An integrated assessment of climate change impacts from the regional scale of the area of Peloponnese to the local scale of the area of Messinia

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Abstract An integrated assessment of the climate change impacts for the vulnerable area of Peloponnese with a special focus on Messinia region was performed within the framework of the NSRF/Cooperation 2009 project XENIOS. To this end, output from selected regional climate models developed within the framework of EU project ENSEMBLES using the A1B emissions scenario, is employed. Changes in mean and extreme climate indices, concerning air temperature, precipitation, as well as sector-specific indices for forest fire risk and energy demands are estimated. These changes are calculated between a 30-year reference period (1961–1990) and two future periods (2021-2050 and 2071-2100) taking the ensemble mean of the RCMs. Furthermore, in order to study Messinia's climate evolution due to climate change, the Thin Plate Spline (TPS) interpolation method is used to downscale the climatic output of the ENSEMBLES RCMs from the initial grid of 25km spatial resolution for Peloponnese into a finer one of 5km. In general, the results suggest an increase in the number of hot days (Tmax>30°C) of up to 60 additional days per year and an increase in the number of dry days up to 30 days per year, leading to greater energy requirements and higher fire risk conditions by the end of the century.

1 Introduction

Recent studies both on present and future climate have shown that the Eastern Mediterranean and Greece, in particular, is one of the most vulnerable regions regarding climate change due to its sensitivity to rising temperatures and precipitation reduction (IPCC 2007, Giorgi and Lionello 2008, Zanis et al. 2009). This paper presents an assessment of the impacts of climate change for the vulnerable region of Peloponnese, and more specifically for the high biodiversity area of the Messinia, within the framework of NSRF/Cooperation 2009 project XENIOS. In particular, the XENIOS Project addresses the climate change synergistic impacts on the aforementioned areas and focuses on the consequences for the tourism sector in the near future. In this paper, emphasis is given to indices relevant to maximum temperature, daily precipitation, fire risk and energy requirements.

2 Data and Methodology

In the current study, daily output data from three regional climate models (RCMs) developed at KNMI (Netherlands), METO (UK) and MPI (Germany) within the framework of the EU ENSEMBLES project have been used (www.ensembles-eu.org). All models have a horizontal resolution of 25 km × 25 km and use the A1B greenhouse gases emissions scenario (Nakicenovic et al. 2000).

In order to study Messinia's climate evolution due to climate change, Thin Plate Spline (TPS) interpolation method has been used to downscale the RCMs output from the grid of 25km into a finer one of 5km spatial resolution. TPS is a stochastic method that creates a surface which passes through the control points and has the least possible change in slope at all points. In the present study, a three-dimensional (3D) interpolation method of position and elevation is used based on the TPS interpolation as proposed by Hutchinson (1998), who investigated the climatic dependence on topography and showed that there is a small but significant elevation effect on the daily climatic data.

Furthermore, in order to assess fire risk in the domain of study the Canadian Fire Weather Index (FWI) is used. The FWI model is non-dimensional, based on physical processes and has been used at several locations, including the Mediterranean basin (e.g. Moriondo et al. 2006, Karali et al. 2014). It provides numerical ratings of relative fire potential based solely on weather observations. The meteorological inputs to the FWI System are daily noon values of temperature, relative humidity, 10m wind speed and precipitation during the previous 24 hours and are described in detail in van Wagner (1987).

The impacts of temperature increases on energy requirements, especially during summer period, are investigated using the concept of cooling degree days that are defined as the difference of mean air temperature from a base temperature. In the current study, the base temperature of 25°C is used as defined for the Mediterranean region by Giannakopoulos et al. (2009).

Finally, past experience has shown that no single model is perfect for all climate variables and statistics considered (Christensen and Christensen, 2007). Therefore, in this study, the ensemble mean of daily output data from the aforementioned RCMs is used. Present day simulations cover the period 1961-1990 and are used here as reference for comparison with future projections for the periods 2021-2050 (near future) and 2071-2100 (distant future).

3 Results and discussion

As far as present day climate is concerned, according to the ensemble mean output, the number of hot days, namely the days with maximum temperature greater than 30°C, range from 5 to 90 days per year. Higher values are depicted in the southern part (including Messinia) and north western parts of Peloponnese (Fig. 1a). The number of dry days, the days with daily total precipitation amounts less than 1mm, increases from 250 per year in the north-west to 330 days per year to the south-east (Fig 1b) of Peloponnese. Messinia depicts 250-290 dry days per year. The number of days requiring heavy cooling (i.e. days requiring cooling of more than 5°C from the base temperature of 25°C), follow the same pattern as hot days. Messinia prefecture requires 0-12 days of heavy cooling per year for the control period (Fig 1c). The drier conditions and higher temperature throughout the year in the eastern side of Peloponnese (not shown) lead to the higher number of days with elevated fire risk, as depicted in Fig. 1d. For Messinia, elevated fire risk days range between 20 and 60 days per year.

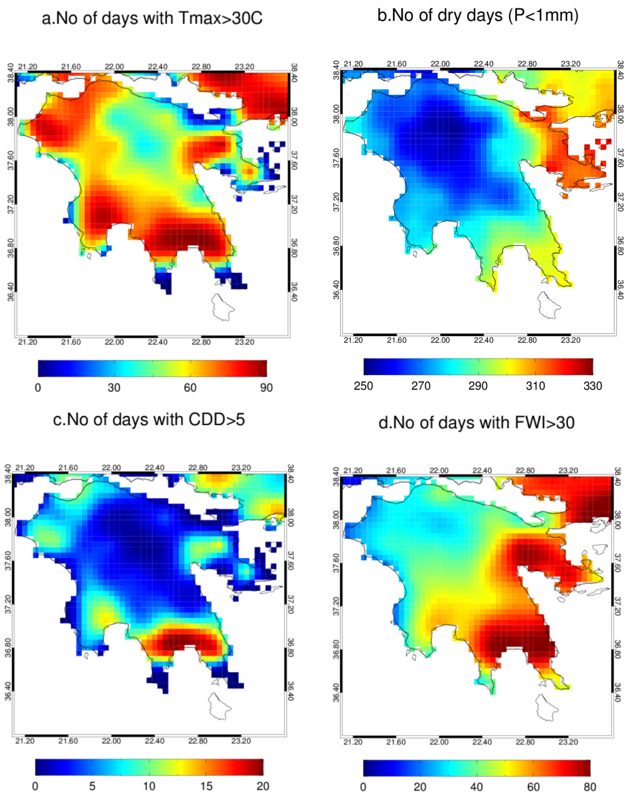

Fig 1. a) Number of days with maximum temperature greater than 30°C, b) number of dry days (P<1mm), c) number of days with high energy requirements (CDD>5) and d) number of days with elevated fire risk (FWI>30) for the control period (1961-1990).

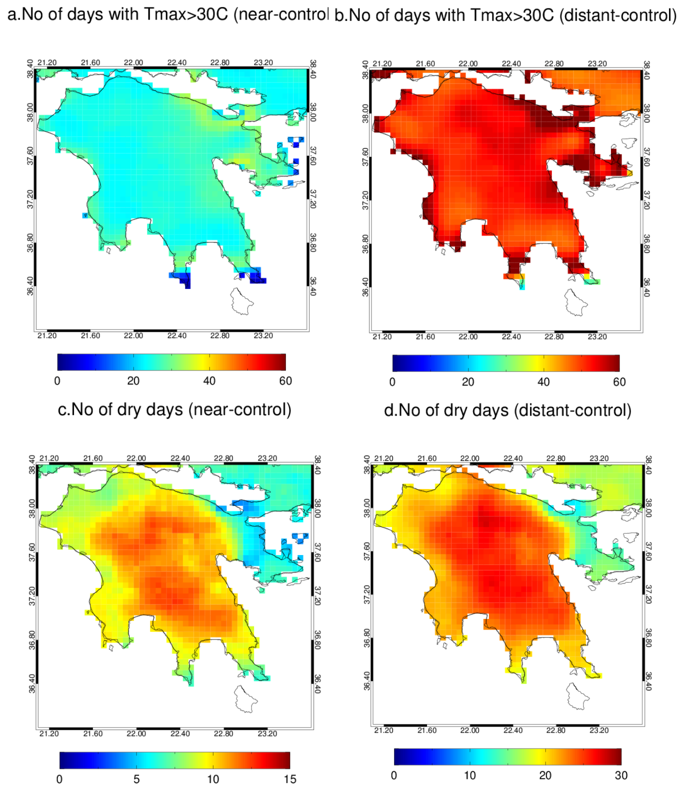

Fig. 2. Changes in the (a,b) number of days with Tmax>30°C and (c,d) number of dry days (P<1mm) in the near (left column) and in the distant future (right column).

Figures 2 and 3 depict spatial patterns of change for the selected extreme indices. Hot days are estimated to occur more frequently in the whole domain of study. In particular, an increase of 20-30 additional days per year is expected throughout Peloponnese in the near future (Fig. 2a) while this increase will be up to 2 months/year in the distant future (Fig. 2b). Regarding precipitation, models predict that in the near future the number of dry days may increase by 5-12 days/year (Fig. 2c). Greater increases up to 30 days/year almost in the entire domain are expected in the number of dry days by the end of the century (Fig 2d).

Consistent with the findings for the reference period, the ensemble mean projections suggest greater increases in the number of days with high energy requirements in Messinia and eastern coastal areas up to 25days per year (Fig. 3a). Quite dramatic changes in CDD for the period 2071-2100, with 40-60 additional cooling days in the same areas are expected (Fig. 3b). As far as future fire risk is concerned, decrease in total winter precipitation in combination with an increase in mean summer temperature (not shown) leads to an increase in the number of days with elevated fire risk in the entire domain for both the near and distant future. In Messinia, an increase of up to 20days/year is expected in the near future while this increase is 40 additional days per year in the distant future (Fig.3c,d).

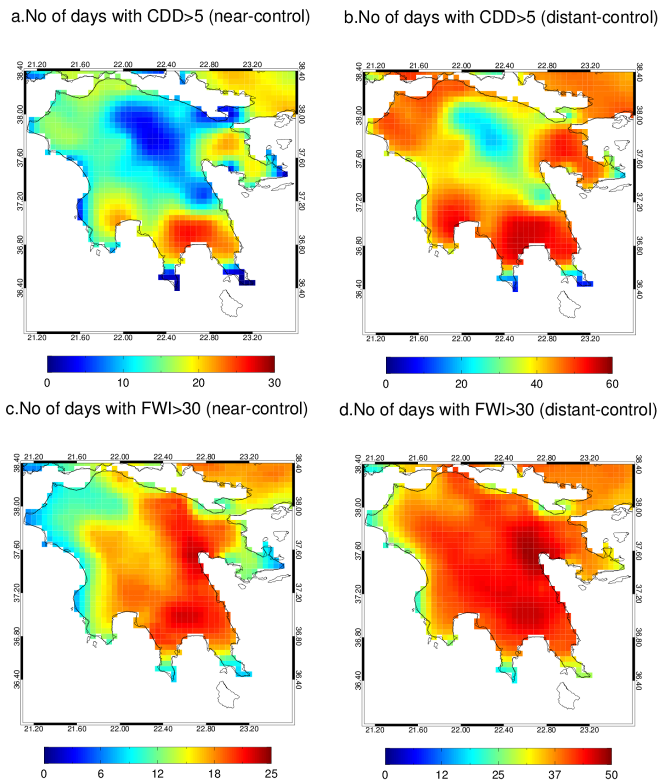

Fig. 3. Changes in the (a,b) number of days with CDD>5 and (c,d) in the number of days with FWI>30 in the near (left column) and in the distant future (right column).

4 Conclusions

In the current study an assessment of the impacts of climate change for the vulnerable region of Peloponnese and in particular of the Messinia prefecture within the framework of XENIOS project is presented. Thin Plate Spline interpolation method has been used in order to downscale the RCMs output from the grid of 25km into a finer one of 5km spatial resolution. The ensemble mean of the three RCMs used, suggests an increase of up to 2 additional months/year with temperatures exceeding 30°C, while increases up to 30 days/year almost in the entire domain are expected in the number of dry days by the end of the century. In Messinia, quite dramatic changes in CDD for the period 2071-2100, with 40-60 additional cooling days are expected. As long as elevated fire risk is concerned, an increase of 40 additional days per year is anticipated. Synthesis of our results with results concerning extreme geophysical phenomena and air pollution is needed, in order to study the synergistic interrelation between climate change impacts and natural disasters so as to study the tourism development of Messinia.

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