AFWA'S USE OF WRF IN THE JOINT ENSEMBLE FORECAST SYSTEM (JEFS) PROJECT

Jeffrey Cunningham[1], Timothy Nobis, Daniel Rozema, Mike Sestak[2] and Tony Eckel[3]
Air Force Weather Agency
Offutt AFB, NE 68113

1. Introduction

The Air Force Weather Agency (AFWA) in conjunction with the Fleet Numerical and Oceanographic Center (FNMOC) and other organizations have embarked on a joint venture to explore the feasibility of providing robust stochastic weather forecasts through ensemble forecasting systems to their respective Department of Defense (DoD) customers (Condray and Addison 2006). This venture, called the Joint Ensemble Forecast System (JEFS) project, is designed to test the value, utility, and operational feasibility of ensemble forecasting to DoD operations. A major component of JEFS prototype is the Joint Mesoscale Ensemble (JME), which consists of both Weather Research and Forecasting - Advanced Research WRF (WRF-ARW) members and the Coupled Ocean/Atmosphere Mesoscale Prediction System (COAMPS) members. This abstract provides an overview of how the JEFS project incorporates WRF into a prototype mesoscale ensemble forecast system.

2. Joint Mesoscale Ensemble (JME) Description

a. *Overview*

For practical purposes, the AFWA portion of the JME will consist of two versions: a baseline version and a developmental version. The baseline JME design will be frozen around October 2007 and be used for a one year period of overall JEFS "value/utility" testing and evaluation. The developmental version will be continuously updated with improvements and will be used for experimentation purposes only. Enhancements from the developmental JME, which add value to mesoscale ensembles, may be considered for operational implementation at a later date.

b. *Window Sizing and Resolution*

JME will focus on a 5-km inner nest and 15-km model domain over East Asia (Figure 1) with a 45-km outer nest to step down from coarse resolution global model lateral boundary conditions (Rozema 2007). 5-km was chosen to match AFWA's current deterministic MM5 window setup. Experiments will be conducted with the developmental JME on a 3-km inner nest over the Korean Peninsula to capture the uncertainty in smaller-scale motions. If the 3-km inner nest objective is achieved, the outer nests will likely be 81-km, 27-km, and 9-km, respectively. Model grid spacing greater than a few km up to around 10-km is not handled well in today's limited area models. Historically, convective parameterization schemes were designed for models with grid spacing over 10-km (Kalnay 2003). Below 4-km, models begin to explicitly resolve convection. Thus a 3-km inner nest might be a better choice than a 5-km inner nest. Despite the possible advantages of modeling at a 3-km, limited development time and hardware constraints

[1] Corresponding Author Address: 106 Peacekeeper Drive Ste 2N3 Offutt AFB, NE 68113, Jeffrey.cunningham@afwa.af.mil
[2] Fleet Numerical Meteorological Oceanographic Center, Monterey, CA
3 Currently a Military Instructor at the Naval Postgraduate School, Monterey, CA

will require the JME baseline to focus on a 5-km inner nest.

East Asia was chosen as the geographic area of study, since it contains challenging weather and a wide assortment of DoD assets. It is an excellent region to prove the value of ensembles to DoD operations. Depending on computer resource availability, other windows may be setup for testing over CONUS during free computer cycle time.

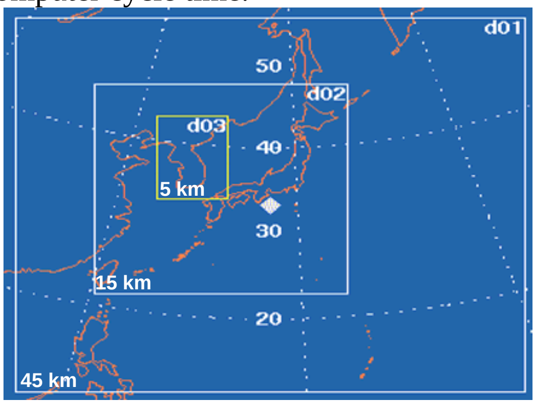

Figure 1. Nested domains of the JME: 45- and 15-km over East Asia and the additional 5-km inner nest over the Korean Peninsula.

c. *Ensemble Member Configuration*

Ensemble members in the baseline JME will be from multiple operational centers, multi-model, and will consist of two daily, 60-h EFs with a minimum of 20 (ideally 30 plus) individual mesoscale model runs at each cycle. (Note: Exact model configuration may change based on the actual hardware configuration). To maximize efficient use of computer hardware and to take advantage of the multiple data assimilation schemes and the multi-model approach to capture initial condition and model uncertainty, 10 members will run on FNMOC hardware and 10 on AFWA hardware (Rozema 2007).

To account for initial condition uncertainty, baseline JME members ran at AFWA will be based on a "Stage-1" coupled WRF/WRF-VAR/ETKF Ensemble Prediction System developed at NCAR. To account for model uncertainty, AFWA baseline JME members will consist of various model versions (i.e., different combinations of physics packages), and perturbations to surface boundary parameters (sea surface temperature, soil moisture, soil temperature, roughness length, and albedo). The developmental JME version will consider stochastic physics approaches to capturing model uncertainty. FNMOC baseline members will be based on the ensemble transform (ET) initial conditions and will also use will be focused on varying the parameters within particular cumulus, boundary layer and radiation schemes, rather than swapping whole schemes to account for model uncertainty (Rozema 2007).

d. *Calibration*

Various post-processing calibration techniques will be employed by the JME to calibrate both the first moment (bias) and second moment (spread) of the estimated probability density function (PDF). Particularly, the advanced observation based gridded bias correction and Bayesian Model Averaging (BMA) techniques, developed by University of Washington through NCAR will be applied to JME output (Raftery, et al. 2005).

4. Military Application

By far the most practical purpose of the JEFS project will be the testing and evaluation of ensemble forecasting on military applications. Several operational units will test JME forecasts in both forecast decision processes and operator decision maker processes. By applying an understanding of decision theory and human factors, best practices will be recorded on how to best integrate stochastic weather into real DoD decision processes. The lessons learned will have profound impacts on the future direction of Air Force Weather and likely benefit the greater weather community, as well.

5. Summary

AFWA is taking large steps towards understanding how to make mesoscale ensembles a reality to forecasters and forecast users. WRF, as a major component of the JME, is making this happen.

6. References

Condray, M. and V. Addison, 27 September 2006: *Joint Ensemble Forecast System (JEFS) Memorandum of Agreement (MOA)*.

Rozema, D., 2007 (in coordination): *Joint Ensemble Forecast System (JEFS) Plan*.

Kalnay, E., 2003: *Atmospheric Modeling, Data Assimilation, and Predictability*. Cambridge University Press, 341 pp.

Raftery, E. T. Gneiting, F. Baladaoui, and M. Polakowski, 2005: Using Bayesian Model Averaging to Calibrate Forecast Ensembles. *Monthly Weather Review*, **133**, 1155-1174.