CCSM Land Model Working Group Report
The Village at Breckenridge, Breckenridge, Colorado
Wednesday, 21 June 2006

The Land Model Working Group (LMWG) met jointly with the Biogeochemistry Working Group (BGCWG) for 1.5 hours. During this meeting, Keith Oleson and Reto Stockli provided an update on the status of the Community Hydrology Project. The new hydrology scheme shows improvements in the timing and amplitude of runoff (especially at high latitudes), the partitioning of evapotranspiration, photosynthesis, soil water storage, and frozen soil hydrology. Additionally, a significantly improved land surface dataset, developed by Peter Lawrence, is available. A few minor issues remain, including excessive soil evaporation and a reconsideration of how to specify the root profile. These topics were discussed in detail during the LMWG meeting, and plans were laid out to conclude and document the Community Hydrology Project by the end of 2006.

The format of the subsequent 1.5 hours LMWG meeting consisted of a number of 1-2 slide, 5-minute talks on a variety of topics, followed by a general discussion on possible development activities for CLM4 (beyond the Community Hydrology Project).

Mark Flanner: Radiative forcing of black carbon on snow, effects on albedo and timing of snowmelt
Dave Gochis: Update on status of fine-mesh model (see below)
Norm Miller: Land-surface – groundwater coupling
Dmitry Nicolsky: Soil temperature profile, sensitivity to soil depth and surface organic soil layer
Dave Lawrence: Thermal and hydrologic properties of organic soil

The remainder of this report summarizes the status of various ongoing developmental projects. A number of projects are in progress that could, given time and resources, be included in the CLM4 release. The projects include: development of a fine mesh, high resolution land version of the model; new parameterizations for snow cover and snow albedo; development of an urban model; inclusion of prognostic canopy airspace scheme; transient land cover change; DGVM; and organic soils. Progress and remaining challenges for each development project are listed below. In general, the projects either address significant biases in the current model or add new scientific capability that is likely to be important for future IPCC assessment reports. A significant challenge for the LMWG is that software engineering support is not available to maintain the existing model, to merge the various development branches, and for code testing and optimization.

Community Hydrology Project: The Community Hydrology Project is nearing completion. Excessive soil evaporation and specification of rooting profile remain to be resolved, but the project is expected to be completed by December 2006. The code is being reviewed for its scientific content. Software engineering support is requested to allow for incorporation into the main developmental version of CCSM. This includes a software engineering code review, testing of the code across the suite of CCSM supported platforms and model configurations, and code to generate new required surface datasets for the various CCSM surface grids. In addition, there are a number of outstanding miscellaneous software engineering bugs/code fixes required including: two-stream floating point error; adding a warning error for ERRSOI imbalance; PFT-to-column averaging error for soil evaporation; occasional water balance errors; and snow age.

Fine mesh model: The architecture for the incorporation of a fine mesh version of the model has been developed through the efforts of Tony Craig, Dave Gochis, and Andrea Hahmann. The next phase is to develop and test methods for downscaling precipitation, temperature, and other atmospheric fields to account for elevation, aspect, and other topographic features. A significant limitation is that the atmosphere component model currently determines whether or not precipitation falls as rain or snow. When sub-grid scale topography is introduced, this is no longer a reasonable method. The 2x increase in computational cost (CAM/CLM) remains a significant limitation. Tony Craig provides software engineering support for this project.

Snow cover, snow albedo: Dave Lawrence, Zong-Liang Yang, Guo-Yue Niu, and Mark Flanner are going to lead an effort to improve the representation of snow cover and snow albedo. The plan is to work closely with the Polar Climate Working Group and the Atmosphere Model Working Group on this project as snow albedo and surface air temperature has significant influence on high latitude climate. This task is expected to help correct high-latitude temperature biases.

Urban model: The urban model, developed by Keith Oleson, Gordon Bonan, and Johann Feddema, is in the testing phase. A global dataset for urban model parameters is being compiled, so that global simulations can be performed and the sensitivity of climate to urban land cover can be tested. Projections that urban area may expand dramatically in the coming century means that implementation of dynamic urban area is desirable. Additionally, the model simulates the temperature and humidity of the city, which are important for human health studies. The current implementation of the urban model is no longer compatible with the latest developmental version of CLM. Software engineering support is requested to bring the code up to date.

Canopy air space: Sam Levis, Forrest Hoffman, Reto Stockli, and Gordon Bonan are working to incorporate a canopy air space treatment into CLM. This requires significant reworking of the code, and merging the extensively revised code with various ongoing developmental branches (e.g., urban model, fine mesh, CN, DGVM) will be a considerable effort. Although introduction of canopy air space is not likely to significantly alter long-term climate statistics, it does improve the numerical stability of the model and allows for carbon and water isotopes. Forrest Hoffman provides software engineering support for this project.

Transient land cover change: The CLM can support transient land cover change simulations in which land cover changes from year-to-year due to human land uses (e.g., tropical deforestation). The ability to conduct transient land cover change simulations over the period 1870-2100 is emerging as a high priority in the international land modeling community. This feature in CLM has not been exercised for several months, has to be brought up to date, and has to be tested and validated across the various developmental branches. It is also essential to ensure that this land cover change is the same as that being implemented by the BGCWG for carbon cycle simulation. Software engineering support is requested for this task.

DGVM: One branch of CLM allows for the DGVM to be implemented only for areas in which crops and grazing are not specified. This allows for a more accurate depiction of vegetation dynamics, limiting that feedback to only areas of the world with natural vegetation not managed by people. This feature in CLM has not been exercised for several months, has to be brought up to date, and has to be tested and validated across the various developmental branches. Software engineering support is requested for this task. Additionally, if the SSC decides to include DGVM capability in CCSM4, software engineering support is required to merge this branch with the BGCWG carbon model.

Organic soil and deeper soil column: The introduction of organic soil matter and a deeper soil column has been shown to significantly improve the temperature structure and evolution of the soil and is likely to significantly affect high-latitude hydrology and the sensitivity to climate change. Dave Lawrence, in collaboration with Andrew Slater, Vladomir Romanovsky, and Dmitry Nicolsky, is leading the effort on this project.

Software Engineering Support:

The projects outlined above will require significant software engineering support for their success. Here we provide a list of ongoing model development projects, their priority, and the anticipated level of software engineering support required.

Project	**Priority**	**Support Level required**	**Comments**
Fine mesh model	high	high	Tony Craig
Community hydrology	high	medium	New dataset for topographic parameter, F_{max} (mksrf_fmax); code review; code testing; optimization; various bug fixes
Snow cover, snow albedo	high	low	
Urban model	medium	high	Bring code up to date; code testing and optimization; merge with various code branches
Prognostic canopy airspace	medium	high	Forrest Hoffman
Transient land cover change	medium	high	Bring code up to date; code testing and optimization; merge with various code branches
DGVM	medium	high	Bring code up to date; code testing and

			optimization; merge with various code branches
Organic soil, deeper soil column	medium	low	

In addition to the scientific projects listed above, there are a number of urgently required pure software engineering tasks that need to be completed to help streamline and improve the model development process and to maintain computational efficiency in light of the new functionality. Updating the CLM testing framework is particularly critical as the lack of a suitable testing framework impacts all development activities.

CLM testing framework: The testing framework must be completely rewritten to provide the ability to routinely test both the current CLM science, as well as many of the new features that are being introduced. This would encompass routine testing of CN, CASA, dynamic land use, and DGVM. In the future these tests would encompass the urban code and the fine mesh model. All of these features need to be tested to determine if changes introduced in one part of the system have unanticipated side effects on other functional components (such as CN). Routine testing within CAM and CCSM must also be performed. The creation of a new test framework would ensure the robustness of both the current CLM code base and also provide the ability to detect software problems on a much faster time scale as new science and software is added to the system.

Parallel I/O: Parallel I/O needs to be incorporated into CLM to permit the CCSM system to run on new architectures with much more stringent memory limitations (such as the IBM Bluegene). A separate project is currently under way leveraging software support from both SCD and SciDAC to create a parallel I/O utility that can be utilized by all CCSM components. Once this utility is available, however, it must be incorporated within the CLM code base.

RTM parallelization: RTM needs to be parallelized. This is a pure software engineering effort, but will also become more important as CLM begins to be run on much higher resolution grids.

Attendees:

Adam Wolf, Carnegie Institution
Arthur Greene, IRI
Yoshihiro Asaoka, CRIEPI
Ian Baker, Colorado State University
Gordon Bonan, NCAR
Charles Hakkarinen, retired
John Dennis, NCAR
John Drake, Oak Ridge National Lab
Falguni Patadia, University of Alabama-Huntsville
Johannes Feddema, University of Kansas

Haishan Chen, GaTech
Colette Heald, University of CA, Berkeley
Huilin Gao, GaTech
James Edwards, IBM
Zong-Liang Yang, University of TX, Austin
Lixin Lu, Colorado State University
Gao-Yue Niu, University of TX, Austin
Keith Oleson, NCAR
Samuel Levis, NCAR
Reto Stockli, Colorado State University
Taotao Qian, NCAR
Vladimir Alexeev, University of Alaska, Fairbanks
Wenge Ni-Meister, City University of New York
Yan Huang, GaTech
Dmitry Nicolsky, University of Alaska, Fairbanks
Rong Fu, GaTech
Craig Collier, Scripps Institution of Oceanography
David Lawrence, NCAR
Steve Running, University of Montana
Norman Miller, University of CA, Berkeley
David Gochis, NCAR
Mark Flanner, University of CA, Irvine
Peter Lawrence, University of CO, Boulder
Andrea Hahmann, NCAR
Forrest Hoffman, Oak Ridge National Lab