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Northern Hemisphere summer season lengthening at 1.5 and 2.0 degree global warming

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In the context of Paris Agreement, it is essential to quantify climate changes and relative risks due to different mitigation targets of global warming. This study examines changes in the timing and length of summer season over the Northern Hemisphere (NH) at 1.5 and 2.0 degrees of global warming by using the multi-AGCM large-ensemble simulations provided by the Half a degree Additional warming, Prognosis and Projected Impacts (HAPPI) project. Five AGCMs provide more than 100 runs of 10-year length for three experiments: All-Hist (current decade: 2006-2015), Plus15 (1.5 degree warmer), and Plus20 (2.0 degree warmer than pre-industrial condition). Summer season onset and withdrawal over the NH extratropics are calculated from the HAPPI simulations using a method based on relative thresholds which represent the warmest quarter of the year on each location. Results show that all AGCMs predict significant increases in summer season length over NH. On average, summer is projected to start earlier by 8.3 days and 14.3 days relative to the current decade while summer withdrawal will be delayed by 7.5 days and 13.1 days at 1.5 and 2.0 degree warming, respectively. Generally, summer onset advance is larger than summer withdrawal delay, consistent with previous studies. Regional analysis reveals that summer season lengthening is relatively larger in mid latitudes than high latitudes with the largest change in Mediterranean and the smallest change in North Asia. Comparison between 1.5 and 2.0 degree experiments indicates that there will be 6 days earlier onset and 5.5 days later withdrawal of summer season due to the additional 0.5 degree warming, more strongly in lower latitudes. Along with the summer season expansion, the occurrences of extreme hot days (such as 10-year return values) are also found to robustly increase, particularly in lower latitudes and Mediterranean region. Our results demonstrate that warming mitigation by a half degree would significantly reduce summer season lengthening and the associated increases in risk like extreme heat waves over the NH.