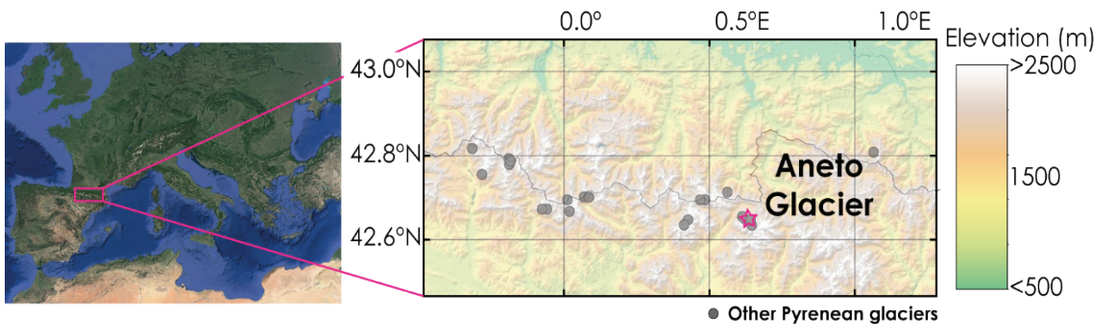
Comparison of 3D surfaces from historical aerial images and UAV acquisitions to understand glacier dynamics: The Aneto glacier changes in 40 years

I. Vidaller, J. Revuelto, E. Izagirre, J. García, F. Rojas- Heredia, J.I. López-Moreno



Introduction

Pyrenean glaciers have shown a marked area and thickness decrease in the last century, especially in the last decades, and currently are highly threatened by **climate change**.

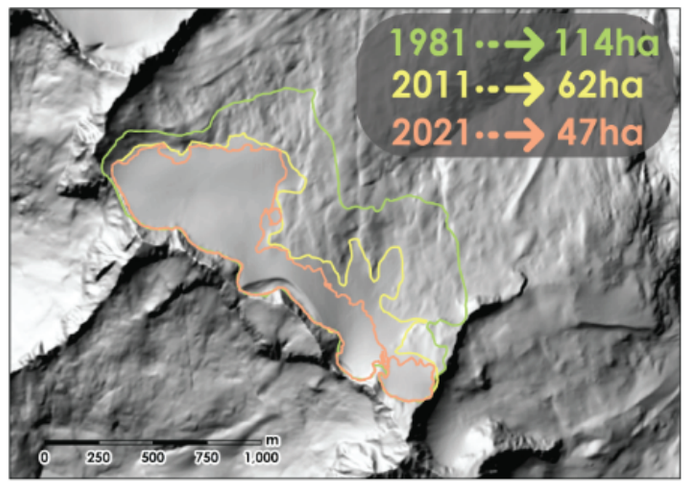
Out of the 39 glaciers existing in the Pyrenees in 80's decade, **21 very small glaciers** remain in this mountain range, from which only four have more than 10 ha.

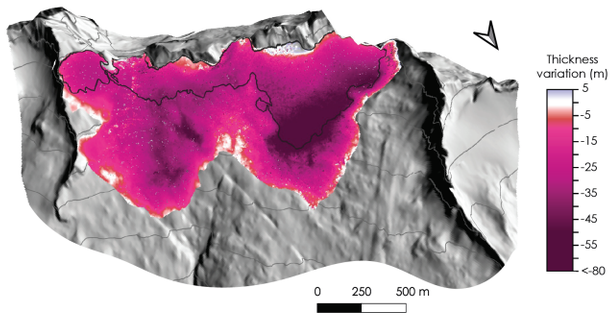
Probably, the most emblematic glacier of these four is **Aneto glacier** as it is located in the North-East face of the highest summit in the Pyrenees, the Aneto peak (3404 m a.s.l.).

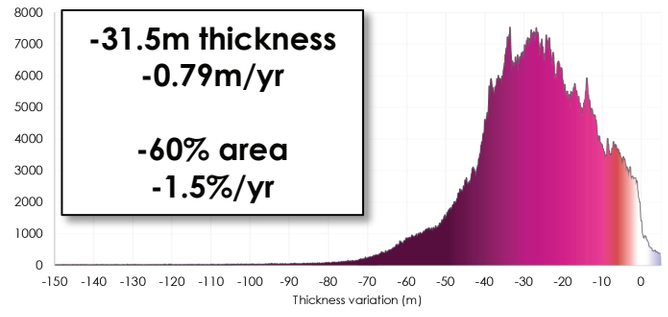
This work presents the Aneto glacier surface reconstruction from aerial images obtained in **1981**, and its comparison with the glacier surface obtained in **2021** with Unmanned Aerial Vehicles images.

The 1981, 2011 and 2021 images have been processed with **Structure from Motion** (SfM) algorithms to reconstruct the **Digital Surface Model** (DSM) of the glacier and nearby terrain.

Taking into account aerial images of different years, we have obtained the **area changes** in Aneto glacier.







1981-2021 period

Taking advantage of the accurate **geolocation of the UAV** images in 2021, the DSM obtained has a **precise representation** of glacier surface. Oppositely the aerial images of 1981 lack of a precise geolocation and thus require a post processing analysis. The aerial images of the **80´s have been firstly geolocated with Ground Control Points** (GCP) of known coordinates within the study area (summits, crests, and rock blocks with unaltered position).

After this initial geolocation, the DSM of 1981 was generated with SfM algorithms. Nevertheless, this DSM still lacks of a geolocation accurate. To allow a **comparison** between the 1981 and the 2021 DSMs, the glacier surface in 1981 was registered to the 2021 surface with an **Iterative Close Point** (ICP)routine in the **surrounding area** of the glacier. The technique described in this work may be applicable to other **historical aerial images**, which may allow studying glacier evolutions all over the world for dates without field observations.

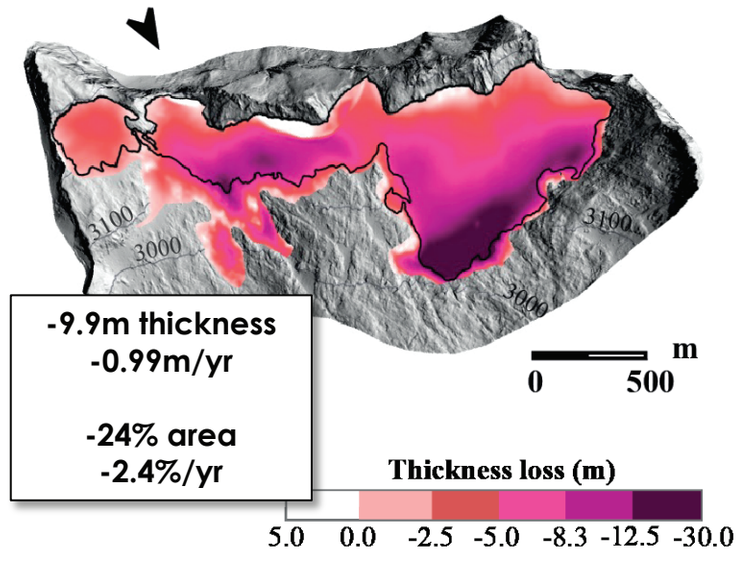
The surface comparison generated with images that have a temporal difference of **40 years,** have shown the dramatic area and thickness loss of this glacier, with **area decreasing more than 68 ha**, and an average t**hickness reduction of 31.5 m.** In this period, the glacier has reduced its extent in about a 60%.

2011-2021 period

2011 data was obtained from a **LiDAR** fly of the Spanish Geographical Institute (IGN). Data were processes in the same form as 1981 ones.

There is a recent **acceleration** in the rate of shrinkage if we compare these data with the obtained for the period 2011-2021, in which **area loss reach 24% and thickness reduction almost reach 10 m.**

During **1981-2021** period the shrinkage rate is **0.79 m thickness/year and 1.5% area/-year,** meanwhile, during **2011-2021** period the shrinkage rate is **0.99 m thickness/year and 2.4% area/year.**



IPE Instituto Pirenaico de Ecología CSIC

EGU