SYMPOSIUM OP'24 ADVANCING OCEAN PREDICTION SCIENCE FOR SOCIETAL BENEFITS

Theme #5

Toward NASA/GMAO Coupled Data Assimilation Using JEDI

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Introduction

NASA's Global Modeling and Assimilation Office (GMAO) is establishing coupled Earth system capabilities using the Joint Effort for Data Assimilation Integration (JEDI) framework, developed in collaboration with the Joint Center for Satellite Data Assimilation (JCSDA). Marine and atmospheric components will utilize a weakly-coupled data assimilation approach. The implementation of the sea-ice, ocean, and coupled analysis (SOCA) component of JEDI is highlighted here, while parallel work on atmospheric data assimilation is also in progress. Improvements to the ocean data assimilation system (ODAS) include: **1)** adopting the JEDI framework, **2)** a new coupled GCM, and **3)** incorporation of new observation sources.

Upgraded GEOS-JEDI Ocean Data Assimilation System

1) A modern workflow

The **S**well **W**orkflow **E**cosystem, **L**ayout and **L**auncher (SWELL) is a Python-based system for constructing, configuring and deploying GEOS workflows. Highlights include:

- **Cylc** workflow engine designed for NWP
- On-prem Github CI/CD, nightly JEDI builds
- Generic, shared YAML configurations for Earth system models and GEOS/JEDI applications
- Collaborative diagnostics and observation database software: **EVA** and **R2D2**

2) Updating Model and DA Setup

GCM & DA setup	Current ODAS	JEDI ODAS
Ocean Model	MOM5 (0.25-deg, 50 levels)	MOM6 (0.25-deg, 75 levels)
Sea-ice Model	CICE4	CICE6
DA method	LETKF	JEDI 3DFGAT
DA window	5 days	6 hours*

*: 6 hours, due to atmospheric analysis forcing

3) Incorporating more observations

Data Type	Current ODAS	JEDI ODAS
ADT	Sentinel 3a, Jason-3, Saral	Sentinel 3a/b, Cryosat-2N, Jason-3, Saral
SST	OSTIA	GMI*
SSS	SMOS, SMAP	SMOS, SMAP
In-situ	Argo, XBT, TAO, CTD, PIRATA, RAMA	Argo, XBT, TAO, CTD, PIRATA, RAMA
Ice Conc.	-	AMSR2*

*: More observations are being evaluated

Testing the new approach

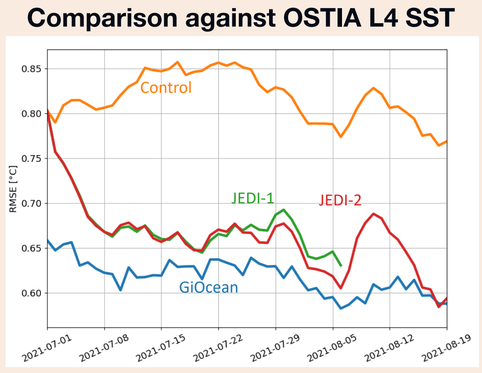
- A static **B** with multivariate balance (Weaver et al., 2005) was used during testing. For correlation lengths, explicit diffusion was employed (Weaver and Courtier, 2001), using the Rossby radius for horizontal and MLD for vertical correlations.
- GEOS reanalyses (MERRA2 and GEOS-IT) were used for atmospheric forcing
- MOM6 IC is a spun-up run from WOA18, CICE6 IC is from a long-term seasonal average.
- MOM6 Incremental Analysis Update (IAU), with direct insertion of CICE6 restart data (using category aggregates)

Experiment	Ocean + Sea-ice Models	Atmos. Forcing	DA Method	Obs.
Control	MOM6+CICE4	MERRA-2	No DA	-
JEDI-1	MOM6+CICE6	GEOS-IT	3DFGAT	JEDI w/out in-situ
JEDI-2	MOM6+CICE6	GEOS-IT	3DFGAT	JEDI
GiOcean*	MOM5+CICE4	GEOS-IT	LETKF	Current

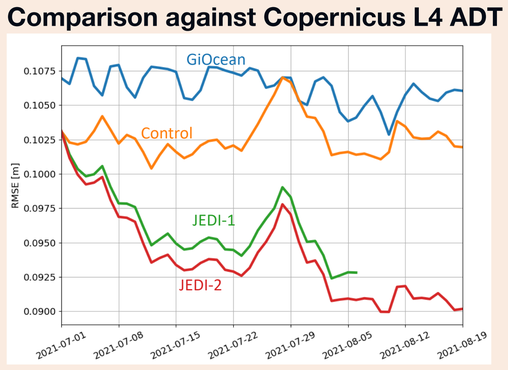
*: GiOcean is the current ODAS product of GMAO driven by GEOS-IT, a recent atmospheric analysis dataset.

Results

Comparison against OSTIA L4 SST

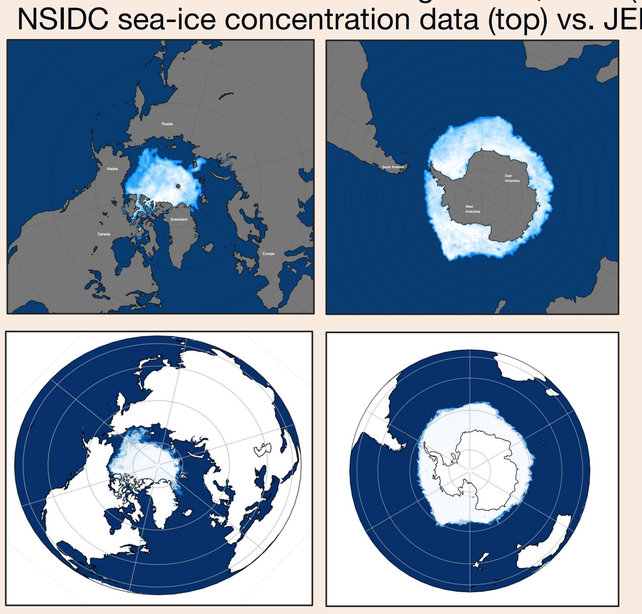


Comparison against Copernicus L4 ADT



- L4 verification data and model outputs were regridded to a 1-degree regular grid (60N-60S) for comparison purposes
- The SST state showed improvement, reaching current ODAS levels by the end of the simulation
- The model update from MOM5 (50 levels) to MOM6 (75 levels), lead to SSH improvements. This enhancement was further supported by altimeter and in-situ data assimilation through the $K_{\eta T}$ and $K_{\eta S}$ balances (Weaver et al., 2006)

Sea-ice concentrations on August 14th, 2021 (Cycling DA after 45 days). NSIDC sea-ice concentration data (top) vs. JEDI-2 outputs (bottom)



- Arctic results show that most of the large-scale features were accurately depicted
- Observed Antarctic summer sea-ice growth was captured
- Quantitative analysis is underway

Next Steps

- Switch from static to hybrid background error covariance by testing online and offline ensemble members
- Implement the LETKF approach from JEDI/SOCA into the SWELL workflow
- Expand data sources through collaboration with partners, including incorporating PACE and SWOT data

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