Measuring Very Small Soil Fluxes of N2O & CH4 using a New OF-CEAS Technology

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Abstract

N_2O and CH_4 soil flux studies traditionally consider certain time periods and certain ecosystems to be of low importance due to very small or negligible expected flux rates. Periods of such "negligible" fluxes are rarely reported because small fluxes are hard to resolve, measurements are costly, time-consuming, and often take a lot of power. "Negligible" flux sites are also rarely studied because small fluxes are hard to resolve, measurements are time-consuming and costly, and it is hard to get funding to measure something when the error bars cross zero. However, such fluxes may not be negligible in time when multiplied by long time duration, for example, 340 out of 365 days per year. Similarly, these may not be negligible in space when multiplied by a large area. When GHG budgets are of interest, very small fluxes multiplied by hundreds of days or square kilometers, or both, could easily exceed large fluxes multiplied by few days or square kilometers. The new OF-CAES technology [1-7] has very low minimum detectable flux which may help make more of such measurements valuable and valid in both time and space. The presentation will demonstrate the field data on the N_2O and CH_4 soil flux performance of this new technology. Conceptual simulations will demonstrate the significant advantages of using the technology when measuring small N_2O and CH_4 fluxes over time and space. References: [1] Burba, 2021. Eddy Covariance Method for Scientific, Regulatory, and Commercial Applications. LI-COR Biosciences, 660 pp (under review) [2] Burba, 2021. Atmospheric Flux Measurements. In Advances in Spectroscopic Monitoring of the Atmosphere. Elsevier Science, 618 pp [3] Koulikov and Kachanov, 2014. Laser-based cavity-enhanced optical absorption gas analyzer with laser feedback optimization. US Patent 8659758 [4] Leggett et al, 2019. Development of Trace CH_4 and CO_2 Analyzers: Performance Evaluation Studies, GCWerks Integration, and Field Results. AGUFM [5] Minish et al, 2019. New High-Precision Low-Power CO_2 and CH_4 Analyzers for Multiple Applications. Geophysical Research Abstracts, Vol. 21 [6] Romanini et al, 2014. Introduction to cavity-enhanced absorption spectroscopy. In Cavity-Enhanced Spectroscopy and Sensing. Springer, 546 pp [7] Xu et al, 2020. How do soil temperature and moisture regulate N_2O flux from an urban lawn? AGUFM

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Abstract Text:

N_2O and CH_4 soil flux studies traditionally consider certain time periods and certain ecosystems to be of low importance due to very small or negligible expected flux rates. Periods of such “negligible” fluxes are rarely reported because small fluxes are hard to resolve, measurements are costly, time-consuming, and often take a lot of power. “Negligible” flux sites are also rarely studied because small fluxes are hard to resolve, measurements are time-consuming and costly, and it is hard to get funding to measure something when the error bars cross zero.

However, such fluxes may not be negligible in time when multiplied by long time duration, for example, 340 out of 365 days per year. Similarly, these may not be negligible in space when multiplied by a large area. When GHG budgets are of interest, very small fluxes multiplied by hundreds of days or square kilometers, or both, could easily exceed large fluxes multiplied by few days or square kilometers.

The new OF-CAES technology [1-7] has very low minimum detectable flux which may help make more of such measurements valuable and valid in both time and space. The presentation will demonstrate the field data on the N_2O and CH_4 soil flux performance of this new technology. Conceptual simulations will demonstrate the significant advantages of using the technology when measuring small N_2O and CH_4 fluxes over time and space.

References:

[1] Burba, 2021. Eddy Covariance Method for Scientific, Regulatory, and Commercial Applications. *LI-COR Biosciences*, 660 pp *(under review)*

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[4] Leggett et al, 2019. Development of Trace CH_4 and CO_2 Analyzers: Performance Evaluation Studies, GCWerks Integration, and Field Results. *AGUFM*

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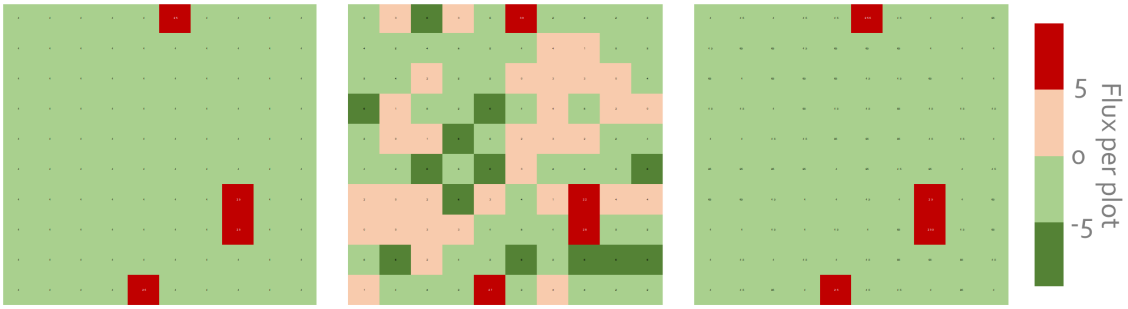
Concept of Resolving Very Small Fluxes over Space



- Here we show a simulated dataset over an area consisting of 100 small plots with a very small gas consumption of -1 units per plot in most plots, and with large gas releases of 25 units per plots in a few plots
- This would be a proxy for a typical situation for a desert or forest environments with a few wetlands (for CH_4), or for a mixed-use fertilized agricultural field with unfertilized pastures and other areas (for N2O)
- The true flux is shown on the left map, the flux measured with a large random error of +/-5 is shown in the middle, and the flux with a much smaller random error of +/-0.5 is shown in the right map above
- The sum of fluxes over each area in these examples was 4 for true flux, -56 for the flux measured with a large random error, and 4.5 for a flux measured with a small random error
- The measurements with errors exceeding the typical fluxes from most of the area have led to over -1000% error, and indeed could not be used when measuring over such territories
- The new OF-CEAS technology is closer to what is shown on the right map and may be used for such measurements over many more territories than traditional technologies

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