Impact of climate change on snow cover in the mountainous regions of France using high resolutions climate simulations

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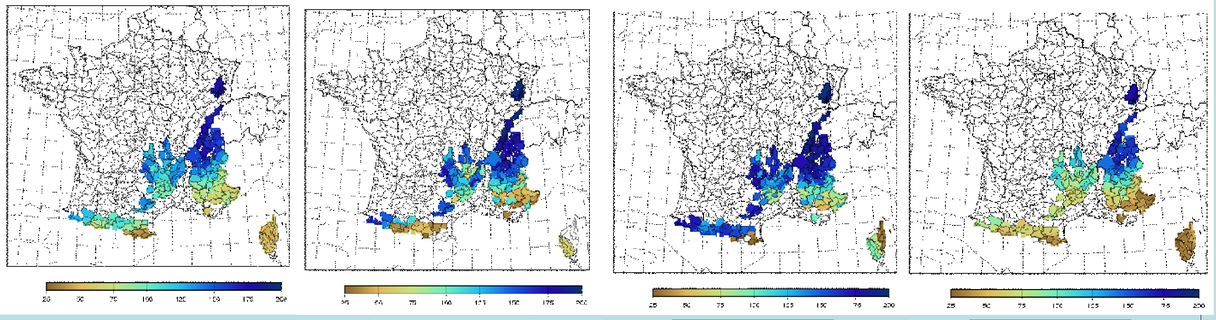
The present study shows the very first results about the snow cover over France under climate changes and its estimates over mountain areas (Alpes, Pyrenees, Massif Central, Voges, Jura and Corse) including surface elevation effects. It is a part of the scientific project SCAMPEI [1], addressing some aspects of French mountain areas vulnerability with respect to climate changes in the21st century. The scientific approach lies on the use of high resolution (12 km) limited area climate models under 3 IPCC scenarios (A1B, A2, B1) as well as on meso-scale statistical downscaling (8 km) of the surface atmospheric fields. Dynamical downscaling are performed with 3 limited area climate models (ALADIN, LMDZ, MAR), while the statistical downscaling is based on the IPCC AR4 database and Météo-France ARPEGE climate scenarios, downscaled on the 8 km grid using the DSCLIM statistical method [2]. A very strong emphasis in the project is put on the uncertainty estimation by considering explicitly the various sources of uncertainty (GCM, emission scenarios, downscaling methods). A multi-model interpretation of the RCMs and IPCC AR4 projections is foreseeing to be applied when treating the uncertainty issues.

1. Present climate simulation

The first step was to compare the ability of the models and respectively the downscaling techniques to represent the present climate. For this aim, the 12 km grid RMC models have been driven by 50 km Météo-France ARPEGE climate model or the LMD model. Then the surface meteorological variables were unbiased by quantile-quantile technique [3] and projected over an 8 km grid. The same ARPEGE climate projection was downscaled on 8 km grid using the DSCLIM statistical method, the local information being provided by the SAFRAN meteorological analyses over the 8 km grid. The snow cover is calculated using the SURFEX land surface model [4] on the 8 km grid over France, and also on different elevations in mountainous areas in order to better take into account the orography variations. The parameter, used to present the present climate as well as the climate change impact on the snow cover is the mean annual snow cover duration (the sum of the days in the year with snow cover on the ground) (Fig. 1). The three downscaled snow cover estimates are compared to a reference run consisting of a SURFEX run forced by the SAFRAN analysis.

Fig. 1 RMC models and DSCLIM disparity in the mean snow cover duration per year, calculated for the reference period (1961-1990) at 1500 m altitude for 6 mountain areas (Alpes, Pyrenees, Massif Central, Voges, Jura and Corse).



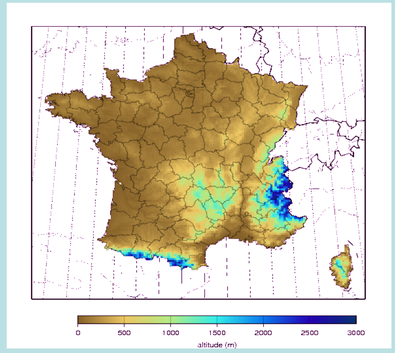
SAFRAN | ALADIN | LMDZ | DSCLIM

On sees a greeter uncertainty in the present snow characteristics representation in Pyrenees and Corse, less uncertainty in the Massif Central and South Alpes, and lowest one in Voges, Jura and North Alpes.

2. Estimation of climate change impact on the snow characteristics

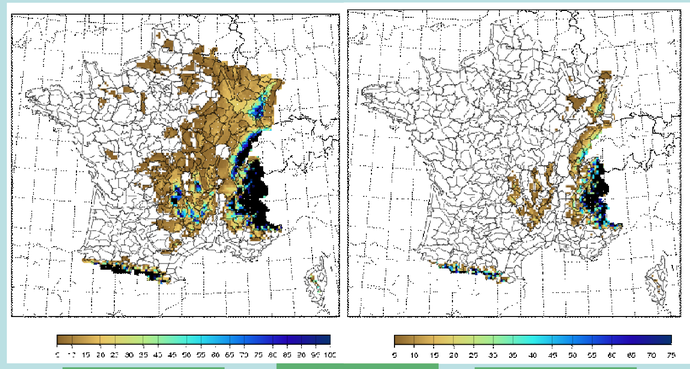
A general overview of the expected impact of the climate change on the snow characteristics at 8 km resolution over France is given by the maps in Fig. 2. They present the same characteristic, obtained from the ALADIN A1B projection for the reference period (1961-1990) and the end the 21st century (2071-2100). A strong decrease of the days with snow per year is determined by this RMC model at the end of the century.

Illustration of the orography of France on 8 km grid, used for the data calculation in Fig. 2



OROGRAPHY of the 8 km grid

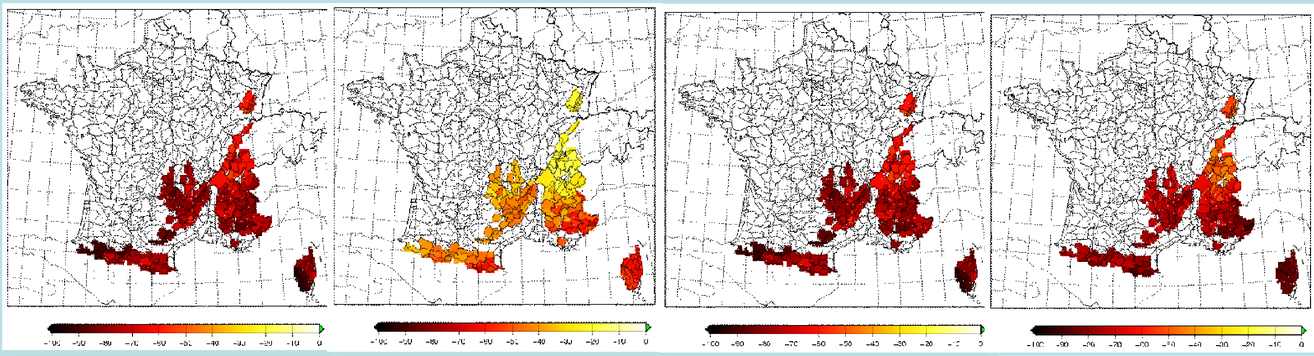
Fig. 2 Mean snow cover duration per year, determined by ALADIN A1B projection at 8 km resolution over France for two periods: 1961-1990 and 2071-2100.



1961-1990 | ALADIN A1B | 2071-2100

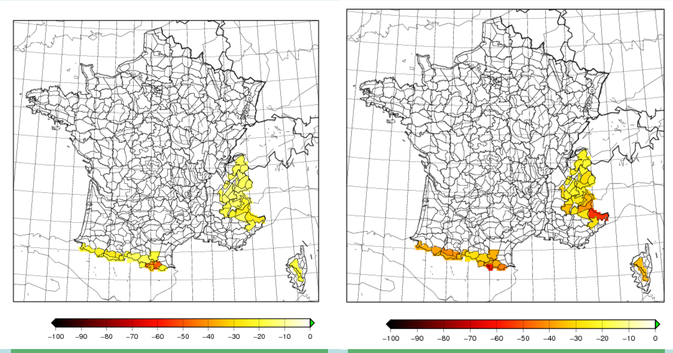
An estimation of the variation (in %) of this characteristics for two future periods (2021-2050 and 2071-2100) versus the reference one is given in the next figures. Data of two models projections, for two altitudes - 1500m and 2400 m, are shown (Fig. 3.1 and 3.2 respectively). At 1500m ALADIN RCM presents a high variation since the near future period (Fig. 3.1.a and 3.2.c), while the LMDZ RCM indicates greater variation at the end of the century (Fig. 3.1.b and 3.2.d).

Fig. 3.1 Variation, expressed in % of the mean snow cover duration per year, determined by ALADIN A1B and LMDZ A1B projections at 1500 m altitude over the mountain regions for the period 2021-2050 versus 1961-1990 (a and b) and the period 2071-2100 versus 1961-1990 (c and d).



a) ALADIN 2021-2050 vrs 1961-1990 | b) LMDZ 2021-2050 vrs 1961-1990 | c) ALADIN 2071-2100 vrs 1961-1990 | d) LMDZ 2071-2100 vrs 1961-1990

Fig. 3.2 The same as in Fig. 3.1 but for 2400 m altitude.



ALADIN 2071-2100 vrs 1961-1990 | LMDZ 2071-2100 vrs 1961-1990

At 2400 m altitude the change in the number of the snow caver days are between 20% and 60% maximum at the end of the century.

References:

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