

## **Thermokarst lake dynamics in the continuous and isolated permafrost zones, Mongolia**

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Thermokarst lakes are one of the most common features on the moist depressions and valleys in Mongolian permafrost region. Although the spatiotemporal changes of thermokarst lake dynamics have not been investigated in the region so far. These lakes are defined as lakes that occupy generally closed depressions formed by the settlement of ground following of ice rich permafrost or melting of massive ice. After a thermokarst lake has formed, the lake size may change due to continued permafrost thaw, variations in air temperature, potential evapotranspiration and precipitation. The aims of this study are (1) to provide quantitative information on the temporal and spatial changes of thermokarst lakes in Mongolia and (2) to address the effects of the long-term trends of hydro-climatic regimes and permafrost degradation on the changes of thermokarst lakes.

This study used the high spatial resolution Corona (1962-1968), Landsat ETM+ (1999-2001), and ALOS/AVNIR-2 (2006-2007) satellite images to determine changes of thermokarst lake dynamics at seven study sites in the continuous and isolated permafrost zones of Mongolia. Lakes larger than 0.1 ha (1000 m<sup>2</sup>) were analyzed using remote sensing and geographical information system tools. Between 1962 and 2007, the total number and area of thermokarst lakes increased by +25% (296 to 371), and +9% (3350 ha to 3651 ha) in the continuous permafrost zone, respectively. These changes correspond to the appearance of 77 new lakes (158 ha) during the last 45 years. In contrast, lakes in the isolated permafrost zone have decreased by -40% (108 to 64) in number and -10% (409 ha to 367 ha) in area from 1962 to 2007. The changes in lake area and number are likely to be attributed to shifts in climate regimes and local permafrost conditions. Since 1962, the mean annual air temperature and potential evapotranspiration have increased significantly in the northern continuous permafrost zone compared to the southern isolated permafrost zone. Due to ongoing atmospheric warming without any significant trend in annual precipitation, patches of ice-rich subsurface have thawed, and the number and area of thermokarst lakes have accordingly developed in the continuous permafrost zone. Shrinking of thermokarst lakes in the isolated permafrost zone may be due to disappearing permafrost, deepening of the active layer, and increased water loss through surface evaporation and subsurface drainage.

This study provides the first baseline information of thermokarst lake changes in Mongolia, filling the gap in sub-Arctic lake inventories at regional scales such as the southern fringe of Siberian permafrost region.