1 Variable and parameter overview

1.1 c:G:LA

variable	unit	range	description
L	GtC	$0 \leqslant L \leqslant C^*$	terrestrial carbon stock
A	GtC	$0 \leqslant A \leqslant C^*$	atmospheric carbon stock
M	GtC	$0 \leqslant M \leqslant C^*$	maritime carbon stock
T	GtC	$0 \leqslant T$	global mean temperature
parameter	unit	range	description
C^*	GtC	> 0	total global carbon stock
Σ	km^2	> 0	available earth surface area
a_0	a^{-1}	$\geqslant 0$	respiration baseline coefficient
a_T	$\mathrm{a}^{-1}\,\mathrm{GtC}^{-1}$	$\geqslant 0$	respiration sensitivity to temperature
l_0	$\mathrm{km\,a}^{-1}\,\mathrm{GtC}^{-1/2}$	$\geqslant 0$	photosynthesis baseline coefficient
l_T	$\mathrm{km\,a}^{-1}\,\mathrm{GtC}^{-3/2}$	$\geqslant 0$	photosynthesis sensitivity to temperature
m	1	> 0	solubility coefficient
δ	a^{-1}	> 0	diffusion rate

Table 1: Overview of the variables and free parameters of the c:G:LA model which describes the essential dynamics of the natural sub-system of the earth via the carbon cycle.

1.2 c:G:LAP

variable	unit	range	description
P	H	$0 \leqslant P$	human population
K	\$	$0 \leqslant K$	physical capital stock
B	$\mathrm{GtC\,a}^{-1}$	$0 \leqslant B$	biomass extraction flow
W	$\$\ \mathrm{H}^{-1}\mathrm{a}^{-1}$	$0 \leqslant W$	wellbeing
parameter	unit	range	description
p	a^{-1}	> 0	fertility rate maximum
W_p	$\$\mathrm{a}^{-1}\,\mathrm{H}^{-1}$	> 0	fertility saturation wellbeing
q_0	$\$\mathrm{a}^{-2}\,\mathrm{H}^{-1}$	$\geqslant 0$	mortality baseline coefficient
q_T	$\$\mathrm{a}^{-2}\,\mathrm{H}^{-1}\mathrm{GtC}^{-1}$	$\geqslant 0$	mortality sensitivity to temperature
q_P	$\mathrm{km}^2\mathrm{a}^{-1}\mathrm{H}^{-1}$	$\geqslant 0$	population carrying capacity
b	$\mathrm{GtC}^{3/4}\,\mathrm{a}^{-1}\,\mathrm{H}^{-3/4}$	$\geqslant 0$	biomass offtake rate
y	$\$\,\mathrm{GtC}^{-1}$	$\geqslant 0$	wellbeing sensitivity to consumption
w_L	$\$\,\mathrm{km}^2\,\mathrm{GtC}^{-1}\,\mathrm{a}^{-1}\,\mathrm{H}^{-1}$	$\geqslant 0$	wellbeing sensitivity to land carbon

Table 2: Overview of the additional variables and free parameters of the co-evolutionary c:G:LAP model which describes a hunter-gatherer scenario of global scale.

1.2.1 Reduction to two dimensions (c:G:LP)

It is noteworthy that the dimension of the three-dimensional c:G:LAP model can be reduced if we assume the diffusion of carbon between atmosphere and oceans to be very fast so that A and M are always in equilibrium. The schematic overview for this case is shown in Figure **??**. Making use of equation (**??**) the following holds:

$$M = mA \qquad \Rightarrow \qquad A = (C^* - L)/(1+m) \tag{1}$$

As A is now a derived variable only L and P are left as dynamic variables and one has again a two-dimensional sub-model which will be abbreviated c:G:LP. The resulting ordinary differential equations are:

$$\dot{L} = L\left(\left(l_0 - l_T \frac{C^* - L}{1+m}\right)\sqrt{\frac{C^* - L}{\Sigma(1+m)}} - \left(a_0 + a_T \frac{C^* - L}{1+m}\right)\right) - bL^{1/4}P^{3/4} \tag{2}$$

$$\dot{P} = P\left(\frac{2pWW_p}{W^2 + W_p^2} - \frac{q_0 + q_T \frac{C^* - L}{1+m}}{W} - \frac{q_P P}{\Sigma}\right) \tag{3}$$

This model is relatively similar to the model of Brander and Taylor [**?**] and allows for phase plane analysis and analytical results considering nullclines and stabilities.

2 Parameter overview

The following table 3 gives an overview on all parameters introduced so far and their best estimates from available data.

parameter	unit	dimensional value	non-dim. value
Σ	km^2	$1.5 \cdot 10^8$	1
C^*	GtC	4500	1
m	1	1.5	1.5
δ	a^{-1}	0.01	1
a_0	a^{-1}	0.023	2.3
a_T	$\mathrm{a}^{-1}\,\mathrm{GtC}^{-1}$	$2.11 \cdot 10^{-5}$	9.5
l_0	$\mathrm{km\,a}^{-1}\,\mathrm{GtC}^{-1/2}$	20.1	11.0
l_T	$\mathrm{km\,a}^{-1}\,\mathrm{GtC}^{-3/2}$	$3.25 \cdot 10^{-3}$	8.0
p	a^{-1}	0.04	4
W_p	$\$\mathrm{a}^{-1}\,\mathrm{H}^{-1}$	2000	1
q_0	$\$\mathrm{a}^{-2}\,\mathrm{H}^{-1}$	20	1
q_T	$\$\mathrm{a}^{-2}\,\mathrm{H}^{-1}\mathrm{GtC}^{-1}$	0	0
q_P	$\mathrm{km}^2\mathrm{a}^{-1}\mathrm{H}^{-1}$	0	0
b	$\mathrm{GtC}^{3/4}\,\mathrm{a}^{-1}\,\mathrm{H}^{-3/4}$	$6.2 \cdot 10^{-8}$	0.36
y	$\$\,\mathrm{GtC}^{-1}$	varied	
w_L	$\$\,\mathrm{km}^2\,\mathrm{GtC}^{-1}\,\mathrm{a}^{-1}\,\mathrm{H}^{-1}$	varied	

Table 3: Overview on the estimated parameter values. Dimensional parameters can be converted to non-dimensional values using the formulas given in sections **??** and **??**. These values serve as default if not stated otherwise.