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Evaluating the effect of alternative carbon allocation schemes in a land surface model (CLM4.5) on carbon fluxes, pools, and turnover in temperate forests

Francesc Montané et al.

Correspondence to: Francesc Montané (francesc.montane@gmail.com)

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SUPPLEMENTARY METHODS AND FIGURES

C allocation scheme effect on initial aboveground biomass and C_{stem}/C_{leaf} ratio

To evaluate the effect of different C allocation approaches in initial aboveground biomass in equilibrium and we also compared them with tree-ring estimates of aboveground biomass data for 1980. The C allocation scheme used has a strong influence on initial aboveground biomass and the C_{stem}/C_{leaf} ratio, which can be explained with Eq. (4). When the model is in equilibrium conditions, $dB_i/dt=0$ in Eq. (4), and denoting B_{stem} with C_{stem}, and B_{leaf} with C_{leaf}:

$$a_{stem}NPP = NPP_{stem} = u_{stem}C_{stem} \quad (5)$$

$$a_{leaf}NPP = NPP_{leaf} = u_{leaf}C_{leaf} \quad (6)$$

After dividing Eq. (5) by Eq. (6):

$$a_{stem}/a_{leaf} = NPP_{stem}/NPP_{leaf} = (C_{stem}/C_{leaf}) \times (u_{stem}/u_{leaf}) \quad (7)$$

$$C_{stem}/C_{leaf} = \frac{(NPP_{stem}/NPP_{leaf})}{(u_{stem}/u_{leaf})} \quad \text{or} \quad C_{stem}/C_{leaf} = \frac{(a_{stem}/a_{leaf})}{(u_{stem}/u_{leaf})} \quad (8)$$

In D-CLM4.5 $NPP_{stem}/NPP_{leaf} \approx 2$ and $a_{stem}/a_{leaf} \approx 2$ for evergreen sites in favorable conditions (e.g. mean annual NPP $\approx$ 1000 $gCm^{-2}year^{-1}$) and for deciduous sites; $u_{stem}/u_{leaf}=0.02$ for deciduous and $u_{stem}/u_{leaf}=0.06$ for evergreen forests. Therefore, in D-CLM4.5 $C_{stem}/C_{leaf} \approx 33$ for evergreen sites in favorable conditions; and $C_{stem}/C_{leaf} \approx 100$ for deciduous sites.

Because the alternative C allocation approaches have different NPP_{stem}/NPP_{leaf} ratio than the one in D-CLM4.5, they showed different C_{stem}/C_{leaf} ratio, despite having the same u_{stem}/u_{leaf} . We compared the C_{stem}/C_{leaf} ratio from the different C allocation schemes and parameterizations with available observations for the sites (Table 1).

In reference to the initial aboveground biomass (leaf+stem), we can use Eq. (4), and assuming equilibrium conditions, $dB_i/dt=0$, then:

$$a_{leaf}NPP + a_{stem}NPP = u_{leaf}C_{leaf} + u_{stem}C_{stem} \quad (9)$$

$$ANPP = u_{leaf}C_{leaf} + u_{stem}C_{stem} = C_{stem}(u_{stem} + u_{leaf}C_{leaf}/C_{stem}) \quad (10)$$

$$C_{stem}^{*} = ANPP/(u_{stem} + u_{leaf}C_{leaf}/C_{stem}) = ANPP/u_{stem}(1 + (NPP_{leaf}/NPP_{stem})) \quad (11)$$

Similarly to Eq (10),

$$ANPP = u_{leaf} C_{leaf} + u_{stem} C_{stem} = C_{leaf} (u_{leaf} + u_{stem} C_{stem} / C_{leaf}) \quad (12)$$

$$C_{leaf}^{*} = ANPP / (u_{leaf} + u_{stem} C_{stem} / C_{leaf}) = ANPP / u_{leaf} (1 + (NPP_{stem} / NPP_{leaf})) \quad (13)$$

Hence,

$$C_{aboveground}^{*} = C_{leaf}^{*} + C_{stem}^{*} = ANPP / u_{leaf} (1 + (NPP_{stem} / NPP_{leaf})) + ANPP / u_{stem} (1 + (NPP_{leaf} / NPP_{stem})) \quad (14)$$

where C_{stem}^{*}, C_{leaf}^{*}, and $C_{aboveground}^{*}$ refer to stem C, leaf C and aboveground C in equilibrium conditions, respectively. Therefore, the aboveground biomass in equilibrium conditions will depend on aboveground NPP (*ANPP*), the NPP_{stem}/NPP_{leaf} ratio (or a_{stem}/a_{leaf} ratio) and the turnover rates for leaf and stem (u_{leaf} and u_{stem}).

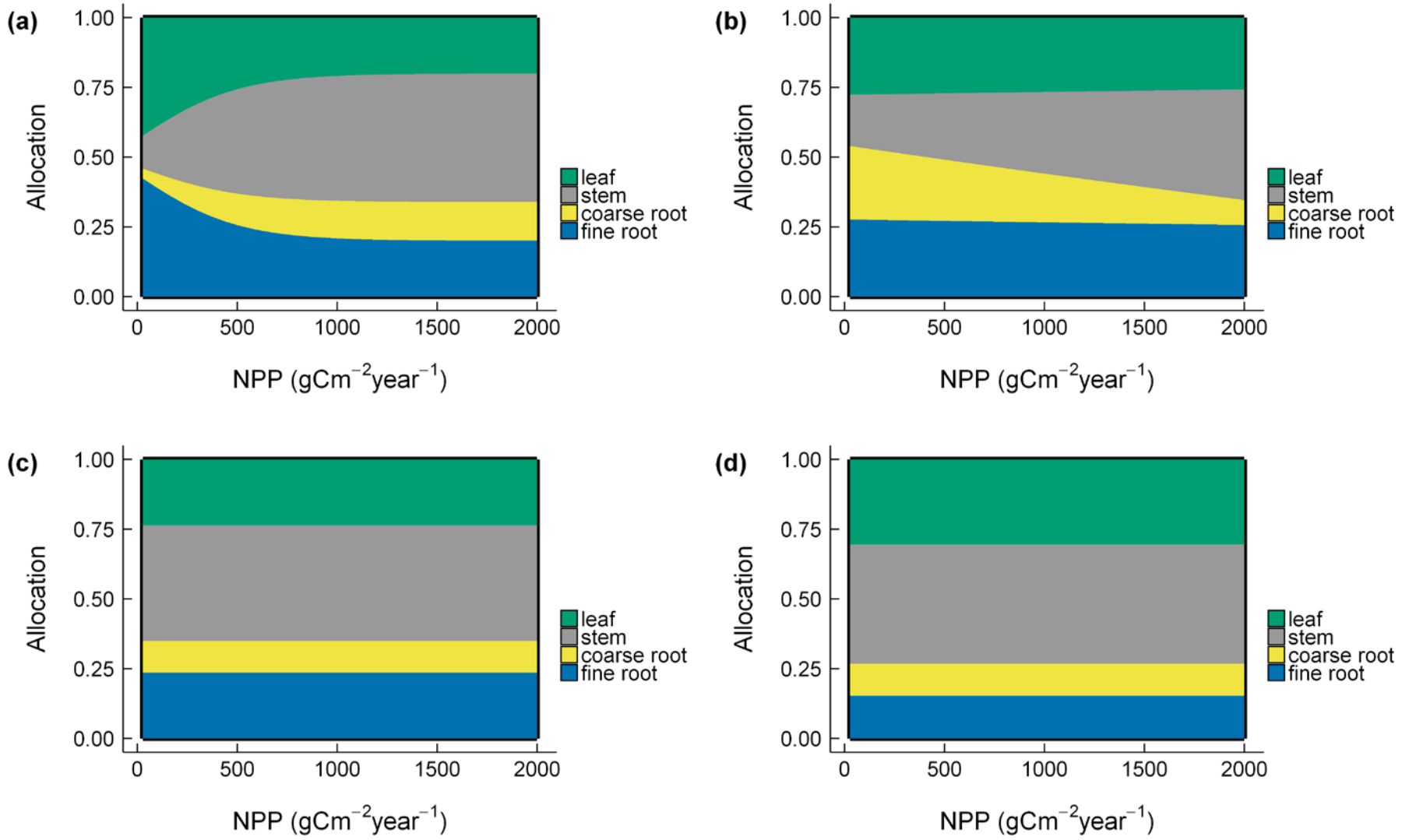
(a)
(b)
(c)
(d)
Allocation
1.00
0.75
0.50
0.25
0.00
0
500
1000
1500
2000
NPP (gCm^{-2}year^{-1})
leaf
stem
coarse root
fine root

Figure S1. Carbon allocation to the different plant pools (leaf, stem, coarse root, and fine root) as a function of annual Net Primary Productivity (NPP) in: (a) D-CLM4.5 C allocation scheme described in Oleson et al., 2013; (b) D-Litton C allocation scheme based on Litton et al., 2007; (c) F-Evergreen C allocation scheme based on Luyssaert et al., 2007; (d) F-Deciduous C allocation scheme based on Luyssaert et al., 2007.

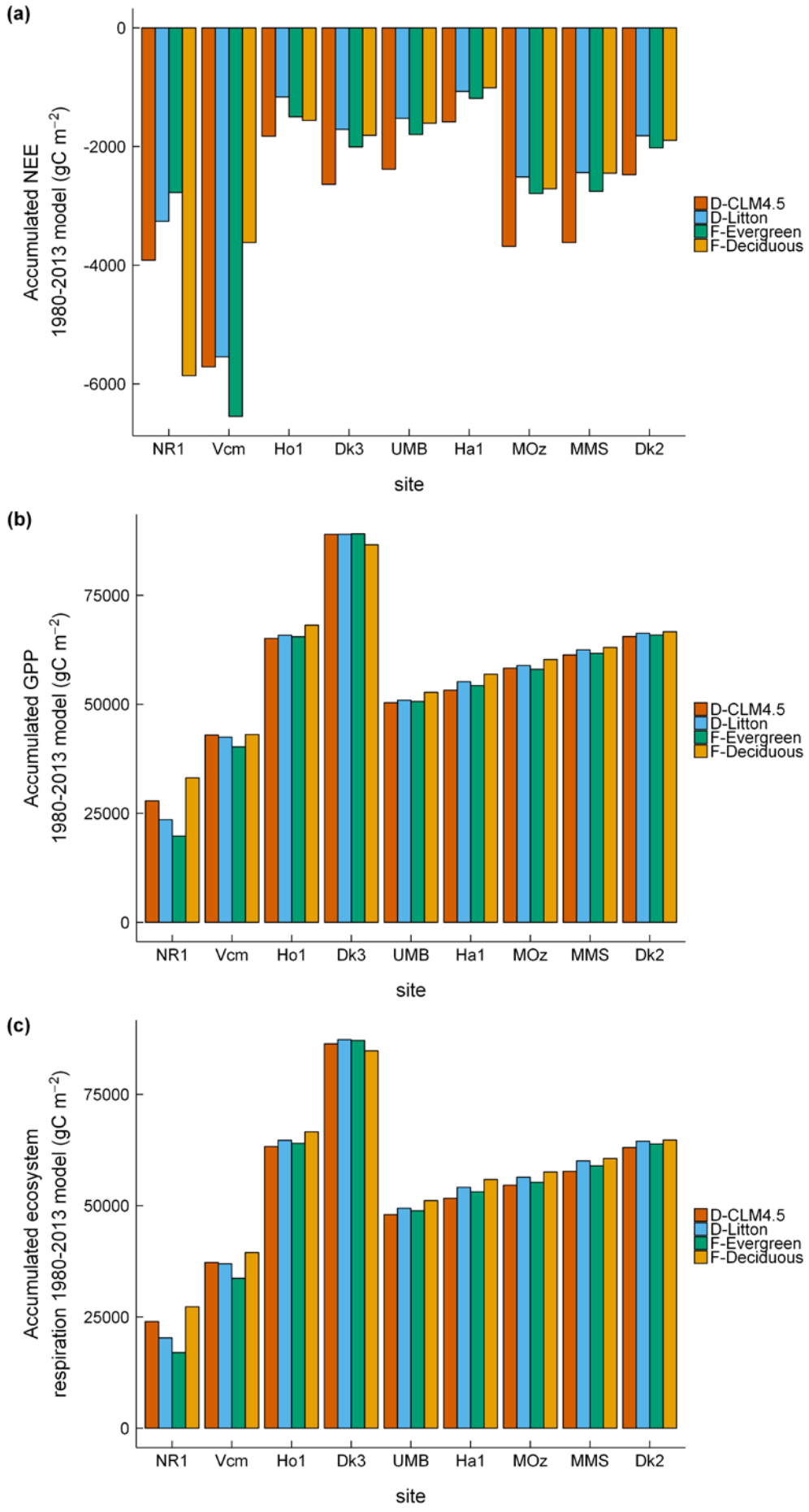
(a)
Accumulated NEE
1980-2013 model (gC m^{-2})
0
-2000
-4000
-6000
NR1
Vcm
Ho1
Dk3
UMB
Ha1
MOz
MMS
Dk2
site
D-CLM4.5
D-Litton
F-Evergreen
F-Deciduous
(b)
Accumulated GPP
1980-2013 model (gC m^{-2})
75000
50000
25000
0
NR1
Vcm
Ho1
Dk3
UMB
Ha1
MOz
MMS
Dk2
site
D-CLM4.5
D-Litton
F-Evergreen
F-Deciduous
(c)
Accumulated ecosystem
respiration 1980-2013 model (gC m^{-2})
75000
50000
25000
0
NR1
Vcm
Ho1
Dk3
UMB
Ha1
MOz
MMS
Dk2
site
D-CLM4.5
D-Litton
F-Evergreen
F-Deciduous

Figure S2. Accumulated (a) NEE, (b) GPP, (c) and ecosystem respiration during 1980-2013 for the four C allocation schemes.