Offline tests of CABLE2.0

Two offline tests have been conducted using CABLE 2.0, one uses the half-hourly meteorological forcing and fluxes measured at 12 eddy-flux towers, and the other runs globally using the three-hourly forcing provided by the Global Soil Water Project II for the period 1990.

Model setup

(1) Initialization of temperature and moisture of six soil layers, depth, density and age of three snow layers

The initial values are read in from the initial condition datafile "*gridinfo_CSIRO_1x1.nc* " in the CABLE-AUX package for global offline simulations, and the values for the nearest land point are found and used for single site simulations.

(2) Surface data.

Vegetation and Zobler soil texture types for each patch within a land cell are read from the initial condition file *gridinfo_CSIRO_1x1.nc* for the global offline case, while in the single-site cases, site-specific vegetation types are used. Basic vegetation and soil physical parameters for running CABLE are then obtained from the lookup table provided by the input file *def_veg_params.txt* for vegetation and *def_soil_params.txt* for soil in the CABLE-AUX package. For single-site simulations, the canopy height, C4 fraction and reference height are overwritten by site-specific data if available. Monthly-averaged LAI (leaf area index) was regridded from MODIS collection 5 datasets and recorded in *gridinfo_CSIRO_1x1.nc* for initialization. In this test, switch *soilparmnew* is set TRUE, the spatially-specific soil parameters are provided by file *gridinfo_CSIRO_1x1.nc* and were generated from the UM ancillary files so that conditions are comparable to ACCESS runs. Snow-free ground albedo was also generated from the UM ancillary files and recorded in *gridinfo_CSIRO_1x1.nc* for initialization.

(3) For each eddy flux site, two simulations using CABLE2.0 were done. One sets "icycle" to 0 and the other to 3 (the former using the old carbon module while the latter simulates all nutrient cycles using CASA-CNP). Because CASA-CNP used for simulating soil respiration runs with a daily timestep, the simulated net ecosystem carbon exchange with icycle=3 does not have any diurnal cycle (see Known Issues below). A special case of icycle=1 (using only the carbon cycle in CASA-CNP) was performed for the site Tumbarumba to illustrate some points.

(4) All results for individual eddy flux sites have been uploaded to the *CABLE2.0_benchmark* workspace on the PALS web site (www.pals.unsw.edu.au) for access by any registered PALS users. These results can be compared to those done in the public workspace using CABLE1.4b, the previous released version.

(5) For the global offline run, a simulation with icycle=3 was done without feedbacks in LAI or Vcmax. The results are presented in this document.

(6) It is important to note that default values as CABLE would have used in global simulations have been used for all the simulations. It is not our intention here to optimize model parameters or initial model states to improve the model performance in the single-site simulations.

Basic information about eddy flux sites

Data from 12 flux sites were chosen for this benchmarking test. These sites represent five major plant functional types from eight different countries. Some basic information about each site is listed below. Further information can be obtained from the various FLUXNET web sites.

Site	Source	Latitude	Longitude	Country	Data available	CSIRO veg type	Soil type
Amplero	CarboEurope	41.90N	13.61E	Italy	2003-6	6	4
Audubon	Ameriflux	31.5907N	110.5092W	USA	2003-5	6	4
Boreas	Fluxnet Canada	55.8796N	98.4808W	Canada	1997-2003	1	1
Cabauw	CarboEurope	51.971N	4.927E	Netherlands	2003-6	6	4
Havard Forest	Ameriflux	42.5378N	72.1715W	USA	1994-2001	4	2
Hyytiala	CarboEurope	61.8474N	24.2948E	Finland	2001-4	1	4
Loobos	CarboEurope	52.1679N	5.74396E	Netherlands	1997-2006	1	4
Mer Bleue	Fluxnet Canada	45.4094N	75.5186W	Canada	1999-2005	11	4
Palangkaraya	Asianflux	2.345N	114.036E	Indonesia	2002-3	2	6
Tharandt	CarboEuropeIP	50.9636N	13.5669E	Germany	1998-2005	1	2
Tumbarumba	OzFlux	35.6557S	148.152E	Australia	2002-5	2	2
Wallaby Creek	OzFlux	37.429S	145.187E	Australia	2006	2	2

Results

Eddy flux sites

When comparing the recent simulations using CABLE2.0 (with icycle=0) to the previous simulations using CABLE1.4b, please note that a) the vegetation classification has changed from the IGBP types as used in CABLE1.4b to the CSIRO types, so do corresponding vegetation parameter values; b) LAI dataset has changed from MODIS collection 4 to collection 5, c) the soil parameter values has changed from the values of soil physical parameters from the look-up table to the spatially-specific soil parameters generated from UM ancillary files, d) snow-free ground albedo dataset has changed, and e) the global initialization file now has finer resolution (changed from ~2x2 degree grid to 1x1 degree grid). Generally, the energy and water conservation has much improved. It is also reflected in the improvement for most of the simulated latent, sensible heat and net radiation fluxes. However, there is no obvious improvement in the simulation of NEE flux – some sites are improved while others are not. A large part of this difference could be explained by the different soil type/properties used in these two simulations. From the comparison of several familiar sites, the use of site-specific soil parameter values as used in CABLE1.4b may have resulted in better simulations for those sites, as the globally spatially explicit dataset of soil physical parameters may not be representative for the sites at the eddy flux towers.

Major differences in the two CABLE2.0 simulations for each flux site are the diurnal trends, and annual cycle of net ecosystem carbon exchange (NEE). In these two simulations, one should bear in mind that the number of carbon pools considered are different and the total pool sizes are different as well. The annual cycle of NEE with icycle=0 (sitename_oldC) is quite different from that with icycle=3 (sitename_CNP), as dynamics of all nine carbon pools is simulated in the latter case whereas only plant carbon pool dynamics is simulated in the former. The simulation with icycle=0 has quite reasonable diurnal cycles for all fluxes, whereas only mean daily values are presented for icycle=3 due to the daily time step of CASA-CNP (see Known Issues). Thus, it would be prudent not to compare the 'DiurnalCycle', 'Scatter' and 'Pdf' (probability density function) outputs for the variable 'NEE' on the PALS site.

The special run Tumba_C demonstrates how NEE output would look like when a diurnal cycle of photosynthetic flux was added to the daily-averaged respiration flux of the day before. Comparing Tumba_C with Tumba_oldC, it is clear that the night time NEE flux is now simulated much better than using the old carbon module. This change is also the reason for a bigger overlap in the 'Pdf' plot of NEE flux and for other improvements in various plots of NEE.

Incoming long-wave radiation is not often measured at many eddy flux sites, and was estimated using the Swinbank equation. For sites with large discrepancy between the modeled and observed net radiation, it is possible that errors in the estimated incoming long-wave radiation may have significantly contributed to the discrepancies.

Global simulation averaged over the period 1986-1995

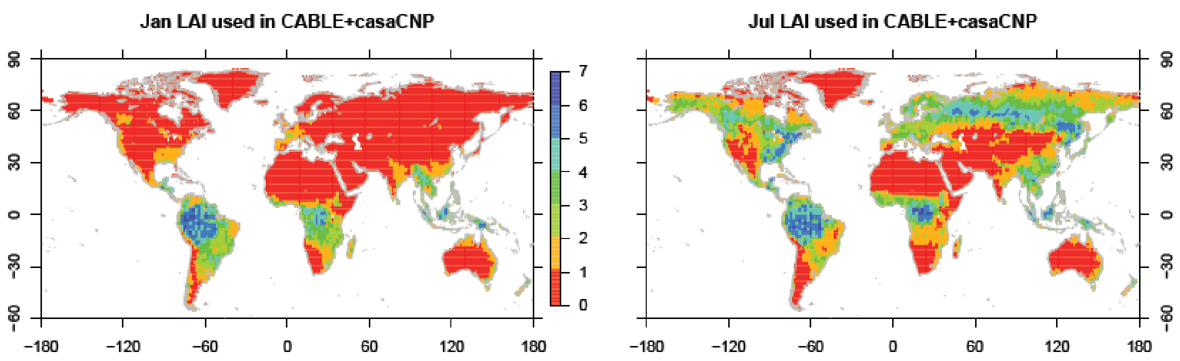

Figure 1. The monthly canopy leaf area index (LAI) for January (left panel) or July (right panel) from the MODIS collection 5 as used in the CABLE2.0 simulations.

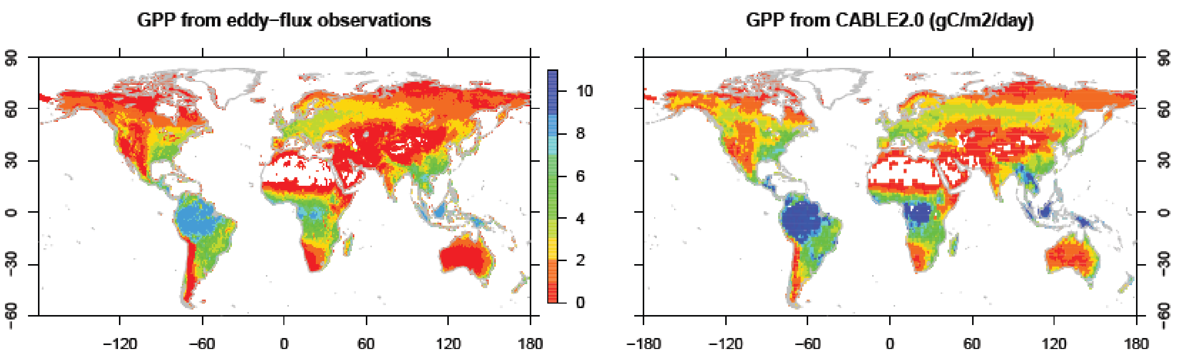

Figure 2. Comparison of the mean annual GPP as derived from the eddy flux measurements for 1982-2008 by Beer et al. (2010) and the simulated annual GPP by CABLE for 1986-95.

We ran CABLE2.0 at 1° by 1° spatial resolution using the 3-hourly meteorological forcing from GSWPII for a ten-year period, and monthly canopy LAI from MODIS collection 5. As shown in

Figure 1, canopy LAI varies very strongly in the temperate region and quite small in the subtropical and tropical regions between January and July.

Figure 2 compares the simulated annual GPP by CABLE2.0 for the period 1986-95 with the mean annual GPP for the period 1982 to 2008 derived from the eddy flux measurements (Beer et al. 2010). The simulated annual GPP by CABLE is higher for most regions but have a similar spatial pattern as derived from the eddy flux measurements (Beer et al. 2010).

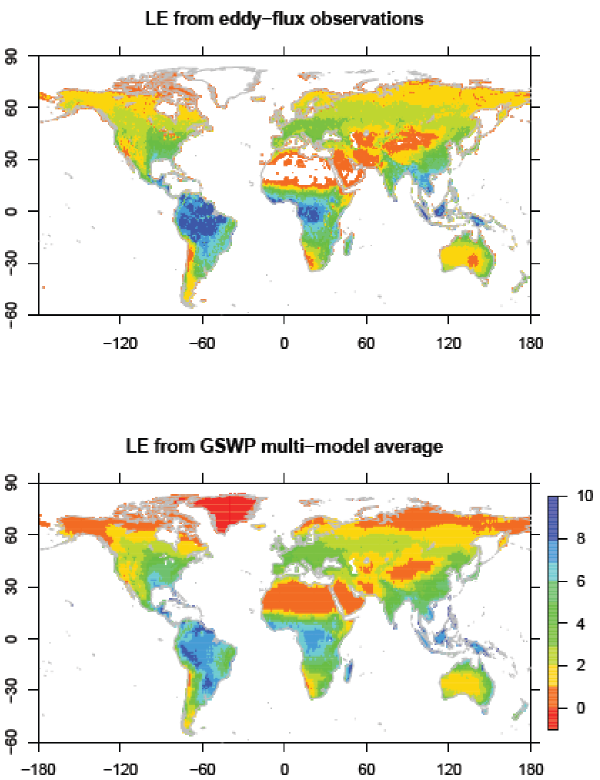

Figure 3. Comparison of the mean annual latent heat fluxes from eddy flux measurements for 1982-2008 (top left), or from the ensemble mean of multiple GSWP II models for 1986-95 (bottom left) with that from CABLE 2.0 simulation for 1986-95 (top right).

Figure 3 shows that the simulated spatial pattern of annual LE by CABLE2.0 is consistent with those derived from eddy flux measurements or the ensemble mean of multi models for GSWPII. The stronger resemblance between the two model results could be the result of using the same meteorological forcing, especially the prescribed precipitation in those years. However, it also is quite noticeable that the simulated annual LE by CABLE 2.0 for the tropical forest ecosystems is lower than the other two estimates. This will be discussed later.

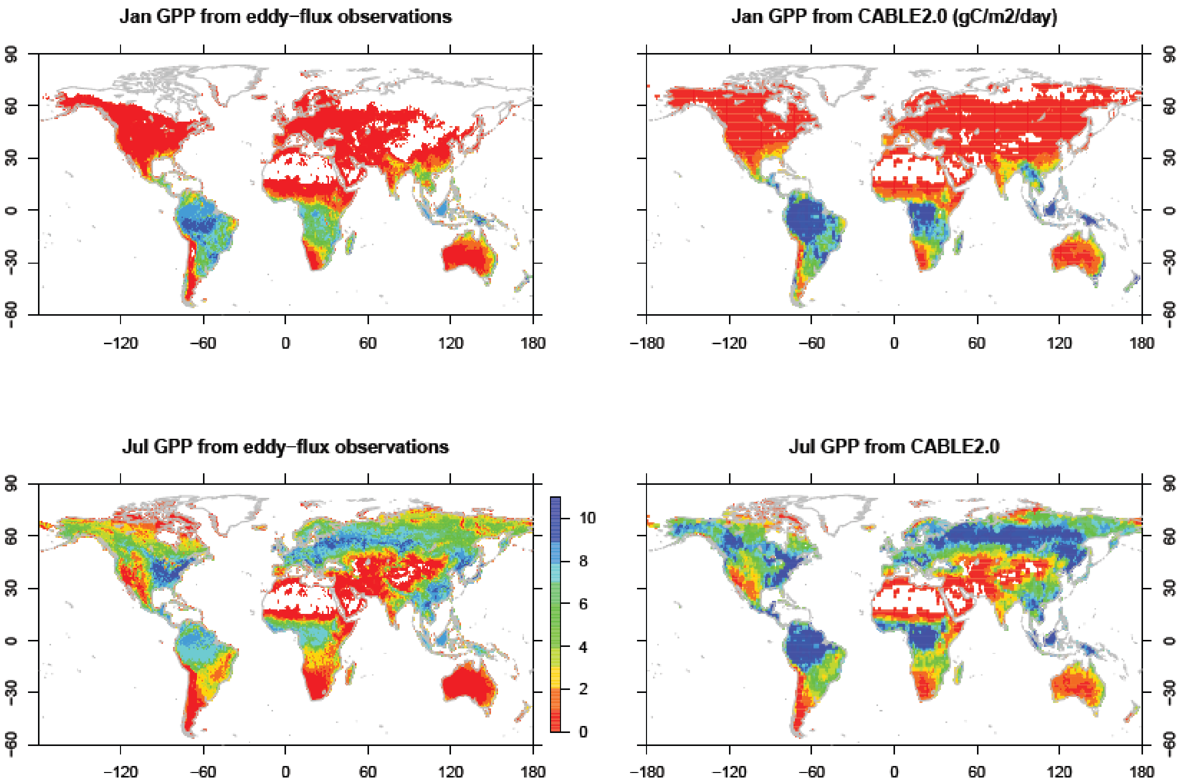

Figure 4. Comparison of the mean monthly GPP for January (top panels) or July (bottom panels) from the estimates for 1982-2008 by Beer et al. (2010) (left panels) with the simulated mean monthly GPP by CABLE 2.0 for 1986-95 (right panels).

Figure 4 compares the mean monthly GPP for January or July for the period 1982 to 2008 by Beer et al. (2010) with the monthly mean GPP for January or July as simulated by CABLE2.0 for the period 1986-95. The higher GPP as modeled by CABLE 2.0 is apparent in both months.

Figure 5 compares the mean monthly LE for January or July from eddy flux measurements for the period 1982 to 2008 with the monthly mean LE for January or July as simulated by CABLE2.0 for the period 1986-95. As pointed out before, the simulated annual LE by CABLE 2.0 for the tropical forest ecosystems is lower than the eddy flux measurements.

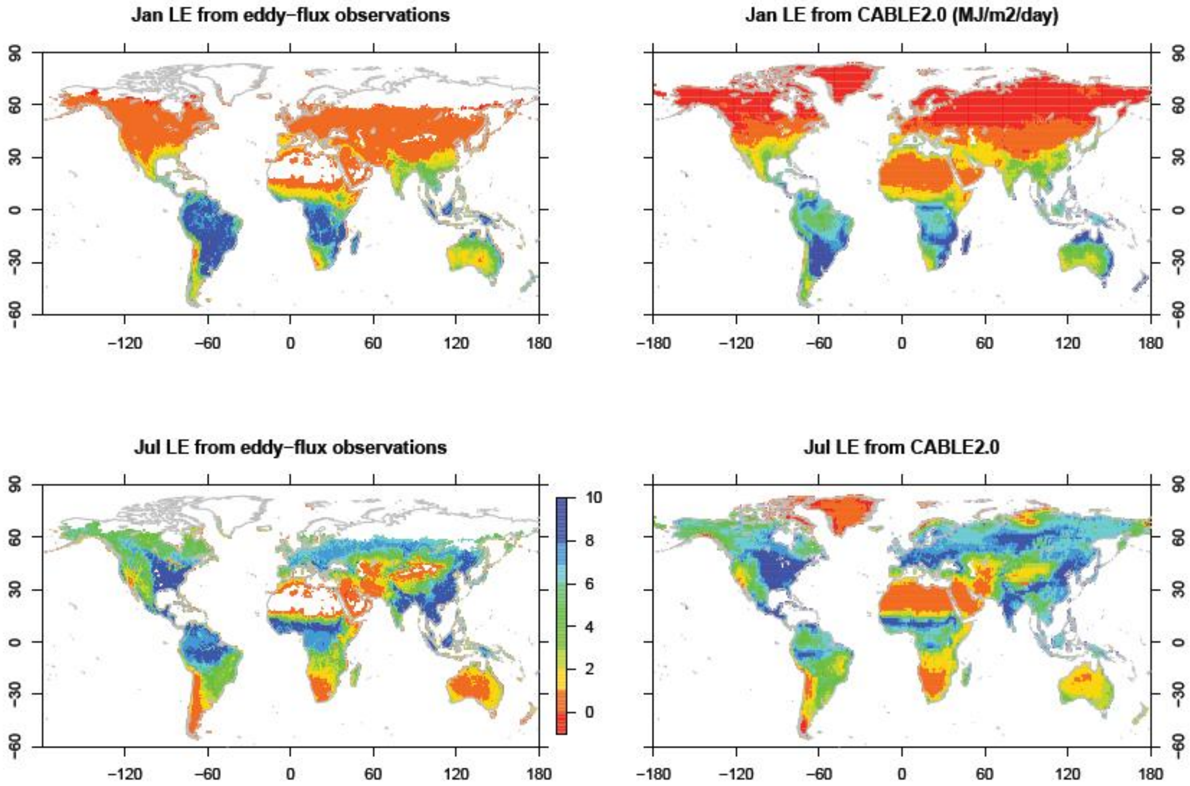

Figure 5. Comparison of the mean monthly LE for January (top panels) or July (bottom panels) from eddy flux measurements for 1982-2008 (left panels) with those from CABLE 2.0 simulation for 1986-95 (right panels).

Known issues

When running CABLE2.0 with "icycle" set to >1, only the daily mean NEE is included in the model output, as soil respiration is only calculated daily (e.g. Tumba_CNP case vs Tumba_oldC case on PALS). Net photosynthesis and plant respiration are calculated within the canopy submodel at hourly or whatever the time step in the meteorological forcing. When icycle is set to 1 or 0, the hourly NEE is calculated as the difference between hourly net photosynthesis and the sum of hourly plant respiration and mean daily soil respiration the previous day, therefore an apparent diurnal cycle of NEE is estimated (e.g. Tumba_C case on PALS). As the diurnal cycle comparison is quite useful, the NEE reporting frequencies for various CASA-CNP setups will be reconsidered in the near future.