Geophysical Research Abstracts
Vol. 12, EGU2010-2990, 2010
EGU General Assembly 2010

Modelling productivity in a mixed C3 and C4 Australian savanna using a soil-plant-atmosphere model

Cate Macinnis-Ng (1), Rhys Whitley (1), Lindsay Hutley (2), Jason Beringer (3), Melanie Zeppel (1), Mathew Williams (4), Belinda Medlyn (5), and Derek Eamus (1)

(1) University of Technology Sydney, Functional Plant Biology and Climate Change, Department of Environmental Sciences, Broadway, Australia (cate.macinnis@uts.edu.au), (2) School of Science & Primary Industries, Charles Darwin University, Australia, (3) School of Geography and Environmental Science, Monash University, Australia, (4) School of Geosciences, University of Edinburgh, UK, (5) Department of Biological Sciences, Macquarie University, Australia

The Soil-Plant-Atmosphere (SPA) model of Williams et al. (1996) is a mechanistic model which simulates ecosystem carbon and water fluxes over multiple canopy and soil layers at fine temporal scale. To-date, this model has not included consideration of C4 vegetation that is typically present in tropical savannas. We added a C4 photosynthesis routine to the model to allow estimation of the gross primary productivity (GPP) of a mixed (C3 and C4) tropical savanna in northern Australia. Much of Australia's savanna consists of a seasonal C4 grass understorey with a C3 open tree canopy, including evergreen, semi-deciduous and deciduous species. The tall annual grasses make up approximately half of the leaf area index (LAI) in the wet season (November to March) when 90% of annual rain falls but they die back in every dry season (April to October).

The seasonal cycle of leaf area and foliar N distributions were defined for each canopy layer and each layer was designated as C3 or C4 for application of the applicable photosynthesis model. The SPA model was then run over a 5 year period (2001-2005) and compared to measured eddy covariance data. There was good agreement between modelled and measured GPP values. The model explained between 80 – 87% of the variance and had a low root-mean-square error (RMSE) of between 0.0206 – 0.5742 g C m-2 d-1.

The contribution of the grass to total annual GPP was approximately 66%, highlighting the importance of including the C4 grasses in the model. Approximately 60% of the total (trees and grasses) annual GPP occurred during the wet season. Landscape quantum yields were calculated as the response of GPP to PAR between 50 and 250 μmol m-2 s-1 and compared for wet and dry seasons, in both morning and afternoons. This was highest for the wet season mornings (0.0282 mol CO2 per mol photon) and lowest for dry season afternoons.

A sensitivity analysis of GPP revealed that daily GPP was most sensitive to changes in understorey LAI and foliar N and relatively insensitive to changes in Vcmax, Jmax and minimum leaf water potential. Current observed values of foliar N, LAI and other parameters appear to be optimal for maximising GPP in the current climate. No relationship was found between wet season or annual GPP and total wet season precipitation, or annual total GPP and wet/dry season length and it is concluded that GPP at this site is energy limited rather than water limited. Finally, GPP was also shown to have an upper limit caused by the limitations of the hydraulic architecture of the canopy.

We are currently applying this model to an analysis of the ecophysiology of a north American desert ecosystem.