MAE598 Fall 2012 HW6 - first draft

The difficulty level of this exercise is "**D**". This is a "bonus homework". You may return any answers you have to receive extra points. Alternatively, you may expand the exercise into the final report.

In this exercise, we will use a global atmospheric model to simulate the effects of El Nino (= a positive anomaly of tropical Central/Eastern Pacific sea surface temperature) on the global circulation pattern and especially the seasonal climate over the U.S. The framework considered in this exercise can be adopted for the so-called two-tier seasonal climate prediction, which will be discussed in class. The knowledge on the two-tier prediction system is not necessary for the completion of this exercise.

1. The model

The model we will use is the NCAR CCM3 (Community Climate Model version 3). Although we have a much newer version of the model, CAM3, set up on our computers, it was not selected for this exercise because it runs 7 times slower than CCM3. You will find out that this is not trivial for multi-year simulations. The model has a T42 spectral resolution with a corresponding 128x64 Gaussian grid, and 18 vertical levels. It adopts a hybrid coordinate system (which we will explain in class) in the vertical direction. In the lower atmosphere, it resembles the classical "sigma coordinate" system which is terrain-following. This makes it relatively easy to analyze the model output over land where one might encounter complicated topography.

The model is driven by a build-in seasonal and diurnal cycle of solar radiation (at the top of the atmosphere) and the specified (but time-varying) global sea surface temperature (SST) at the lower boundary. The detail of how to specify the boundary condition and model parameters and execute a simulation will be given later.

Although the model can be run in a "weather forecast" mode with daily or hourly output, for our purpose we will be interested in only the monthly mean (or accumulation) of the relevant meteorological variables. The model will be set up to provide only monthly output. This will dramatically reduce the size of the output. The standard output is in netCDF format but output in fortran binary may be available for selected variables. The detail will be given later.

2. The main objective

You will execute a pair of multi-year (~ 5 years) simulations driven by different SSTs, one from a "normal year" (or the long-term climatological mean) and the other from an "El Nino year" (or a "La Nina year"; La Nina refers to the opposite phase of El Nino, with a colder than normal tropical Central/ Eastern Pacific SST.) The difference between the two runs will be the effect of the El Nino SST anomaly on the climate in remote (away from the tropics) regions. The two SST datasets for the boundary conditions will be prepared for you. Tentatively, we will consider the 1982-83 El Nino event.

For the bonus homework only, you are expected to

(1) Execute two runs under the "normal" and "El Nino" conditions. Evaluate the differences between the two in terms of (A) the seasonal mean global mid- or upper-tropospheric flow (e.g., 200 hPa zonal velocity, 500 hPa height) and (B) the seasonal mean precipitation over the U.S.

For the final report, in addition to (1), you may consider the following extra work:

(2) Perform the simulations for a second El Nino event or a La Nina event and compare the results with those from (1).

(3) Perform longer runs for one or both of your El Nino/La Nina cases to determine how the "effect of El Nino" (as deduced from the difference between the normal and El Nino runs) depends on the length of the simulations. If the effect is weak, we need longer runs for the "signal" to stand out against the background internal "noise" (due to internal variability unrelated to the El Nino SST anomaly).

For the final report, more in-depth discussions are expected. You will also be required to write a summary of the model architecture, based on your reading of the NCAR Technical Report for CCM3.