SnowBall project

Climate change impact on snow-related processes

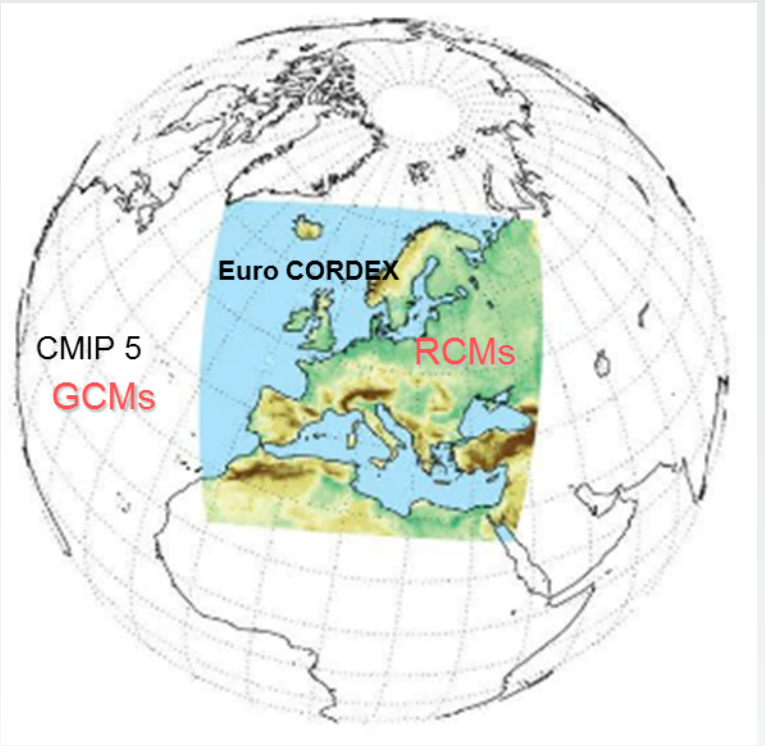
Roxana BOJARIU, Ciprian CORBUȘ, Rodica MIC, Narcisa MILIAN, Alexandru DUMITRESCU, Marius-Victor BIRSAN, Sorin-Ionuț DASCĂLU, Mădălina GOTHARD, Liliana VELEA, Roxana CICĂ, Cristian Lucian GRECU, Adrian Alin PAȘOL

Overview

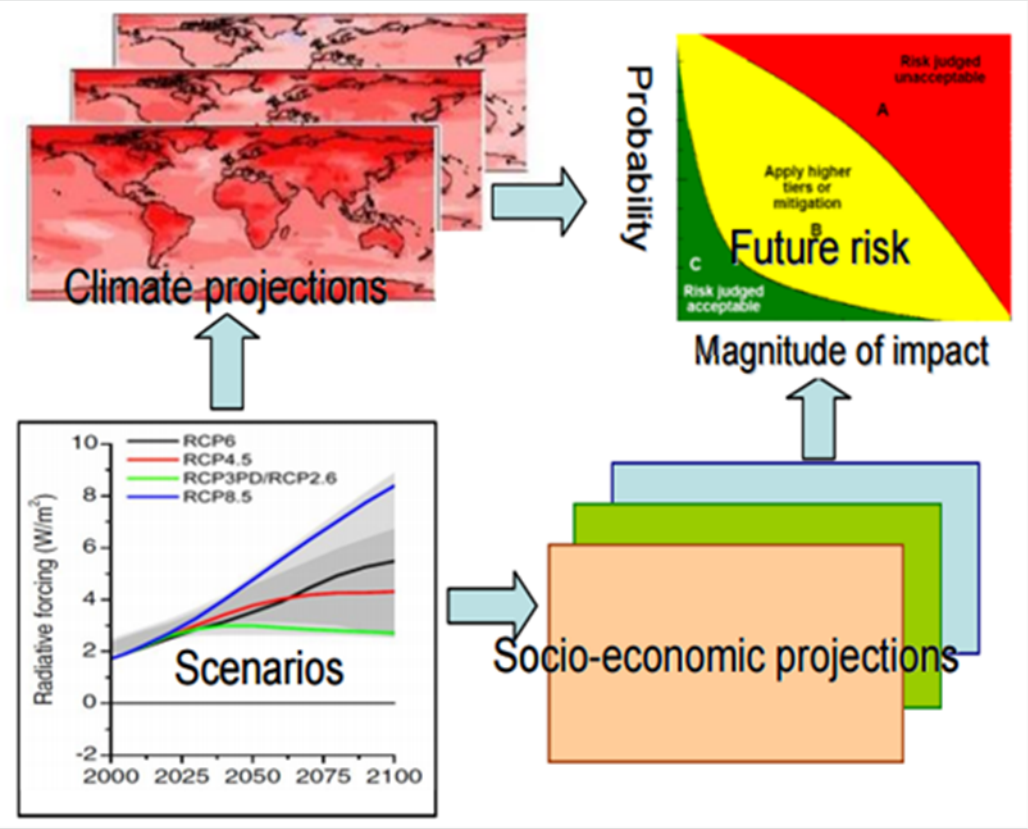
- Snow-related climate modeling results
- Impact of snow-related changes on number of days with ski conditions in Romanian Carpathians
- Hydrological modeling with melted snow component under future climate scenario
- Avalanche statistics
- Conclusions

Regional and global climate models

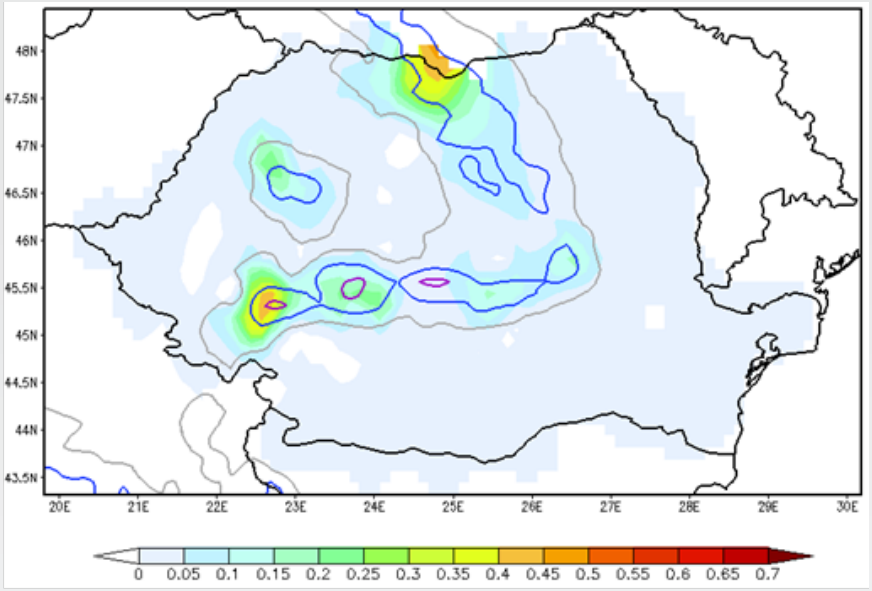
Nr.	Regional climatic modeling center	Regional model (EURO-CORDEX)	Global model (CMIP 5)
1	CLMcom (CLMcom Consortium)	CLM 4-8-17	MPI-ESM-LR
2	DMI (Danish Meteorological Institute)	HIRHAM5	ICHEC-EC-EARTH
3	KNMI (The Royal Netherlands Meteorological Institute)	RACMO 22E	ICHEC-EC-EARTH
4	MPI-CSC (Max-Planck Insitute–Climate Service Center, Hamburg, Germany)	REMO 2009	MPI-ESM-LR
5	SMHI (Swedish Meteorological and Hydrological Institute)	RCA4	ICHEC-EC-EARTH



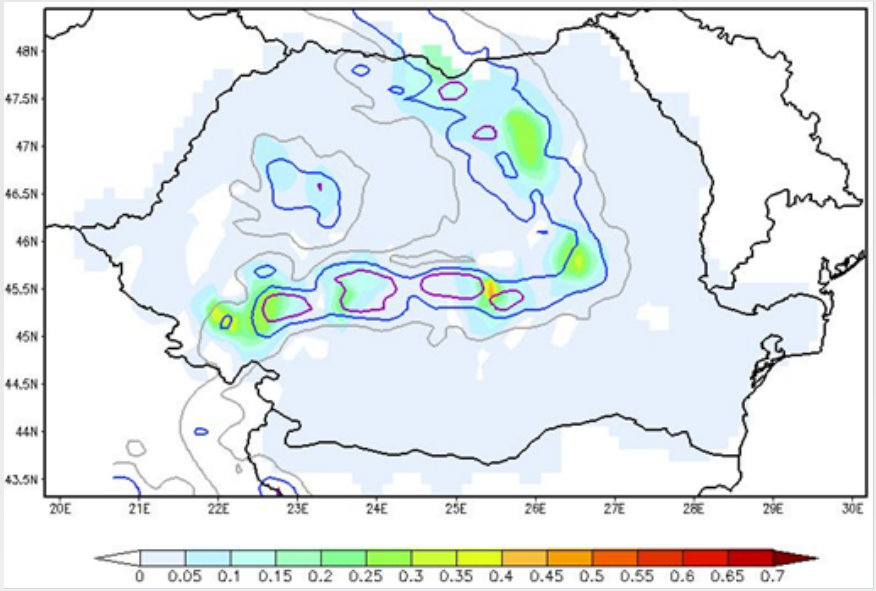
Future risk assessment



Observed and simulated snow depth (1972-2001)/validation of regional climate models

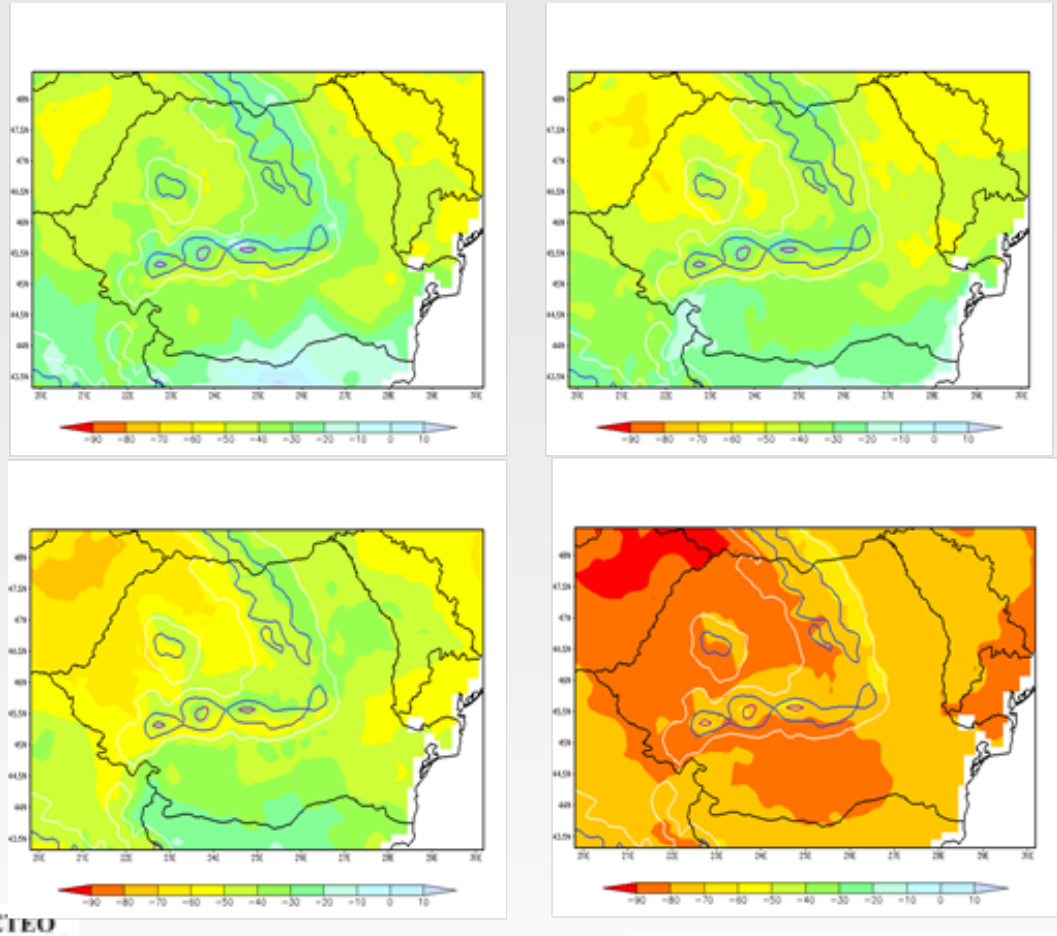


Multiannual averages of snow depth (in m) for the interval October-June 1972-2001. The data are from muti-model ensemble of 5 RCMs. For the comparison, the map was built with the simulated values from the model grids which were interpolated at the locations of meteorological stations.



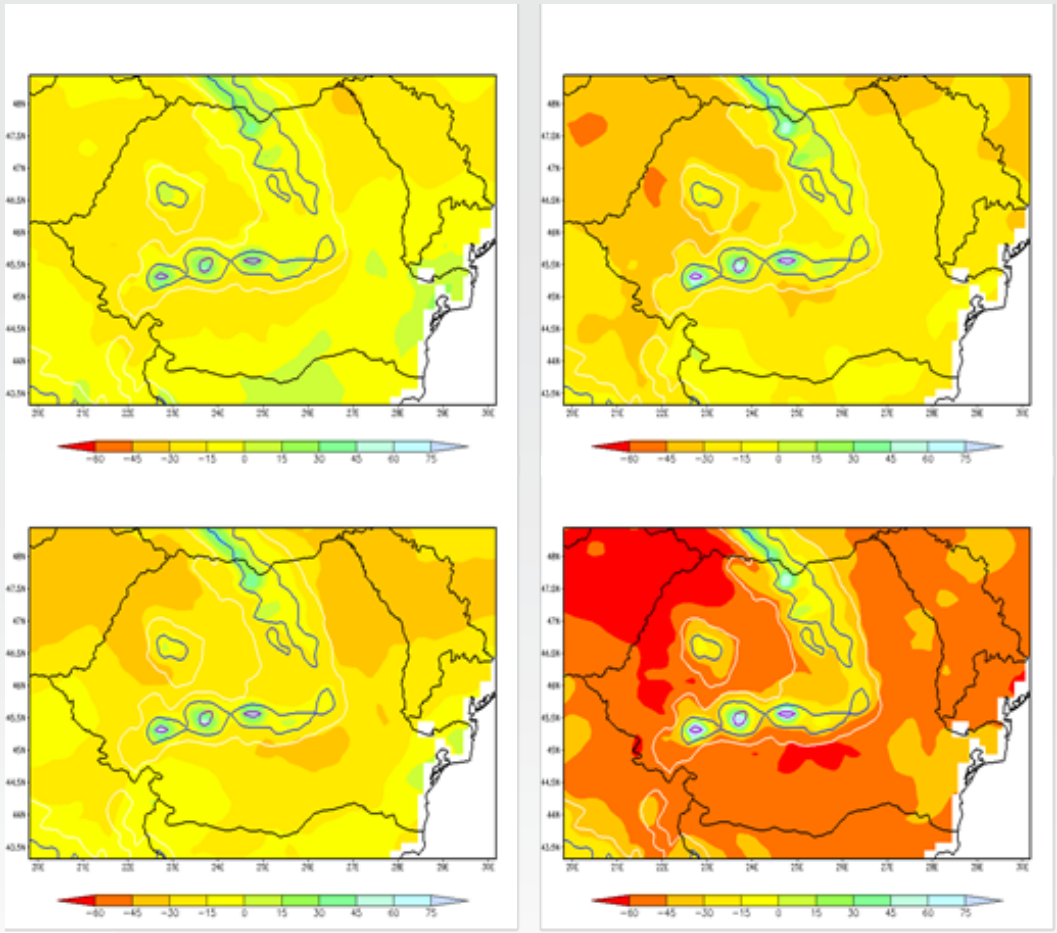
Multiannual averages of snow depth (in m) for the interval October-June 1972-2001. The data are from 119 meteorological stations covering the Romanian territory.

Snow amount changes



Changes in the ensemble means of the amount of snow (%) in the cold season (October to April) under moderate concentrations scenario (RCP 4.5, left) and high concentration scenario (RCP 8.5, right), for the intervals 2022–2050 (top) and 2072–2100 (bottom) compared to the reference period 1972–2001. Contour lines illustrate the topography of the model (white line - up to 500 m, blue line - up to 1000 m, and magenta line - up to 1500 m).

Changes of mean snow melt amount



Changes of mean snow melt amount (in %) in the interval October–April throughout Romania, under the moderate concentration scenario (RCP 4.5, left) and high concentration scenario (RCP 8.5, right) for the interval 2022–2050 (top) and 2072–2100 (bottom) compared to the reference period 1972–2001. Contour lines illustrate the topography of the model (white line - up to 500 m, blue line - up to 1000 m, and magenta line - up to 1500 m).

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Remote sensing, model and in-situ data fusion for snowpack parameters and related hazards in a climate change perspective (SnowBall)

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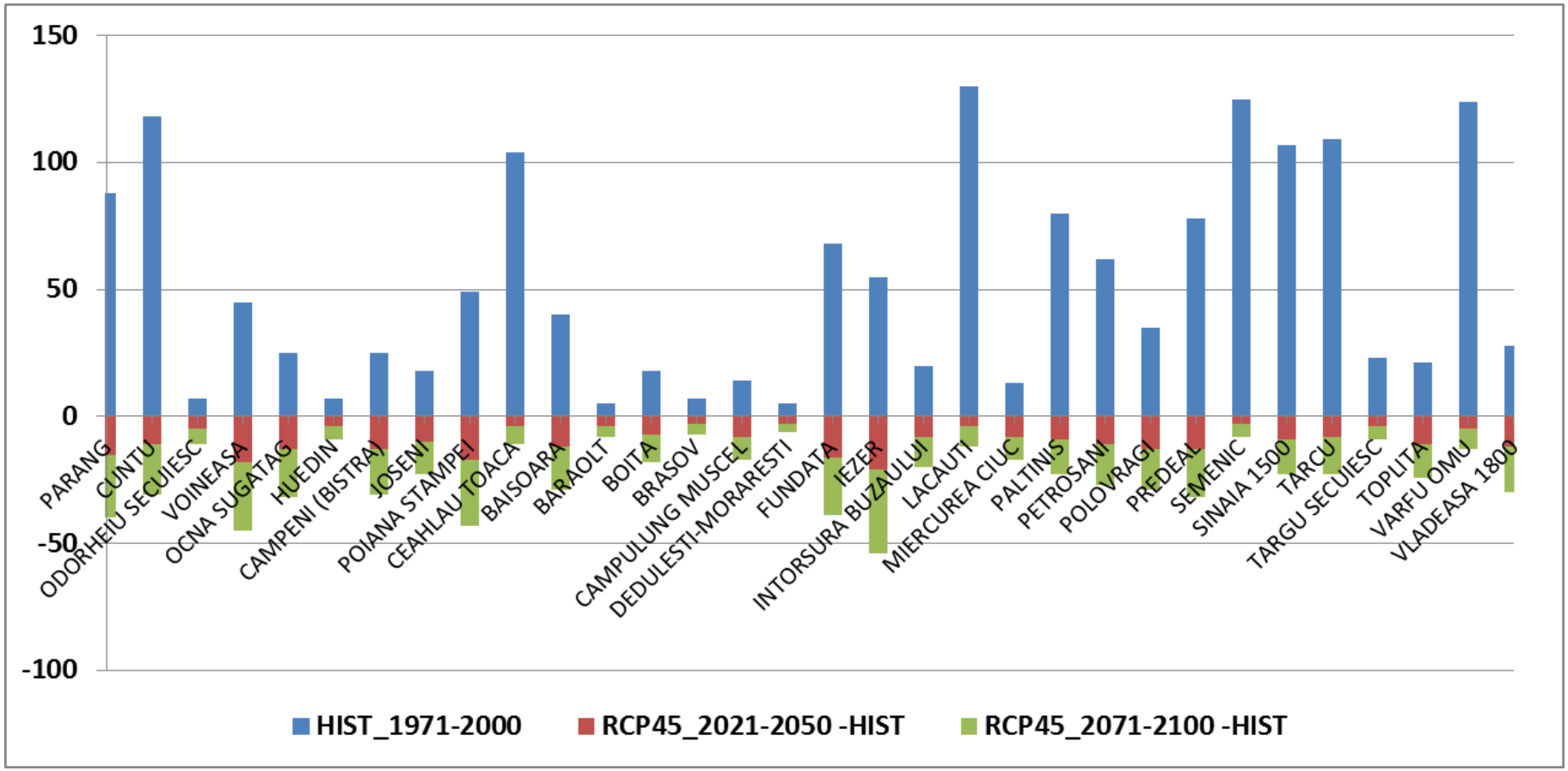
Mean number of days in a ski season with snow depth larger than 30 cm at 32 Romanian stations (blue) and changes under RCP 4.5 scenario for periods 2021-2050 (red) and 2071-2100 (green) based on bias corrected output of 5 RCM models.



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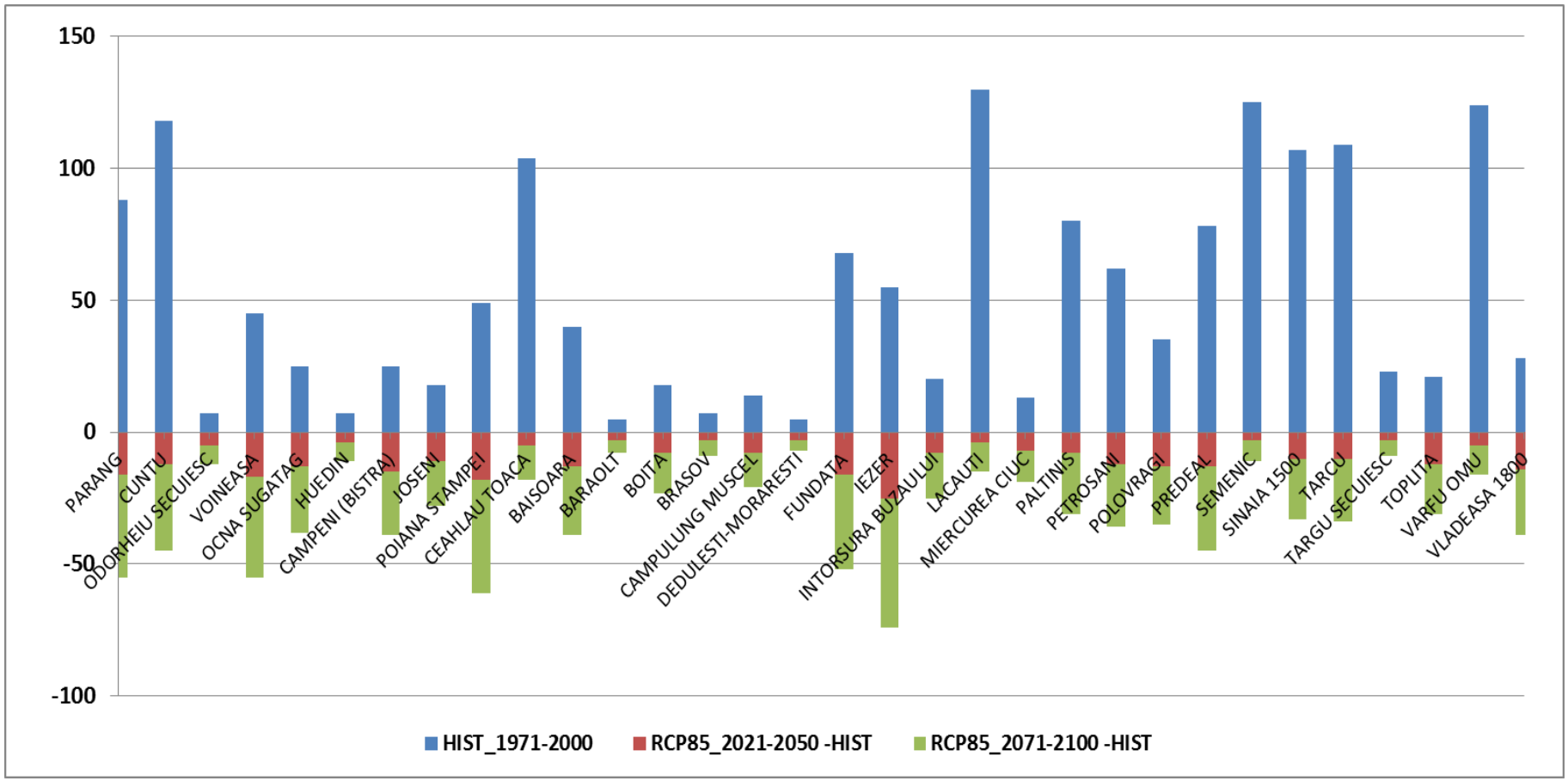

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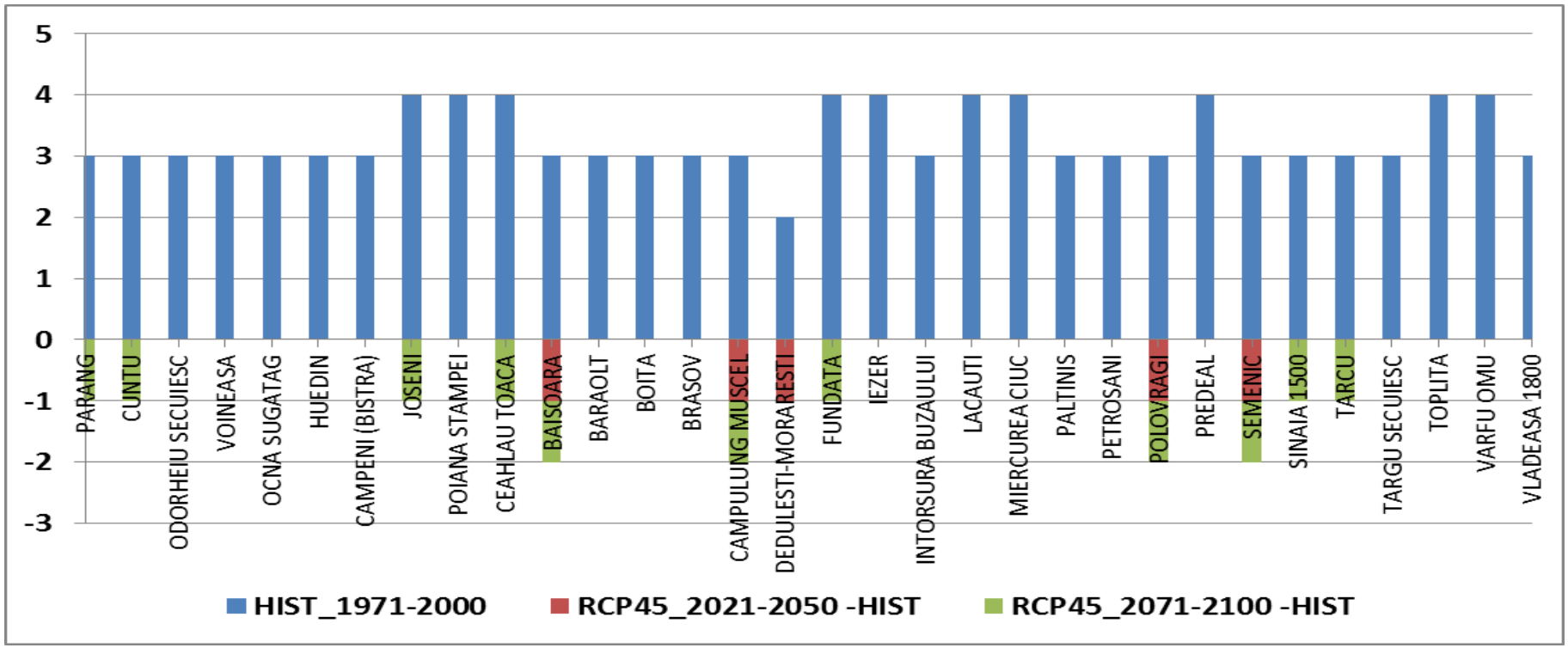
Mean number of months in a ski season with proper snowmaking conditions for 32 Romanian stations and changes under RCP 4.5 scenario for periods 2021-2050 (red) and 2071-2100 (green) based on bias corrected output of 5 RCM models.



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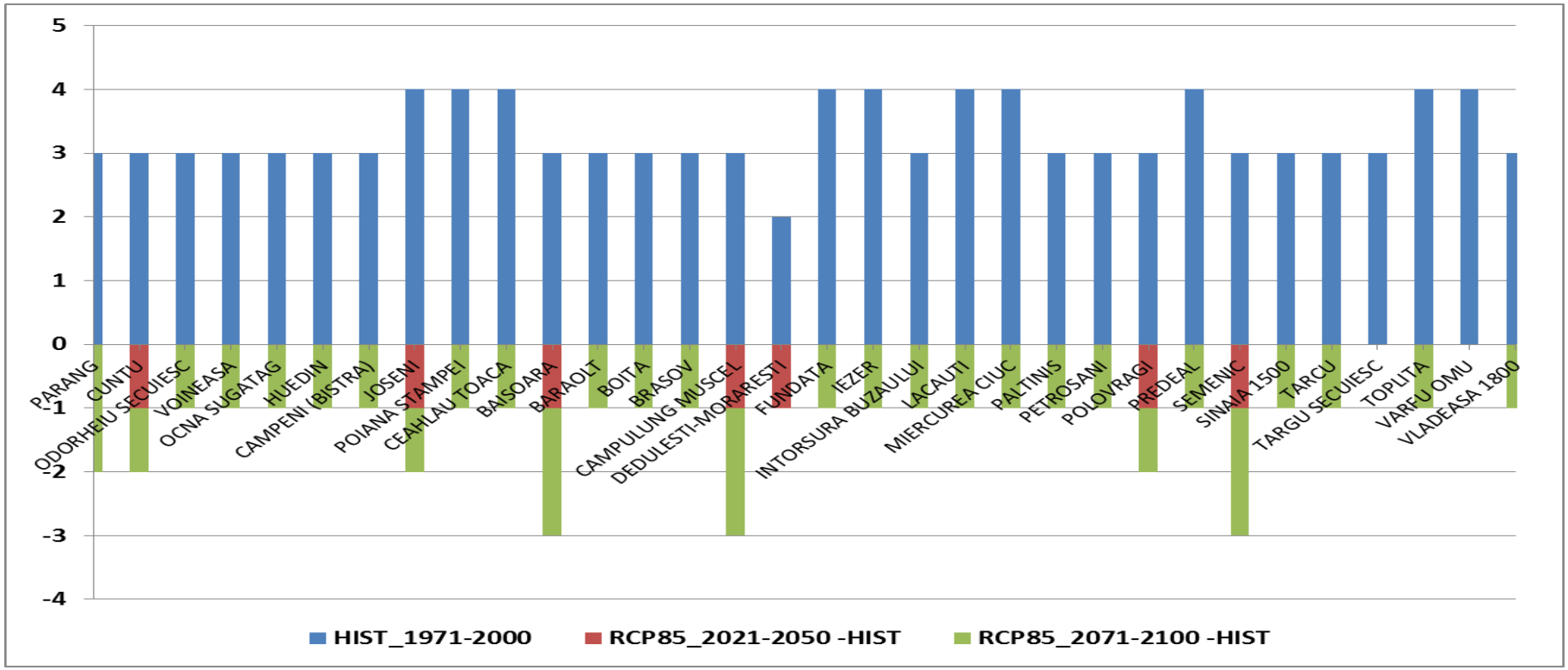

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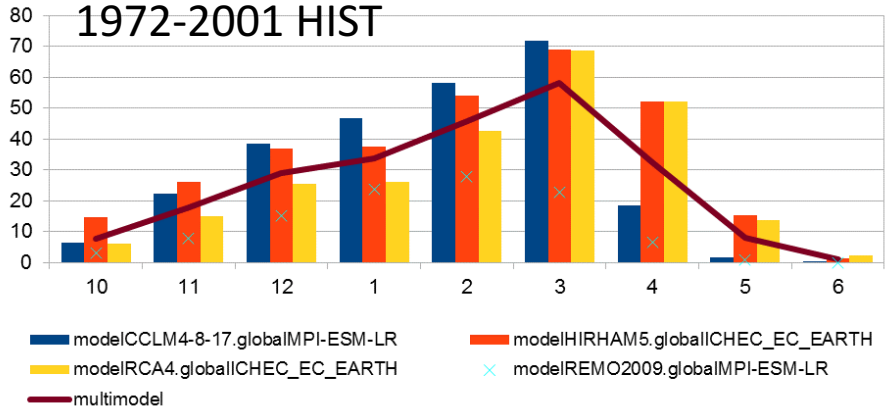
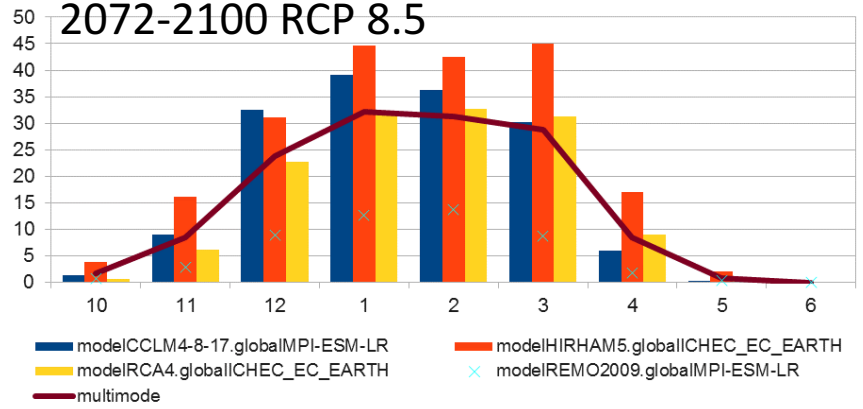
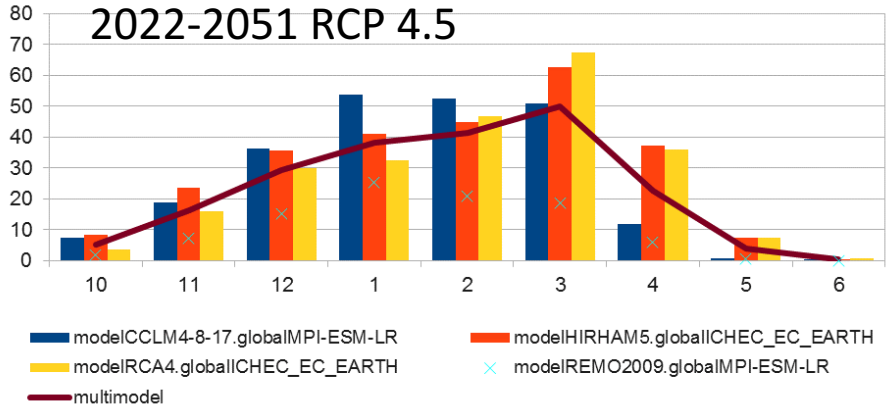
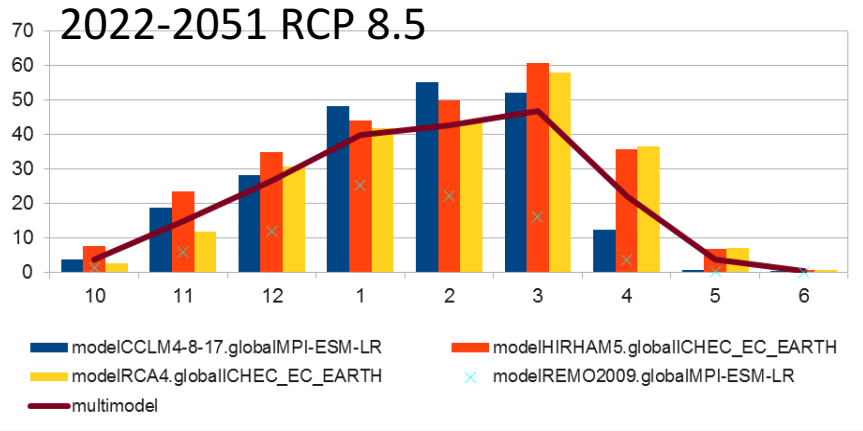
Amount of melted snow (kg/m2) for grids at altitudes > 500 m

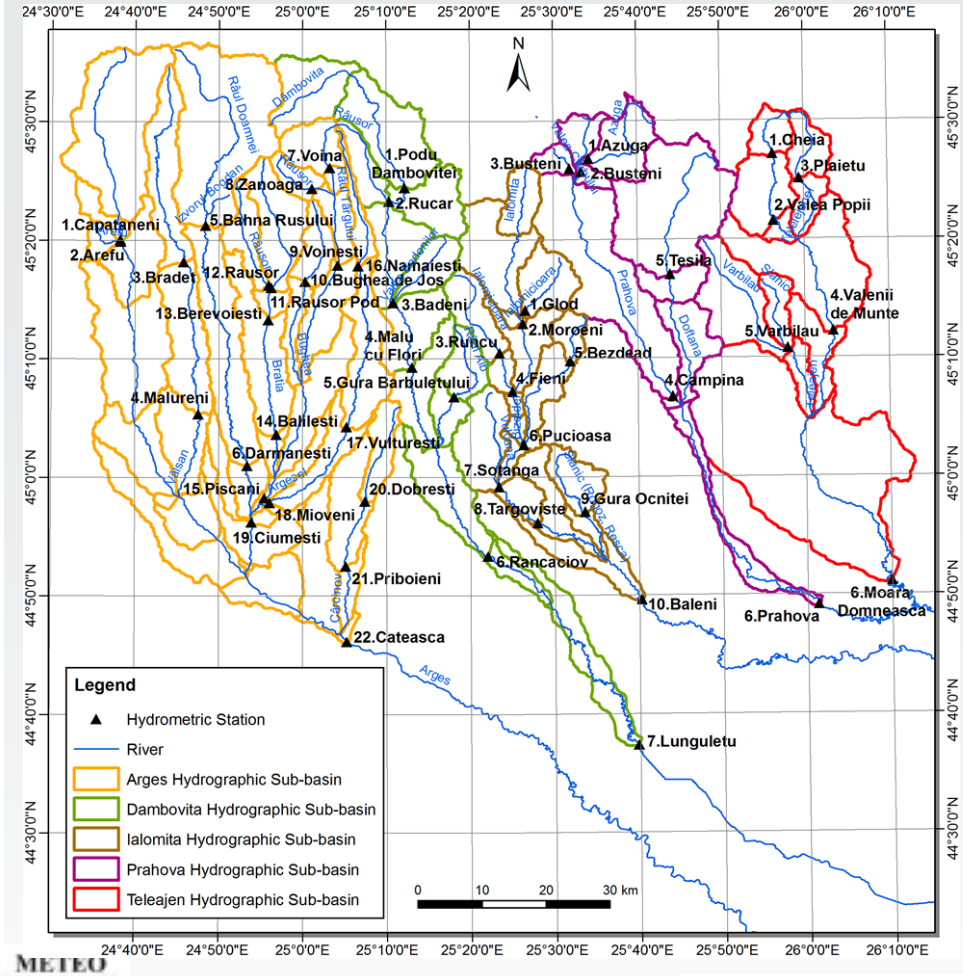




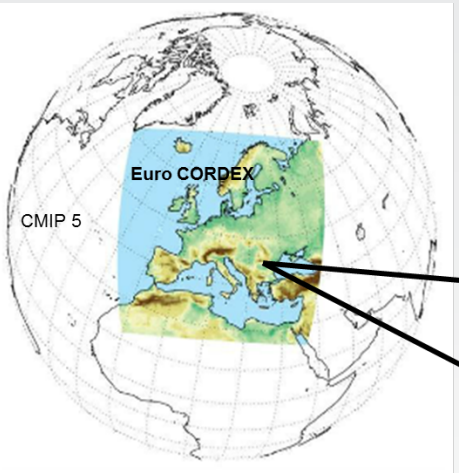


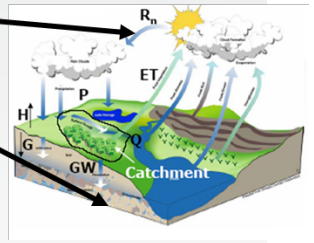


Hydrological modelling of streamflow with melted snow component

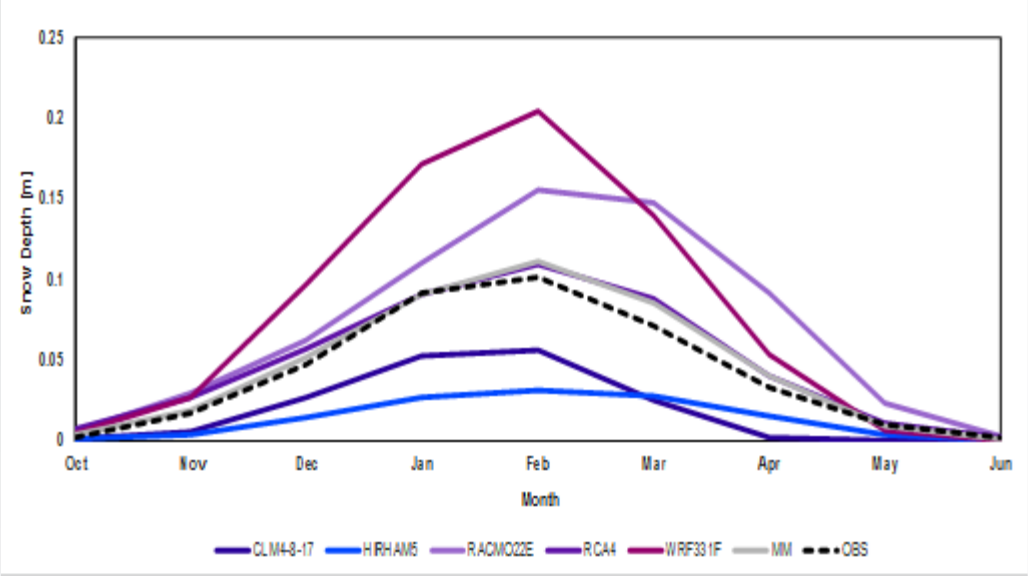


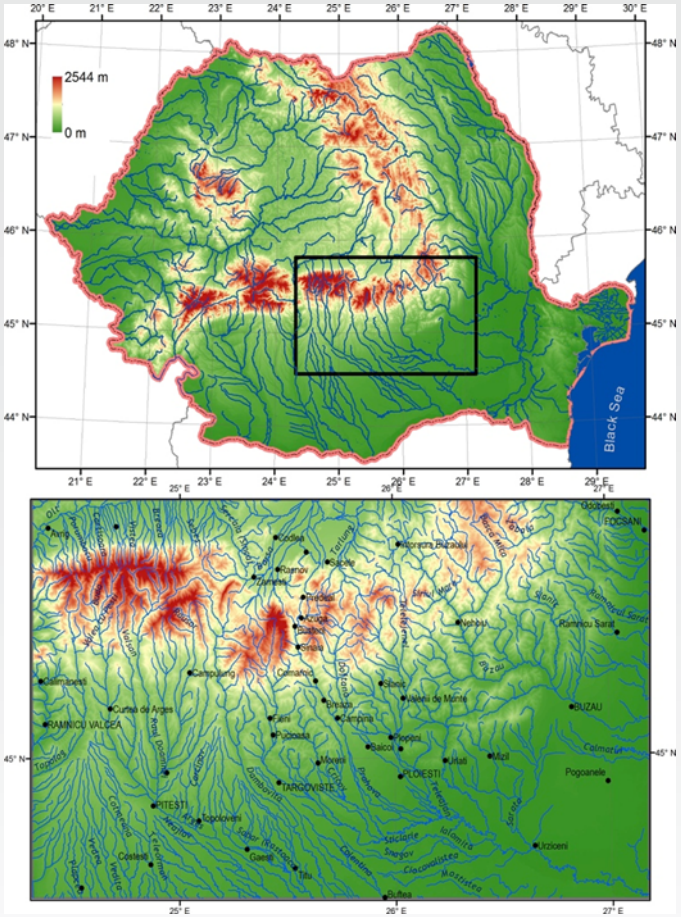
Hydrometric stations used for the area of interest (the upper area of the Argeş and Ialomiţa Rivers).





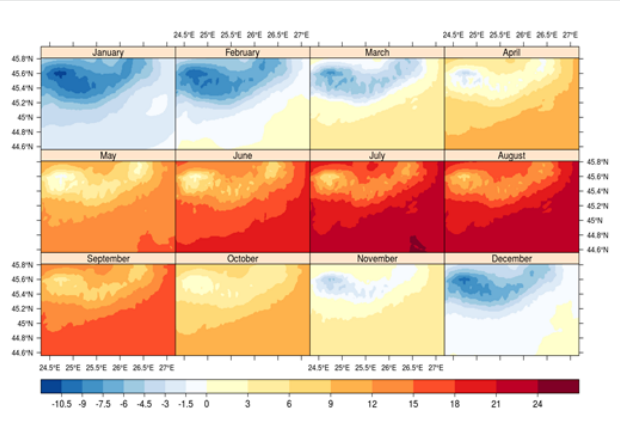
Climate imput of hydrological model CONSUL



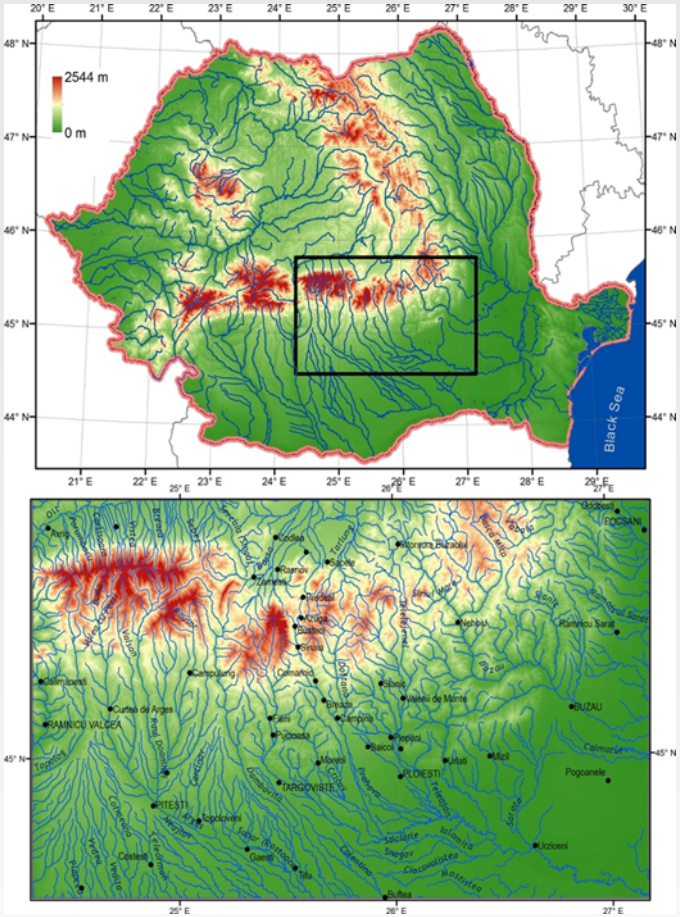


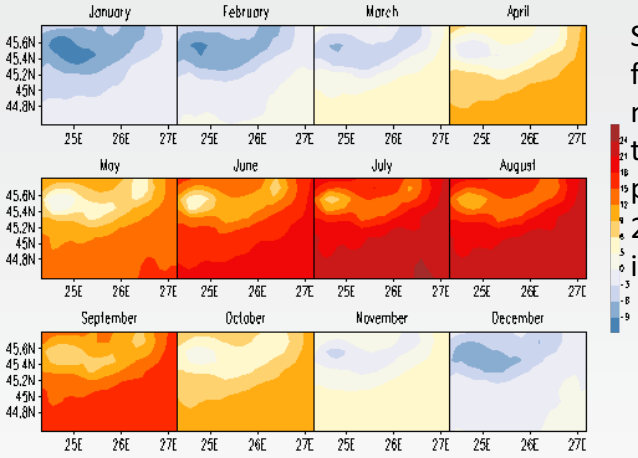
Observed (dotted line) and simulated monthly values of averaged snow depth (colored soild lines, in m) over Romania from 5 numerical experiments with 5 RCMs covering the interval 1972-2001. Ensemble mean of the RCM simulations is in grey (MM). Data are from the EURO-CORDEX initiative.

Climate imput of hydrological model CONSUL



Disaggregated values of temperature (in °C) over the area of interest for the present climate (1981-2010). Resolution is 0.01 ° in latitude and longitude





Simulated temperature from the regional climate model RCA4 (in °C) over the area of interest for the present climate 1981-2010. Resolution is 0.125 ° in latitude and longitude.

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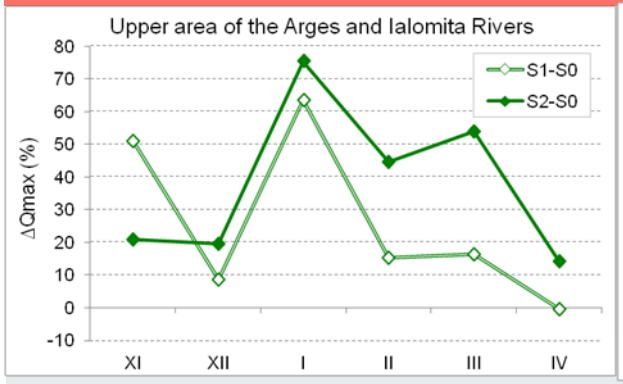
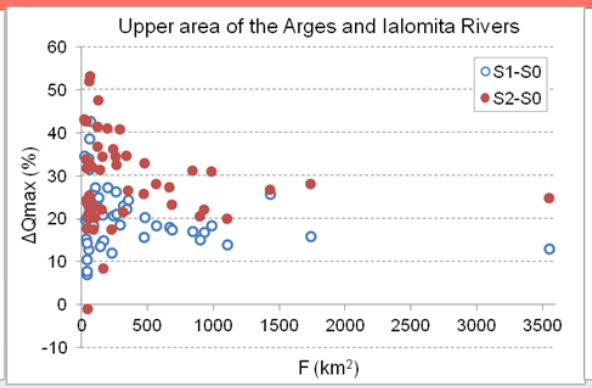
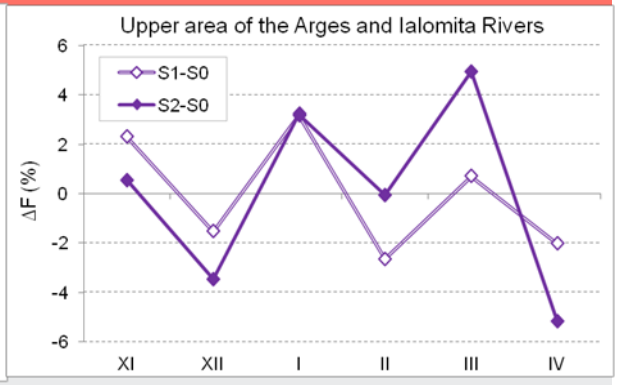
Results of hydrological modeling



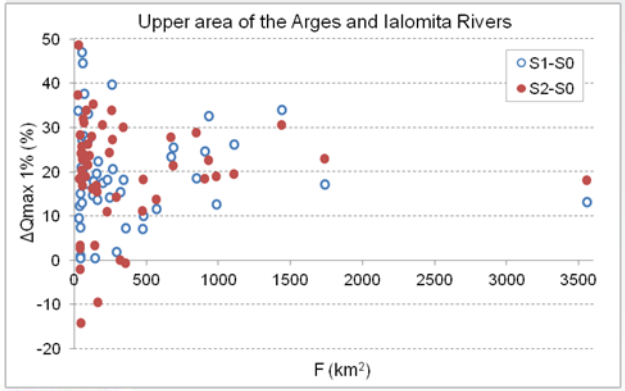
Variations of the relative deviations (%) of the multiannual average values of average monthly discharges for S1 and S2 scenarios compared to S0 scenario, in the upper area of the Argeş and Ialomiţa Rivers



Relative deviations (%) of the maximum discharges during November to April, multiannual averages, for S1 and S2 scenarios compared to S0 scenario, at hydrometric stations from upper area of the Argeş and Ialomiţa Rivers

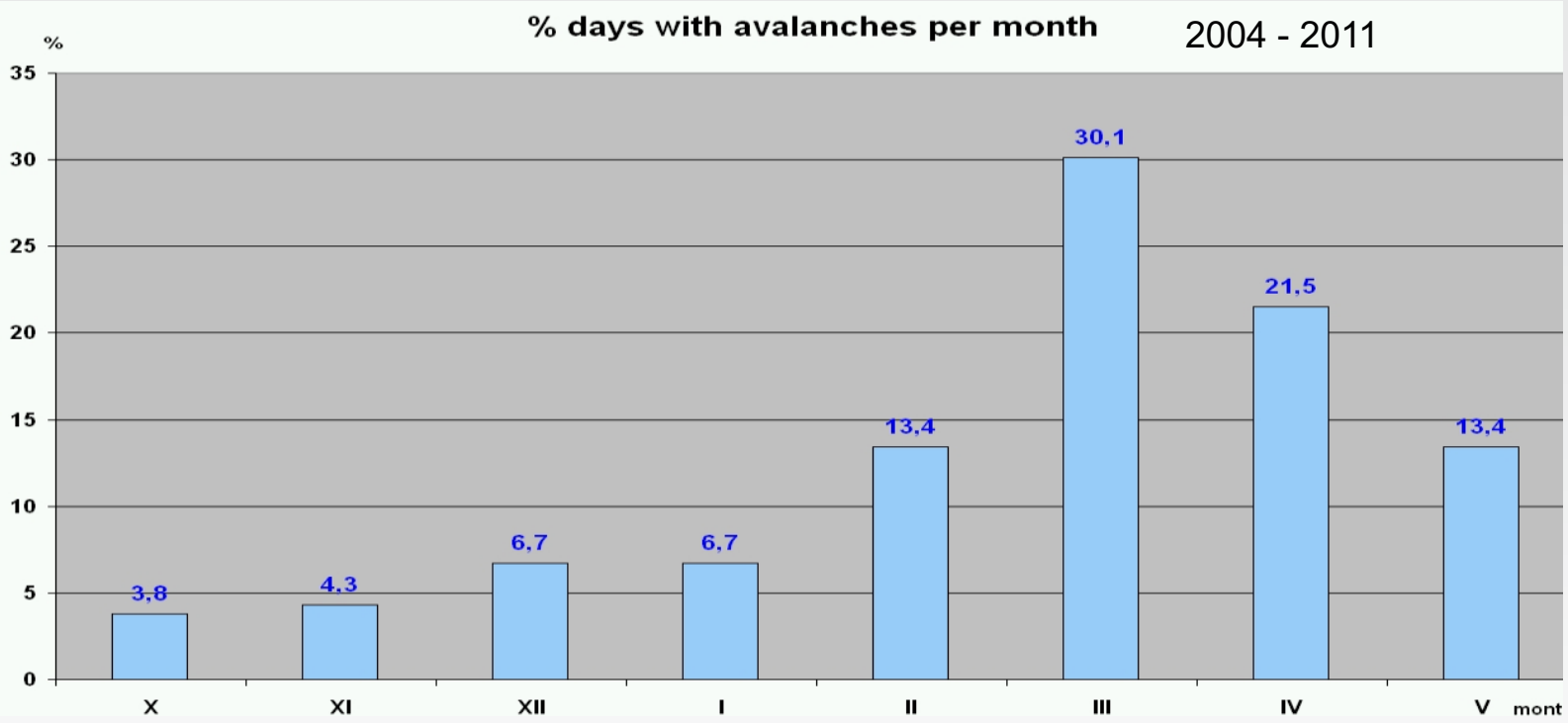


Variations of the relative deviations (%) of the occurrence mean number (F) of maximum discharges, during November to April, on calendar months, in S1 and S2 scenarios compared to S0 scenario, in the sections of the hydrometric stations from upper area of the Argeş and Ialomiţa Rivers



Relative deviations (%) of the maximum discharge during November to April, with the probability of exceeding 1%, calculated for S1 and S2 scenarios compared to S0 scenario and the corresponding surfaces of the hydrometric stations from upper area of the Argeş and Ialomiţa Rivers

Avalanche frequency under present climate (875 cases)



Conclusions

- Seasonal snow amounts will strongly decline all over Romanian territory. The decrese in snow amount could be larger than 80% (compared with the reference period October-April 1971-2001) in areas from the Western, central and Southern Romania. In mountains, the reduction is slightly smaller ranging from 60% to 80% at the end of the 21st century, in the worst case scenario.
- The reduction in snow amounts have impact on many socio-economic activities. The number of days with good ski conditions in a season is decreasing in the Carpathians under climate change.
- The analysis of the ensemble means of 5 RCMs show that snow melting will be enhanced in the mountain region of Romania, under climate change. This increase of snow melt amounts leads to an increased risk of flooding in this region, in the cold season (October–April).
- The hydrologic modelling applied to the sub-basins corresponding to the rivers Argeş and Ialomiţa, located mainly in mountain areas, supports the above mentioned findings and add more local details about the maximum discharge and flood statistics there.
- The results of the hydrologic model (CONSUL) indicate that multiannual averages of maximum discharges during the interval from November to April show increases compared with present climate (1981-2010) under moderate (RCP 4.5) and worst (RCP 8.5) climate change scenarios. For sub-basins with larger areas, the increases are systematically larger under the worst scenario compared to those under the moderate one showing how the climate change signal overcome the noise beyond specific spatial scales of river basins.
- As for the changes in the avalanche statistics under climate change, more studies are needed to identify signals at the very fine spatial scales which characterize this snow-related hazard.