this item, all actions and decisions of the meeting were reviewed to ensure responsibilities were clear and the timing was agreed. A consolidated list of all actions is included at Appendix 8.

11. Future Agenda for SC

The agenda for the next meeting is already taking shape. The co-chairs noted that the deep ocean and data assimilation should be specific agenda items. The SC would also like to give early consideration to the measures of performance by which TPOS 2020 will be judged, a natural part of the project management framework we have adopted.

It was also noted that the SC may want to invite observers to future meetings either in person or remotely when discussing specific activities and connections to other groups.

Action 26: The SC co-Chairs to explore opportunities to engage an Indonesian scientist as an observer at SC-2.

No less than five offers to host the next meeting were received, and the Co-Chairs were appreciative of the enthusiasm to support TPOS 2020. Japan has previously been identified as a possible location and Ken Ando agreed to determine whether they wished to exercise this option at this time. The Co-Chairs and Project Office will follow-up with those who offered to schedule future meetings.

Appendix 1: SC-1 Agenda

Agenda
First meeting of the TPOS 2020 Steering Committee

6-9 October, KIOST, Korea

Revised 6 October

1. Opening and introductions
45 mins

- Welcome from co-Chairs
- Welcome from local hosts
- Brief introductions (all SC members)
- Logistics – Katy Hill, local hosts
    - Reception/dinner 6 Oct ~ 1800
- Documentation (www.tpos2020.org see below)

2. Agenda
10 mins

- Desired outcomes of meeting (co-Chairs)
- Adopt/modify agenda for meeting
- Visit Satellite lab 7 or 8 Oct

3. Background and SC Terms of Reference
20+20+20
References: TPOS 2020 Workshop Report, Section 8 on Governance

- TPOS Workshop (Smith, Hill; TPOS Workshop Report)
- TPOS 2020 Project outline and scope – Smith
    - Illustrative project outcomes
    - Role of Resources Forum and sponsor support
- TPOS 2020 Project SC Terms of Reference – Smith and Kessler

4. Selected scientific presentations
[3 or 4 presentations that will provide a 'deep dive' into specific issues; scheduled at appropriate times through the session]

30+30+30 mins

- Scientific presentation #1: ENSO and its diversity – what we do/do not know (Harry Hendon)
- Presentation #2: Integration of remote sensing and approach to cal/val (Tom F)

- Scientific presentation #3: 2016 GOE : PIONEER (Pacific and Indian Ocean Network Establishment for global Environment Research) (Dong-Chull Jeon)

5. Overview of scientific issues/questions

[Generally referenced against Workshop Report; Background papers from La Jolla; co-Chairs' correspondence]
120 mins

Purpose: Initial exposure of key scientific issues and questions (the TPOS rationale) including aspects for which we can seek early decisions/guidance

- Scientific rationale: issues, questions (co-Chairs)
- Round-the-table
  - Each: #1 issue; #1 opportunity

6. Key challenges

[Roughly aligned with big issues identified in La Jolla; referenced against Workshop Report; Background papers from La Jolla]

[In each case suggest there should be a recap of the current strategy and rationale; a recap on what the current TPOS looks like for this aspect, what works well/less well; and an outline of proposed work (as appropriate). 6(b) has been annotated as an example.

a. ENSO Modelling and assimilation challenges

[75 minutes] *References: WP #4, #5, #8b, #2; various WCRP reports*

- ENSO prediction – Arun K
- What are the targets of ocean model development? – Yukio M
- The coupled system: Physical parameterisations and key processes (see also 6d) – Bill L, Harry H (presentation #1)

Outcome sought: Agree on approach, possibly including links to external groups

b. Broadscale sampling, etc.

[75 mins] *References: WP #3, #9, #10, #11; TT #1 (Appendix 5 on broadscale sampling, Report*)

Two thoughts from Dean R.:

(1) Observing system design is a balance between what is needed for scientific and operational objectives and what is practical from a cost standpoint.

(2) In order to weigh the design trade-offs, it is essential to know the spatial/temporal statistics of the observed fields very accurately, better than we typically know them.

- Led by Sophie C, Ken A., Tom F
  - How: Recap broadscale strategy (spatial, temporal scales)
  - Why: scientific rationale and desired impact
  - Status: what works well; less well; opportunities, risks
  - What: Argo, SOOP, TAO/TRITON, remote sensing (ALT, SST)
  - Proposed approach and schedule (tbd): TT to develop revised objectives, principles (include efficiency and effectiveness)

NB ITEM 6E WILL BE SCHEDULED AFTER 6B

c. Biogeochemistry and biology

[60 min] *[Reference: La Jolla presentations; WPs #6, #7]*

- Recap of the main issues and the rationale for systematic observation - Pete Strutton
- Status of TPOS for biogeochemistry and biology
- Options for developing a sustained system

d. Diurnal variability, air-sea fluxes and near-surface dynamics.

[Recap of the issues raised in La Jolla; specific proposals for action]
[60 mins] References: WP #3, #11.

- Bill L to lead discussion

e. Approaches to observation of boundary regions.

[Recap of the issues raised in La Jolla; processes]
[90 mins] References: WP #3, #8a, #9-11

- Eastern Pacific – Ken T
- Western Pacific/boundary current region –Dake C, Weidong Yu, Dongchull J, Billy K
    - Also see Presentation #3

Outcome sought: guidance on the key issues, SC approach

f. (New) Other aspects – discussion

- The deep ocean (ref. Dean's message)
- Data management (Ken Ando; see also papers from La Jolla)
- Societal impacts (Arun K)
- Data assimilation sensitivity experiments (OSE/Val Workshop)
    - Salinity observation and assimilation
- Time series
- New technology
- …

7. Discussion of big challenges and priorities

[90 mins]

- An initial distillation of the key messages and themes emerging from items 1 through 6.
    - One group might comprise near-term tasks that the SC can deliver in, say, 2 years.
    - A second group might comprise tasks that will require deeper coordination and facilitation.
    - A third group may comprise tasks that will be led elsewhere but for which TPOS 2020 is willing to play a significant role.
    - Finally, there may be tasks that are beyond TPOS 2020, either in scope, or duration.

7bis (new) Agency scientific plans

- Dongchull's presentation
- NOAA TPOS proposal

8. Review of recommendations from La Jolla

[60 mins] [Sections 9.2-9.7 from La Jolla Workshop Report]

This will go over ground covered by 7 but may also reveal aspects that we need to give further consideration to.

- Led by Co-Chairs
  - Not a detailed discussion; more filtering and sorting
- Decide:
  - Is the recommendation relevant to the TPOS 2020 SC?
  - If yes, decide where/how the action might be achieved.
  - Options might include a Task Team, the SC itself perhaps via an agenda item at the next meeting, or another body/expert group.

9. Approach to TPOS 2020 Project

- Developing a Project Plan - Secretariat
  - A "lite" project approach, but focused and specific
  - Achievable goals (finished by 2020)
  - Key partnerships
  - Leadership

- Establishment of Task Teams (see suggestions in Workshop Report)
- Other sub-projects to emerge from initial discussion

10. Action plan for 2014-15

- *Ideally, the Co-Chairs would like to present a summary of actions for discussion and agreement some time during the morning of day 4.*

11. Future agenda for SC

- Membership
- Meetings
  - Including intersessional discussion

Appendix 2: SC Membership, Attendance

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Appendix 3: Project, SC and RF Draft Terms of Reference

TPOS 2020 Project Terms of Reference (DRAFT)

The TPOS 2020 Workshop and Review has recommended the creation of a TPOS 2020 Project to achieve the major change from a loosely coordinated set of ocean observing activities in the tropical Pacific to a systematic, sustained TPOS by 2020.

The Project will:

- Achieve a significant change for sustained observing and leave a legacy for GOOS of a robust, efficient and effective contribution in the tropical Pacific.
- Focus on the tropical Pacific Ocean but embrace partnerships with the meteorological and adjacent coastal/regional ocean communities, as appropriate.
- Embrace contributions from multiple agencies and countries through a coordinated portfolio of resources and high-level oversight of the scientific and technical design, sub-projects and interfaces to the user community.
- Operate within the context of the Framework for Ocean Observation and build on existing activities while at the same leading needed change.

The TPOS 2020 Project will be autonomous and self-supporting but will coordinate with relevant existing intergovernmental bodies through the GOOS Steering Committee.

The overarching goals of the Project are:

- To refine and adjust the TPOS to monitor, observe and predict the state of ENSO and advance scientific understanding of its causes.

- To determine the most efficient and effective method for sustained observations to support prediction systems for ocean, weather and climate services of high societal and economic utility, including underpinning research.

- To advance and refine the knowledge of the predictability horizon of the tropical Pacific variability (physical and biogeochemical), as well as its impacts in global climate.

- To determine how interannual to multidecadal variability and human activities impact the relation between marine biogeochemistry and biology to carbon budgets, food security and biodiversity.

A Resources Forum broadly representative of the sponsors of TPOS 2020 will be responsible for coordinating the variety of resources needed for the Project to succeed and support a TPOS 2020 Project.

TPOS 2020 Steering Committee Terms of Reference

The Steering Committee will:

- Provide scientific and technical oversight for the planning, system design, and implementation of the TPOS,
- Assess the evolving set of requirements through dialogue with relevant users and stakeholders,
- Coordinate a set of (pilot) projects designed to test and evaluate options, which initially may include:
    - Studies of potential broad-scale sampling strategies,
    - Investigation of potential sustained requirements for air-sea interaction and circulations and interactions in the upper ocean,
    - Studies of potential approaches in the tropical Pacific boundary current regions and the equatorial wave guide,

- Assess potential technology options for delivering a more effective and efficient TPOS; Coordinate with other relevant scientific/expert panels and bodies, including those responsible for GOOS information systems and services,
- Together with the Resources Forum, manage communication and reporting. The TPOS 2020 Project will report to the GOOS SC.

It will meet at least once per year but may meet more frequently if required.

The membership of the Steering Committee shall not exceed 10 (or 12) and should include expertise broadly representative of the scientific and technical elements of the observing system, as well as expertise in the use and application of TPOS products.

TPOS-2020 Resources Forum Terms of Reference

The TPOS Resources Forum will:

1. Facilitate and coordinate the provision of resources by member institutions required to advance TPOS 2020 activities based on recommendations from, and in consultation with, the TPOS Steering Committee (Figure 1),

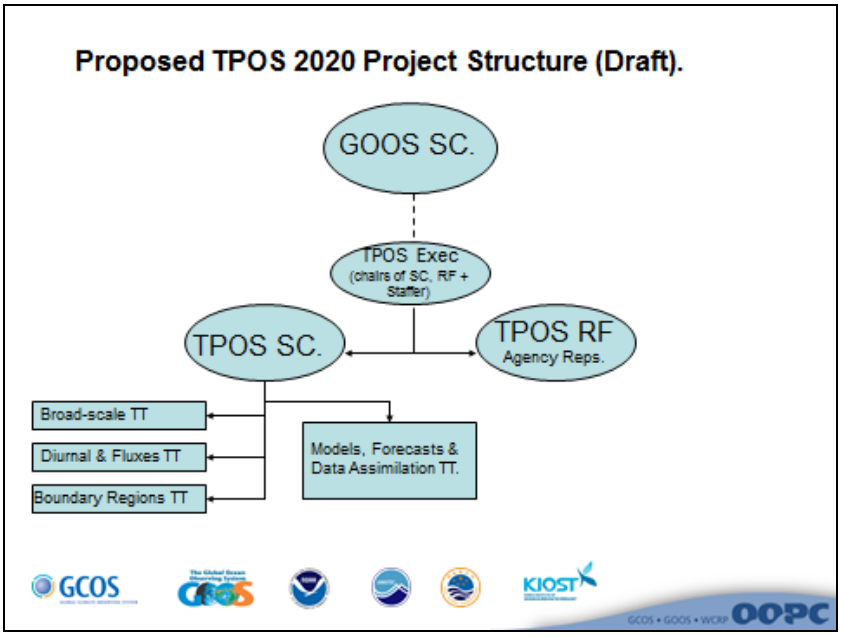
2. Promote and encourage contributions from institutions in non-participating countries and expand membership of the TRF as necessary,

3. Facilitate and coordinate resources that may be applied to the TPOS, including necessary research involving observing, observing technology development/testing, modelling, and scientific analysis; observing infrastructure (e.g., ship resources and/or deployment of observing assets); , as well as Secretariat and travel support,

4. Explore the potential for international resources from Official Development Assistance (ODA) agencies to develop and sustain the TPOS,

5. Explore bilateral and multi-lateral partnerships (e.g., JCOMM PANGEA Framework resource sharing) as a means to complement national resources,

6. Coordinate with the CLIVAR Pacific Panel, Indian Ocean Observing System (IndOOS) Resources Forum (IRF), Pacific Islands GOOS, DBCP TAO Implementation Panel (TIP), PIRATA Resources Board and other relevant resourcing bodies.



Appendix 4: Task Team TORs

Task Team on evaluating and improving the Backbone[8] Tropical Pacific Observing System

Sampling for the backbone observing system has as its goal to

(a) Observe and quantify the state of the ocean, on time scales from weekly to interannual/decadal;
(b) Provide data in support of, and to validate and improve, forecasting systems;
(c) Support calibration and validation of satellite measurements;
(d) Advance understanding of the climate system in the tropical Pacific, including through the provision of observing system infrastructure for process studies; and
(e) Maintenance and, as appropriate, extension of the tropical Pacific climate record[9].

Depending on the mechanisms that are of importance, different spatial sampling strategies may be needed in different regions. Temporal and spatial resolution needs also depend upon the region and variable of interest; in and near the equatorial waveguide, higher temporal and meridional resolution of temperature, salinity, carbon system variables and currents are needed than in many extra-equatorial areas. Similar considerations probably apply to the near-surface layer and the eastern and western boundary regions. For some variables and in some regions, the scales that we wish to observe are well known; in others, it will be necessary to plan for an evolving sampling strategy as new information is gained.

In principle we wish to use an integrated approach; that is, the Backbone TPOS achieves its objectives through a combination of in situ and remote approaches, augmented as appropriate with models and data assimilation.

The initial “ENSO observing system” in the tropical Pacific depended upon a combination of repeat XBT tracks (some with ship-borne ADCPs), surface drifters, Voluntary Observing Ships, island tide gauges, the sparse TAO mooring array and some repeat hydrography; satellite oceanography was in its infancy at the beginning of this system. Considerable technological progress has been made since then. Satellite ocean observing is now an established technology: The Argo profiling float array is a proven source of temperature, salinity, and float displacement observations, and air-sea carbon flux observations are

[8] The term “broadscale” was adopted in La Jolla following on from its usage in WOCE and GOOS/GCOS. However, the Steering Committee concluded it would be wise to move away from a specific space scale and instead focus on those elements which support broad objectives, from the shorter time and space scale of ocean prediction and intraseasonal variability, to the longer time and broader space scales of seasonal-to-interannual and decadal variability. The term ‘backbone’ was preferred, reflecting that we are referring to cornerstone/fundamental contributions to the overall system.

[9] The US National Research Council (at the request of NOAA) provided a definition Climate Data Record in the context of satellite records: "a time series of measurements of sufficient length, consistency, and continuity to determine climate variability and change." In TPOS, we might wish to use 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.”

proven. New autonomous technologies such as gliders and wavegliders have been developed and also need to be considered in the future backbone TPOS observing strategy.

Consistent long-term climate records are fundamental to diagnose trends and multi-decadal variability, and to maintain credible climatologies. The GCOS Climate Monitoring Principles for the evolution of observing system elements comprise an important set of guidelines for the transition from the present into the TPOS beyond 2020. The TPOS 2020 Project provides an opportunity to evaluate options and to conduct any needed transitions in a way that minimises harm to the Tropical Pacific ocean data record.

The major objective of this Task Team is to articulate the purpose and requirements for the backbone observations in the tropical Pacific and to recommend a feasible process for achieving a new configuration of the observing suite.

Some specific questions that must be addressed are:

- What are the unique capabilities of the 'legacy' ENSO observing system elements, and what are the enhancements that have been made over the past decade that should be continued in the TPOS beyond 2020 in support of a backbone observing system? This consideration should include efficiency, effectiveness and utility.

- What contributions can we reasonably assume will continue courtesy of global observation efforts (eg, SST, altimetry, Argo, TAO/TRITON moorings, scatterometer winds, ocean colour)

- What enhancements/modifications to these efforts should be sought?

- What will be the data synthesis strategy for integrating the full multivariate suite of backbone observations into a coherent view of ocean structure and variability of the region?

- Anticipating the future evolution of prediction systems and drawing on advice from the Biogeochemical TT, determine the initial strategy for backbone biogeochemical observations?

These questions should be addressed while considering the feasibility of new observation platforms and sensors for the backbone sampling and what mitigation efforts/options are needed to ensure robustness of the observing system.

Consideration should also be given to the adequacy of data systems, taking into account the tight time constraints of operational assimilation systems.

The Task Team should liaise with the other Task Teams as appropriate and take account of guidance being developed on time-series[10].

[10] Work initiated at SC Meeting 1, including guidance on the approach.

Process

The Task Team will be chaired by Sophie Cravatte and Susan Wijffels (tbc)

The Task Team will work mainly by correspondence but allowance will be made for one (or two) meetings. The aim would be to reach conclusion by mid-2016 (report to TPOS2020 SC 3) but an interim report should be available for TPOS 2020 SC meeting 2 (Sep/Oct 2015).

Task Team on Planetary Boundary Layers {Coupling, Interaction, Processes}

Background

- TPOS SC distillation of White Paper(s)

Improved monitoring, understanding, parameterization and modelling of ocean surface (air-sea interaction) and near-surface processes has been identified as a priority for TPOS 2020. Many essential ocean and climate variables are now derived from a combination of satellite and in situ data. Supporting the observational needs of these synthesis activities is essential (e.g., GHRSST for SST). Thus satellite calibration/algorithm development and validation requirements along with product synthesis pathways need to be imbedded in the new TPOS 2020 design.

In addition, improved understanding is leading to new requirements. For instance the importance of the diurnal cycle in modulating SST and air-sea exchange is now apparent. The parameterization of fluxes (and boundary layer processes) under different regimes (stable/unstable boundary layer, sea wave state dependency, etc.) also need dedicated observations.

The observational needs regarding improved monitoring and modelling of ocean surface and near-surface processes are likely to have two components: sustained detailed observations and process studies. It is the role of this Task Team to identify which requirements are best met via a sustained observing effort (> 5 years)[11], and which can be addressed with specific short-term process campaigns.

The TPOS 2020 whitepapers have identified some requirements and identified questions for discussion. For instance, in a future TPOS, should all buoys have velocity, salinity, temperature and meteorological state variables measured hourly? Higher vertical resolution is needed in the upper ocean – what are the exact needs? Are sites for direct measurements of flux-eddy correlation needed and, if so, where and how many? Is tying these specialised measurements to sites permanently the right strategy, or should they be moved around to cover different regimes?

It is also evident that so-called Large Eddy Simulations (LES) of the oceanic boundary layer can contribute to both the interpretation of ocean observations and to the development of improved parameterisations in models and within data assimilation systems. Such approaches show promise for improving understanding and representation of physical processes in the upper ocean.

The capabilities of present and near-horizon technologies should be taken into account when designing future configurations. The design of the backbone tropical Pacific observing system is being considered by another Task Team, and other Task Teams are focusing on other aspects of the TPOS 2020 Project. Liaison will be required with each of these teams and, in particular with those formulating plans for process studies in the eastern and Western Pacific.

- Further elaboration of issues arising from the 1st TPOS SC meeting at KIOST, Ansan

Diurnal Coupling

[11] In consultation with the Task Team for the backbone tropical Pacific observing system

1) Key diurnal process to observe and understand are upper ocean stratification due to solar heating, and night-time convection
2) Rectification as observed in SST; and expected in ocean mixing
3) Regimes of boundary layer coupling; (e.g. SST air-temperature coherences, leads-lags)
4) Observations for process modelling (e.g.LES) boundary conditions, forcing and verification

Surface Fluxes

1) Validation of satellite surface radiation products and NWP estimates
2) CAL/VAL for satellite precipitation
3) Bulk versus more direct turbulent fluxes (departures from "mean" transfer coefficients; wind wave conditions)
4) Regions of strong remote coupling with Indian Ocean

Additional considerations within the context of TPOS 2020 activities

1) The evolving backbone and Process Experiments
2) Emphasis on variability at diurnal, intra-seasonal (MJO), seasonal-interannual (ENSO) time scales, and prediction associated with the latter two.
3) Focus on distinguishable regimes. Possibilities include
    - Eastern Boundary (Galapagos to coasts of Ecuador and Peru)
        - LWnet minimum, reduced solar, Upwelling winds
    - Eastern Tropical Pacific (~130W to Galapagos)
        - Maximum to net heat flux (> 120 W/m2)
    - Central Tropical Pacific (Range of migration of eastern extent of Warm Pool)
        - Maximum variance in P
    - Western Warm Pool (region of net surface heat flux < 20 W/m2)
        - Prime Indian Ocean coupling, Maximum P-E
    - Trade wind maximum/deep-sharp thermocline regime near 140W
        - long history of boundary layer work; east edge of the warm pool
    - Off-equatorial regimes (e.g. SPCZ, ITCZ, stratus regions)
        - Potentially important ocean-atmosphere interactions for decadal variability and/or climate change

Terms of Reference

Starting with the background and context provided above, guidance from the TPOS whitepapers and other available reports, and taking into account both existing and near horizon capabilities:

a) Formulate a practical observing strategy and technical sampling requirement to ensure comprehensive air-sea fluxes can be estimated at hourly or better resolution across a set of key ocean and climate regimes in the tropical Pacific, covering the full suite of state variables to estimate heat, moisture, and momentum exchanges, including through use of bulk formula.

    - The Context provides a number of suggestions on possible regimes that the TT may use as a basis for identifying around five regimes with distinct characteristics.

b) Develop recommendations about the oceanic and atmospheric boundary layer measurements needed to meet TPOS objectives, and the space-time sampling required for those measurements. In particular, measurements that should resolve the diurnal cycle in the oceanic and atmospheric boundary layers will be identified.

c) Consider whether a subset of regimes where direct eddy-correlation approaches might be used is feasible and of value.

d) Liaise with the existing and developing ocean satellite and modelling community on efficiently meeting their present and future requirements for ocean surface data.

e) Engage biogeochemical and ecosystem experts to ensure the needs of key gas exchange calculations are met.

f) Liaise with the other TPOS 2020 Task Teams to maximize logistical and scientific synergies.

Carry out a risk analysis of the proposed approach (e.g., dependency on a single satellite mission or communications systems or ship time) and suggest possible mitigation strategies (e.g., some redundancy).

The Task Team will report to the TPOS 2020 SC and complete the initial phase (refinement of goals, initial plan, key questions) of its work by October 2015.

Task Team for Modelling and Data Assimilation

Background

- From the La Jolla Workshop and associated White Paper(s)

The Workshop identified inadequacies in models and in data assimilation as the major limiting factors for effective use of TPOS observations in seasonal-to-interannual climate predictions and the accuracy of related products, including both the analysis of the ocean state and the predictive skill of coupled model forecasts. Inadequacies could be model errors associated with either the atmospheric or oceanic component of the coupled models, or could be related to data assimilation methodologies.

Experience with atmospheric reanalyses and weather forecast systems clearly indicates that more useful information can be extracted from observations as the forward models and assimilation systems improve. Further, just as multi-model forecasts for sub-seasonal and seasonal time scales have led to greater forecast reliability and increased accuracy, so too multi-model analyses could lead to greater reliability in the estimation of the ocean state and for the quantification of analysis errors. In summary, the "route to impact" for the TPOS 2020 observations is inextricably linked to improvements in the modelling and assimilation systems, and to enhanced coordination across various centers engaged in ocean analysis and prediction.

Given the remarks above about the criticality of such efforts for achieving scientific and societal impact of the TPOS 2020 observations, the TPOS 2020 needs to embrace modelling and assimilation activities as part of its overall strategy. The results from these efforts will also assist in the identification of model errors, areas of large uncertainty where model/reanalyses diverge (and additional observational constraints may be required), and process studies needed for improving relevant model components. In addition, further coordinated observing system and process study experiments may be needed to assist the design of a future observing system beyond TPOS 2020. Modelling and assimilation activities, therefore, should involve (ocean and coupled) model and forecast system developers and TPOS observationalists.

TPOS observational requirements will also vary with the evolution of the forecasting systems both in the context of providing adequate observations and to further challenge analysis and forecasting systems. As model resolution increases, the observational needs for forecast initialization, process evaluation, parameterization and verification may change. For TPOS 2020, the typical ocean resolution would range from about 1° x ½° for climate applications (likely finer by 2020) to $^{1}/_{12}$ of degree (or higher) for global medium-range ocean forecasting. The vertical resolution of the upper ocean is already about 1 m in some models but is coarser around the depth of the thermocline. The increased model resolution and complexity of the forecasting system in the future (coupled ocean-atmosphere-wave models for the medium range) also has implications on the requirements for initialization.

- Guidance from the 1st TPOS 2020 Steering Committee meeting

Improvement in the forward model for ocean and intraseasonal to interannual climate prediction systems was regarded as a priority; no amount of improvement in the observing system or assimilation methodology will be able to adequately mitigate the issues arising from systematic model errors. Similarly, the accurate depiction of key processes across a wide range of time and space scales (diurnal, intraseasonal, interannual, decadal) is germane to

Pacific climate and its global impacts. Analysis/assimilation issues have been identified and will need to be addressed in parallel. The diversity among ENSO events, and the changes in variability and predictability and model skill between different epochs, also underlines a need for improved understanding of the two-way interaction of ENSO (and other variability such as the Madden-Julian Oscillation) with the background climate based on existing and enhanced observations and models.

The TPOS 2020 Project has a number of potential strategies available to enhance the value derived from the observing system: improvements in assimilation systems to optimise the value derived from existing observational assets; and sensitivity studies to contribute to the design of the observing system, leading to a more efficient and effective use of existing and planned resources.

The immediate implication for TPOS 2020 is that a significant fraction of the observational effort will need to be directed towards improved understanding of processes and mechanisms, which in turn should be coordinated with a program of improved model parameterisations and reduced systematic error; an additional benefit is that such data/model studies also contribute to improved design and reduced inefficiencies of the observing system.

A number of processes/mechanisms received attention:

- Processes in the fresh pool region of the western, including moist convection in the vicinity of the ITCZ on timescales from diurnal to intraseasonal to interannual and decadal;
- The role of salinity variations in variability, predictability and prediction on intraseasonal to interannual timescales;
- Improved understanding of coupling between the surface and the thermocline;
- Impact of the slowly varying large scale environment (e.g., decadal oscillations) on ENSO predictability diversity and forecast skill; and
- Interactions and teleconnections with other tropical regions and the extra tropics/mid-latitudes (e.g., the NW Pacific).

A number of options were considered in order to address these and related issues:

- Investigate opportunities to engage with the WCRP/GEWEX Grand Challenge on Clouds Convection and Climate Sensitivity to address Convection/ITCZ issues.
- Engage with the Year of the Maritime Continent initiative, perhaps in conjunction with the Chinese Western Pacific Big Cross effort, SPICE-related activities etc., which are likely to deliver model improvement and improved knowledge of the East Asian monsoon, especially at intraseasonal time scales (i.e. the MJO).
- Improve understanding of coupling between the surface and the thermocline; a model/data process experiment in the cold tongue mixing and upwelling region was discussed.
- Promote intercomparison studies on the assimilation of salinity in ocean and climate models.
- Develop an improved framework for observing sensitivity studies, one that draws more widely on the accrued scientific knowledge in addition to model guidance.
- Examine options for a tropical ocean systematic errors workshop, involving observational, modelling and assimilation experts, perhaps in conjunction with WGCM and WGNE.

The TPOS 2020 SC accepts that it may not have the mandate to lead in all of these areas so engagement and cooperation with existing mechanisms (e.g., WGCM, WGNE, GEWEX-GASS, WCRP Cloud, Circulation and Climate System Grand Challenge) will be important.

Additional Context

- The terms of reference for the TPOS 2020 Steering Committee;
- Task teams created for the Backbone tropical Pacific Observing system and for the Planetary Boundary Layer; activities initiated for the western Pacific, central-eastern tropical Pacific, and for the eastern Pacific.
- Upcoming workshops on (ocean) Observing System Evaluation (Toulouse, 10-11 December); Ocean Salinity Science and Salinity Remote Sensing Workshop (Exeter, 26-28 November); and the planning the Year of the Maritime Continent initiative (Singapore, January 2015).

Terms of Reference

- To develop strategies for coordinated modelling and assimilation activities for designing and planning the future TPOS observing systems, such as those proposed by the other task teams.

- To identify pathways that will contribute to improved understanding of systematic errors and subsequent model improvements, especially through promotion of joint activities with other bodies that have mandates to improve models.

- To contribute modelling and data assimilation insights into the identification of observational requirements.

- To provide guidance on the assessment of the impact of modelling and assimilation, including through systematic continuous evaluation (metrics and process-oriented diagnostics), OSEs, and OSSEs, of the TPOS and its design, especially using the multi-model approach.

- As appropriate, recommend strategies for model initialization that will promote the efficient use of TPOS information.

- To provide recommendations on improving coordination among centers currently engaged in ocean analysis and prediction towards assessment of TPOS and its influence on predictions.

Process

The Task Team will report to the SC annually.

Nominated Co-Chairs: Magdalena Balmaseda (ECMWF, tbc) and Arun Kumar (NOAA/NWS/NCEP/CPC).

Appendix 5: Time-Series Working Group

Time-series contributions to the climate record[12] in TPOS

a. Background

- OOPC/OceanSites is the over-arching mechanism for coordinating fixed-point time-series (majority in deep water).
- TRITON/TAO (and PIRATA) are considered as a whole and there has been no differentiation of contributions from specific sites (to my knowledge).
- OceanSites is mostly concerned with time-series that are proposed and supported in their own right; that is, a multivariate comprehensive time series is the primary objective.
- Multi-disciplinary sites have been promoted since the outset.
- In TPOS 2020, we are considering fixed-point measurements that are contributions within an integrated system, including the tropical moored buoy array system.

b. Possible criteria/factors for assessing value

TPOS 2020 will consider a broad suite of requirements, covering many different time and space scales, and multiple uses and purposes. Here we wish to consider just one of those purposes, to maintain a fixed point time series of one or more physical and/or biophysical parameters.

This brief note aims to provide a framework for the evaluation of fixed-point time series to the tropical Pacific Climate Record (see footnote).

Something similar to the following were used to guide the initial OceanSites selection (in their case it was an include/exclude selection, but with a bias to the former):

- Representativeness: Extent to which key aspects of different modes of spatial-temporal variability were and/or will be captured;
- Continuity, homogeneity and length of the existing record;
- Surface and depth coverage and quality and accuracy;
- The suite of measurements that have been maintained, and their complementarity;
- Resources and logistics for deployment and maintaining the site
    - ship time, servicing, etc
- Modes of data delivery (real-time, near-real-time and delayed-mode);

[12] The US National Research Council (at the request of NOAA) provided a definition Climate Data Record in the context of satellite records: "a time series of measurements of sufficient length, consistency, and continuity to determine climate variability and change." In TPOS, we might wish to use 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." In WMO the definition of climate includes a period (30 years) but in a world where we sometimes have shorter but more comprehensive data sets (eg, Argo, TAO/TRITON) is seems sensible to be more general.

- Availability of adjacent (spatial) contextual data; and
- The utility of sites as test-beds/prototypes for the development of observing technologies

c. Process for the TPOS 2020 SC

- Refine and agree the criteria that will be used to evaluate the value of individual time series; perhaps 110W might be used as a test case
- Seek feedback from OceanSites and OOPC on the proposed approach.
- Form a small team, with a leader from the SC, to elaborate on the purpose and utility of time series within TPOS (the requirement statement) and to identify the highest ranking sites and perhaps any further locations that should be investigated.

Appendix 6: TPOS 2020 Workshop Actions. Status and Progress

1. TPOS 2020 Goals

- Status: SC is actively managing project scope

- TPOS 2020 Governance
  - A TPOS 2020 Steering Committee
    - Status: Created
  - A Resources Panel/Forum
    - Status: In progress/evolving
  - A Project Office
    - Status: Done (interim)

2. Recommendations: advancing modelling

- Status: Proposed near-term Modelling and Data Assimilation Task Team
  - Observing system sensitivity/impacts
  - Targeted activity on modelling and data

3. Recommendations: existing requirements

- Identify and sustain critical long climate records as a priority.
  - Status: Time-series working group being formed
- Maintain and improve broadscale sampling
  - Status: Formation of a Backbone Task Team
- TRITON moorings could be converted to flux reference sites by adding a long wave radiation sensor
  - Status: Creation of Surface TT
- Improved humidity sensors should be added to moored time series
  - Status: Very specific / consideration is the job of the Surface TT
- Encourage integration of biogeochemistry and biology.
  - Status: Creation of BGC TT

a. Recommended revisions/adjustments to the existing observing system to:

- Ensure all components, including satellites, in situ, models, data, and information management are considered part of the observing system.
  - Status: To some degree these are under short and long-term consideration
  - Issue: Not much energy to look at Data Management currently in SC. Pilot data management project discussed. Co-chairs are exploring to avoid the risk of leaving DM to others.
- Satellites should be considered an integral component of the observing system
  - Status: Ongoing, SC, TT
- Ships should be recognized as an essential component
  - Status: Ongoing by TPOS 2020 SC, TTs
  - Issue: We don't have a way to ensure other than through TTs, that this is done. Project needs a way to get that message out in a way that is refined and resaid in a way that has impact. A key message to Resource Forum.
- Ensure that there is sufficient redundancy
  - Status: Ongoing monitoring by SC

4. New requirements

- Evaluating requirements and improving broadscale observations
  - Status: Backbone TT - and others as needed
- Diurnal variability and air-sea fluxes
  - Status: Planetary Boundary Layer TT
- Evaluating requirements and observing approaches in eastern, western and equatorial boundary regions
  - Status: SC members have begun scoping first 2; latter dropped as specific activity
- Task Team is needed to focus on modelling, assimilation and synthesis
  - Status: Modelling and Data Assimilation TT

a. Delivery of data and information

- In principle, around 10% of effort in D&I management
  - Status: Not addressed explicitly
- A small set of performance indicators (metrics)
  - Status: Will be monitored as an activity by the SC, but not done (premature)

b. Coordination of the observing system

- Return TAO to 80% data return as soon as possible
  - Status: Not SC action; (completed by NOAA October, 2014)
- Impact of the reduction in the TRITON Array
  - Status: Under consideration the Backbone TT
- Communication and coordination among existing partners
  - Status: Requires a concerted TRF and SC effort
- Broaden engagement in supporting the TPOS, enabling new partners
  - Status: SC launching with early successes
- Improved strategies for coordination and oversight of observing system
  - Status: SC will launch a coordinated effort with the Distributed Project Office and TRF
- Ongoing scientific oversight of the design, implementation, and evaluation of the TPOS and its components is needed
  - Status: Being done initially by SC; beyond 2020 is a TBD
- Routine communication between all nations and parties involved in developing/implementing TPOS is required.
  - Status: Coordinated effort required by SC, TRF, Project Office
- There should be a long-term plan for dedicated servicing support for the TPOS
  - Status: Needs consideration
- An assessment of risks to the observing system and associated mitigation efforts/options, e.g., redundancy, sensor diversity, etc., is needed.
  - Status: An SC action - but not done
  - Issue: GOOS SC discussed similar action. Framework for risk assessments discussed.

Appendix 7: TPOS 2020 Project Management

Below is a proposed outline of a "Lite" Project Management approach for TPOS 2020. A Distributed Project Office will manage the creation and oversight of a suite of tools and plans designed to support the TPOS 2020 Project. Tools and activities will include, but not be limited to, a project Work Breakdown Structure, an Integrated Master Schedule, a Change Control process, a Risk Management process, and a detailed Engagement and Communications Plan. An outline of planned DPO elements and functions is provided below:

Project Management Approach

- "Lite" Project Management
    - Enough documentation to properly manage, but not too much
    - Highlight:
        - Objectives and breakdown of work
        - Schedules and deliverable
        - Cross-dependencies and risks
- Distributed project management support
    - Key role of TPOS 2020 Office
    - Again looking for the 'lite' right touch
- Activities thus Far:
    - Supporting SC 'project', TRF (not without issue)
    - Drafted preliminary version of a TPOS 2020 Project Plan

Project Management Elements

- Project Execution
    - Scope Management
        - Maintain focus on what TPOS 2020 will and will not do
    - Stakeholder Management
        - Create and maintain routine communications among all implementation partners with a goal of assessing risks to the system and managing associated mitigation activities
- Individual and Integrated Work Breakdown
    - ➢ Used to track cross-product dependencies and a critical path
    - Steering Committee
    - Resource Forum
        - Executive Committee
    - Sub-projects:
        - Task Teams
        - Workshops, Ongoing related projects
    - Distributed Project Office

Project Management Functions

- Project Change Control
    - Manage variations to plans and associated impacts
- Risk Assessment and Issues Management
    - Anticipate vulnerabilities and their likelihood
    - Mitigation strategies
    - Document and follow issues as they arise
    - Ultimate responsibility with the SC
- Effort and resource tracking
    - Most resources will not be under our control

- Reporting and advice

Project functions – Communication

- Core facilities for partners
    - Intranet, webex facilities etc
    - SC, TRF, Sub-project secretariat and support
    - Documentation
- Among project participants
    - Groups such as JCOMM and CLIVAR will need to understand how TPOS 2020 will work as a project
- Target audiences may include but not be limited to:
    - International/intergovernmental Orgs (IOC, WMO)
    - International Obs and Research Programmes
    - Agencies (planning and implementation)
    - Implementing Agencies/PI's (those directly investing in TPOS 2020)
    - TPOS 2020 SC Members, Task Teams, etc.
    - Broader user community.

Appendix 8: Consolidated list of Actions and Decisions

(Owners in **Bold**)

Action 1: Explore the possibility for a future meeting joint with the IndOOS SC. **(TPOS Co-Chairs, Weidong Yu and Yukio Masumoto to discuss).**

Action 2: Brief the AtlantOS Executive on outcomes from 1st TPOS SC **(Katy Hill to discuss with Martin Visbeck and Albert Fischer).**

Action 3: Discuss potential TPOS 2020 modelling contribution to the WCRP/GEWEX "Grand Challenge" on Clouds, Convection and Climate Sensitivity. Seek interest and opportunities to engage in these convection and ITCZ issues **(Harry Hendon and Neville Smith; Dec 2014)**

Action 4: Consider the development of an equatorial upwelling and mixing process studies. SC Subgroup to determine next steps. **(The SC formed a small sub-group comprising Dongchull Jeon, Ken Takahashi, Arun Kumar, Sophie Cravatte, Tom Farrar and Billy Kessler to develop a proposal for such a study by Feb 2015).**

Action 5: Draft abstract for OSEval Workshop: Salinity, observing system sensitivity studies and lessons to be drawn from model innovation tendencies**. (Neville; by end of October).** Need to identify SC member to attend.

Action 6: Seek information on meeting of French P.I's interested in TPOS and modelling issues, attached to the OSEval Workshop (**Katy Hill to contact Alex Ganachaud; Oct 2014)**

Action 7: Check with WWRP/WCRP Subseasonal to Seasonal Steering Group and WGNE regarding workshop plans and connections. **(Neville, Harry)**

Action 8: Develop plans/work together on a systematic errors workshop, covering the tropical oceans, roughly 18-24 month horizon **(Co-Chairs; Co-Chairs M&DA TT; proposition by 31 March 2015).**

Action 9: Redraft Modelling and Data Assimilation TT Scope and TORs for SC approval out of session **(Neville Smith; by end of October).**

Action 10: Complete revisions to Backbone TT terms of reference and confirm nominated second co-Chair **(Co-Chairs; Oct 2014).**

Action 11: Pete Strutton to lead development of scope of a Biogeochemistry TT, including identification of deliverables and TT membership. The Terms of Reference would be considered and agreed out of session **(Draft by end November 2014).**

Action 12: Finalise TORs of Planetary Boundary Layers Task Team, including Co-Chairs and possible team members **(Tom Farrar, with co-Chairs, by end October)**

Action 13: Form a Drafting Group to gather information on existing and planned activities and, subject to the Steering Committee's consideration of the Group's assessment of the above, begin drafting of instructions for a Task Team or other mechanism to oversee development of a project in the Western Pacific **(Ken Ando, by the end of February 2015)**

Action 14: Develop TORs for a Task Team to focus on the eastern Tropical Pacific boundary region, giving priority to engaging regional experts and institutions **(Ken Takahashi/Billy Kessler; deadline: end November).** In addition to defining needed observational, goals of the TT could include: (a) Capacity build for improved sustained observing capability; and (b)

Facilitate the development of a regional research project, which may contribute guidance for a sustained observing system.

Action 15: Draft criteria for evaluating fixed-point time-series and circulate for final agreement by SC members **(deadline: 17th October; see Appendix 5),** and circulate to OOPC and OceanSites for comment and feedback **(deadline 24th October 2014).**

Action 16: Identify a small group from the SC (with other participants, as appropriate) to document existing fixed-point time-series in the tropical Pacific and to provide recommendations on their priority to the Backbone tropical Pacific Observing System TT and to the SC **(Co-Chairs, Jan 2015)**

Action 17: SC members to consider TPOS needs in the context of DOOS Strategy (www.ioc-goos.org/doos).

Action 18: Deep ocean observations (below 500 m) to be an agenda item for next meeting **(TPOS2020 Project Office).**

Action 19: Recommendation: identify good case studies/exemplars of the societal relevance/impact of Tropical Pacific observations. Work with researchers working in climate impacts, and also agencies who are taking up and using data for societal applications **(all SC; by SC meeting 2).**

Action 20: An agenda item on data assimilation issues should be included for SC 2 **(TPOS 2020 Project Office).**

Action 21: SC to draft a short note on the role of ships as a component of the Observing System, including example actions to improve the role/contribution (e.g., Transmit underway CTD Data on GTS, ancillary observations and engineering tests). **(Co-Chairs; By February: proposed timing for next RF).**

Action 22: Update the TPOS 2020 draft prospectus, which was written at the end of the TPOS 2020 Workshop, for use in promotion/engagement activities **(Billy K to redraft, Project Office to coordinate layout/printing).**

Action 23: Develop a Communications and Engagement Plan for the TPOS 2020 Project. **(Project Office, N Smith)**

Action 24: TPOS paper to be developed and presented at the 3rd ENSO Conference in Guayaquil, 12-14th November, Ecuador **(Ken Takahashi, Project Office to coordinate development).**

Action 25: Develop TPOS slides set. High level summary for SC members to use to promote TPOS 2020 **(Project Office/Co-Chairs).**

Action 26: The **SC co-Chairs** to explore opportunities to engage an Indonesian scientist as an observer at SC-2.

Decision 1: The Steering Committee agreed to form a Modelling and Data Assimilation Task Team, with Terms of Reference as given in Appendix 5.

Decision 2: The Steering Committee agreed to form a Backbone tropical Pacific Observing System Task Team with terms of Reference as given in Appendix 5.

Decision 3: It was agreed to form a Task Team on the Planetary Boundary Layer, to include air-sea interaction and fluxes and the ocean boundary layer (mixing and upwelling). (See appendix 5 for Task Team scope, key issues and TORs)

Decision 4: The Steering Committee agreed to form a Task Team for the eastern tropical Pacific boundary region, subject to inter-sessional agreement on the Terms of Reference.

Decision 5: Data and information management discussions to be taken offline with relevant groups (Neville, David L.)

Decision 6: The Steering Committee agreed to focus its energy on regular reporting of TPOS activities and progress, and associated outreach. The SC members agreed toto act as advocates for the project.

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