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The Rhythm of Carbon Cycle in Agricultural Ecosystems and Its Drivers: An Application of Wavelet Analysis

Yahn-Jauh Su[1,2]*, Michael Abraha[1,2,3], Jiquan Chen[2,3] and G. Philip Robertson[1,2,4] *e-mail: suyahnja@msu.edu

[1]W.K.Kellogg Biological Station, Michigan State University, Hickory Corners, MI 49060
[2]Great Lakes Bioenergy Research Center, Michigan State University, East Lansing, MI 48824
[3]Department of Geography/CGCEO, Michigan State University, East Lansing, MI 48824
[4]Department of Crop and Soil Sciences, Michigan State University, East Lansing MI 48824

I. Introduction

The carbon fluxes between ecosystem and the atmosphere are affected by biophysical factors, such as temperature, water availability and the phenology of plant. The major drivers and their effects on the components of carbon cycle, i.e. ecosystem respiration and photosynthesis, may be different among biomes underneath different climate regimes. The exploration of the relationships between carbon fluxes and their regulators are difficult since the relative importance and interactions of regulators may be different across different ecosystems and change through time (Fig. 1 & Fig. 2). In addition, the phenology of plants which respond to local climate in each year increase the complexity of the responses of photosynthesis and ecosystem respiration. Comparing the rhythm of carbon fluxes and the values of climate variables, including the frequency, relative magnitude, and the synchronization rate and time-lag may help us clarify the major driver at different temporal scales through time.

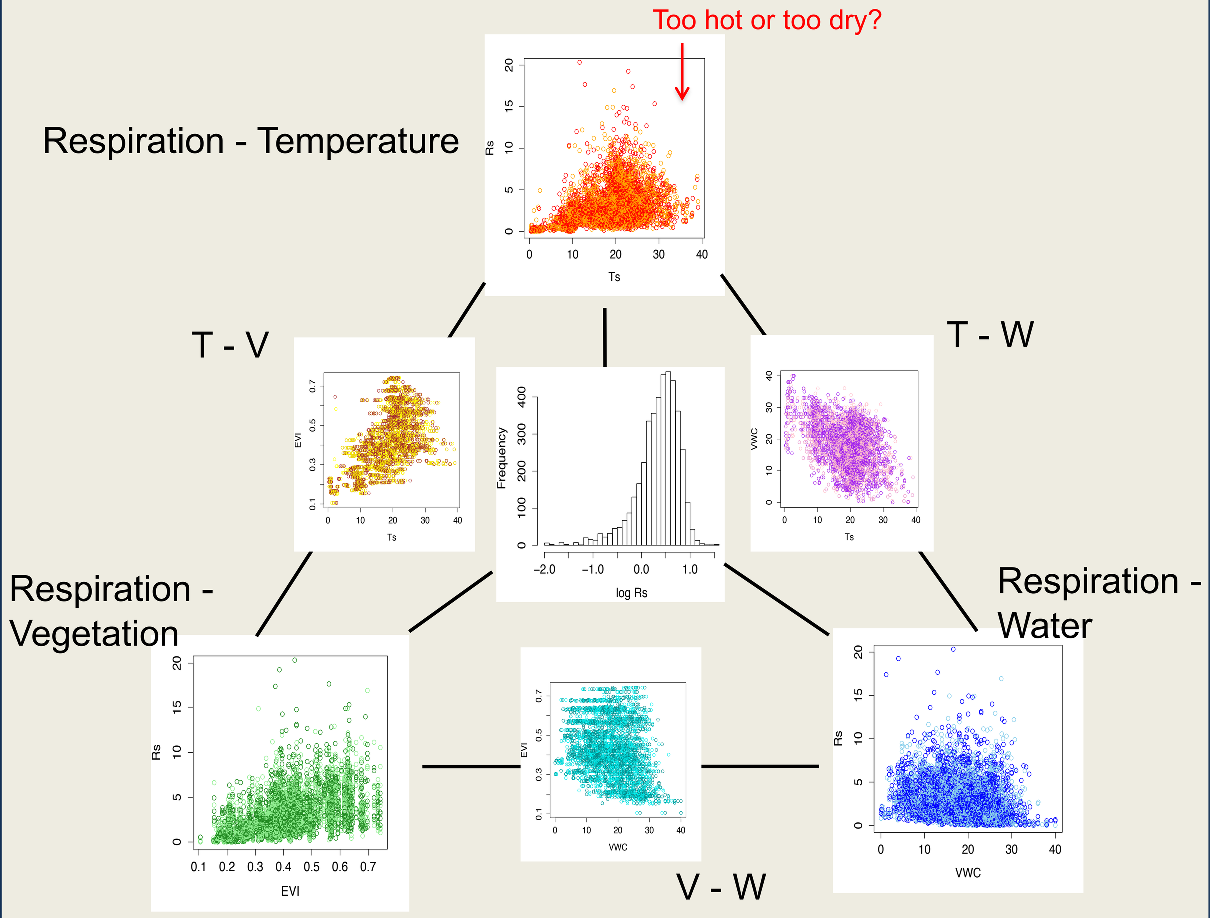


Figure 1. The confounding effects of the drivers of respiration due to the correlation between drivers.

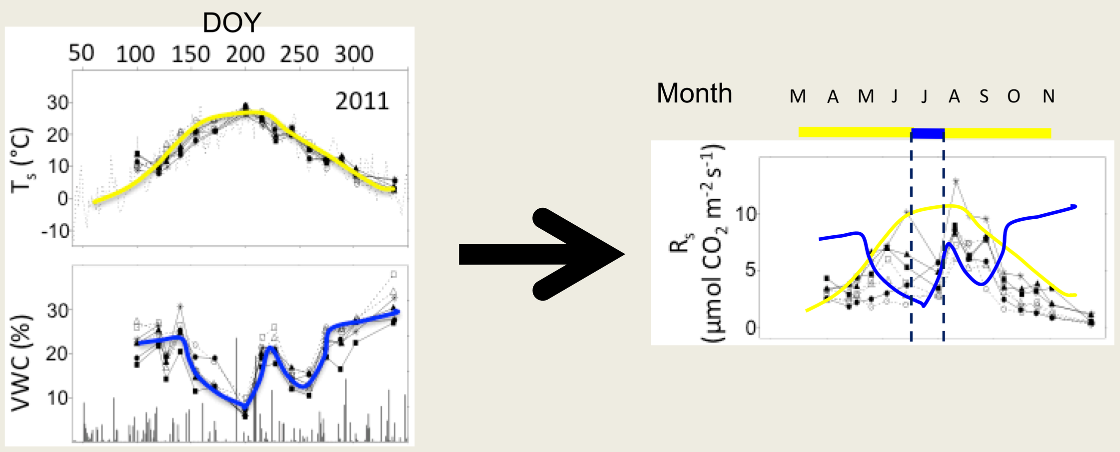
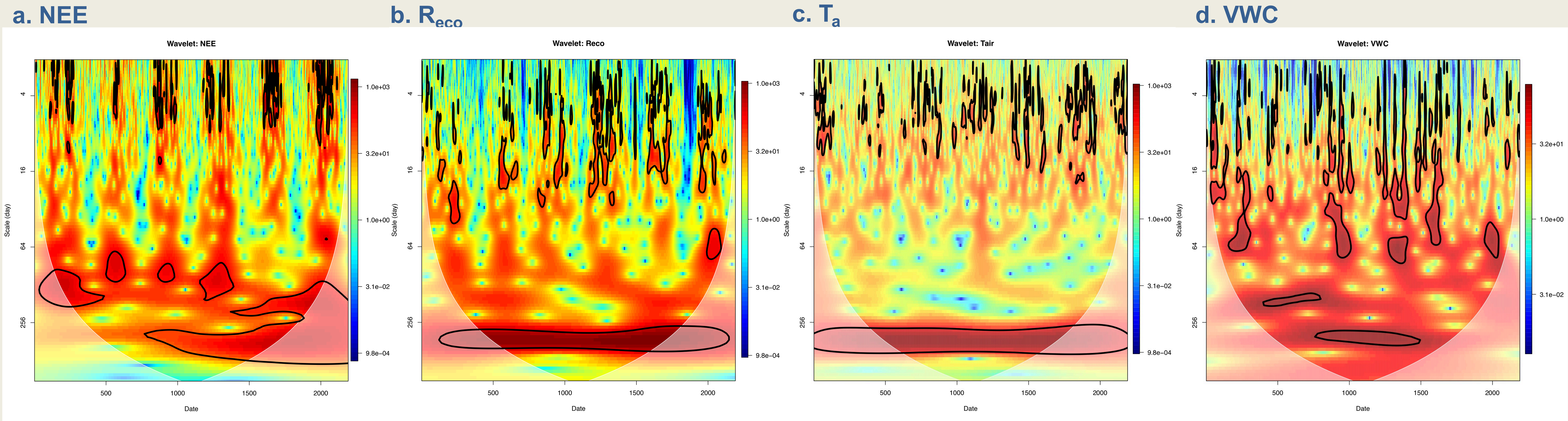


Figure 2. The major drivers of respiration at different timing of growing season. Temperature determines the respiration in most of the growing season while soil water content plays important role in late July.

III. Results

A. Wavelet transform (WT) of NEE, R_{eco}, T_a and VWC (only CRP-Pr treatment as an example)

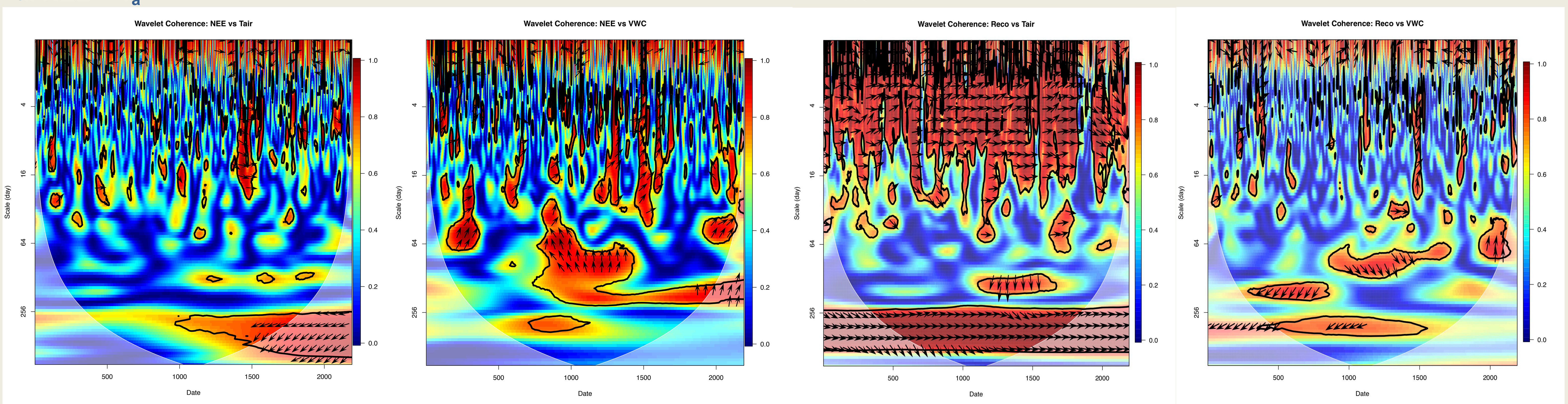
a. NEE b. R_{eco} c. T_a d. VWC



B. Wavelet transform coherence (WTC)

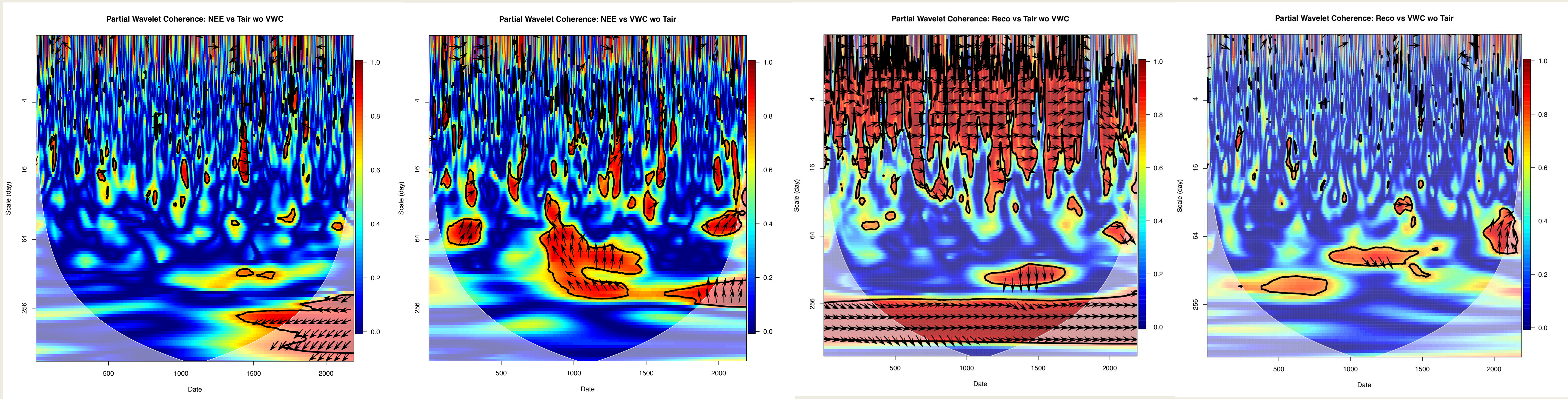
→ In-phase ↓ X leaded Y by 90° ← Anti-phase ↑ X lagged Y by 90°

a. NEE ~ T_a b. NEE ~ VWC c. R_{eco} ~ T_a d. R_{eco} ~ VWC



C. Partial wavelet coherence (PWC)

a. NEE ~ T_a without VWC b. NEE ~ VWC without T_a c. R_{eco} ~ T_a without VWC d. R_{eco} ~ VWC without T_a



II. Methods

Location

GLBRC scale-up sites of Kellogg Biological Station (42° 40'N, 85° 40'W) (Fig. 3).

Experimental design

- 3 **crops**: **corn, switchgrass & restored prairie**
- 2 **LUHs**: grassland of the Conservation Reserve Program (**CRP**) and corn-soybean rotation agricultural farms (**AGR**) (Fig. 3 & 4)
- 1 **Reference**: undisturbed brome grass CRP

Independent variables

Air temperature (***T_a***) & Soil moisture (***VWC***)

Dependent variables & raw data treatment

NEE: net ecosystem exchange of CO_2

R_{eco}: ecosystem respiration

NEE data were directly measured at 10 Hz frequency from eddy-covariance towers (Fig. 5). The bad data were removed and fulfilled by gap filling. R_{eco} data were calculated by temperature-based models based on nighttime NEE data. The data were calculated to average daily values and then run wavelet analysis by "biwavelet" package in R.

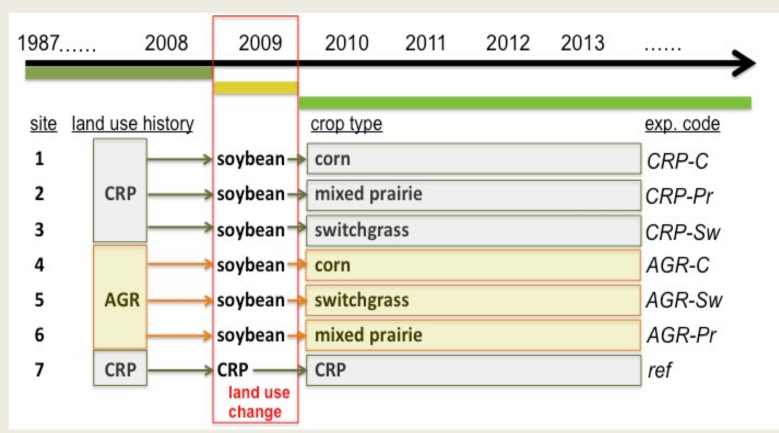


Figure 3. The experimental designs and timelines of seven experiment sites.

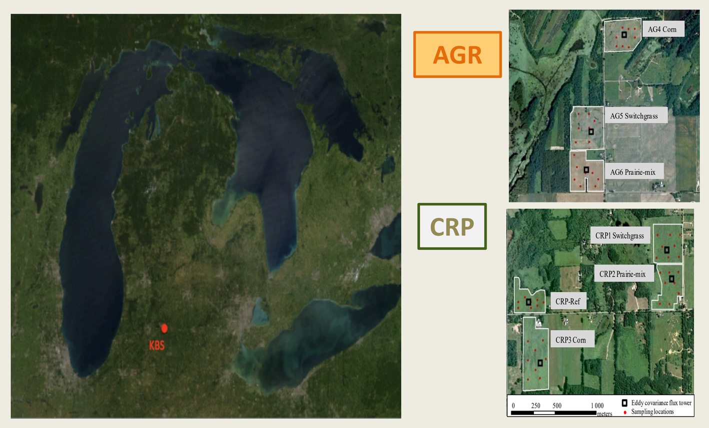


Figure 4. Study site location in southwestern MI, USA and experimental layout of scale-up field sites with location of sampling plots and EC flux towers.

Figure 5. The measurements of ecosystem carbon fluxes by eddy-covariance towers.