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Supplement of

Inclusion of a cold hardening scheme to represent frost tolerance is essential to model realistic plant hydraulics in the Arctic–boreal zone in CLM5.0-FATES-Hydro

Marius S. A. Lambert et al.

Correspondence to: Marius S. A. Lambert (marius.lambert@geo.uio.no)

Supplemental

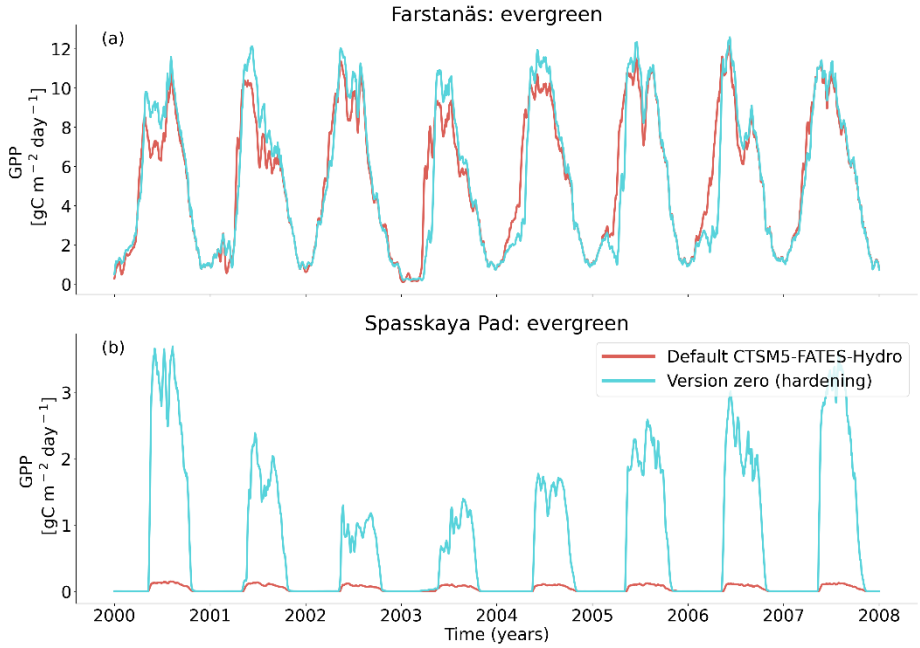

Figure S1: Gross primary productivity for needleleaf evergreen trees at the sites of a) Farstanäs, and b) Spasskaya Pad, during the period 2000-2008. The default simulation is shown in red, and the hardening simulation is shown in blue.

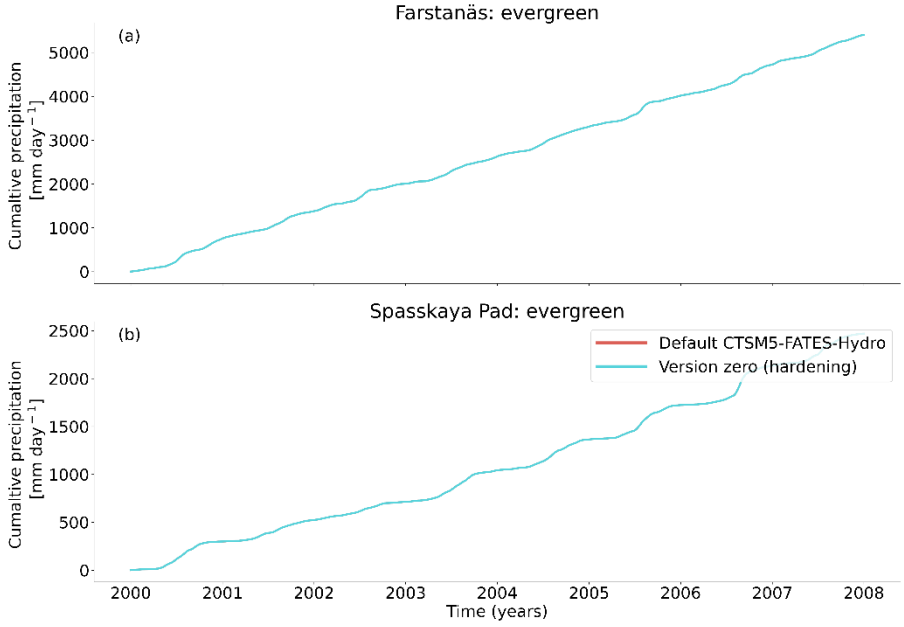

Figure S2: Cumulative total precipitation for needleleaf evergreen trees at the sites of a) Farstanäs, and b) Spasskaya Pad, during the period 2000-2008. The default simulation is shown in red, and the hardening simulation is shown in blue.

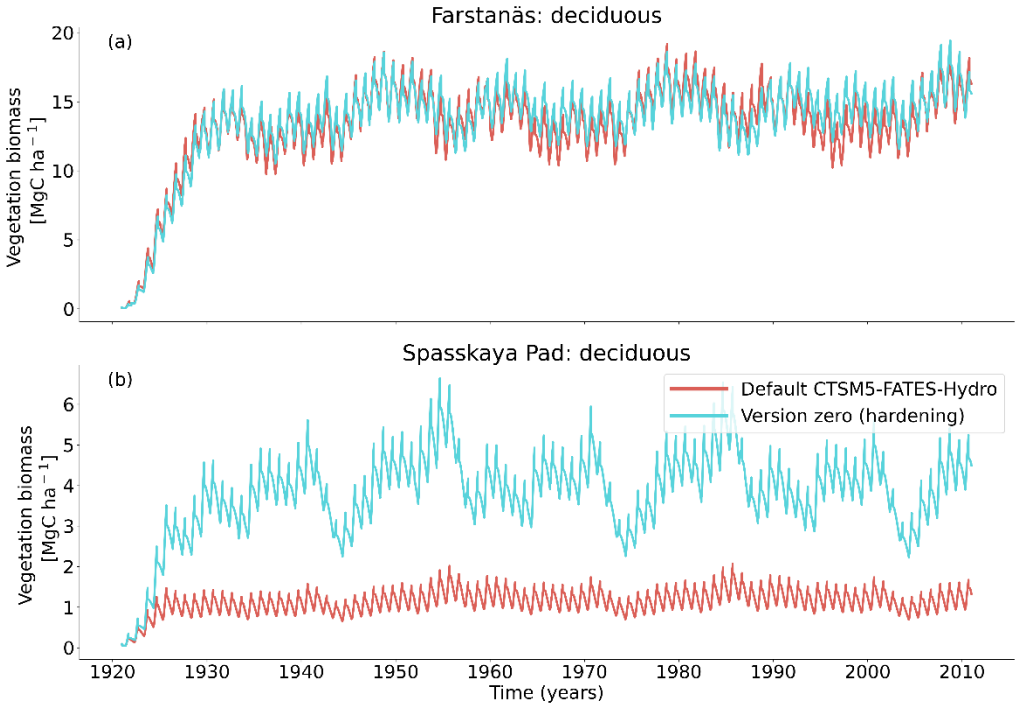

Figure S3: Living biomass for broadleaf deciduous trees at the sites of a) Farstanäs, and b) Spasskaya Pad, during the period 1921-2011 (atmospheric forcing: 3*[1981-2011]). The default simulation is shown in red, and the hardening simulation is shown in blue.

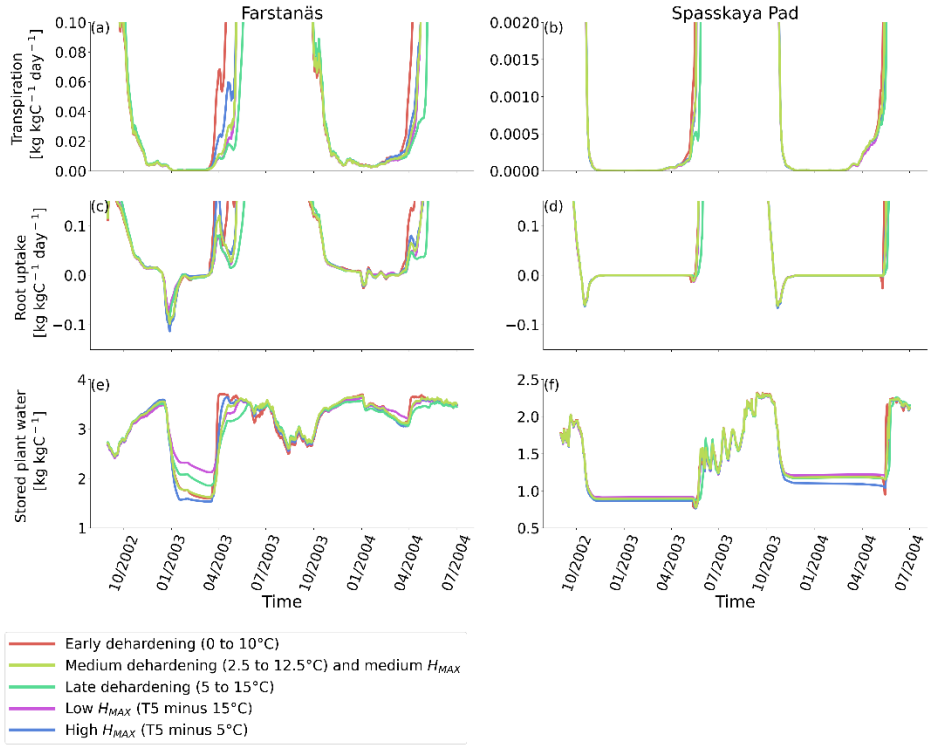

Figure S4: Plant water fluxes from dehardening and maximum hardiness level sensitivity analysis simulations for needleleaf evergreen trees at the sites of: Left) Farstanäs, and Right) Spasskaya Pad, during the period 2002/09-2004/07. Top: transpiration, middle: root water uptake, and bottom: stored plant water.

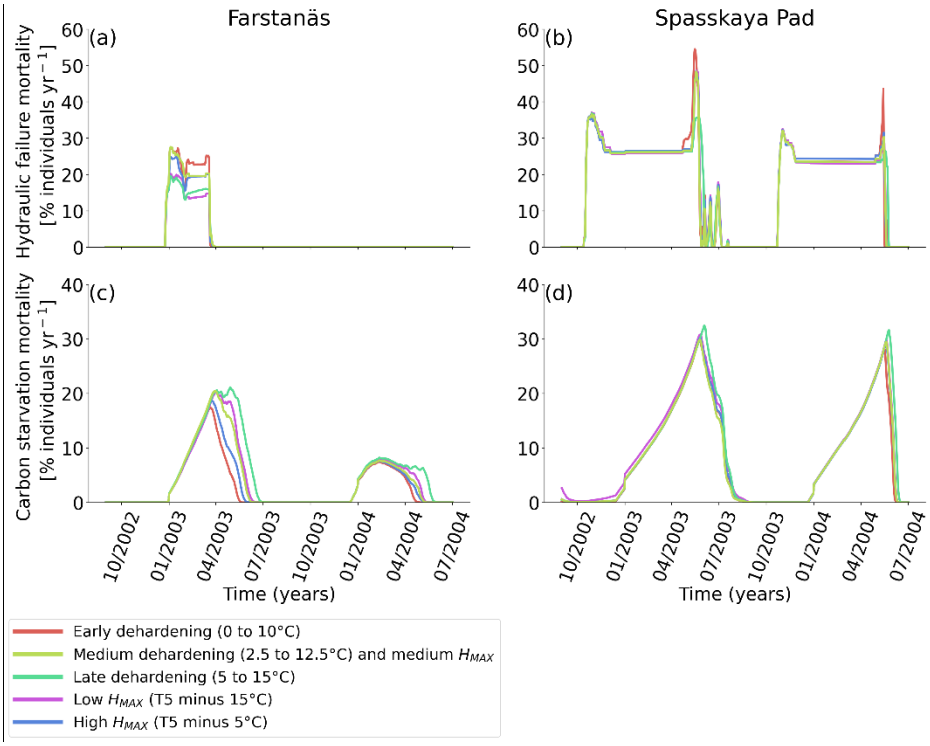

Figure S5: Mortality rates from dehardening and maximum hardiness level sensitivity analysis simulations for needleleaf evergreen trees at the sites of: Left) Farstanäs, and Right) Spasskaya Pad, during the period 2002/09-2004/07. Top: hydraulic failure mortality, and bottom: carbon starvation mortality.

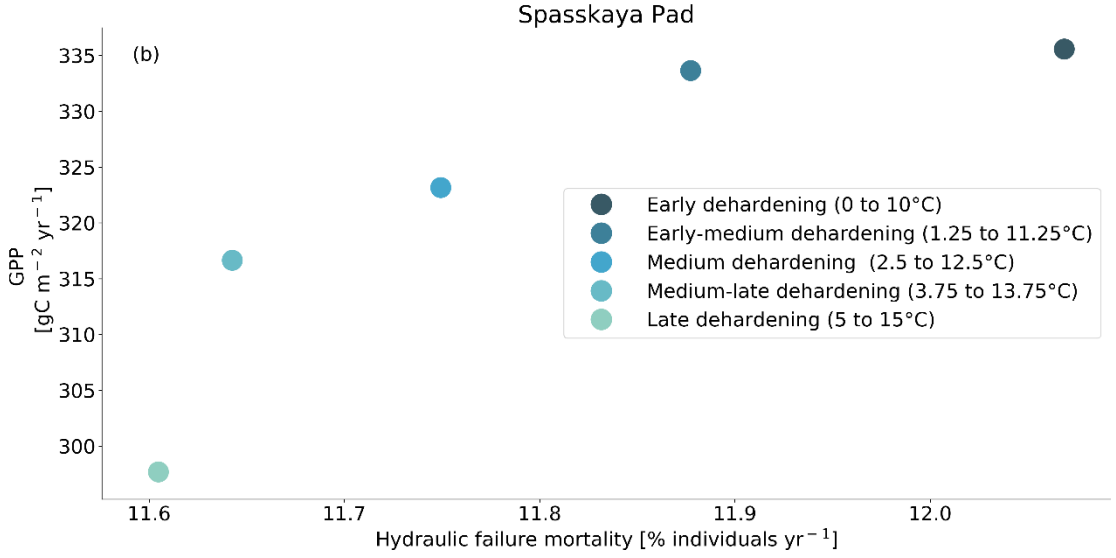

Figure S6: Trade-off between hydraulic failure mortality and gross primary productivity for evergreen needleleaf trees at Spasskaya Pad for 5 dehardening sensitivity experiments. The mortality rates are averaged over the 30 year period 1981 to 2011.

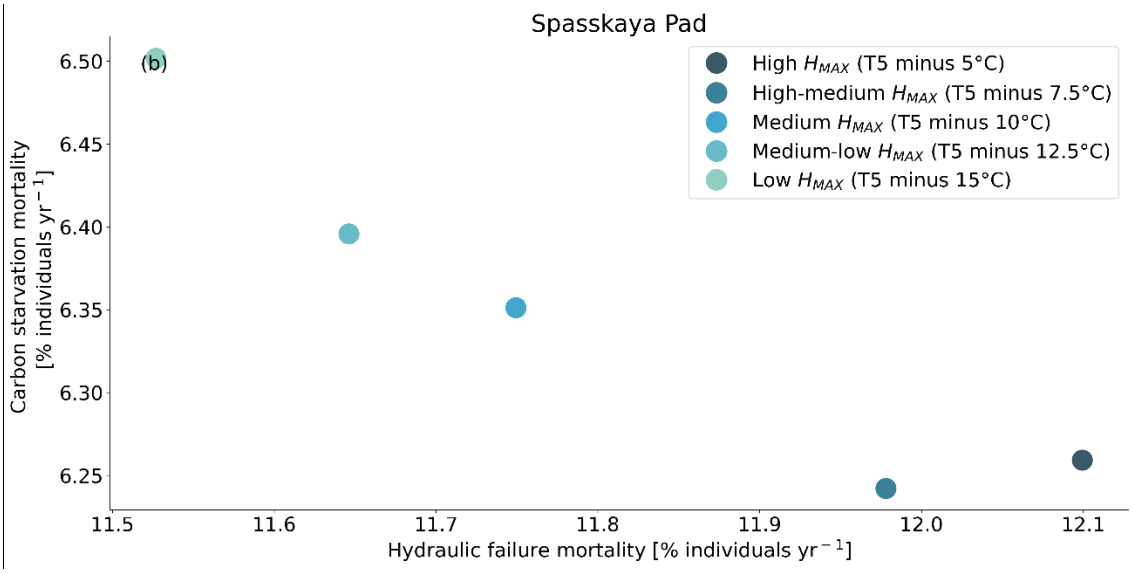

Figure S7: Trade-off between hydraulic failure mortality and carbon starvation mortality for evergreen needleleaf trees at Spasskaya Pad for 5 maximum hardiness level sensitivity experiments. The mortality rates are averaged over the 30 year period 1981 to 2011.

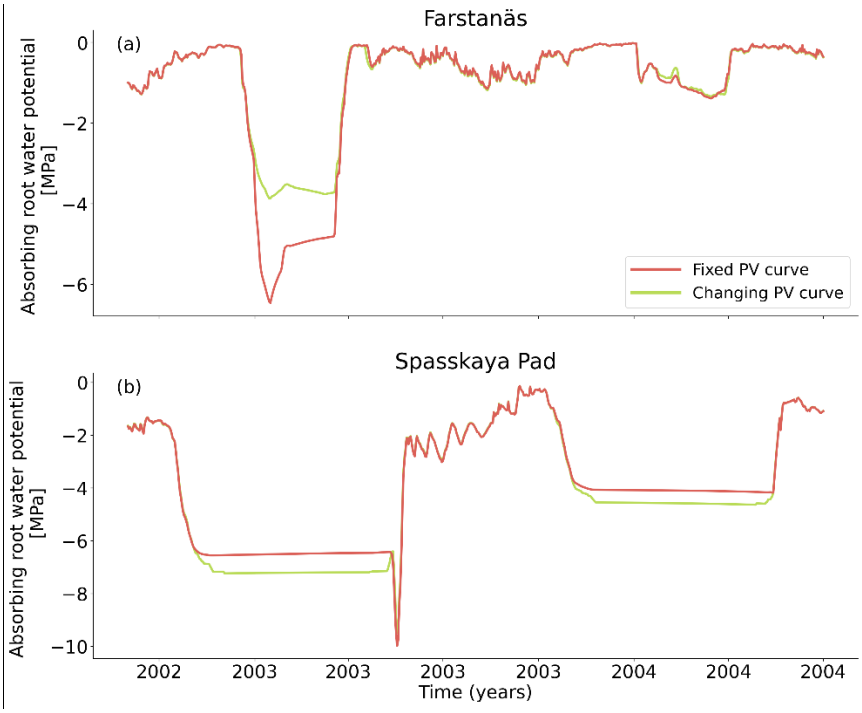

Figure S8: Absorbing root water potential from PV curve sensitivity analysis simulations for needleleaf evergreen trees at the sites of a) Farstanäs, and b) Spasskaya Pad, during the period 2002/09-2004/07.

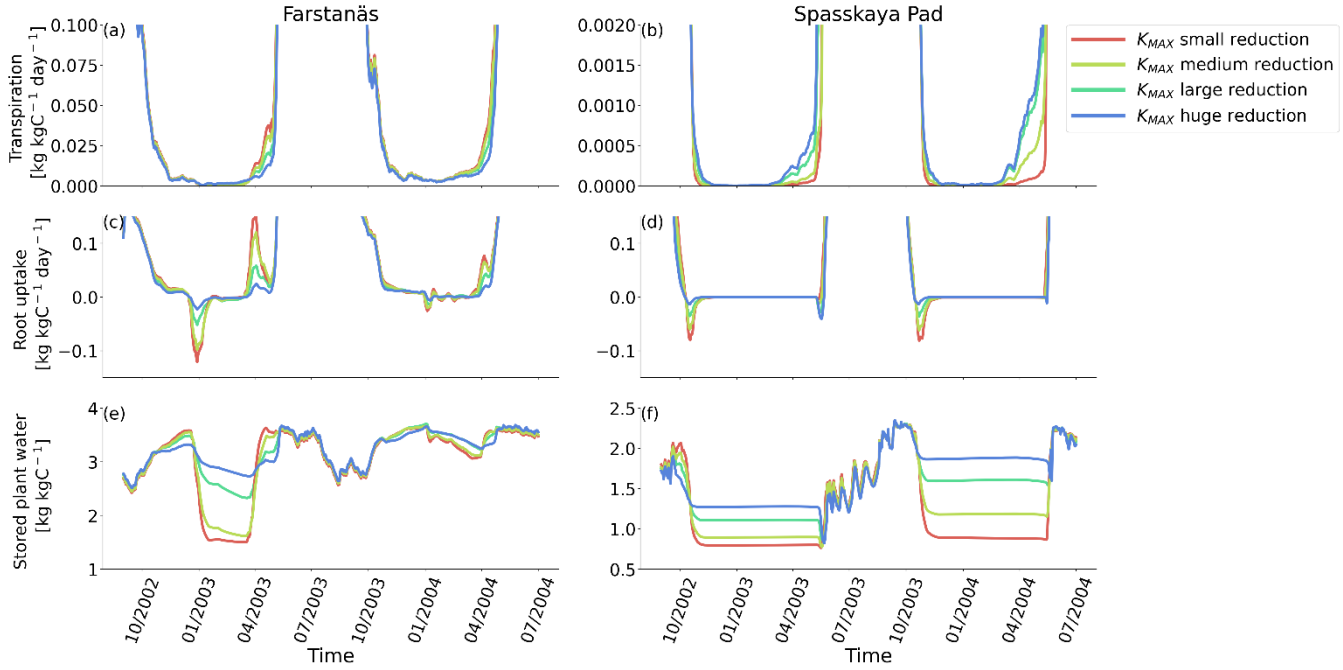

Figure S9: Plant water fluxes from Kmax sensitivity analysis simulations for needleleaf evergreen trees at the sites of: Left) Farstanäs, and Right) Spasskaya Pad, during the period 2002/09-2004/07. Top: transpiration, middle: root water uptake, and bottom: stored plant water.

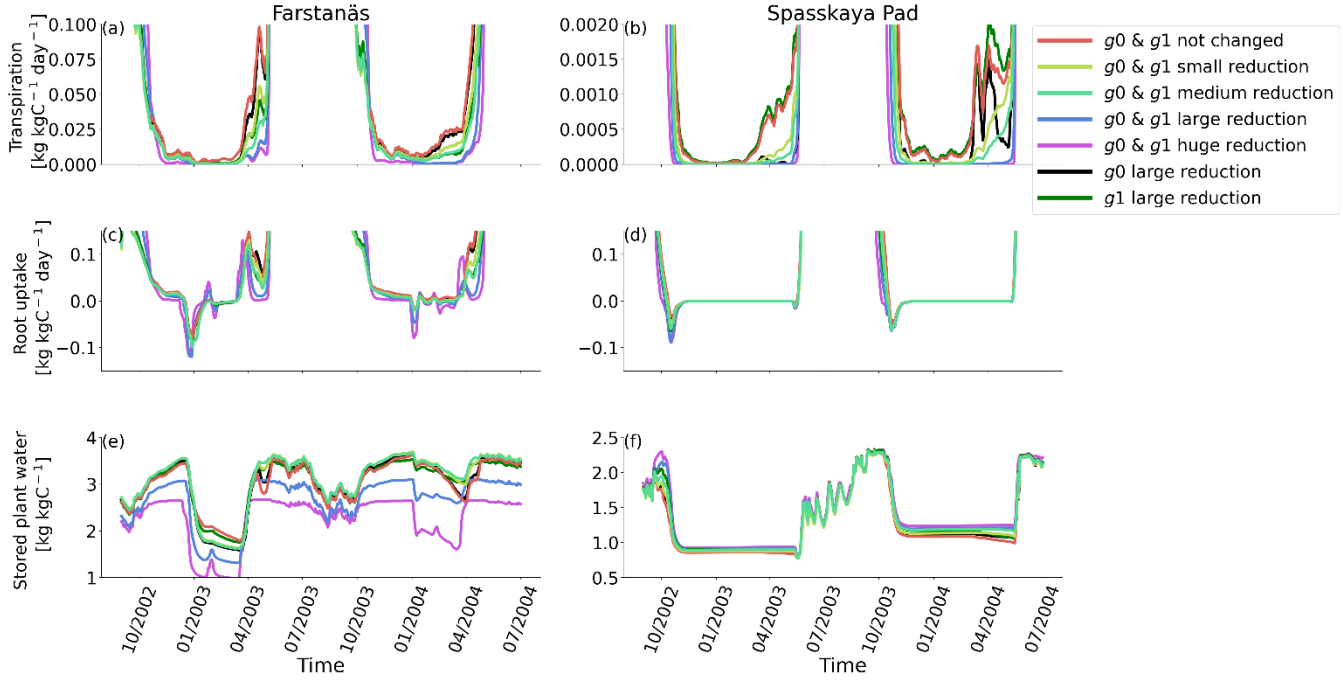

Figure S10: Plant water fluxes from g0 sensitivity analysis simulations for needleleaf evergreen trees at the sites of: Left) Farstanäs, and Right) Spasskaya Pad, during the period 2002/09-2004/07. Top: transpiration, middle: root water uptake, and bottom: stored plant water.

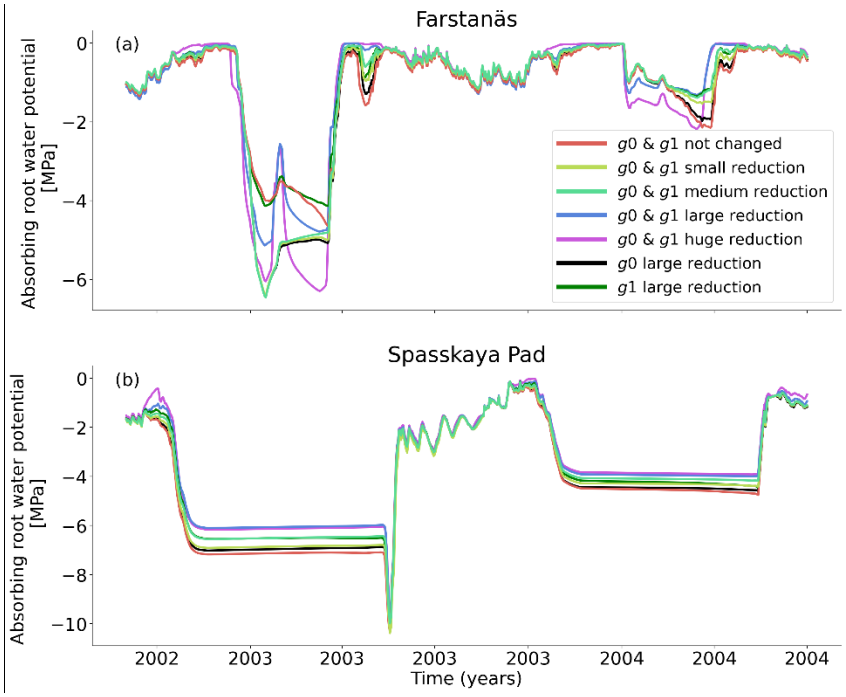

Figure S11: Leaf water potential from g0 sensitivity analysis simulations for needleleaf evergreen trees at the sites of a) Farstanäs, and b) Spasskaya Pad, during the period 2002/09-2004/07.

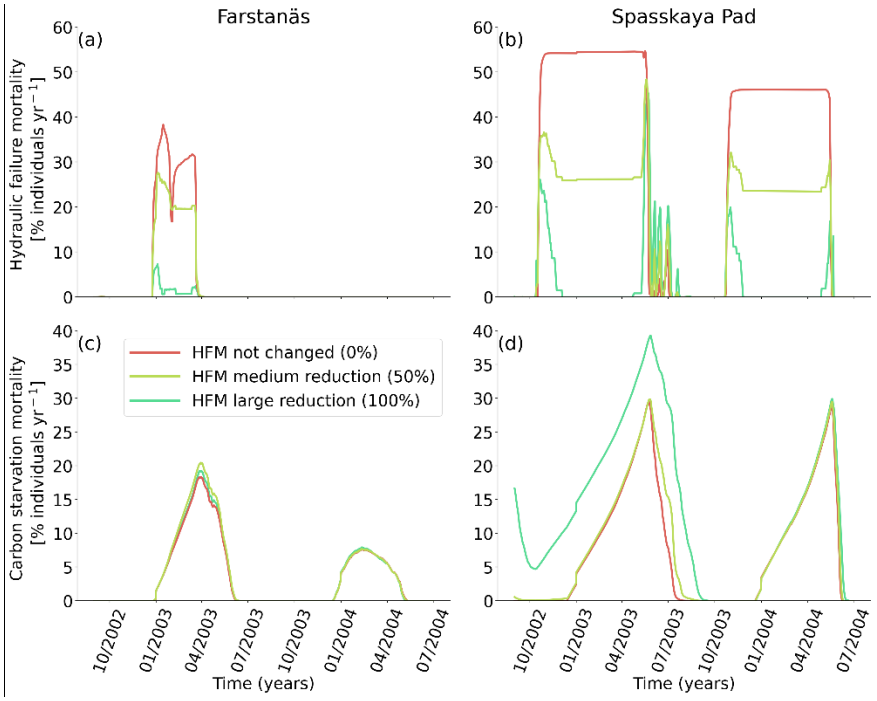

Figure S12: Mortality rates from hydraulic failure mortality sensitivity analysis simulations for needleleaf evergreen trees at the sites of: Left) Farstanäs, and Right) Spasskaya Pad, during the period 2002/09-2004/07. Top: hydraulic failure mortality, and bottom: carbon starvation mortality.

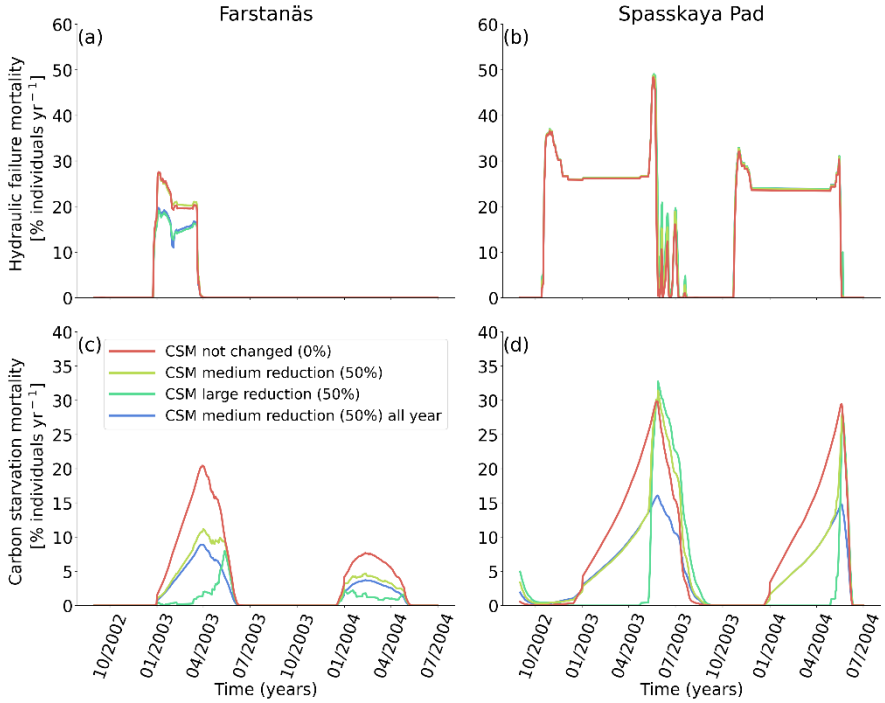

Figure S13: Carbon starvation mortality rate from carbon starvation mortality sensitivity analysis simulations for needleleaf evergreen trees at the sites of a) Farstanäs, and b) Spasskaya Pad, during the period 2002/09-2004/07.

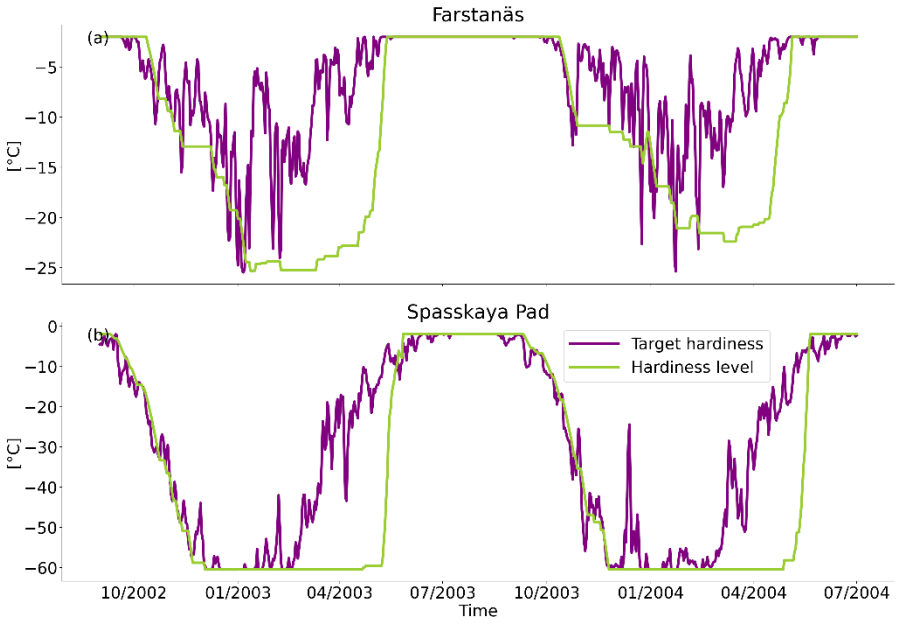

Figure S14: Target hardiness and hardiness level for needleleaf evergreen trees at the sites of a) Farstanäs, and b) Spasskaya Pad, during the period 2002/09-2004/07.

Parameters for standard runs	Description	Value and unit
Parameters for hardiness model		
H_{min}	Minimum hardiness level[a]	−2 °C
H_{max}	Maximum hardiness level[c]	−30 °C
S_{aut}	Start of autumn (start of hardening)[a]	Julian day 210
S_{spr}	Start of spring (start of dehardening) for Southern Sweden[a]	Julian day 1
H_t^*	Target hardiness level[a]	F (daily mean temperature)
r_h^*	Rate of hardening[a]	0–1 °C/day
r_{dh}^*	Rate of dehardening[a]	0–5 °C/day
W_d	Winter dormancy[a]	From days 260 to 365
Parameters for calculation of the growth reducing factor		
b	Slope parameter[b]	0.2 $°C^{-1}$
$LT50$	"Lethal temperature"[c]	20 °C

Table S1: Parameters for the frost hardiness and frost damage model (Rammig et al. 2010).

[a] Values from Jönsson et al. (2004).

[b] Values from Kellomäki et al. (1995).

[c] Values from Bigras and Colombo (2000).