# Orographical modulation of regional fine scale precipitation change signals - European examples

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PAPER-WRITING WORKSHOP ON THE ANALYSIS OF CORDEX-CORECLIMATE PROJECTIONS
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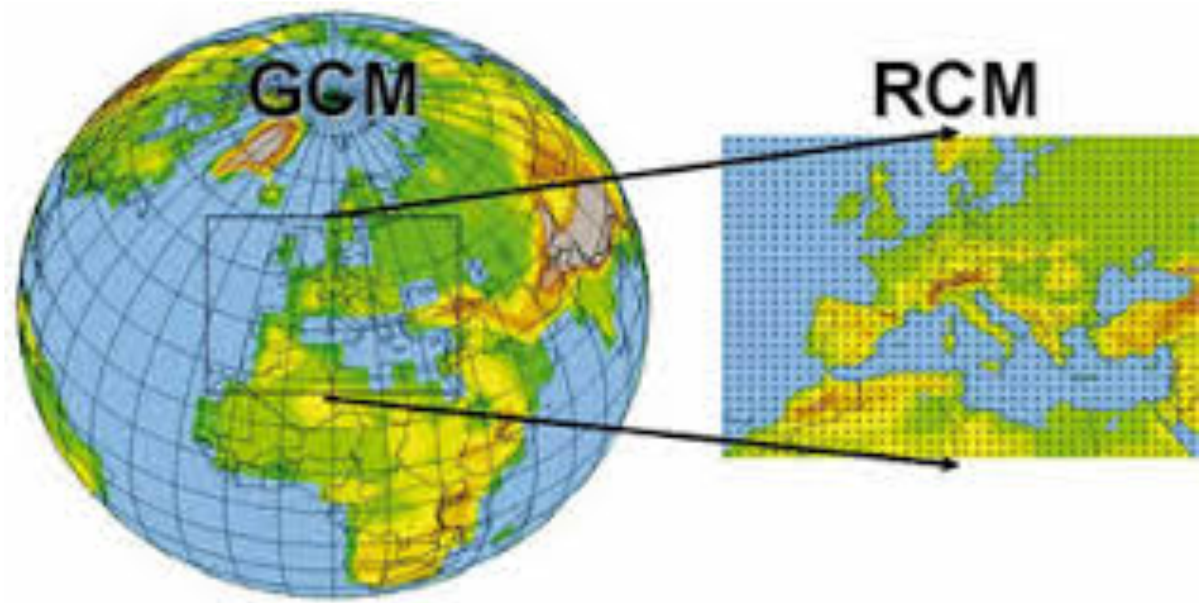
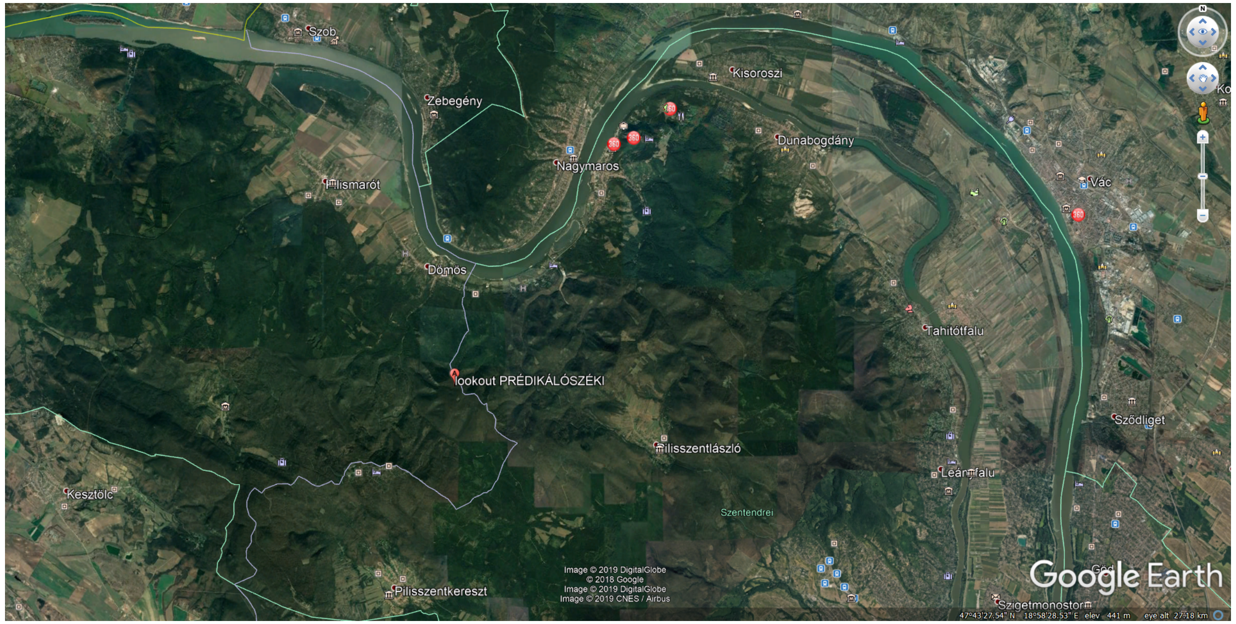
- Introduction
- European examples
- Summary

## Finer resolution may lead to:

- more detailed ***topography*** (shores, mountains)
- more detailed description of ***vegetation***
- more accurate ***soil type*** classification
- more precise description of ***extremes***
- ***different tendecies*** of changes (opposite of GCMs)




Szob
Zebegény
Kisoroszi
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Pilismarót
Vác
Dömös
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lookout PRÉDIKÁLÓSZÉK
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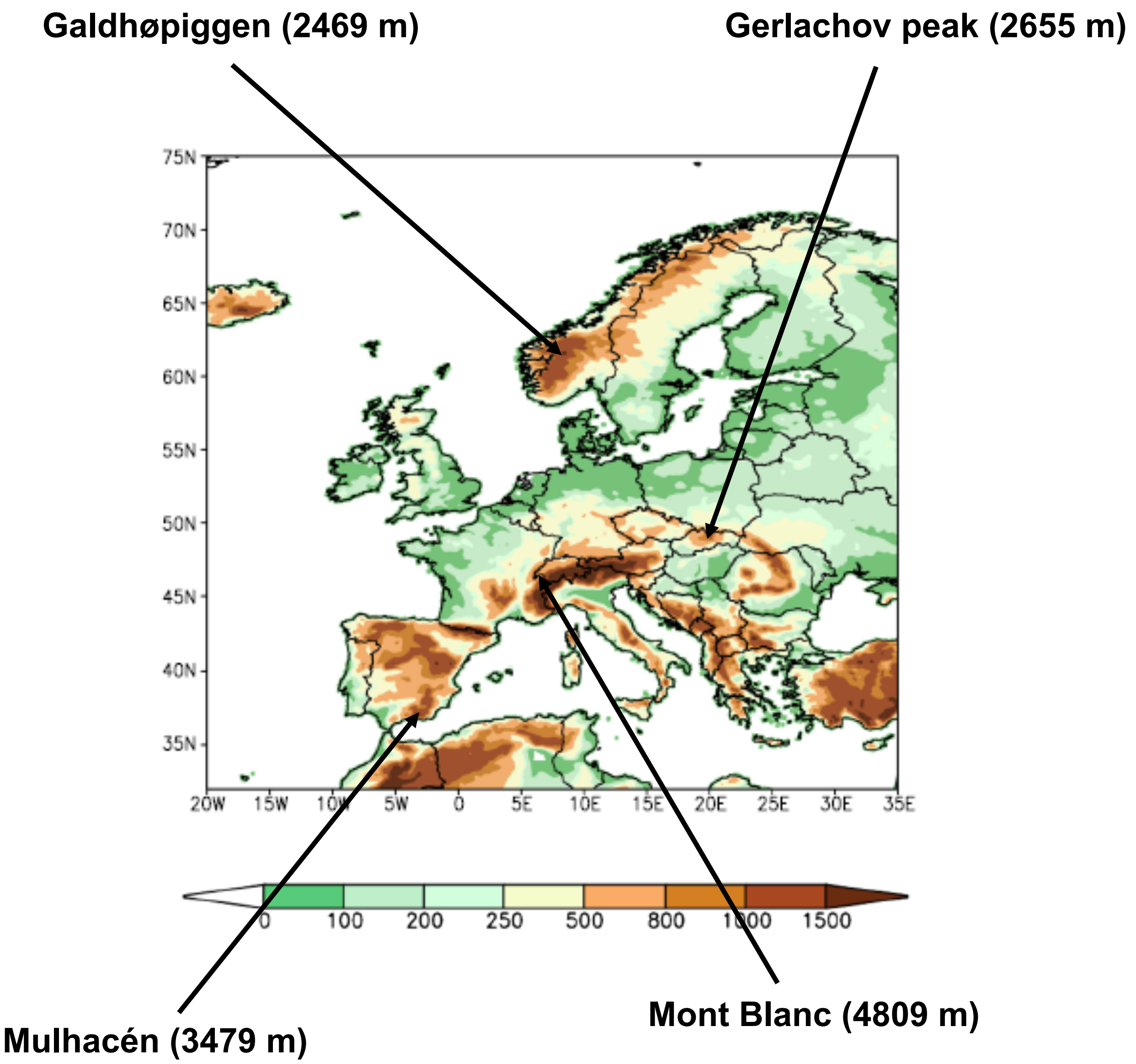
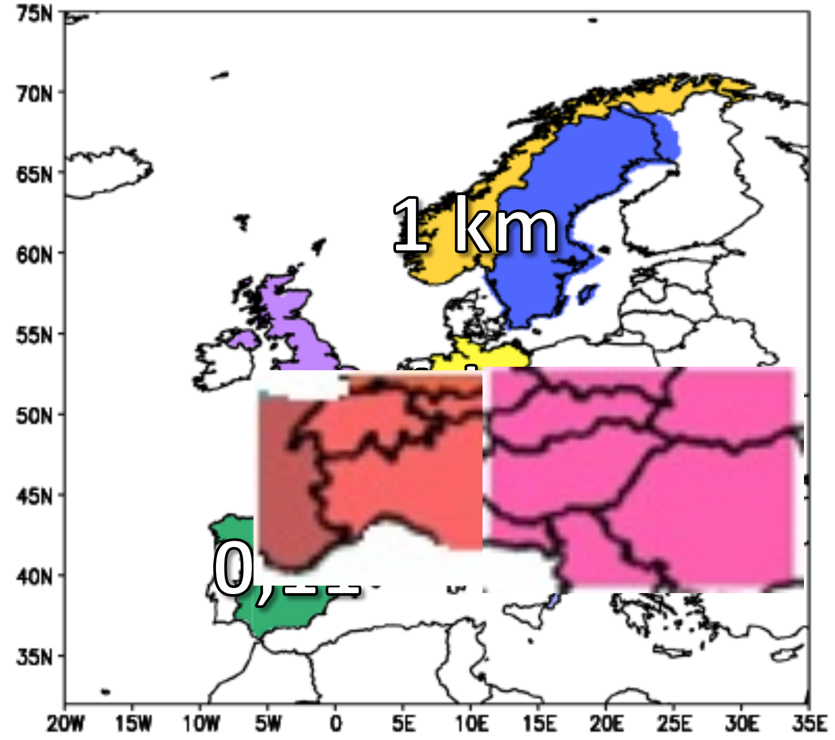
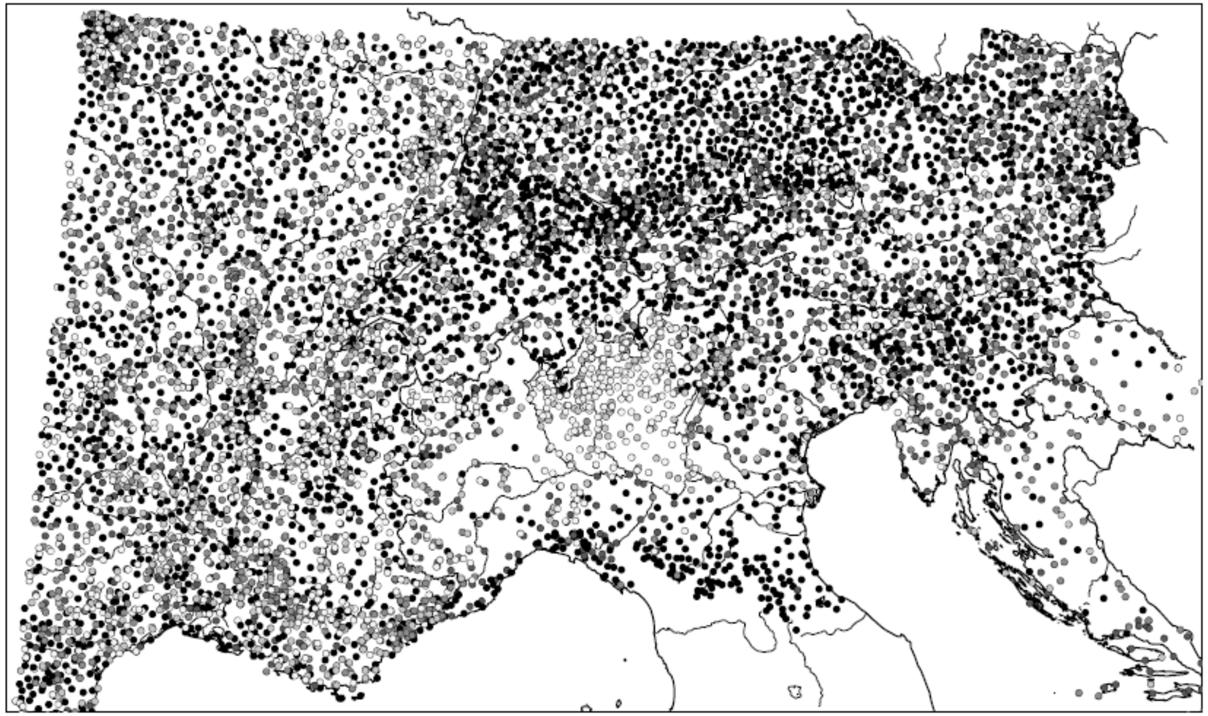
Pilisszentlászló
Leányfalu
Kesztölc
Szentendrei
Pilisszentkereszt
Szigetmonostor
Google Earth

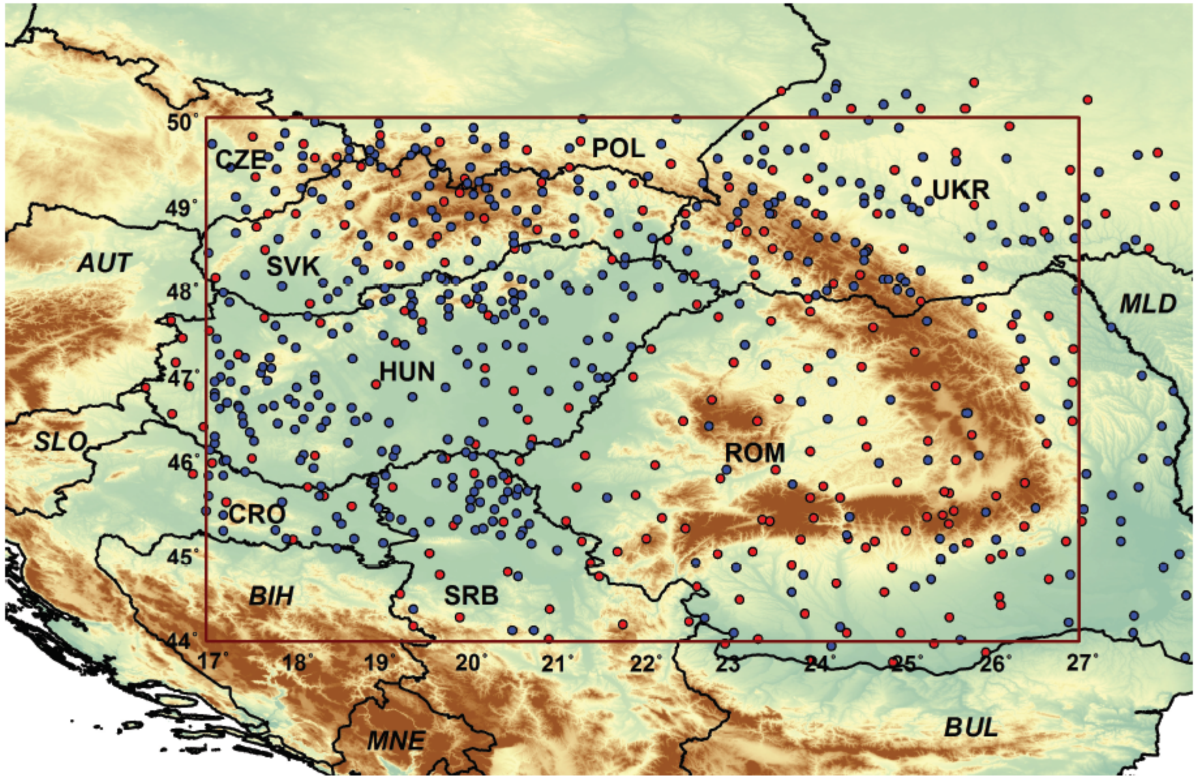



(Fantini et al., 2016)

Resolution: 1’ (~2 km)

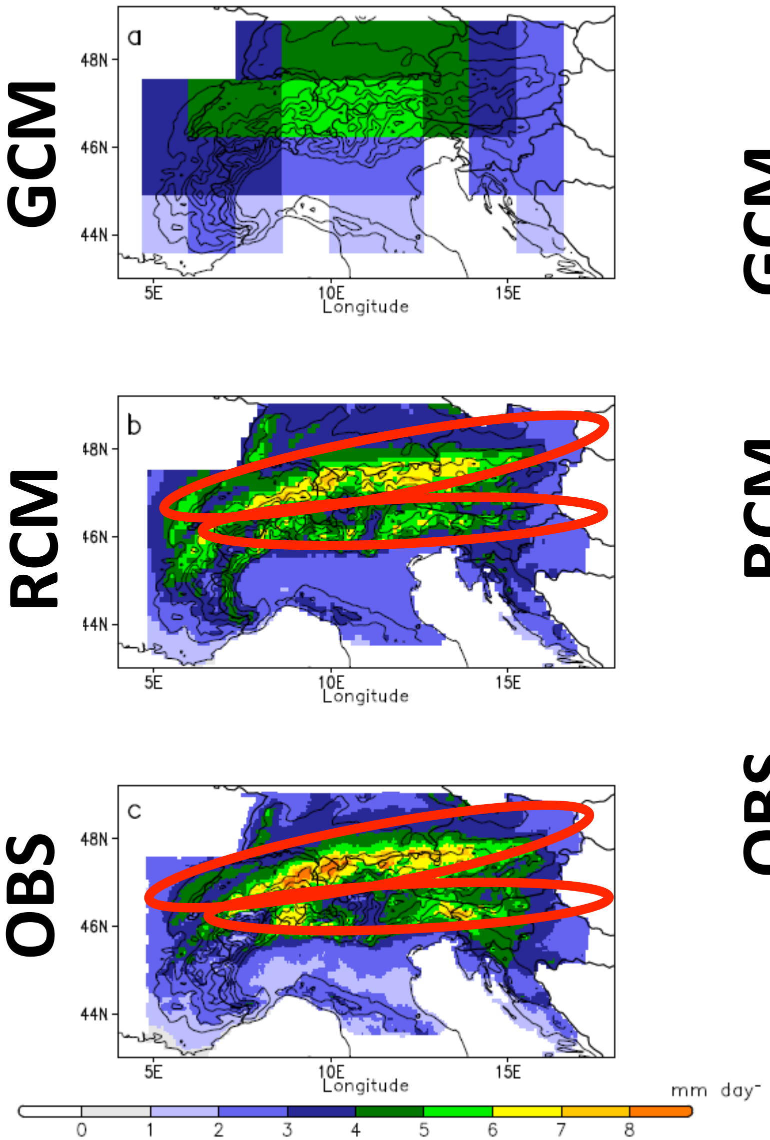




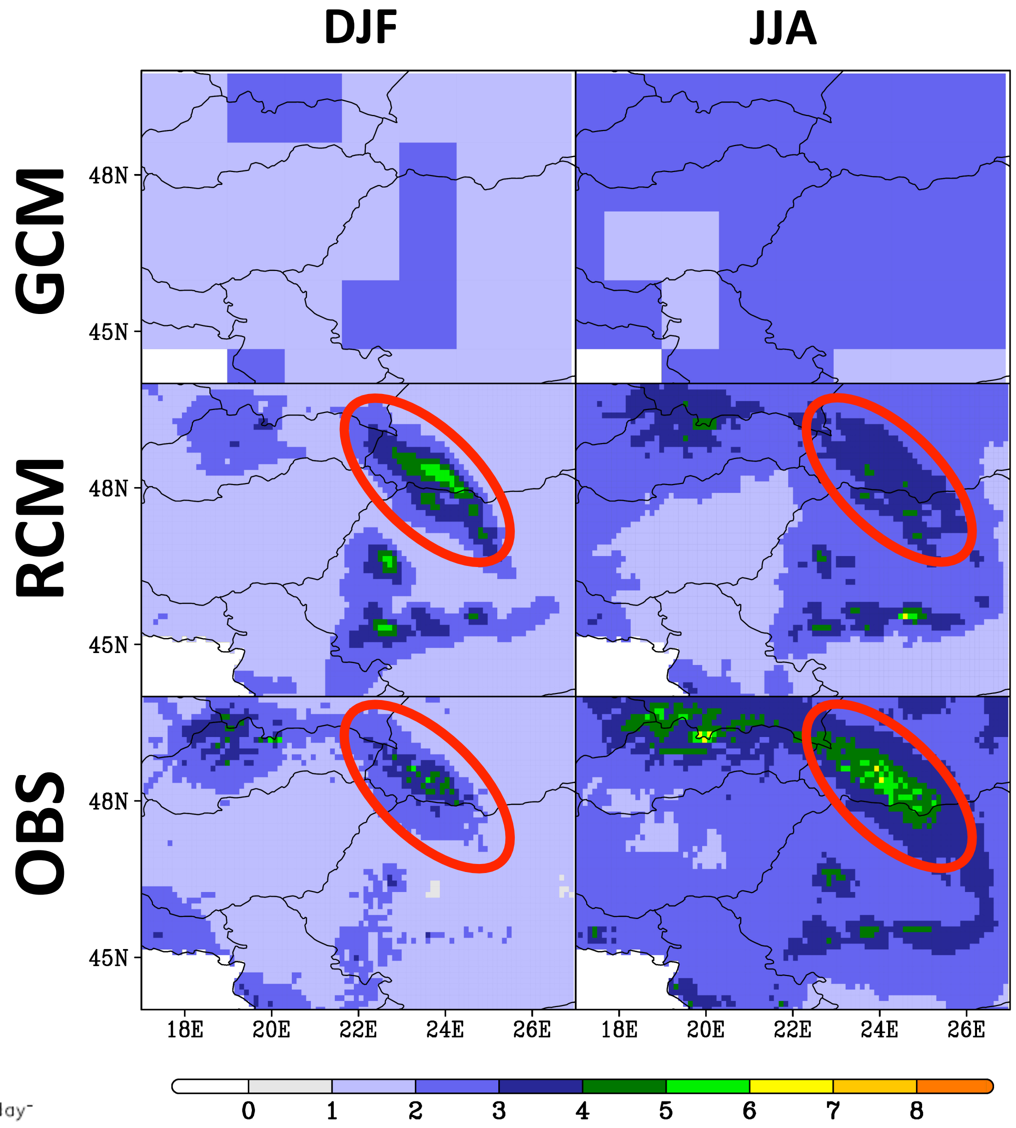

**reference dataset:** EURO4M-APGD (Isotta et al., 2014)
**period:** 1971-2008
**resolution:** 5 km
**Number of stations**: 5500

**reference dataset:** CARPATCLIM (Szalai et al., 2013)
**period:** 1961-2010
**resolution:** ~10 km
**Number of stations**: 904

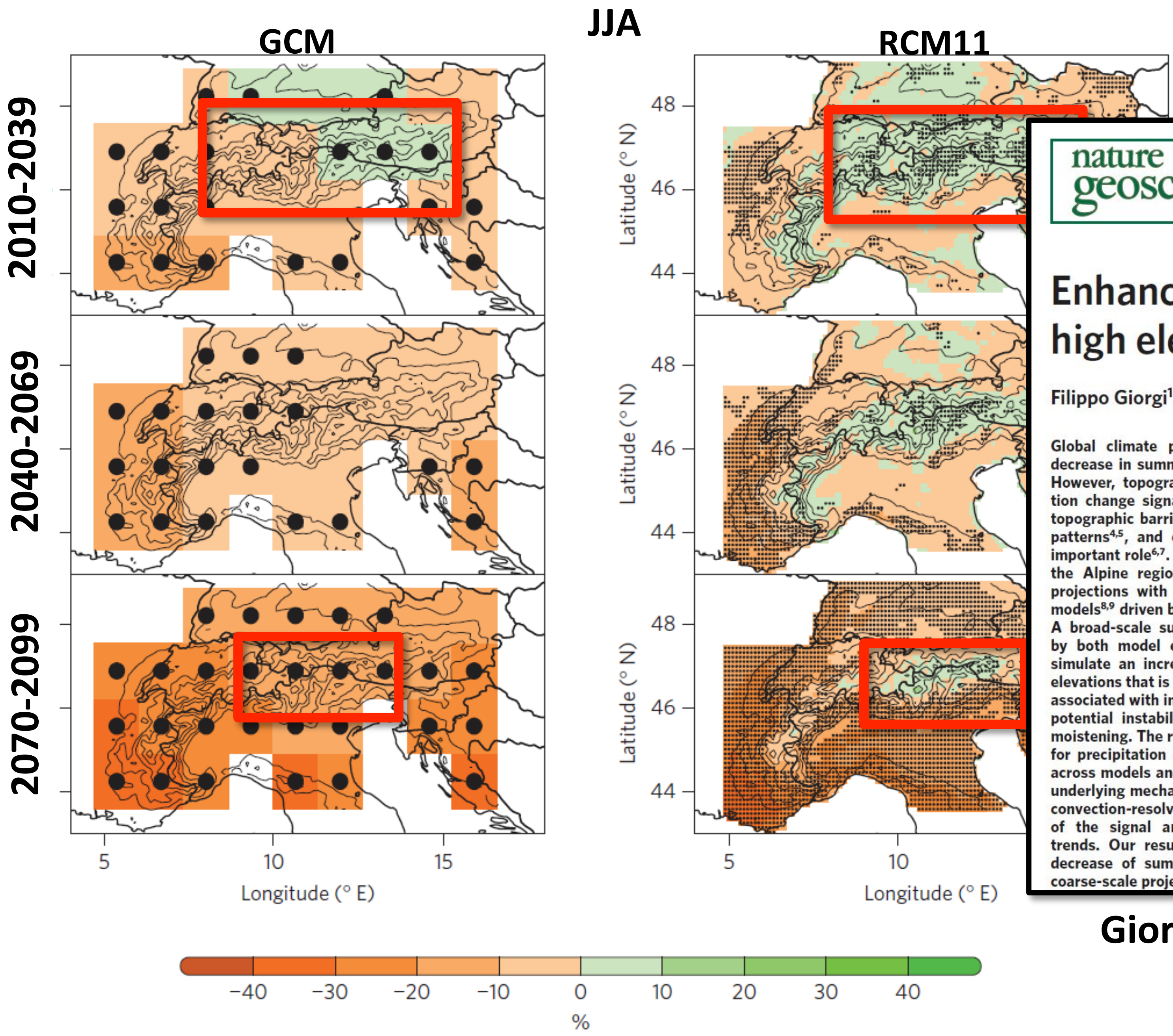
# Alps



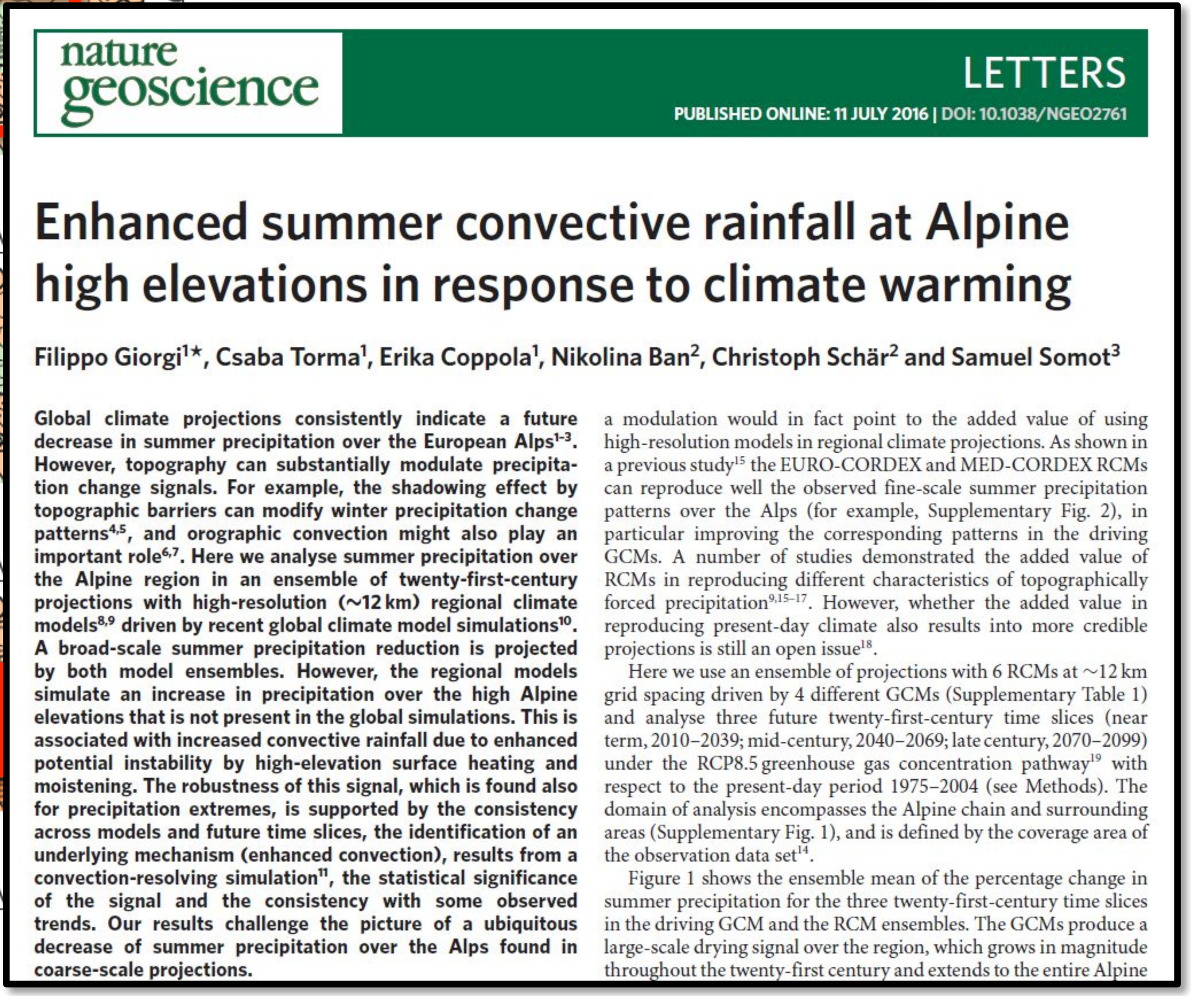

# Carpathians




**RCM ensemble is able to capture the topographically-induced precipitation patterns.**




**Contrary to global trends**



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# Enhanced summer convective rainfall at Alpine high elevations in response to climate warming

Filippo Giorgi[1]*, Csaba Torma[1], Erika Coppola[1], Nikolina Ban[2], Christoph Schär[2] and Samuel Somot[3]

**Global climate projections consistently indicate a future decrease in summer precipitation over the European Alps[1–3]. However, topography can substantially modulate precipitation change signals. For example, the shadowing effect by topographic barriers can modify winter precipitation change patterns[4,5], and orographic convection might also play an important role[6,7]. Here we analyse summer precipitation over the Alpine region in an ensemble of twenty-first-century projections with high-resolution (~12 km) regional climate models[8,9] driven by recent global climate model simulations[10]. A broad-scale summer precipitation reduction is projected by both model ensembles. However, the regional models simulate an increase in precipitation over the high Alpine elevations that is not present in the global simulations. This is associated with increased convective rainfall due to enhanced potential instability by high-elevation surface heating and moistening. The robustness of this signal, which is found also for precipitation extremes, is supported by the consistency across models and future time slices, the identification of an underlying mechanism (enhanced convection), results from a convection-resolving simulation[11], the statistical significance of the signal and the consistency with some observed trends. Our results challenge the picture of a ubiquitous decrease of summer precipitation over the Alps found in coarse-scale projections.**

a modulation would in fact point to the added value of using high-resolution models in regional climate projections. As shown in a previous study[15] the EURO-CORDEX and MED-CORDEX RCMs can reproduce well the observed fine-scale summer precipitation patterns over the Alps (for example, Supplementary Fig. 2), in particular improving the corresponding patterns in the driving GCMs. A number of studies demonstrated the added value of RCMs in reproducing different characteristics of topographically forced precipitation[9,15–17]. However, whether the added value in reproducing present-day climate also results into more credible projections is still an open issue[18].

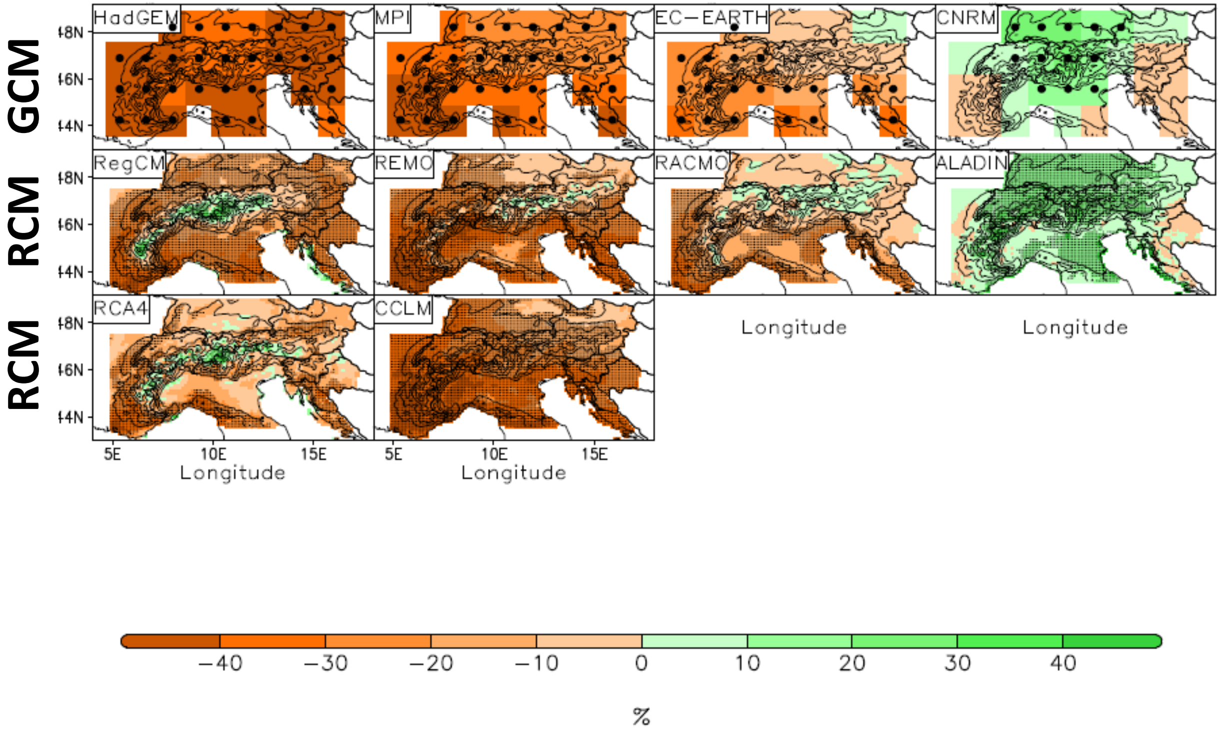
Here we use an ensemble of projections with 6 RCMs at ~12 km grid spacing driven by 4 different GCMs (Supplementary Table 1) and analyse three future twenty-first-century time slices (near term, 2010–2039; mid-century, 2040–2069; late century, 2070–2099) under the RCP8.5 greenhouse gas concentration pathway[19] with respect to the present-day period 1975–2004 (see Methods). The domain of analysis encompasses the Alpine chain and surrounding areas (Supplementary Fig. 1), and is defined by the coverage area of the observation data set[14].

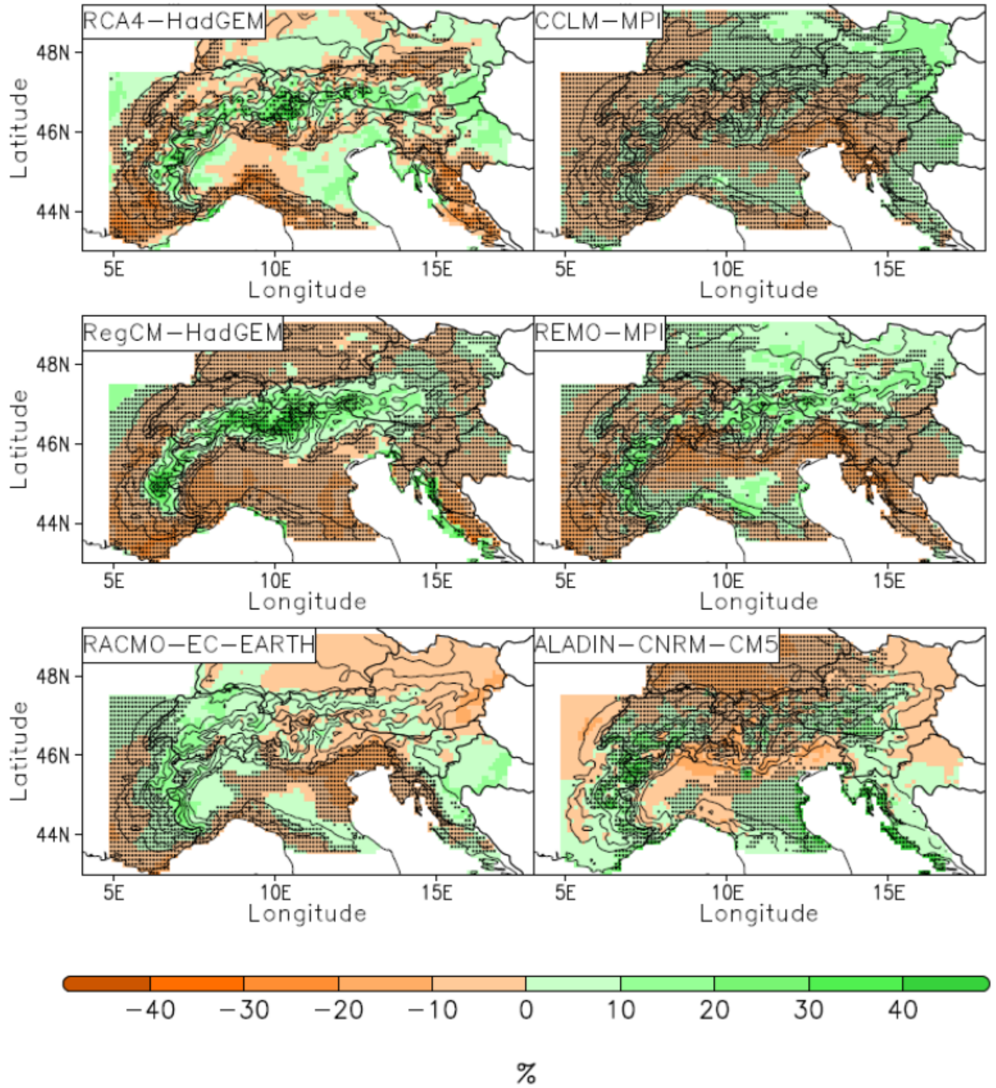
Figure 1 shows the ensemble mean of the percentage change in summer precipitation for the three twenty-first-century time slices in the driving GCM and the RCM ensembles. The GCMs produce a large-scale drying signal over the region, which grows in magnitude throughout the twenty-first century and extends to the entire Alpine

**Giorgi et al., 2016 (Nature Geoscience)**
**https://goo.gl/4y8ZjA**

# DS of ΔP (2099-2070)-(1975-2004), JJA

## ΔP (2099-2070)-(1975-2004), JJA

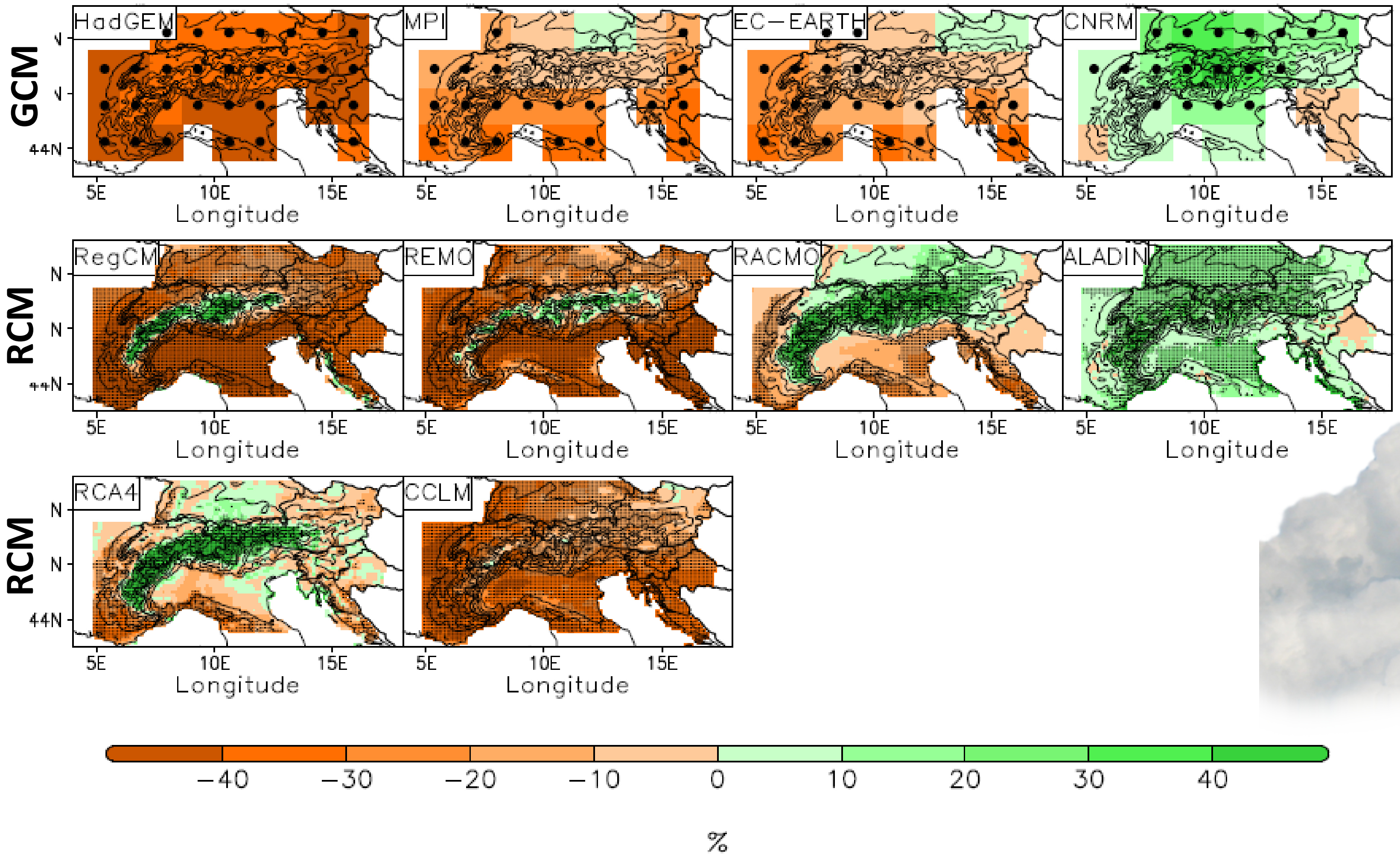


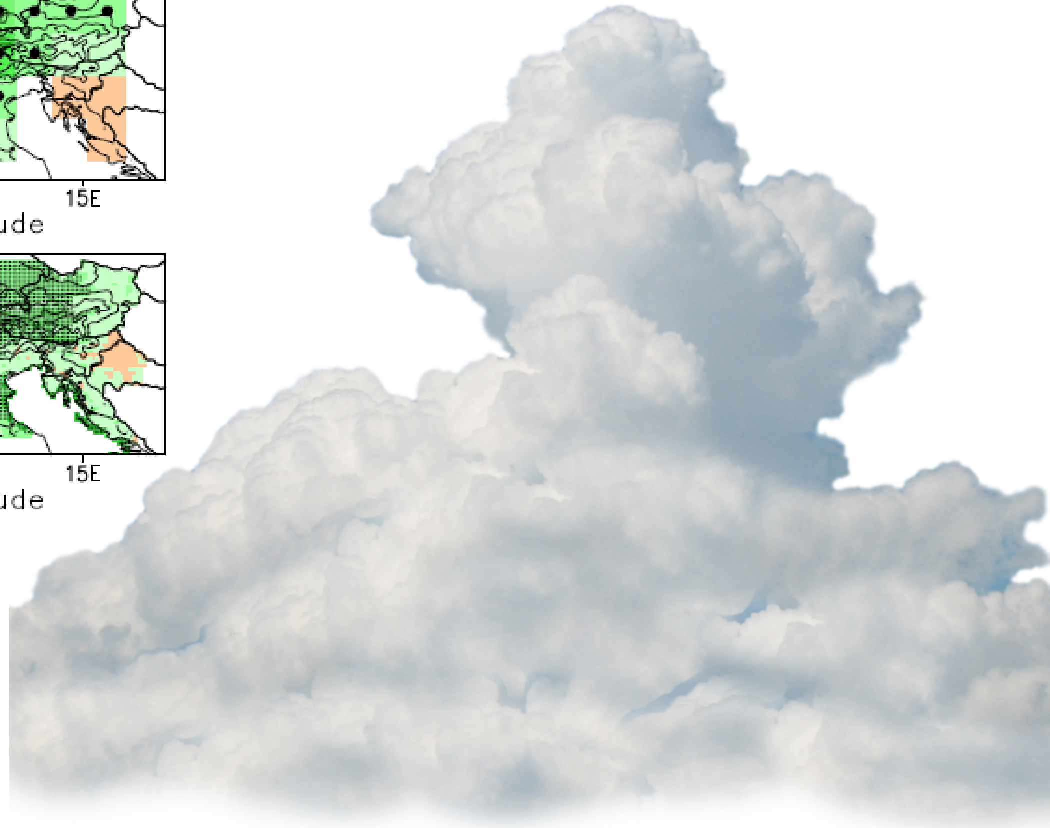




$$DS(\Delta P) = (\Delta P_{RCM_i} - \Delta \bar{P}_{RCM_i}) - (\Delta P_{GCM_j} - \Delta \bar{P}_{GCM_j})$$

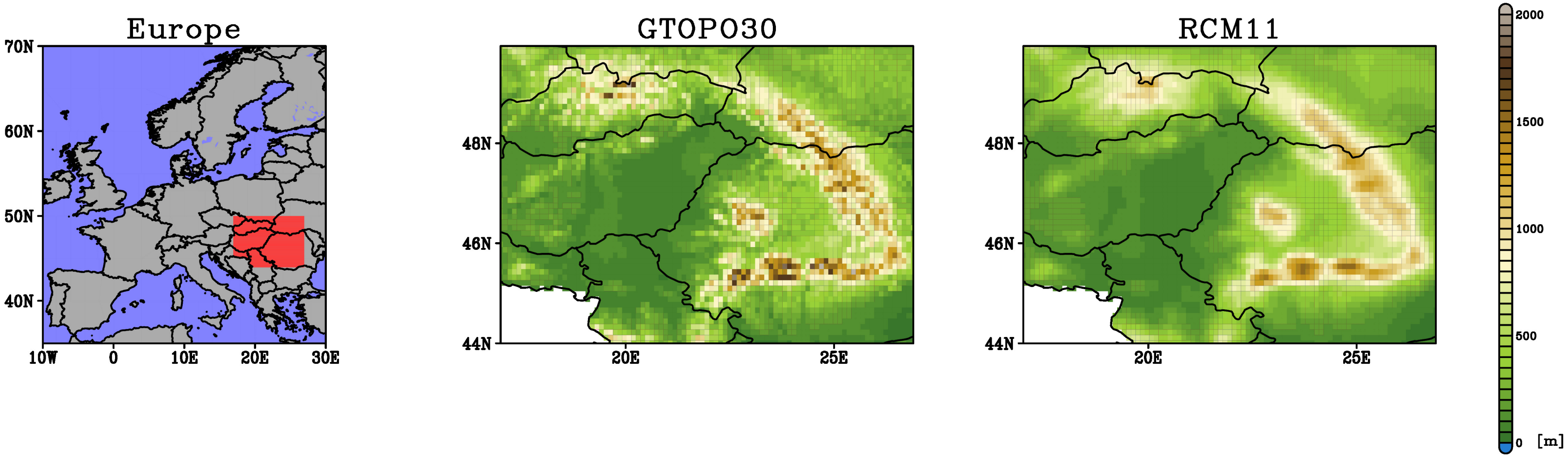
→ measure of the fine scale modulation of the signal by the RCMs

# $\Delta P_{convective}$ (2099-2070)-(1975-2004), JJA



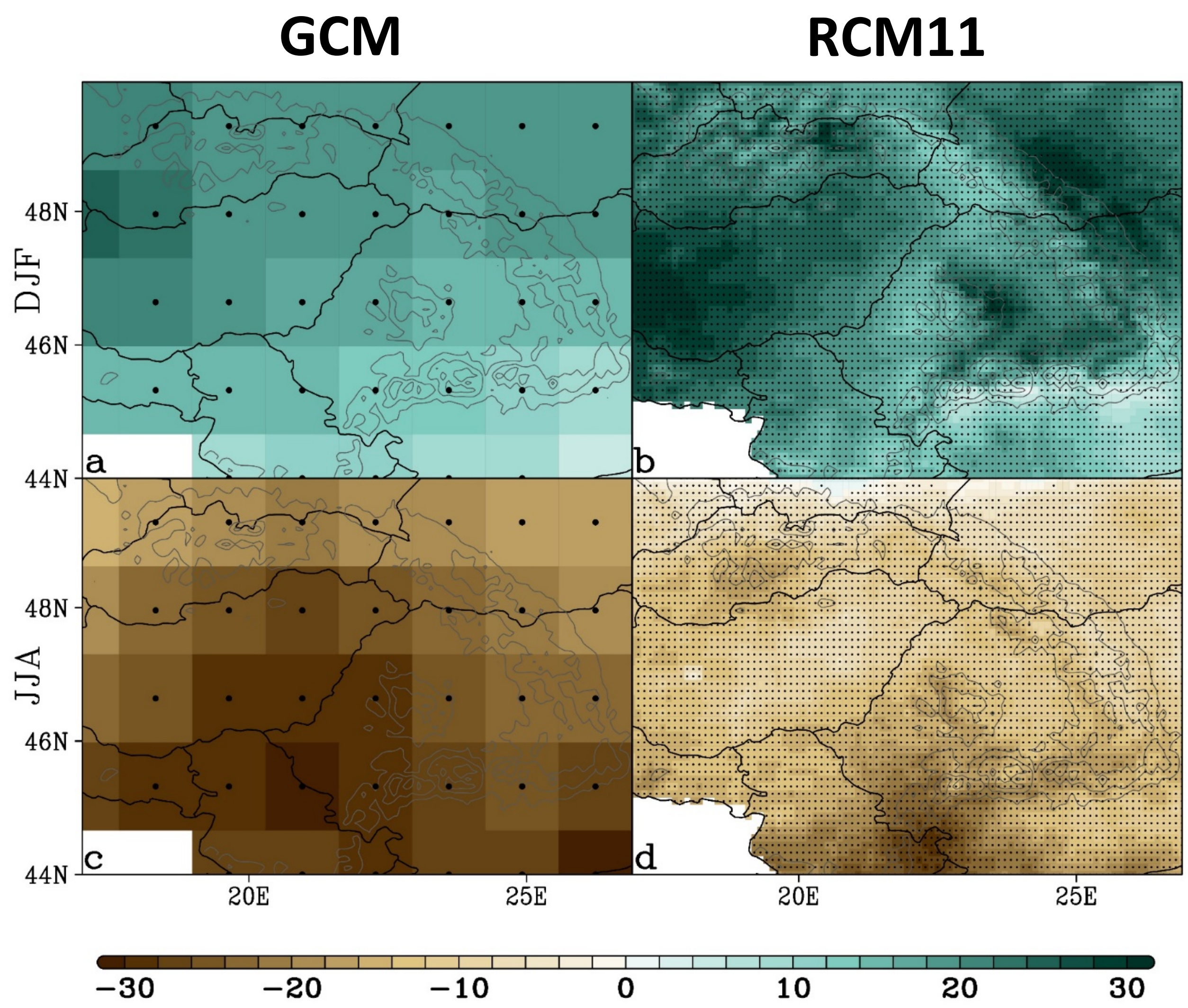
# The Carpathian Region




**Driving GCMs:**
MPI-ES-MR
EC-EARTH
CNRM-CM5
HadGEM-ES

**RCMs:**
CCLM, REMO
RACMO
ALADIN
RegCM4.3, RCA

# (2070-2099)-(1975-2004)

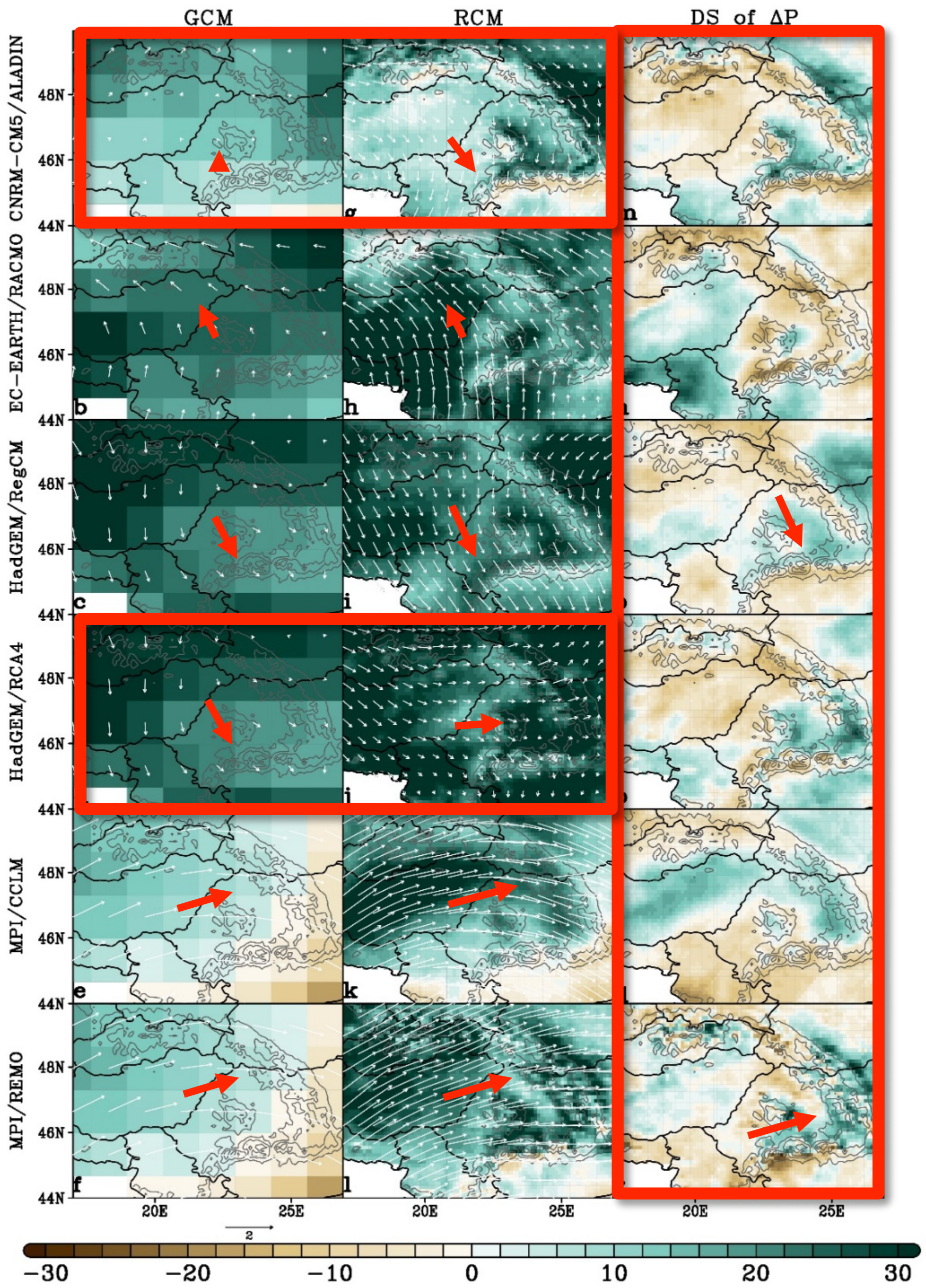



Atmospheric Science Letters


RCMs show more precipitation in DJF and less during JJA by the end of the 21st century (inherited by driving GCMs)

Significant differences between GCM and RCM11, which can be attributed to orographical origin.

**Contrary to global trends**



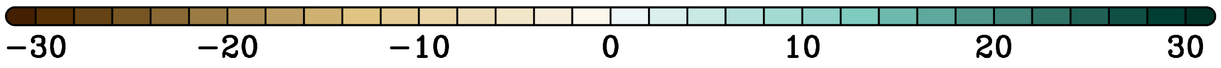

# Changes in mean winter (DJF) precipitation (2070-2099) vs (1975-2004)

The change in regional scale wind is mostly driven by the GCMs.

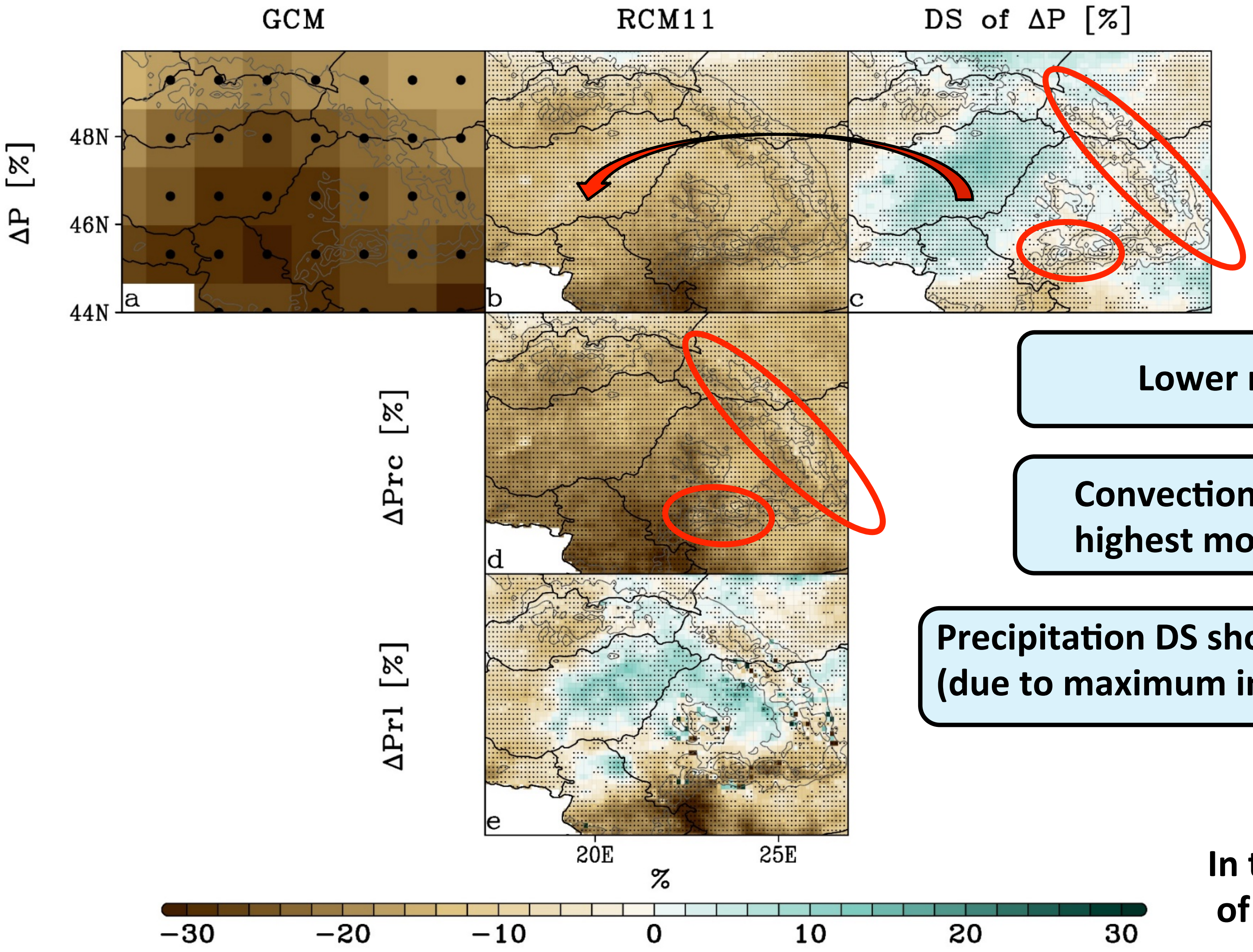
A key factor determining the regional spatial distribution of the winter precipitation change signal over the Carpathian region by the end of the 21st century is the orientation of the mountain chains with respect to the main flow change.

↓

Topographically induced signal is mostly of dynamical nature



# Ensemble average percent change in summer precipitation (2070-2099 vs 1976-2005)

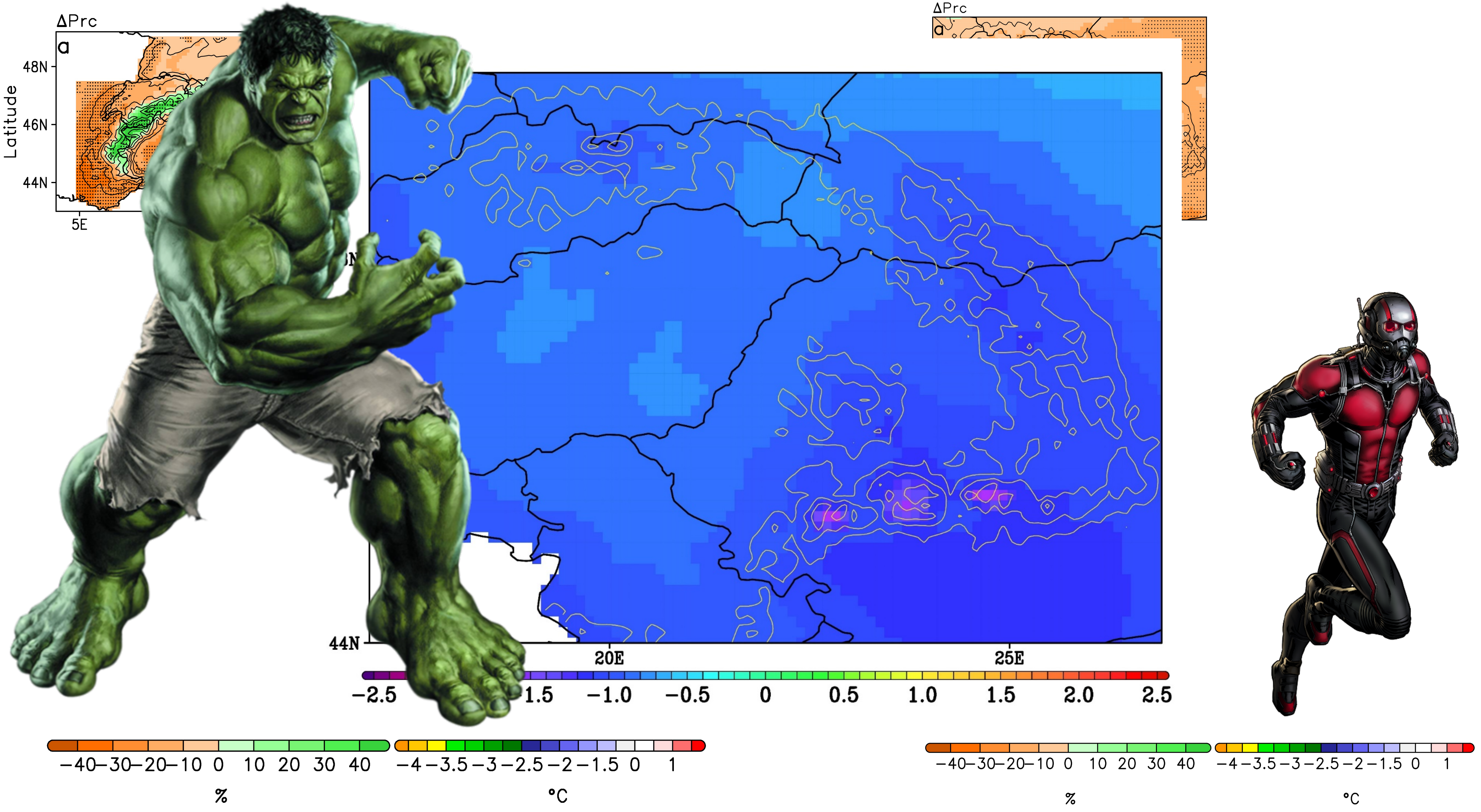



Lower reduction of precipitation in the RCMs

Convection shows a less marked decrease over the highest mountain peaks

Precipitation DS shows small but positive values over the peaks (due to maximum increase in potential for convection)

In the summer, the topographic forcing is mostly of thermodynamical nature


ΔPrc
a
48N
46N
44N
Latitude
5E
44N
20E
25E
−2.5
1.5
−1.0
−0.5
0
0.5
1.0
1.5
2.0
2.5
−40−30−20−10 0 10 20 30 40
%
−4 −3.5 −3 −2.5 −2 −1.5 0 1
°C
ΔPrc
a
−40−30−20−10 0 10 20 30 40
%
−4 −3.5 −3 −2.5 −2 −1.5 0 1
°C

- **Topography strongly modulates the local climatic precipitation change signal**

- **Elevation and orientation of mountains play key roles in such processes**

- **High resolution representation of topography in climate models is crucial for the provision of fine scale precipitation projections in mountainous regions**

**Take home messages!**

# References:

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