Greenhouse Gas Monitoring: Flux Towers

Summer Field Trip
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Stop 1

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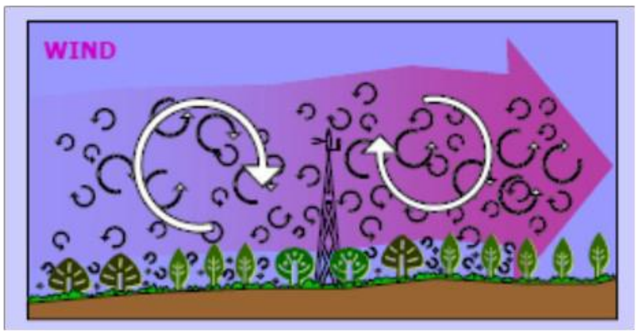
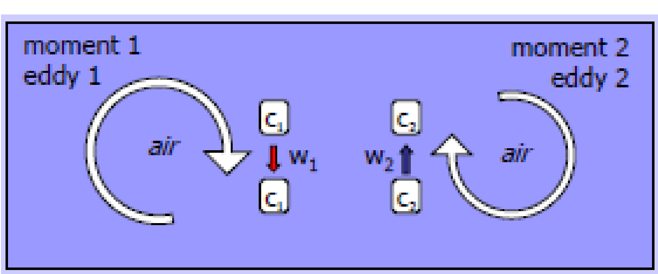
Establishing a baseline of carbon uptake and nitrogen loss between the atmosphere and agricultural land is one goal of the REACCH project. The most direct and accurate way to measure these greenhouse gas exchanges at the field level is by the *eddy covariance flux* method.

How Eddy Covariance Works:

- The air in the surface layer of the atmosphere consists of turbulent eddies, analogous to the visible eddies in water flowing down streams and rivers. The cartoon below illustrates this movement.

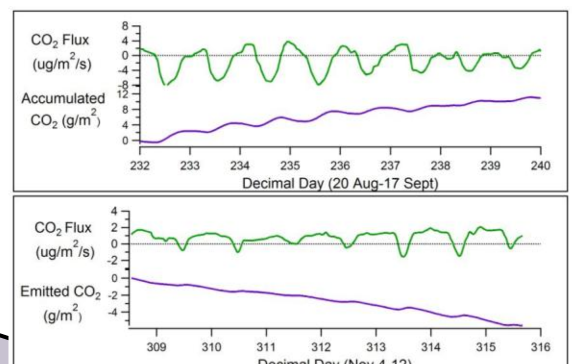


- Each eddy contributes to updrafts and downdrafts at the surface. Updrafts carry gases and heat from the surface up into the atmosphere, while downdrafts bring CO_2 and other gases down to the surface.
- Net release or uptake of gases such as CO_2 can be measured through fast measurement of updraft and downdraft speeds and the associated CO_2 concentrations (see inset).
- For a simple visualization, the diagram below shows gas being brought to the surface for uptake during a downdraft (moment 1) and gas carried away from the surface in an updraft during moment 2.



Our Measurements:

- There are currently two operational sites: one no-till, annual crop and one conventional-till, crop-fallow.
- Two more sites will be installed this summer: one conventional till, annual crop and one high rainfall, conventional till. There are plans to install a tower at an irrigated site.
- We will have continuous, long-term data sets of CO_2 fluxes from all sites, and periodically measure fluxes of N_2O.
- Example data from one site is shown below. The top graph shows a time series of CO_2 fluxes and carbon accumulation for a period at the end of summer, the bottom for winter:



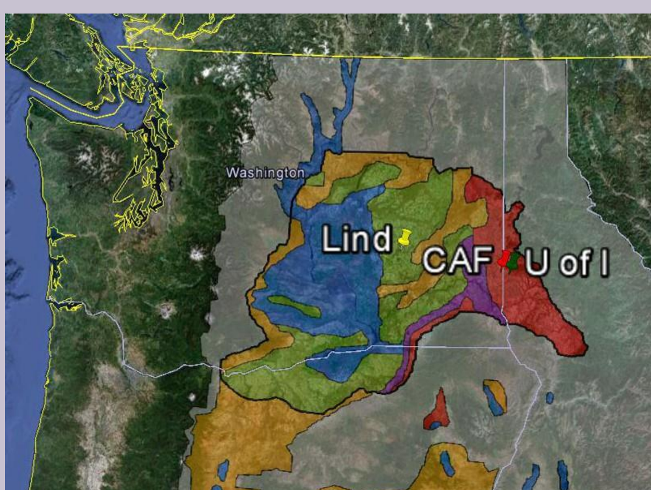
- Measure 3-dimensional wind speed (ws) at 10Hz with a sonic anemometer, CO_2 concentration ($[CO_2]$) at 10Hz with an infrared gas analyzer (IRGA)
- Take the average of the ws and $[CO_2]$
- subtract this from each measurement —> instantaneous variation from the mean
- Multiply the two variances to get the covariance
- The equation for the flux is: $F=\overline{\rho_a w' s'}$ where ρ_a is the density of air, primes denote fluctuations from the mean, and over-bars denote averaging

Images from *A Brief Practical Guide to Eddy Covariance Measurements,*
LiCor Biosciences: http://www.licor.com/env/applications/eddy_covariance/book.html

Broader Impacts of This Work:

- We will need to compare "before and after" data to see if our research has an impact.
    - Before= business as usual scenario in terms of both weather and farm management,
    - After = shifting weather patterns, alternative management strategies
- Baseline data will help policymakers set measurable goals for reducing agriculture's role in emitting greenhouse gases.
    - We'll start by measuring the greenhouse gases that current farming practices emit, how much carbon these practices sequester, and how much nitrogen and water they use
    - Then we'll use a computer simulation to assess how other farming methods might change these numbers.
- Understanding the potential for carbon sequestration under various management practices is potentially useful to growers interested in participating in a carbon emissions trading market.

Images of the CAF (left) and Lind (right) flux measurement tower sites



Location of the flux tower sites across the Inland Pacific Northwest. The colored areas represent different agroecological zones.

Data and Other Resources Available to Educators:

- From all active sites, continuous measurements of
    - Wind Speed and Direction
    - CO_2 Concentration
    - Ambient Temperature
    - Ambient Pressure
    - Relative Humidity
    - Net Radiation
    - Photosynthetically Active Radiation (PAR)
    - Precipitation
    - Soil Temperature
    - Soil Moisture
- Periodic measurements of N_2O and other gaseous reactive nitrogen species
- Information on management practices
    - Tillage
    - Fertilization
    - Seeding
    - Harvest
- Website: *http://reacch.nkn.uidaho.edu/about-reacch/objectives/gas-monitoring/*