ABSTRACT

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Variability and synchrony in 10,000 years of Alaskan fire history: Controls and implications of fire-regime change

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Background/Question/Methods

Boreal forest and tundra biomes are globally important because the mobilization of large carbon stocks and changes in energy balance could act as a positive feedbacks to ongoing climate change. In Alaska, wildfire is a key driver of ecosystem structure and function, and therefore a critical process connecting high-latitude ecosystems with the larger Earth system. Paleoecological records from Alaska reveal the sensitivity of fire regimes to climatic and vegetation change over centennial to millennial time scales, highlighting increased burning concurrent with warming or with increased landscape flammability. Yet uncertainty remains about the timing and spatial extent of fire-regime responses to Holocene environmental change. We synthesized 27 published sediment-charcoal records from four Alaskan ecoregions to evaluate variability and synchrony in fire activity during the Holocene. The timing of fire events was estimated with a peak analysis, integrating measures of temporal uncertainty. We developed composite records of biomass burning by modeling charcoal accumulation rates as a zero-inflated log-normal process.

Results/Conclusions

Biomass burning varied over centennial and millennial time scales within each of the four ecoregions and across Alaska. Both biomass burning and fire frequency increased significantly with the expansion of black spruce, c. 4-6 thousand years ago. Biomass burning also increased during the Medieval Climate Anomaly (MCA) in some regions, but our results do not indicate prolonged periods of synchrony in the timing of fire activity across Alaska. Limits to fire synchrony suggest important stabilizing vegetation feedbacks. Biomass burning increased more quickly during the Holocene than fire frequency, which may indicate an increase in the average severity or size of fire events during warm periods. Our analysis also suggests significant increases in biomass burning over the last century across Alaska. Our analysis documents the sensitivity of fire activity to broad environmental change, like climate warming or major shifts in vegetation flammability. However, the lack of prolonged synchrony and apparent tradeoffs between vegetation change and biomass burning indicate important stabilizing feedbacks that may confer resilience of Alaskan ecosystems to novel fire regimes. Widespread, simultaneous increases in fire activity across Alaska would be unprecedented in the last 4,000 years or more.