Working with Data: Soil Respiration at Harvard Forest

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Figure: Soil Warming Experiment at Harvard Forest. Cables are buried in different plots to heat (or not) the soil 5°C above the ambient temperature in order to determine the effect on soil CO_2 emissions. Figure Source: `http://harvardforest.fas.harvard.edu/photos/soil-warming-control-plot`

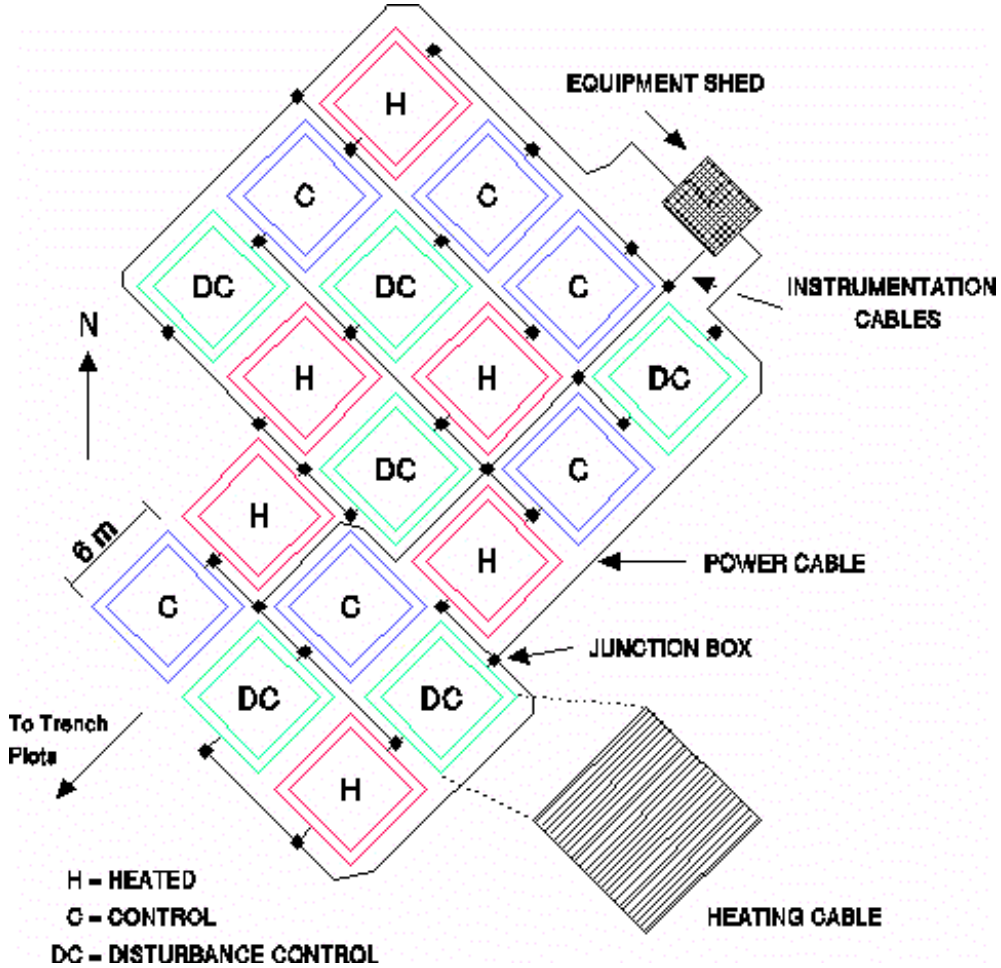

Figure: Experiment begun in 1991 consisting of 18 total plots, each 6×6 m^2, of three different types: H (heated via buried cables), C (control, undisturbed with no cables), DC (disturbed control, buried cables with no heat). DC plots used to distinguish effects from heating versus cable installation.

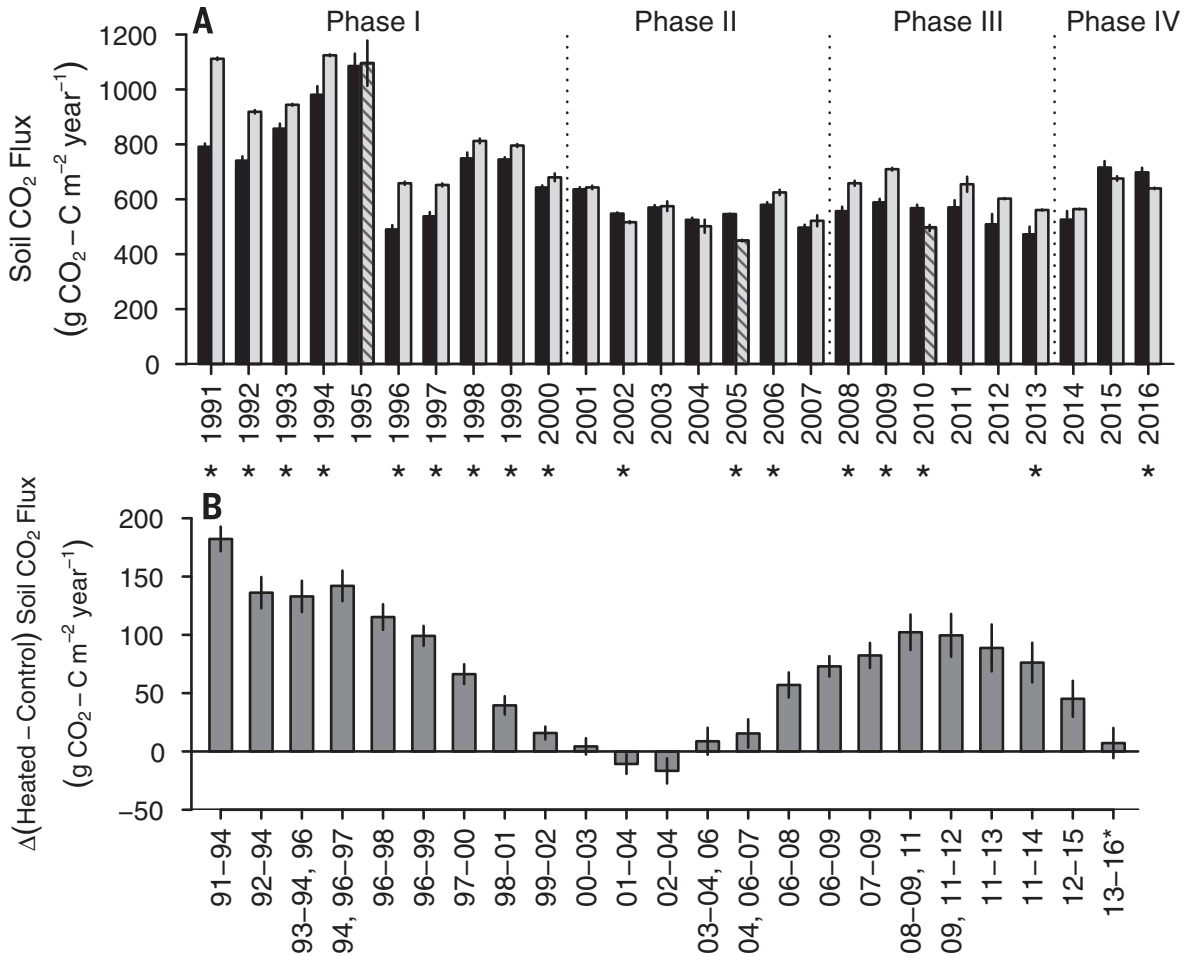

Figure: Figure 1 from "Long-term pattern and magnitude of soil carbon feedback to the climate system in a warming world," Melillo et. al., *Science* **358**, 101–105 (2017). (A) shows soil CO_2 emissions from control plots (black) compared with heated plots (gray). (B) gives the four-year rolling mean change in emissions (heated − control).

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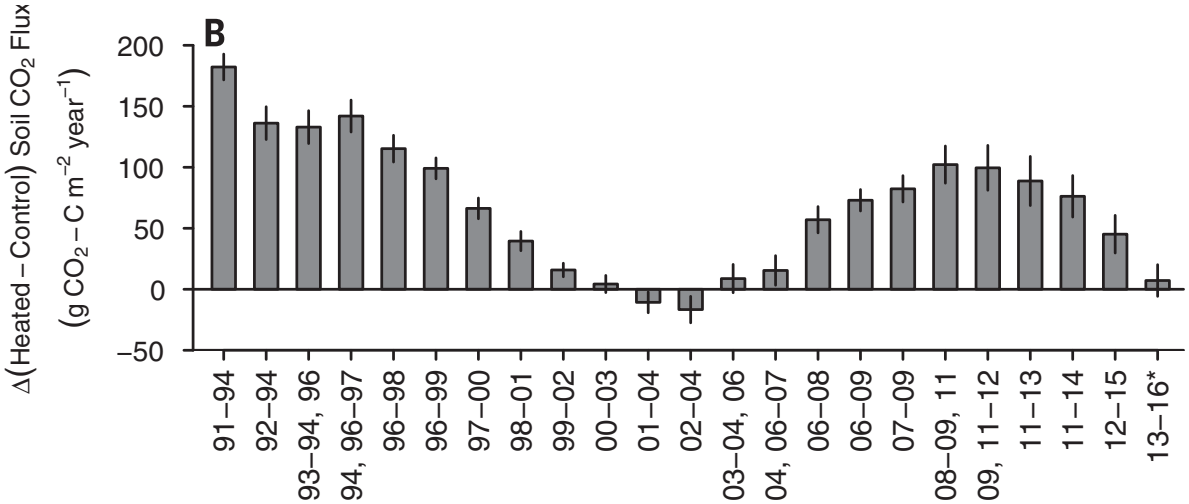
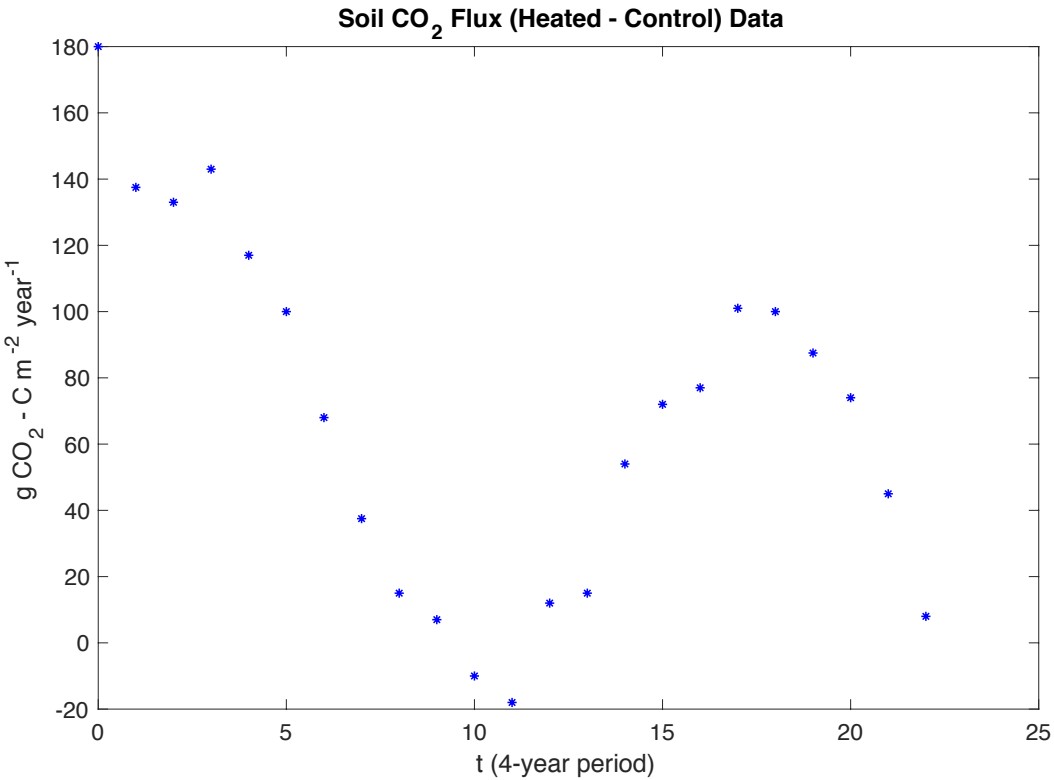
5. Over the full 26-year study, 17% of the soil carbon contained in the top 60 cm of the heated soil was lost.


B
Δ(Heated – Control) Soil CO2 Flux
(g CO2 – C m−2 year−1)
200
150
100
50
0
−50
91–94
92–94
93–94, 96
94, 96–97
96–98
96–99
97–00
98–01
99–02
00–03
01–04
02–04
03–04, 06
04, 06–07
06–08
06–09
07–09
08–09, 11
09, 11–12
11–13
11–14
12–15
13–16*


Soil CO2 Flux (Heated - Control) Data
g CO2 - C m-2 year-1
180
160
140
120
100
80
60
40
20
0
-20
0
5
10
15
20
25
t (4-year period)

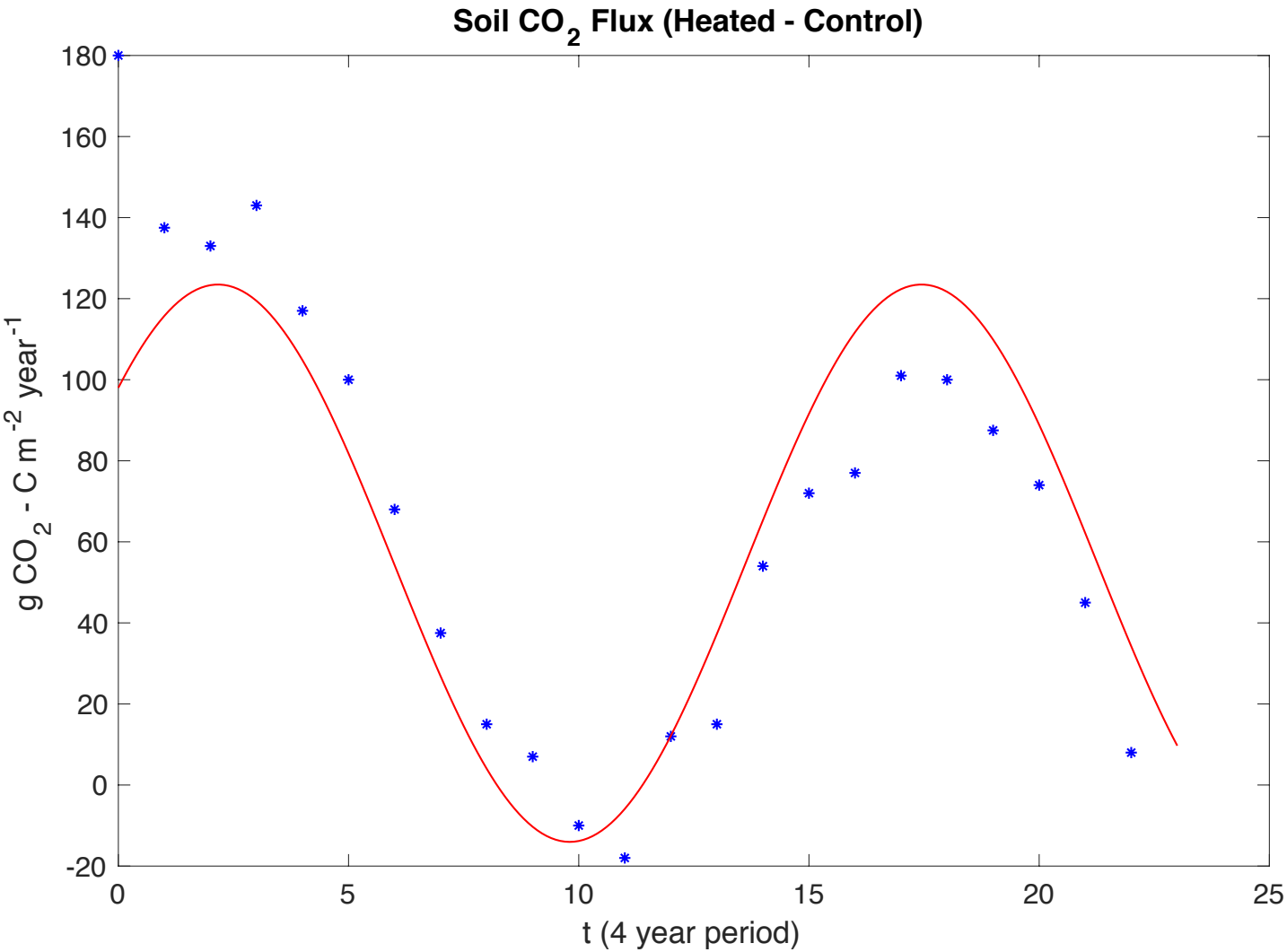


Figure: Cosine fit to soil CO_2 flux data. $F = a\cos(b(t-c)) + d$, where $a = 68.76, b = 0.41, c = 2.16$, and $d = 54.72$. The R^2-value is 0.7821 and the period of the fit is 15.28 years.

Matlab Code

```
format long;
plot(t,F,'b*');  %% Data Plot: t = years, F = CO2 flux values

per = 15.28;   %% Period; estimated to minimize R^2 value
b = 2*pi/per;

%%  Least squares approach to fit standard cosine curve
X = [cos(b*t) sin(b*t) ones(23,1)];   %% Least-squares matrix
v = inv(X'*X)*X'*F;   %% Least-squares solution

a = sqrt(v(1)^2 + v(2)^2);  %% amplitude of cosine fit
c = atan(v(2)/v(1))/b;  %% phase shift
d = v(3);   %% vertical shift

s = [0:0.1:23];
y = a*cos(b*(s-c)) + d;
plot(t,F,'b*',s,y,'r');  %% Plot of data and fit together

FHat = X*v;
Rsqrd = (norm(FHat-mean(F))/norm(F-mean(F)) )^2;
%% R^2 value is 0.7821
```