Notations

Forcings and Variables

R_c RFCO2 CO2 (effective) radiative forcing W m²² R_x ERFX Non-CO2 effective radiative forcing W m²² R ERF Effective radiative forcing W m²² T T Global surface temperature anomaly K yes T_d Td Deep ocean temperature anomaly K yes U_{obc} OHC Ocean heat content (anomaly) W yr m²² H_{lin} H1in Linear part of thermosteric sea level rise mm H H_{lin} Hthx Total thermosteric sea level rise mm yes H_{lin} Hthx Total thermosteric sea level rise mm yes H_{lin} Hthx Total thermosteric sea level rise mm yes H_{lin} Hthx Total sea level rise mm yes H_{lin} Hthx Total sea level rise mm yes U_{lin} Hthx Total sea level rise mm yes U_{lin} Hthx Total sea level rise mm yes I_{lin} U_{lin} Co_j	ln manual	In code	Description	Units	Prog?	Dims
$R = \text{ERF} \text{Effective radiative forcing} \qquad W \text{m}^{-2}$ $T = \text{T} \text{Global surface temperature anomaly} \qquad K \qquad yes$ $T_d = \text{T} \text{T} \text{Global surface temperature anomaly} \qquad K \qquad yes$ $U_{\text{ohc}} = \text{OHC} \text{Ocean heat content (anomaly)} \qquad W \text{yr} \text{m}^{-2}$ $H_{\text{lin}} = \text{Hin} \text{Linear part of thermosteric sea level rise} \qquad mm$ $H_{\text{thx}} = \text{Hin} \text{Linear part of thermosteric sea level rise} \qquad mm$ $H_{\text{thx}} = \text{Hin} \text{Intermosteric sea level rise} \qquad mm$ $H_{\text{tot}} = \text{Hin} \text{Intermosteric sea level rise} \qquad mm$ $H_{\text{tot}} = \text{Hin} \text{Intermosteric sea level rise} \qquad mm$ $V_{\text{conj}} = \text{Intermosteric sea level rise} \qquad mm$ V_{co	R_c	RFco2	CO2 (effective) radiative forcing	W m ⁻²		
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	R_x	ERFx	Non-CO2 effective radiative forcing	W m ⁻²		
T_d TdDeep ocean temperature anomalyKyes $U_{\rm ohc}$ OHCOcean heat content (anomaly)W yr m-2 $H_{\rm lin}$ H1 Linear part of thermosteric sea level risemm $H_{\rm thx}$ HthxTotal thermosteric sea level risemm $H_{\rm ice}$ HiceIce contributions to sea level risemm $H_{\rm tot}$ HtotTotal sea level risemm $H_{\rm tot}$ HtotTotal sea level risemm $C_{o,j}$ Co_jChange in surface ocean carbon subpoolsPgC $P_{\rm gC}$ Yes $j \in [1,5]$ C_o CoChange in surface ocean carbon poolPgC C_d CdChange in deep ocean carbon poolYes C_d CdChange in surface DIC μ mol kg^- 1 $P_{\rm dic}$ GuicSubcomponent of pcO2ppm $P_{\rm coean}$ FoceanFoceanPgC yr^1 $P_{\rm coean}$ FoceanOcean carbon sinkPgC yr^1 $P_{\rm mpp}$ $P_{\rm mpp}$ Relative change in NPP1 $P_{\rm mpp}$ $P_{\rm mpp}$ Relative change in heterotrophic respiration rate1 $P_{\rm mpp}$ NPPNet primary productivityPgC yr^1	R	ERF	Effective radiative forcing	W m ⁻²		
$U_{\rm ohe}$ OHC Ocean heat content (anomaly) W yr m^{-2} $H_{\rm lin}$ H1in Linear part of thermosteric sea level rise mm $H_{\rm thx}$ Hthx Total thermosteric sea level rise mm yes $H_{\rm ice}$ Hice Ice contributions to sea level rise mm yes $H_{\rm tot}$ Htot Total sea level rise mm yes $U_{\rm out}$	T	Т	Global surface temperature anomaly	K	yes	
$H_{ m lin}$ Hlin Linear part of thermosteric sea level rise mm $perconstant M_{ m thx}$ Total thermosteric sea level rise mm $perconstant M_{ m thx}$ Total sea level rise mm $perconstant M_{ m tot}$ Htot Total sea level rise mm $perconstant M_{ m tot}$ Htot Total sea level rise mm $perconstant M_{ m tot}$ Htot Total sea level rise mm $perconstant M_{ m tot}$ Co_j Change in surface ocean carbon subpools $perconstant M_{ m thx}$ PgC $perconstant M$	T_d	Td	Deep ocean temperature anomaly	K	yes	
$H_{\rm thx}$ HthxTotal thermosteric sea level risemmyes $H_{\rm ice}$ Hicelce contributions to sea level risemm $H_{\rm tot}$ HtotTotal sea level risemmyes $C_{o,j}$ Co_jChange in surface ocean carbon subpoolsPgCyes $j \in [1,5]$ C_o CoChange in surface ocean carbon poolPgC C_d CdChange in deep ocean carbon poolyes $C_{\rm dic}$ dicChange in surface DIC μ mol kg $^-$ 1 $P_{\rm dic}$ pdicSubcomponent of pCO2ppm $P_{\rm CO2}$ pCO2CO2 partial pressure at the ocean surfaceppm $F_{\rm ocean}$ FoceanOcean carbon sinkPgC yr $^{-1}$ $T_{\rm npp}$ r_nppRelative change in WIPP1 $T_{\rm fire}$ r_fireRelative change in heterotrophic respiration rate1 $F_{\rm npp}$ NPPNet primary productivityPgC yr $^{-1}$	$U_{\rm ohc}$	ОНС	Ocean heat content (anomaly)	W yr m ⁻²		
H_{tot} HiceIce contributions to sea level risemm H_{tot} HtotTotal sea level risemmyes $C_{o,j}$ Co_jChange in surface ocean carbon subpoolsPgCyes $j \in [1,5]$ C_o CoChange in surface ocean carbon poolPgC C_d CdChange in deep ocean carbon poolyes c_{dic} dicChange in surface DIC μ mol kg^- 1 P_{dic} pdicSubcomponent of pCO2ppm P_{CO2} pCO2CO2 partial pressure at the ocean surfaceppm F_{ocean} FoceanOcean carbon sinkPgC yr^-1 T_{npp} r_nppRelative change in NPP1 T_{rh} r_fireRelative change in wildfire intensity1 T_{npp} NPPNet primary productivityPgC yr^-1	H_{lin}	Hlin	Linear part of thermosteric sea level rise	mm		
H_{tot} Htot Total sea level rise mm yes $C_{o,j}$ Co_j Change in surface ocean carbon subpools PgC yes $j \in [1,5]$ C_o Co Change in surface ocean carbon pool PgC C_d Cd Change in deep ocean carbon pool yes C_{dic} dic Change in surface DIC μ mol kg $^ P_{dic}$ pdic Subcomponent of pCO2 ppm P_{CO2} pCO2 CO2 partial pressure at the ocean surface ppm F_{ocean} Focean Ocean carbon sink P_{gC} yr $^{-1}$ T_{npp} r_{npp} Relative change in NPP 1 T_{rh} r_{rh} Relative change in heterotrophic respiration rate 1 F_{npp} NPP Net primary productivity P_{gC} yr $^{-1}$	$H_{ m thx}$	Hthx	Total thermosteric sea level rise	mm	yes	
$C_{o,j}$ Co_j Change in surface ocean carbon subpools PgC yes $j \in [1,5]$ C_o Co Change in surface ocean carbon pool PgC C_d Cd Change in deep ocean carbon pool yes c_{dic} dic Change in surface DIC μ mol kg ⁻ 1 P dic pdic Subcomponent of pCO2 ppm P cocan Focean Ocean carbon sink PgC yr ⁻¹ T npp T npp Relative change in NPP 1 T fire T fire Relative change in wildfire intensity 1 T nph Relative change in heterotrophic respiration rate 1 T npp NPP Net primary productivity PgC yr ⁻¹	$H_{\rm ice}$	Hice	Ice contributions to sea level rise	mm		
C_o Co Change in surface ocean carbon pool PgC C_d Cd Change in deep ocean carbon pool yes C_{dic} dic Change in surface DIC μ mol kg-1 P_{dic} pdic Subcomponent of pCO2 ppm P_{CO2} pCO2 CO2 partial pressure at the ocean surface ppm F_{ocean} Focean Ocean carbon sink PgC yr-1 T_{npp} r_{npp} Relative change in NPP 1 T_{rh} r_{rh} Relative change in heterotrophic respiration rate 1 F_{npp} NPP Net primary productivity PgC yr-1	$H_{\rm tot}$	Htot	Total sea level rise	mm	yes	
C_d Cd Change in deep ocean carbon pool yes c_{dic} dic Change in surface DIC μ mol kg $^-$ 1 P_{dic} pdic Subcomponent of pC02 ppm P_{CO2} pC02 CO2 partial pressure at the ocean surface ppm F_{ocean} Focean Ocean carbon sink PgC yr $^{-1}$ r_{npp} r_{npp} Relative change in NPP 1 r_{th} r_{th} Relative change in wildfire intensity 1 r_{npp} Relative change in heterotrophic respiration rate 1 F_{npp} NPP Net primary productivity PgC yr $^{-1}$	$C_{o,j}$	Co_j	Change in surface ocean carbon subpools	PgC	yes	$j \in [\![1,5]\!]$
$c_{ m dic}$ dic Change in surface DIC μ mol kg $^{-}$ 1 $P_{ m dic}$ pdic Subcomponent of pCO2 ppm $P_{ m CO2}$ pCO2 CO2 partial pressure at the ocean surface ppm $F_{ m ocean}$ Focean Ocean carbon sink PgC yr $^{-1}$ $r_{ m npp}$ $r_{ m npp}$ Relative change in NPP 1 $r_{ m rh}$ Relative change in wildfire intensity 1 $r_{ m rh}$ Relative change in heterotrophic respiration rate 1 $F_{ m npp}$ NPP Net primary productivity PgC yr $^{-1}$	C_o	Со	Change in surface ocean carbon pool	PgC		
P dic Change in surface DIC 1 P dic pdic Subcomponent of pCO2 ppm P CO2 pCO2 CO2 partial pressure at the ocean surface ppm F ocean Focean Ocean carbon sink PgC yr^1 r npp r_npp Relative change in NPP 1 r fire r_fire Relative change in wildfire intensity 1 r rh Relative change in heterotrophic respiration rate 1 F npp NPP Net primary productivity PgC yr^1	C_d	Cd	Change in deep ocean carbon pool	yes		
$PCO2$ pCO2 CO2 partial pressure at the ocean surface ppm F_{ocean} Focean Ocean carbon sink $PgC yr^{-1}$ r_{npp} r_{npp} Relative change in NPP 1 r_{fire} r_{fire} Relative change in wildfire intensity 1 r_{rh} Relative change in heterotrophic respiration rate 1 F_{npp} NPP Net primary productivity $PgC yr^{-1}$	$c_{ m dic}$	dic	Change in surface DIC	_		
F_{ocean} Focean Ocean carbon sink $P_{gC yr^{-1}}$ r_{npp} r_{npp} Relative change in NPP 1 r_{fire} r_{fire} Relative change in wildfire intensity 1 r_{rh} Relative change in heterotrophic respiration rate 1 F_{npp} NPP Net primary productivity $P_{gC yr^{-1}}$	$p_{ m dic}$	pdic	Subcomponent of pCO2	ppm		
$r_{\rm npp}$ r_npp Relative change in NPP 1 $r_{\rm fire}$ r_fire Relative change in wildfire intensity 1 $r_{\rm rh}$ Relative change in heterotrophic respiration rate 1 $F_{\rm npp}$ NPP Net primary productivity PgC yr^1	$p_{\text{CO}2}$	pCO2	CO2 partial pressure at the ocean surface	ppm		
$r_{\rm fire}$ r_fire Relative change in wildfire intensity 1 $r_{\rm rh}$ Relative change in heterotrophic respiration rate 1 $F_{\rm npp}$ NPP Net primary productivity PgC yr^1	$F_{ m ocean}$	Focean	Ocean carbon sink	PgC yr ⁻¹		
$r_{ m rh}$ Relative change in heterotrophic respiration rate 1 Figure 1 NPP Net primary productivity PgC yr $^{-1}$	$r_{ m npp}$	r_npp	Relative change in NPP	1		
$F_{ m npp}$ NPP Net primary productivity PgC yr $^{-1}$	r_{fire}	r_fire	Relative change in wildfire intensity	1		
	$r_{ m rh}$	r_rh		1		
$E_{ m fire}$ Emissions from wildfire PgC yr $^{-1}$	$F_{\rm npp}$	NPP	Net primary productivity	PgC yr ⁻¹		
	$E_{\rm fire}$	Efire	Emissions from wildfire	PgC yr ⁻¹		

ln manual	ln code	Description	Units	Prog?	Dims
$E_{\rm harv}$	Eharv	Emissions from harvest and grazing	PgC yr ⁻¹		
$F_{ m mort}$	Fmort	Mortality flux	PgC yr ⁻¹		
$E_{\rm rh1}$	RH1	Litter heterotrophic respiration	PgC yr ⁻¹		
F_{stab}	Fstab	Stabilization flux	PgC yr ⁻¹		
$E_{\rm rh2}$	RH2	Active soil heterotrophic respiration	PgC yr ⁻¹		
$F_{\rm pass}$	Fpass	Passivization flux	PgC yr ⁻¹		
$E_{ m rh3}$	RH3	Passive soil heterotrophic respiration	PgC yr ⁻¹		
$F_{\rm land}$	Fland	Land carbon sink	PgC yr ⁻¹		
$E_{\rm rh}$	RH	Heterotrophic respiration	PgC yr ⁻¹		
C_v	Cv	Vegetation carbon pool	PgC	yes	
C_{s1}	Cs1	Litter carbon pool	PgC	yes	
C_{s2}	Cs2	Active soil carbon pool	PgC	yes	
C_{s3}	Cs3	Passive soil carbon pool	PgC	yes	
C_s	Cs	Total soil carbon pool	PgC		
$r_{ m rt}$	r_rt	Relative change in permafrost respiration rate	1		
\bar{a}	abar	Theoretical thawed fraction	1		
a	a	Actual thawed fraction	1	yes	
$E_{\rm pf}$	Epf	Emissions from permafrost	PgC yr ⁻¹		
$C_{\mathrm{th},j}$	Cth_j	Thawed permafrost carbon subpools	PgC	yes	$j \in [\![1,3]\!]$
$C_{ m fr}$	Cfr	Frozen permafrost carbon pool	PgC		
$E_{\rm CO2}$	Eco2	Anthropogenic CO2 emissions	PgC yr ⁻¹		
C	C02	Atmospheric CO2 concentration	ppm	yes	
рН	рН	Surface ocean pH	1		

Parameters

In	In	Description	Units	Dims
manual	code	Description	Offits	Dillis

ln manual	In code	Description	Units	Dims
ϕ	phi	Radiative parameter of CO2	W m ⁻²	
$T_{2\times}$	T2x	Equilibrium climate sensitivity	K	
Θ_s	THs	Heat capacity of the surface	W yr m ⁻² K ⁻¹	
Θ_d	THd	Heat capacity of the deep ocean	W yr m ⁻² K ⁻¹	
θ	th	Heat exchange coefficient	W m ⁻² K ⁻¹	
$\epsilon_{ m heat}$	eheat	Deep ocean heat uptake efficacy	1	
$\alpha_{ m ohc}$	аОНС	Fraction of energy warming the ocean	1	
$\Lambda_{ m lin}$	Llin	Linear factor for thermosteric SLR	mm m ² W ⁻¹ yr ⁻¹	
$\Lambda_{ m thx}$	Lthx	Equilibrium thermosteric SLR	mm K ⁻¹	
$\Lambda_{\rm tot1}$	Ltot1	Linear equilibrium ice-related SLR	mm K ⁻¹	
Λ_{tot2}	Ltot2	Quadratic equilibrium ice-related SLR	mm K ⁻²	
τ_{thx}	tthx	Timescale of thermosteric SLR	yr	
τ_{ice}	tice	Timescale of ice-related SLR	yr	
$lpha_{ m dic}$	adic	Conversion factor for DIC	μmol kg ⁻¹ PgC ⁻¹	
$\beta_{ m dic}$	bdic	Scaling factor for DIC (~ for MLD)	1	
$\gamma_{ m dic}$	gdic	Sensitivity of pCO2 to climate	K ⁻¹	
T_o	То	Preindustrial surface ocean temperature	°C	
$ u_{ m gx}$	vgx	Surface ocean gas exchange rate	yr ⁻¹	
$\gamma_{\rm gx}$	ggx	Sensitivity of gas exchange to climate	K ⁻¹	
$\alpha_{o,j}$	aoc_j	Surface ocean subpools fractions	1	$j \in [\![1,5]\!]$
$\tau_{o,j}$	toc_j	Timescales of surface ocean subpools	yr	$j \in [\![1,5]\!]$
κ_{τ_o}	k_toc	Scaling factor for timescales of surface ocean subpools	1	
$\beta_{\rm npp}$	bnpp	Sensitivity of NPP to CO2 (= fertilization effect)	1	
$\alpha_{\rm npp}$	anpp	Shape parameter for fertilization effect	1	

In manual	ln code	Description	Units	Dims
$\gamma_{\rm npp}$	gnpp	Sensitivity of NPP to climate	K ⁻¹	
$\beta_{\rm fire}$	bfire	Sensitivity of wildfire intensity to CO2	1	
$\gamma_{\rm fire}$	gfire	Sensitivity of wildfire intensity to climate	K ⁻¹	
$\beta_{ m rh}$	brh	Sensitivity of heterotrophic respiration to fresh organic matter	1	
$\gamma_{\rm rh}$	grh	Sensitivity of heterotrophic respiration to climate	K ⁻¹	
$F_{\rm npp,0}$	npp0	Preindustrial NPP	PgC yr ⁻¹	
$ u_{\mathrm{fire}}$	vfire	Wildfire intensity	yr ⁻¹	
ν_{harv}	vharv	Harvest and grazing rate	yr ⁻¹	
ν_{mort}	vmort	Mortality rate	yr ⁻¹	
ν_{stab}	vstab	Stabilization rate	yr ⁻¹	
$\nu_{ m rh1}$	vrh1	Litter heterotrophic respiration rate	yr ⁻¹	
$\nu_{\mathrm{rh}23}$	vrh23	Soil (active and passive) respiration rate	yr ⁻¹	
$\nu_{ m rh3}$	vrh3	Passive soil respiration rate	yr ⁻¹	
α_{pass}	apass	Fraction of passive soil	1	
α_{lst}	aLST	Climate scaling factor over permafrost regions	1	
$\gamma_{\mathrm{rt}1}$	grt1	Sensitivity of (boreal) heterotrophic respiration to climate	K ⁻¹	
γ_{rt2}	grt2	Sensitivity of (boreal) heterotrophic respiration to climate (quadratic)	K ⁻²	
κ_{rt}	krt	Scaling factor for sensitivity of permafrost respiration to climate	1	
a_{\min}	amin	Minimal thawed fraction	1	
κ_a	ka	Shape parameter for theoretical thawed fraction	1	
γ_a	ga	Sensitivity of theoretical thawed fraction to climate	K ⁻¹	
$\nu_{ m thaw}$	vthaw	Thawing rate	yr ⁻¹	
ν_{froz}	vfroz	Freezing rate	yr ⁻¹	
$\alpha_{ ext{th},j}$	ath_j	Thawed permafrost carbon subpools fractions	1	$j \in [\![1,3]\!]$

In manual	In code	Description	Units	Dims
$\tau_{\text{th},j}$	tth_j	Timescales of thawed permafrost carbon subpools	yr	$j \in [\![1,3]\!]$
$\kappa_{\tau_{ m th}}$	k_tth	Scaling factor for timescales of surface ocean subpools	1	
$C_{\mathrm{fr,0}}$	Cfr0	Preindustrial frozen permafrost carbon pool	PgC	
α_C	aCO2	Conversion factor for atmospheric CO2	PgC ppm ⁻¹	
C_{pi}	CO2pi	Preindustrial CO2 concentration	ppm	
κ_{pH}	k_pH	Scaling factor for surface ocean pH	1	

Equations

1. Climate

diagnostic

•
$$R_c = \phi \ln \left(\frac{C}{C_{\text{pi}}} \right)$$

•
$$R = R_c + R_x$$

prognostic

•
$$\Theta_s \frac{dT}{dt} = R - \frac{\phi \ln(2)}{T_{2\times}} T - \epsilon_{\text{heat}} \theta (T - T_d)$$

•
$$\Theta_d \frac{\mathrm{d}T_d}{\mathrm{d}t} = \theta \left(T - T_d\right)$$

2. Sea level

diagnostic

•
$$U_{\text{ohc}} = \alpha_{\text{ohc}} (\Theta_s T + \Theta_d T_d)$$

•
$$\frac{\mathrm{d}U_{\mathrm{ohc}}}{\mathrm{d}t} = \alpha_{\mathrm{ohc}} \left(\Theta_s \frac{\mathrm{d}T}{\mathrm{d}t} + \Theta_d \frac{\mathrm{d}T_d}{\mathrm{d}t}\right)$$

•
$$H_{\text{lin}} = \Lambda_{\text{lin}} U_{\text{ohc}}$$

•
$$\frac{\mathrm{d}H_{\mathrm{lin}}}{\mathrm{d}t} = \Lambda_{\mathrm{lin}} \frac{\mathrm{d}U_{\mathrm{ohc}}}{\mathrm{d}t}$$

prognostic

•
$$\frac{\mathrm{d}H_{\mathrm{thx}}}{\mathrm{d}t} = \frac{\mathrm{d}H_{\mathrm{lin}}}{\mathrm{d}t} - \frac{H_{\mathrm{thx}} - H_{\mathrm{lin}}}{\tau_{\mathrm{thx}}} + \frac{\Lambda_{\mathrm{thx}} - \Lambda_{\mathrm{lin}} \, \alpha_{\mathrm{ohc}} \, (\Theta_s + \Theta_d)}{\tau_{\mathrm{thx}}} \, T_d$$

•
$$\frac{dH_{\text{tot}}}{dt} = \frac{dH_{\text{thx}}}{dt} - \frac{H_{\text{tot}} - H_{\text{thx}}}{\tau_{\text{ice}}} + \frac{\Lambda_{\text{tot1}} + \Lambda_{\text{tot2}} T - \Lambda_{\text{thx}}}{\tau_{\text{ice}}} T$$

diagnostic (2nd)

•
$$H_{ice} = H_{tot} - H_{thx}$$

•
$$\frac{dH_{\text{ice}}}{dt} = \frac{dH_{\text{tot}}}{dt} - \frac{dH_{\text{thx}}}{dt}$$

3. Ocean carbon

diagnostic

•
$$C_o = \sum_j C_{o,j}$$

•
$$c_{\text{dic}} = \frac{\alpha_{\text{dic}}}{\beta_{\text{dic}}} C_o$$

$$p_{\text{dic}} = (1.5568 - 0.013993 \, T_o) \, c_{\text{dic}}$$
$$+ (7.4706 - 0.20207 \, T_o) \, 10^{-3} \, c_{\text{dic}}^{2}$$

•
$$-(1.2748 - 0.12015 T_o) 10^{-5} c_{\text{dic}}^{3}$$

 $+(2.4491 - 0.12639 T_o) 10^{-7} c_{\text{dic}}^{4}$
 $-(1.5768 - 0.15326 T_o) 10^{-10} c_{\text{dic}}^{5}$

•
$$p_{\text{CO2}} = (p_{\text{dic}} + C_{\text{pi}}) \exp(\gamma_{\text{dic}} T)$$

•
$$F_{\text{ocean}} = \nu_{\text{gx}} (1 + \gamma_{\text{gx}} T) (C - p_{\text{CO}2})$$

prognostic

•
$$\frac{\mathrm{d}C_{o,j}}{\mathrm{d}t} = -\frac{C_{o,j}}{\kappa_{\tau_o} \, \tau_{o,j}} + \alpha_{o,j} \, F_{\text{ocean}}$$

•
$$\frac{\mathrm{d}C_d}{\mathrm{d}t} = \sum_{i} \frac{C_{o,j}}{\kappa_{\tau_o} \ \tau_{o,j}}$$

4. Land carbon

diagnostic

•
$$r_{\rm npp} = \left(1 + \frac{\beta_{\rm npp}}{\alpha_{\rm npp}} \left(1 - \left(\frac{C}{C_{\rm pi}}\right)^{-\alpha_{\rm npp}}\right)\right) (1 + \gamma_{\rm npp} T)$$

•
$$r_{\text{fire}} = \left(1 + \beta_{\text{fire}} \left(\frac{C}{C_{\text{pi}}} - 1\right)\right) \left(1 + \gamma_{\text{fire}} T\right)$$

•
$$r_{\rm rh} = \left(1 + \beta_{\rm rh} \left(\frac{C_{s1}}{C_{s1} + C_{s2} + C_{s3}} \left(1 + \frac{\nu_{stab}}{\nu_{rh23}}\right) - 1\right)\right) \exp(\gamma_{\rm rh} T)$$

•
$$F_{\text{npp}} = F_{\text{npp},0} r_{\text{npp}}$$

•
$$E_{\text{fire}} = \nu_{\text{fire}} r_{\text{fire}} C_v$$

•
$$E_{\text{harv}} = \nu_{\text{harv}} C_v$$

•
$$F_{\text{mort}} = \nu_{\text{mort}} C_v$$

•
$$E_{\rm rh1} = \nu_{\rm rh1} \, r_{\rm rh} \, C_{s1}$$

•
$$F_{\text{stab}} = \nu_{\text{stab}} r_{\text{rh}} C_{s1}$$

•
$$E_{\text{rh2}} = \frac{\nu_{\text{rh23}} - \nu_{\text{rh3}} \, \alpha_{\text{pass}}}{1 - \alpha_{\text{pass}}} \, r_{\text{rh}} \, C_{s2}$$

•
$$F_{\text{pass}} = \nu_{\text{rh}3} \frac{\alpha_{\text{pass}}}{1 - \alpha_{\text{pass}}} r_{\text{rh}} C_{s2}$$

•
$$E_{\text{rh3}} = \nu_{\text{rh3}} r_{\text{rh}} C_{s3}$$

•
$$F_{\text{land}} = F_{\text{npp}} - E_{\text{fire}} - E_{\text{harv}} - E_{\text{rh}1} - E_{\text{rh}2} - E_{\text{rh}3}$$

prognostic

•
$$\frac{\mathrm{d}C_v}{\mathrm{d}t} = F_{\rm npp} - E_{\rm fire} - E_{\rm harv} - F_{\rm mort}$$

•
$$\frac{\mathrm{d}C_{s1}}{\mathrm{d}t} = F_{\mathrm{mort}} - F_{\mathrm{stab}} - E_{\mathrm{rh1}}$$

•
$$\frac{\mathrm{d}C_{s2}}{\mathrm{d}t} = F_{\mathrm{stab}} - F_{\mathrm{pass}} - E_{\mathrm{rh2}}$$

•
$$\frac{dC_{s3}}{dt} = F_{pass} - E_{rh3}$$

diagnostic (2nd)

•
$$E_{\rm rh} = E_{\rm rh1} + E_{\rm rh2} + E_{\rm rh3}$$

•
$$C_s = C_{s1} + C_{s2} + C_{s3}$$

5. Permafrost carbon

diagnostic

•
$$r_{\text{rt}} = \exp(\kappa_{\text{rt}} \gamma_{\text{rt1}} \alpha_{\text{lst}} T - \kappa_{\text{rt}} \gamma_{\text{rt2}} (\alpha_{\text{lst}} T)^2)$$

•
$$\bar{a} = -a_{\min} + \frac{(1 + a_{\min})}{\left(1 + \left(\left(1 + \frac{1}{a_{\min}}\right)^{\kappa_a} - 1\right) \exp(-\gamma_a \kappa_a \alpha_{\text{lst}} T)\right)^{\frac{1}{\kappa_a}}}$$

•
$$E_{\rm pf} = \sum_{j} \frac{C_{{\rm th},j}}{\kappa_{\tau_{\rm th}} \; \tau_{{\rm th},j}} \, r_{\rm rt}$$

prognostic

•
$$\frac{da}{dt} = 0.5 \left(\nu_{\text{thaw}} + \nu_{\text{froz}} \right) (\bar{a} - a) + 0.5 \left| \left(\nu_{\text{thaw}} - \nu_{\text{froz}} \right) (\bar{a} - a) \right|$$

$$\bullet \ \frac{\mathrm{d}C_{\mathrm{th},j}}{\mathrm{d}t} = \alpha_{\mathrm{th},j}\,\frac{\mathrm{d}a}{\mathrm{d}t}\,C_{\mathrm{fr},0} - \frac{C_{\mathrm{th},j}}{\kappa_{\tau_{\mathrm{th}}}\,\tau_{\mathrm{th},j}}\,r_{\mathrm{rt}}$$

diagnostic (2nd)

•
$$C_{\text{fr}} = (1 - a) C_{\text{fr},0}$$

•
$$\frac{\mathrm{d}C_{\mathrm{fr}}}{\mathrm{d}t} = -\frac{\mathrm{d}a}{\mathrm{d}t} C_{\mathrm{fr},0}$$

6. Atmospheric CO2

diagnostic

• pH =
$$\kappa_{pH}$$
 (8.5541 - 0.00173 C + 1.3264 10^{-6} C^2 - 4.4943 10^{-10} C^3)

prognostic

•
$$\alpha_C \frac{\mathrm{d}C}{\mathrm{d}t} = E_{\mathrm{CO2}} + E_{\mathrm{pf}} - F_{\mathrm{land}} - F_{\mathrm{ocean}}$$