Volume drop of Pyrenean Glaciers from 2011 to 2020 observed with airborne techniques; LiDAR and SfM

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Pyrenean glaciers are one of the southernmost glaciers in Europe. These ice bodies have suffered a fast retreat in the last decades mainly caused by the temperature increase of the last century. Here, we use state of the art airborne techniques to present the most complete evaluation of glacier volume change from 2011 to 2020.

In 2011 the Spanish Geographical Institute covered the entire country with airborne LiDAR. The glacier topography on the Spanish side of the Pyrenees (and also several hundreds of meters beyond the French border) was retrieved between September and November, when snow cover was minimal. In autumn 2020, we used different Unmanned Aerial Vehicles to survey 17 out of the 19 Pyrenean glaciers. The images acquired in these flights were processed with Structure from Motion algorithms to reconstruct the Digital Surface Model (DSM) in 3D of the glacier surfaces and nearby terrain.

Differencing of the DSM in 2011 and 2020 reveals a drastic retreat and volume loss. The mean elevation drop is 7 m, some glaciers had losses of more than 12 m in average with a surface lowering of more than 20 m locally. The mean annual mass balance observed when considering the 2D projection of glaciers surface was -1.83 m w.e./yr. Taking into account the true glaciers extent from the 3D surface retrieved from the UAV observations, the annual mass balance decreases to -1.30 m w.e./yr. The difference between these mass balances highlights the impact that utilising close range remote sensing observations have, when compared to satellite acquisitions, to accurately observe glaciers evolution in steep mountain areas.