Atmospheric carbon flux measurements for agricultural sites in the Inland Northwest

Heather Baxter, Shelley Pressley, Brian Lamb, Sarah Waldo, Jackie Chi, Patrick O’Keeffe
Washington State University
Introduction to Objective 2

• Greenhouse Gas Monitoring Objective
  • Our group:
  • Key questions
    • What are the net greenhouse gas fluxes of CO₂ and N₂O for northwest croplands?
    • How are these fluxes affected by location and crop management systems?
  • Approach
    • Direct measurement of CO₂ and N₂O 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$_2$O 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 CO₂ 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$_2$O 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$_2$O 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 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 CO2 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

