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ABSTRACT TITLE: Evaluation of the seasonal dynamics of photosynthesis and drought stress in CMIP5 models

ABSTRACT: In many northern terrestrial ecosystems, photosynthesis during summer is fueled by the accumulation of snow and soil moisture during winter and spring. With longer growing seasons expected during the next several decades as a consequence of climate warming, increasing drought stress is possible if earlier onset of photosynthesis and transpiration is not balanced by increases in precipitation during the growing season or increases in ecosystem water use efficiency (WUE). We present long-term carbon isotope records in atmospheric CO_2 and tree ring cellulose at two AmeriFlux sites (Wind River and Metolius) as examples to illustrate how ecosystem WUE may respond to seasonal and interannual variations in soil water conditions. Here we examined the timing of spring photosynthetic onset in CMIP5 models using eddy covariance observations and atmospheric CO_2 mole fraction observations. Our results indicate that many of the CMIP5 models exhibit an early onset bias in photosynthesis and transpiration for the contemporary period. In some models, the early onset of photosynthesis appears to cause ecosystems to more rapidly consume soil moisture reserves, leading to low biases in latent heat fluxes during mid-summer, and as a consequence, greater atmospheric heating and reduced precipitation over the interior of northern continents. We also discuss how photosynthesis and drought stress are likely to change during the 21st century and how contemporary biases may influence future projections of change. We provide a new set of physiological mechanisms that may reduce spring photosynthesis biases in climate models.