Supplement of Geosci. Model Dev., 10, 3499–3517, 2017
https://doi.org/10.5194/gmd-10-3499-2017-supplement
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Supplement of

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

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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, \( \frac{dB_i}{dt} = 0 \) in Eq. (4), and denoting \( B_{stem} \) with \( C_{stem} \), and \( B_{leaf} \) with \( C_{leaf} \):

\[
a_{stem} \cdot \text{NPP} = NPP_{stem} = u_{stem} C_{stem} \tag{5}
\]

\[
a_{leaf} \cdot \text{NPP} = NPP_{leaf} = u_{leaf} C_{leaf} \tag{6}
\]

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

\[
\frac{a_{stem}}{a_{leaf}} = \frac{NPP_{stem}}{NPP_{leaf}} = \left( \frac{C_{stem}}{C_{leaf}} \right) \times \left( \frac{u_{stem}}{u_{leaf}} \right) \tag{7}
\]

\[
\frac{C_{stem}}{C_{leaf}} = \left( \frac{NPP_{stem}/NPP_{leaf}}{u_{stem}/u_{leaf}} \right) \quad \text{or} \quad \frac{C_{stem}}{C_{leaf}} = \left( \frac{a_{stem}/a_{leaf}}{u_{stem}/u_{leaf}} \right) \tag{8}
\]

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:

\[
a_{leaf} \cdot \text{NPP} + a_{stem} \cdot \text{NPP} = u_{leaf} C_{leaf} + u_{stem} C_{stem} \tag{9}
\]

\[
ANPP = u_{leaf} C_{leaf} + u_{stem} C_{stem} = C_{stem} \left( u_{stem} + u_{leaf} \frac{C_{leaf}}{C_{stem}} \right) \tag{10}
\]

\[
C_{stem}^* = ANPP \left( u_{stem} + u_{leaf} \frac{C_{leaf}}{C_{stem}} \right) = ANPP \left( 1 + \left( \frac{NPP_{leaf}}{NPP_{stem}} \right) \right) \tag{11}
\]
Similarly to Eq (10),
\[
ANPP = u_{\text{leaf}} C_{\text{leaf}} + u_{\text{stem}} C_{\text{stem}} = C_{\text{leaf}} \left( u_{\text{leaf}} + u_{\text{stem}} \frac{C_{\text{stem}}}{C_{\text{leaf}}} \right)
\]
(12)
\[
C_{\text{leaf}}^* = \frac{ANPP}{u_{\text{leaf}} + u_{\text{stem}} \frac{C_{\text{stem}}}{C_{\text{leaf}}}} = \frac{ANPP}{u_{\text{leaf}} \left( 1 + \frac{NPP_{\text{stem}}}{NPP_{\text{leaf}}} \right)}
\]
(13)

Hence,
\[
C_{\text{aboveground}}^* = C_{\text{leaf}}^* + C_{\text{stem}}^* = \frac{ANPP}{u_{\text{leaf}} \left( 1 + \frac{NPP_{\text{stem}}}{NPP_{\text{leaf}}} \right)} + \frac{ANPP}{u_{\text{stem}} \left( 1 + \frac{NPP_{\text{leaf}}}{NPP_{\text{stem}}} \right)}
\]
(14)

where $C_{\text{stem}}^*$, $C_{\text{leaf}}^*$, and $C_{\text{aboveground}}^*$ 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 $NPP_{\text{stem}}/NPP_{\text{leaf}}$ ratio (or $\alpha_{\text{stem}}/\alpha_{\text{leaf}}$ ratio) and the turnover rates for leaf and stem ($u_{\text{leaf}}$ and $u_{\text{stem}}$).
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.
Figure S2. Accumulated (a) NEE, (b) GPP, (c) and ecosystem respiration during 1980-2013 for the four C allocation schemes.