Central and Eastern Europe Climate Change Impact and Vulnerability Assessment

Specific targeted research project

1.1.6.3.I.3.2: Climate change impacts in central-eastern Europe

D2.4: RCM simulations forced by models

Due date of deliverable: 1st December 2008
Actual submission date: 3th May 2009

Start date of project: 1st June 2006 Duration: 36 months

Lead contractor for this deliverable: OMSZ

Revision (final)

Project co-funded by the European Commission within the Sixth Framework Programme (2002-2006)		
Dissemination Level		
PU	Public	X
PP	Restricted to other programme participants (including the Commission Services)	
RE	Restricted to a group specified by the consortium (including the Commission Services)	
CO	Confidential, only for members of the consortium (including the Commission Services)	

Participant id	RCM	LBC (driving model)	Resolution of LBC	RCM domain	STATUS			Short summary	Remarks
					1961-1990	2021-2050	2071-2100		
CHMI	ALADIN-CLIMATE/CZ	ARPEGE-CLIMAT	~50 km	LON: 7 – 27 E LAT: 44 – 51 N	READY	READY	READY	D2.4_CHMI	Historic run integrated additionally to 2000 as in case of ERA
CUNI	RegCM 3	ERA40 double-nested from 25km ICTP RegCM run	1 deg (25km)	184x164 gridpoints, ds=10km, central point: 49.0N, 15.8E	READY	READY	READY	D2.4_CUNI	1991-2000 ready
ELU	RegCM 3	ERA40 double-nested from 25km ICTP RegCM run	1 deg (25km)	120x100 gridpoints, ds=10km, central point: 47.5 N, 18.5 E	READY	READY	READY	D2.4 ELU	1991-2000 ready
NIMH	ALADIN-CLIMATE	ARPEGE-CLIMAT	~50 km	LON: 20.5-30 E LAT: 39-46 N	READY	READY	READY	D2.4_NIMH	1961-2000: LBC: ERA-40
NMA	RegCM 3	ERA40 double-nested from 25km ICTP RegCM run	1 deg (25km)	ds=10km, central point: 46 N, 25 E	READY	READY	READY	D2.4_NMA	1961-2000: LBC: ERA-40 ready
OMSZ	ALADIN-CLIMATE	ARPEGE-CLIMAT	~50 km	lat: 44.64 –50.01 N lon: 12.44 –25.22 E	READY	READY	READY	D2.4_OMSZ	1961-2000: LBC: ERA-40

OMSZ

Hungarian Meteorological Service

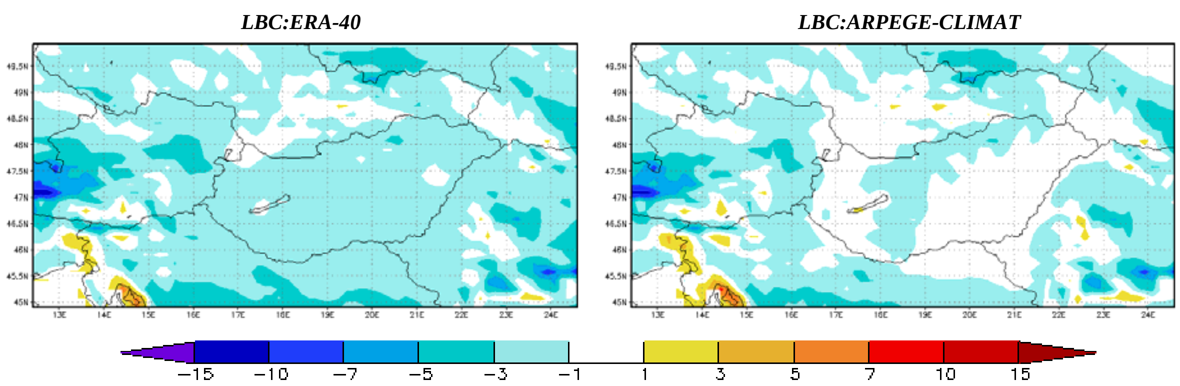
1. ALADIN-Climate – basic description:

- Model version: **ALADIN-Climate V4.5**
- Domain: **Charpatian Basin** (lat: 44.64 – 50.01 N; lon: 12.44 – 25.22 E)
- Horizontal resolution: **10 km**
- Integration period: **1960-1990; 2020-2050**; **2070-2100**
- Evaluation period: **1961-1990; 2021-2050**; **2071-2100**
- LBC: **ARPEGE-CLIMAT;** coupling: **6h**
- Dynamics: Spectral model
  Hydrostatic
  Hybrid vertical coordinates
  SISL advection scheme
  LBC: Davies-scheme
  Prognostic variables: surface pressure
  temperature
  horizontal wind components
  specific humidity
- Physics: FMR radiation scheme
  ISBA scheme for soil
  Bougeault scheme for deep convection
  Ricard and Royer scheme for large scale cloudiness
  Smith scheme for large scale precipitation

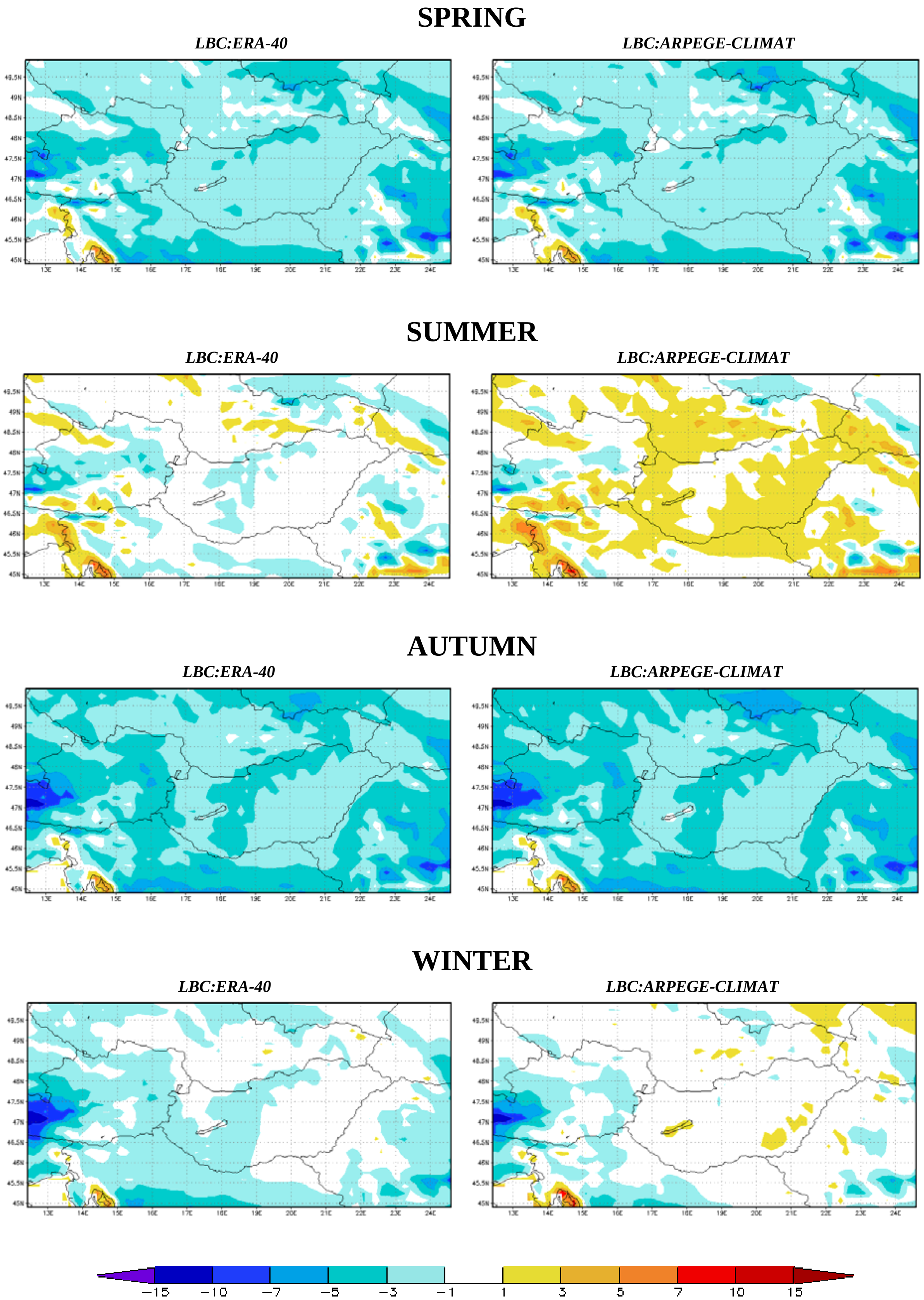
2. **RESULTS (1961-1990)** – preliminary results

- **<u>Temperature</u>** *(ALADIN – CRU(10')[^{o}C])*

Difference of annual mean temperature



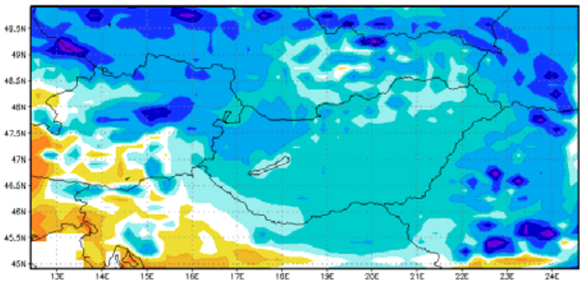
Difference of seasonal mean temperature



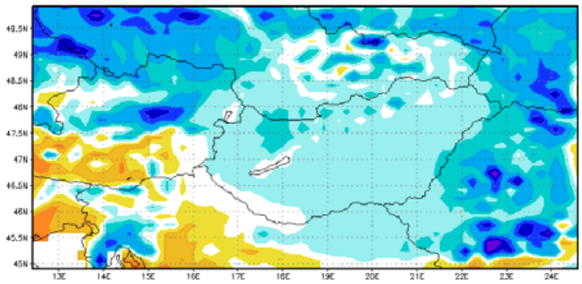
- **Precipitation** *([ALADIN– CRU(10’)]/CRU(10’) [%])*

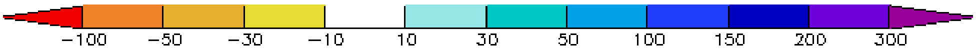
Annual relative difference of precipitation

LBC:ERA-40



LBC:ARPEGE-CLIMAT

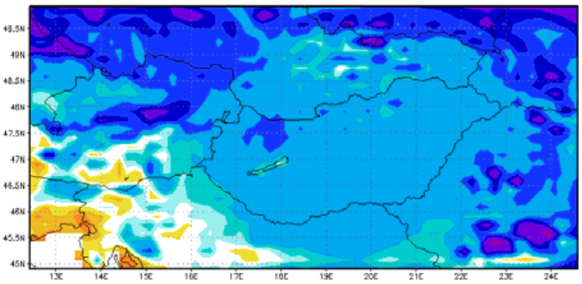




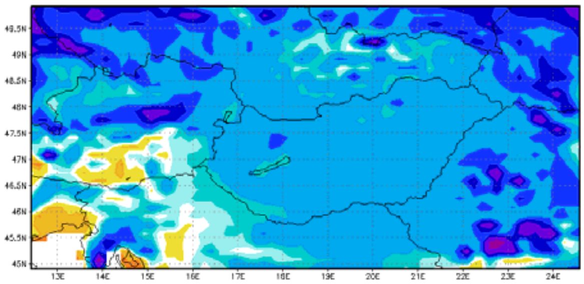
Seasonal relative difference of precipitation

SPRING

LBC:ERA-40

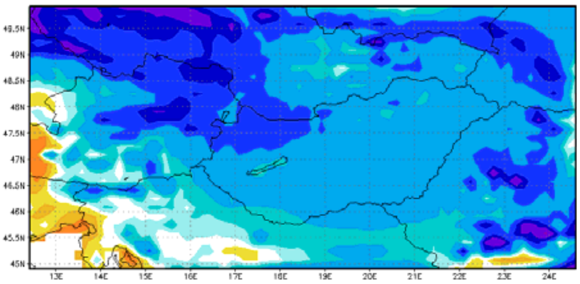


LBC:ARPEGE-CLIMAT

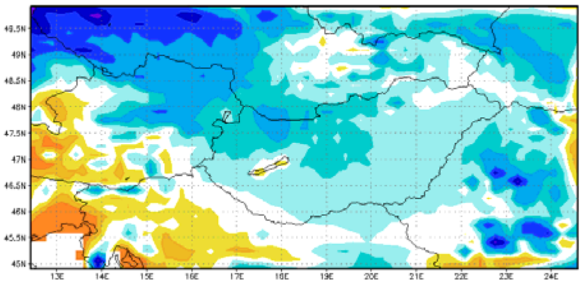


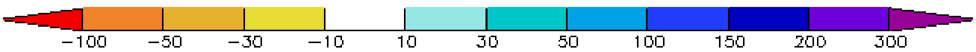
SUMMER

LBC:ERA-40



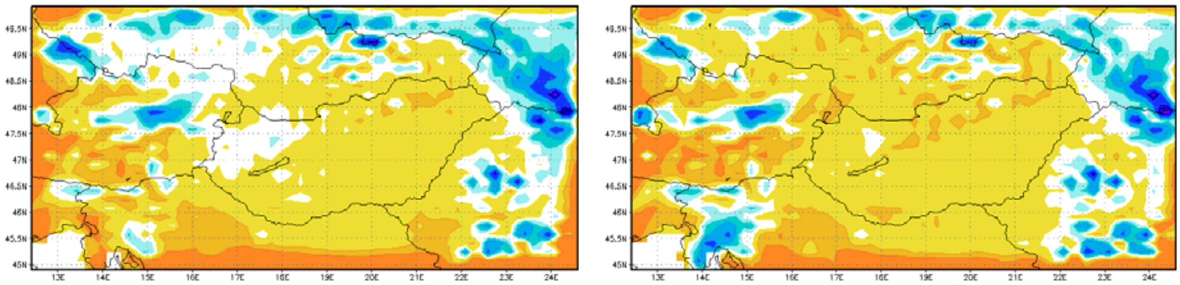
LBC:ARPEGE-CLIMAT





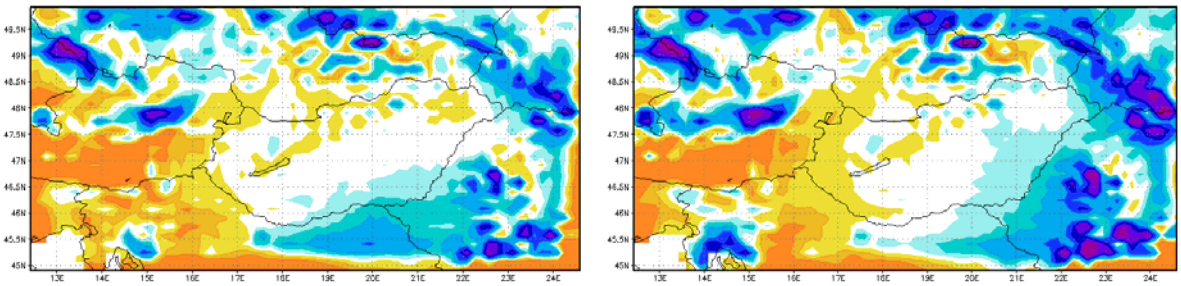
AUTUMN

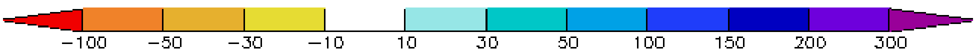
LBC:ERA-40 *LBC:ARPEGE-CLIMAT*



WINTER

LBC:ERA-40 *LBC:ARPEGE-CLIMAT*

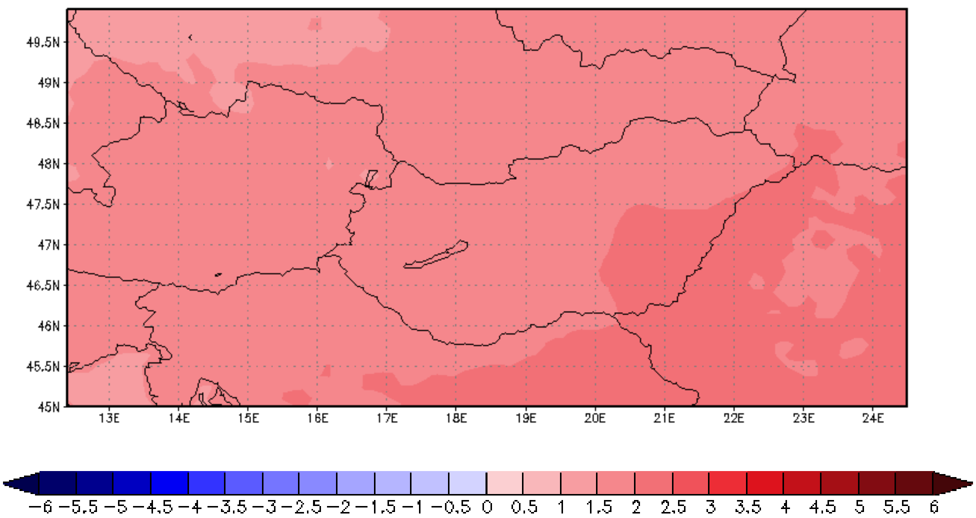




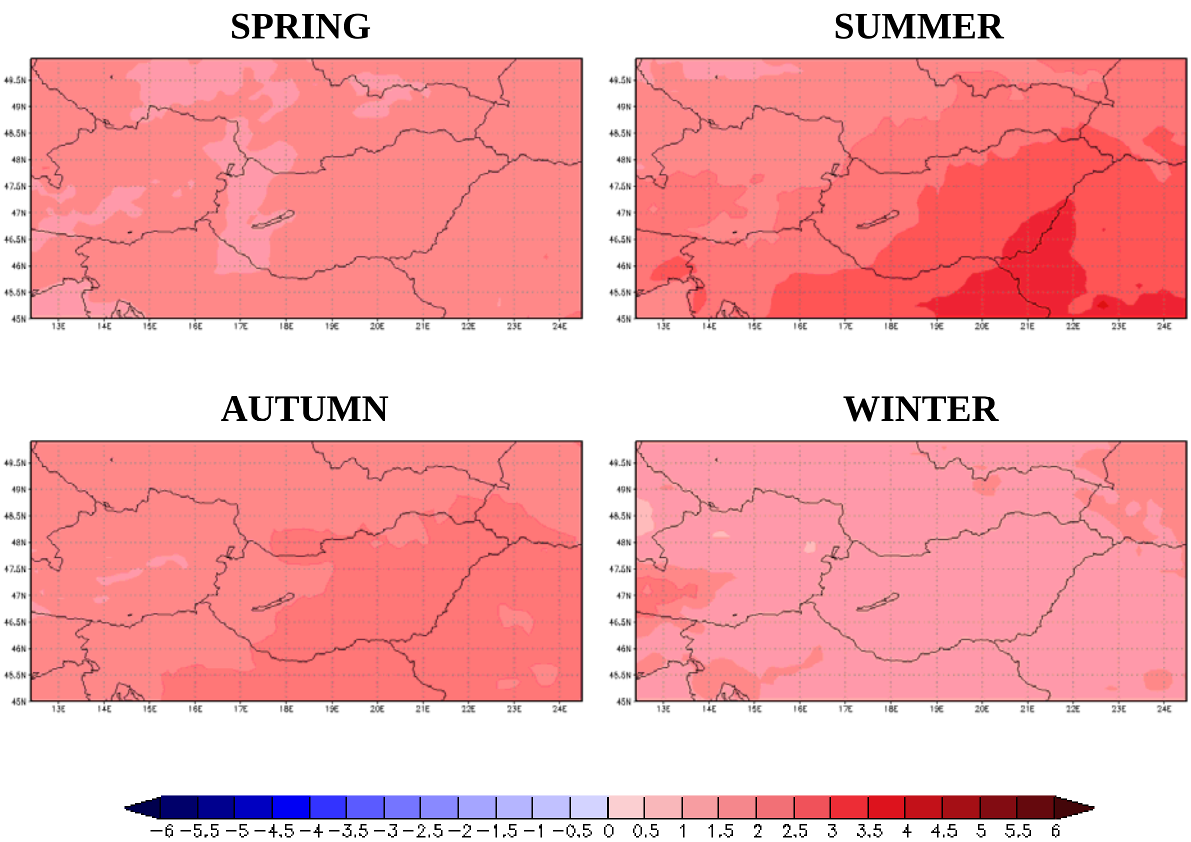
3. FIRST RESULTS (2021-2050)

- **<u>Temperature</u>** *(ALADIN$_{2021\text{-}2050}$(LBC:ARP) – ALADIN$_{1961\text{-}1990}$(LBC:ARP))*

Difference of annual mean temperature



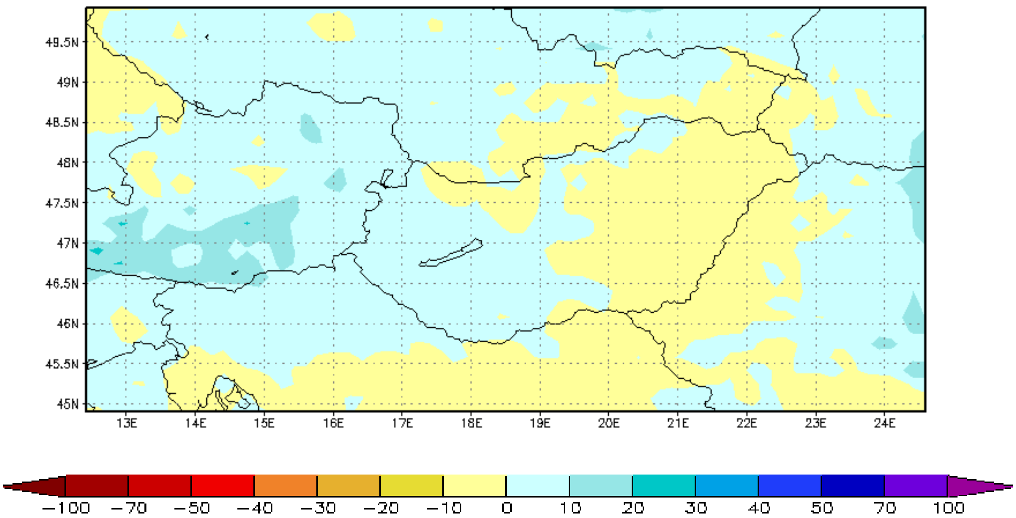
Difference of seasonal mean temperature



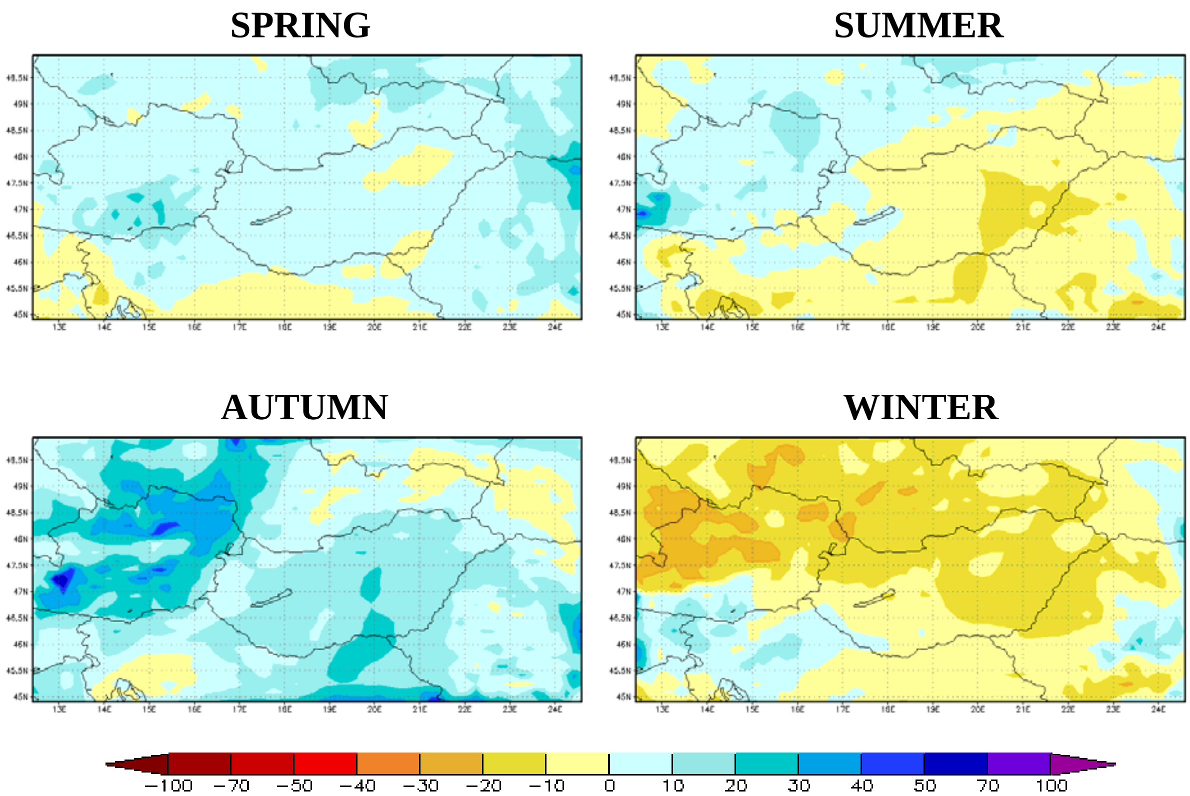
- **<u>Precipitation</u>**

((ALADIN$_{2021\text{-}2050}$(LBC:ARP) – ALADIN$_{1961\text{-}1990}$(LBC:ARP))/ ALADIN$_{1961\text{-}1990}$(LBC:ARP))

Annual relative difference of precipitation



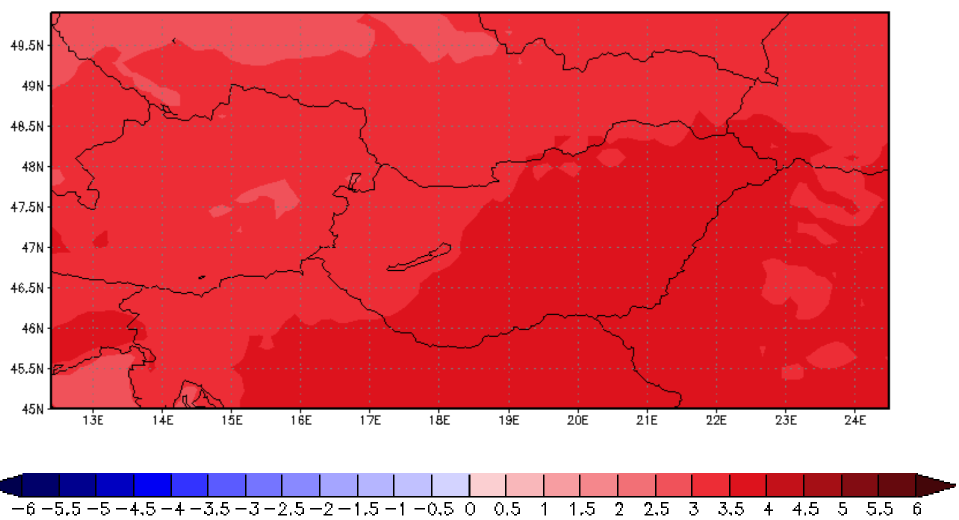
Seasonal relative difference of precipitation



4. FIRST RESULTS (2071-2100)

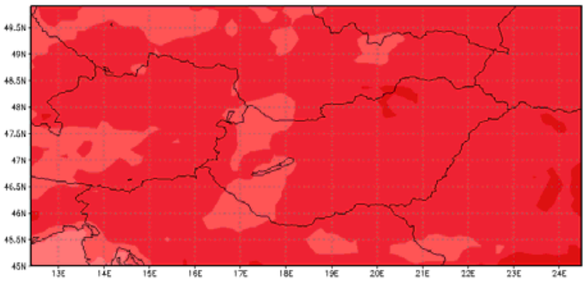
- **<u>Temperature</u>** *(ALADIN$_{2071\text{-}2100}$(LBC:ARP) – ALADIN$_{1961\text{-}1990}$(LBC:ARP))*

Difference of annual mean temperature

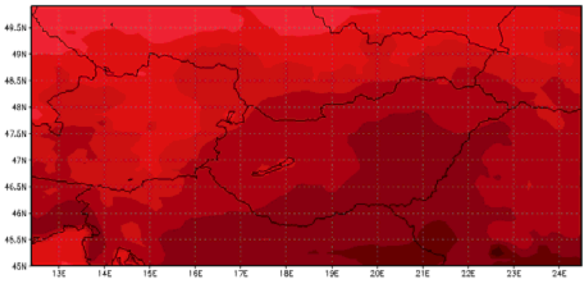


Difference of seasonal mean temperature

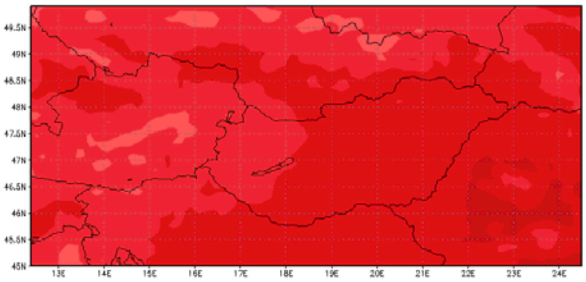
SPRING



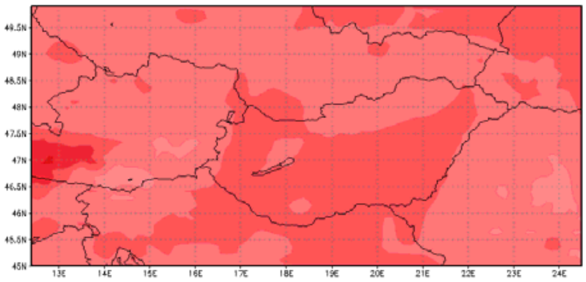
SUMMER

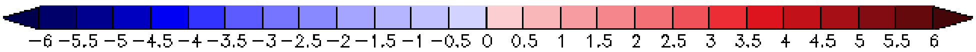


AUTUMN



WINTER

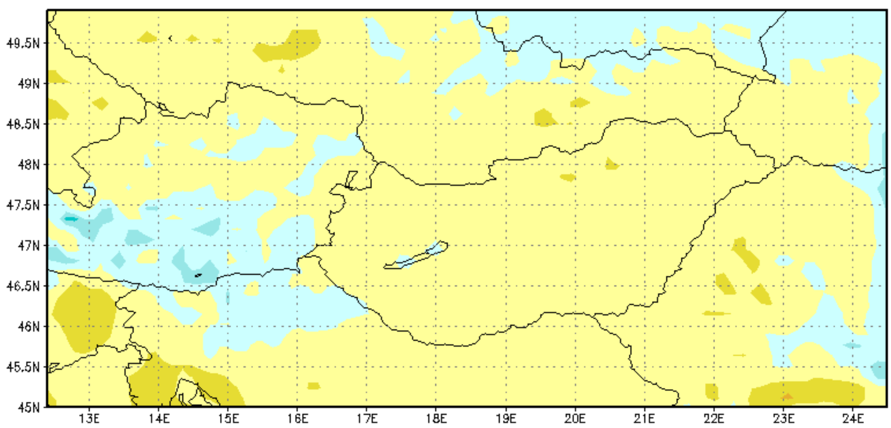


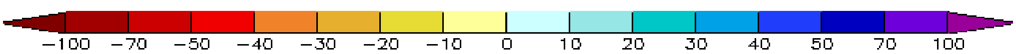


- **<u>Precipitation</u>**

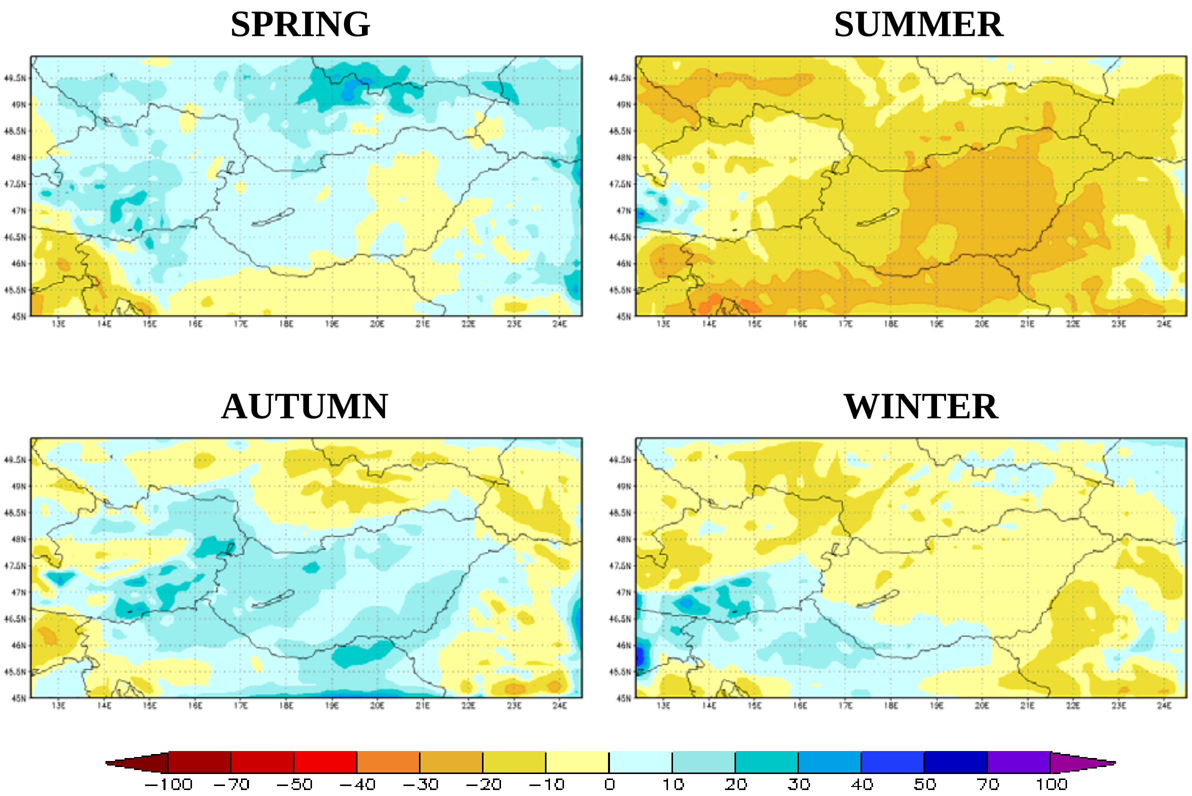
((ALADIN$_{2071\text{-}2100}$(LBC:ARP) – ALADIN$_{1961\text{-}1990}$(LBC:ARP))/ ALADIN$_{1961\text{-}1990}$(LBC:ARP))

Annual relative difference of precipitation





Seasonal relative difference of precipitation



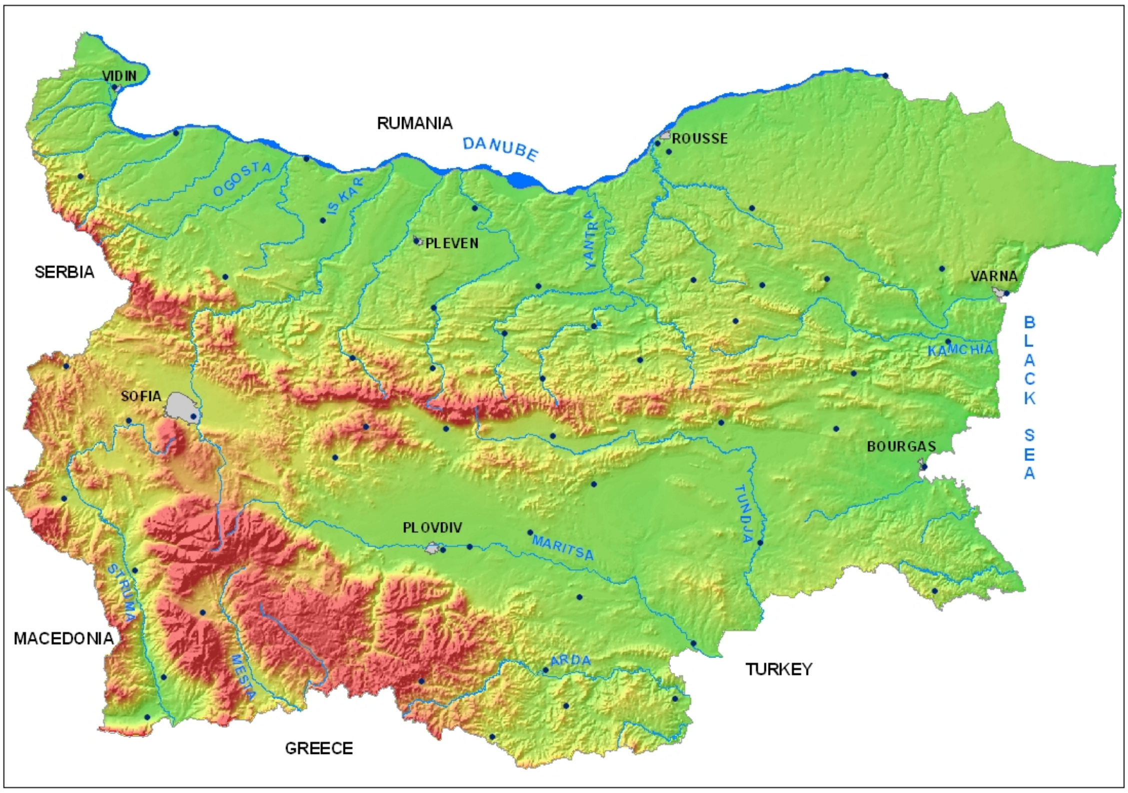
5. Planned validation (1961-1990)

- Observations: CRU (10’) (www.cru.uea.ac.uk)
  Hungarian interpolated gridded dataset (0.1 deg)
- Investigated parameters: Temperature
  Precipitation
  Diurnal temperature range
  Relative humidity (not for CRU)
  Wind speed (not for CRU)
- Validation criterion: Average fields (annual, seasonal, monthly)
  Standard deviations
  RMSE, MAE etc. (against OBS.)
  Trends (decadal means)

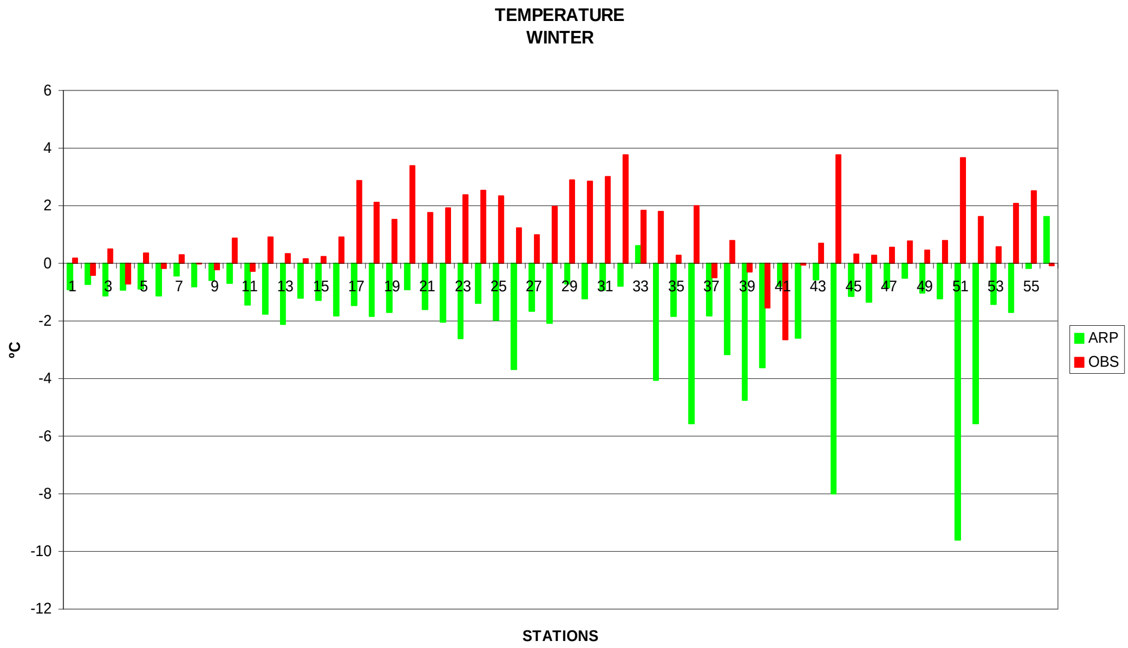
NIMH

Verification of 1960-1989 runs.

Observations from stations situated in different places with different land and topography characteristics are used for this verification. An important criterion is the quality and the period without breaks. The distribution of the chosen 56 stations is presented on the figure:



The monthly mean values over the 30 years period for temperature and precipitation are given on the next figures. The simulations with forcing from ARPEGE model are mentioned by ARP, respectively by ERA40 and OBS stays for observations from the selected 56 stations.


TEMPERATURE
WINTER
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-8
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°C
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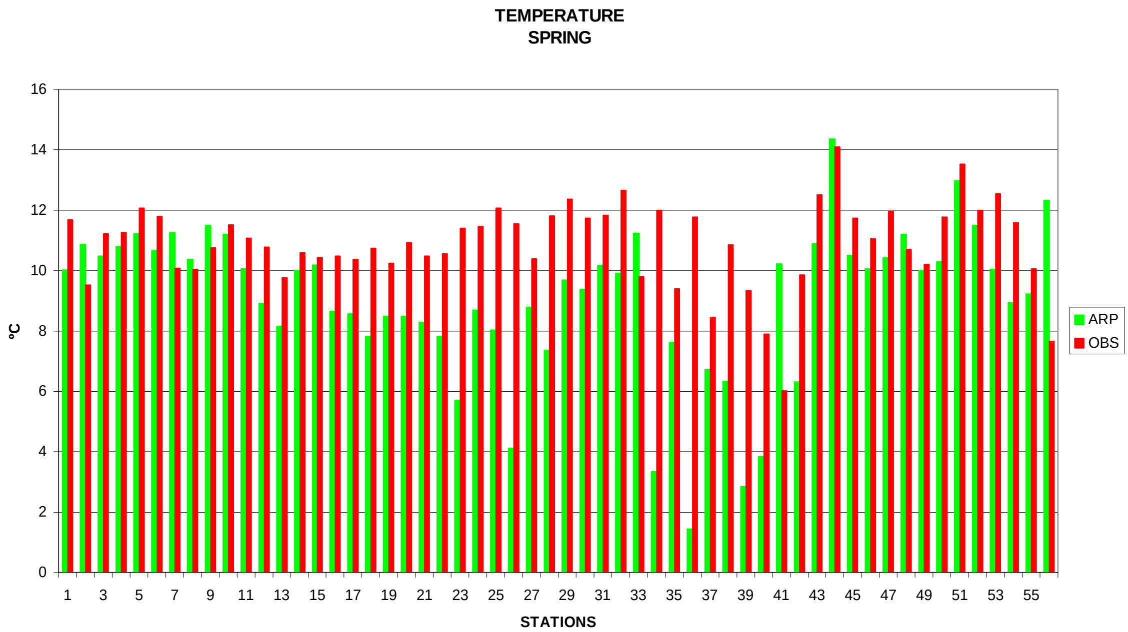
53
55
STATIONS
ARP
OBS


TEMPERATURE
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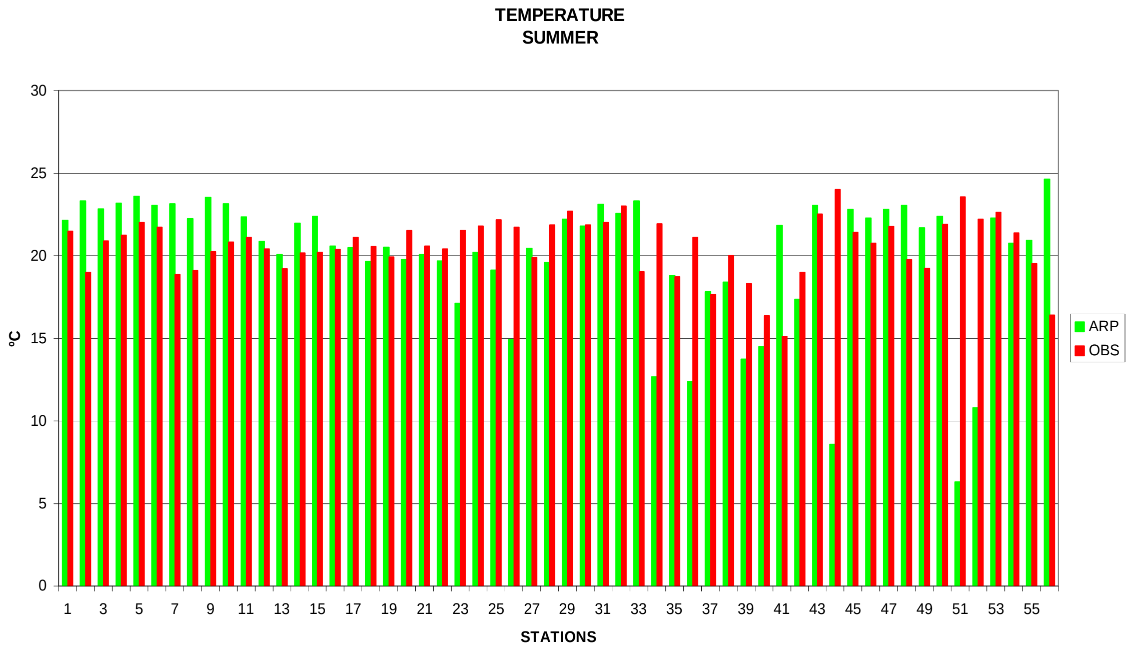
STATIONS
ARP
OBS


TEMPERATURE
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STATIONS
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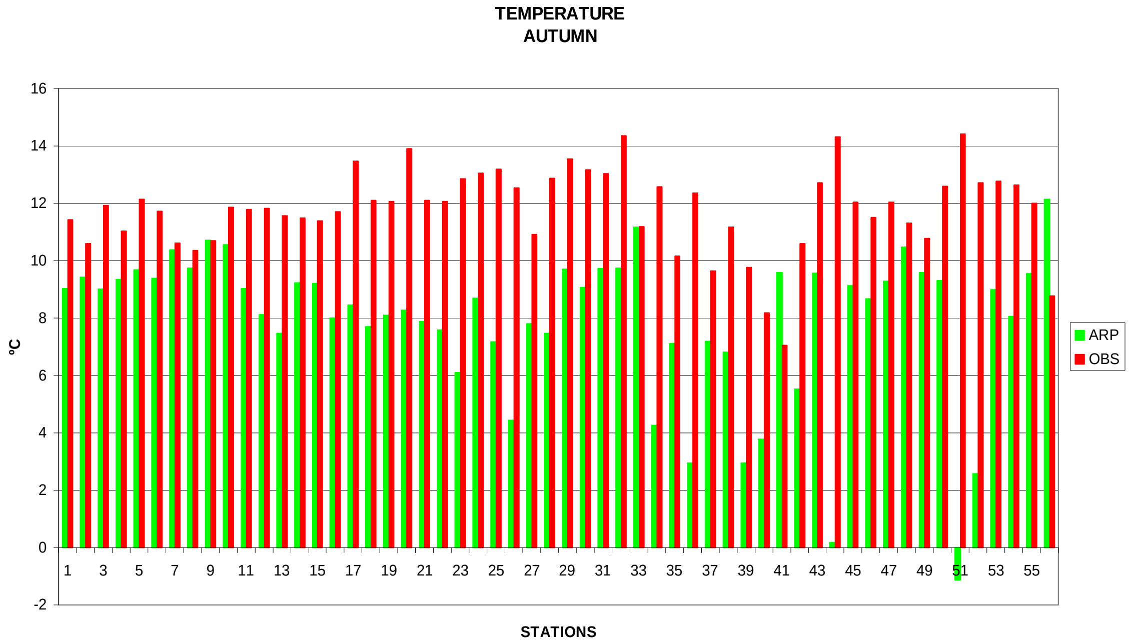
OBS


TEMPERATURE
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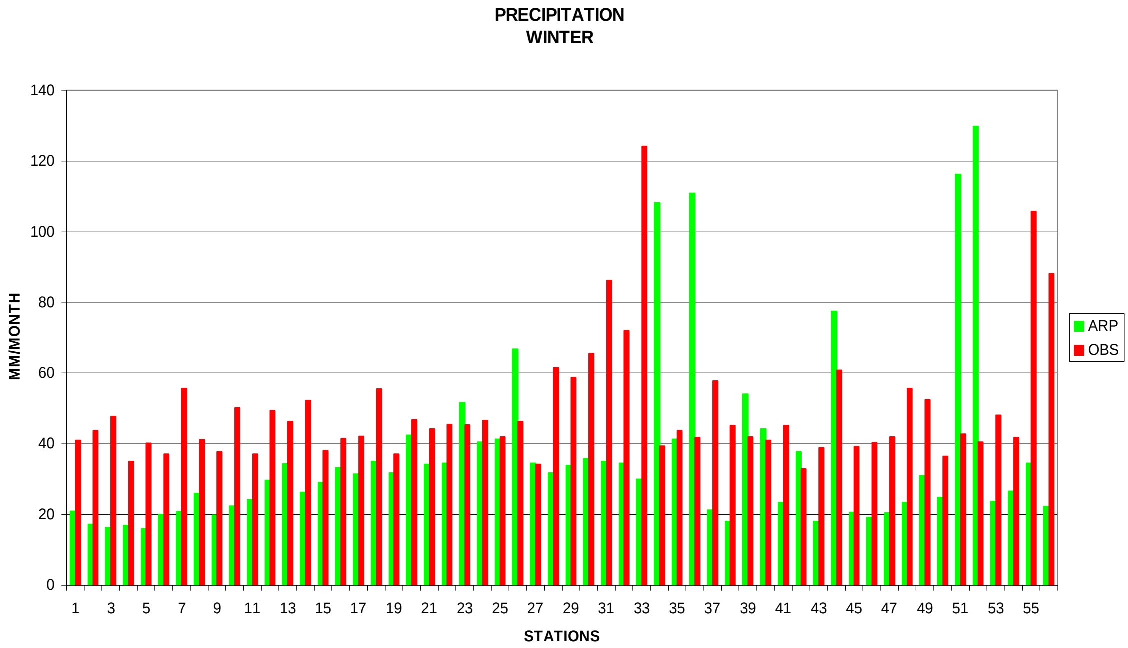
STATIONS
ARP
OBS


PRECIPITATION
WINTER
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STATIONS
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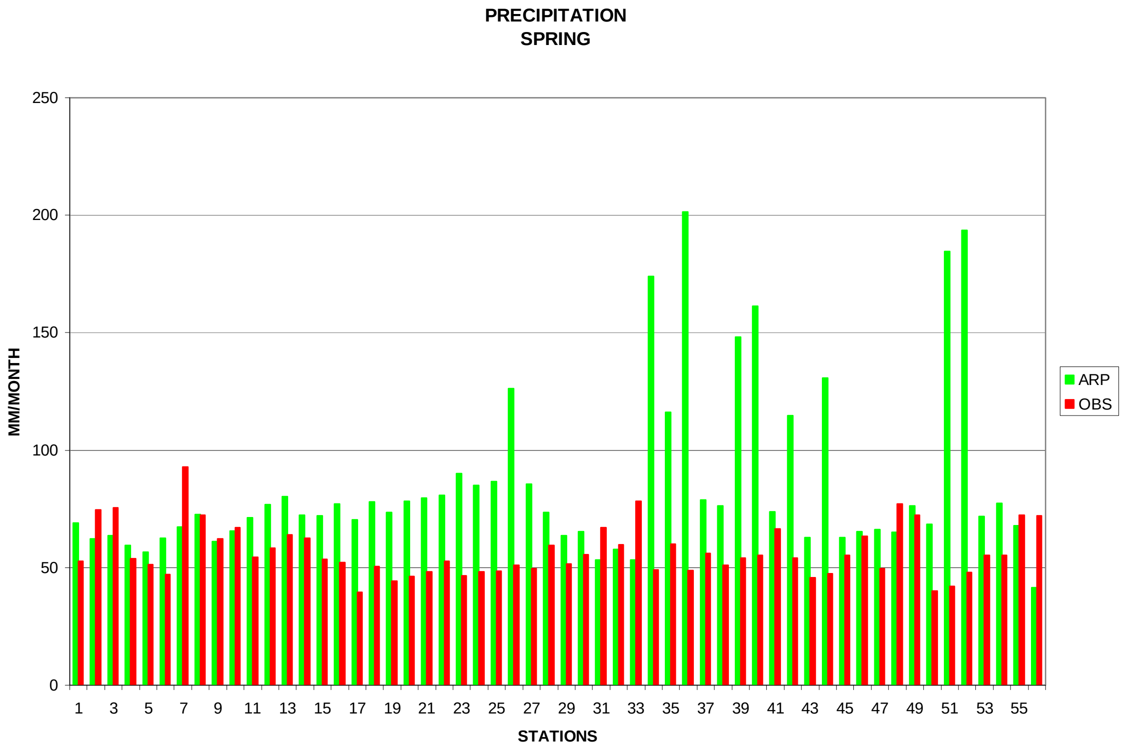
PRECIPITATION
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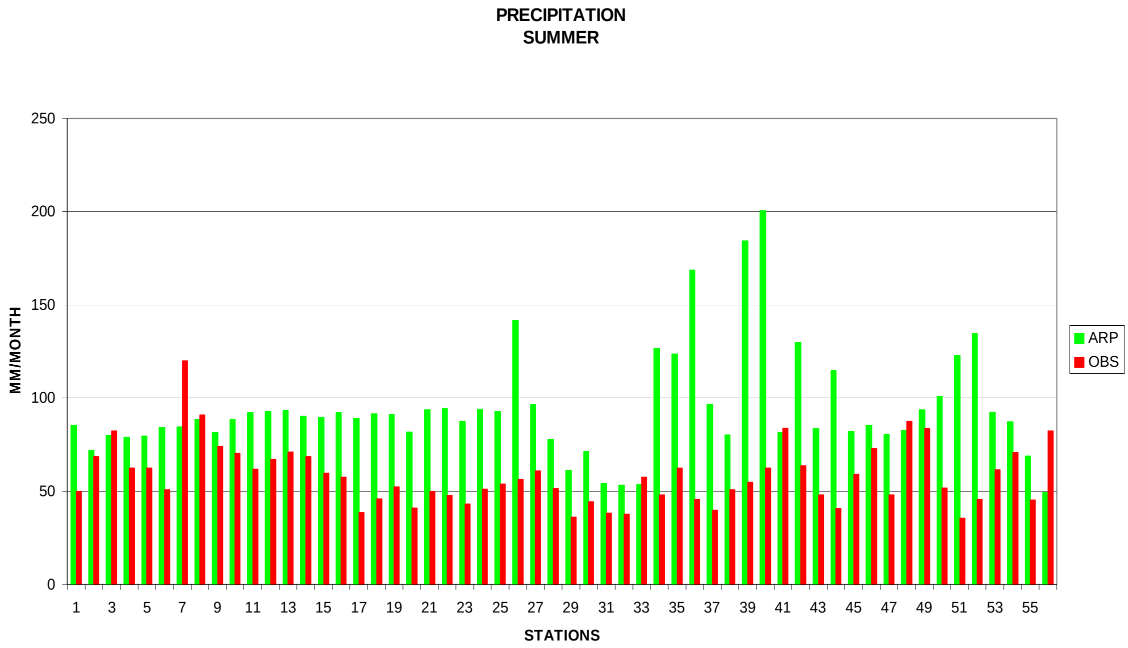
PRECIPITATION
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MM/MONTH
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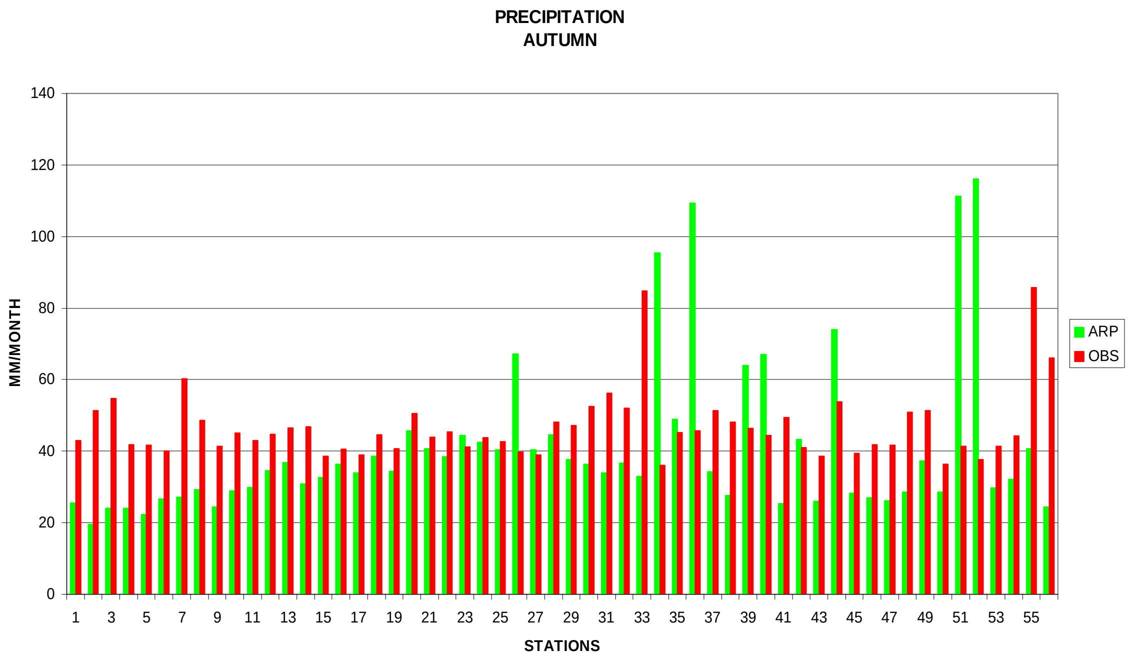
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35 37 39 41 43 45 47 49 51 53 55


PRECIPITATION
AUTUMN
MM/MONTH
STATIONS
ARP
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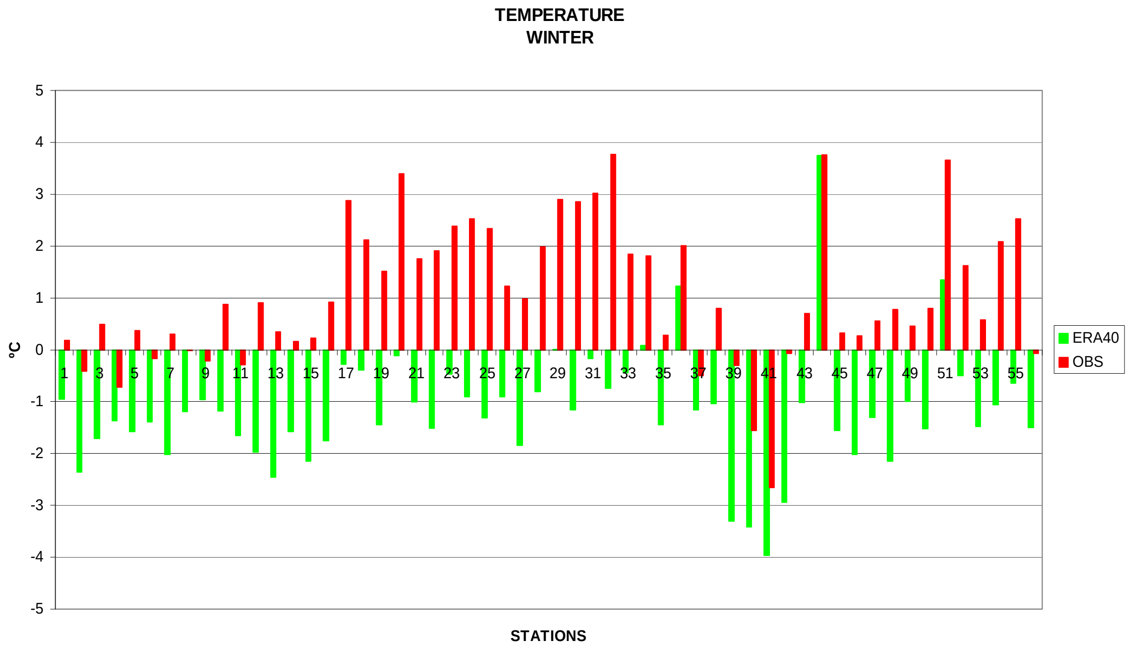
TEMPERATURE
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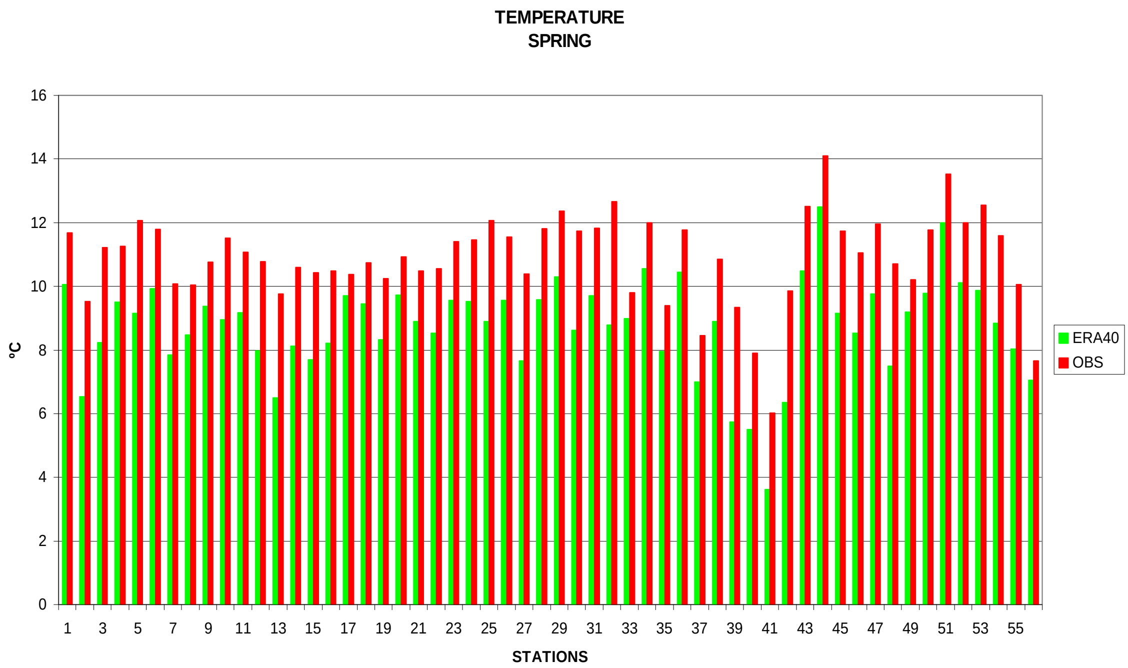
STATIONS
ERA40
OBS


TEMPERATURE
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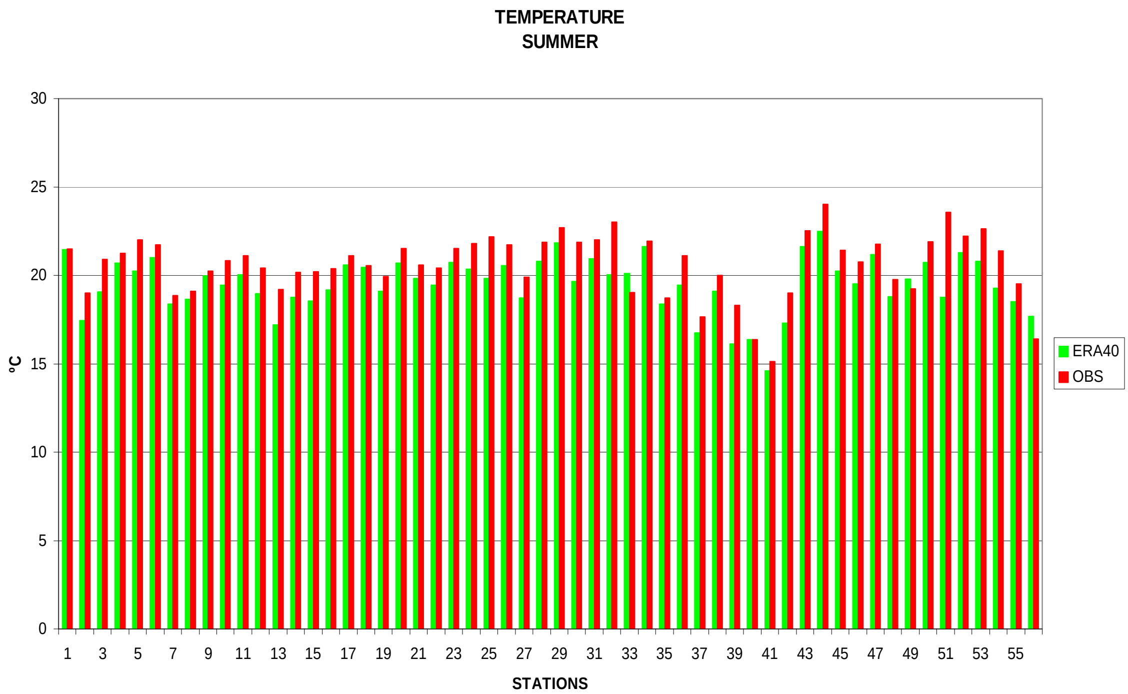
STATIONS
ERA40
OBS


TEMPERATURE
SUMMER
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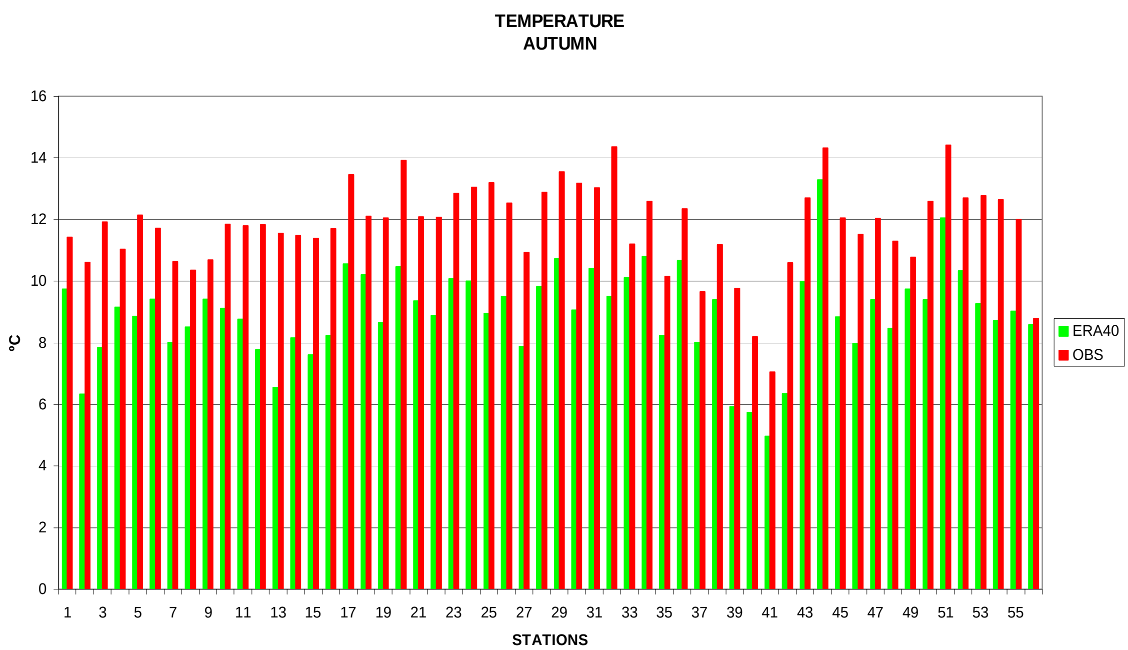
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35 37 39 41 43 45 47 49 51 53 55
STATIONS
ERA40
OBS


TEMPERATURE
AUTUMN
°C
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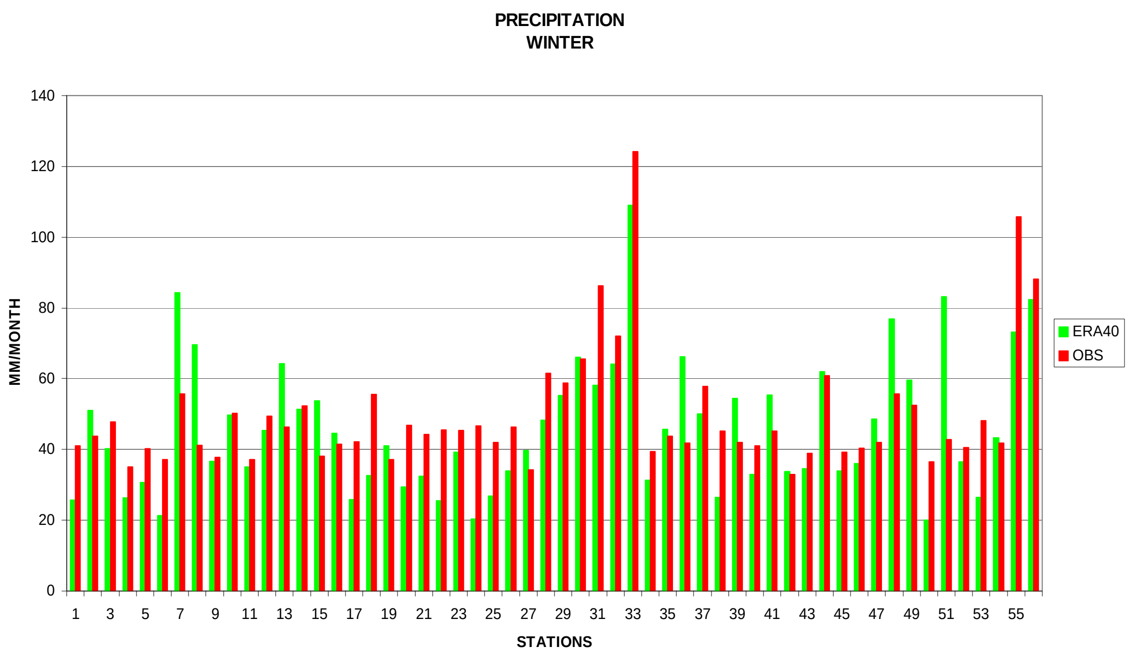
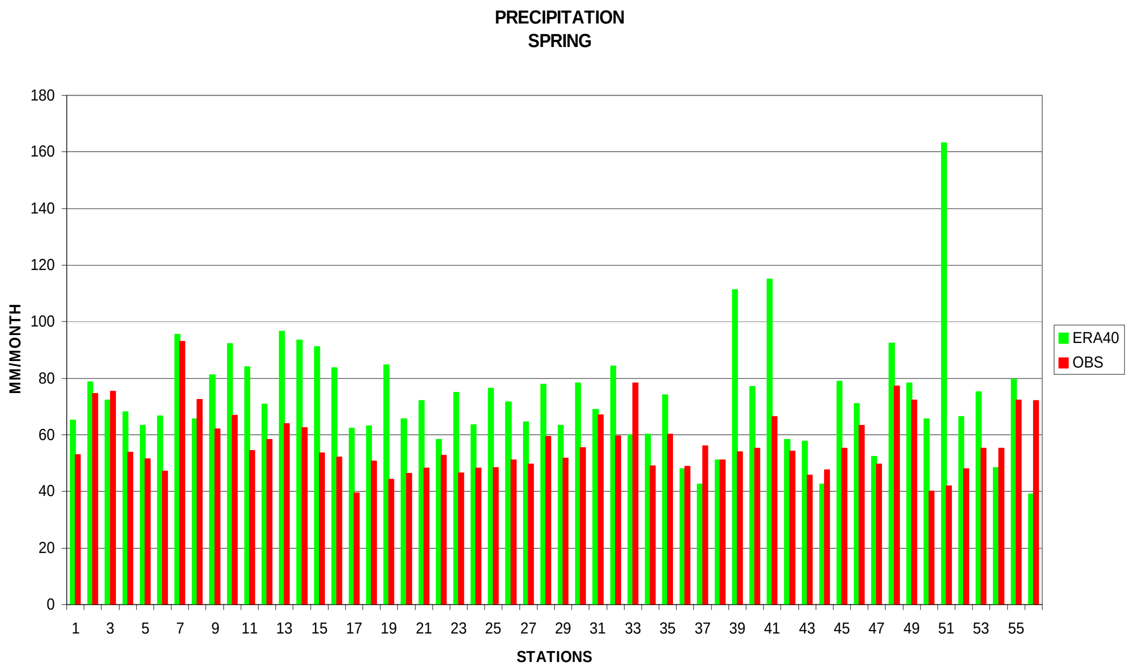
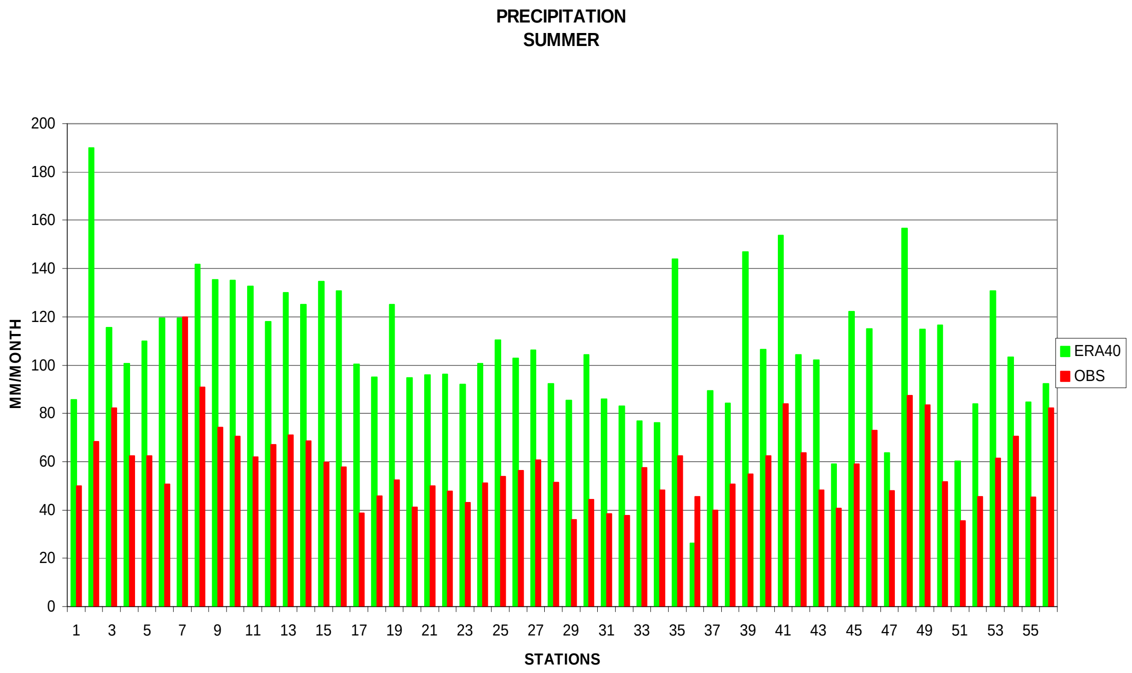
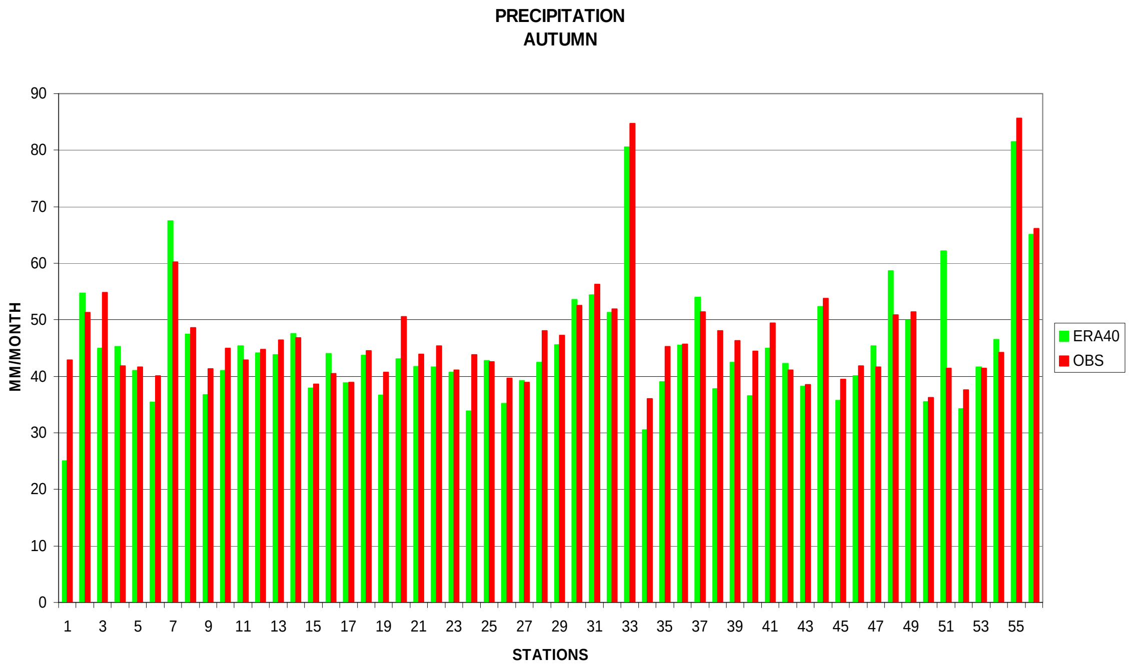
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35 37 39 41 43 45 47 49 51 53 55
STATIONS
ERA40
OBS


PRECIPITATION
WINTER
MM/MONTH
STATIONS
ERA40
OBS


PRECIPITATION
SPRING
MM/MONTH
STATIONS
ERA40
OBS


PRECIPITATION
SUMMER
MM/MONTH
STATIONS
ERA40
OBS


PRECIPITATION
AUTUMN
MM/MONTH
STATIONS
ERA40
OBS

ELU

Department of Meteorology, Eötvös Loránd University

RegCM3 Beta description:

- Model version: **RegCM3 (Beta)**
- Domain: **Carpathian Basin** (using 120 × 100 gridpoints), which can be characterized by the following four corners, and the central point of the domain:

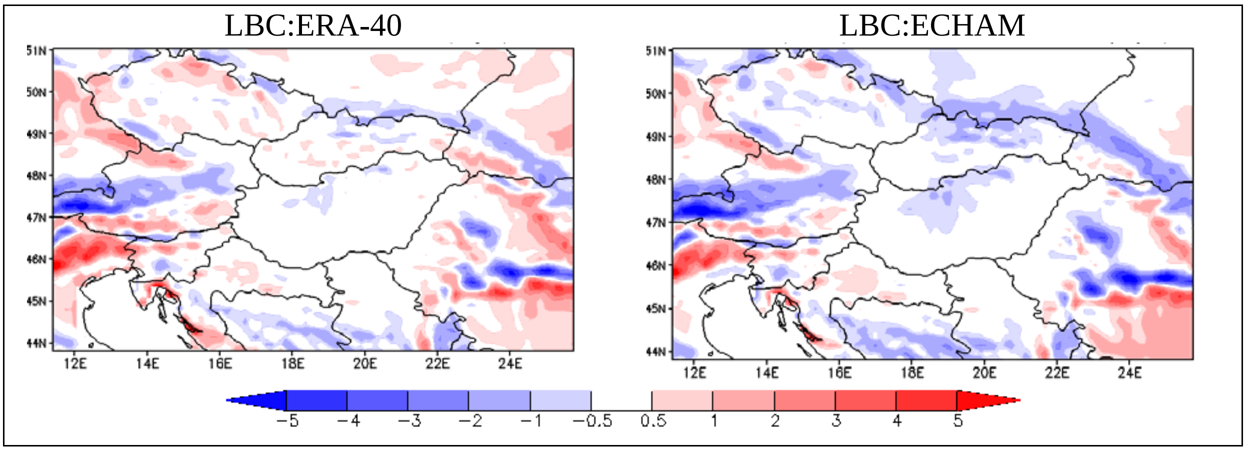
	Latitude	Longitude
SW	45.20°N	14.00°E
SE	45.15°N	23.10°E
NW	49.75°N	13.35°E
NE	49.70°N	23.55°E
Center point	47.5°N	18.5°E

- Horizontal resolution: **10 km**
- Temporal resolution: **30 s**
- Integration period: **1960-1990; 2020-2050**; **2070-2100**
- Evaluation period: **1961-1990; 2021-2050**; **2071-2100**
- LBC: **ECHAM driven RegCM (25 km)**
- Vertical levels: **18 atmospheric levels in σ-coordinates + 3 soil layers**
- Plane geometry: **Lambert projection**
- In order to decrease the precipitation bias from RegCM3, the following parameters were changed:
  -- the cloud-to-rain autoconversion rate was decreased from 0.0005 to 0.00025,
  -- the raindrop evaporation rate coefficient was increased from $0.2 \cdot 10^{-4}$ to $1.0 \cdot 10^{-3}$ $(kg\ m^{-2}\ s^{-1})^{-1/2}\ s^{-1}$,
  -- the raindrop accretion rate was decreased from 6 to 3 m^3 kg s.
- Dynamics: Hydrostatic model with σ vertical coordinates
- Physics: Grell (1993) and Fritsch & Chappell (1980) convective schemes

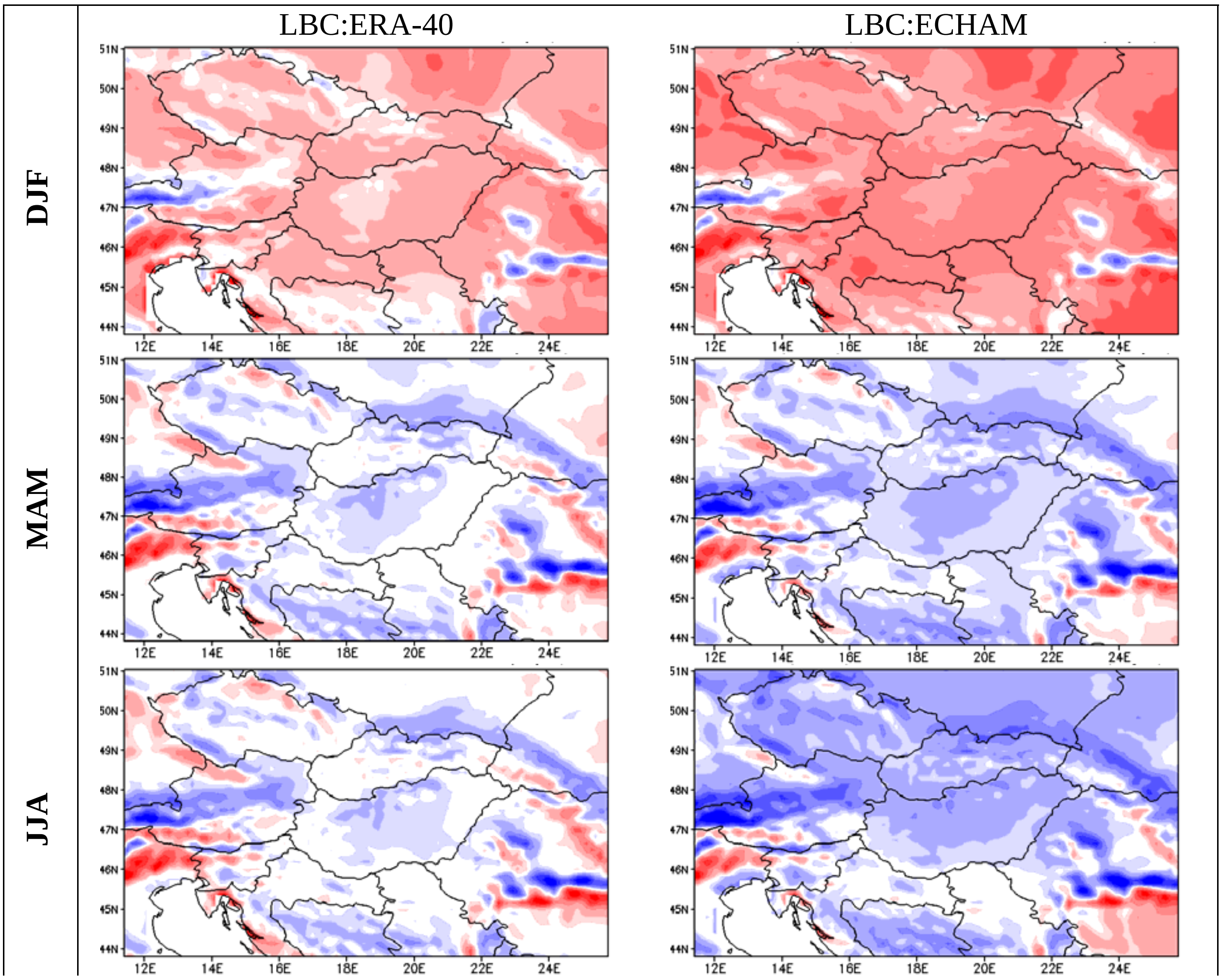
RESULTS (1961-1990)

Temperature *(RegCM – CRU(10')[^{o}C])*

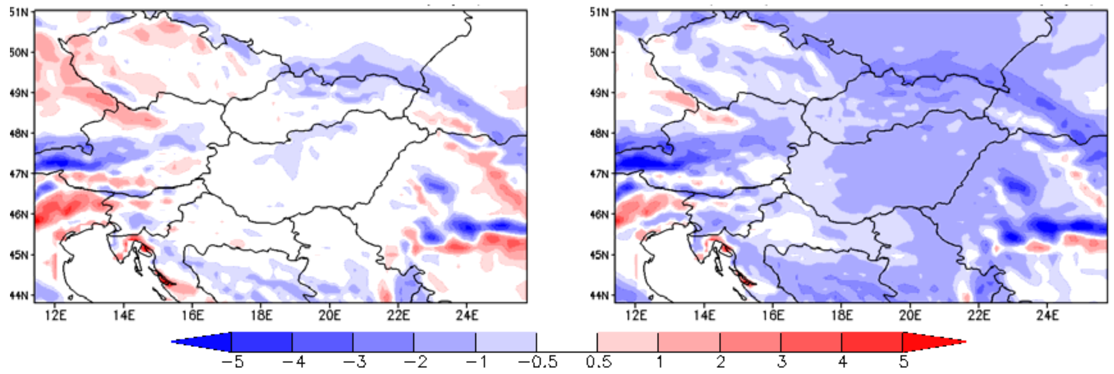
Difference of annual mean temperature



Difference of seasonal mean temperature

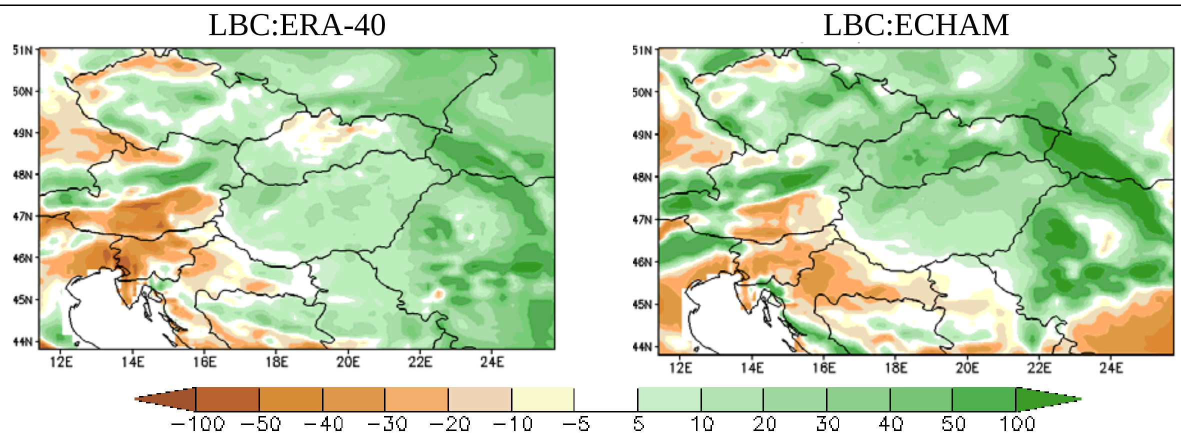


SON

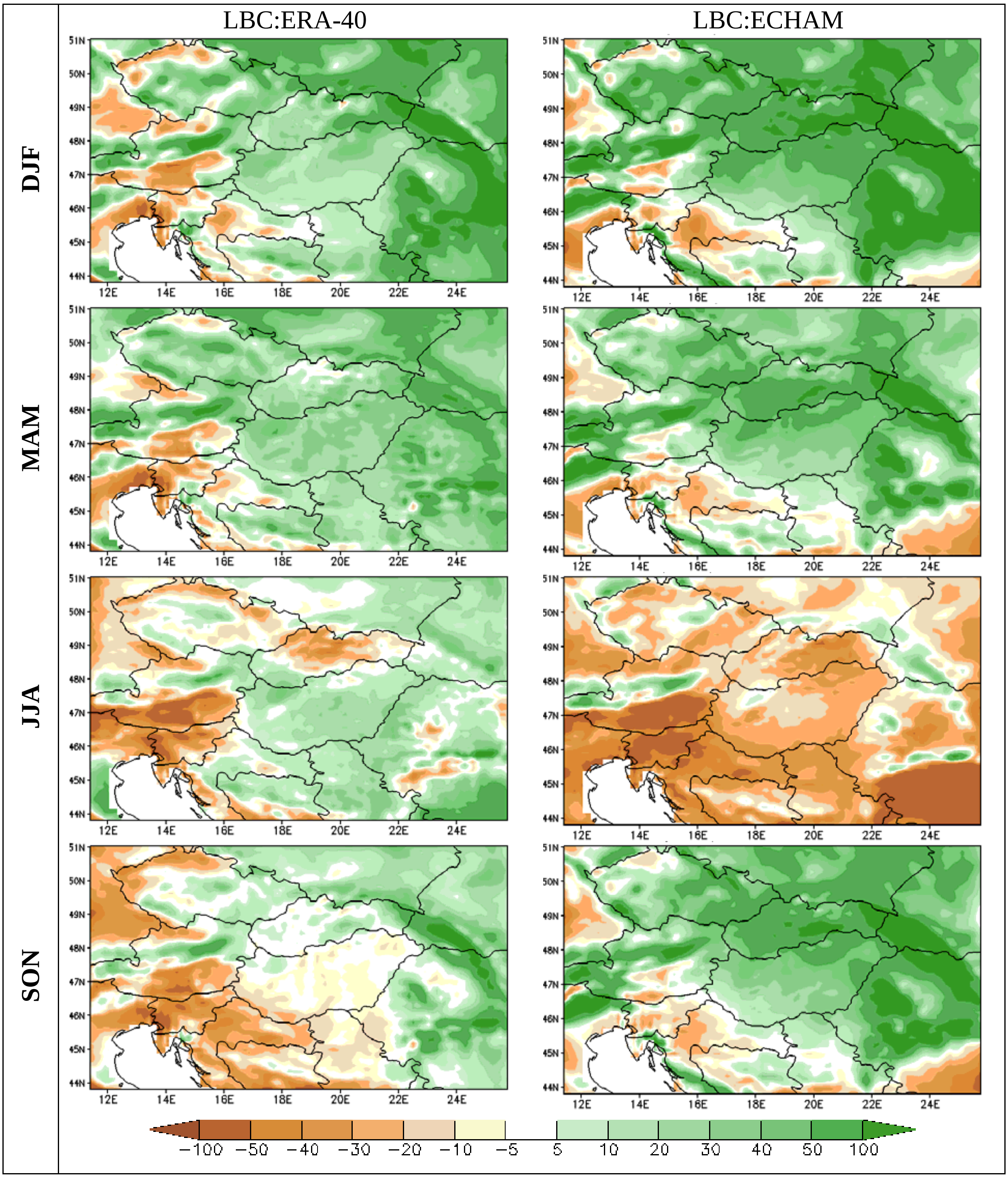


Precipitation *([RegCM– CRU(10')]/CRU(10') [%])*

Annual relative difference of precipitation



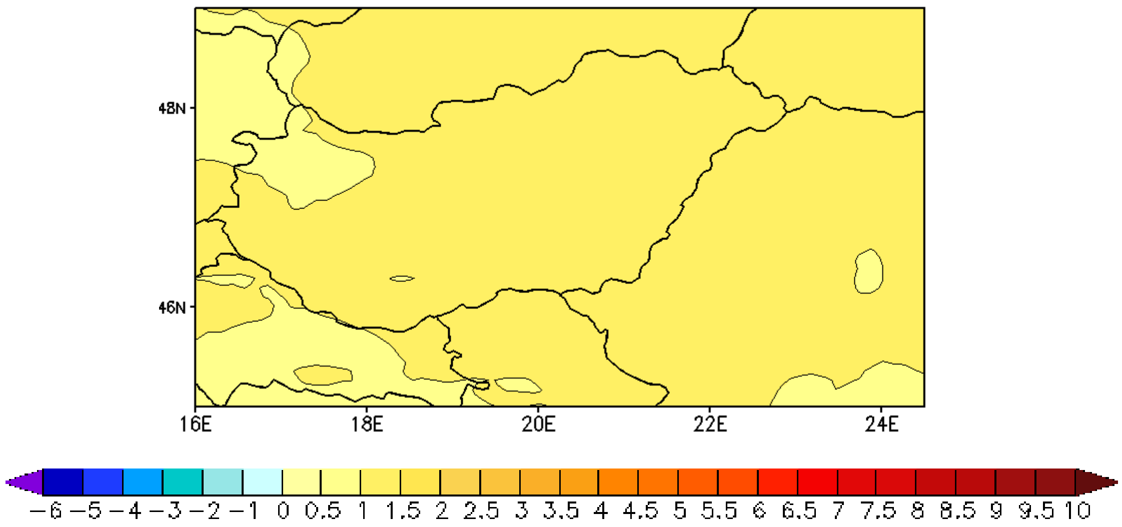
Seasonal relative difference of precipitation



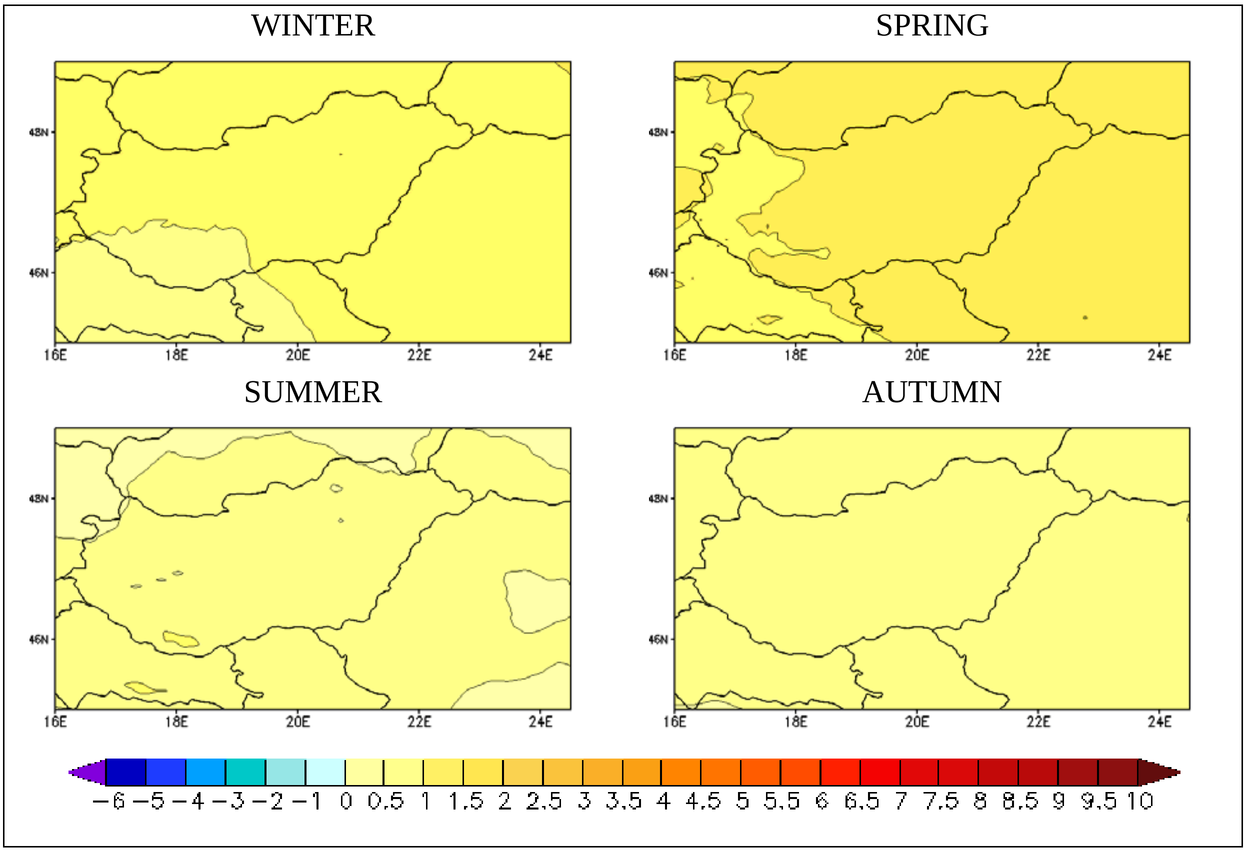
REGIONAL CLIMATE CHANGE RESULTS FOR THE PERIOD 2021-2050

Temperature *($RegCM_{2021\text{-}2050}$– $RegCM_{1961\text{-}1990}$)*

Difference of annual mean temperature

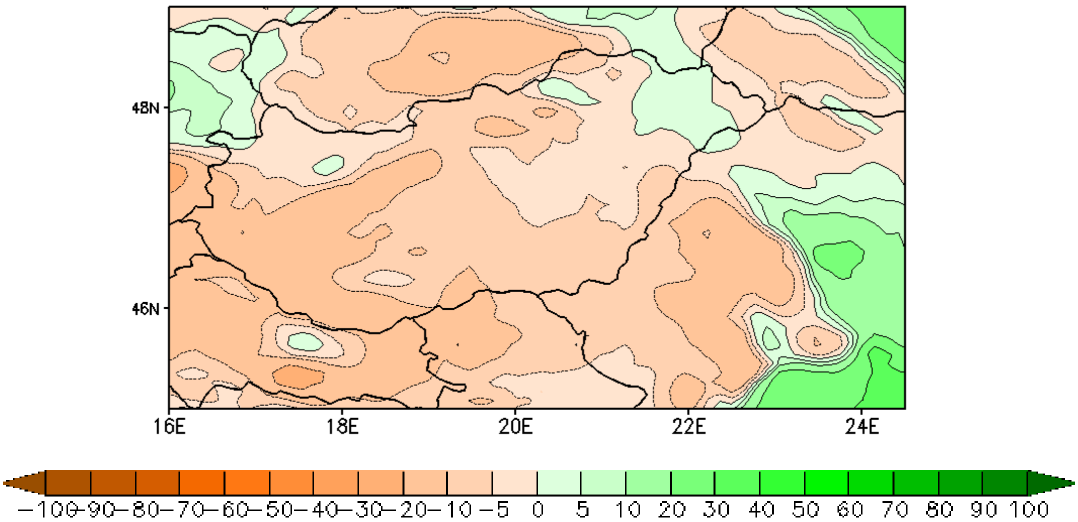


Difference of seasonal mean temperature

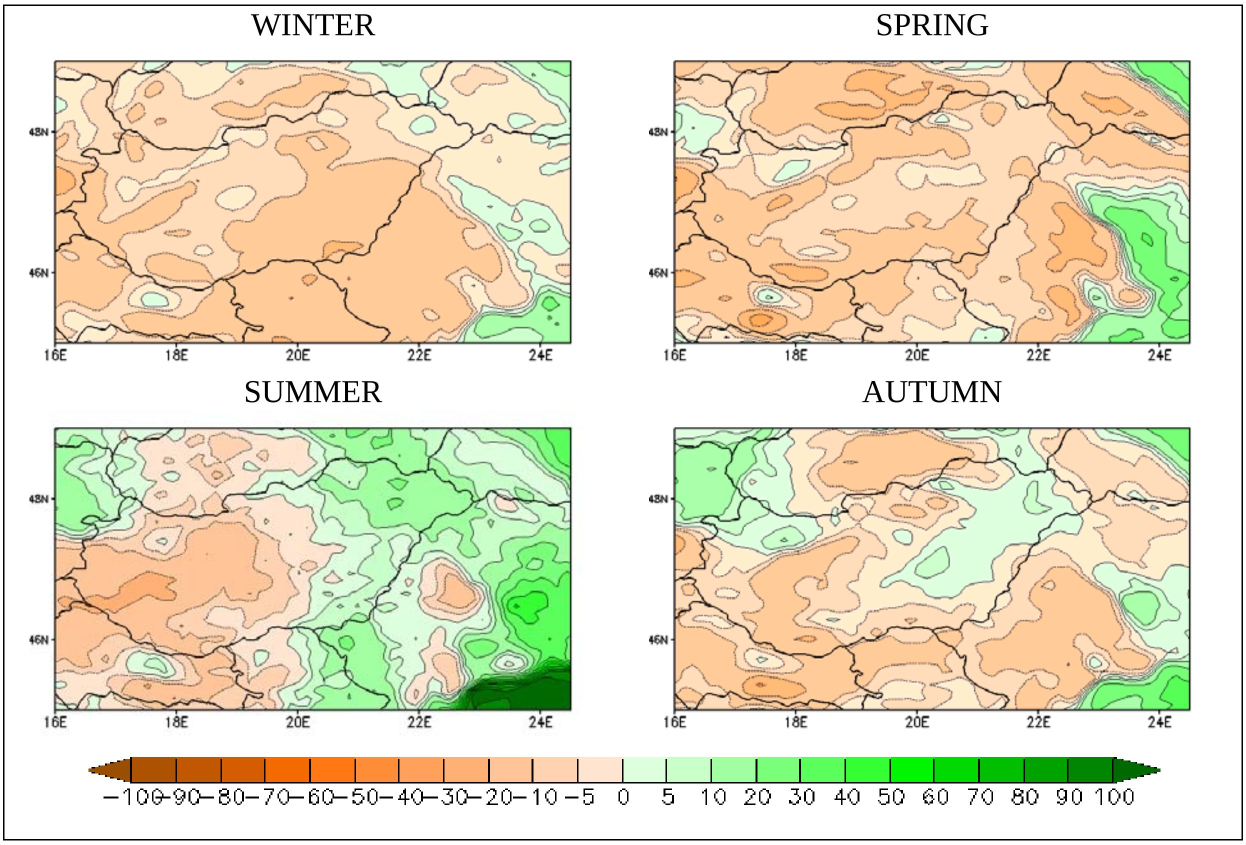


Precipitation $((RegCM_{2021\text{-}2050} - RegCM_{1961\text{-}1990})/RegCM_{1961\text{-}1990})$

Annual relative difference of precipitation



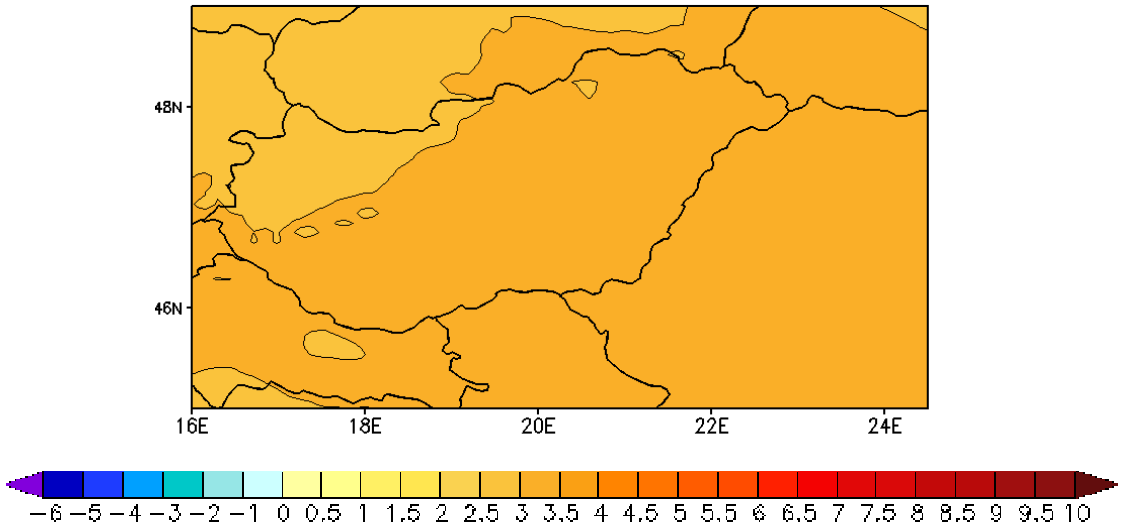
Seasonal relative difference of precipitation



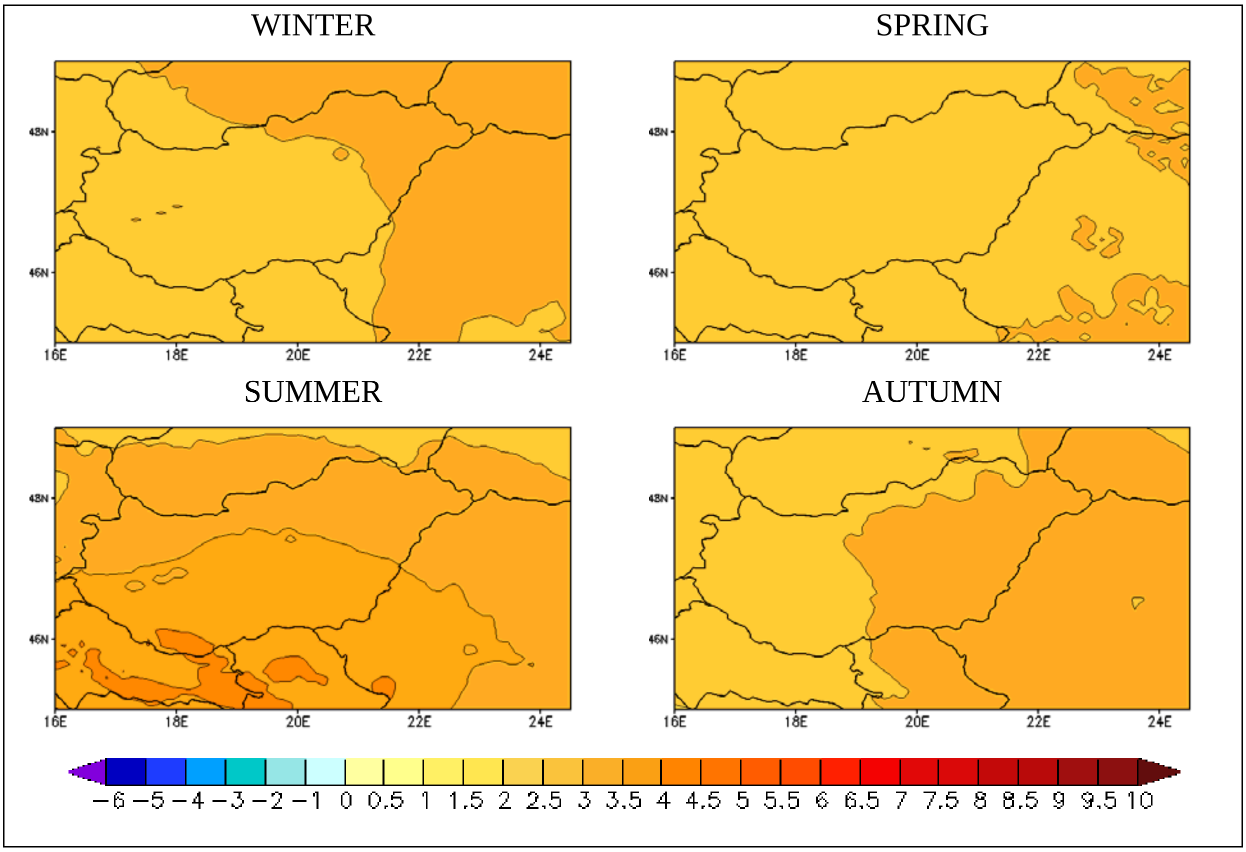
REGIONAL CLIMATE CHANGE RESULTS FOR THE PERIOD 2071-2100

Temperature *(RegCM$_{2071\text{-}2100}$– RegCM$_{1961\text{-}1990}$)*

Difference of annual mean temperature

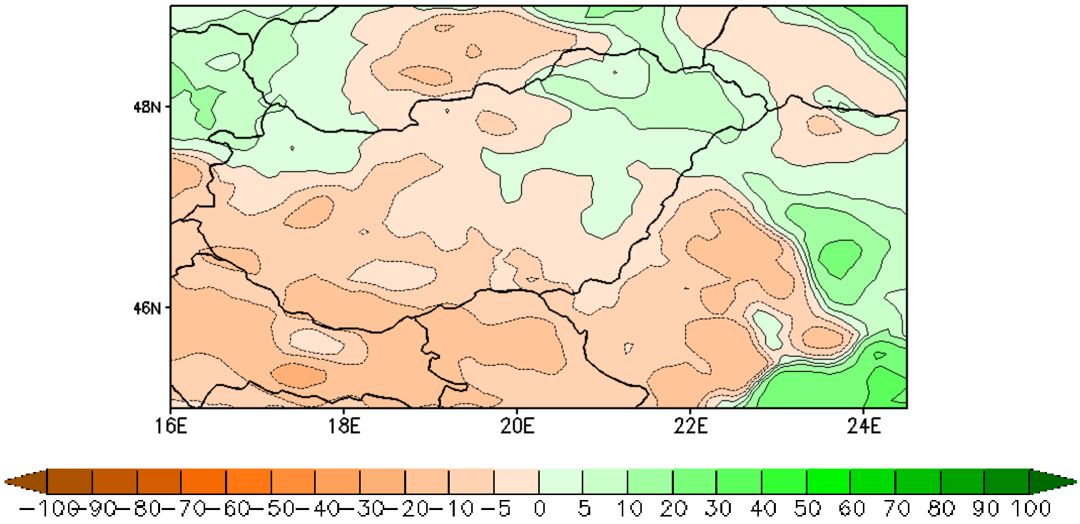


Difference of seasonal mean temperature

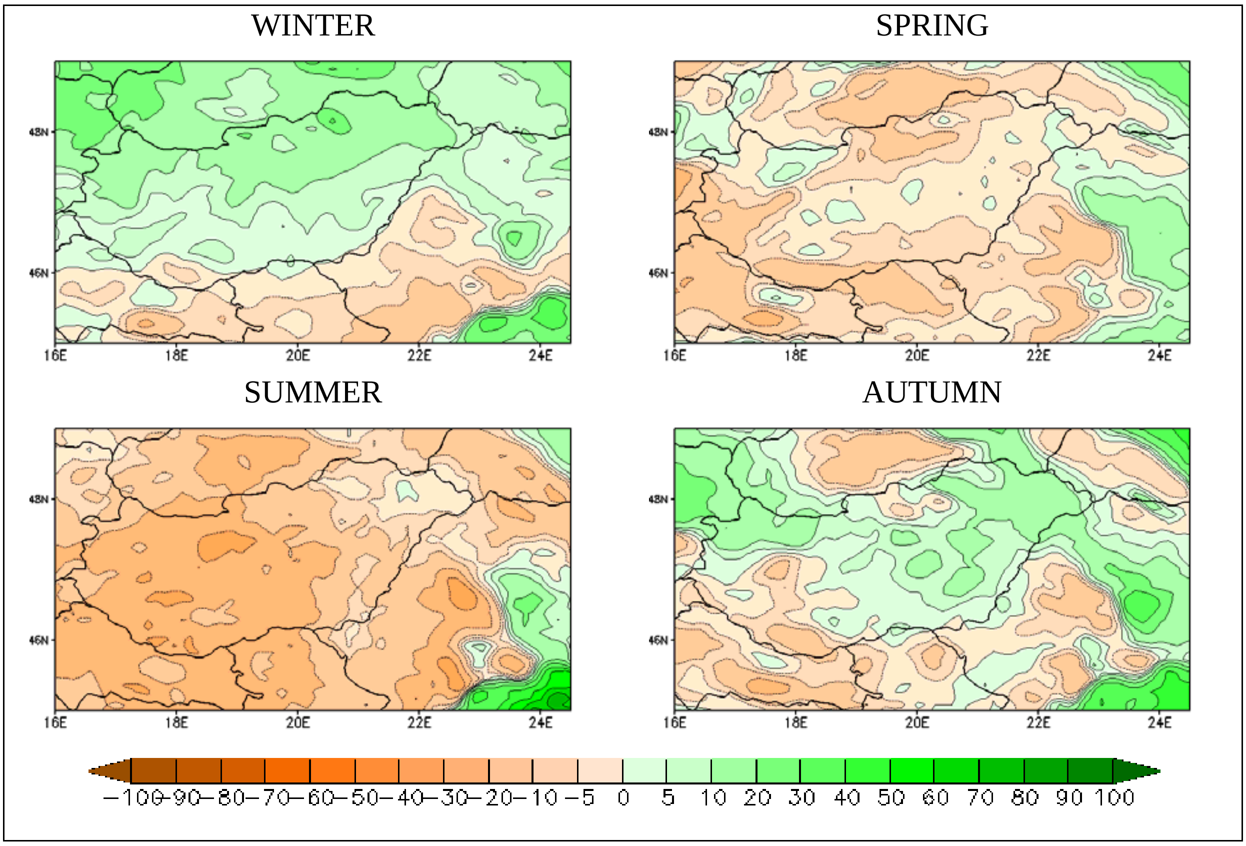


Precipitation $((RegCM_{2071\text{-}2100} - RegCM_{1961\text{-}1990})/RegCM_{1961\text{-}1990})$

Annual relative difference of precipitation



Seasonal relative difference of precipitation



CUNI

Department of Meteorology and Environment Protection, Charles University in Prague

Model description

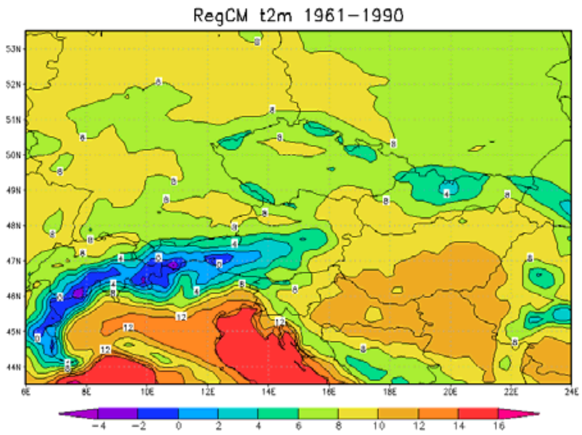
- Model version: RegCM3 (alfa)
- Domain: 184x164 grid-points, central point: 49.0N, 15.8E, Lambert conformal projection
- Horizontal resolution: 10 km
- Time step: 30 s
- Integration period: 1960-1990 (+ extended till 2000), 2020-2050, 2070-2100
- Spin-up time: 12 months
- LBC: ERA40 for present-time climate evaluation, ECHAM for control and future time slices, double nested through 25km RegCM run performed by ICTP
- Vertical levels: 23
- Model parametrization: Grell convective precip. scheme with Fritsch & Chappell closure assumption

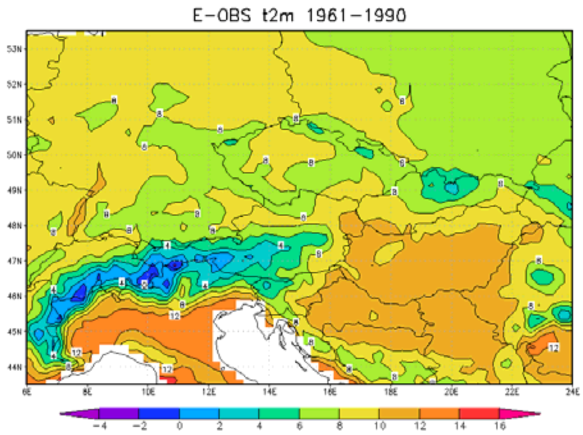
Results

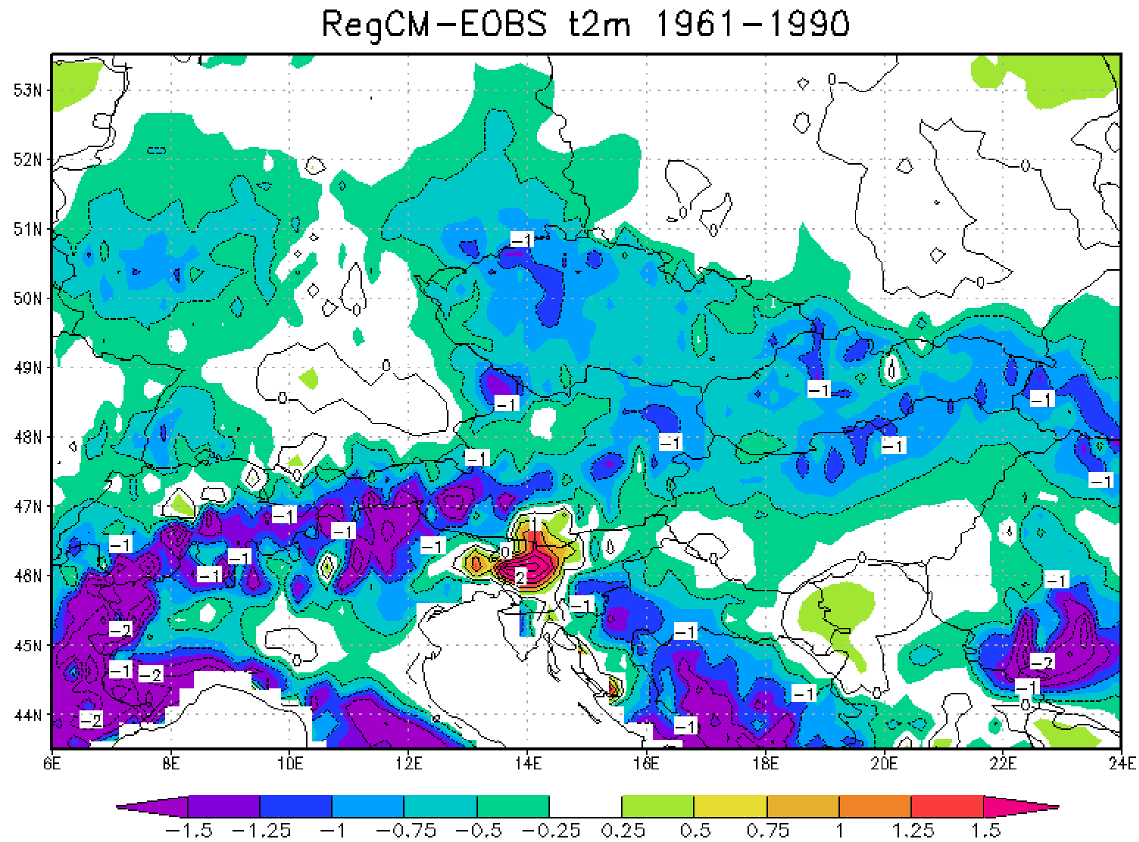
Validation

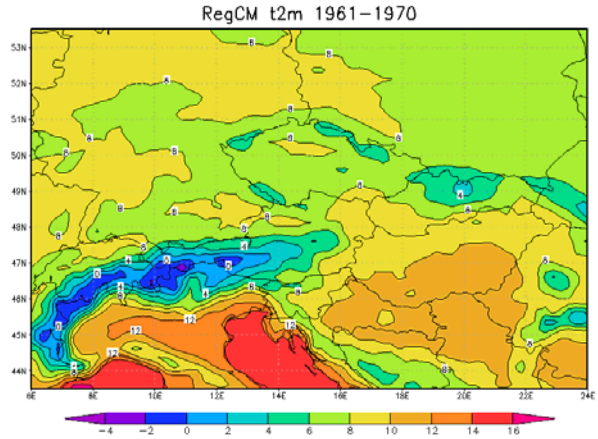
Model results validated using *Ensembles E-OBS 2.0* dataset

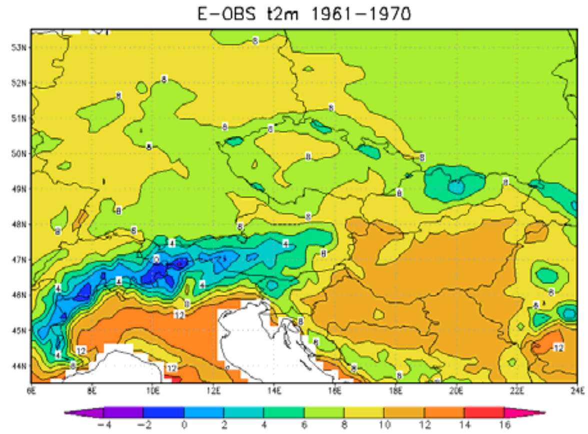
Temperature

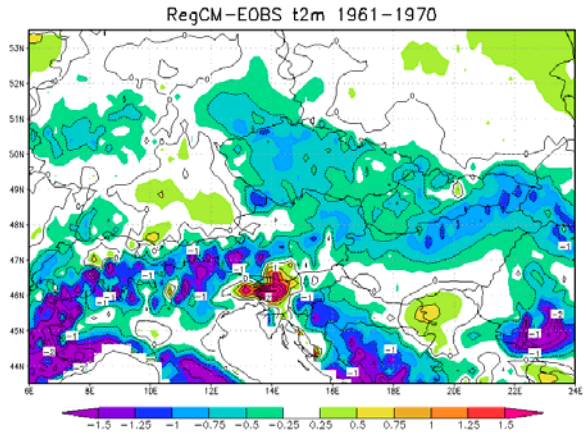


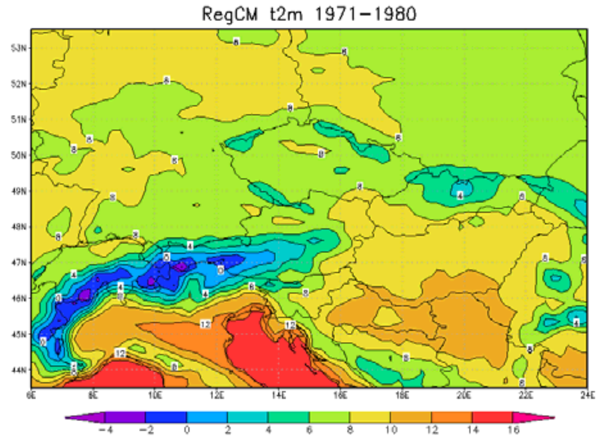


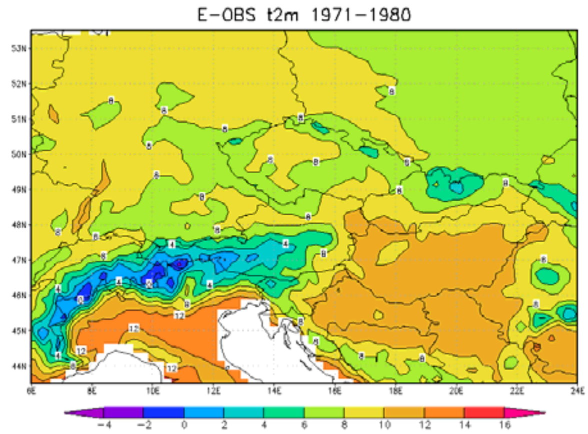


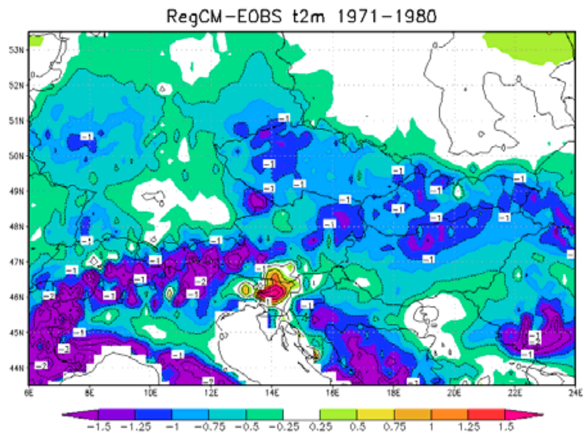

RegCM t2m 1961-1970

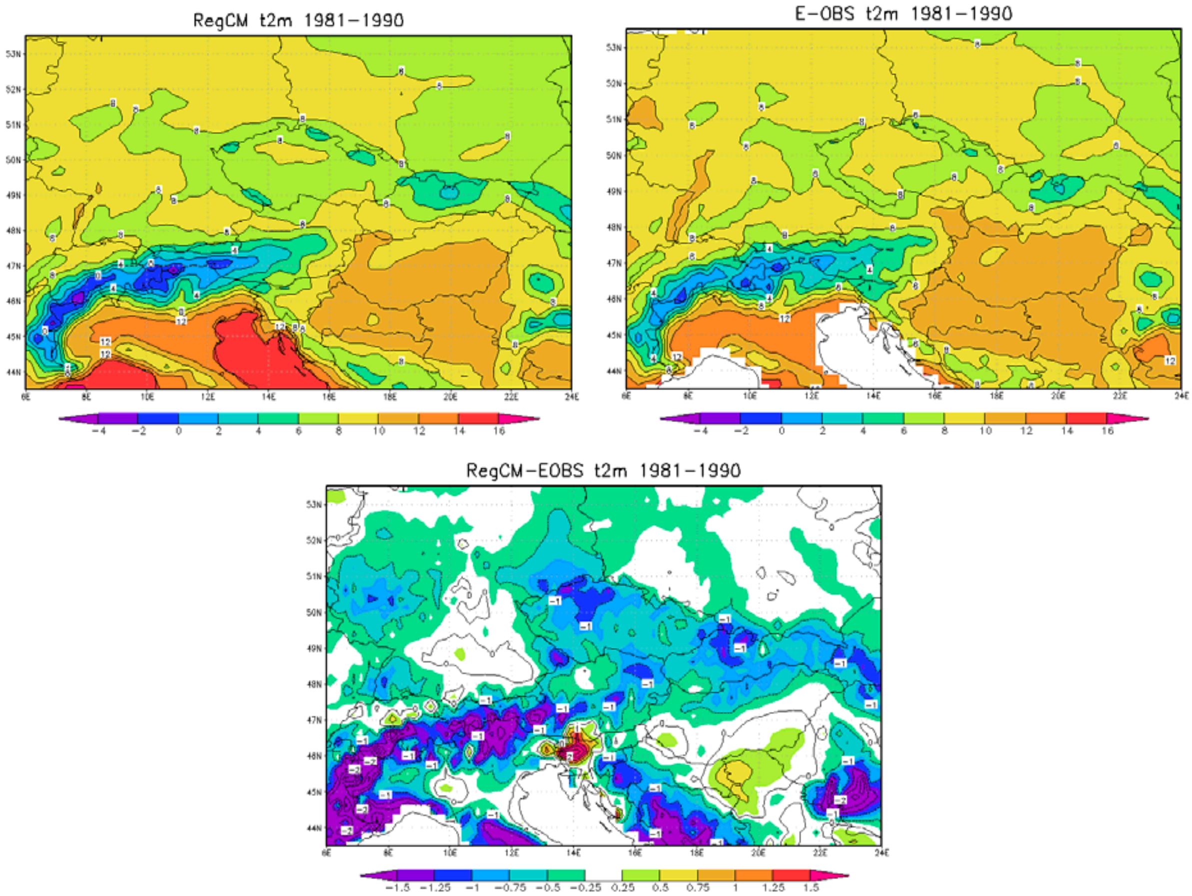

E-OBS t2m 1961-1970


RegCM-EOBS t2m 1961-1970

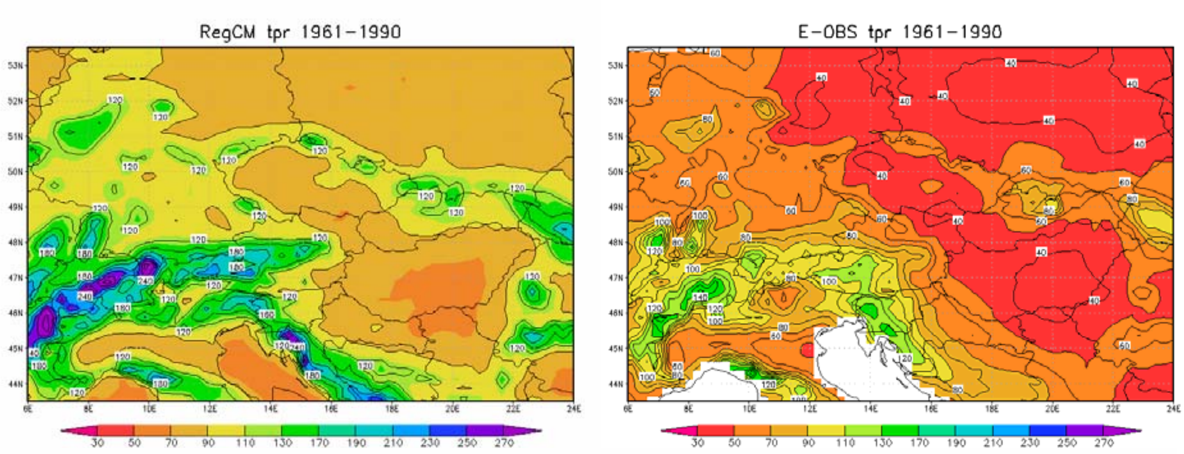

RegCM t2m 1971-1980

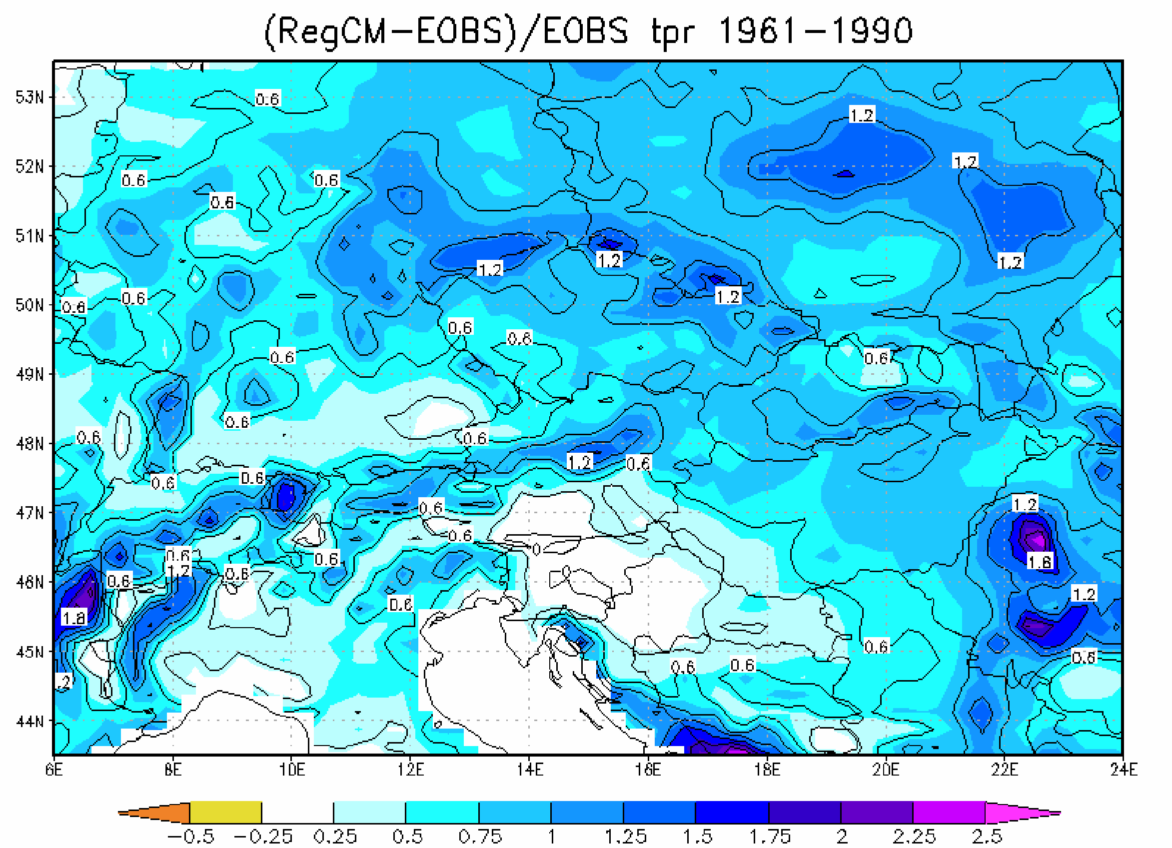

E-OBS t2m 1971-1980

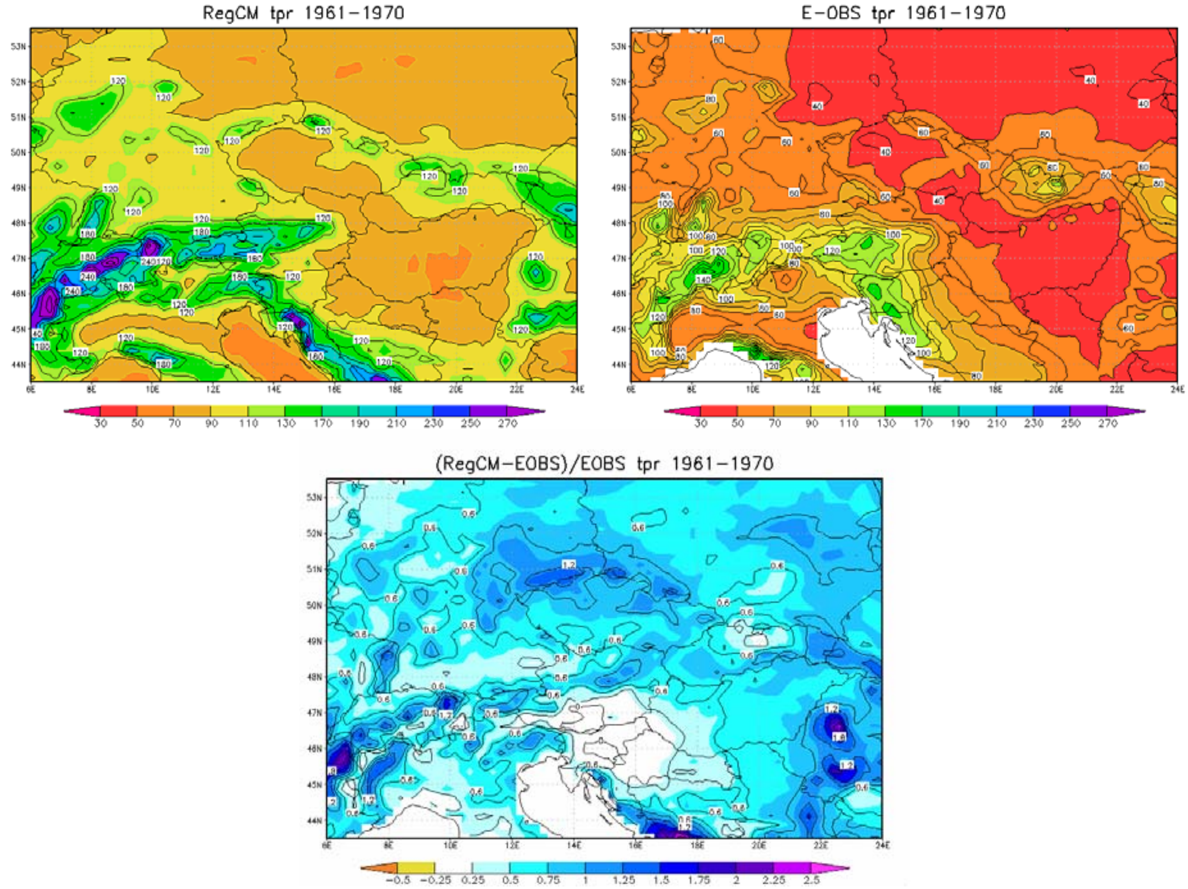

RegCM-EOBS t2m 1971-1980

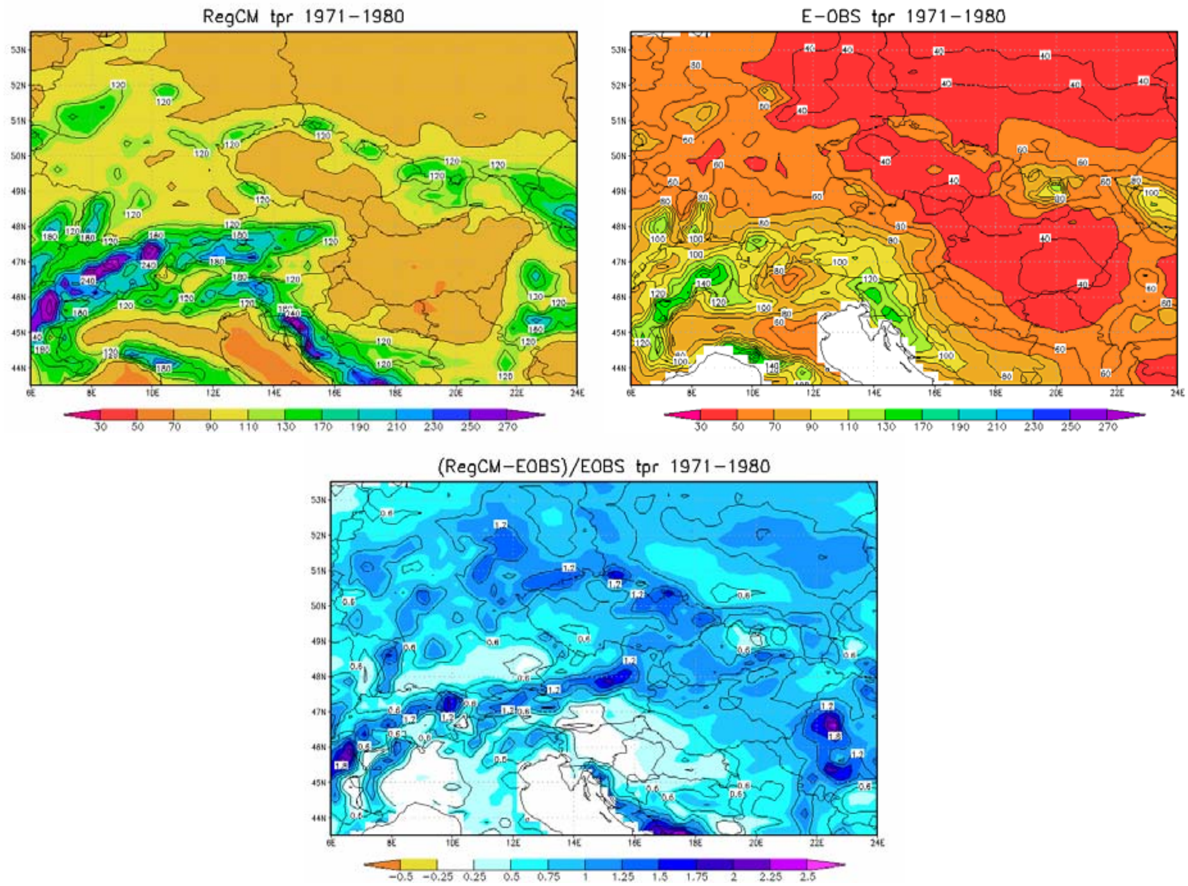

RegCM t2m 1981-1990
E-OBS t2m 1981-1990
RegCM-EOBS t2m 1981-1990
-4 -2 0 2 4 6 8 10 12 14 16
-1.5 -1.25 -1 -0.75 -0.5 -0.25 0.25 0.5 0.75 1 1.25 1.5

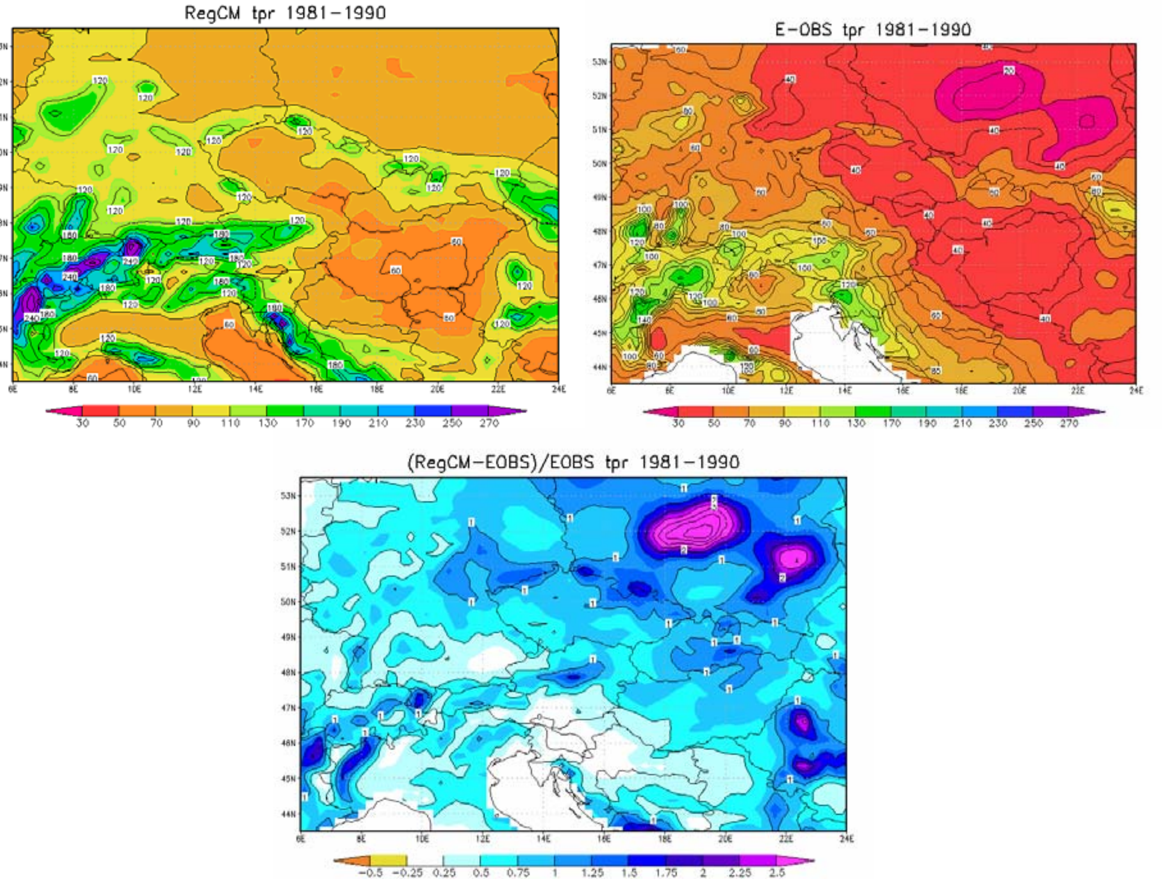
Precipitation






RegCM tpr 1961-1970
E-OBS tpr 1961-1970
30 50 70 90 110 130 170 190 210 230 250 270
(RegCM-EOBS)/EOBS tpr 1961-1970
-0.5 -0.25 0.25 0.5 0.75 1 1.25 1.5 1.75 2 2.25 2.5


RegCM tpr 1971-1980
E-OBS tpr 1971-1980
30 50 70 90 110 130 170 190 210 230 250 270
(RegCM-EOBS)/EOBS tpr 1971-1980
-0.5 -0.25 0.25 0.5 0.75 1 1.25 1.5 1.75 2 2.25 2.5

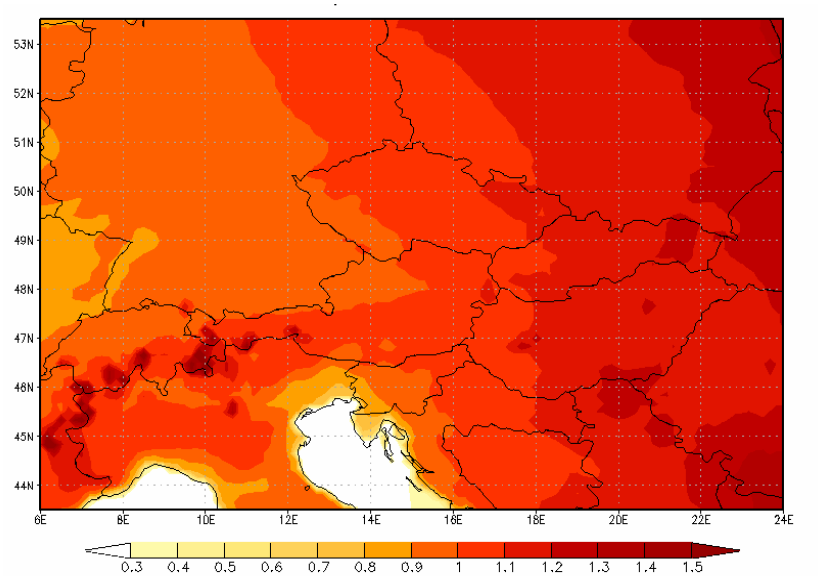

RegCM tpr 1981-1990
E-OBS tpr 1981-1990
30 50 70 90 110 130 170 190 210 230 250 270
(RegCM-EOBS)/EOBS tpr 1981-1990
-0.5 -0.25 0.25 0.5 0.75 1 1.25 1.5 1.75 2 2.25 2.5

Climate response

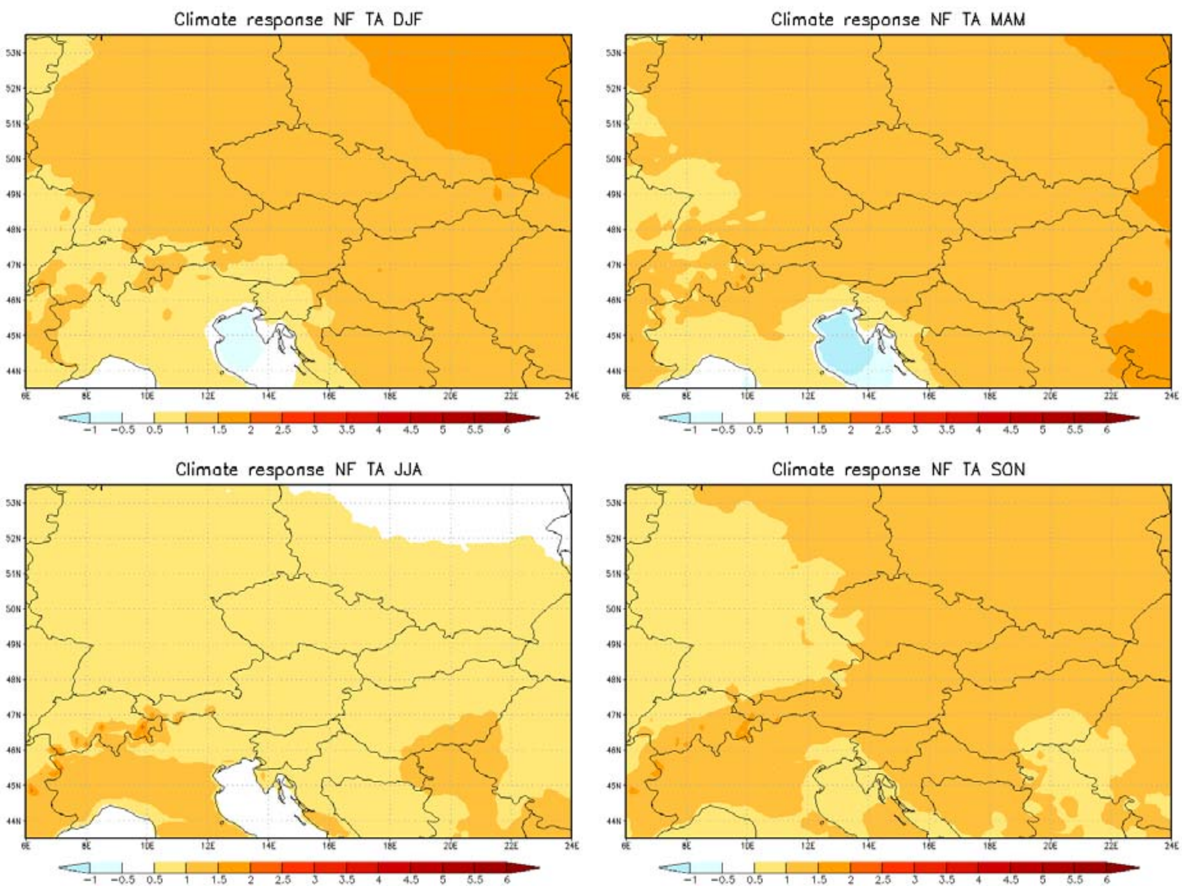
Using control period 1961-1990 of ECHAM forced RegCM run

Temperature

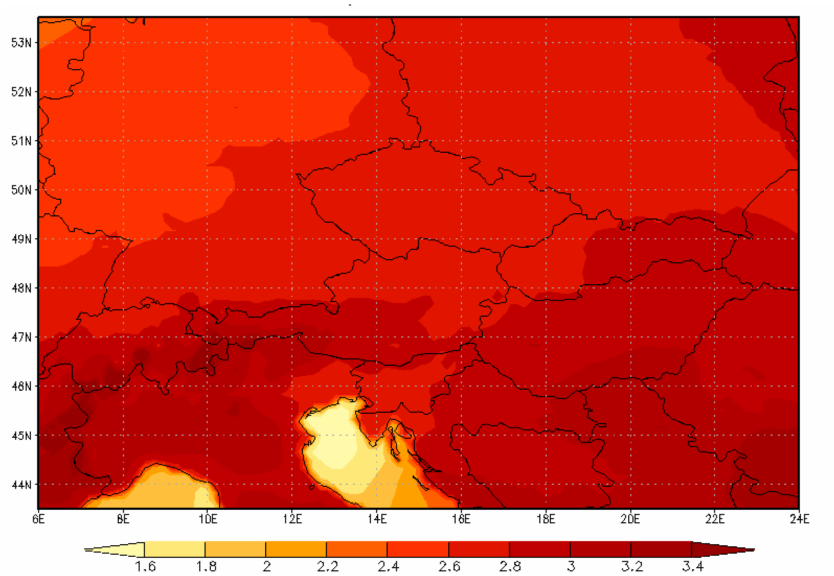
Climate response in the near future time slice (2021-2050) – annual mean temperature change



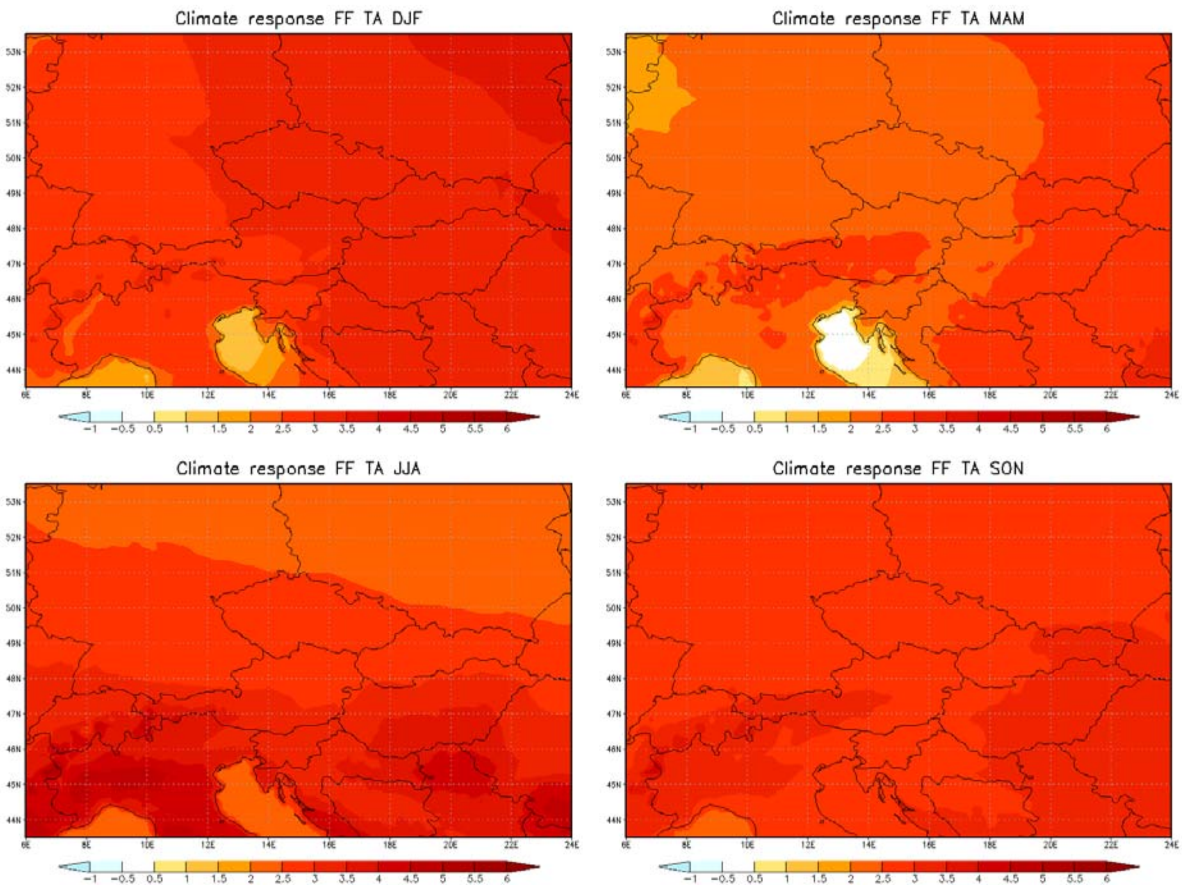
Seasonal mean temperature change (2021-2050)



Climate response in the far future time slice (2071-2100) – annual mean temperature change



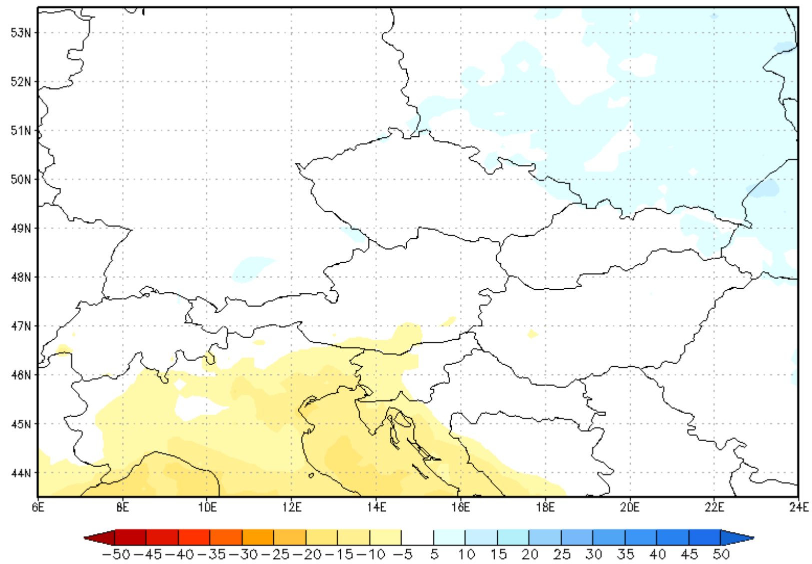
Seasonal mean temperature change (2071-2100)



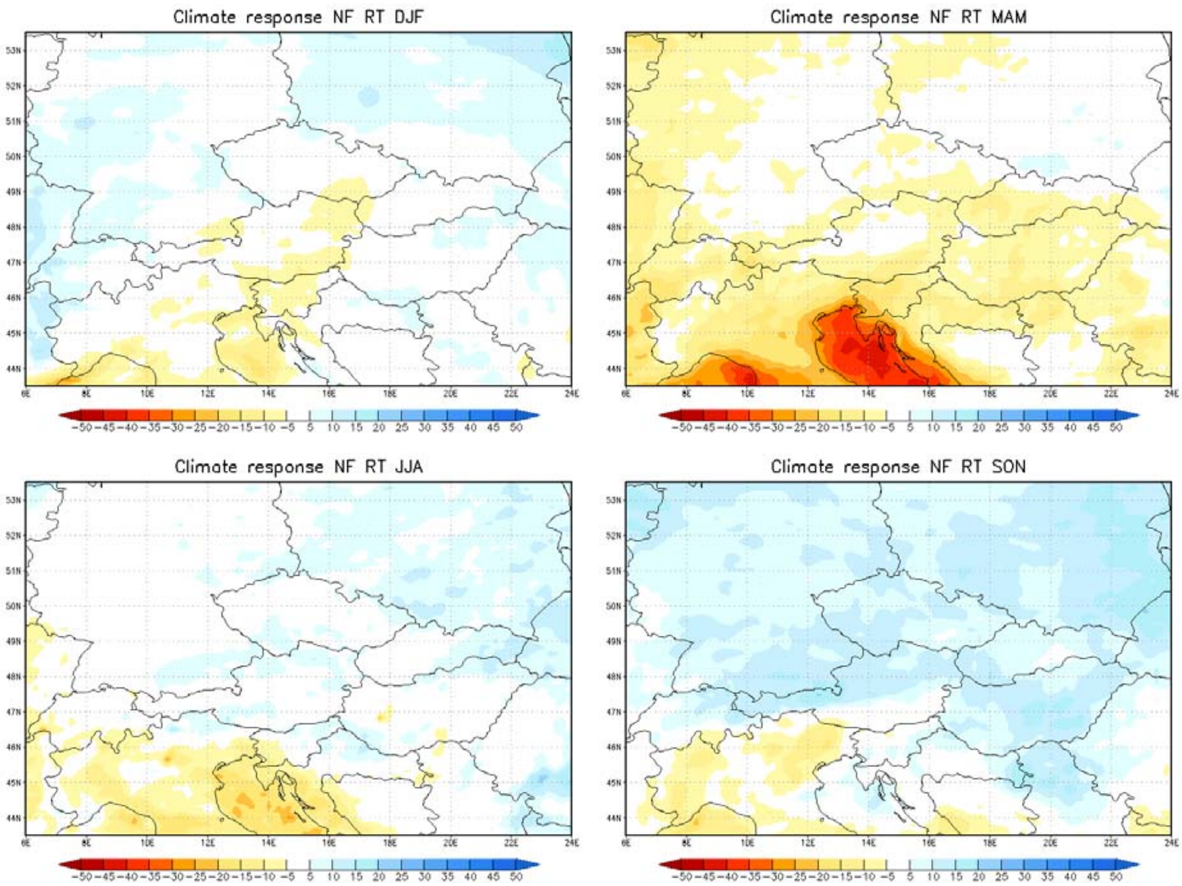
Precipitation

Climate response in the near future time slice (2021-2050)

Annual mean precipitation change [relative difference in %]

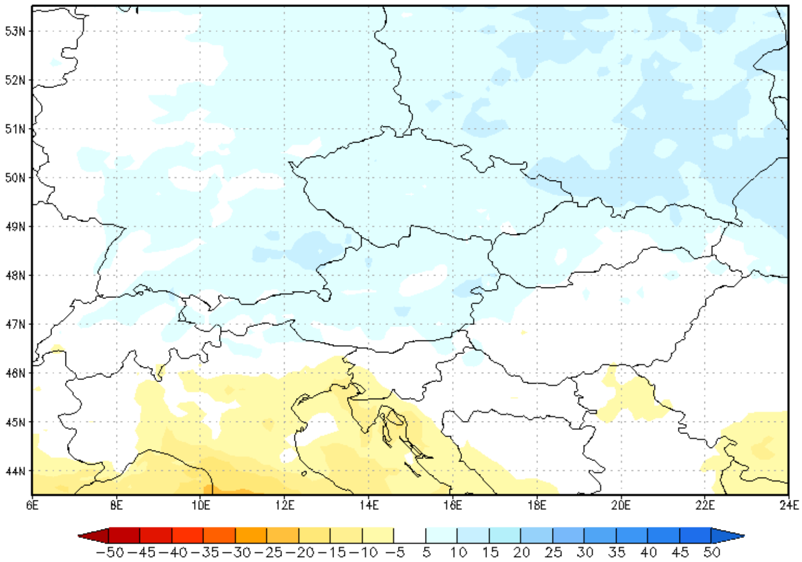


Seasonal mean precipitation change (2021-2050) [relative difference in %]

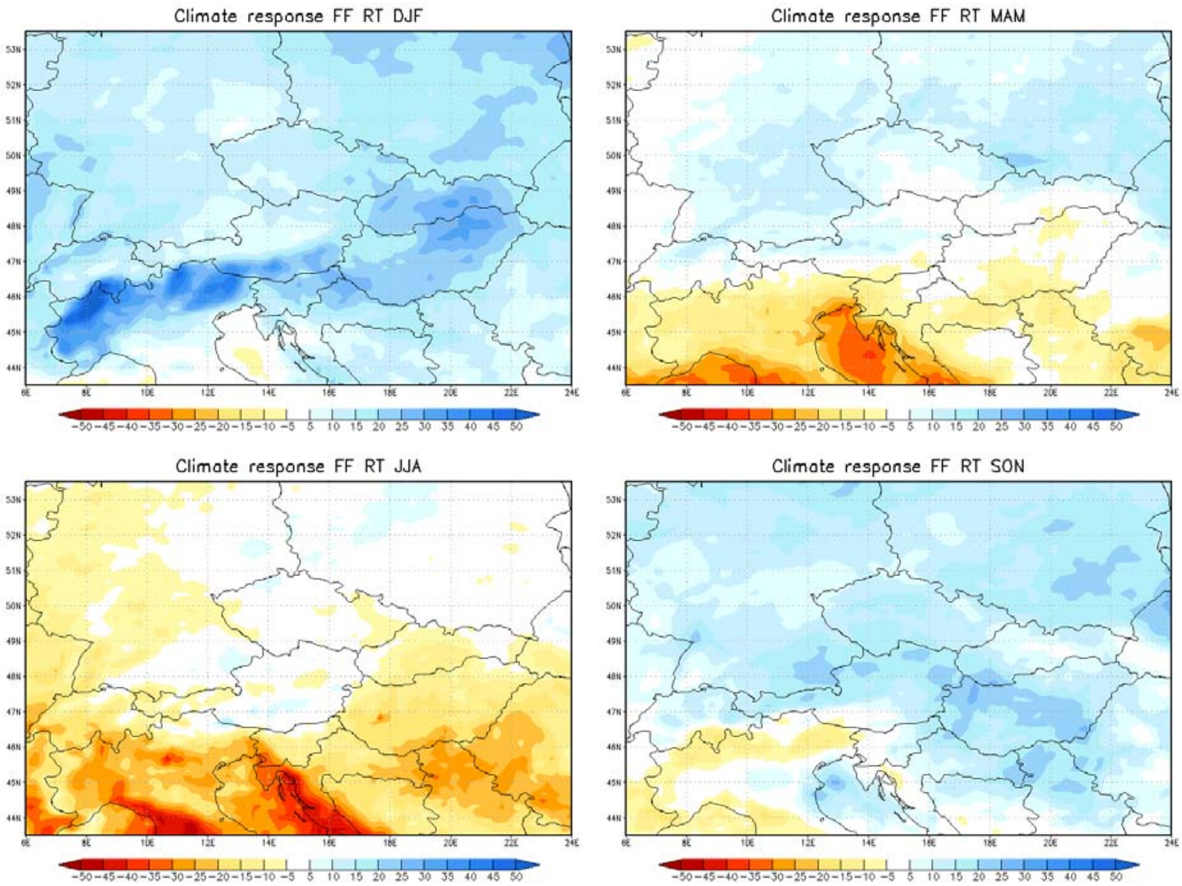


Climate response in the near future time slice (2071-2100)

Annual mean precipitation change [relative difference in %]



Seasonal mean precipitation change (2071-2100) [relative difference in %]



NMA

RegCM3 Beta description:

- Model version: **RegCM3 (Beta)**
- Domain: **Romania and Black Sea** (using 156 × 102 gridpoints), which can be characterized by the following four corners, and the central point of the domain:

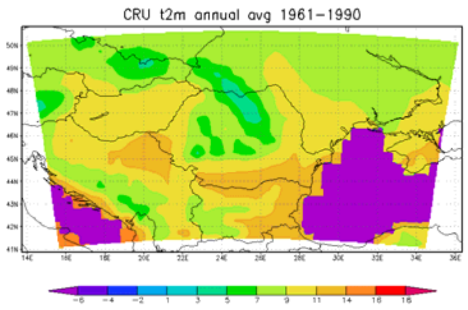
	Latitude	Longitude
SW	41.0275°N	15.627°E
SE	41.016°N	34.495°E
NW	50.175°N	14.095°E
NE	50.150°N	36.192°E
Center point	46.0°N	25.0°E

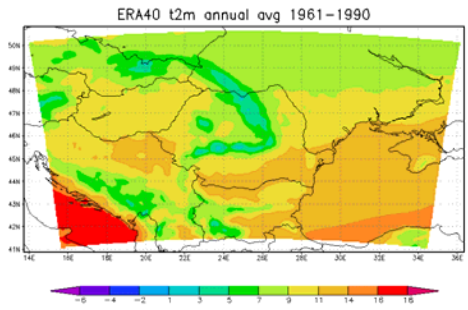
- Horizontal resolution: **10 km**
- Temporal resolution: **30 s**
- Integration period: **1960-2000; 2020-2050**; **2070-2100**
- Evaluation period: **1961-1990; 2021-2050**; **2071-2100**
- LBC: **ECHAM driven RegCM (25 km)**
- Vertical levels: **18 atmospheric levels in σ-coordinates + 3 soil layers**
- Plane geometry: **Lambert projection**
- In order to decrease the precipitation bias from RegCM3, the following parameters were changed:
  -- the cloud-to-rain autoconversion rate was decreased from 0.0005 to 0.00025,
  -- the raindrop evaporation rate coefficient was increased from $0.2 \cdot 10^{-4}$ to $1.0 \cdot 10^{-3}$ (kg m^{-2} s^{-1})$^{-1/2}$ s^{-1},
  -- the raindrop accretion rate was decreased from 6 to 3 m^3 kg s.
- Dynamics: Hydrostatic model with σ vertical coordinates
- Physics: Grell (1993) and Fritsch & Chappell (1980) convective schemes

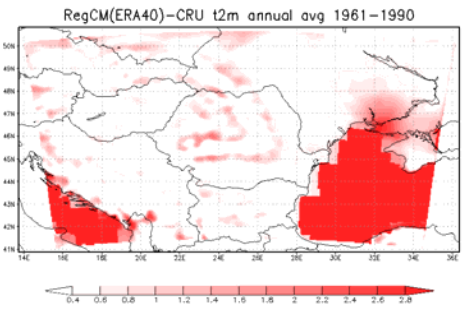
RESULTS (1961-1990)

Temperature *(RegCM – CRU(10')[^{o}C])*

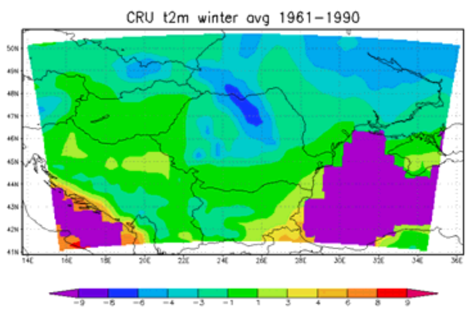
ANNUAL

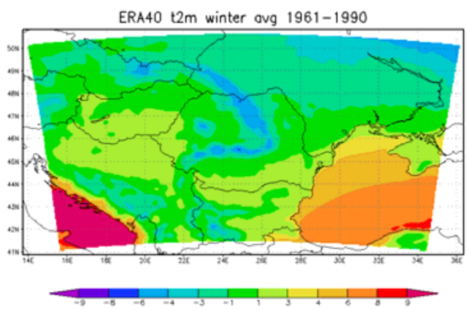


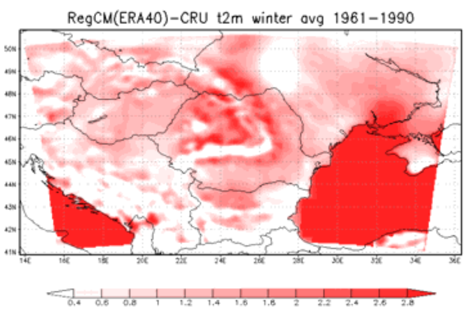




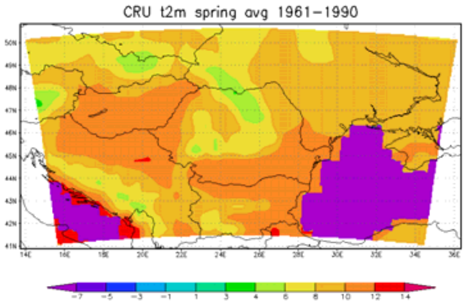
WINTER

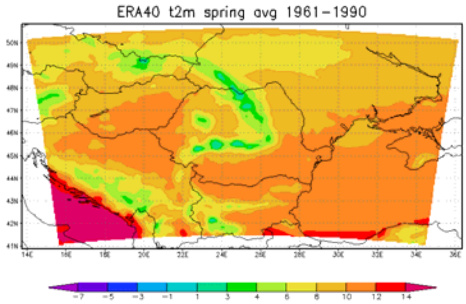


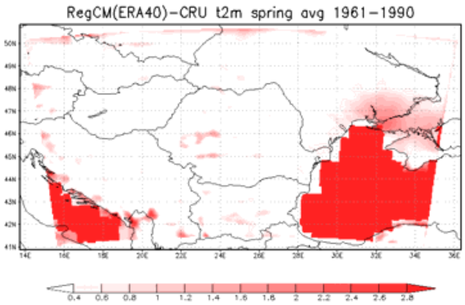




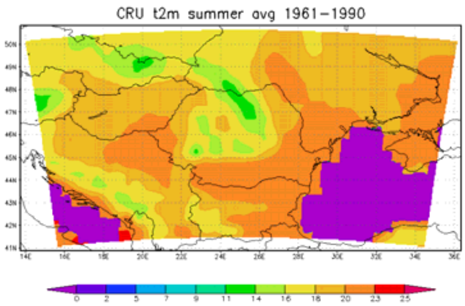
SPRING

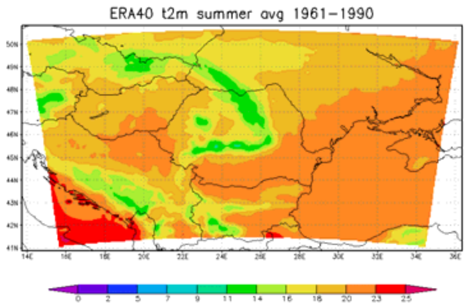


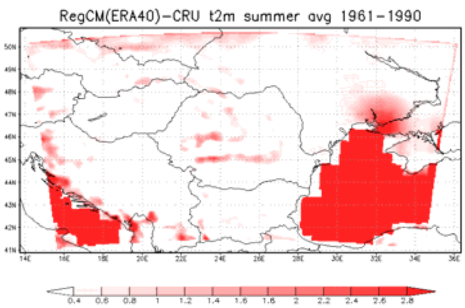




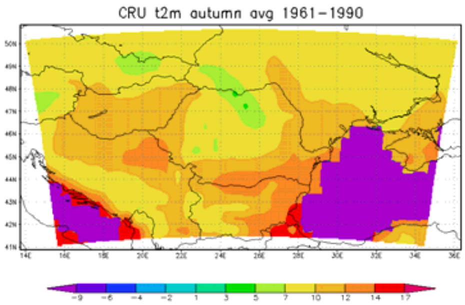
SUMMER

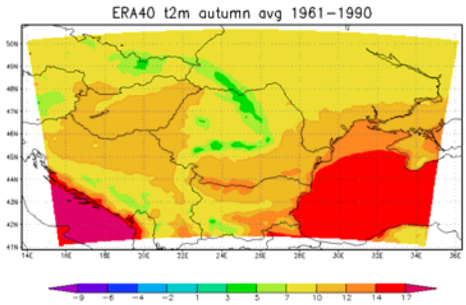


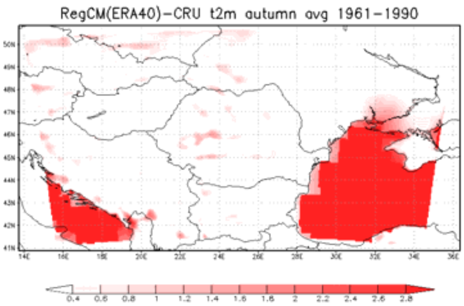




AUTUMN

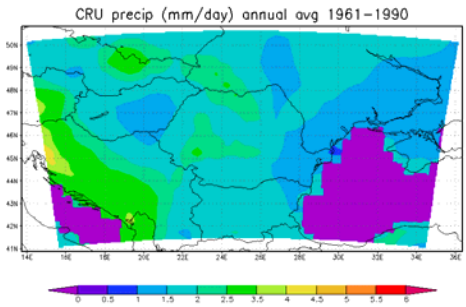


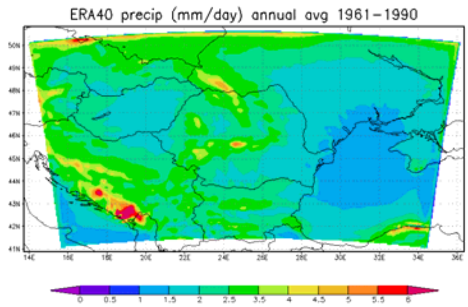


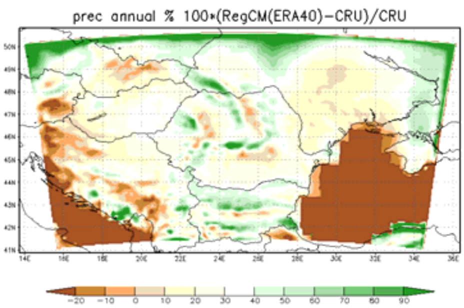


Precipitation *([RegCM– CRU(10’)]/CRU(10’) [%])*

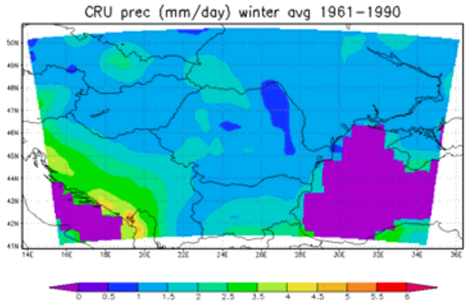
ANNUAL

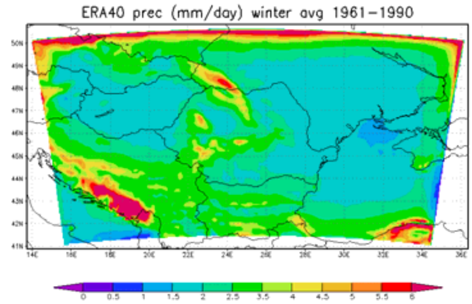


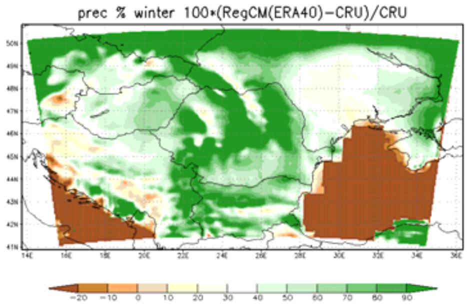




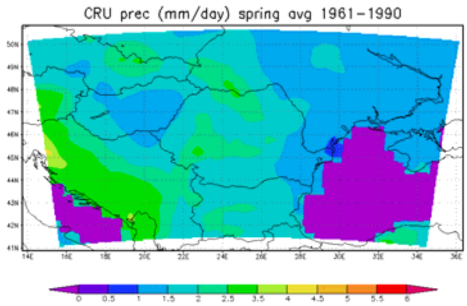
WINTER

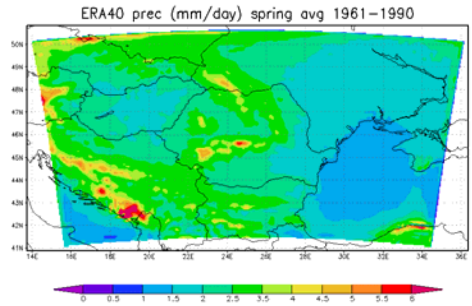


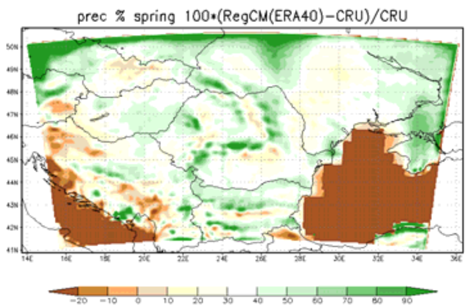




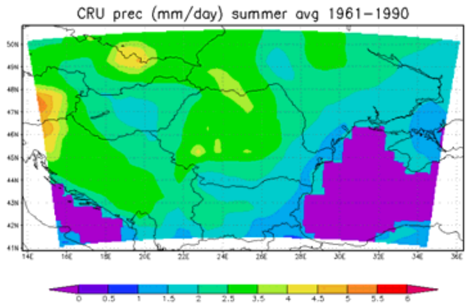
SPRING

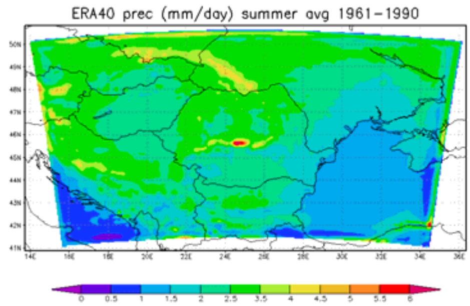


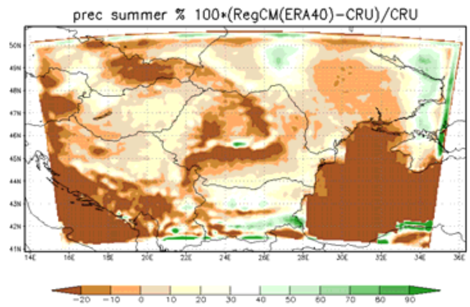




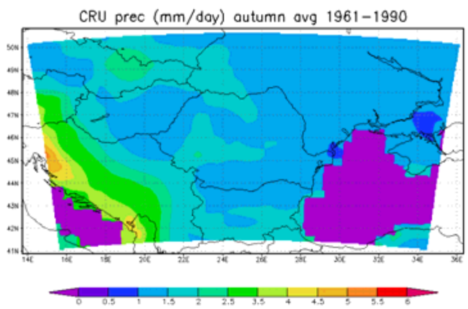
SUMMER

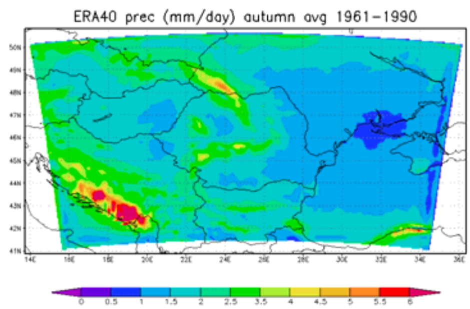


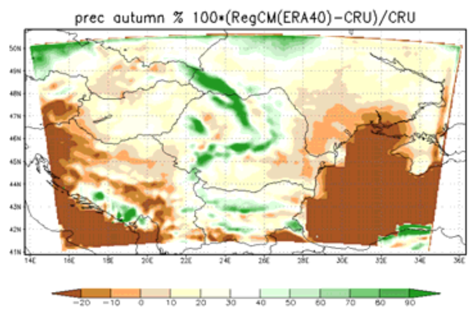




AUTUMN



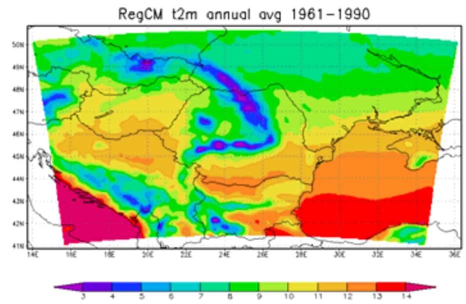


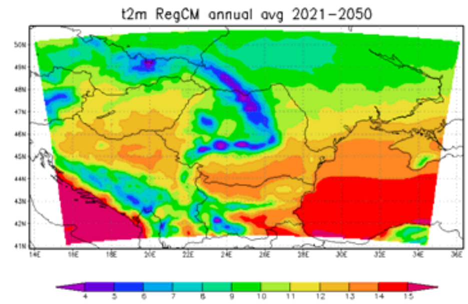


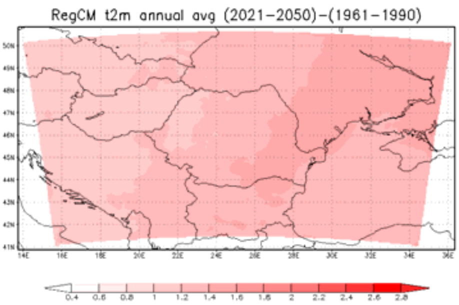
REGIONAL CLIMATE CHANGE RESULTS FOR THE PERIOD 2021-2050

Temperature *($RegCM_{2021-2050}$– $RegCM_{1961-1990}$))[^{o}C]*

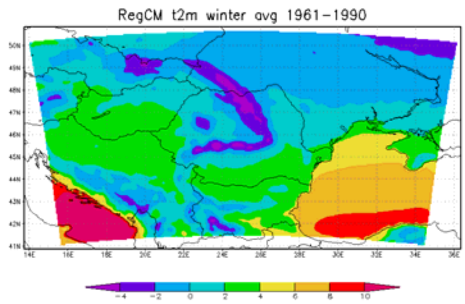
ANNUAL

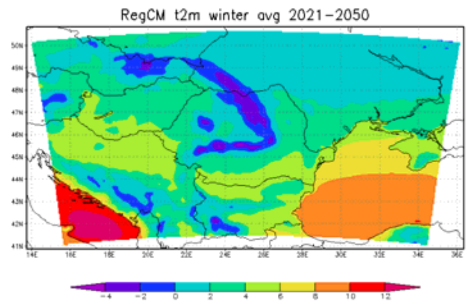


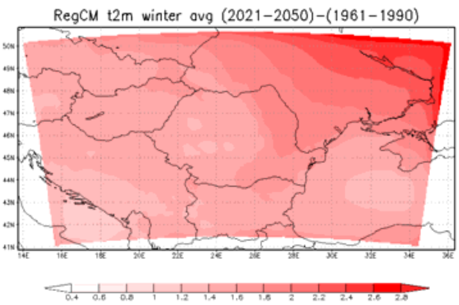




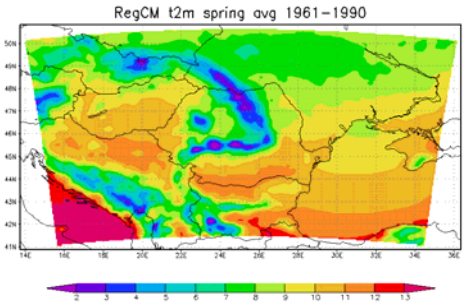
WINTER

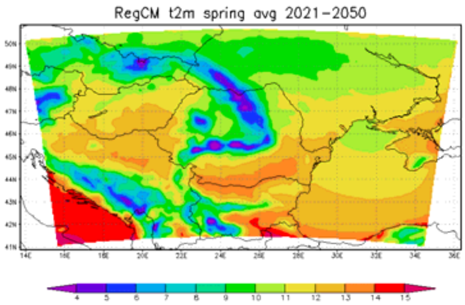


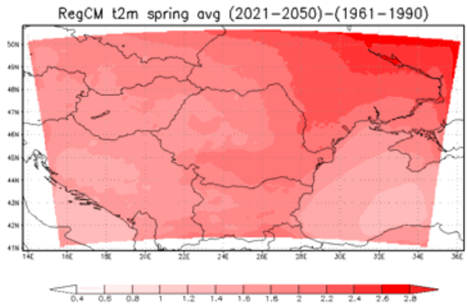




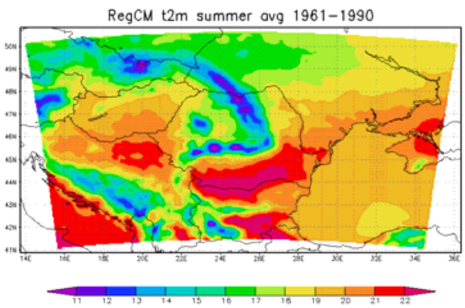
SPRING

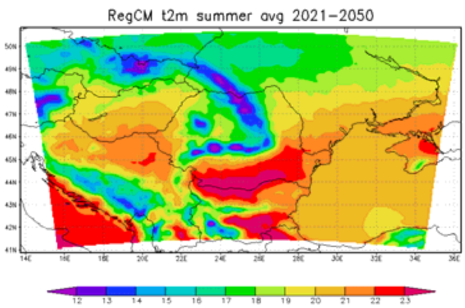


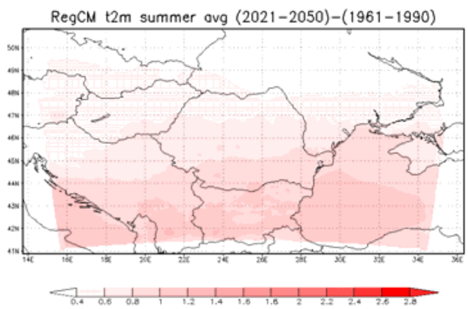




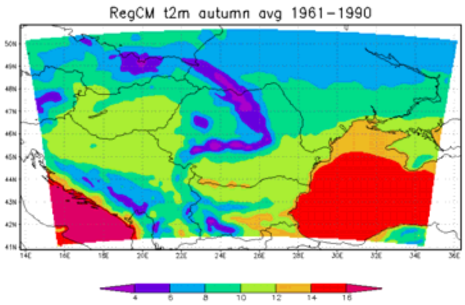
SUMMER

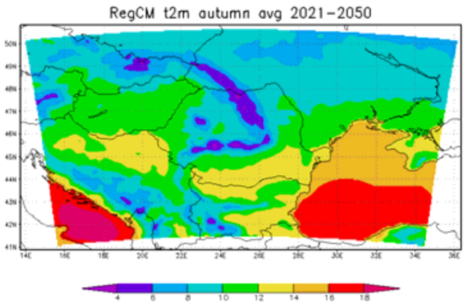


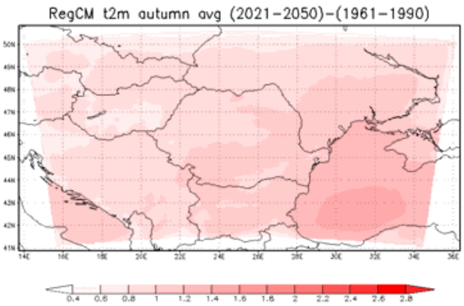




AUTUMN

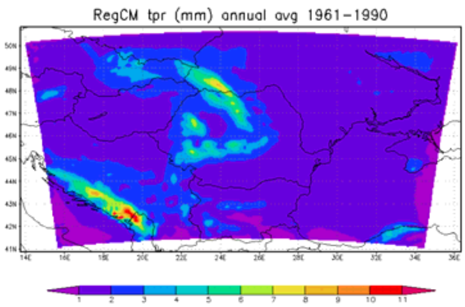


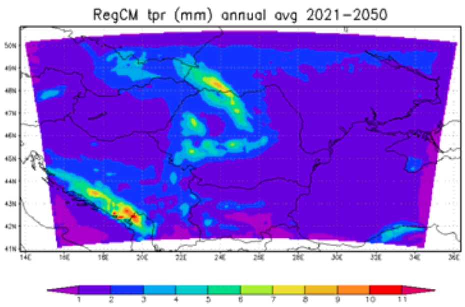


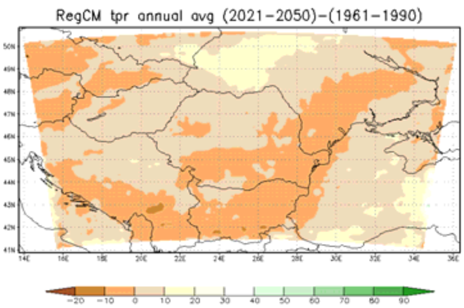


Precipitation *$((RegCM_{2021\text{-}2050} – RegCM_{1961\text{-}1990}) / RegCM_{1961\text{-}1990})[\%]$*

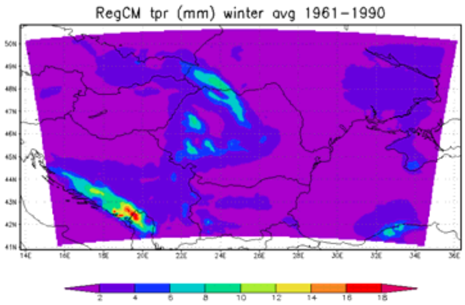
ANNUAL

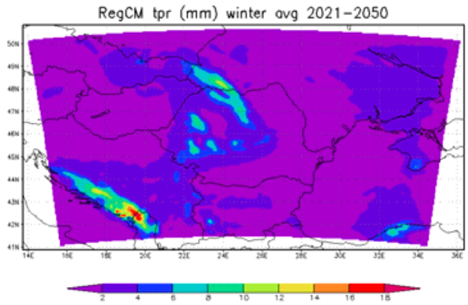


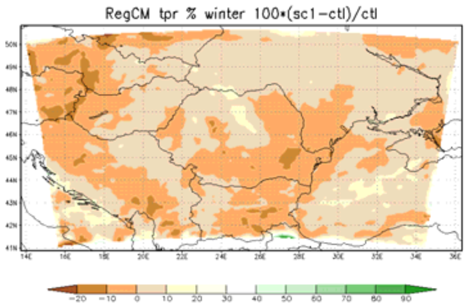




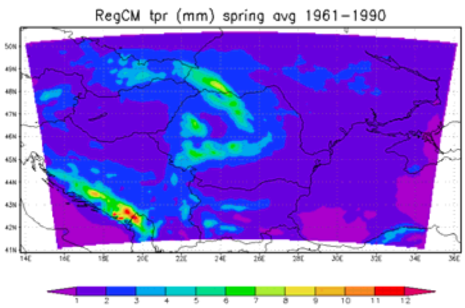
WINTER

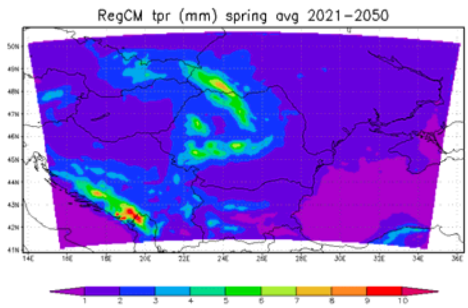


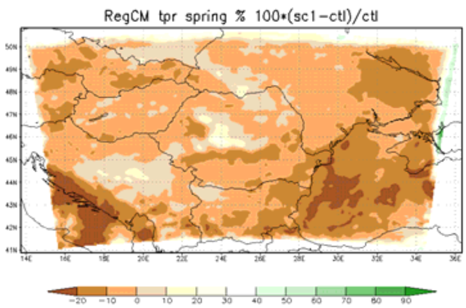




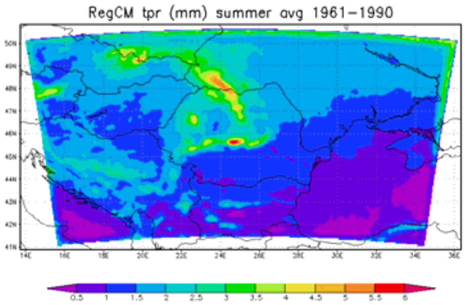
SPRING

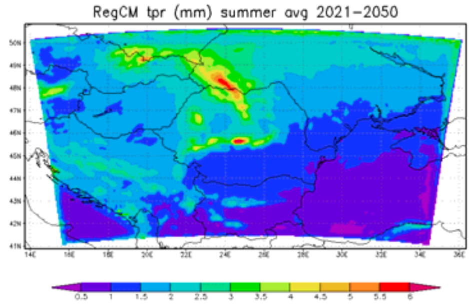


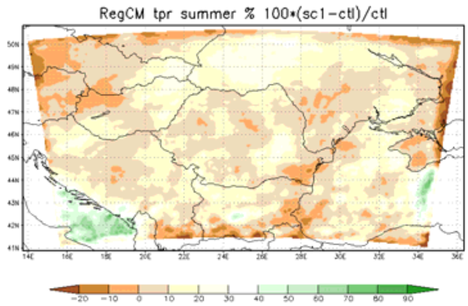




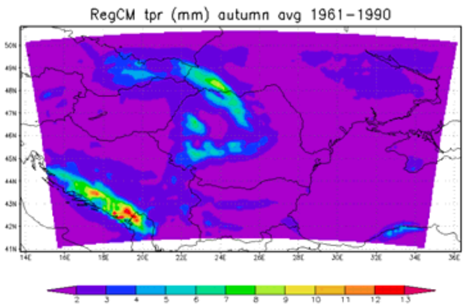
SUMMER

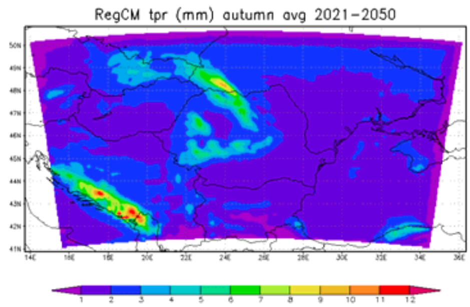


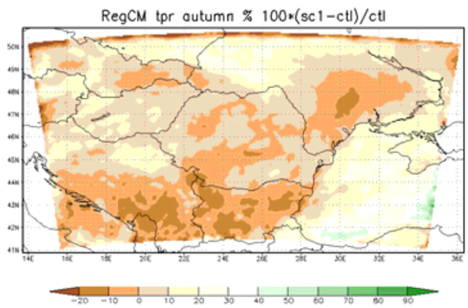




AUTUMN



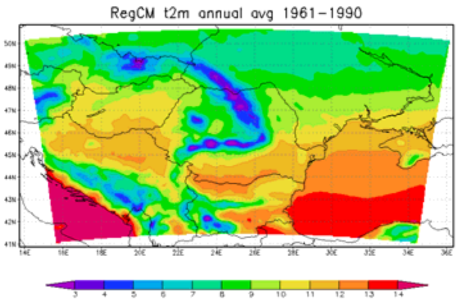


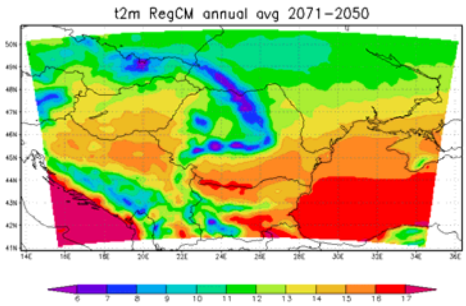


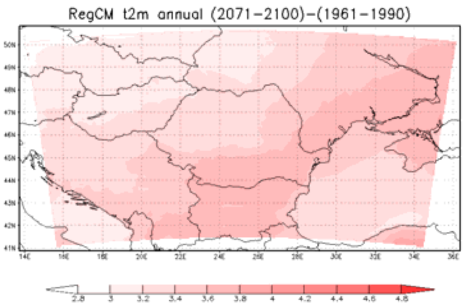
REGIONAL CLIMATE CHANGE RESULTS FOR THE PERIOD 2071-2100

Temperature *(RegCM$_{2071\text{-}2100}$– RegCM$_{1961\text{-}1990}$))[^{o}C]*

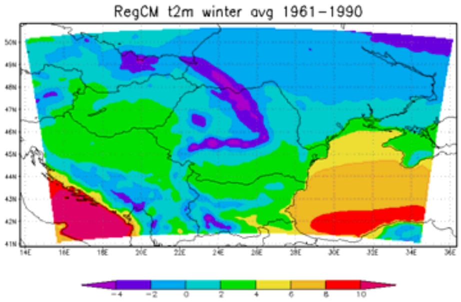
ANNUAL

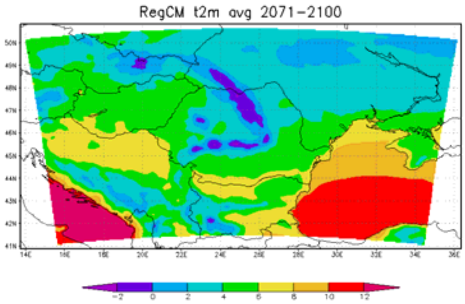


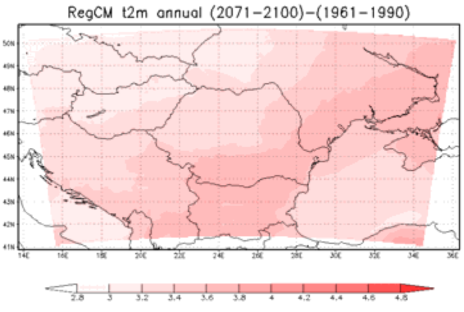




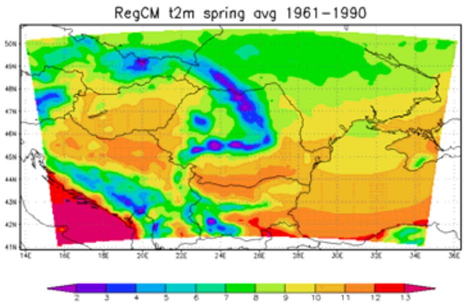
WINTER

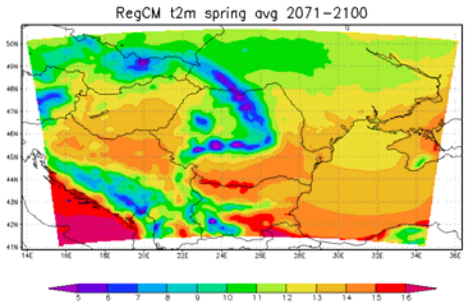


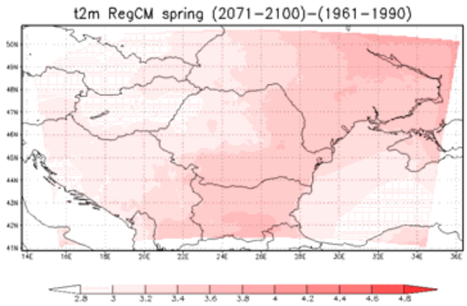




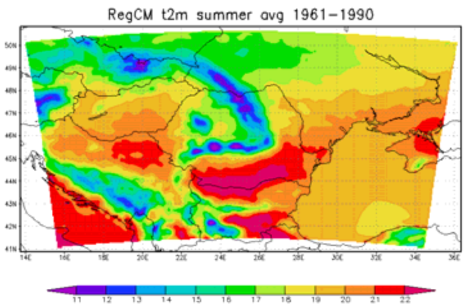
SPRING

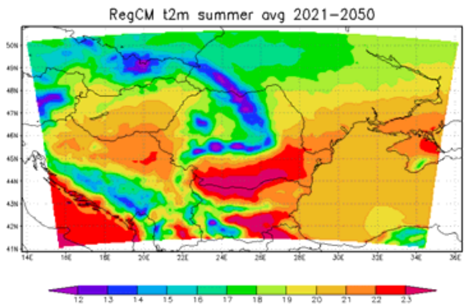


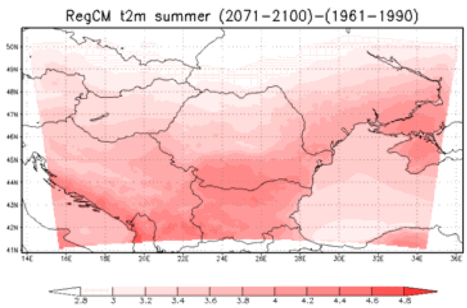




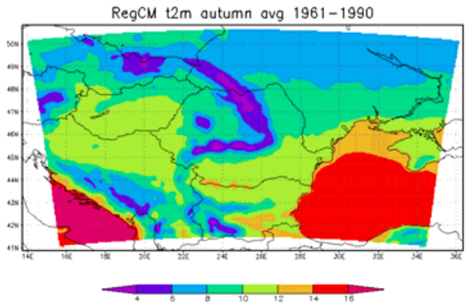
SUMMER

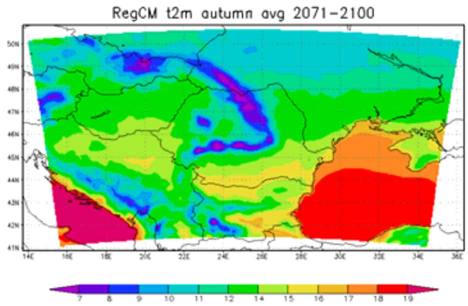


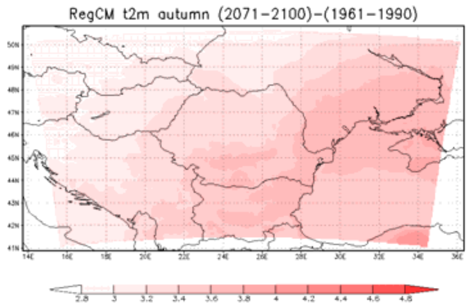




AUTUMN

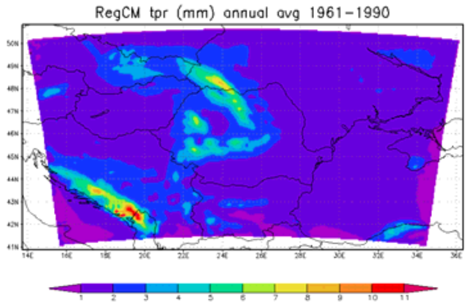


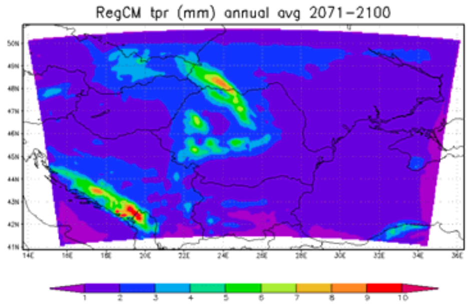


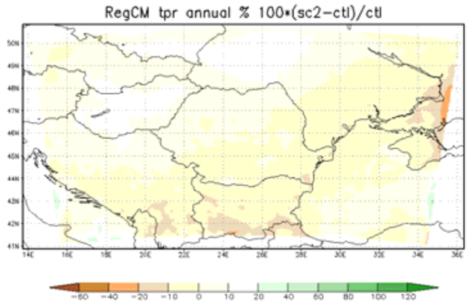


Precipitation *$((RegCM_{2071\text{-}2100} - RegCM_{1961\text{-}1990}) / RegCM_{1961\text{-}1990})[\%]$*

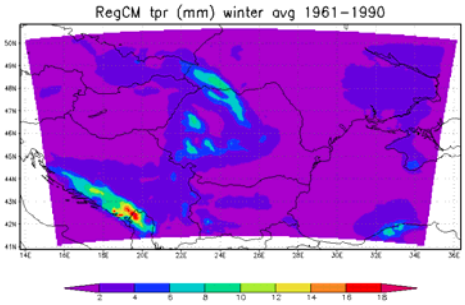
ANNUAL

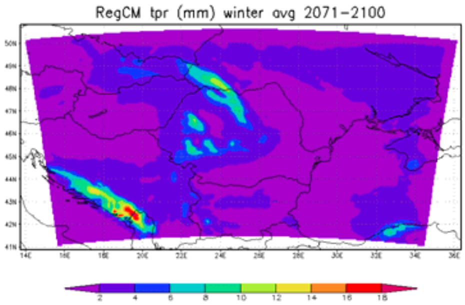


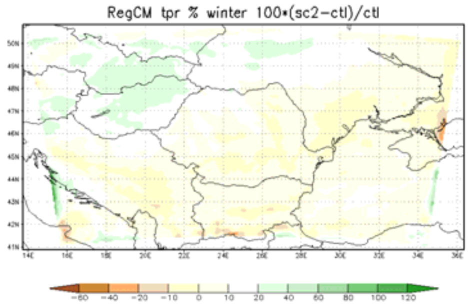




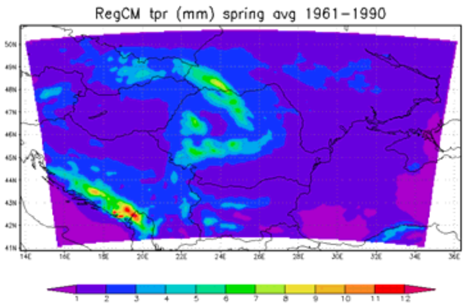
WINTER

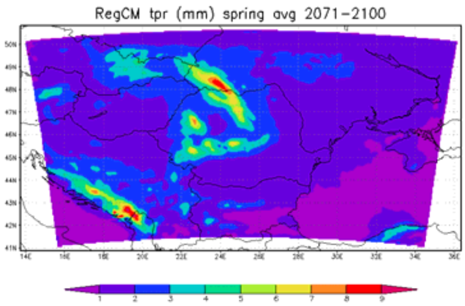


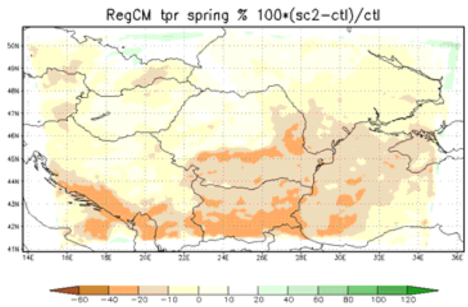




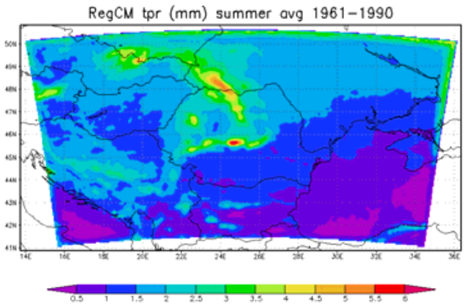
SPRING

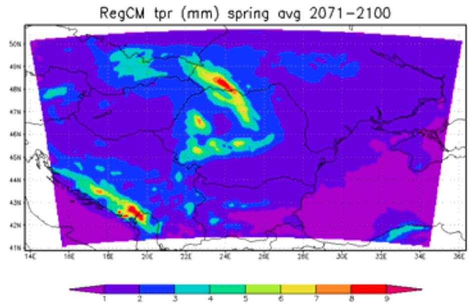


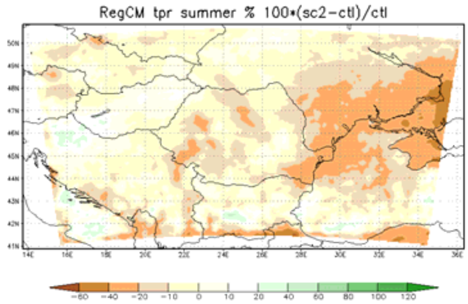




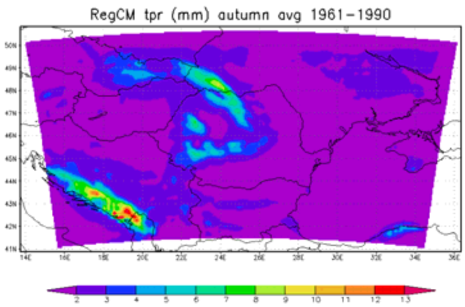
SUMMER

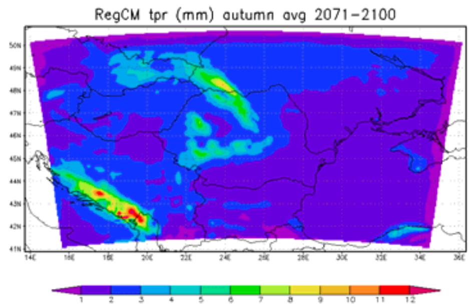


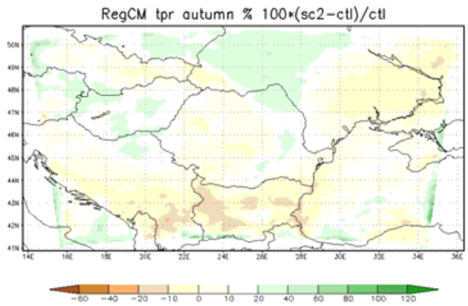




AUTUMN







CHMI

Czech Hydrometeorological Institute

- Model name: ALADIN-Climate/CZ
- Model version: Cycle 28 of NWP model version as used at CHMI
- Model formulation: Semi-implicit semi-lagrangian advection scheme

  Spectral formulation (for dynamics)

  ACRANEB radiation scheme

  Bougeault modified deep convection scheme

  ISBA scheme for interaction with surface

  Diagnostics schemes for precipitation and cloudiness

- Integration domain extension:148 x 74 points
- Integration domain projection: Lambert conform (tangent case)
- Integration domain center: 38,25 °N, 17 °E
- Horizontal resolution: 10 km
- Vertical resolution: 43 levels
- Time step: 450 s.
- Integration experiments: 1960-2000 (ERA-40 LBC)

  1960-2000 (ARPEGE-Climat LBC)

  2020-2050 (ARPEGE-Climat LBC)

  2070-2100 (ARPEGE-Climat LBC)

RESULTS (1961-1990)

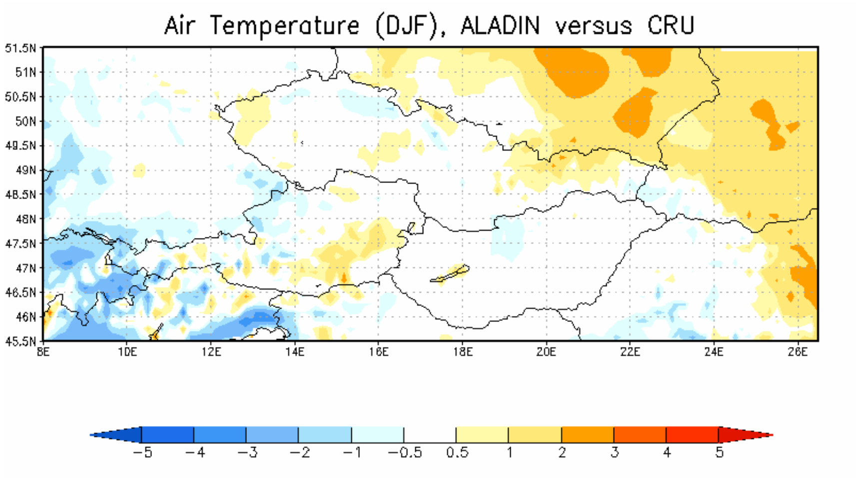
Model was validated against the CRU dataset over the whole integration domain. Over the territory of the Czech Republic the model was further compared with a CHMI gridded dataset of station observations of 10 km spatial resolution. The CHMI gridded dataset was prepared within the CECILIA project and is based on CHMI station records.

The validation is also planned to be extended on the E-OBS dataset.

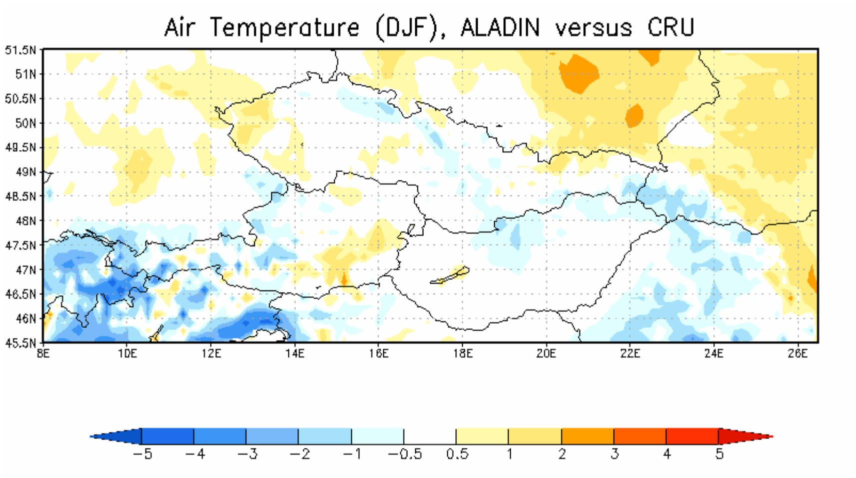
Temperature *(ALADIN – CRU(10’) [ºC]*

Difference of seasonal mean temperature

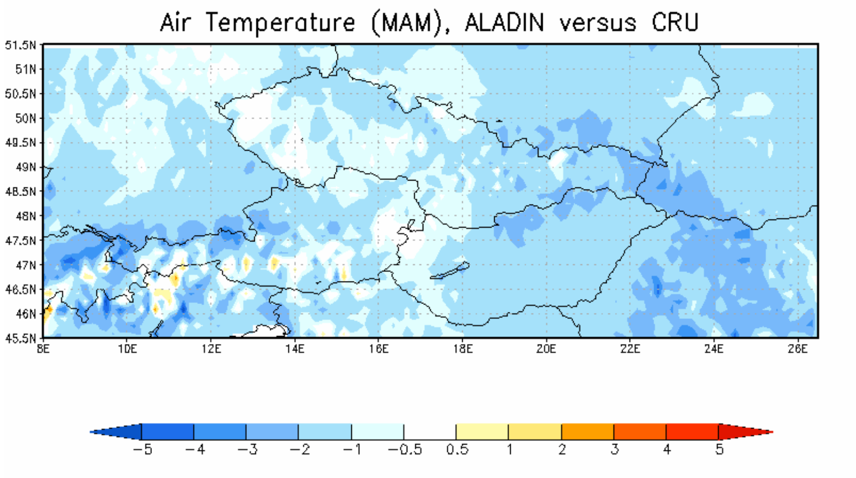
ERA-40: winter



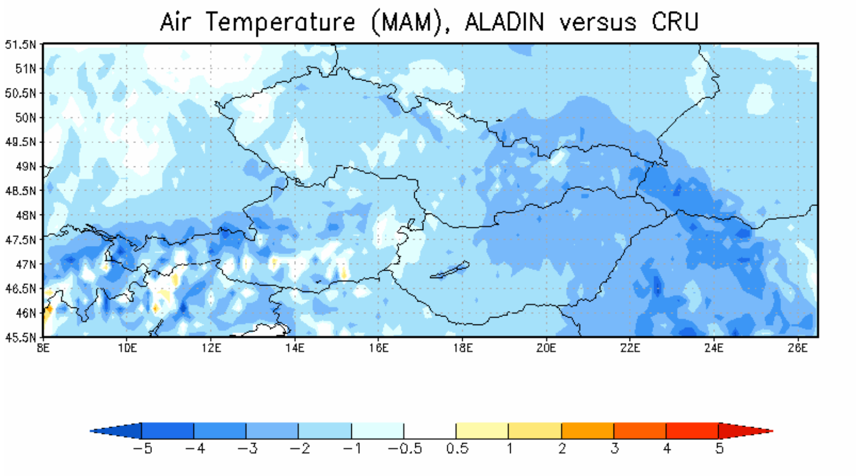
ARPEGE: winter



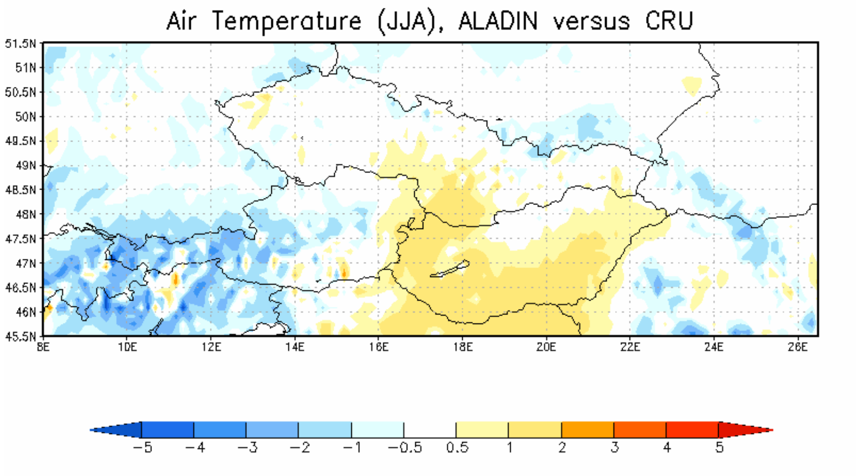
ERA-40: spring



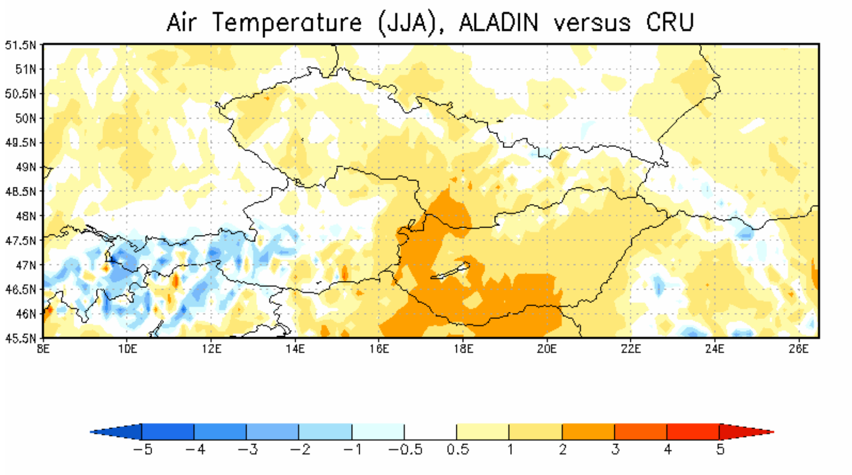
ARPEGE: spring



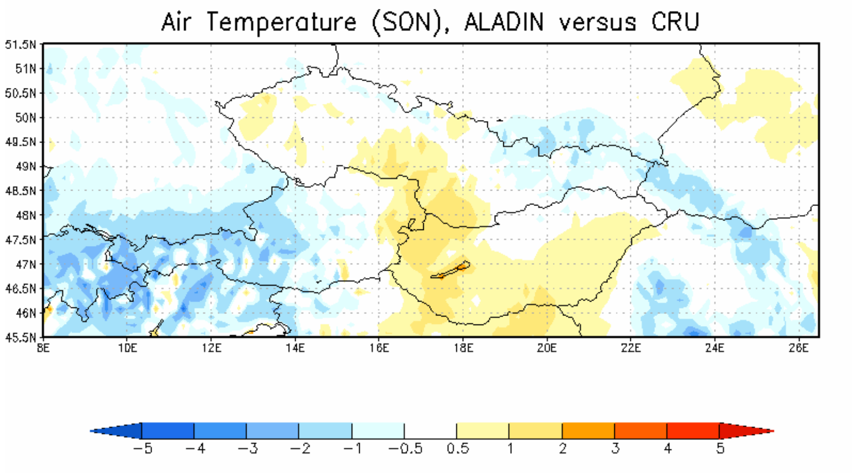
ERA-40: summer



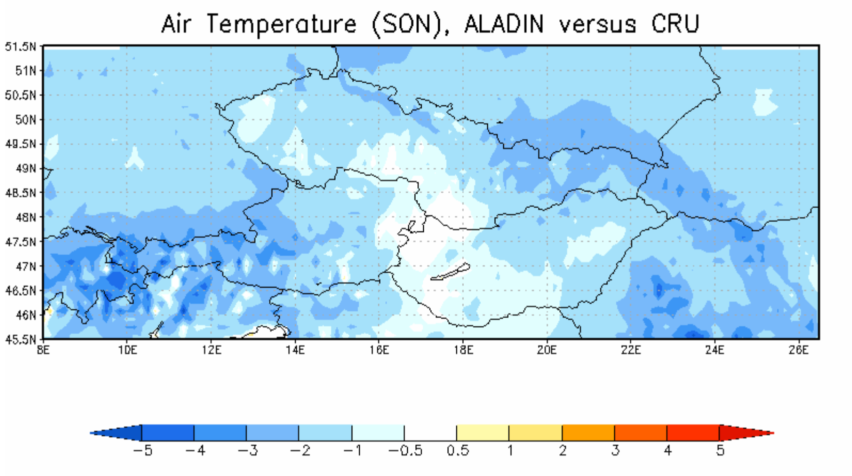
ARPEGE: summer



ERA-40: autumn



ARPEGE: autumn



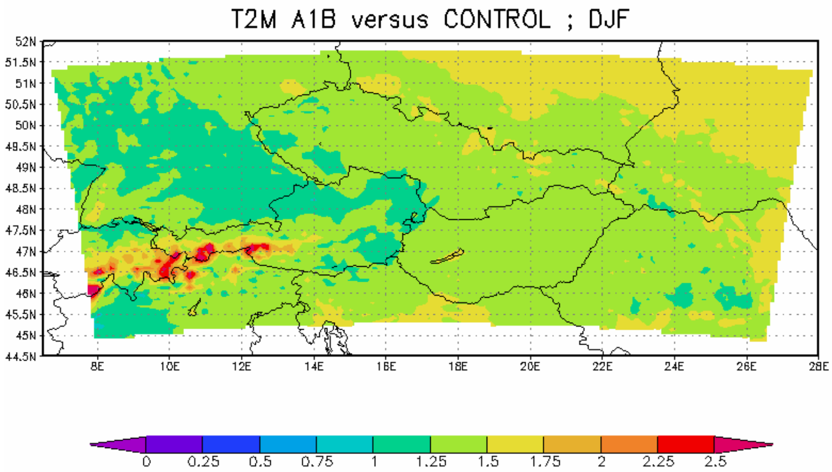
REGIONAL CLIMATE CHANGE RESULTS FOR THE PERIODS 2021-2050 and 2071-2100

Projected change of climate change was assessed by comparison of scenario (2021-2050 or 2071-2100) and control past (1961-1990) model simulations. Over the territory of the Czech and Slovak Republic the model data was corrected according to validation results carried out for the period 1961-1990. After the correction, the model scenario outputs were compared directly with the station (measured) data.

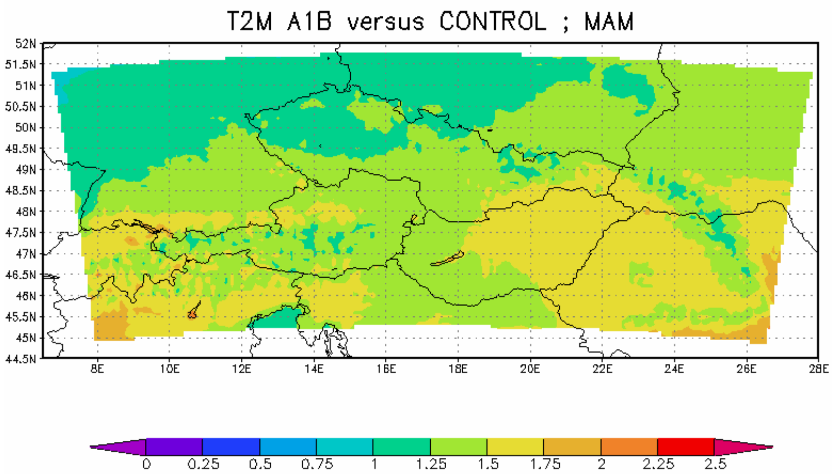
The presented results should be considered as preliminary. The further evaluation will focus on more meteorological parameters than presented here.

Temperature *(ALADIN$_{2021-2050}$ – ALADIN$_{1961-1990}$ [ºC])*

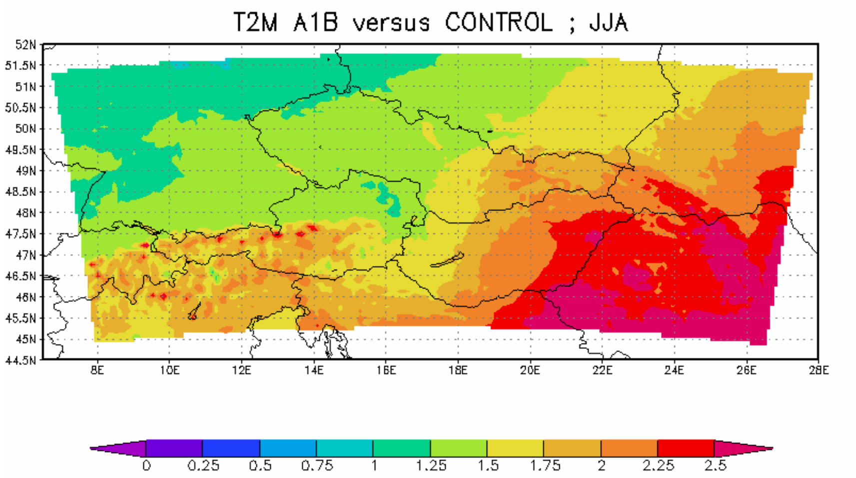
Winter:



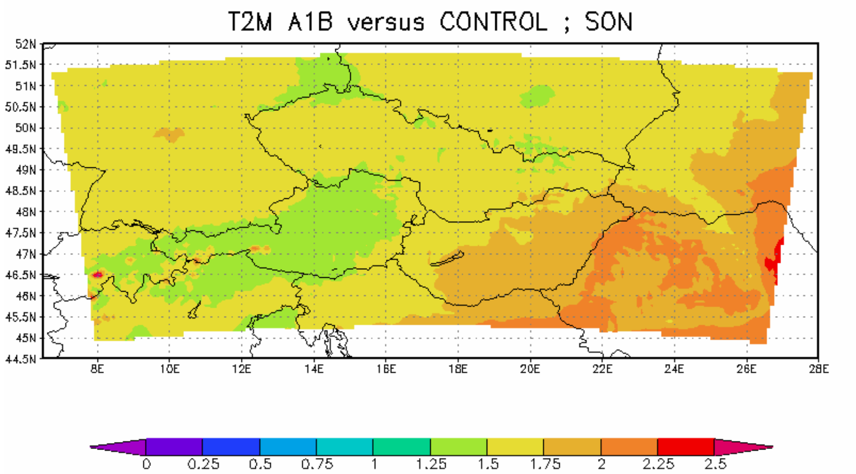
Spring:



Summer:



Autumn:



Temperature *($ALADIN_{2021\text{-}2051\ bias\ corrected}$ – Station $data_{1961\text{-}1990}$ [ºC])*

Difference of seasonal mean temperature

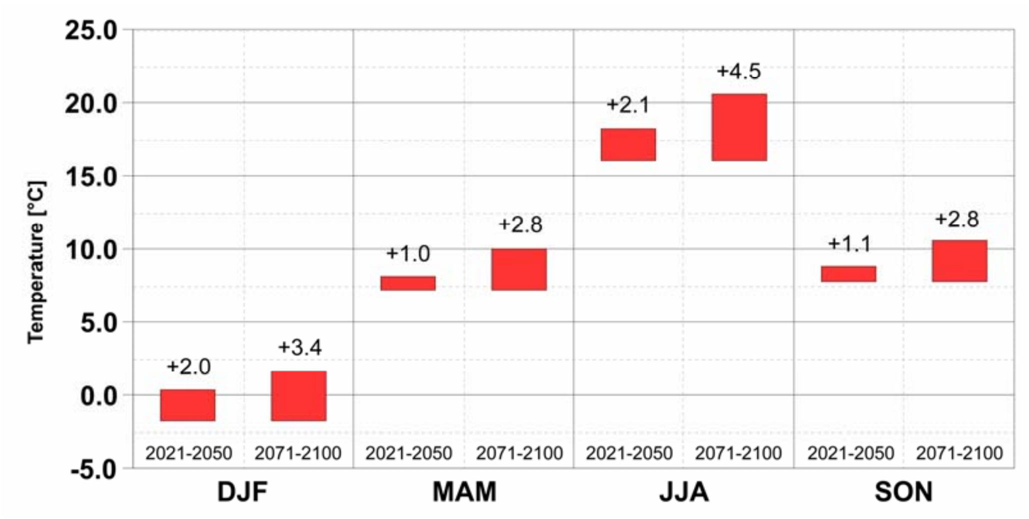
winter

spring

summer

autumn

The projected change of seasonal mean temperature in the Czech Republic for 2021-2050 and 2071-2100 periods against the reference period 1961-1990.



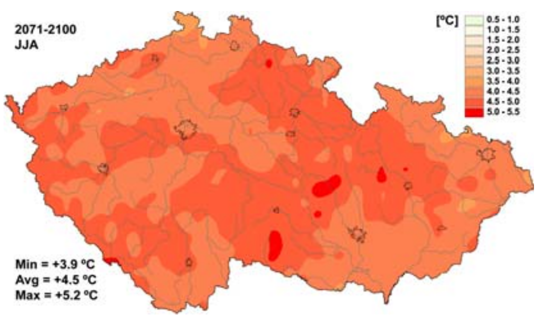
Temperature *(ALADIN$_{2071\text{-}2100\ bias\ corrected}$ – Station data$_{1961\text{-}1990}$ [ºC])*

Difference of seasonal mean temperature

winter

spring

summer

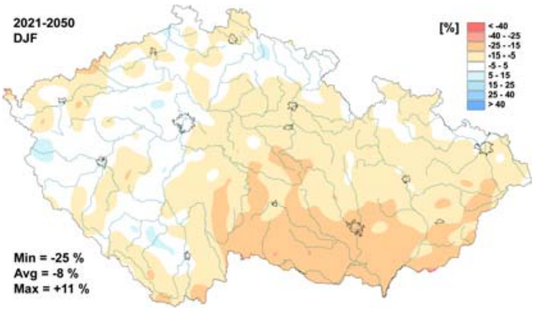


autumn

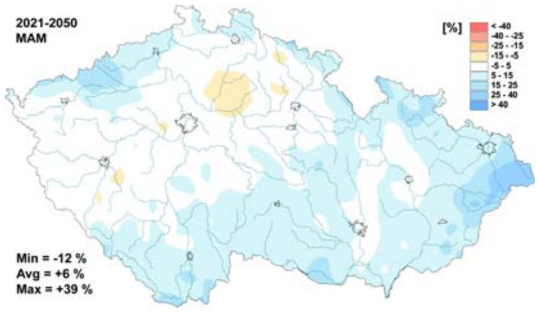
Precipitation *(ALADIN$_{2021-2051\ bias\ corrected}$ / Station data$_{1961-1990}$ [%])*

Relative difference of seasonal mean precipitation

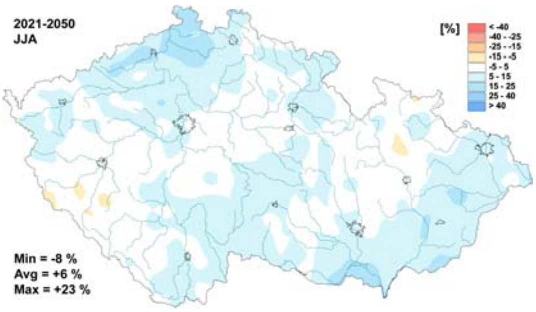
winter



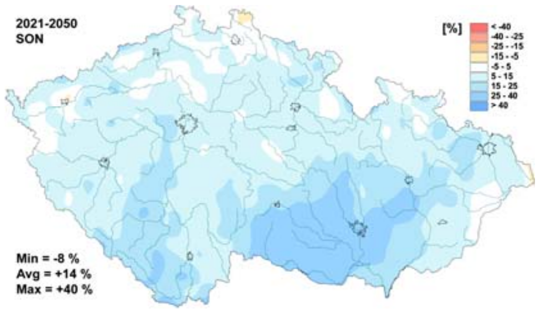
spring



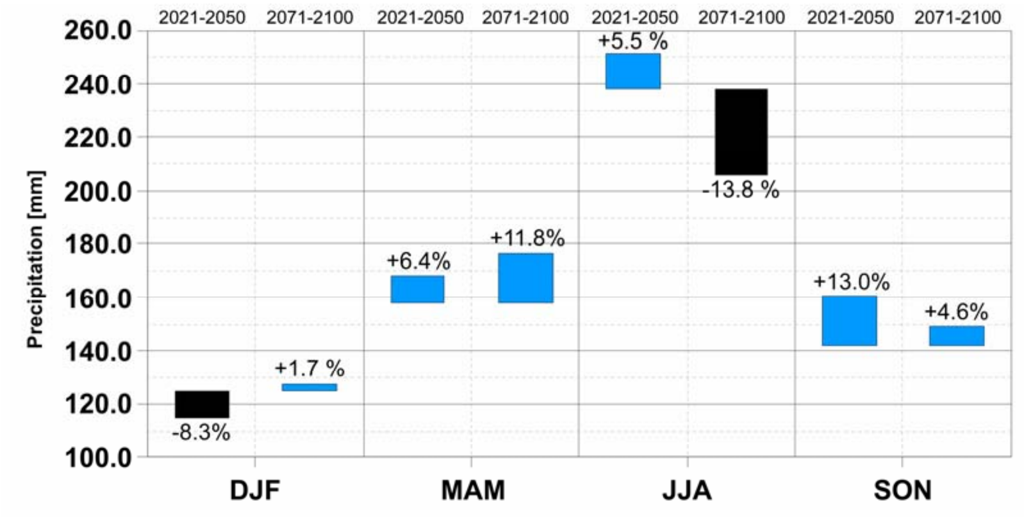
summer



autumn



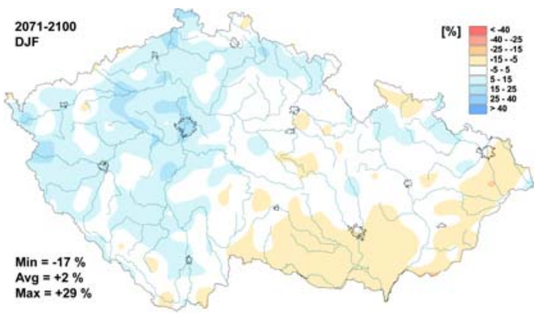
The projected change of seasonal mean precipitation in the Czech Republic for 2021-2050 and 2071-2100 periods against the reference period 1961-1990.



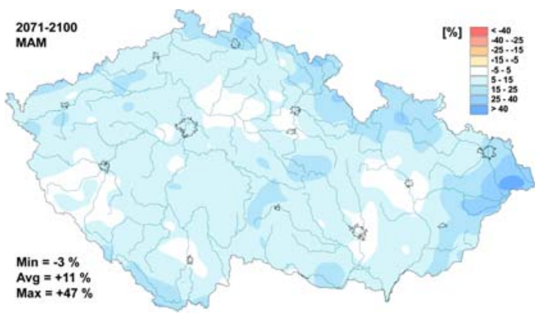
Precipitation *(ALADIN$_{2071\text{-}2100\ bias\ corrected}$ / Station data$_{1961\text{-}1990}$ [%])*

Relative difference of seasonal mean precipitation

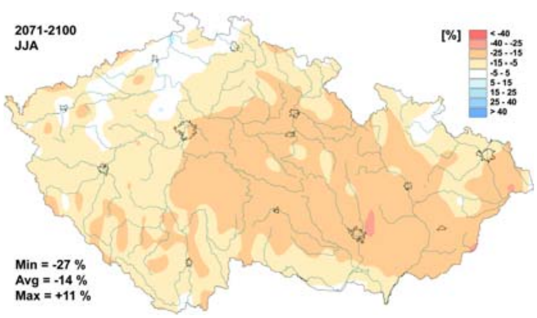
winter



spring



summer



autumn