Detection and measurement of highly active rock glaciers using multi-temporal high-resolution orthophotos of virtual globes, such as Google Maps and Microsoft Virtual Earth/ Bing Maps

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Abstract

High mountain areas are subject to continuous change in surface morphology. In this article we will focus on rapidly moving rock glaciers which act as a significant means of mass transport in high mountain environments. In recent years acceleration of rock glacier creep/flow has been observed at several test sites in Europe. The rock glacier speed-up observed is often accompanied by ruptures and disintegration of the surface, sliding processes, and down-wasting of loose material. Rapidly creeping rock glaciers (> 1 m/a) are potentially more prone to hazards than slower ones.

The kinematic state of a rock glacier can be determined by different measuring techniques, e.g., geodetic survey, airborne and spaceborne earth observation techniques. Change detection based on multi-temporal high-resolution orthophotos (orthoimages) has proved to be highly successful in deriving dense fields of 2D/3D surface displacement vectors. However, the production/acquisition of multi-temporal high-resolution digital orthophotos – at least two different epochs are needed – is generally quite costly, especially if large areas need to be covered.

In the following we will briefly describe how to detect highly active rock glaciers using high-resolution orthophotos of at least two virtual globes, and to precisely quantify their movement. *What are the prerequisites?* The high-resolution (airborne or satellite) image data of the virtual globes (in our example Google Maps and Microsoft Virtual Earth/ now Bing Maps) must be of different dates. These data may also be retrieved from governmental or other GIS servers freely accessible to the public. Our practical example refers to the western and central part of the Schober group (46°58'N, 12°44'E), which belongs to the Hohe Tauern range, Austria, and holds many rock glaciers of different activity state. It is most convenient to open both virtual globes using an Internet browser, preferably side by side. *How to detect surface movement?* Scroll and zoom in to an area of interest. Both virtual globes should display more or less the same area in plane view. Make a screenshot (*print* key) of each instance and cut out the homologous areas. The maximum zoom level of both virtual globes provides a ground sampling distance of 20 cm. Produce printouts of both orthophotos and look for motion parallaxes with the help of a stereoscope. If the 3D view is flat, there is no surface movement or surface deformation. Assuming that both orthophotos are geometrically perfect, an observed virtual 3D relief (hill or depression) would indicate surface change. The experienced observer can do this simple investigation more easily directly on the screen with the naked eye. This procedure allows us to instantaneously identify all areas of surface movement. The geometric quality of the multi-temporal orthophotos can be checked thoroughly in all stable areas (around the rock glacier). *How to numerically quantify the movement?* If you do not know the exact acquisition dates of the two data sets, you can only measure relative movement (against the stable surroundings of the rock glacier). Use the pixel query function of, e.g., Photoshop for measuring pixel coordinates of homologous points to compute displacements (unit = pixel). In our practical example the date of acquisition of both orthophotos could be easily deduced from the annotations and through cross-checking public GIS servers (of BEV and Land Tirol), which evidently sold their orthophotos to the virtual globes mentioned. The orthophoto of Google Maps is watermarked and dates from 18.9.2002. The orthophoto of Microsoft Virtual Earth is of a lower quality, however without watermarks, and dates from 21.9.2006. The pixel values obtained can now be scaled appropriately to obtain annual values (m/a). *How to automatically measure a 2D displacement vector field?* A Matlab-based toolbox has been developed to accomplish this task. Methods of computer vision (Förstner interest operator, NCC, RANSAC, etc.) were implemented to co-register both orthophotos and to measure motion parallaxes with sub-pixel accuracy. Visualization is done through vector plots, isotachs and animations. The high quality of the automatic mapping procedure has been checked using the original aerial photographs of the data providers.