# NOAA-NCEP Next Generation Global Ocean Data Assimilation System (NG-GODAS)

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Efforts to modernize the forecasting systems at the National Oceanic and Atmospheric Administration (NOAA) have resulted in the collaborative development of the Unified Forecasting System (UFS). Comprising the core of future operational systems for global weather, sub-seasonal and seasonal forecasting, the NOAA UFS research to operations (R2O) program builds on several key features, unification of the data assimilation with the Joint Effort for Data Assimilation Integration (JEDI), development of the fully coupled atmosphere-ocean-ice-wave model, modernization of observations processing, modularization and unification of the workflow, and verification of the analysis and forecast. Under the UFS R2O program, the JEDI-based sea-ice ocean coupled assimilation system (SOCA) has been integrated with the Modular Ocean Model version 6 (MOM6, [1]) and the Community Ice Code version 6 (CICE6, [2]) to establish the NG-GODAS system.

We introduce here the NG-GODAS 40 year reanalysis project: experiment configuration, observation data archiving, and preliminary results. In the JEDI object oriented prediction system (OOPS) software structure, the SOCA interface provides a core framework of algorithms that combine generic building blocks for the MOM6 and CICE6 data assimilation application algorithms. A few articles (Trémolet, 2020, Holdaway *et al.*, 2020, and Honeyager *et al.*, 2020) introduce a key concept of the JEDI software system, to highlight how different data assimilation systems can be seamlessly established through the OOPS software infrastructure. A triple horizontal mesh grid, 1$^{o}$ global configuration of the MOM6 model with 75 vertical layers is coupled with the CICE version 6 featuring multiple ice thickness categories and the elastic–viscous–plastic sea ice dynamics model. The initial conditions are set with the OMIP-2 MOM6-SIS2 simulations (Tsujino *et al.*, 2020). The MOM6-CICE6 coupled system is forced with a set of atmospheric fluxes from the NOAA climate forecast system reanalysis (CFSR, 1979~2000) and the global ensemble forecast system (GEFS, 2000-2019).

In addressing the bias issues of the CFSR fluxes, the climatology of the DRAKKAR DFS52 forcing set (Dussin *et al.*, 2014) was applied to adjust precipitation rate, downward shortwave, downward longwave, and wind of the CFSR forcing set. Along with the SOCA MOM6-CICE6 model interfaces, the generic marine observation operators and data handling capabilities of the JEDI unified observation operator and interface for observation data access (IODA) systems are also utilized. In order to unify the various types of file formats and levels of observation data sets, we established a 40 year marine observation database system in the JEDI IODA format.

Table 1 shows satellite and in-situ observation data sets used in the 40 year NG-GODAS reanalysis experiment: satellite sea surface temperature, sea surface salinity, in-situ temperature and salinity, absolute dynamic topography, sea ice concentration, and sea ice freeboard thickness. For the 40 year NG-GODAS reanalysis production run, we have validated the analysis results by comparing them with the current operational ocean monitoring data assimilation systems, GODAS and CFSR. Results are compared against the UK MET office Hadley center EN4.0.2 objective analysis [3] for the time period 2015~2016. In Figure 1, the temperature and salinity mean analysis fields are compared to understand how closely each operational system matches the UK MET office EN4 analysis. Compared against the current operational systems, the NG-GODAS provides considerably improved analysis results. In particular, salinity fields of the NG-GODAS analysis are significantly closer to the EN4 analysis output. This preliminary result demonstrates that the SOCA-based NG-GODAS analysis system is well suited to serve as a building block for the future marine data assimilation system of the NOAA UFS R2O project.

| Input stream | Provider | Period | 1979 | 1988 | 1990 | 1992 | 1994 | 1996 | 1998 | 2000 | 2002 | 2004 | 2006 | 2008 | 2010 | 2012 | 2014 | 2016 | 2018 | 2020 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ADT | NESDIS | 1993~ | | | | | | | | | | | | | | | | | | |
| In-situ T/S | FNMOC | 1998~ | | | | | | | | | | | | | | | | | | |
| In-situ T/S | WOD | 1979~ | | | | | | | | | | | | | | | | | | |
| avhrr/sst l3u | NESDIS | 2002~2018 | | | | | | | | | | | | | | | | | | |
| avhrr/sst l3c | ESA/CCI | 1981~2016 | | | | | | | | | | | | | | | | | | |
| viirs/sst l3u | NESDIS | 2012~ | | | | | | | | | | | | | | | | | | |
| windsat/sst l3u | GHRSST | 2004~2018 | | | | | | | | | | | | | | | | | | |
| sss/smap | NASA | 2015~ | | | | | | | | | | | | | | | | | | |
| sss/smos | NESDIS | 2010~ | | | | | | | | | | | | | | | | | | |
| sss/aquarius | JPL | 2011~2015 | | | | | | | | | | | | | | | | | | |
| emc_ice | NCEP | 2000~ | | | | | | | | | | | | | | | | | | |
| nsidc_ice | NCEI | 1988~2015 | | | | | | | | | | | | | | | | | | |
| cryosat2_ice | ESA | 2010~ | | | | | | | | | | | | | | | | | | |

Table 1. Marine observation data sets assimilated in the NG-GODAS 40 year reanalysis experiment.

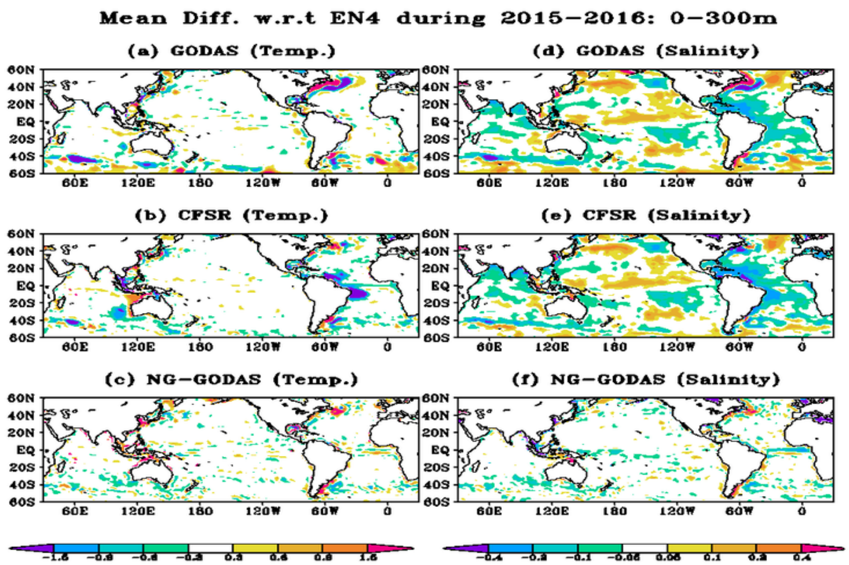


Figure 1. Upper 300m temperature (left columns) and salinity (right columns) mean difference fields for GODAS (top), CFSR (middle) and NG-GODAS (bottom). Differences were computed against EN4.2.

## References

Dussin, R., Barnier, B., Brodeau, L., and Molines, J. M. (2014). The Making of Drakkar Forcing Set DFS5, DRAKKAR/MyOcean Report 01-04-16.

Holdaway, D., Vernières G., Wlasak M., and King S., 2020: Status of Model Interfacing in the Joint Effort for Data assimilation Integration (JEDI). JCSDA Quarterly, 66, Winter 2020.

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[1] https://www.gfdl.noaa.gov/mom-ocean-model
[2] https://github.com/CICE-Consortium/CICE
[3] https://www.metoffice.gov.uk/hadobs/en4