CARBON-CLIMATE INTERACTIONS: RESULTS FROM THE CSIRO GLOBAL CLIMATE MODEL

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ABSTRACT
Using the CSIRO global climate model (CCAM) coupled with a terrestrial carbon cycle model, we carried out two simulations using the protocol of C4MIP (Coupled Carbon Cycle Climate Model Intercomparison Project) Phase I to study the influences of increasing atmospheric CO_2 concentration and changes in sea surface temperature over the last 100 years on CO_2 between atmosphere and 11 biomes. It was found that the inter-annual variation of net ecosystem prediction of global terrestrial biosphere is significantly correlated to the variation of land surface temperature from 1980 to 1999, and the increase in net ecosystem production can be largely explained by the increase in net primary production from CO_2 fertilization from 1970 to 1999 in our model. The response of net ecosystem production to CO_2 fertilization is strongest in tropical rainforest and not significant in tundra. Our estimates of net ecosystem production of global terrestrial biosphere in 1990's agree well with the results from an inversion study by Allison et al. [this volume].

INTRUDUCTION
Carbon dioxide is the most important anthropogenic greenhouse gas in the atmosphere. Its concentration in the atmosphere depends on the emissions from various anthropogenic and natural sources and uptake by plants and ocean. Uptake by plants and ocean also depends on atmospheric CO_2 concentration, therefore prediction of future atmospheric CO_2 concentration and climate change requires implementation of a fully interactive carbon cycle over land and ocean into a global climate model. Two pioneering studies by Cox et al [2000] and Friedlingstein et al. [2001] predicted significantly different atmospheric CO_2 concentration and consequently global warming by year 2100. As a result the international science community launched a major study: C4MIP. Here we report some preliminary results from a study using CSIRO global climate model coupled with a terrestrial carbon cycle model.

RESULTS
We have developed and implemented a land surface model into the CSIRO global climate model (CCAM) for studying carbon-climate interactions. Following the protocol of C4MIP Phase I experiment, we carried out two simulations involving integration of the global climate model forward from 1900 to 2000. One uses the prescribed sea surface temperature (SST), prescribed radiative forcing, CO_2 emissions from fossil fuel use, land use change and ocean and the land biosphere is driven with the observed global mean atmospheric CO_2 concentrations from 1900 to 2000 (Run 1). The other uses the same prescribed fields from 1900 to 2000 except the global atmospheric CO_2 concentrations seen by the land biosphere after 1970 was kept constant at the level of 1970 (Run 2). Results from Run 1 show that the agreement is quite good between modeled and observed monthly mean surface CO_2 concentrations at most stations in the northern hemisphere, but rather poor in the southern hemisphere. The net ecosystem production from the global terrestrial biosphere changed from being slightly negative before 1950 (-0.1 ± 0.8 Gt C year^{-1}, or a carbon source), to being positive (0.7 ± 1.1 Gt C year^{-1}, or a carbon sink) after 1970. Inter-annual variation of the NEP of global terrestrial biosphere over the last decades is closely related to anomaly of global land surface temperature, being slightly positive in 1997 and 1998 (<0.2 Gt C year^{-1}) and strongly positive in 1992, 1996 and 1999 over the last decade. These results agree quite well with independent inversion studies [*Allison et al*. this volume].

We also calculated the annual gross primary production, net primary production and net ecosystem production of 11 different land biomes from 1900 to 2000. Results show that changes in net ecosystem production of most biomes are largely driven by changes in net primary production that is quite sensitive to increasing CO_2 concentration (or so-called CO_2 fertilization). The CO_2 fertilization effect is strongest in the tropical rainforest and not significant in the tundra (see Fig. 1). Without the observed increase in atmospheric CO_2 concentrations after 1970's, the net ecosystem production of global terrestrial biosphere would be negative (or a source), the tropical rainforest and savanna would have become carbon sources rather than sinks, because of the increase in land surface temperature.

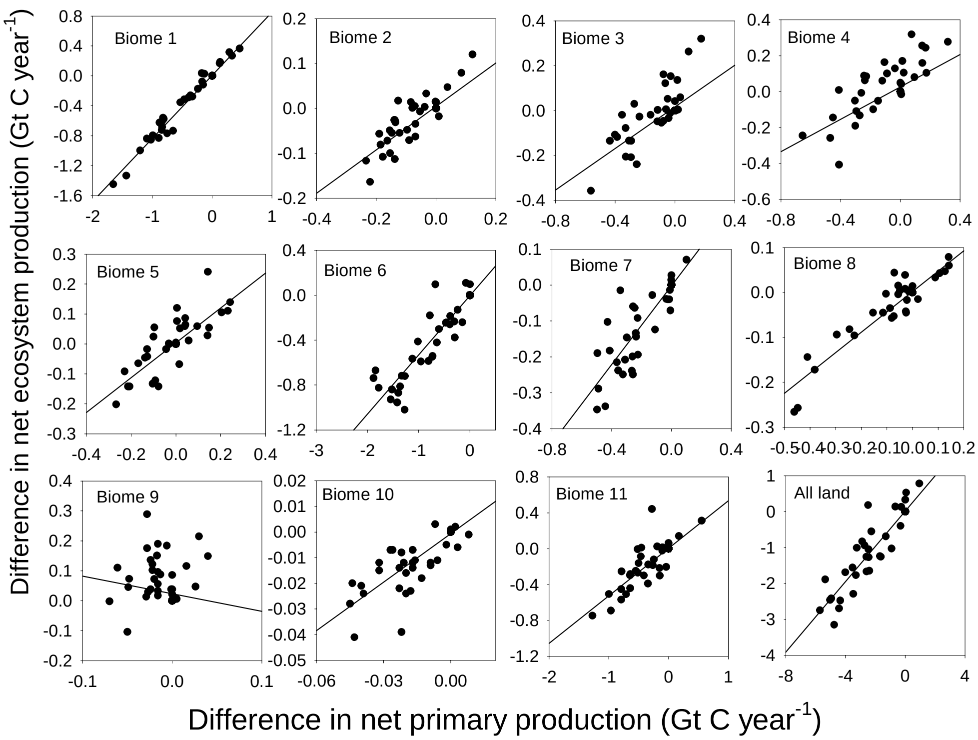

Fig. 1. Differences in net ecosystem production and net primary production between Run2 and Run1 from 1970 to 1999 for all 11 biome types and all biomes together. The 11 biomes are: broad-leaf evergreen tropical rainforest (1), broad-leaf deciduous forest (2), broad-leaf and needle-leaf forest (3), needle-leaf evergreen forest (4), needle-lead deciduous forest (5), savanna (6), perennial grassland (7), broad-leaf shrubs (8), tundra (9), bare soil and desert (10) and agricultural or C3 grassland (11).

REFERENCES

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