Study of climate change impacts on tourism in Messenia using a regional climate model

Douvis K.[1*], Kapsomenakis J.[1], Zanis P.[2], Konsta D.[1], Zerefos C.[1]

1 Research Centre for Atmospheric Physics and Climatology, Academy of Athens

2 Department of Meteorology and Climatology, School of Geology, Aristotle University of Thessaloniki

*corresponding author e-mail: kdouvis@academyofathens.gr

Abstract The regional climate model RegCM4 was used to study climate change and the respective impacts at the area of Messenia, in southwestern Peloponnese. The model was used to subscale the results of the earth system model MPI-ESM initially to a resolution of 50 km and subsequently to 13.3 km. This study is part of Program XENIOS which focuses on the impacts of climate change on tourism using a synergistic and multidisciplinary approach. Emphasis is given on the change of climatic parameters that affect tourism, such as cloudiness and solar radiation. The combination of temperature rise and cloudiness reduction suggests that the touristic season may spread out into the transitional seasons. At the same time the higher temperatures projected for the future may cause the outdoors environment to become unattractive, downgrading the tourism product for the current peak of the touristic season. Also the reduction of precipitation throughout the year may cause a negative effect to the local flora and, combined with the temperature rise, to increase the risk of wildfires.

1 Introduction

The main tools used for climate change projections are global climate models, i.e. complex computer programs that describe the atmospheric motion and conditions. In the latest years they are named Earth System Models (ESMs) as they have evolved in complexity by incorporating several other components that describe the earth system: the oceans, the land surface, land and sea ice, carbon cycle, aerosols and chemistry, land and ocean biology. ESM simulations are extremely demanding in computational resources, especially in high resolution. This lead to rather low resolution global simulations, as well as to the development of Regional Climate Models (RCMs) for the downscaling of the ESM results in limited area domains.

Climate change simulation results are used in the process of decision making. In order to be suitable for use by decision makers, the climate projections need to be converted into projections of the impacts in specific sectors, i.e. human health, energy resources, agriculture, water resources, tourism and other economic sectors.

Tourism sector is a particularly important economic sector for Greece, including Messenia. The quality of the tourism product is in turn very sensitive to the quality and attractiveness of the external environment which depends heavily on local climate. In the present study an RCM is used to produce a climate change projection in order to assess the impacts of climate change to the tourism industry of Messenia, in the south-western Peloponnese. It is part of XENIOS Project which focuses in the area of Messenia, Greece. XENIOS Project studies a wide range of geophysical phenomena (climatic, geological, hydrological, ecological) with a synergistic approach and with a scope to study their effects on tourism which is one of the most important local products.

2 Data and Methodology

The Regional Climate Model RegCM4 (Giorgi et al. 2012) was used for the simulation of climate change until the end of the 21st century. More specifically, the results of MPI-ESM (Giorgetta et al. 2013) were downscaled from 1.875° (≈ 200 km) to 50 km (Lowres) and subsequently to 13.3 km (Hires). Fig. 1 presents the elevation in the three simulations. The resolution of each simulation can be deduced by the size of the grid points. The simulation periods are 1980-1999 (REF) and 2080-2099 (FUT) according to the RCP8.5 scenario (van Vuuren et al., 2011).

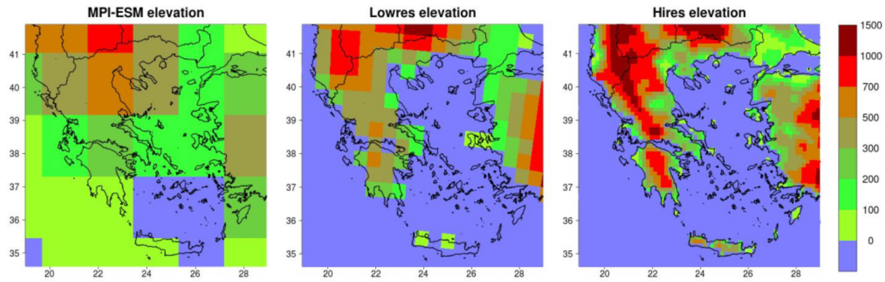

Fig. 1. The elevation in the simulation of MPI-ESM (left) and in the two RegCM4 simulations, Lowres (center) and Hires (right).

Prior to the simulation, the model performance was evaluated against observations from ground stations gridded data, soundings and satellites. Twelve months of re-analysis data were downscaled using the same domain configuration for 11 different model set-ups. Key climatological parameters were compared to the observations in order to chose the optimum model set-up. Focus was given to the simulation of clouds as it is a climatic parameter of high importance for the touristic product. After the optimization of the model for Lowres, the procedure was repeated for Hires in order to select the optimum set-up out of 7 different configurations. For Lowres convection was described by the MIT convection scheme (Emanuel and Zivkovic-Rothman 1999) over ocean grid points and by the Grell convection scheme (Grell 1993) with the the Arakawa-Schubert closure (Grell et al. 1994) over land. For Hires the MIT convection scheme was used with an increased specific humidity threshold for the initiation of convection (elcrit=0.01, default=0.0011). Fig. 2 presents part of the procedure for Hires. The selected set-up (blue) performed best in reproducing the observed (red) mean monthly cloud cover over Messenia, especially over sea and during the wet period of the year.

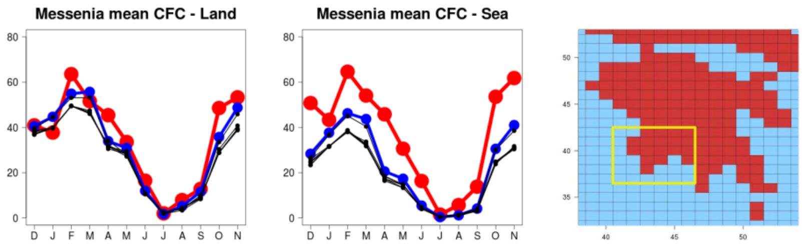

Fig. 2. The comparison of mean monthly cloud fractional cover time series over Messenia produced by the 7 simulations that were tested for the Hires calibration with satellite observations. The horizontal axes run from December 2006 to November 2007. The observational time series (red) were derived from the Meteosat data with a resolution of 0.05º x 0.05º, higher than the model grid. The results of the selected set-up are blue and the results of the 6 rejected set-ups are black. Left: The time-series over land, center: the time-series over sea, right: the land-sea mask of the model in the area of Peloponnese, the grid points that were included in the calculations are in the yellow frame.

3 Results

Fig. 3 presents the change in mean temperature for each individual season between the future period and the reference period. Temperatures rise in all seasons with a minimum of 2.5 to 3°C in winter and a maximum of 4 to 5°C in summer. The temperature increase is higher in the interior of the Peloponnese and milder near the coast, except in winter when it is higher in the north-east.

Fig. 4 presents the percentage change in precipitation for each individual season between the future period and the reference period. Overall precipitation decreases. The decrease is mostly prominent (over 30%) in spring and in winter except along the eastern and north-eastern coastline. In autumn the decrease is mostly under 20%. In summer mixed signals are observed, decrease prevails but given that summer precipitation is limited this corresponds to slight precipitation height changes. In terms of precipitation height (not shown) the decrease is most prominent in the winter, especially in the western and south-western Peloponnese, in most of which it exceeds 2 mm/day.

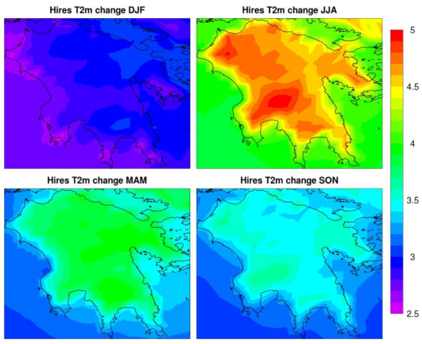

Fig. 3. The change in seasonal temperature between FUT (2080-2099, CRP8.5) and REF (1980-1999). Left column: winter and spring, right column: summer and autumn.

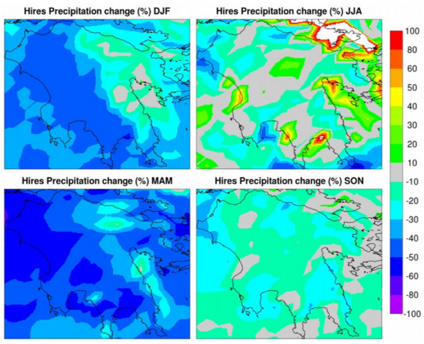

Fig. 4. Same as in Fig. 3, but for the percentage change in seasonal precipitation.

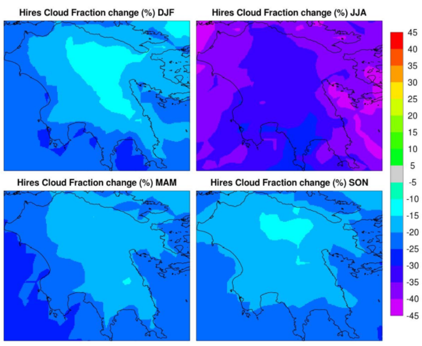

Fig. 5. Same as in Fig. 4, but for the percentage change in seasonal cloud fractional cover.

Fig. 5 presents the percentage change in cloud fractional cover for each season. A reduction is projected for all seasons with similar results for winter, spring and autumn: reduction of 15-25% in most of Peloponnese, including Messenia. In summer the reduction is much higher, over 30% in most of Messenia. However, in absolute values the reduction is smallest in the summer as the mean cloud cover is very small (not shown).

Fig. 6 presents the range of daily maximum and of daily minimum temperature at 2m for the 12 months of the year for a coastal grid point near the center of Messenia which is shown in the inset at the top left. The summer temperature rise will cause this season to become less hospitable, with often overwhelming maximum temperatures and with a weakened relieving effect of the minimum temperature. On the contrary, winter cold will be less severe. The transient months are projected to move away from summer and towards the winter. For example the months of September and May in the reference period resemble more to the months of August and June respectively in the future period in terms of maximum and minimum temperatures. Similar description applies to all the land grid points in the area of Messenia.

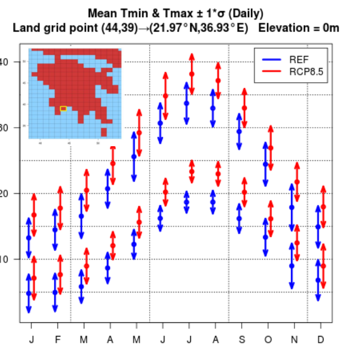

Fig. 6. The range of daily maximum temperature and of daily minimum temperature in FUT (2080-2099, red) and in REF (1980-1999, blue) for the grid point shown in the inset, top left. The dots correspond to the mean monthly extreme temperatures. Each arrow corresponds to one standard deviation of the total daily values of the respective month, therefore the range denoted by both arrows of each dot corresponds roughly to 68% of the variability.

4 Conclusions

The results of a climate simulation by MPI-ESM were downscaled to 13.3 km using RegCM4 in order to study the consequences of climate change to the tourism sector of Messenia by the end of the 21st century.

The most prominent feature of the projected climate change is the rise in temperature. It will cause the summer season to become too warm and unattractive to tourists. On the other hand, the warming of transitional seasons will make them more attractive, especially in combination with the warming of the sea waters. This means that the tourism demand will seize to be mostly concentrated in the present peak season and it will be spread more evenly throughout the year, especially in the transitional months but also in the winter. Aside from the temperature rise this effect will be enhanced by the decrease of precipitation and cloudiness in the transitional seasons and winter. Precipitation is perceived by tourists as an inconvenience as it obstructs them from enjoying the outdoors environment, while sunshine is considered to be a significant attraction. One more reason is that the cost of air-conditioning for the warm season is expected to increase dramatically.

Another important consideration, not only for the tourism sector, is the issue of water resources, including availability and quality. The reduced precipitation and cloudiness and the increased temperature will cause a shortage of water. Planned management of water resources is considered necessary, including the acquisition and distribution of fresh water, as well as the management of water demand for agriculture and other anthropogenic needs, i.e. the choice of low-water demanding crops and the construction of facilities. The water shortage will also challenge the conservation of non-anthropogenic environment which is an important asset for the tourism industry. Natural flora and fauna are expected to suffer a strong stress due to lack of water and desertification will be a possibility that should be addressed. Fire hazard will increase dramatically and measures for fire security must be taken in advance, in order to increase not only the capability to put out fires but also in order to manage the forests in order to make them less prone to mega-fires.

Acknowledgments The study is supported by XENIOS project (no 09COP-31-867) financed by the EU (ERDF) and Greek national funds through the Operational Program “Competitiveness and Entrepreneurship”; of the National Strategic Reference Framework (NSRF) Research Funding Program COOPERATION 2009.

References

Emanuel KA and Zivkovic-Rothman M (1999) Development and evaluation of a convection scheme for use in climate models. J. Atmos. Sci., 56, 1766–1782.

Giorgetta MA, Jungclaus JH, Reick CH, Legutke S, et al. (2013) Climate and carbon cycle changes from 1850 to 2100 in MPI-ESM simulations for the coupled model intercomparison project phase 5. Journal of Advances in Modeling Earth Systems, 5, 572-597. doi:10.1002/jame.20038.

Giorgi F, Coppola E, Solmon F, Mariotti L and others (2012) RegCM4: model description and preliminary tests over multiple CORDEX domains. Climate Research 52:7-29. doi:10.3354/cr01018.

Grell G (1993) Prognostic evaluation of assumptions used by cumulus parameterizations, Mon. Wea. Rev., 121, 764–787.

Grell GA, Dudhia J and Stauffer DR (1994) Description of the fifth generation Penn State/NCAR Mesoscale Model (MM5), Tech. Rep. TN-398+STR, NCAR, Boulder, Colorado, pp. 121, 1994.

van Vuuren D, Edmonds J, Kainuma M, et al. (2011) The representative concentration pathways: an overview. Climatic Change 109:5–31. doi 10.1007/s10584-011-0148-z.