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Sun-induced chlorophyll fluorescence detects the response of tree species to extreme heat events

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The intensity and number of extreme heat events, such as short-term heat waves (hw), has increased, and current projections forecast the global land area experiencing heat waves will double by 2020. Sun-induced chlorophyll fluorescence (SiF) has been a new probe to detect plant photosynthesis and their response to extreme climate event at regional- and global- scale. However, understanding the SiF response of different tree species to short-term hw is still limited due to the lack of knowledge of the detailed physiological mechanism for specific tree species. In this study, we explored the SiF response of four temperate tree species, i.e. southern red oak (Quercus falcata), Shumard oak (Quercus shumardii), and eastern white pine (Pinus echinata) and yellow poplar (Liriodendron tulipifera) to the simulated short-term hw in a plant growth chamber by a novel SIF observing system- the Fluorescence Auto-Measurement Equipment (FAME). Two-year-old, well-irrigated potted saplings were exposed to progressively increasing temperature diurnal cycles over a period of 7 days, with peak midday air temperature Tmax 37 °C (pre-hw, 3 days), Tmax 47 °C (hw-d1, 1 day), Tmax 49 °C (hw-d2, 1 day), Tmax 51 °C (hw-d3, 1 day), and then back to Tmax 37 °C (post-hw, 1 day). We developed an advanced spectral fitting method (SFM) to retrieve the SIF of four tree species. The fluorescence yield of southern red oak and Shumard oak observed by FAME is less 53.3% than yellow poplar and white pine during hw cycle. Our results show that tree species with lower SIF, i.e. southern red oak and Shumard oak have higher heat tolerance than ones with higher SIF, i.e. yellow poplar and white pine. Furthermore, this study implies that satellite SIF has great potential to detect heat stress conditions for tree species in a timely manner on a large scale.