# Multi-Convection as a Multi-Model Proxy for Climate Studies

By Timothy E. LaRow and Steven Cocke
Florida State University
larow@coaps.fsu.edu

A different method of generating multi-model ensembles for climate integrations is developed. Instead of using multi-models, as currently being done by some of the major operational centers, we will use a single model, the FSU coupled model (LaRow and Krishnamurti 1998, Cocke and LaRow 2000), with six different state-of-the-art deep convective parameterizations. The six convection schemes are: Emanuel and Zivkovic-Rothman (1998), Zhang and McFarlane (1995), Krishnamurti et al (1983), Pan and Wu (1994), Moorthi and Suarez (992) and Hogan and Rosmond (1991).

## Experimental Details

Six model formulations are integrated for a 12 year (1986-1997) period. The integrations commence on 1 November of the respective year and continue for 210 days. The initial conditions for the atmospheric model are taken from 12UTC ECMWF analysis. The ocean initial conditions are taken from a continuous initialization procedure (LaRow and Krishnamurti 1998). This set of experiments is called MM (multi-model). A control integration was conducted for the same 12 years using the Pan and Wu convection scheme. This is the standard configuration used in the FSU coupled model. For each year, a five member ensemble was developed by varying the initial start date of the atmospheric model using consecutive start dates centered on 1 November. This set of experiments is called MA (multi-analysis). Weekly and monthly mean fields and anomalies are derived for both the MM and MA and are defined with respect to the individual model's climatology.

## Results

The Relative Operating Characteristic (ROC) is used to quantify the skill of the forecast. The ROC is a probabilistic measure of the skill and the ROC curve is a plot of the hit rate vs. false alarm rate for the ensemble. The measure of skill is determined by the area under the ROC curve (see Palmer et al 2000). A perfect deterministic forecast will have an area equal to one while a forecast exhibiting no skill will have a value less than 0.5. The area under the SST ROC curves ($A_{ROC}$) for threats of 0.0°, 0.5° and 1.0° K in the Niño-4, Niño-3 and Niño-3.4 for all DJF (n=36) from the MM and MA are shown in Table 1. Reynolds and Smith (1994) weekly SST was used for the observations. The larger values are in **bold**. Both the MM and MA show skill greater than 0.5; however, the MM $A_{ROC}$ score is consistently larger compared to the MA's score. The Niño-3 region shows the highest average skill for both the multi-model and multi-analysis. The Niño-4 region shows the least amount of skill for the MM and MA. The diminished skill in the Niño-4 region is partly attributed to the fact that there is a sharp decline in the number of events at higher threats in the western Pacific. The area averaged number of events in the Niño-4 decrease from 20 for threats=0 decreasing to just two for threats=1.0. The ROC curves for the last three-months (March-April-May) (not shown) of the forecasts show that the coupled model still possesses moderate skill ($A_{ROC}$ >0.5) out seven months.

Table 1. SST ROC Score

| Threat=0 | MM | MA | Threat=0.5 | MM | MA | Threat=1.0 | MM | MA |
|---|---|---|---|---|---|---|---|---|
| Niño-4 | **0.776** | 0.749 | Niño-4 | **0.693** | 0.682 | Niño-4 | 0.630 | **0.638** |
| Niño-3 | **0.844** | 0.829 | Niño-3 | **0.857** | 0.786 | Niño-3 | **0.839** | 0.809 |
| Niño-3.4 | **0.897** | 0.883 | Niño-3.4 | **0.828** | 0.792 | Niño-3.4 | **0.739** | 0.714 |

DJF precipitation ROC scores for four selected domains are shown in Table 2. Highlighted in **bold** are the higher values of the ROC. For all domains selected the MM has the higher skill (as measured by the ROC). Lack of skill ($A_{ROC}<0.5$) exists in the Brazil domain for the MA for all precipitation threats. The Xie and Arkin (1997) monthly precipitation data set was used for the observations.

Table 2. Precipitation ROC Score

| Threat=0.5 | MM | MA | Threat=1.0 | MM | MA | Threat=2.0 | MM | MA |
|---|---|---|---|---|---|---|---|---|
| Southeast U.S. | **0.582** | 0.555 | Southeast U.S. | **0.579** | 0.538 | Southeast U.S. | **0.567** | 0.512 |
| Brazil | **0.561** | 0.482 | Brazil | **0.549** | 0.480 | Brazil | **0.551** | 0.481 |
| Northern Hemisphere | **0.626** | 0.610 | Northern Hemisphere | **0.625** | 0.607 | Northern Hemisphere | **0.584** | 0.573 |
| Tropical Pacific | **0.735** | 0.707 | Tropical Pacific | **0.739** | 0.713 | Tropical Pacific | **0.713** | 0.707 |

This work is supported by NOAA grants NA76GP0521 and NA86GP00231.

Cocke, S. D and T. E. LaRow, 2000: Seasonal Predictions using a Regional Spectral Model Embedded within a Coupled Ocean Atmosphere Model. *Mon. Wea. Rev.*, **128**, 689-708.

Emanuel K. A., and M. Zivkovic-Rothman, 1998: Development and evaluation of a convective scheme for use in climate models. Unpublished manuscript.

Hogan, T. F., and T. E. Rosmond, 1991: The description of the Navy operational global atmospheric prediction system's spectral forecast model. *Mon. Wea. Rev.*, **119**, 1786-1815.

Krishnamurti, T., S. Low-Nam, and R. Pasch, 1983: Cumulus parameterization and rainfall rates II. *Mon. Wea. Rev.*, **111**, 816-828.

LaRow, T. E., and T. Krishnamurti, 1998: Initial Conditions and ENSO prediction. *Tellus*, **50A**, 76-98.

Moorthi, S., and M. J. Suarez, 1992: Relaxed Arakawa-Schubert: A parameterization of moist convection for general circulation models. *Mon. Wea. Rev.*, **120**, 978-1002.

Palmer T. N., C. Brankovic and D. S. Richardson 2000: A probability and decision-model analysis of PROVOST seasonal multi-model ensemble integrations. *Quart. J. Roy. Met. Soc.*, **126**, 2013-2035.

Pan, H-L., and W.S. Wu, 1994: Implementing a mass flux convection parameterization package for the NMC MRF model. Preprints, Tenth Conf. on Numerical Weather Prediction, Portland, OR, Amer. Meteor. Soc., 96-98.

Reynolds, R. W. and T. M. Smith, 1994: Improved global sea surface temperature analyses using optimum interpolation. *J. Climate*, **7**, 929-948.

Xie, P., and P. A. Arkin, 1997: Global Precipitation, a 17-year monthly analysis based on gauge observation, satellite observations, and numerical model output. *Bull. Amer. Meteor. Soc.*, **78**, 2539-2558.

Zhang, G. L. and N. A. McFarlane, 1995: Sensitivity of climate simulations to the parameterization of cumulus convection in the Canadian Climate Centre general circulation model. *Atmos. Ocean*, **33**, 407-446