Future evolution of the snowpack evolution in the Iberian peninsula

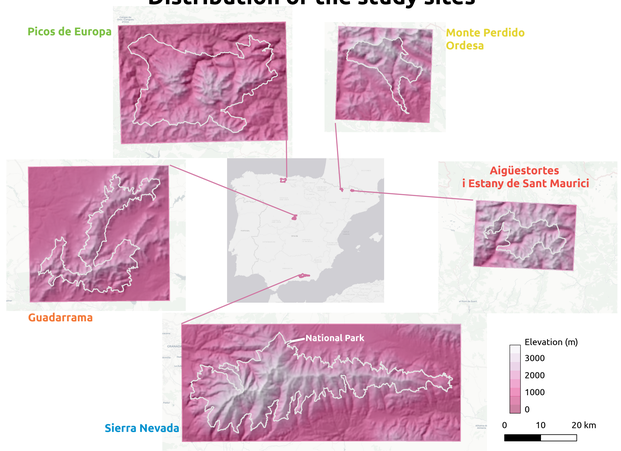
Jesus Revuelto[1], **César Deschamps-Berger**[1], Nacho Lopez-Moreno[1], Laura Sourp[2], Sylvia Terzago[3], Francico Roja[1], Marion Reveillet[4]
1. IPE-CSIC, Zaragoza, Spain. 2. CESBIO, Toulouse, France, 3. ISAC, Torino, Italia, 4. IGE, Grenoble, France

Seasonal snowpack in mountains of the Iberian peninsula

More than **half of the Iberian peninsula are mountains covered by seasonal snowpack.** The snowpack has a large impact on the hydrology of many headwaters (Ebro river), on the flora and fauna and on human activities (e.g. ski resorts in the Pyrenees, the Guadarrama, the Sierra Nevada). Estimations of how the snowpack will evolve in the future climate are necessary to predict the evolution of mountain ecosystems and anticipate the managent of water as a resource. This work focuses on the evolution of the snowpack in mountain ranges spreaded over the Iberian peninsula in the XXIst century.

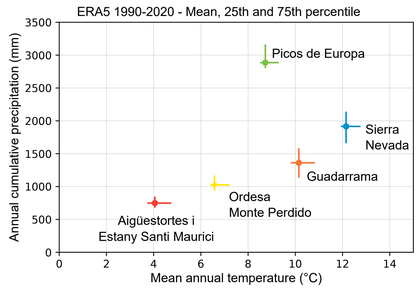
1. Study sites - Five spanish national parks

Distribution of the study sites



The **five study sites** were selected for their high environmental value as they all contain **a national park**. They all reach height above 2000 m. The highest summit of the peninsula, the Mount Mulhacen (3479 m) lies in the Sierra Nevada.

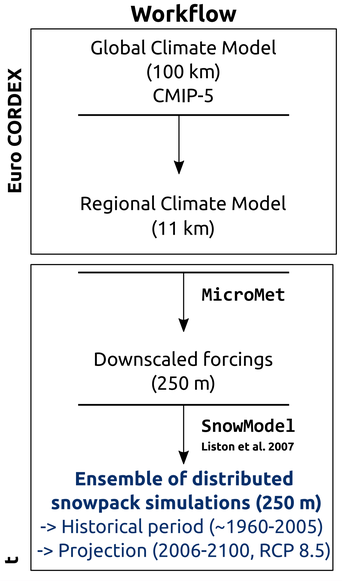
Climatological statistics of the study sites (ERA5)



The climate of the study sites differ sensibly with more accumulation close to the littoral (Picos de Europa, Sierra Nevada) and higher temperature for Sierra Nevada (lower lattitude) and Guadarrama (lower elevation).

2. Methods - Snowpack distributed simulations forced by Euro CORDEX climatological data

Workflow



The **Euro-CORDEX climatological data** (air temperature, precipitation, wind, humidity) were **downloaded with the esgf-py client**. They were downscaled from their native resolution(~11 km) to the simulations resolution (0.25 km) with **MicroMet** using the Copernicus DEM 30 m resampled at 0.25 km.

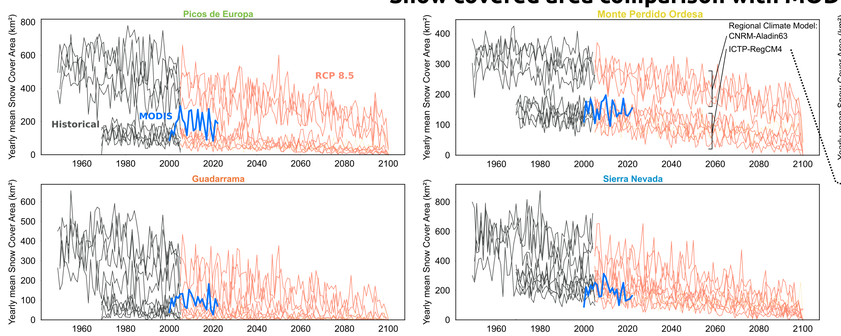
Eight Euro-CORDEX members are available for the historical period (~1960-2005) and seven for the projection period in the RCP 8.5 scenario (2005-2100). Some members RCP 2.6 and 4.5 are used as well but not shown here.
The snowpack simulation were evaluated with MODIS snow cover area.

Euro-CORDEX member

Global Climate Model	Regional Climate Model	Historical period (19XX-2005)	RCP8.5 2006-2100)
MOHC-HadGEM2-ES	ICTP-RegCM4-6	⊗	⊗
MPI-M-MPI-ESM-LR		⊗	⊗
CNRM-CM5		⊗	⊗
ICHEC-EC-EARTH		⊗	⊗
NCC-NorESM1-M		⊗	⊗
CNRM-CM5	CNRM-ALADIN63	⊗	-
MPI-M-MPI-ESM-LR		⊗	⊗
MOHC-HadGEM2-ES		⊗	⊗
NCC-NorESM1-M		⊗	⊗

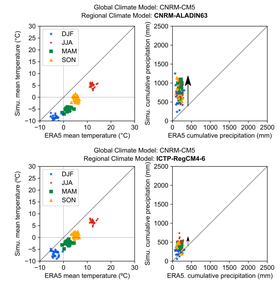
3. Results - Less snow in the future,

Snow covered area comparison with MODIS



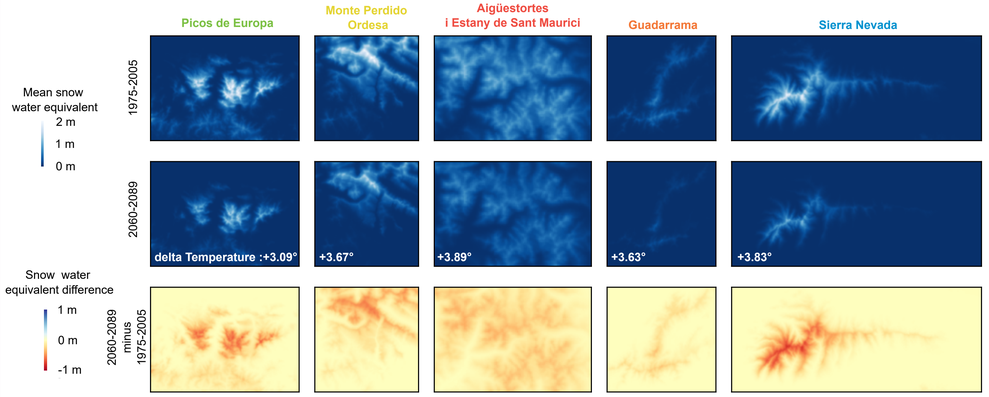
We observe a **large spread between Euro-CORDEX members**.
The Regional Climate Model has the largest impact on the snowpack simulation. Compared to MODIS, CNRM-Aladin63 tends to largly overestimate the snow cover, ICTP-RegCM4 tends to underestimate it. By comparison with ERA5 data, this mismatch seems caused by **errors in precipitation**.
The **snow cover is expected to decrease in the future** in the RCP 8.5 scenario. This scenario is currently not the most likely but it can still be useful to analyse the sensitivity of each region to future warmings.

Precipitation and temperature comparison with ERA5



4. Results - Snow sensibility to temperature change

Map of Snow Water Equivalent and SWE change (mean of the ensemble)



Despite similar increase in temperature, the impact varies strongly between regions.
The loss of snow is for instance much more important in the Sierra Nevada and Picos de Europa than in Aigüestortes although the temperature is similar in both sites.
The snow decrease seems stronger at high elevation.

Conclusion and perspectives

Less snow is expected in the future in the mountains of the Iberian peninsula. The expected increase of temperature will not be compensated by precipitation changes.
The impact on snowpack is modulated by the local climate and topography.

The variability between Euro-CORDEX member is large and depends mostly on the Regional Climate Model used.

As expected, directly forcing a snowpack model by Euro-CORDEX climatological data does not result in sufficiently accurate snowpack simulations. Further work will focus on adjustement on the historical period to obtain more realistic simulations.

Acknowledgement

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