Appendix

Table A1. Variables and parameters of the model FROSTOL.

Quantity	Type	Units	Description	Default value	Notes
T_{L50}	state variable	°C	lethal temperature for the 50% of the plants		ranges from T_{L50c} to T_{L50i}
rT_H	rate variable	°C d^{-1}	hardening rate		
rT_D	rate variable	°C d^{-1}	dehardening rate		
rT_R	rate variable	°C d^{-1}	respiration under a snow cover stress rate		
rT_S	rate variable	°C d^{-1}	low temperature stress rate		
T_{L50i}	auxiliary variable	°C	T_{L50} initial value		assumed to be constant and cultivar dependent
T_{i1} and T_{i2}	parameter	°C	threshold induction temperature	+10 and -4	assumed to be cultivar independent
f_R	auxiliary variable	°C	respiration factor		
f_S	auxiliary variable	unitless	snow depth function		ranges from 0 to 1
f_V	auxiliary variable	unitless	vernalisation function		ranges from 0 to 1
D_V	auxiliary variable	d	vernalisation days		
T_{L50c}	parameter	°C	maximum frost tolerance of the cultivar		assumed to be constant and cultivar dependent
c_H	parameter	°C d^{-1}	hardening coefficient	0.0093	
c_D	parameter	$°C^{-3}$ d^{-1}	dehardening coefficient	2.7×10^{-5}	
c_R	parameter	d^{-1}	respiration stress coefficient	0.54	
c_S	parameter	°C d^{-1}	low temperature stress coefficient	1.9	
S_t	parameter	cm	snow depth threshold	12.5	
T_C	driving variable	°C	crown temperature		
S	driving variable	cm	snow depth		

Table A2. Variables and parameters of the model by Byrns *et al.* (2020).

Quantity	Type	Units	Description	Default value	Notes
T_{L50}	state variable	°C	lethal temperature for the 50% of the plants		ranges from T_{L50c} to $T_{L50\ initial}$
rT_H	rate variable	°C d^{-1}	hardening rate		
rT_D	rate variable	°C d^{-1}	dehardening rate		
rT_R	rate variable	°C d^{-1}	respiration under a snow cover stress rate		estimated through a similar approach to the one of Bergjord *et al.* (2008)
rT_S	rate variable	°C d^{-1}	low temperature stress rate		estimated through a similar approach to the one of Bergjord *et al.* (2008)
T_{L50i}	parameter	°C	T_{L50} initial value	-3	assumed to be constant and cultivar dependent
T_i	auxiliary variable	°C	threshold induction temperature		assumed to be constant and cultivar dependent
T_{L50adj}	auxiliary variable	°C	damage-adjusted T_{L50}		
T_{DS}	state variable	°C	amount of dehardening due		

			to low temperature stress		
T_{L50c}	parameter	°C	maximum frost tolerance of the cultivar		assumed to be constant and cultivar dependent
c_H	parameter	°C d^{-1}	hardening coefficient	0.014	
c_R	parameter	d^{-1}	respiration stress coefficient	0.54	
c_S	parameter	°C d^{-1}	low temperature stress coefficient	0.654	
T_{cm}	auxiliary variable	°C	mean crown temperature of the last 5 days		
T_{csd}	auxiliary variable	°C	standard deviation of the mean crown temperature of the last 5 days		
f_R	auxiliary variable	°C	respiration factor		
f_{VRT1}	auxiliary variable	unitless	progress to the vegetative reproductive transition		ranges from 0 to 1
f_{ML}	auxiliary variable	unitless	minimum leaf number requirement		ranges from 0 to 1
f_{PR}	auxiliary variable	unitless	photoperiod requirement		ranges from 0 to 1
f_{VR}	auxiliary variable	unitless	vernalisation requirement		ranges from 0 to 1
f_{VRT2}	auxiliary variable	unitless	vegetative reproductive transition factor		ranges from 0 to 1
T_C	driving variable	°C	crown temperature		
L_D	driving variable	h	day lenght		

Table A3. Variables and parameters of the model by Lecomte *et al.* (2003).

Quantity	**Type**	**Units**	**Description**	**Default value**	**Notes**
T_R	state variable	°C	crop frost resistance		ranges from T_{RN} (initial value) to T_{RX1}
rT_H	rate variable	°C d^{-1}	hardening rate		
rT_D	rate variable	°C d^{-1}	dehardening rate		ranges from T_{RN} to T_{RX}
T_{RPot}	auxiliary variable	°C	potential resistance acquirable during the current time-step	-6	assumed to be cultivar indipendent
T_{RN}	parameter	°C	minimal frost resistance		depends on genotype and phenological stage
T_{RX}	auxiliary variable	°C	maximal frost resistance		assumed to be constant and cultivar dependent
T_{RX1}	parameter	°C	maximal frost resistance threshold		
T_{RX2}	parameter	°C	maximal frost resistance at coleoptile stage		
T_a	driving variable	°C	average daily air temperature		
N_L	auxiliary variable	n	number of leaves		
N_{Lf}	parameter	n	number of leaves when T_{RX} has its lowest value		
N_{Li}	parameter	n	number of leaves when T_{RX} has its maximum value		

Table A4. Symbol conversion table.

Model	Symbol in this review	Equation number in this review	Symbol in the original paper	Equation in the original paper	Description	Type	Units
FROSTOL	T_{L50}	3; 5 and 9	LT_{50}	2; 3 and 5	lethal temperature for the 50% of the plants	state variable	°C
FROSTOL	rT_H	2 and 3	RATEH	1 and 2	hardening rate	rate variable	°C d^{-1}
FROSTOL	rT_D	2 and 5	RATED	1 and 3	dehardening rate	rate variable	°C d^{-1}
FROSTOL	rT_R	2 and 6	RATER	1 and 4	respiration under a snow cover stress rate	rate variable	°C d^{-1}
FROSTOL	rT_S	2 and 9	RATES	1 and 5	low temperature stress rate	rate variable	°C d^{-1}
FROSTOL	T_{L50i}	1 and 5	LT_{50i}	equations without number	LT_{50} initial value	auxiliary variable	°C
FROSTOL	T_{i1} and T_{i2}	3 and 5	10 and -4	2 and 3	threshold induction temperature	parameter	°C
FROSTOL	f_R	6 and 7	RE	equations without number	respiration factor	auxiliary variable	°C
FROSTOL	f_S	6 and 8	*f*(snow depth)	equations without number	snow depth function	auxiliary variable	unitless
FROSTOL	f_V	3; 4 and 5	*f*(V)	2; 3 and 7	vernalisation function	auxiliary variable	unitless
FROSTOL	D_V	4	VD	7	vernalisation days	auxiliary variable	d
FROSTOL	T_{L50c}	1 and 3	LT_{50c}	2	maximum frost tolerance of the cultivar	parameter	°C
FROSTOL	c_H	3	H_{param}	2	hardening coefficient	parameter	°C d^{-1}
FROSTOL	c_D	5	D_{param}	3	dehardening coefficient	parameter	$°C^{-3}$ d^{-1}
FROSTOL	c_R	6	R_{param}	4	respiration stress coefficient	parameter	d^{-1}
FROSTOL	c_S	9	S_{param}	5	low temperature stress coefficient	parameter	°C d^{-1}
FROSTOL	S_t	8	T_S_max	4	snow depth threshold	parameter	cm
FROSTOL	T_C	3; 5; 7 and 9	TC	2; 3 and 5	crown temperature	driving variable	°C
FROSTOL	S	8	snowdepth	equation without number	snow depth	driving variable	cm
Byrns *et al*. (2020)	T_{L50}	10, 16 and 18	LT50	5; 6 and 8	lethal temperature for the 50% of the plants	state variable	°C
Byrns *et al*. (2020)	rT_H	10	accRate and accFlow	5	hardening rate	rate variable	°C d^{-1}
Byrns *et al*. (2020)	rT_D	16	dehardRate and dehardFlow	6	dehardening rate	rate variable	°C d^{-1}
Byrns *et al*. (2020)	rT_R	10; 13; 16 and 17	respFlow	5; 6 and 7	respiration under a snow cover stress rate	rate variable	°C d^{-1}
Byrns *et al*. (2020)	rT_S	10; 13 and 18	LTstressFlow	5 and 8	low temperature stress rate	rate variable	°C d^{-1}
Byrns *et al*. (2020)	T_{L50i}	16 and 18	initLT50	6 and 8	LT_{50} initial value	parameter	°C
Byrns *et al*. (2020)	T_i	10; 11 and 16	thresholdTemp	5 and 6	threshold induction temperature	auxiliary variable	°C
Byrns *et al*. (2020)	T_{L50adj}	10 and 12	LT50DamageAdj	5	damage-adjusted LT_{50}	auxiliary variable	°C
Byrns *et al*. (2020)	T_{DS}	12; 13 and 18	dehardAmtStress	8	amount of dehardening due to low temperature stress	state variable	°C
Byrns *et al*. (2020)	T_{L50c}	11 and 12	LT50c	equations without number	maximum frost tolerance of the cultivar	parameter	°C
Byrns *et al*. (2020)	c_H	10	no symbol	5	hardening coefficient	parameter	°C d^{-1}
Byrns *et al*. (2020)	c_R	17	no symbol	7	respiration stress coefficient	parameter	d^{-1}
Byrns *et al*. (2020)	c_S	18	no symbol	8	low temperature stress coefficient	parameter	°C d^{-1}
Byrns *et al*. (2020)	T_{Cm}	17	fiveDayTempMean	7	mean crown temperature of the last 5 days	auxiliary variable	°C
Byrns *et al*. (2020)	T_{Csd}	17	fiveDayTempSD	7	standard deviation of	auxiliary	°C

					the mean crown temperature of the last 5 days	variable	
Byrns *et al*. (2020)	f_R	17	no symbol	7	respiration factor	auxiliary variable	°C
Byrns *et al*. (2020)	f_{VRT1}	14	VRProg	equation without number	progress to the vegetative reproductive transition	auxiliary variable	unitless
Byrns *et al*. (2020)	f_{ML}	14	mflnFraction	1	minimum leaf number requirement	auxiliary variable	unitless
Byrns *et al*. (2020)	f_{PR}	14	photoProg	3	photoperiod requirement	auxiliary variable	unitless
Byrns *et al*. (2020)	f_{VR}	14	vernSaturation	2	vernalisation requirement	auxiliary variable	unitless
Byrns *et al*. (2020)	f_{VRT2}	10, 15 and 16	VRFactor	4; 5 and 6	vegetative reproductive transition factor	auxiliary variable	unitless
Byrns *et al*. (2020)	T_C	10; 16 and 18	crownTemp	5; 6 and 8	crown temperature	driving variable	°C
Byrns *et al*. (2020)	L_D	14	daylength	3	day lenght	driving variable	h
Lecomte *et al*. (2003)	T_R	19 and 22	R_d	3.1; 5 and 6	crop frost resistance	state variable	°C
Lecomte *et al*. (2003)	rT_H	19; 22 and 23	dR	3.1; 3.2 and 5	hardening rate	rate variable	°C d^{-1}
Lecomte *et al*. (2003)	rT_D	19 and 24	dR	4 and 6	dehardening rate	rate variable	°C d^{-1}
Lecomte *et al*. (2003)	T_{RPot}	19; 20; 22 and 23	$PotR_d$	3.1; 3.2; 5 and 6	potential resistance acquirable during the current time-step	auxiliary variable	°C
Lecomte *et al*. (2003)	T_{RN}	20; 23 and 24	MinR	3.2 and 4	minimal frost resistance	parameter	°C
Lecomte *et al*. (2003)	T_{RX}	20 and 21	MaxR	1	maximal frost resistance	auxiliary variable	°C
Lecomte *et al*. (2003)	T_{RX1}	21 and 24	R_s	1 and 4	maximal frost resistance threshold	parameter	°C
Lecomte *et al*. (2003)	T_{RX2}	21	R_c	1	maximal frost resistance at coleoptile stage	parameter	°C
Lecomte *et al*. (2003)	T_a	20 and 24	T_m	4	average daily air temperature	driving variable	°C
Lecomte *et al*. (2003	N_L	21	LS	1	number of leaves	auxiliary variable	n
Lecomte *et al*. (2003	N_{Lf}	21	fLS	1	number of leaves when T_{RX} has its lowest value	parameter	n
Lecomte *et al*. (2003	N_{Li}	21	iLS	1	number of leaves when T_{RX} has its maximum value	parameter	n

S1. ALFACOLD

The state variable in ALFACOLD (*CTT*) is initialized to 0°C; its minimum value is limited by the auxiliary variable *CTMX* (°C), which is the maximum cold tolerance being the lowest subzero temperature that a cultivar can tolerate without being killed. Kanneganti *et al*. (1998) used a single initial value of cold tolerance temperature (*CTT*=0°C) for alfalfa cold-hardy, cold-sensitive and non-hardy cultivars, while the genetic potential for maximum cold tolerance (*CTMX*) differs between the abovementioned types of cultivars as a function of a fall growth score (*FGS*, a standard scale for describing alfalfa cultivar's potential for dormancy and cold tolerance (Barnes *et al*., 1992).

The net increase or decrease of frost tolerance (Eq. S1.1) is expressed as the difference between the daily rate of hardening (*HRI*,°C d^{-1}) and the daily rate of dehardening (*HRD*,°C d^{-1}).

$$\frac{\Delta CTT}{\Delta t} = (HRI - HRD) \qquad \text{(S1.1)}$$

The daily rate of increase in cold tolerance due to hardening (*HRI*,°C d^{-1}), Eq. S1.2, is directly proportional to the maximum rate of hardening (*CHRMX*,°C d^{-1}), which represents the influence of genotype on frost tolerance acquisition, and to a rate modifier (*ETDRI*, unitless) that, being a function of the average daily crown temperature (*CRTMP*,°C), represents its effect on the maximum hardening rate.

$$HRI = CHRMX \times ETDRI \qquad \text{(S1.2)}$$

Hardening starts when crown temperature (*CRTMP*) is lower than 15°C (indeed when crown temperature is lower than 15°C *ETDRI* ranges from 0 to 1, while when the crown temperature is higher than 15°C *ETDRI* ranges from 0 to -1) and continues at its maximum rate (*CHRMX*) when crown temperature drops below 10°C. That is represented in the model by means of the rate modifier *ETDRI* (Eq. S1.3).

$$ETDRI = \begin{cases} 1 & when\ CRTMP \leq 10 \\ -\frac{1}{5} \times CRTMP + 3 & when\ 10 < CRTMP \leq 20 \\ -1 & when\ CRTMP > 20 \end{cases} \quad \text{(S1.3)}$$

One difference between this and the other models is that the reversal of hardening, which occurs when crown temperature is warmer than 15°C, is modeled separately from dehardening by assigning negative values to *ETDRI* (from 0 to −1) when crown temperature is higher than 15°C. Kanneganti *et al.* (1998) adopted this approach because the reversal of hardening, which occurs during autumn and early winter, has been found to be much slower than dehardening that occurs at similar temperatures during spring.

The dehardening process, in contrast to Bergjord *et al.* (2008) and Fowler *et al.* (2014), is simulated for the period of time during which the daylength (*DL*, h) increases, since the photoperiod has been reported to induce metabolic changes related to the start of dehardening.

The daily rate of dehardening (*HRD*,°C d^{-1}) is formalised (Eq. S1.4) through the use of a maximum dehardening rate (*CDRMX*,°C d^{-1}) expressing the genetic control on the process and through a rate modifier (*ETDRB*, unitless).

$$HRD = \begin{cases} CDRMX \times ETDRB & if\ (DL_t - DL_{t-1}) > 0 \\ 0 & if\ (DL_t - DL_{t-1}) \leq 0 \end{cases} \quad \text{(S1.4)}$$

The rate modifier *ETDRB* (Eq. S1.5) represents the effect of average daily crown temperature: *ETDRB* is zero for crown temperatures below 0°C (meaning that no dehardening occurs), while it increases from zero to one as crown temperature rises from 0 to 5°C; for temperatures above 5°C its value is constant and set to one (meaning that dehardening occurs at its maximum rate).

$$ETDRB = \begin{cases} 0 & when\ CRTMP \leq 0 \\ \frac{1}{5} \times CRTMP & when\ 0 < CRTMP < 5 \\ 1 & when\ CRTMP \geq 5 \end{cases} \quad \text{(S1.5)}$$

ALFACOLD estimates the average daily soil temperature in the crown region at 3 cm depth (*CRTMP*,°C) through Ritchie's (Ritchie, 1991) model (Eq. S1.6 and S1.7). The average daily crown temperature is obtained averaging the estimates of the daily maximum (*CRTMX*,°C) and minimum (*CRTMN*,°C) crown temperatures. The maximum and minimum crown temperatures are calculated as functions of daily maximum (*TMX*,°C) and minimum (*TMN*,°C) air temperatures and of snow depth (*DS*, cm).

$$\mathrm{CRTMX} = \begin{cases} 2 + TMX \times [0.4 + 0.0018 \times (DS - 15)^2] & if\ TMX < 0 \\ TMX & if\ TMX \geq 0 \end{cases} \quad \text{(S1.6)}$$

$$\mathrm{CRTMN} = \begin{cases} 2 + TMN \times [0.4 + 0.0018 \times (DS - 15)^2] & if\ TMN < 0 \\ TMN & if\ TMN \geq 0 \end{cases} \quad \text{(S1.7)}$$

Plant mortality due to freezing injury is estimated by ALFACOLD through a crop death coefficient (PDF, d^{-1}), which quantifies the fraction of a crop, described as plant density, that die when the crown temperature (*CRTMP*) drops below the cold tolerance temperature (*CTT*). When the crown temperature is warmer than the cold tolerance temperature no freezing injury is simulated since PDF=0. For each cultivar, the authors determined a potential rate of plant death (*PDFMX*, d^{-1}°C^{-1} below *CTT*), therefore the model estimates (Eq. S1.8) plant death at a cultivar-specific rate and in proportion to plant current stare of cold tolerance.

$$PDF = PDFMX \times max(0, CTT - CRTMP) \quad \text{(S1.8)}$$

S2. CERES-WHEAT

Frost tolerance is simulated by CERES-Wheat through a hardening index (*HI*, unitless) based on the concepts by Gusta and Fowler (1976). This hardening index is used to determine, on a daily basis, the temperature at which the plants are killed by frost. A winterkill function is then applied between emergence and anthesis; if the conditions are met, this leads to the death of 100% of the plants. The hardening index (*HI*, unitless) ranges from 0 to 2 (fully hardened plant). Its value (Eq. S2.9) is increased by hardening and decreased by dehardening (Ritchie, 1991).

$$HI_t = HI_{t-1} + (dH - dD) \times t \qquad \text{(S2.9)}$$

The crown temperature average (T_{cr},°C) and maximum (T_{cr_max},°C) values are calculated as in ALFACOLD model. Hardening (Eq. S2.10) is assumed to take place in two crown temperature ranges: the first one is referred to the first phase of hardening (that is completed after 10 days of exposure to this temperature range), the second one is referred to the second phase of hardening (completed in 12 days of exposure). Hardening is also assumed to occur, during the first phase, at temperatures above the indicated range: in this case the hardening increment is calculated proportionally. At the end of the first hardening phase the hardening index is equal to 1, while at the end of the second hardening phase the hardening index is equal to 2.

$$dH = \begin{cases} 0.1 & if\ HI < 1\ and - 1 \leq T_{cr} \leq 8 \\ 0.083 & if\ HI > 1\ and\ T_{cr} \leq 0 \end{cases} \qquad \text{(S2.10)}$$

The daily decrement of the hardening index due to dehardening process is a function of the maximum crown temperature. The dehardening decrement (Eq. S2.11) is higher during the first hardening phase and lower during the second one.

$$dD = \begin{cases} 0.04 \times \left(T_{cr\_max} - 10\right) & if\ HI < 1\ and\ T_{cr\_max} > 10 \\ 0.02 \times \left(T_{cr\_max} - 10\right) & if\ HI > 1\ and\ T_{cr\_max} > 10 \end{cases} \quad \text{(S2.11)}$$

The hardening index is used to estimate a threshold killing temperature (T_k,°C) through a fixed function (Eq. S2.12). The author (Ritchie, 1991) assumes that when the difference between the average daily crown temperature and the threshold killing temperature is higher than 7°C at least the 95% of the plants are subject to a winterkill event.

$$T_k = -6 \times (1 - HI) \quad \text{(S2.12)}$$

S3. EPIC

EPIC computes, with a daily time step, a multiplicative stress factor which is then used to reduce the standing live biomass (B_{AG}). A unique formalisation of the stress factor is adopted for the entire simulation of the crop cycle. The stress factor is named frost damage factor *FRST* (unitless). The resulting frost damage is greater for early growth stages and tends to 0 for the final development stages (Sharpley and Williams, 1990).

The frost damage factor is a function of the minimum daily air temperature (T_{mn},°C) that includes two parameters ($af_{j,1}$ and $af_{j,2}$) to define crop frost sensitivity. The frost damage factor (Eq. S3.13) is estimated for dormant fall planted crops when the minimum temperature is below -1°C (Sharpley and Williams, 1990).

$$FRST_i = \frac{-T_{mn,i}}{-T_{mn,i} - \exp(af_{j,1} + af_{j,2} \times T_{mn,i})} \quad \text{(S3.13)}$$

The crop biomass reduction (ΔB_{AG}, t ha^{-1}) during the dormant winter period is then estimated (Eq. S3.14) by the authors (Sharpley and Williams, 1990) as a function of the frost damage factor, a heat unit index (*HUI*, unitless) and a day length reduction factor (*FHR*, unitless).

$$\Delta B_{AG,i} = 0.5 \times B_{AG,i} \times (1 - HUI_i) \times \max(FRH_i, FRST_i) \quad \text{(S3.14)}$$

S4. APSIM

Similarly to EPIC, APSIM computes, with a daily time step, a multiplicative stress factor that is used to reduce the leaf area index (*LAI*) for the entire simulation of the crop cycle. The stress factor ($k_{sen, frost}$, unitless) is used to estimate the leaf area senescence due to frost ($\Delta LAI_{sen, frost}$, unitless, Eq. S4.15). Its value is obtained through linear interpolation using a function of the daily minimum air temperature that is defined by two parameters, currently its default value is set to zero meaning that frost stress is not taken into account in this version of APSIM wheat growth model (Zheng *et al.*, 2015).

$$\Delta LAI_{sen,frost} = K_{sen,frost} \times LAI \quad \text{(S4.15)}$$

In addition to leaf senescence due to leaf aging ($\Delta LAI_{sen, age}$) and due to shading ($\Delta LAI_{sen, light}$), the daily total leaf area senescence (ΔLAI_{sen}, Eq. S4.16) is estimated considering: frost ($\Delta LAI_{sen, frost}$), heat ($\Delta LAI_{sen, heat}$) and water ($\Delta LAI_{sen, sw}$) stress.

$$\Delta LAI_{sen} = \max(\Delta \mathrm{LAI}_{sen,age}, \Delta \mathrm{LAI}_{sen,light}, \Delta \mathrm{LAI}_{sen,frost}, \Delta \mathrm{LAI}_{sen,heat}, \Delta \mathrm{LAI}_{sen,sw}) \quad \text{(S4.16)}$$

S5. STICS

The multiplicative stress factor approach used by STICS differs from EPIC and APSIM due to the number of different stress factors calculated: STICS employs four different functions to obtain four frost stress indices (*FGELLEV*, *FGELJUV*, *FGELVEG*, *FGELFLO*). Each stress index is calculated for a specific phenological phase and acts proportionally on a different growth state variable. The response to the temperature and therefore the entity of frost damage depends on the development stage of the crop. These frost stress indices range between 1 (no frost damage) and 0 (lethal frost). *FGELLEV* is computed for the plantlet phase and reduces plant density; *FGELJUV* and *FGELVEG* are calculated for juvenile phase and for post-juvenile phase, respectively, and they both accelerate leaf area senescence. The last one, *FGELFLO*, concerns the reproductive phase which is not of interest for this review.

The four stress indices (*FGELLEV*, *FGELJUV*, *FGELVEG*, *FGELFLO*) are calculated as functions of minimal crop temperature (*TCULTMIN*,°C) that can obtained through empirical approach or energy balance. Each stress function is defined by four parameters representing *TCULTMIN* values (Brisson *et al*., 2009). Two parameters, the temperature at the beginning of frost action, ($TDEBGEL_P$, 0°C) and lethal temperature ($TLETALE_P$, -13°C) are independent of phenological stage; while the others are stage-dependent (temperatures corresponding to 10%, $TGEL10_P$, and 90% frost damage, $TGEL90_P$) therefore these parameters assume different values in different phenological stages. The stress functions, which are split linear functions, are reported by the authors (Brisson *et al*., 2009) in graphical form.

Plant density reduction due to frost damage (Eq. S5.17) is represented by multiplying the plant density at emergence (*DENSITE(ILEV)*, plant m^{-2}) by the stress index of the plantlet phase (*FGELLEV(I)*, unitless).

$$DENSITE(I) = DENSITE(ILEV) \times FGELLEV(I) \qquad \text{(S5.17)}$$

To determine the leaf death acceleration due to stress factor (*SENSTRESS*, unitless), the frost stress indices *FGELJUV* and *FGELVEG* (indicated both as *FSTRESSGEL* in Eq. S5.18) are compared with other two stress indices: the water stress (*SENFAC*, unitless) and the nitrogen stress indices (*INNSENES*, unitless) that are both active on leaf death.

$$SENSTRESS(J) = \min\left(SENFAC(J), INNSENES(J), FSTRESSGEL(J)\right) \qquad \text{(S5.18)}$$