J. Geogr. Sci. 2010, 20(3): 323-332
DOI: 10.1007/s11442-010-0323-6

Spatial and temporal variation of global LAI during 1981–2006

LIU Siliang[1,2], *LIU Ronggao[1], LIU Yang[1,2]

1. Institute of Geographic Sciences and Natural Resources Research, CAS, Beijing 100101, China
2. Graduate University of Chinese Academy of Sciences, Beijing 100049, China

Abstract: Earth is always changing. Knowledge about where changes happened is the first step for us to understand how these changes affect our lives. In this paper, we use a long-term leaf area index data (LAI) to identify where changes happened and where has experienced the strongest change around the globe during 1981–2006. Results show that, over the past 26 years, LAI has generally increased at a rate of 0.0013 per year around the globe. The strongest increasing trend is around 0.0032 per year in the middle and northern high latitudes (north of 30°N). LAI has prominently increased in Europe, Siberia, Indian Peninsula, America and south Canada, South region of Sahara, southwest corner of Australia and Kgalagadi Basin; while noticeably decreased in Southeast Asia, southeastern China, central Africa, central and southern South America and arctic areas in North America.

Keywords: global change; leaf area index; spatiotemporal variation; hot-spot areas

1 Introduction

Earth is always changing. However, many evidences have shown that recent human actions accelerated these changes and some changes may be irreversible (IPCC, 2007). These changes would seriously affect our lives so that they are concerned by people from various disciplines. Knowledge about where changes happened is the first step to understand what has led to these changes and what steps should be taken to control them. Vegetation covers three-fourths of the Earth's land surface, and plays a key role in global hydrological, biochemical cycles and energy balance. In the context of global change, vegetation has changed as it responds to rising temperature, shifting precipitation patterns and other factors (IPCC, 2007). This vegetation change would alter global matter and energy cycle, and has feedback effects to climate. Owing to uneven distribution of natural and anthropogenic impacts and differential response of different vegetation types, the spatial distribution of the change is stratified. Where changes happened? Which place has experienced the most dramatic change? And what kind of change has occurred? The answers to these problems are important for

Received: 2009-08-07 **Accepted:** 2009-12-18
Foundation: 863 Program, No.2007AA12Z158; National Science & Technology Pillar Program, No.2006BAC08B04; 2008BAK50B06; 2008BAK49B01
Author: Liu Siliang (1986–), MA Candidate, specialized in quantitative remote sensing. E-mail: lslrsgis@gmail.com
***Corresponding author:** Liu Ronggao, E-mail: liurg@igsnrr.ac.cn

global environmental research.

Satellite remote sensing serves as the most effective means to track the changes of earth with its distinct advantage in collecting global data with every day since the 1970s. AVHRR Normalized Difference Vegetation Index (NDVI) series were employed as the proxy to study long term variation of vegetation at global or continental scale. Plant growth in the northern high latitudes was found increased during 1981–1991 from GIMMS NDVI and PAL NDVI data sets (Myneni *et al*., 1997; Myneni *et al*., 1998). The subsequent work confirmed this finding using NDVI from 1981–1999 (Lucht *et al*., 2002; Slayback *et al*., 2003), and suggested that temperature rising is probably the primary cause for vigorous vegetation growth in the northern high latitudes (Zhou *et al*., 2003; Zhou *et al*., 2001). Later, Xiao and Moody (2005) correlated global vegetation activities with climate using NDVI from 1981–1998, and identified regions highly controlled by temperature and precipitation. All these studies employed NDVI as the indicator of vegetation growth status. However, different sensors have distinct spectral responses which affect NDVI value (Trishchenko *et al*., 2002). And significant artificial anomalies within NDVI were found owing to orbit drift and illumination effects (Cuomo *et al*., 2001; Sobrino *et al*., 2008). In addition, these studies only analyzed the data before 2000.

LAI, defined as half the total leaf area per unit ground (Chen and Black, 1992), is directly linked to vegetation activities and comparable among different ecosystems. It has removed the effects of spectral response, illumination and orbit drift during data acquisition. It should be better, at least theoretically, than NDVI as the indicator of vegetation status. The objective of this paper is to use LAI to estimate global vegetation variation trend and identify hot-spot areas of this change during 1981–2006. First, temporal variation of global leaf area in this period is presented. Then, geographic distribution of global LAI trend over the 26 years is mapped, and the hot-spot areas with extreme trends are identified.

2 Method

A 26-year LAI data record is generated by a retrieval algorithm based on 4-Scale model, at 8 km resolution and a bimonthly (half a month) time step, from July 1981 to December 2006. The spatial extent is 63°S–90°N, 180°W–180°E. All continents except Antarctic are included in the data record. The algorithm uses GIMMS NDVI (Tucker *et al*., 2005) and UMD land cover (Hansen *et al*., 2000) as input. Specific description of the algorithm is given by Deng *et al*. (2006) and Liu *et al*. (2007).

Let $LAI(Y, HM, L, C)$ be LAI of pixel at line L, column C, in bimonth HM, and year Y. The average annual LAI is calculated as

$$\overline{LAI}(HM,L,C)=\frac{1}{N_y}\sum_{Y=1982}^{2006}LAI(Y,HM,L,C) \quad (1)$$

where N_y is the number of years ($N_y = 25$). The anomaly of LAI is defined as

$$LAI\_Anomaly(Y,HM,L,C)=LAI(Y,HM,L,C)-\overline{LAI}(HM,L,C) \quad (2)$$

The average LAI of a certain latitudinal zone is calculated as

$$\overline{LAI}(HM)=\frac{1}{N_y}\frac{1}{N_{LS}}\frac{1}{N_c}\sum_{Y=1982}^{2006}\sum_{L=L_1}^{L_2}\sum_{C}LAI(Y,HM,L,C) \quad (3)$$