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CMIP6 multi-model projection of summer season expansion over the Northern Hemisphere land areas

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Due to the ongoing robust global warming, summer season is expected to get warmer in future over the Northern Hemisphere (NH) land areas. This study examined how the summer season defined by local temperature-based thresholds would change during the 21st century under Shared Socioeconomic Pathway scenarios (SSP1-2.6, SSP2-4.5 and SSP5-8.5) using Coupled Model Intercomparison Project phase 6 (CMIP6) multiple model simulations. The projection results relative to the current climatology (1995-2014) indicate the significant advance of summer onset and delay of withdrawal over all NH land areas except high latitude locations, with longer than 10 days of summer expansion even in the weakest scenario (SSP1-2.6) in the near-term future (2021-2040). The advance and delay of summer season timing become stronger in the mid-term (2041-2060) and long-term (2081-2020) future periods, ranging from about 10 days to a month depending on SSP scenarios. Largest summer expansion is observed in the middle latitudes, including Europe in high latitude, while the weakest changes are seen over North Asia. Canadian Arctic region is characterized by an asymmetric change with a small advance of summer onset but a relatively large delay in summer ending. CMIP6 models exhibit large inter-model differences, which increase from near-term to long-term future periods. Western North Asia region display larger inter-model difference in summer onset projections while Europe has the largest inter-model spread of summer withdrawal changes. Physical mechanisms associated with these regional and timing-dependent changes in the future summer season lengthening will be further examined.