Towards a new quality-controlled daily climate dataset for the Pyrenees, 1950-2015

Serrano-Notivoli, R. [1], Cuadrat, J.M. [1], Copons, R. [2], Cunillera, J. [3], Gascoin, S. [4], López-Moreno, J.I. [5], Luna, M.Y. [6], Pons, M. [1], Prohom, M. [3], Rodriguez, E. [6], Saz, M.A. [2], Soubeyroux, J.M. [7], Tejedor, E. [2], Trapero, L. [1], Verfaille, D. [7].

(1) University of Zaragoza (UNIZAR), (2) Andorran Research Institut (IEA-CENMA), (3) Servei Meteorològic de Catalunya (SMC), (4) Centre d'Études Spatiales (CESBIO), (5) Instituto Pirenaico de Ecología (CSIC-IPE), (6) Agencia Estatal de Meteorología (AEMET), (7) Météo-France (MF).

Observatorio Pirenaico del Cambio Climático
Observatoire Pyrénéen du Changement Climatique
Observatori Pirinenc del Canvi Climàtic
Observatory Pyrenean of Climate Change

Abstract:

Previous works using lower-density datasets addressed warming rates with slight differences depending on the season and diffuse trends for precipitation. New and more accurate results in spatio-temporal variations of these climate variables are expected on behalf the development of the CLIM'PY project, which aims to: i) detect past trends with instrumental data and, ii) estimate future behaviours in climatic variables based on projected scenarios. Temperature, precipitation and snow cover in the Pyrenees will be analysed within the framework of the project. In this communication, we present the methodology we will follow to conduct the quality control analysis of daily temperature and precipitation, which will include 673 stations of Spain, France and Andorra, covering the period 1950-2015.

Temperature and precipitation:

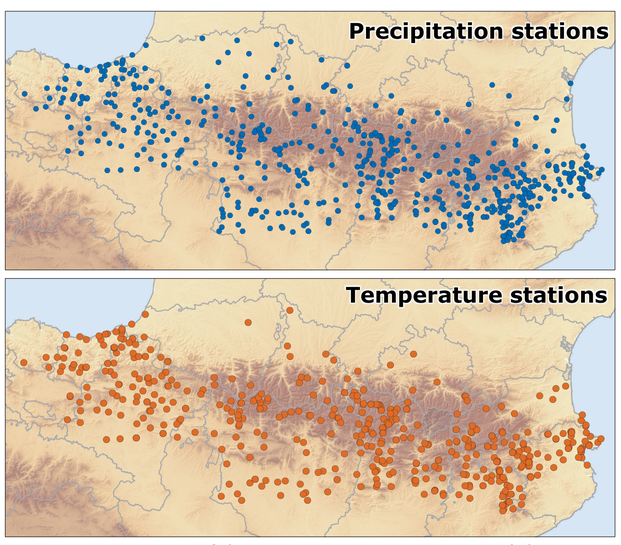

Figure 2: Location of the 660 precipitation stations and the 493 temperature stations that will be used to assess the climate evolution.

Climate monitoring (1950-2015)

Daily data of the 30 longest and continuous data series will be aggregated to monthly scale and a complete homogenisation process will be applied to obtain comparable and uninterrupted series. These series will be used to a long-term climate monitoring in Pyrenees. The aim with this work is to assess the changes of temperature and precipitation in the Pyrenean range with future annual updates when available information.

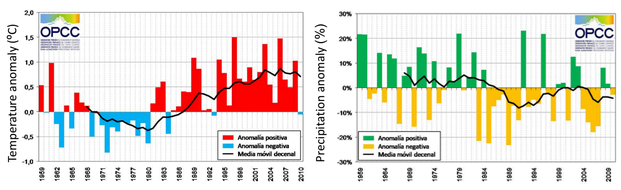

Figure 4: Temperature (left) and precipitation (right) anomalies in Pyrenees derived from previous Pyrenean Climate Change Observatory Project (OPCC-1)

Daily gridded dataset (1981-2015)

The daily precipitation and temperature data series (Figure 2) will be reconstructed from 1981 to 2015 following methods described in Serrano-Notivoli *et al*. (2017). This methodology is based on an exhaustive quality control of daily data and the estimation of new values in those days with missing observations. Once the original data series are complete, they serve as basis for the building of a new gridded dataset. The 1x1 km spatial resolution of the grid (Figure 3) will be useful to analyse spatial and temporal patterns of extreme precipitation and temperature indices, regional differences, trends in water availability or heat and cold waves recurrence, etc.

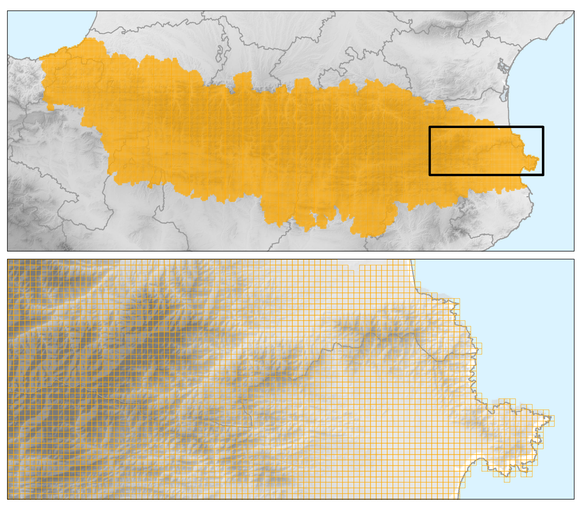

Figure 3: 1x1 km gridded dataset (top) at 1:1,500,000 scale and detail (bottom) at 1:300,000.

The 27 WMO-ETCCDI extreme precipitation and temperature indices will be computed over the gridded dataset to describe the spatial and temporal distribution of the extreme events in the mountain range. These indices will help to a better decision-making policies, especially in environmental risks such as floods or droughts.

Future projections:

The aim of this part of the project is to apply future climatic projections adapted to the Pyrenean area, based on the new IPCC-AR5 scenarios (EUROCORDEX, HARMONIE and CMIP5 simulations). Two main stages are planned:

1) Future scenarios of temperature and precipitation: The projections will be carried out based on the IPCC scenarios, corrected by the SAFRAN dataset.
2) Forcing of snow cover simulations to different horizons in 21st century. In this stage, we will produce new models and projections of snow cover (snow cover duration, accumulation, heavy snowfall occurrence, etc.) to different time horizons through the assimilation of regional high-resolution climatic models simulations.

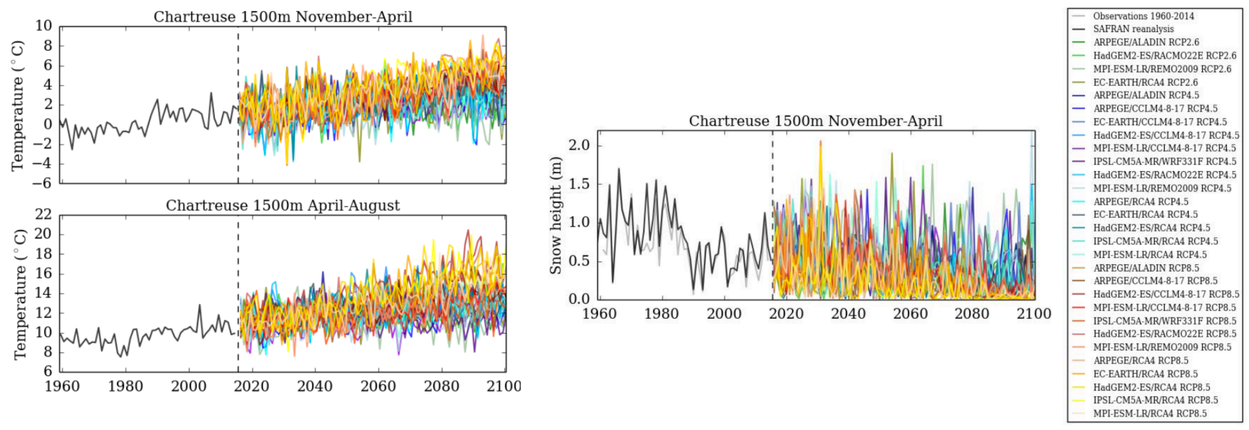

Figure 7: Future projections for temperature (left) and snow cover (right) at specific locations in the Pyrenees comparing the observations and SAFRAN reanalysis with the different simulations of IPCC-AR5.

The information obtained in this part of the work will allow to analyse the consequences of the eventual future evolution of the climate in the Pyrenees that affect to the human activities and the natural systems, serving as a mean to develop adaptation measures. The climatic projections will be leaded by AEMET and Météo-France, using the same criteria for the both sides of the mountain range, which allows an integrated point of view of the global change in this territory.

Methods and data:

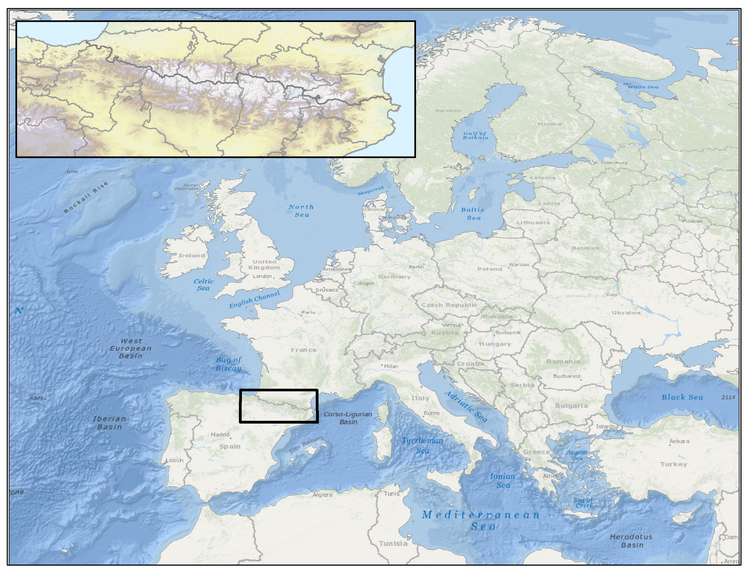

Figure 1: The Pyrenees cover a large territory of 430 km long and 80 km average wide, with elevations ranging from 0 at coastlines to 3,404 m in the central area.

The study area comprises the border between Spain, France and Andorra. The highest elevations (>3,000 m) are located in the Spanish side, with a progressive gradient to north (more pronounced) and south, and to both seasides. The CLIM'PY project is a joint effort of the three countries to share their climatic information. More than 600 stations will be used to assess the evolution of climate from the mid-20th century. 57 (8%) of these stations are located over 1,500 m. The mean length of precipitation data in 1950-2015 period is 25.6 years and 77 stations (11%) have more than the 90% of daily observations. The mean length in temperature is 21.4 years and 33 stations (5%) have more than 90% of daily observations.

Temperature and precipitation
The data treatment will be divided in two main stages: i) quality control and reconstruction of daily data and ii) monthly homogenization of representative (reconstructed) series. This work will generate, respectively, two products: a high-resolution (1x1 km) daily gridded dataset from 1981 to 2015, and a set of climate change monitoring indices based on monthly data. The grid will be useful to assess the spatial and temporal distribution of extreme events, while the monthly approach will be used to evaluate changes in trends from the second half of the 20th century by the calculation of different Climate Change indices.

Snow cover
Using the data from high-elevation observatories, the daily snow depth in winter seasons will be analysed at specific locations to assess the evolution of the snow amount through time. Furthermore, the snow cover will be analysed using MODIS and LANDSAT images when available.

Future projections
The climatic future projections will be adapted to the Pyrenean range area based on the IPCC AR5 scenarios (EUROCORDEX, HARMONIE and CMIP5 simulations will be used). The snow cover will be also simulated for different moments in 21st century.

The results of the CLIM'PY project will be used for the Climate Change assessment of the Pyrenees, within the framework of the Pyrenees Climate Change Observatory (OPCC), managed by the Working Community of the Pyrenees (CTP).

Snow cover:

An analysis of the spatio-temporal variation of the snow cover and the snow depth will be carried out covering the whole territory of Pyrenees. The snow is a highly sensitive variable to climate change, and the snow cover and its temporal evolution is of key importance to identify the impacts in the water resources.
To assess the changes on the snow cover we will use the ERHIN network (from 1985), CH-Ebro telenivometers, and high-elevation stations (>1,500 m) from the networks of Météo-France, AEMET, Servei Meteorològic de Catalunya and Institut d'Estudis Andorrans.

Figure 5: Sources of information in snow cover and depth in the Pyrenees. The telenivometer (left) measures depth and density of snow, same as the manual measures (center), while TLS (right) is used to measure complete areas.

The dataset of snow cover will be completed with the use of satellite images of MODIS and LANDSAT for 2000-2015 period and they will be validated with the observed snow depth at stations and the SAFRAN dataset from Météo-France. A simulation using Surfex-Crocus will be made, forced with SAFRAN to the analysis of snow cover.

The MODIS analysis will be applied in three stages: i) validation with the snow stations (telenivometers, high-elevation stations); ii) estimation of values in pixels with missing/wrong data or cloud-covered; and iii) application of the analysis by obtaining global statistics for the whole Pyrenees.

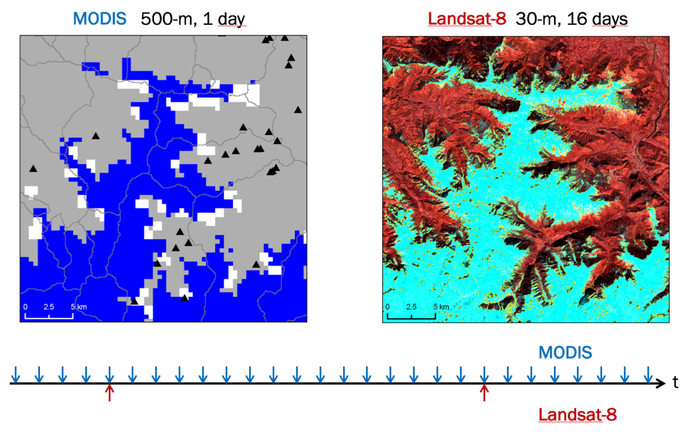

Figure 6: The analysis using satellite images will use MODIS snow cover product at daily scale of 500 m spatial resolution and LANDSAT-8 30 m resolution every 16 days.

The aim is the study of its recent evolution, the modelling and the forcing of simulations of the snow cover

References:

Cuadrat JM, Serrano-Notivoli R, Saz MÁ, Tejedor E, Prohom M, Cunillera J, Soubeyroux JM, Deaux N. 2013. Creación de una base de datos homogenizada de temperaturas para los Pirineos (1950–2010). *Geographicalia*, 63-64, pp. 63-74.
Dumont M and Gascoin S. 2016. Optical remote sensing of snow cover. In *Land Surface Remote Sensing in Continental Hydrology*, pp. 115-137. DOI: 10.1016/B978-1-78548-104-8.50004-8
López-Moreno JI, Pomeroy JW, Revuelto J, Vicente-Serrano SM. 2013. Response of snow processes to climate change: Spatial variability in a small basin in the Spanish Pyrenees. *Hydrological Processes*, 27 (18), pp. 2637-2650. DOI: 10.1002/hyp.9408
Serrano-Notivoli R, de Luis M, Saz MÁ, Beguería S. 2017. Spatially-based reconstruction of daily precipitation instrumental data series. *Climate Research*. 73 (3), pp. 167-186. DOI: 10.3354/cr01476

Aknowledgements:

CLIM'PY project is funded by the European Union through the Interreg-POCTEFA territorial cooperation program, created to encourage the sustainable development in the border region between Spain, France and Andorra. Researchers from UNIZAR were also supported by the Government of Aragón through the 'Programme of research groups' (group H38, 'Clima, Agua, Cambio Global y Sistemas Naturales').

Interreg POCTEFA
Fondo Europeo de Desarrollo Regional (FEDER)