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Snow covers detection using terrestrial photography. Application to a mountain catchment in Alps region (France).

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In August 2005, a significant mudflow leaded to major impacts damages at the Sainte-Agnes village located downstream the Vorz torrent (35 km2, elevations ranging from 1248m and 2977m, Alps region, France). To meet the demand of populations and civil authorities a research program was launched to both monitor and model these regions to help to quantify water resources and vulnerability to such hazardous events, including their probable evolutions do to climatic changes.
This communication focuses on one of the several forcing variables of the water cycle in mountainous regions: the snow covering. Indeed, its controls a significant part of the future available water resources and may strongly interact with liquid precipitations during snow melting season. Usual sensors such as remote sensing cannot easily quantify accurately the snow covering for small mountainous catchment at hydrological models spatial and temporal resolutions (typically Dx < 50m, Dx= 30'-1h). Consequently, we decided to develop a specific monitoring system based on terrestrial photos. Two cameras were installed within the catchment at two different elevations (1950m and 2250m). Each camera acquires pictures every 2-3 hours from 8.00am to 8.00pm. Thus, a lot of data on snow covering are acquired at a minimal costs.

The first step of this technique is to place the cameras at "optimal location", i.e. able to see a large surface of the catchment with various elevations and aspects. This position must also be reached by direct solar radiation to recharge the embedded solar panel. A 2 or 3 hours sampling time-step was chosen for pictures shots (depending to available energy and memory capacity of camera). Indeed it allows observing all the day and offers an accurate sampling of the melting period. First major difficulty of this technique is the retro mapping of the 2D pictures from the camera on the 3D Digital Terrain Model to distribute the snow covering by elevation and aspects. The second difficulty is to automatically distinguish the snow from other meteorological "white" objects (fog, clouds, etc.) taking into account for the very various luminosity and cloud covers conditions.
To make the 2D to 3D conversion, the camera referential needs to be replaced in the catchment referential by geometrical transformations. This operation is automatically realized by automatic recognition of geo referenced ground points (particular DTM points) within the camera pictures and resolution of a matrix system. Solving this inverse matrix problem raises numerous mathematical difficulties that will be discussed in the presentation. When successfully solved, every picture pixel can then be dropped on the DTM taking into account classical problems such as hidden faces.

The automatically detection of the snow pixels in each picture is then achieved. The recurrent problem is the changing of luminosity and cloud cover of the catchment. It is often very difficult to distinguish between white clouds and snow within the picture by automatic algorithm. Difficulties also arise when shading effects fade colours of the compressed pictures. An original automatic auto-calibrating algorithm leading to robust snow identification was then developed and will be discussed.

This type of sensor seems well adapted to mountains areas and extremes conditions because of the low energy consumer, the autonomy and the number of measures realized. The multiplicity of picture and the number of snow cover measures allows forcing the hydrological model, which is coupled with a snow modelling of the catchment. Moreover, this sensor is particularly economic compare to use of traditional remote sensing.