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Why we need better predictive models of vegetation phenology

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Vegetation phenology is strongly affected by climate change, with warmer temperatures causing earlier spring onset and delayed autumn senescence in most temperate and boreal ecosystems. In arid regions where phenology is driven by the seasonality of soil water availability, shifts in the timing, intensity, and total amount of precipitation are, likewise, affecting the seasonality of vegetation activity. Changes in the duration of the growing season have important implications for ecosystem productivity and uptake of CO_2 from the atmosphere, as well as site water balance and runoff, microclimate, ecological interactions within and across trophic levels, and numerous feedbacks to the climate system associated with the surface energy budget.

However, an outstanding challenge is that existing phenology sub-models used in ecosystem, land surface, and terrestrial biosphere models fail to adequately represent the seasonality, or sensitivity to environmental drivers, of vegetation phenology. This has two implications. First, these models are therefore likely to perform poorly under future climate scenarios. Second, the seasonality of important ecological processes and interactions, as well as biosphere-atmosphere feedbacks, is likely to be misrepresented as a result.

Using data from several recent analyses, and focusing on temperate and boreal ecosystems, we will review current challenges associated with modeling vegetation phenology. We will discuss uncertainties associated with phenology model structure, model parameters, and driver sensitivity (forcing, chilling, and photoperiod). We will show why being able to extrapolate and generalize models (and model parameterization) is essential. We will consider added challenges associated with trying to model autumn phenology. Finally, we will use canopy photosynthesis and uptake of CO_2 as an example of why improved understanding of the "rhythm of the seasons" is critically important.