Titolo della tesi

Copernicus Big Data and Earth Engine for Glacier Health Monitoring: an Innovative Methodology and Infrastructure Design

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Riassunto della tesi (max 2 pagine)

The aim of the current work is to create an on-line tool in order to obtain glacier velocity field estimations and to share and publish the results directly in Google Earth Engine. To do this, the project has been based on Copernicus Big Data and on Google Earth Engine potentialities.

Glaciers are persistent bodies of dense ice that are constantly moving under their weight. Nowadays, around 10 percent of land area on Earth is covered by glacial ice and around 75 percent of the world fresh water is stored in them. In the last century, the glacier masses have decreased at unprecedented rates because of the global warming; in fact, glaciers are very sensitive to temperature variations, and so they may be considered the most reliable indicators of climate changes. For that reason, glacier monitoring is a very important element in climate change studies. Among other parameters, glacier surface velocity plays a crucial role in glacier monitoring; in fact, this parameter is connected to glacier mass balance, since it is useful in order to compute the flow rate that reaches the ablation area, and may be a stability indicator since it measures the rate at which a glacier is sliding. The measurement may be operated both in a direct way and in a indirect one. The direct method consists in positioning some recognizable points on the glacier and in surveying those points at a distance, in order to measure the displacements. This method guarantees very accurate measurements but calls for very expensive expeditions and may be operated only on few points. The indirect method consists in the comparison between two images acquired in different times. By using this method, satellite imagery enables the continuous monitoring of wide areas and provides information independent from logistic constraints.

The current work has been based on Sentinel-1 big data and Google Earth Engine platform. Sentinel-1 is a satellite mission that is part of Copernicus program, an European program whose aim is to make European Union independent in the environment

monitoring sector. Nowadays, it is composed by two satellites, Sentinel-1A and Sentinel-1B. The satellites carry SAR sensors, which, differently from optical sensors, manage to acquire data in all the weather conditions. Their orbits are sun-syncronous and near-polar. The two satellites have a revisiting time equal to 12 days; because the two satellites fly in the same orbital plane 180 phased in orbit, the mission revisiting time is 6 days. Sentinel-1 acquires RADAR imagery in four different modes in all the world.
Google Earth Engine is an on-line platform for processing Earth observation data, where several raster datasets, among which also Sentinel-1 data, are stored.
The processing method is implemented in a on-line infrastructure, Google Cloud Platform, that allows users to compute the codes and to store data on-line. The tool is composed by two parts: the Backend, where the processing steps are implemented, and the Frondend, where there is the interaction between users and the platform.
The processing method is composed by four steps: the creation of a database where all the parameters necessary to the algorithm are stored, the image selection from Google Earth Engine, the displacement estimation by using a template matching algorithm and a least squares estimation of the glacier velocity fields. The glacier characteristics are extracted by the glaciers outlines obtained from the Rundolph Glaciers Inventory, a globally complete inventory of glacier outlines.
This method has been implemented on 21 glaciers belonging to Campo de Hielo Norte, Chile. About 4000 template matching results have been obtained, with a high temporal and spatial resolution and a high redundancy; it has been so possible to operate the estimation method in a effective way. The results obtained demonstrate that the current method gives robust estimation of glaciers velocity fields, especially in the ablation area. For the future, it is important to develop some aspects: the comparison with results obtained from other methods, the improvement of an effective filtering system, in order to discard not robust data- which are located almost in the accumulation area-the masking of foreshortening and layover areas and the parallelization of the different process in order to decrease the computational time.