ISDA-Online

May 7, 2021 15 – 17 UTC

“Coupled Data Assimilation”

Session Chair: Javier Amezcua (University of Reading and NCEO, UK)
Co-chairs: Nora Schenk (DWD, Germany) and Ting-Chi Wu (RIKEN, Japan)

Program:

15:00 – 15:10 Welcome

15:10 – 15:30 Coupled Ocean-Atmosphere Covariances in Global Ensemble Simulations: Impact of an Eddy-Resolving Ocean
Sergey Frolov, Carolyn A. Reynolds, Michael Alexander, Maria Flatau, Neil P. Barton, Patrick Hogan, Clark Rowley

15:30 – 15:50 Strongly coupled data assimilation with the coupled ocean-atmosphere model AWI-CM: comparison with the weakly coupled data assimilation
Qi Tang, Longjiang Mu, Helge Goessling, Tido Semmler, and Lars Nerger

15:50 – 16:10 Multivariate localization functions for strongly coupled data assimilation
Zofia Stanley, Ian Grooms, and William Kleiber

16:10 – 16:30 Development of Global Ensemble-based Data Assimilation System in JEDI for Aerosol Forecasting and Reanalysis using the GEFS-Aerosols Model
Bo Huang, Mariusz Pagowski, Cory Martin, Samuel Trahan, Dan Holdaway, Andrew Tangborn, Daryl Kleist, Shobha Kondragunta, Arlindo da Silva, Sarah Lu, Shih-Wei Wei

16:30 – 16:50 Data assimilation in coupled chaotic dynamics and its combination to machine learning to infer unresolved scale error
Alberto Carrassi, Laurent Bertino, Marc Bocquet, Julien Brajard, Jonathan Demaeyer, and Stephane Vannitsem

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
  04 – 06 pm BST (London) | 05 – 07 pm CEST (Berlin)
  11 – 01 am CST (Shanghai) | 00 – 02 am JST (Tokyo) | 01 – 03 am AEDT (Sydney)
  08 – 10 am PDT (San Fran.) | 09 – 11 am MDT (Denver) | 11 – 01 pm EDT (New York)

Coupled Ocean-Atmosphere Covariances in Global Ensemble Simulations: Impact of an Eddy-Resolving Ocean

Sergey Frolov[1,2], Carolyn A. Reynolds[3], Michael Alexander[2], Maria Flatau[3],
Neil P. Barton[3], Patrick Hogan[4], Clark Rowley[3]

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[3] Navy Research Laboratory, USA
[4] National Oceanic and Atmospheric Administration, USA

Patterns of correlations between the ocean and the atmosphere are examined using a high-resolution (1/12° ocean and ice, and 1/3° atmosphere) ensemble of data assimilative, coupled, global, ocean-atmosphere forecasts. This provides a unique perspective into atmosphere-ocean interactions constrained by assimilated observations, allowing for the contrast of patterns of coupled processes across regions and the examination of processes affected by ocean mesoscale eddies. Correlations during the first 24 hours of the coupled forecast between ocean surface temperature and atmospheric variables, and between ocean mixed layer depth and surface winds are examined as a function of region and season. Three distinct coupling regimes emerge: (1) regions characterized by strong sea surface temperature fronts, where uncertainty in the ocean mesoscale influences ocean-atmosphere exchanges; (2) regions with intense atmospheric convection over the tropical oceans, where uncertainty in the modeled atmospheric convection impacts the upper ocean; and (3) regions where the depth of the seasonal mixed layer (MLD) determines the magnitude of the coupling, which is stronger when the MLD is shallow and weaker when the MLD is deep. A comparison with models at lower horizontal (1/12° vs. 1° and 1/4°) and vertical (1-meter vs. 10-meter depth of the first layer) ocean resolution reveals that coupling in the boundary currents, the Tropical Indian Ocean, and the Warm Pool regions requires high levels of horizontal and vertical resolution. Implications for coupled data assimilation and short-term forecasting are discussed.

Strongly coupled data assimilation with the coupled ocean-atmosphere model AWI-CM: comparison with the weakly coupled data assimilation

Qi Tang[1,2,3], Longjiang Mu[1,4], Helge Goessling[1], Tido Semmler[1], Lars Nerger[1]

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[2]Institute of Geographic Sciences and Natural Resources Research, China
[3]Chinese Academy of Sciences, China
[4]Qingdao National Laboratory for Marine Science and Technology, China

We compare the results of strongly coupled data assimilation and weakly coupled data assimilation by analyzing the assimilation effect on the prediction of the ocean as well as the atmosphere variables. The AWI climate model (AWI-CM), which couples the ocean model FESOM and the atmospheric model ECHAM, is coupled with the parallel data assimilation framework (PDAF, http://pdaf.awi.de). The satellite sea surface temperature is assimilated. For the weakly coupled data assimilation, only the ocean variables are directly updated by the assimilation while the atmospheric variables are influenced through the model. For the strongly coupled data assimilation, both the ocean and the atmospheric variables are directly updated by the assimilation algorithm. The results are evaluated by comparing the estimated ocean variables with the dependent/independent observational data, and the estimated atmospheric variables with the ERA-interim data. In the ocean, both the WCDA and the SCDA improve the prediction of the temperature and SCDA and WCDA give the same RMS error of SST. In the atmosphere, WCDA gives slightly better results for the 2m temperature and 10m wind velocity than the SCDA. In the free atmosphere, SCDA yields smaller errors for the temperature, wind velocity and specific humidity than the WCDA in the Arctic region, while in the tropical region, the error are larger in general.

Multivariate localization functions for strongly coupled data assimilation

Zofia Stanley[1], Ian Grooms[1], William Kleiber[1]

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Localization is widely used in data assimilation schemes to mitigate the impact of sampling errors on ensemble-derived background error covariance matrices. In strongly coupled data assimilation, when different components have disparate dominant spatial scales, localization between model domains must properly account for the multiple length scales at play. In this talk we present two new multivariate localization functions, one of which is a multivariate extension of the fifth-order piecewise rational Gaspari-Cohn localization function; the within-component localization functions are standard Gaspari-Cohn with different localization radii while the cross-localization function is newly constructed. The functions produce non-negative definite localization matrices, which are suitable for use in variational data assimilation schemes. We compare the performance of our two new multivariate localization functions to two other multivariate localization functions and to the univariate analogs of all four functions in a simple experiment with the bivariate Lorenz '96 system. In our experiment the multivariate Gaspari-Cohn function leads to better performance than any of the other localization functions.

Development of Global Ensemble-based Aerosol Data Assimilation System using JEDI for Aerosol Forecasts in the UFS-GOCART Model

Bo Huang (CU/CIRES and NOAA/ESRL/GSL),
Mariusz Pagowski (CU/CIRES and NOAA/ESRL/GSL),
Cory Martin (RedLine Performance Solutions at NCEP/EMC),
Andrew Tangborn (IMSG at NCEP/EMC),
Dan Holdaway (JCSDA and NASA),
Daryl Kleist (NOAA/NWS/NCEP/EMC),
Shobha Kondragunta (NOAA/NESDIS/STAR)

A three-dimensional ensemble-variational (EnVar) aerosol data assimilation (DA) system was developed based on the Joint Effort for Data assimilation Integration (JEDI) led by JCSDA to produce global aerosol analyses and forecasts in the NOAA's Unified Forecast System (UFS) coupled with the Goddard Chemistry Aerosol Radiance and Transport (GOCART) scheme. The local ensemble transform Kalman filter in JEDI is adopted to produce ensemble background covariances which are further blended with static background covariances in the variational solver. This system is capable of assimilating aerosol optical depth (AOD) retrievals at 550 nm derived from the Visible/Infrared Imager Radiometer Suite (VIIRS) and Moderate Resolution Imaging Spectroradiometer (MODIS) instruments. Two AOD forward operators were developed in JEDI's Unified Forward Operator framework. They rely on aerosol scattering properties from lookup tables provided by the Community Radiative Transfer Model and NASA, respectively.

Initial results show that the forward operator using NASA lookup tables is in a better agreement with AOD observations. Cycled DA experiments of assimilating VIIRS AOD retrievals at 550 nm and using the forward operator with NASA lookup tables show that the assimilation significantly improves aerosol forecasts in the UFS-GOCART model by comparing with aerosol reanalyses from NASA and ECMWF. To further improve the performance of this system, stochastically perturbed aerosol emissions are developed to ameliorate spread deficiency of the background ensemble. Ensemble background covariances are blended by the static counterpart to reduce sampling error in the background ensemble. Filter divergence that occurs due to difficulty of vertically localizing integrated AOD observations is addressed by recentering the analyses, or applying model-space vertical localization through modulated ensemble form in the filter. Impacts of these recent developments are being examined and will be presented.

Data assimilation in coupled chaotic dynamics and its combination to machine learning to infer unresolved scale error

Alberto Carrassi [1,2], Laurent Bertino[3], Marc Bocquet[4], Julien Brajard[3],
Jonathan Demaeyer[5], Stephane Vannitsem[5]

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Data assimilation (DA) in systems with many scales of motions is a methodological and technological challenge. The core issue is the scale separation acting as a barrier to the propagation of the information across model components. We focus on coupled DA (CDA) using the ensemble Kalman filter (EnKF). We elucidate the mechanisms of information propagation by using a linear analysis and deduce that: (i) cross components effects are strong from the slow to the fast scale, but (ii) intra-component effects are much stronger in the fast scale. Thus, while observing the slow scale benefits the fast, the latter must be observed with high frequency before its error contaminates the slow scale. Numerical experiments are performed with the atmosphere-ocean model, MAOOAM. The experiments confirm the need of observing the fast scale, but show also that, despite its slow temporal scale, frequent observations in the ocean are beneficial. The model coupling strength is responsible for the emergence of a degeneracy in the Lyapunov spectrum, with many quasi-neutral modes. By using the covariant Lyapunov vectors (CLVs) we show that they are related to coupling mechanisms and are natural manifestation of the atmosphere-ocean interactions. As opposed to the uncoupled case, they must be included in a CDA EnKF to achieve good performance. Finally, we show how CDA and machine learning can be combined to infer parametrization of the unresolved scales. It generates a data driven parametrization that is then added to the physical model to form a hybrid physical-data-driven model. Results show the goodness of the hybrid model and the importance of using CDA in the training so to embody coupled mechanisms otherwise absent in the raw data.

- doi.org/10.1007/s10955-020-02525-z
- doi.org/10.1098/rsta.2020.0086
- Carrassi, Bocquet, Demaeyer, Grudzien, Raanes, & Vannitsem (2021). Data assimilation for chaotic dynamics. Springer Vol IV on Data Assimilation (In press) - arXiv:2010.07063v2