Updating and applying the global soil respiration database (SRDB) for carbon cycling research

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Project Abstract:

The soil-to-atmosphere CO_2 flux (soil respiration, R_S) is the second largest carbon exchange between atmosphere and terrestrial and it plays an important role in global carbon cycling. Field R_S measurements were compiled into a global soil respiration database (SRDB) a decade ago, which has been widely used. Many new questions, however, require data which are currently not included in the SRDB. We restructured and updated the database to a new version, SRDB-V5, with several new fields collected and integrated (e.g., R_S measurement time, collar insertion depth, collar area), and older fields emended for consistency. We also updated the database from new published papers through 2017, greatly improving its spatio-temporal coverage compared with the older version.

One application of this new database involves probing the global carbon cycle for inconsistencies. For example, estimates of global GPP and R_S are typically made separately, however, and their consistency has not been previously evaluated. We show that most estimates of global GPP and R_S, typically derived from satellite-driven models and upscaled chamber fluxes respectively, are irreconcilable. Partitioning global R_S estimates into shoot and root respiration and computing the resulting GPP produces values (GPP_{Rs}, bootstrap mean 143^{+30}_{-20} Pg C yr^{-1}) significantly higher than most canonical GPP estimates (112 ± 18 Pg C yr^{-1}). Similarly, the soil respiration flux implied by GPP (Rs_{GPP}, bootstrap mean of 72 ± 11 Pg C yr^{-1}) is inconsistent (5.3%, $P < 0.001$) with canonical R_S (87 ± 9 Pg C yr^{-1}). Our findings thus demonstrate a large gap between global GPP and R_S estimates, one with implications for our understanding of global productivity, carbon turnover time, and terrestrial sensitivity to climate change.

The other application of this comprehensive global soil respiration database is to evaluate current carbon models. Currently our models vary significantly with respect to model structures, kinetic representations and the dependence and the sensitivity to key climate drivers, including soil moisture events, reflecting diverse assumptions underlying transfers of carbon among pools and representations of microbial and mineral processes. This database with extensive spatial-temporal coverage will enable systematic exploration and evaluation of current carbon models and harness the sources of uncertainties.