Climatological Averaging and Application of Optical Vegetation Index based on MODIS

Jing Liang, Hanyu Lu*, Song Wu and Leiding Ding

College of Big Data and Information Engineering, Guizhou University, Guiyang 550025, China.
E-mail: luhanyu@163.com

Abstract. In view of the problem that the inversion of soil moisture is greatly affected by vegetation coverage, this paper uses MODIS vegetation products. By eliminating the data of cloud, rain, snow and other quality damage data, the global climate mean data set is compensated by the linear interpolation method after the data average processing. The results showed that NDVI vegetation index changed regularly with seasons, and the change rule was different in different regions. The single pixel interior can accurately reflect the variation trend of the vegetation index of different pixel NDVI in one year. It can describe the seasonal variation of vegetation in the global pixel, reflect the change of green degree, and meet the need to correct the accuracy of vegetation influence.

1. Introduction
Soil moisture is one of the key influencing factors in the climate system. It can affect photosynthesis, transpiration and emission of plants. It is widely used in hydrology, meteorology and agriculture[1-16]. However, in the process of soil moisture inversion, most of the inversion algorithms are mainly used in bare land or low vegetation coverage areas. The inversion process is limited by the accuracy of vegetation impact correction, especially in high vegetation coverage areas. In order to correct the effect of vegetation cover on the inversion process, most inversion algorithms need to input auxiliary vegetation information. But sometimes this method can not reliably reflect the seasonal change of vegetation information and may contain error information, and it is more complicated.

In this paper, four points in Guizhou were selected as the study area, and the NDVI vegetation index data were averaged by using MODIS vegetation data products. A set of NDVI vegetation index data set was generated, through which the vegetation index of each pixel in the world could be viewed conveniently and quickly. Compared with the method of input auxiliary data, the data set of vegetation index is more pertinent, eliminating the error data caused by uncertain factors, and time interpolation is carried out for the rejected data, which can meet the requirement of calculating vegetation optical thickness. Therefore, it can better reflect the global vegetation change law throughout the year and meet the needs of correcting the accuracy of vegetation impact.

2. Research Area and Data Selection

2.1. Choice of Research Area
Geomorphology of Guizhou belongs to the plateau mountainous area of Southwest China. The terrain of Guizhou is high in the West and low in the east. It inclines from the middle to the north, East and south. The average elevation is about 1100 meters. The mountainous area of Guizhou plateau is mostly mountainous, which is known as "eight mountains, one water and one field".Guizhou, located
in the hinterland of Southwest China, borders Guangxi, Yunnan, Hunan, Sichuan and Chongqing, and is the junction of Southwest China. Guiyang City, Zunyi City, Tongren City, Kaili City and so on, with a total area of 176,167,700 square kilometers, is a well-known mountain tourism province in China. The typical subtropical humid monsoon climate, small temperature changes, large area of rainfall and precipitation, rainy season is more obvious, due to the special topographic and climatic structure, the weather in Guizhou is generally more clear and cloudy, and the annual average temperature is kept at 15-18 degrees Celsius. The zonal vegetation in Guizhou Province consists of subtropical evergreen broad-leaved forest, evergreen broad-leaved forest, coniferous forest, deciduous broad-leaved forest and yew community.

2.2. Data Selection
Vegetation index is used to describe the number of vegetation, growth, coverage and other indicators of parameters, can roughly reflect the vegetation information. At present, vegetation index has developed many forms, such as normalized difference vegetation index (NDVI), enhanced vegetation index (EVI), Temperature Vegetation Drought Index (TDVI), ratio vegetation index (RVI). The normalized difference vegetation index (NDVI) has been widely used in\[6-8\].

In this paper, normalized difference vegetation index (NDVI) is applied to averaging vegetation index.

Among them, Pnir and r represent spectral reflectance, respectively, the bands are: near-infrared band and visible red band. Usually, normal vegetation can receive visible light radiation to reflect near infrared radiation, but the reception performance of abnormal vegetation affected by diseases, insect pests, drought and other factors is different from that of normal vegetation. The change of NDVI vegetation index can reflect the vegetation coverage and growth situation. From formula 1, we can know that the NDVI data range is \(-1, 1\) and the NDVI value will be negative only when disturbed by the rain, snow or cloud damage data; when the NDVI value is close to 0, it represents the vegetation coverage is very low or the surface is bare; when it is close to 1, it indicates the vegetation growth is good and the vegetation is bare, high vegetation coverage and luxuriant vegetation.

In the current field of remote sensing satellites, many satellites carry sensors that can obtain NDVI vegetation index data products. After summarizing and analyzing, it is found that the MOD13A2 data product of Terra satellite has 16-day time resolution and ground resolution as high as 1 KM. Conditions to meet the purpose of this study and design, this paper selected Terra Star MOD13A2 data products as research data.

| Table 1. MOD13A2 Product Features |
|-----------------------------------|
| Features                          | Description                  |
| Temporal Granularity              | 16-Day                       |
| Temporal Extent                   | February2000-Present         |
| Spatial Extent                    | Global                       |
| File Size                         | ~9 MB                        |
| Coordinate System                 | Sinusoidal                   |
| Datum                             | N/A                          |
| File Format                       | HDF-EOS                      |
| Geographic Dimensions             | 1200 km x 1200 km            |
| Number of Science Dataset (SDS)   | 12                           |
| Layers                            | 1200 x 1200                  |
| Pixel Size                        | 1000 m                       |
3. Experimental Method

3.1. Formatting the Title
Firstly, the downloaded MODIS data is preprocessed, which is divided into three steps: extraction, mosaic and transformation projection. MRT (MODIS Re-projection Tool) is used as a tool to extract three layers of data: NDVI vegetation index, Quality Labeling and acquisition time. After the splicing is done during the re-projection, selecting the nearest neighbor algorithm and converting sinusoidal projection into geographic projection, using the benchmark WGS84. The data dimension is transformed from 43,200 *16,800 to 36,000 *15,000, and a global pixel map is finally obtained through the MRT data processing tool.

3.2. Vegetation Index Climate Averaging
Climate averaging requires judging and deleting each pixel based on the quality identifier of the processed data, eliminating the impaired data and compensating with linear interpolation. The main process is as follows:
• The preprocessed data will be identified by MODIS quality control, and the data with large error will be eliminated.
• Generate the annual sequence in each MODIS pixel with the data that meets the quality requirement.
• Averaging the NDVI vegetation index with an average interval of 10 days.
• Interpolating the data of low quality by time interpolation.

4. Experimental Results and Analysis

4.1. Data Processing
To show the process of climate averaging, a pixel located in Guiyang, Guizhou Province (26.11 degrees north latitude, 107.11 degrees east longitude) is selected as an example. The data processing process is shown in Figure 1 (A-C).

Figure 1. Data processing process.

The scatter points shown in Figure 1A are the original data of all NDVI vegetation indices from 2000 to 2016 when the damage data are removed by quality control markers. The abscissa coordinates correspond to the composite date of NDVI vegetation indices. The red circle in Fig. 1b shows the result of climate averaging the NDVI vegetation index over the whole year at a 10-day interval. We found that the average point after the loss of a large number of, the reason can be broadly considered as the weather in Guiyang is changeable, three days without clear weather characteristics lead to Guiyang rainy and other damage data. After compensating by linear interpolation, the green circle in Fig. 1C shows the results of climate averaging after linear interpolation compensation.

According to the climatic mean processing structure, the NDVI vegetation index was mainly distributed between 0 and 0.4, and the low NDVI value in winter was maintained around 0.1. With the
change of season time, the NDVI exponent increased gradually in summer, and the maximum value was close to 0.4. Because NDVI vegetation index can basically replace the greenness of vegetation, the process in the map can reflect the process of vegetation growth and change to a certain extent. Normally, the nearer the value of NDVI (0-1), the lower the surface bareness or vegetation coverage; the nearer the medium value of NDVI (0.5), the more vegetation coverage is general or dense, and the main vegetation is grassland or shrub. High value means vegetation is luxuriant, showing tropical rain forest. It can be seen from the processing process that the NDVI value of the pixel is moderately low, mainly between 0.1 and 0.4. This is because the geographical location of Guiyang is located in the area where the vegetation is more abundant.

4.2. Single Pixel Climatic Averaging

In order to better display the results of climate averaging, this paper selects four pixels, which are located in the central, northeastern, southeastern and western parts of Guizhou Province. The climate averaging is shown in Figure 2.

As shown in Figure 2, the four pictures are single pixels located in Anshun, Kaili, Liupanshui and Tongren, respectively. Through the analysis of the data in the chart, it can be concluded that the average climatic results of Tongren pixel in Liupanshui and Tongren are good, less affected by the rainy season, and the average climatic results are ideal. In the rainy season, the maximum NDVI value is close to 0.8, but the NDVI value is a little scattered and maintained at 0.7 after data compensation, which indicates that the vegetation is flourishing. The NDVI value of Liupanshui pixel maintained at
0.5 after data compensation, but the NDVI value was dispersed greatly, especially in rainy season, which could be attributed to the annual heavy rainfall in this area. The above two pixel data climate average results can better reflect the growth process of local vegetation. In Anshun and Kaili pixels, the NDVI value maintained at 0.4 after removing and compensating the damaged data, indicating that the vegetation growth in the two areas was general, and the dispersion of NDVI value of the two pixels also existed, which could be attributed to heavy rainfall.

5. Conclusion
In this paper, four points in Guizhou Province were selected as the study area, the NDVI vegetation index of MODIS is used as a supplement, and its quality control label is used to eliminate the damage factors such as cloud, rain and snow, then, the global climate average data set with 10 days interval is formed by data averaging and linear interpolation, which is used to calculate the vegetation water content of each pixel in each period. This data set can well reflect the seasonal variation characteristics of vegetation, has good reliability, and does not need to update frequently. For a single pixel, the time series of NDVI vegetation index can be obtained by each pixel method, and the damage data can be effectively controlled, and good average data can be obtained by eliminating and interpolating compensation; for global pixels, the seasonal variation characteristics of vegetation information and the transfer of greenness can be reflected more intuitively.

6. Acknowledgments
Guizhou Natural Science Foundation Project ([2017] 2816, [2016] 5604, [2015] 3054, [2014] 7633, [2011] 3111); Guizhou Overseas Talents Project ([2015] 14, [2015] 20); Guiyang National High-tech Zones Talents Project ([2014] 012).

7. References
[1] Tian Hui, Wang Chenghai, Wen Jun, et al. Passive Microwave Remote Sensing of Soil Moisture in Mongolian Arid Area Based on Simplified Parameter Method[J].Journal of Geophysics, 2012, 55 (2): 416-427.
[2] Zhao Tianjie. Passive microwave remote sensing of soil moisture [D]. Beijing: Beijing Normal University, 2012, 6.
[3] Xu Lina, Niu Ruiping, Shang Xiuzhi. Inversion of soil moisture in the Three Gorges Reservoir area using temperature and Vegetation Drought index. Computer engineering and application, 2011, 47 (25): 235-244.
[4] Zhong Ruofei, Guo Huadong, Wang Weimin. Progress in retrieving soil moisture by passive microwave remote sensing [J]. Remote sensing technology and application, 2011, 20 (1): 50-57.
[5] Song Dongmei, Zhang Xi, Yang Xiuchun, et al. Spatiotemporal distribution characteristics of MODIS vegetation index in the source area of the Three Rivers [J]. Geographic study, 2011, 30 (11): 2068-2074.
[6] Chen Shulin, Liu Yuanbo, Wen Zuomin. A review of soil moisture retrieval by satellite remote sensing [J]. Progress in Earth Science, 2012, 27 (11): 1193-1203.
[7] T J Jackson, D Chen, M Cosh, et al. Vegetation water content mapping using Landsat data derived normalized difference water index for corn and soybeans [J]. Remote Sensing of Environment, 2004, 92 (2): 475-482.
[8] Xiamesinur Mason River, Hou Junying. Soil moisture inversion based on NDVI estimation of vegetation scattering[J]. Anhui Agricultural Science, 2013, 41 (29): 11652-11653.
[9] Shi Yu, Gong Hengrui, Zhang Xu, et al. [J] Retrieval of soil moisture from temperature and vegetation index of Fengyun No. 3. Surveying and mapping science, 2015, 40 (11): 64-84.
[10] Yan Nana, Wu Bingfang, Huang Huiping, et al. Extraction methods of vegetation state index and temperature condition index [J]. World Science and Technology Research and Development, 2005, 27 (4): 65-71.
[11] Y X Gu, H Eric, W Brian. Evaluation of MODIS NDVI and NDWI for vegetation drought monitoring using Oklahoma Mesonet soil moisture data [J]. Geophysical Research Letters, 2008, 35 (22): 1092-1104.
[12] Du Jiaqiang, Shu Jianmin, Wang Yuehui, et al. Comparison of MODISNDVI and GIMMSNDVI on the Qinghai-Tibet Plateau [J]. Journal of Applied Ecology, 2014, 25 (2): 533-544.

[13] Zheng Youfei, Huang Tunan, Duan Changchun, et al. [J]. Microwave Remote Sensing Soil Moisture Retrieval Algorithms and Products [J]. Jiangsu Agricultural Sciences, 2017, 45 (5): 1-7.

[14] Run Junjie, Qiao Mu, Zhou Hongfei, et al. Vegetation changes in Yili Valley of Xinjiang based on MODIS_NDVI [J]. Arid land geography, 2013, 36 (3): 513-519.

[15] Zuo Yushan, Wang Wei, Hao Yanli, Liu Hong. Study on land cover classification based on MODIS imagery - Taking Beijing-Tianjin-Hebei region as an example [J]. Progress in geographic science, 2014, 33 (11): 1557-1564.

[16] Chen Hongyan, Zhao Gengxing, Chen Jingchun, Wang Ruiyan, Gao Mingxiu. Remote sensing inversion of salinity in the Yellow River estuary region based on improved vegetation index [J]. Journal of Agricultural Engineering, 2015.