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How predictable are human-induced changes in the seasonal cycle of surface temperature?

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The seasonal cycle is fundamental to the Earth's climate system, accounting for the vast majority of temperature variance, and yet its role is often under-appreciated. Understanding how the seasonal cycle of surface temperature will change in the future, and by when, is a key question with important implications. The detection of these changes is made challenging by the internal variability of the climate system, which masks externally forced signals such as those arising from increased greenhouse gases. A conventional approach to this problem is to use an ensemble of climate model simulations generated from differences in initial conditions alone. Such an ensemble facilitates the identification of externally forced signals amidst internally generated variability. Using a state-of-the-art coupled climate model initial condition ensemble (Community Earth System Model – Large Ensemble), we address the detection and quantify the predictability of changes in the seasonal cycle of surface temperature in response to increasing greenhouse gases. The ensemble consists of forty realizations of the climate system that are initialized at 1920 and run using historical forcing from 1920 – 2005 and RCP 8.5 forcing from 2006 - 2100. Using the large ensemble, we address two specific questions about the seasonal cycle of surface temperature and its geographic pattern: 1) how do the future ensemble mean amplitude and phase of the seasonal cycle change in response to RCP 8.5 forcing? and 2) when will these changes be first detectable at the 95% confidence level?

Our results reveal large regional differences in the predictability of changes to the seasonal cycle of surface temperature. As soon as the coming decade, human induced changes to the seasonal cycle are found be detectable over Western Europe and Northern Africa, and yet some regions, such as the Eastern United States, are projected to have few predictable changes by the end of this century, even utilizing the full forty member ensemble. Significant increases in amplitude are projected over Western Europe and the West coast of the United States, with large decreases found over Siberia and Canada by the end of the 21st Century. The phase of the seasonal cycle advances by 1 to 5 days over most land regions. Ongoing work evaluating the robustness of these results across existing CMIP class model ensembles will also be presented. Lastly, the potential implications of these results will also be discussed.