2nd GOV-OSEval-TT/GSOP-CLIVAR Workshop

(& E-AIMS meeting)

CLS, Toulouse, France

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Workshop report

Prepared by

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Presentations referred to in this report are available from the GODAE OceanView website at https://www.godae-oceanview.org/outreach/meetings-workshops/task-team-meetings/coss-tt-workshop-2014/presentations/

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1. Workshop introduction

a. Workshop objectives

The evolving nature of the ocean observing system (emerging technologies, possible obsolescence of existing approaches), as well as the ever changing societal needs (new applications and services, new science questions), imply that the fit-for-purpose of the ocean observing system requires continuous evaluation. The evaluation should take into account the needs of different communities, namely operational forecasting of the atmosphere and ocean at different time scales (from days to years), climate monitoring, c as well as the wider oceanographic and scientific community. The evaluation should include both physical and biochemistry variables, with a global and regional scope.

The overarching goal of this workshop was to provide a forum for the exchange of ideas on ocean observing system experiments and to review the ongoing activities and results regarding the impact of global and regional ocean observing system for short-range forecasting, seasonal to decadal forecasting and reanalyses obtained since the GOV symposium by GOV and CLIVAR GSOP groups.

This workshop should help to achieve the goals for the next five years through a community effort. It will be important to improve our ability to perform Community OSEs with all associated groups, to reinforce our role in the provision of guidance and requirements to observational agencies and to develop new diagnostics to assess the impact of ocean observations.

We hope at this workshop to review the latest results from the different groups, to revise/refine the GOV OSEval-TT work plan and to consolidate the cooperation with CLIVAR GSOP group.

The workshop was organised to be a mix of oral presentations, open discussion, and poster presentations.

1	**Status / results for each observing system**
a	ARGO
b	Tropical Observing system
c	Biogeochemistry
d	Altimetry

2	**Review of the approaches / methods**
a	Routine monitoring: limitations, potential improvements
b	OSE
c	OSSE: nature run or observations and error simulations?
d	Alternative methods: which methods are mature enough to be implemented in the operational systems?

3	How to promote and sustain OSEval-TT and CLIVAR-GSOP activities?
a	How to enhance the coordination between GOV OSEval-TT and CLIVAR-GSOP?
b	How to enhance the link with observation agencies (space and in-situ) and intergovernmental bodies (GOOS, OOPC,..)?
c	How the TT could become an authoritative source of advice and evidence on the relevance and impact of the observing system?

***Table 1**: Abstracts (oral/poster) were invited to cover the above categories*

b. Host, attendance and abstracts

The workshop was held at the new CLS conference centre in St Agnes/ Ramonville on the 10-11 December 2014, and was hosted by CLS and IOOT. The new CLS venue at the Parc Technologique du Canal was an ideal location for holding the workshop, providing ample space and a pleasant environment for exchange, meals and discussion.

The workshop was organised back-to-back with the E-AIMS project meeting which allowed useful exchange with the European community involved in Argo.

The workshop was well attended, about 40 people registered for the whole event with a few extra local visitors attending individual sessions/presentations. The workshop audience was broad representing many countries, organisations and projects involved in the maintenance and exploitation of the global ocean observing system. 24 abstract were submitted of which most were presented orally.

2. Science sessions

a. Group introductions

This workshop was initiated by the GODAE Ocean View Observing System Evaluation Task Team (OSEval-TT)[1] with support from GSOP-CLIVAR and the E-AIMS project. The objective of this introduction session was twofold:

- to provide status reports of the GODAE OceanView (G. Larnicol) and CLIVAR/GSOP (M. Balmaseda) programmes and
- to give a status report of the E-AIMS European project (P.Y. Le Traon), and also
- to give an overview of the In-situ (K. Hill) and satellite observing system (P.Y. Le Traon).

In particular the two last presentations provide a good summary of the role of the observing systems in the operational oceanography, the main requirements coming from the observational agencies.

The main goal of the **GOV Observing System Evaluation Task Team** (OSEval-TT) is the provision of ongoing demonstrations of the impacts of observations on global and regional ocean forecast and analysis systems and to provide consistent and scientifically justified requirements and feedbacks to agencies in charge of Global and Regional Ocean Observing Systems.

The priorities and challenges for the next five year are manifold and will include:

→ **Community engagement** with CLIVAR-GSOP and with the observational agencies. Community activities will require applying multiple systems to equivalent experiments and is a way of establishing system-independent, robust results.
→ **Investment**: Substantially increase the efficacy of our community activities through a dedicated support mechanism, e.g. find funding for a postdoctoral researcher, etc. →Support from observational agencies welcome.
→ **Outcome:** Guidance for observational agencies to optimise the GOOS, and convince funders of the value of ocean observations to ocean forecasting and those beneficiaries of ocean forecasting
→ **Work Plan**: Define annual projects → draft during last GOV ST meeting (Beijing).

More information can be found online: Presentation (pdf).

E-AIMS, introduced by *Pierre-Yves Le Traon, Ifremer/Mercator Ocean (PYLT)* is an EU FP7-project that ensures a long-term European contribution to Argo. The plan is for Europe to establish an infrastructure in for ¼ of the global array, by deploying about 250 floats per year to contribute to the Argo core mission including regional enhancements (Nordic seas,

[1] See section 1. Workshop introduction

Mediterranean & Black seas) (maintain an array of 800 floats), prepare and contribute to the extension of Argo (e.g. biogeochemistry, deep ocean, polar regions) and through this support users and their application, in particular ocean and climate research and operational oceanography (GMES/Copernicus Marine Service). This will include setting up a new European legal structure (Euro-Argo ERIC) that will allow European countries to consolidate and improve their contribution to Argo international. The project is likely to extend into 2015.

The outcome from the E-AIMS project on the required evolution for Argo and Euro-Argo need to be discussed /shared with the wider community and this workshop provides a useful opportunity to do this. A special E-AIMS meeting following the workshop will allow reviewing activities and preparing final recommendations and reports.
More information can be found online: Presentation (pdf).

CLIVAR-GSOP has been working together with GOV for many years and collaborations have been quite fruitful, e.g. the organisation of reanalyses intercomparison exercise (ORAIP). *Magdalena Balmaseda (MB), ECMWF* introduced the current GSOP perspective about the adequacy of the observing system for climate applications and research, and whether existing observations are fully used and exploited. She also asked whether the currently used evaluation methods are good enough. This workshop provided the opportunity to share experiences on the use and outcomes from the current evaluation methods and whether alternative methods are useful and ready to be adopted widely. MB also highlighted the need to identify priorities for common short and long-term evaluation activities.
More information can be found online: Presentation (pdf).

Katy Hill (KH), WMO gave an overview of the current **in-situ observing system** status. The completion level has been fairly static in the past years. The main focus for the observation agencies is now on sustaining the ocean observing system. KH mentioned a variety of issues with the different components of the system. In some cases sustaining the system needs guidance on how best to maintain it (bottom-up, top-down approaches at OceanSites) while in other cases manufacturing problems (e.g. drifter net work), over employment or the wrong coverage has to be addressed. TAO/TRITON is at risk of further degrading due to inadequate servicing of the moored buoys. It is vital to find resources for the continuation of the in-situ observing system. Consideration includes involving new countries (e.g. China) to contribute to the TAO/TRITAN array maintenance. It is vital to set up good communication links to support this effort.
More information can be found online: Presentation (pdf).

The status of the **satellite observing system** was presented by *PYLT*. Altimetry remains the most important satellite observing systems for ocean analysis and forecasting and multiple-mission high resolution products are readily available (e.g. SSALTO/DUACS) offering a range of improvements (timeliness, regional products, climate). The new Mean Dynamic Topography (MDT) from GRACE and GOCE have made a major impact. Altimetry shows a very strong complementarity with Argo. But the Altimeter constellation remains fragile and will require to progressively “infuse” new technology (e.g. SAR/altimetry, SWOT).

GHRSST has contributed greatly to the satellite high resolution SST observations through major improvements in data processing issues and use of different types of sensors, including considerable developments in the L4 activities. The GHRSST community continues to thrive and the Regional/Global Task sharing Framework is stable. However, there are major challenges with the gap in dual-view infrared radiometry since the loss of AATSR on ENVISAT. The status of passive microwave SST is fragile. Improved data assimilation schemes are still needed to make a better use of high resolution SST observation (e.g. diurnal cycle, mixed layer dynamics, mesoscale).

Ocean colour observations are increasingly needed for operational applications (e.g. water quality, eutrophisation, HAB). However, in the past years only a small number of missions have provided OC and now higher resolutions and specialized OC products are required to monitor e.g. the coastal environment and contribute to coastal management. Assessment of the uncertainties associated with ocean colour products and improvement of OC data accuracy are required by the user communities. There is also a requirement to enlarge the bio-geochemical variables available from the in-situ observing system (for cal/val and to complement OC data in data assimilation systems) (e.g. Bio-Argo).The potential of OC data to calibrate or improve biogeochemical models is considerable but development lags behind other remote sensing techniques. This is a challenging and high priority research topic for operational oceanography.

Satellite Sea surface salinity products have recently (since 2009) become available and there is now a growing archive of 10-day SSS data sets from SMOS and Aquarius. The ocean community needs to fully invest in the critical assessment and application of the data and demonstrate its utility.

International cooperation (GOOS, CEOS) and a well organized scientific community, i.e. OSTST (altimetry), GHRSST (SST), IOCCG (Ocean Colour) play a critical role in the sustainability of the satellite observing system. We are not fully exploiting the information content of satellite observations, so there is a need to further develop OSE/OSSE activities to define requirements, quantify impacts and improve data assimilation (DA) systems to explore observation correlated errors, biases or representativity. In addition in-situ data are mandatory to calibrate, validate and complement satellite observations. The potential of satellite observations is not and will not be fully realized without a sustained in-situ observing system. It is vital to support the coordination of activities that provide more information about the usefulness and benefit of ocean observations.
More information can be found online: Presentation (pdf).

b. Satellite session

Gilles Larnicol, CLS introduced the objective of the satellite sessions as to review the current OSE/OSSE activities looking at different components of the satellite observing system and to provide feedback and advice on the design or at least on the impact of satellite observations on the model/assimilation systems. Furthermore it was planned to identify evaluation studies (OSE/OSSE/others) to be performed by GOV and CLIVAR GSOP groups in the next 1-2

years. A proposal for community OSEs was presented (see below). This list is open for discussion and can be revised as needed.
More information can be found online: Presentation (pdf).

Initial time	End time	Data with-held	Due date
7/2013	12/2013	Degraded Argo array (-20%)	4/2015
7/2014	12/2014	X altimeter(s) of the constellation (TBD)	4/2016
7/2015	12/2015	Tropical moorings	4/2017
7/2016	12/2016	X% of Argo (TBD)	4/2018
7/2017	12/2017	X altimeter(s) of the constellation (TBD)	4/2019

Table 2: Proposed community OSEs during the next 4-5 years

Elisabeth Remi, (Mercator-Océan), provided a summary of **studies assessing the Impact of current altimetry missions on Mercator Ocean analysis and forecasting.** She described their approach which is similar than numerous GODAE centers. It consists in the set-up of the recent OSE experiment carried out at Mercator Ocean which included one year experiments for 2012 with the global ¼° ocean system and North Atlantic 1/12° system, looking at the impact of different satellite altimeter data. In both systems (depending on region) increasing the number of altimeters lead to a reduction of the SLA residuals and innovations, decreasing the SSH error. This also positively impacted the in-situ and SST error reduction. However, the impact on different model resolutions is not clear yet and raised questions on its effectiveness
Main feedback was that despite a lot of OSEs having already been performed in the past by several GODAE groups, and help to quantify the impact of the present observation network in each analysis/forecasts system, it also is very helpful to verify that satellite altimeter information is « optimally » used in the system. Indirectly, it induces improvements of the assimilation system performance. These studies help us to characterize the impact of a given altimeter mission that depends on the region and the altimeter characteristics (observation error, repetitivity). As the results also depend of the forescasting system performance (model resolution, assimilation scheme maturity) it was strongly encouraged that each centers performed studies at a regular basis. The new stake will be to demonstrate the usefulness of the new high resolution sensors as the SAR mode of C2 and the future sentinel-3 mission. At longer term, we need to be prepared to assimilate the future SWOT mission who will imply drastic evolution in the way to assimilation these swath data instead the conventional along track data.
More information can be found online: Presentation (pdf).

In the context of future mission, Mounir Benkiran, CLS/Mercator-Océan, introduced a study attempting to adapt the assimilation system **for the SWOT mission** (launch planned in 2020). A regional system was used (IBI region) to set up an OSSE to learn about the impact of the new data on the forecasting system. It shows that the current assimilation system can handle the SWOT data well, and that assimilation of SWOT data will improve model results. Positive impact on the in situ T/S profiles through correction of the vertical

projection can also be expected. A lot of work still remains covering both, to manage the observation errors which will still have to be assessed and to take into account the bad temporal sampling of SWOT mission.
More information can be found online: Presentation (pdf).

Guillaume Vernieres, NASA/GSFC introduced a study on the **Impact of the Assimilation of Aquarius Sea Surface Salinity Data in the GEOS Ocean Data Assimilation System** which analyzes globally the along-track (Level 2) Aquarius SSS retrievals obtained using both passive and active L-band observations. Aquarius along-track retrieved SSS are assimilated into GEOS-5. Large biases and errors apparent in an earlier system version are corrected and the observed Aquarius SSS retrieval mapped into the ocean model's bulk salinity in the topmost layer. The impact of the assimilation is evaluated by comparisons with Argo salinity observations, and shows a significant reduction of the global biases and RMS of observations-minus-forecast differences at in-situ locations, particularly in the tropics and southern latitudes.
More information can be found online: Presentation (pdf).

Tony Lee, NASA/JPL, presented an update of **Aquarius and the assimilation of Aquarius data.** Aquarius has provided global views of sea surface salinity (SSS) at 7-day interval since August 2011, with accuracy close to the mission target (better quality in the tropics and subtropics than at higher latitudes). Aquarius data have been used to study the linkages of SSS with ocean circulation and water cycle and to improve ocean state estimation & climate prediction. More feedback on the impacts of Aquarius data in data assimilation is needed. Aquarius data distribution & documentation is being facilitated trough NASA/JPL's Physical Oceanography Data Active Archive Center (PO.DAAC).
More information can be found online: Presentation (pdf).

The two presentations dedicated to Aquarius mission exhibit the same conclusions. The first one is that Sea surface salinity data from Aquarius has a strong bias that needs to be corrected before assimilation. Then, with specific adaption of the data assimilation systems (observation and background errors), Aquarius could have a positive impact in forecast system, in particular for seasonal forecasts. Conclusions are similar for SMOS mission.

It has to be noted that no presentations were given covering Ocean Colour and Sea surface temperature. Ocean colour assimilation is still in its early stages and consequently prevents robust impact studies to be carried out.

Action 1 (2-GOV/GSOP):	PYLT to contact workshop attendees to request information about requirements for future salinity observations (in context of ISSI workshop, no date/location provided)

c. Session on the Tropical Observing System

Neville Smith introduced the session presenting the Tropical Pacific Observing System 2020 project or TPOS 2020. Due to the degradation of the TAO/TRITON observing system over the past years, steps are now being taken to restore and improve the array and to make it more robust. TPOS has been created to review observing system requirements and implementation, and to deliver plans and advice on a sustainable, efficient and effective observing system beyond 2020. A number of task teams are being set up to provide advice on the future "backbone" Observing System and on modelling and data assimilation. This will be accompanied by observational and modelling studies aimed at improving understanding and parameterisations used in both the forward models and in data assimilation, as well as addressing predictability and systematic mode errors. It is also being suggested to set up a framework of OSEs. TPOS tries to achieve a major change in how to use the observing system/network by putting in targeted goals, involve important players and by following a set schedule. TPOS will also join up with the Indian Ocean Panel to help other observing systems to learn from their experience. More information can be found online: Presentation (pdf).

Yosuke Fujii, MRI-JMA presented a study focussing on the **Evaluation of the Tropical Pacific Observing System from the Ocean Data Assimilation Perspective in the TPOS2020 workshop.** The recent degradation of the TAO array has triggered the need for new evaluation studies to identify requirement for the tropical Pacific observing system from a data assimilation perspective. The use of OSEs should determine to what extent these requirements are delivered by existing network and the GODAE Ocean View OSEval-TT is well placed to provide support. Further loss of TAO/TRITON data could lead to a degradation of forecast skill and could have detrimental effects on many applications based on ocean DA systems. Only continued deployment and maintenance and potentially redesigning the tropical mooring arrays in all ocean basins would counter this issue. This should be aided by an internationally coordinated multi-model effort in (tropical) observing system evaluation. At the TPOS2020 workshop multi-system analysis activities for observing system evaluations were recommended, as well as intercomparisons of real-time ocean analysis and multi-system OSEs.
More information can be found online: Presentation (pdf)

Yan Xue, NOAA/NCEP presented her work on the **Evaluation of Tropical Pacific Observing Systems Using NCEP and GFDL Ocean Data Assimilation Systems.** Coordinated Observing System Experiments (OSEs) were conducted using NCEP's GODAS and GFDL's ECDA during 2004-2011. Data *withholding* OSEs were evaluated with observations (TAO temperature, TAO currents, altimetry SSH) and analyzed data (EN4 temperature and salinity analysis, OSCAR surface current analysis). Without assimilation of in situ data, both GODAS and ECDA had large mean biases, STD biases and RMSE. Assimilation of in situ data significantly reduced mean biases, STD biases and RMSE in all variables except zonal current at equator. For constraining temperature analysis, the mooring data is more critical than the Argo data in the equatorial Pacific, but the Argo data is more important in off-equatorial regions. For constraining salinity, sea surface height and surface current analysis, the influence of Argo

data is more critical. Impacts of observations on ocean analysis are sensitive to configuration of data assimilation schemes, indicating that a multi-model approach is needed to assess the value of tropical Pacific observing systems.
More information can be found online: Presentation (pdf).

Siva R Reddy, INCOIS presented on the **Impact of in-situ Ocean Observations on global ocean analysis using INCOIS-GODAS.** The impact of the moored buoys, profiling floats, and ship-based observations used in the OSE study indicated that Argo has the strongest positive impact, while moored buoy observation data did not significantly improve the quality of the global ocean analysis. Further experiments are required to understand the reason for these differences.
More information can be found online: Presentation (pdf).

Introducing a new project *Fabrice Hernandez, Mercator Ocean* highlighted the proposal for a French Research initiative: **"Impact des Observations dans les Océans Tropicaux" or Impact of Observation in Tropical Oceans**. The motivation for this project comes from the recent problems in maintaining the TAO/TRITON array (and potentially other moorings) and to share the effort of analysing /redesigning the tropical observing systems in collaboration with a larger research community (e.g. atmosphere). It will be beneficial to align plans for impact studies with other projects. Amongst other things, the hope is that this will lead to improvements of assimilation systems (Mercator Ocean) and to an assessment the observing system impact of more Tropical Oceans.
More information can be found online: Presentation (pdf).

d. Argo session

The session analyzed design issues related to the development of the new phase of Argo. PYLT introduced the session and gave a summary of recent discussions within the international Argo steering team. It has been proposed to extend the coverage of the global Argo mission (T&S from the surface down to 2000 m) to cover high latitude regions and marginal seas and to augment the sampling by a factor of two in equatorial and western boundary current regions. This corresponds to a new target of about 4200 active floats. In addition two new missions are proposed: deep Argo and bio-Argo. These represent major evolutions for Argo. All these evolutions require careful design and implementation. OSEs and OSSEs are useful tools for guiding the design but their limitations must be fully understood. The following topics were covered during the session: impact of Argo observations at global and regional (Mediterranean) scales and design of deep Argo. These studies clearly demonstrate that Argo has a major impact on global and regional data assimilation systems. Without Argo data or even with a degraded Argo array temperature and salinity analysis and forecasting errors are very significantly degraded. The main recommendation is thus to at least maintain the Argo array as it is as of today. Several recommendations were also given on future studies. GOV systems are particularly suited, for example, to analyze requirements in western boundary current and tropical regions (dispersion of floats, signal/noise ratio, synergies with altimetry). In addition to simple

metrics (reduction of analysis and forecast errors, forecast skills), other metrics should also be developed and used (e.g. better estimation of climate indices at global and regional scales, better representation of important physical processes, impact on biogeochemistry models through improvement of vertical velocity fields). OSEs/OSSEs based on statistical approaches should also be used in parallel with the more complex OSEs/OSSEs based on data assimilation systems. As far as deep Argo is concerned, first OSSE results already show that data assimilation systems are not sufficiently constrained at depths and will be significantly improved with deep Argo data. Preliminary results suggest that an array of 1000 floats profiling once every month up to a 4000 depth (i.e. 1/9 of the existing global Argo sampling) would allow correcting most of the model biases at depth. Some regions are more important than others and specific tools exist (e.g. adjoint methods) to quantify where observations matter more. No presentations were given on Bio-Argo but this aspect was partly covered during the discussion. The first priority for Bio-Argo should be to use existing data sets (oxygen and Chl-a) to validate models and better characterize model errors. OSSEs in coupled physical/biogeochemical models should also be developed to guide the development of Bio-Argo.

Elisabeth Remy, Mercator Ocean presented on the **Impact of Argo floats on ocean analysis and forecast at Mercator Ocean**. A one-year OSE was carried out to assess the impact of Argo data on the ¼° global ocean analysis and forecasts (PSY3V3). Several set-ups were compared (runs without Argo floats, with only half of the float number and with the full array) and results show that assimilating Argo data has a strong positive impact on temperature and salinity estimates at all depth, linked with an Observation – Forecast error reduction both in term of variability and bias. Only using half of Argo floats degrades system performance of the system at all depths. The impact was higher at depth where water masses from outflow or deep convection are better represented in the surface layers, particularly in the tropical band and energetic ocean regions where the largest impact is found. OSSE, where observations are simulated from a fully known ocean simulation are also planned to simulate extension of the future deep ARGO network.
More information can be found online: Presentation (pdf).

Robert King, Met Office presented on **The Impact of Argo on short-term coupled prediction.** The recent development of short-range coupled prediction systems at the Met Office allows assimilation of data into both ocean and atmosphere components of the coupled model. An OSE (assimilation of all available atmosphere and ocean observations and withholding the Argo data from the ocean component) was used to assess the impact of the Argo data on both the ocean and atmosphere. The coupled OSE shows that the impact on SST is mainly limited to equatorial regions and WBCs, while there is significant sub-surface effect on temperature and salinity. Particular interest was given to the impact of Argo on short-range weather forecasts using an extreme weather event (Hurricane Sandy). There is little effect in the atmosphere analyses, however SST differences impact the analysis for Hurricane Sandy. There is no clear systematic impact from the sub-surface differences.
More information can be found online: Presentation (pdf).

Jenny Pistoia, INGV presented **OSEs and OSSEs with ARGO Assimilation in the Mediterranean Sea**. An OSE was set up to test the impact of the multi-platform observing system, composed of Argo and satellite altimetry, with the Mediterranean Forecasting System which produces daily analyses for the Copernicus service. Performed OSEs show that ARGO assimilation is crucial to maintain low RMS error in spite of assimilation of satellite altimetry. ARGO impact on the analysis quality amounts to a lower vertical average error of about 20-30% in temperature and salinity respectively. The OSSE synthetic ARGO used in the experiments is testing the optimal parking depth, the vertical and time sampling scheme. This experiment shows that lower parking depths or shorter drifting time decrease the analysis RMSE (by about 20%) for T and S with respect to standard ARGO set up and that vertical ARGO profile sub-sampling increases the analysis error (of 15% for T and 10% for S). Full profile transmission could be considered as a major improvement for MyOcean Med-MFC analysis.
More information can be found online: Presentation (pdf).

Shuhei Masuda, JAMSTEC presented a talk on **Toward an Optimal Design of Deep Profiling Float Network.** The importance of deep ocean observations has been recognized in connection with the global changes in bottom-water warming (below 2000m). An ocean data synthesis system (K7 consortium) using an adjoint approach is applied to identify the possible key regions of deep ocean temperature changes. Several Deep floats are deployed in the key sites detected by the sensitivity exercise to improve state estimation and to uncover the mechanism of deep ocean changes. Monitoring the changes in oceanic heat content focusing particularly on the inter-annual to multi-decadal variations allows developing an effective geographic deployment strategy for deep profiling floats. An adjoint sensitivity analysis implies that changes in the water temperature in the local areas in the Southern Ocean can have subtle influence on the water warming in the pentadal/decadal time-scale. In addition an OSE is planned using two global data synthesis systems in JAMSTEC with different architectures to help provide a general evaluation of the observing system.
More information can be found online: Presentation (ppt)

e. Session on Evaluation methods

This session focussed on the aspect of observing system evaluations and their associated evaluation methods. A variety of evaluation methods (as presented by MB) are listed below:

- Observing System Experiments (OSEs), e.g. to explore the impact on reanalyses and forecasts.
- Observing System Simulation Experiments (OSSEs) or twin/sibling experiments.
- Automatic diagnostics of observation impacts in analysis and forecasts.
- Identification of areas of uncertainty (intercomparison, ensembles)
- Identification of sensitivity areas (growing modes, either dynamical or empirical).

OSEs and OSSEs are the most widely used evaluation methods, and can help to address the impact of the observations on the ocean state estimation and in the forecasts. However they can be quite expensive and although they are useful evaluation tools their results should be interpreted carefully. OSEs can underestimate the impact of observations, since deficiencies in the data assimilation/forecasting systems imply sub-optimal use of observations. On the other hand OSSEs can be over-optimistic, since they often neglect structural error. Statistical methods offer a nice complement to the model-based evaluation tools, since they are not affected by errors in the ocean model (Stephanie Guinehut presentation). However, they are still sensitive to the parameters used to characterize the observation error and its spatial-temporal correlation scales.

It was acknowledged that there is need for automatic evaluation tools that can provide ready information on the observation impact in existing systems, either dynamically or statistically. More effort should be devoted to implement these automatic evaluation methods operationally (such as degrees of freedom for signal, analysis sensitivity, forecast sensitivity…), as it is common practice in NWP.

The intercomparison exercises can also be useful to identify regions of large uncertainty, and to evaluate how uncertainty evolves as a function of the observing system. The current Ocean ReAnalyses Intercomparison Project (ORAIP) has been used to provide quantitative information of adequacy of the observing system, as used by the current assimilation methods, for the estimation of ocean variability relevant for climate. In this approach, the different ocean reanalyses are used to build an ensemble. The signal-to-noise ratio, defined as the ratio between ensemble mean and ensemble spread, is calculated for a selection of variables and for different temporal components (mean state, interannual variability and trends). The results have been submitted to a dedicated special issue in Climate Dynamics.

Along similar lines, the multi-ORA monitoring initiative is an attempt to exploit a variety of operational ocean reanalysis for real-time monitoring of climate systems (Yan Xue presentation). It also produces estimations of signal-to-noise, thus providing prompt diagnostics of those areas where the observing system is adequate or deficient. The current multi-ORA monitoring focuses on the Tropical Pacific thermal field, and aims primarily at the monitoring of ENSO. There is scope to extend the monitoring activities to other variables and other ocean basins.

There is also need to facilitate the use of observations by the modelling community. Diagnostic tools that compare model output with observations at appropriate time and location area widely used by the data assimilation community, but they are not commonly used by the modelling community. These tools have the advantage to provide detailed comparison with observations without the need of excessive model field output. The used of diagnostics in observation space by the modelling community will ultimately facilitate model development.

Improvement of models and data assimilation methods will results in better exploitation of the observations. An example is the development of coupled-data assimilation systems (Patrick Laloyaux presentation), which offers promising perspectives for the better exploitation of surface observations.

There was much discussion about the metrics used in the evaluation. They should be objective and statistically significant, they should have relevance for climate and society, and they should be discerning. Since it is probably difficult to define metrics that achieve all these characteristics, it was proposed to use a mix of metrics:

i) objective statistical metrics (such as forecast skill or fit-to-obs in predetermined areas); these are objective, but not always discerning, since often the statistics over a large number of cases hides important details;
ii) relevant climate/societal indices used for monitoring climate and
iii) specific case studies, which should provide more discerning criteria than the objective skill scores.

This workshop provided the opportunity to share experiences on the use and outcomes from the current evaluation methods and whether alternative methods are useful and ready to be adopted widely. MB also highlighted the need to identify priorities for common short and long-term evaluation activities.

Patrick Laloyaux, ECMWF presented on the **Observing system evaluation in a coupled assimilation system at ECMWF.** He described the ECMWF prototype assimilation system (CERA) that incorporates simultaneously ocean and atmospheric observational data in a coupled ocean-atmosphere model. The system is a valuable tool for observing system evaluation, especially for surface observations. Idealized single observation experiments show the impact of ocean observations in the atmospheric boundary layer, and vice versa. The CERA system has also been used to evaluate the impact of scatterometer winds on the atmospheric and oceanic states. Interestingly, a "reprogrammable" Argo float was used as independent validation of the assimilation of scatterometer case study.
More information can be found online: Presentation (pdf).

Stephanie Guinehut, CLS presented on the **Observing System Evaluation in the ARMOR3D observation-based system.** ARMOR3D combines in-situ and satellite observations using statistical methods to produce 3D T&S and geostrophic current fields. The degree of freedom of signal (DFS) method is then applied to assess the relative impact of satellite and in-situ observation for the construction of the ARMOR3D T & S fields. Results shown were very consistent with the space/time distribution of the different observing systems and with

parameters used in the OI method. Redundant information was found in the tropical moorings (due to large correlation scales used in OI) and in the satellite + climate dataset to correct the mid to large-scale part of the field. No redundancy was found in Argo. TH DFS method was seen as very useful for on-the-fly metrics or observing system design studies. More information can be found online: Presentation (pdf).

Yan Xue, NOAA/NCEP, presented the **Multi-ORA real-time ocean monitoring initiative.** Ocean reanalysis that are produced in real-time (mostly for initialization of seasonal forecasts) are used for the monitoring of the tropical Pacific, with emphasis on ENSO. Several centres send thermal data in agreed grids to NCEP, where relevant sections and indices are defined and plotted in a uniform format. The ensemble mean and spread are used to evaluate the signal and associated uncertainty. The signal-to-noise ratio provides guidance of the adequacy of the current analyses and observing systems to monitor ENSO. The initiative, which started in Feb 2014 with NCEP, ECMWF and JMA now includes GFDL, NASA and BoM, and it is being extended to include MERCATOR and Met Office.

http://www.cpc.ncep.noaa.gov/products/GODAS/multiora_body.html

3. Status on Observing Systems requiring evaluation

a. Tropical Pacific Observing System (TPOS)

Boundary currents (Eastern & Western Pacific) represent important areas for **TPOS** and were considered for **case studies**. These will need proper planning and would require a new group (within TPOS) to be set up, with someone that can coordinate this activity, maybe for one observing system only. It was suggested that the focus could be on Western boundary currents and the tropical East-West Pacific. It is anticipated that not many experiments will be possible but e. g. selecting to withhold mooring data in West or East Pacific, or TAO TRITON (2N-2S) could be an option. Alternatively, previous TAO/TRITON experiments done for other years (Yosuke Fujii) could be repeated. YF confirmed that JAMSTC has used TAO/TRITON for forecast impact studies to explore the impact of ocean moorings. Also salinity experiments would be useful, including sub-surface salinity (to investigate predictability). The upper 100 m will also be a focus for TPOS.

Siva R Reddy, INCOIS (and Jiang Zhu) confirmed that they plan to work together on OSE/OSSEs in the Indian Ocean (at NCEP). Tony has stepped down from CLIVAR and wants to know about plans for OSE/OSSEs in the Indian Ocean.

Action 2 (2-GOV/GSOP):	Tony Lee to contact Indian Ocean colleagues to check with them if they are planning to contribute to TPOS through OSEs

TPOS should consider providing recommendations to the observation community, e.g. where TAO data have the most impact, e.g. equatorial region, meridional or ITCZ. Such impact studies will need high-resolution models. GOV/GSOP groups are best places to address this. Case studies would also be useful in learning more about models and DA

systems and how to improve the observing and forecasting systems. Such studies can currently only contribute to existing systems and only passively contribute to the new designs.

More communication with the TPOS committee and the instrumentation developers will be needed to maximise the usefulness of any activity.

b. Sea Surface Salinity (SSS)

TL has campaigned for **SSS** data to be used in ocean models but uptake of data is slow. Communication between the users and the forecasting centres is very important and needs to be encouraged. Most systems do not yet assimilate SSS. The assimilation effort is in its early stages and only when a number of OOFS assimilate SSS, OSE experiments can be conducted. In parallel, new improved version of SSS products will available both for Aquarius and SMOS. Impact of these new products shall be assessed.

c. Altimetry

Sentinel-3 mission will be more likely launched in November 2015. Then, new high resolution altimeter data will be available from beginning 2016 and it is important to prepare for this. It was recommended to explore the impact of this mission to ensure that the systems can handle high resolution date and show the usefulness of the Sentinel-3 output. This recommendation comes from experience with AltiKa, where it was difficult to show value.

SWOT data (launched in 2020) should also be considered for evaluation (using OSSEs), which was seen as a particular important task for the DA-TT that really need to anticipate the advent of the new mission Running case studies for SWOT might be the best use of time and resources (date/time scales are very important). One aspect would be to check the seamless transition from one satellite to another using different metrics (i.e. skill scores, indices or case studies)

Longer timescales and regional OSEs could also be considered (e.g. to explore the effect of kinetic energy transports, heat or fresh water transport). To carry out these studies volunteers are needed and people who can contribute should come forward.

d. Deep Ocean Observing System (DOOS)

When looking towards the future observing systems the focus does not need to be on real time. Priorities for the GOOS have been identified by OOPC and Katy H will share the document describing the plans with everyone who is interested.

A new approach will include an observing system for the **deep ocean** (DOOS) and Dean R will focus on the Tropical Pacific for deep observation needs. This is one aspect that this

group should consider and should be part of the work plan, including real-time intercomparisons (salinity, transports, etc.)

e. Microwave SST (loss of)

It was mentioned that there is concern about microwave SST being threatened by remote sensing. It is important to show what impact **a loss of microwave SST** would have on the observing system, e.g. tropical ocean, but also with regard to YOPP or mid/high latitude of the Atlantic. In addition, most of group use gridded map, but high resolution (level 2) impact should be assessed**.**

4. Proposals for future activities

a. COMMUNITY OSEs – Best Practices

It was proposed to set up and run Community OSEs and to identify evaluation studies (OSE/OSSE/others) to be performed by GOV and CLIVAR GSOP groups during the next 1-2 years, taking into account existing initiatives/projects such as TPOS or AtlantOS. (Also compare table 2 in "2.2 Satellite session".)

It was also proposed to run annual community OSEs and perform one study per year, covering a 6 months period. The 3 OSEs should be run in the following way:

ALL: OSE that assimilates "all" observations
NONE: OSE that assimilates no observations
COSE: OSE that with-holds an agreed set of observations

It is hoped that

- Results/feedbacks can be provided on an annual basis
- Use of COSEs can be widened to address more COSEs each year
- Periods covered for some OSEs will be extended (more than 6 months) depending on observing system
- Adequate diagnostics (forecast metrics, ocean indices, case studies) can be defined
- Type of experiment is defined (OSE, OSSE, intercomparison,..)

Following the presentations given during the "Introduction" session for GOV OSEval and CLIVAR/GSOP, it was established that there is a clear need to perform "Community OSEs" at an annual basis in order to be in the position to provide up to date feedbacks to the observational agencies on the impact of the observing system in the short term and seasonal to decadal forecast systems. Coordinate and set up "Community OSEs" is of upmost importance for establishing system independent and robust results. However, this means that each group integrate this work in their core activity.

In practice,

- The "Community OSEs" shall involve multiple systems to perform equivalent experiments producing same diagnostics (metrics, ocean indices,...). Ideally, each group should perform the same full scenario/experiment.

- In case of integrating a new observing system in an operational system, it was recommended to perform OSEs to quantify the impact of this new observing system;

- It is also encouraged to analyse the impact of observations, and in addition to generate forecast metrics also analyse the ocean climate indices.

- It is recognised that for some observing system, DA assimilation is in its early stages and sometimes not ready to perform relevant OSEs.

- OSEs will be most efficient if done in real time; this also has the value of providing information about the operational systems which should be continuously improved including DA methodology.

b. Proposals for activities in the OSEval-TT:

i. OSEs on demand

The OSEval community should be ready to provide prompt feedback to on-going programs which need imminent decisions. One of them is the TPOS2020 program, which aims at revising the Tropical Pacific Observing system with a holistic perspective. Other is ATLANTOS and Deep Argo. Although the limitations of OSEs are appreciated it may still be useful to conduct experiments for specific areas, especially those that could be oversampled in the near future as a result of specific observational campaigns. such as the Equatorial Pacific, especially to detect the impact of new Iridium Argo, and the WBC, since soon it is expected that there will be oversampling on some WBC. Pierre-Yves Le Traon could be the contact person. Discussions about how experiments and outcomes could be organised in very small workshops (1 day) or through teleconference meetings. Such activities initially need flexible engagement which can be followed by a consolidated workshop. It will be useful to document the activity plan details and to coordinate a good solution for the workshops for the next 4-5 years (Neville S. & Fabrice H.).

This should involve **documenting the outcomes** from the OSEs including diagnostics or indices and could for example focus on SWOT. It was suggested to ask Tony Lee to get involved.

Magdalena Balmaseda proposed a specific case study for OSEs on demand: July-August 2014 in the Equatorial Pacific, since the evolution of the surface and subsurface thermal structure in the Equatorial Pacific during that time surprised many: by July a cold-spell finished the expected strong El Nino that had started to develop in April. It is likely that the details of the intraseasonal variability play a dominant role in this event. Hence, it is important to understand how the different components of the observing system affected the representation of the phase and intensity of the ocean intraseasonal variability during this time. TPOS could play a role in bringing groups and people together. Names proposed included: Mike McPhadden (NOAA), William Kessler (NOAA, PMEL), Harry Hendon (CAWCR) and Matt Wheeler (CAWCR). MB and NS were asked to take this forward.

Action 3 (2-GOV/GSOP):	GL to contact OSEval TT members to identify the groups that are keen to perform studies

ii. Extension of Multi-ORA monitoring

The ongoing multi-ORA initiative at NCEP focuses on the tropical thermal field and consists of the monitoring of indices and spatial fields using several ORAs. The current procedure is relatively easy to follow, since the processing centre (NCEP) provided very clear instructions on the required fields. Every month, each operational centre (producer centre) provides the thermal information as requested by the processing centre. In this case, NCEP requests anomalies (respecting a prescribed climatology) of tropical 3D fields of temperature in the WOA grid (1x1 lat/lon, 41 levels in the vertical), as well as D20 and averaged temperature in upper 300m.

The above procedure could be extended to include targeted monitoring of other ocean basins and variables. It is better left to the initiative of the processing centres, which can define the monitoring metrics based on their expertise. It may be possible to extend this to the Indian Ocean and Atlantic Ocean, and also to include salinity. Yan Xue from NCEP is the contact point for any further extension of the real-time monitoring. Siva R Reddy (INCOIS) will visit NCEP shortly, and it could be a good opportunity to extend the real-time monitoring to the Indian Ocean. Oscar Alves expressed an interest to do this for salinity and Tony Lee is interested in the AMOC transport.

Action 4 (2-GOV-GSOP):	Yan X. and Siva R. to produce proposal for Indian Ocean Monitoring. Magdalean B. to contact Oscar Alves to confirm interest on salinity intercomparison

c. Meetings/workshops

Organisation of **future meetings** should ideally be done in consultation with the other GOV task teams. An opportunity to discuss arrangements could be the next GOVST meeting in Sydney when the week could be mostly dedicated to short, shared TT meetings focussing on specific topics.

OSEval-TT activities in the coming year will follow the work plan. It needs to be decided how the work is being shared, as well as looking for modelling and DA groups to produce results. The IV-TT will liaise with the COSS-TT on metrics and GOV in general should align itself closer to other programmes, also with those from the atmospheric sciences area.

TPOS will organise a systematic error workshop in the next two year, also to bring in knowledge from GEWEX[2] and other groups

The secretariats of GOV, OOPC, GSOP, JCOMM, etc. should set up meetings (teleconferences) to support these efforts through discussing and informing the other secretariat about what is going on to save time and effort.

[2] Global Energy and Water Exchanges Project

We should share information about other projects and workshop planned which are related to OSEs.

The next OSEval-TT workshop should reflect the progress made since this meeting and set up so that the best outcome can be achieved. Ideas of how best to set up the next meeting would be forwarded to the organisers.

5. Recommendations

a. General recommendations for the Evaluation of the Ocean Observing System

1. The Evaluation of the Ocean Observing System should be done taking into account the different operational and research applications (short range and long-range forecasting, climate reanalyses, research and biochemistry applications).
2. Evaluation of the Observing System should be a routine activity on operational centres to provide ready feedback to the observing agencies.
3. Coordinated evaluation activities are needed to eliminate the system-dependence from the results, and to quantify and reduce the error in the evaluation.
4. Participation in concerted activities such multi-system OSEs, and real-time monitoring are encouraged.
5. The design and outcome of the concerted activities should link to ongoing international programs such as TPOS2020 and ATLANTOS.
6. The evaluation metrics should contain a mix of objective skill scores, impact on index of physical/ societal relevance, and specific case studies.
7. The different systems should invest on implementation of software infrastructure for automatic evaluation of the observing system
8. Observation space diagnostic tools commonly used by the data assimilation community should be shared with the modelling community, to help to diagnose and correct model systematic errors.
9. Data assimilation and forward models need to be improved. There should be a strong link between research-development and operational implementation to guarantee that the operational systems are state of the art.

b. Next workshop

The Task Team could meet every 2 years inviting the relevant GOV task teams and GLIVAR/GSOP. Next meeting is to be confirmed.

Appendices

Appendix A: Agenda

Wednesday, 10 December 2014 - **morning**

Time	Title	Presenter
08:30 – 09:00	Registration (Payments, badges, poster set-up, etc.	N/A
09:00 – 09:15	1.1 Welcome (Practical information, local info, posters, cocktail, etc.	TBC
1. Introduction session – chaired by **Gilles Larnicol**		
09:15 – 09:35	1.2 GODAE Ocean View and the OSEval-TT activities meeting (20 min)	G. Larnicol (CLS)
09:35 – 09:45	1.3 The FP-7 European E-AIMS project (Euro-Argo OSE/OSSE) (10 min)	P.Y. Le Traon (MERCATOR/IFREMER)
09:45 – 10:00	1.4 OSE/OSSE activities in CLIVAR GSOP (15 min)	M. Balmaseda (ECMWF)
09:45 – 10:00	1.5 Overview of the In-situ observing system (15 min)	K Hill (WMO)
10:00 – 10:15	1.6 Overview of the satellite observing system (15 min)	P. Y. Le Traon (MERCATOR/IFREMER)
10:15 – 10:45	Coffee break / Poster viewing	
2. Satellite session – chaired by **Gilles Larnicol**		
10:45	2.1 Introduction to satellite sesssion	Gilles Larnicol
10:45 – 11:05	2.2 Impact of current altimetry missions on Mercator Ocean analysis and forecasting (20 min)	S. Verrier (MERCATOR OCEAN)
11:05 – 11:25	2.3 Preparation of the SWOT mission(20 min)	M. Benkiran (MERCATOR OCEAN/CLS)
11:25 – 11:45	2.4 The Impact of the Assimilation of Aquarius Sea Surface Salinity Data in the GEOS Ocean Data Assimilation System (20 min)	G. Vernieres (NASA/GFSC)
11:45 – 12:00	2.5 Aquarius update and assimilation of Aquarius data (15 min)	T. Lee (NASA/JPL)
12:00 – 12:45	Discussion session (45 min)	

Wednesday, 10 December 2014 **- afternoon**

12:45 – 14:00	Lunch / Poster Viewing	
3. Tropical Observing System – chaired by **Neville Smith**		
14:00 – 14:20	3.1 The TPOS 2020 project (20 min)	N. Smith
14:20 – 14:40	3.2 Evaluation of the Tropical Pacific Observing System from the Ocean Data Assimilation Perspective in the TPOS2020 Workshop (20 min)	Y. Fujii (JMA/MRI)
14:40 – 15:00	3.3 Evaluation of Tropical Pacific Observing Systems Using NCEP and GFDL Ocean Data Assimilation Systems (20 min)	Y. Xue (NOAA/NCEP)
15:00 – 15:20	3.4 Impact of Global Ocean Observation systems on ocean analysis using INCOIS-GODAS (20 min)	S Siva Reddy (INCOIS)
15:20 – 15:30	3.5 Observation impacts on tropical Oceans: French initiatives (10 min)	F. Hernandez (Mercator Ocean)
15:30 – 16:20	Discussion session (50 min)	
16:20 – 16:50	Coffee break / Poster viewing	
4. Evaluation methods – chaired by **Magdalena Balmaseda**		
16:50 – 17:10	4.1 Observing system evaluation in a coupled assimilation system at ECMWF (20 min)	P. Laloyaux (ECMWF)
17:10 – 17:30	4.2 Ensemble-based array performance assessment (20 min)	P. De Mey (LEGOS)
17:30 – 17:50	4.3 Monitoring the Ocean from observations (20 min)	S. Guinehut (CLS)
17:50 – 18:30	Discussion session (40 min)	
18:30 – 20:30	Poster viewing & Cocktail	

Thursday, 11 December 2014

Time	Title	Presenter
5. Argo session – chaired by **Pierre-Yves Le Traon**		
09:00 – 09:10	5.1 The evolution of ARGO for the next decade (10 min)	P. Y. Le Traon (MERCATOR/IFREMER)
09:10 – 09:30	5.2 Impact of Argo data assimilation on Mercator Ocean global analysis and forecasting systems (20 min)	E. Remy (Mercator Ocean)
09:30 – 09:50	5.3 The impact of Argo on short-term coupled prediction using OSEs and OSSEs (20 min)	R. King (Met Office)
09:50 – 10:10	5.4 OSEs and OSSEs with ARGO Assimilation in the Mediterranean Sea (20 min)	J. Pistoia (INGV)
10:10 – 10:30	5.5 Toward an Optimal Design of Deep Profiling Float Network (20 min)	S. Masuda (JAMSTEC)
10:30 – 11:00	Coffee break / Poster viewing	
11:00 – 12:00	Discussion session (1 hour)	
6. Summary and next steps – chaired by **Gilles Larnicol**		
12:00 – 13:00	6.1 GOV OSEval-TT & CLIVAR-GSOP Work Plan	G. Larnicol (CLS) & M. Balmaseda (ECMWF)
13:00 – 14:00	Lunch / Poster viewing	
14:00 – 15:30	6.2 Summary of session, main recommendations and future work	Session chairs
15:30 – 16:00	Coffee break	
16:00 – 17:00	6.3 List of actions, next meeting, … Any Other topic	G. Larnicol, M. Balmaseda, PY. Le Traon
17:00	Workshop closes	

Posters

ID	Surname	First name	Affiliation	Title
1	Bourassa	Mark	COAPS, Florida State University	Development of a New Approach to Accuracy Assessment of Ocean Observations
2	Fujii	Yosuke	JMA-MRI	Recent ocean observation system evaluation studies in JMA/MRI
3	Gehlen	Marion	Laboratoire des Sciences du Climat et de l'Environnement	The Fixed point Open Ocean Observatory network: Multidisciplinary observations from the Air-Sea Interface to the Deep Seafloor
4	Valdivieso	Maria	Department of Meteorology, University of Reading	Air-Sea Heat Flux Estimates from an Ensemble of Global Ocean Reanalyses
5	Wedd	Robin	Bureau of Meteorology	Argo Real-Time Quality Control Intercomparison
6	Xue	Yan	NCEP/NOAA	Real-time Ocean Reanalyses Intercomparison for Quantifying Uncertainties in Ocean Reanalyses and Monitoring Climate Variability

Appendix B: Participants list

No	Name	First name	Affiliation	Country
1	Albert	Aurelie	LEGI	France
2	Balmaseda	Magdalena	ECMWF	UK
3	Benkiran	Mounir	CLS	France
4	Bourassa	Mark	COAPS, Florida State University	USA
5	Drevillon	Marie	Mercator Ocean	France
6	Drillet	Yann	Mercator Ocean	France
7	Fujii	Yosuke	JMA/MRI	Japan
8	Ganachaud	Alexandre	LEGOS	France
9	Garric	Gilles	Mercator Ocean	France
10	Gehlen	Marion	Laboratoire des Sciences du Climat et de l'Environnement	France
11	Gilbert	Denis	Fisheries and Oceans Canada	Canada
12	Greiner	Eric	CLS	France
13	Guinehut	Stephanie	CLS	France
14	Haines	Keith	University of Reading	UK
15	Hernandez	Fabrice	Mercator Ocean	France
16	Hill	Katy	Ocean Observations Panel for Climate (OOPC)/WMO	WMO
17	King	Robert	UK Met Office	UK
18	Laloyaux	Patrick	ECMWF	UK
19	Larnicol	Gilles	CLS	France
20	Le Traon	Pierre-Yves	Ifremer & Mercator Ocean	France
21	Lea	Daniel	Met Office	UK
22	Lee	Tong	JPL/NASA	USA
23	Martin	Matt	Met Office	UK
24	Masuda	Shuhei	JAMSTEC	Japan
25	Mulet	Sandrine	CLS	France
26	Perruche	Coralie	Mercator Ocean	France
27	Pistoia	Jenny	INGV	Italy
28	Poulain	Pierre-Marie	OGS	Italy
29	Pouliquen	Sylvie	IFREMER	France
30	Remy	Elisabeth	Mercator Ocean	France
31	Siva Reddy	S	INCOIS	India
32	Smith	Neville	Unaffiliated	Australia

33	Sterl	Andreas	KNMI	Netherlands
34	Testut	Charles-Emmanuel	Mercator Ocean	France
35	Tranchant	Benoit	CLS	France
36	Valdivieso	Maria	University of Reading	UK
37	Vernieres	Guillaume	NASA	USA
38	Verrier	Simon	Mercator-Ocean/Ifremer	France
39	Weaver	Anthony	CERFACS	France
40	Wedd	Robin	Bureau of Meteorology	Australia
41	Wilmer-Becker	Kirsten	Met Office	UK
42	Xue	Yan	NCEP/NOAA	USA

Appendix C: Action list

Action 1 (2-GOV/GSOP):	PYLT to contact workshop attendees to request information about requirements for future salinity observations (in context of ISSI workshop, no date/location provided)
Action 2 (2-GOV/GSOP):	Tony Lee to contact Indian Ocean colleagues to check with them if they are planning to contribute to TPOS through OSEs
Action 3 (2-GOV/GSOP):	GL to contact OSEval TT members to identify the groups that are keen to perform studies
Action 4 (2-GOV-GSOP):	Yan X. and Siva R. to produce proposal for Indian Ocean Monitoring. Magdalean B. to contact Oscar Alves to confirm interest on salinity intercomparison