Community Earth System Model

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Land Model Working Group

David Lawrence, Liang Yang, Keith Oleson, Peter Lawrence, Sean Swenson
dlawren@ucar.edu
NCAR, P.O. Box 3000, Boulder CO, 80307-3000 USA

Chairs: David Lawrence and Liang Yang; Liaison: Sam Levis

Background

The Land Model Working Group contributes to the development of the Community Land Model (CLM4). CLM formalizes and quantifies concepts of ecological climatology. It represents and allows the investigation of the physical, chemical, and biological processes by which terrestrial ecosystems affect and are affected by climate across a variety of spatial and temporal scales. The central theme is that terrestrial ecosystems, through their cycling of energy, water, chemical elements, and trace gases, are important determinants of climate. The land surface is also the critical interface through which climate change impacts humans and through which humans can effect global environmental change.

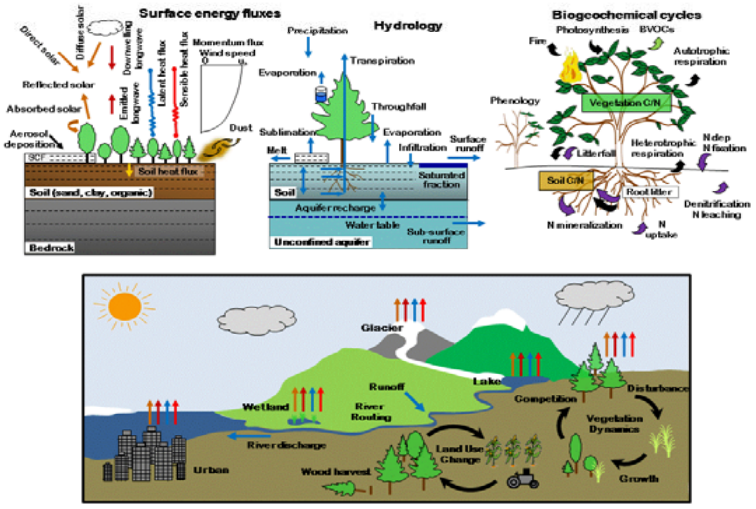


Fig. 1: Schematic diagram illustrating processes represented in CLM4.

Land cover and land use change

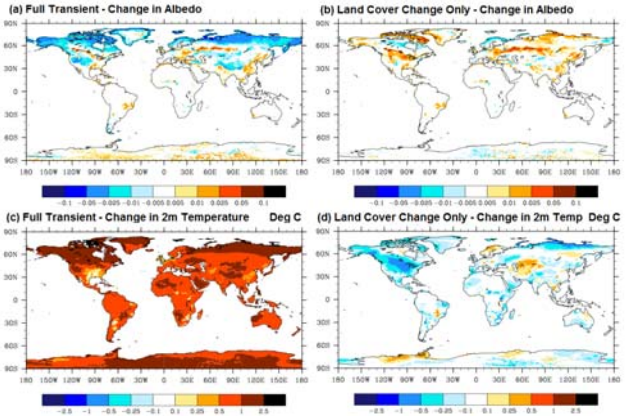


Fig. 2: Impact of historical land cover change on surface albedo and $T_{air.}$ in CESM1.

Research Highlights

Urban-Rural Contrasts

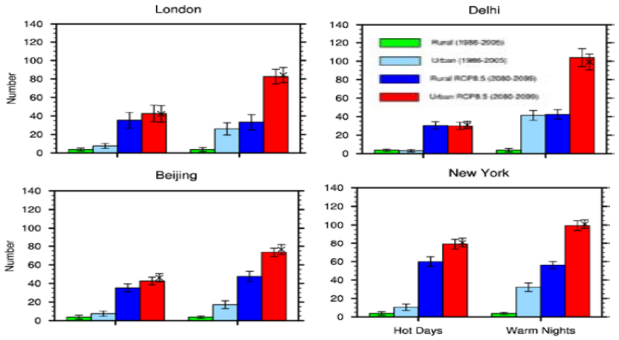
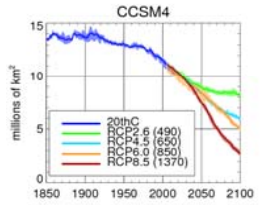


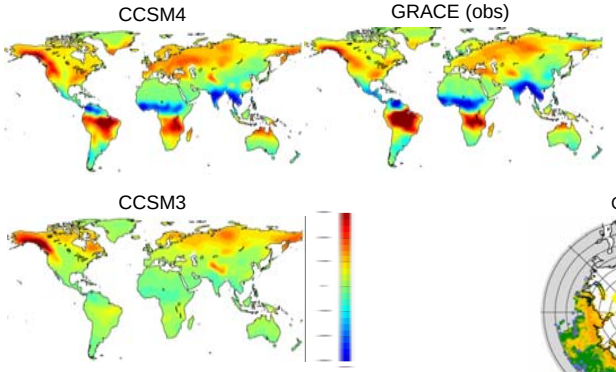
Fig. 3. Average annual frequency of hot days and warm nights. Hot days are defined as days where the daily max T_{air} exceeds the 99th percentile of the 1986-2005 rural daily max $T_{air.}$ Warm nights are defined similarly using the daily min T_{air}.

Permafrost Projections

Fig. 4. Simulated permafrost distribution and active layer thickness compared against observed distribution estimate. Time series of historical and projected area with near-surface permafrost (i.e., permafrost present within top 3m of soil).



Water Cycle



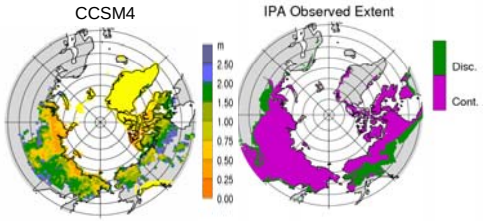


Fig. 5. Difference in mean soil water content between spring (MAM) and fall (SON)

Summary

CLM4 and CESM1 are increasingly suited for the study of the role of land processes in climate and climate change. There are several LMWG and BGCWG projects in progress or recently completed in the LMWG and BGCWG that integrate unrepresented aspects of the land system into CLM including the addition of crop, irrigation, and methane emissions models, a prognostic wetland distribution scheme, water and carbon isotopes, and ecosystem demography concepts. Efforts are also ongoing to improve existing parameterizations, including projects on vegetation and soil carbon dynamics, nitrogen dynamics, lake model thermodynamics, cold region hydrology, sub grid soil moisture and snow, and more advanced river discharge modeling. Work is also underway to improve and evaluate model parameterizations and parameters through data assimilation and perturbed parameter experiments.

References

Lawrence, D.M., et al., 2011: Parameterization improvements and functional and structural advances in version 4 of the Community Land Model. *J. Adv. Model. Earth Sys.*, **3.**
Lawrence, D.M., et al., 2011: The CCSM4 land simulation, 1850-2005: Assessment of surface climate and new capabilities. *Submitted to J. Climate CCSM4 Special Collection*.
Lawrence, D.M., et al., 2011: Simulation of Present-day and Future Permafrost and Seasonally Frozen Ground Conditions in CCSM4. *In Press J. Climate CCSM4 Special Collection*.
Lawrence, P.J., et al., 2011: Simulating the Biogeochemical and Biogeophysical Impacts of Transient Land Cover Change and Wood Harvest in the Community Climate System Model (CCSM4) from 1850 to 2100. *Submitted to J. Climate CCSM4 Special Collection*.
Oleson, K.W., 2011: Contrasts between Urban and Rural Climate in CCSM4 CMIP5 Climate Change Scenarios. *In Press J. Climate CCSM4 Special Collection.*