OceanPredict '19

GODAE OceanView Symposium | 6-10 May 2019 Halifax, Canada

Advancing the science and application of ocean predictions

POSTER ABSTRACTS

Theme 2:
Observations for Ocean Prediction

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P3 - **Abstract ID: 3549304**

Sun-Ocean-Climate interaction and Implications for Inter-annual to Decadal Climate Prediction

Ndah, Anthony[1] [1]NF-POGO Centre of Excellence in Operational Oceanography, Alfred Wegener Institute, Helgoland, Germany anthony.ndah@awi.edu

Weather and climate variations on inter-annual to decadal timescales are strongly coupled with upper ocean heat fluxes. However, skillful predictions at inter-annual to decadal timescales remain largely elusive due to the enormous complexity and feedbacks. A data-driven study aimed at estimating and quantifying the time-varying effects of solar irradiance on ocean temperature is undertaken. The motivation is to uncover patterns of energetic interactions between the Earth-systems primary heat-source and the dominant heat storage system (ocean), for a better process-level understanding and prediction of ocean-climatic changes at inter-annual and decadal time-scale. A combination of parametric and non-parametric statistical methods including Cumulative Deviations (CD) Test, Standardized Normal Heterogeneity Test (SNHT), Cross-Correlation Analysis, Coherency Analysis and Cross-spectral Analysis and Ordinary Least-square Regression analysis, applied to extensive datasets of total solar irradiance (TSI), sun spot numbers (SSN), Net short-wave and long wave radiation flux (NSWR and NLWR), and sea surface temperature (HADSST1). Focusing on the regional scale encompassing the South China marginal Seas, the results reveal the following: 1). a maximum average time-lag of approximately 42 years exist between the long-term changes in solar irradiance and SST. By applying this lag, the linear association between SST and TSI/SSN improves by orders of magnitude. 2). a bottom-up, double bridge mechanism is proposed: the oceanic bridge, is based on the oceans large heat capacity, capable of accumulating and shedding excess heat during periods both high frequency 11 years, and low frequency solar cycles). Second, the atmospheric bridge governed by atmospheric green-house gases, predominantly CO2 which trap long-wave radiation predominantly from the ocean, coupled with the initial short-wave energy trapped directly by gas molecules in the atmosphere, and air-masses / lateral heat transport. 3). Based on 1 and 2 above, a simple lag-integrated graphical model which mimics the moving average filter, was used to predict ocean temperature changes for the period 2016 2043 representing inter-annual and decadal variability, including ENSO (timing / intensity) and hiatus events. The study concludes that the main direct driver of regional climate at interannual / decadal scales is bottom-up (the oceanic bridge) modulated by the background time-lag and the atmospheric top-down response which amplifies the warming effect. This greatly could improve our fore-knowledge and predictive response capabilities to decadal scale variability in precipitation, surface temperatures and upper ocean heat content, and their effects on the high-impact meteorological events such as tropical cyclones, floods, droughts, heat and cold waves.

Keywords: Applications - Climate change research, DA - Data assimilation diagnostics, Systems - Ocean Prediction Systems types (forecasting, analysis, scales, assessment, regions, ecosystem, ice, wave, etc.), Systems - Earth-system models, Evolution - Future perspective and new frontiers in Operational Oceanography

Presenter:
Anthony Ndah
NF-POGO Centre of Excellence in Operational Oceanography, Alfred Wegener Institute
Helgoland, Germany
anthony.ndah@awi.edu

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P5- Abstract ID: 3550809

COMPIRA concept, future operation of SSH observation with a fine resolution

Isoguchi, Osamu [1], Matsui, Kai[2] [1]RESTEC, Tsukuba, Japan [2]JAXA, Tsukuba, Japan isoguchi_osamu@restec.or.jp

Japan Aerospace Exploration Agency (JAXA) is working on a conceptual study of altimeter mission named Coastal and Ocean measurement Mission with Precise and Innovative Radar Altimeter (COMPIRA), which will carry a wide-swath altimeter named Synthetic aperture radar (SAR) Height Imaging Oceanic Sensor with Advanced Interferometry (SHIOSAI). Capturing meso/submeso-scale phenomena and operational oceanography are one of COMPIRAs main objectives. Orbit specifications are thus designed to be better for operational oceanography including coastal forecast. That is, a spatial grid sampling is 5km and an observation times per revisit period (about 10 days) is 2 to 3 times. In order to meet both sampling frequency and spatial coverage requirements in mid-latitudes as much as possible, orbit inclination was set relatively low, 51 degrees. Although this sampling frequency is, of course, not enough high to capture time evolution of coastal phenomena, an assimilation process would compensate its time evolution if 2D SSH fields was observed at least once within decal time scale of phenomena. Simulated sea surface heights (SSH) are generated from regional ocean numerical models and the COMPIRA orbit and error specifications. The several regional model data around Japan were provided by Japan Agency for Marine-Earth Science and Technology (JAMSTEC), Kyushu University, Meteorological Research Institute (MRI). Their specifications are as follows: spatial and temporal grid interval range from 1.5km to 3km, and 30 minutes to 3 hours, respectively. Some models incorporate tidal components. The generated simulation data will be used to develop an optimal method to generate mapped data products using and tide models using COMPIRA. Identical twin experiments are also planned to not only investigate the effect of wide-swath SSH measurements on coastal forecast but also develop an assimilation method that can be applied to 2D SSH measurements. In the workshop, the characteristics of the simulated data, which include a comparison of snapshots and its temporal evolution, and effective resolutions etc., are presented.

Keywords: Observations - Satellite ocean observing systems, Observations - Observation impacts, Observations - New observation types,

Presenter:
Osamu Isoguchi
RESTEC
Tsukuba, Japan
isoguchi_osamu@restec.or.jp

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P6 - Abstract ID: 3555809

Detecting marine heatwaves

Schlegel, Robert[1], Oliver, Eric[1], Hobday, Alistair[2], Smit, Albertus[3] [1]Dalhousie University, Halifax, Canada [2]CSIRO, Canberra, Australia [3]University of the Western Cape, Bellville, South Africa robert.schlegel@dal.ca

It is now known that marine heatwaves (MHWs) have been increasing in duration and intensity globally for decades. There are however many ocean, sea, and coastal regions that have not been sampled continuously for 30 or more years, as is the standard recommendation for detecting MHWs. It was therefore necessary to quantify the size of the effect that short time series duration or missing data may have on the accurate detection of MHWs where optimal data are not available. It was found that time series as short as ten years did not produce MHWs of significantly different durations or intensities than either 20 or 30 year time series, nor was the accurate creation of seasonal signals or 90th percentile thresholds statistically significantly affected, but it is still preferable to use time series at least 20 years in length. It was also found that MHWs detected in time series missing as much as 25% of their data did not differ significantly from those detected in complete time series. A greater amount of missing data prevented the accurate creation of the 90th percentile threshold, which in turn prevented the accurate detection of MHWs. The best practices for how to improve the precision of MHW detection with sub-optimal time series has been itemised and is discussed in detail here using specific case studies of three notable MHWs from the literature.

Keywords: Applications - Climate change research, DA - Assimilation of new observation types, Observations - New observation types, Systems - Ocean product distribution/dissemination and accessibility, Systems - Visualisation

Presenter:
Robert Schlegel
Dalhousie University
Halifax, Canada
robert.schlegel@dal.ca

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P8 - **Abstract ID: 3558321**

Impact of High-Resolution Sea Surface Salinity Observations on Ocean Analysis/Forecast Skill

Nyadjro, Ebenezer[1], D'Addezio, Joseph [2], Souopgui, Innocent [1], Smith, Scott[3], Carrier, Matthew [3], Ngodock, Hans[3], Osborne, John [4], Jacobs, Gregg [3] [1]University of New Orleans, New Orleans, USA [2]University of Southern Mississippi, Stennis Space Center, USA [3]Naval Research Laboratory, Stennis Space Center, USA [4]The American Society for Engineering Education , DC, USA enyadjro@uno.edu

The role of salinity in improving ocean analysis and forecast skill is increasingly recognized particularly due to the need for minimizing uncertainty in surface freshwater flux. Part of the challenge in accomplishing this is due to the lack of high-resolution salinity data. At present, satellite-derived sea surface salinity (SSS) is obtained from the European Space Agencys Soil Moisture and Ocean Salinity (SMOS) and NASAs Soil Moisture Active Passive (SMAP) missions. In addition, Argo profiles provide salinity data for the upper 2000 m of the ocean every 10 days on a 33 grid. The relatively course horizontal resolutions of these salinity products have been cited as possible limitations in enhancing ocean forecast skill. In this pilot study, we make a case for higher spatial and temporal resolution SSS observations for ocean prediction. To assess the merit of the hypothesis, we perform a series of observing system simulation experiments (OSSEs) in the Arabian Sea, a region with high salinity variability. We use the regional US Navy Coastal Ocean Model (NCOM) and its three-dimensional data analysis component (3DVAR) to assimilate simulated very high-resolution SSS data in order to quantify the impact these observations have on analysis/forecast skill. Results suggest that higher resolution salinity data more effectively constrains the model, enhances the forecast skill, and improves its consistency with the truth. The causes for improvements and suggestions for further fidelity are discussed.

Keywords: Observations - Observing system assessments and design, Observations - Satellite ocean observing systems, Observations - In-situ ocean observing systems, Observations - Observation impacts, Observations - Estimates of measurement errors

Presenter:
Ebenezer Nyadjro
University of New Orleans
New Orleans, USA
enyadjro@uno.edu

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P9 - Abstract ID: 3561259

New CNES-CLS18 Mean Dynamic Topography of the Global Ocean From Altimetry, Gravity and In-situ Data

Mulet, Sandrine[1], Rio, Marie-Helene[2], Etienne, Helene[1], Picot, Nicolas[3], Dibarboure, Gerald[3] [1]CLS, Toulouse, France [2]ESA, Frascati, Italy [3]CNES, Toulouse, France smulet@groupcls.com

The Mean Dynamic Topography (MDT) is a key reference surface for altimetry. It is needed for the calculation of the ocean absolute dynamic topography, and under the geostrophic approximation, the estimation of surface currents. Those are required for a wide range of applications as the management of fishery resources, the monitoring of potential pollution, maritime security Also, the MDT is the missing component for the optimal assimilation of altimeter data into operational ocean system as those run under the Copernicus Marine Environment Monitoring Services (CMEMS).

CNES-CLS Mean Dynamic Topography solutions are calculated by merging information from altimeter data, GRACE and GOCE gravity data and oceanographic in-situ measurements from drifting buoy velocities and hydrological profiles. The objective of this communication is to present the newly updated CNES-CLS18 MDT. The main novelties compared to the previous CNES-CLS13 solution is the use of updated input datasets: the GOCO05S geoid model (instead of DIR4) is used together with all drifting buoy velocities (SVP-type and Argo floats) and hydrological profiles (CORA database) available from 1993 to 2017 (instead of 1993-2012). The new solution also benefits from improved data processing (in particular, a new Ekman model is used to extract the geostrophic component from the buoy velocities) and methodology (in particular, the correlation scales used for the multivariate mapping have been revised).

An evaluation of this new solution compared to the previous version and to other existing MDT is done through comparison to independent in-situ data. Further validation by super-users such as monitoring and forecasting centres have also been performed. Compared to the CNES-CLS13 solution, the new CNES-CLS18 MDT shows improved performance everywhere and more significantly in coastal areas and in strong western boundary currents.

Keywords: Observations - In-situ ocean observing systems, Observations - Satellite ocean observing systems, Observations - Ocean monitoring based on observing systems, Systems - General ocean monitoring (including those based on ocean DA and prediction systems),

Presenter:
Sandrine Mulet
CLS
Toulouse, France
smulet@groupcls.com

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P11 - Abstract ID: 3563680

Contribution of the GODAE OceanView Observing System Evaluation Task Team to OceanObs'19

Fujii, Yosuke[1], Coauthors, and[2] [1]JMA/MRI, Tsukuba, Japan [2]GODAE Ocean View, Tsukuba, Japan yfujii@mri-jma.go.jp

OceanObs19 is a good opportunity to demonstrate the value of Observing System Evaluation (OS-Eval) efforts which have been made or are ongoing to contribute to observing system review and design in GODAE OceanView (GOV). Thus, the GOV OS-Eval Task Team has submitted a Community White Paper (CWP) on OS-Eval efforts collaborating with some relevant groups (e.g, CLIVAR-GSOP, ECCO, etc.) The CWP highlights examples that illustrate the potential of the related OS-Eval methodologies and recent achievements, and then discusses about the limitations of OS-Eval. It indicates that most significant limitation is reduction of robustness and reliability of the results due to their system-dependency. Inability of performing evaluation in near real time is also critical. A strategy to mitigate the limitations and to strengthen the impact of evaluations is discussed. In particular, the CWP emphasizes the importance of collaboration for multi-system evaluation and communication with ocean observational communities on the design of OS-Eval, required resources, and effective distribution of the results. Finally, it recommends to further develop OS-Eval activities at international level with the support of the GOV and other international ocean observation, data assimilation and prediction groups.

Keywords: Observations - Ocean Obs '19, Observations - Observing system assessments and design, Observations - Observation impacts, DA - Observation impact assessment methods,

Presenter:
Yosuke Fujii
JMA/MRI
Tsukuba, Japan
yfujii@mri-jma.go.jp

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P12 - Abstract ID: 3569457

Towards a regional model for the Labrador coast and shelf

Sobral, Fernando [1], Oliver, Eric[1] [1]Dalhousie University, Halifax, Canada fernando.sobral@dal.ca

The coast and shelf waters off of Labrador, in northeastern Canada, form an important oceanic transition zone between the Arctic and Atlantic regions of Canada. Is an area that hosts significant fisheries, is home to Indigenous groups seeking to protect the marine environment, and is also presenting significant ocean climate change in recent decades. The region forms the western boundary of the subpolar gyre present in the Labrador Sea, whos western boundary current is the Labrador Current. The Labrador Current, flowing south-eastward, is a continuation of the cold and relatively low salinity waters of Baffin Island Current and the warmer and more saline waters of a branch of the West Greenland Current. Sea ice coverage is present for a considerable period, from January until April (50% areal ice concentration) and covers large areas where it much of the ice is transported south into the region by the Labrador Current. Despite the regions importance, there is a lack of long observational time series, particularly for coastal regions. Climate change is bringing impacts to the inhabitants and very little is known about the consequences of these changes in the ocean. We will present an overview of the oceanography of the region, present available observational data, and outline plans for a modelling study to examine aspects of the regional physical oceanography and marine biogeochemistry in more detail. Available observations that will be shown, particularly for the coastal and nearshore zones, include community-based monitoring projects such as from Community-based Observation of Nunatsiavut coastal Ocean Circulation (CONOC) project. The proposed modelling framework is to use ROMS for the physical oceanographic process including also sea-ice and eventually marine biogeochemical model components. The domain will cover the entire coast of Labrador, and offshore the just off the shelf edge. In the first instance, a hindcast covering the period since 1993 will be performed and complemented with a set of process studies to examine specific research questions as interannual and decadal variability and long-term trends. SST and sea ice coverage trends for the region will be presented, which indicate significant warming and sea ice loss.

Keywords: Models - Ecosystem/BGC modelling, Observations - In-situ ocean observing systems, Models - Model assessments and verification, Applications - Climate change research, Observations - Satellite ocean observing systems

Presenter:
Fernando Sobral
Dalhousie University
Halifax, Canada
fernando.sobral@dal.ca

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P13 - **Abstract ID: 3571394**

Tailored Altimeter Products for Assimilation Systems

Pujol, M.-Isabelle[1], Faugère, Yannice[1], Mounir, Benkiran[2], Dibarboure, Gérald[3] [1]CLS, Ramonville Saint-Agne, France [2]Mercator Ocean, Ramonville Saint-Agne, France [3]CNES, Toulouse, France mpujol@groupcls.com

In 1998, first Level3 along-track, user friendly altimeter products have been developed with support from CNES and delivered to the users on AVISO+. The Level3 processing includes a homogenisation of the SLA for the different altimeters (i.e. reduction of the global and regional biases), allowing the users to directly use the products without any pre-processing. They are widely used for different applications, including assimilation in numerical models. Since 2008, such products are generated and disseminated by the Copernicus Marine Service (CMEMS; previously MyOcean during its demonstration phase). They allow the user to change the physical content of the altimeter measurement in consistency with the model capabilities and characteristics, thus considerably improving the results of the assimilation of the altimeter measurement into the models.

With the future altimeter missions as the large swath SWOT mission, the altimeter processing will face a new challenge: be able to accurately process the signal at finer spatial scales. On the other hand, users and more particularly modelers need to make their system ready for assimilation and propagation of the finer scale structures observed. With that objective, a new generation of along-track products is under development with support from CNES. They are derived from high resolution (20Hz) altimeter measurement and are specifically processed in order to solve finer scales up to ~30 km. Experimental datasets, with a nearly 1km (5Hz) sampling, are already available on AVISO+ (https://www.aviso.altimetry.fr/duacs) and can be tested by users. Recent development enabled to optimize the Sentinel3 SAR altimeter processing (Boy 2017, Moreau,2018) and the Jason/Altika noise level (Zaron 2016, Tran 2019) and will allow us to better exploit the fine-scale content of the altimetric missions. New experimental products will be delivered in 2019 with an operational production foreseen in 2020.

Operational and experimental TAPAS product and their impact for numerical models will be presented.

Keywords: Observations - Satellite ocean observing systems, Observations - New observation types, , ,

Presenter:
M.-Isabelle Pujol
CLS
Ramonville Saint-Agne, France
mpujol@groupcls.com

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P14 - Abstract ID: 3572530

Objective design of coastal HF Radar networks using ensemble-based array modes

Skandrani, Chafih[1], Charria, Guillaume[2], De Mey-Frémaux, Pierre[3] [1]NOVELTIS, Labège, France [2]IFREMER, Brest, France [3]LEGOS, Toulouse, France chafih.skandrani@noveltis.fr

In the framework of the European projects FP7 JERICO (http://www.jerico-fp7.eu/) and H2020 JERICO NEXT (http://www.jerico-ri.eu/), this study consisted in carrying out an objective design analysis of coastal HF radar networks with the ArM (Array Modes) method (Le Hnaff et al., 2009; Lamouroux et al., 2016; Charria et al., 2016). The ArM approach is a non-assimilative, data-model synergistic approach: it uses ensembles in response to known error sources to describe prior (model) uncertainties, and aims at quantitatively evaluating the performance of the observation network at detecting those uncertainties amidst observational noise. The ArM analysis consists in calculating and interpreting spectra of the representer matrix, as well as modal representers, making it possible to visualize the model error structures which are detectable by the radar observations and, in a second step, potentially controllable through data assimilation. The performances of two existing Bay of Biscay HF radar observation sites deployed on the Spanish Basque coast as well as a projected third site on the French Landes coast were evaluated with the ArM method, separately or by combinations of two and three sites. We considered only radial velocities from the radars. The ensembles were composed of two sets of 50 members from two different 3D oceanic models with differing resolutions: MARS-3D (4km) and Symphonie (500m), respectively. Tests showed that adding radars improves the detection of model errors by increasing the quantity and location of observations that lead to efficient sampling of model error structures. In particular, the third projected radar site would bring a clear improvement at sampling zonal surface velocity errors in the model, because of its location. Using higher-resolution ensembles (approximating higher-resolution model errors) leads to similar results, qualitatively, but differences appear when examining the spatial structures of errors detected by the arrays (in the form of modal representers). Finally, we studied the impact of correlated measurement errors, e.g. via sea state which can contaminate radar-derived velocities via Stokes drift. We found that our previous conclusions regarding the existing array performance and the positive impact of a third site were not significantly modified by such correlated noise contamination.

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

Presenter:
Chafih Skandrani
NOVELTIS
Labège, France
chafih.skandrani@noveltis.fr

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P15 - Abstract ID: 3573260

Towards a community-based ocean observing system for coastal Labrador

Oliver, Eric[1], Aporta, Claudio[1], Avery, Laura[2], Richards, Clark[3], Wallace, Douglas[1], Atamanchuk, Dariia[1]
[1]Dalhousie University, Halifax, Canada [2]Marine Environmental Observation, Prediction and Response Network (MEOPAR), Halifax, Canada [3]Fisheries and Oceans Canada, Dartmouth, Canada eric.oliver@dal.ca

Ocean circulation is poorly observed in coastal Labrador, and yet a predictable marine environment is important for food security and the preservation of culture there. This region is undergoing significant ocean climate change in recent decades, including an air temperature rise of 2 degrees Celcius since 1993 and 75% loss of sea ice cover since 1969. Locals have recently reported an increasing number of incidents of people breaking through sea ice while travelling in winter. This has led to great uncertainty around the safety of traditional travel routes as well as the sustainability of wintertime hunting and fishing activities. The region also lies in the critical transition zone between the Atlantic and Arctic Oceans and adjacent to areas of deep convection in the Labrador Sea, which are important for global climate dynamics and biogeochemical cycling. This region is home to the Labrador Current, which flows out of the high-latitude regions and into the productive fishing grounds off Atlantic Canada. The dynamics in this region, namely the export of nutrients south, may be changing which would have significant impacts on ecosystems and fisheries even further south. While natural climate variability plays a strong role in this region, the impact of long-term climate change is unequivocal.

This presentation will show several activities which taken together make significant strides towards a community-based ocean observing system for coastal Labrador: (1) the Community-based Observing of Nunatsiavut coastal Ocean Circulation (CONOC) project which aims to improve our knowledge of coastal ocean currents using ocean drifters, engage with community youth through oceanography summer schools where we will build these drifters together, and facilitate workshops to record and transfer traditional knowledge of coastal ocean currents from community elders; (2) the Coastal Ocean Monitoring in Nunatsiavut (COM-N) project which is establishing regular oceanographic monitoring, through a Voluntary Observing Ship, along the ferry route serving communities in northern Labrador, and (3) the Community-based Observing of the coastal Nunatsiavut Ocean in Winter (CONOW) pilot project which will partner with communities in Nunatsiavut to perform regular observations of the coastal ocean in winter, under the sea-ice. Plans for expansion of the observing system to include other communities, techniques, and variables will also be presented. The data arising from these projects (freely available) will be useful to community and governments plans for marine management and climate change adaptation, improve estimates of future ocean change in the region, and be available for model validation and data assimilation systems.

Keywords: Observations - In-situ ocean observing systems, Observations - New observation types, Evolution - Enhancing community collaboration (observations, modelling, operations, users), ,

Presenter:
Eric Oliver
Dalhousie University
Halifax, Canada
eric.oliver@dal.ca

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P16 - Abstract ID: 3576252

Observation Impact Statement on SSS data assimilation in two global operational ocean forecasting systems

REMY, Elisabeth[1], Martin, Matthew[2], Tranchant, Benoit[3], King, Robert[2], Greiner, Eric[3] [1]Mercator Ocean, Ramonville Saint Agne, France [2]MetOffice , Exeter, UK [3]CLS, Ramonville Saint Agne, France eremy@mercator-ocean.fr

In the framework of the SMOS Nino 2015 ESA project (https://www.godae-oceanview.org/projects/smos-nino15/), the impact of satellite SSS data assimilation on global ocean analysis and forecasts was assessed with the Met Office and Mercator Ocean systems. The analysis focuses on the Tropical Pacific Ocean during the 2015 El Nino event, as a strong negative salinity anomaly was observed. Observing System Experiments (OSE) were designed and carried out to analyze the impact of SMOS, SMAP and Aquarius SSS data assimilation from 2014 to early 2016. Both forecasting systems are based on current or future version of the real time ones operated today, assimilating in situ, altimetry and SST observations. Even if a SSS bias correction has to be implemented on both, the impact was shown to be globally positive in the Tropical regions: the misfit to the in situ salinity observation is reduced when satellite SSS observation are assimilated. Common diagnostics, mostly based on different observation innovations, were applied to produce an Observation Impact Statement (OIS) on behalf of the GODAE OceanView (GOV). We will present this OIS, highlighting the relevant conclusions on the impact of SSS data assimilation in the context of operational oceanography and aiming at providing a valuable feedback to the data producing centres. We will also present the commonalities and discrepancies in the sensitivity of the two systems to satellite SSS assimilation before discussing the perspectives of this study.

Keywords: DA - Assimilation of new observation types, , , ,

Presenter:
Elisabeth REMY
Mercator Ocean
Ramonville Saint Agne, France
eremy@mercator-ocean.fr

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P18 - Abstract ID: 3601526

Estimation of First-Year Sea Ice Melt Pond Fraction from Compact Polarization SAR

Li, Haiyan[1], Perrie, Will[1] [1]Bedford Institute of Oceanography, Dartmouth, Canada haiyan.li@dfo-mpo.gc.ca

Melt ponds are a common feature on Arctic sea ice. They are linked to the sea ice surface albedo and transmittance of energy to the ocean from the atmosphere and thus constitute an important process to parameterize in Arctic climate models and simulations. This paper presents a first attempt to retrieve the melt pond fraction from compact polarization (CP) SAR (Synthetic Aperture Radar) imagery, which has wider swath and shorter revisit time than the quad-polarization systems, e.g. RADARSAT-2. The importance is that in February 2019, the Canadian Space Agency (CSA) will launch RADARSAT Constellation Mission, consisting of three identical satellites capable of using CP SAR to cover 90% of the global ocean every day, and Canadas polar regions several times a day, at high spatial resolution. From RADARSAT-2 satellite images, the co-polarization (co-pol) ratio has been verified to provide estimates of melt pond fractions. However, it is a challenge to link CP parameters and the co-pol ratio. The theoretical possibility of making this linkage with the CP parameter C22/C11 (the ratio between the elements of the covariance matrix of CP SAR) for melt pond detection and monitoring is presented with the tilted-Bragg scattering model for the ocean surface [Valenzuela, 1978]. Our empirical transformed formulation denoted the compact polarization and quad-pol (CPQD) model, is proposed. Our methodology is based on the existing VV/HH melt pond fraction retrieval method for satellite RADARSAT-2 data. Note that VV/HH is exactly the ratio of vertical-vertical send-receive radar backscatter, to horizontal-horizontal send-receive radar backscatter, for RADARSAT-2 data. The tilted-Bragg scattering model suggests the theoretical potential of coefficients of the scattering matrix (namely C22/C11) from CP mode data for melt pond observations. Thus, the linkage between C22/C11, from CP mode data, and scattering components, from quad-pol data, can be established with our collocated number of quad-pol observations of open ocean water. We used two data sets. Our CPQD is firstly based on 2062 RADARSAT-2 quad-pol SAR images, collocated with in situ measurements. Secondly, we compared the retrieved melt pond fraction with CP parameters simulated from quad-pol SAR data with results retrieved from the co-pol ratio from quad-pol SAR observations acquired during a recent field experiment, the Arctic-Ice Covered Ecosystem in a Rapidly Changing Environment (Arctic-Ice) field project conducted from May to June 2012. The results are shown to be comparable for observed melt pond measurements in spatial and temporal distributions. Thus, the utility of CP mode SAR for melt pond fraction estimation on first year level ice is established. This work builds on previous studies by Haiayn Li, William Perrie et al. presented in 2017 in JGR https://doi.org/10.1002/2017JC013248.

Keywords: Observations - Satellite ocean observing systems, Observations - New observation types

Presenter:
Will Perrie
Bedford Institute of Oceanography
Dartmouth, Canada
william.perrie@dfo-mpo.gc.ca

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P19 - Abstract ID: 3601743

Along satellite track evaluation of GODAE Class 4 sea level anomaly files

Xu, Jinshan[1], Davidson, Fraser[2], Smith, Gregory[3] [1]Fisheries and Oceans Canada, Dartmouth, Canada [2]Fisheries and Oceans Canada, St John's, Canada [3]Environment and Climate Change Canada, Dorval, Canada
jinshan.xu@dfo-mpo.gc.ca

The GODAE Ocean View Class 4 file, permits the evaluation of the reproduction of eddy kinetic energy and along track wave spectrum of the participating GODAE Ocean View Global forecast systems. Herein we examine for the North West Atlantic the forecast evaluation of Eddy Kinnetic Energy and Along track wave spectrum versus the satellite observations. We investigate the gradient and slope of the sea level anomaly fields through the use of along track Homevoller plots.

High resolution (1km) along track data due to better retracking algorithms, suggest that current class 4 GOV SLA file data may under-represent energy in the ocean. Our results suggest that higher resolution GOV systems increase the eddy kinetic energy in the predictions, but still underestimates the energy compared to coarse observed (7km) along track SLA data. Along track wave spectrum plots in the Gulf Stream region show good agreement at low wave numbers with marked differences across GOV systems and satellite observations and higher wave numbers (i.e between 80-300 km). Results from other geographic observations will be explored and presented. Our results suggest interesting ways to determine impact of new data assimilation approaches and other upgrades on the GOV prediction systems. While in GODAE Ocean View, Class 4 metrics are the comparison between predicted and observed values, here we present a derived Class 4 approach where the class 4 files are used to construct derived fields for further verification.

Keywords: Systems - Prediction system performance & evaluation, Systems - Prediction system validation/ intercomparisons, Observations - Observation requirements and data streams, Models - Model assessments and verification, DA - Model and observation systematic errors

Presenter:
Jinshan Xu
Fisheries and Oceans Canada
Dartmouth, Canada
jinshan.xu@dfo-mpo.gc.ca

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P20 - Abstract ID: 3601786

Time series ocean observations in the Bedford Basin

Haverstock, Anna[1], Waclawik, Magda [1], Davis, Richard[1], Wallace, Doug[1] [1]Dalhousie University, Halifax, Canada
anna.haverstock@dal.ca

Bedford Basin, Nova Scotia, has been host to frequent monitoring by Fisheries and Oceans Canada (DFO) at the Bedford Institute of Oceanography (BIO) since the 1960s until the program was formalized into the Bedford Basin Monitoring Program (BBMP), a weekly time series established in 1999. Bedford Basin began as a convenient location for monitoring but is now known to be representative of conditions on the Scotian Shelf. A time series of this length and frequency provides valuable environmental data, giving insight into how various parameters are changing over time. In 2008, the Coastal Environmental Observation Technology and Research (CEOTR) group at Dalhousie University joined the BBMP to begin a bio-optical time series, beginning the close relationship between the academic and government researchers. Over the years, both sides of the program have grown significantly with support by the Marine Environmental Observation Prediction and Response (MEOPAR) Network of Centres of Excellence. Weekly profiles in the deepest region of the Bedford Basin collect CTD data as well as dissolved oxygen, pH, nitrate, backscattering, chlorophyll and CDOM fluorescence, absorption, attenuation, downwelling irradiance and upwelling radiance. These in situ measurements are supplemented by discrete water samples collected to validate sensor data. Sampling has expanded to support student projects researching nitrogen isotopes, halogen compounds, microbial composition, and genomics. In recent years the data has been standardized according to international protocols and is now available to researchers and the public via an ERDDAP server in a wide variety of formats.

Keywords: Observations - In-situ ocean observing systems, Observations - Observation operators, Observations - Ocean monitoring based on observing systems, Observations - Observation impacts,

Presenter:
Anna Haverstock
Dalhousie University
Halifax, Canada
anna.haverstock@dal.ca

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GODAE OceanView Symposium | 6-10 May 2019 Halifax, Canada
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P21 - Abstract ID: 3601787

The Impact of XBTs data into HYCOM+RODAS in the Metarea V

Dorfschafer, Geoff[1], Tanajura, Clemente[2], Costa, Filipe[2] [1]Oceanographic Modeling and Observation Network (REMO), Salvador, Brasil [2]REMO, Salvador, Brasil geoceanografia@gmail.com

This work has as main scope the inclusion of XBT data in the ocean data assimilation system constructed by the Oceanographic Modeling and Observation Network (REMO) which employs the Hybrid Coordinate Ocean Model (HYCOM) and an Ensemble Optimal Interpolation (EnOI) scheme. This system, called HYCOM+RODAS, is able to assimilate sea surface temperature,vertical profiles of temperature (T) and salinity (S) from Argo andgridded sea level anomaly. In order to assimilate Argo data, RODAS employs the approach in which the T/S profiles are projected into the model isopycnic layers and pseudo-observed model layer thicknesses are assimilated. HYCOM+RODAS was only able to assimilate vertical profiles of T with the companion S. To overcome this limitation, an effort was realized to produce synthetic salinity profiles to accompany XBT data or any other T profile in a region of great interest for REMO, the so-called Metarea V (36S-7N, west of 20W until the Brazilan coast). The synthetic salinity was estimated by a combination of nonlinear regression on T with monthly climatological data. The climatology was utilized for estimating S in the top layers while specific5-degree polynomials were applied in deeper layers. This choice was based on lower root mean square deviations with respect to independent observations.

In order to investigate the impact of the new XBT data into RODAS, observation system evaluation (OSE) experiments wereperformed using HYCOM model. Three different assimilation runs were evaluatedfor the year of 2012. One experiment aimed at reproducing RODAS alone (RODAS). Previous publications showed that when assimilating T/S profiles into HYCOM with EnOI scheme, the user must choose one variable - T or S, to diagnose. Besides observations already assimilated by RODAS,701 XBTs present in the Metarea V were also added in other two experiments. In one of them, T was assimilated directly while S was diagnosed (RODAS_XBT - S diag), and in the other, the opposite occured (RODAS_XBT - T diag). An other run without assimilation (FREE) was also considered. Preliminary results show that the chosen diagnosed variable may be signifficant in some aspects of the present OSE.
New OSE experiments are under way, in which PIRATA data will be included in a full assimilation run with SST, SLA , Argo and XBT data. The results will be reported.

Keywords: Observations - In-situ ocean observing systems, Observations - Observation impacts, Observations - Observing system assessments and design, ,

Presenter:
Geoff Dorfschafer
Oceanographic Modeling and Observation Network (REMO)
Salvador, Brasil
geoceanografia@gmail.com

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P22 - Abstract ID: 3603736

MyOceandataSQL: an open-source application to store and distribute ocean observation data

Donnet, Sebastien[1], Castro, Damian[2], Ratsimandresy, Andry[3] [1]Fisheries and Oceans Canada, St. John's, NL, Canada [2]Database Development and Consulting, St. John's, NL, Canada [3]Fisheries and Oceans Canada, St. John's NL, Canada sebastien.donnet@dfo-mpo.gc.ca

Oceanographic observation plays a key role in ocean forecasting as they areused for data assimilation within ocean model and for model validation andtuning during ocean model development. Oceanographic data collection ischallenging and expensive. Yet, despite this harsh reality, many data collectionefforts are either not optimised or wasted due to a lack of efficient andpractical data management tools and/or capacity. With the growth of aquaculture activities on the Newfoundland coast and thenecessity to better understand and forecast the oceanographic processes that canaffect these activities, the Aquaculture section of the Northwest AtlanticFisheries Centre (NAFC), Department of Fisheries and Oceans Newfoundland region,has been collecting a fairlylarge number of oceanographic data and needed a quick way to efficiently extract and visualise all available data for analysis as well as for model development.Existing databases within the department are scattered amongst regional centres,generally outdated and lack of nowadays technology. e.g. a map on which one caneasily zoom in to interactively explore what data are available. In addition,none of the existing database could handle our varied set of observation withinthe same application. i.e. CTD profiles, ADCP, moored sonde (e.g. thermistorsand moored CTD), drifters, tide gauge and weather station data.

MyOceandataSQL was developed to fullfil this necessity. It is an interactiveSQL database which uses MySQL and Google Map. The present work describes theweb-based database with the objective that the simple user-interfaces (upload,selection, and download) will provide a versatile, open-source, and modular toolto archive and distribute diverse type of oceanographic data. It can handledata from any kind of platform (profiling, mooring, drifting). MyOceandataSQL isdesigned to be used by a variety of users (e.g. oceanographers, oceanographicdata end-users including industry and decision makers).

Keywords: Applications - Aquaculture, Observations - In-situ ocean observing systems, Systems - Ocean product distribution/dissemination and accessibility, ,

Presenter:
Andry Ratsimandresy
Fisheries and Oceans Canada
St. John's NL, Canada
andry.ratsimandresy@dfo-mpo.gc.ca

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

P23 - Abstract ID: 3606193

Advances in using satellite altimetry for monitoring and predicting coastal storm surges

Han, Guoqi[1] [1]Fisheries and Oceans Canada, St. John's, Canada guoqi.han@dfo-mpo.gc.ca

Storm surges are the major cause for coastal flooding, resulting in catastrophic damage to properties and loss of life in coastal communities. Thus it is important to utilize new technology to enhance our capabilities of observing storm surges and ultimately to improve our capacity for forecasting storm surges and mitigating damage and loss. Storm surge has long been observed by coastal tide gauges, high-water marks and pressure gauges. Numerical models have been used to provide operational real-time forecasts of the timing and magnitude of storm surge, providing the scientific basis for issuing flood warnings. Tide gauge data are most reliable and have been used to understand storm surge features. However, tide gauges are quite sparse and not installed in some coastal communities. During extreme storm surges, typically reliable tide gauges may not work properly or fail completely. For example, during Hurricane Katrina, many tide gauges failed along the New Orleans and Mississippi coasts. Therefore, timely and accurate observations from other sources would be useful to complement tide-gauge data for monitoring storm surges and for improving model prediction. Satellite altimetry provides all-weather sea level measurements globally. While its data quality deteriorates few tens of kilometers from coast, it provides useful information over the continental shelf and in the deep ocean where tide gauge data are not typically available. In recent years, a variety of experimental coastal altimetry products have been developed, which may reach a few km from shore. We present examples of storm surges observed by nadir satellite altimetry, during Hurricane Sandy off New York, Hurricane Isaac in the Gulf of Mexico, as well as typhoon and cyclone events elsewhere. We show how and how well satellite altimeter data can be used to derive coastal storm surge features. We further present examples on how the altimeter observations can be used to calibrate storm surge modelling. Finally, we discuss the potential of a wide-swath altimetry mission, the Surface Water and Ocean Topography (SWOT), for observing storm surges.

Keywords: Observations - Ocean monitoring based on observing systems, Observations - Satellite ocean observing systems,

Presenter:
Guoqi Han
Fisheries and Oceans Canada
St. John's, Canada
guoqi.han@dfo-mpo.gc.ca

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P24 - Abstract ID: 3607554

High-resolution measurements of surface currents on the Scotian Shelf using a high-frequency radar system (CODAR)

Davis, Richard[1], Sheng, Jinyu[1], deYoung, Brad[2] [1]Dalhousie University, Halifax, Canada [2]Memorial University, St. John's, Canada richard.davis@dal.ca

A high-frequency radar system installed at coastal locations can be used to provide estimates of spatial patterns of the speed and direction of surface current and also to estimate surface wave heights. Measurements of these properties are important to many stakeholders, including researchers, emergency and oil spill responders, harbor pilots, recreational boaters and surfers, and meteorologists. In 2016 the Marine Environmental Observation Prediction and Response (MEOPAR) Network of Centres of Excellence installed a 4.8 MHz long-range CODAR system off Halifax Harbour, Nova Scotia, with one station at Sandy Cove and another at Clam Harbour Provincial Park. The system provides hourly surface currents radial data with 6 km radial resolution for an area up to 200 km off the coast.Comparisons of the CODAR measurements of surface currents with the near-surface (at 20 m) currents measured by an ADCP at Halifax Line andthe surface currents produced by a shelf circulation model demonstrate that the CODAR system has reasonable skill for monitoring surface currents over the inner Scotian Shelf. The CODAR data are generally expected to be accurate to within 10 cm/s incurrent speed and 10 degrees in the current direction. Our analysis has revealed that the quality of the wave results depend strongly on the time of day with substantial signal degradation at night. Data from the high-frequency radar system can and has been used to validate models of ocean circulation.

Keywords: Observations - Ocean monitoring based on observing systems, Observations - Observation requirements and data streams, Observations - Observation impacts, Models - Model assessments and verification,

Presenter:
Richard Davis
Dalhousie University
Halifax, Canada
richard.davis@dal.ca

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P25 - Abstract ID: 3609953

Bedford Basin Benthic Pod – Platform for ocean observation and data validation

Evans, Madison [1], Haverstock, Anna [1], Davis, Richard[1], Adams, Darrell[1], Wallace, Doug [1] [1]Dalhousie University, Halifax, Canada madison.evans@dal.ca

In 2006 Dalhousie deployed the Bedford Basin Optical Mooring Buoy (BBOMB) near the sampling site of the Bedford Basin Monitoring Program (BBMP) to provide high temporal resolution data to complement a concurrent discrete sampling program. The BBMP is a weekly time series established in 1999 by the Fisheries and Oceans Canada (DFO) at the Bedford Institute of Oceanography (BIO). Dalhousie joined the BBMP in 2008 with a bio-optical time series. The BBOMB was removed from the water in 2009 due to logistical problems. In August 2018 Dalhousie deployed a benthic pod with support from the Marine Environmental Observation Prediction and Response (MEOPAR) Network of Centres of Excellence, reusing much of the equipment from the BBOMB as well as a dissolved oxygen unit provided by RBR and a carbon dioxide sensor provided by BIO. The pod also reused equipment from benthic pods deployed by the Ocean Tracking Network (OTN) from 2011 to 2016. The pod was deployed at a depth of 61 m at the sampling site of the BBMP for three months. The pod sampled conductivity, pressure, temperature, nitrate, dissolved oxygen concentration, carbon dioxide concentration, and chlorophyll fluorescence every hour of the day. The high sampling rate provided the possibility to capture short-term environmental events and chemical interactions that may have been missed by the weekly monitoring program. For example an intrusion event, in which warm salty water from offshore is forced into the deep waters of the Bedford Basin, was clearly captured in October 2018. Bottom temperatures rose from 3.5 degC to 6.5 degc in approximately 48 hours while bottom oxygen concentration went from hypoxic to over 200 micromoles. The weekly BBMP data can be used to validate the pod measurements, ensuring that any drift associated with the deployment can be corrected. The pod data is publicly available for other researchers to use and is particularly useful for model validation. The first deployment was a success, leading to a second deployment planned for the end of February to catch the spring bloom in the Bedford Basin. Future possible developments include collecting the data in near real-time and including different instruments to measure parameters such as pH.

Keywords: Observations - Ocean monitoring based on observing systems, Evolution - Enhancing community collaboration (observations, modelling, operations, users), Observations - In-situ ocean observing systems, ,

Presenter:
Madison Evans
Dalhousie University
Halifax, Canada
madison.evans@dal.ca

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P27 - Abstract ID: 3613375

Observation Impact in a Regional Reanalysis of the East Australian Current

Kerry, Colette[1], Roughan, Moninya[1], Powell, Brian[2] [1]University of New South Wales, Sydney, Australia [2]University of Hawaii at Manoa, Honolulu, USA c.kerry@unsw.edu.au

The use of Data Assimilation, whereby we combine a numerical model and oceanic observations, results in a more accurate ocean state estimate than either modelling or observations alone.The East Australia Current (EAC), the Western Boundary Current of the South Pacific subtropical gyre, dominates the circulation along the east coast of Australia and identifying observations that best constrain its transport and eddies may help improve circulation estimates.We combine a numerical ocean model of the EAC system with an unprecedented observational data set, using 4-dimensional variational data assimilation, to generate a high-resolution ocean state estimate over a 2-year period (Jan 2012 - Dec 2013).In assessing system performance it is useful to know how each observation contributes to the solution and variational methods allow us to quantify the observation impacts directly.Using the regional reanalysis we calculate the impacts of observations from various platforms in informing model estimates of volume transport and eddy kinetic energy in the EAC.The most influential observations are, in this order, satellite-derived Sea Surface Temperature (SST), radial components of sea surface velocity from an High-Frequency (HF) radar array midway along the coast, satellite-derived Sea Surface Height (SSH), temperature, salinity and velocity observations from a full-depth mooring array in the upstream portion of the domain, and subsurface hydrographic data measured by ocean gliders. Not only do the HF radar observations have high impact on transport estimates at the array location, they have significant impact both up and downstream. Likewise, the impact of the mooring array observations is far reaching, contributing to transport estimates hundreds of kilometers downstream. The observation impact of deep gliders deployed into eddies is particularly high. Significantly, we find that observations taken in regions with greater natural variability contribute most to constraining the model estimates.SSH and SST observations of the region of elevated eddy energy between 32-37S have more impact than the same observations taken elsewhere. Observations taken in the upper 400m of the water column contribute more to changes in the circulation estimates than deeper observations, as they sample the depth region of greatest uncertainty and reveal information about the structure of the mixed layer and pycnocline.Understanding which observations are useful in informing model estimates of the EAC is a key step towards providing improved state estimates and predictions, yet more work is required to understand the relative importance of observing the variable versus less variable regions of the ocean.

Keywords: Observations - Observation impacts, Observations - Observing system assessments and design, Observations - International ocean observation projects (e.g. YOPP, TPOS2020, etc.), DA - Observation impact assessment methods, DA - Variational data assimilation

Presenter:
Moninya Roughan
University of New South Wales
Sydney, Australia
mroughan@unsw.edu.au

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

P28 - Abstract ID: 3613778

Introduction to Korean Ocean Research Stations (KORSs) of the Korea Hydrographic and Oceanographic Agency

Byun, Do-Seong[1], Lee, Jooyoung[1], Lee, Eunil[1], Jeong, Jinyong[2] [1]Korea Hydrographic and Oceanographic Agency, Busan, Republic of Korea [2]Korea Institute of Ocean Science and Technology, Busan, Republic of Korea
dsbyun@korea.kr

The Korean Ocean Research Stations (KORSs) of the Ieodo, Shinan Gageocho and Ongjin Socheongcho were constructed in 2003, 2009 and 2014, respectively, which are located in the open seas including jurisdictional sea areas of Korea and are used to conduct oceanographic, meteorological and environmental observation. The Ieodo Ocean Research Station (IORS) is situated on submarine rock called Ieodo in the East China Sea. The Korea Hydrographic and Oceanographic Agency (KHOA) has been running these KORSs after taking over control of IORS from the Korea Institute of Ocean Science and Technology (KIOST) in 2007, followed by the Gageocho and Socheongcho Stations in 2016. The KHOA has been conducting a program of IORS field trip since 2014 in order to further enhance it to be an international observation station and being made to conduct field trips at the Shinan Gageocho and Ongjin Socheongcho ORSs. Located 149 km southwest of Jeju Island, the IORS makes an ideal spot for oceanographic and meteorological research due to its presence at the pathway of typhoons heading for the Korean Peninsula. It has 29 pieces of equipment installed for collecting oceanographic, meteorological and environmental data. Six academic research projects were carried out in 2018. The Gageocho and Socheongcho Stations have 13 and 23 pieces of observation equipment installed, respectively. Efforts are also being made to conduct research stay to foster them as international stations along with the Ieodo Ocean Research Station. The KORSs were newly included into OceanSITES as a shallow water pilot observatory in Aug. 31, 2018. The KHOA ultimately aims to establish these three stations as global scientific stations through a variety of academic research.

Keywords: Observations - In-situ ocean observing systems, Observations - Observing system assessments and design, Observations - Observing system needs and future challenges, Observations - Satellite ocean observing systems, Observations - Ocean Obs '19

Presenter:
Do-Seong Byun
Korea Hydrographic and Oceanographic Agency
Busan, Republic of Korea
dsbyun@korea.kr