

# Climate modeling and climate change scenarios

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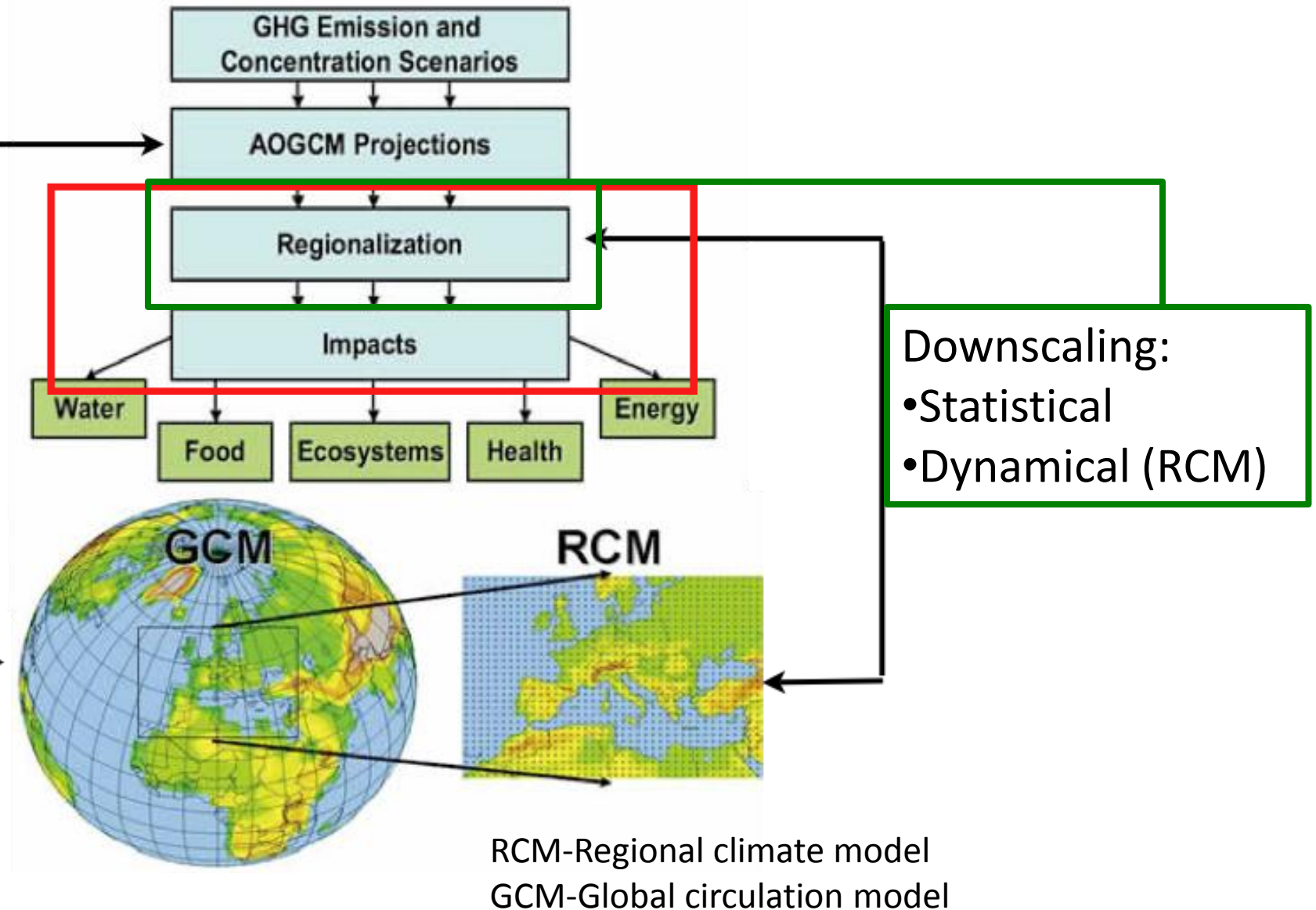
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BorivojRajkovic, Fizičkifakultet, Beograd

Milan Dacic, RHMSS, SEEVCCC

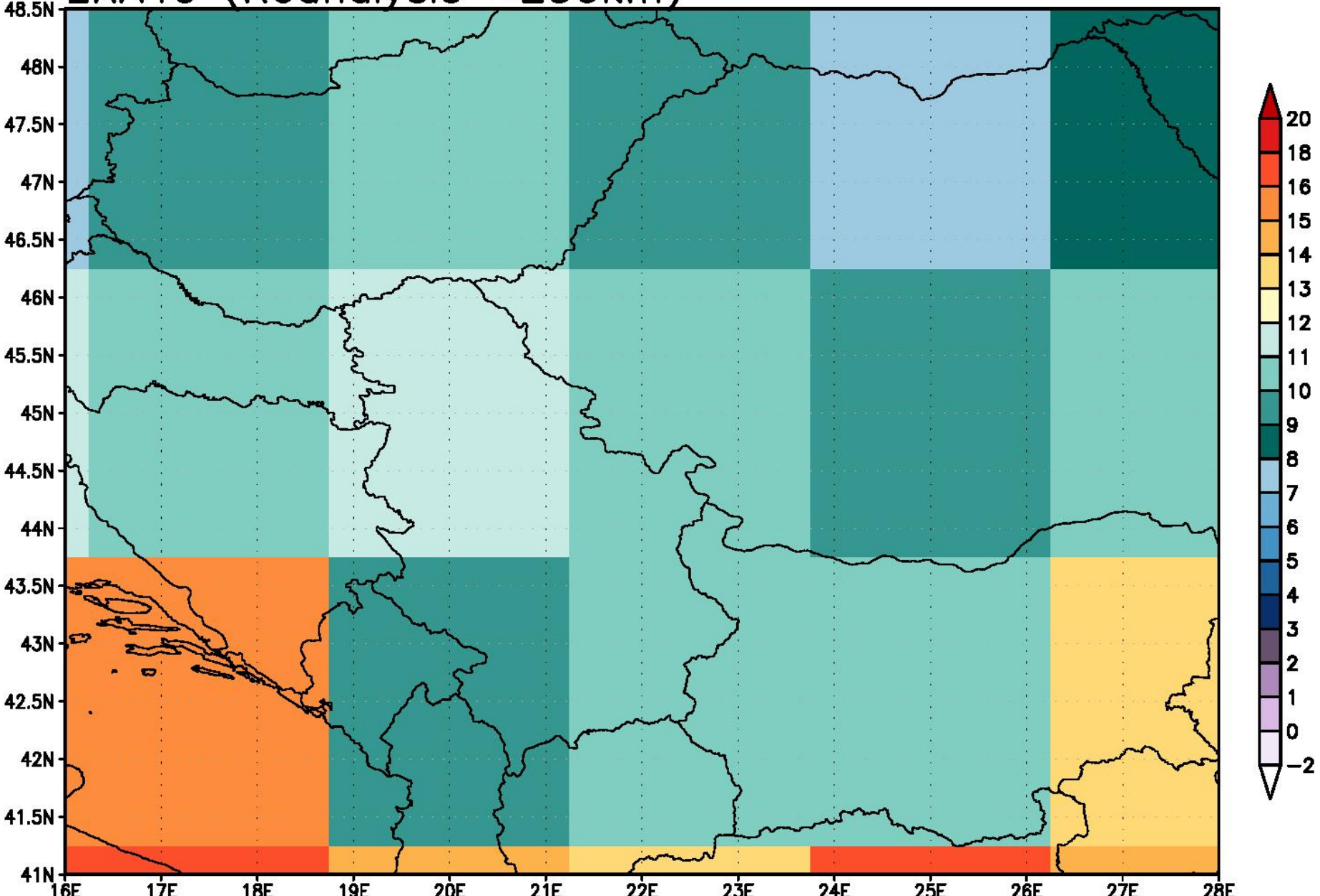
GoranPejanovic, RHMSS, SEEVCCC

# Regionalization of climate change scenarios



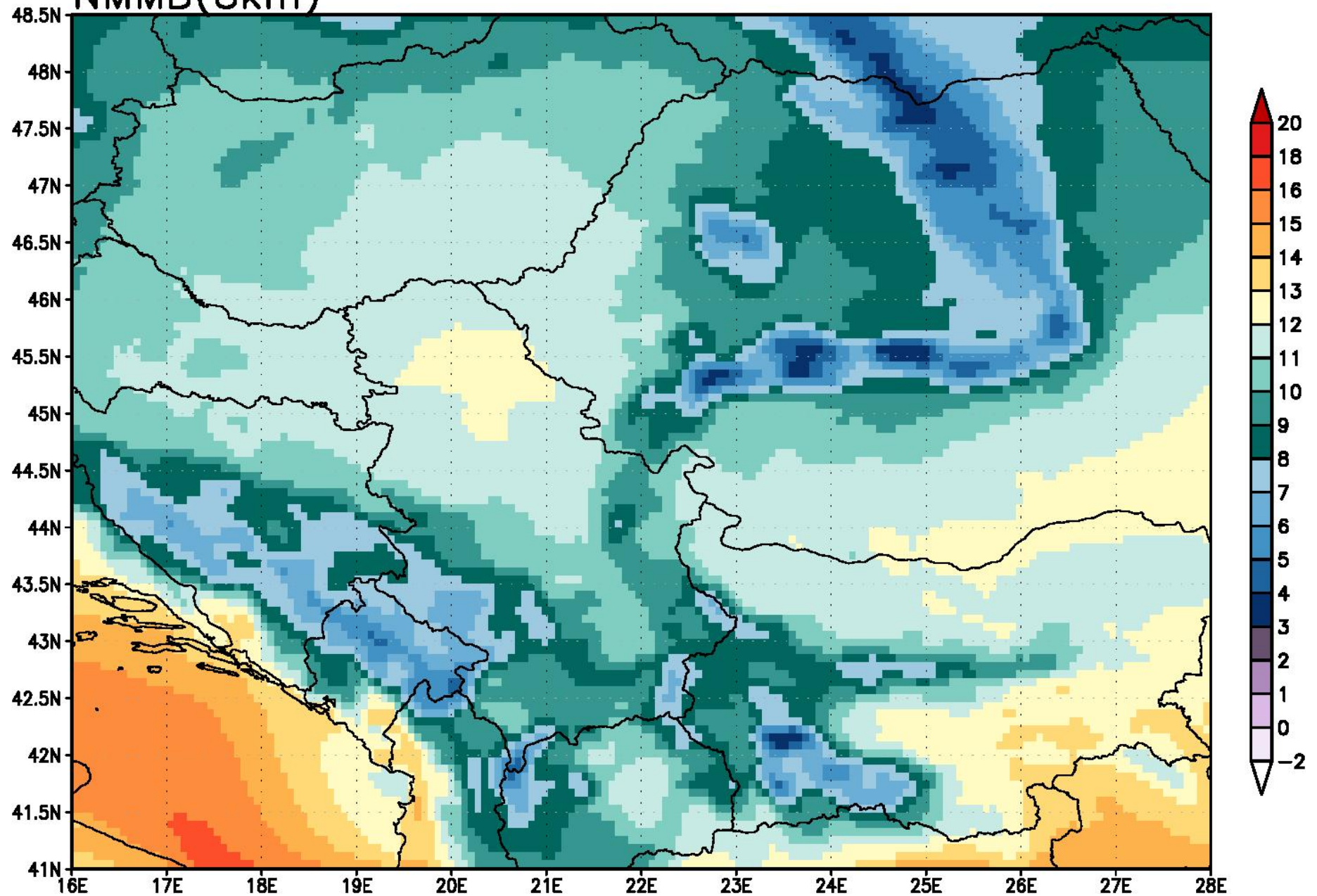
## Global model mean annual temperature 1971-2000

## ERA40 (Reanalysis ~250km)



# Regional model mean annual temperature 1971-2000

NMMB(8km)



# **Coupled Regional Climate Model - EBU-POM**

## **Atmospheric model:**

- **EBU – Eta Belgrade University**
- **0.25 horizontal resolution (~25 km) / 32 vertical levels,**
- **NOAH – Land Surface Scheme,**
- **Annual cycle of vegetation fraction.**

## **Ocean model: POM**

- **Princeton Ocean Model**
- **0.2 horizontal resolution / 21 vertical levels (Med sea).**

## **Coupler:**

- **Every 6 min exchange between atmosphere and ocean.**

Djurdjevic and Rajkovic, 2002, 2008, 2010;

Gualdi et al, 2006;

Krzic et al 2011; Bellafiore et al, 2011

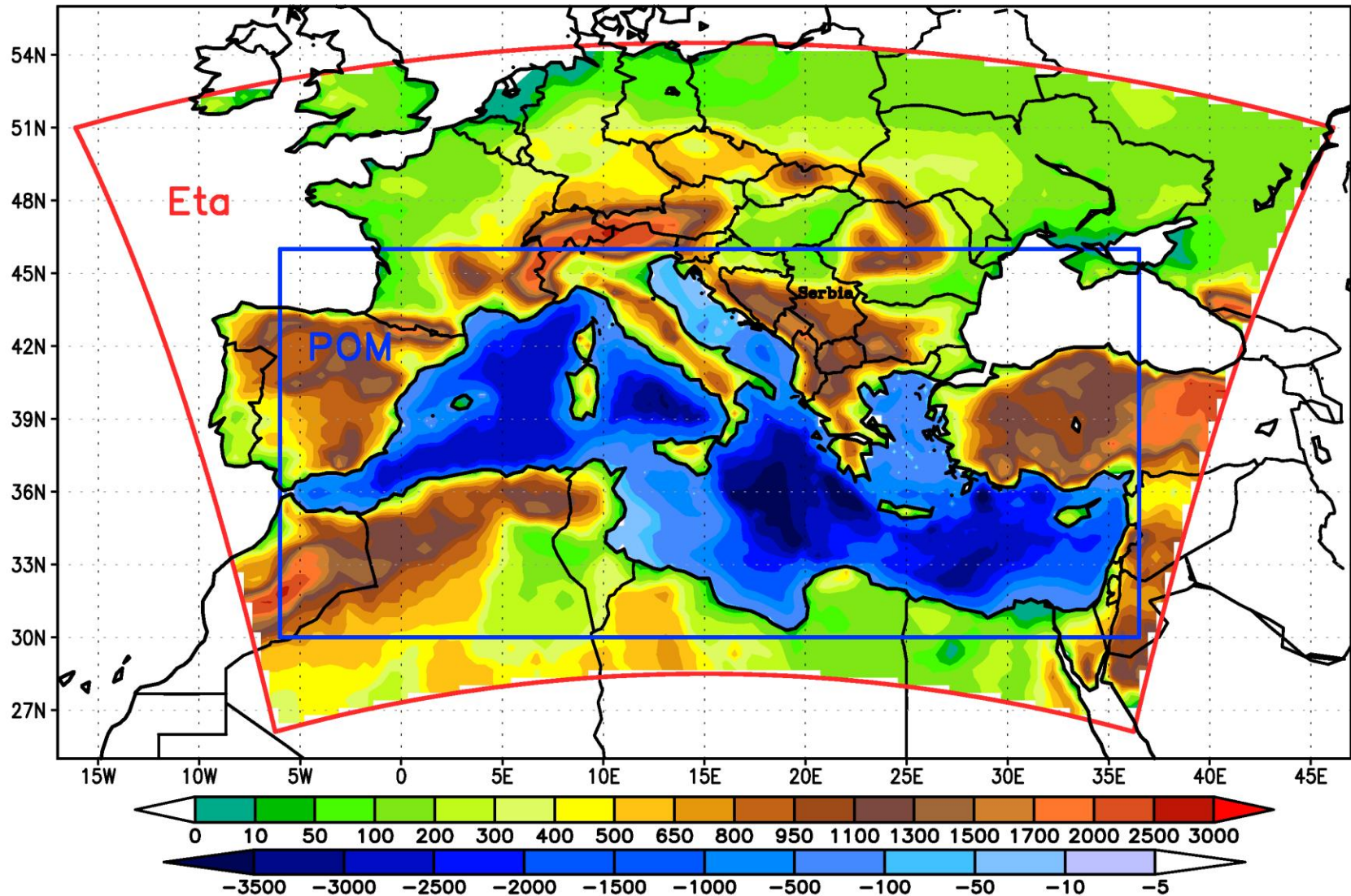
Ruml et al 2012;

Stojanovic et al 2013

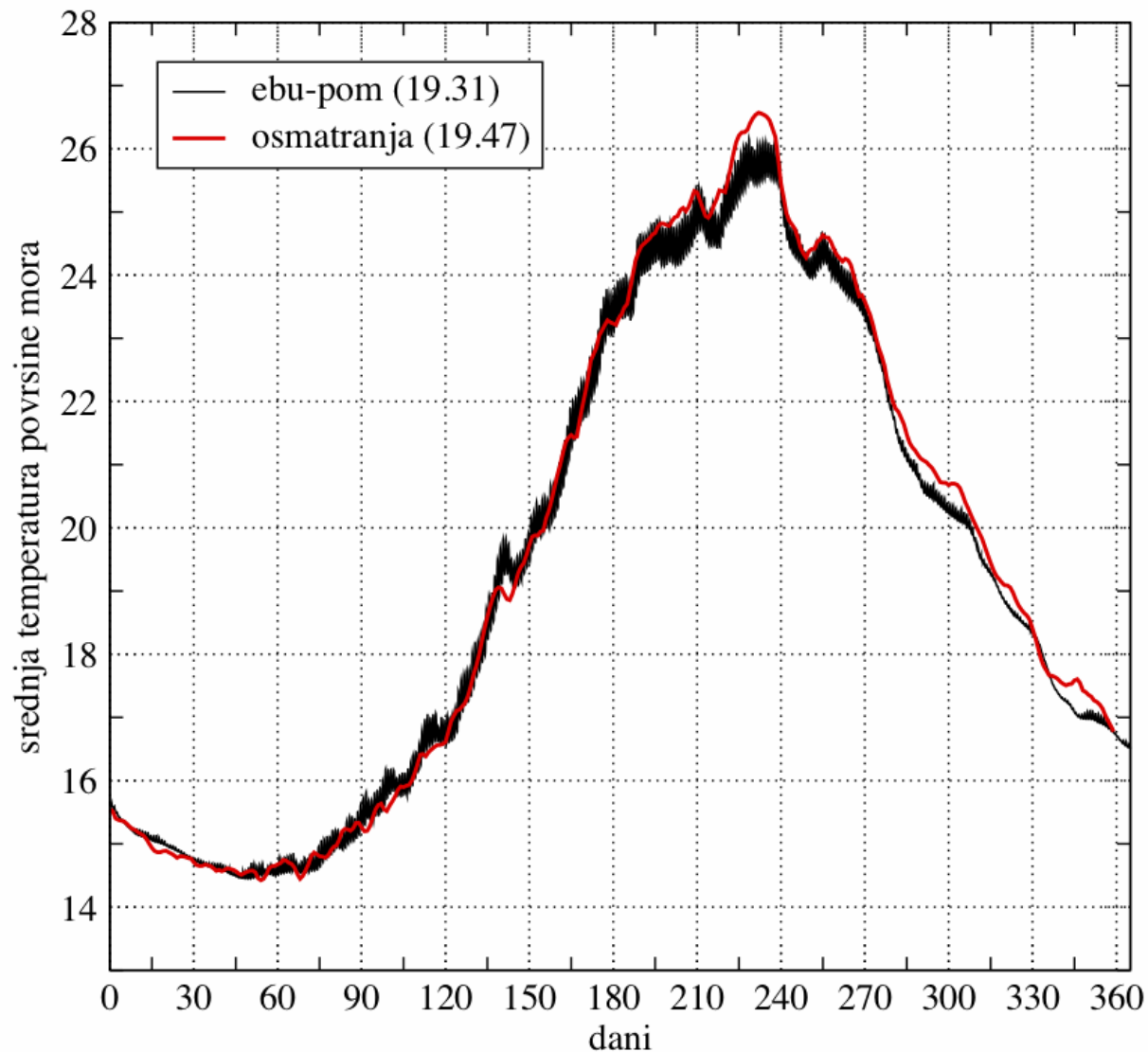
# Coupled Regional Climate Model - EBU-POM

## Typical model domain

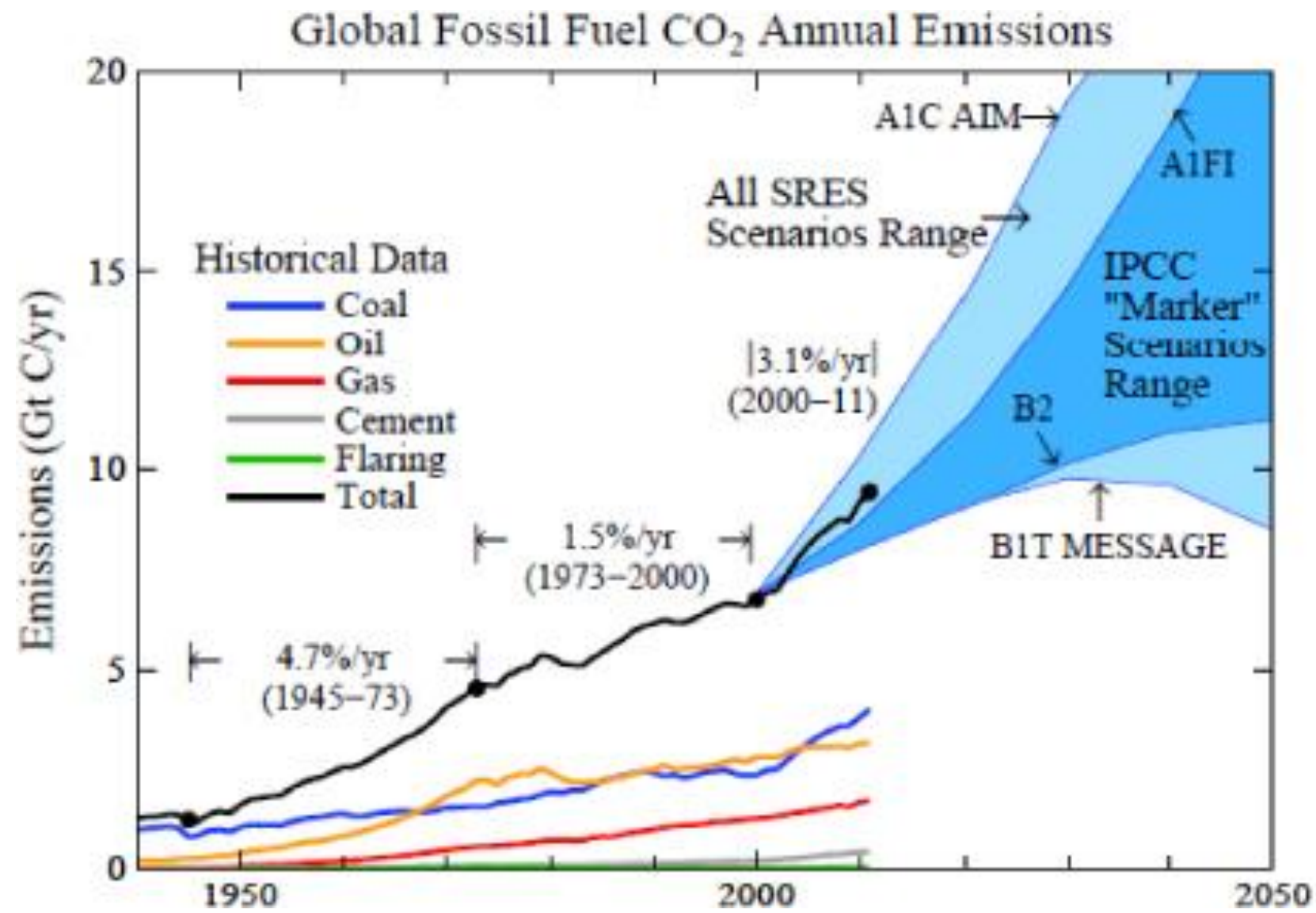
Model orography and bathymetry (m)



## Mediterranean Seas Surface Temperature



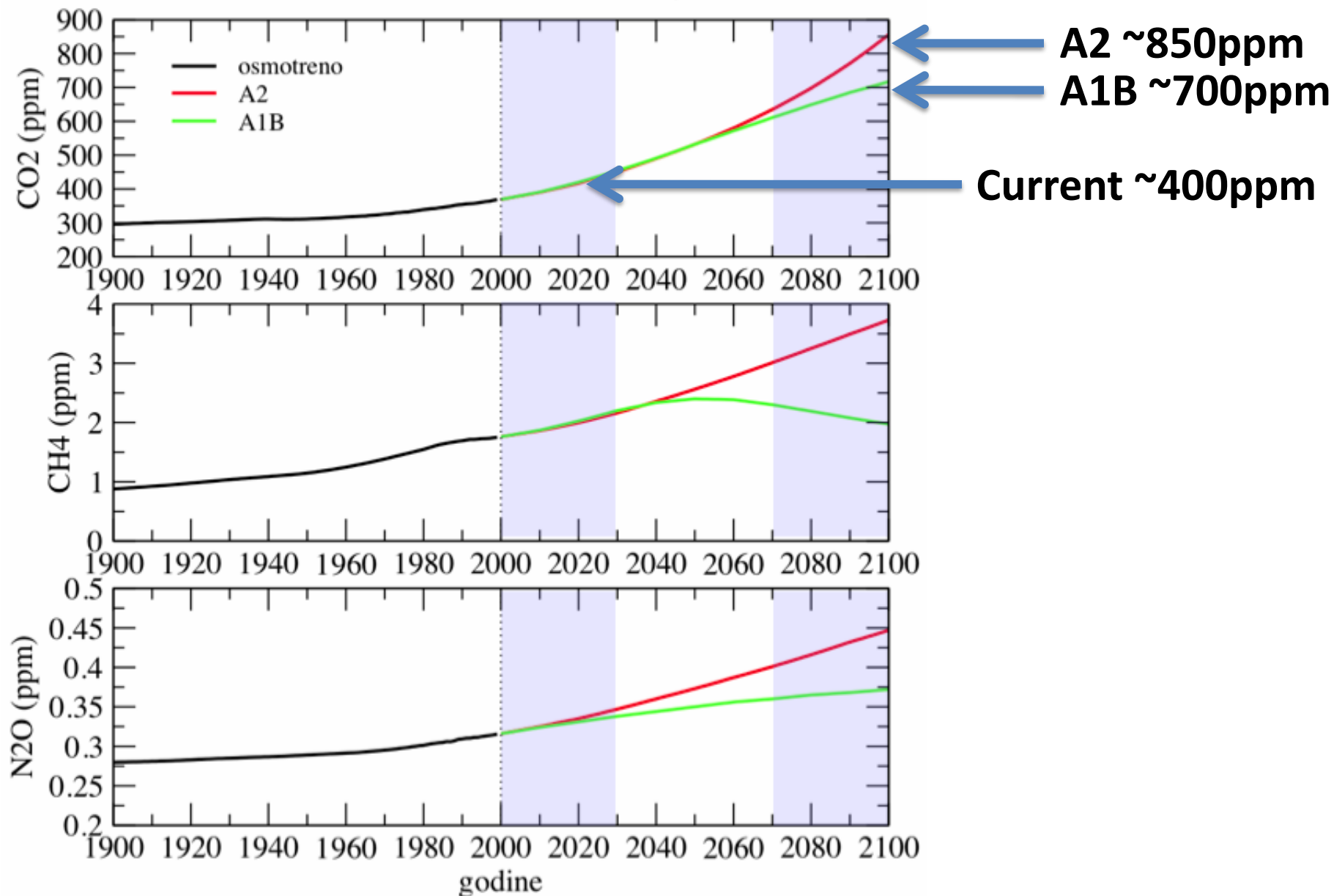
# GHG emissions in atmosphere



Source: Hansen et al 2013

# GHG concentration in atmosphere

CO<sub>2</sub>, CH<sub>4</sub> i N<sub>2</sub>O koncentracije

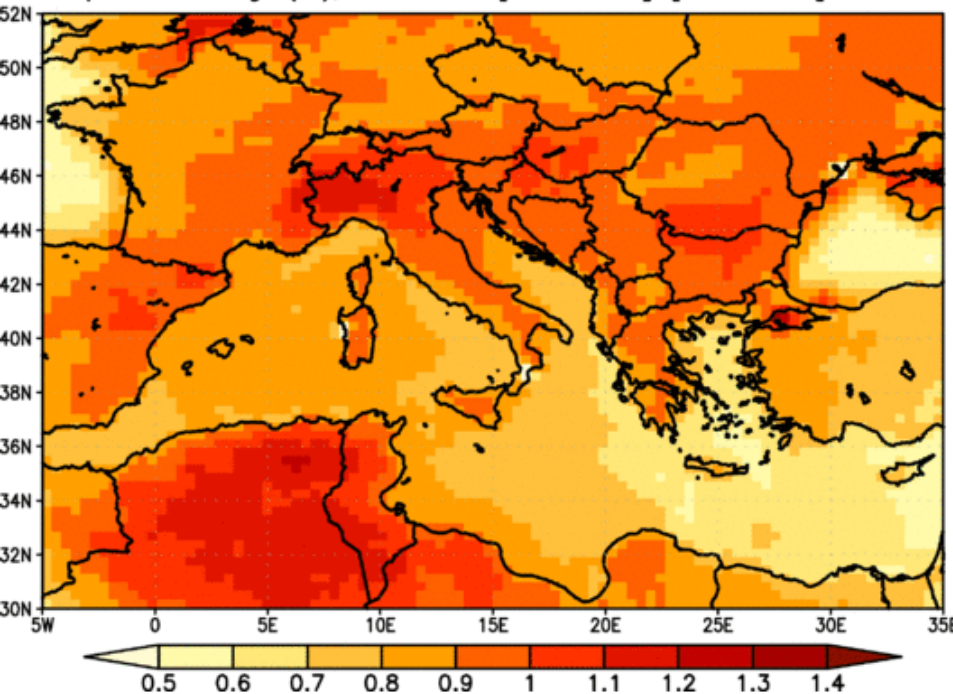


# Scenario A1B:2001-2030

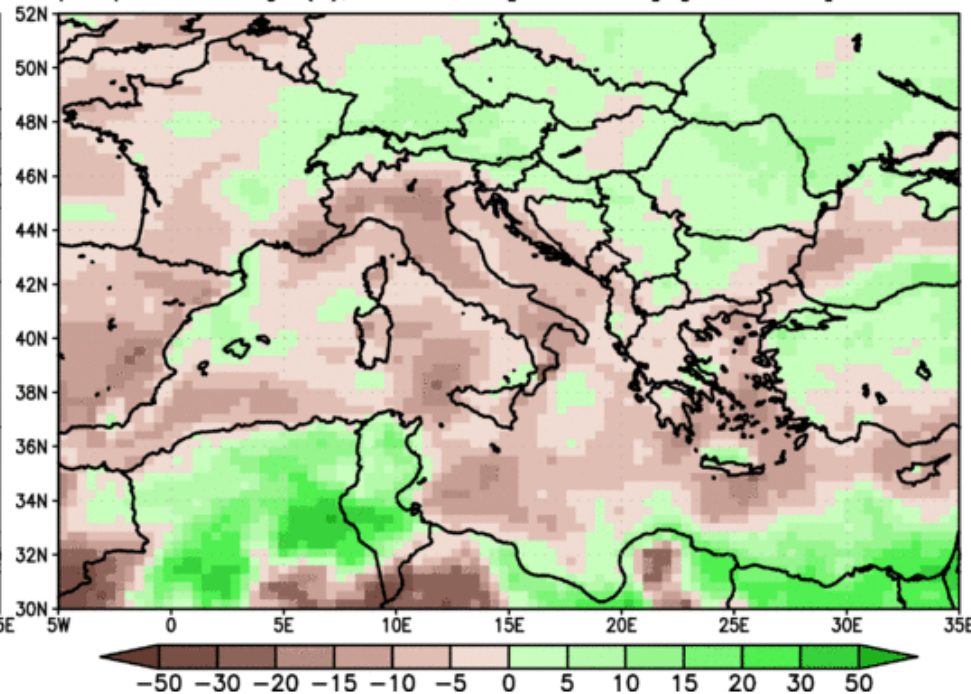
## Annual temperature and precipitation change with respect to 1961-1990

**Serbia:**  
**Temperature change  $\sim +1^\circ\text{C}$**   
**Precipitation change -5 to +5%**

temperature change ( $^\circ\text{C}$ ), ann season [2001–2030]–[1961–1990] :: a1b



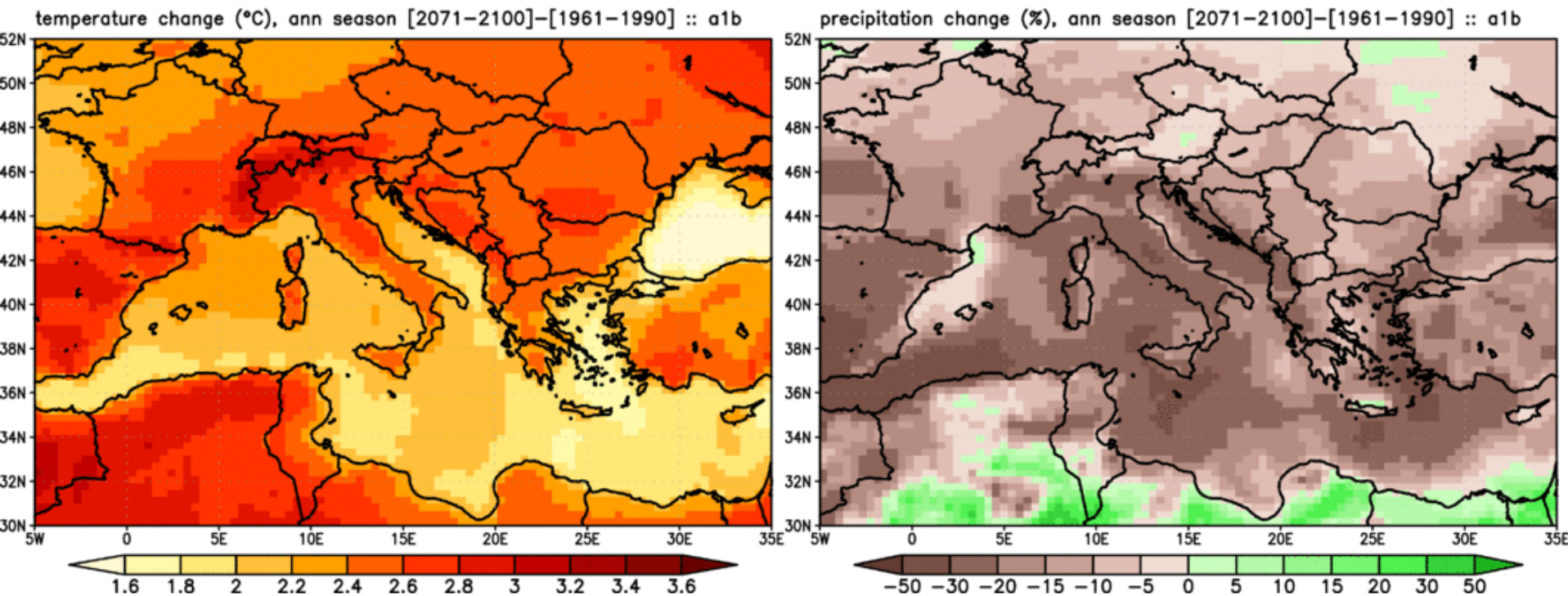
precipitation change (%), ann season [2001–2030]–[1961–1990] :: a1b



# Scenario A1B:2071-2100

## Annual temperature and precipitation change with respect to 1961-1990

**Serbia:**  
**Temperature change  $\sim +2.8^{\circ}\text{C}$**   
**Precipitation change -10%**



# A1B and A2 for Serbia

## Temperature (seasonal and annual change)

	A1B 2001–2030	A1B 2071–2100	A2 2071–2100
DJF	0.5 – 1.0	1.8 – 2.2	2.6 – 3.6
MAM	1.0 – 1.2	2.4 – 2.8	3.6 – 4.0
JJA	1.2 – 1.4	3.2 – 3.6	4.2 – 4.6
SON	0.5 – 0.9	1.8 – 2.2	2.6 – 3.2
YEAR	0.8 – 1.1	2.4 – 2.8	3.4 – 3.8

## Precipitation (seasonal and annual change)

	A1B 2001–2030	A1B 2071–2100	A2 2071–2100
DJF	–10 – 5	–20 – 0	–15 – 15
MAM	–15 – 15	–15 – 10	–30 – 0
JJA	–5 – 30	–30 – 5	–50 – 10
SON	–10 – 20	–30 – 5	–30 – 10
YEAR	–5 – 10	–15 – 0	–15 – 5

# Comparison with other models – uncertainty

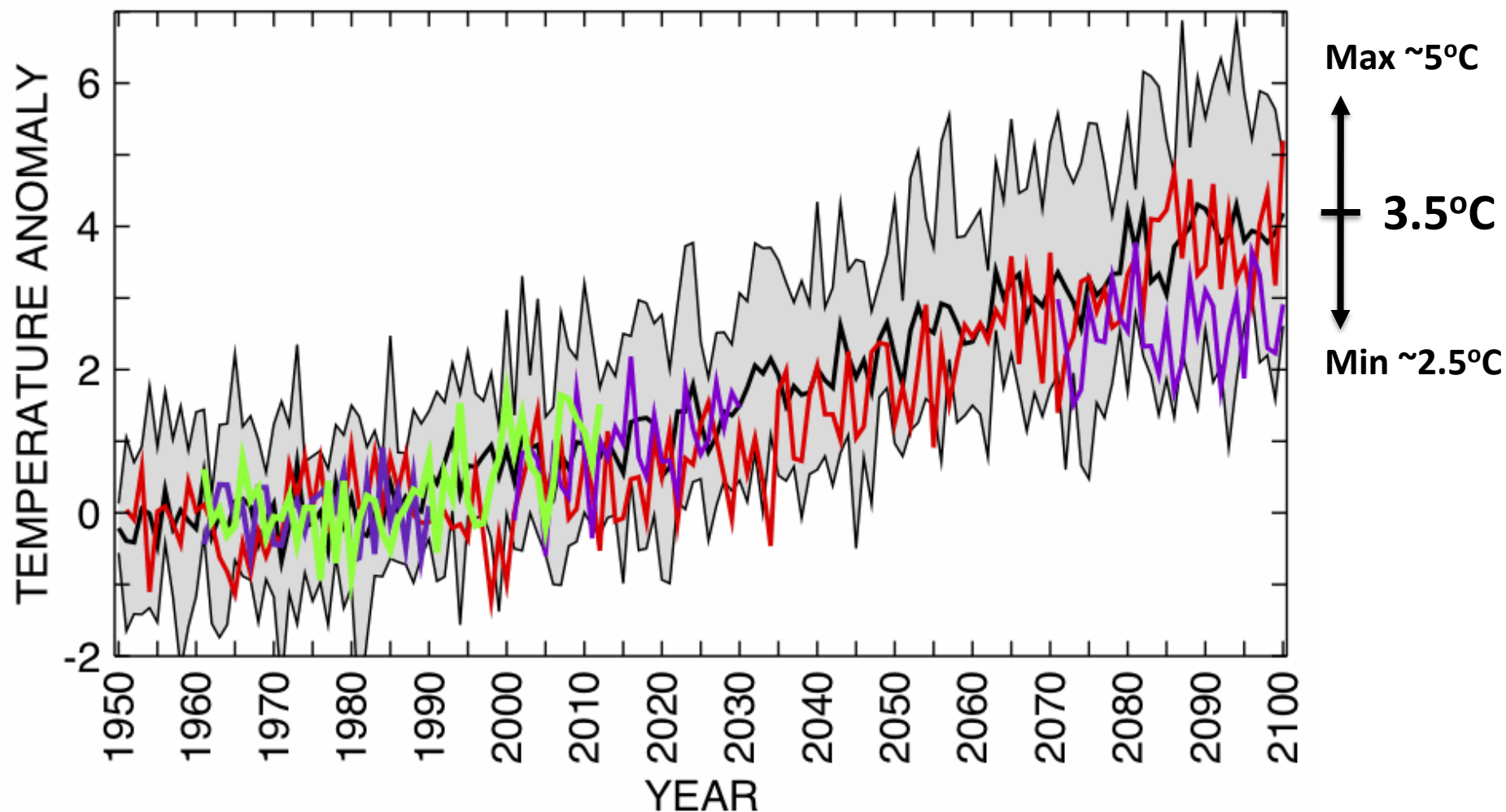
## Temperature anomaly for Serbia from 16 models 1950-2100

### SRES A1B

ENSEMBLES  
RCMs (16)

MAX  
MEAN  
MIN

EBUPOM - ECHAM5  
EBUPOM - SXG  
OBSERVED



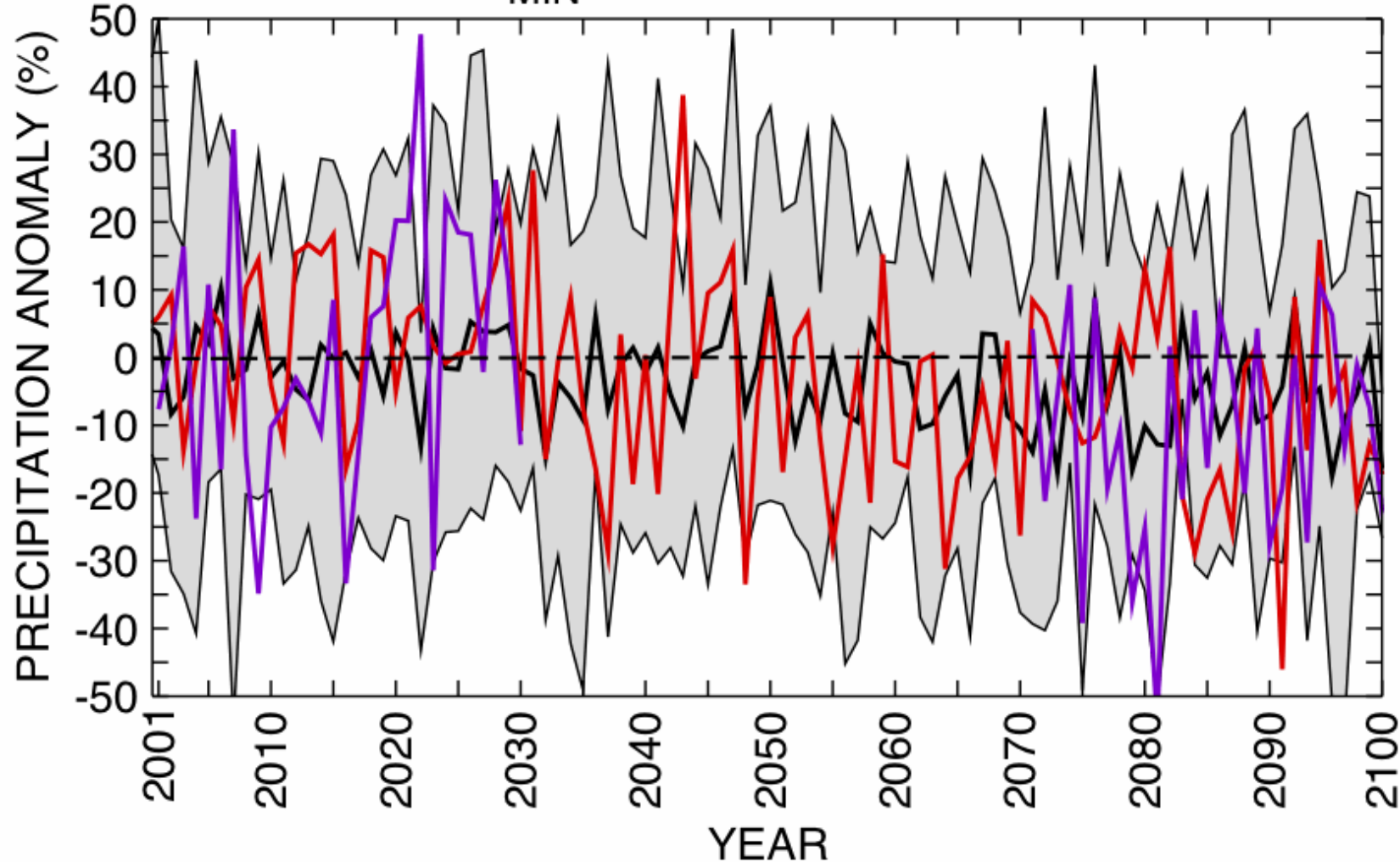
# Comparison with other models – uncertainty

## SRES A1B

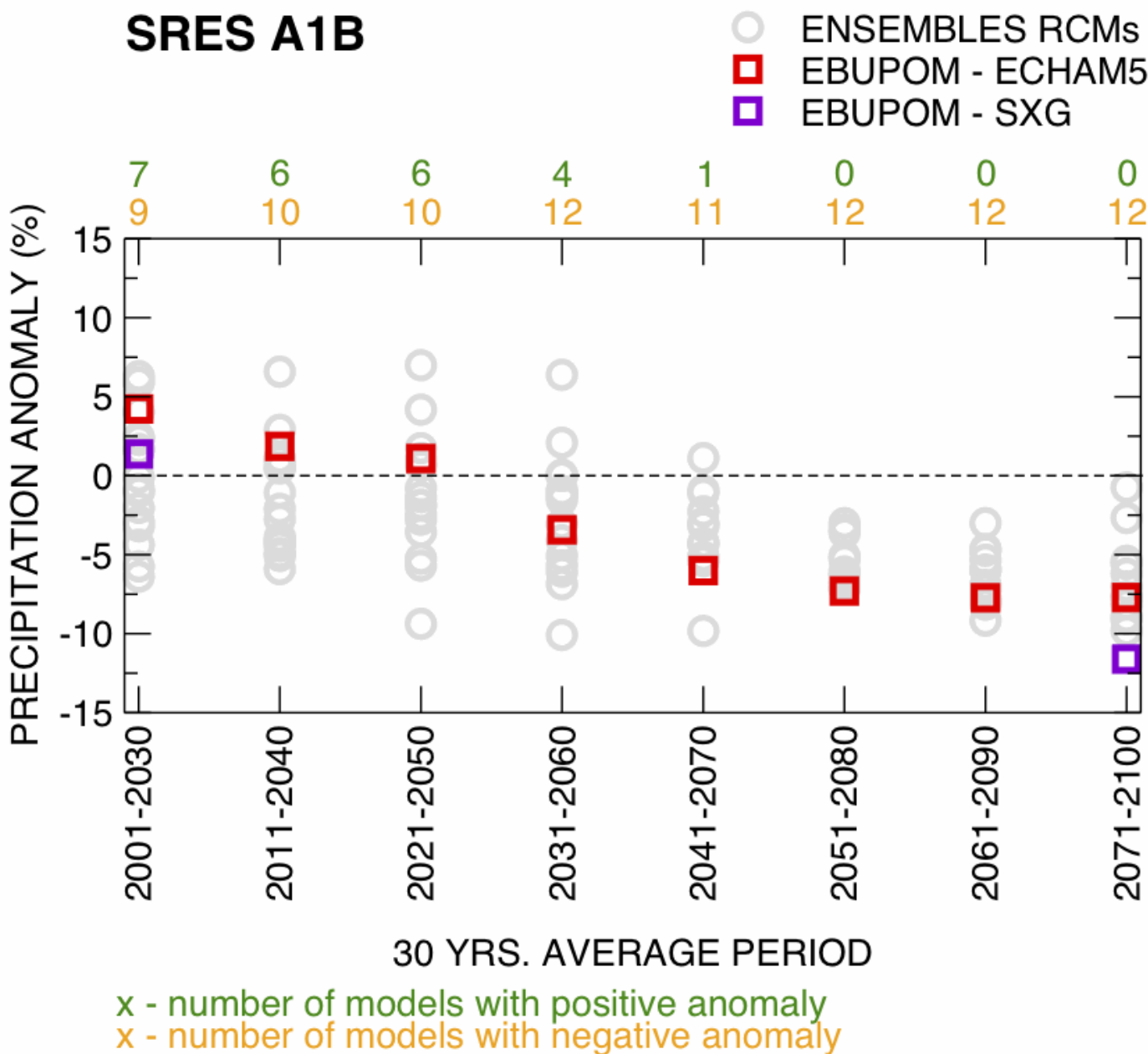
ENSEMBLES  
RCMs (16)

MAX  
MEAN  
MIN

EBUPOM - ECHAM5  
EBUPOM - SXG



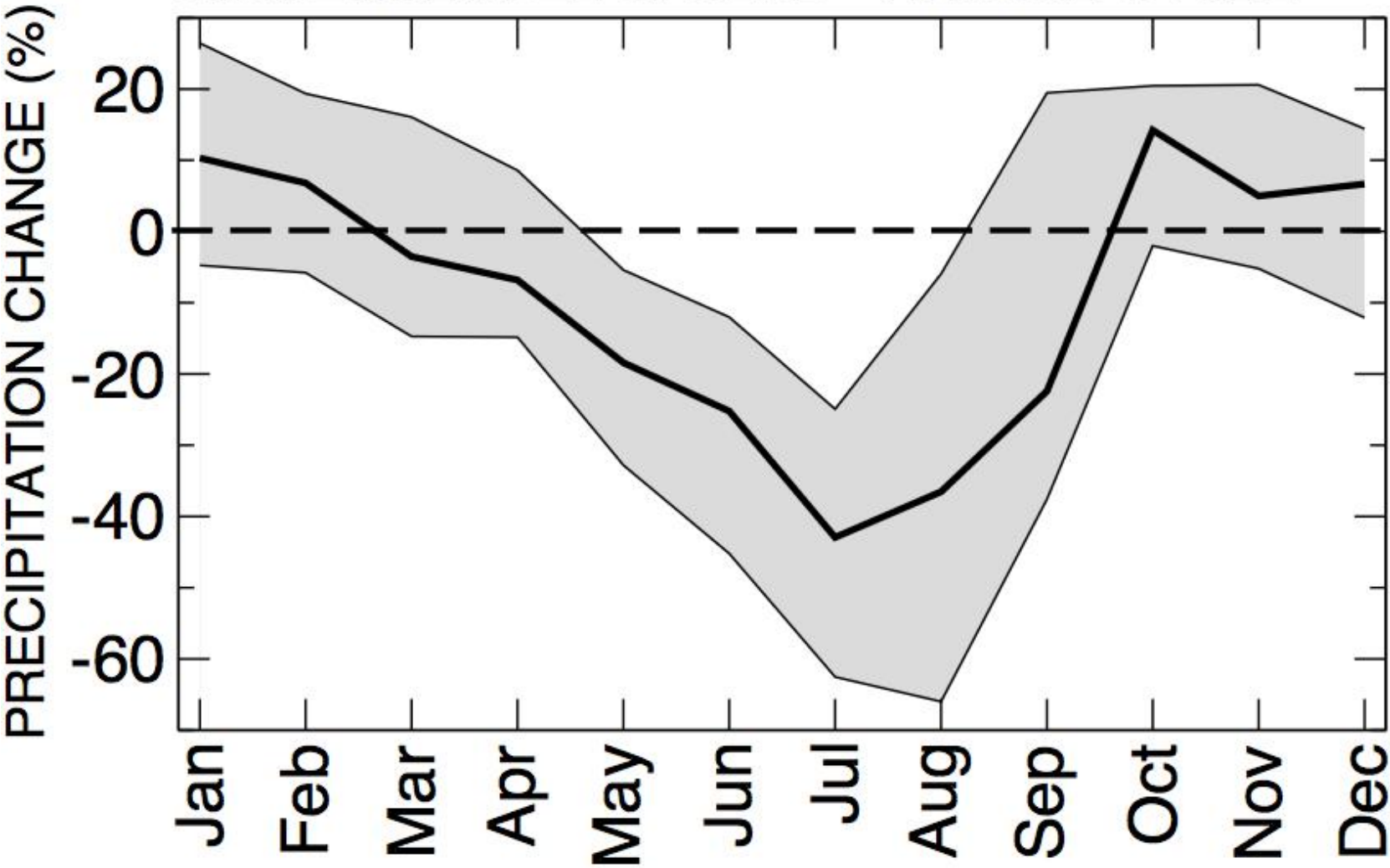
# Comparison with other models – uncertainty



# Comparison with other models – uncertainty

**SRES A1B 2071-2100**

**RCM ENSEMBLE SPREAD - ANNUAL CYCLE**



# Changes of climate indices

**FD** - number of frost days

daily minimum temperature  $< 0^{\circ}\text{C}$

**SU** - number of summer days

daily maximum temperature  $> 25^{\circ}\text{C}$

**TR** - number of tropical nights

daily minimum temperature  $> 20^{\circ}\text{C}$

**GSL** - growing season length

count of days between first span of at least six days where daily mean temperature  $> 5^{\circ}\text{C}$  and first span in second half of the year of at least six days where daily mean temperature  $< 5^{\circ}\text{C}$

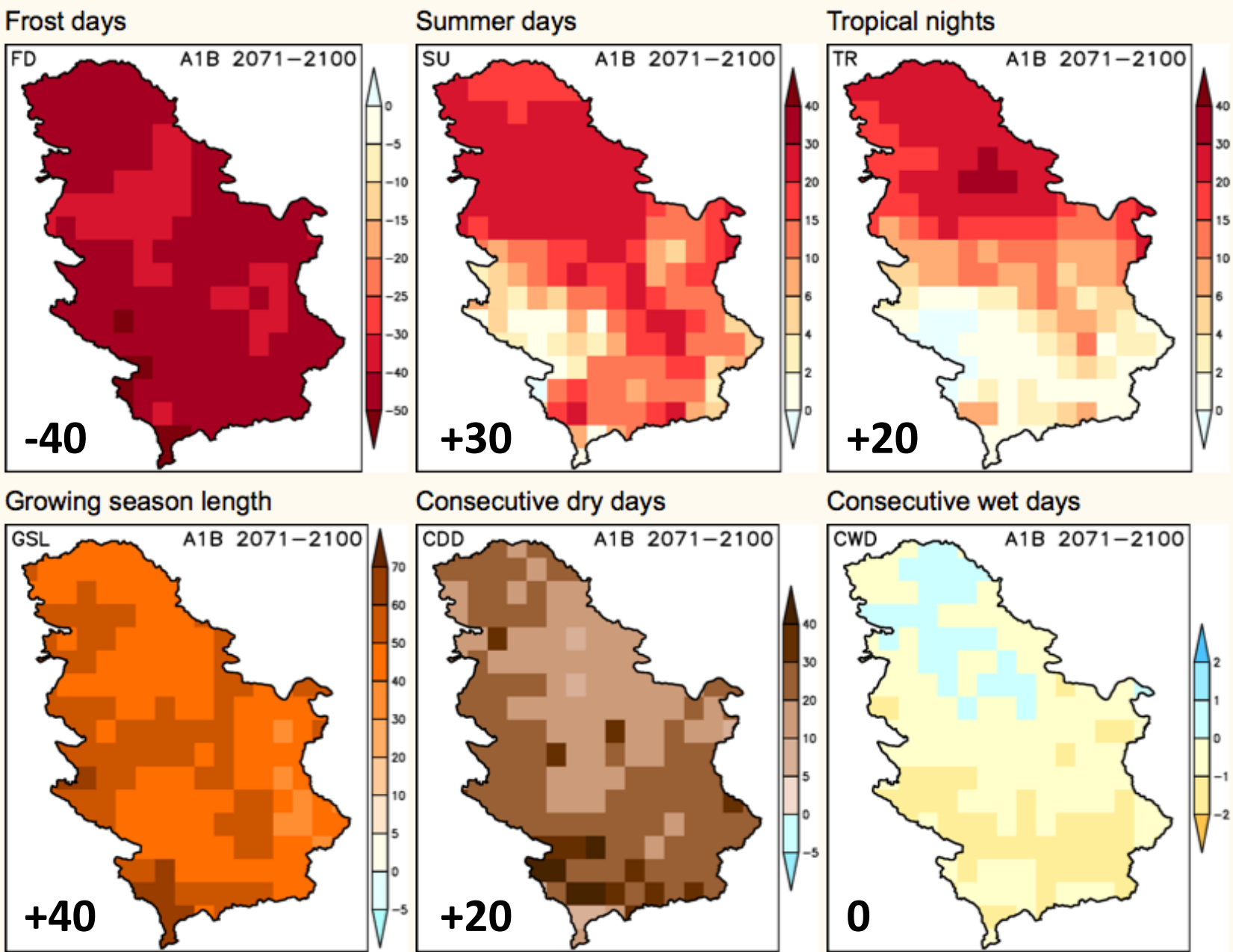
**CDD** - consecutive dry days

maximum length of dry spell (daily precip  $< 1\text{ mm}$ )

**CWD** - consecutive wet days

maximum length of wet spell (daily precip  $\geq 1\text{ mm}$ )

# Changes of climate indices



# **Calculate impact**

## **First approach:Indices**

### **Examples:**

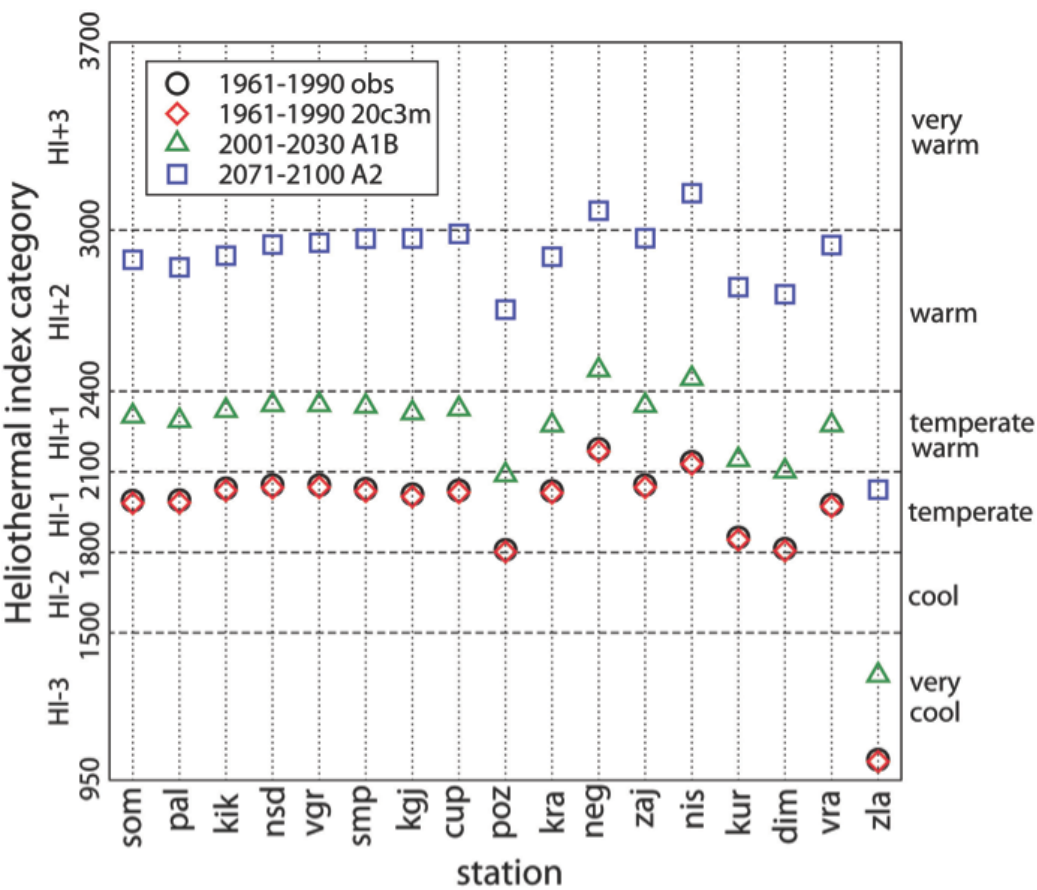
- **Grape/vine production**
- **Agriculture production**

# Impact: Grape and vine production (Ruml et al, 2012)

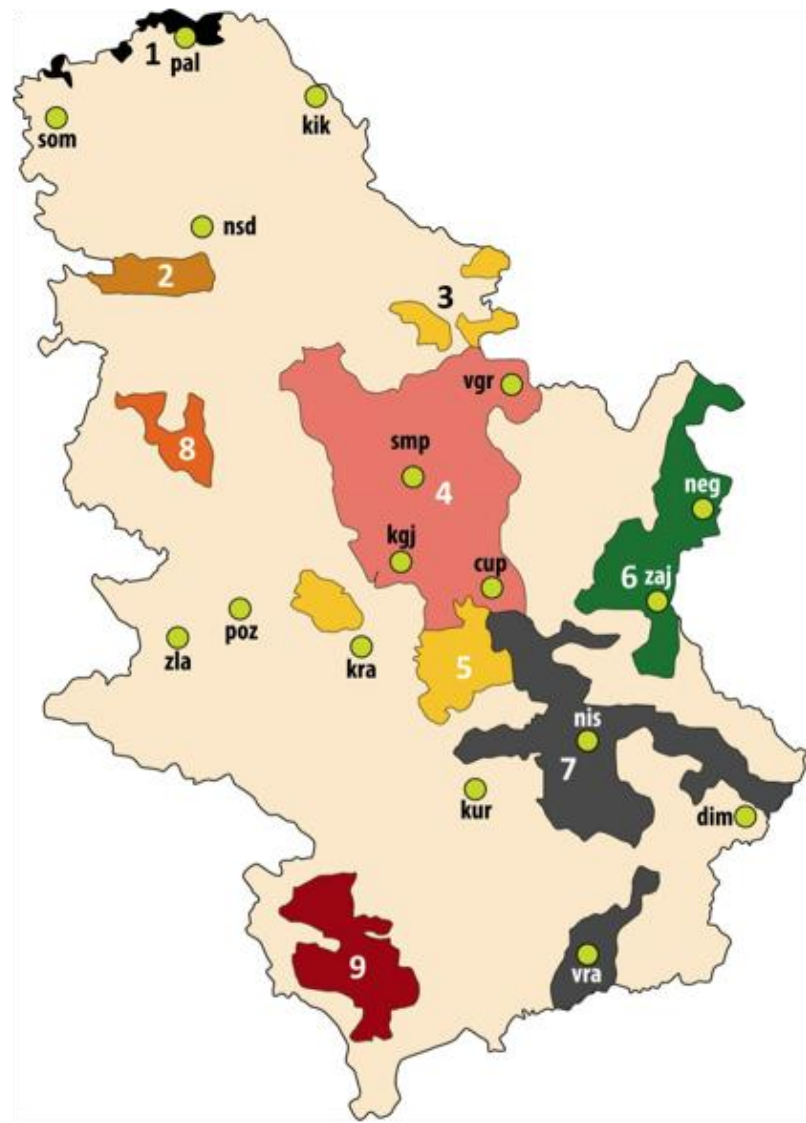
Model results are BIAS corrected for more precise assessment on possible climate impact.

Impact is presented using climate indices specially defined for vineyard classification.

- Heliothermal index (temperature)
- Dryness index (precipitation & evapo)
- Cool night index (Sept. temperatures)



## Traditional vine production regions in Serbia

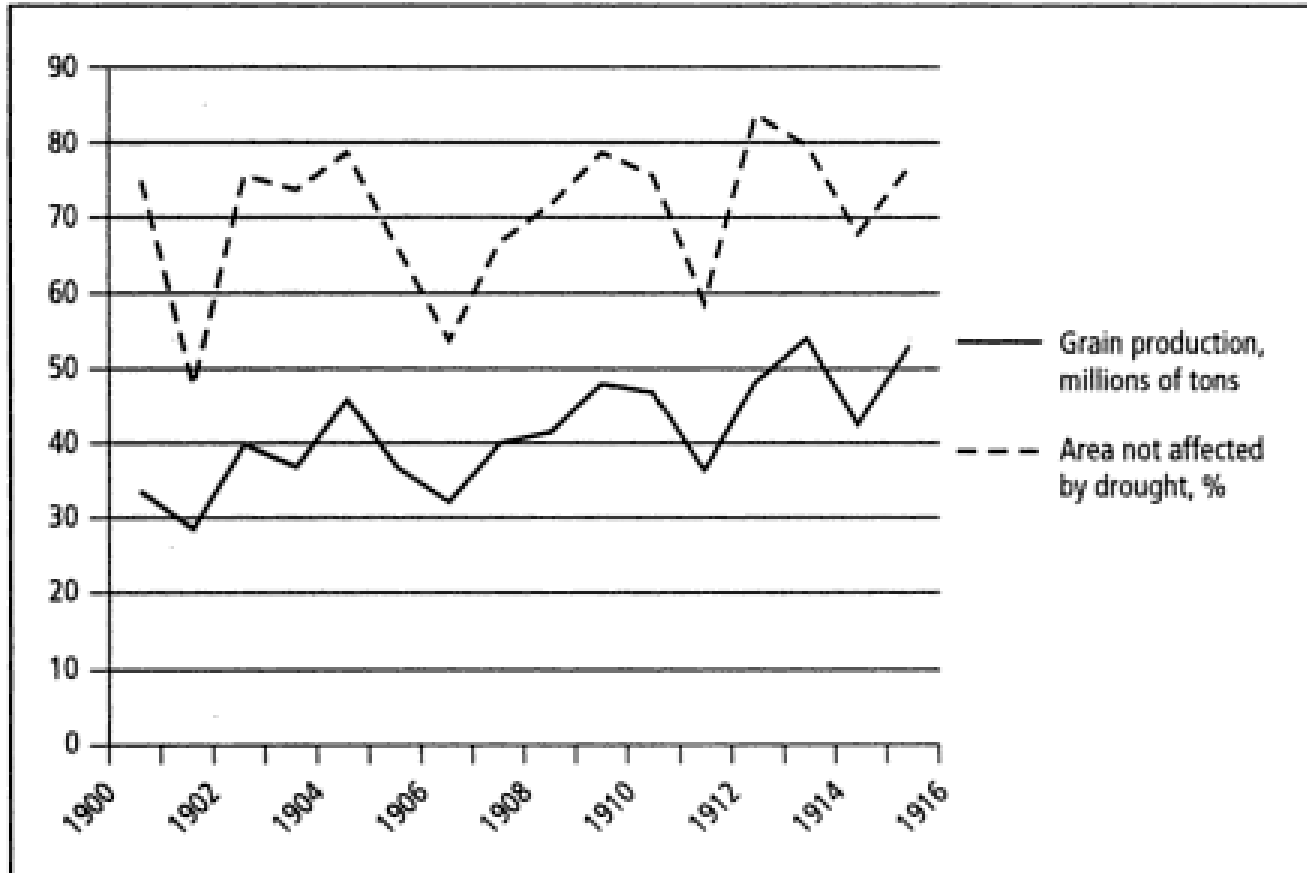


# Impact: Agriculture production

## Hydrothermal coefficient – HTC (Seljaninov,1966)

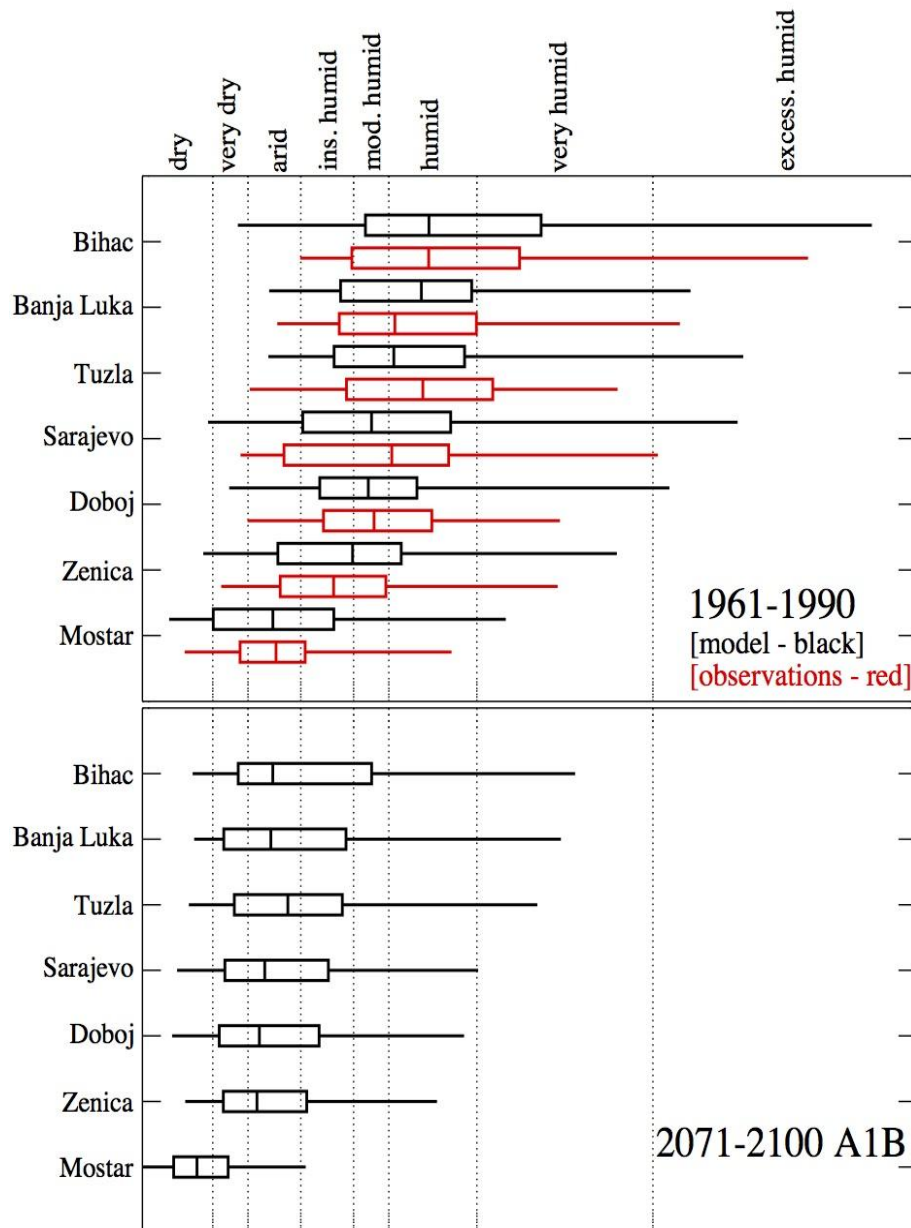
0.4 - 0.7	very dry
0.7 - 1.0	dry
1.0 - 1.3	insufficiently wet
> 1.3	wet

Figure 3.2. Gross grain production and scale of drought in European Russia, 1900–1915



Source:  
Dronin and Bellinger, 2005

# Impact: Agriculture production



## HTC in Bosnia and Herzegovina

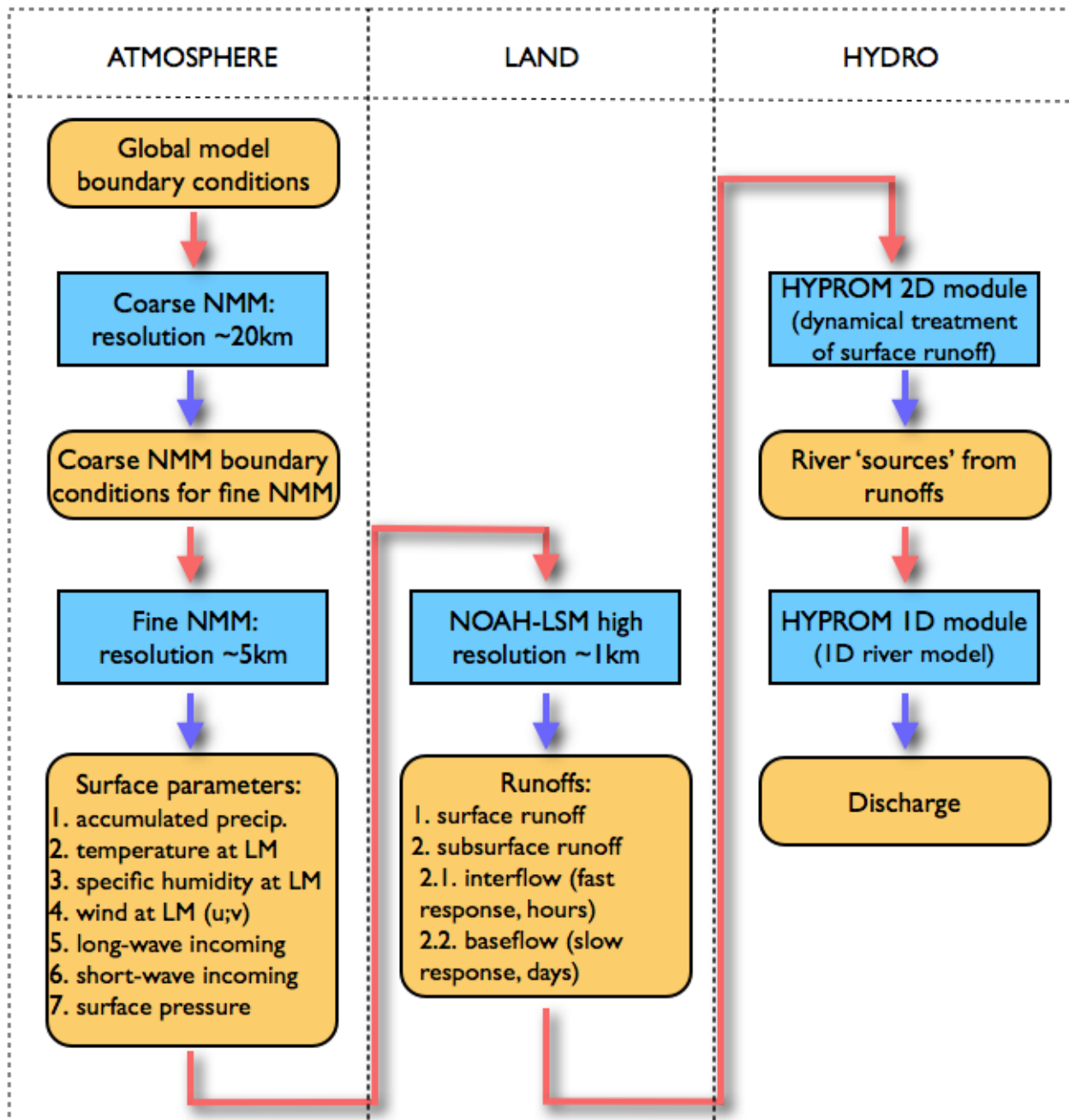
Source:  
Trbic and Djurdjevic, 2012

**Calculate impact**

**Second approach: Keep on modeling**

**Examples:**

- **Hydrology**

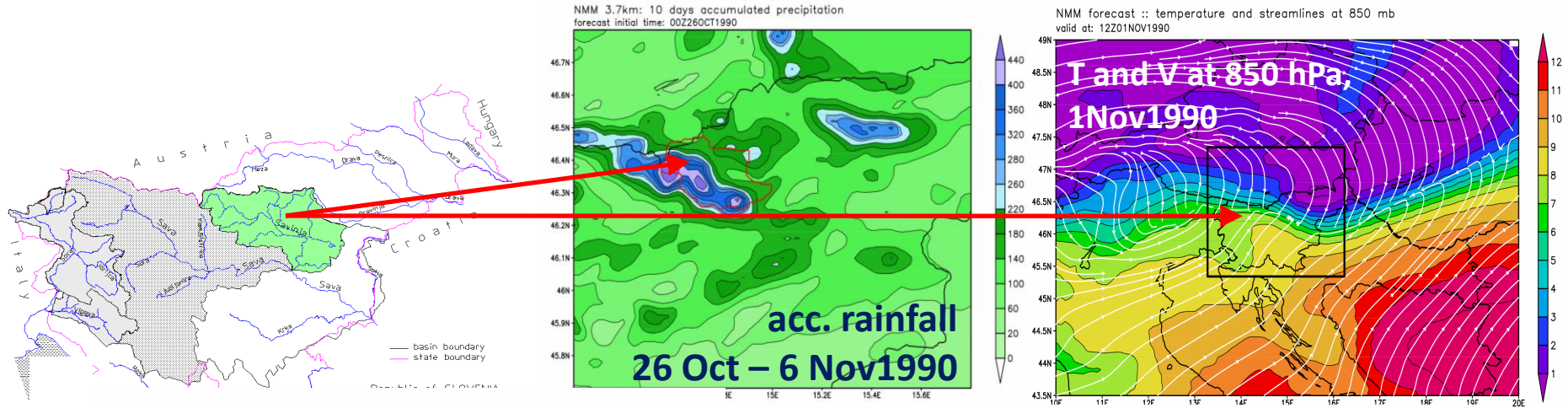


**More nesting and downscaling!**

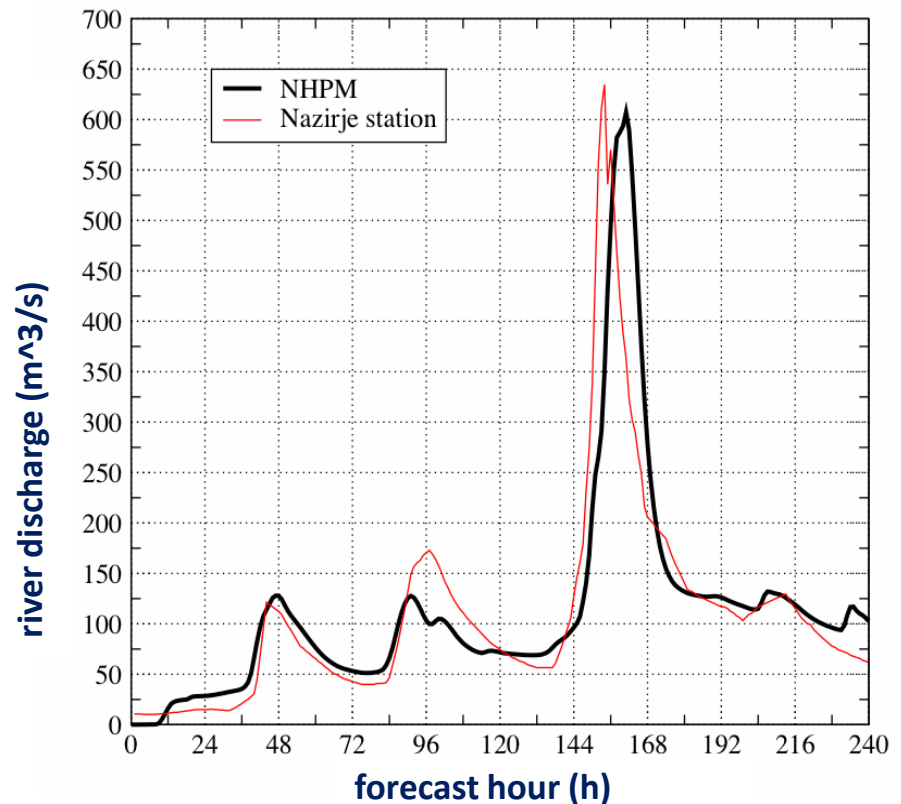
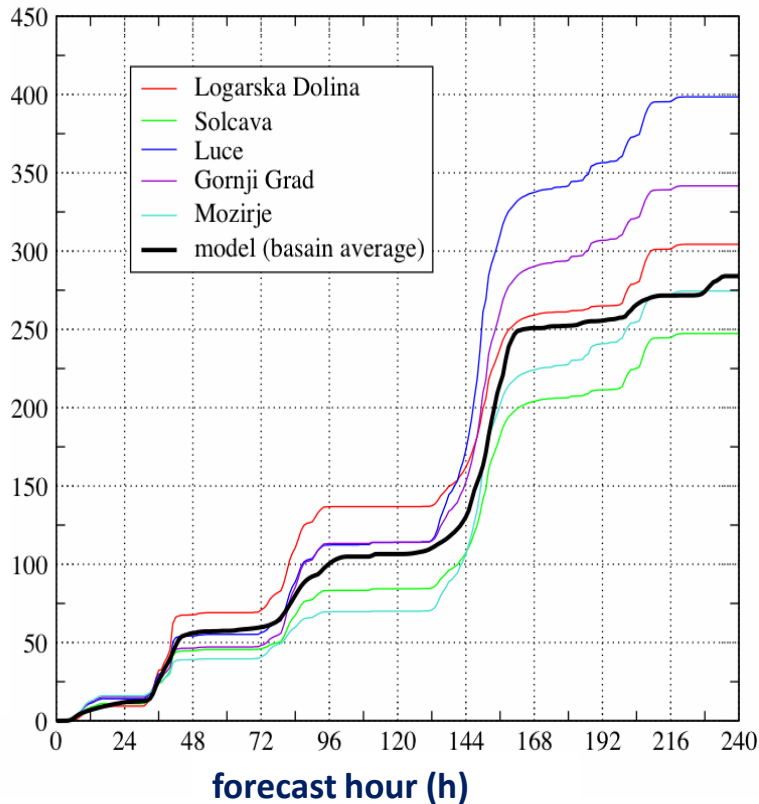
**Combination of:**  
**NMMB - Atmosphere**  
**NOAH – Surface**  
**HYPROM - Hydrology**

**HYPROM – Dynamical hydrology model**  
(Nickovic et al, 2011)

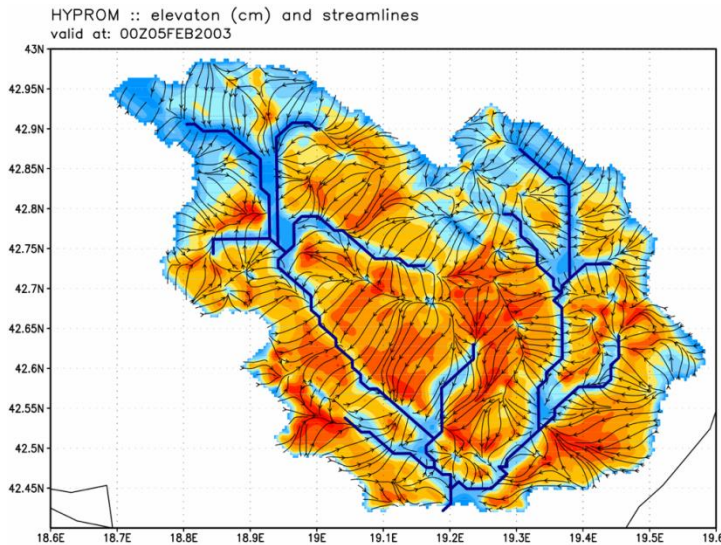
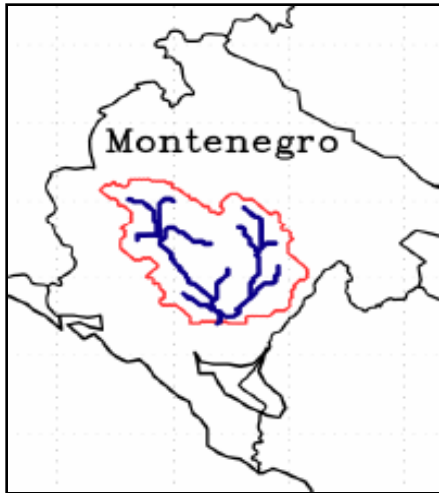
# Slovenia - Savinja river 26/10 – 6/11 1990



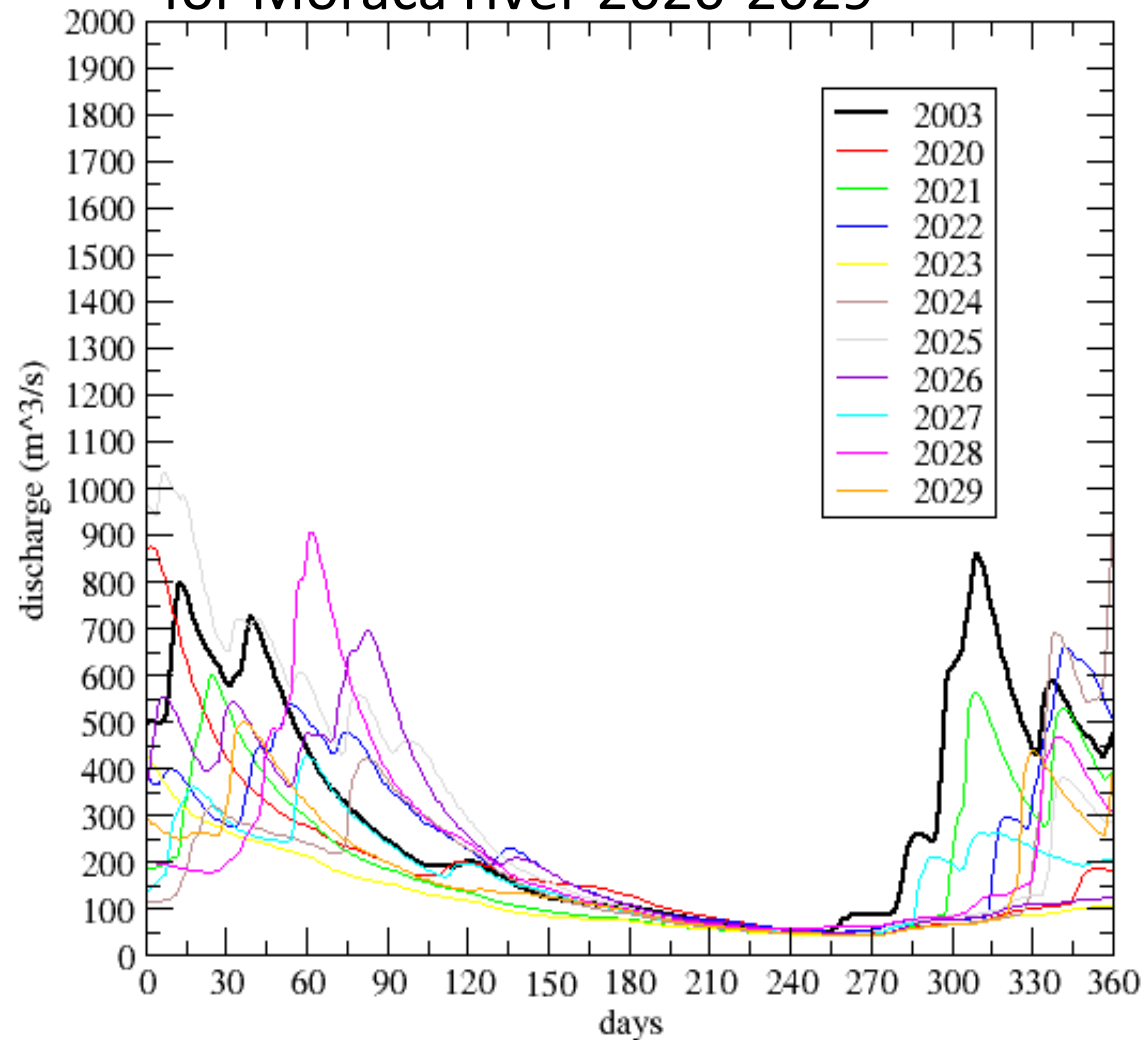
model vs. observations  
accumulated precipitation (mm)



# HYPROM – climate simulation

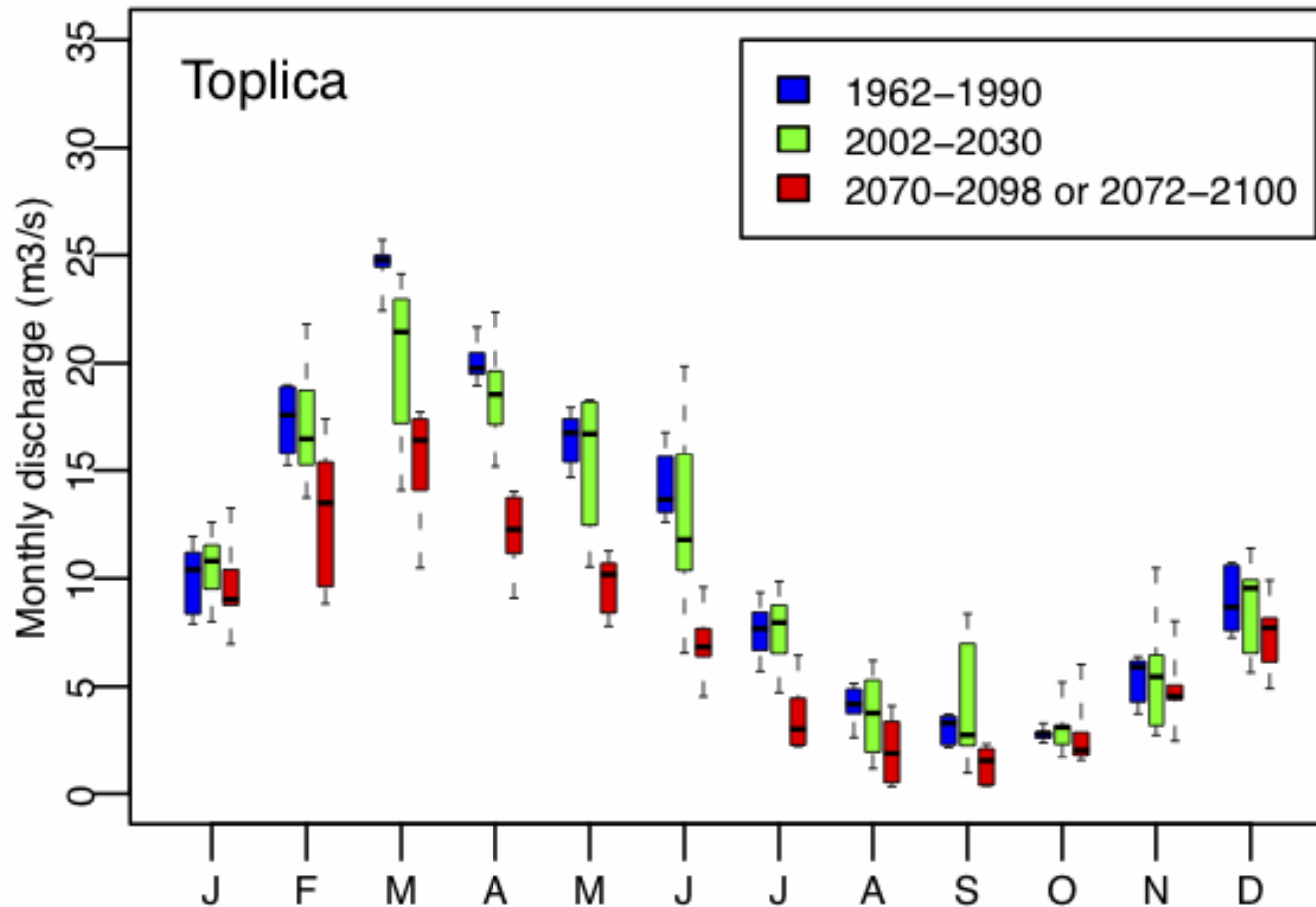


## Climate simulations for Morača river 2020-2029



# HBV model – climate simulation

## Project: Effects of climate change in the Kolubara and Toplica catchments, Serbia (NVE, RHMSS, SEEVCC)



Source:  
IngjerdHaddeland (Ed.)  
2013.

*Distribution of monthly mean discharge values  
for the six RCM-HBV combinations in the  
Toplica catchment.*

# **Conclusions on the future climate**

## **Following A1B**

- **+3.5°C temperature increase**
- **-10% decrease in annual precipitation**
- **-50% in summer precipitation**
- **intensification of extremes**
- **serious impact on many sectors**