APPARENT TRENDS IN PHOTOSYNTHETIC CAPACITY OF MONSOON ASIA FROM 1982 TO 2002

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ABSTRACT

The rapid economic growth of Monsoon Asia raises concerns about the future of carbon stored in the terrestrial ecosystems of the region, especially in connection with climate change [*Tian et al.*, 2003; *Canadell et al.*, 2002; *Oikawa and Ito*, 2001; *Esser*, 1995]. The regional carbon budget for 1980s suggests that Monsoon Asia as a whole acted as source [*Tian et al.*, 2003], although some parts of the region acted as sink. Here we provide some evidence from satellite data that photosynthetic capacity of the region changed in the manner that suggests similar conclusion. Comparing the period 1982-1992 and the period 1992-2002, we found that the photosynthetic capacity of the territory generally decreased in the forest zone and increased in the non-forest zone of the region.

APPROACH

We characterize photosynthetic capacity of a territory by the area covered with photosynthetically active vegetation (PAV) and introduce a grid variable, f_{PAV}, which stands for the fraction of a grid cell covered with PAV. (Grid, here, means geographic grid of half-degree resolution.) Deciduous plants are leafless during the dormant season, and so f_{PAV} may vary on seasonal basis. The amplitude enlarges with the ratio between deciduous and evergreen species. The minimal value of f_{PAV} gives the fraction of a grid cell covered with evergreen vegetation. The maximal value gives the fraction of the cell that covered either with deciduous or evergreen vegetation and, thus, tells us which fraction of the cell is vegetated.

The changes in f_{PAV} were tracked by using monthly values of AVHRR-NDVI for the period from July 1981 to December 2002 that were recently compiled into a public data set, so called GIMMS-NDVI [see *Slayback et al*., 2003 and references therein]. The advanced radiometers of very high resolution (AVHRRs) measure reflectance of the Earth surface in the 0.5-0.7 μm range and in the 0.7-1.1 μm range of light wavelengths. The difference in reflectance is expressed in the form of normalized difference vegetation index (NDVI), which is close to zero for bare ground, and comprise to 0.7 or higher for PAV, depending on the fraction of photosyntetically active radiation (PAR) it absorbs. In other words, NDVI of a grid cell should correlate to $f_{PAR} \times f_{PAV}$, where f_{PAR} is the fraction of incident PAR absorbed by PAV. In many cases the changes in f_{PAR} are minor [*Alexandrov and Oikawa*, 1997], and thus one may assume that the changes in f_{PAV} are proportional to changes in NDVI.

We calculated average monthly values of GIMMS-NDVI for two 11-year periods: from 1982 to 1992 and from 1992 to 2002, and used them to evaluate the trends in photosynthetic capacity of the region, characterized by $\overline{f}_{PAV} = \sum_{m=1}^{12} f_{PAV}(m)\,u(T_m)$ where T_m is the monthly temperature, and u is a step function: $u=1$, when $T_m>0$, otherwise it is equal to zero. In addition, we evaluated the trends in the area covered with evergreen vegetation, characterized by $\breve{f}_{PAV} = \min\{ f_{PAV}(m) \mid m \in \{1, 2, \ldots, 12\}, T_m > 0\}$ and in the vegetated area, characterized by $\widehat{f}_{PAV} = \max\{ f_{PAV}(m) \mid m \in \{1, 2, \ldots, 12\}\}$.

RESULTS

The results of calculations (Table 1) show that the size of vegetated area decreased in the forest zone and seemingly support the concerns that lands cleared from forest were in the end converted to fallow or degraded shrublands, not to croplands [*Houghton*, 2002]. The positive shifts in $\widehat{f}_{PAV}$, which are widespread in the non-forest zone, may be a combined result of favorable climatic variations and changes in land management. Comparing the 11-year periods we filter out the effects related to short-term monsoon variability, but this cannot exclude the effects related to “monsoon epochs”. The positive shifts in $\breve{f}_{PAV}$, common in the non-forest zone, were supposedly induced by this long-term monsoon variability that now favours encroachment of trees and shrubs into grasslands. It is worth to mention that $\breve{f}_{PAV}$ increased also in many parts of the forest zone, that is to say, the remained forests became more evergreen. This may be a result of intensified forest management that normally favors evergreen species. Nevertheless, the positive shifts in $\breve{f}_{PAV}$ seemingly cannot compensate the negative shifts in $\widehat{f}_{PAV}$: the average photosynthetic capacity generally decreased in the forest zone.

Table 1. The percentage of land where the positive (negative) shifts in f_{PAV} are apparent..

Pattern	Forest zone	Non-forest zone
$d\widehat{f}_{PAV} > 0.005$ ($d\widehat{f}_{PAV} < -0.005$)	21% (62%)	49% (18%)
$d\breve{f}_{PAV} > 0.005$ ($d\breve{f}_{PAV} < -0.005$)	53% (27%)	55% (6%)
$d\bar{f}_{PAV} > 0.005$ ($d\bar{f}_{PAV} < -0.005$)	24% (37%)	55% (7%)

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