B21K-2346 - Controls on soil respiration rates at sites throughout North America

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INTRODUCTION

Soil respiration is the largest flux of carbon from terrestrial ecosystems to the atmosphere. In addition, soil respiration is ecologically important since it represents total biological activity of soil biota. This project had two aims:

1. Develop an open-access soil respiration data product based on freely available National Ecological Observatory Network (NEON) data.
2. Investigate controls on soil respiration across the NEON sites.

NEON is an ecological monitoring network consisting of 81 sites throughout the US (Fig. 1a). A wide range of data are collected using standardized protocols and all data are freely available. Each of the 47 terrestrial sites include five sensor-based soil plots, which contain soil CO_2 concentration measurements at 3 depths (from 2 cm to ~12 cm), as well as soil temperature and moisture profiles and other measurements (Fig 1b).

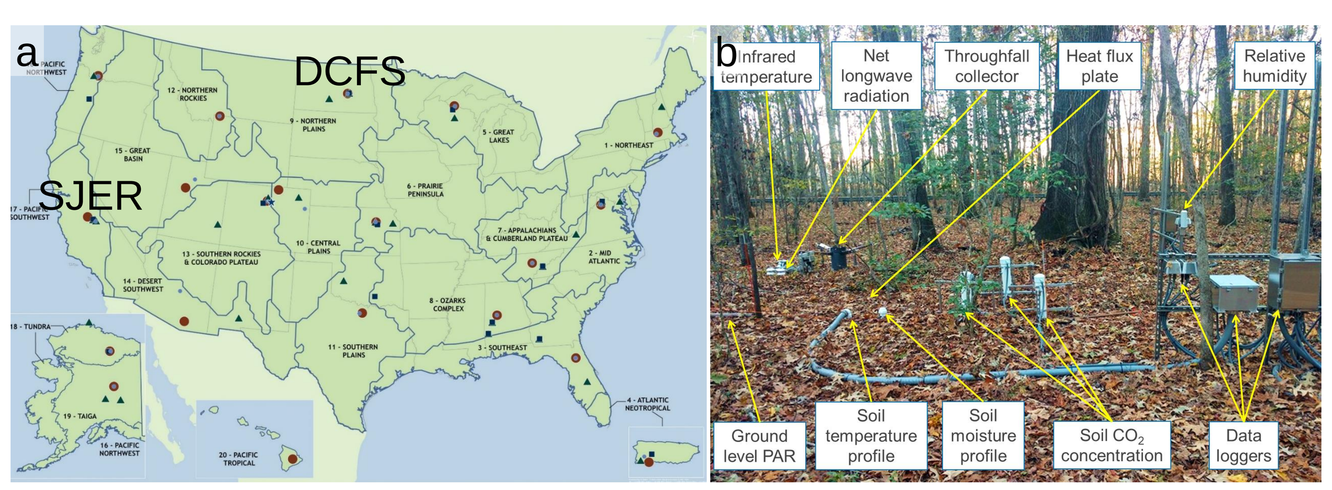

Figure 1. Location of NEON sites (a). A sensor-based soil plot (b).

METHODS

Soil CO_2 fluxes were calculated using the gradient method from April to September 2019 at all sites. The soil CO_2 concentration gradient was combined with estimates of soil CO_2 diffusivity in Fick's first law to calculate the flux between the measurement levels. These fluxes were extrapolated to the soil surface to determine the CO_2 flux from the soil to the atmosphere.

METHODS cont.

Fluxes were flagged and excluded if one or more input data streams were flagged, if the flux deeper in soil was greater than surface flux, or if the surface flux was <-1 µmol m^{-2} s^{-1} since this indicated that one or more of the assumptions of the gradient method were violated.

RESULTS

Only 5% of the flux data between Apr-Sept 2019 was unflagged, which was primarily due to one or more input data streams being flagged. Despite this, over 100,000 unflagged half-hourly soil CO_2 flux data points were generated during this 6 month period, which is equivalent to ~6 site-years of continuous flux data.

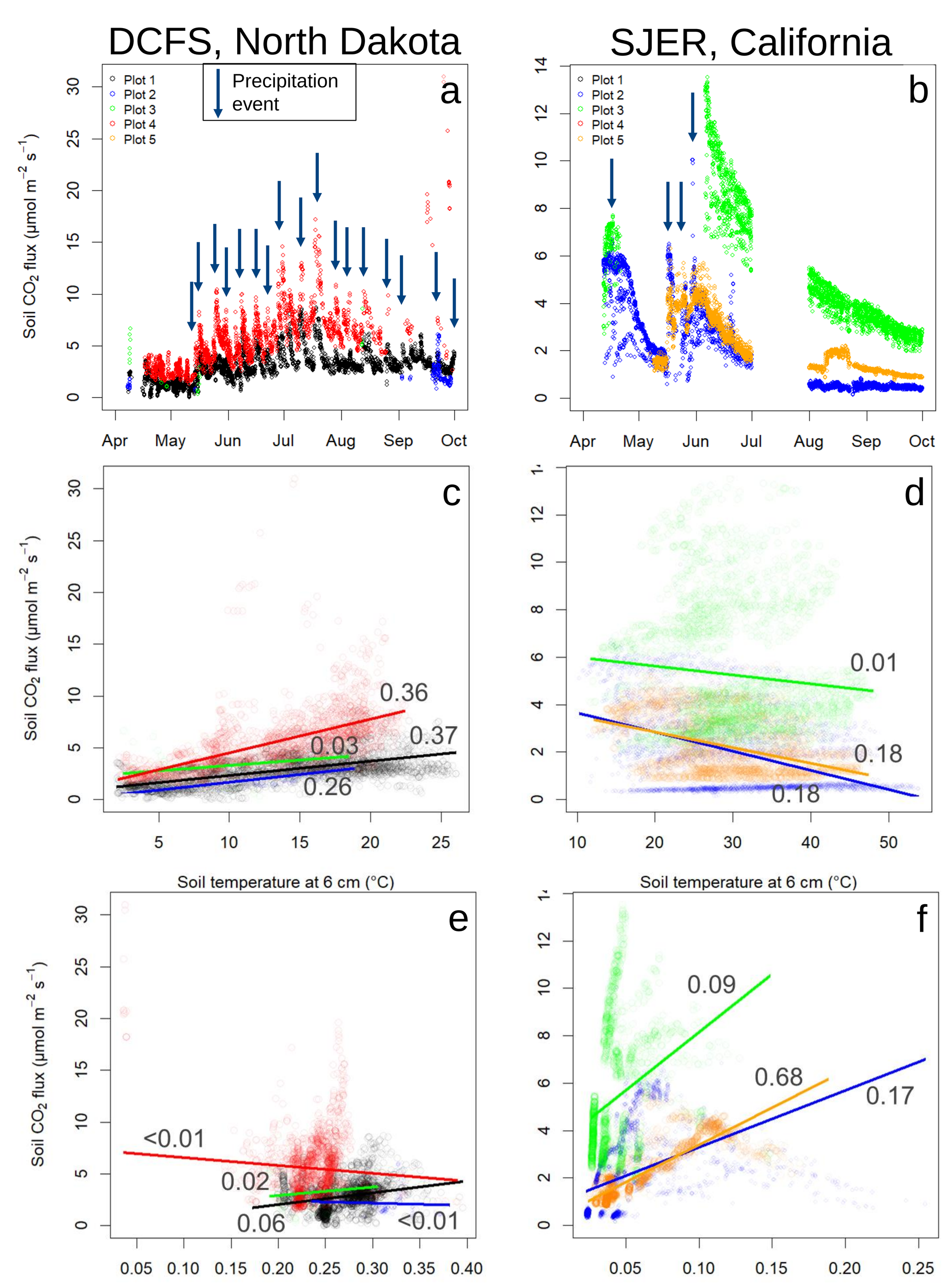

Figure 2. Soil respiration at DCFS (a) and SJER (b). Colors represent the different soil plots at each site. Soil respiration versus soil temperature (c & d) and soil moisture (e & f) are shown with a regression annotated with the proportion of variation explained.

Flux data from two sites (DCFS, ND, and SJER, CA) are shown in Figure 2. DCFS is a grassland with cold winters and warm humid summers. While SJER is an open canopy oak-grassland site with cool wet winters and hot dry summers. At DCFS soil respiration was positively correlated with soil temperature and unrelated to moisture in most soil plots (Fig. 2).

RESULTS cont.

In contrast, at SJER respiration was either negatively related or unrelated to temperature, but positively related to moisture (Fig. 2). This is consistent with expected relationships to climate at these sites.

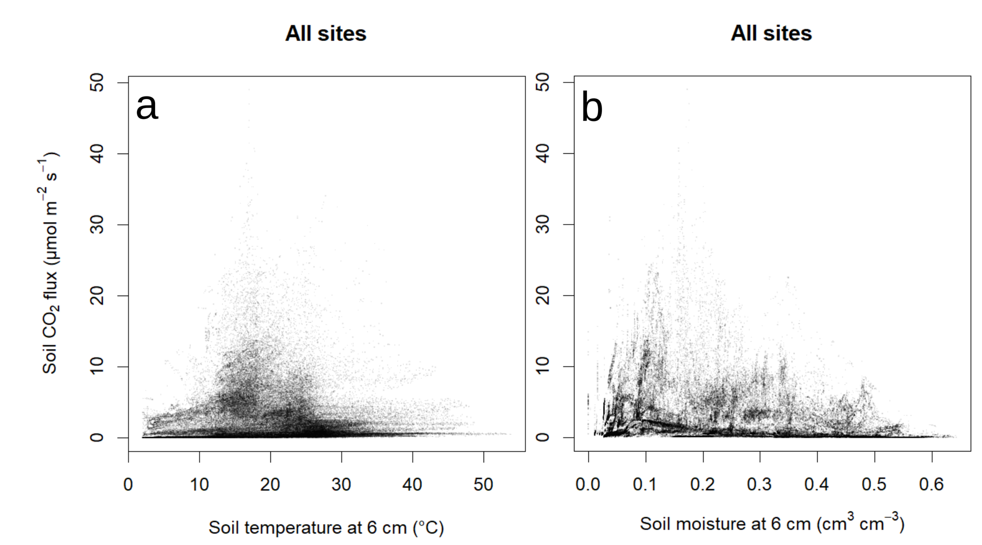

Figure 3. Soil respiration data from all sites and soil plot plotted against soil temperature (a) and moisture (b).

Across all sites soil temperature and moisture only explained 34% of the variation in respiration (Fig. 3), indicating that other properties must also be important in controlling respiration at this scale.

CONCLUSION

Soil respiration data product

The soil CO_2 flux data product seems plausible in terms of the magnitude of the fluxes, their seasonality, and relationship to temperature and moisture. This suggests that they are accurate, but further validation is required.

Controls on soil respiration

Temperature and moisture only explain about one third of the variation in soil respiration. The role of other potentially controlling factors requires further investigation, with many relevant types of data available from NEON, including photosynthetic rates, root biomass, microbial biomass and community composition, and soil organic matter content.

ACKNOWLEDGEMENTS

The NEON Soil Sensor Technical Working Group and Jim Tang encouraged the development of the soil respiration data product. Hundreds of scientists have been involved in the design, establishment, and operation of NEON.

This material is based upon work supported by NSF's National Ecological Observatory Network which is a major facility fully funded by the National Science Foundation.