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Environmental fluctuations of the Lake Chany complex in western Siberia based on NOAA images

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ABSTRACT: The Lake Chany complex, located in Western Siberia, consists of the large shallow lakes with an average depth of about 2 m. The lake area fluctuates according to water level that depends closely on the amount of inflow (snow-melt) and the evaporation, since the lake complex has no outflow river. Based on NOAA/AVHRR satellite normalized difference vegetation index (NDVI) data of the ice-free periods in 2000 and 2001, we evaluated the seasonal changes in the lake area and the surrounding vegetations of the Lake Chany complex. In late April or early May, the maximum lake area was observed and the lake area decreased drastically until late May or early June. Then, the lake area decreased gradually from early June to late August. The lake area in August was about 70 % of the maximum. Then, the area tends to increase by early October. Compared with the ground truth in August 2001, the seasonally fluctuated areas on NOAA images corresponded to the vast vegetations with several km in width of reed (*Phragmites communis*) stands which seem to be influenced by the inflow of snow meltwater and the growth of reeds.

Key Words: Lake Chany, NOAA images, lake area, seasonal fluctuation, *Phragmites communis*

Introduction

The Lake Chany complex is situated in the Barabinsk steppe between the rivers Ob and Irtish in western Siberia at an elevation of 106 m above sea level. The average depth is about 2 m with a maximum of 8.5 m. The inflow from the rivers Chulym and Kargat is mainly (91 per cent) supplied by snowmelt, whereas there is no outflow river from the lake complex. The lake area fluctuates according to the water level that depends closely on hydrological fluctuations in this region (Aladin and Plotnikov 1993).

Using the NOAA satellite normalized difference vegetation index (NDVI) data of the ice-free periods in

2000 and 2001, we evaluated the seasonal changes in the lake area and the surrounding vegetations of the Lake Chany complex. Furthermore, we compared NOAA images with the data from the ground truth in August 2001.

Materials and Methods

The Lake Chany complex is located between 54°30' - 55°09'N and 76°48' - 78°12'E. The lake complex consists of the Bolshye (large) Chany, the Malye (small) Chany, and the Lake Yarkul, which are connected with channels. The Bolshye Chany consists of four sectors. The western part (Yudinskyi pool) of the Bolshye Chany is now isolated by dams, and this section is almost dried up. The others are Chinyaikhinskii pool (southern part), Tagano-Kazantsevskii pool (central part), and Yarkov pool (eastern part). The endorheic catchment area is about 30,000 km^2. The climate is continental. The duration of ice-covered is between the beginning of November and the end of April (Aladin and Plotnikov 1993).

The NOAA data from Advanced Very High Resolution Radiometer (AVHRR) is received at the Siberian Branch of the Russian Academy of Sciences (SB RAS) in Novosibirsk, Russia to study the Siberian environments and the changes. A direct computer network named VSAT system using Russian communication satellite is connected between Tohoku University in Sendai, Japan and SB RAS. To construct the Siberian Image Database, the received NOAA/AVHRR data are transferred to Tohoku University by VSAT system (Kudoh *et al.* 2001).

The clear images without clouds above the Lake Chany were selected from the Image Database of NOAA-14 satellite in 2000 and 2001. We used the images from April 25th to October 6th in 2000, since the ground was covered with snow before the late April and there were not good images for the analyses after the early October due to cloudy weather in the winter season. In 2001, several images from April 20th to September 24th were available for the analyses. We estimated the lake areas form the images of the normalized difference vegetation index (NDVI) derived from NOAA/AVHRR data. NDVI, which is the most well-known vegetation index, combines spectral data of channel 1 (580 - 680 nm, visible) and channel 2 (725 - 1100 nm, near infrared): NDVI = (channel 2 - channel 1)/(channel 2 + channel 1) (Tucker and Sellers 1986). We evaluated the lake surface using two cases of ranges in NDVI value. The case 1 is the range from -1.0 to -0.1 and the case 2 is the range from -1.0 to -0.06. The numbers of the pixels classified by the NDVI values of the case 1 and 2 were counted, respectively. One pixel of the image corresponds to 1.1 km x 1.1 km on the ground.

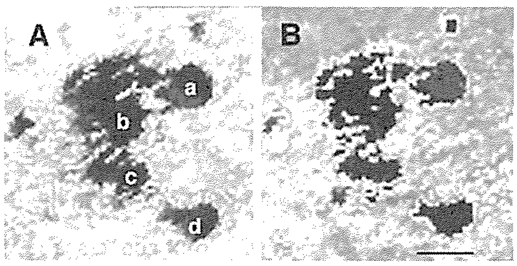

Fig. 1. NDVI images of the Lake Chany on May 12th (A) and August 1st (B) in 2001. The sectors a, b and c correspond to the Bolshye Chany and the sector d is the Malye Chany. a: Yarkov pool, b: Tagano-Kazantsevskii pool, c: Chinyaikhinskii pool. Bar: 20 km.

Results and Discussion

The examples of NDVI images of the Lake Chany on May 12th and August 1st in 2001 are shown in Fig. 1. The black parts in the NDVI images correspond to the lake surface areas. From the NDVI image on May 12th, the land area between Yarkov pool and

Tagano-Kazantsevskii pool and the channel area between Chinyaikhinskii pool and the Malye Chany look narrow compared with the image on August 1st in 2001. Accordingly, the lake surface areas of Tagano-Kazantsevskii pool and Chinyaikhinskii pool on May 12th were larger than those on August 1st, whereas the lake area of the Malye Chany did not changed between two images.

To estimate the lake surface area, we compared two cases of the NDVI ranges. Using the range of case 1 (from -1.0 to -0.1), the large bays with about 2 km in width were not recognized on the NDVI images. Therefore the case 1 tends to underestimate the lake surface by comparison with the observation of the ground truth in August 2001. Using wider range of the case 2 (from -1.0 to -0.06), additional pixels with NDVI values from -0.1 to -0.06 corresponded to the areas of the shorelines and the large bays. Hence we adopted the NDVI values form -1.0 to -0.06 (the case 2) for estimation of the lake surface.

Figure 2 shows the seasonal changes in the lake surface areas of the Lake Chany expressed in square km. In early May 2001, the maximum lake area (1747 km^2) was observed. The lake area decreased drastically to 1248 km^2 until late May and then decreased gradually to 1107 km^2 from late May to early August. The lake area in August was about 70 % of the maximum. On the contrary, the lake area tends to increase from August to late September. Although we have no data of July and August in 2000 due to the trouble of the VSAT system, the seasonal changes of the lake area in 2000 were similar to those in 2001.

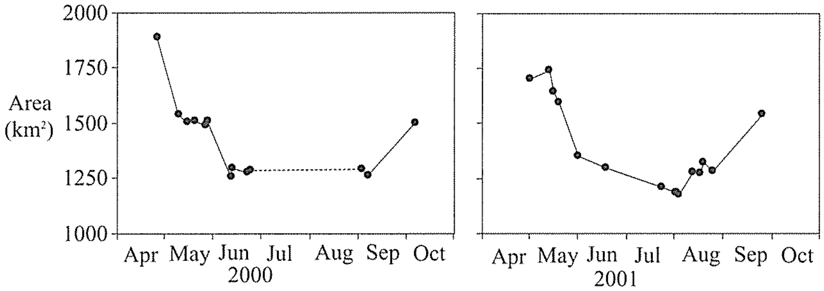

Fig. 2. The seasonal changes in the water area of the Lake Chany in 2000 and 2001.

In late April, the snow in the catchment area thawed and the meltwater run into the Lake Chany. The runoff may explain the maximum area of the lake surface in late April or early May. As spring proceeds, the evaporation from the lake seems to reduce the water level, and then the lake surface area may decrease. From late August, the water level may rise due to the cloudy or rainy weather in autumn.

In the seasonally fluctuated areas on the NDVI images, the reed (*Phragmites communis*) communities are situated at the shore margins and formed vast vegetation of several km in width. It may be plausible that the vegetations of reed were covered with snow in winter season and then aboveground bodies of reed lay down in the water during early spring. If so, some of the reed communities may be recognized as lake surface on the NOAA image. The rapid growth of the reeds which lay down in the water may cover the lake surface. Consequently, the rapid decrease of lake area in spring season may be observed.

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