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Data Article

A dataset of endorheic basins on detailed delineation and classification for the Qinghai–Tibet Plateau

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ABSTRACT

Endorheic basins are important geomorphological and ecological units on the Qinghai-Tibet Plateau (QTP), which is undergoing a rapid evolution of its lake system structure and drainage reorganization that is threatening local ecology, infrastructures and residuals owing to climate change. This dataset provides a detailed delineation and classification of endorheic basins on the QTP for understanding the complex dynamics under climate changes. A newly-developed algorithm, namely the Joint Elevation-Area Threshold (JEAT) algorithm (Liu et al, 2024), is applied for delineating endorheic basins based on digital elevation model (DEM). A total of 184 endorheic basins were divided, of which the permanent divide lines were characterized. All the endorheic basins were further categorized into five groups based on the hydraulic connectivity attributes, which have been commonly observed since 2000. The dataset also includes basic information such as drainage area, water surface area, and water storage volume of each endorheic basin. It is particularly beneficial for digital watershed analysis towards ecological restoration and

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water resource management on the environmentally vulnerable QTP.

Specifications Table

Subject	Earth and Planetary Sciences - Earth Surface Processes - Hydrology, Geomorphology
Specific subject area	Endorheic basin extraction, Hydraulic connectivity among endorheic basins, Endorheic basin classification
Data format	Raw, Analysed
Type of data	Tables, Figures
Data collection	Digital Elevation Models from MERIT DEM. The lake map in 2022 from National Tibetan Plateau Data Center(NTPDC, China). GTOPO30 World Hillshade Map from the GIS software. Investigation with Google Earth images
Data source location	Raw data location: https://hydro.iis.u-tokyo.ac.jp/~yamadai/MERIT_DEM/ https://data.tpdc.ac.cn/ Analysed data location: https://doi.org/10.6084/m9.figshare.25019060.v1
Data accessibility	Repository name: HHU_QTP_Endorheic_Delineation_Classification Data identification number: DOI: 10.6084/m9.figshare.25019060 Direct URL to data: https://doi.org/10.6084/m9.figshare.25019060.v1
Related research article	J.T. Liu, F.Y Ni, S.G. Ma, Y. Kang, P.F. Wu, M.Y. Feng, Extraction and classification of endorheic units in the Qiangtang endorheic basin considering hydraulic connectivity, Advances in Water Science (2024). Online DOI: http://kns.cnki.net/kcms/detail/32.1309.P.20240108.1058.002.html.

1. Value of the Data

- This data is valuable as it provides a comprehensive delineation and classification of endorheic basins on the Qinghai-Tibet Plateau (QTP), which is still insufficient for regional watershed analysis. Additionally, a dependable algorithm namely the Joint Elevation-Area Threshold (JEAT) algorithm for endorheic basin delineation is adopted [1]. It characterizes the hydrogeomorphological and hydrometerological features of endorheic basins and presents a simple procedure that does not rely on remote sensing images. Compared to the existing methods, the JEAT has been proven to be more accurate in delineating endorheic basins.
- Given the history of drainage reorganizations that have occurred on the QTP, existing methods are currently inadequate for identifying the hydraulic connectivity among endorheic basins with lake levels rising under global climate change. Using the JEAT, the dataset can provide accurate results on endorheic basin delineation with permanent divide lines regarding potential reorganizations. The result will be the foundation of regional, and even global watershed analysis.
- In terms of ecological restoration and water resource management, the dataset also contains drainage area, water surface area, and water storage volume of each endorheic basin. It may serve as input data for researchers to calculate water balance or as a reference for ecological problems, which is vital important for analysing the water demands of residents, and helpful for the local government to make ecological, industrial, agricultural, and domestic water policies in endorheic QTP.

2. Background

Endorheic basins occupy one-fifth of the Earth's surface [2,3]. In China, endorheic basins are mainly located on the QTP, and they cover more than 70% of the arid region. Since 2000, continuous warming has accelerated lake expansion in the endorheic basin, floodings spreading from upstream to downstream along the connective rivers and thus drainage reorganization events, which have greatly changed hydrological regimes in the endorheic QTP and may pose more risks of outburst flooding or potential ecological threats [4–6]. A total of 11 drainage reorganization events that have been observed in the QTP from 2000 to 2018, which involves 24 endorheic basins with area of approximately 61000 km^2 [4]. To better understand the drainage reorganizations in QTP, the accurate divide lines for endorheic basins are important. However, accurate delineation of endorheic basins remains a big challenge. Existing methods commonly treat depressions in digital elevation model (DEM) as false objects and subsequently fill them, which may alter the authentic topography of endorheic basins. In addition, although considering true depressions, they will regard endorheic basins as isolated depressions, which neglects divide changes caused by potential connectivity under global warming. Therefore, a newly developed algorithm, namely JEAT, is adopted for delineating endorheic basins [1]. The JEAT divdes the endorheic basins to reflect the endorheic units, which illustrates all the connectivity phenomenon have occurred. The division results not only include the endorheic basins which located in the endorheic QTP, but also involve some basins which are neglected in exorheic basins. Subsequently, all the endorheic basins are categorized into distinct groups based on potential forms of hydraulic connectivity, which reflects the possibly reorganization locations. The dataset aims to investigate hydrological, geomorphological, and ecological characteristics of each endorheic basin with Google Earth images and visual interpretation. We hope it will serve as a valuable reference dataset for ecological analysis.

3. Data Description

3.1. Master data

The master data contains various characteristic information of the endorheic basins. The basic hydrogeomorphological and hydrometerological characteristics of each endorheic basin are provided in Appendix 1, which provides essential information about geographical locations, meterological attributes and categories of endorheic basins. Appendix 2 provides information about lakes ($\geq$1km^2) located in each endorheic basin, which are considered as one of the most important factors in endorheic basins. In addition, one can find the drainage area, water surface area, and water storage volume of each endorheic basin in Appendix 3. These data are necessary for orienting the possibe reorganization locations and ecological analysis such as water resource management. For more detailed information about the master data, one can refer to Table 1.

3.2. Shapefiles

The shapefiles of delineation and classification results are provided as QTP_delineation.shp and QTP_classification.shp. They contain the spatial distribution of endorheic basins. Detailed information about shapefiles can be found in Table 2, including its ID number, shape type which is provided by GIS software, drainage area and category for each endorheic basin.

Table 1
Appendix table description.

Appendix	Column	Field	Description
1	1	ID	id number of each endorheic basin
	2	central latitude	latitude of center point
	3	central longitude	longitude of center point
	4	central elevation	elevation of center point
	5	annual mean temperature	annal mean temperature of each endorheic basin
	6	rate of temperature change	temperature change rate of each endorheic basin
	7	annal mean precipitation	annal average precipitation of each endorheic basin
	8	rate of precipitation change	precipitation change rate of each endorheic basin
	9	category	classification category of each endorheic basin
	10	height of low divides	height of various low divides
2	1	lake (≥1km^2)	name of each lake (≥1km^2)
	2	lake area	area of each lake (≥1km^2)
	3	central latitude	central latitude of each lake (≥1km^2)
	4	central longitude	central longitude of each lake (≥1km^2)
	5	central elevation	central elevation of each lake (≥1km^2)
3	1	drainage area	drainage area of each endorheic basin
	2	water surface area	total water surface area of each endorheic basin
	3	water storage volume	water storage volume of lakes (greater than 1 km^2)

Table 2
Attribute table description.

Shapefiles	Column	Field	Description
QTP_delineation.shp	1	FID	order number
	2	Shape	shape type of each endorheic basin
	3	Area	drainage area of each endorheic basin
QTP_classification.shp	1	FID	order number
	2	Shape	shape type of each endorheic basin
	3	Category	category of each endorheic basin

4. Experimental Design, Materials and Methods

The raw data includes DEMs and a lake map on the QTP. MERIT DEM by Yamazaki [7] with a 3-arc second resolution was used. It has demonstrated good applications in high mountain areas, which meets the research requirements. The lake map was obtained from the NTPDC, which provides basic information about the lake area in 2022 [8].

The JEAT algorithm was introduced to address the challenges of endorheic basins delineation [1]. It adopts two joint thresholds, i.e., the elevation threshold and the area threshold, to recognize the complex characteristics of hydraulic connectivity in the endorheic regions. In the JEAT algorithm, the elevation threshold characterizes the height of low divide between two endorheic basins, while the area threshold identifies false depressions caused by narrow streams that are not captured by DEM [9].

First, the algorithm identifies all the initial depressions in endorheic regions including false depressions. Starting from the bottom of each depression, it searches all the inflow grid cells based on the flow direction matrix by iFAD8 [10] and RWFlood algorithms [11]. In the next step, it is important to compare the height of low divide and drainage area with two joint thresholds separately. For details of the JEAT method, one can refer to the literature [1]. Historical remote sensing images in the Google Earth and visual interpretation have been implemented to validate the algorithm [1]. It has been proved that the algorithm can capture the hydraulic connectivity between endorheic basins well. After clarifying the effects of different combinations of elevation-area thresholds, a set of optimal thresholds is obtained as 10 m-50 km^2. For the QTP, a total of 184 endorheic basins were identified.

Based on the phenomenon which have been observed, 5 different connectivity categories has been introduced (See Fig. 1). All the endorheic basins were further categorized into 5 groups according to hydraulic connectivity attributes. Each basin unit in Category I usually includes two false endorheic sub-basins with very low divide line, each of which serves as the outlet for the other. As endorheic lake levels rise under climate warming, these two false endorheic sub-basins will connect each other. Category II represents a continuum of depression units with a visible upstream and downstream relationship. Usually, the lake level in the upstream depression could reach the height of its low divide during summer floodings, and thus both depressions were connected. In Category III, the relationship between inner-depressions is more complex, as one endorheic basin doesn't necessarily have only two depressions like Category I and II. In this case, several low divide lines should be considered to compare with the given elevation threshold. When all lake levels reach the elevation threshold, all the sub-basins will be connected together. Category IV represents isolated endorheic basins with high terrain relief around it, which commonly exists in high mountain areas. The height of divide is so high that endorheic lake levels almost cannot reach the overflow point. Category V represents a depression group with a number of smaller depressions that are blocked by very low divide lines. A casual rainstorm event may lead to hydraulic connectivity among all the depressions within one group, i.e., lake levels of all the depressions reach the elevation threshold.

Afterwards, Google Earth images were used to obtain the central latitudes, central longitudes, central elevations for each endorheic basin. These information are important for orienting the possibly reorganization locations. The annual mean temperature, annual mean precipitation, rates of precipitation and temperature changes referred to [12,13], which illustrates the basic hydrometeorological features in each basin. The Google Earth images and the lake map from NT-PDC were also utilized to obtain the names, areas, central latitudes, central longitudes, central elevations, and current levels of lakes. The lakes are one of the most important factors, which directly demonstrate the connectivity rivers between endorheic basins. For ecological analysis, we calculated the drainage area in GIS software and used the lake map to determine the water surface area, i.e., the sum of lake area in each endorheic basin. Afterwards, a simple method based on the theory of terrain similarity both above and below the lake level is adopted for

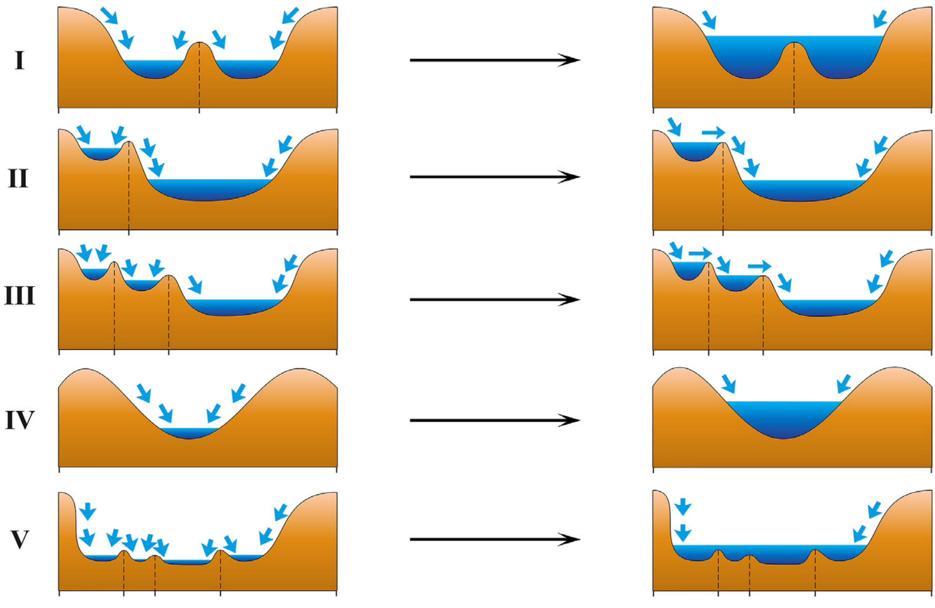

Fig. 1. Schematic forms of hydraulic connectivity among endorheic basins [4].

calculating water storage volume [14]. We chose the lake levels from Google Earth images to be the maximum level. Corresponding surface area and storage volume were recorded as lake level rising, and after calculating the storage volume above and below the water level, the storage volume of each lake can be determined. Finally, the water storage volume of each endorheic basin would be calculated. The volume of lakes and its total surface area are very important for future evaluating water resources in endorheic basins, which can further be used to ecological analysis.

4.1. Creation of the master data and shapefiles

The ID numbers of each endorheic basin were assigned, which is according to the sub-basins of the QTP. Hydrogeomorphological and hydrometerological attributes including central longitude, central latitude, central elevation, annual mean precipitation, annual mean temperature, rates of precipitation and temperature changes were first obtained for each endorheic basin. Lakes ($\geq$1 km^2) were also identified. For ecological analysis, drainage area, water surface area and water storage volume were provided. More detailed information can be found in Appendix 1, Appendix 2 and Appendix 3.

Through using the JEAT algorithm, a total of 184 endorheic basins were obtained. These endorheic basins were further categorized into five groups to illustrate the endorheic units with permanent divide lines. The results showed that the division endorheic basins are mainly located on the Qiangtang Endorheic Basin [1] and the Qaidam Basin. The basins in Qaidam Basin usually have large area because of numerous ephemeral rivers. Several endorheic basins are located on the exhorheic basins, such as Brahmaputra Basin, the Indus Basin, the Ganges Basin, and the Amu Darya Basin. These basins generally locate on the upstream mountain area, which may result outburst floodings in summer or by glacier lakes collapse. Specifically, there are 6, 41, 11, 123, and 3 endorheic basins in Category I-V, respectively. The Category IV has the largest quantity, which means the isolated depressions are very common in the QTP. The amount of Category I, II and III is next to the Category IV, which illustrates the high possibility of hydraulic connectivity that can occurr in the future. The depression groups are not usual, which have a large number of small lakes that change rapidly even in one precipitation event. To create the shapefiles, we added a column in the attribute table, namely Category, which assigned a unique category number to each polygon (i.e., endorheic basin). We also added a GTOPO30 World Hillshade Map as the base map in the GIS software to display the category for each basin clearly. Five colors were further applied to plot these polygons for different colors (See Fig. 2). Category I to V are red, orange, green, blue and purple separately. The boundary lines of the QTP and its sub-basins were repesented by adjusting the transparency of their polygons. Afterwards, we thickened the lines of endorheic basins to depict their boundaries. The shapefile of world rivers was added to display the drainage network on the QTP.

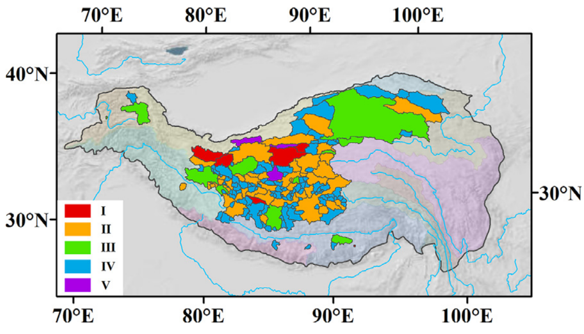

Fig. 2. The delineation and classification in Qinghai-Tibet Plateau.

Limitations

Not applicable.

Ethics Statement

The authors have read and follow the ethical requirements for publication in Data in Brief and declare that the current work does not involve human subjects, animal experiments, or any data collected from social media platforms.

Data Availability

HHU_QTP_Endorheic_Delineation_Classification_Dataset (Original data) (Figshare(www.figshare.com)).

CRediT Author Statement

Feiyu Ni: Methodology, Data curation, Writing – original draft; **Jintao Liu:** Supervision, Writing – review & editing; **Pengfei Wu:** Data curation, Writing – review & editing; **Meiyan Feng:** Writing – review & editing; **Xuyang Sun:** Writing – review & editing; **Tianke Bai:** Data curation, Writing – review & editing; **Xuhui Shen:** Writing – review & editing; **Bianbalamu:** Data curation.

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Supplementary Materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.dib.2024.110369.

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