Scale dependent impact of Climate Change in the Alpine Region: Hydrological Budget Comparison between Low, Medium, High and very High Resolution Regional Climate Model simulations.

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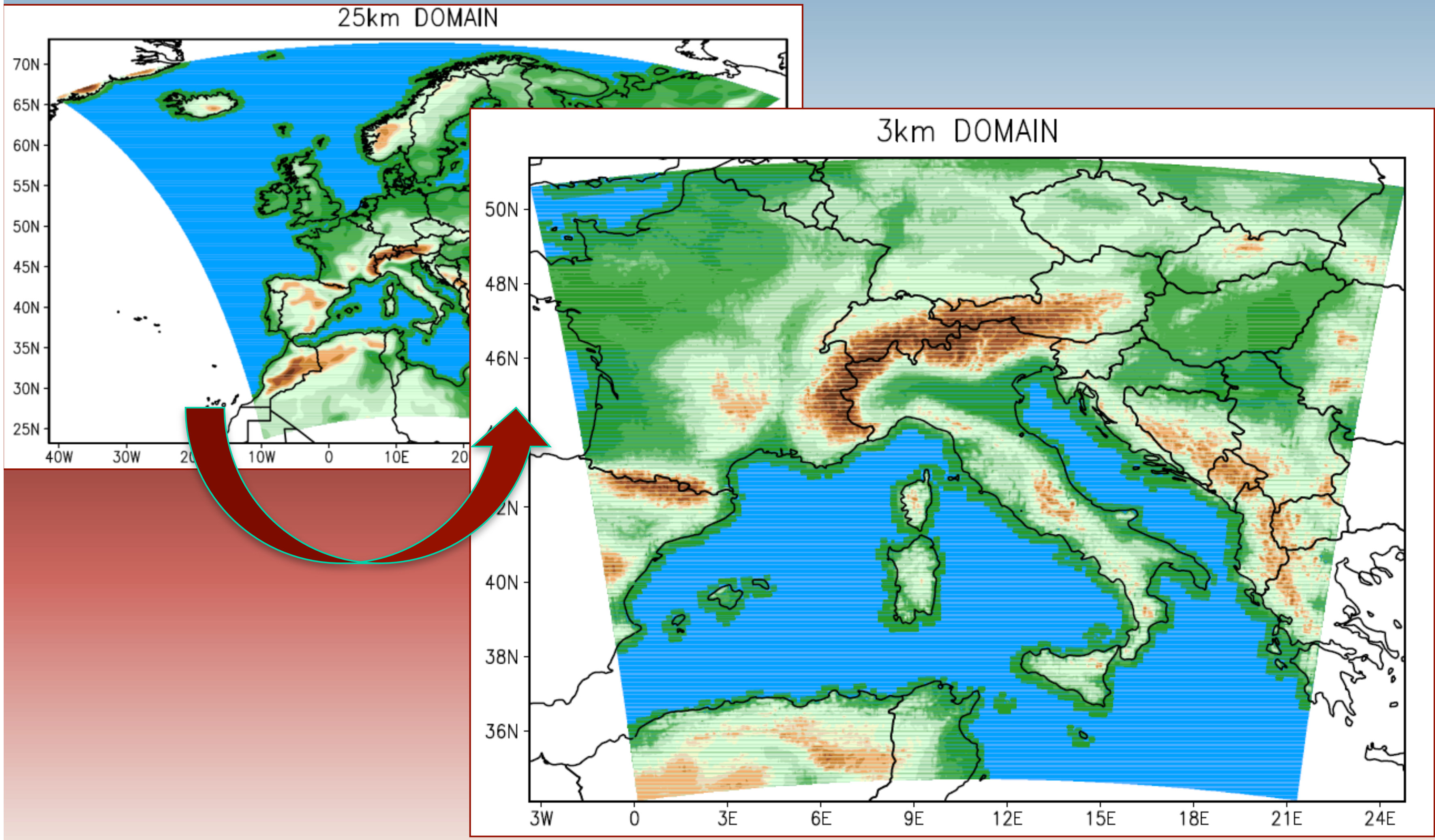
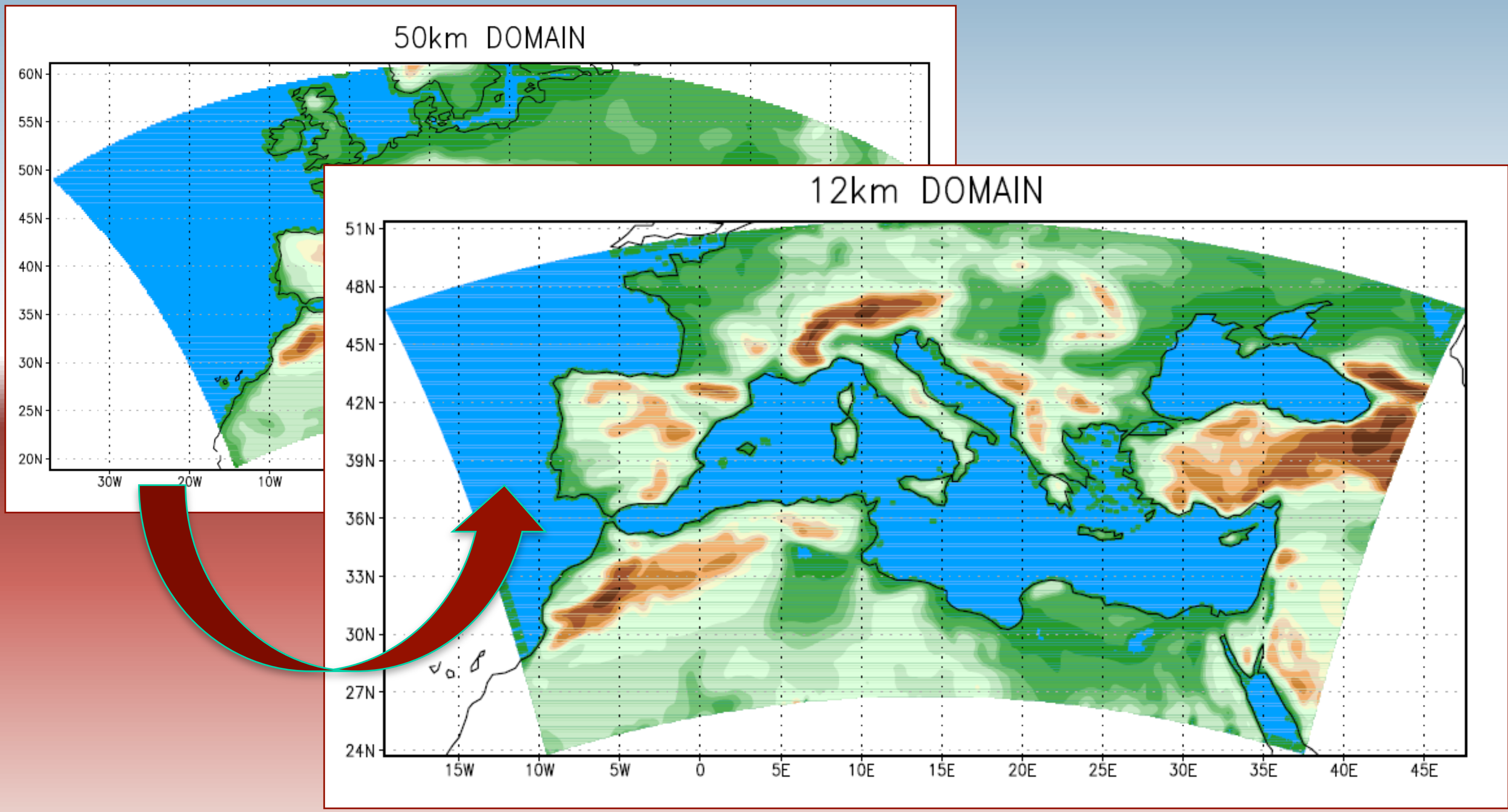
Configuration of the RegCM ECHAM-CMIP3 driven simulation with the future scenario “A1B”:



Configuration for the RegCM HadGEM-CMIP5-driven simulation with the future scenario "RCP8.5":



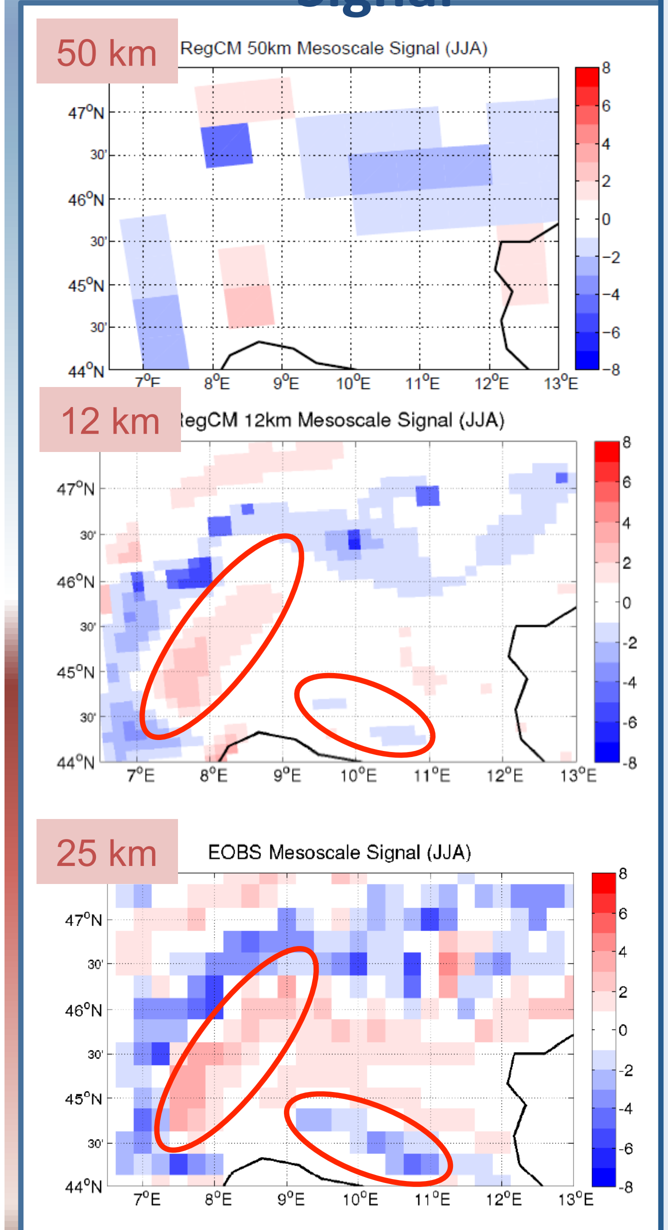
RCM ADDED VALUE: 1. The Mesoscale Signal

The RegCM signal has been decomposed into a large-scale component and a mesoscale signal as done in Coppola et al. (2010):

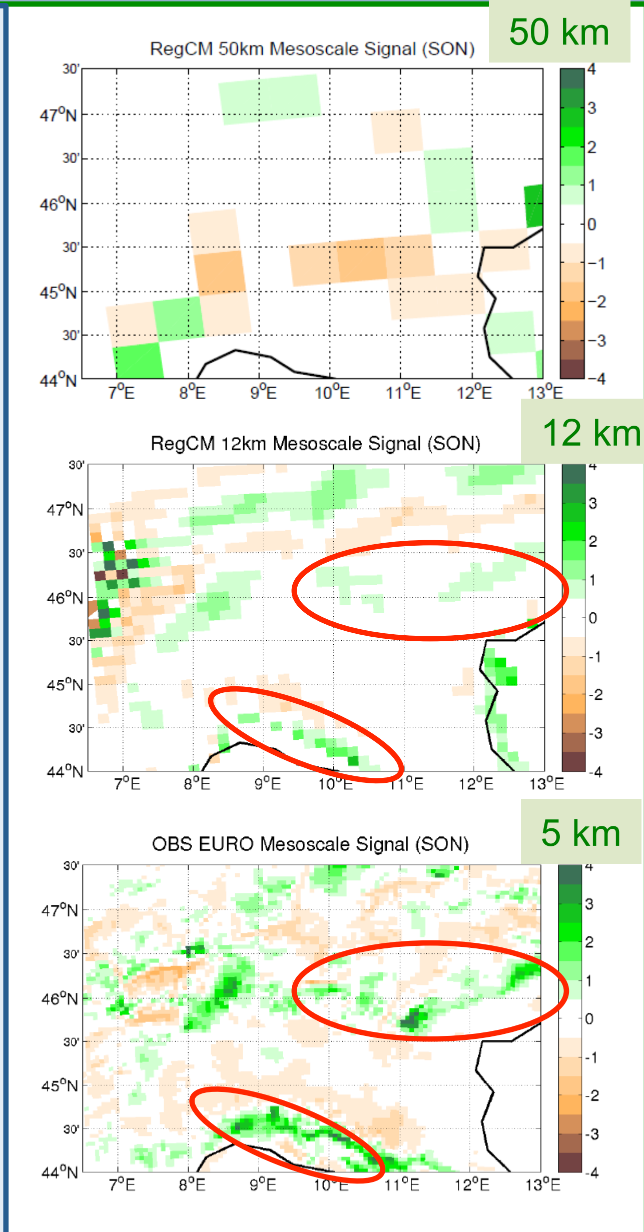
1. The large-scale component was identified by carrying out a spatial average of the RCM fields to reach a resolution of ~ 100 km.

2. The mesoscale signal was then obtained by simply subtracting the calculated large-scale component from the full RCM fields. This generates an anomaly field in which the large-scale component is filtered out.

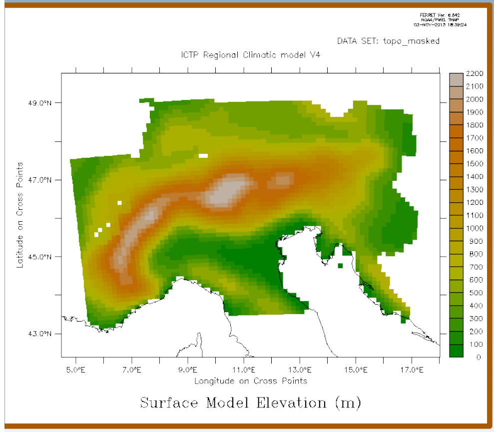
RCM ADDED VALUE: 1. The Mesoscale Signal

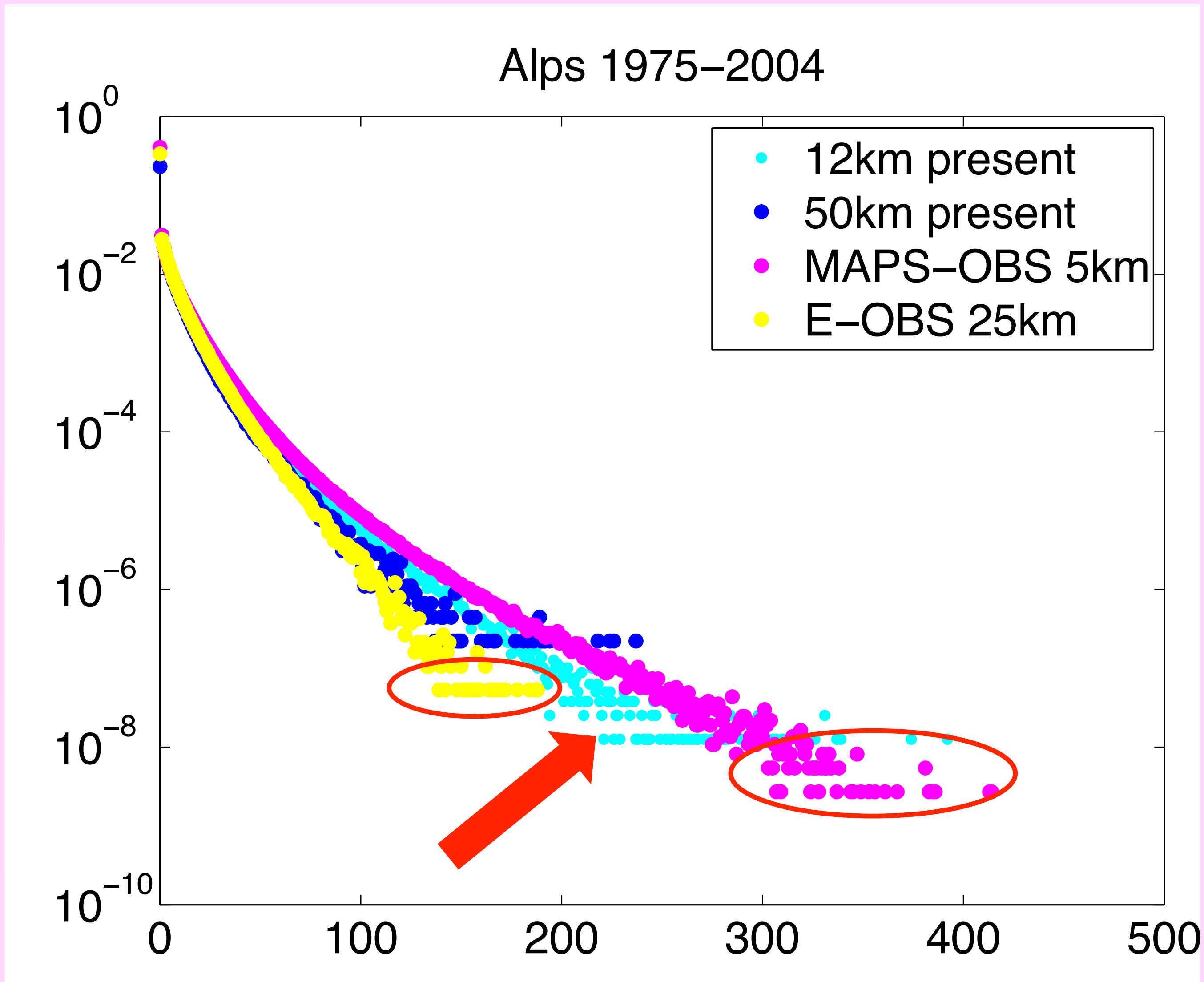


- Both examples of temperature and precipitation mesoscale signal show that the higher resolution run can better represent the observed variables spatial distribution at high resolution.
- The RegCM spatial features are essentially tied to the topography with large negative values over the Alpine chain and positive values over the Po valley of northern Italy for temperature and positive values in the mountain areas and negative in the valley for precipitation.



RCM ADDED VALUE: 2. Importance of the observed data-set in the model validation





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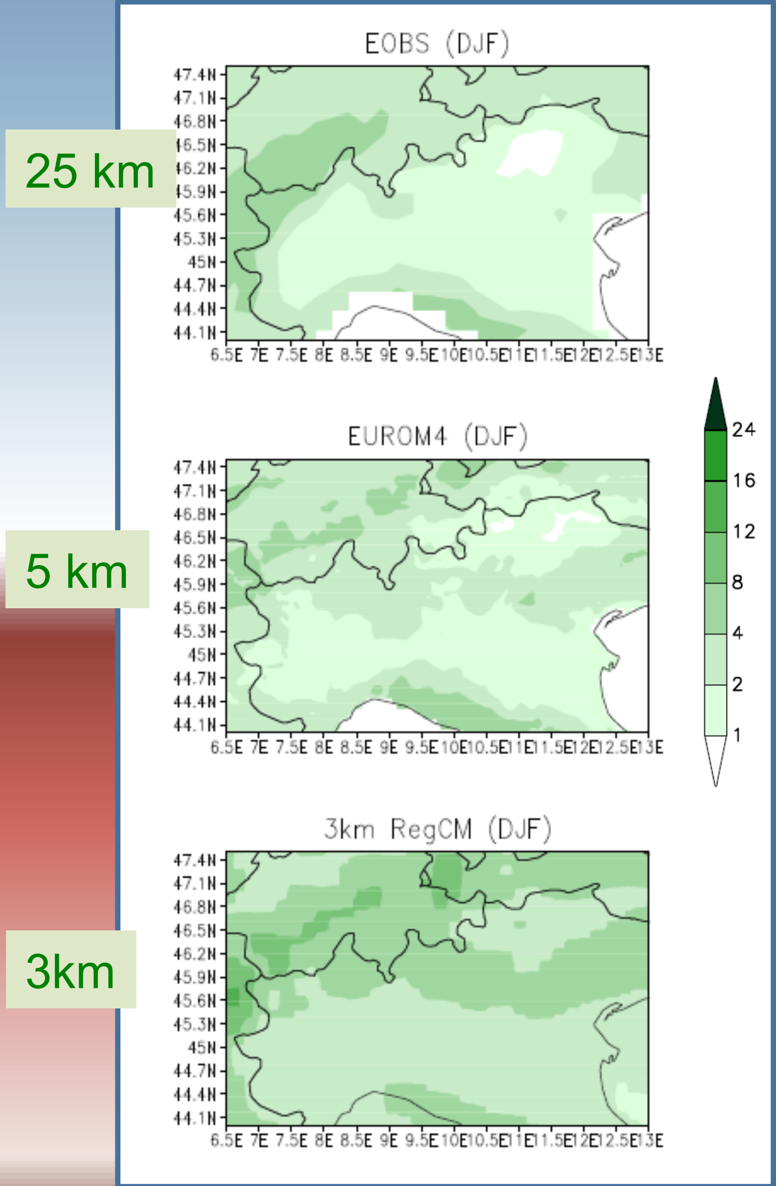
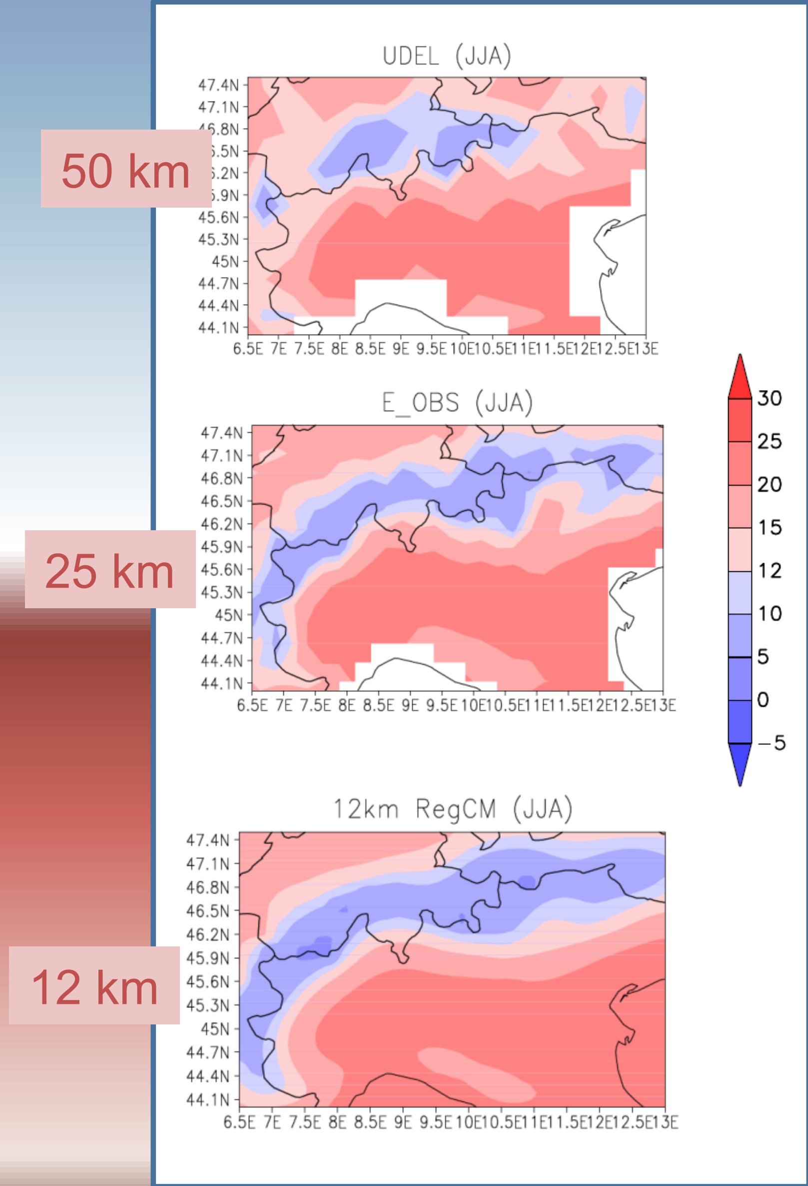
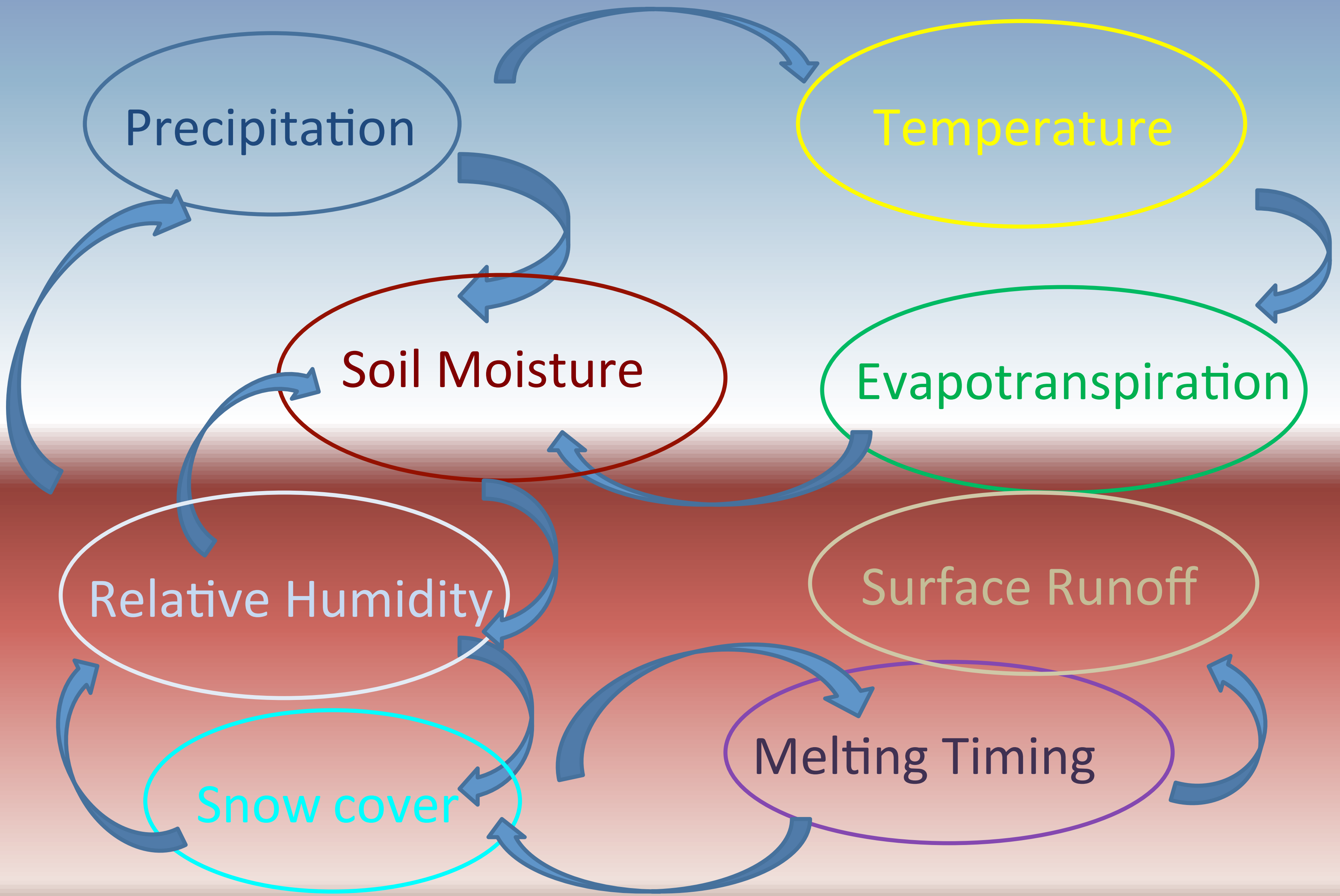
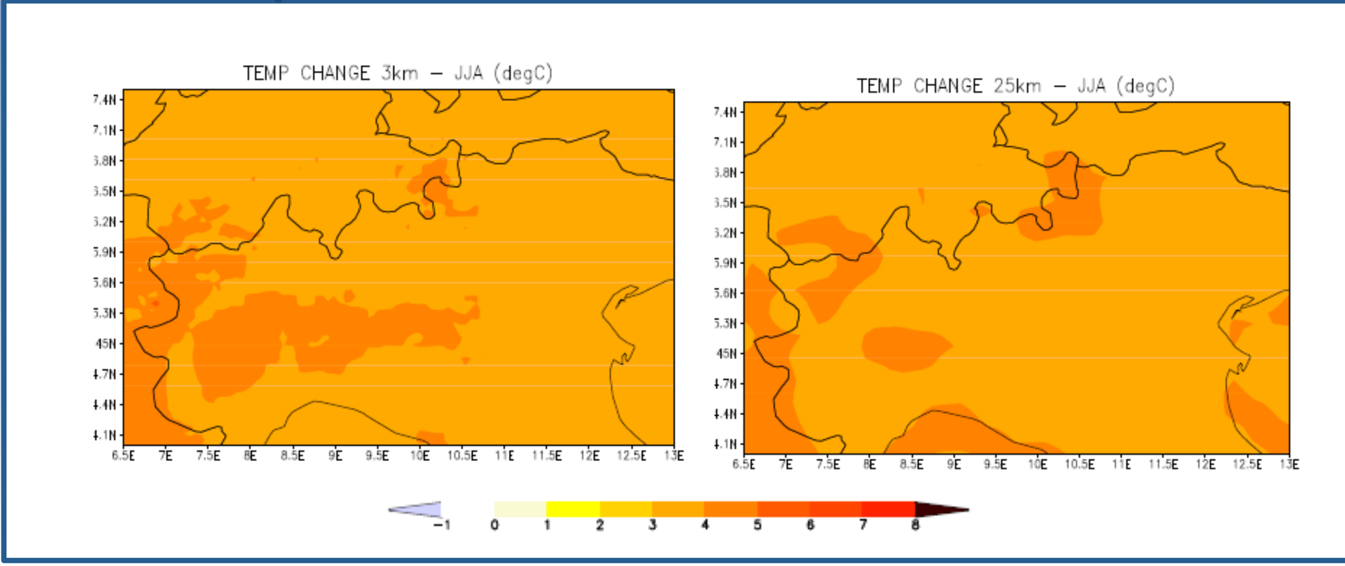


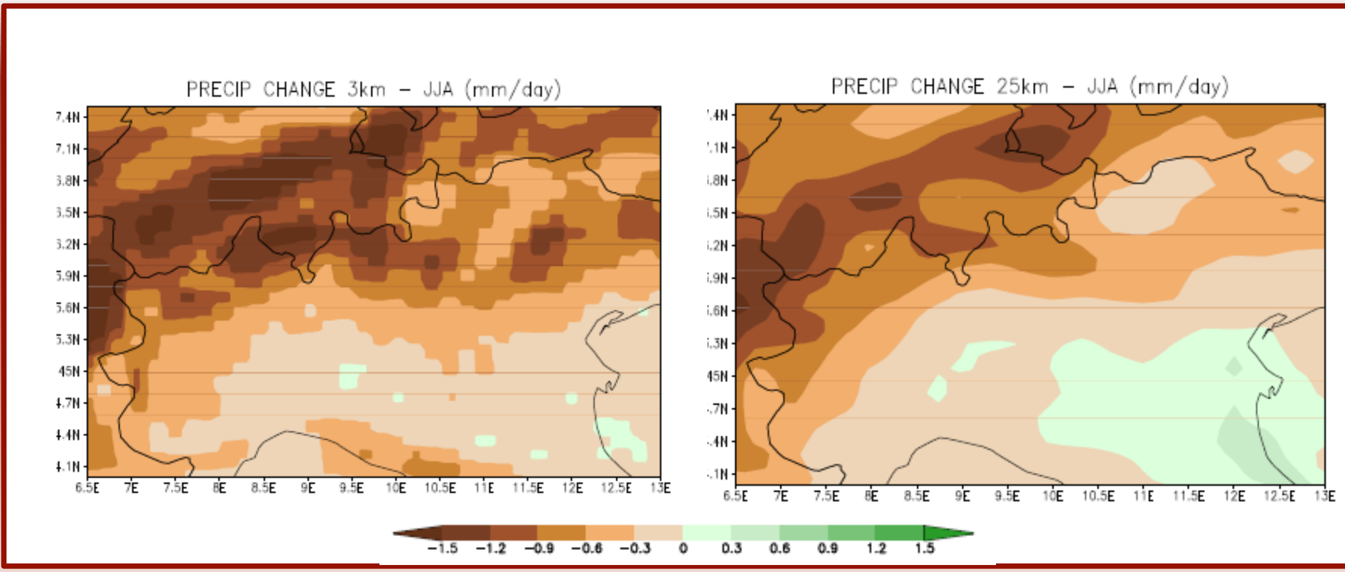


The variables involved in the Surface Hydrological Budget and the importance of resolution in the Climate Change Signal

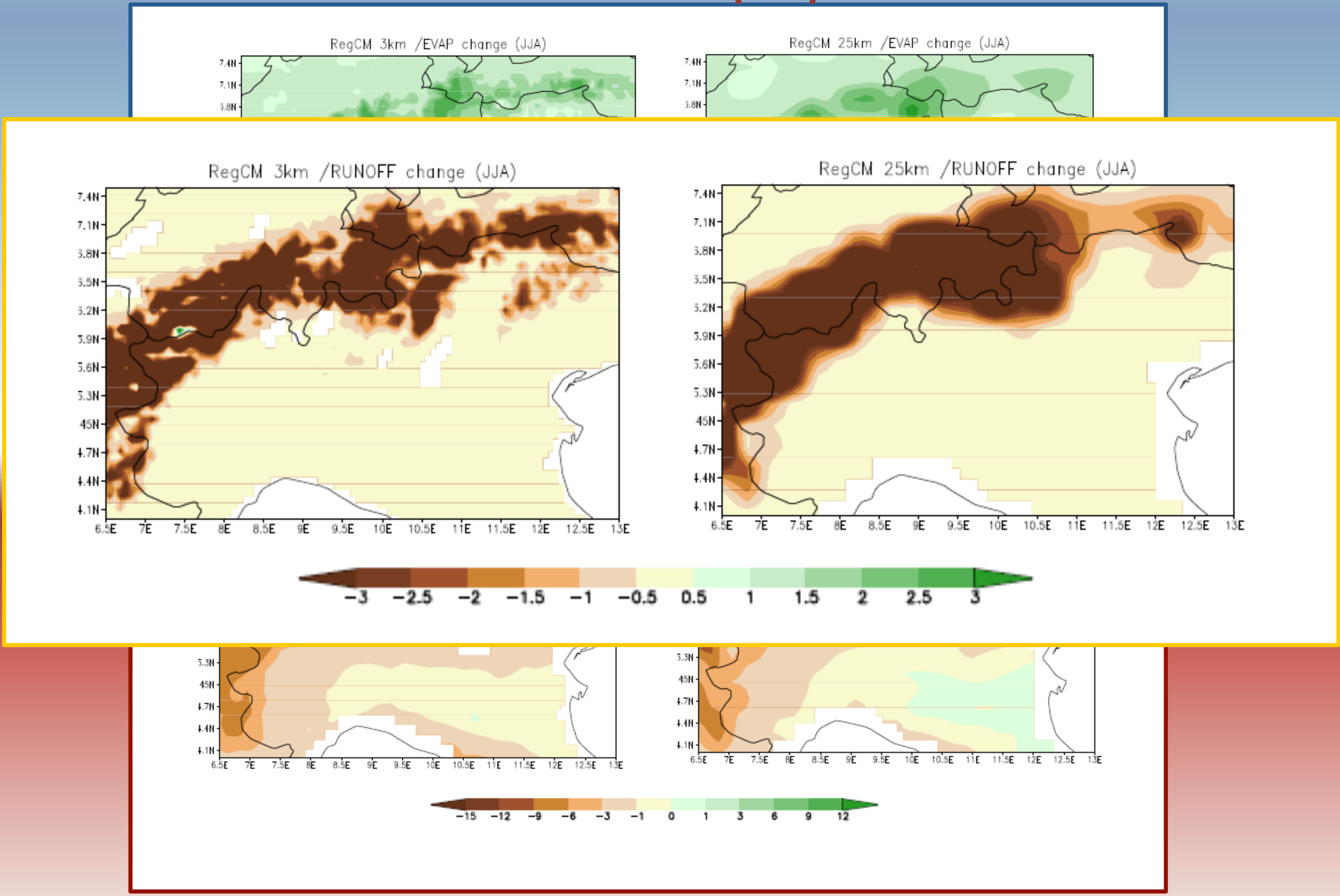


The Seasonal Change Signal for the RegCM ECHAM-CMIP3 driven (A1B scenario) simulation: SUMMER (JJA)

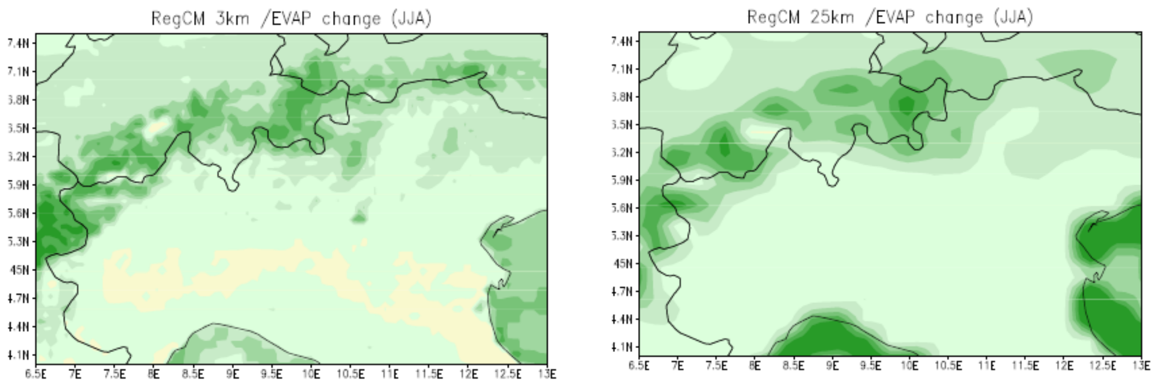




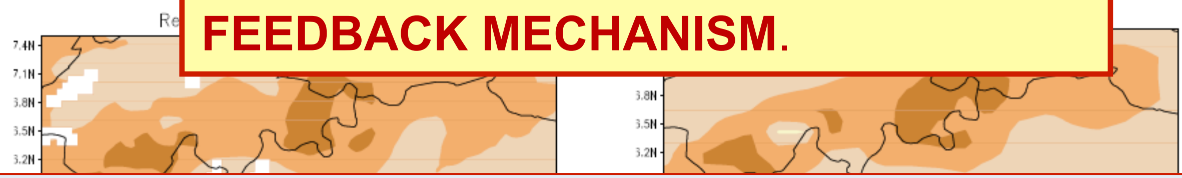
The Seasonal Change Signal for the A1B scenario simulation: SUMMER (JJA)



The Seasonal Change Signal for the A1B scenario simulation: SUMMER (JJA)



The **precipitation decrease** occurs **DESPITE** the greater water vapor content and it is associated with a **LOCAL FEEDBACK MECHANISM**.

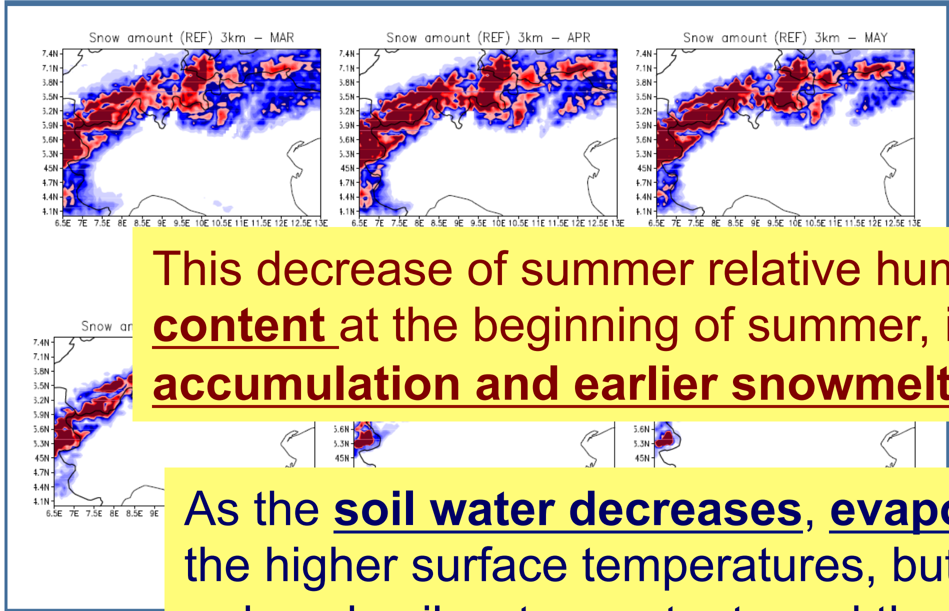


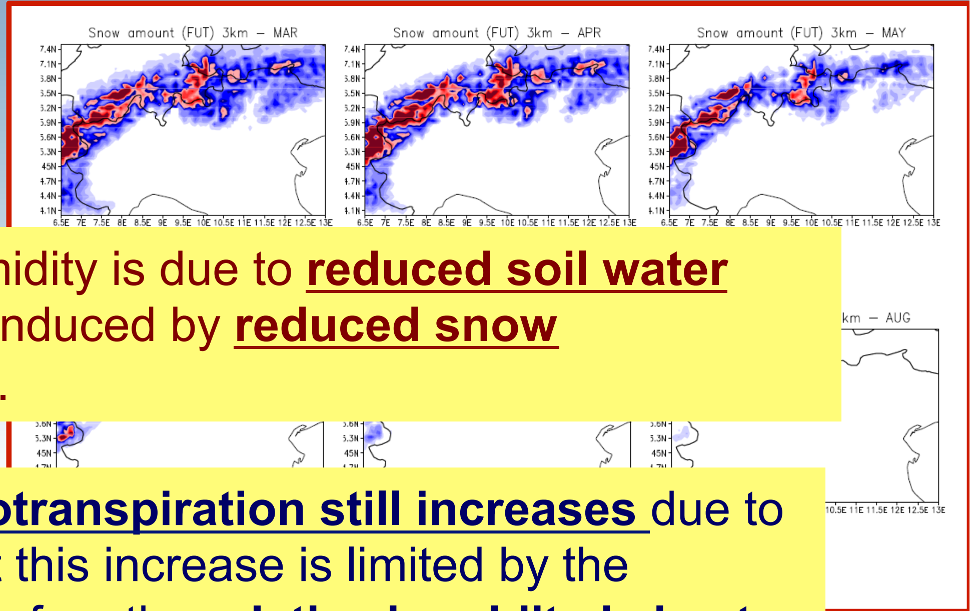
Most of the precipitation decrease is due to the **non-convective component** since the convective precipitation remains on average essentially unchanged.

To exploit the change of non-convective precipitation we analyze as in Im et al.(2010) the **temporal evolution of snow cover** and **the relative humidity change from the spring to summer months**.

Change in snow cover and relative humidity from Spring to Summer for the 3km resolution simulation

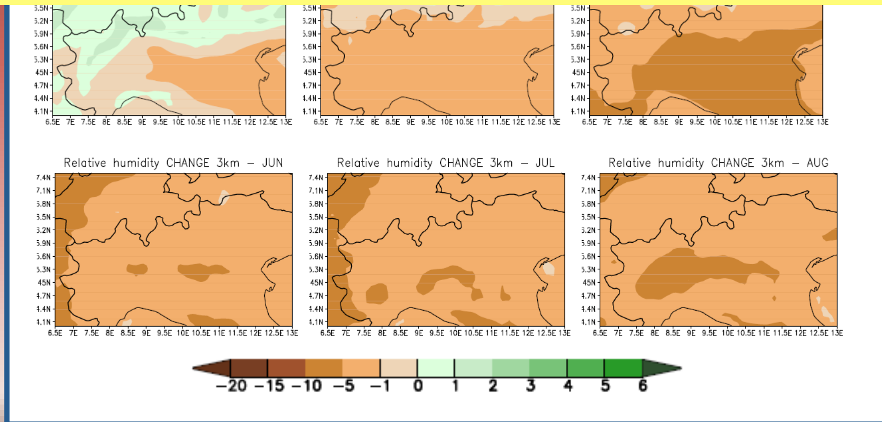
Reference Period (1970-2000) **Future (2070 -2100)**



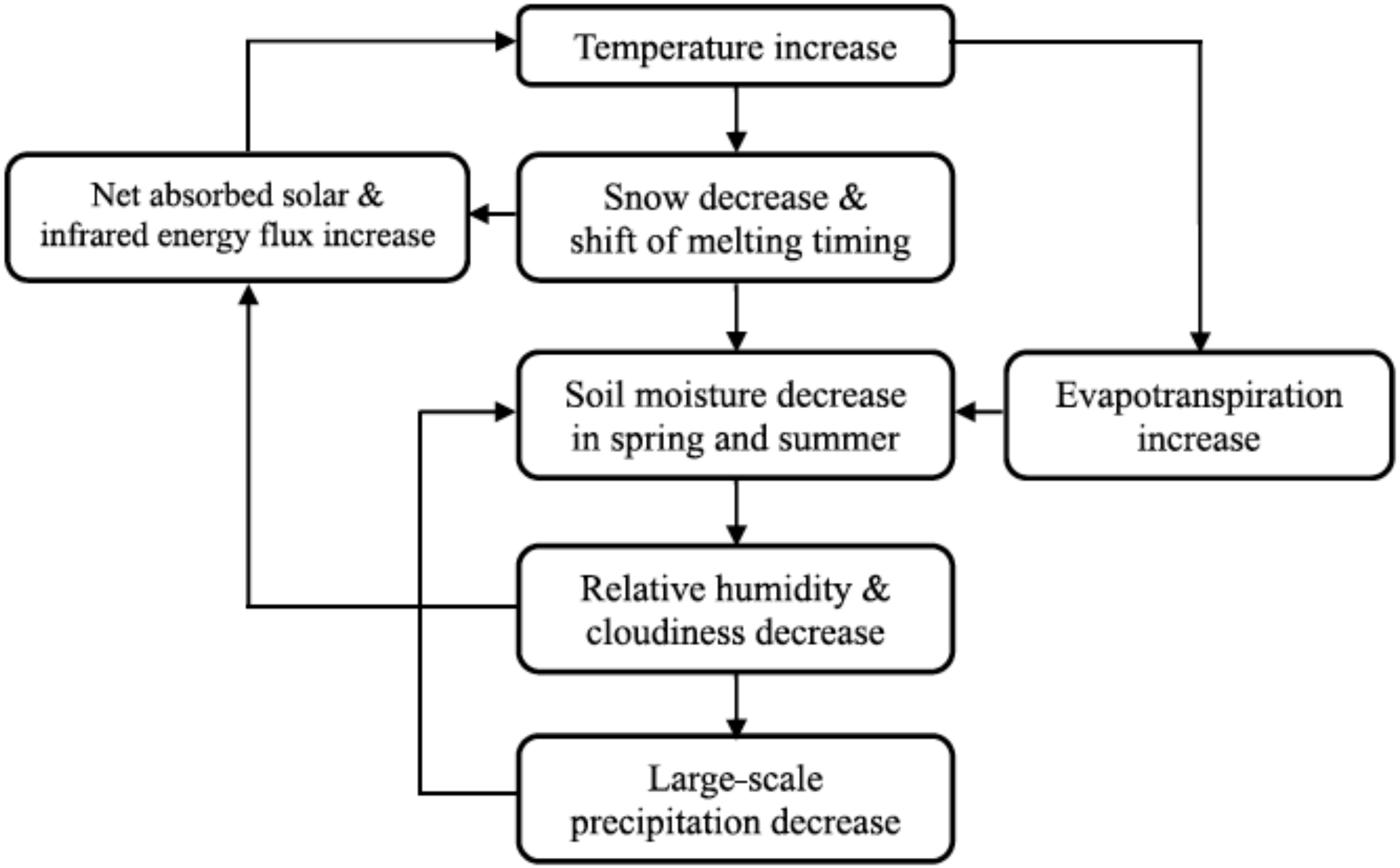


This decrease of summer relative humidity is due to **reduced soil water content** at the beginning of summer, induced by **reduced snow accumulation and earlier snowmelt**.

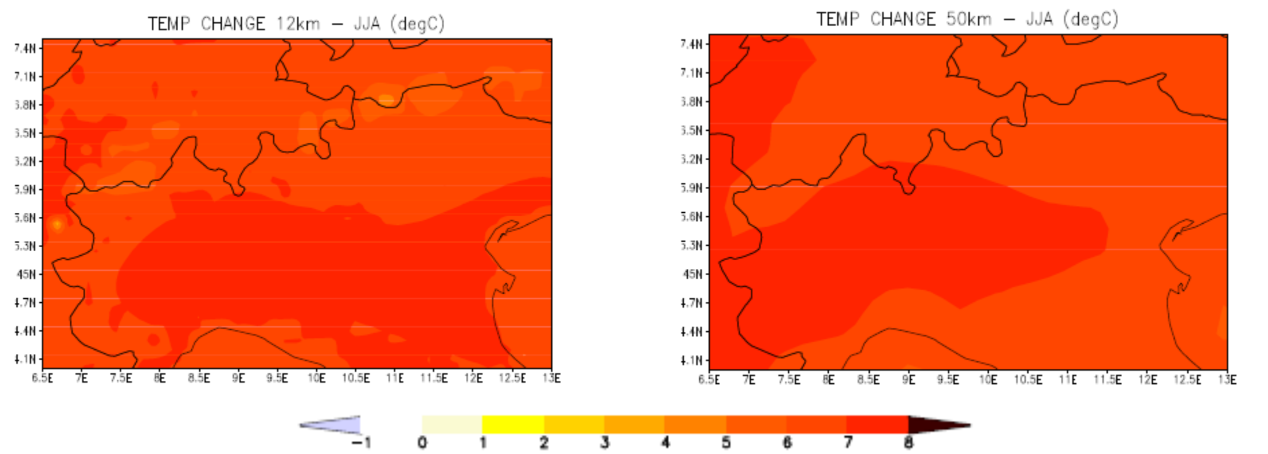
As the **soil water decreases**, **evapotranspiration still increases** due to the higher surface temperatures, but this increase is limited by the reduced soil water contents and therefore the **relative humidity is kept at reduced values** under the warming.

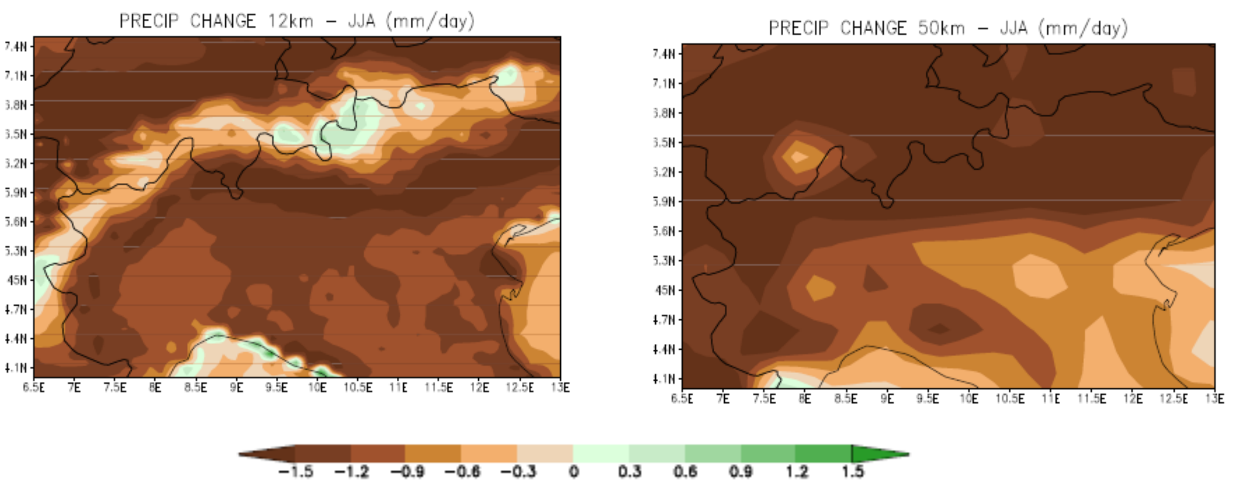


Local Feedback Mechanism



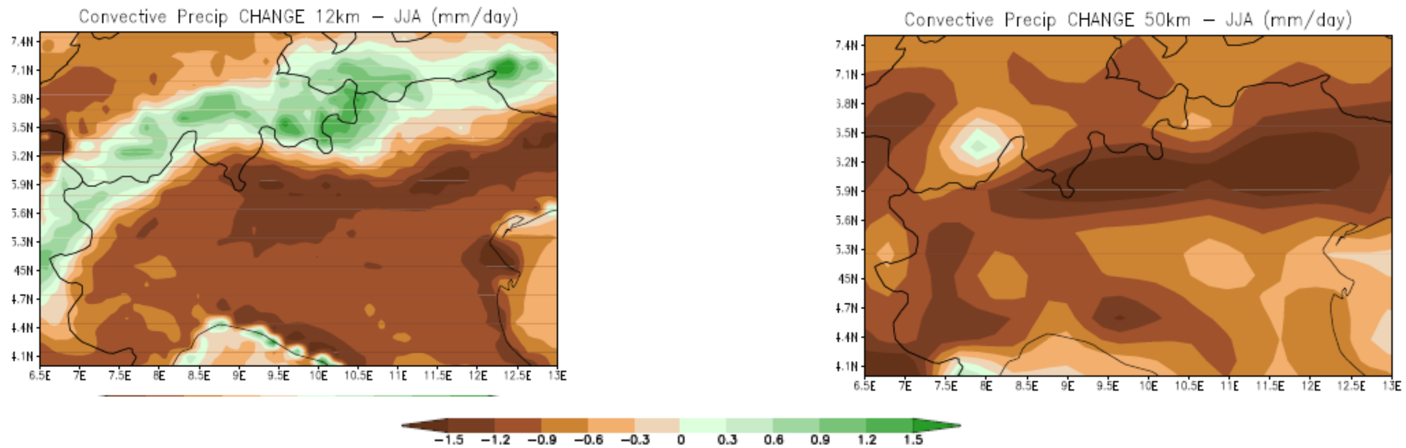
The Seasonal Change Signal for the RegCM HadGEM-CMIP5-driven (RCP8.5 scenario) simulation: SUMMER (JJA)





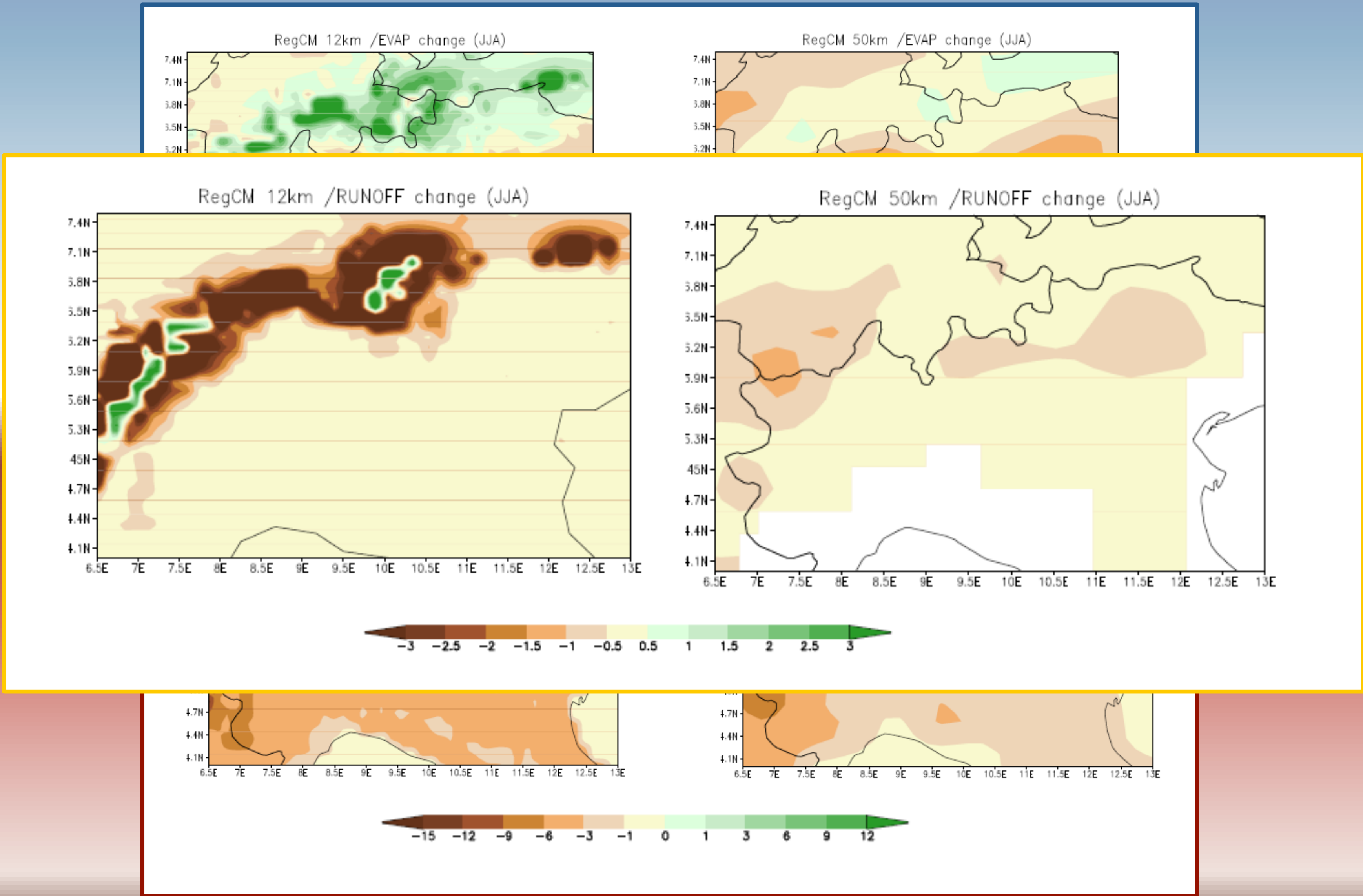
Change in convective precipitation (seasonal mean for JJA)

12 km **50 km**

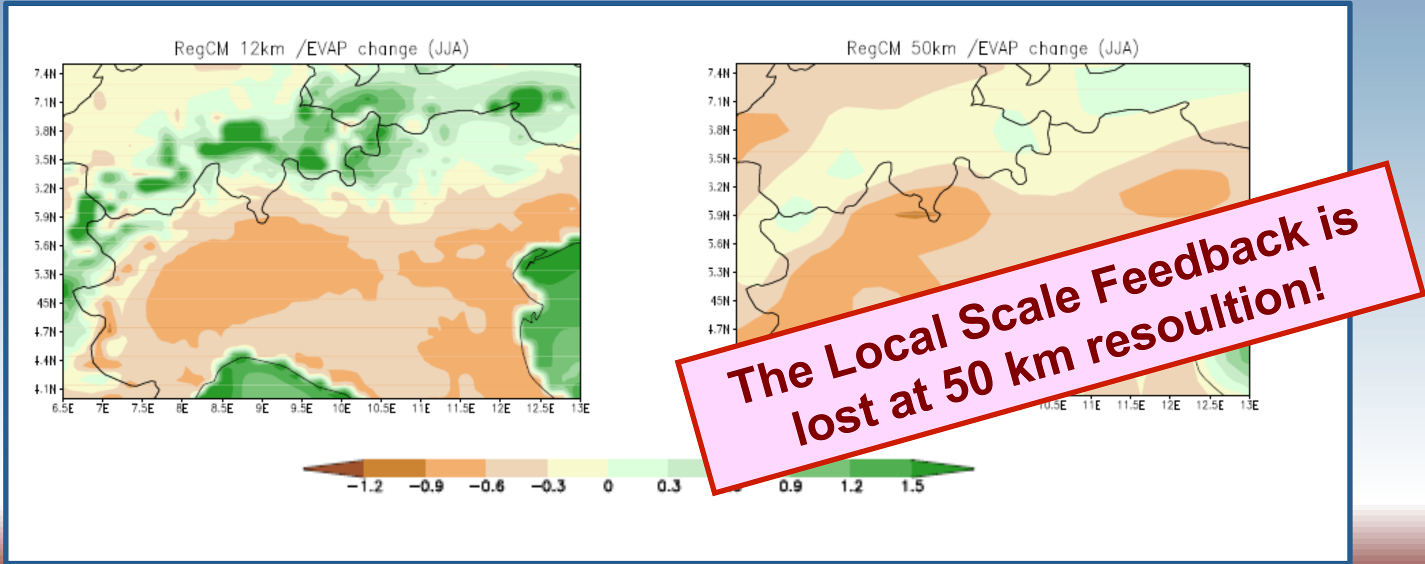


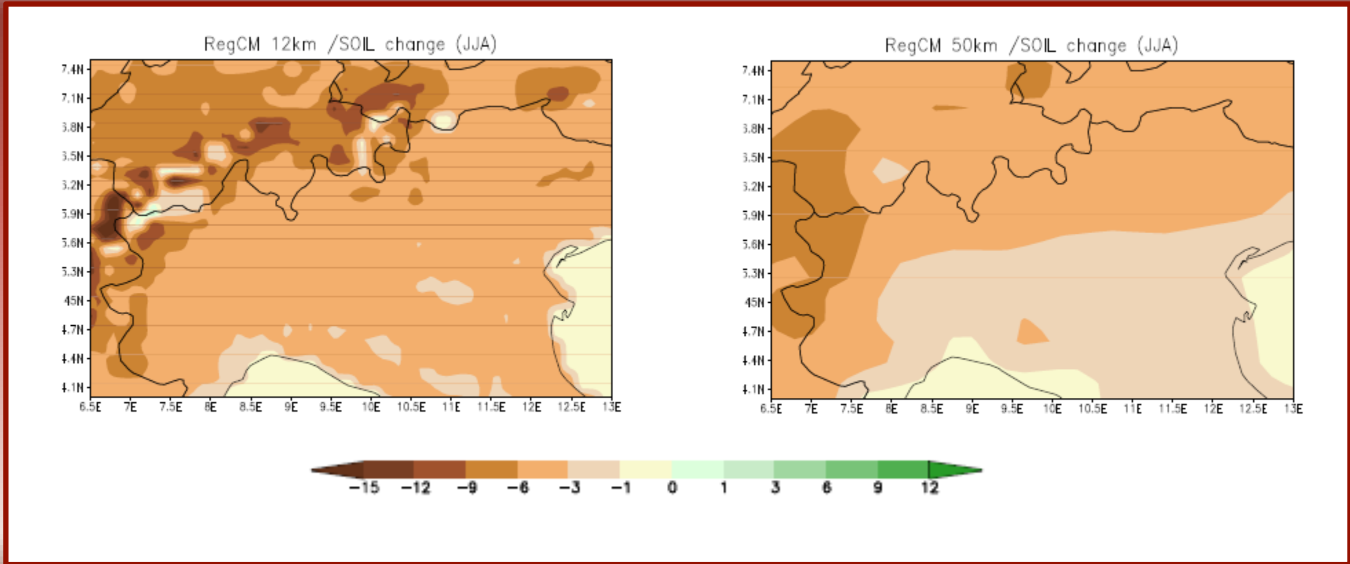
This result is in line with the summer drying evolving altitude-specific found by Fisher et al. (2013): the precipitation decrease is mostly due to the non-convective fraction, since orography still keeps convection high and leads to precipitation formation.

The Seasonal Change Signal for the RCP8.5 scenario simulation:
SUMMER (JJA)



The Seasonal Change Signal for the RCP8.5 scenario simulation: SUMMER (JJA)





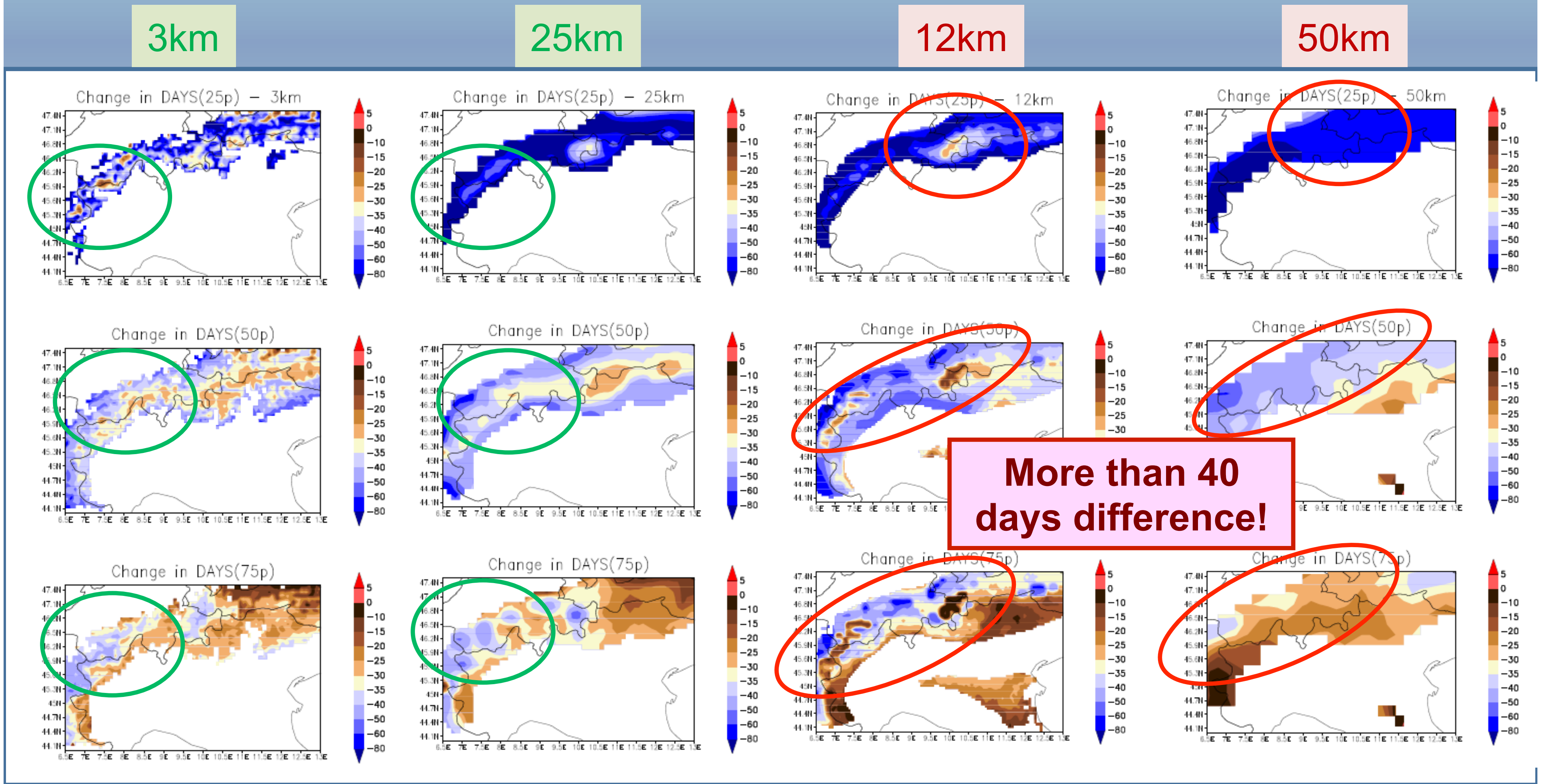
Snowmelt-Driven Runoff (SDR) TIMING CALCULATION:

- Following Moore et al. [2007], we calculated the Julian Day inside the water year (from October to September of the following year), on which each percentile of that year's annual flow occurred.

- To investigate on the early, middle and late seasonal flows we calculated the 25th, 50th and 75th percentiles.

- These calculations were performed only for regions in which 50% or more of the annual runoff occurs in April-July that are the regions which are dominated only by SDR.

SDR timing change for the 4 resolutions



Both space resolutions and the GHG scenario used play a role in the SDR timing change.

Summary

❖ When doing a model validation is crucial choosing the correct observation data-set, according to the spatial resolution of the model.

❖The snow-albedo feedback mechanisms involved in the hydrological budget and the snow-melt driven runoff are both resolution and scenario dependent.

References

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