OceanPredict '19
GODAE OceanView Symposium | 6-10 May 2019 Halifax, Canada
Advancing the science and application of ocean predictions

Theme 2: Observations for Ocean Prediction

Session 3: Capturing global/basin scale ocean variations through observation and data assimilation

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The 2018-19 El Nino

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Since May 2018, ENSO forecast models predicted the likely onset of El Nio for 2018-19, though neutral conditions prevailed in the tropical Pacific through the end of boreal summer 2018. There was at the same time a substantial build up of excess heat content below the surface that rivaled the build up prior to the initiation of the 1997-98 and 2015-16 El Nios, which were among the strongest on record. This heat content, the fuel the powers El Nino development, laid dormant until two strong westerly wind bursts occurred in October 2018, apparently setting the wheels in motion for the long awaited El Nio. We will review the evolution and predictions of the 2018-19 warm event in the context of the ENSO observations over the past several years to show how aspects of this event challenge our understanding of ENSO dynamics.

Keywords: Observations - In-situ ocean observing systems, Systems - Ocean Prediction Systems types (forecasting, analysis, scales, assessment, regions, ecosystem, ice, wave, etc.), Systems - Prediction system performance & evaluation, ,

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10-year Efforts of Evaluating the Tropical Pacific Observing Systems using ocean data assimilation and prediction systems

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This presentation gives a comprehensive review of the efforts of evaluating the tropical Pacific Observing System (TPOS), including the TAO/TRITON array and Argo floats, using ocean data assimilation and prediction systems in the last 10 years. Observing System Experiment (OSE) studies using seasonal forecasting systems have been repeatedly conducted at the European Centre for Medium-range Weather Forecast (ECMWF), the Japan Meteorological Agency (JMA), and the National Centers for Environmental Prediction (NCEP) since late 2000s. Those studies generally indicate positive impacts of TAO/TRITON data on ENSO forecasts, as well as complementary roles of TAO/TRITON and Argo data on ENSO monitoring and prediction. However, the results showed some inconsistencies in the impacts of the observational data, and this indicates the necessity for further improvements to the coupled forecast models and data assimilation schemes. Recently, JMA examined the impacts of the number of Argo profiles using OSEs and indicated that further increase of Argo floats would be effective in reducing analysis errors in most areas of the tropical Pacific, particularly in the NINO3 region.

The international Real-Time Ocean Reanalysis Intercomparison Project (RT-ORA-IP) was started in 2014 following the recommendation of the TPOS2020 workshop in the same year. In the project, an ensemble of nine ocean reanalyses has been routinely collected at NCEP and the Australian Bureau of Meteorology. The temporal and spatial variations of the ensemble spread of temperature and salinity have been monitored and used to discern the influences of the TPOS data on the uncertainty of the ocean reanalyses in near real time. The spread of analysis fields among the reanalyses is found to be sensitive to the spatial and temporal variations of in situ data density, and so it can be a good indicator of soundness and effectiveness of the TPOS.

Mercator Ocean also provides invaluable information to assess the new design of TPOS (doubling Argo Floats around the equator) proposed by the TPOS2020 project based on estimating analysis errors and Observing System Simulation Experiments (OSSEs). The OSSE result indicate that doubling Argo significantly improves the representation of salinity intraseasonal variability, and of the intraseasonal displacements of the salinity front at the eastern edge of the Warm Pool. We expect that the GODAE OceanView follow-on project, OceanPredict, will take over the activities of evaluating tropical Pacific observation data in order to support the observing system design in the TPOS2020 project.

Keywords: Observations - Observing system assessments and design, Observations - International ocean observation projects (e.g. YOPP, TPOS2020, etc.), Systems - Multi-model ensemble systems, Observations - Ocean Obs '19,

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Impact of Satellite Sea Surface Salinity Observations on ENSO Predictions from the GMAO Seasonal Forecast System

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El Nio/Southern Oscillation (ENSO) has far reaching global climatic impacts and so extending useful ENSO forecasts would be of great benefit for society. However, one key variable that has yet to be fully exploited within coupled forecast systems is accurate estimation of near-surface ocean density. Satellite sea surface salinity (SSS), combined with temperature, help to identify ocean density changes and associated mixing near the ocean surface.

We assess the impact of satellite SSS observations for improving near-surface dynamics within ocean analyses and how these impact dynamical ENSO forecasts using the NASA GMAO Sub-seasonal to Seasonal (S2S_v2.1) coupled forecast system (Molod et al. 2018 - i.e. NASAs contribution to the NMME project). For all initialization experiments, all available along-track absolute dynamic topography and in situ observations are assimilated using the LETKF scheme similar to Penny et al., 2013. A separate reanalysis additionally assimilates Aquarius V5 (September 2011 to June 2015) and SMAP V4 (March 2015 to present) along-track data.

We highlight the impact of satellite SSS on ocean reanalyses by comparing validation statistics of experiments that assimilate SSS versus our current prediction system that withholds SSS. We find that near-surface validation versus observed statistics for salinity are slightly degraded when assimilating SSS. This is an expected result due to known biases between SSS (measured by the satellite at ~1 cm depth) and in situ measurements (typically measured by Argo floats at 3 m depth). On the other hand, a very encouraging result is that both temperature, absolute dynamic topography, and mixed layer statistics are improved with SSS assimilation.

Previous work has shown that correcting near-surface density structure via gridded SSS assimilation can improve coupled forecasts. Here we present results of coupled forecasts that are initialized from GMAO S2S spring reanalyses that assimilate/withhold along-track (L2) SSS. In particular, we contrast forecasts of the big 2015 El Nio, the 2016 La Nia and the 2018 weakEl Nio. For each of these ENSO scenarios, assimilation of satellite SSS improves the forecast validation. Improved SSS and density upgrade the mixed layer depth leading to more accurate coupled air/sea interaction.

From March to June 2015, the availability of two overlapping satellite SSS instruments, Aquarius and SMAP, allows a unique opportunity to compare and contrast forecasts initialized with the benefit of these two satellite SSS observation types. We assess the impact of satellite sea surface salinity (SSS) observations on dynamical ENSO forecasts for the big 2015 El Nio.

Keywords: Observations - Satellite ocean observing systems, DA - Assimilation of new observation types, Observations - Observation impacts, Models - Coupled modelling, Systems - Prediction system performance & evaluation

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The PIRATA array in the tropical Atlantic: Enhancements and perspectives in support of operational oceanography

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PIRATA (Prediction and Research Moored Array in the Tropical Atlantic) is a multinational program initiated in 1997 to improve knowledge and prediction of ocean-atmosphere variability in the tropical Atlantic, motivated both by fundamental scientific questions, and societal needs and impacts.

It now consists of 18 moorings measuring ocean temperature/salinity in the upper 500/120 m respectively, and near-surface air temperature, relative humidity, wind, rainfall, and shortwave radiation. Some also measure downward longwave radiation, atmospheric pressure, and ocean currents. Daily-averaged data are transmitted in real-time to GTS and GDAC. Since 2006, some moorings have acquired measurements of ocean CO2 and O2. Additionally, at the equator, three subsurface ADCP moorings are maintained. During annual servicing cruises, recorded high frequency data are collected and later calibrated. These dedicated cruises also allow for the complementary acquisition of a large number of measurements along repeated ship track lines. A transition to the next-generation tropical flex moorings began in 2015, allowing real-time transmission of hourly averages, a significant advance for operational oceanography.

Most GODAE systems assimilate daily PIRATA T/S, which combined with Argo profiles correct the vertical structure of currents and water mass properties at depth, especially near the thermocline, as demonstrated by recent OSE/OSSEs (e.g. Gasparin et al, 2018). However, Argo floats are subject to equatorial surface divergence: only PIRATA moorings with hourly-daily resolution constrain equatorial Kelvin waves. Unfortunately, the present array is too sparse and shallow to constrain the deep ocean. CO2 and O2 sensors offer unique time-series for assessments of the carbon cycle and oxygen distributions in recent GODAE coupled biogeochemical forecast systems.

Beyond sustaining the 2-decades moored time series at existing sites, several enhancements are suggested that would benefit GODAE improvements: 1) adding more instrumentation to better define near-surface structures and ocean-atmosphere feedbacks; 2) enhancements for carbon cycle and biogeochemical studies; 3) array expansion into regions that are presently undersampled or not sampled at all.

Keywords: Observations - In-situ ocean observing systems, Observations - Observing system needs and future challenges, Systems - Prediction system validation/ intercomparisons, Applications - Climate change research, DA - Assimilation of new observation types

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Towards robust estimations of the deep ocean variability with deep Argo

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As a key element of the global ocean observing system, the Argo array has successfully provided large-scale ocean temperature and salinity estimates in the upper 2000 dbar for more than fifteen years, and is going to extend measurements to the deeper ocean. This major evolution of the global ocean observing system promises to reveal unprecedented details of the deep ocean variability, and to reduce large inconsistencies between ocean reanalyses. In this study, a set of 6-yr simulations is used to quantitatively assess how the implementation of a global deep Argo array will improve the representation of temperature and salinity in ocean reanalyses. The methodology is based on extracting ocean observing system data sets from a realistic simulation in order to be assimilated in a data assimilation system. The comparison of the ocean estimates from the data assimilation system with that of the realistic simulation demonstrates that the deep Argo extension will provide a significant constraint in the deep ocean by eliminating strong temperature and salinity biases existing in ocean reanalyses. In addition to improving the time mean, the experiments show that a global deep Argo array will be able to capture long-term variability by preventing model drift, leading to significant error reductions of ocean heat, freshwater gains and sea level rise. Thus, the present work exploits the capabilities of ocean data assimilation systems to provide comprehensive information for the evolution of the integrated global ocean observing system from the operational oceanography perspective.

Keywords: Observations - In-situ ocean observing systems, Observations - Observing system assessments and design, Observations - International ocean observation projects (e.g. YOPP, TPOS2020, etc.), Observations - Ocean Obs '19, Observations - Observing system needs and future challenges

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Observing systems for oceanic boundaries

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Ocean boundary current systems are key components of the climate system, are home to highly productive ecosystems, and have numerous societal impacts. Establishment of a global network of boundary current observing systems is a critical part of ongoing development of the Global Ocean Observing System. The characteristics of boundary current systems are reviewed, focusing on scientific and societal motivations for sustained observing. Techniques currently used to observe boundary current systems are reviewed, followed by a survey of the current state of boundary current observing networks globally. Next steps in the development of boundary current observing systems are considered, leading to several specific recommendations.

Keywords: Observations - In-situ ocean observing systems, Observations - International ocean observation projects (e.g. YOPP, TPOS2020, etc.), Observations - Integration of local/coastal measurements in the global observing system, Evolution - International and intergovernmental collaboration, Observations - Ocean Obs '19

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