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Global analysis of simulated 21st century changes in daily temperature variability

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Global climate models (GCM) and their performance can be assessed in many ways. Studies using GCM simulations are commonly based on monthly mean values. There are two main reasons for this: Firstly, the relatively large grid-box size used in the GCMs make the daily distribution appear smoother than is observed in reality. This is further emphasized over heterogeneous surfaces, where GCMs do not simulate the local climate well. Secondly, the processing of daily data is technically more demanding and time consuming as the data volumes are larger. The most obvious use of daily data has been extreme value analysis or impact modeling. Regional climate model data are often used for these kinds of studies. Besides extreme values, however, the variability of climate on all time scales heavily affects the lives of people. As adaptation to climate is strongly affected by climate variability, changes in variability need to be taken into account when planning the adaption to future climate changes. In our study, we have analyzed the distribution of daily mean temperatures as simulated by 15 CMIP3 (Coupled model Intercomparison Project 3) models. For each model, the distribution in each three-month season is defined by calculating 101 percentile values. The analysis was done both for the simulated present-day climate of 1981-2000 and the projected changes taking place in the A1B scenario climate of 2081-2100. Our specific aim in this study was to find how much the climate model data user should trust these changes of the distribution, which are generally expected to be more uncertain than the time mean changes. This was quantified using leave-one out cross-validation. We try to obtain a global picture of the simulations and provide all of our results as zonally averaged values that do not distinguish between surface types. Compared to the ERA40 reanalysis, the present-day bias in the model simulations is relatively small, being the largest over the high latitudes and for the lowest daily mean temperatures. Generally, the model bias relative to ERA40 is negative, but throughout the temperature distribution the observed climate is within the range of the model ensemble. Throughout the distribution axis and all over the world, daily mean temperature increases in the 21st century. The variability is projected to decrease consistently over high latitudes, while over low latitudes approximately between 40∞S-40∞N the temperature increase is relatively uniform across the distribution. Changing cryospheric conditions affect significantly the daily mean temperature variability, as very cold temperatures are reached only over snow or ice-covered areas and the variability is significantly smaller over ocean than over ice areas. As the projected 21st century changes in the sea ice and snow cover extent are very diverse in the ensemble, the inter-model variability of temperature distribution changes is also the largest over high latitudes. Nevertheless, the cross-validation reveals that the information of the temperature distribution changes provided by the CMIP3 ensemble is potentially useful for climate data users. The use of daily resolution data should never lead to a substantial disadvantage in projection accuracy in comparison with the use of simulated monthly mean temperature changes, but wherever temperature distribution is simulated to change in the future, the cross-validated errors are smaller if this information is taken into account. The benefit is the largest near the tails of the temperature distribution, but it depends on the season, being the smallest during the local summer. On the other hand, over low latitudes the user gains no extra advantage in using daily resolution data, making the choice between monthly and daily resolution temperature data largely insignificant.

References Ylhaisi, J.S. and J. Raisanen, 2011: 21st century changes in daily temperature variability in CMIP3 climate models, Journal of Climate, in preparation.