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Regional climate change under high-end global warming

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Global emissions of greenhouse gases have continued to rise throughout the 20th and 21st centuries. If no steps are taken to reduce these emissions, it is likely that global temperatures will exceed the limit of 2 deg.C by 2100 (relative to the preindustrial period) desired by the EU. The climate projections from the IPCC Fourth Assessment Report (AR4) suggest that global temperatures will increase between 1.6 and 6.9 deg.C by 2100, relative to the preindustrial period. Global mean temperature increases of 4 deg.C or more (referred to as 'high-end' projections) are therefore entirely possible. Here, we examine changes in temperature and precipitation from several ensembles of climate models, focusing on those projections where global mean temperatures increase by 4 deg.C or more by the 2090s. We have examined projections from the AR4 models, and the Hadley Centre's perturbed physics ensembles (Qump; based on the HadCM3 climate model). One of the Qump ensembles included an interactive carbon cycle. Previous work has shown that feedbacks between climate and the carbon cycle can result in enhanced global warming. These ensembles used greenhouse gas concentrations from a subset of the SRES emission scenarios B1, A1B, A2 and A1FI. The results show that high-end climate change would be avoided if emissions follow the B1 trajectory. However, high-end changes become increasingly frequent under the A1B, A2 and A1FI scenarios (in that order). Overall, 52 of the 131 projections analysed were classed as high-end. The high-end projections suggest that 4 deg.C global warming could be reached by the 2080s, or by the 2070s if emissions are high. If feedbacks from the carbon cycle are strong, 4 deg.C could be reached as early as the 2060s, although our current understanding suggests that such strong feedbacks are unlikely. We also compared global maps of temperature and precipitation changes from the high-end and the remaining members of each ensemble. We found that, using multi-model means, high-end projections generally have similar patterns of change to non high-end projections. This result indicates that high-end models do not behave very differently to non high-end models. Enhanced warming, of up to 15.2 C, is projected over the Arctic in the high-end projections. The projected warming in northern hemisphere winter is much greater than that seen in the summer period. Other areas which are projected to experience a large degree of warming are west and southern Africa, where temperatures may increase between 6 and 10 deg.C. Temperatures in parts of South America could increase between 6 and 13 deg.C; in the Qump ensembles, the warming is concentrated over Amazonia, but in the AR4 ensembles the warming lies to the north and south of this region. The AR4 ensembles project an area of cool water to form in the North Atlantic, between the UK, Greenland and Newfoundland; this feature is not seen in the Qump ensembles. Significant reductions in precipitation are projected by all models in the tropical and subtropical regions between 45 N and 45 S. Areas common to all ensembles are the Mediterranean, west and South Africa, and central America. However, the Qump ensembles suggest a drying in Indonesia whereas the AR4 ensembles project increasing precipitation in this area. There is also little agreement in the location of wetter and drier areas over South America between the AR4 and Qump ensembles. Some of the enhanced warming over Africa is likely to be caused by drier soils resulting from the reduced precipitation.