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Spatial-temporal Annual Precipitation Dataset in the China–Mongolia–Russia Economic Corridor (1982–2018, 1-km/y)

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Abstract: A spatial interpolation analysis of precipitation in the China–Mongolia–Russia Economic Corridor over the past 37 years was carried out, and an optimal model was selected to generate a 1 km network dataset, which can be used to support the study of economic development, vegetation distribution, climate change, and ecological environment construction in the China–Mongolia–Russia Economic Corridor. Based on measured data of 353 meteorological stations in the China–Mongolia–Russia Economic Corridor region, operations such as reading, merging, checking, and statistical spatial interpolation batch code generation of data were performed. In addition, longitude and latitude were used as variables in the ANUSPLIN software interpolation to square the precipitation. Using the thin-disk smooth spline method, a 1 km grid interpolation dataset of precipitation in China, Mongolia, and Russia from 1982 to 2018 was obtained. The correlation coefficient (R^2) was used to verify the correlation between the interpolation results and the meteorological station data, and the R^2 was 0.937,7. The mean absolute error (MAE) and the root mean square error (RMSE) were used as the accuracy evaluation indicators, and the average values of MAE and RMSE were 4.546,4 and 2.305,7 mm, respectively. The dataset includes the raster data of the annual average precipitation for each year from 1982 to 2018. The dataset is archived in .tif format with a spatial resolution of 1 km and consists of 185 data files with a data size of 5.43 GB. This raster dataset is relatively new in terms of accuracy and time series, and is openly shared and downloaded. It can provide data support for research on the terrestrial ecosystems and spatiotemporal changes in the China–Mongolia–Russia Economic Corridor.

Keywords: China–Mongolia–Russia Economic Corridor; annual precipitation; ANUSPLIN; 1 km

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CSTR: https://cstr.escience.org.cn/CSTR:20146.14.2022.03.13

Dataset Availability Statement:

The dataset supporting this paper was published and is accessible through the *Digital Journal of Global Change Data Repository* at: https://doi.org/10.3974/geodb.2022.02.07.V1 or https://cstr.escience.org.cn/CSTR:20146.11.2022.02.07.V1.

1 Introduction

The "Belt and Road" initiative is launched by China to promote international cooperation and a win–win situation in the new era, to build an ecological civilization, and to jointly achieve the 2030 sustainable development goals[1]. The "China–Mongolia–Russia Economic Corridor" is one of the six economic corridors of the Silk Road. The construction of the "China–Mongolia–Russia Economic Corridor" will bring great benefits to the countries along the route; however, there are huge differences in the resources and environmental conditions in different regions, complex and diverse ecosystems, and fragile ecological environments, which have had a profound impact on regional social and economic development. Therefore, as there is a need to strengthen the protection of the environment, biodiversity and natural resources, to respond to climate change, to fight against and reduce disasters, to improve disaster risk management capabilities, and to promote pragmatic cooperation in the fields of tourism, think tanks, media, renewable energy, and energy efficiency, a series of related studies are being conducted[2,3]. Therefore, it is necessary to establish a set of high-resolution, long-term series, and annual precipitation grid interpolation datasets to provide basic meteorological data for the construction of the "China–Mongolia–Russia Economic Corridor", and for the study of the environment, vegetation, and water conservancy.

These data are based on the daily precipitation data of 353 meteorological stations in the "China–Mongolia–Russia Economic Corridor" area from 1982 to 2018. The widely used ANUSPLIN software meteorological data spatial interpolation method, developed by the Australian National University, is used. Longitude and latitude are used as the variables interpolated by ANUSPLIN software. The thin plate spline (TPS) method was used to generate a 1 km grid interpolation dataset of precipitation in the "China-Mongolia-Russia Economic Corridor" from 1982 to 2018, and this was compared with the actual values of the meteorological stations.

2 Metadata of the Dataset

The metadata of the Spatial-temporal annual precipitation dataset of the China–Mongolia–Russia Economic Corridor (1982–2018, 1-km/y)[4] are summarized in Table 1. They include the dataset full name, short name, authors, dataset year, temporal resolution, spatial resolution, data format, data size, data files, data publisher, data sharing policy, etc.

3 Methods

3.1 Data Sources

The data of meteorological stations in China used in this dataset come from the "Annual Value Dataset of China's Surface Climate Data" released by the National Meteorological Science Data Center. A total of 108 meteorological stations in the study area were selected from meteorological stations in Russia and Mongolia. The data come from the daily observation data provided by the National Oceanic and Atmospheric Administration (NOAA) of the United States. A total of 224 meteorological stations in Russia and 21 meteorological

Table 1 Metadata summary of the Spatial-temporal annual precipitation dataset of the China–Mongolia–Russia Economic Corridor (1982–2018, 1-km/y).

Items	Description				
Dataset full name	Spatial-temporal annual precipitation dataset in China–Mongolia–Russia Economic Corridor (1982–2018, 1-km/y)				
Dataset short name	CMREC_Prcp				
Authors	Li, G. S. HGB-7976-2022, Remote Sensing and Geographic Information Research Center, Northeast Institute of Geography and Agroecology, Chinese Academy of Sciences, liguangshuai@iga.ac.cn Yu, L. X., Remote Sensing and Geographic Information Research Center, Northeast Institute of Geography and Agroecology, Chinese Academy of Sciences, yulingxue@iga.ac.cn Liu, T. X., School of Geography Science, Changchun Normal University, liutingxiang@ccsfu.edu.cn Bu, K., Remote Sensing and Geographic Information Research Center, Northeast Institute of Geography and Agroecology, Chinese Academy of Sciences, bukun@iga.ac.cn Yang, J. C., Remote Sensing and Geographic Information Research Center, Northeast Institute of Geography and Agroecology, Chinese Academy of Sciences, yangjiuchun@iga.ac.cn Jiao, Y., Remote Sensing and Geographic Information Research Center, Northeast Institute of Geography and Agroecology, Chinese Academy of Sciences, jiaoyue@iga.ac.cn Bao, Y. L., School of Geography Science, Inner Mongolia Normal University, baoyulong@imnu.edu.cn Zhang, S. W., Remote Sensing and Geographic Information Research Center, Northeast Institute of Geography and Agroecology, Chinese Academy of Sciences, zhangshuwen@iga.ac.cn				
Geographical region	including China, Mongolia, parts of Russia (27°47′N–61°57′N, 25°51′E–157°51′E)				
Year	1982–2018	Temporal resolution	Year	Spatial resolution	1 km
Data format	.tif		Data size	5.43 GB	
Data files	Including 37 annual average precipitation data files in the China-Mongolia-Russia Economic Corridor. Among them: yyyy_prcp.tif is the annual average precipitation data, such as 1982_prcp.tif is the 1982 average precipitation data				
Foundations	Chinese Academy of Sciences (XDA2003020301); National Natural Science Foundation of China (42071025); Ministry of Science and Technology of P. R. China (2017FY101301)				
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 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 per cent 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[5]				
Communication and searchable system	DOI, CSTR, Crossref, DCI, CSCD, CNKI, SciEngine, WDS/ISC, GEOSS				

stations in Mongolia were selected. In the end, a total of 353 surface meteorological stations in the China–Mongolia–Russia Economic Corridor were selected (Figure 1). The precipitation data for the three countries were organized into a format suitable for use by the ANUSPLIN software for subsequent spatial batch interpolation processing. The boundary of the China–Mongolia–Russia Economic Corridor refers to the spatiotemporal dataset of the average temperature in the China–Mongolia–Russia Economic Corridor[6].

Digital elevation model (DEM) data come from the Global Multi-resolution Terrain Elevation Data (GMTED2010), the United States Geological Survey (USGS), and a spatial dataset of global land areas jointly launched by the National Geospatial-Intelligence Agency (NGA). This dataset was released in 2010 with a spatial horizontal resolution of 30 arcseconds. The DEM data in this study are based on the GMTED2010 data, are processed by ArcGIS 10.3 software, and are spatially integrated to obtain DEM data with a spatial resolution of 1 km (Figure 1). The ArcGIS software is then used to convert to the ASCII format for backup.

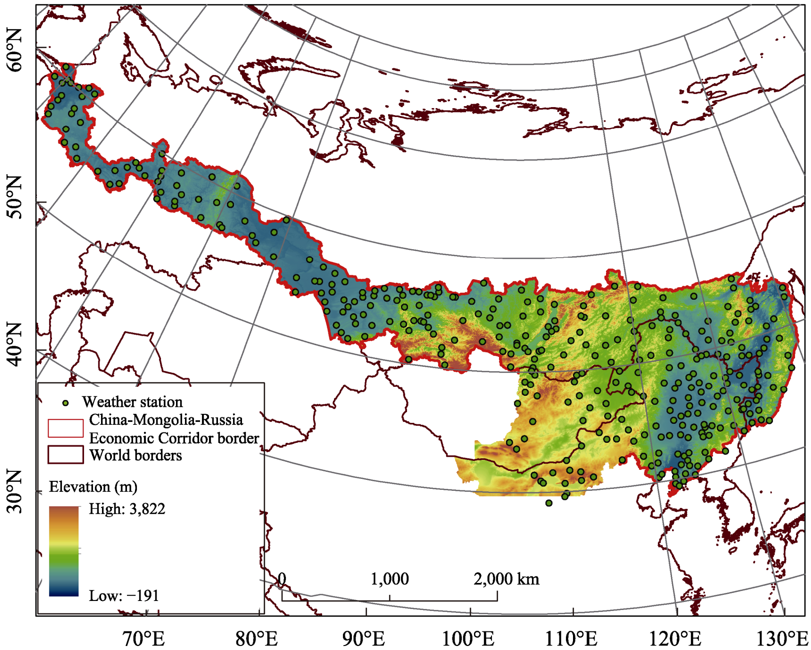

Figure 1 Spatial distribution and digital elevation model (DEM) of ground meteorological stations in the China–Mongolia–Russia Economic Corridor

3.2 Research Method

This year's precipitation spatiotemporal dataset uses a multivariate data interpolation analysis software product (ANUSPLIN) developed by the Australian National University[7,8]. The two modules, APLINA and LAPGRD, are mainly used for precipitation and temperature interpolation. The built-in thin-disk smooth spline function interpolation effect is superior to Kriging and other interpolation methods[9–11]. In the spatial interpolation of precipitation in this dataset, the optimal spatial interpolation model is used; that is, the local thin-disk smooth spline function with latitude and longitude as independent variables[12], and the interpolation effect is best when the number of test splines is set to 2.

3.3 Technical Route

The generation process of this dataset includes four parts: source data input, source data processing, data output, and spatial interpolation (the main process is shown in Figure 2). The source data input, processing, and output include integrating the precipitation data and meteorological station information in the China–Mongolia–Russia Economic Corridor from 1982 to 2018 and using SPSS software to process it into a data format suitable for ANUSPLIN software. In addition, ArcGIS is used to resample the DEM data to 1 km, crop and transform the projections, and output it in the ASCII format reserved for interpolation. Spatial interpolation is mainly completed in ANUSPLIN software by writing splina.cmd and lapgrd.cmd scripts.

3.4 Error Analysis

In order to verify the accuracy of the ANUSPLIN interpolation, this paper uses correlation analysis and error analysis to test the accuracy of the interpolation results[13–15]. To test the correlation between the predicted value and the observed value of the weather station, the correlation coefficient (R^2) was calculated:

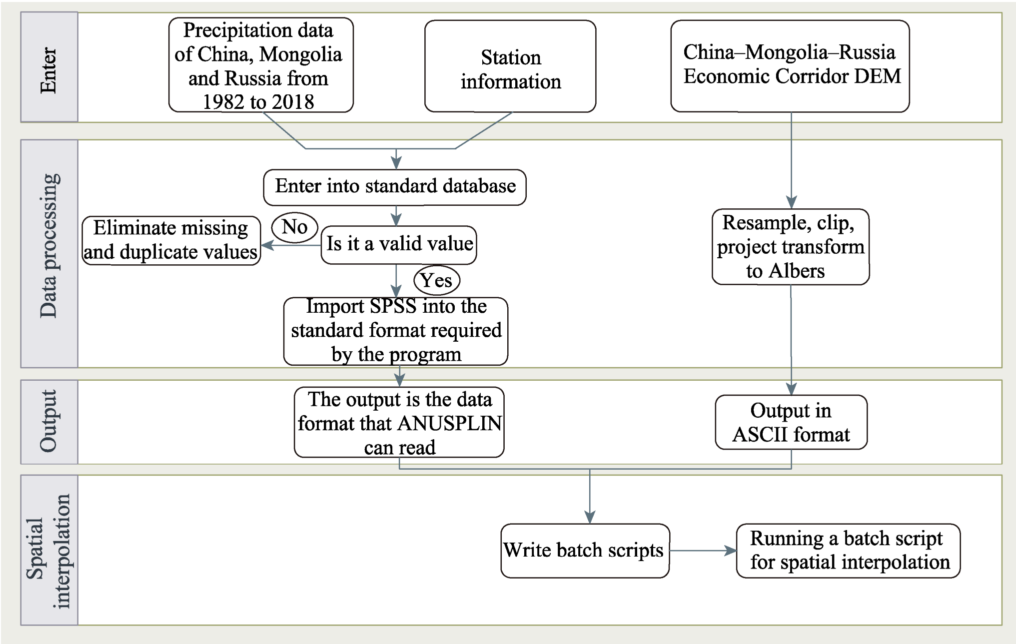

Figure 2 Dataset research and development technology flow chart

$$R^2 = \frac{\sum_i (\hat{y}_i - y_i)^2}{\sum_i (y_i - \bar{y}_i)^2} \tag{1}$$

The formula numerator represents the residual predicted using the predicted value, and the denominator denotes the residual predicted using the sample mean for all data. When $R^2 < 0$, the residuals of the model predicted results are larger than the residuals of the baseline model (predicting all data with the sample mean), indicating that the model predicted results are very poor. When $R^2 > 0$, the larger the R^2, the smaller the residual error of the model prediction result, and the better the prediction effect.

$$RMSE = \sqrt{\frac{1}{m}\sum_{i=1}^{m}(x^{(i)} - y^{(i)})^2} \tag{2}$$

where m is the number of stations, and $x^{(i)}$. and $y^{(i)}$ represent the observed and predicted values of the i-th weather station, respectively. The mean absolute error reflects the true error, which is the average of the absolute errors. The smaller the MAE, the smaller the error.

$$MAE = \frac{\sum_{i=1}^{n}|y_i - x_i|}{n} \tag{3}$$

where n is the number of stations, and y_i and x_i represent the observed and estimated values of the i-th station, respectively.

4 Data Results and Validation

4.1 Data Composition

The spatiotemporal dataset of annual precipitation in the China–Mongolia–Russia Economic Corridor (1982–2018, 1-km/y) includes 37 data files of annual average precipitation in the

China–Mongolia–Russia Economic Corridor. Among them, yyyy_prcp.tif is the annual average precipitation data; for example, 1982_prcp.tif is the 1982 average precipitation data.

4.2 Data Results

Figure 3 shows the spatial distribution of the average annual precipitation from 1982 to 2018 obtained using ANUSPLIN software interpolation. It can be seen from the figure that the precipitation in the entire China–Mongolia–Russia Economic Corridor shows a clear trend of decreasing from the coast to the inland. The annual precipitation difference between the low-value area and the high-value area in the entire study area is more than 1000 mm, and the difference is very significant. The annual precipitation in western Inner Mongolia along with the South Gobi League and East Gobi League of Mongolia is less than 100 mm, and this is the area with the least annual precipitation in the China–Mongolia–Russia Economic Corridor. The annual precipitation is greater than 800 mm in the western part of the Republic of Khakassia, southeastern Kemerovo Oblast, southern Krasnoyarsk Territory, southern Altai Territory, and southwestern Buryatia. On the Pacific coast, China's Liaoning province and the eastern part of Jilin province, as well as Russia's coastal border region and the eastern region of Khabarovsk Krai, the precipitation can reach more than 800 mm.

The relationship between precipitation and topography is very close, especially in coastal areas. In the China–Mongolia–Russia Economic Corridor, there are the Changbai Mountains and the Xiaoxing'an Mountains in the eastern part of Northeast China. They are closer to the ocean and thus receive more ocean water vapor. The warm and humid air from the ocean is forced to lift when it encounters the mountains, forming more terrain rain. Although the Greater Xing'an Mountains in Northeast China are farther from the sea, they receive less warm and humid ocean water vapor than the Xiao Xing'an Mountains and the Changbai Mountains, and have less precipitation. Mongolia's Ulaanbaatar City, Selenge League, Orkhon League, and parts of Kent League have slightly more precipitation due to terrain uplift. The eastern part of Russia is mainly blocked by the Sikhote Mountains, which traps the warm and humid water vapor of the Pacific Ocean on the windward slopes of the mountains.

4.3 Data Validation

Using the measured values of meteorological stations in the China–Mongolia–Russia Economic Corridor region and the ANISPLIN interpolation results to verify the accuracy, the results are shown in Figure 5. The verification results show that the ANUSPLIN software can better simulate the distribution of the annual average precipitation in the China–Mongolia–Russia Economic Corridor with latitude and longitude as the independent variables. The correlation coefficient (R^2) ranged from 0.873,5 to 0.989,5, the root mean square error (RMSE) was 0.863,9–4.986,1 mm, and the mean absolute error (MAE) was 1.3654–13.542,4 mm. From the perspective of the correlation coefficient, root mean square error and mean absolute error, the ANUSPLIN interpolation software has relatively high accuracy in interpolating multi-year precipitation in the China–Mongolia–Russia Economic Corridor.

5 Discussion and Conclusion

Based on the precipitation data of meteorological stations, station information, and DEM data in the area, this dataset uses ANUSPLIN meteorological interpolation software to establish a 1 km annual precipitation grid data in the China–Russia–Mongolia Economic Corridor from 1982 to 2018. The results of the observation and the interpolation of the meteorological stations are used for verification. The verification results show that the average value of the correlation coefficient (R^2) is 0.937,7, the average value of the root

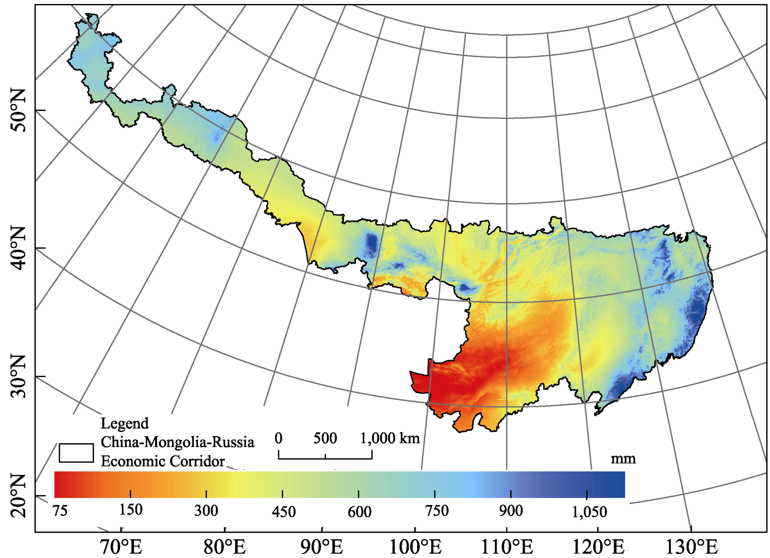

Figure 3 Distribution map of annual average precipitation in the China–Mongolia–Russia Economic Corridor

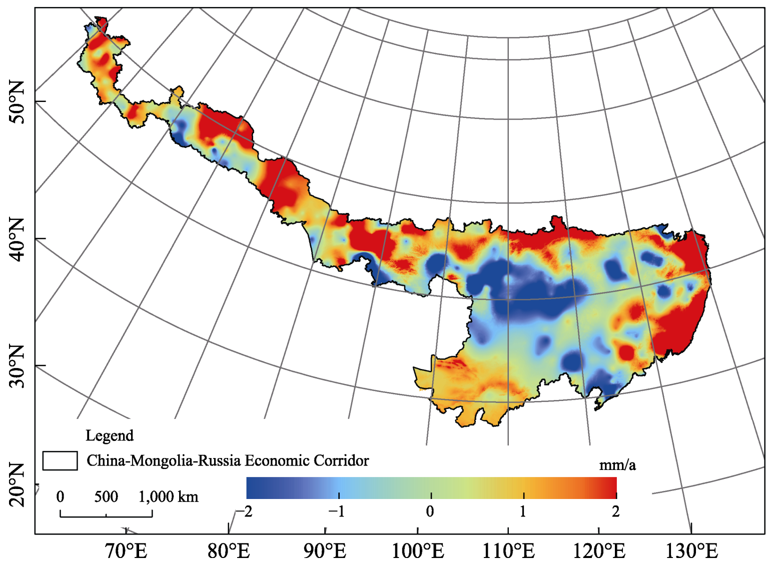

Figure 4 Spatial distribution of the slope rate of annual average precipitation changes in the China–Mongolia–Russia Economic Corridor from 1982 to 2018

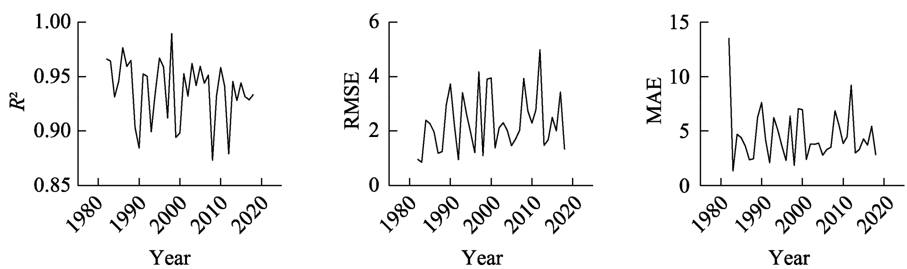

Figure 5 Average precipitation and interpolation results accuracy verification from 1982 to 2018

mean square error (RMSE) is 2.305,7 mm, and the average value of the mean absolute error (MAE) is 4.546,4 mm, while the verification shows that the accuracy of the ANUSPLIN interpolation is high. The dataset reflects the distribution of annual precipitation in the China–Mongolia–Russia Economic Corridor from 1982 to 2018, and provides basic meteorological data for the construction of the “China–Mongolia–Russia Economic Corridor”. In addition, it provides data support for the study of the environment, vegetation, water conservancy, and the ecology, along with social and other aspects.

Author Contributions

Yu, L. X., Liu, T. X. designed the algorithms of dataset. Li, G. S., Jiao, Y., Bao, Y. L., Bu, K., Yang, J. C., Zhang, S. W., contributed to the data processing and analysis. Li, G. S., Yu, L. X. wrote the data paper.

Conflicts of Interest

The authors declare no conflicts of interest.

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