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DYNAMICS OF GLACIERS AND PATTERNS OF PALEO-GLACIATION IN MUNKHSARDIG

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Degradation of glaciers is a main indicator of global warming. In this study, we have determined the dynamics of glacier and paleo-glaciation patterns based on the satellite image processing approach using a geographic information system and remote sensing. As a result, glacier area considerably decreased by 57.3% (51.6 ha) in last 37 years (1970-2007). Glacier on the north and south-facing slopes melt up to the 47 m and 80 m, respectively. Air temperature anomaly have been increased by 2.16°C in the during 1970-2007, and it will be continuing that glacier of Munkhsardig will completely melt in 2043 (after 30 years from the 2007).

Key words: Munkhsaridag, glacier, aspect, moraine deposit

ДИНАМИЧЕСКАЯ ИЗМЕНИВОСТЬ НЫНЕШНЫХ ОЛЕДЕНЕНИЙ И ИХ ДРЕВНИЕ СЛЕДЫ ГОРЫ МУНХСАРЬДАГ СЕВЕРНОЙ МОНГОЛИИ ОЛЕДЕНЕНИЙ

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Одним из основных проявлений теплений климата оттаяния оледенения и ледовитых рек. В наших исследований проводилось дистанционное зондирование динамической изменчивости нынешних оледенения и следов древних оледенения горы Мунхсарьдаг Северной Монголии и обработанной на основе методики географической информационной системы. В общем между 1970-2007 гг. оттаялись 51.6 га или 57.3% площадей оледенения. А также уменьшались оледенение задней склоны на 47 м, а с южной склоны до 80 м. А также к 2043 году или через 30 лет будет полностью оттаяны оледенение горы Мунхсарьдаг.

Ключевые слова: Мунхсарьдаг, оледенение, аспект, морайн депозит

Mountain ranges of Mongolia were formatted by new tectonic movements in during the end of the 3rd and beginning of the Quaternary era. After mountains uplifting, cold climate was dominated in there, and then glaciers were generated [1].

Since 1870, Russian travelers and researchers mentioned in their reports about primary conclusion of glaciers in Mongolia, while it has been systematically conducting by research expeditions since 1921 [2].

Paleo-glaciation patterns are abundantly occurred in the mountainous ranges in Mongolia, such as Khentii, Khangai, Altai and Khuvsgul. Although present-glaciers are extended in small part of in these mountains, it is clearly evident by recent conclusion of researchers that area of present-glaciers has been decreasing significantly.

Glacier investigation in the middle of 20th century was estimating area using an aerial photography and topographic maps, and then slightly changed into a comparison of time series images and estimating glaciers dynamics based on climate data in the end of 20th century. This investigation has been developing intensively using a GIS technology and RS applications. Installing automatic weather station, observing discharge of river from glaciers, sampling ice, and radio-carbon dating give us understanding clearly reconstructed paleoclimate condition and dynamics of glaciers for 100 years.

Munkhsardig is located at edge of boundary between Mongolia and Russia, and elevation of the summit is 3491 m o.s.l which is highest point of Khuvsgul mountain ranges (Figure 1).

The main objectives of this study are (i) determining the paleo-glaciation patterns, and (ii) calculating the dynamics of glacier area based on satellite images and topographic maps.

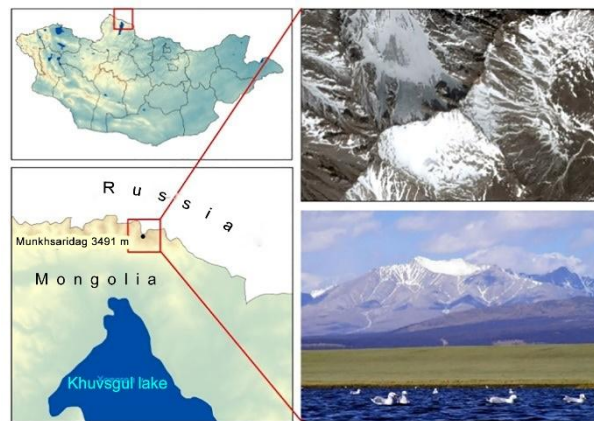


Figure 1 – Location map of Munkhsaridag and photo captured from shoreline of Khuvsgullake

Data and methodology

- Landsat images (1986/7/23,2000/8/6,2007/8/11)
- ASTER DEM 30 m
- Daily air temperature in Renchinlkhumbé station
- Topographic map (M47-10 sheet 1970)
- High resolution image(Google Map)

Digital Number (DN) of Landsat image bands was converted into radiance and reflectance using ENVI software, and in order to illustrating of glaciers and other areas, RGB combination of 7, 4, and 2 bands created false color of reflectance. NDSI (Normalized Difference Snow Index) was calculated in each year, and then we have mapped probability of glacier extent using index ranges from 0.4 to 1.0.

$$\text{NDSI} = \frac{\text{GREEN} - \text{SWIR1}}{\text{GREEN} + \text{SWIR1}} \quad (1)$$

Exposition of glaciers, moraine deposit of paleo-glaciation, floodplain, and elevation of lower boundary of glaciers were estimated from ASTER GDEM with 30 m spatial resolution [5].

Glacier area of Munkhsaridag in 1970, 1986, 2000, and 2007 have estimated by our approach 90.1 ha, 95.1 ha, 54.5 ha, and 38.5 ha, respectively

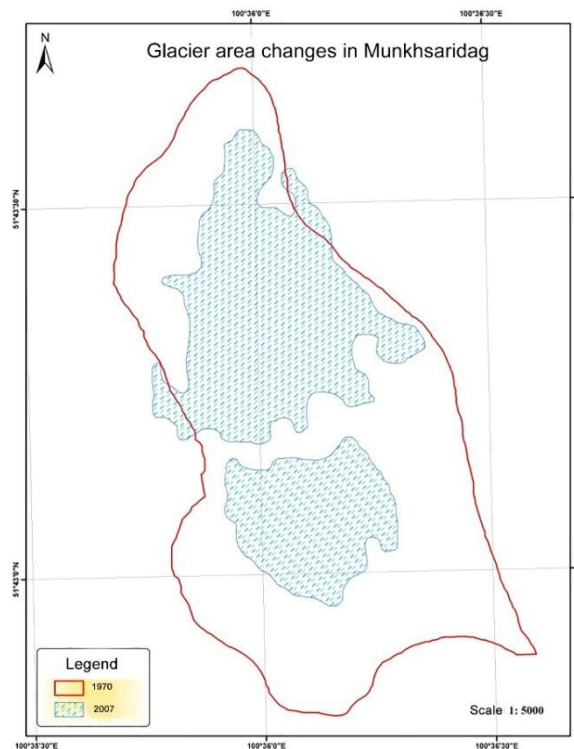


Figure 2 – Glacier changes of Munkhsaridag

Glacier area considerably decreased by 57.3% (51.6 ha) in last 37 years (1970-2007; Figure 2). Glacier lower altitude of 1970 and 2007 was at 2892 m and 2939 m in north-facing slopes, while at 3150 m and 3230 m in south-facing slopes, respectively. Glacier lower altitude on the north and south-facing slopes melt up to the 47 m and 80 m, respectively (Figure 3)

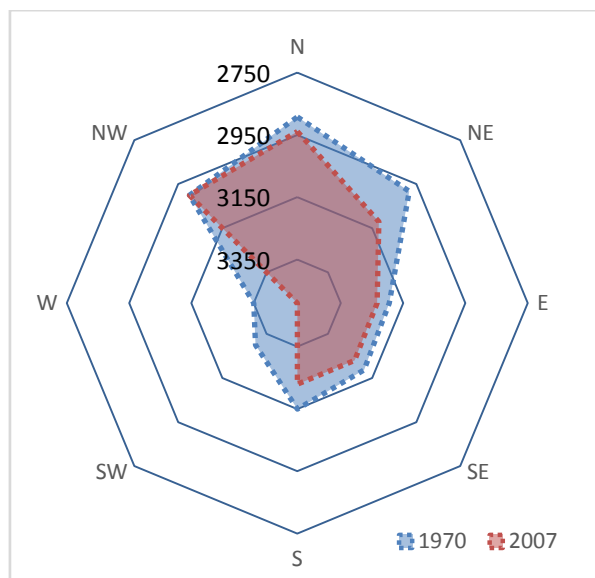


Figure 3 –Glacier lower altitude and exposition in 1970 and 2007.

Glaciers of the north, south and south-east slopes place took 71.1% and 76% of total glacier area in 1970 and 2007. Glaciers of west and south-west slopes, meanwhile, was 4.2% in 1970 which had completely melted in 2007 (Table 1).

Table 1–Glaciers percentage in eight aspects in four images in Munkhsaridag

Aspect	Unit	1970	1986	2000	2007
North	%	33.44	33.92	50.52	55.37
North-east	%	9.94	9.09	3.75	1.6
East	%	6.59	11.97	3.66	1.84
South-east	%	18.83	13.44	10.48	10.67
South	%	18.04	15.32	17.2	18.51
South-west	%	3.51	1.59	0.02	0
West	%	0.59	1.82	0.04	0
North-west	%	9.06	12.85	14.32	12

Glaciation cycles occurred frequently in during the quaternary era in Mongolian territory. The first glaciation in lower Pleistocene before the second glaciation occurred in Upper Pleistocene which was height of the all glaciation at the center part of mountain ranges. In Munkhsaridag, Khuvsgulmountains, paleo-glaciation had occurred 2-3 times centrally this summit [1].

Rock debris predominantly occupies in the steep slopes of Munkhsaridag, and can be clearly observe paleo-glaciation patterns in there [6]. Glacier of south-facing slopes is situated within the largest cirque, while no glaciers in east side cirque which has steep slopes and average elevation is about 3000m. However, paleo-glaciation patterns witnessed in the north-facing slopes, and approximately 240 m height end moraine is located at 2380 m, it blocked a melted water stream and the glacier lake has been forming behind the natural dam. Current end moraine, meanwhile, is situated

at 2705 m and floodplain with 500m length and 270 m width take place between end moraine and small lake (Figure 4).

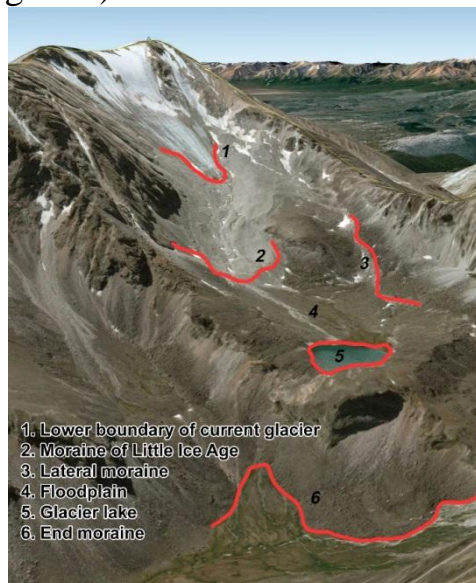


Figure 4 – Paleo-glaciation patterns on north-facing slopes, Munkhsaridag

Glacier area in Munkhsaridag mountain tend to decrease in the study period and it considerably decreased by 57.3% (51.6 ha) in last 37 years (1970-2007). Glacier lower altitude of 1970 and 2007 was at 2892 m and 2939 m in north-facing slopes, while at 3150 m and 3230 m in south-facing slopes, respectively. Glacier lower altitude on the north and south-facing slopes melt up to the 47 m and 80 m, respectively

The 68.9% of glaciers are located in the north side of mountain according to the estimation of latest image (2007). Air temperature anomaly have been increased by 2.16°C in the during 1970-2007, and it will be continuing that glacier of Munkhsardig will completely melt in 2043 (after 30 years from the 2007). End moraine of paleo-glaciation and current glacier are located at 2380 m and 2705 m, respectively. The distance between paleo and current end moraine is 325 m, while lower altitude of glaciers melted up to 220 m.

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