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Temporal Evolution of Seasonal Crop-Specific Climatic Indices in Greece, Based on ERA- and CMIP6- derived Data

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Abstract. This study presents an updated temporal evolution of seasonal crop-specific climatic indices in Greece, based on ERA5- and CMIP6- derived temperature and precipitation data. The indices include days with (a) daily maximum air temperature Tmax> 30◦C in spring (HD30spr) and Tmax>35◦C in summer (HD35sum), respectively, (b) daily minimum air temperature Tmin< 0 °C (frost days) in spring and (c) spring and summer precipitation of the reference period (1950-2023) and in the near future (2024-2050) (NF). The climatic indices related to Tmax (Tmin) presented increasing (decreasing) trends, with both ERA5 and CMIP6 data, towards the present and strong (weak) increases in the NF. Precipitation showed statistically weak decreasing trends in spring, increasing trends in summer, and weak decreasing trends for both seasons in the NF.

Keywords: crop-specific climatic indices; ERA5; CMIP6 simulations; Greece

1. Introduction, data and methods

The agricultural sector in Greece provides food, services and resources, guaranteeing the livelihood of approximately 12-13% of the total labor force in Greece and contributing up to 4% of the national gross domestic product, almost double the European average. This study presents an updated temporal evolution of seasonal crop-specific climatic indices in Greece based on ERA5- and CMIP6- derived temperature and precipitation data. The indices include days with (a) maximum daily near surface air temperature (TMAX) > 30◦C in spring (Mar-May) (HD30spr) and and (TMAX) > 35◦C in summer (Jun-Aug) (HD35sum), respectively, (b) minimum daily near-surface temperature (TASMIN) < 0 °C (frost days) in spring and (c) spring and summer precipitation of the reference period (1950-2023), covering critical periods in which wheat, olives and grapes are more sensitive to water and/or temperature stress. ERA5 data is produced by the Copernicus Climate Change Service (C3S) at a 0.25° x 0.25° (25km x 25km) resolution at ECMWF. A multi-model ensemble of up to 30 global climate models, driven by the SSP1-2.6 scenario, covering the same reference period and a near future period (2024-2050) (NF), at the same spatial resolution (0.25° x 0.25°), was also used. The aggregated over Greece seasonal indices were downloaded from the Climate Change Knowledge Portal (CCKP 2025). The workflow is described in the same portal.

2. Results and conclusions

Over the historical period (1950-2023), the emergence of climate change signal increases towards the present. Therefore, comparing a full period (1950-2023) with trends over more recent intervals (1970-2023 and 1990-2023) can demonstrate the intensification or not of the forced change over the natural variability. In figure 1, through the three trend lines, 1950-2023, 1970-2023, and 1990-2023, for each dataset (CMIP6 and ERA5), progressive changes in the trend towards the present could be identified.

The frequency of HD30spr for ERA5 increases from a non-statistically significant trend of 0.04d/10yr in 1950-2023 to a statistically significant trend of 0.16d/10yr in 1970-2023, which remains unchanged (although non-statistically significant) in the most recent period (1990-2023). Although CMIP6 presents considerably fewer HD30spr days over the historical period 1950-2023 (0.85 d/10yr for CMIP6 vs 7.9 d/10yr for ERA5, on average), it presents an increasing trend from 0.03d/10yr in 1950-2023 to 0.05d/10yr in 1970-2023, to 0.08d/10yr in the most recent 1990-2023 (all statistically significant), and it is projected to come near to 0.19d/10yr in the NF. HD35sum is more frequently observed (a) than HD30spr and (b) with ERA5 than with CMIP6. Its frequencies, like HD30spr, through the three trend lines, for each dataset, increase significantly towards the present. It is projected to come near to 1.3d/10yr in the NF. Over the period 1950-2023, the average frequency of spring frosts is more frequent with ERA5 than with CMIP6. Both datasets present decreasing trends towards the present (statistically significant only in the case of CMIP6 though). Spring frosts are expected to minimally increase by 0.05d/10yr in the NF with CMIP6. Over the historical period, (a) ERA5 presents more spring and summer precipitation than CMIP6 and (b) both datasets show statistically weak decreasing trends in spring and increasing trends in summer, except for ERA5 in 1990-2023. A weak decreasing trend is also projected in the NF for both seasons.

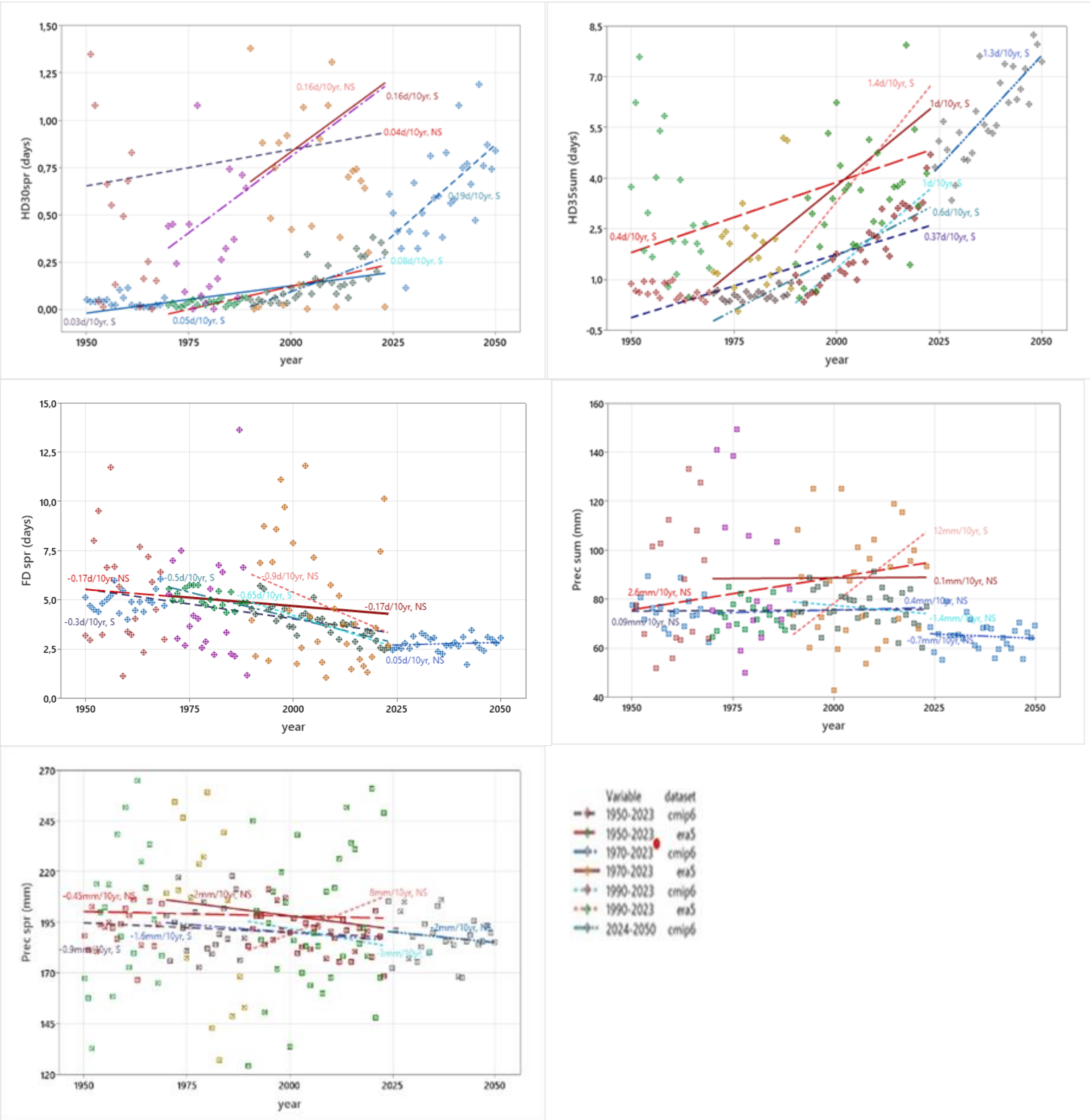

Figure 1. Trend (S and NS for statistical significant and non-significant, respectively) comparison in frequency days with TMAX > 30∘C in spring (HD30spr), days with TMAX > 35∘C in summer (HD35sum), days with TMIN < 0 °C (frost days) in spring, spring (Prec spr) and summer (Prec sum) precipitation, with ERA5- and CMIP6- data, for the periods 1950-2023, 1970-2023, 1991-2023 and 2024-2050 for Greece.

In conclusion, the climatic indices related to (a) Tmax (i.e. HD30spr and HD35sum) presented increasing trends, with both ERA5 and CMIP6 data, towards the present and in the NF, (b) Tmin (spring frost days) presented decreasing trends over the historical period and weak increases in the NF and (c) precipitation showed statistically weak decreasing trends in spring, increasing trends in summer and weak decreasing trends for both seasons in the NF.

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