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Soil CO$_{2}$ efflux in boreal Scots pine stands: Temporal and spatial variation

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Soil CO_2 efflux was measured with a portable chamber in a managed Scots pine forest in Finland for three years. Our objectives were 1) to identify factors related to temporal variation of soil CO_2 efflux in a boreal pine forest, 2) to evaluate simple predictive models of temporal variation, and 3) to assess spatial variation of soil CO_2 efflux on different scales and across different development stages of the forest.

Plot averages for soil CO_2 efflux ranged from 0.04 to 0.90 $gCO_2m^{-2}h^{-1}$ during the snow-free period, i.e. May –October, and from 0.04 to 0.13 $gCO_2m^{-2}h^{-1}$ in winter. Soil temperature was a good predictor of soil CO_2 efflux. A quadratic model of ln-transformed efflux and a Lloyd &Taylor version of the Arrhenius function had the best fit among temperature response models, explaining 68–87% of the variation over the snow-free period.

The results revealed strong seasonality: at a given soil temperature soil CO_2efflux was higher later in the season than in spring and early summer. Regression coefficients for temperature (approximations of a Q_{10} value) of month-specific models decreased with increasing average soil temperatures. Efflux in July, the month of peak photosynthesis, showed no clear response to temperature or moisture.

The effect of moisture early in the season was confounded by simultaneous advancement of growing season and increase in temperature. In a dry year, however, the effect of drought was evident as soil CO_2 efflux was some 30% smaller in September than in the previous wet year.

Spatial variation of soil CO_2 efflux was measured at two locations some 30 km apart. The main set-up consisted of three 20 m x 20 m plots with 10 randomly chosen, permanent measurement points in each, measured for three years. They represented two stands and two stages of forest development: one plot in a stand at pole stage (40 years old) and two plots in an older stand (65 yrs). Tree location data and root density samples were collected to be related to variation in the observed efflux. In another location some 30 km south, two plots with the similar set-up, one in a pole stage stand (25 yrs) and other in a mature stand (85 yrs), were measured. In addition, a small plot of 0.6 m x 0.6 m was measured to study spatial variability on a small scale with 25 permanently placed measuring collars next to each other on homogenous moss cover.

Preliminary results show that spatial variation within the plots was great from time to time: Coefficient of variation ranged from 0.10 to 0.60 and standard deviation was about one third of the plot mean. Differences in soil CO_2efflux between plots in the same forested area were relatively small but consistent.