Model Development of the Unified Forecast System for Subseasonal to Seasonal Timescales

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Introduction

In response to the Weather Research and Forecasting Innovation Act of 2017, NCEP is developing a seasonal to subseasonal forecast model utilizing the Unified Forecast System. The Unified Forecast System is a community based coupled earth system model with applications from regional to global scales and from weather to climate timescales. This coupled model development is actively underway at NCEP and the first operational goal for the fully coupled atmosphere-ocean-ice-wave model will be the Global Ensemble Forecasting System GEFSv13 in FY2023, followed by a seasonal forecasting system in FY2025. Here we will describe the current state of the subseasonal to seasonal coupled model, provide selected results to demonstrate progress and discuss future plans.

Model Description

For the subseasonal to seasonal timescales we are employing an atmospheric model with the Finite Volume Cubed Sphere (FV3) dynamical core with GFS physics and GFDL microphysics, the Modular Ocean Model (MOM6) and the Los Alamos Sea Ice Model (CICE5). These models are coupled together using the NOAA Environmental Modeling System (NEMS) which currently contains both a driver and a mediator. The coupling infrastructure is built employing the National Unified Operational Prediction Capability (NUOPC) Layer [Theurich, 2016] on top of the Earth System Modeling Framework (ESMF).

For the results here, the atmospheric model uses the C384 cubed sphere grid (~25km) with 64 layers. The ocean model employs a ¼° tripolar grid with 75 hybrid coordinate layers following the OM4.0 setup [Adcroft, 2019]. The ice model uses the same tripolar grid as the ocean and does not use Mushy thermodynamics. In the current implementation using the NEMS mediator, atmosphere/ice fluxes are computed by the ice model and atmosphere/ocean fluxes are computed by the atmospheric model. The atmospheric model's land/sea mask does not match the ocean/ice mask and does not permit fractional land masks. For interpolating the sea surface temperature from the ocean to the atmosphere, a conservative interpolation is used and then if a valid temperature is not obtained, nearest neighbor is used to fill remaining non-land points. The fluxes received by the ocean model are a combination of the fluxes computed by the atmosphere and ice weighted by the ice fraction.

Results

Development is actively ongoing, however, our intermediate results show great promise for the future operational systems. For brevity just the ice area in the Arctic for 2017 is shown in Figure 1. This compares two different UFS prototypes showing the impacts of initial conditions, comparing CFSR (UFS_p2) versus CPC ice analysis (UFS_p3) initial conditions. The atmosphere is also initialized by CFSR and the ocean model is initialized from the CPC 3Dvar analysis for both prototypes. Initial assessments of all UFS prototypes have shown skill improvement over CFSv2 for all components, including improvement of predictions for ice concentration, area, and extent in the polar regions.

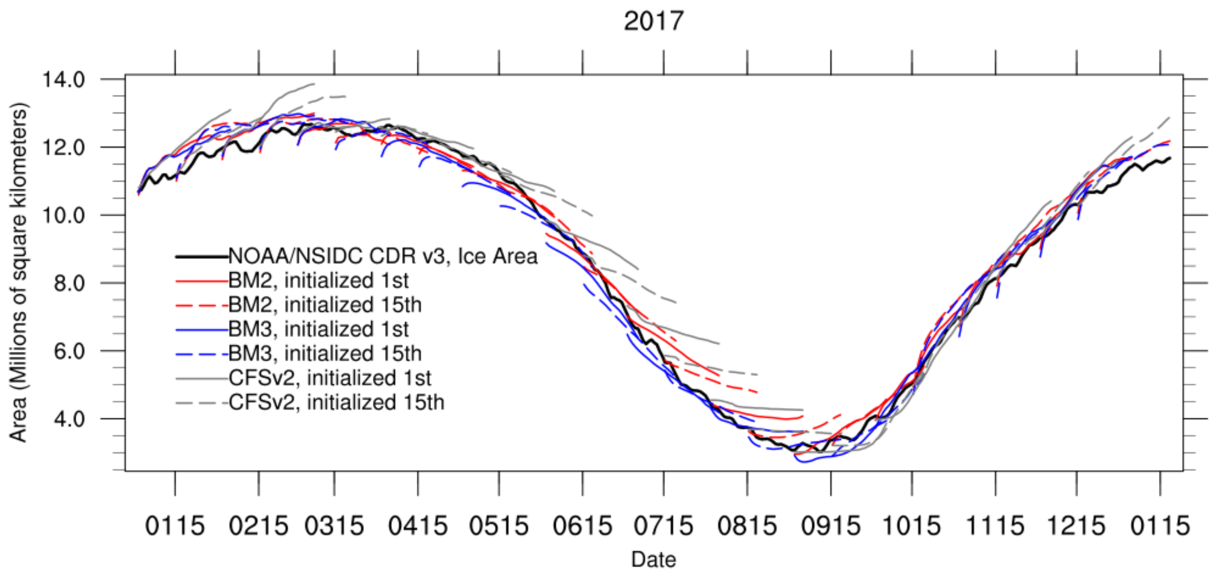

Figure 1. This figure shows the ice area for the year 2017 for the Arctic comparing two different UFS prototypes (UFS_p2, UFS_p3), with CFSv2, and NOAA/NSIDC CDR v3 ice area (https://nsidc.org/data/g02202/versions/3).

Future Developments

Model and engineering development activities are actively ongoing. Future engineering development activities will include transitioning to the Common Community Physics Package (CCPP) for the atmospheric model and to the Community Mediator for Earth Prediction Systems (CMEPS) for the mediator. Future planned model developments include adding the wave model WAVEWATCH III, to add sea-state dependent roughness back to the atmosphere and to include sea-state dependent Langmuir mixing in the ocean. Additional improvements will include updates to the GFSv16 atmosphere component with increased vertical resolution, model physics tuning, and data assimilation.

References

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