

International Workshop on Operational Oceanography for Developing Countries — 12th CAS-TWAS-WMO Forum

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Background

Developing countries are more vulnerable to ocean hazards due to a lack of knowledge of the adjacent marginal and coastal seas, and moreover, capability in operational oceanography. In recent years some of the larger (richer) developing countries such as China, India, Brazil and South Africa have started building their own operational ocean forecasting systems in response to resilient economic growth. Overall, the field of operational oceanography in developing countries is either growing at a high rate, grappling to become established, or in most cases does not exist at all. It is therefore timely to create a dedicated forum for operational oceanographers from developing countries to converge to discuss needs, progress, promote the exchange of information, share data and expertise, and assist one another in their development. Full funding for this first-ever forum was provided by the CAS-TWAS-WMO¹ consortium to assemble a selection of scientists, PhD and Post-doctoral students active in the field of operational oceanography. This article conveys a synopsis of the forum, proceedings, and discussion on the final day.

Scientific committee

The scientific committee assembled to organise this forum comprised: Prof Qingcun Zeng (Chairman, Institute of Atmospheric Physics/CAS, China), Prof Jiang Zhu (Institute of Atmospheric Physics/CAS, China), Prof Clemente Tanajura, (Federal University of Bahia, Brazil), Prof Mauro Cirano (Federal University of Bahia, Brazil), Prof Hui Wang (National Marine Environmental Forecast Centre, China), Prof Michael Roberts (Oceans and Coasts Research, Department of Environment Affairs, South Africa), Dr Bjorn Backeberg (Nansen-Tutu Centre for Marine Environmental Research, University of Cape Town, South Africa), Dr M. Ravichandran (INCOIS, India), Dr Francis Pavanathara (Indian National Centre for Ocean Information Services, India).

Forum, Themes and content

Objectives of the meeting were to provide a starting point to strengthen collaboration among all developing countries interested in operational oceanography and to discuss common scientific and infrastructural issues. The definition of operational oceanography was allowed to be broad to garner as much progress (activities) as possible. Although there was no dedicated session on demands, services and challenges, many of the papers articulated these as rationale or applications for the R&D, and included improving short and long (ENSO) marine weather, climate and ocean forecasts, oil and gas support, disaster response, harbour and transport safety, fisheries forecasting and combating marine pollution. Forty four oral papers and four posters were presented (China 16, India 10, Brazil 9, South Africa 6, Chile 1, Indonesia 1, Nigeria 2, Kenya 1, Intergovernmental Oceanographic Commission 2). Themes and content were:

Theme 1: Operational Ocean Forecasting (short-range to ENSO)

Overview of the operational activities in the National Marine Environmental Forecasting Centre (NMEFC) in China. JCOMM's coordination for operational ocean forecasting. Indian's ocean forecast system. SIPO — an integrated forecast modelling initiative for the coastal Humboldt Current system in central Chile. The REMO regional modelling plan to support environmental licensing in Brazil. Activities and short-term ocean forecast for the Brazilian oil industry. A South African regional ocean simulation for the Comoros Basin. Assessment of key performance indicators for global operational ocean models around southern Africa. Research initiatives with the potential to contribute to environmental prediction in the South-western Atlantic Ocean. The Intergovernmental Oceanographic

¹ Chinese Academy of Sciences, The World Academy of Sciences, World Meteorological Organisation

Commission (IOC) of UNESCO and its role in capacity building in ocean science and transfer of marine technology to developing countries. Recent progress in developing a large-size ensemble forecast system with coupled data assimilation (Leefs-CDA) for ENSO prediction in the Pacific. *OceanSAfrica* — a project developing operational oceanography capabilities for Africa. Prediction of SST over the Tropical Indian Ocean with application to short-term climate forecasting in China. Operational oceanography applied to navigation in the Patos Lagoon harbour area in southern Brazil. Developments in monitoring and solutions to the persistent problem of marine debris (including in situ SST measurements) along the coastline of Lagos, Nigeria. Fishing ground map prediction to support fishery catches in Indonesia.

Theme 2: Ocean Research and Modelling

Indian Ocean simulation at $1/10^\circ$ using ROMS. Coupled physical-biogeochemical modelling. Ocean heat content (OHC) as a better parameter than SST for cyclone disaster management. Observed anomalous surface layer temperature inversion in the Bay of Bengal during January 2013. Notes on the ASCAT gridded wind product for an assimilation system of the Tropical Indian Ocean. Non-linear effect on the generation of Yanai waves in the western Equatorial Indian Ocean. Modelling study of ocean fronts in the Yellow Sea in summer. Tides and wind driven circulation in the tropical and South Atlantic using the Brazilian *Brazcoast System*. Validation of hind-casts of surface wind over the west coast of India and eastern Arabian Sea using the high resolution WRF Model. Long-term simulations of the South Atlantic Ocean.

Theme 3: Ocean Observations and Data Analysis

Observed long term trends in the surface marine meteorological and air-sea flux parameters in the tropical Indian Ocean during the past six decades ocean data assimilation. Developing the in situ observational component for operational oceanography in South African *OceanSAfrica* project. Historical XBT bias corrections to improve data assimilation for models. Observed variability of the upper Bay of Bengal haline stratification over 2009-2012. Building a Southern Ocean Observing System (SOOS). Strategies for improved management of marine records off the coast of Africa. A case of mechanism and consequences of past and present climate changes over West Africa. Brazilian contributions to efforts towards a sustained observing system in the South Atlantic. The China Argo program and applications to oceanography. Three-dimensional temperature and salinity reconstruction in the South China Sea. Multiyear observations of the Brazil Current baroclinic transport variability near 22°S .

Theme 4: Ocean data assimilation

Preliminary results of the first version of the Brazilian REMO multivariate ocean data assimilation system into HYCOM (RODAS. H1). Argo data assimilation into HYCOM with the EnOI method in the Atlantic Ocean with different vertical localization schemes. Improvement of assimilating Argo scheme based on the Ensemble Optimal Interpolation (EnOI) method and HYCOM2.2. Assimilative modelling of HYCOM in the seas around China by the EnOI. Assimilation of various types of ocean data in the Indian and Pacific Oceans. The impact of ocean data assimilation on the WRF-ROMS coupled forecast of a series of heavy rainfall events in Hainan Island in the early October 2010 using a case study of a large mesoscale eddy in the South China Sea. Design and evaluation of a global ocean data assimilation system. The South China Sea operational forecasting system: model and data assimilation. Ensemble data assimilation using an unstructured adaptive mesh ocean model. A regional simulation of the greater Agulhas Current system with data assimilation.

Synopsis, discussion and way forward

With 48 scientists, post-graduates and students from eight countries participating in the 3 day forum (China, Brazil, India, South Africa, Chile, Indonesia, Kenya, Nigeria), there was little doubt that this first time grouping was successful in initiating dialogue in the field of operational oceanography. The variety of presented topics suggest China, Brazil, India, South Africa, Chile and Indonesia had good knowledge of their respective adjacent ocean systems achieved through their own efforts as well as international interest as a result of their location to ocean phenomena of regional and global importance. Ocean modelling was particularly strong in China and India, with Brazil, South Africa and Chile having fewer models running and resources. China, India, Brazil and South Africa have

operational ocean buoy networks in place, and are currently assimilating observational data (mostly SST, SSH, Argo TS) into models. Only China and India offer formal operational forecasts, with Brazil presently moving into a pre-operational mode. Other than China and India, none of the other countries have a formal, coherent and funded program/project to establish operational oceanography. This was strongly noted as a major impediment in establishing this field of specialisation in developing countries.

Areas which require attention in developing countries are (1) internal and regional optimisation of resources (2) access to high performance computing (3) improved capacity in data assimilation (4) quality assurance of databases with high speed open access, and (5) communal identification of existing and new efforts, projects and collaboration. In terms of data sharing, INCOIS has taken the lead and made data available on their website. National oceanographic databases should similarly liaise with single data control protocols. IODE was designed for such a purpose. Data sharing agreements could also assist, e.g. Korea, Japan and China could be used as a template.

Collaboration and development can be strengthened by joint (1) deployment of instrumentation such as XBTs and Argo floats (2) research field projects especially in those regions that are not regularly visited by international research vessels such as Nigeria and Kenya (3) submissions for Chinese funding (4) hosting of a summer school possibly in Brazil in 2015, and promotion of a student-scientist-technician exchange program for which China has funding to support visits between 1–26 weeks, Brazil has funding for post-docs/PhD/M Sc visits, and TWAS has scholarships for travel China, India, Brazil. The question of whether convergences should be encouraged in terms of models, assimilation data sets and in situ observational systems, was not resolved.

Discussion on the way forward soundly indicated that a follow-up forum was needed to ensure that the momentum generated by this initial meeting was not lost. Cape Town was suggested as a possible host with March 2016 providing sufficient time for meaningful progress. Full funding will be required to ensure wide participation. Each country must promote their own national institutions for operational oceanography, and that this grouping of interested developing countries must become formal. The *Forum for Operational Oceanography in Developing Countries* (OODC) was proposed and accepted as an interim name. The participants clearly articulated that the forum must be driven by scientific and technical objectives and as far as possible avoid political interventions. The OODC should be formally linked to GODAE OceanView as a task team (TT) to ensure international recognition and state of the art information sharing. Such formality (i.e. OODC) should assist coordination in this community and fund raising for meetings. A website will be set up to show case this grouping and assist in communication. The themes used in this meeting proved successful in grouping interests, highlighting progress, problems and stimulating collaboration, and therefore will be adopted in OODC. The scientific committee of this first forum will be used to establish the OODC and arrange the follow up forum.