Soil CO_2 fluxes through a temperate watershed

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Quantifying soil gas dynamics is needed for global C cycle models, projecting feedbacks between climate change and terrestrial ecosystem C balance, and assessing bedrock weathering through enhanced acidity from CO_2 dissolution into porewaters. We seek to link patterns in soil CO_2 fluxes with dissolved inorganic C (DIC) in porewaters, which will allow modelling of CO_2 loss from soils to the atmosphere and through the advective outflux of DIC-containing porewaters from watersheds. Soil CO_2 fluxes were measured at the land surface and calculated at depth using Fick's Law, pCO_2, and soil properties for a first-order catchment at the Susquehanna Shale Hills Critical Zone Observatory [1]. We measured soil CO_2 along a planar slope and swale depression, with discrete sampling depths at the ridge, mid-slope, and valley. We compared CO_2 flux data with DIC for soil porewaters and groundwater [2]. Surface CO_2 flux positively correlates with soil temperature and moisture up to 0.25 m^3 m^{-3}; above this value it is negatively correlated with soil moisture. On average, surface CO_2 flux is higher for the wetter swale depression (4.67±2.96 μmol m^{-2} s^{-1}) than the drier planar slope (3.67±2.48 μmol m^{-2} s^{-1}). However, there is high spatial variability along the two transects that does not correlate with hillslope position or soil depth, but is likely the result of heterogeneous leaf litter distribution (R^2 = 0.69). At depth, CO_2 fluxes to the atmosphere decrease rapidly (to ~1 μmol m^{-2} s^{-1} at 10 cm and to nearly zero below 30 cm) and are positively correlated with porosity and negatively correlated with soil moisture. Under drier conditions and at >50 cm depth, we observe small CO_2 fluxes towards the groundwater. This downward flux is confirmed by observations of groundwater $\delta^{13}C_{DIC}$ that indicate mixing between DIC from soil CO_2 and ankerite dissolution in the parent shale [2].

[1] Hasenmueller et al. (2015) *Appl. Geochem.* **63**, 58-69. [2] Jin et al. (2014) *Geochim. Cosmochim. Acta* **142**, 260-280.