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VIIRS/DNB Monthly and Yearly Nighttime Light Dataset in Beijing-Tianjin-Hebei Region (2013–2018)

Chen, M. L.[1,2] Cai, H. Y.[1*]

1. State Key Laboratory of Resources and Environmental Information System, Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences, Beijing 100101, China;
2. University of Chinese Academy of Sciences, Beijing 100049, China

Abstract: The new generation nighttime light data, which sensed by the Visible Infrared Imaging Radiometer Suite Day/Night Band (VIIRS/DNB) are severely subject to stray light, resulting in the appearance of a large number of missing pixels in mid and high latitudes, especially in the summer. Therefore, to obtain the consecutive spatial-temporal nighttime light data and promote the application of nighttime light data, this study applied the cubic Hermite interpolation algorithm to interpolate the missing values from May to August in Beijing-Tianjin-Hebei region. This dataset includes the monthly and yearly average subsets. The time span is 2013–2018, the spatial resolution is 15″, and the data size is 292 MB. Moreover, since the ephemeral light was filtered out, this dataset is more applicable tostable socio-economic research, rather than ephemeral light research. The research results related to the dataset were published in *Progress in Geography* (Vol. 38, No. 1, 2019).

Keywords: VIIRS/DNB nighttime light; cubic Hermite interpolation; missing pixels; monthly average composite; Beijing-Tianjin-Hebei region; Progress in Geography

1 Introduction

The new generation nighttime light (NTL) data, which sensed by the Visible Infrared Imaging Radiometer Suite Day/Night Band (VIIRS/DNB) are severely vulnerable to stray light, resulting in the appearance of massive distorting pixels in mid and high latitudes, especially in the summer (May to August)[1]. To address this problem, NOAA provided two versions of the NTL, denoted by the VCM (VIIRS Cloud Mask) and VCMSL (VIIRS Cloud Mask with Stray Light), respectively. Pixels contaminated by the stray light were eliminated in the VCM version, and therefore numerous missing pixels existed in this version. The VCMSL version co-

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***Corresponding Author:** Cai, H. Y. Y-8555-2019, State Key Laboratory of Resources and Environmental Information Sys-tem, Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences, caihy@igsnrr.ac.cn
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[2] Chen, M. L, Cai, H. Y. Monthly and yearly VIIRS/DNB nighttime light data based on cubic Hermite model in Beijing-Tianjin-Hebei region [DB/OL]. Global Change Research Data Publishing & Repository, 2019. DOI: 10.3974/geodb.2019.05.14.V1.

vers more data toward the poles after corrected the distorting pixels by a stray light correction procedure provided by Mills[2]. However, two significant imperfections exist in the VCMSL version. One is the absence of data in 2012 and 2013 in this version, and the other one is that the quality still need to be improved[2–3]. For example, radiation suddenly becoming low in some areas were found in the VCMSL version[4]. Thereby, interpolating missing values is importance for obtaining consecutive spatial-temporal NTL data and promoting its application.

Given the fact that the missing pixels tend to exist over a large area, interpolation based on temporal interpolation method is more suitable than spatial interpolation method. The cubic Hermite interpolation is one of the most prevalent temporal interpolation algorithms. This algorithm has the advantages of high accuracy and no overshoot[5–6]. Therefore, this algorithm was used to interpolate the missing pixels of the VIIRS/DNB NTL data in the summer (May to August). Furthermore, the Beijing-Tianjin-Hebei region is a representative economic and population agglomeration area in China, located in the middle latitude region and is contaminated by the stray light in the summer. Hence, this study mainly focused on interpolating missing pixels in this region, produced a monthly average data without missing pixels (here after called the interpolated NTL data), and synthesized annual average data on this basis.

2 Metadata of Dataset

The metadata of "Monthly and yearly VIIRS/DNB nighttime light data based on cubic Hermite model in Beijing-Tianjin-Hebei region"[7] is 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

3.1 Data

The original data of this study were the monthly VCM composites from 2012 to 2019. When interpolating the missing pixels in May to August based on the cubic Hermite interpolation method, the eight months before May and the eight months after August of the VCM data served as the original data. Taking 2015 as an example, monthly VCM data from September 2014 to April 2015, and September 2015 to April 2016 are the original data for interpolation.

Table 1 Metadata summary of "Monthly and yearly VIIRS/DNB nighttime light data based on cubic Hermite model in Beijing-Tianjin-Hebei region"

Items	Description
Dataset full name	Monthly and yearly VIIRS/DNB nighttime light data based on cubic Hermite model in Beijing-Tianjin-Hebei region
Dataset short name	VIIRS_DNB_Hermite_JJJ
Authors	Chen, M. L. Y-3945-2019, State Key Laboratory of Resources and Environmental Information System, Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences, chenml.19b@igsnrr.ac.cn Cai, H. Y. Y-8555-2019, State Key Laboratory of Resources and Environmental Information System, Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences, caihy@igsnrr.ac.cn
Geographical region	The Beijing-Tianjin-Hebei region
Year	2013–2018 Temporal resolution monthly and yearly
Spatial resolution	15″ Data format .tif Data size 292 MB
Data files	The dataset consists two subsets: One subset is yearly average product, the other subset is monthly average product

(***To be continued on the next page***)

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Items	Description
Foundations	Ministry of Science and Technology of P. R. China (2017YFC0503803); Chinese Academy of Sciences (XDA20010203, ZDRW-ZS-2017-4)
Data publisher	Global Change Research Data Publishing & Repository, http://www.geodoi.ac.cn
Computing Environment	MATLAB, campus license of Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences ArcGIS campus license of Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences
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 (data products), and publications (in this case, in the *Journal of Global 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[8]
Communication and searchable system	DOI, DCI, CSCD, WDS/ISC, GEOSS, China GEOSS

3.2 Algorithm Principle

Background noise and ephemeral light were not removed from the current VIIRS/DNB NTL data. Consequently, some pixels with negative values and abnormally high-valued existed in the original NTL data. The threshold method was used to eliminate the outliers. Pixels with negative values were reassigned to zero[9]. The biggest median value of the whole study period in the study area, 285 nW cm^{-2} sr^{-1}, was served as the up threshold. Pixels with a value larger than 285 nW cm^{-2} sr^{-1} were reassigned to that value.

The core idea of the cubic Hermite interpolation is to construct a polynomial no higher than cubic degree between each two adjacent nodes. Time nodes of a pixel are assumed to be $x=\{x_1,x_2,...,x_n\}$. Correspondingly, its radiations are assumed to be $y=\{y_1,y_2,...,y_n\}$. After calculating at the pixel level, the interpolation curve $f(x)$ will meet: (1) $f(x_i)=y_i,\ i=1,2,...,n$; (2) the polynomial between any two adjacent nodes is no higher than cubic degree; (3) satisfy the first derivative, but not necessarily the second derivative. that is, the curve should stay shape preserving[10], and the results would not exceed the maximum value of the original data. Calculations were accomplished by using MATLAB.

3.3 Data Processing

The technical flow of producing the monthly and yearly interpolated NTL data is shown in Figure 1. Taking 2015 as an example, the monthly VCM NTL data from September 2014 to April 2016 (except May to August 2015) in Beijing-Tianjin-Hebei region were collected as the original data. After the outliers being removed and the cubic Hermite interpolation calculation, the monthly interpolated NTL data from May to August 2015 were produced. On this basis, combining with monthly VCM NTL data in other months of 2015, the annual average NTL data of 2015 was synthesized.

4 Results and Validation

4.1 Data Products

The dataset consists of two subsets. One subset is the yearly average composite. Its time span is from 2013 to 2018. The other subset is the monthly average product, including monthly data of May to August of 2013 to 2018.

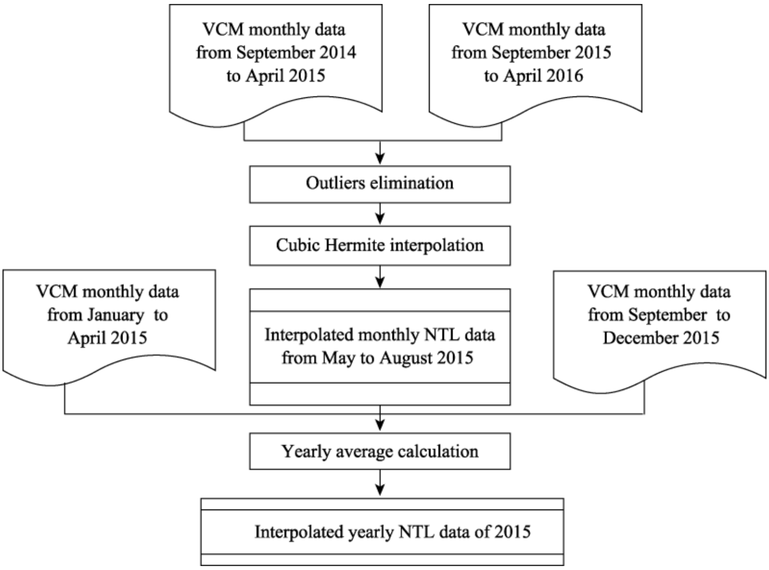

Figure 1 Flow chart for producing the interpolated monthly and yearly nighttime light data

4.2 Data Results

An example of interpolated NTL data is shown in Figure 2. Both monthly (Figure 2a) and yearly (Figure 2b) data can significantly describe the outlines of Beijing, Tianjin, Shijiazhuang, and other middle and small cities. They also reflected the radiation differences within the cities. In a certain city, in general, the largest radiations were commonly located in the airport, such as the Beijing Capital International Airport, the Tianjin Binhai International Airport, and the Tianjin Tanggu Airport (Figure 2b). The radiations of these places

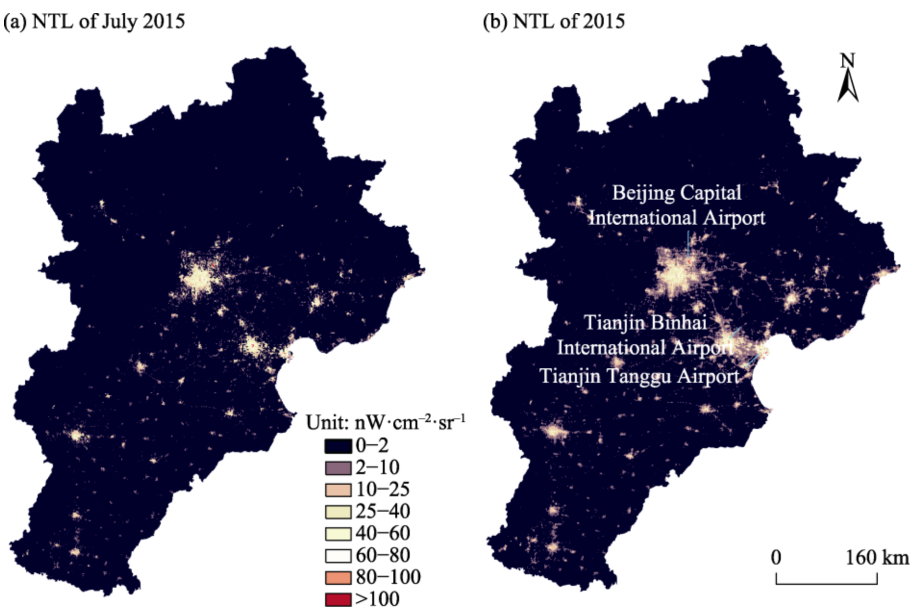

Figure 2 The interpolated nighttime light data

can reach more than 200 nW cm^{-2} sr^{-1}. The smallest radiations usually sprawled in the urban fringe. Their radiations tended to be less than 10 nW cm^{-2} sr^{-1}. The radiations in other regions within the city were about 10–100 nW cm^{-2} sr^{-1}, with the radiation of 50–100 nW cm^{-2} sr^{-1} in the developed commercial areas.

4.3 Data Validation

The NTL data were mainly composed by stable artificial light. If the cities did not suffer any disaster or war, their radiation time series should fluctuate slightly[11–12]. Therefore, radiation time series of three version of NTL data (the VCM version, the VCMSL version and the interpolated version) in the study area during September 2014 to April 2016 were compared. As shown in Figure 3, in the non-summer months, there was little variation between the three versions. In the summer months (May to August), however, obvious differences were easy to distinguish. In the VCM version, due to the remove of the contaminated pixels, its radiation dropped sharply during the summer months, even dropped to zero in June. On the contrary, the radiation time series of the VCMSL version and the interpolated version tended to be more stable resulting from stray light correction. However, further comparison revealed that the radiation of the VCMSL version in July was much smaller than other months. Spatially, its nighttime light contrast was weakened and the urban texture was not clearly depicted (Figure 4b). In contrast, the interpolated version was most stable, and its spatial distribution could reflect the texture of the city (Figure 4a).

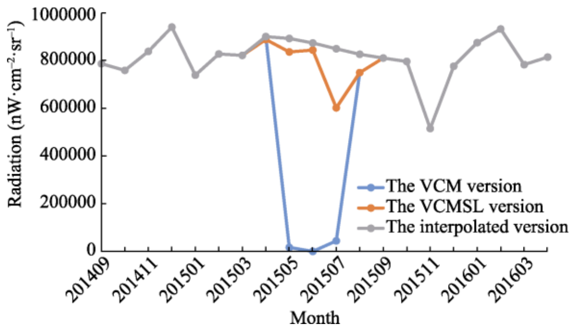

Figure 3 The radiation time series comparison of the three versions nighttime light data

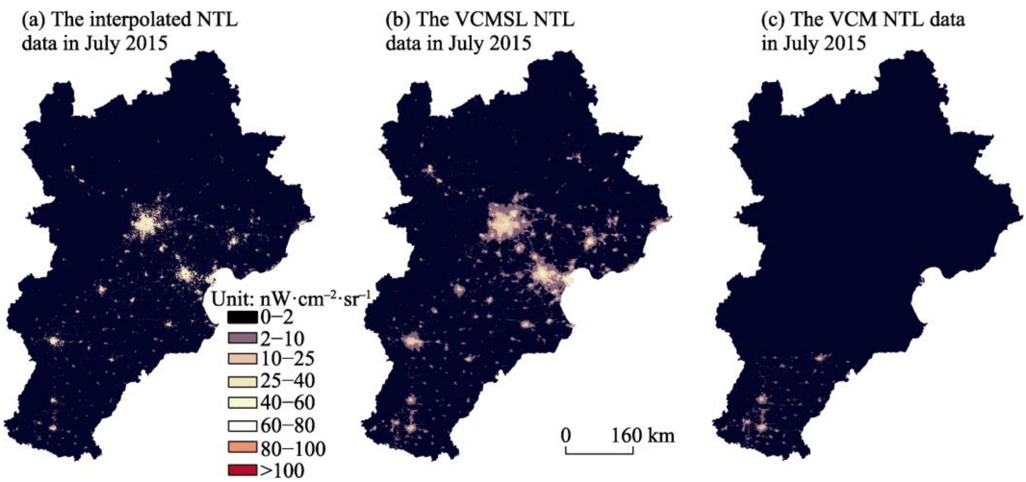

Figure 4 The comparison of three nighttime light data (taking July 2015 as an example)

5 Discussion and Conclusion

As one of the commonly used interpolation algorithms, the cubic Hermite interpolation has obvious advantages. It does not require the original data to conform to the statistical distribution. Its calculation only requires a short time to accomplishment and does not require subjective intervention. Most importantly, its results are stable[10]. Therefore, this algorithm is suitable for VIIRS/DNB NTL interpolation that with a large number of pixels and a short time series. In addition, the calculation of this algorithm is based on the average state of the original data, to some extent ensures that the interpolated results to be stable, and consequently avoid the situation that the radiation become too small in certain months in the VCMSL version. Thus the interpolated version is more consistent with the fact that most nighttime light show slow changes. At the same time, the algorithm can effectively filter out fire and abnormally high-valued outliers, so that it is more effectively applied to the study of social and economic activities research.

Nevertheless, the cubic Hermite interpolation has its limitations. Firstly, the algorithm has a high requirement on the length of the original data. Secondly, the algorithm is easily subject to outliers. Third, since the interpolation calculation is mainly based on stable light, the results do not reflect ephemeral light. So the interpolated dataset is mainly applicable to the study of stable light that reflecting social and economic activities, rather than the ephemeral light research.

Author Contributions

Chen, M. L. designed the algorithms of the dataset and wrote the data paper. Cai, H. Y. contributed to the arrangement and the revision of the data paper.

References

[1] Mills, S. D., Straka, W., Mills, S, P., *et al.* Illuminati the capabilities of the suomi national polar-orbiting partnership (NPP) visible infrared imaging radiometer suite (VIIRS) day/night band [J]. *Remote Sensing*, 2013, 5(12): 6717–6766.

[2] Mills, S., Weiss, S., Liang, C. VIIRS day/night band (DNB) stray light characterization and correction [C]. Earth Observing Systems XVIII. International Society for Optics and Photonics, 2013, 8866(11): 350–354.

[3] Bennett, M. M., Smith, L. C. Advances in using multitemporal night-time lights satellite imagery to detect, estimate, and monitor socioeconomic dynamics [J]. *Remote sensing of environment*, 2017, 192: 176–197.

[4] Chen, M. L., Cai, H. Y. Interpolation methods comparison of VIIRS/DNB nighttime light monthly composites: a case study of Beijing [J]. *Progress in Geography*, 2019, 38(1): 126–138.

[5] Geng, A. C. The application of matlab in teaching of cubic spline interpolation function [J]. *Value Engineering*, 2016, 35(18): 181–182.

[6] Fritsch, F. N., Carlson, R. E. Monotone piecewise cubic interpolation [J]. *SIAM Journal on Numerical Analysis*, 1980, 17(2): 238–246.

[7] Chen, M. L., Cai, H. Y. Monthly and yearly VIIRS/DNB nighttime light data based on cubic Hermite model in Beijing-Tianjin-Hebei region [DB/OL]. Global Change Research Data Publishing & Repository, 2019. DOI: 10.3974/geodb.2019.05.14.V1.

[8] GCdataPR Editorial Office. GCdataPR data sharing policy [OL]. DOI: 10.3974/dp.policy.2014.05 (Updated 2017).

[9] Shi, K., Yu, B., Huang, Y., *et al*. Evaluating the ability of NPP-VIIRS nighttime light data to estimate the gross domestic product and the electric power consumption of China at multiple scales: a comparison with DMSP-OLS data [J]. *Remote Sensing*, 2014, 6(2): 1705–1724.

[10] Manni, C. On shape preserving C2 Hermite interpolation [J]. *BIT Numerical Mathematics*, 2001, 41(1): 127–148.

[11] Li, X., Zhang, R., Huang, C., *et al*. Detecting 2014 Northern Iraq Insurgency using night-time light imagery [J]. *International Journal of Remote Sensing*, 2015, 36(13): 3446–3458.

[12] Li, X., Li, D., Xu, H., *et al*. Intercalibration between DMSP/OLS and VIIRS night-time light images to evaluate city light dynamics of Syria's major human settlement during Syrian Civil War [J]. *International Journal of Remote Sensing*, 2017, 38(21): 5934–5951.