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Seasonal Temperature Changes and their Impacts on Vegetation in the Northern Latitudes

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Plant growth in the northern latitudes is highly responsive to increased temperature over recent decades. Annually pulsing terrestrial biomass principally leads to the phasing of seasonal cycling of atmospheric CO2 concentrations by ecosystem shifts between a net source and a net sink of carbon, dependent on the dynamic equilibrium between photosynthesis and respiration. Changing phase and amplitude in these two mutually interwoven cycling processes have been addressed as biological consequences of global climate change. Although previous observations based on long-term satellite data suggested that escalating plant activities are followed by increased seasonal amplitude and extended growing season, these threshold-based measurements conflate the overall productivity and seasonal variations of vegetation dynamics. Here we report our findings about the changes of annual phase and amplitude of terrestrial vegetation cycling in Eurasia and North America inferred from the yearly interval sinusoids of plant greenness series. We used three sinusoidal components to measure the cyclic fluctuation for yearly vegetation dynamics including the 0th harmonic (AVE) that indicates the overall vegetation productivity, the amplitude of the 1st harmonic (AMP) that is related to the seasonal variation of plant activities and the phase of the 1st harmonic (PHA) that depends on the timing of phenological events over yearly growing seasons. We have analyzed 8km × 8km gridded NOAA/AVHRR time series data of normalized difference vegetation index (NDVI), an indicative of photosynthetic activity of vegetation canopies derived from the Global Inventory Monitoring and Modeling Studies (GIMMS).

Our findings derived from the long-term time series of NDVI and temperature anomaly records have shown that regional differences with respect to changes in overall productivities and dynamic characteristics of annual cycle could imply diverse responses of terrestrial vegetation to globally changing climate. There exhibit clear trends of increased overall plant productivity, decreased seasonal variations, altered phases, and earlier spring green-up in the annual cycles of terrestrial ecosystems in the northern latitudes during 1982-2005. The earlier onset of green-up events is strongly impacted by warming spring. The vegetation dynamics in autumn, however, are more complex. It apparently needs to take into account more holistic relationships between climatic factors and the equilibrium of altering photosynthesis and respiratory of terrestrial ecosystems in a changing climate. Our findings also suggest that more conspicuous changes in overall vegetation productivity and seasonal phases of ecosystems have been observed in Eurasia than in North America, largely because a more rapid rise in temperature has been recorded in Eurasia over recent decades.

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