ZHADANG GLACIER: ORTHORECTIFICATION OF TERRESTRIAL TIME-LAPSE CAMERA IMAGES FOR SNOW LINE MAPPING

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Glaciers are characteristic elements of high mountain environments and represent key indicators for the ongoing climate change. The covering snowpack considerably affects the glacier-ice surface temperature and thus the meltdown of the glaciers which in recent decades has been accelerating worldwide. Therefore, the detailed investigation as well as the accurate delineation of the actual snow line – here defined as the fluctuating lower altitudinal boundary of a snow-covered area – are of high importance.

Zhadang Glacier is located in the western Nyainqentanglha Mountain Range in the central part of the Tibetan Plateau (30°28.24' N, 90°38.69' E). The glacier is debris-free, covers an area of 2.0 km^2, has a length of 2.2 km and flows from 6,090 to 5,515 m a.s.l. Recent measurements have shown that the whole glacier is below the equilibrium line altitude (ELA) and experiences significant glacier volume loss.

Between 2009 and 2012 there have been several field campaigns to Zhadang glacier within the framework of the joint Sino-German research projects "TiP" (Tibetan Plateau: Formation – Climate – Ecosystems; Subproject: Dynamic Response of Glaciers on the Tibetan Plateau to Climate Change) and "WET" (Variability and Trends in Water Balance Components of Benchmark Drainage Basins on the Tibetan Plateau). Two terrestrial cameras were installed and have been continuously operating between May 2010 and September 2012 generating 6,225 images of Zhadang Glacier with a frequency of three resp. six images per day (Fig. 1 and Fig. 2). The result is a globally unique dataset.

Figure 1: Original images taken by Camera 1 on July 16th 2011 (red box: 16:00 image used for snow line mapping)

Figure 2: Original image taken by Camera 1 on July 16th 2011 at 16:00

In order to use this dataset for snow line mapping all images had to be georeferenced and orthorectified. The biggest challenge was the problem of the shifting camera positions due to deformations of the ground (melting und refreezing) and hence the offset in the image coordinates. This was resolved by combining the manual orthorectification of one image per week and a subsequent application of a spline interpolation to determine the changed image coordinates. The actual orthorectification was finally realized by applying a fully automated batch processing of all images.

The most favorable image of each day, i.e. with the best illumination and the lowest amount of cloud cover/shadows, was chosen for the manual snow line mapping process. The final aim was the calculation of the mean elevation of the snow line for every day of the data collecting period materialized by intersecting the mapped snow lines with resampled SRTM 3 data (Fig. 3 and Fig. 4). Considering the fact that there were several weeks either with full snow cover (especially DJFM) or without any snow (especially JJAS) this aim could be achieved. The results are currently being used for the evaluation of a glacier mass balance model developed at RWTH Aachen, Germany.

Another remarkable result is the proof of the existence of intense ablation due to heavy snow drift and sublimation on Zhadang Glacier during the winter months (DJFM). Both processes strongly affect the onset of the melting period during the summer months (JJAS). The extent of the snow free areas on the glacier is currently being mapped.

Figure 3: Orthorectified image with snow line taken by Camera 1 on July 16th 2011 at 16:00 (mean elevation of the snow line was calculated at 5,626 m a.s.l.)

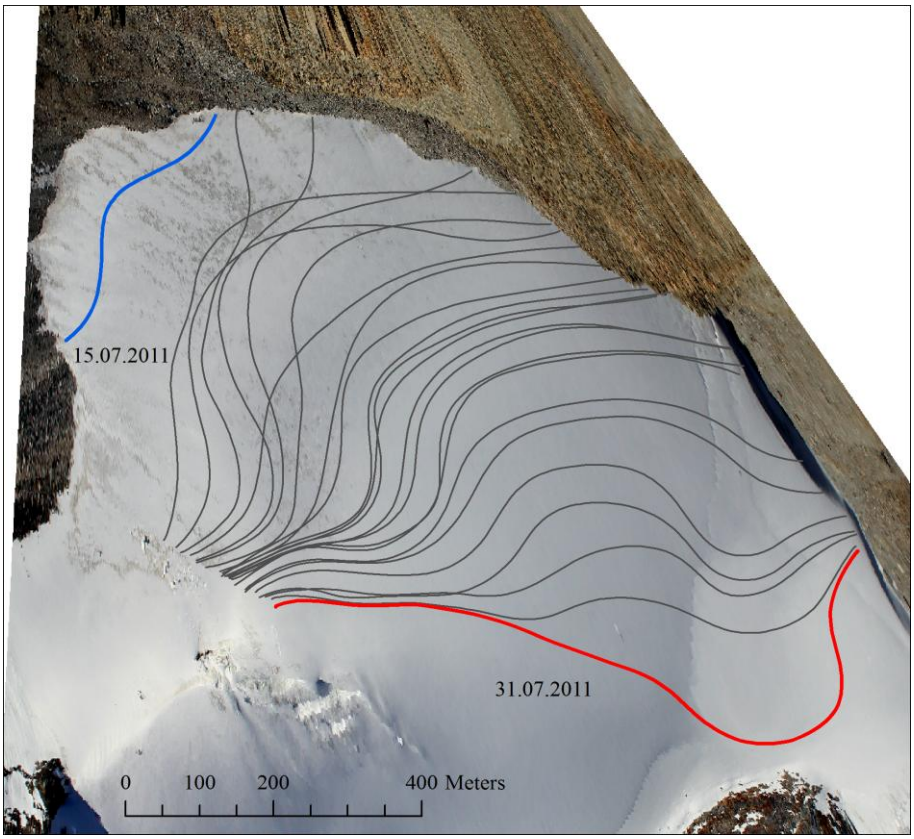

Figure 4: Snow line fluctuation during July 2011 with minimum (red) and maximum (blue) snow cover

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