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Challenges and Uncertainties in Climate Change and Impact Analyses

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Abstract: The Mediterranean basin is particularly susceptible to and vulnerable to the effects of climate change. Water scarcity as a result of decreased surface runoff and groundwater levels is undoubtedly one of the most critical effects of climate change, particularly for the southern Mediterranean regions. Despite the advancements made recently in the study of climate change and its effects on water resources, results and outcomes should still be handled with caution because any projections for the future of the climate and any implications that result from them will invariably be impacted by some degree of uncertainty resulting from each stage.

Keyword: Reliability, climate, mediterranean basin

Introduction

As mentioned in Mediterranean Basin (MB), there has been and will likely continue to be a decrease in annual precipitation over the majority of its regions as well as a general warming trend, particularly during the summer. In certain regions of the MB, the combined impact of the decline in total annual precipitation and air warming, which has a direct impact on all of the processes involved in the soil water balance, might result in severe water shortages. The nations with the most severe impacts may be those where the management of water resources is still a serious problem. Groundwater recharge and soil water content are predicted to decrease throughout southern Europe and North Africa, especially during the summer, while river flow, lake levels, and reservoir accessibility are predicted to diminish in many parts of the MB. The decrease in water supplies may have a number of effects on the agriculture sector, including severe losses in crop production, as well as on the security of food and energy. A decline in TFP of between -20% and -30% in the MB was found, for instance, when the effect of anthropogenic climate change recorded between 1961 and 2010 was examined on worldwide agricultural Total Factor Productivity (TFP). These factors present significant challenges for the projected increase in population, which is projected to reach 9.1 billion by 2050 and, consequently, for the rise in the need for food and energy. Beginning with the literature review conducted in the companion paper, this paper concentrates on the most important recent studies on climate change in the MB over the previous ten years of research, limiting the research to studies that have already been published in journals with high impact factors and chosen by using Scopus and Google Scholar as databases. The article specifically focuses on: i) the key concerns surrounding climate change modelling and impact evaluations; and ii) the key challenges that prospective future changes may face in terms of water availability in the MB.

The evaluation of emission scenarios, the use of GCMs (Global Circulation Models) and downscaling techniques, the development and application of hydrological models, and frequently the coupling with other impact models (such as land use/cover or water use models) make up the typical modelling chain for assessing the impacts of climate change. Because meteorological and hydrological variables must be projected decades into the future, uncertainty is still a significant concern despite the booming activity, advances made in this subject, and its impact on water supplies. Due to the ambiguity surrounding these investigations, any result or conclusion should always be handled with the appropriate caution.

In fact, each step of the process for determining the impact of climate includes potential sources of uncertainty, such as measurement errors from instruments, data processing errors, aggregation errors due to incomplete temporal and/or spatial data coverage, unpredictability of future natural processes (such as volcanic eruptions, ecosystem dynamics), limited space and time resolution of models, incomplete understanding of some Earth system processes, and/or the uncertainty associated with the future effects of human activity on the climate.

The climate scenarios chosen for a given impact study should always adhere to a set of fundamental standards. For instance, they should be consistent with a wide range of global warming projections based on various greenhouse gas emissions scenarios, such as those reported in the fifth (AR5) Intergovernmental Panel on Climate Change (IPCC) report, and/or various shared socio-economic pathways (SSPs), such as those reported in the sixth (AR6) IPCC report. They should also be representative of the potential range of future regional climate change. Additionally, because impact models need data variables at various temporal (from the annual to the sub-hourly) and geographical (from the global to the plot) scales as input,Climate scenarios should be able to depict changes in a large enough number of variables over a long enough time period. In addition, careful consideration must be given to the selection of the most appropriate hydrological, water management, and system behavior-based models, as well as the integration strategy used and the parameterization of those models in non-stationary conditions.

Challenges and Uncertainties in Climate Change Modeling and Impact Analyses

Despite numerous recent attempts to quantify the effects of climate change on water supplies, it is always advisable to read the results of such research with the understanding that they are subject to uncertainty from various sources. It has already been mentioned that uncertainties might spread throughout the entire modelling process (i.e., the emission scenario, GCM, downscaling, and impact models), and it is never simple to assess and lower uncertainty related to each source. This calls for appropriate sensitivity assessments to constantly be used in conjunction with probabilistic frameworks to support the implications of climate change.

The following sections discuss the different sources of uncertainty, schematically represented in Fig. 1, and their influence on the assessment impact of climate change.

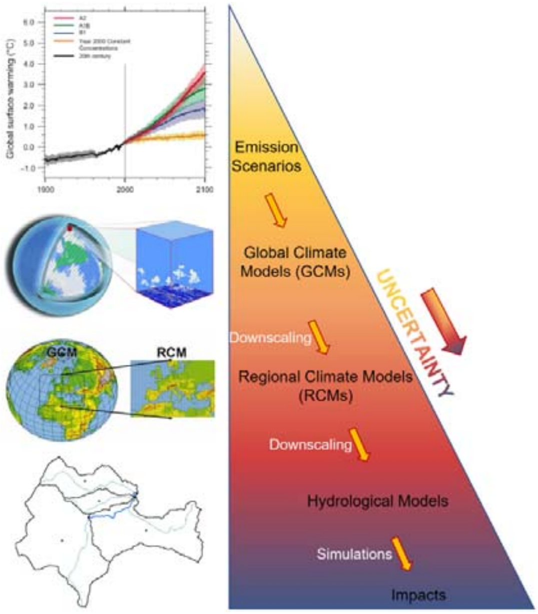

Fig.1.Schematic representation of different sources of uncertainty in climate predictions and impact analyses

Conclusion

All of the hydrological balance's elements are changing in the Mediterranean Basin, perhaps as a result of climate change in addition to the region's normal inter-annual fluctuation. Studying water supply trends is crucial in this area because water resources affect various Mediterranean nations' economies and security. The studies reviewed here show that over the MB, climate change has been significantly reducing freshwater availability, which has resulted in crop productivity losses. This is in relation to a significant rise in water demand, use, and consumption brought on by population growth and economic development, suggesting a future with greater water stress. 196 members of the United Nations Framework Convention on Climate Change negotiated the Paris Agreement. Although this represents an important milestone for fixing sustainable goals, in view of the ongoing climate change in the MB, a big effort is still required to the scientific community and policy makers to promote and implement sustainable solutions to mitigate projected impact on water resources. In addition to thinking outside the box and utilising unconventional resources, innovative research and applied technical solutions, such as the water-energy-food-ecosystems nexus, should be investigated. Governance should take into account the various needs and priorities for managing water and other natural resources in the different parts of Manitoba, where differences in socioeconomic conditions and water availability between the northern and southern regions may be exacerbated in the future by climate change. It is urgently necessary to develop top-down policy-based approaches, involving all the stakeholders, that are oriented to minimise the anthropogenic impact, for example, by reducing the irrigated areas or increasing irrigation efficiency, to mitigate the likely increasing water scarcity.

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