ASEC 2025 Conference

The 6th International Electronic Conference on Applied Sciences

09–11 December 2025 | Online

MDPI

Precipitation and Temperature Projections over Greece using CMIP6 model simulations under different SSP scenarios

Ioannis Logothetis[1,2,*], Kleareti Tourpali[1] and Dimitrios Melas[1]

[1] Laboratory of Atmospheric Physics, Department of Physics, Aristotle University of Thessaloniki, 54124 Thessaloniki, Greece

[2] Centre for Research and Technology Hellas, Chemical Process and Energy Resources Institute, Thermi, 57001 Thessaloniki, Greece

* Correspondence: ilogothe@physics.auth.gr

INTRODUCTION

The Mediterranean is characterized as a climate Hot-Spot. Under a changing climate, heat extremes and droughts are projected to increase whereas precipitation is projected to decrease (IPCC AR6)

Our investigation examines the precipitation and temperature evolution over Greece during the period from 1850 to 2100. Timeseries from multi-model mean precipitation and temperature, averaged over continental Greece, are calculated from twelve (12) CMIP6 (6th Phase of Coupled Model Intercomparison Project) model simulations to study future changes under different Shared Socioeconomic Pathways (SSPs). The analysis focuses on projected precipitation both for annual and seasonal temporal scales. Results indicate a reduction both for annual (about 20% for the extreme scenario) and seasonal precipitation over continental Greece. Finally, regarding temperature, the CMIP6 multi-model mean indicated substantial warming during the last period of 21st century.

METHODS

DATA: Monthly mean precipitation and near surface temperature of 12 CMIP6 model simulations (Table 1) during:

- **historical period** (1850-2015) and
- **21st century** (2015-2100) for SSP scenarios

The analysis focuses on:

- continental Greece
- the period where the maximum changes are observed – the last period of 21st century

As **reference period** is considered the period from 1980 to 2005 (basis period).

***Table 1**. List of CMIP6 model simulations that used in the analysis*

Model	Institute (country)	Resolution (lon/lat)	Ensemble	Reference
ACCESS-ESM1-5	Australian Community Climate and Earth System Simulator Earth System Model Version 1.5	192 x 145	r1i1p1f1, r2i1p1f1 r3i1p1f1	Ziehn et al. 2019 https://doi.org/10.22033/ESGF/CMIP6.2288
AWI-CM-1-1-MR	Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research	384 x 192	r1i1p1f1	Semmler at al. 2018 https://doi.org/10.22033/ESGF/CMIP6.2543
BCC-CSM2-MR	Beijing Climate Center (BCC) Climate System Model	320 x 16	r1i1p1f1	Xin, Xiaog et al., 2018 https://doi.org/10.22033/ESGF/CMIP6.1725
CAMS-CSM1-0	Chinese Academy of Meteorological Sciences, Beijing 100081, China	320 x 160	r1i1p1f1	Rong, Xinyao (2019) https://doi.org/10.22033/ESGF/CMIP6.1399
CESM2-WACCM	Community Earth System Model Version 2, National Center for Atmospheric Research (NCAR), universities, and other research institutions	288 x 192	r1i1p1f1	Danabasoglu, Gokhan, 2019 https://doi.org/10.22033/ESGF/CMIP6.10024
CanESM5	Canadian Centre for Climate Modelling and Analysis, Environment and Climate Change Canada	128 x 64	r1i1p1f1	Swart, Neil Cameron et al. (2019) https://doi.org/10.22033/ESGF/CMIP6.1317
FGOALS-f3-L	Chinese Academy of Sciences (CAS) Flexible Global Ocean-Atmosphere-Land System (FGOALS-f3-L)	360 x 180	r1i1p1f1	YU, Yongqiang (2019) https://doi.org/10.22033/ESGF/CMIP6.3054
IPSL-CM6A-LR	Institut Pierre Simon Laplace, France	144 x 143	r2i1p1f1	Boucher, Olivier et al. 2018 https://doi.org/10.22033/ESGF/CMIP6.1534
INM-CM5-0	Institute for Numerical Mathematics, Russian Academy of Science, Russia	180 x 120	r1i1p1f1	Volodin, Evgeny et al. 2019 https://doi.org/10.22033/ESGF/CMIP6.5081
KACE-1-0-G	National Institute of Meteorological Sciences/Korea Meteorological Administration, Climate Research Division, Republic of Korea	192 x 144	r1i1p1f1	Byun, Young-Hwa et al. 2019 https://doi.org/10.22033/ESGF/CMIP6.8350
MPI-ESM1-2-HR	Max Planck Institute for Meteorology, Germany	384 x 192	r1i1p1f1	von Storch et al. 2017 https://doi.org/10.22033/ESGF/CMIP6.762
MRI-ESM2-0	Meteorological Research Institute, Japan	128 x 64	r1i1p1f1	Yukimoto, Seiji et al. 2019 https://doi.org/10.22033/ESGF/CMIP6.621

RESULTS

- The multi-model mean temperature shows a warming for SSP scenarios. In particular, the maximum warming is shown during the last period of 21st century and it is about:
  - 2.0°C for SSP1-2.6
  - 3.0°C for SSP2-4.5
  - 4.5°C for SSP3-7.0
  - 5.0°C for SSP5-8.5

  (Fig. 1)

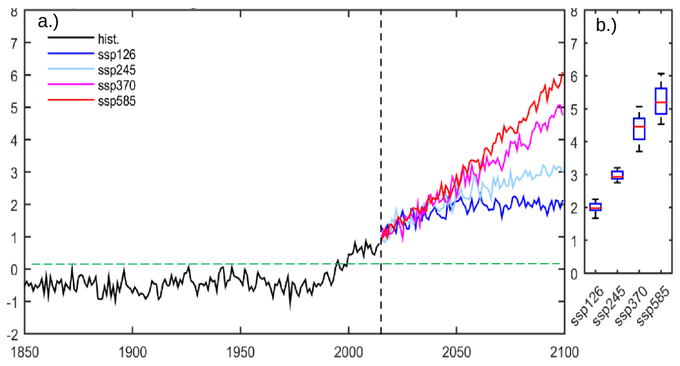


***Figure 1**. **(a)** Annual multi-model average time series of temperature anomalies over continental Greece(wrt to basis period) for different SSPs. **(b)** Boxplot of annual multi-model average anomalies of temperature over continental Greece during period from 2070 to 2100 (wrt to basis period) for different SSPs.*

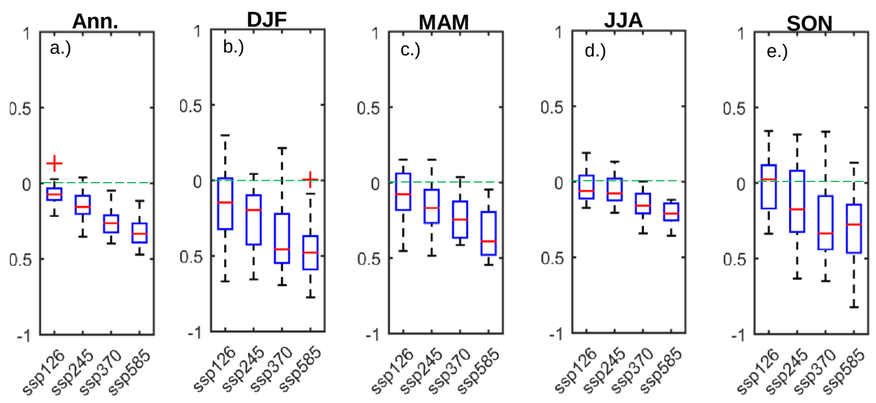


***Figure 2**. Boxplot of (**a**) annual (**b**) DJF (**c**) MAM (**d**) JJA (**e**) SON multi-model average anomalies of precipitation (mm/day) over continental Greece during period from 2070 to 2100 (wrt to basis period) for different SSPs.*

	SSP1-2.6	SSP2-4.5	SSP3-7.0	SSP5-8.5
Ann.	1%	7%	15%	20%
DJF	6%	8%	20%	20%
MAM	3%	12%	17%	30%
JJA	16%	18%	27%	41%
SON	0%	9%	20%	15%

***Table 2**. Precipitation changes (%) during future period (2070-2100) wrt basis period for different SSPs.*

- The multi-model mean precipitation shows a reduction for SSP scenarios. In particular, the maximum warming is shown during the last period of 21st century and it is about:
  - 0.05 $\mathrm{mm} * \mathrm{day}^{-1}$ for SSP1-2.6
  - 0.10 $\mathrm{mm} * \mathrm{day}^{-1}$ for SSP3-7.0
  - 0.25 $\mathrm{mm} * \mathrm{day}^{-1}$ for SSP2-4.5
  - 0.35 $\mathrm{mm} * \mathrm{day}^{-1}$ for SSP5-8.5

  (Fig. 2a &Fig3a),

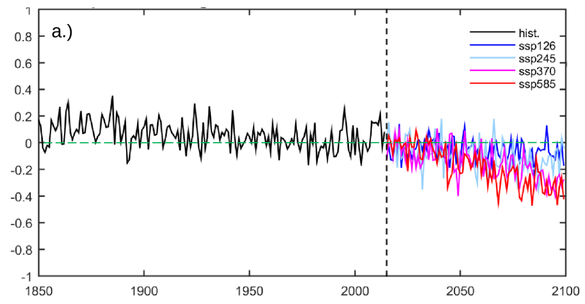
- The dryer season (JJA) shows high reduction of precipitation (about 27 and 40% for SSP3-7.0 and SSP5-8.5, respectively)

  (Table 2 & Fig. 3)

- MAM and SON also show a reduction of precipitation (ranges between 15 and 41% among SSPs)

  (***Table 2 & Fig. 3***)

- SSP5-8.5 shows the maximum reduction of averaged precipitation,



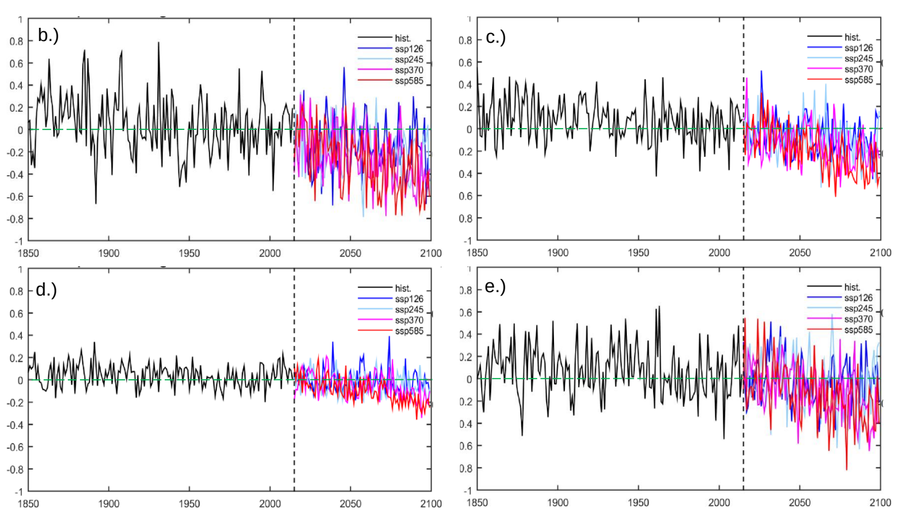


***Figure 3**. Timeseries of (**a**) annual (**b**) DJF (**c**) MAM (**d**) JJA (**e**) SON multi-model average time series anomalies (wrt to basis period) of precipitation (mm/day) over continental Greece for different SSPs.*

CONCLUSION

- **Temperature*/ precipitation*** → **increases*/ decreases* during future period** – these changes range from 2.0 to 5.0°C and 0.05 to 0.35 $\mathrm{mm} * \mathrm{day}^{-1}$, respectively (over continental Greece)
- **The maximum changes** → **during the last period of 21st century** (SSP3-7.0 &SSP5-8.5),
- **In Seasonal terms, precipitation is reduced (**mainly during the last period of 21st century). In particular:
  - DJF ~0.5 $\mathrm{mm} * \mathrm{day}^{-1}$ (20%, wrt basis period) both for SSP3-7.0 & SSP5-8.5,
  - MAM and SON ~15 to 30% for SSP3-7.0 and SSP5-8.5 and,
  - JJA – the dryer period for Greece – ~ 0.05 to 0.2 $\mathrm{mm} * \mathrm{day}^{-1}$ for SSPs.

REFERENCES

- *Zanis, P.; Georgoulias, A.K.; Velikou, K.; Akritidis, D.; Kalisoras, A.; Melas, D. Future Projections of Precipitation Extremes for Greece Based on an Ensemble of High-Resolution Regional Climate Model Simulations. Atmosphere, 15, 601. https://doi.org/10.3390/atmos15050601, 2024*
- *Cos, J., Doblas-Reyes, F., Jury, M., Marcos, R., Bretonnière, P.-A., and Samsó, M.: The Mediterranean climate change hotspot in the CMIP5 and CMIP6 projections, Earth Syst. Dynam., 13, 321–340, https://doi.org/10.5194/esd-13-321-2022, 2022*
- *Dobler, A., Benestad, R.E., Lussana, C. et al. CMIP6 models project a shrinking precipitation area. npj Clim Atmos Sci **7**, 239 (2024). https://doi.org/10.1038/s41612-024-00794-z*

ARISTOTLE UNIVERSITY OF THESSALONIKI

CMIP The World Climate Research Programme's Coupled Model Intercomparison Project