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Analysis of projected changes in heat wave frequency for Eastern/Central Europe on the basis of regional climate model simulations

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Heat wave events are important temperature-related climatological extremes due to their impacts on human health. In the future, they are very likely to occur more frequently and more intensely not only in the Carpathian Basin located in Eastern/Central Europe, but in most regions of the world because of global warming. In order to develop adaptation and mitigation strategies on local scale, it is essential to analyze the projected changes related to heat waves. In 2004, a Heat Health Watch Warning System was developed on the basis of a retrospective analysis of mortality and meteorological data in Hungary to anticipate heat waves that may result in a large excess of mortality. In the frame of this recently introduced Health Watch System, three levels of heat wave warning are applied. They are associated to the daily mean temperature values, and defined as follows: (i) Warning level 1 (advisory for internal use) is issued when the daily mean temperature exceeds 25 ^{o}C. (ii) Warning level 2 (heat wave watch) is issued when the daily mean temperature for at least 3 consecutive days exceeds 25 oC. (iii) Warning level 3 (heat wave alert) is issued when the daily mean temperature for at least 3 consecutive days exceeds 27 ^{o}C. In this paper, frequency of the above climatic conditions are analyzed using regional climate model RCM experiments. Global coverage of simulated climate conditions can be obtained from global climate models (GCMs), however, their horizontal and temporal resolutions are too coarse to provide appropriate information on national/regional scales. To this purpose, RCMs nested in GCMs are applied. These fine resolution numerical models are able to estimate the regional climate change consequences of global warming. At the Dept. of Meteorology, Eotvos Lorand University two different RCMs have been adapted: RegCM and PRECIS. RegCM is a 3-dimensional, sigma-coordinate, primitive equation model, and it was originally developed by Giorgi et al. Currently, it is available from the ICTP (International Centre for Theoretical Physics). The initial and lateral boundary conditions of the 10-km horizontal resolution experiments have been provided by the ECHAM GCM for the A1B emission scenario for three different time slices (1961-1990, 2021-2050, and 2071-2100). PRECIS is a hydrostatic RCM (HadRM3P) developed at the UK Met Office, Hadley Centre, and nested in HadCM3 GCM. It uses 25 km horizontal resolution transposed to the Equator and 19 vertical levels with sigma coordinates. Experiments for the Eastern/Central European domain are accomplished for 3 different emission scenarios: A1B, B2 and A2. For B2 and A2, the last three decades of the 21st century are compared to the 1961-1990 reference period, while in case of A1B a transient run 1951-2100 is completed. On the basis of the RCM experiments of RegCM and PRECIS, the frequency changes of heat warning cases in the Carpathian basin located in Eastern/Central Europe are analyzed. The climate conditions of the 1961-1990 (as a reference), and 2021-2050, 2071-2100 future periods are evaluated using both the RegCM and the PRECIS outputs. Based on the results of the present study, the following main conclusions can be drawn: (i) Heat waves are very likely to occur more frequently in the 21st century than in the reference period, 1961-1990. (ii) By the end of the 21st century heat warning level 3 is projected to occur with similar frequency as the heat warning level 1 in the reference period. (iii) By the end of the 21st century the average first occurrence of the heat warning days is simulated to shift earlier, and the average last occurrence later, than in the reference period - thus the length of the heat wave season is projected to become remarkably larger. (iv) For each time slices (both reference and future periods), PRECIS simulations suggest a more often occurrence of heat warning cases in the Carpathian basin than the RegCM experiments.