C_4 VEGETATION COVERAGE AND PHOTOSYNTHESIS IN SOUTH AMERICA: SEASONAL AND INTERANNUAL VARIATIONS

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ABSTRACT
We build upon a previous approach to predict C_3 and C_4 fractions on the land surface using new higher resolution satellite datasets on vegetation growth form and crop type coverage. The approach relies upon the near-universal restriction of C_4 photosynthesis to the herbaceous growth form and the differing performance of C_3 and C_4 plants in various temperature and radiation regimes. MODIS-derived data provide detailed information on growth form composition (%herbaceous, %woody, and %bare for each grid cell). Precipitation and temperature variations are derived from station data climatologies. Combining these data with MODIS-derived NPP fields from 2001, we predict latitudinal variations in C3 and C_4 photosynthesis for South America. These variations will be discussed in the context of the global carbon cycle and the difficulty they pose for interannual inversion studies using global CO_2 and $\delta^{13}C$ atmospheric data.

INTRODUCTION
The photosynthetic pathway employed by plants is a crucial distinction for modeling biosphere-atmosphere CO_2, $^{13}CO_2$, and $CO^{18}O$ exchanges, and for understanding the response of vegetation to global change because of the different functional responses of C_3 and C_4 plants to nitrogen, radiation, and temperature. C_4 plants make up a large proportion of global crops, such as the corn belt of the US Great Plains and the numerous maize/sorghum/tef cropping regions of Africa. Finally, the C_3:C_4 composition of the terrestrial biosphere is likely to be changing as a result of CO_2 fertilization (which primarily affects C_3 plants) and land use/cover changes which exchange one pathway with another (such as cutting a C_3 tropical forest and replacing it with C_4 pasture grasses, or woody encroachment, which in many of the areas in the American Southwest involves the invasion of C_4 grasslands by C_3 shrubs.

RESULTS
Global maps of C_3 and C_4 crop percentages

The percentage of C_3 and C_4 crops is required to predict the C_3 and C_4 fractions of the land surface, as the planting of crop types does not always follow the climate rules used to predict C_3 or C_4 dominance in natural grasslands and this effect must be accounted for (*Still et al.* 2004). C_4 corn (maize) is one of the top three agricultural crops in the world, and is responsible for the nutritional well being of several hundred million people and many animals that consume it as silage or in other forms (*Leff et al*. 2004). Additionally, there are several other important C_4 crops, including sorghum, sugarcane, millet, and tef. Thus, a basic and crucial step in predicting C_3 and C_4 vegetation and carbon fluxes globally is to map the distribution of C_3 and C_4 crops. Figure 1 is a global map of C_3 and C_4 croplands.

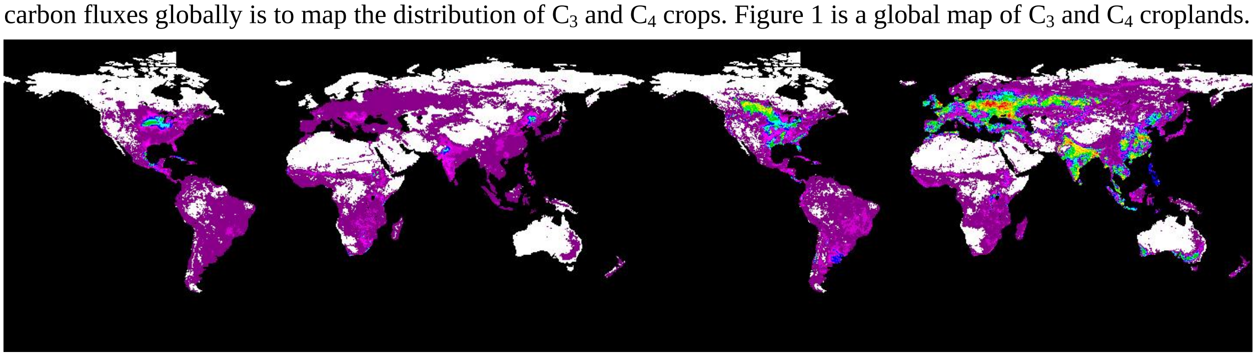

Fig. 1The percent of croplands that are C4 (left panel) or C3 (right panel). Crop type was determined from the maps of *Leff et al.* (2004), and a C4 or C3 designation was then assigned to each crop type based on known pathway characterizations. The ‘corn belt’ in the North American Great Plains shows up rather well in the left panel.

C_3 and C_4 cover and NPP in South America

Figure 2 is the predicted C_3 and C_4 vegetation percentage for South America. As can be seen in this figure, C_4 vegetation is concentrated in the cerrado grassland and savanna regions south and east of the vast Amazon forest. There is also a sizable C_4 component to the savanna and grassland biomes north of the forest such as the Gran Sabana of Venezuela.

Figure 3 is mean annual NPP for South America in 2001. The average NPP for C_3 and C_4 vegetation across South America is shown in Figure 4. The highest average C_4 NPP is in Roraima and the Gran Sabana region north of the Amazon forest, where NPP and the C_4 fraction are both high (see Figs. 3 and 4). The average NPP for C_3 vegetation increases sharply at 15 °S near the cerrado-forest border and peaks at the equator. From inspection of Figures 3 and 4, it is apparent that there are very few C_4 plants right at the equator (lowland moist tropical forest) and the NPP is very high in this latitude band.

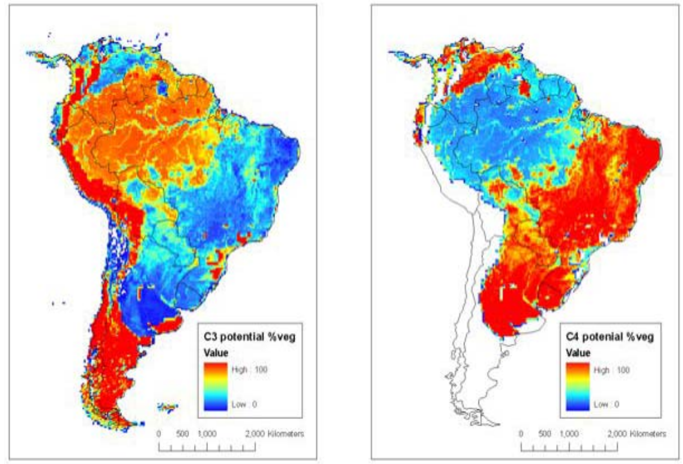

Fig. 2. The percentage of vegetation that uses the C_3 photosynthetic pathway (left panel) and the percent that uses the C_4 photosynthetic pathway (right panel) in South America.

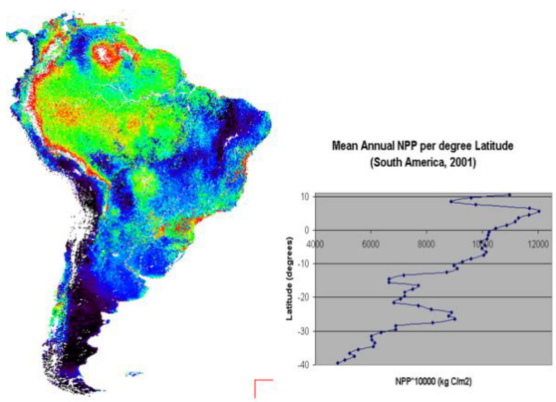

Fig. 3. Mean annual MODIS NPP for South America at 1km (left) and a cross-section of average NPP by latitude band multiplied by 10,000 (right)

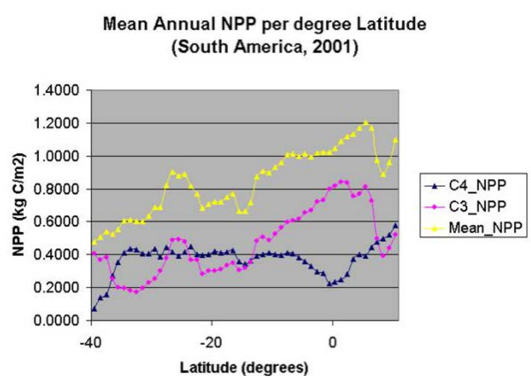

Fig. 4. C_3 and C_4 average NPP per latitude band (kg C/m^2) in South America. Mean annual NPP was obtained from the MODIS product.

REFERENCES

Leff B, Ramankutty N, Foley JA. Geographic distribution of major crops across the world. *Glob. Biogeochem. Cycles 18* (1), 2004.

Still CJ, Berry JA, Collatz GJ, and RS DeFries. The global distribution of C_3 and C_4 vegetation: carbon cycle implications. *Glob. Biogeochem. Cycles 17*(1), 2003.