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“Lane Processes in a High Resolution Community Climate Model with Sub-Grid Scale Parameterizations”

The funded activity was at the University of Arizona with Co-Is, A. Hahmann, M. Shaikh, Z.-L. Yang, and X. Zeng. The funding remained at Arizona under the direction of Dr. Hahmann after the movement of the PI to Gatech. The 3 task areas proposed were to a) further implement the concept of a land sub-mesh by extending previous developments to higher resolution and interfacing with the soon expected next generation NCAR atmospheric, expected to include a version of Williamson’s semi-Lagrangian dynamical core; b) develop and upgrade the sub-mesh land parameterizations; and c) improve several aspects of the land surface parameterization for both BATS and the LSM code.

For the first task, Hahmann formulated a numerically effective approach for representing global land processes on a 0.5 deg mesh and interfaced to the T42 resolution CCM3. She successfully implemented integrations with this formulation. Hahmann and Dickinson (2001) describe results from such integrations using the BATS and LSM land models when the only subgridscale heterogeneity included is that of land cover. This simulation was compared to standard T-42 control simulations. Large effects on tropical precipitation were found but only surface temperatures were affected in middle latitudes.

More recent progress has been made in inclusion of spatial heterogeneity in precipitation and topography over a GCM atmospheric grid square. A second activity, done in cooperation with Williamson at NCAR, has been to carry out a study of the dependence on resolution of land related climatological parameters, using a preliminary version of Williamson’s semi-Lagrangian dynamical code. After extensive work to develop the needed boundary conditions, model runs were carried out at T-63, T-127, T-191, and T-239. The 18-year AMIP2 simulations were only completed for the two lower resolutions. Significant conclusions were that a) CCM3 unlike earlier versions of CCM scaled well with resolution; that is, little or no tuning was needed to get global average energy quantities to be unchanged with resolution; b) winter precipitation patterns improved substantially with resolution but serious biases in summer precipitation largely remained at higher resolution. The intent to repeat this study with the next generation frozen NCAR model is still pending awaiting the release of that model. Duffy' s group at DOE/LLNL is currently exploring simulations with CCM3 at T-239 and we are providing our experience to facilitate their study.

The second task consists of developing the data sets and rules required to scale between the grid-squares of the atmospheric model and the finer spatial representation of the land model. This representation is referred to as tiles since the individual elements are not required to be squares or rectangular but in principle can take any polygonal shape that allows the tiles to span the area represented by the atmospheric grid square. Because of numerical difficulties that are otherwise encountered, we excluded tiles that cross the boundaries of the atmospheric grid-square. Atmospheric variables given on the lowest atmospheric level are assumed to be the same for all tiles under the grid-square. The most important variables to vary between tiles are elevation, precipitation, and radiation. Elevation is used to structure precipitation and chose between rain and snow. Initial tests were completed showing the importance of the sub-grid specifications of elevation and precipitation

The proposed third task evolved into supporting some aspects of the common land model development (Dai, 2003). It is not possible to adequately summarize here all the many strong features of this new model. It provides substantial improvement over LSM in its numerical schemes for soil layering and computation of water and energy fluxes. It provides an effective snow scheme with adoptive layering. Zeng, et al (2002) document various aspects of simulated climate that are improved over LSM through use of CCM with CCM3. It particularly improves the simulated runoff and shows substantial improvement in simulated temperatures.

The now standard procedure of specifying leaf-areas from satellite data is analogous to the specification of SSTs for the ocean. Incorporation of the facets of vegetation that most interact climatically requires modeling of interactive leaf-areas. The third task also supported some efforts to develop this concept in the context of the BATS land model.

<u>Publications Under Grant</u>:

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Zeng, X., M. Shaikh, Y. Dai, and R.E. Dickinson, 2002: Coupling of the Common Land Model to the NCAR Community Climate Model. J. Clim., **15**, 1832-1854.

Dickinson, R. E., S. E. Zebiak, J. L. Anderson, M. L. Blackmon, C. DeLuca, T. F. Hogan, M. Iredell, M. Ji, R. B. Rood, M. J. Suarez and K. E. Taylor, 2002: How Can We Advance Our Weather and Climate Models as a Community? BAMS, **83**, 431-434.