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Carbonyl Sulfide for Tracing Carbon Fluxes Field Campaign Report

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Acronyms and Abbreviations

ARM	Atmospheric Radiation Measurement Climate Research Facility
COS	carbonyl sulfide
DOE	U.S. Department of Energy
GPP	gross primary productivity
Hz	hertz
SGP	Southern Great Plains, an ARM megasite
TES	Terrestrial Ecosystem Science, a DOE program

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1.0 Background

The April-June 2012 campaign was located at the U.S. Department of Energy (DOE)'s Atmospheric Radiation Measurement (ARM) Climate Research Facility Southern Great Plains (SGP) site Central Facility and had three purposes. One goal was to demonstrate the ability of current instrumentation to correctly measure fluxes of atmospheric carbonyl sulfide (COS). The approach has been describe previously as a critical approach to advancing carbon cycle science1,2, but requires further investigation at the canopy scale to resolve ecosystem processes. Previous canopy-scale efforts were limited to data rates of 1Hz. While 1 Hz measurements may work in a few ecosystems, it is widely accepted that data rates of 10 to 20 Hz are needed to fully capture the exchange of traces gases between the atmosphere and vegetative canopy. A second goal of this campaign was to determine if canopy observations could provide information to help interpret the seasonal double peak in airborne observations at SGP of CO_2 and COS mixing ratios. A third goal was to detect potential sources and sinks of COS that must be resolved before using COS as a tracer of gross primary productivity (GPP).

2.0 Notable Events or Highlights

The campaign provided the first canopy-scale observations of the COS fluxes. These measurements confirmed the expectation from laboratory leaf chamber studies that the normalized relative uptake of COS to CO_2 by plants ranges from 1 to 2 and that plant uptake is generally the dominant COS surface flux for the growing seasons. However, the campaign also found an unexpected net ecosystem source of COS at high temperatures that may contribute to the double peak observed in airborne observations (Figure 1).

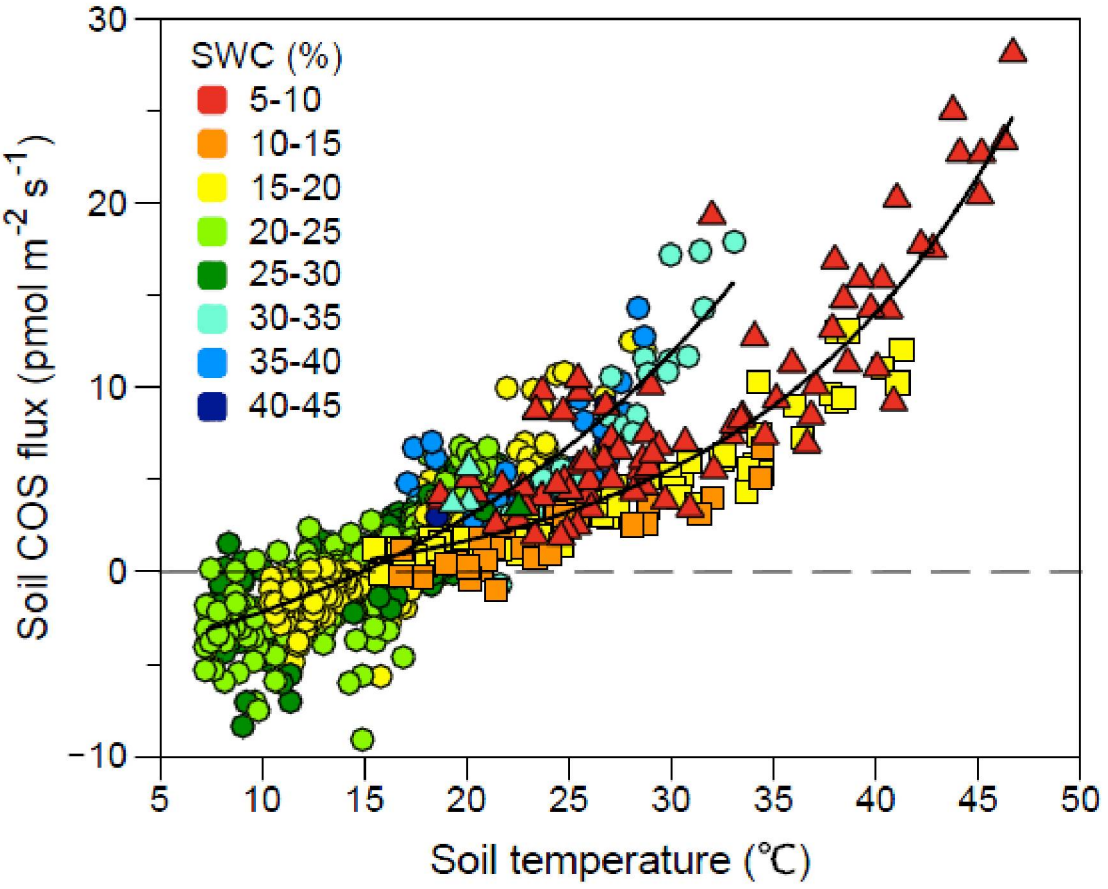

Figure 1. Relationship of soil COS flux to soil temperature observations at the ARM SGP Central Facility.

3.0 Lessons Learned

This experiment confirms the approach that continental GPP can be constrained by COS observations from airborne and tall tower platforms. This is the most important objective as there currently are relatively few observational constraints on gross carbon fluxes at regional scales.

COS has also been proposed as a tracer for partitioning fluxes at the canopy scale for eddy flux sites. Our results indicate that more information may be needed about local COS ecosystem sources of COS to ensure the validity of this application.

4.0 Results

The results of this campaign (described above) were communicated through two scientific publications and several presentations at the AGU Fall Meeting, DOE Terrestrial Ecosystem Science (TES) meeting, and Ameriflux meeting3,4.

5.0 Publications

5.1 Journal Articles/Manuscripts

Maseyk, K, JA Berry, D Billesbach, JE Campbell, MS Torn, M Zahniser, and U Seibt. "Sources and sinks of carbonyl sulfide in an agricultural field in the Southern Great Plains." 2014. *Proceedings of the National Academy of Sciences of the United States of America* 111(25): 9064-9069, doi:10.1073/pnas.1319132111.

Billesbach, D, JA Berry, U Seibt, K Maseyk, MS Torn, ML Fischer, M Abu-Naser, and JE Campbell. 2014. "Growing season eddy covariance measurements of carbonyl sulfide and CO_2 fluxes: COS and CO_2 relationships in Southern Great Plains winter wheat." *Agricultural and Forest Meteorology* 184: 48-55, doi:10.1016/j.agrformet.2013.06.007.

5.2 Meeting Abstracts/Presentations/Posters

Berry, JA, JE Campbell, IT Baker, SA Montzka, and SR Kawa SR. "Using atmospheric measurements of carbonyl sulfide to constrain conductance." In *AGU Fall Meeting Abstracts 2009* December (Vol. 1, p. 07).

Maseyk, KS, U Seibt, JA Berry, DP Billesbach, J Campbell, and MS Torn. "Strong soil source of carbonyl sulfide in an agricultural field." In *AGU Fall Meeting Abstracts 2012* December (Vol. 1, p. 04).

Abu-Naser, M, JE Campbell, and JA Berry. "Regional-scale carbon flux partitioning using atmospheric carbonyl sulfide." In *AGU Fall Meeting Abstracts 2011* (Vol. 1.).

Seibt, UH, KS Maseyk, C Lett, W Sun, JA Berry, DP Billesbach, J Campbell, and MS Torn. "Ecosystem and soil fluxes of carbonyl sulfide (COS) and CO_2 to constrain rates of gross photosynthesis." In *AGU Fall Meeting Abstracts 2013* December (Vol. 1, p. 05).

Campbell JE, JA Berry, U Seibt, SJ Smith, and SA Montzka. "Atmospheric carbonyl sulfide constraints on terrestrial carbon cycling in the C4MIP models." In *AGU Fall Meeting Abstracts 2012* December (Vol. 1, p. 0487).

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6.0 References

1 Berry, J, A Wolf, JE Campbell, I Baker, N Blake, D Blake, AS Denning, SR Kawa, SA Montzka, U Seibt, K Stimler, D Yakir, and Z Zhengxin. 2013. "A coupled model of the global cycles of carbonyl sulfide and CO_2: A possible new window on the carbon cycle." *Journal of Geophysical Research: Biogeosciences* 118(2): 8428521, doi:10.1002/jgrg.20068.

2 Campbell, JE, GR Carmichael, T Chai, M Mena-Carrasco, Y Tang, DR Blake, NJ Blake, SA Vay, GJ Collatz, I Baker, JA Berry, SA Montzka, C Sweeney, JL Schnoor, and CO Stainier. 2008. "Photosynthetic

control of atmospheric carbonyl sulfide during the growing season." *Science* 322(5904): 1085-1088, doi:10.1126/science.1164015.

3 Billesbach, D, JA Berry, U Seibt, K Maseyk, MS Torn, ML Fischer, M Abu-Naser, and JE Campbell. 2014. "Growing season eddy covariance measurements of carbonyl sulfide and CO_2 fluxes: COS and CO_2 relationships in Southern Great Plains winter wheat." *Agricultural and Forest Meteorology.* 184: 48-55, doi:10.1016/j.agrformet.2013.06.007.

4 Maseyk, K, JA Berry, D Billesbach, JE Campbell, MS Torn, M Zahniser, and U Seibt. 2014. "Sources and sinks of carbonyl sulfide in an agricultural field in the Southern Great Plains." *Proceedings of the National Academy of Sciences of the United States of America* 111: 9064-9069, doi:10.1073/pnas.1319131111.

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