Assessing the impacts of climate change in Iberian mountains using the nextGEMS km-scale global climate simulations

Diego García-Maroto, Luis Durán, Elsa Mohino, Álvaro González-Cervera

Departamento de Física de la Tierra y Astrofísica, Universidad Complutense de Madrid, Madrid, 28040, España (diegar20@ucm.es)

Objectives

Can we use km-scale global climate models to directly study specific regional phenomena such as snow depth in medium height mediterranean mountains without the need of regionalization?

What are the main limitations?

What future changes do this new simulations project in snow specific indices such as days with snow cover?

Data and simulations

Two simulations of the IFS-FESOM[1,2] model are analysed in this work:

Model	Simulation	Period	Scenario	Resolution
IFS-FESOM	production-hist	1990-2019	Historical forcing	Native: 9km Regrided: ~12.5 km
IFS-FESOM	production	2020-2049	SSP3-7.0	

Four reanalysis-based snow depth datasets are considered in order to assess the performance of the model:

Dataset	Native resolution	Relevant information
CERRA[3]	5 km	Dynamical downscaling of ERA5
CERRA-Land[4]	5 km	Dynamical downscaling of ERA5 with SURFEX as the soil component
ERA5-Land[5]	9 km	Downscaling of the land component of IFS, only the land component is regionalized.
IPE[6]	10 km	Snow depth dataset for Iberia using WRF and FSM forced by ERA-Interim

Methods

- Snow Depth data is downloaded from all data sources. In some cases, when snow Depth in meters is not available, it is derived from the snow depth water equivalent and the snow density
- All snow depth data is converted to daily frequency by taking the median.
- All data is regrided into a common latitude-longitude grid with resolution 0.125º, to make comparisons between different datasets more useful.
- Four mountain regions are defined (see Figure 1).
- Computation of relevant indices. Only the extended winter NDJFM is considered. Data is aggregated annually by water years.
  - **Snow Cover Days (SCD)**: number of days with snow depth over 1 cm.
  - **Frost Days (FD)**: number of days with minimum temperature below 0º C.
  - **Wet Day (WD)**: number of days with total precipitation over 1 mm.
  - **Snow Covered Area**: daily mean area where snow depth is over 1 cm.

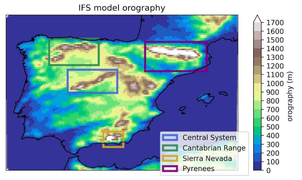

Figure 1: model orography and mountain regions of interest in this work.

References

The key references can be found by scanning the QR code:

SCAN ME

Acknowledgements

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Performance during the historical period

The IFS-FESOM model **can** be used for assessing climatic characteristics of the snow depth of mediterranean mountain regions.

Even so, there are still some limitations and biases:

- The model seems to be in the higher range of the considered datasets when analysing snow cover days. This bias is especially prominent in low to mid elevated areas.
- In some regions, the model suggests a higher interannual variability and extremes not present in the reanalysis-based products.

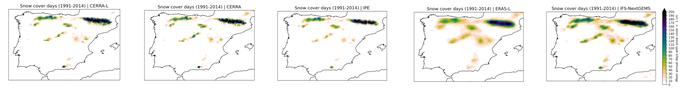

Figure 2: map of the mean annual days with a snow cover over 1 cm for the four reanalysis-based datasets and the IFS model historical simulation. All maps are represented for the common historical period of 1991 to 2014.

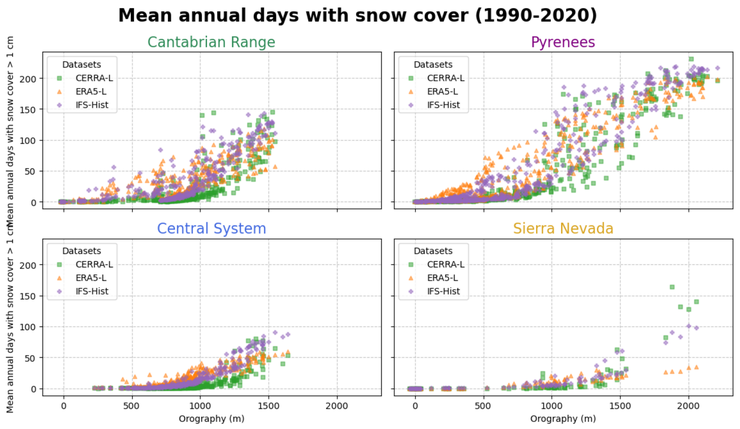

Figure 3: scatters of the mean annual days with a snow cover of over 1 cm in each gridpoint of the main four mountain regions of the Iberian Peninsula against the elevation of each gridpoint. Two reanalysis datasets are displayed along the IFS model historical simulation for the period 1991 to 2019.

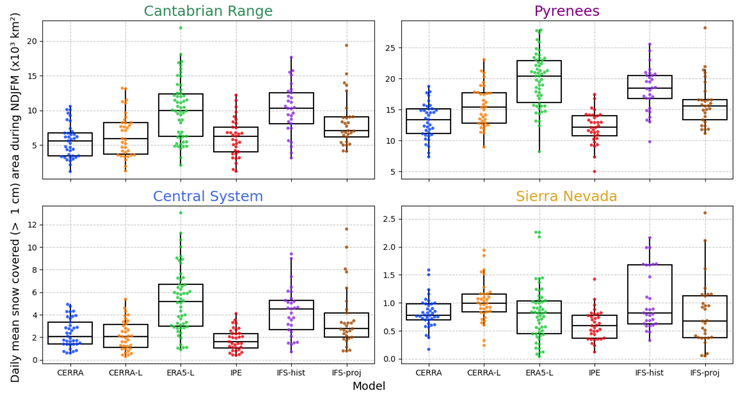

Figure 4: boxplots of NDJFM daily mean snow-covered area in the four main mountain regions of the Iberian Peninsula. Four different reanalysis datasets are shown as well as the IFS model for both the historical period (1990-2019) and the projection (2020-2049).

Changes in the near future projection

All mountain regions lose a significant amount of snow cover days from 1991-2009 to 2031-2049.

- The most affected would be low and middle altitude zones as well as the southernmost mountain regions.
- The main driver of this reduction is the rise in temperature, which generates a significant reduction of Frost Days (FD) in all the Iberian Peninsula.
- In the southern mountain regions, a reduction of Wet Days (WD) is also a key driver.

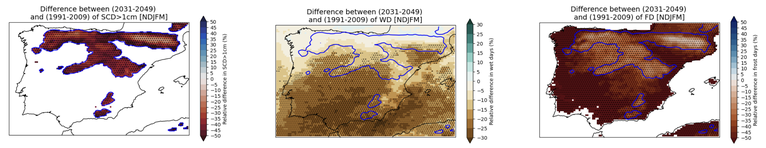

Figure 5: change in the number of Snow Cover Days, Wet Days and Frost Days between the first 19 extended winters of the historical simulation (1991-2009) and the last 19 extended winters of climate projection (2031-2049). The main study region where there are at least 10 mean annual days with snow cover over 1 cm is highlighted in blue.

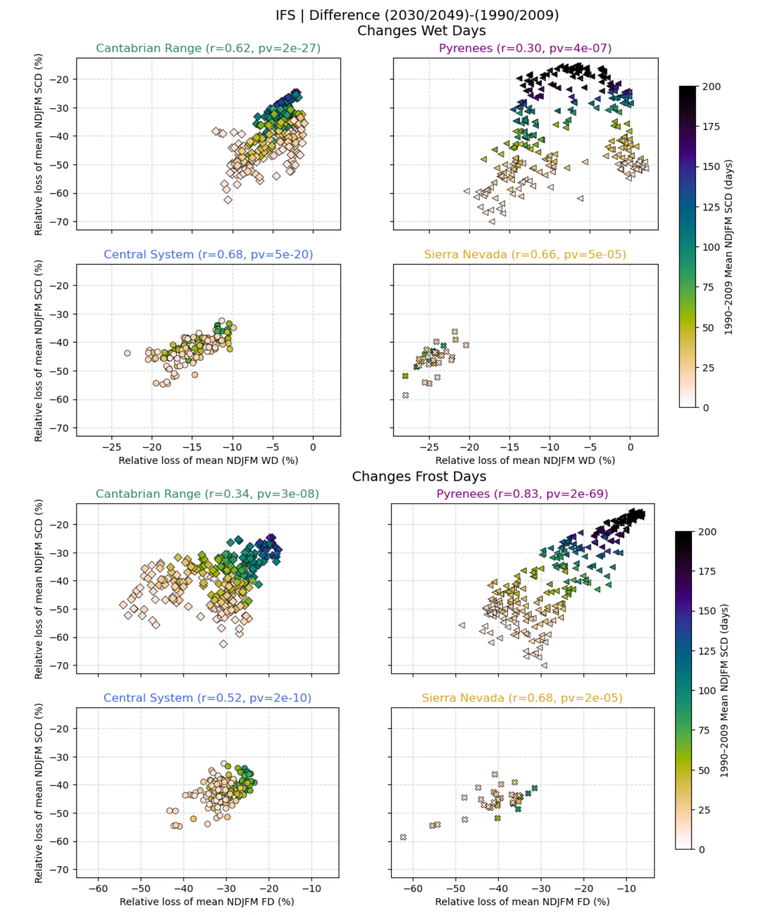

Figure 6: scatter plots of the relative loss of snow cover days against the relative loss of Frost Days (four upper panels) and Wet Days (four lower panels) between periods 1991-2009 and 2031-2049 for the main four mountain regions previously defined (see Figure 1). Only gridpoints where the mean SCD exceed 10 days during the 1991-2009 period are considered.