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Soil respiration: from fine-scale processes to global patterns

Michael Bahn
Institute of Ecology, University of Innsbruck, Innsbruck, Austria (michael.bahn@uibk.ac.at)

Soil respiration constitutes the largest flux of carbon (C) from terrestrial ecosystems to the atmosphere. This talk will outline some key challenges currently faced by soil respiration research and will focus on two aspects at the very extreme ends of scales, i.e. the small temporal and the large spatial scale.

While there is consistent evidence that soil CO_2 emissions and ecosystem C inputs through photosynthesis are strongly linked from daily to annual timescales, it is still debated whether and how soil respiration is coupled to photosynthesis on a diel timescale. Attempts to derive such a link from a hysteresis in the soil temperature - respiration relationship face the problem of confounding a range of possible physical-chemical and biological effects. Alternatively, the short-term link between canopy photosynthesis and soil respiratory processes can be studied using isotopic labelling experiments. Here, results from a pulse labelling experiment in grassland will be shown, tracing the fate of freshly photosynthesized carbon from leaf to root and different microbial groups, and its return to the soil surface as respired CO_2. The study demonstrates a rapid transfer of photoassimilates in the plant-soil system and their immediate use in belowground respiratory processes. Diurnal variations in the isotopic signature of soil respired CO_2 suggest that the plant-derived substrates used for soil respiratory processes vary between day and night.

A major challenge at the large scale is to account for the considerably spatial variability of soil respiration, which is of similar order of magnitude as its temporal variability. Based on a reanalysis and synthesis of 72 site-years for 58 forests, plantations, savannas, shrublands and grasslands from boreal to tropical climates it will be shown that total annual soil CO_2 emissions are closely related to soil respiration at mean annual soil temperature (SR_{MAT}), irrespective of the type of ecosystem and biome. For seasonally dry sites where annual precipitation (P) is lower than potential evapotranspiration (PET), annual soil respiration can be predicted from wet season SR_{MAT} corrected for a factor related to P/PET. This finding indicates that it is sufficient to measure SR_{MAT} for obtaining a highly constrained estimate of its annual total. This should substantially increase our capacity for assessing the spatial distribution and interannual variation of soil CO_2 emissions across ecosystems, landscapes and regions, and thereby contribute to improving the spatio-temporal resolution of a major component of the global carbon cycle.