CO$_2$ diffuse processes in soils: impacts of rainfall, snowpack and closed chambers

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CO$_2$ efflux from the soil:
Integration of CO$_2$ produced from all layers of soil.

\[ F_1 = F_2 + \sum S_1 \]
Ideal CO$_2$ profile

Daytime CO$_2$ profile

Diffuse process:

$$ F = -D_s \frac{dC}{dz} $$

\[ C = az^2 + bz + c, \text{ if production is constant} \]
CO₂ profile measurement

CO$_2$ profile in soils after rainfall in California

CO$_2$ profile under snowpack at Harvard Forest
Under the steady state, the snowpack does not physically change CO$_2$ fluxes, but does change the CO$_2$ concentration gradient and diffusivity.
Under the transient period (during snow fall or melting), the snow fall decreases the flux and the melting of snowpack increases the flux.
Soil $\text{CO}_2$ profile under snowpack

![Graph showing $\text{CO}_2$ concentration (PPM) over different depths (2 cm, 8 cm, 16 cm) and months (Dec, Jan, Feb, March).]
CO$_2$ concentration and snow depth
Total CO$_2$ efflux over the winter (90 days) = 50.6 gC m$^{-2}$
CO$_2$ efflux vs. temperature

$Q_{10} = 3.8$
$R^2 = 0.18$

$Q_{10} = 1.3$
$R^2 = 0.32$
CO$_2$ profile and automated chambers at Harvard Forest
Soil CO\textsubscript{2} profile and [CO\textsubscript{2}] in closed chambers
Soil CO$_2$ profile and [CO$_2$] in closed chambers
CO$_2$ efflux and [CO$_2$] in closed chambers
CO$_2$ efflux and [CO$_2$] in closed chambers

For every 100 ppm increase in CO$_2$ concentration inside the chamber, CO$_2$ efflux could be decreased by 0.08 µmol m$^{-2}$ s$^{-1}$. 

\[ F = 3.59 - 0.0008 \text{ C} \]
Conclusions

• The physical impacts of snowpack vary between under the steady state and during the transient period (snow fall or melting). $Q_{10}$ is higher in the low temperature range than that in the high temperature range in winter.

• The closed chamber decreases the CO$_2$ gradient in soil and thus may underestimate CO$_2$ efflux.
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Questions and Comments???