Subseasonal Forecast Skill of the FIM-iHYCOM Coupled Model

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1 Introduction

Earth-system prediction skill on subseasonal to seasonal timescales is rather limited in the current generation of numerical models. Two types of ensemble prediction have been shown to be effective, to some extent at least, in reducing forecast error: (1) use of an ensemble whose members are diversified by both perturbed initial conditions and stochastic perturbations of model physics in a single model; (2) use of different models in a "multi-model ensemble", all running with perturbed initial conditions. To maximize the gain from ensemble methods, approach (2) requires that special attention be paid to model diversity in order to ensure sufficient spread among ensemble members. This makes models employing nontraditional numerics especially attractive in multi-model ensembles. The coupled model FIM-iHYCOM developed at NOAA's Earth System Research Laboratory falls into this category and is one of the models providing forecasts for NOAA's Subseasonal Experiment.

2 Models and Experiments

The atmospheric model FIM (Bleck et al. 2015), developed as a tool for medium-range to subseasonal prediction, has been coupled to iHYCOM, an icosahedral-grid rendition of the ocean model HYCOM (Bleck 2002). Both FIM and iHYCOM are 3-dimensional hydrostatic gridpoint models that operate on a common icosahedral horizontal grid and use similar adaptive near-isentropic vertical grids. Due to the shared horizontal grid as well as an identical time step, no spatial or temporal interpolation is needed when passing information from one model component to the other. This guarantees conservation, not only globally but also locally, of all fluxes across the air-sea interface. Equally important, there is no discrepancy between the two components on the location of the coastline.

FIM uses the 2015 Global Forecast System (GFS) physics package, with an option of switching its Simplified Arakawa-Schubert shallow and deep convective cloud parameterization to a variant of the Grell and Freitas (2014) scheme (SAS and GF hereafter). Once-per-week subseasonal hindcasts with 4 time-lagged ensemble members over a 16-year period have been carried out with the FIM-iHYCOM coupled model at 60 km horizontal resolution, comparing skills using SAS and GF (FIM-SAS and FIM-CGF, respectively) to the NOAA operational model CFSv2, as well as the GF scheme in uncoupled FIM atmospheric-only mode (FIM-AGF).

To illustrate the icosahedral horizontal grid, Fig. 1 displays the ocean depth around New Zealand at 30 km grid resolution (30 km runs are underway).

3 Results

The Realtime Multivariate Madden-Julian Oscillation (MJO) index (RMM) and velocity potential MJO index (VPM) for various FIM-iHYCOM runs and CFSv2 ensemble mean forecasts are shown in Fig. 2 as a function of lead time, including (top) bivariate RMM correlation, (bottom) bivariate root-mean-square error (solid) and 4-member ensemble spread(dashed). FIM-CGF and CFSv2 have similar skill, error, and spread, and are better than FIM-SAS. The uncoupled FIM-AGF fares worst. Using GF to parameterize deep convection was found to improve the skill of MJO predictions as described in Green et al. (2017).

Fig. 3 compares the Anomaly Correlation Coefficients (ACC) for different lead weeks in boreal summer (June through August, JJA) and winter (December through February, DJF) for the 2 m temperature from FIM-CGF and CFSv2 over land in North America. The ACC is highest at lead times of 1 and 2 weeks, especially in winter. There is some skill beyond 2 weeks, benefiting from averaging both in time (weekly) and space ($5^\circ \times 5^\circ$), compared to daily means and $1^\circ \times 1^\circ$ averaging (not shown).

4 Summary

Preliminary results indicate that the forecast skill of FIM-iHYCOM is comparable to that of NOAA's operational CFSv2 model at the subseasonal time scale. FIM-iHYCOM uses an unstructured horizontal grid and an adaptive vertical coordinate without the need to interpolate fluxes at the air-sea interface. Given that both FIM and iHYCOM are very different from the current North American Multi-Model Ensemble models, they will add diversity to multi-model ensembles, and will likely improve the overall skill of subseasonal prediction.

This work is viewed as a part of NOAA's effort to improve subseasonal forecast and a step toward seamless prediction covering the range from medium-range numerical weather prediction to annual time scales.

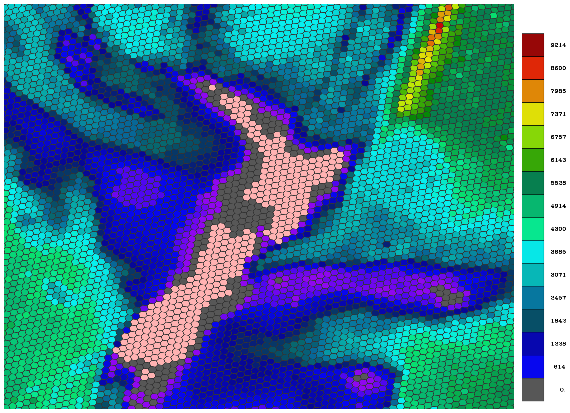

Figure 1: Sample figure showing land areas and ocean depth (m) on icosahedral grid at 30 km resolution.

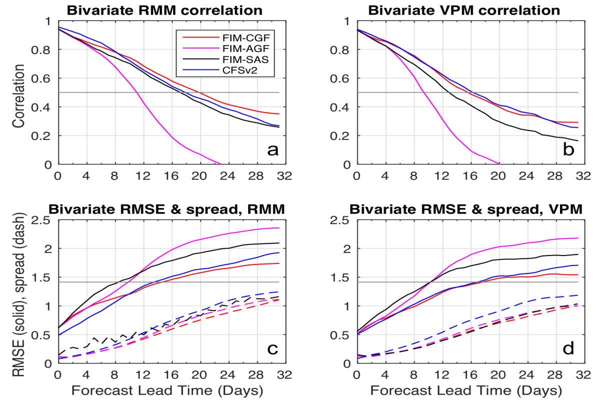

Figure 2: Model performance as a function of lead time for FIM-iHYCOM coupled GF and SAS (FIM-CGF and FIM-SAS, respectively), atmospheric only GF (FIM-AGF) and CFSv2 ensemble mean forecasts of the RMM (left) and VPM (right) indices. Top: Bivariate RMM correlation; Bottom: Bivariate root-mean-square error (solid) and 4-member ensemble spread (dashed).

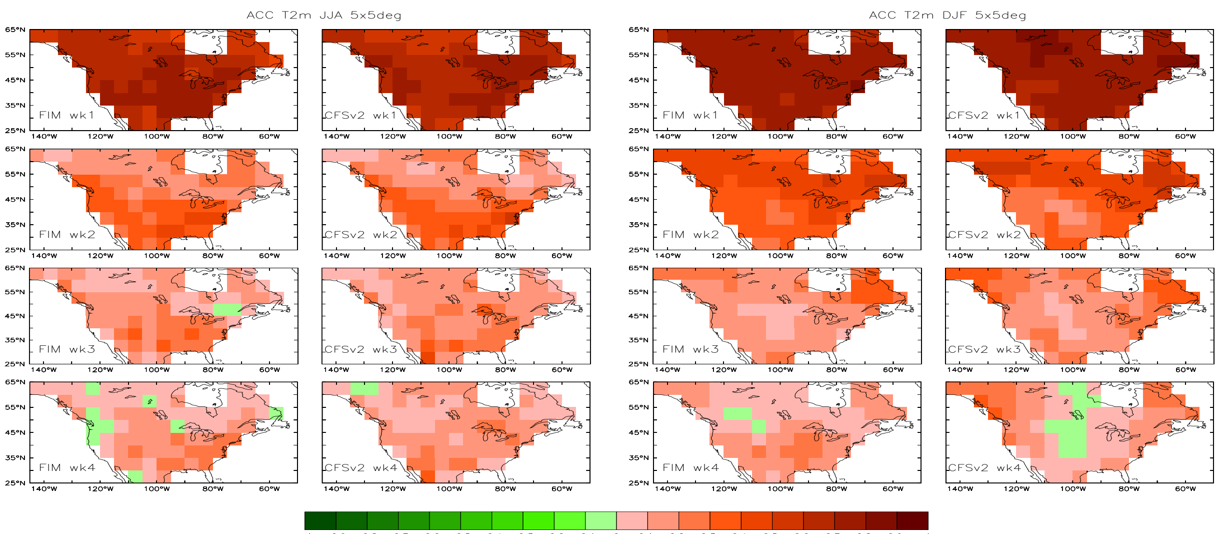

Figure 3: ACC for 2 m temperature in JJA (left) and DJF (right) from FIM-iHYCOM (FIM-CGF) and CFSv2 at different lead times. Data are averaged over 5°× 5° grid boxes.

References

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