A Global Database of Gas Fluxes from Soils after Rewetting or Thawing, Version 1.0

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Revision date: March 28, 2012

Summary

This database contains information compiled from published studies on gas flux from soil following rewetting or thawing. The resulting database includes 222 field and laboratory observations focused on rewetting of dry soils, and 116 field laboratory observations focused on thawing of frozen soils studies conducted from 1956 to 2010. Fluxes of carbon dioxide, methane, nitrous oxide, nitrogen oxide, and ammonia (CO_2, CH_4, N_2O, NO and NH_3) were compiled from the literature and the flux rates were normalized for ease of comparison. Field observations of gas flux following rewetting of dry soils include events caused by natural rainfall, simulated rainfall in natural ecosystems, and irrigation in agricultural lands. Similarly, thawing of frozen soils include field observations of natural thawing, simulated freezing-thawing events (i.e., thawing of simulated frozen soil by snow removal), and thawing of seasonal ice in temperate and high latitude regions (Kim et al., 2012). Reported parameters include experiment type, location, site type, vegetation, climate, soil properties, rainfall, soil moisture, soil gas flux after wetting and thawing, peak soil gas flux properties, and the corresponding study references. There is one comma-delimited data file.

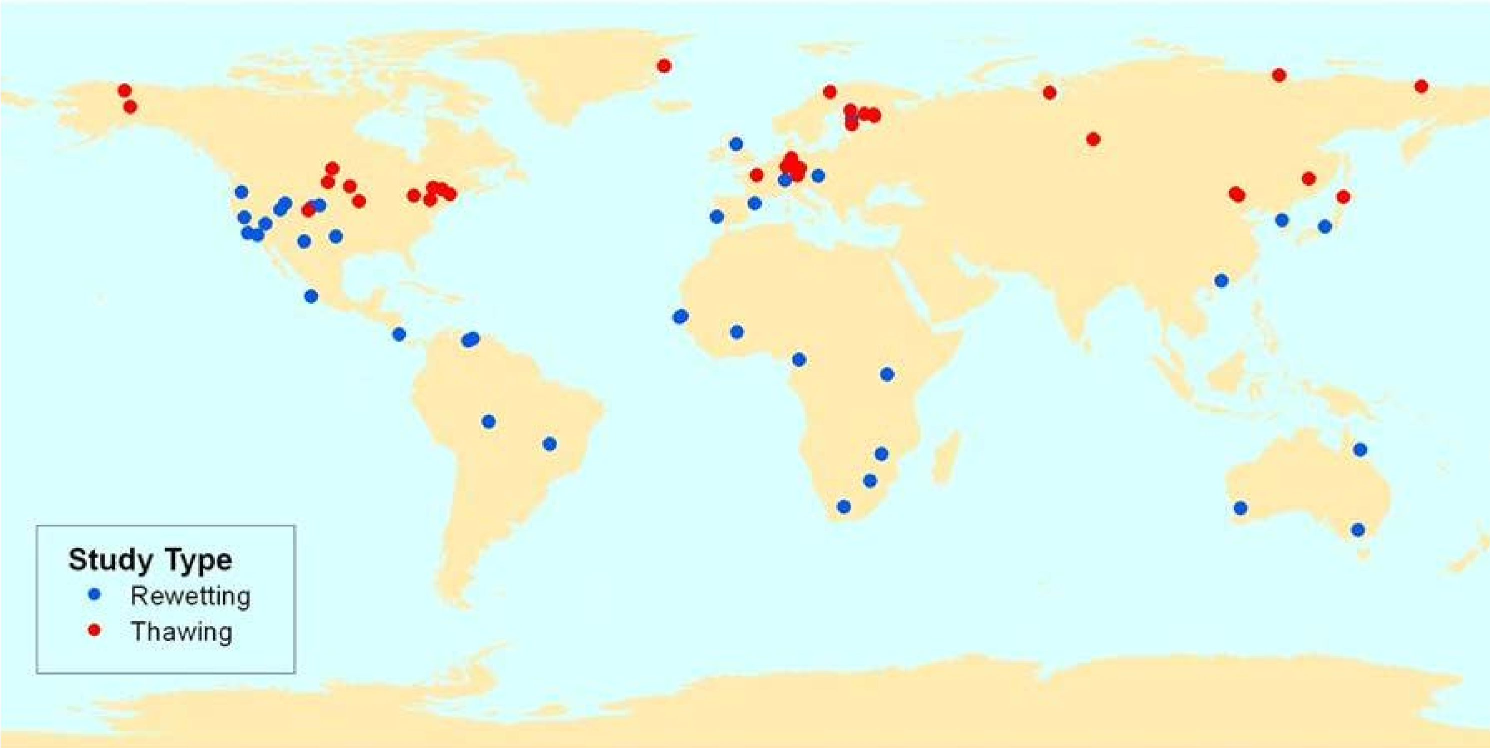

Figure 1. Location of 215 out of 338 cited database observations.

The compilers of the Rewetting, Thawing, and Soil Gas flux (RTSG) database (Kim, D.-G., et al., 2012) make it available to the scientific community both as a traditional static archive (ORNL DAAC) and as a dynamic community database that may be updated over time by interested users.

The dynamic version of the database is hosted on Google Docs:
https://spreadsheets.google.com/ccc?key=0AjWu6bR8SA9idHY4Tk5TdDZDMWgtMEJsUVhFOWhKLWc&hl=en.

The compilers have created a Blog entitled "Rewetting, thawing and soil gas fluxes" (http://rewettingandthawing.blogspot.com/), to provide a place where the scientific community can share and update the fast growing knowledge and data on the study of the effects of rewetting and thawing on CO_2, CH_4, N_2O, NO and NH_3 fluxes.

The ORNL DAAC will update the database on an annual basis to incorporate changes and additions submitted by the RTSG community via the Google Code site and by Kim, D.-G., R. Vargas, B. Bond-Lamberty, and M. R. Turetsky.

Transaction logs for the RTSG-data files will be maintained.

ORNL DAAC Version Record

RTSG Version	ORNL DAAC Release Date	Studies Included	Records	Date Range	Date Superseded
Version 1.0	2012/04/10	126	338	1956-2010	First archived version

Data Citation:

Cite this data set as follows:

Kim, D.-G., R. Vargas, B. Bond-Lamberty, and M. R. Turetsky. 2012. A Global Database of Gas Fluxes from Soils after Rewetting or Thawing, Version 1.0. Data set. Available on-line [http://daac.ornl.gov] from Oak Ridge National Laboratory Distributed Active Archive Center, Oak Ridge, Tennessee, U.S.A. http://dx.doi.org/10.3334/ORNLDAAC/1078

Table of Contents:

1. Data Set Overview:

Project: Effects of soil rewetting and thawing on soil gas fluxes: a review of current literature and suggestions for future research.

This database contains information compiled from published studies on gas flux from soil following rewetting or thawing. The resulting database includes 222 field and laboratory observations focused on rewetting of dry soils, and 116 field laboratory observations focused on thawing of frozen soils studies conducted from 1956 to 2010. Fluxes of CO_2, CH_4, N_2O, NO and NH_3 were compiled from the literature and the flux rates were normalized for ease of comparison. Field observations of gas flux following rewetting of dry soils include events caused by natural rainfall, simulated rainfall in natural ecosystems, and irrigation in agricultural lands.

2. Data Characteristics:

Data are presented in one comma-delimited ASCII file: **global_rtsg_flux_v1.csv**

File name note: data worksheet will be saved as a .csv file for archiving and renamed.

Missing values are represented by blank cells.

Column	Heading	Units/format	Description
1	RecID		Record Identification
2	Gas		Gas Type (CO2, CH4, N2O, NO, NH3)
3	ChangeType		Change Type (Rewetting, Thawing)
4	Experiment_type		Experiment Type (Field, Lab)
5	Experiment_type_note		Experiment Type Notes (e.g. Rainfall exclusion)
6	Date	(format varies by study)	Date Sampled/Data collected (seldom provided)
7	Location		Study Location
8	Lat	decimal degree; positive=north negative=south	Latitude (Not always provided)
9	Long	decimal degree; positive=east negative=west	Longitude (Not always provided)
10	Elevation Site_type	m	Elevation
11	Site_type		Site Type (e.g. Forest, Grasslands, Crop field)
12	Vegetation		Vegetation (e.g. Scots pine, Norway Spruce)
13	MAT	degree C	Mean annual temperature as reported in study
14	MAP	mm	Mean annual temperature as reported in study
15	Soil_type		Soil description (classification and texture)
16	Soil_BD	g/cm3	Soil bulk density
17	Soil_C	%	Soil Carbon
18	Soil_N	%	Soil Nitrogen
19	Soil_pH		Soil pH
20	Soil_pH_notes		Soil pH Notes
21	Rainfall	mm	Amount of natural or simulated precipitation during a rewetting event.
22	T_incubation	degree C	Incubation temperature
23	T_soil_pre	degree C	Soil Temperature before manipulation
24	T_soil_post	degree C	Soil Temperature after manipulation
25	SM_pre	Varies	Soil Moisture before Rewetting/Thawing Event
26	SM_post	As reported in individual studies.	Soil Moisture after Rewetting/Thawing Event
27	SM_change	As reported in individual studies. See Flux-units	Soil Moisture change as result of Rewetting/Thawing Event
28	Flux_pre_raw	As reported in individual studies. See Flux-units	Reported Flux measurement before Rewetting/Thawing Event (character field)
29	Flux_post_raw	As reported in individual studies. See Flux-units	Reported Flux measurement after Rewetting/Thawing Event (Character field)
30	Flux_pre	As reported in individual studies. See Flux-units	Extracted Flux measurement before Rewetting/Thawing Event (Numeric field)
31	Flux_post	As reported in individual studies. See Flux-units	Extracted Flux measurement after Rewetting/Thawing Event (Numeric field)
32	Flux_units	As reported in individual	Flux units for extracted Flux measurements before/after Rewetting/Thawing

		studies.	Event
33	Conversion		Conversion factor for Flux measurements from as reported units to normalized units. Flux_pre/ Flux_post converted to Flux_pre_norm/Flux_post_norm. See also companion file **unit_conversion_table_v1.csv**
34	Flux_pre_norm	See Flux_norm_units	Normalized Flux measurements before Rewetting/Thawing Event
35	Flux_post_norm	See Flux_norm_units	Normalized Flux measurements after Rewetting/Thawing Event
36	Flux_units	mg gas/kg/hr or mg gas/m2/hr	Flux Normalized units for Flux_pre_norm and Flux_post_norm values
37	Flux_change	%	Amount of change in Flux because of Rewetting/Thawing Events
38	Flux_change_notes		Flux change notes
39	Cumulative_flux_during_peak	As reported in individual studies.	Cumulative Flux during peak period (See Figure 1)
40	Peak_lag	hrs	(Lag time) Amount of time peak flux occurred after thawing
41	Duration	hrs	The duration of enhanced flux of soil gas fluxes following soil rewetting and thawing in field and laboratory experiments
42	Annual_budget_contrib	%	Annual Budget Contributions. See referenced study.
43	Surplus_emissions	As reported in individual studies.	Surplus Emissions. See referenced study.
44	Notes		Notes
45	Ref_short		Reference (Short)
46	Ref_long		Reference

Example Data Records:

```
RecID,Gas,ChangeType,Experiment_type,Experiment_type_notes,Date,Location,Lat,Long,Elevation,Site_type,Vegetation,
MAT,MAP,Soil_type,Soil_BD,Soil_C,Soil_N,Soil_pH,Soil_pH_notes,Rainfall,T_incubation,T_soil_pre,T_soil_post,SM_pre,
SM_post,SM_change,Flux_pre_raw,Flux_post_raw,Flux_pre,Flux_post,Flux_units,Conversion,Flux_pre_norm,Flux_post_norm,
Flux_norm_units,Flux_change,Flux change_notes,Cumulative_flux_during_peak,Peak_lag,Duration,Annual_budget_contrib,
Surplus_emissions,Notes,Ref_short,Ref_long
....
1,CH4,Rewetting,Field,,,"Sidney, NE, USA",41.233,-103,1311,Cropland (winter wheat-fallow tillage management system/no
till/autumn 1995),,8.5,411,"Duroc loam (a fine-silty, mixed, mesic Pachic Haplustoll)",1,3.2,0.29,6.9,6.9,,,,,,,,15.1 +/- 4.1 g
C ha-1 d-1,,-15.1,,g C/ha/day,0.0056,-0.084,,mg gas/m2/hr,76,76,,,,,,,"Kessavalou et al., 1998","Kessavalou, A., Doran, J.W.,
Mosier, A.R., Drijber, R.A., 1998. Greenhouse gas fluxes following tillage and wetting in a wheat-fallow cropping system.
Journal of Environmental Quality 27, 1105-1116. http://jeq.scijournals.org/cgi/content/abstract/27/5/1105"
....
169,NO,Rewetting,Field,Rainfall simulation,,"20 km south of Brasilia, District Federal, Brazil",-15.933,-47.851,,Savana_burned,
dense scrub of shrubs and trees,,1350,,,6.06,0.32,4.17,4.17,10,,,,,,,10 ng N m-2 s-1*,110 ng N m-2 s-1*,10,110,ng N/m2/s,0.0077,
0.077,0.849,mg gas/m2/hr,1000,,,,,,,,"Poth et al., 1995","Poth, M., Anderson, I., Miranda, H., Miranda, A., Riggan, P., 1995.
The magnitude and persistence of soil NO, N2O, CH4, and CO2 fluxes from burned tropical savanna in Brazil. Global
Biogeochemical Cycles 9, 503-513. doi:10.1029/95GB02086 "
....
338,NO,Thawing,Lab,,,"Xilin River catchment, Inner Mongolia, China",,,,Marshland,"Phragmites australis, Carex appendiculata,
Iris lactea var. chinensis and Hippuris vulgaris",0.8,330,sandy loam,1.315,2.575,0.28,6.85,6.3-7.4,,,-10,5,,,,< 5 ug NO m-2 h-1,15 ug NO m-2 h-
1,5,15,µg NO/m2/hr,0.0001,0,0.001,mg gas/m2/hr,200,200,,,,,,,"Yao et al., 2010","Yao, Z., Wu, X., Wolf, B., Dannenmann, M., Butterbach-Bahl, K.,
BrŸggemann, N., Chen, W., Zheng, X., 2010. Soil-atmosphere exchange potential of NO and N2O in different land use types of Inner Mongolia as
affected by soil temperature, soil moisture, freeze-thaw, and drying-wetting events. J. Geophys. Res. 115, D17116. doi:10.1029/2009jd013528."
```

Companion File: unit_conversion_table_v1.csv

Refer to the companion file for the conversion factors-- Conversion factor for Flux measurements from as reported units to normalized units. Flux_pre/ Flux_post converted to Flux_pre_norm/Flux_post_norm. See data file column 33.

Site boundaries: (All latitude and longitude given in decimal degrees)

Site (Region)	Westernmost Longitude	Easternmost Longitude	Northernmost Latitude	Southernmost Latitude	Geodetic Datum
Global (point)	-149.633	160.525	74.50	-36.45	unknown

Time period:

- The data set covers the period 1956 to 2009

3. Data Application and Derivation:

Rewetting and thawing events are important short-term transitional phenomena in terms of hydrology and the thermodynamics of soil systems. Through this review and the compiled database, investigators identified that major soil gases such as CO_2, CH_4, N_2O, NO, and NH_3 are influenced substantially by these events. The mechanisms that control these fluxes during rewetting and thawing events are not fully understood, but are critical for our understanding of C and N dynamics and land-atmosphere gas exchange.

Specifically investigators noted that there is a lack of studies on CH_4, NO, and NH_3 fluxes. Future climatic change is likely to alter the frequency and intensity of drying-rewetting events and thawing of frozen soils. Thus, rewetting and thawing events could become more critical for land-atmosphere gas exchange and may be more important to incorporate in biogeochemical models. Advancements in this research field are likely to come from high frequency measurements of gas fluxes, soil microbial analysis, isotope measurements, and stronger collaborations between the process-based modeling community and the experimental scientific community.

4. Quality Assessment:

Investigators research revealed that overall, the scientific community has a limited understanding both of the responses of soil gases following rewetting or thawing and of their impact on annual budgets. First, this is because of the relative few studies on this topic. Second, many studies report the magnitude of peak flux or increased rate of flux following rewetting or thawing, but often do not identify: (1) whether peak fluxes are significantly different from fluxes of pre-drought or pre-frozen periods, (2) the change in soil moisture or soil temperature, (3) the time lag between rewetting or thawing events and peak fluxes, (4) peak flux durations, (5) cumulative emissions in peak fluxes, and (6) their contributions to annual budgets. Efforts to collect such information will contribute to improving our understanding of the response of gas fluxes to rewetting and thawing events.

Changes in the relative proportion of CO_2, CH_4, N_2O, NO, and NH_3 (e.g. CO_2/CH_4) emitted following rewetting and thawing compared with that of pre-disturbance conditions are poorly understood. To report these ratios and the change, additional efforts are required to conduct multiple gases measurements. This is important since a good understanding of the variation of the relative proportion will improve our understanding of the impact of rewetting or thawing on annual gas budgets (Kim et al., 2011).

5. Data Acquisition Materials and Methods:

Data on changes in gas fluxes of CO_2, CH_4, N_2O, NO, and NH_3 following rewetting and thawing were acquired by searching existing refereed literature published between 1950 and 2010. Investigators searched using Web of Science and Google Scholar with search terms such as “rewetting”, “thawing”, “peak flux”, “peak emission”, and names of gases.

Investigators included both field and laboratory studies, but did not include studies of the longer term effects of changing active layer depths in this review, as changes in gas fluxes in response to permafrost thaw are affected by both changing soil and plant successional processes. The resulting data set includes 222 field and laboratory observations focused on rewetting of dry soils, and 116 field and laboratory observations focused on thawing of frozen soils.

For studies that reported temporal changes in gas flux rates pre- and post rewetting or thawing events in a single treatment (Fig. 2a), investigators calculated the change in gas flux rates (%) using the flux values observed before the event (i.e. rewetting or thawing) along with peak flux values that occurred post-event:

$$\text{Flux change} = \frac{(\text{Peak flux post\_event}) - (\text{Flux pre\_event}) \times 100\ \%}{(\text{Flux pre\_event})}$$

where Flux change (%) is the relative effect of the event on gas flux, Peak flux_post_event is the rate of peak gas flux following the event and Flux_pre_event is the rate of gas flux before the event (i.e. rewetting or thawing). For studies that compared gas fluxes between simulated (representing either rewetting or thawing treatments) and control treatments (Fig. 2b), investigators calculated changes in gas fluxes exactly as in Eq. (1) but using Peak flux_Exp (the rate of peak gas flux following the treatment) and Flux_Control (the rate of gas flux observed at the control at the time peak gas flux).

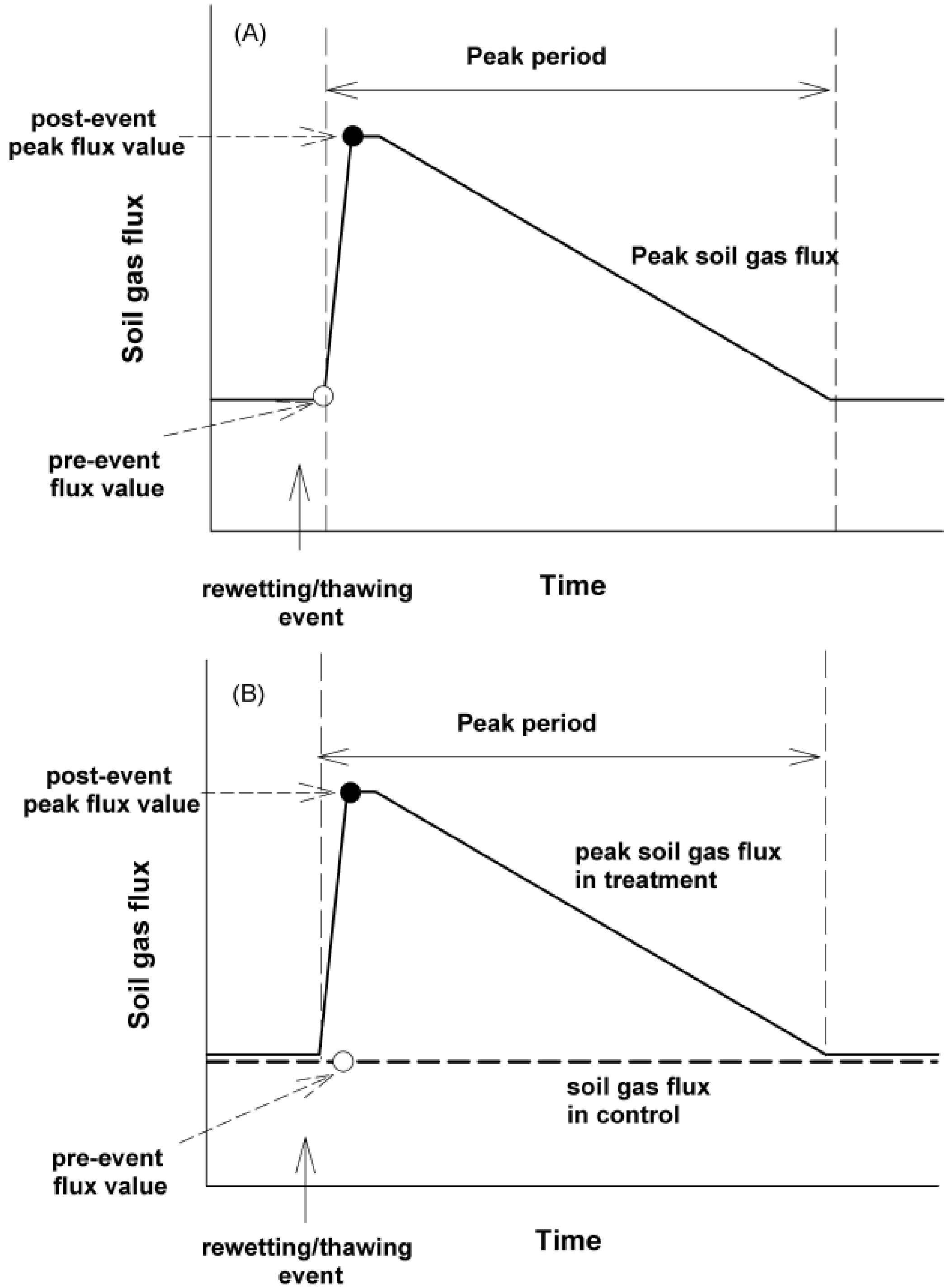

Figure 2. Hypothetical figures representing peak soil gas flux in rewetting of dry soils and thawing of frozen soils and peak flux period. (A) Peak gas flux in natural rewetting or thawing event (solid line) and pre-event flux value (white dot) and post-event peak flux value (black dot) were used to determine flux change rate; (B) peak gas flux in rewetting or thawing treatment (solid line) and gas flux in control (dashed line) and pre-event flux value (white dot, the flux value in control when post-event peak flux value is read) and post-event flux value (black dot) used to determine flux change rate.

Data on changes in gas fluxes of CO_2, CH_4, N_2O, NO, and NH_3 following rewetting and thawing were acquired by searching existing refereed literature published between 1950 and 2010. Investigators searched using Web of Science and Google Scholar with search terms such as “rewetting”, “thawing”, “peak flux”, “peak emission”, and name of gases.

Investigators included both field and laboratory studies, but did not include the longer term effects of changing active layer depths in this review, as changes in gas fluxes in response to permafrost thaw are affected by both changing soil and plant successional processes. The resulting data set includes 222 field and laboratory observations focused on rewetting of dry soils, and 116 field and laboratory observations focused on thawing of frozen soils.

Overall, change rates of CO_2, CH_4, N_2O, NO, and NH_3 fluxes of pre- and post-rewetting and thawing events were determined by fitting linear models to the relationship between flux pre-event and peak flux post-event for both rewetting and thawing events. All analyses were performed using R 2.12.1. (R Development Core Team, 2010). If gas fluxes were presented only in a figure without numeric values reported in text or tables, investigators calculated the corresponding values from the figure.

6. Data Access:

This data is available through the Oak Ridge National Laboratory (ORNL) Distributed Active Archive Center (DAAC).

Data Archive Center:

Contact for Data Center Access Information:
E-mail: uso@daac.ornl.gov
Telephone: +1 (865) 241-3952

7. References:

Kim, D.-G., Vargas, R., Bond-Lamberty, B., and Turetsky, M. R. 2012. Effects of soil rewetting and thawing on soil gas fluxes: a review of current literature and suggestions for future research, Biogeosciences, 9, 2459-2483, doi:10.5194/bg-9-2459-2012.