

Monitoring activities of the last pyrenean glaciers

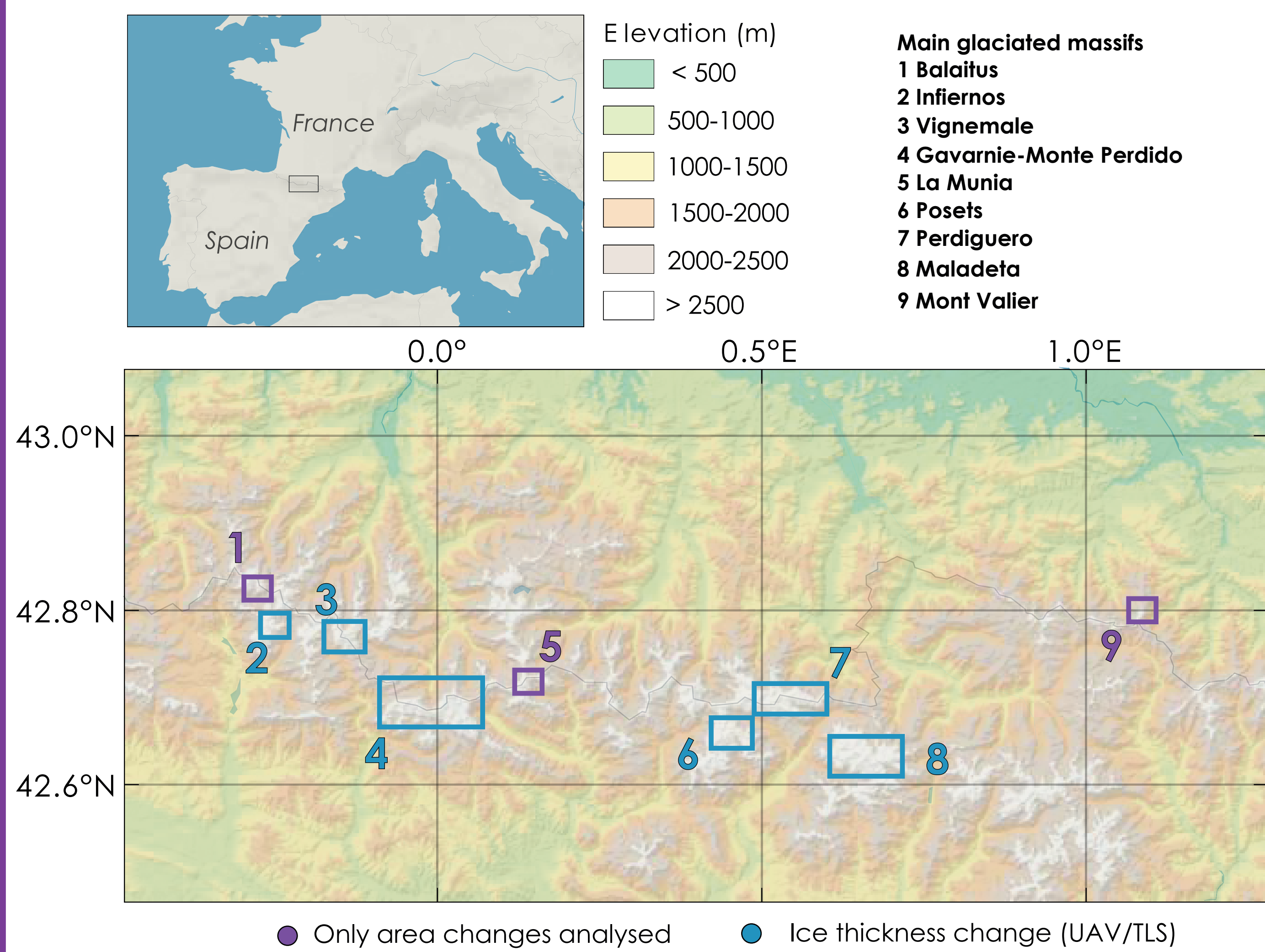
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Introduction

Pyrenean glaciers are classified as **very small glaciers** (<0.5 km²), but still they are the most important concentration of ice bodies in southern Europe.

The **increase of temperature** after Little Ice Age (LIA) produce an evident **shrinkage and wastage** since 1850, and has been accelerated in the last decades, leading them to a **situation close to disappear**.



Methods



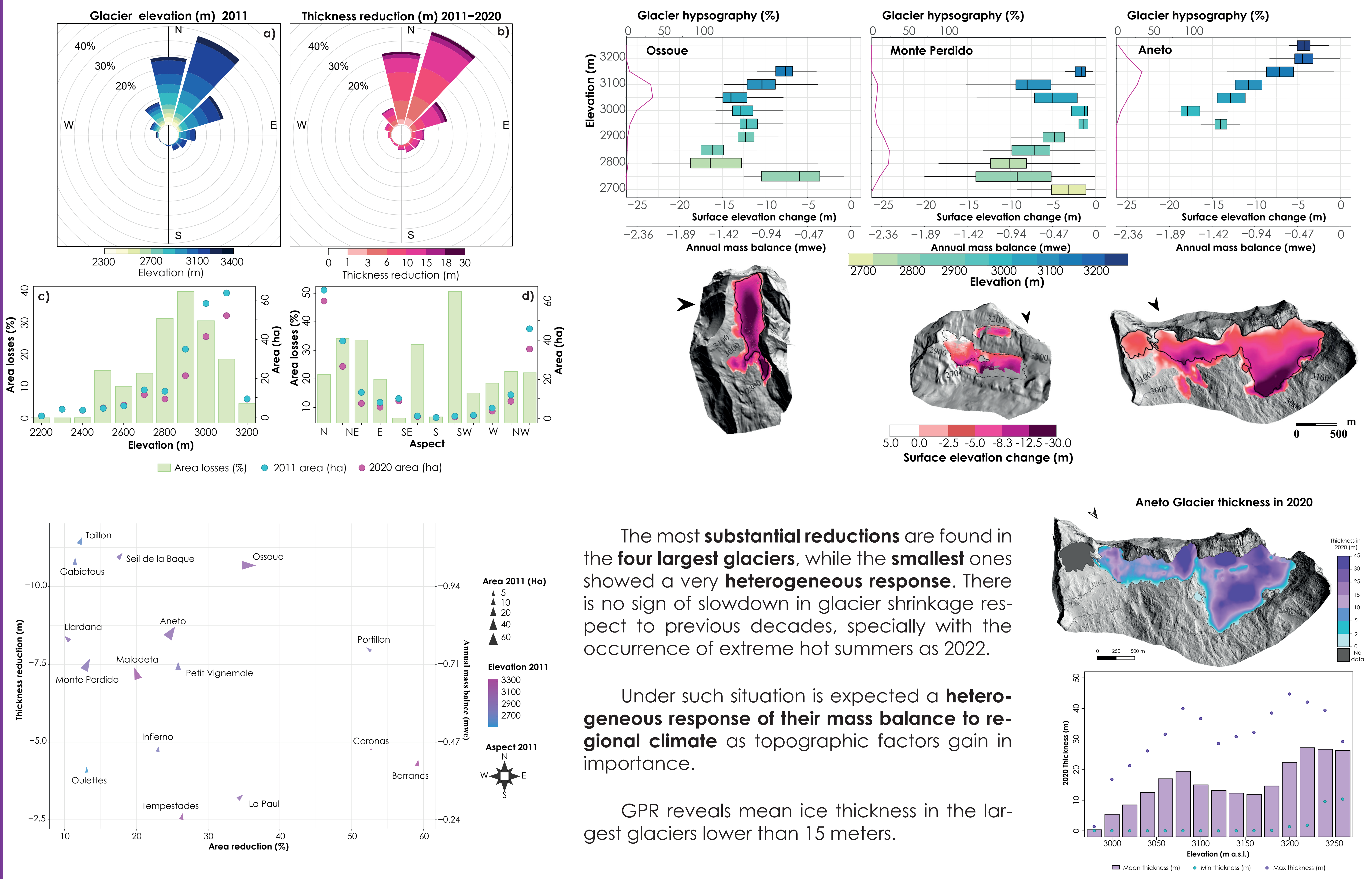
Different **remote sensing** techniques and ground surveys are used, to estimate **glacier changes** in the last decade.

- + **Satellite** (LiDAR, Planet and Rapid Eye images)
- + Unmanned Aerial Vehicle (**UAV**)
- + Terrestrial Laser Scanner (**TLS**)

Also, to quantify **ice thickness**, Ground Penetrating Radar (**GPR**) has been used in the most important ice bodies.

Results

Results show that for the period **2011-2020**, Pyrenean glaciers have **lost 23.2%** (293.9 ha to 229.2 ha) of its **area** and the **mean thickness loss** in all the glaciers studied (17 out of 24) is **6.3 m**, which means that some of these glaciers have lost half thickness in this time period.



The most **substantial reductions** are found in the **four largest glaciers**, while the **smallest** ones showed a very **heterogeneous response**. There is no sign of slowdown in glacier shrinkage respect to previous decades, specially with the occurrence of extreme hot summers as 2022.

Under such situation is expected a **heterogeneous response of their mass balance to regional climate** as topographic factors gain in importance.

GPR reveals mean ice thickness in the largest glaciers lower than 15 meters.

Conclusions

From 2011 to 2020, the Pyrenees has been reduced **-23.2% of its area**, **6.3 m ice thickness** and an area-weighted specific mass balance of **-0.59 m w. e. yr⁻¹**, a similar rate since the 1980s, so **glacier shrinkage** in the Pyrenees and **wastage have not slowed down** in the last few years.

The **smallest glaciers** show a variable response to the warming climate, they are controlled by **topoclimatic factors**, meanwhile the biggest ones present similar changes, so area controlled by **regional climate**. Differences between area and ice thickness losses confirm that glaciated area is not a good proxy to determine glaciers mass balance.

This results indicate that **Pyrenean glaciers are in a clear imbalance** with the regional climate and will likely **disappear in the next few decades**.