# Test Plan: CICE Sea Ice Model for NGGPS

*Final 16 March 2016*

*POC: Shan Sun – NOAA ESRL/GSD/GMTB – shan.sun@noaa.gov*

## Introduction

After reviewing several sea ice models at the Sea Ice Workshop organized by Global Modeling Test Bed (GMTB) in February 2016, the committee has selected the Los Alamos Community Ice CodE (CICE) as the sea ice model to be incorporated as a component of Next-Generation Global Prediction System (NGGPS). The GMTB is proposing to carry out testing and evaluations with this model in two phases as the next step.

## Testing framework

Hebert et al. (2015) showed that the Arctic Cap Nowcast/Forecast System (ACNFS) demonstrated a high level of skill compared to persistence in 1-7 day forecasts over a period of one year. ACNFS uses CICE version 4.0 [Hunke and Lipscomb, 2008] as the sea ice model two-way coupled to the HYbrid Coordinate Ocean Model (HYCOM) [Bleck, 2002; Metzger et al., 2014, 2015].

Building on this study, we propose to base the test on a similar configuration. In order to make the test most relevant for NGGPS, there will be three important differences with respect to the Herbert et al. (2015) configuration. First, CICE will be upgraded to its latest version v5, [in which both the code structure and the state variables are similar to v4. The CICE5 code does include a number of new physics options such as the mushy-layer thermodynamics and two new melt pond parameterizations.] V5.1.2 is available at http://oceans11.lanl.gov/svn/CICE/tags/release-5.1.2.
Second, atmospheric forcing will be from CFSv2 instead of NAVGEM. Third, CICE will be running stand alone, receiving ocean boundary conditions derived from CFSv2, instead of an active ocean model.

Due to limits of time and manpower (deadline end of FY 2016, ¼ FTE), we will focus on the CICE sea ice model alone experiments, instead of utilizing the NOAA Environmental Modeling System (NEMS) coupler as proposed earlier. This course of action stems from reports received from the group working on the development of CFS v3, which indicate that there are both technical difficulties and scientific issues related to the NEMS coupler that still need to be addressed before the fully coupled system can be used.

The initial conditions for CICE will be derived from CFSv2, as will be the boundary conditions (forcing) from atmosphere and ocean mentioned earlier.

The model will run on the global domain, and be integrated for 16 days, starting on the 1st and 15th of each month of 2015 (total 24 cases).

## Phases of testing

Given the NGGPS's goal of providing improved accuracy for forecasting from a few hours to a month for resolutions ranging from 1 to 100 km, it is anticipated that options within the sea ice model will likely be necessary to meet all the needs of the different NGGPS forecast applications. Thus we propose to test the model with two different horizontal resolutions.

### Phase 1: CICE at a coarser resolution (~120km at EQ, ~30km at N.Pole)

We plan to start with the gx1 (nominal 1-degree) bathymetry that comes with the CICE v5. Initial conditions for the ice system, as well as the boundary conditions from the atmosphere and ocean will be interpolated onto the gx1 ice grid from the CFSv2 reanalyses. For CICE, CFSv2 will provide multilayer ice/snow temperatures, concentration, thickness and velocity. A methodology to initialize CICE's 7-layer ice temperatures from CFS v2's 4 layers will be devised before starting the test.

### Phase 2: CICE at a finer resolution (~60km at EQ, ~15km at N. Pole)

Initial conditions and boundary forcings will be the same as in Phase 1, except they are now from GFS ¼ degree data at a much higher horizontal resolution than CFS_v2. The forcings will be interpolated onto the ice grid at an even higher horizontal resolution, ~15km.

In both phases, we will archive daily sea ice concentration, thickness, velocity and edge during the integrations. The archive will be made available in netcdf format on the "theia" or other computers given permission. Sea ice forecast verification against the NCEP 1/12th degree analyses and observations will be performed by GMTB and by EMC collaborators led by Bob Grumbine.
Performance metrics will include

- Report the execution requirement (cores, seconds)
- Concentration
    - 2x2 categorical, PoD, FaR, %correct, False confidence rate
    - Continuous bias and Root Mean Square Error (RMS)
    - Murphy skill score on RMS
    - Comparison against baselines such as persistence and climatology

- Velocity
    - Error radius (+ 4 others ... per Grumbine 2013)
    - Comparison against baseline
- Edge
    - Dhukovsky et al.?

Results will be subjectively compared against those of Hebert et al. (2015), even though neither data assimilation nor ocean coupling is proposed in this work with CICE. Comparison with other existing ice model output from colleagues, e.g., RASM-ESRL, will also be carried out for the CICE evaluation.

## Timeline, milestones, deliverables

A final report will be due at the end of the FY 2016. We plan to have the CICE model running in 1-2 weeks, using the forcing and boundary conditions provided together with the CICE source code. Then we will replace its forcing and boundary conditions by the same products from GFSv2, after being interpolated onto the CICE grid. This will be done in Week 6-8. We will then evaluate the model simulations against the best observations available. The first evaluation will be done at the coarse resolution in 2-3 months, around June, before moving onto the fine resolution simulations. The final evaluation for simulations on both coarse and fine resolution will be done in September. Additional model evaluations will be carried out both at GMTB and at EMC. The final model code will hopefully be back to the original repository where we checked out v5.1.2.

## References


Hebert, D. A., R. A. Allard, E. J. Metzger, P. G. Posey, R. H. Preller, A. J. Wallcraft, M. W. Phelps, and O. M. Smedstad, 2015: Short-term sea ice forecasting: An assessment of ice concentration and ice drift forecasts using the U.S. Navy's Arctic Cap Nowcast/Forecast System, J. Geophys. Res. Oceans, 120, doi:10.1002/2015JC011283. □

Hunke, E., and W. Lipscomb, 2008: CICE: The Los Alamos Sea Ice Model documentation and software user's manual version 4.0, Tech. Rep. LA-CC-06-012, Los Alamos Natl. Lab., Los Alamos, N. M.□

Bleck, R., 2002: An oceanic general circulation model framed in hybrid isopycnic-Cartesian coordinates, Ocean Modell, 4(2), 219–219, doi: 10.1016/S1463-5003(01)00017-8.

Metzger, E., et al., 2014: US Navy operational global ocean and Arctic ice prediction systems, Oceanography, 27(3), 32–43.

Metzger, E. J., H. E. Hurlburt, A. J. Wallcraft, J. F. Shriver, O. M. Smedstad, P. Thoppil, and D. S. Franklin, 2008: Validation test report for the Global Ocean Prediction System v3.0 - 1/128 HYCOM/NCODA phase 1. Tech. Rep. NRL/MR/7320-0809148, Naval Res. Lab., Stennis Space Cent., Hancock, Miss.

Grumbine, Robert 2013: Long Range Sea Ice Drift Model Verification MMAB Tech Note 315, 22 pp.