Summary of the Integrated Approach Session

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The integrated approach session was held on Wednesday March 15. Presentations and posters covered a wide range of activities: synergy between remote sensing and in-situ data, development of operational oceanography systems, model validation, and impact of the integrated approach on research and applications.

The main integrated systems developed as part of GODAE were presented. They cover both high resolution (eddy permitting or eddy resolving) systems that focus on ocean mesoscale description and forecasting as well as lower resolution systems that are developed for climate applications. Such applications require a precise and dynamically consistent description of the ocean state. Use of advanced data assimilation techniques (e.g. 4D-VAR, Ensemble Kalman Filter) allows diagnostic studies such as those of ocean heat balances. A major issue for effective data assimilation is to estimate the model error covariance and there has been significant advance in how to better prescribe these errors. Reanalysis activities are also conducted and are now providing an improved and integrated description of the ocean state over the last 15 years. Interesting presentations on the use of data assimilation to understand the Meridional Overturning Circulation and to monitor ocean heat transport were given.

Studies on the impact of altimetry and Argo on seasonal forecasts were also presented. While positive impacts have been demonstrated, this has required significant improvements in the data assimilation systems. As an example, Argo and altimetry are now used in the ECMWF operational seasonal forecasting system. It is important to realize that further efforts are needed to make full use of new observational data sets. The difficulty of this should not be underestimated. Coupled models are also critically dependent on observations for initialisation or for validation. As far as sea level is concerned, the importance of 1cm accuracy of large scale sea level for climate monitoring and modelling was emphasized. A strong recommendation is that all altimeters should be referenced to T/P and the Jason series and that significant overlap between missions must be planned.

Statistical data analysis techniques are also used to synthesize disparate datasets, for example in estimation of currents or temperature and salinity fields. Presentations and posters in the session provided very convincing results. Such data products, which may also include simplified dynamics, have the advantage of greater fidelity to the underlying data. They can be optimized for a specific problem and used together with results from more complex data assimilation systems.

Several presentations on Mean Dynamic Topographies (MDTs) were given. MDTs are now much improved thanks to GRACE data and the use of in-situ data sets (e.g. drifters and floats). This has a large impact on the assimilation of altimeter data in ocean models. Researchers should develop GOCE-derived MDTs as soon as possible as they will have a strong impact on operational oceanography applications.

Synergistic use of models and data is also crucial to validate and to improve the models. Significant improvements have been made over recent years to better parameterize mixing and the effect of topography. Models have also been used for observing system design experiments (e.g. Argo and SMOS), and these efforts should be pursued.

Coupling of physics and biology was also covered in the session through the joint analysis of altimetry, sea surface temperature, ocean colour and model data. The different mechanisms that could explain the observation of planetary waves both in altimeter, sea surface temperature and ocean colour were reviewed. Horizontal advection is an important mechanism but vertical mixing and biological effects cannot be ruled out. Other studies have shown the importance of ocean physics on the development of phytoplankton bloom in the wake of islands.

A main conclusion from the session is that major advances have been achieved over the past 5 years towards the development of an "integrated" approach to describe and forecast the ocean. These integrated descriptions of the ocean state are now available and are being used to better characterize and understand ocean and coupled climate variations. We need to continue to be very active in developing further links with applications. This is crucial for justifying the long-term sustainability of the global ocean observing system. Use of Argo and altimetry was also shown to be essential to develop an improved understanding of the ocean climate variations. The strong synergies between Argo and altimetry will become more or more obvious as Argo develops.