ISDA-Online

February 10, 2023 15 – 17 UTC

"Ocean Data Assimilation"

Organizers: *Max Yaremchuk (NRL,US)*
Hao Zuo (ECMWF, UK)
Nora Schenk (DWD, Germany)

Data assimilation is used more and more widely in operational oceanography and to produce climate reconstructions. With the advent of coupled NWP at many operational centres, improving methods for ocean (and coupled) data assimilation becomes even more important. We invite contributions on ocean DA and coupled ocean-atmosphere DA (with the focus on the ocean component) in all types of models.

Program: (All talks: 17' + 3' Q&A)

15:00 – 15:05 **Welcome**

15:05 – 15:25 **Improvement of the Ocean 4D-Var Scheme for High-Accuracy Sea Surface Temperature Analysis and Forecast**
Norihisa Usui, Yosuke Fujii, Nariaki Hirose, Ichiro Ishikawa

15:25 – 15:45 **Estimation of Spatially and Temporally Varying Biogeochemical Parameters in a Global Ocean Model**
Nabir Mamnun, Christoph Völker, Mihalis Vrekoussis, Lars Nerger

15:45 – 16:05 **Predicting the Sea-Ice and Ocean State by Combining Sea-Ice and Ocean Data Assimilation with Atmospheric Wind Nudging**
Svetlana N. Loza, Marylou Athanase, Longjiang Mu, Jan Streffing, Miguel Andrés-Martínez, Lars Nerger, Tido Semmler, Dmitry Sidorenko, Helge F. Goessling

16:05 – 16:10 **Time buffer**

16:10 – 16:30 **The Impact of Hybrid Oceanic Data Assimilation in a Coupled Model: A Case Study of a Tropical Cyclone**
Tsz Yan Leung, Amos S. Lawless, Nancy K. Nichols, Daniel J. Lea, Matthew J. Martin

16:30 – 16:50 **Guidance on Localization for Strongly Coupled Atmosphere-Ocean Data Assimilation**
Zofia Stanley, Clara Draper, Sergey Frolov, Laura Slivinski, Wei Huang, Jeffrey Whitaker, Henry Winterbottom

16:50 – 17:00 **Closing: Information on upcoming sessions**

Please note:

- When you login to the session before 15:00 UTC, and everything is quiet, this is most likely because we muted the microphones.
- The times in UTC are approximate. In case of technical problems, we might have to change the order of the presentations.
- **Time Zones**: 15 – 17 UTC

03 – 05 pm GMT (London)	04 – 06 pm CET (Berlin)	
11 – 01 am CST (Shanghai)	00 – 02 am JST (Tokyo)	02 – 04 am AEDT (Sydney)
07 – 09 am PST (San Fran.)	08 – 10 am MST (Denver)	10 – 12 am EST (New York)

Improvement of the Ocean 4D-Var Scheme for High-Accuracy Sea Surface Temperature Analysis and Forecast

Norihisa Usui[1], Yosuke Fujii[1], Nariaki Hirose[1], Ichiro Ishikawa[1]

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Many ocean data assimilation systems use gridded sea surface temperatures (SSTs) produced by statistical interpolation methods such as optimal interpolation. Such gridded SSTs are however spatio-temporally smoothed. Therefore, in a high-resolution ocean data assimilation system, it is desirable to assimilate satellite Level-2 data directly, rather than the gridded data. In this study, we developed a method to analyze the SST field with high accuracy within the framework of the four-dimensional variational (4D-Var) method. In 4D-Var assimilation systems at eddy-resolving resolution, the assimilation window is usually set to about 10 days, and increments to the initial condition is optimized by minimizing the cost function. Although this setting is reasonable for analysis of ocean internal variations such as changes in ocean current and ocean internal temperature, it would not be appropriate for SST because the SST variability is influenced not only by the oceanic internal dynamics but also by the atmospheric forcing. In this study, we propose a new 4D-Var scheme to reproduce detailed spatial-temporal SST variations with guaranteed reproducibility of ocean internal variations. In the new scheme, daily SST increments within the assimilation window are added to control variables, and they are assumed to be independent from other control variables such as temperature and salinity increments to the initial condition. We implemented this scheme into the Meteorological Research Institute Multivariate Ocean Variational Estimation (MOVE) system and conducted an experiment to assimilate Himawari-8 SST together with altimeter data and in-situ temperature and salinity. In addition to details of the developed scheme, early results of the assimilation experiment will be presented.

Estimation of Spatially and Temporally Varying Biogeochemical Parameters in a Global Ocean Model

Nabir Mamnun[1], Christoph Völker[1], Mihalis Vrekoussis[2], Lars Nerger[1]

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Ocean biogeochemical (BGC) models are, in addition to measurements, the primary tools for investigating ocean biogeochemistry, marine ecosystem functioning, and the global carbon cycle. These models contain a large number of not precisely known parameters and are highly uncertain regarding those parametrizations. The values of these parameters depend on the physical and biogeochemical context, but in practice values derived from limited field measurements or laboratory experiments are used in the model keeping them constant in space and time. This study aims to estimate spatially and temporally varying parameters in a global ocean BGC model and to assess the effect of those estimated parameters on model fields and dynamics. Utilizing the BGC model Regulated Ecosystem Model 2 (REcoM2), we estimate ten selected BGC parameters with heterogeneity in parameter values both across space and over time using an ensemble data assimilation technique. We assimilate satellite ocean color and BGC-ARGO data using an ensemble Kalman filter provided by the Parallel Data Assimilation Framework (PDAF) to simultaneously estimate the BGC model states and parameters. We assess the improvement in the model predictions with space and time-dependent parameters in reference to the simulation with globally constant parameters against both assimilative and independent data. We quantify the spatio-temporal uncertainties regarding the parameter estimation and the prediction uncertainties induced by those parameters. We study the effect of estimated parameters on the biogeochemical fields and dynamics to get deeper insights into modeling processes, and discuss insights from spatially and temporally varying parameters beyond parameter values.

Predicting the Sea-Ice and Ocean State by Combining Sea-Ice and Ocean Data Assimilation with Atmospheric Wind Nudging

Svetlana N. Loza[1], Marylou Athanase[1], Longjiang Mu[1,2], Jan Streffing[1], Miguel Andrés-Martínez[1], Lars Nerger[1], Tido Semmler[1], Dmitry Sidorenko[1], Helge F. Goessling[1]

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With declining Arctic sea ice and increasing human activities in polar oceans, reliable sea ice prediction is urgently required to meet scientific and social-economic needs. Numerical sea ice, ocean, climate and earth system models in combination with observational information have been used as tools for generating forecasts. One such data assimilative model is the AWI Coupled Prediction System (AWI-CPS) which has been developed by Mu et al. (2022). The current version of the system is based on the AWI climate model AWI-CM v3.0 (Streffing et al. 2022) that is composed of FESOM2.0 as sea-ice ocean component and of the Integrated Forecasting System (OpenIFS) as atmospheric component. The sea-ice concentration, thickness, drift, sea surface height, and sea surface temperature and salinity are assimilated into the system with an Ensemble-type Kalman filter within the Parallel Data Assimilation Framework (PDAF; Nerger and Hiller, 2013). In the previous AWI-CPS version (Mu et al. 2022), the assimilation of sea ice and ocean observational data demonstrated promising performance with respect to the predicted ocean and sea ice states. To further improve the predictive skill of our system, we have augmented the sea ice and ocean data assimilation system with relaxation (nudging) of the large-scale atmospheric dynamics to the ERA5 re-analysis data. Constraining the large-scale atmospheric circulation has the potential to reduce initial-state errors not only in the (previously unconstrained) atmosphere, but also in the ocean and sea-ice. Correspondingly, the data assimilation analysis increments are reduced as the ”corrected” atmospheric forcing leads to more accurate model background states. Improvements are most obvious for the initial and predicted sea-ice drift. We present preliminary results based upon data assimilation experiments conducted for the year 2018. More comprehensive analyses will be performed with the new system running over the time period 2003 – 2022.

The Impact of Hybrid Oceanic Data Assimilation in a Coupled Model: A Case Study of a Tropical Cyclone

Tsz Yan Leung[1,2,3], Amos S. Lawless[2,3], Nancy K. Nichols[2,3], Daniel J. Lea[1], Matthew J. Martin[1]

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Tropical cyclones tend to result in distinctive spatial and temporal characteristics in the upper ocean, which suggests that traditional, parametrisation-based background-error covariances in oceanic data assimilation (DA) may not be suitable. Using the case study of Cyclone Titli, which affected the Bay of Bengal in October 2018, we explore hybrid methods that combine the traditional covariance modelling strategy used in variational methods with flow-dependent estimates of the ocean's error covariance structures based on a short-range ensemble forecast. This hybrid approach is investigated in the UK Met Office's state-of-the-art system. Single-observation experiments in the ocean reveal that the hybrid approach is capable of producing analysis increments that are time-varying, more anisotropic and vertically less uniform. When the hybrid oceanic covariances are incorporated into a weakly coupled DA system, the sea-surface temperature (SST) in the path of the cyclone is changed, not only through the different specifications of background-error covariances used in the SST assimilation, but also through the propagation of subsurface temperature differences to the surface as a result of vertical mixing associated with the cyclone's strong winds. The coupling with the atmosphere then leads to a discrepancy in the cyclone's central pressure, which brings forth further SST differences due to the different representations of the cyclone's emerging cold wake.

Guidance on Localization for Strongly Coupled Atmosphere-Ocean Data Assimilation

Zofia Stanley[1,2], Clara Draper[2], Sergey Frolov[2], Laura Slivinski[1,2], Wei Huang[1,2], Jeffrey Whitaker[2], Henry Winterbottom[1,2]

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We address the question of how to implement vertical localization in a strongly coupled atmosphere-ocean system, where observations of the atmosphere can directly impact the ocean and vice-versa. Localization serves to mitigate the impact of sampling errors on ensemble-derived estimates of background error covariance matrices and thus a properly specified localization scheme is essential. Vertical localization methods have been developed for multiple earth system components separately. However, guidance on how to localize the cross-domain error covariances used in strongly coupled systems is needed. In this work we use forecasts from a global 1-degree coupled atmosphere-ocean model to inform vertical localization strategies for strongly coupled atmosphere-ocean data assimilation systems. We compare errors associated with several "optimal" localization schemes.