LCLUC Abstract

Case Studies and Diagnostic Models of the Inter-annual Dynamics of Deforestation in Southeast Asia: is the missing sink for carbon in land cover change?

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This proposal will develop regional research on the dynamics of land use and cover change in Southeast Asia in collaboration with a team of regional scientists who have been working together since 1993. The proposal focuses on merging satellite remote sensing data from existing NASA programs, in particular the Landsat Pathfinder project, with new remotely sensed data and socio-economic data to improve our understanding the inter-annual dynamics of deforestation, regrowth and a suite of other land use transitions in this important region. This work will lead toward the development of empirical diagnostic models of the deforestation process and improve our understanding of the causes of deforesation. Models which result from this research will capture the fine spatial and temporal patterns of deforestation and will be better able to compute future trends in deforestation. This research will greatly improve terrestrial ecosystem and carbon cycle models and help ellucidate the cause of dampened biogenic source terms observed in inter-annual measurements of atmospheric CO2 and O2 for the tropics. Measurements from remote sensing data and socio-econometric modeling of the controls on rates of deforestation and abandonment on an annual basis from 1986 to 1994 will ellucidate the role of land use change as a missing sink for carbon.

OVERALL RESEARCH RATIONALE

Tropical deforestation is an important source of greenhouse gases, but large uncertainties in the exact magnitude exist due to imprecise data on the rates of deforestation in a few key regions of the tropics, particularly Southeast Asia. In recent years there has been much progress in acquiring and analyzing satellite data from Landsat and Spot to better quantify the average annual rate of deforestation over the last 10-20 years. NASA's Landsat Pathfinder project, the UN Food and Agriculture Organization's Tropical Forest Assessment, and the European Union's TREES project have all contributed to improving the measurements of the rate of deforestation using decadal or semi-decadal estimates. The Landsat Pathfinder Project, for instance, estimated the rate of deforestation in Southeast Asia between 1973 and 1985 and 1985 and 1992 using complete inventories of Landsat data at each of these dates.

Although these estimates provide a sound basis for constraining the relative magnitude of the deforestation flux over a timeframe consistent with most previous modeling efforts, it is also important to obtain interannual rates of deforestation to be used in conjunction with new interannual constrained source-sink models (e.g. Ciais et al. 1995, Keeling et al. 1995, Bender et al. 1996, Keeling et al. 1996).

The global budget for sources and sinks of carbon deduced from changes in annual atmospheric CO2 or O2 measurements suggest that the tropics are neither a strong source nor a strong sink (Keeling et al. 1996). Ciais et al. (1995) estimate that the northern tropics are a source, but the southern tropics are a small sink. They propose two explanations for the sink-to-neutral magnitude: (i) an increase in tropical Net Ecosystem Production to offset deforestation sources, and (ii) evidence for a combination of reduced rates of deforestation and increased regrowth of previously cleared land "which underscore the uptake of carbon by recovering forests on land abandoned by shifting agriculture and also suggest reduced clearing rates based on satellite analyses".

Such observations are somewhat inconsistent with interdecadal deforestation data from satellites suggest that tropical deforestation has contributed to a significant net source of carbon. One important explanation is that there are significant interannual differences in the rates of deforestation leading to periods of asynchrony in the relative contribution to the net flux from clearing vs. regrowth. In this scenario two important conditions must be met: (1) large interannual departures in rates of deforestation from the decadal mean values reported by Pathfinder results, and (2) abandonment of land to secondary forests which accumulate carbon is an important part of the deforestation process, accounting for large areas. In years in which deforestation rates are greatly less than the decadal mean, and with the large abundance of areas of secondary succession and forest regrowth due to high rates of abandonment in previous years we would expect to see a significant dampening of the carbon source computed from the decadal mean data alone.

RESEARCH QUESTIONS ADDRESSED BY THIS PROPOSAL

This proposal will be constructed around two overarching research questions:

1. Are the inter-annual dynamics and rates of deforestation and abandonment to secondary forest significantly different than the decadal mean in Southeast Asia, and can this account for a dampening of the biogenic source of carbon apparent in annual observations of atmospheric carbon dioxide and oxygen?

2. Through the integration of socioeconomic and satellite data and the development of dynamic deforestation models, can we improve our understanding of the dynamics of deforestation in the tropics and the various controls (proximate and distant determinants) on rates of deforestation and regrowth and land use transition sequences?

The project is focused on global change research related to the global carbon cycle, and is thus related to the programmatic objectives of NASA's Earth Science Enterprise, but it concentrates heavily on the specific aspects of land use and cover change rather than biogeochemistry. The results of this work will couple to biogeochemistry and carbon cycle models, but will focus on developing new insights into causes of the fine scale spatial and temporal patterns of cover change. We will use empirical observations from satellites and couple these to integrated models. We propose our research around a framework of Case Studies in intensive study sites and regional analysis for large-scale integration of results.