Popular science summary of the "Changes of surface hydrology of a mountain glacier studied with very high resolution aerial and satellite images and machine learning" project

On the Surface of each glacier a layer of snow is formed every year in winter. This snow melts in summer – during the ablation season. Meltwater thus created runs off in different ways. Different surfaces of the glacier have different impact on the water's movement. Snow is the main source of meltwater, firn is able to store some of the water in its pores, while bare glacial ice lets water flow downglacier and the crevasses present in ice serve as wells through which water can enter the interior of the glacier. All these phenomena form the overall glacier's surface hydrology. In case of most of the land-terminating glaciers the melting is the most important way in which they are losing ice. That is why knowledge of phenomena related to water run-off is crucial for studies of shrinking of glaciers. Besides the meaning of the surface run-off for the glaciers themselves it is also important for humans. In many regions of the world, for example in Andes or Himalaya, glacial meltwater is one of the main sources of fresh water living at the foothills of these mountains. In the era of global warming tracking changes of glacial hydrology may be a key to water resource management in such places.

The goal of the project is to describe the surface hydrology of Universidad glacier, located in Andes in central Chile. Aerial and satellite images will be used to create maps of distribution of kinds of glacial surfaces (ice and snow facies) and drainage network. Each of images to be used in the project will come from a different time so it will be possible to investigate what changes and if any at all affect the water conditions on Universidad's surface.

During the project remote sensing methods – relying on analysis of Earth's surface with aerial and satellite photos - will be used. The project team will acquire images with very high resolution, which means that their pixel covers a small part of the Earth's surface. Such photographs show the terrain with very high accuracy and allow for mapping even very narrow streams. In their work the scientists will employ modern data processing methods: object-based image analysis and machine learning algorithms. In object-based analysis the subject of a study are objects – groups of neighbouring pixels in similar colour. On a photograph of Earth's surface such objects correspond to terrain objects, for example dark streams or very bright snow patches. The objects can be described with features such as mean pixel brightness, contrast between the darkest and brightest pixels and their geometric shape. These features, and many others, will be used to decide which objects represent which type of surface. During the project the investigators will manually identify objects belonging to the desired classes. These objects' characteristics will be used to train the machine learning algorithms. To be able to classify objects they need first to "learn" what properties do different classes have. Classificators thus created will be able to assign each of the remaining objects to appropriate class – and this way create a map of glacier's surface.

A collection of such maps, each corresponding to a different time, will be used for change detection. Maps from different years will be compared to assess changes of extent of different ice facies between subsequent ablation seasons. The investigators expect, that the firn zone will shrink with time, revealing the glacial ice. The short-term part of the project will rely on maps of the drainage network. They will serve as base to track changes of stream course during a single ablation season. It is expected, that the largest, main streams, the „trunks" of the network, will probably remain unchanged, but small streams, especially those developed in snow and firn, will probably shift. In comparison of the images from different years it is expected, that a new stream network forms each year. A different situation, retaining of stream beds between the ablation seasons, will however also be a valuable information about the glacier. The results of change detection will be compared to meteorological and hydrological from nearby rivers and meteorological stations. This way it will be possible to tell how strongly do the atmospheric conditions influence the glacier's surface hydrology and how its changes reflect in the nearby river's discharge.