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Remote sensing based forest phenology data of Northeast China (2000-2010)

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Abstract: Phenology is a discipline and comprehensive indicator of climate and environment changes. Forest phenology is a comprehensive biological index to reflect the influence of short-term or long- term climate change on forest growth stages. With the aid of remote sensing technology, we develop a model to calculate the data from phenological observation points into region scale. MODIS provides time- series information both in seasonal and annual changes to study the phenology. Based on MODIS Enhanced Vegetation Index (EVI) from 2000-2010, we extracted forest phenological variables using percentage thresholds method in Northeast China, which include start of growing season (SOS), end of growing season (EOS) and length of growing season (LOS). The phenological data from published papers and field observed data in the same area were used to validate the results. The validation indicates that forest phenophase from MODIS EVI data is feasible.

Keywords: MODIS EVI; forest; phenology; Northeast China

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1 Introduction

Forest phenology products based on MODIS Enhanced Vegetation Index (EVI) is the important achievements on remote sensing phenological monitoring in Northeast China, where the forestry change is more sensitive in global and regional climate change[1-3]. The dataset of forest phenology products of Northeast China (2000-2010) is useful for monitoring the vegetation response to the climate change.

2 Dataset description

The descriptions of the dataset of remote sensing based forest phenology data of Northeast China (Forest phenology products_NE China for short) are recorded. These information include the dataset full name, dataset short name, corresponding author, authors, geographical region of the dataset content, year of the dataset, number of the dataset tiles,

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Table 1 Summary of the forest phenology products_NE China metadata

Full name of the dataset	Remote sensing based forest phenology data of Northeast China (2000-2010)		
Short name of the dataset	Forest phenology products_NE China		
Corresponding Author	YU Xinfang (yuxf@igsnrr.ac.cn)		
Authors	YU Xinfang, Institute of Geographic Sciences and Natural Resources Research, CAS. yuxf@igsnrr.ac.cn ZHUANG Dafang, Institute of Geographic Sciences and Natural Resources Research, CAS. zhuangdf@lreis.ac.cn WANG Qiankun, Institute of Geographic Sciences and Natural Resources Research, CAS; Southwest Forestry University, wqkone.2@163.com		
Study Area	The study area is in the Northeast China (115°09′-135°52′E and 38°72′-53°55′N), including Jilin, Heilongjiang, Liaoning provinces and Hulunbeir, Xiangan, Tongliao and Chifeng districts in eastern Inner Mongolia		
Year of the dataset	2000-2010		
Spatial Resolution	500 m		
Data Format	ARCGIS GRID	Dataset size	155 MB
Data publisher	Global Change Research Data Publishing and Repository. DOI: 10.3974/		
Date access and services platform	Global Change Research Data Publishing and Repository, Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences, http://www.geodoi.ac.cn National Data Sharing Infrastructure of Earth System Sciences of China, http://www.geodata.cn		
Academic editors	LIU Chuang, SHI Ruixiang, XU Xinliang, HE Shujin		
Data Sharing Policy	The authors of the dataset agree to publish the data here according to the Article I of Data Sharing Policy of the Global Change Data Publishing and Repository, which states that the dataset can be used freely for research, education, and decision making, any users for commercial uses should get formal permission from IGSNRR/CAS.		

dataset spatial and temporal resolution, dataset format and size, data publisher, data sharing platform and contact information, technical editors, foundation and the data sharing policy. Table 1 summarizes the main metadata elements of the Forest phenology products_NE China dataset.

3 Methods

3.1 The indicators of monitoring forest phenology by remote sensing

The study in phenological characteristics of remote sensing inversion is not the phenology of a single plant or plant specific community, but the pixel which is consisted of different plant[4-5]. Due to the integrated remote sensing target, the details of the plant phenology characteristics may be ignored. In the pixel phenology, which includes various plants, the contribution of individual plant phenology is reduced. The pixel's comprehensive is usually a general description of the beginning and end of the growing season data, rather than the more specific observations, such as the first lamina or germination time and so on. So remote sensing based phenological monitoring index is different from the ground phenological observations in point based, it is integrated index by ground observation indexes and the corresponding phenological characteristics of more generality[6-7]. Estimating the key phenological index from satellite remote sensing data usually includes growth start date, end date and length of growing season, etc[8-9]. The start of growing season (SOS) is the start date of the actively growing vegetation period, it refers to the date of the most plants begin to normal growth and development. The end of growing seasons (EOS) is the end date of the active vegetation growing. It refers to the date of the most plant cannot normal growth and the leaves begin to change color, which corresponds with the ground phenology of corresponding stage autumn leaves change color and leaves. The length of growing season (LOS) refers to the number of days during which the plant can grow. It is determined by the phases of start date and end date.

3.2 Methodology of forest phenology data development in Northeast China

The 8-day Land Surface Reflectance product (MOD09A1) from 2000 to 2010 was used in this study (EROS, USGS, https://lpdaac.usgs.gov/products/modis_products_table) [10]. MOD09A1 product contains three spectral bands (blue, red and near infrared, 841-875 nm) with a spatial resolution of 500 m. The Enhanced Vegetation Index (EVI) was calculated using these reflectance data.

Since EVI has improved the Normalized Difference Vegetation Index (NDVI) of certain defects, especially the atmospheric noise, background, saturation problem, it has a higher sensitivity than that of NDVI in high biomass areas[11]. The calculation formula of EVI is as follows[12]:

$$EVI = 2.5 \times \left(\frac{p_{nir} - p_{red}}{L + p_{nir} + C_1 p_{red} - C_2 p_{blue}} \right) \tag{1}$$

Where $C_1 = 6$, $C_2 = 7.5$, and $L = 1$, p_{nir}, p_{red} and p_{blue} is the reflectance of the blue, red and near infrared bands, respectively.

This study we used Double Logistic (D_L) model which offered by TIMESAT to fit the time- series data in this study. To calculate forest phenology individually, the forest zones of Northeast China were extracted from the region based on the 1:100,000 Land Use Map of China, 2000 (Data Center for Resources and Environmental Sciences, Chinese academy of sciences). Considering the regional characteristics of forest in Northeast China and basic rationales of the above methods, the percentage threshold method was used to identify forest phenology (Figure 1). The EVI thresholds of 0.2 and 0.27 were used to justify the start of growing season (SOS) and the end of growing season (EOS) respectively according to our previous studies. For a series of EVI in a given year, we detected the EVImax (maximum EVI) and the EVImin (minimum EVI) in the first half of the year. The SOS EVI value for a given pixel was calculated using the formula as

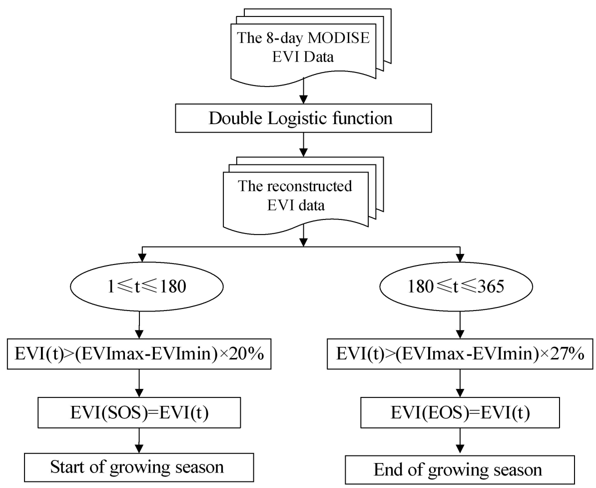

Figure 1 Flowchart of the percentage threshold method

$$\text{EVIstart} = \text{EVImin} + (\text{EVImax-EVImin}) \times 0.2 \tag{2}$$

Then, the day with EVIstart was determined as the SOS. The EOS was defined using the same method with equation as

$$\text{EVIend} = \text{EVImin} + (\text{EVImax-EVImin}) \times 0.27 \tag{3}$$

Where EVImin was the minimum EVI in the last half of the year.

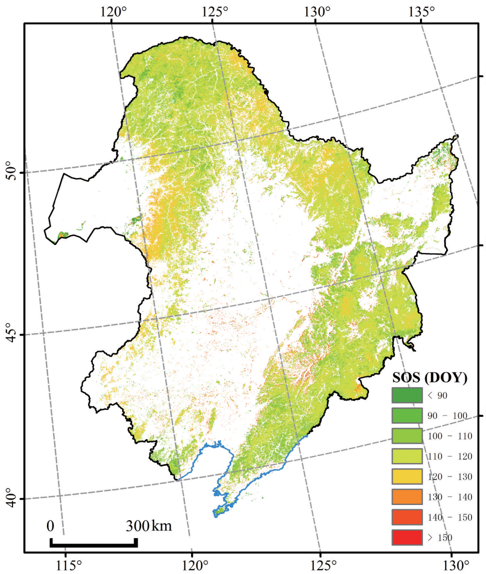

Figure 2 Map of forest SOS in Northeast China, 2010

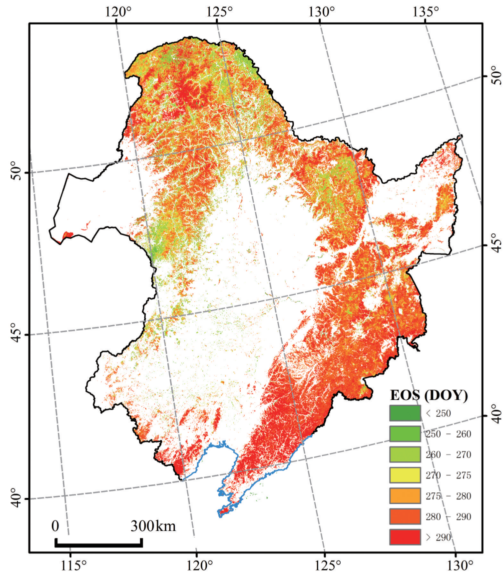

Figure 3 Map of forest EOS in Northeast China, 2010

4 Data products

Three groups of data were conducted from this research, they are start of forest growing season (SOS) data in Northeast China (Figure 2), end of forest growing seasons (EOS) in Northeast China (Figure 3), and length of forest growing season (LOS) in Northeast China (Figure 4). Total 33 data files covering 11 years from 2000 to 2010 in the remote sensing based forest phenology data of Northeast China[13].

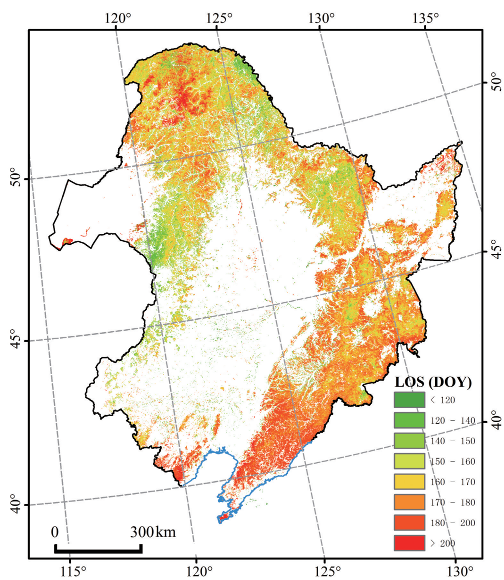

Figure 4 Map of forest LOS in Northeast China, 2010

5 Data validation

Based on the sample data of the experimental forest farm in Maoer Mountain (127° 30′- 127° 34′ E and 45° 20′- 45° 25′ N) in 1984, the birch leaf started on 16 May, leaves began on 27 September[14]. The other deciduous trees mostly leaf in mid- May and leaves in mid- September, were also considered to be samples. The data of Liangshui natural reserve in 1984 shows that larch began leaf in early May, leaves in mid-September. Korean pine leaf began in mid-June, mid-October deciduous and the other broadleaf began leaf in May, late while leaves from late September to early October. According to the phenological patterns drawn by Guozhi Sun, Larch at the Heilongjiang Xiaoxing'anling Mountain area began growing on 20 April to 10 May, birch growing began on 10 May to 20 May[15]. A phenology observation point (Mudanjiang observation point) data which used in Chen Xiaoqiu's article show that the average start of growing season from 1982 to 1993 is in the first 98 days of order date, and the average end of growing season is in the first 289 days of the order date[1]. It showed that the beginning dates of the growing season focus on the 9th to 12th dekad (deakd is the calendar unit in China, one month can be divided into three dekads, ten days for each usually), the end of the growing season focus on the 26th to 30th dekad. Comparing the above information, we see that the phenology based on MODIS data have certain comparability with the survey data. The validation indicates that forest phenophase from MODIS EVI data is feasible.

6 Conclusion

The time series of forest phenology products of Northeast China (2000-2010) is a useful indicator to monitor the vegetation response to the climate change. The methodology integrating time series of remote sensing EVI data and local knowledge and information in points is a practical way in monitoring a region based studies, especially in Northeast China, a sensitive region to climate changes.

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