



LIFE08 ENV/IT/436

PROJECT ACT

ADAPTING TO CLIMATE CHANGE IN TIME

Climate model projections

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Introduction: data & methods

Temperature and precipitation projections for the three target areas (Ancona, Bullas, Patras) were extracted from the gridded fields generated by three Regional Climate Models (RCMs) and two high-resolution Global Climate Models (GCMs).

From each gridded field, the “land” grid point closest to each target area was considered.

Data were downloaded from the websites:

- GCMs:

PCMDI (<http://www-pcmdi.llnl.gov/>), Program for Climate Models Diagnosis and Intercomparison

- RCMs:

ENSEMBLES project (<http://ensemblesrt3.dmi.dk/>)

Research line: production of regional climate scenarios for impact assessments



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Introduction: data & methods

Projections for Regional Climate Models are available only for the emission scenario A1B (the intermediate scenario).

Projections for Global Climate Models are also available for the A2 (pessimistic) and B1 (optimistic) emission scenarios.

The chosen RCMs were selected according to this 3 criteria:

- high spatial resolution
- number of output parameters
- easy and clear procedures for gridded data extraction

The chosen GCMs have the spatial resolution closer to that of the selected RCMs.



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Introduction: data & methods

GCMs results are used to evaluate:

- The range of the projections for the climatic variables according to different emission scenarios.
- The differences between the GCMs and RCMs projections for the target areas.



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Introduction: data & methods

RCMs

Model	Ownership	Resolution
CNRM-RM5.1	Meteo France (CNRM)	25 km
SMHIRCA	Swedish Meteorological and Hydrological Institute (SMHI)	25 km
KNMI-RACMO2	The Royal Netherlands Meteorological Institute (KNMI)	50 km

GCMs

Model	Ownership	Resolution
CNRM	Meteo France (CNRM)	(2°x1.5°) about 300 km
INGV	Istituto Nazionale di Geofisica e Vulcanologia (INGV)	(2°x1.5°) about 300 km

Introduction: data & methods

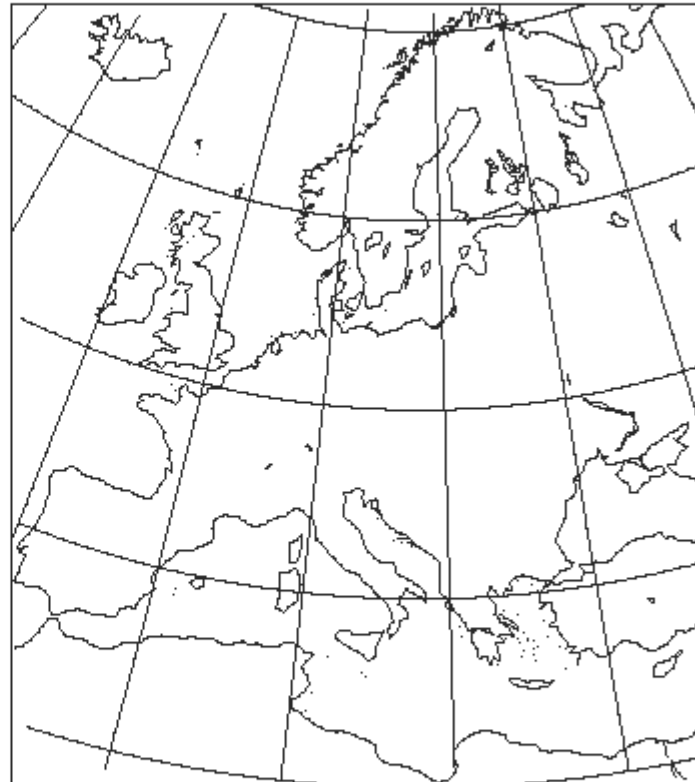
ENSEMBLES RCM Minimum Area

exlon = 18.0000, eqlat = 50.7500, polon = -162.000, polat = 39.2500
starlon = -21.7200, starlat = -20.6800, endlon = 15.4600, endlat = 20.9000
lx= 170, ly= 190, delta= 0.220000, NG= 32300, NG10= 39900



0.22 degree (25km) grid mesh

exlon = 18.0000, eqlat = 50.7500, polon = -162.000, polat = 39.2500
starlon = -21.6100, starlat = -20.5700, endlon = 15.3500, endlat = 20.7900
lx= 85, ly= 95, delta= 0.440000, NG= 8075, NG10= 12075



0.44 degree (50km) grid mesh

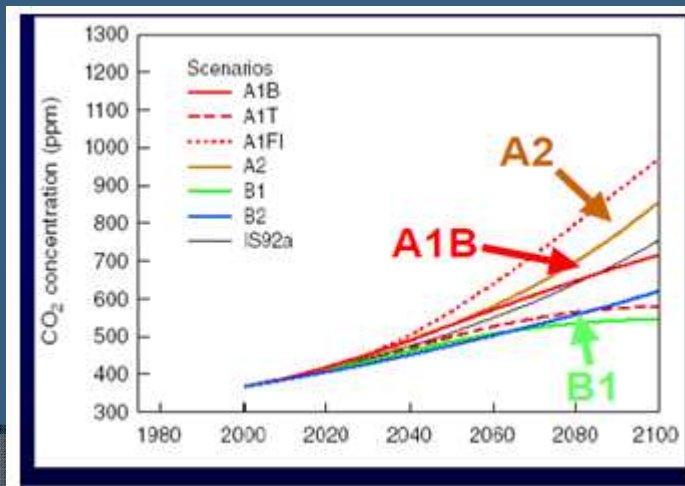
Introduction: data & methods

THE EMISSION SCENARIOS OF THE IPCC SPECIAL REPORT ON EMISSION SCENARIOS (SRES)

A1B scenario: rapid future economic growth and rapid introduction of new and more efficient technologies, based on a balance across fossil-intensive and non-fossil energy sources. Global population peaks in mid-century and declines thereafter.

A2 scenario: Economic development is primarily regionally oriented with per capita economic growth and technological change more fragmented and slower than other scenarios. Continuously increasing population.

B1 scenario: a convergent world with the same global population, that peaks in mid-century and declines thereafter, with rapid change in economic structures toward a service and information economy, with reductions in material intensity and the introduction of clean and resource-efficient technologies.



TO OBSERVE:
A: high economic growth
B: low economic growth
1: stable population
2: increasing population

← CO₂ concentrations projections

Temperature projections: general results

Model projections are presented as temperature anomalies with respect to 1961-1990, sampled every 10 years.

RCMs results:

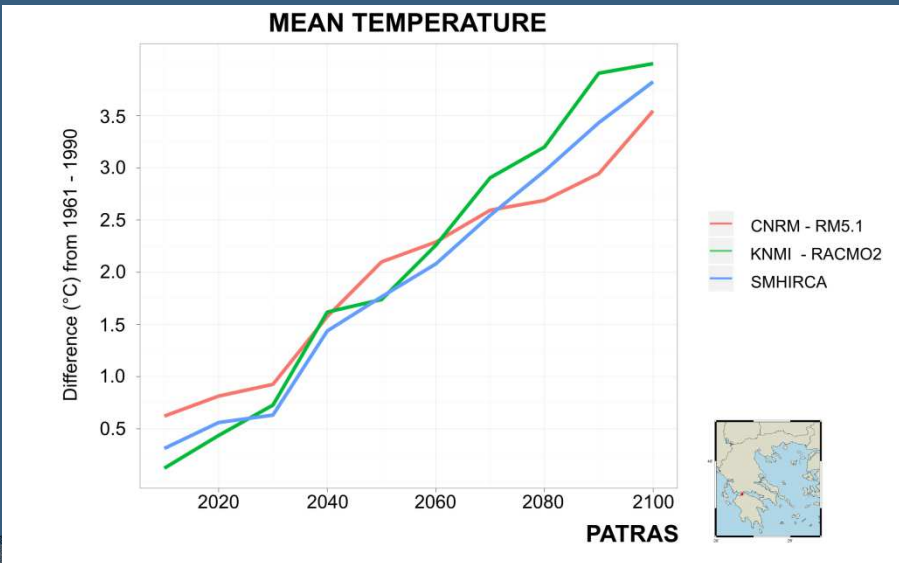
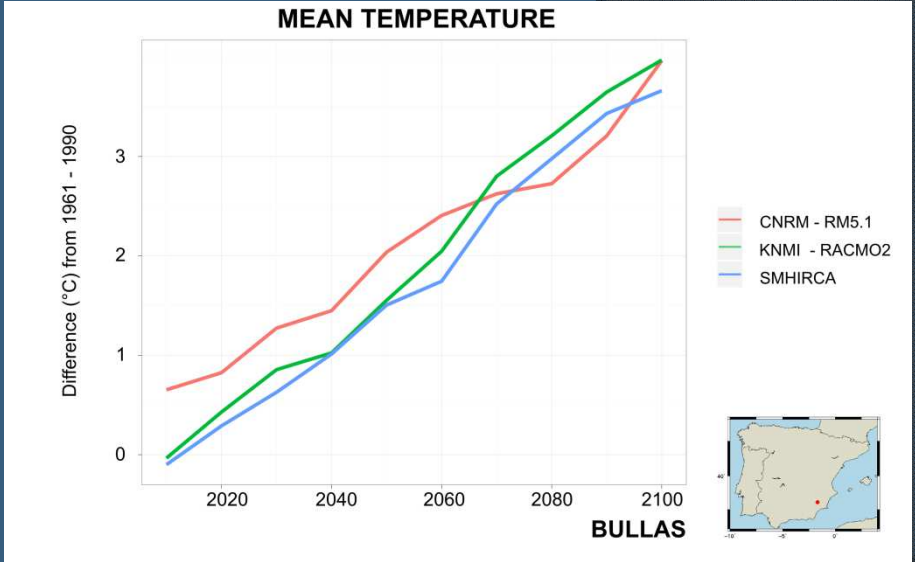
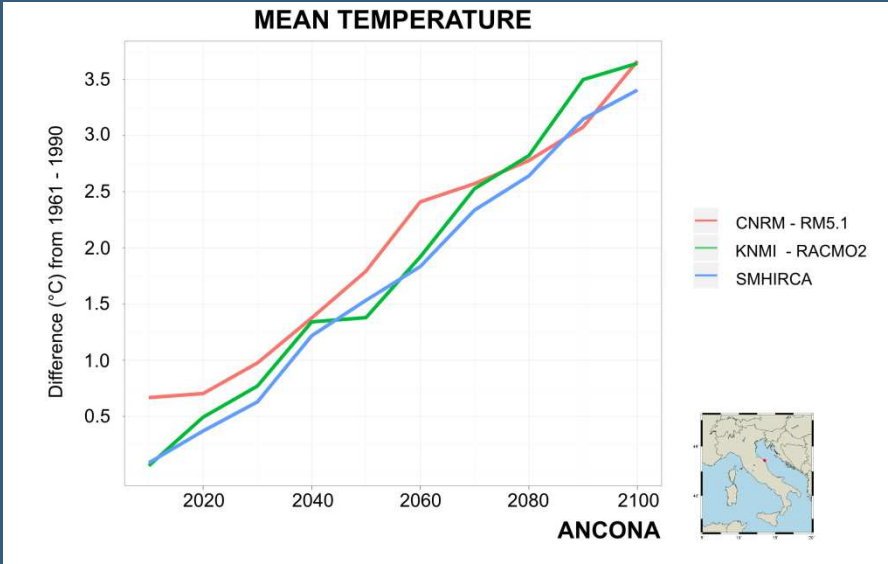
the mean temperature exhibits a trend which is almost linear throughout the whole century, with no time periods with trend significantly different from the mean rate of the temperature increase.

the trend of the minimum and maximum temperatures doesn't show any significant difference respect to the increase of the mean temperature.

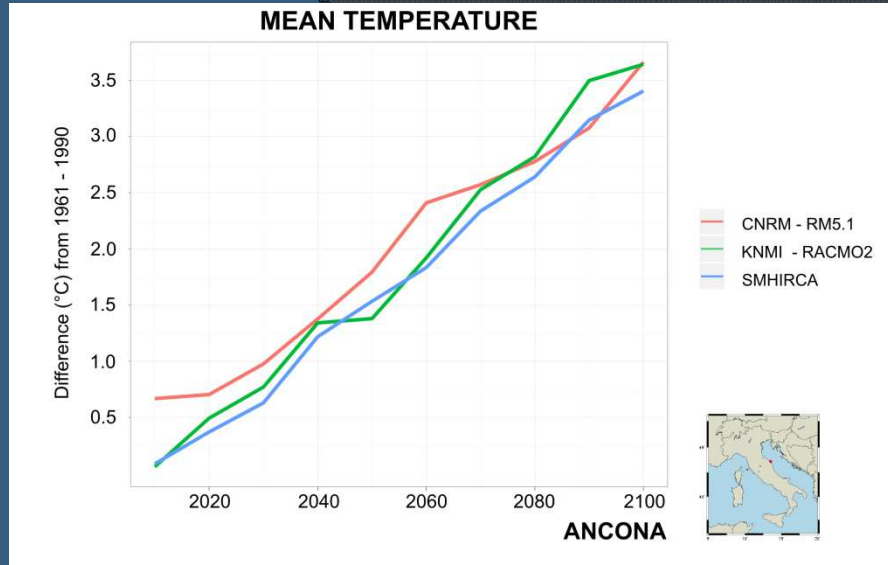
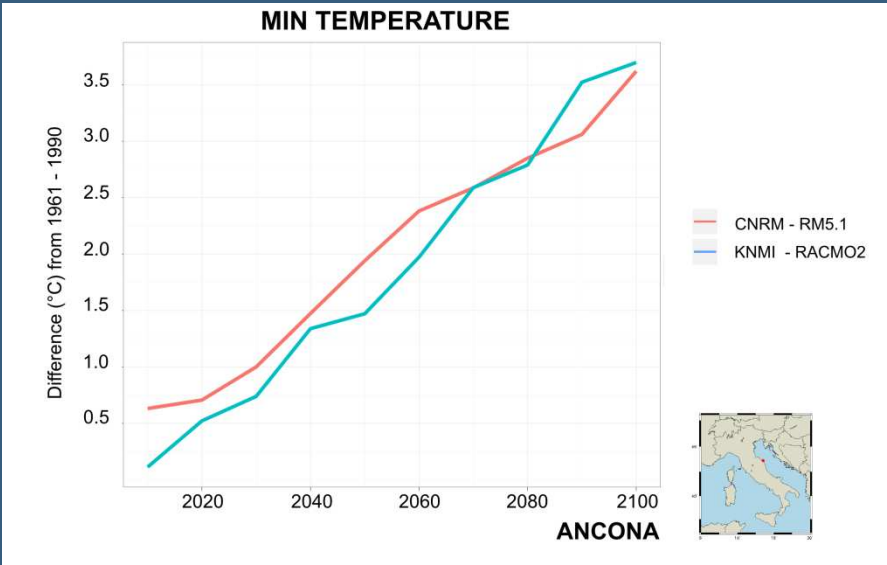
GCMs results:

a warming stronger in summer and weaker in winter is predicted for all the emission scenarios.

RCMs

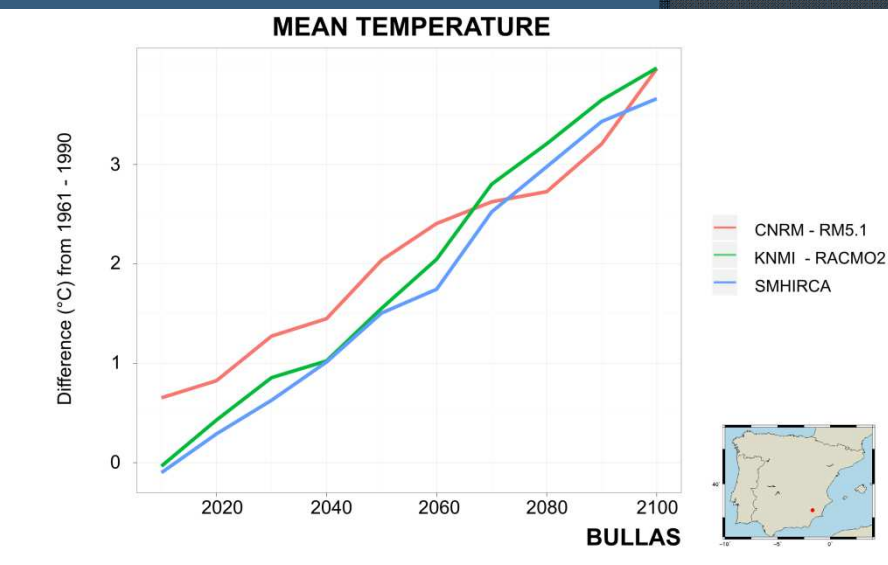
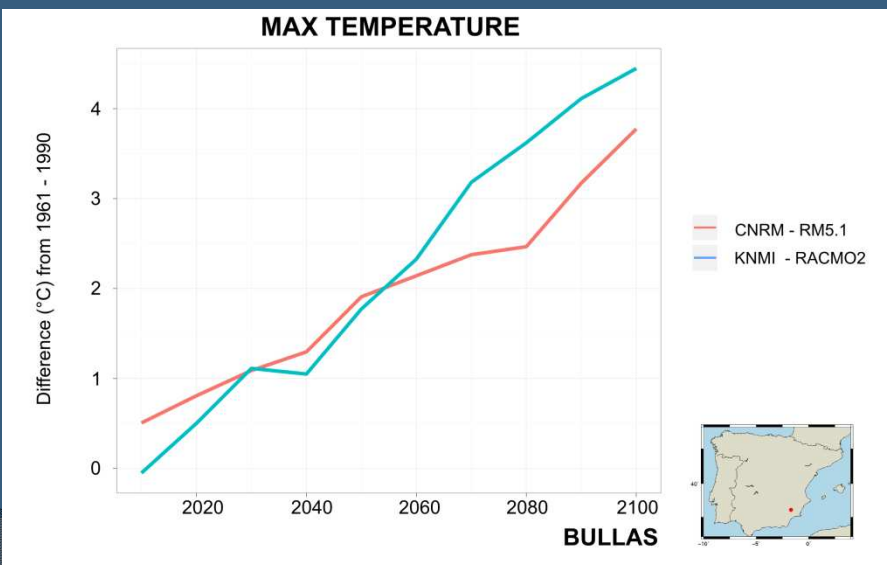


Trends almost linear throughout the whole century

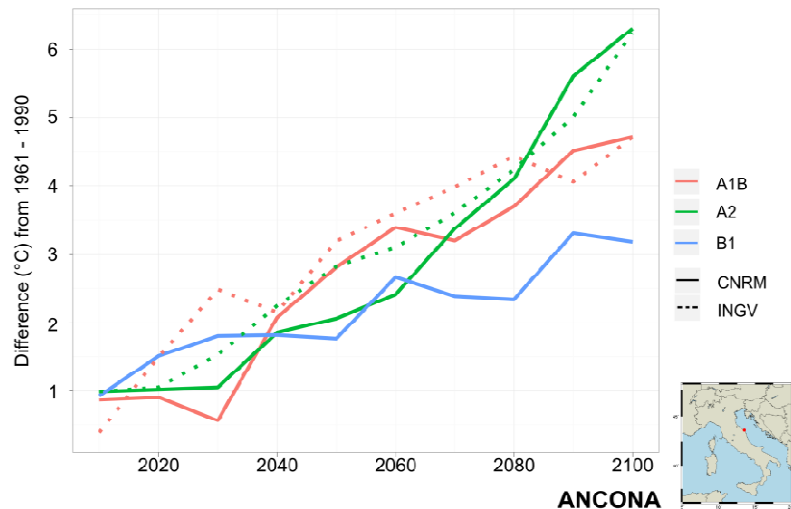


RCMs

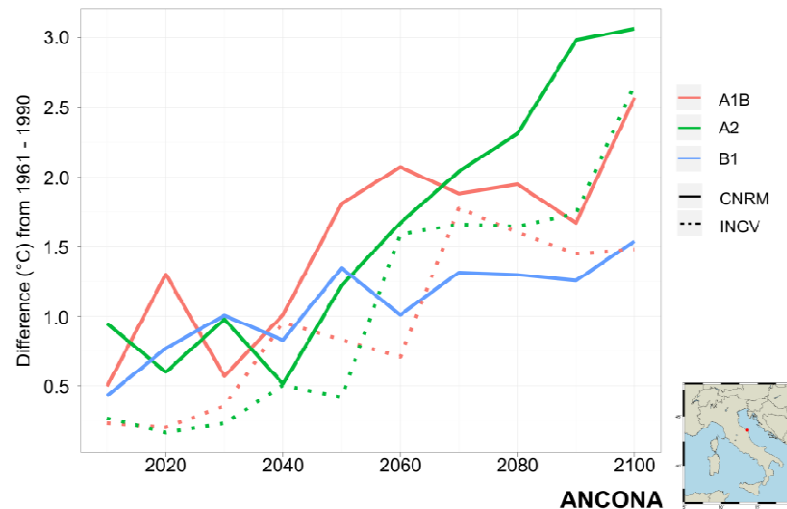
trends of the minimum and maximum temperatures don't show significant differences respect to mean temperature trends (two examples shown)



MEAN TEMPERATURE - SUMMER



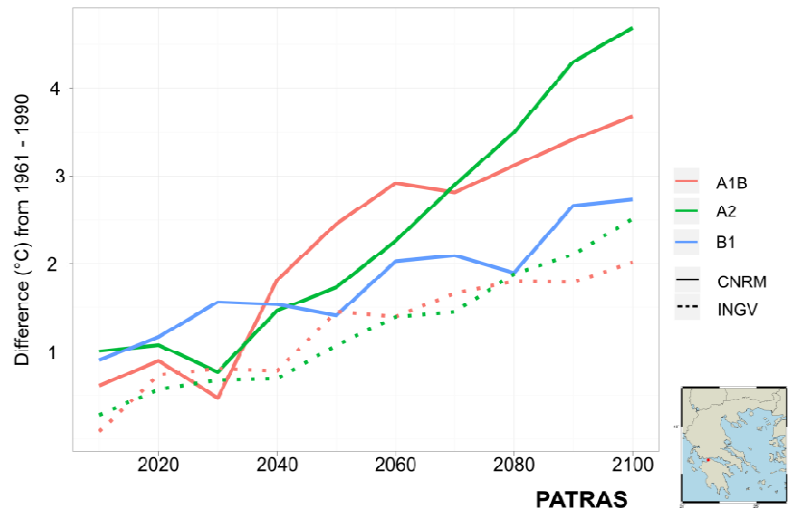
MEAN TEMPERATURE - WINTER



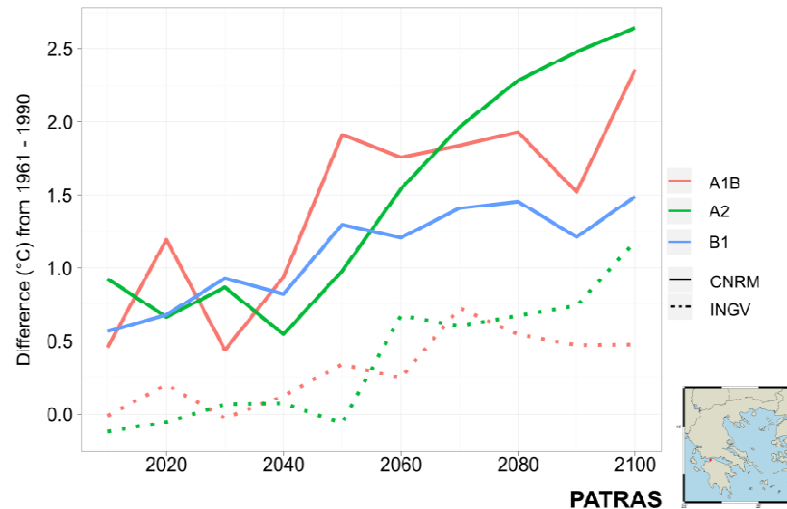
GCMs

warming stronger in summer and weaker in winter for all the emission scenarios (two examples shown).

MEAN TEMPERATURE - SUMMER



MEAN TEMPERATURE - WINTER



Temperature projections: RCMs results

Ancona

1. An increase of the mean temperature at the end of the century between 3.4 °C (SMHIRCA) and 3.7 °C (RM5.1).
2. A warming more pronounced in summer (between 3.9 °C and 5.7 °C) and less in spring (between 2.4 °C and 2.9 °C).

Bullas

1. A rise of the mean temperature at the end of the century between 3.7 °C (SMHIRCA) and 4.0 °C (RM5.1 and RACMO2).
2. A warming more pronounced in summer (between 4.9 °C and 5.6 °C) and less in spring (between 2.0 °C and 3.3 °C).

Patras

1. A rise of the mean temperature at the end of the century between 3.5 °C (RM5.1) and 4.0 °C (RACMO2).
2. A warming more pronounced in summer (between 4.5 °C and 5.1 °C) and less in spring (between 2.4 °C and 3.0 °C).

Temperature projections: GCMs results

Ancona

A1B scenario: warming at the end of the century between 2.9 °C (INGV) and 3.4 °C (CNRM), lower than RCMs.

A2 scenario: warming at the end of the century between 4.2 °C (INGV) and 4.7 °C (CNRM).

B1 scenario: warming at the end of the century of 2.1 °C (CNRM).

Bullas

A1B scenario: warming at the end of the century between 2.8 °C (INGV) and 3.8 °C (CNRM), lower than RCMs.

A2 scenario: warming at the end of the century between 3.8 °C (INGV) and 4.8 °C (CNRM).

B1 scenario: warming at the end of the century of 2.5 °C (CNRM).

Patras

A1B scenario: warming at the end of the century between 1.4 °C (INGV) and 2.9 °C (CNRM), lower than RCMs.

A2 scenario: warming at the end of the century between 2.0 °C (INGV) and 3.6 °C (CNRM).

Temperature projections: GCMs results

Ancona

Maximum increase: 6.3 °C in the A2 scenario (CNRM)

Minimum increase: 1.5 °C in the A1B scenario (INGV) and in the B1 scenario (CNRM)

Bullas

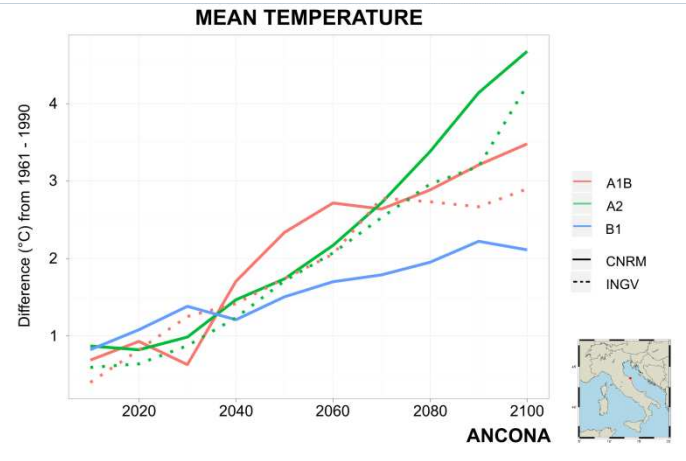
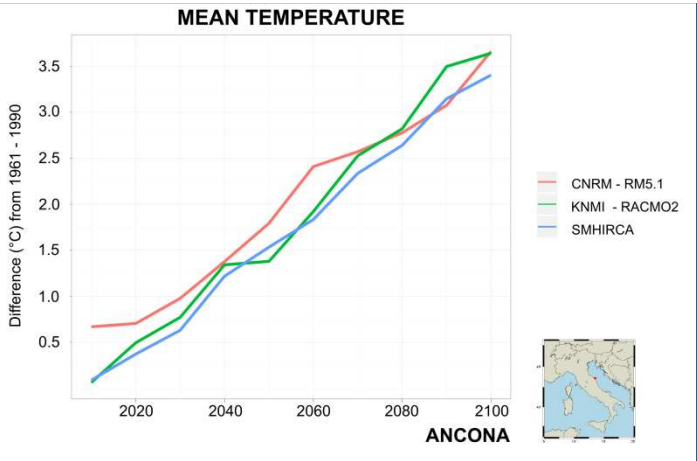
Maximum increase: 6.5 °C in the A2 scenario (CNRM)

Minimum increase: 1.6 °C in the A1B scenario (INGV)

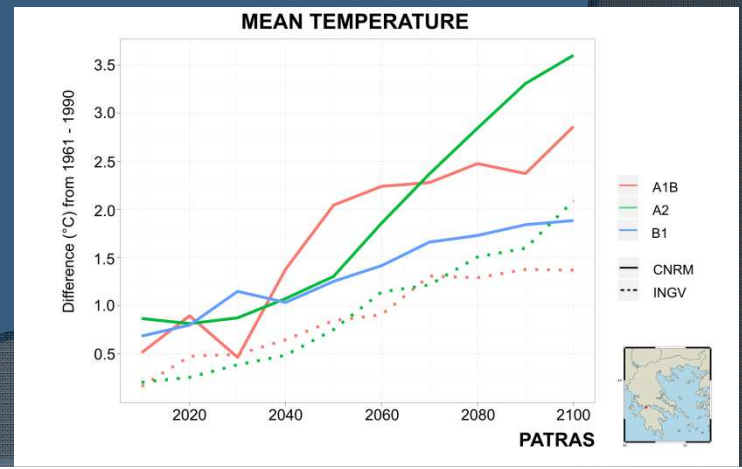
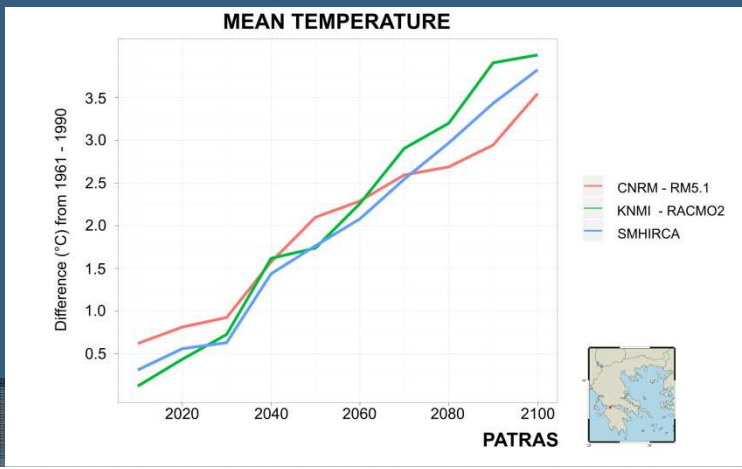
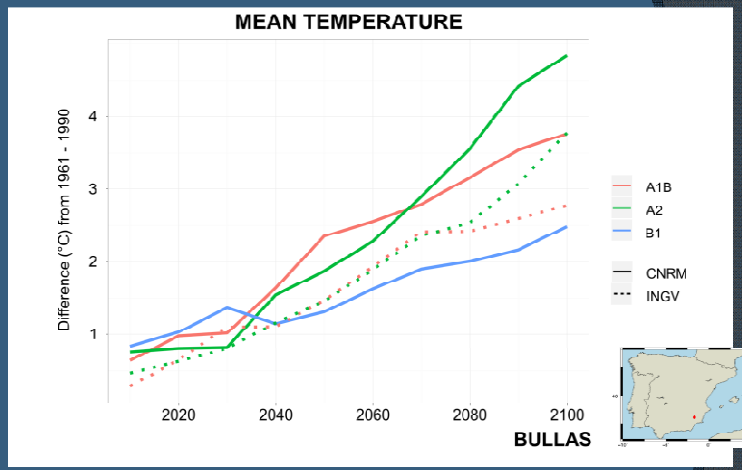
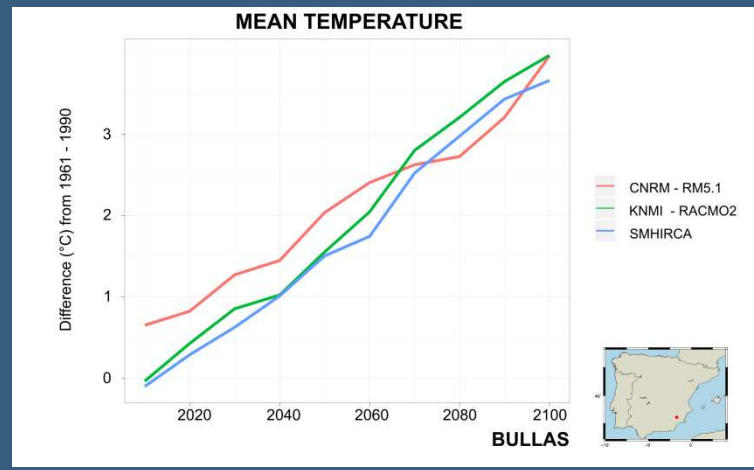
Patras

Maximum increase: 4.7 °C in the A2 scenario (CNRM)

Minimum increase: 0.5 °C in the A1B scenario (INGV)



Temperatures
RCMs vs GCMs



Precipitation projections: general results

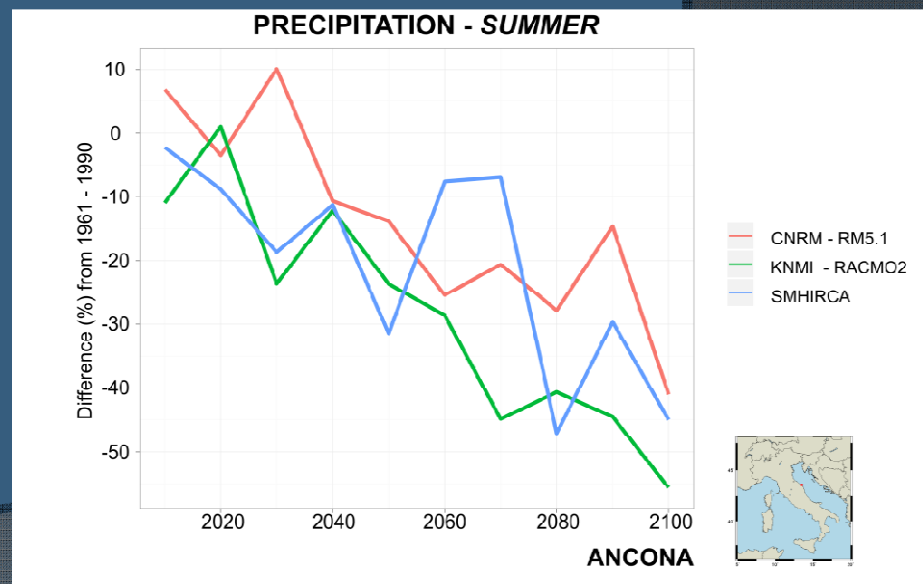
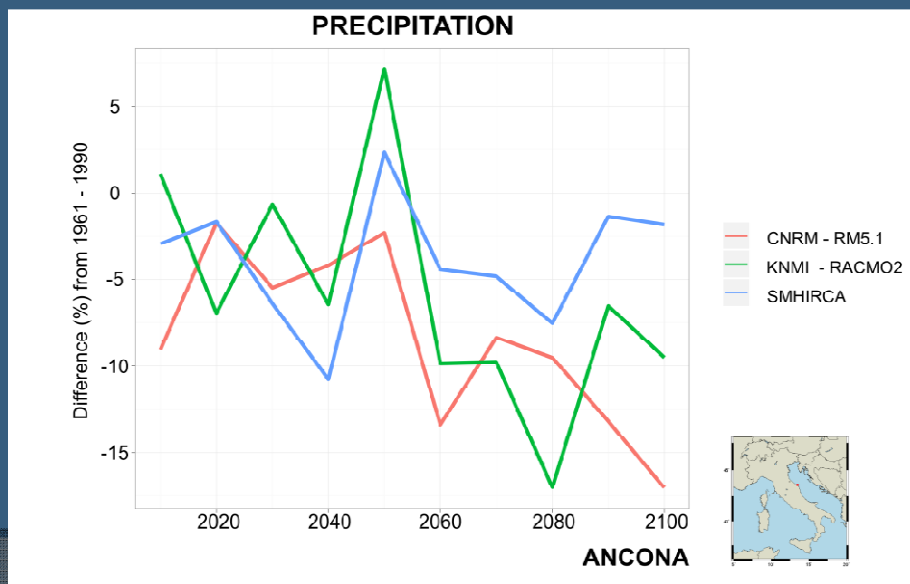
Model projections are presented as percentage variation of annual cumulated precipitation with respect to 1961-1990, sampled every 10 years.

RCMs and GCMs results:

Larger uncertainty and irregular behaviour of precipitation projections, with respect to temperature projections.

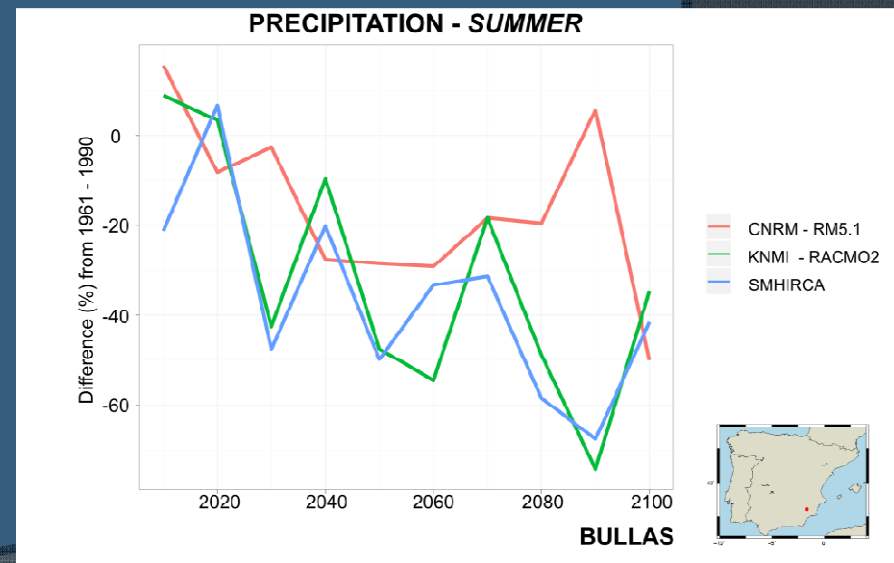
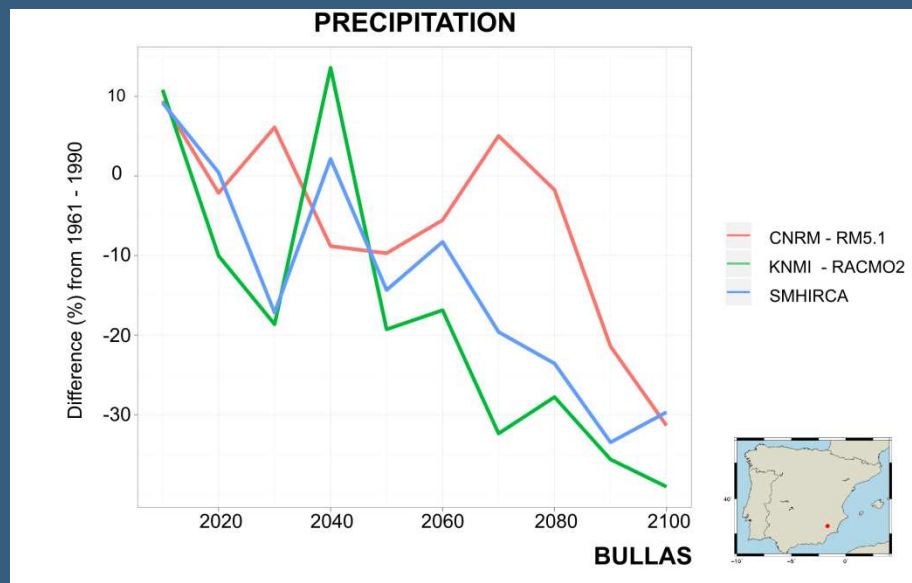
Precipitation projections : RCMs results for Ancona

- 1.Reduction of annual cumulated precipitation at the end of the century between -1.8% (SMHIRCA) and -17% (RM5.1).
- 2.Two models out of three predict a relative maximum of precipitation (higher than present) in the middle of the century.
- 3.Summer is the only season with almost always decreasing precipitation and an overall reduction of the seasonal cumulated precipitation ranging between -41.0% and -55.6%.
- 4.Two models out of three predict an increase of autumn (+17.0% and +42.9%) and winter (+6.0% and +8.8%) precipitation



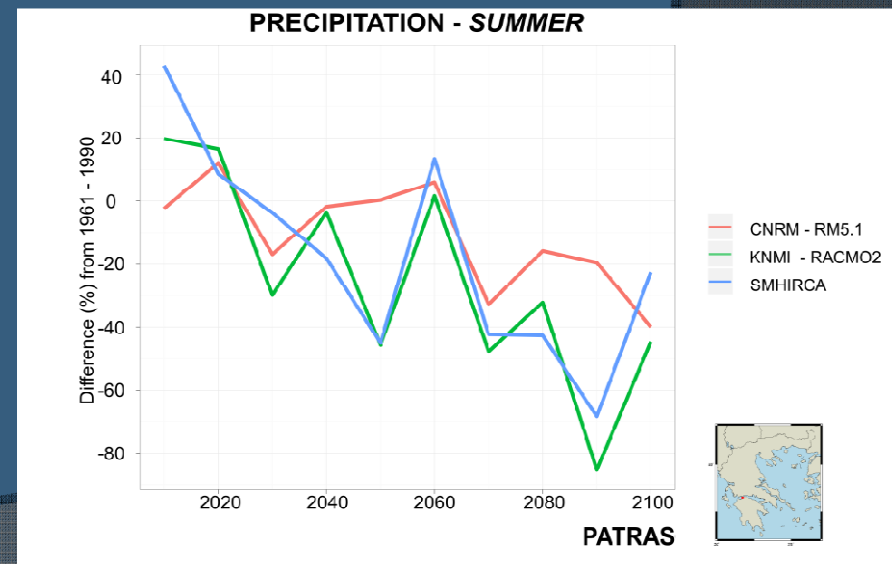
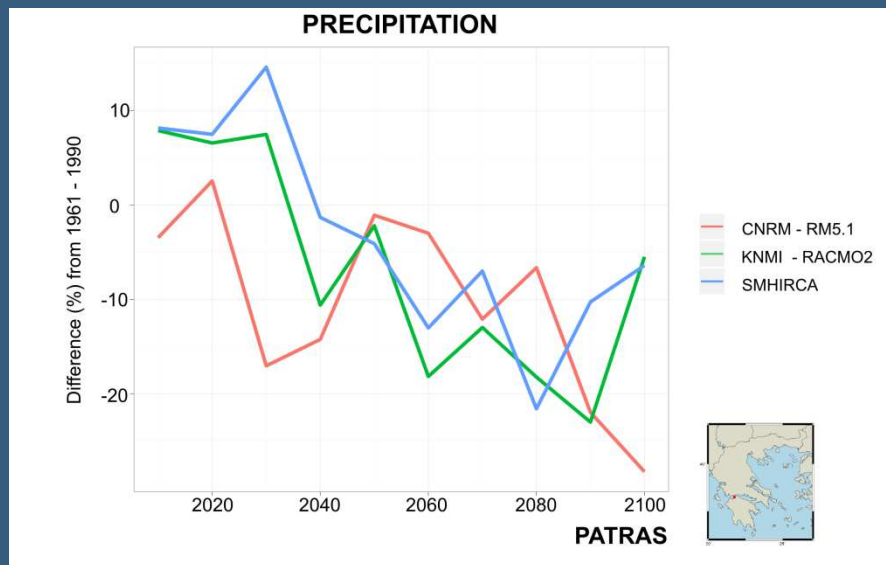
Precipitation projections : RCMs results for Bullas

- 1.Reduction of annual cumulated precipitation at the end of the century between -29.7% (SMHIRCA) and -39.0% (RACMO2).
- 2.All models predict a relative maximum of precipitation in 2040 and one model predict a second relative maximum in 2070.
- 3.Summer is the season with the stronger reduction of the precipitation at the end of the century, ranging between - 34.6% and - 50.0%.



Precipitation projections : RCMs results for Patras

- 1.Reduction of annual cumulated precipitation at the end of the century between -5.5% (RACMO2) and -28.3% (RM5.1).
- 2.All the RCMs show a irregular decreasing trend of annual precipitation over the century; no clear relative maximum are shown.
- 3.Summer is the season with the strongest reduction of the seasonal totals, ranging between - 22.6% and - 44.6% at the end of the century.
- 4.Only two models predict an increase of the seasonal precipitation: RACMO2 in autumn (+ 14.3%) and SMHIRCA in winter (+ 8.7%).



Precipitation projections: GCMs results

Ancona

A1B scenario: reduction at the end of the century between -16.8% (CNRM) and -27.7% (INGV).

A2 scenario: reduction at the end of the century between -27.5% (CNRM) and -33.6% (INGV).

B1 scenario: reduction at the end of the century of -12.3%(CNRM).

Bullas

A1B scenario: reduction at the end of the century between -30.7% (INGV) and -32.7% (CNRM).

A2 scenario: reduction at the end of the century between -37.1% (INGV) and -37.8% (CNRM).

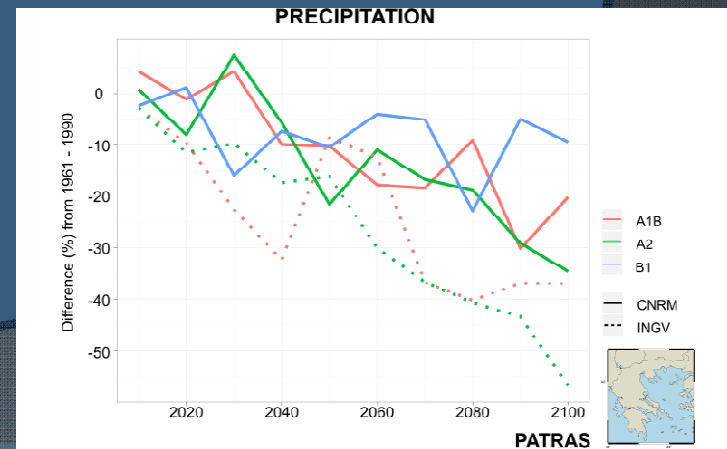
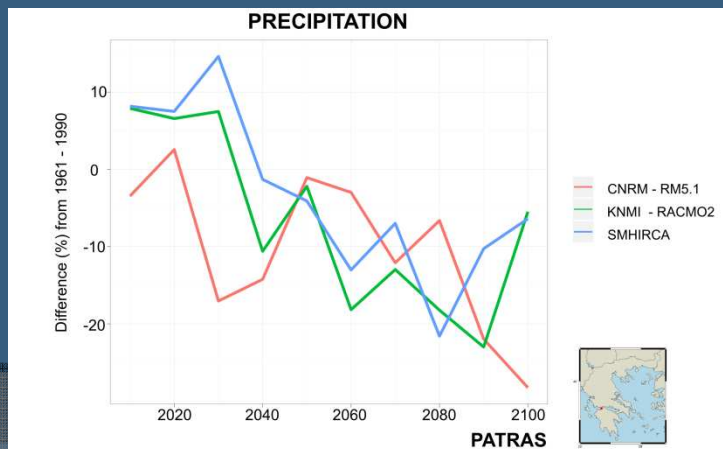
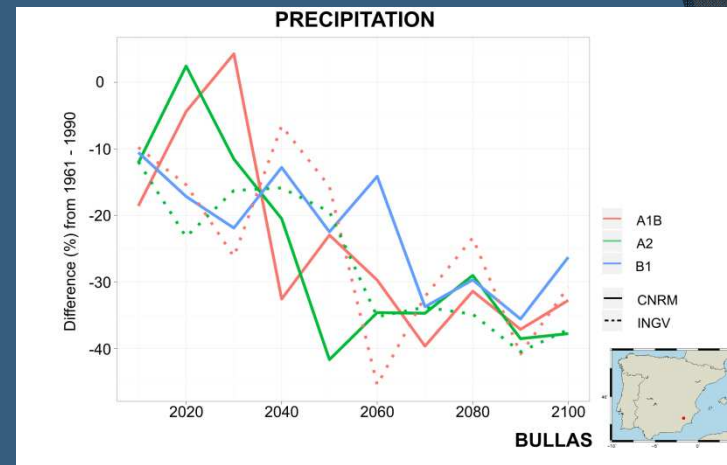
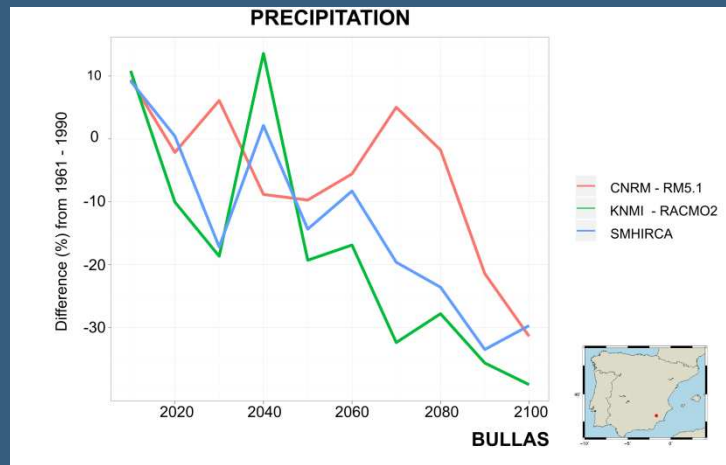
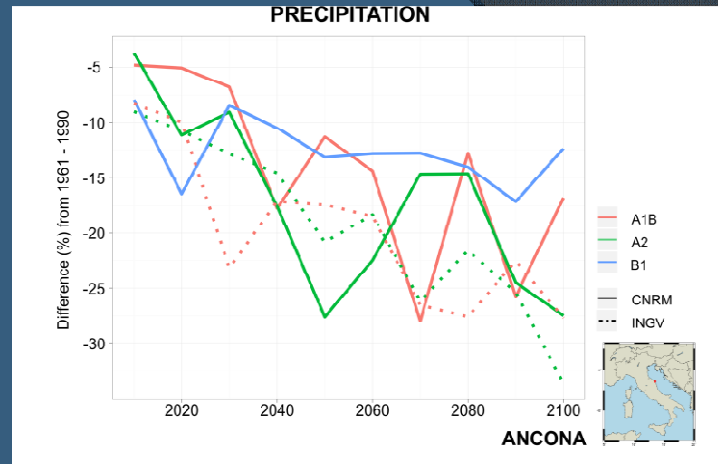
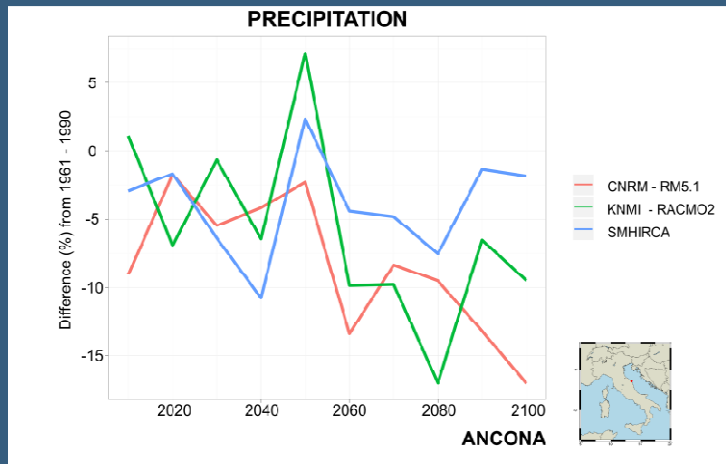
B1 scenario: reduction at the end of the century of -26.3% (CNRM).

Patras

A1B scenario: reduction at the end of the century between -20.1% (CNRM) and -36.9% (INGV).

A2 scenario: reduction at the end of the century between -34.6% (CNRM) and -56.8% (INGV).

Precipitations
RCMs vs GCMs



TABLES

Mean Temperature projections: RCMs results

MODELS	MEAN TEMPERATURE Variation (°C) at 2100				
	WINTER	SPRING	SUMMER	AUTUMN	ANNUAL
ANCONA					
CNRM-RM+5.1	+2.8	+2.9	+5.7	+3.4	+3.7
KNMI-RACMO2	+3.4	+2.8	+4.8	+3.6	+3.6
SMHIRCA	+3.3	+2.4	+3.9	+4.0	+3.4
BULLAS					
CNRM-RM+5.1	+3.6	+3.3	+4.9	+4.0	+4.0
KNMI-RACMO2	+3.4	+2.7	+5.5	+4.3	+4.0
SMHIRCA	+2.8	+2.0	+5.6	+4.3	+3.7
PATRAS					
CNRM-RM+5.1	+2.6	+3.0	+5.1	+3.4	+3.5
KNMI-RACMO2	+3.6	+2.8	+5.1	+4.4	+4.0
SMHIRCA	+3.6	+2.4	+4.5	+4.8	+3.8

TABLES

Min Temperature projections: RCMs results

MODELS	MINIMUM TEMPERATURE Variation (°C) at 2100				
	WINTER	SPRING	SUMMER	AUTUMN	ANNUAL
ANCONA					
CNRM-RM+5.1	+2.7	+2.8	+5.7	+3.3	+3.6
KNMI-RACMO2	+3.5	+2.9	+4.5	+3.8	+3.7
BULLAS					
CNRM-RM+5.1	+3.5	+3.5	+5.2	+4.3	+4.1
KNMI-RACMO2	+3.1	+2.1	+5.2	+4.2	+3.6
PATRAS					
CNRM-RM+5.1	+2.5	+2.8	+5.2	+3.6	+3.5
KNMI-RACMO2	+3.7	+2.7	+5.1	+4.7	+4.0

TABLES

Max Temperature projections: RCMs results

MODELS	MAXIMUM TEMPERATURE Variation (°C) at 2100				
	WINTER	SPRING	SUMMER	AUTUMN	ANNUAL
ANCONA					
CNRM-RM+5.1	+2.7	+2.9	+5.7	+3.4	+3.7
KNMI-RACMO2	+3.3	+2.9	+5.0	+3.3	+3.6
BULLAS					
CNRM-RM+5.1	+3.5	+3.4	+4.7	+3.6	+3.8
KNMI-RACMO2	+3.8	+3.5	+6.0	+4.5	+4.4
PATRAS					
CNRM-RM+5.1	+3.0	+3.0	+5.1	+3.1	+3.6
KNMI-RACMO2	+3.4	+2.9	+5.4	+4.2	+4.0

TABLES

Mean Temperature projections: GCMs results

SCENARIOS	MEAN TEMPERATURE Variation (°C) at 2100				
	WINTER	SPRING	SUMMER	AUTUMN	ANNUAL
ANCONA					
A1B					
CNRM	+2.6	+2.9	+4.7	+3.7	+3.4
INGV	+1.5	+2.2	+4.7	+3.2	+2.9
A2					
CNRM	+3.0	+4.8	+6.3	+4.5	+4.7
INGV	+2.7	+3.6	+6.2	+4.6	+4.2
B1					
CNRM	+1.5	+1.9	+3.2	+1.8	+2.1
INGV					
BULLAS					
A1B					
CNRM	+2.5	+3.7	+5.2	+3.7	+3.8
INGV	+1.6	+2.4	+4.1	+2.9	+2.8
A2					
CNRM	+2.8	+5.5	+6.5	+4.5	+4.8
INGV	+2.6	+3.4	+5.3	+3.8	+3.8
B1					
CNRM	+2.0	+2.7	+3.3	+2.0	+2.5
INGV					
PATRAS					
A1B					
CNRM	+2.3	+2.6	+3.7	+2.8	+2.9
INGV	+0.5	+1.2	+2.0	+1.8	+1.4
A2					
CNRM	+2.6	+3.7	+4.7	+3.3	+3.6
INGV	+1.2	+1.8	+2.5	+2.8	+2.0
B1					
CNRM	+1.5	+1.8	+2.7	+1.5	+1.9
INGV					

TABLES

Precipitation projections: RCMs results

MODELS	PRECIPITATION Variation (%) at 2100				
	WINTER	SPRING	SUMMER	AUTUMN	ANNUAL
ANCONA					
CNRM-RM+5.1	+8.8	-16.7	-41.0	-14.2	-17.0
KNMI-RACMO2	-14.4	-20.2	-55.6	+42.9	-9.5
SMHIRCA	+6.0	-1.5	-45.0	+17.0	-1.8
BULLAS					
CNRM-RM+5.1	-19.0	-27.9	-50.0	-33.5	-31.4
KNMI-RACMO2	-42.6	-48.2	-34.6	-29.0	-39.0
SMHIRCA	-16.8	-41.0	-41.5	-27.2	-29.7
PATRAS					
CNRM-RM+5.1	-23.0	-27.3	-39.9	-29.2	-28.3
KNMI-RACMO2	-0.5	-15.3	-44.6	+14.3	-5.5
SMHIRCA	+8.7	-27.8	-22.6	-1.5	-6.4

TABLES

Precipitation projections: GCMs results

SCENARIOS	PRECIPITATION Variation (%) at 2100				
	WINTER	SPRING	SUMMER	AUTUMN	ANNUAL
ANCONA					
A1B					
CNRM	-6.5	-28.2	-23.0	-19.7	-16.8
INGV	-18.1	-31.0	-46.9	-23.5	-27.7
A2					
CNRM	-21.9	-47.4	-5.2	-34.1	-27.5
INGV	-18.3	-44.5	-43.4	-30.8	-33.6
B1					
CNRM	+2.4	-33.4	-12.4	-12.4	-12.3
INGV					
BULLAS					
A1B					
CNRM	-48.7	-41.6	-35.4	-1.0	-32.7
INGV	-36.1	-38.2	-56.0	-10.9	-30.7
A2					
CNRM	-60.5	-68.7	-3.0	-3.4	-37.8
INGV	-18.6	-56.1	-42.1	-35.2	-37.1
B1					
CNRM	-21.2	-49.8	-31.5	-8.0	-26.3
INGV					
PATRAS					
A1B					
CNRM	-30.3	-6.4	+5.0	-14.7	-20.1
INGV	-39.9	-41.6	-88.9	-29.0	-36.9
A2					
CNRM	-30.7	-57.4	-22.3	-34.6	-34.6
INGV	-53.8	-60.0	-79.2	-59.8	-56.8
B1					
CNRM	-13.8	-4.2	-5.7	-6.0	-9.4
INGV					



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