B13A-1536: A decade of precipitation extremes shape long-term forest-atmosphere carbon and water flux within a temperate mesic forest

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The northeastern U.S. has experienced a rapid rise in extreme precipitation events and total precipitation due to climate change. Despite higher overall precipitation, long-term near-surface soil moisture at the Harvard Forest in Petersham, MA has decreased since 2010, a pattern also observed in other global temperate forest regions. In this study, we used more than thirty years of ecosystem-atmosphere water and carbon exchange at the Harvard Forest to understand the impact of precipitation extremes during the past decade on ecosystem water and carbon fluxes and the strength of land-atmosphere coupling.

We found that in this mesic temperate forest, well-drained post-glacial soils rapidly drain surplus moisture from large rain events, while the remaining moisture necessary to preserve local humidity is quickly lost to evapotranspiration unless frequently replenished by rainfall. This region has also experienced two hot summer droughts during the past decade, causing further hydrological stress with carbon cycle implications. Furthermore, meteorological conditions in the nongrowing season have particularly shifted to warmer, drier conditions that set the stage for more frequent summer soil moisture deficits. In response to this past decade of hydrological extremes, we have observed a dampening of canopy light response curves, indicating lower rates of carbon uptake during the growing season and a parallel decline in ecosystem respiration as soils dry. More frequent dry conditions during key phenological windows, the intense delivery of rainfall during a shorter temporal window in the growing season, and rising summer temperatures and lower humidity have combined to decrease the ecosystem carbon uptake by photosynthesis and created large interannual variation in the strength of the net carbon sink at Harvard Forest during the past decade compared to the prior two decades of this study.