Time: Friday, 24 October 2008

Place: 1st Floor Conference room (Salle des Vents)

Presenter: Dr. Michael Fox-Rabinovitz, University of Maryland

Title: "Development of fast and accurate neural network emulations of model physics parameterizations"

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Abstract

Calculation of model physics is a computational "bottleneck" of climate and NWP models. Model physics calculations take ~ 60-70% of the total calculation time for typical GCMs like the NCAR CAM and NCEP CFS model. Model radiation is the most time consuming component of the models and take ~ 60-70% (depending on the frequency of radiation calculations) of the model physics calculations for these typical GCMs.

Statistical Learning Techniques (SLT) and specifically Neural Networks (NN) provide an effective tool for fast and accurate approximations of complex multidimensional mappings like model physics parameterizations. This approach has been applied for development of accurate and fast NN *emulations* of model long- and short-wave radiation parameterizations (LWR and SWR) for the above state-of-the-art GCMs.

Developed NN emulations of model radiation are very accurate and more than one to two orders of magnitude faster than the original radiation parameterizations. NN emulation r.m.s. errors or deviations from the original parameterization are small, i.e., within typical observational errors or uncertainties, and are not accumulating in time. The obtained biases are negligible, i.e., close to calculation round-off errors.

Validation of the parallel decadal climate simulations and seasonal predictions using the original model radiation (the control run) and its NN emulations (the NN run) shows a close similarity of the parallel control and NN runs. Namely, the differences between the parallel runs are mostly within typical observation or reanalysis errors or uncertainties. It means that the accuracy and integrity of the GCMs have been well preserved when using NN emulations.

The NN approach is being also applied for development of new convection *parameterizations* based on advanced observations (ARM data, etc.) and data simulated by high resolution Cloud Resolving Models (CRMs), which better take into account sub-grid scale effects. A prototype (or a proof of concept) for a NN convection parameterization for NCAR CAM has been developed based on CRM simulated data by using the NN capability to learn dependencies from data.

These successful developments show the realistic potential of using the new hybrid modeling approach combining deterministic model components based on first principles (e.g., model dynamics) with statistical learning components (e.g., model physics, chemistry, etc.) based on statistical learning techniques (like NNs) for improving both model computational performance and quality of description of model multi-scale physical processes.