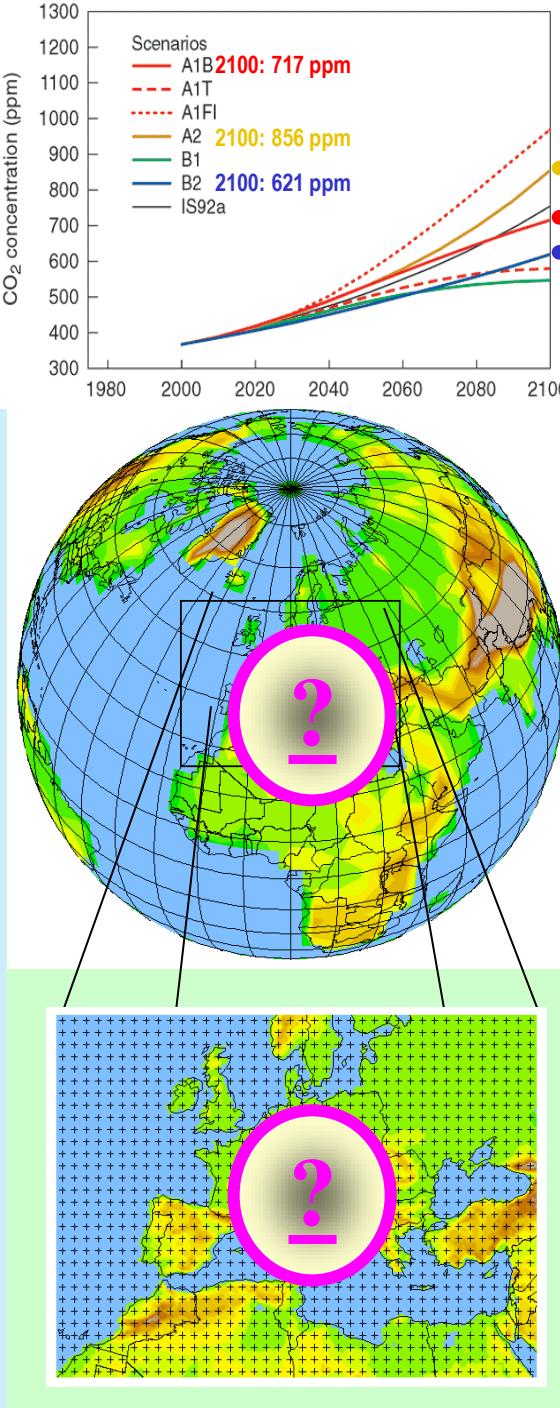


Projections of mean and extreme climatological conditions for Central/Eastern Europe

J. Bartholy and R. Pongrácz



Department of Meteorology Eötvös Loránd University
Budapest, Hungary



OUTLINE

I. RCM experiments at
the Dept. of Meteorology
Eötvös Loránd University

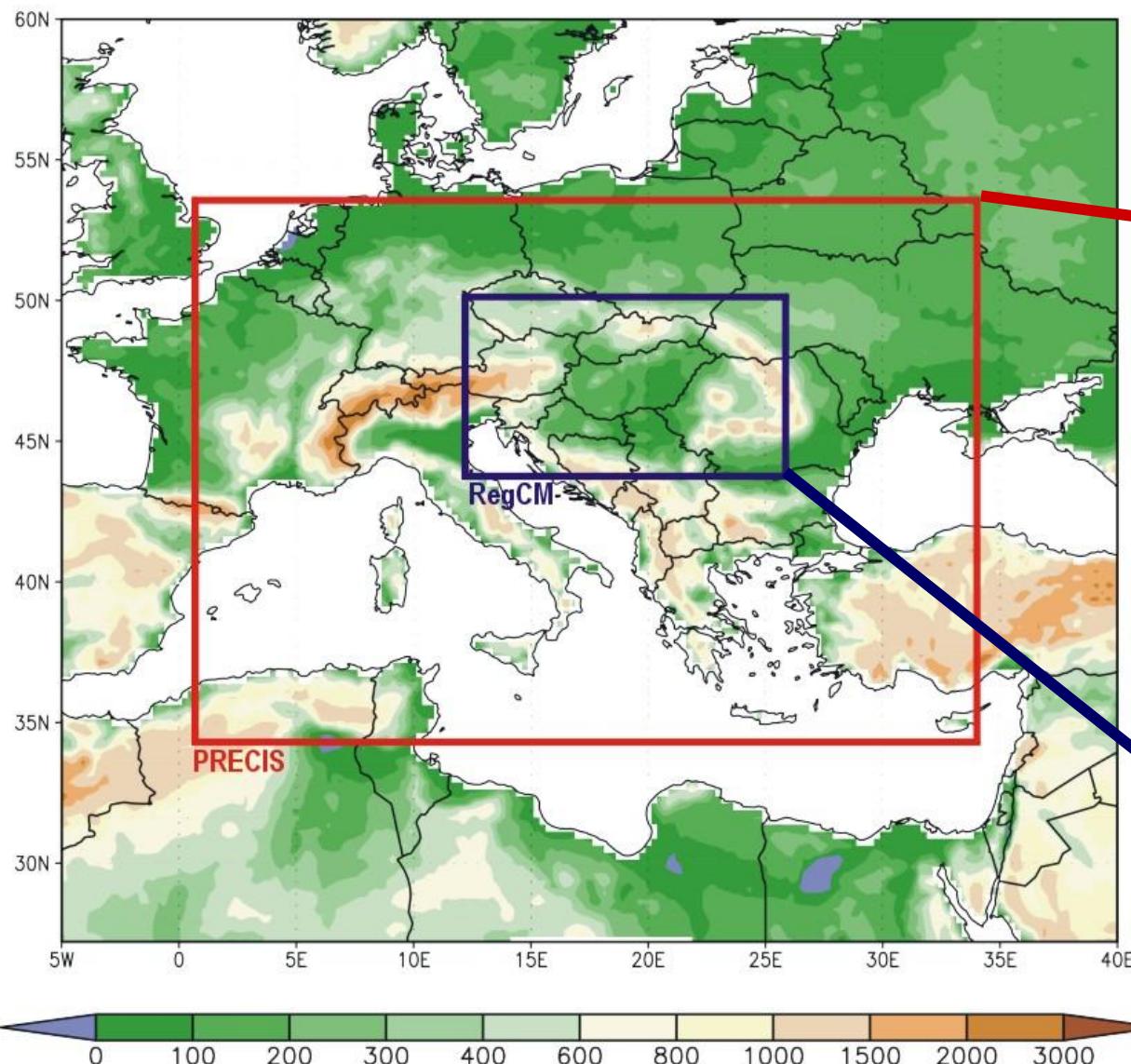


II. Analysis of different scenario
results: SRES A2, A1B, B2

III. Analysis of model ensembles
results from European RCM
experiments



Integration domain of the RCM experiments



Larger domain,
25 km spatial
resolution:
PRECIS

Smaller domain,
10 km spatial
resolution:
RegCM

RCM adaptations at the Dept. of Meteorology Eötvös Loránd University

RCM	PRECIS	RegCM/RegCM β
Developer	UKMO Hadley Centre	ICTP, Trieste IT
Start of adaptation	Autumn 2002	Autumn 2005
Horizontal resolution	25 km	10 km
Applied coordinates	Rotated spherical system	Lambert projection
Vertical levels	19 hybrid atmospheric + 4 soil layers	18 sigma atmospheric + 3 soil layers
Spin-up time	2 years	1 years
Integrations time intervals	5 min	1.5 min
Completed and planned experiments	CTL: 1961-1990 ERA40 CTL: 1961-1990 HadCM3 A2: 2071-2100 HadCM3 B2: 2071-2100 HadCM3 CTL+A1B: 1951-2100 HadCM3	CTL: 1961-2000 ERA40 CTL: 1961-2000 ECHAM5 A1B: 2021-2050 ECHAM5 A1B: 2071-2100 ECHAM5 CTL/RegCM4 * (50 km): 1981-2010 ERA-Interim Planned (CORDEX): CTL+RCP4.5 RegCM4 * (50 km): 1950-2100 CTL+RCP8.5 RegCM4 * (50 km): 1950-2100

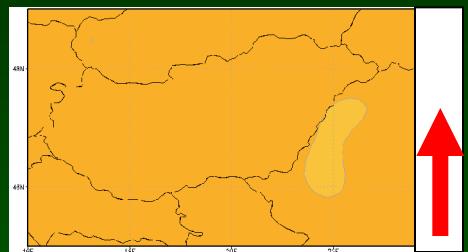
Results:

**Climate change projections
for the 21st century
for Hungary**

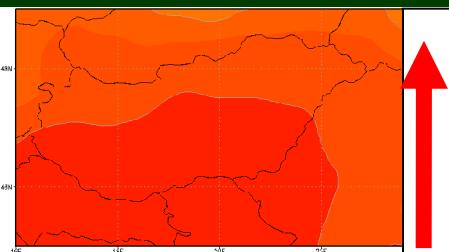
**Analysis of different scenarios
using PRECIS simulations**

Simulated seasonal temperature change by 2071–2100 (reference period: 1961–1990)

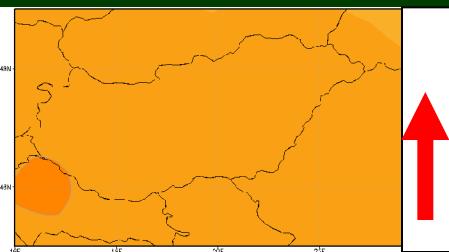
Spring



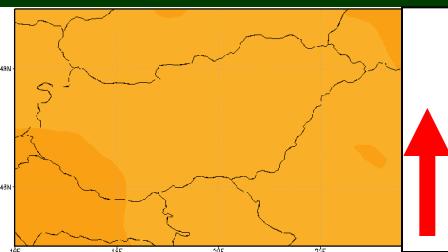
Summer



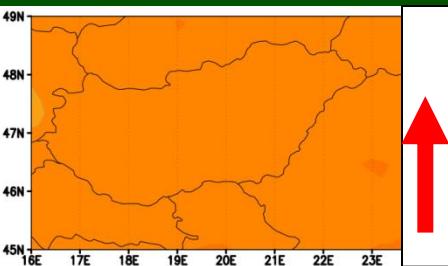
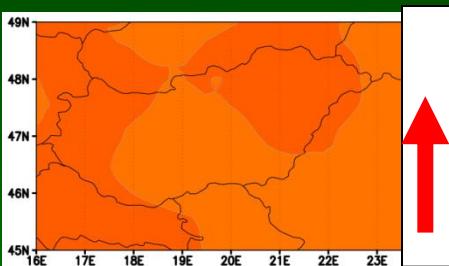
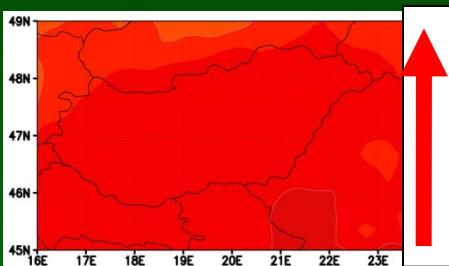
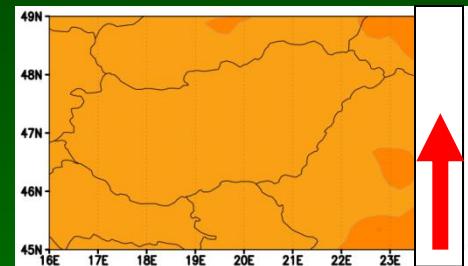
Autumn



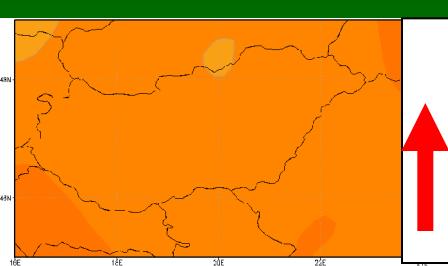
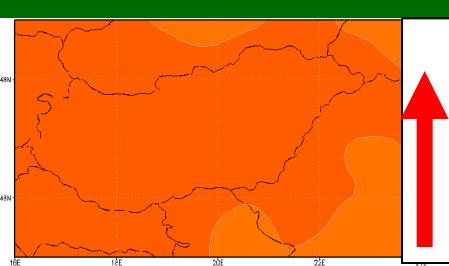
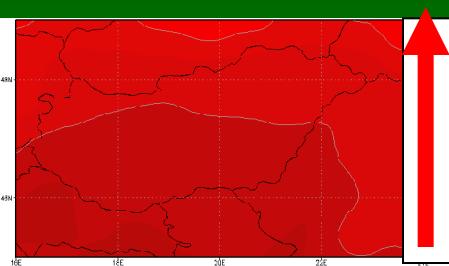
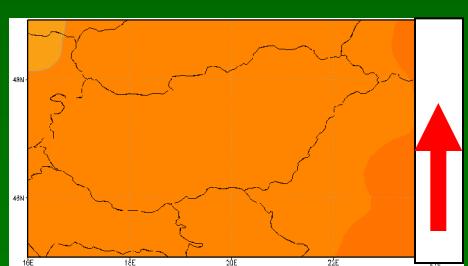
Winter



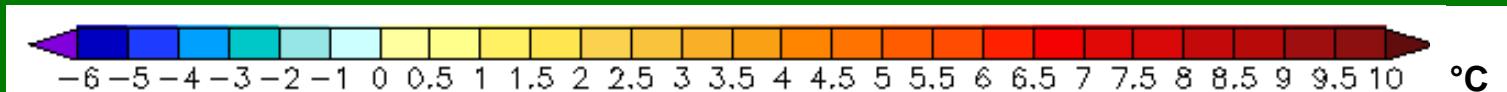
B2 scenario



A1B scenario

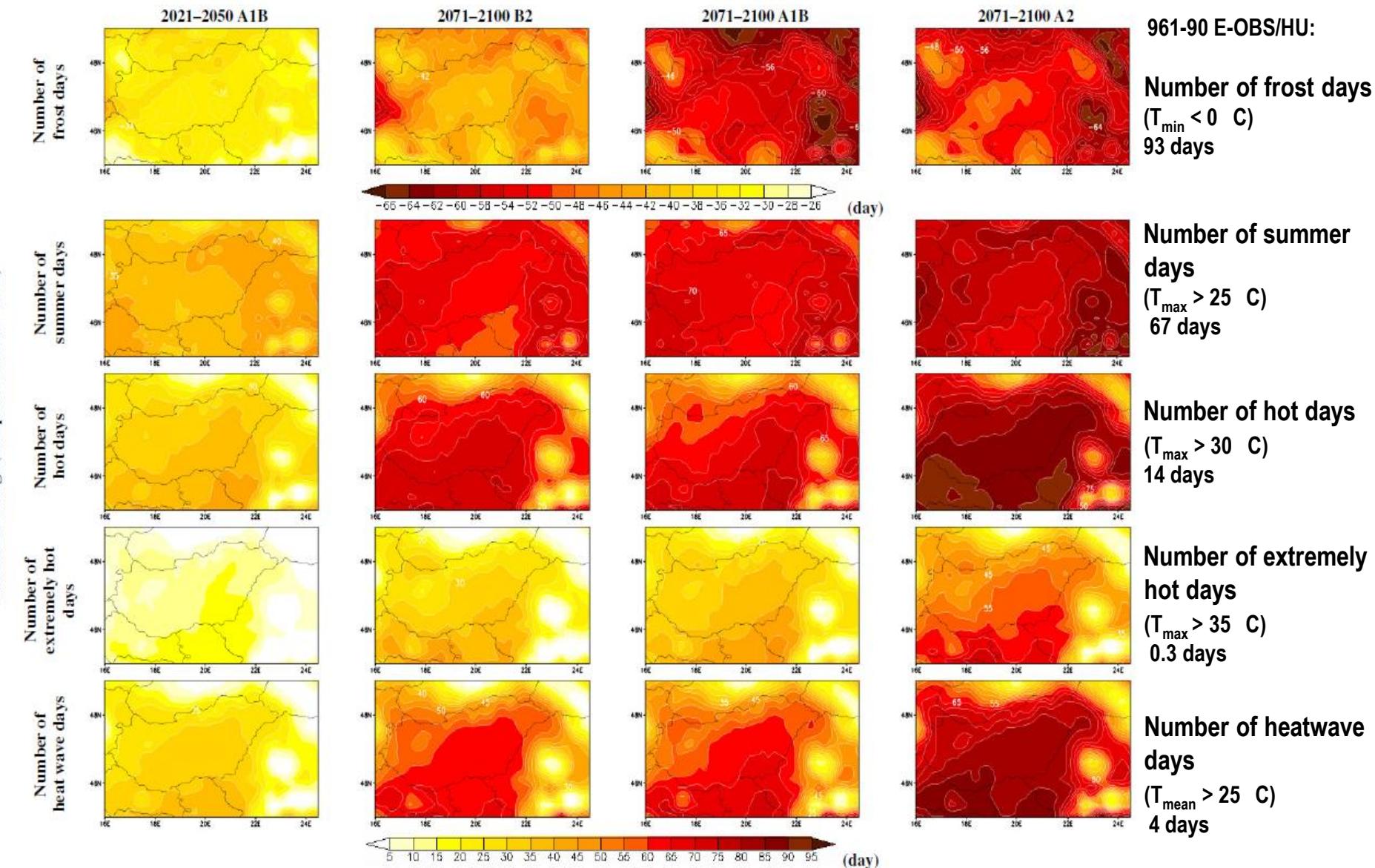


A2 scenario



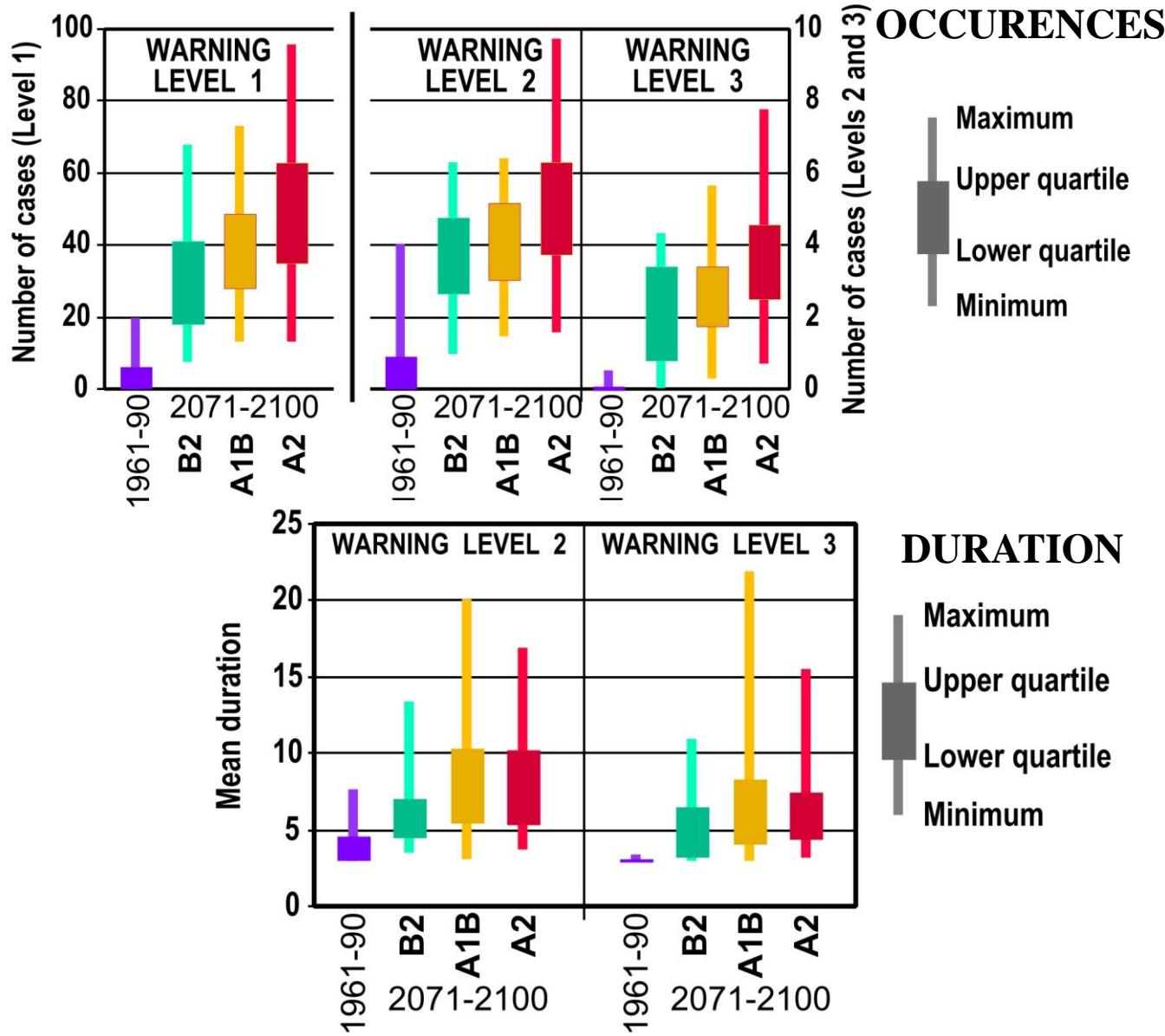
Projected change: increasing temperature (especially in summer)

Temperature-related climate indices for projecting extreme conditions



Spatial mean and duration of heat wave warning levels

(Hungary: 229 grid cells)



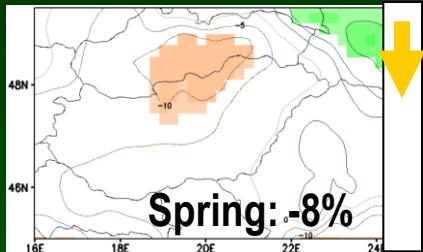
By the end of the 21st century

-- the occurrences of heat wave warning level cases are projected to change by ~10 times,

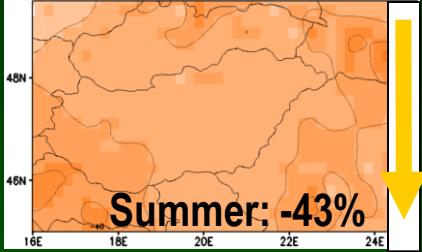
-- the mean duration of heat wave warning levels are projected to double

Simulated seasonal precipitation change by 2071–2100 (reference period: 1961–1990)

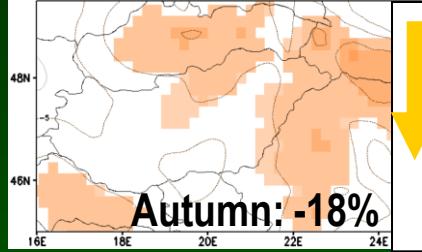
Spring



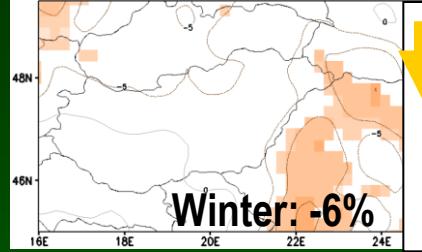
Summer



Autumn



Winter

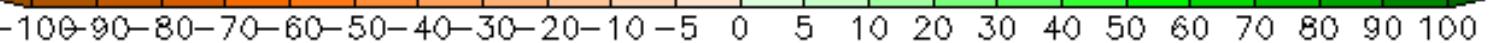


B2 scenario

Spring: -8%

Spring: +5%

Spring: -13%



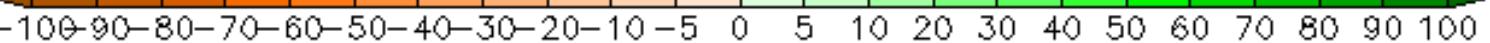
%

A1B scenario

Summer: -33%

Autumn: -4%

Summer: -58%

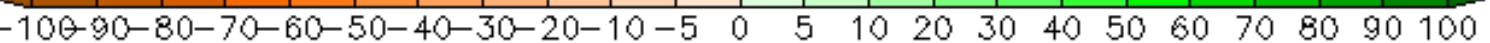


%

A2 scenario

Autumn: -8%

Autumn: -8%

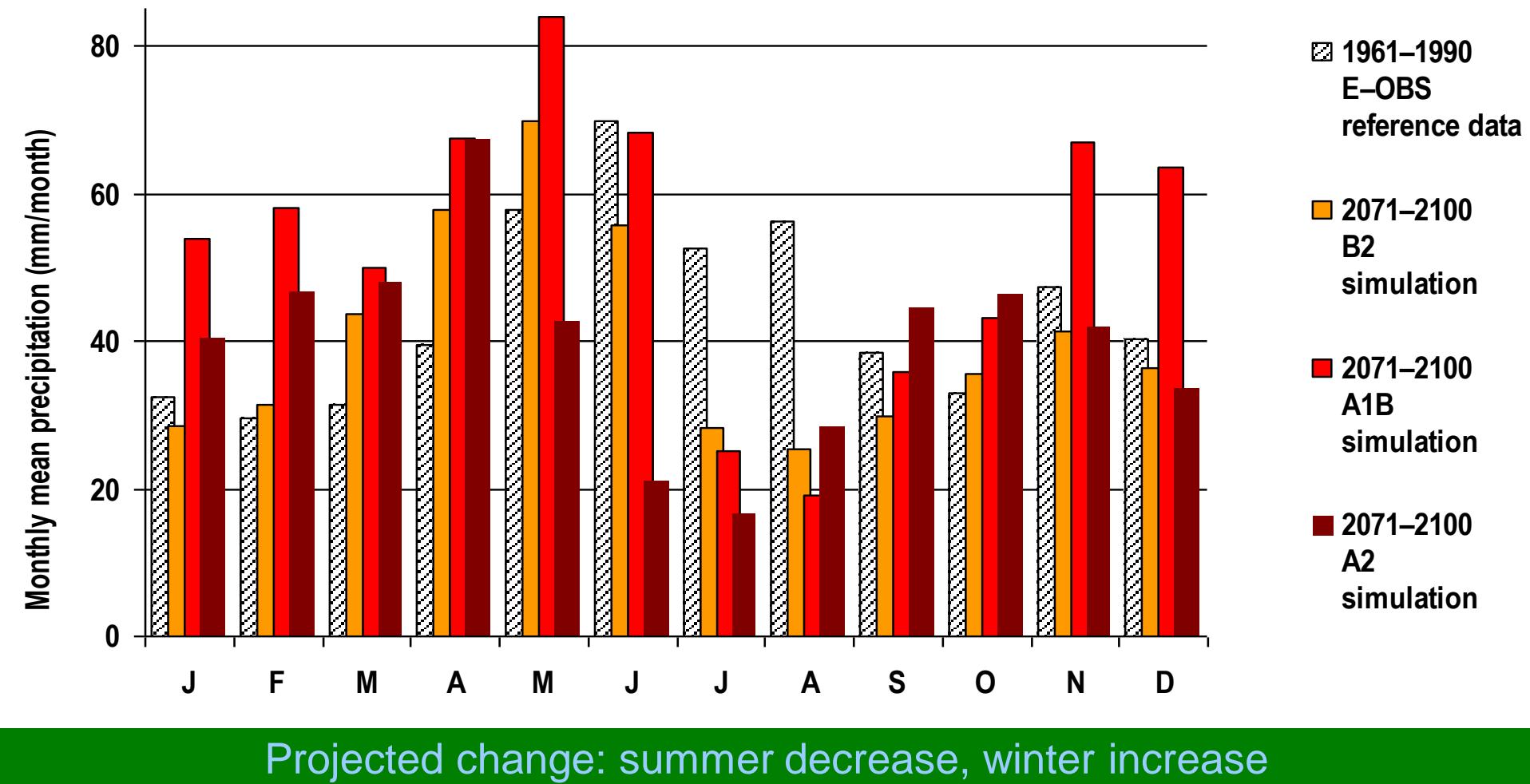


%

Projected change: summer decrease, winter increase

Annual distribution of monthly mean precipitation

(mm/month)



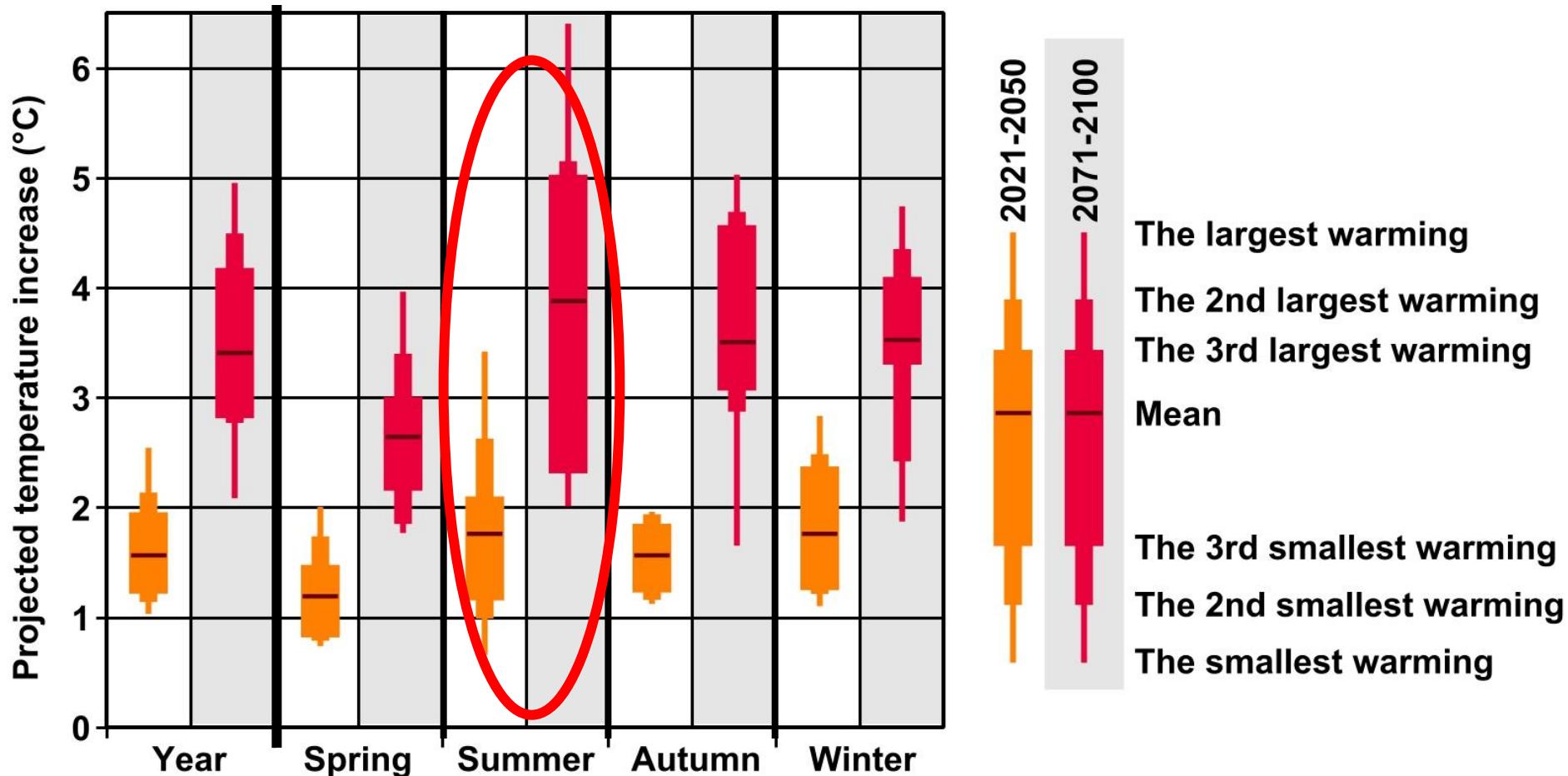
Results:

**Climate change projections
for the 21st century
for Hungary**

**Analysis of different models
using
ENSEMBLES simulation outputs**

Projected seasonal temperature change, A1B scenario

Reference period: 1961-1990

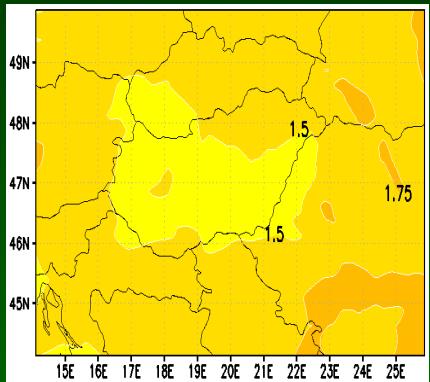


- Estimated warming by 2021-2050: 1-3 °C, by 2071-2100: 2-6 °C
- The largest seasonal warming is projected for summer
- The largest warming is projected by the HadCM-driven RCM simulations

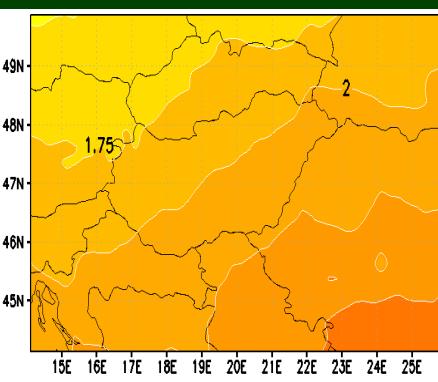
Estimated seasonal temperature change: using 11 model simulation results for A1B scenario

(Reference period: 1961-1990)

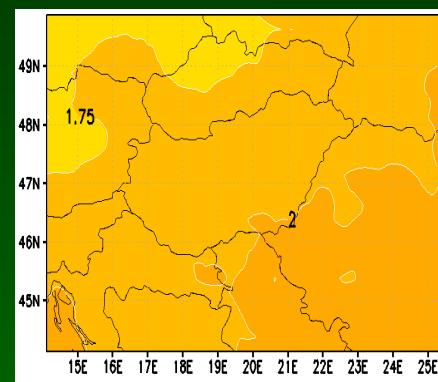
Spring



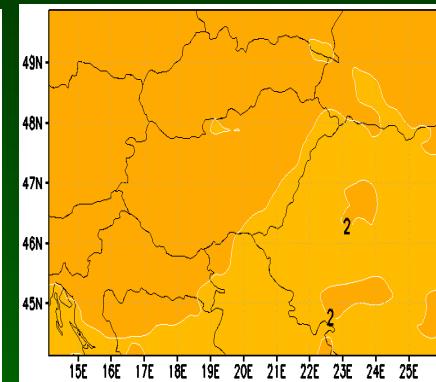
Summer



Autumn



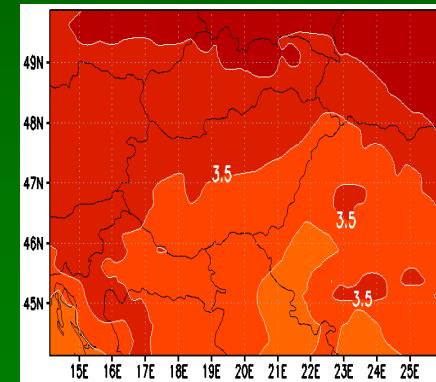
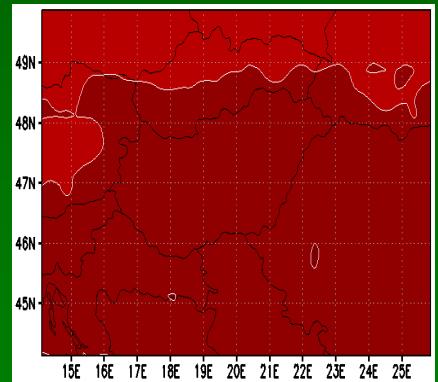
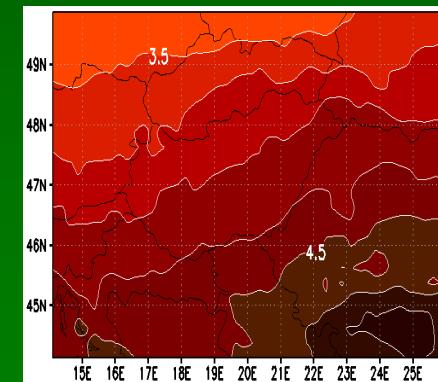
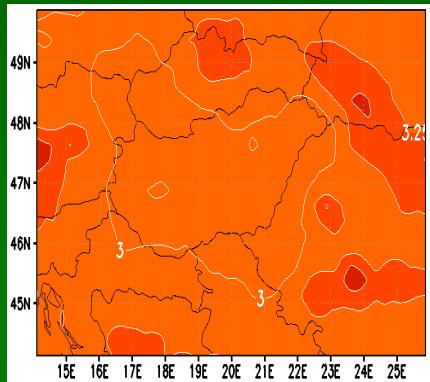
Winter



2021-2050

- Projected warming: 1.25 – 3.25 °C; the estimated warming is larger from North to South

2071-2100

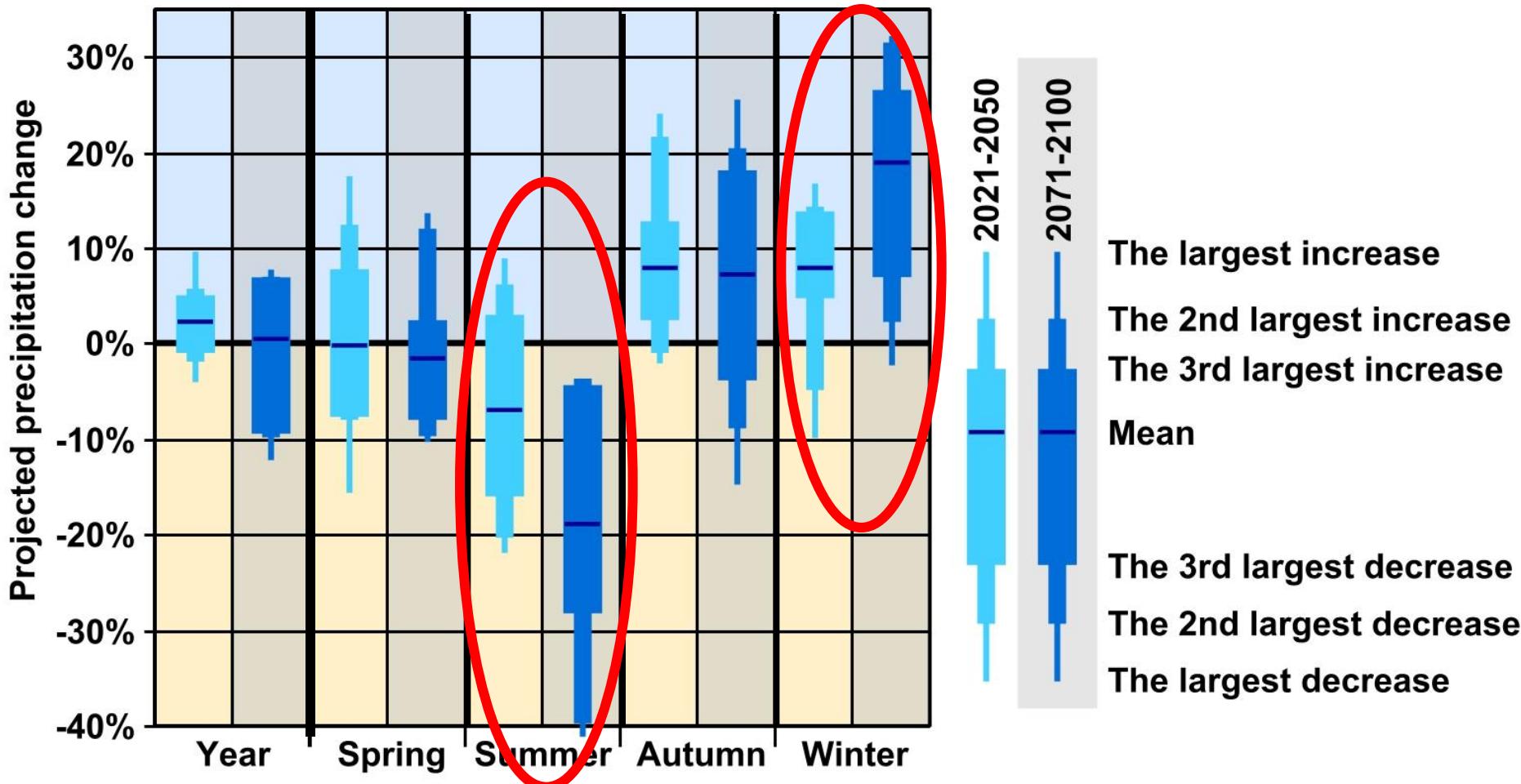


- Projected warming: 2.75 – 5 °C; the largest increase is estimated for summer



Projected seasonal precipitation change, A1B scenario

Reference period: 1961-1990

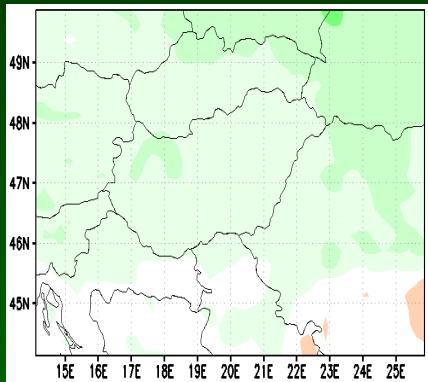


- 2021-2050: the projected changes don't exceed 15-20%, and mostly not significant
- 2071-2100: precipitation decrease is projected for summer (by 10-40%)
precipitation increase is projected for winter (by 5-30%)

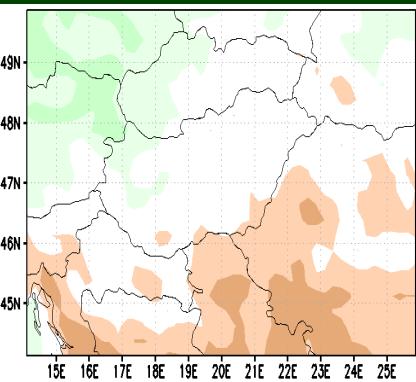
Estimated seasonal precipitation change: using 11 model simulation results for A1B scenario

(Reference period: 1961-1990)

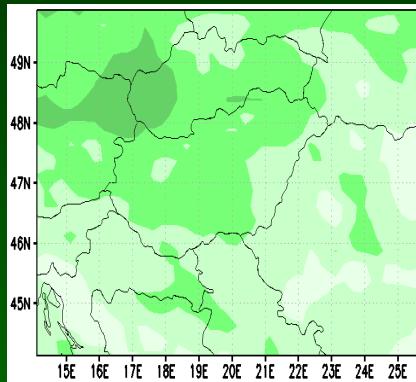
Spring



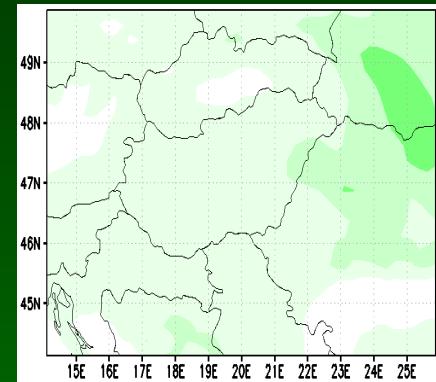
Summer



Autumn



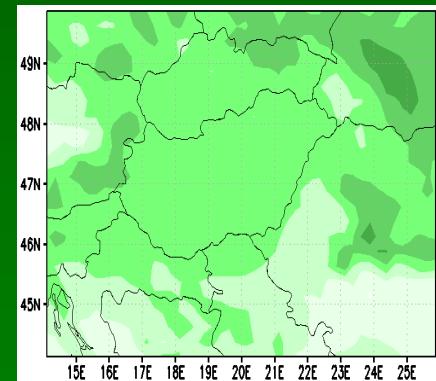
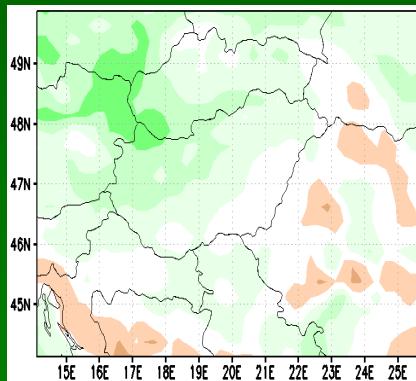
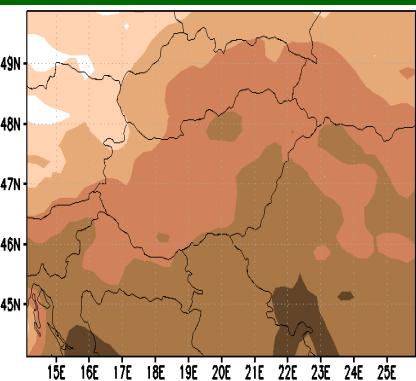
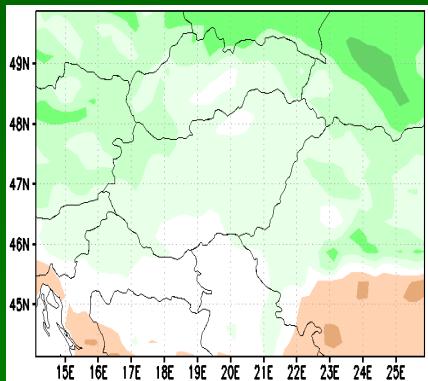
Winter



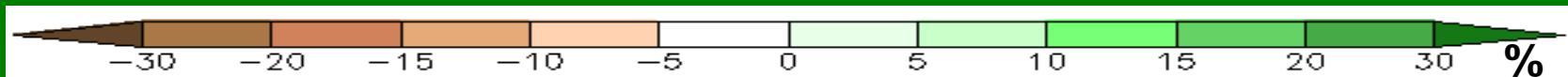
2021-2050

- Precipitation decrease in summer (~20%), the rest of the year: increase (~5-20%)

2071-2100

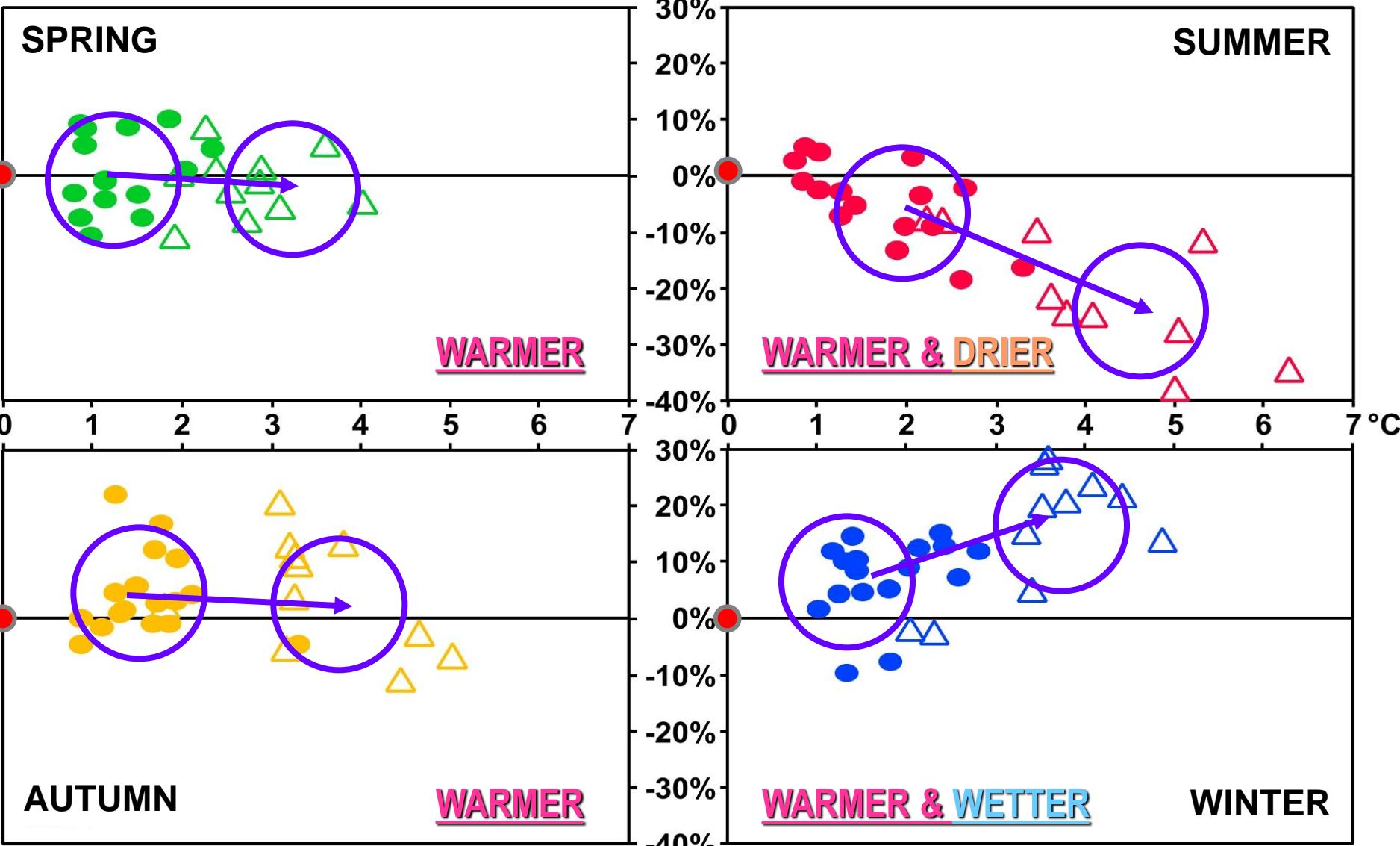


-The largest precipitation decrease / increase is projected for summer / winter (~30% / ~20%)



Projected temperature and precipitation change for Hungary

Reference period: 1961-1990 ●



RESULTS OF RCM ENSEMBLES: PRECIPITATION INDICES

**What trends are estimated for Hungary and
for the Central/Eastern European domain?**

CDD: Maximum length of consecutive dry days ($R < 1 \text{ mm}$)

Reference period: 1961-1990

Winter

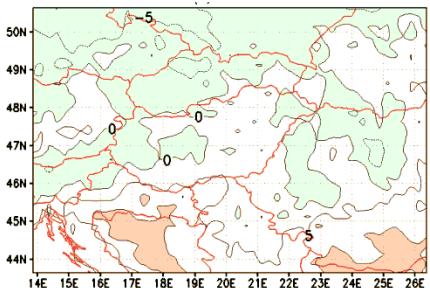
Spring

Summer

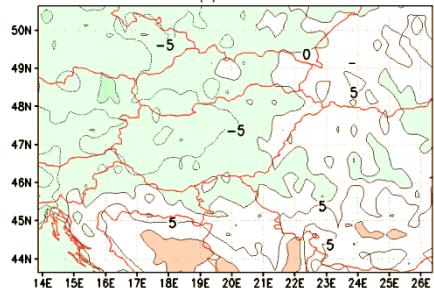
Autumn

E-OBS:

17 days



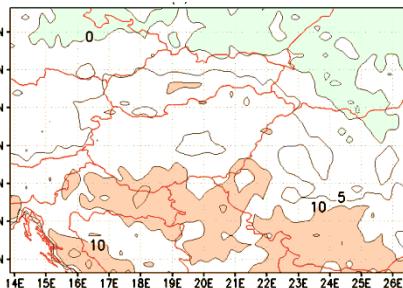
1%



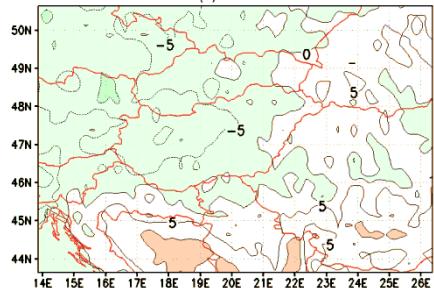
0%

Spring

15 days



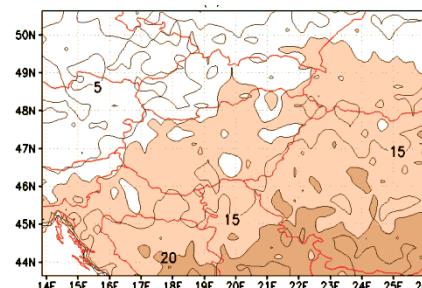
5%



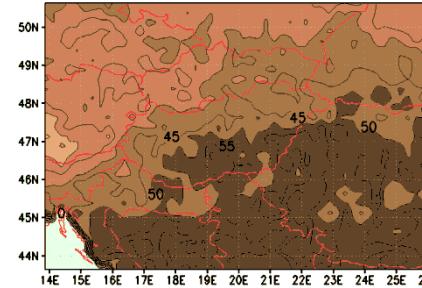
11%

Summer

12 days

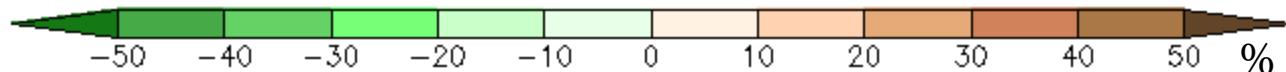


12%



-2%

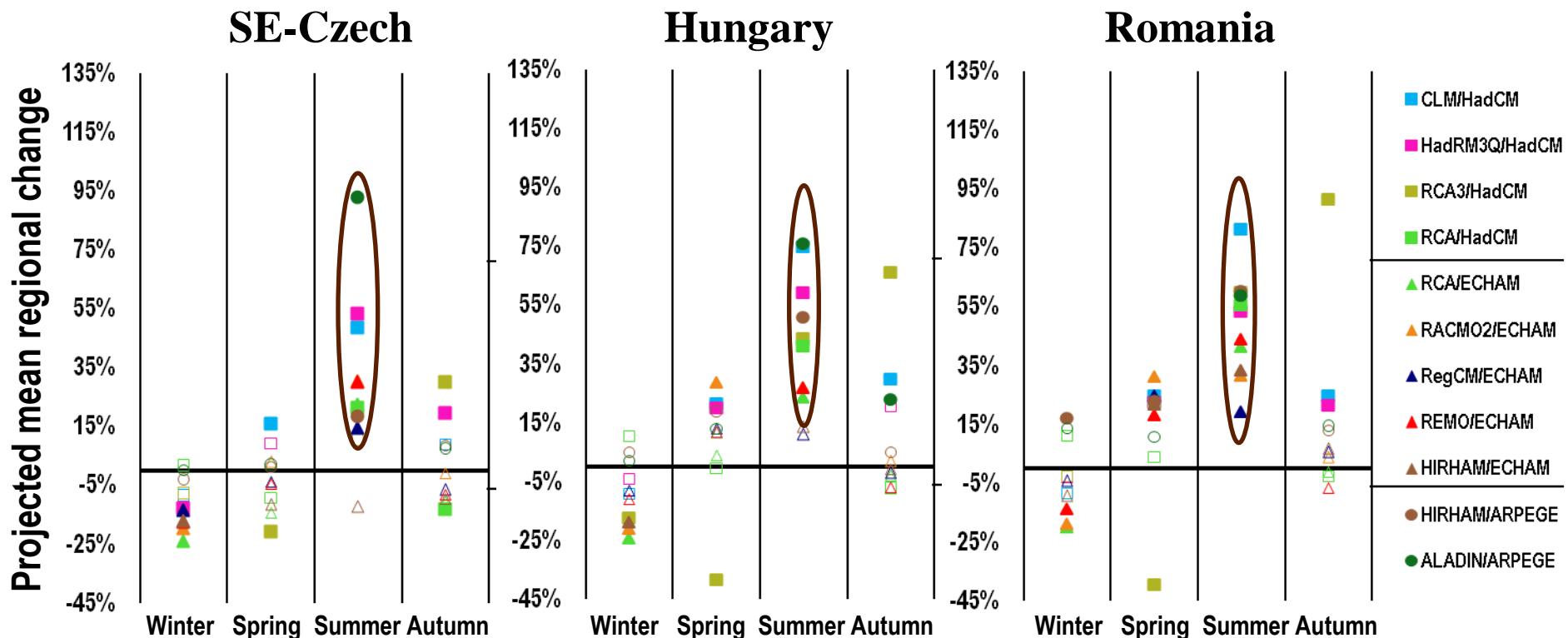
14%



⇒ Considerable increase in summer

CDD: Maximum length of consecutive dry days ($R < 1 \text{ mm}$)

Projected change by 2071-2100 relative to the 1961-1990 reference period



- Significant increase in summer

	2071–2100 (2021–2050)	Winter	Spring	Summer	Autumn
SE-Czech		-6% (-4%)	0% (2%)	38% (5%)	5% (-4%)
Hungary		-4% (1%)	12% (8%)	48% (12%)	14% (-3%)
Romania		3% (3%)	17% (7%)	54% (19%)	18% (-3%)

RR10: Number of heavy precipitation days ($R > 10$ mm)

Reference period: 1961-1990

Winter

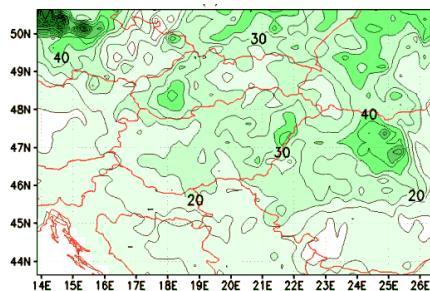
Spring

Summer

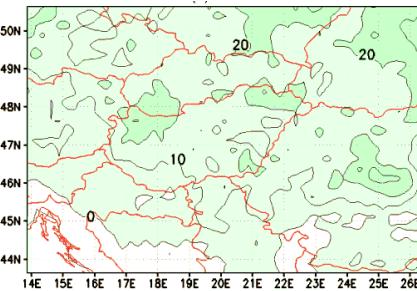
Autumn

E-OBS:

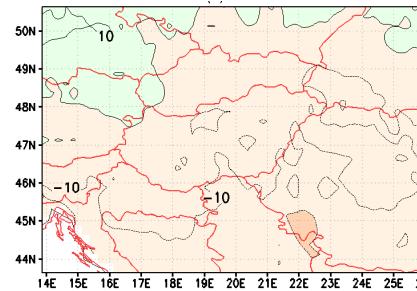
2 days



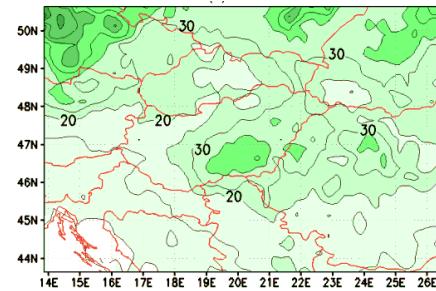
21%



11%

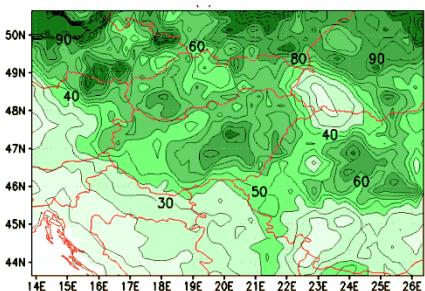


-7%

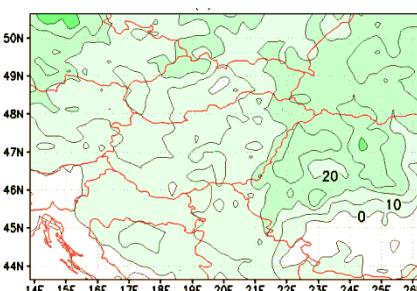


24%

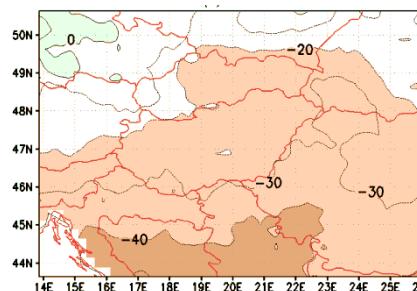
2021-2050



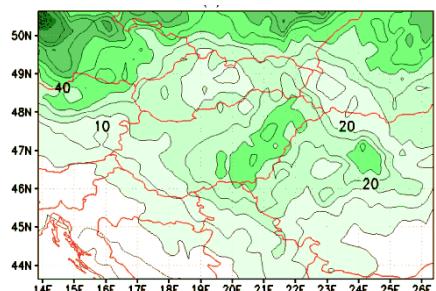
54%



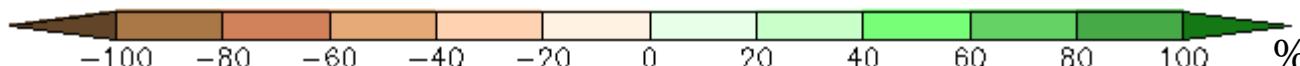
14%



-25%



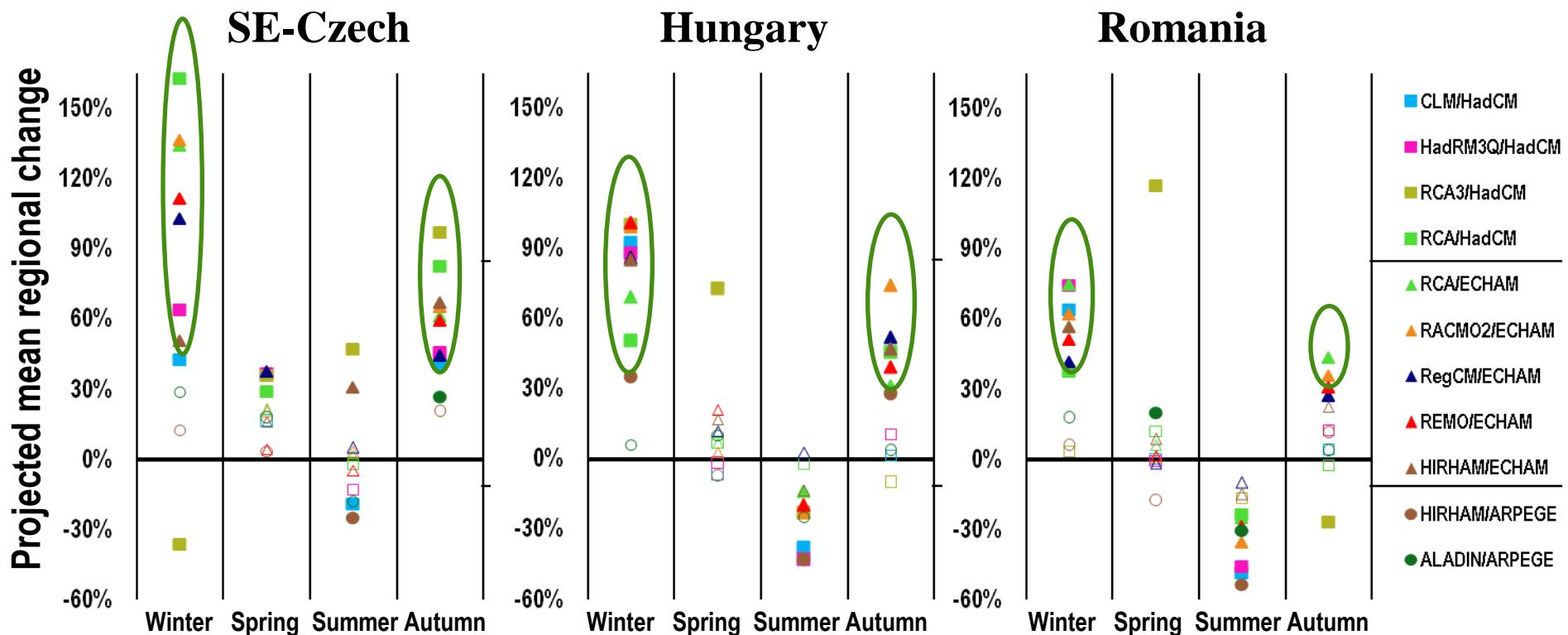
23%



⇒ Generally increase, except in summer

RR10: Number of heavy precipitation days ($R > 10 \text{ mm}$)

Projected change by 2071-2100 relative to the 1961-1990 reference period



- Significant increase in winter and autumn

	2071–2100 (2021–2050)	Winter	Spring	Summer	Autumn
SE-Czech		91% (35%)	22% (14%)	-2% (5%)	58% (45%)
Hungary		65% (24%)	12% (14%)	-25% (-8%)	30% (27%)
Romania		47% (20%)	14% (11%)	-33% (-12%)	16% (22%)

CONCLUSIONS

WHAT DO THE RCM-SIMULATIONS PROJECT FOR HUNGARY?

⇒ TEMPERATURE

Warming is projected to continue:

The largest warming is estimated for summer

More frequent, more intense warm extremes

Less cold extremes

⇒ PRECIPITATION

Drier summers and wetter winters are projected

Longer and more frequent drought events in summer