Feasibility of Reanalysis Derived Forcing for SCM/CRM Studies in the Mid-Latitudes

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Despite recent advancements in global climate modeling, models produce a large range of climate sensitivities for the Earth. This range of sensitivities results in part from uncertainties in modeling clouds. To understand and improve cloud parameterizations in Global Climate Models (GCMs), simulations should be evaluated using observations of clouds. Detailed studies can be conducted at Atmospheric Radiation Measurements (ARM) sites which provide adequate observations and forcing for Single Column Model (SCM) or Cloud Resolving Model (CRM) studies. Unfortunately, forcing for SCM/CRMs is sparse and not available for many locations or times.

A potential solution to this problem is to utilize reanalyses to develop forcing. In doing so, long-term forcing datasets could be developed for a number of locations to investigate specific scientific questions. Prior to developing this dataset, however, careful considerations need to be made. The underlying models used in reanalyses may propagate errors into the forcing limiting their usefulness. It is reasonable to assume that reanalysis based forcing is most likely to work for regions such as the CONUS where reanalyses should be better constrained to observations.

To determine the feasibility of reanalysis based forcing in the mid-latitudes, the North American Regional Renalysis (NARR) was first compared to ARM observations and forcing at the Southern Great Plains (SGP) site from 1999-2008. Comparisons to sounding data revealed that NARR had many positive aspects when compared to ARM continuous forcing. In general, atmospheric state variables (wind, temperature, and humidity) for NARR had smaller biases and errors than ARM. One negative aspect for NARR included a positive bias of humidity in the upper-troposphere. This bias was larger in magnitude during the warm season.

A key component of SCM/CRM forcing is the vertical tendencies of temperature and humidity. Vertical velocities are perhaps the hardest variable to reconcile. Not surprisingly, this field had the largest disagreement between the ARM continuous forcing and the NARR. Although the two datasets had similar timeseries of vertical velocities, ARM (NARR) had stronger upwelling (downwelling) during the warm season that significantly influenced monthly means. This result is not surprising considering ARM forcing constrains the column budgets of moisture, heat, and mass using precipitation and radiation information in a constrained variational analysis. Most of the disagreement between the two datasets was the result of convection, and despite this finding, it was determined that the development of NARR forcing would be a worthwhile endeavor.

NARR forcing was developed from 1999-2008 for a GCM sized gridbox (2.5°×2.0° longitude, latitude) centered on the ARM SGP site. NARR data were interpolated to 25 hPa vertical layers and to hourly means to match the resolution of the ARM forcing. Using adjacent gridboxes, finite differences were used to calculate the advective tendencies of moisture and temperature. Due to noise in the original fields (especially for vertical velocity), several versions of the forcing were developed using boxcar filters to smooth the individual fields.

NASA GISS AR5 SCM simulations using the ARM and NARR forcings were completed to test their ability to reproduce the observed cloud field at the ARM SGP site. Although both forcings reproduced an annual cloud field that resembled the observations, there were frequent biases. These biases were directly related to the input humidity fields. For example, the positive bias of upper tropospheric humidity in NARR yielded too many clouds in the SCM simulation. Both sets of forcing had advantages and disadvantages making it difficult to pick a clear winner. Instead, the ensemble of runs was used to identify parameterization issues in the SCM and to identify problems that may be forcing related.

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