Atmospheric carbon flux measurements for agricultural sites in the Inland Northwest

WASHINGTON STATE UNIVERSITY
World Class. Face to Face.

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Introduction to Objective 2

- Greenhouse Gas Monitoring Objective
  - Our group:
  - Key questions
    - What are the net greenhouse gas fluxes of CO_2 and N_2O for northwest croplands?
    - How are these fluxes affected by location and crop management systems?
  - Approach
    - Direct measurement of CO_2 and N_2O fluxes using eddy covariance flux methods.
    - Deploy and operate four (current) to six flux towers in the REACCH domain.

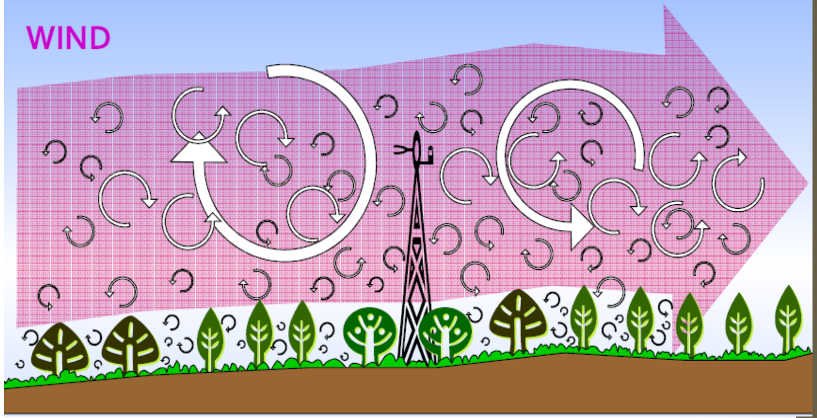
What is a Flux?

- How much Carbon or Nitrogen is exchanged between the atmosphere and a crop and soil in terms of mass per unit surface area per unit time (this is the flux).
- Positive flux is from the surface to the atmosphere.
- CO_2 fluxes are usually negative during the day (photosynthesis) and positive at night (respiration).
- N_2O fluxes are positive at all times, but can be very small and highly variable.

My Project

- Objectives
  - Learning principles of eddy covariance.
  - Tower set up and maintenance.
  - Analyzing flux data.
  - Relationships between CO_2 and the environmental conditions.

Methodology: Tower



- Winds contain turbulent eddies which we see or feel as updrafts and downdrafts.
- An updraft carries gases (like CO_2 or N_2O released from the soil) upward away from the surface, while a downdraft carries gases (like CO_2) down to the surface where it can be taken up by the crop.
- The updraft/downdraft speeds and associated concentrations of CO_2 or N_2O can be measured with fast sensors mounted on a tower.
- The net flux is the average of the product of up/down velocity covariance (w') and concentration covariance (C') ($\bar{F} = \overline{w'C'}$), and is usually averaged over 30 minutes.
- This is the Eddy Covariance method

Methodology (cont'd)

- Flux method advantages
  - Provides measurements at the field scale (100's of meters).
  - Operates continuously
  - Doesn't disturb the vegetation.
- Measurement requirements:
  - Tower must be located in a representative field.
  - Field must be large enough to provide a homogeneous upwind measurement area.
  - Sensors must be fast enough to capture the range of updraft/downdraft motions.

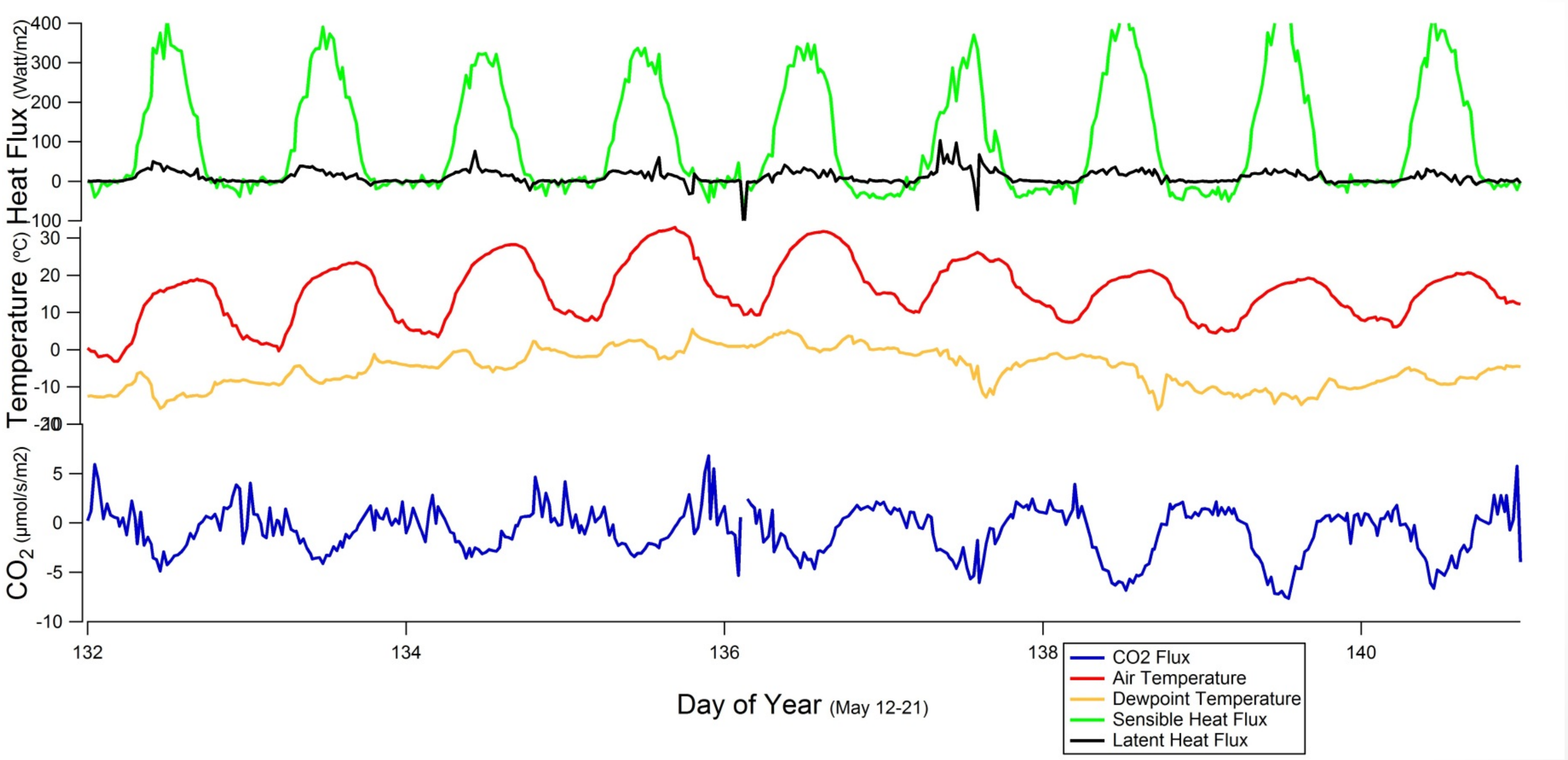
METHODOLOGY CONT'D

- Four sites currently in operation:
  - Cook Farm—no till site.
  - Cook Farm South—conventional till site.
  - Idaho Site—high rainfall conventional till.
  - Lind—lower rainfall conventional till summer wheat fallow rotation site.

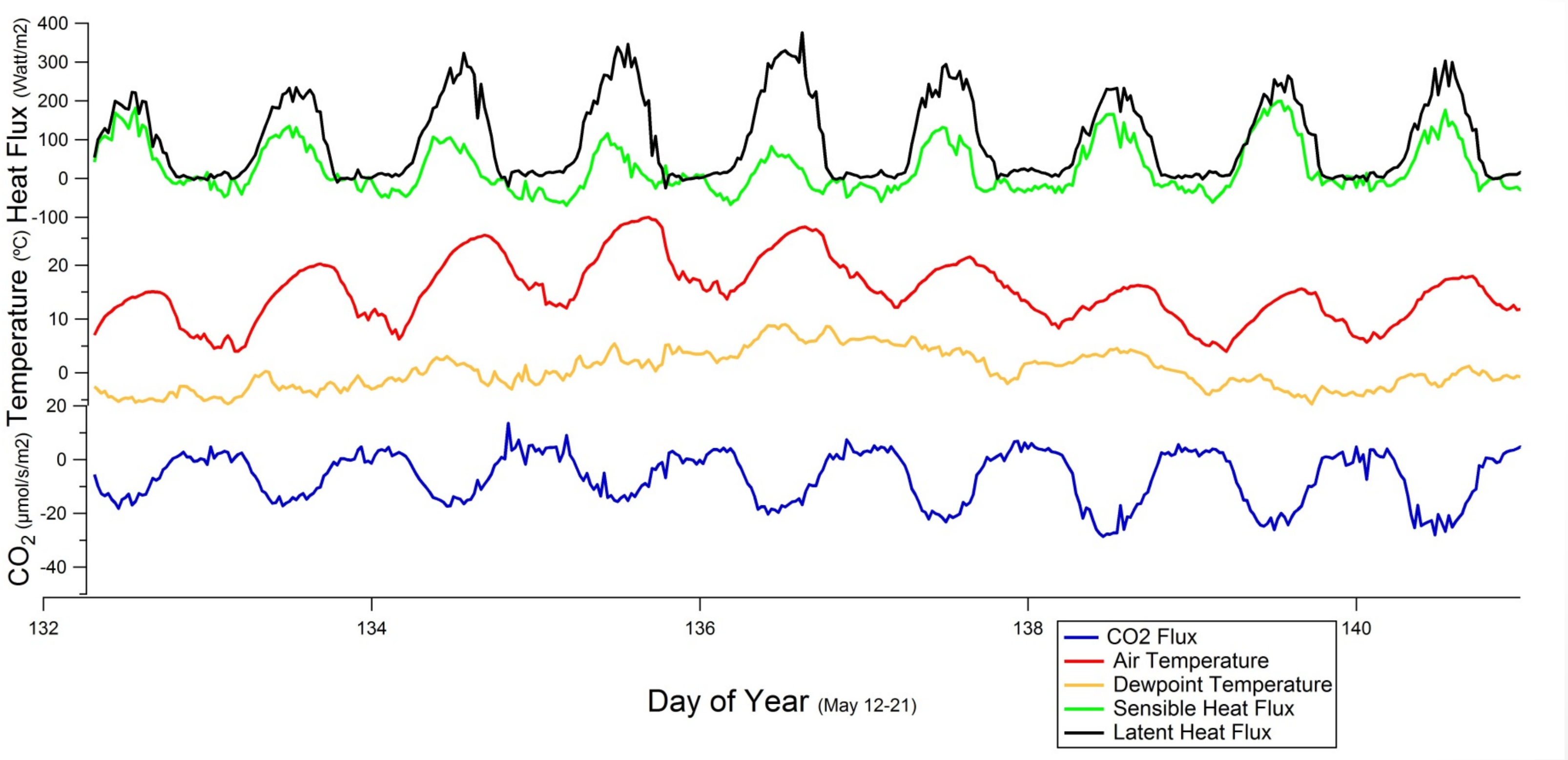
METHODOLOGY CONT'D

- Weather measurements
  - Temperature, humidity, solar radiation, pressure, wind speed and direction, and precipitation
- Surface energy measurements
  - Sensible heat flux –transport of heat to/from the surface
  - Latent heat flux—energy transfer due to evapo-transpiration of water
- Canopy Light Interception measurements
  - For use in the CROPSYST model
  - Estimates leaf area index
- Biomass measurements
  - Above ground biomass
- Soil Measurements
  - Soil temperature and moisture

Typical Daily Fluxes at the Lind Site (May 12-21, 2012)

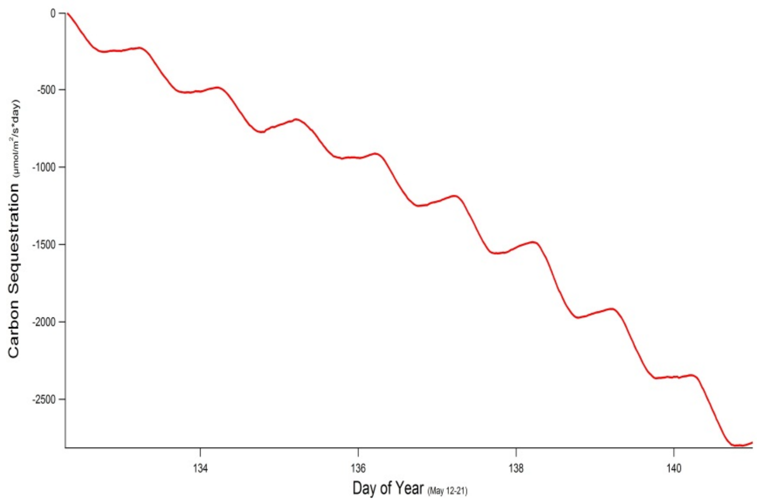


Typical Daily Fluxes at Cook Farm (May 12-21, 2012)

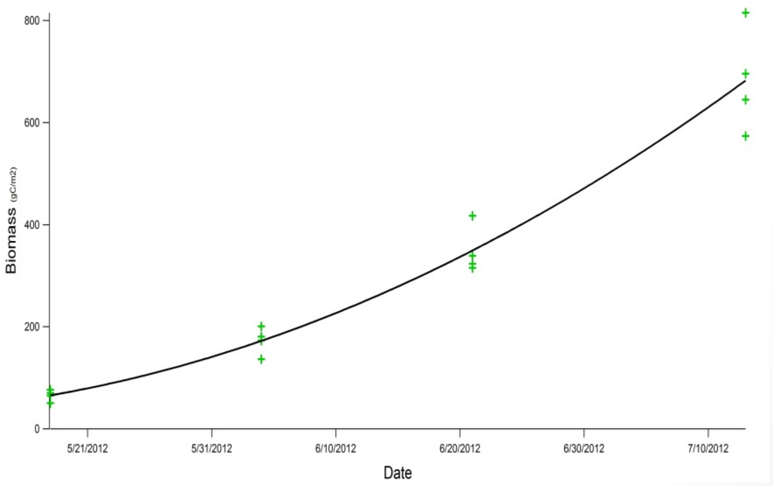


Net carbon sequestration—Cook (May 12-21, 2012)

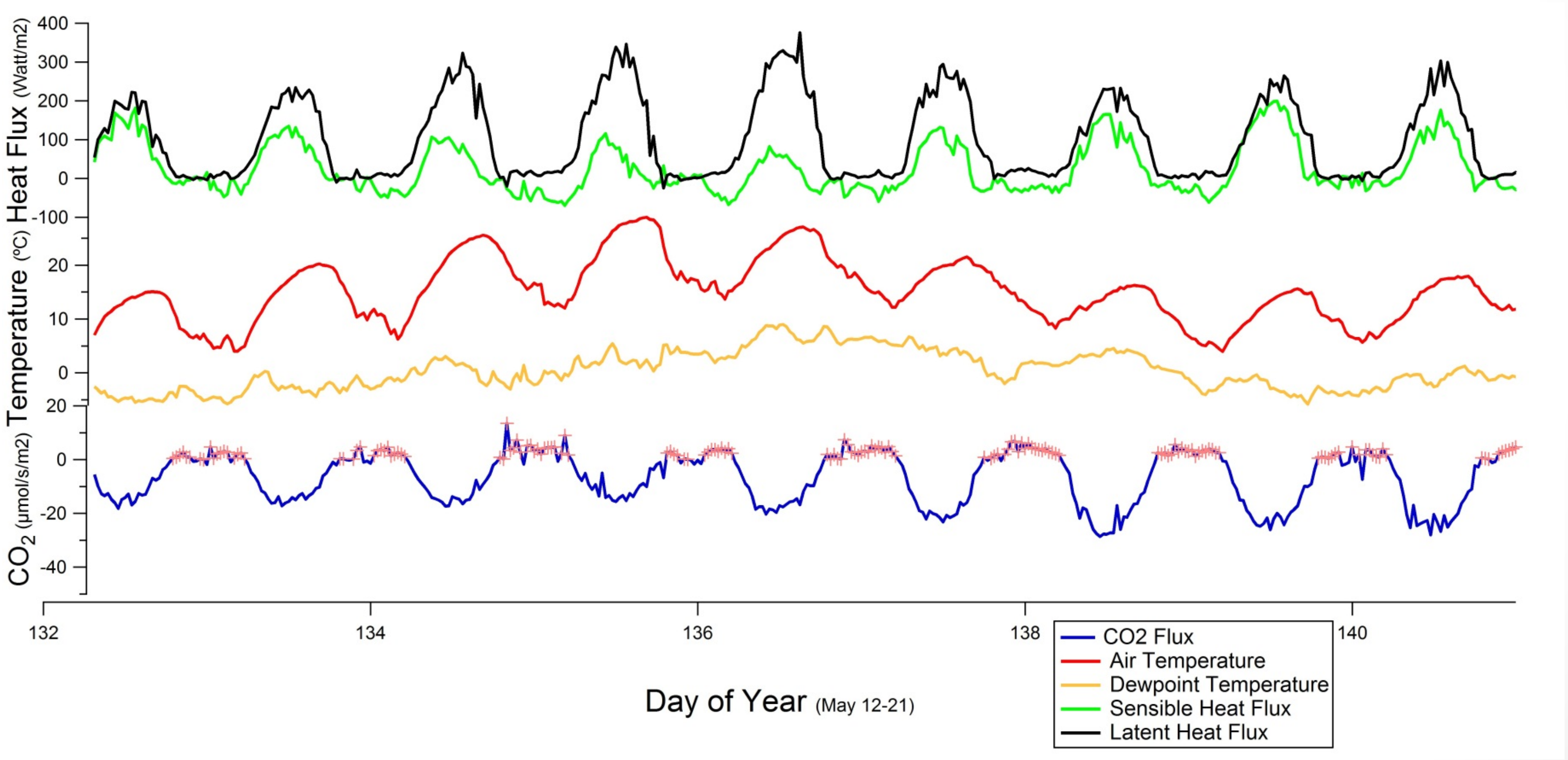
Cook Sequestration Trend



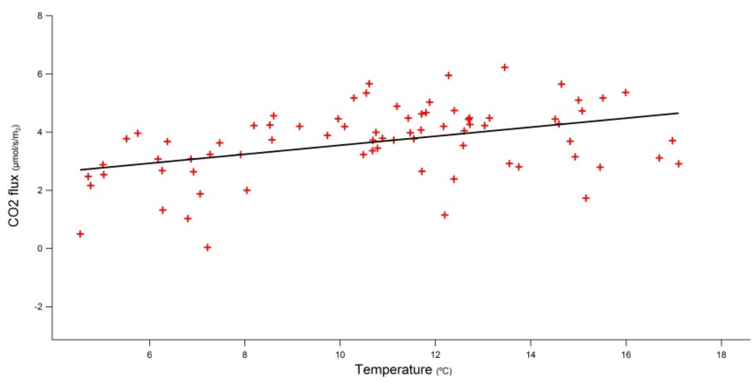
Cook Biomass Trend



Cook Farm Night Respiration (May 12-21, 2012)



Cook Temperature and Respiration Trend (May 12-21, 2012)



- Trend of increasing CO_2 with increasing temperature matches expected literature trend.
- Most closely matches the R_{10} value of a lightly used mid-European grassland, as found by Michael Bahn, et. al.

Conclusions

- Carbon dioxide, sensible heat, and latent heat exhibit diurnal patterns, as expected.
- Fluxes of CO_2 and latent heat at the fallow site (Lind) are much smaller in magnitude (compared to the vegetated site), yet there is still a slight diurnal pattern indicating either reduced biomass growth (weeds) and/or soil microbial activity.
- Preliminary data shows respiration increasing at higher temperatures at Cook farm in this time period as expected.

Future Plans

- Continue same data analyses of flux relationships on longer time periods and for each site to test accuracy through time and compare differences between crop management systems and locations.
- Calculate net annual carbon budget at each site using flux and biomass measurements.

References

- **Soil Respiration in European Grasslands in Relation to Climate and Assimilate Supply.** Michael Bahn, et. al. *Ecosystems,* (Dec., 2008), 11(8), pp. 1352-67.
- **Whole Plant Respiration and Photosynthesis of Wheat Under Increased CO_2 Concentration and Temperature.** Roger M. Gifford. *Global Change Biology,* (1995), pp. 385-396.
- **A Brief Practical Guide to Eddy Covariance Flux Measurements.** G. Burba, D. Annderson. V. 1.0.1 (2005).