ISDA-Online

March 12, 2026 / 15 – 17 UTC
(4 – 6 pm CET / 9 – 11 am MDT / 12 pm – 2 am JST)

“Ocean data assimilation”

Organizers and Conveners: *Qi Tang (University of Neuchâtel / University of Basel, Switzerland), Lars Nerger (AWI, Germany), Daniel Lea (MetOffice, UK)*

Data assimilation into the ocean has advanced strongly over the recent years with also operational ocean forecasting becoming common practice. The sparseness of ocean observations, its dynamics, and the interaction with coupled components, like sea ice, marine biogeochemistry, coasts, atmosphere results in particular challenges. We invite contributions on DA into the ocean and its coupled components.

Program: (UTC)

15:00 – 15:05	**Introduction**
15:05 – 15:40 (30’+5’)	**Data Assimilation in the NOAA US West Coast Ocean Forecast System (invited talk)** Alexander L. Kurapov, Parisa Heidary, Bahram Khazaei, Scott Durski
15:40 – 15:58 (15’+3’)	**On the choice of velocity variables for variational ocean data assimilation** Laura Risley, Amos Lawless, Matthew Martin, Anthony Weaver
15:58 – 16:16 (15’+3’)	**Near-Real-Time Satellite-Based Ocean Current Assimilation Using a Multi-Model Ensemble Kalman Filter** Shahbaz Baig, Waqas A. Qazi, Rafia Mumtaz
16:16 – 16:34 (15’+3’)	**Effects of Stochastic Parameterization in a Global Ocean Model on Ensemble-Based Data Assimilation** Kate Boden, Ian Grooms
16:34 – 16:52 (15’+3’)	**Hybrid Ensemble Variational Data Assimilation in a high resolution ocean model** Daniel Lea, Matthew Martin, Jennie Waters, Davi Carneiro, Martin Price
16:52 – 17:00	**Closing: Information on upcoming sessions**

Data Assimilation in the NOAA US West Coast Ocean Forecast System (WCOFS)

Alexander L. Kurapov[1], Parisa Heidary[1], Bahram Khazaei[1] and Scott Durski[2]

[1] NOAA NOS/OCS/CSDL/CMMB
[2] CEOAS, Oregon State University

When specifying the background error covariance matrix in variational data assimilation (DA), model variables are transformed into control variables that can be assumed to be approximately uncorrelated. This process is known as the control variable transform. With a view of assimilating ocean surface currents, we seek to develop a transformation that decorrelates horizontal velocity. Helmholtz theorem can be used to separate horizontal velocity into nondivergent and irrotational components. The transformed variables can then be defined as relative vorticity and horizontal divergence, as is typically done in atmospheric DA. In contrast, the NEMOVAR ocean data assimilation system— used at both the Met Office and ECMWF — employs ageostrophic velocity components as control variables. Here, we implement and evaluate alternative velocity control variables within NEMOVAR based on the Helmholtz framework.

The proposed approach is tested using the Nucleus for European Modelling of the Ocean (NEMO) model in its idealised GYRE configuration. Assimilation experiments are conducted with simulated observations representative of the present-day observation network used at the Met Office, supplemented by synthetic satellite-derived total surface current velocity data. We compare the performance of the system using the existing ageostrophic velocity control variables with that of the modified system using alternative velocity variables, both with and without the inclusion of surface current observations.

Results show that the existing operational approach benefits from the assimilation of surface current data. However, use of the proposed new velocity control variables demonstrates the potential for even greater improvements, outperforming the current system across several performance metrics.

On the choice of velocity variables for variational ocean data assimilation

Laura Risley[1], Amos Lawless[2], Matthew Martin[3] and Anthony Weaver[4]

[1] ECMWF
[2] University of Reading, NCEO
[3] Met Office
[4] Cerfacs

When specifying the background error covariance matrix in variational data assimilation (DA), model variables are transformed into control variables that can be assumed to be approximately uncorrelated. This process is known as the control variable transform. With a view of assimilating ocean surface currents, we seek to develop a transformation that decorrelates horizontal velocity. Helmholtz theorem can be used to separate horizontal velocity into nondivergent and irrotational components. The transformed variables can then be defined as relative vorticity and horizontal divergence, as is typically done in atmospheric DA. In contrast, the NEMOVAR ocean data assimilation system— used at both the Met Office and ECMWF — employs ageostrophic velocity components as control variables. Here, we implement and evaluate alternative velocity control variables within NEMOVAR based on the Helmholtz framework.

The proposed approach is tested using the Nucleus for European Modelling of the Ocean (NEMO) model in its idealised GYRE configuration. Assimilation experiments are conducted with simulated observations representative of the present-day observation network used at the Met Office, supplemented by synthetic satellite-derived total surface current velocity data. We compare the performance of the system using the existing ageostrophic velocity control variables with that of the modified system using alternative velocity variables, both with and without the inclusion of surface current observations.

Results show that the existing operational approach benefits from the assimilation of surface current data. However, use of the proposed new velocity control variables demonstrates the potential for even greater improvements, outperforming the current system across several performance metrics.

Near-Real-Time Satellite-Based Ocean Current Assimilation Using a Multi-Model Ensemble Kalman Filter

Shahbaz Baig[1,2], Waqas A. Qazi[2] and Rafia Mumtaz[1]

[1] National University of Sciences and Technology, Pakistan
[2] O.M. Offshore monitoring Ltd., Cyprus

Accurate near-real-time (NRT) estimation of ocean surface currents is often hindered by sparse in-situ observations, intermittent satellite coverage, and structural uncertainties in numerical models. This study presents a robust end-to-end data assimilation framework that directly integrates high-resolution satellite-derived two-dimensional surface velocity vectors into a multi-source Multi-Model Ensemble Kalman Filter (MEnKF).

The methodology utilizes an automated, adaptive Maximum Cross-Correlation (MCC) algorithm to retrieve surface currents from sequential multi-platform AVHRR thermal imagery. To ensure operational robustness despite cloud-cover constraints, a data-enrichment strategy systematically processes valid image pairs within a 24-hour window. The MEnKF explicitly addresses model uncertainty by utilizing a heterogeneous ensemble of global and regional forecasts, including HYCOM, GRTOFS, and NEMO models.

The framework was evaluated along the Galician Coast of Spain using data from January 2021. Validation against independent HF-Radar and regional CMEMS reanalysis confirmed systematic skill gains over background forecasts. Results indicate the system effectively captures mesoscale features, such as jets and eddies, that are typically under-resolved. Optimal performance was achieved at observational densities of 8-12 images per cycle, resulting in a current speed RMSE of approximately 0.18 m/s. Sensitivity analysis further reveals that spatial representativeness and timing are more critical for assimilation accuracy than raw data volume alone. This scalable framework provides a physically consistent pathway for improving NRT predictions in data-sparse regions.

Effects of Stochastic Parameterization in a Global Ocean Model on Ensemble-Based Data Assimilation

Kate Boden and Ian Grooms

University of Colorado, Boulder

Ocean models are critical components for Earth System Prediction on seasonal and longer timescales. Due to computational limitations, global ocean models are often resolved at coarse horizontal scales, on the order of 1°. At this scale, important phenomena such as mesoscale eddies are not resolved. Since mesoscale eddies account for a significant portion of ocean variability, failing to represent them and their impacts on larger-scale processes results in reduced variability in global ocean models.

In the context of ensemble-based data assimilation (DA), the lack of model variability can lead to under-dispersed ensembles. When the model ensemble is under-dispersed, useful observations may be ignored during the assimilation step. Current approaches to deal with this include inflation methods, which artificially increase ensemble spread. In this study, we explore an alternative approach, where a combination of backscatter parameterizations is used to add variability into the model directly. In total, three backscatter parameterization schemes are implemented: stochastic GM + E, stochastic equation of state, and deterministic Leith + E. Previous studies have shown that implementing these schemes in a coarse ocean model results in significant increases in model variability. These results suggest possible improvements to DA performance on coarse models.

We will present results from 40 ensemble member global OSSE experiments using the new ocean component of CESM, MOM6, coupled with the Data Assimilation Research Testbed (DART). The experiments compare MOM6-DART with and without the stochastic backscatter parameterizations. Positive results from these experiments could lead to improvements in ocean reanalysis products and improved initial conditions for Earth System Prediction.

Hybrid Ensemble Variational Data Assimilation in a high resolution ocean model

Daniel Lea, Matthew Martin, Jennie Waters, Davi Carneiro and Martin Price

Met Office

We have developed an updated global ocean and sea-ice ensemble data assimilation (DA) system based on the latest version of the FOAM (Forecasting Ocean Assimilation Model) system run at the Met Office. This work is a follow up to earlier ensemble DA work with a lower 1/4 degree resolution global model and an older version of the ocean model. The ocean model is now NEMO (version 4) and the SI3 sea-ice model, both run at 1/12 degree resolution. The system assimilates data using NEMOVAR at 1/4 degree resolution. A 36 member ensemble of hybrid-ensemble-variational assimilation systems with perturbed observations (values and locations) is run. Running an ensemble of data assimilations can be expensive (despite the DA already being at a lower resolution than the model) and we describe the work to make this more affordable, including for example running the ensemble localisation on a coarser grid.

Each ensemble member is forced at the surface by a separate member of the Met Office Global-Regional Ensemble Prediction System (MOGREPS-G). The unperturbed member is forced by atmospheric fields from the Met Office operational Numerical Weather Prediction (NWP) deterministic system. The system includes stochastic model perturbations and a Relaxation to Prior Spread (RTPS) inflation scheme.

As with that system we demonstrate the ensemble to be reliable for sea level anomaly (SLA), temperature and salinity (the ensemble spread being a good representation of the uncertainty in the ensemble mean). Using hybrid three-dimensional ensemble variational DA (3DEnVar) along with the RTPS inflation scheme leads to a reduction of 20% (5%) in the ensemble mean error for SLA (profile temperature and salinity) compared with the non-ensemble 3DVar system.