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Development and Implementation of Universal Cloud/Radiation Parameterizations in Navy Operational Forecast Models

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Award Number: N00014-13-1-0382
http://www.eaps.purdue.edu/research/clew/index.html

LONG-TERM GOALS

Improve the simulation of atmospheric radiation energy fields in Navy operational weather forecast models, such as the current NAVGEM, by the implementation of modern cloud and radiation parameterizations.

OBJECTIVES

1. Design a parameterization for translating prognostic cloud attributes (liquid or ice water content, drop size, layer cloud fraction) in NAVGEM to quantities that will become the input stream to an atmospheric radiation code. Examples are optical thickness, single scattering albedo and fractional cloud overlap.
2. Implement a cloud overlap scheme for NAVGEM.

APPROACH

1. Run a modern radiation code designed for global models, RRTMG SW and LW (Mlawer et al. 1997, Iacono et al. 2008) in off-line mode for clear skies and prescribed cloud properties on local (Purdue University) computers using the default RRTMG cloud prescriptions.
2. Port a Single Column Model (SCM) version of NAVGEM to the local computer for time-stepped runs at two representative grid points. The grid points chosen correspond to Atmospheric Radiation Measurement (ARM) surface sites (http://www.arm.gov/sites) for which observations are available (Oreopoulos and Mlawer, 2010).
3. Conduct sensitivity tests to modify the relationship between cloud microphysics and cloud cover properties and optical properties such as spectral band average optical thickness and single scattering albedo that are appropriate for NAVGEM, i.e. modify the default cloud optical properties prescribed in RRTMG.

WORK COMPLETED

Objectives 1 and 2 above has been concluded successfully for prescribed input provided by Dr. Ming Liu of NRL Monterey. However, we were only able to compare the SCM with one ARM site, nameley the Southern Great Plains (SGP) site. Since the period of initial performance was only six months, extended to one year, there was not sufficient time to address Objective 3.

RESULTS

The single column model (SCM) was successfully ported to local clusters and run for the single case of 15 April-15 May 2013 at the SGP ARM site. A grid point in the analysis was chosen to represent this surface site and initial and updated conditions for the SCM were chosen from the grid point centered at 97.333W, 36.80N. The ARM SGP site is at 97.485W, 36.605N. We have also used NWS surface observations from Coffeyville, KS located at 95.626W, 37.038N.

Results are presented for a run with the relaxation factor equal to 0.5. This ensures that the model does not drift too far away from the reanalysis. This is not a serious handicap since we are ultimately interested in cloud formation and properties as they relate to the radiation field. Figures 1 through 4 show selected fields from the 30-day simulation. So far we have only been able to compare temperature and radiation fluxes for a brief period. Future work will involve comparison of the entire period for all fields and also for other ARM sites.

Figures 5 through 8 show comparisons of the temperature and hunidity profiles on 18 April 2013 at 18Z. ARM parameters are from a radiosonde and the SCM results are from the 30-day simulation. The correspondence is excellent. However, when we compared the temperature trends over the 24 hour period we found significant differences. This is illustreated in Figures 9 and 10, showing the comparison of surface air temeprature. Although the 18Z temperatures match closely, the previous time period is much warmer in the SCM. This raises an important issue when it comes to comparing a model grid point with point data. It turns out that there was a strong front that had already pased the ARM site but had not appeared in the SCM results which are based on analysis over a large grid. So we looked at a nearby NWS station, Coffeyville, KS, (Figure 11) for the three-day period, 17-19 April. This shows that point measurements across a model grid can differ substantially when there is a sharp weather phenomenon.

Finally, it should be noted that cloud comparisons, hence radiation comparisons will also be fraught with difficulties. Care must be taken when comparing point to grid average measurements. Figure 12 is a GOES image of the ARM site and shows the cloud cover at 18Z, when comparisons were made. The model grid would have been partly cloudy and exact time matches of radiation would not lead to meaningful comparisons. In order to proceed, we must use time and space averaged quantities, which is why we plan to extend comparisons to longer time periods, say monthly means, and for more ARM sites. This will be the thrust of a follow on project.

IMPACT/APPLICATIONS

The goal of this proposal is for an improved modeling system that can be used for forecasts out to seasonal time scales, as stated in the ONR announcement. The payoff will be improved global prediction systems capable of producing useful monthly and seasonal forecasts. These forecasts would provide valuable guidance on phenomena of particular interest to the Department of Defense.

RELATED PROJECTS

None

REFERENCES

Iacono, M.H., J.S. Delamere, E.J. Mlawer, M.W. Shephard, S.A. Clough, and W.D. Collins, 2008: Radiative forcing by long-lived greenhouse gases: Calculations with the AER radiative transfer models. *J. Geophys. Res.*, **113**, D13103.

Mlawer, E.J., S.J. Taubman, P.D. Brown, M.J. Iacono, and S.A. Clough, 1997: Radiative transfer for inhomogeneous atmospheres: RRTM, a validated correlated-*k* model for the longwave. *J. Geophys. Res.*, **102**, 16,663-16,682.

Oreopoulos, L., and E. J. Mlawer, 2010: The continual intercomparison of radiation codes (CIRC). *Bull. Am. Meteorol. Soc.*, **91**, 305-320.

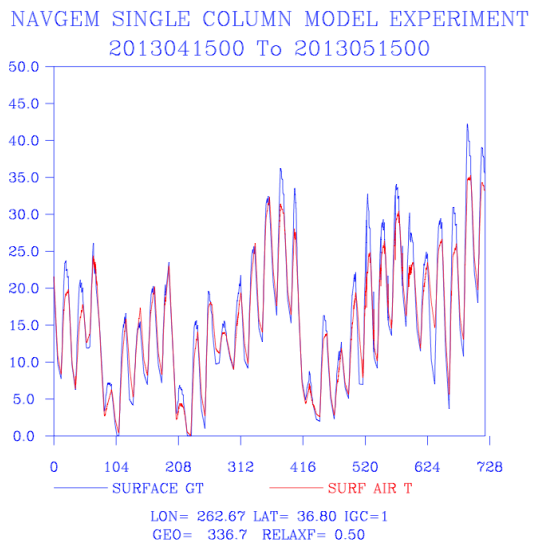

Fig. 1. SCM 30-day surface temperature

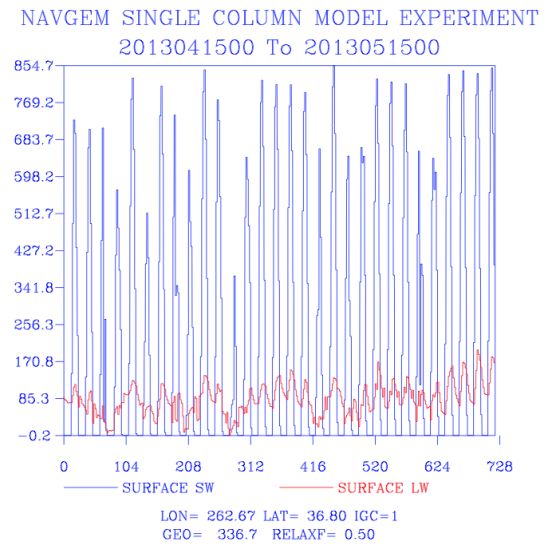

Fig. 2. SCM 30-day surface shortwave and longwave radiation

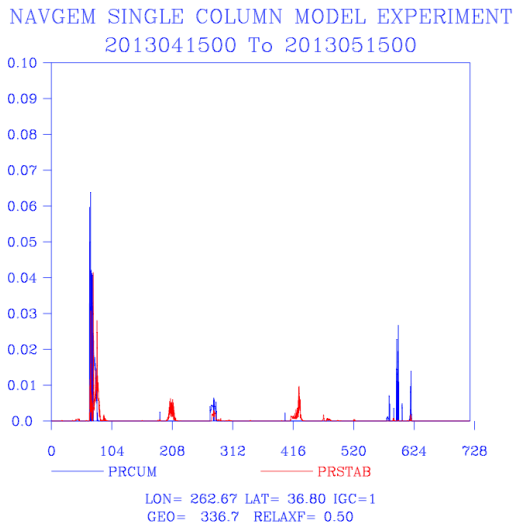

Fig. 3. SCM 30-day cumulus and stable precipitation

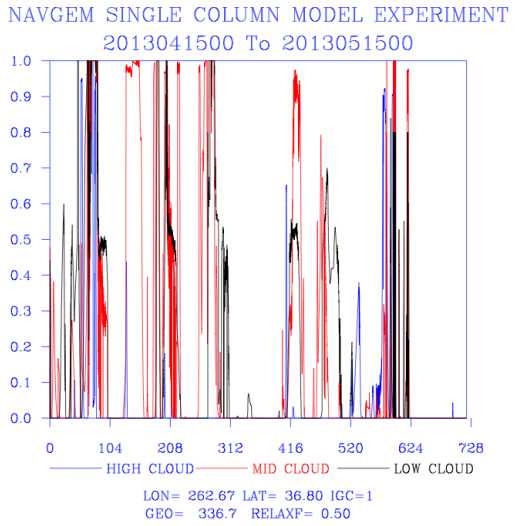

Fig. 4. SCM 30-day cloud cover

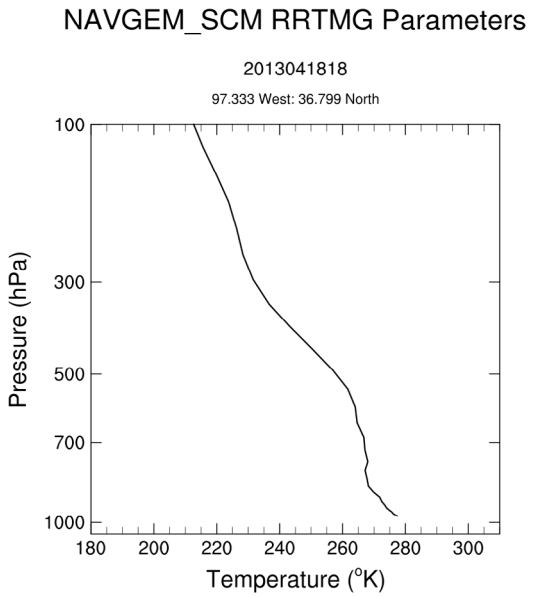

Fig. 5. SCM Temperature profile 18 April 18Z

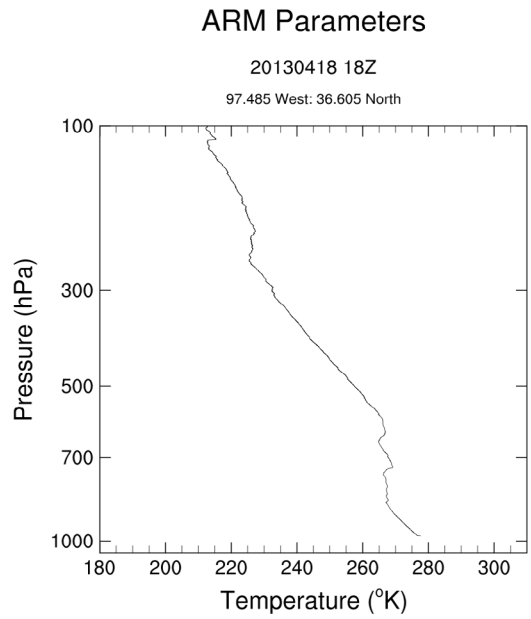

Fig. 6. ARM Temperature profile 18 April 18Z

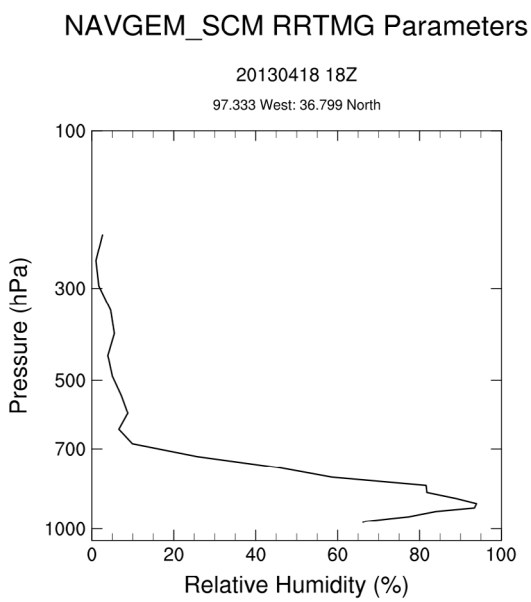

Fig. 7. SCM Humidity profile 18 April 18Z

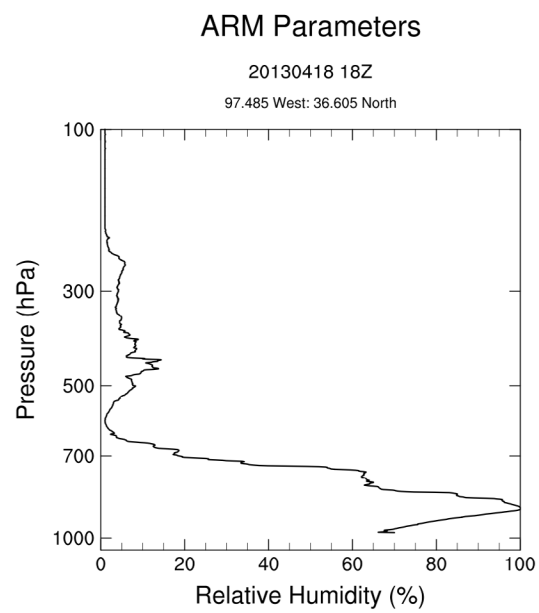

Fig. 8. ARM Humidity profile 18 April 18Z

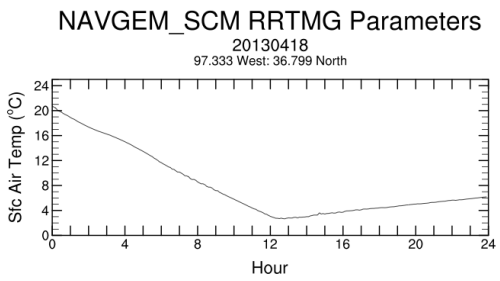

Fig. 9. SCM Surface Temperature 18 April

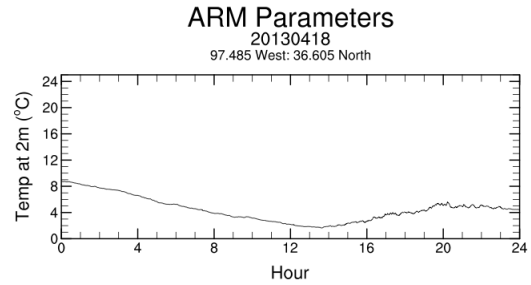

Fig. 10. ARM Surface Temperature 18 April

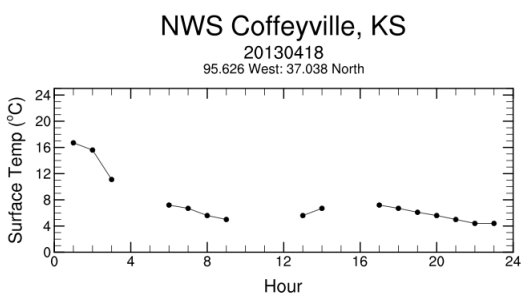

Fig. 11. Coffeyville, KS, Surface Temperature 17-19 April

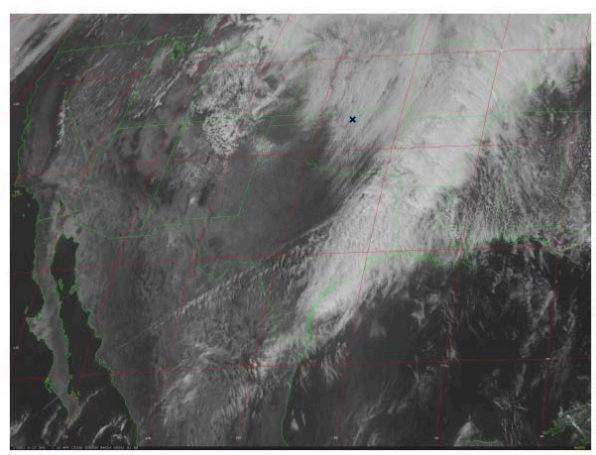

Fig. 12. GOES image at 18Z on 18 April. The ARM site is marked.