CCSM Polar Climate Working Group Meeting
REPORT
21 June 2007
Breckenridge, Colorado
Marika Holland (NCAR) and Elizabeth Hunke (LANL), Co-chairs

This morning working group session featured progress reports on model development efforts since our last meeting, a special advertisement for new observational data becoming available to modelers, and a presentation of arguments against a recent paper whose authors claimed that the range in the IPCC-AR4 Arctic surface energy flux cannot be reconciled with their range in ice thickness, implying a precision tuning of albedo.

Arctic climate projections and progress towards a new CCSM
Marika Holland, National Center for Atmospheric Research

Marika motivated the need to improve present-day Arctic simulations by presenting a range of results from IPCC model projections and relating them to the range in their present-day simulations. Biases in CCSM3 simulations include the ice thickness pattern and the clouds in the Arctic. With the intermediate CCSM3.5 version, many aspects of the simulation are improved, including ice extent and thickness patterns in the Labrador, East Siberian, and Barents Seas, in the central Arctic and in the Southern Ocean. Ice is now too extensive in the GIN Seas, however. While Arctic cloud and radiation biases have improved, ocean profiles degraded. The changes in the ocean simulation may be due to changes in river runoff to the Arctic, computed by the land component.

Impact of melt ponds and Delta-Eddington shortwave in CCSM: Towards CCSM 4.0
David Bailey, National Center for Atmospheric Research

David presented his work on incorporating a new explicit melt pond parameterization and the Delta-Eddington (DE) shortwave radiation scheme into the Community Ice Code version 4.0 (CICE). He found that the new parameterization and physics in atmosphere-ice-slab ocean model experiments (present day and doubled CO2) produced results that were relatively similar to results from experiments using the CCSM3 shortwave with implicit melt ponds. The new melt pond formulation was very sensitive, however, to the prescribed runoff fraction and needing to account for accumulation of water from rain. While the DE shortwave was effectively tuned to produce similar results to the CCSM3 shortwave, the new physics would allow for the addition of soot and algae, as well as a more sophisticated snow model or a snow-aging parameterization with multiple levels in the snow. Some work in progress includes further investigation of the runoff fraction sensitivity, tuning of the DE radiation, and fully-coupled simulations.

Global satellite-derived snow data sets at NSIDC
Mary Jo Brodzik, National Snow and Ice Data Center (NSIDC)

Mary Jo described two satellite-derived snow cover data sets available from the National Snow and Ice Data Center (NSIDC) that could be useful as validation data to the CCSM community. (1) The Northern Hemisphere Weekly EASE-Grid (Equal-Area Scalable Earth-Grid) Snow Cover and Sea Ice Extent data (http://nsidc.org/data/nsidc-0046.html) contains regridded versions of the NOAA weekly snow maps, from 1966 to 2005 (the longest environmental record derived from Earth-observing satellites). The maps are derived from reflectivity measured from available visible-wavelenth sensors, mainly AVHRR and GOES. (2) The Global Monthly EASE-Grid Snow Water Equivalent Climatology (http://nsidc.org/data/nsidc-0271.html) contains global maps of snow water equivalent derived from satellite passive microwave sensors from 1978 to 2005. Although passive microwave snow maps tend to undermeasure snow extent in late fall and early winter and suffer from reduced spatial resolution when compared with snow maps from visible-wavelength sensors, they are capable of indicating snow water equivalent and may prove more useful in studying more realistic heat flux processes. Both data sets are available on-line from NSIDC formatted as flat, binary gridded arrays, although I'm investigating netCDF-CF as a distribution format for the next updates, which I believe will make them more attractive to the CCSM community.

Progress in ice sheet modeling
Bill Lipscomb, Los Alamos National Laboratory

Bill has begun implementing an interactive ice sheet model in the Community Climate System Model (CCSM). The GLIMMER ice model, with wrapping routines denoted as "glc," now runs as a sixth component of concurrent CCSM, along with the atmosphere, ocean, sea ice, land, and coupler components. Currently the ice sheet model reads data files of temperature and precipitation; the next step is to pass these fields through the coupler and return the ice extent, elevation, and freshwater flux. The ice sheet model is quite sensitive to the input fields and may require tuning. In multi-millennial simulations forced by CCSM climatology from a b31 simulation, the ice sheet is too extensive, mainly because of cold temperatures in southern Greenland. When forced with b35 climatology, the southern part of the ice sheet melts excessively. These biases are due in part to errors in interpolating temperature from the atmosphere grid to the ice sheet grid. Coupled climate runs with an interactive Greenland ice sheet will begin this summer, with the goal of including ice sheets in future IPCC simulations. Many model improvements are needed in order to provide reliable climate projections. The ice sheet model should be run at higher resolution (5 km or less) with full stresses and with more realistic treatments of subglacial topography and basal sliding. Accurate downscaling schemes are also needed, along with new methods of coupling the atmosphere and ocean to dynamic ice sheets.

High-latitude-friendly lateral mixing parameterizations for global ocean simulations
Elizabeth Hunke, Los Alamos National Laboratory

Using an ice-ocean coupled model on an eddy-admitting, global, 0.4° mesh, Elizabeth found that simulations of tracer properties and kinetic energy differ much more at high latitudes than at mid-to-low latitudes under different choices for the lateral tracer mixing parameterization, particularly between Gent and McWilliams (GM) mixing, which is Laplacian in form, and biharmonic tracer diffusion. Besides the more physical, rotated diffusivity used in GM, the differences in these two formulations can be traced to two effects, (1) scale selectivity, in which Laplacian forms damp wave energy more quickly than biharmonic mixing formulations, and (2) grid dependence of the diffusion coefficient, which is particularly important at high latitudes where the grid scale decreases dramatically on the sphere. This study explores some effects of these parameterization choices at high latitudes, including the anisotropic GM formulation. Regardless of the mixing parameterization chosen, future global simulations should take into account variations in grid cell area, in order to prevent diffusion from dominating advection in the evolution of high latitude tracers and circulation.

Reconciling the spread of arctic sea ice thickness and surface energy fluxes in the 20C3M ensemble
Eric DeWeaver, University of Wisconsin, Madison

The thickness of Arctic sea ice in climate model simulations depends strongly on surface energy fluxes, so that sea ice thickness may be extremely sensitive to sea ice albedo and cloud radiative forcing. Uncertainty in the surface energy fluxes can thus impose a lower bound on uncertainty in ice thickness, and the uncertainty of these quantities should be manifested in their inter-model spread across climate simulation ensembles. Such lower bounds could be valuable in assessing the credibility of future sea ice simulations and in understanding sea ice thickness sensitivity.

Eric used two thermodynamic equations to create diagnostic estimates of the mean thickness of perennial Arctic sea ice in an ensemble of 20th century climate simulations. The diagnostic thickness estimates are derived solely from surface temperature and energy fluxes, so the inter-model spread in diagnostic thickness can be related directly to the corresponding spread in energy fluxes. In this analysis, the primary source of spread in thickness is the summertime energy fluxes, which have a range of about $60\mathrm{Wm}^{-2}$ and yield an inter-model range of 1 to 5m in thickness. The key factor in relating the spread of thickness to the spread of fluxes is the ensemble-mean value of the net summertime flux: for a sufficiently small mean value, the expected thickness range would be infinite. The ensemble-mean value is found to be consistent with the observations of Lindsay (1998).

The spread in summertime energy flux is strongly related to the spread in albedo, while the spread in longwave radiative forcing, due in part to differences in cloud simulation, is found to play a minor role.

Discussion

Bruce Briegleb volunteered to collaborate with Mark Flanner and others in developing a snow aging parameterization that will complement the delta-Eddington shortwave parameterization.

Eric DeWeaver requested that CAM output cloud optical depth.