Eco-regional boundary data of the Roof of the World

LIU Chuang[1], SHI Ruixiang[1], CHEN Wenbo[2]
(1. Institute of Geographic Sciences and Natural Resources Research, CAS, Beijing 100101, China;
2. Keio Research Institute at SFC, Keio University, Fujisawa 2520882, Japan)

Abstract: The region of the Roof of the World is the highest region in the world, which covers the Qinghai-Tibet Plateau, the Hengduan Mountains, the Himalaya Mountains, the Hindu Kush, and the Pamir Plateau of nine countries, including China, Myanmar, Nepal, Bhutan, India, Pakistan, Afghanistan, Tajikistan, and Kyrgyzstan. We have produced eco-regional boundary data both in Google Earth .kmz and Arc/Info .shp formats, using scenarios of elevation more than 4000 m above sea level, land slopes more than 7 degrees, and integrated with the remote sensing images. Our boundary around the region is 22,089 km, with the total area of the region being 4, 000,947 km^2. Each of the 40 geographical parts of the boundary is identified and coded.

Keywords: Roof of the World; Qinghai-Tibet Plateau; Hindu Kush Himalaya; eco-region; boundary data
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1 Introduction

The Roof of the World region is a special ecosystem area consisting of very high elevation, a large land mass, and deep influences in the surrounding environment[1]. It is one of the most sensitive areas to global environmental changes[2]. For more than a century, many scientists throughout the world have paid much attention to understand this unique geographic region from different dimensions and with different names. For example, this area is known simultaneously as: the Roof of the World (from the Pamir local language)[3], the Qinghai-Tibet Plateau (from China)[4-5], and the Hindu Kush-Himalaya (from the International Centre for Integrated Mountain Development - ICIMOD)[6-8], and the third pole of the world (from Institute of Tibetan Plateau Research, Chinese Academy of Sciences). The data studies that have been published in this region include the ICMOD geographic information system (GIS) data on the "Outline of the Hindu Kush Himalaya Boundary" in 1982[7-8], and Prof. ZHANG Yili from IGSNRR/CAS finished the Qinghai-Tibet Plateau boundary data, in 2002[9]. Although Prof. Zhang's dataset was not formally published, it was re-used and shared in

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Author: LIU Chuang (1948-), Professor, Vice Chair of Expert Committee of China GEOSS, Editor-in-Chief of Global Change Research Data Publishing and Repository, CODATA Prize Recipient (2008). E-mail: lchuang@igsnrr.ac.cn

different ways in China.

The eco-regional boundary data of the Roof of the World (ROTWBND) is a new data product based on regional studies and integrated geographical data analysis. This data paper provides detailed expository information about the data, such as the metadata, and details about the methodology and the procedures used in developing this dataset. It also provides valuable information to explain the data innovations and reliability, as well as how to access the dataset and re-use it.

2 Metadata for the ROTWBND dataset

The descriptions of the ROTWBND dataset are recorded. These information include the dataset full name, dataset short name, corresponding author, authors, geographical region of the dataset content, year of the dataset, number of the dataset tiles, dataset spatial and temporal

Table 1 Summary of the ROTWBND metadata

Dataset full name	Eco-regional boundary data of the Roof of the World
Dataset short name	ROTWBND
Corresponding author	LIU Chuang (lchuang@igsnrr.ac.cn)
Author (s)	LIU Chuang, Institute of Geographic Sciences and Natural Resources Research, CAS, lchuang@igsnrr.ac.cn; SHI Ruixiang, Institute of Geographic Sciences and Natural Resources Research, CAS, shirx@igsnrr.ac.cn; CHEN Wenbo, Keio Research Institute at SFC, Keio University, Japan, chenwb@sfc.keio.ac.jp, chenwb3@gmail.com
Geographical region	The geographical region covers the area from N40°1'52" - N23°11'59", E105°43'45" - E61°28'45", including the Qinghai-Tibet Plateau, Hengduan Mountains, Himalaya Mountains, Hindu Kush, Pamir Plateau. The region covers the area of the following nations: China, Myanmar, Nepal, Bhutan, India, Pakistan, Afghanistan, Tajikistan, and Kyrgyzstan.
Year dataset created	2014
Spatial resolution	30 meters
Data format	.shp, .kmz, .zip Data Size 2.94MB
Data publisher	Global Change Research Data Publishing and Repository, DOI:10.3974/
Data access and services platform	Global Change Research Data Publishing and Repository, Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences, http://www.geodoi.ac.cn National Data Sharing Infrastructure of Earth System Sciences of China, http://www.geodata.cn
Academic editors	ZHU Yunqiang, CHEN Shengbo, HE Shujin
Datasets and data files	The dataset is in two formats, one is the ARC/GIS .shp format, and the other is the Google Earth .kmz format. Users can download Google Earth first, http://www.google.com/earth/download/ge/agree.html, and then download the data with the .kmz format. The dataset consists of four data files. They are: rotwbnd.zip, rotwbnd.kmz, rotwbnd_China.zip, rotwbnd_China.kmz. as follows: 1.rotwbnd.zip, this is the ARC/GIS .shp compressed file of the eco-regional boundary data of the roof of the world. Data size is 1.09 MB. 2.rotwbnd.kmz, Google Earth format file of the eco-regional boundary data of the roof of the world. Data size is 698KB. 3.rotwbnd_China.zip, ARC/GIS .shp compressed file covering the China area of the eco-regional boundary data of the roof of the world. Data size is 748 KB. 4.rotwbnd_China.kmz, Google Earth format file covering the China area of the eco-regional boundary data of the roof of the world. Data size is 446 KB.
Data sharing policy	The authors of the dataset agree to publish the data here according to the Article I of Data Sharing Policy of the Global Change Data Publishing and Repository, which states that the dataset can be used freely for research, education, and decision making; any users for commercial uses should get formal permission from IGSNRR/CAS.

resolution, dataset format and size, data publisher, data sharing platform and contact information, technical editors, foundation and the data sharing policy. Table 1 below summarizes the main metadata elements of the ROTWBND dataset.

3 Methodology for the dataset development

The ROTW dataset is the product of research integrating geographical theory and digital data for the Roof of the World region[10]. The basic theory of regional division was provided by LI Bingyuan[5] and ZHANG Yili[9], which they applied to the Qinghai-Tibet Plateau. The key characteristic to identify the region is the elevation, which is more than 4000 m above sea level. Besides the integrity of the mountain ecological system, the administrative divisions are also included. Based on geographical theory and key elements, the data for elevation and slope classification, and remote sensing imagery are integrated as well. The procedures of the eco-regional boundary data of the Roof of the World is shown in Figure 1.

3.1 Elevation classification data

Elevation classification data are the most important for identifying the eco-region of the Roof of the World, with the key data being features over 4000 meters above sea level. Based on the ASTER DEM v2[11-12], 17 classes of elevation are identified from 500 to 8843 m above sea level, including the 4000 meter class. The 17 classes of elevation data of the Roof of the World were published together with this dataset[13]. The areas for which the elevation is equal and higher than 4000 m above sea level are shown in Figure 2.

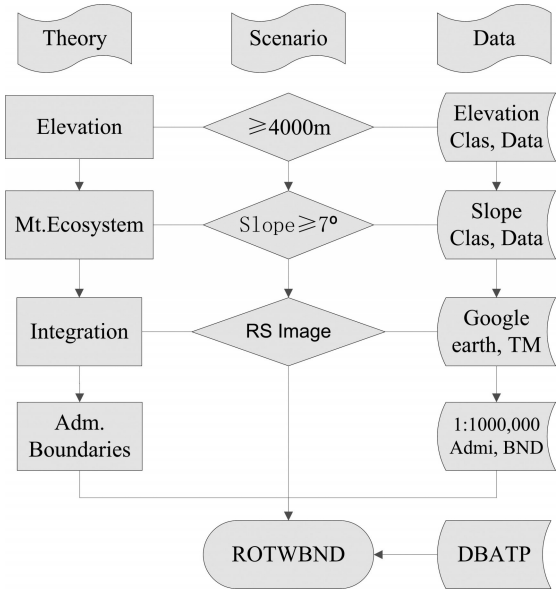


Figure 1 Flowchart of the eco-regional boundary data of the Roof of the World

3.2 Slope classification data

The main differences between ecosystems and environment data of the eco-region of the Roof of the World and the surrounding areas are elevation, topography, and geomorphology. In most areas, such as the border between the Altun Mountains and the Tarim Basin (in China), the border between the Qilian Mountain and the Hexi Corridor (in China), and the border between the Himalaya Mountains and the Gangetic Plain (in Nepal), there are alluvial fans for which the slopes are normally between 5°~10°, and mostly at 7°. Thus, for the raster data of 30 meters

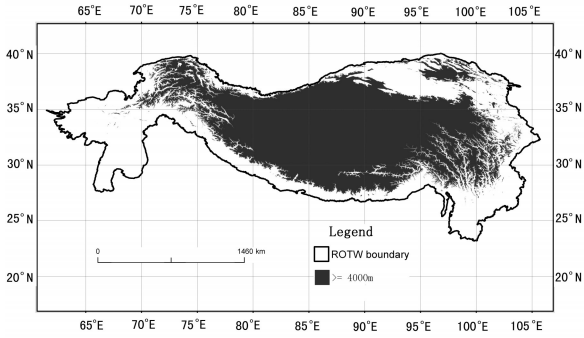


Figure 2 Map of elevation ⩾ 4000 m above sea level in eco-region of the Roof of the World

resolution for slope classification[14], one of the indexes is 7°, as shown below in Figures 3 and 4.

3.3 Integrating remote sensing images to the elevation and slope data

The eco-region of the Roof of the World is an unique comprehensive ecosystem, not only because of its high elevation and deep slope, but because of its other physical elements, such as landform, soil, and vegetation. All of these characteristics are different in remote sensing images. The Landsat ETM and GF1 as well as Google Earth images are applied for the data integration to identify the boundaries between this eco-region and its surrounding areas (Figure 5)[15].

3.4 Administrative boundary data applications

As indicated above, the eco-region of the Roof of the World covers an area that includes nine countries. The data of the national administrative boundaries at a scale of 1:1 million is provided by the National GeoInfomatics Center of China[16]. These data are the basic data for calculating the areas of each country in the region and the length of its boundary[16-17].

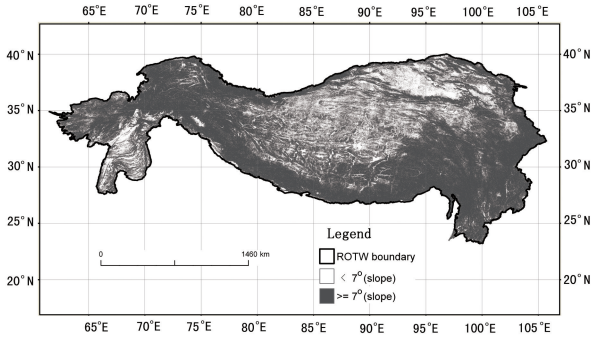


Figure 3 Map of slope >= 7° area in eco-region of the Roof of the World

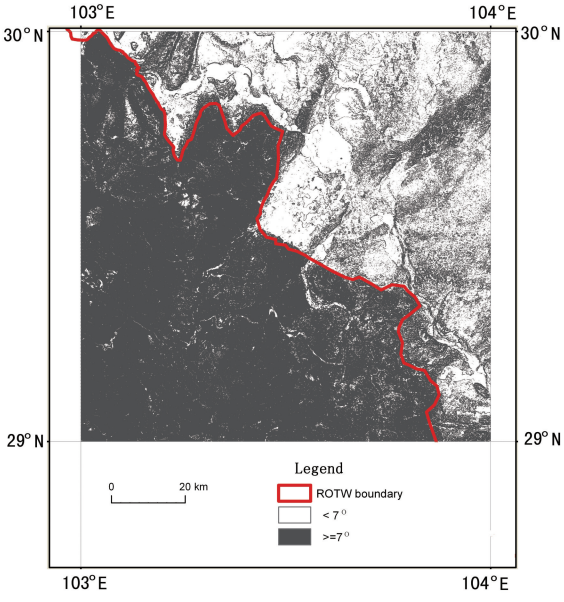


Figure 4 Map of slope ⩾ 7° area in border area between eco-region of the Roof of the World and the Sichuan Basin

4 The dataset

4.1 Introduction of the dataset

The dataset of the eco-region for the Roof of the World include the data of the outline of the region and China's part of the region (Figures 6-8). Four data files are included. They are: rotwbnd.zip, rotwbnd.kmz, rotwbnd_China.zip, and rotwbnd_China.kmz. More specifically, (1) the file named rotwbnd.zip (1.09 MB) is the compressed data in ARCGIS .shp format of the outline of eco-region of the Roof

Figure 5 Matching ROTWBND and remote sensing images in Mt. Yingzhui Shan and Yema Shan of Changma County, Yumen City, Guansu Province (Google Earth, 2014)

of the World; (2) the file named rotwbnd.kmz (729 KB) is the data in Google Earth format; (3) the file named rotwbnd_China.zip (748 KB) is the compressed ARC/GIS .shp format of the outline of the China portion of the eco-region of the Roof of the World; and (4) the file named rotwbnd_China.kmz (446 KB) is the Google Earth format of the outline of the China portion of the eco-region of the Roof of the World.

4.2 Statistics of the length and area of the eco-region of the Roof of the World

According to the Lambert conformal conic projection, the Parallel Standard Latitudes are N 29º and 37º, and the Center Longitude is 84º, and the length of the boundary of the Eco-region of the Roof of the World is 22,089 km. Calculated with the Albers equal-area conic projection with the same standards, the area of the eco-region of the Roof of the World is 4,000,947 km^2.

4.3 Attribute data of the eco-regional boundary of the Roof of the World

The outline of the eco-regional boundary of the Roof of the World is divided into 40 segments according to the differences of its neighbors. The lengths of each segment are identified and calculated via the Lambert conformal conic projection (Table 2).

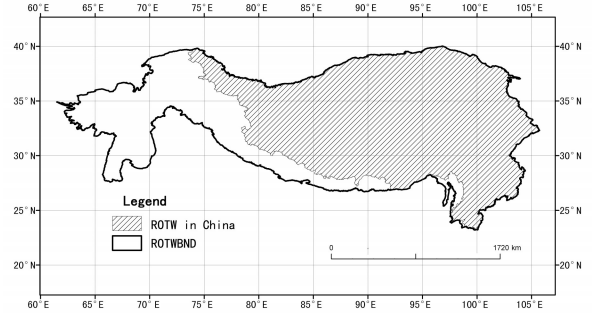


Figure 6 Eco-regional boundary data for the Roof of the World in ARCGIS .shp Format.

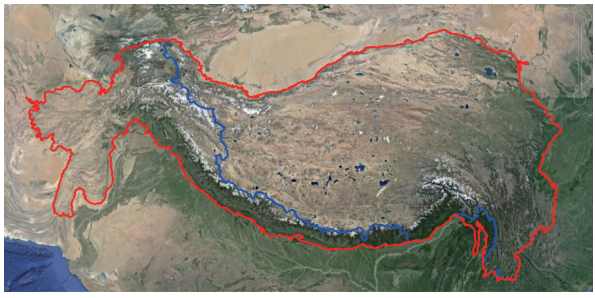


Figure 7 Eco-regional boundary data of the Roof of the World in Google Earth .kmz Format

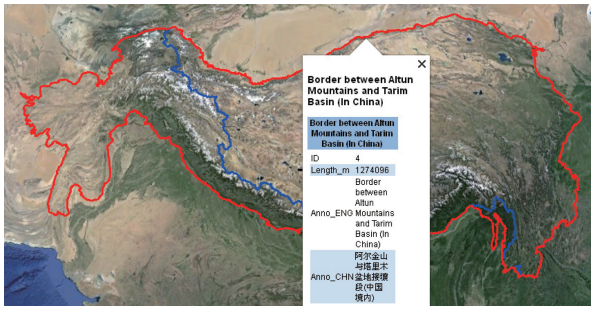


Figure 8 Eco-regional boundary data of the Roof of the World with the attribute data in Google Earth .kmz Format

5 Discussions

5.1 Integrating the national administrative boundary data

Integrating the national administrative boundary data at the scale of 1:1 million to the data of elevation, slope, and remote sensing images in a resolution of 30 m is difficult, since they are not exactly compatible in data resolution and scale. The solution is keeping a 30-m resolution as much as possible; otherwise, we use the 1:1 million data instead, until a new version of the national administrative boundary data made.

5.2 The boundary in the southeastern part of the region

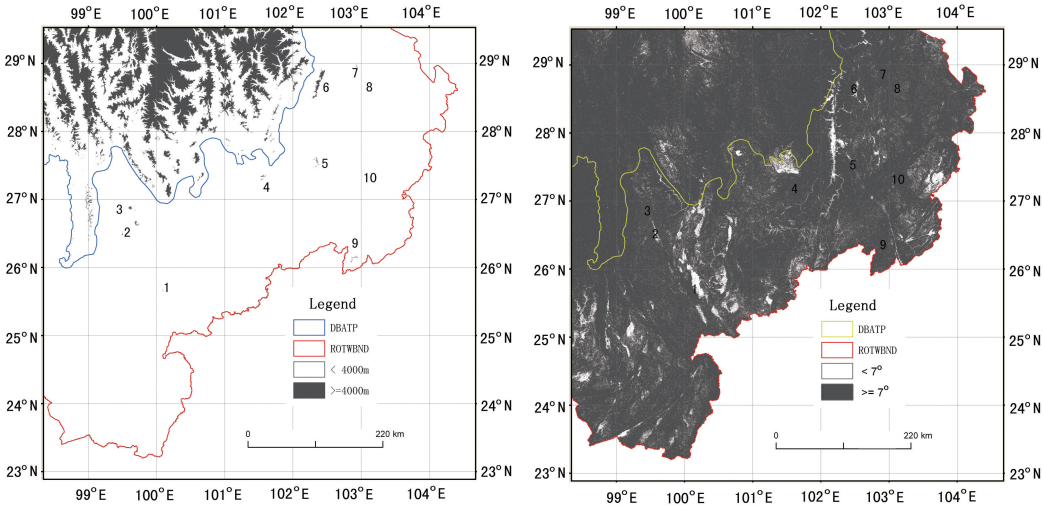
There is a debate regarding the location of the boundary in the southeastern part of the

Table 2 Attribute data of eco-regional boundaries of the Roof of the World

No.	Name of segment	Length (km)
1	Border between the Pamirs and the Tianshan Mountains (in China)	150
2	Border between the Pamirs and the Kashgar Plain (in China)	479
3	Border between the Kunlun Mountains and the Tarim Basin (in China)	2023
4	Border between the Altun Mountains and the Tarim Basin (in China)	1274
5	Border between the Qilian Mountain and the Hexi Corridor (in China)	1344
6	Border between the ROTW and the Loess Plateau (in China)	735
7	Border between the ROTW and the Qinling Mountains (in China)	469
8	Border between the ROTW and the Daba Mountain (in China)	89
9	Border between the ROTW and the Sichuan Basin (in China)	891
10	Border between the ROTW and the Yunnan-Guizhou Plateau (in China)	1032
11	Eastern part of the South Hengduan Mountains (in China)	600
12	Border between China and Myanmar	5
13	Eastern part of the South Hengduan Mountains (in Myanmar)	133
14	Border between China and Myanmar	285
15	Western part of the South Hengduan Mountains (in Myanmar)	1221
16	Eastern border between the Himalaya Mountains and the Brahmaputra Plain (in India)[18-22]	290
17	Border between China and India, which lies in the south of the Himalaya Mountains	432
18	Border between Bhutan and India, which lies in the south of the Himalaya Mountains	526
19	Western border between the Himalaya Mountains and the Brahmaputra Plain (in India)	75
20	Eastern border between the Himalaya Mountains and the Gangetic Plain (in India)	50
21	Border between the Himalaya Mountains and the Gangetic Plain (in Nepal)	1293
22	Western border between the Himalaya Mountains and the Gangetic Plain (in India)	442
23	Border between the Himalaya Mountains and the Indus Plain (in India)	739
24	Border between the Himalaya Mountains and the Indus Plain (in Pakistan)	140
25	Border between the Karakoram Mountains and the Indus Plain (in Pakistan)	510
26	Border between the Sulaiman Mountains and the Indus Plain (in Pakistan)	1361
27	Border between the Central Brahui Range and the Indus Plain (in Pakistan)	266
28	Border between the Central Brahui Range and the Kuthar range (in Pakistan)	183
29	Border between the Central Brahui Range and the Central Makran Ridge (in Pakistan)	115
30	Southern border between the Central Brahui Range and the Registan Sand (in Pakistan)	203
31	Border between the Central Brahui Range and the Registan Sand (in Afghanistan)[23]	125
32	Northern border between the Central Brahui Range and the Registan Sand (in Pakistan)	72
33	Border between the Sulaiman and the Registan Sand (in Afghanistan)	167
34	Border between the Hindu Kush Mountains and the Registan Sand (in Afghanistan)	379
35	Western border of the Hindu Kush Mountains (In Afghanistan)	1482
36	Border between the Hindu Kush Mountains and the Kara-Kum Desert (in Afghanistan)	1392
37	Border between the Hindu Kush Mountains and the Dushanbe oasis (in Afghanistan)	373
38	Border between the Pamirs and the Dushanbe Oasis (in Tajikistan)[24-25]	220
39	Border between the Pamirs and the Gissar-Alai ranges (in Tajikistan)	312
40	Border between the Pamirs and the Gissar-Alai ranges (in Kyrghyzstan)	212

Table 3 Elevation table of each of the peaks over 4000 m in the eastern part of the eco-region of the Roof of the World

No.	Name of peak	Elevation (m)
1	Mt. Diancang Shan (Peak Malong)	4122
2	Mt. Xuebang Shan	4295
3	Mt. Liaojun Shan	4247
4	Mt. Bailin Shan	4393
5	Mt. Luoji Shan (Peak Yereyu)	4359
6	Mt. Xiaoxiangling (Peak Huadoujian)	4791
7	Mt. Ma'an Shan	4288
8	Mt. Daliang Shan (Peak Dafengding)	4043
9	Mt. Gongwang Shan (Peak Xuelinghuofeng)	4344
10	Mt. Yao Shan (Peak Jiaoding Shan)	4041



(A) (B)

Figure 9 Map of boundaries between the ROTW and the DBATP (See Table 3 for the elevation data from No.1 to No.10) (A) Elevation, (B) Slope

region. The key point among the different opinions is how to deal with the transition belt or buffer region from 2000 to 4000 meters above sea level in the Yunnan- Guizhou Plateau and the Hengduan Mountains[26-27]. ZHANG Yili et al. (2002) identified the boundary as shown in the DBATP (Dataset of Boundary and Area in Tibetan Plateau) in Figure 9[9, 28]. It is closer to the contours of the 4000 m above sea level. However, this research finds that there is a series of peaks in which the elevation is higher than 4000 m, which are outside of the DBATP boundary. The peaks, as shown in Figure 9, that are all higher than 4000 m are the following: Mt. Dianchang Shan (4122 m), Mt. Xuebang (4295 m), Mt. Laojun (4247 m), Mt. Bailin (4393 m), Mt. Luoji (4359 m), Mt. Xiaoxiangling (4791 m), Mt. Ma'an Shan (in Guanluo County, 4288 m), Mt. Gongwang Shan (4344 m), and Mt. Yao Shan (4041 m) (Table 3). Furthermore, there is a series of peaks in the Mt. Laojun Shan and Mt. Xiaoxiangling areas that are over 4000 m, instead of only one peak or two peaks. It is very

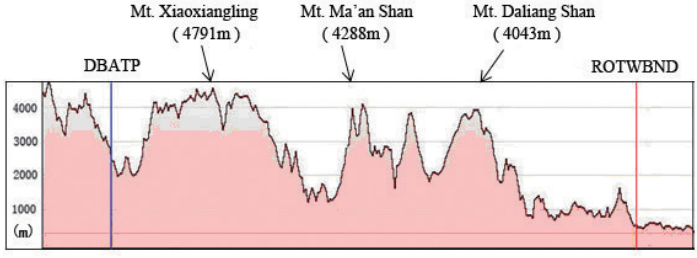


Figure 10 Profile between ROTWBND and DBATP in Sichuan province through Mt. Daliang Shan, Mt. Ma'an Shan and Mt. Xiaoxiang Ling (Integrating with Google Earth Data, May 2014)

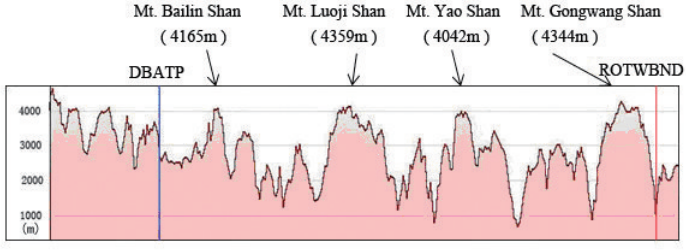


Figure11 Profile between ROTWBND and DBATP in Yunnan and Guizhou provinces through Mt. Gongwang Shan, Mt. Yao Shan, Mt. Luoji Shan, and Mt. Bailin Shan (Integrating with Google Earth Data, May 2014)

clear from the new data that this area is the transfer area from the Yungui Plateau and Mt. Hengduan at 2000 m above sea level to the Qinghai-Tibet Plateau at 4000 m (Figures 10- 12). There is no peak over 4000 m in the eastern part of Asia. According to the principles of geographical regionalization, the authors believe that keeping the maximum similarities and minimum differences within the region, and keeping the mountain ecosystem in a systematic manner, that it is suitable to divide the transfer area into the eco-region of the Roof of the World in this way.

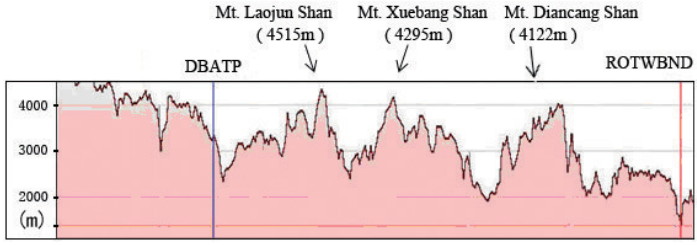


Figure 12 Profile between ROTWBND and DBATP in Southeastern area of Mts. Hengduan through Mt. Diancang Shan, Mt. Xuebang Shan and Mt. Laojun Shan (Integrating with Google Earth Data, May 2014)

6 Conclusions

The roof of the world is the highest region in the world. More and more researchers are involved in global environmental changes studies in this region. The boundary data of eco-region of the roof of the world is a very basic data for their studies. Based on the eco-regional division theory, the data-driven methodology of integrating updated data at a 30-m resolution (DEM, elevation, slope) and remote sensing images is an update way to finalize the new dataset with the new discovering. As the first dataset to be published and openly available for free access and re-use for non-commercial uses from the Global Change Research Data Publishing and Repository (www.geodoi.ac.cn), it could be an example for exploring a new way identified by the Digital Object Identifier (DOI) in practical dimension of global change research data sharing principles.

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References

[1] Sun Honglie, Zheng Du. Evolution and Development of Tibet Plateau. Guangzhou: Guangdong Science and Technology Press, 1998.

[2] Wang Hongzhen. The main stages of tectonic development in Asia. Science in China, 1979, (12): 1187-1197.

[3] Editorial Committee, Dictionary, Shanghai Lexicographical Publishing House, 1999.

[4] Great Soviet Encyclopedia,. Prokhorov A M ed (New York: Macmillan, London: Collier Macmillan, 1974-1983. 31 volumes, three volumes of indexes. Translation of third Russian edition of Bol'shaya Sovetskaya Entsiklopediya (in English).

[5] Li Bingyuan. On the extent of the Qinghai-Xizang (Tibet) Plateau. Geographical Research, 1987, 6(3): 57-64.

[6] Encyclopedia Britannica. Encyclopedia Britannica Online Academic Edition. Encyclopedia Britannica Inc., 2013. Web. 12 Dec. 2013. http://www.britannica.com/EBchecked/topic/266291/Hindu-Kush.

[7] A Strategy and Results Framework for ICIMOD, October 2012, www.icimod.org/resource/9311.

[8] Outline of Hindu Kush Himalayans, ICIMOD, 2014, http://geoportal.icimod.org/Downloads/Download.aspx?ID=3#.

[9] Zhang Yili, Li Bingyuan, Zheng Du, A discussion on the boundary and area of the Tibetan Plateau in China, Geographical Research, 2002, 21(1): 1-8.

[10] Liu Chuang. A new methodology for comprehensive physical regionalization of China supported by EOS in the moderate scale. Progress in Geography, 2004, 23(6): 1-9.

[11] ASTER GDEM 2, Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER), October 2011, Digital Elevation Database, Earth Remote Sensing Data Analysis Center, Japan, ASTER GDS User Service, http://www.gds.aster.ersdac.or.jp/gds_www2002/service_e/inq.c_e/set_inq.c_e.html, LP DAAC User Services, https://lpdaac.usgs.gov/customer_service.

[12] SRTM, Shuttle Radar Topography Mission, 90m Digital Elevation Database. http://srtm.usgs.gov/.

[13] Liu Chuang, Shi Ruixiang, Lv Tingting, Chen Wenbo, Zhou Xian, Wang Zhengxing. Elevation cluster dataset of the eco-region of the Roof of the World, Global Change Research Data Publishing and Repository, (2014), DOI: 10.3974/geodb.2014.01.02.v1, http://www.geodoi.ac.cn/doi.aspx?Id=10.3974/geodb.2014.01.02.v1.

[14] Liu Chuang, Shi Ruixiang, Lv Tingting, Chen Wenbo, Zhou Xian, Wang Zhengxing. Land Slope Cluster Dataset of the Eco- region of the Roof of the World, Global Change Research Data Publishing and Repository, (2014), DOI: 10.3974/geodb.2014.01.03.v1, http://www.geodoi.ac.cn/doi.aspx?Id=10.3974/geodb.2014.01.03.v1.

[15] Google earth. May. 2014.

[16] National Geomatics Center of China, Administrative Boundary Data of China, 2010.

[17] Global Administrative Areas, Boundaries without Limit, http://www.gadm.org/version2, 2012.

[18 Liu Hang, Mao Hanying, Wang Shoucun. Handbook of Physical Geography of the World. Beijing: Knowledge Publishing House, 1984.

[19] Wan Peilin. Dictionary of Mountains and Rivers of the World, Shandong Education Publishing House, 1997.

[20] Zhou Dingguo et al. Chinese- Foreign Language Handbook of Global Geographical Names. Beijing: China Cartographic Publishing House, 1960.

[21] Dictionary of World Location Names. Shanghai Lexicographical Publishing House, 1980.

[22] Volume of Geography, China Encyclopedia. Beijing: Encyclopedia of China Publishing House, 1992.

[23] Border Treaty of The People's Republic of China and the Kingdom of Afghanistan. The Bulletin of the Standing Committee of the National People's Congress, 1963, http://www.law-lib.com/law/law_view.asp?id=94946.

[24] The Agreement on the Border between the People's Republic of China and the Republic of Tajikistan, the Bulletin of the Standing Committee of the National People's Congress, 2000. http://www.law-lib.com/law/law_view.asp?id=96669.

[25] Protocol of Surveying Boundary between the People's Republic of China and the Republic of Tajikistan, the Bulletin of the Standing Committee of the National People's Congress, 2010. http://baike.baidu.com/view/6583305.htm.

[26] Li Bingyuan. Study on Boundary of Mt. Hengduan. Mountain Research, 1987, 5(2): 74-82.

[27] Chen Fubin. Study on the Name of Mt. Hengduan. Mountain Research, 1983, 2(1): 31-33.

[28] Zhang Yili, Li Bingyuan, Zheng Du. Datasets of the boundary and area of Tibetan Plateau, Global Change Research Data Publishing and Repository, 2014, DOI: 10.3974/geodb.2014.01.12.v1, http://www.geodoi.ac.cn/doi.aspx?Id=10.3974/geodb.2014.01.12.v1.