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Towards realistic plant hydraulics and frost damage in the Arctic-Boreal Zone by modelling cold acclimation in CTSM5-Fates (hydro)

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Vegetation of temperate and boreal ecosystems increases its tolerance to freezing when temperatures decrease in autumn. This process is known as hardening, and results in a set of physiological changes at the molecular level that initiates the synthesis of anti-freeze proteins. Together with the freezing of extracellular water, these changes reduce plant water potentials and xylem conductivity. In this study, we implemented a hardening and frost mortality scheme into CTSM5.0-FATES-Hydro, and evaluate how these modifications impact plant hydraulics and vegetation growth. Our work shows that the hydraulic modifications prescribed by the hardening scheme are necessary to model realistic vegetation growth in cold climates, in contrast to the default model that simulates almost nonexistent and declining vegetation due to abnormally large water loss through the roots. The frost mortality scheme also simulates damage from frost events when temperatures drop below the hardiness level of plants, in contrast to the default model where frost is described by a constant PFT temperature threshold. This work makes it possible to use CTSM5-FATES-Hydro to model realistic impacts from frost and droughts on vegetation growth and photosynthesis, leading to more reliable projections of how northern ecosystems respond to climate change.