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Glacier Retreat and Climate Change in Northern Tien Shan (Kazakhstan/Kyrgyzstan) visualized and analysed by DEMs, Landsat and ASTER Data

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The study area Zailiskiy and Kungey Alatau (42.5˚ – 43.5˚ N; 75˚ – 79˚ E), a part of the Northern Tien Shan, is situated at the border between Kazakhstan and Kyrgyzstan. The mountain ranges rise up in the north from the Kazkh Steppe at an altitude of about 800 m asl. up to nearly 5000 m asl. An intramountanious basin, which is filled by Lake Issyk-Kul (1608 m asl.) marks the southern edge. The climate varies within a short distance from semi-humid to semi-arid conditions. The average of the equilibrum line altitude (ELA) is about 3800 – 3900 m asl.

For this study Landsat, ASTER data and a DEM were used to analyse the retreat of glaciers and the consequences. The DEM of Zailiskiy and Kungey Alatau was generated combining the 3-arc-data from the Shuttle Radar Topography Mission (SRTM, 90m-resolution) with DEMs genreated from two ASTER-scenes (years 2000 and 2001, 30m-resolution). The accuracy of the ASTER and SRTM DEMs were analysed by comparison with DEMs derived from contour maps. Results show that the elevation values of the ASTER DEM are often slightly lower in higher altitudes, whereas the elevation values of the SRTM DEM are mostly correct. Problems occour with both DEMs in areas with steep slopes.

The climate change since the end of the 19^{th} century was analysed using time series of 16 climate stations located in the study area, nine of them around 2000 m asl. or higer and four even higher than 3000 m asl. Since the 1930s, latest since the 1950s there is a significant increase of the average yearly temperature. This trend is even greater since the 1970s. Compared to the average of the world the increase in the second half of the last century was in the study area 3 to 4 times as high. The increase of the temperature was even greater during the winter months. However, the temperatures increased less

in the higher altitudes. For the precipitation there was a small rise in avereage, but no significant trend.

The climate data and DEM were also used for a regionalisation of temperatur and precipitation in the study area on the base of a regression analysis. In addition the solar radiation was calculated.

The glacier extent was automatically identified with good acurracy using channels 4, 5 and the NDVI of a Landsat ETM-Scene from the year 1999. Problems occur with debis cover on glacier tongues, and clouds covering some parts of glaciers. With the help of morphometric analyses including tangetial, vertical curvature and slope calculated from the DEM it was possible to delineate many of these covered glaciers. Morphometric analyses also helped to identify the Little Ice Age moraines. A Landsat MSS-Scene from year 1975, ASTER-Scenes from years 2000 and 2001 and data taken from the Glacier Inventory of the former USSR (1960s) were used to study the glacier retreat in four selected valleys in detail.

Melting of the glaciers corresponds highly with the developement of the temperatures. Whereas between 1960 and the 1975 a little deacrese of the glaciers occured, the melting increased significantly after the 1970s. The glaciated area decreased 35-40% and the ELA increased over 70 m since 1960, and over 110 m since the Little Ice Age. However, the reaction of the regional glaciers varies with the climatic conditions, especially with the solar radiation. The ELA shift of glaciers with high radiation input is much greater than glaciers with low radiation input.

Analyses also indicate an increase of glacial lakes. This combined with the concomitant melting of the permafrost and rock glaciers causing increasing danger mass movements and mudflows. 3D visualization technics are used to demonstrate the results of the study.