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Unravelling winter diatom blooms in temperate lakes using high frequency data and ecological modeling

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In temperate lakes, it is generally assumed that light rather than temperature constrains phytoplankton growth in winter. Rapid winter warming and increasing observations of winter blooms warrant more investigation of these controls. We investigated the mechanisms regulating a massive winter diatom bloom in a temperate lake. High frequency data and process-based lake modeling demonstrated that phytoplankton growth in winter was dually controlled by light and temperature, rather than by light alone. Water temperature played a further indirect role in initiating the bloom through ice-thaw, which increased light exposure. The bloom was ultimately terminated by silicon limitation and sedimentation. These mechanisms differ from those typically responsible for spring diatom blooms and contributed to the high peak biomass. Our findings show that phytoplankton growth in winter is more sensitive to temperature, and consequently to climate change, than previously assumed. This has implications for nutrient cycling and seasonal succession of lake phytoplankton communities. The present study exemplifies the strength in integrating data analysis with different temporal resolutions and lake modeling. The new lake ecological model serves as an effective tool in analyzing and predicting winter phytoplankton dynamics for temperate lakes.