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Spatiotemporally Explicit Modeling of Forest Phenology Using Weather and Climatology

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Abstract: Using 35 years of Landsat images for northeastern Minnesota, USA, and more than a decade of phenocamera observations in the Boundary Waters Canoe Area Wilderness, we present analyses and hindcasts of forest phenology. Various studies of forest phenology from both of these perspectives have employed logistic, harmonic, or other curves fitted to long-term observations but then used only that mean curve in subsequent analyses. We have developed a method to explain latent information in the curve residuals, those observed departures from the mean phenology, using seasonal and interannual deviations from the long-term climatology at the same location. While the long-term mean phenology is useful in a diagnostic sense, these phenoclimatological relationships use meteorological measurements at the land surface on a daily basis, allowing us to generate model-based predictions of expected forest phenology (ahead of satellite image availability) that account for interannual variability in weather and climate conditions. At the spatial scale and resolution of Landsat observations, these phenoclimatological relationships advance our understanding of vegetation responses to atmospheric conditions on temporal scales from weeks to seasons. These methods can help improve the representation of forest phenology in weather and climate models, especially its spatiotemporal variability, leading to more realistic effects of vegetation state on energy, carbon, and moisture fluxes at the land–atmosphere interface.

Keywords: climatology, forest, phenology, Landsat, Minnesota, weather