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1-km Grid NPP Dataset Covering Ecological Barrier Zone of China (2000–2015)

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Abstract: As the basis of ecosystem material and energy cycle, Net Primary Productivity (NPP) can reflect the carbon sequestration capacity of vegetation at regional and global scales, which is an important indicator to evaluate the quality of terrestrial ecosystem. Aiming at the production of NPP, based on the principle of light energy utilization rate model and coupled with remote sensing, meteorology, vegetation and soil type data, we conducted a modeling study on the ecosystem productivity of the national barrier zone. In the calculation of parameters, the photosynthetically-active radiation (APAR) was calculated from the data of MOD13A2 NDVI, vegetation map of China, total solar radiation, temperature and precipitation. Compared with other studies and models, the regional evapotranspiration model was used to simulate water stress, in which complex soil parameters are avoided and the operability of the model is enhanced. Taking APAR and actual light energy utilization rate (ε) as input variables of parameterized model-CASA model, the estimation of the national ecological barrier zone 1-km resolution Net Primary Productivity dataset from 2000 to 2015 was realized. Compared with MOD17A3 NPP data of 2000, 2005, 2010 and 2015, the two data have good consistency. The dataset is archived in .tif format (unit: gC m^{-2}), and the projection coordinate system is WGS_1984_Albers. The spatial resolution is 1-km, and the total size of compressed dataset is 53.8 MB.

Keywords: national ecological barrier zone; Net Primary Productivity; light energy utilization rate; CASA model; geographical research

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1 Introduction

Net Primary Productivity (NPP) refers to the total amount of organic matter produced by green plants in unit time and area in terrestrial ecosystem[1], that is, the difference between

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carbon absorbed by photosynthesis and carbon released by respiration[2]. It is the result of mutual adaptation of plant biological characteristics and external environment, and is the material and energy basis for the survival of heterotrophic organisms. As the core parameter of terrestrial ecosystem carbon cycle[3], NPP can not only represent the assimilation effect of the ecosystem on carbon[4], but also is an important index to evaluate the stability of ecological structure and function[5]. NPP is also the main factor to determine the carbon source/sink and regulate the ecological process[6]. Therefore, scholars attach great importance to the study of NPP, and global change and terrestrial ecosystem (GCTE) has identified NPP as one of the core contents of the research[7].

"Two Barriers and Three Belts" ecological barrier zone is an important part of the national ecological security strategic pattern. In response to the "two barriers and three belts" national ecological security barrier framework proposed by the government in the national major function oriented zoning, Fu *et al*.[8] described the scope of the national barrier zone on the basis of ensuring the integrity of the county and carried out a comprehensive assessment of ecosystem services from 2000 to 2010. The main purpose of this dataset is to construct NPP time series products of national barrier zone, to carry out research on trade-offs and synergies of ecosystem services, and to ensure the well-being of mankind. The national ecological barrier zone 1-km resolution Net Primary Productivity dataset (2000–2015) is an important output of ecosystem service science. It is also a vital digital resource for monitoring and evaluating NPP evolution of ecological environment and sustainable development of ecosystem. In this study, we introduced the detailed information of the data, the basic principles of the algorithm, and verified the accuracy of the data.

2 Metadata of the Dataset

The metadata of the dataset[9] are summarized in Table 1. It includes the dataset full name, short name, authors, year of the dataset, temporal resolution, spatial resolution, data format, data size, data files, data publisher, and data sharing policy, etc.

3 Methods

The production of national ecological barrier zone 1-km resolution Net Primary Productivity dataset (2000–2015) is based on a 16 day composite product of MOD13A2 1-km vegetation index[11], China surface climate data daily dataset (V3.0)[12], etc. Based on the CASA model, the quantitative output of NPP was obtained.

3.1 Study Area

The national barrier zone (22°45′N–53°34′N, 82°50′E–134°22′E) includes the ecological barrier of the Qinghai Tibet Plateau, the northeastern forest zone, the northern sand belt, Sichuan Yunnan-Loess Plateau ecological barrier and the southern hill and mountain belt[13]. The total area of the barrier zone is 3,114,874.36 km^2, accounting for about 1/3 of the total land area of China. It includes 18 provinces and 482 counties. The precipitation decreases from southeast to northwest, and the annual average temperature is −6 – 23 °C. The ecosystem types of the study area are diverse and the natural environment is complex[13–15].

3.2 CASA Model

The Carnegie Ames-Stanford Approach (CASA)[16] model based on the principle of light energy utilization was used to quantify the annual NPP in the national ecological barrier zone.

Table 1 Metadata summary of the dataset

Items	Description
Dataset full name	1-km NPP product in national barrier zone of China (2000-2015)
Dataset short name	NBZ_NPP_1km_2000-2015
Authors	Wang, X. F. AAS-5271-2020, The College of Land Engineering; the Key Laboratory of Shaanxi Land Consolidation Project, Chang'an University, wangxf@chd.edu.cn Wang, Y. AAS-5036-2020, The College of Land Engineering, Chang'an University, wangyi-changan134@163.com Yin, L. C. AAS-4914-2020, Key Laboratory of Land Surface Pattern and Simulation, Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences; University of Chinese Academy of Sciences,yinlichang3064@163.com
Geographical region	The provinces include Heilongjiang, Jilin, Qinghai, Gansu, Sichuan, Xinjiang, Inner Mongolia, Hebei, Liaoning, Tibet, Ningxia, Yunnan, Guangxi, Guangdong, Guizhou, Hunan, Jiangxi and Shanxi The northern sand belt (36°45′N–45°06′N, 75°50′E–124°18′E) The ecological barrier of the Qinghai Tibet Plateau (29°40′N–38°10′N, 82°50′E–105°5′E) Sichuan Yunnan-Loess Plateau ecological barrier (24°10′N–38°50′N, 99°05′E–114°25′E) The southern hill and mountain belt (22°45′N–27°10′N, 103°10′E–119°15′E) The northeastern forest zone (40°52′N–53°34′N, 118°48′E–134°22′E)
Year	2000–2015 Temporal resolution 1 year
Spatial resolution	1 km Data format .tif
Data size	53.8 MB (After compression) Projection coordinate system WGS_1984_Albers
Foundations	Ministry of Science and Technology of P. R. China (2018YFC0507300, 2019QZKK0405); Shaanxi Province (2018JM4016)
Data publisher	Global Change Research Data Publishing & Repository, http://www.geodoi.ac.cn
Address	No. 11A, Datun Road, Chaoyang District, Beijing 100101, China
Data sharing policy	***Data*** from the Global Change Research Data Publishing & Repository includes metadata, datasets (in the *Digital Journal of Global Change Data Repository*), and publications (in the *Journal ofGlobal Change Data & Discovery*). ***Data*** sharing policy includes: (1) ***Data*** are openly available and can be free downloaded via the Internet; (2) End users are encouraged to use ***Data*** subject to citation; (3) Users, who are by definition also value-added service providers, are welcome to redistribute ***Data*** subject to written permission from the GCdataPR Editorial Office and the issuance of a ***Data*** redistribution license; and (4) If ***Data*** are used to compile new datasets, the 'ten percent principal' should be followed such that ***Data*** records utilized should not surpass 10% of the new dataset contents, while sources should be clearly noted in suitable places in the new dataset[10]
Communication and searchable system	DOI, DCI, CSCD, WDS/ISC, GEOSS, China GEOSS, Crossref

This method can make use of remote sensing data and methods conveniently, and has less input parameters, so it has become one of the most popular NPP estimation models. The calculation equation is as follows:

$$NPP(x,t) = APAR(x,t) \times \varepsilon(x,t) = \left[SOL(x,t) \times 0.5 \times FPAR(x,t)\right] \times \left[T\varepsilon(x,t) \times W\varepsilon(x,t) \times \varepsilon_{\max}\right] \quad (1)$$

where *NPP* is the Net Primary Productivity (gC m^{-2} a^{-1}) of pixel *x* at time *t*, *APAR* is the photosynthetically active radiation absorbed by vegetation (MJ m^{-2} a^{-1}), which is estimated by the total solar radiation (gC m^{-2}) of *SOL* and the absorption ratio of vegetation fraction of photosynthetically active radiation (*FPAR*); and ε is the efficiency of converting photosynthetically active radiation into organic carbon (gC MJ^{-2}), which is calculated from the maximum light energy utilization rate (ε_{max}, taken as 0.389 gC MJ^{-2}), temperature stress ($T\varepsilon$) and water stress ($W\varepsilon$). Finally, the annual NPP is the sum of the NPP of each month in the same year.

3.3 Technology Route

In this study, we used remote sensing data, data from China meteorological station and various products in the project. The technical route is shown in Figure 1. In CASA model, APAR and ε are the most important parameters. As the driving factor of vegetation photosynthesis,

radiation data is determined by the total solar radiation and FPAR. Secondly, the actual and potential evapotranspiration of the region were calculated by using the regional actual evapotranspiration model proposed by Zhou[17] and the complementary relationship proposed by Boucher[18]. And they were used to describe the influence of available water conditions of vegetation on ε. Compared with other models, the parameters of the model are simple and is easy in operation. The influence of temperature on ε was calculated by NDVI and the optimal temperature derived from monthly average temperature. Finally, *APAR* and ε were used as the input factors of CASA model to quantify the annual NPP of the study area.

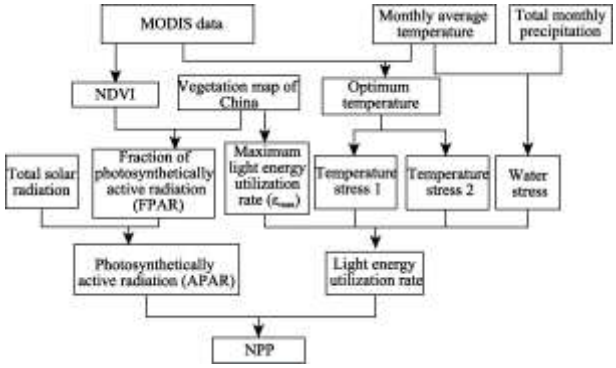

Figure 1 Technology route for development of the dataset

4 Results and Assessment

4.1 Data Results

Data NBZ_ NPP_ 1km_ 2000-2015 is the annual NPP of national barrier zone in .tif format from 2000 to 2015. The spatial resolution is 1-km, the unit is gC m^{-2}, and the projection coordinate system is WGS_1984_Albers, the total size of compressed data is 53.8 MB. After decompressing, the data can be applied in ArcGIS software.

The spatial distribution of NPP at 1-km resolution in 2015 is shown in Figure 2. The national barrier zone pans about 60 degrees in longitudes, and there are obvious differences in climate between regions, so the spatial distribution of NPP is quite different. In brief, the spatial distribution of NPP (2015) has the characteristics of high in the southeast and low in the northwest, with data range from 0–1,004 gC m^{-2}. The highest NPP was found in the southern hill and mountain belt, followed by the ecological barrier of the Qinghai Tibet Plateau, the northeastern forest zone and Sichuan Yunnan-Loess Plateau ecological barrier, and the lowest NPP was found in the northern sand belt. During the study period, NPP showed a slight upward trend (p=0.96).

From 2000 to 2015, the spatial variation of NPP in different regions was quite different. It shows a significant increase trend in Sichuan Yunnan-Loess Plateau ecological barrier and the northern sand belt (p<0.05), with an annual increase of 2.37 gC m^{-2} and 1.25 gC m^{-2}, respectively; however, in the northeastern forest zone, it shows a significant decrease trend (p<0.05), with an annual decrease of 2.23 gC m^{-2}. And there was no significant change of NPP in other areas.

4.2 Accuracy Assessment

In order to verify the accuracy of NPP dataset, we carried out the verification data collection from various sources. The validation data is from NASA[19], and MODIS17A3 NPP data in 2000, 2005, 2010 and 2015 were selected. MRT (MODIS Reprojection Tool) software was used to transform and calculate data. Each year, 54 data points were randomly collected, with a total of 270 NPP values, which were compared with the results of NPP data calculated in corresponding years in this paper (Figure 3). The results show that the difference between them was small (validation data range is 0–1,521.6 gC m^{-2}, simulation data range is 0–1,004.0 gC m^{-2}), the average deviation was about 260 gC m^{-2}, and the overall accuracy

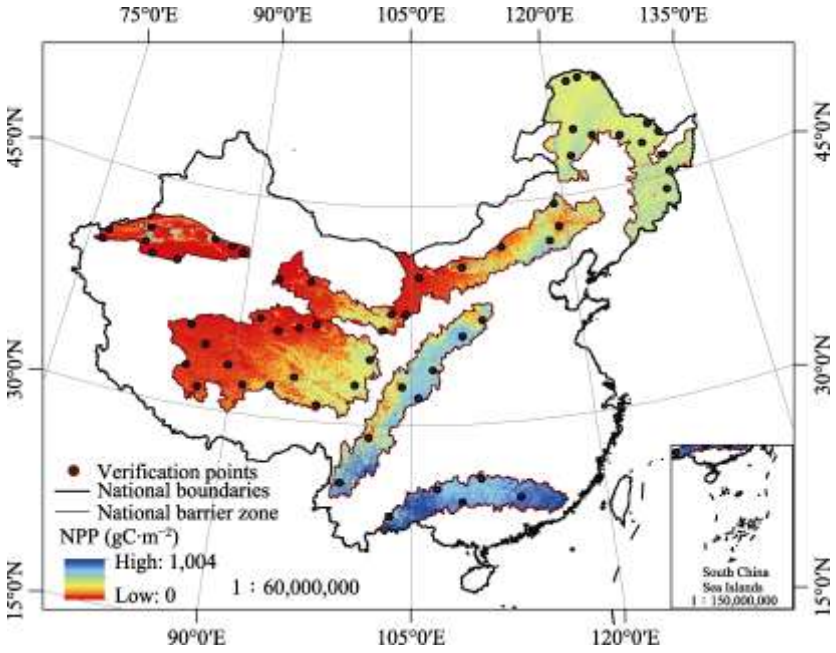

Figure 2 Map of national ecological barrier zone 1-km resolution NPP (2015)

(1 minus *RMSE* divided by the average NPP simulation data) was 81.47%. It can be seen from Figure 3 that the correlation between the validation value and the simulation value is high (R^2=0.94). Therefore, the NPP obtained under the technical process of this paper have high accuracy, which can accurately reflect the change trend of NPP in national barrier zone in recent years from a macro perspective.

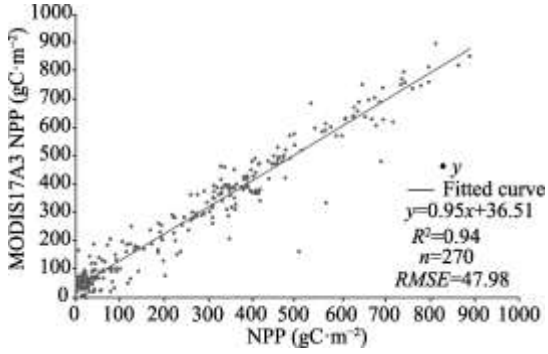

Figure 3 Comparative analysis with MODIS17A3 NPP data (Note: the points in the figure represent the comparison result with MODIS17A3 data, and the line represents the linear fitting result between the two data)

5 Conclusion

In order to construct the NPP time series product of national barrier zone, based on the data of remote sensing, meteorology and soil type to obtain photosynthetically active radiation (APAR) and actual light energy utilization rate (ε), a modeling study of NPP was carried out. Compared with the existing similar products, the dataset has high accuracy and can meet the design objectives. The Net Primary Productivity dataset of national barrier zone with 1-km spatial resolution from 2000 to 2015 shows the spatial distribution of NPP in different periods. It is helpful to study the ecosystem service under the background of global change and analyze the evolution of spatiotemporal pattern of carbon cycle in national ecological barrier area. The dataset can provide reliable basic data and information for comprehensive understanding and grasping the security situation of national ecological barrier area and sustainable development of ecosystem.

Author Contributions

Wang, X. F. designed the overall dataset development, designed the model and algorithm, did the data validation and wrote this data paper, Wang, Y. collected and processed the NPP data and wrote this data paper. Yin, L. C. collected and processed the NPP data.

References

[1] Zhang, Y. L., Qi, W., Zhou, C. P., *et al*. Spatial and temporal variability in the net primary production (NPP) of alpine grassland on Tibetan Plateau from 1982 to 2009 [J]. *Acta Geographica Sinica*, 2013, 68(9): 1197–1211.

[2] Mu, S. J., Li, J. L., Zhou, W., *et al*. Spatial-temporal distribution of Net Primary Productivity and its relation with climate factors in Inner Mongolia from 2001 to 2010 [J]. *Acta Ecologica Sinica*, 2013, 33(12): 3752–3764.

[3] Zheng, Z. T., Zhu, W. Q., Zhang, Y. J. Seasonally and spatially varied controls of climatic factors on Net Primary Productivity in alpine grasslands on the Tibetan Plateau [J]. *Global Ecology and Conservation*, 2019, 21: e00814.

[4] Chen, Y. Z., Tao, Y. W., Cheng, Y., *et al*. Great uncertainties in modeling grazing impact on carbon sequestration: a multi-model inter-comparison in Temperate Eurasian Steppe [J]. *Environmental Research Letters*, 2018, 13(7): 075005.

[5] Crabtree, R., Potter, C., Mullen, R., *et al*. A modeling and spatio-temporal analysis framework for monitoring environmental change using NPP as an ecosystem indicator [J]. *Remote Sensing of Environment*, 2009, 113(7), 1486–1496.

[6] Field, C. B., Behrenfeld, M. J., Randerson, J. T., *et al*. Primary production of the biosphere: integrating terrestrial and oceanic components [J]. *Science*, 1998, 281(5374): 237–240.

[7] IGBP Terrestrials Carbon Working Group. The terrestrial carbon cycle: implications for the Kyoto Protocol [J]. *Science*, 1998, 280(5368): 1393–1394.

[8] Fu, B. J., Wang, X. F., Feng, X. M., *et al*. National Barrier Zone Ecosystem Assessment [M]. Beijing: Science Press, 2016: 271–345.

[9] Wang, X. F., Wang, Y., Yin, L. C. 1-km NPP product in national barrier zone of China (2000–2015) [J/DB/OL]. *Digital Journal of Global Change Data Repository*, 2020. DOI: 10.3974/geodb.2020.03.10.V1.

[10] GCdataPR Editorial Office. GCdataPR Data Sharing Policy [OL]. DOI: 10.3974/dp.policy.2014.05 (Updated 2017).

[11] https://ladsweb.modaps.eosdis.nasa.gov/search/order/.

[12] http://www.cma.gov.cn/.

[13] Wang, X. F. National ecological barrier zone [J/DB/OL]. *Digital Journal of Global Change Data Repository*, 2020. DOI: 10.3974/geodb.2020.03.01.V1.

[14] Wang, X. F., Lesi, M. C., Zhang, M. M. Ecosystem pattern change and its influencing factors of "two barriers and three belts" [J]. *Chinese Journal of Ecology*, 2019, 38(7): 2138–2148.

[15] Yin, L. C., Wang, X. F., Zhang, K., *et al*. Trade-offs and synergy between ecosystem services in national barrier zone [J]. *Geographical Research*, 2019, 38(9): 2162–2172.

[16] Potter, C. S., Randerson, J. T., Field, C. B., *et al*. Terrestrial ecosystem production: a process model based on global satellite and surface data [J]. *Global Biogeochemical Cycles*, 1993, 7(4): 811–841.

[17] Zhou, G. S., Zhang, X. S. A natural vegetation NPP model [J]. *Chinese Journal of Plant Ecology*, 1995, 19(3): 193–200.

[18] Zhang, Z. M. Principle and Method of Calculating Evaporation [M]. Chengdu: Chengdu University of Science and Technology Press, 1990.

[19] http://ladswed.nascom.nasa.gov/.