Objective 2: Monitoring

Establish a baseline and monitor changes in soil carbon and nitrogen levels and GHG emissions related to mitigation of and adaptation to climate change in the region's agriculture.

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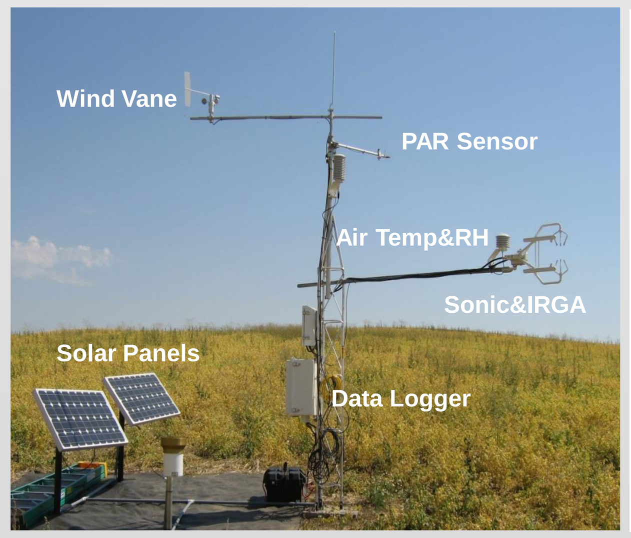
Introduction

to address the overall goal for Objective 2, the following specific tasks are underway:
1) Monitoring greenhouse gas fluxes (CO_2, N_2O) and water vapor fluxes using towers and chambers, 2) Assessment of the impact of wind erosion on C, N budgets, and 3) Monitoring water erosion of C, N as part of the hydrological cycle at the field and watershed scale. Tower based CO_2 and H_2O fluxes are being measured at five sites, ranging from low- to high-rainfall zones and including no-till and conventional tillage practices. At two sites, a hybrid tower/chamber approach is being used to measure N_2O emissions on a continuous basis. Wind event dust samples have been analyzed for N and C loss for fields in the low rainfall zone. Loss of C and N due to water erosion are measured from event sampling and continuous discharge measurements at several watershed scales. Results from each of these tasks are presented here and demonstrate a substantial observational data base for understanding C and N cycling in different wheat cropping zones within the REACCH domain.

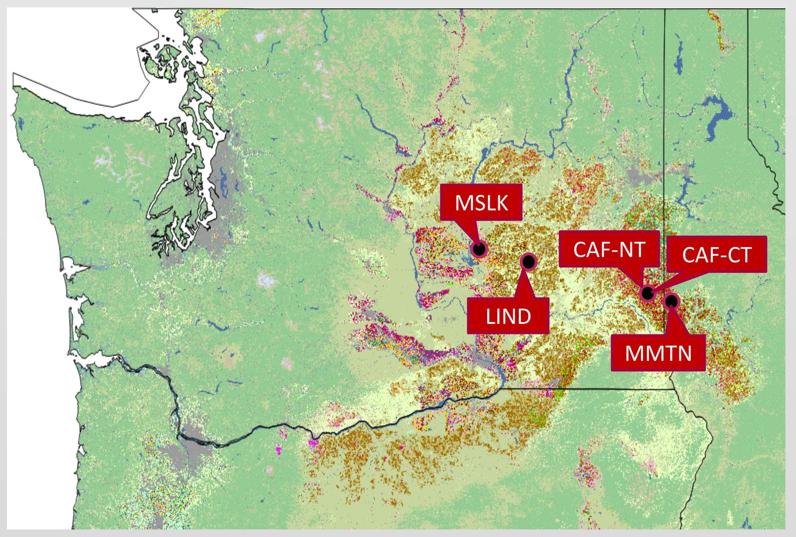
Methods

Eddy Covariance

The eddy covariance technique measures the net ecosystem exchange (NEE) of CO_2 between the atmosphere and the surface. The flux is calculated as a covariance of instantaneous deviations in vertical wind speed (w') measured by a three-dimensional ultrasonic anemometer and instantaneous deviations in the CO_2 concentration (ρ_c') measured by a fast-response infrared gas analyzer: $NEE = \overline{w'\rho_c'}$



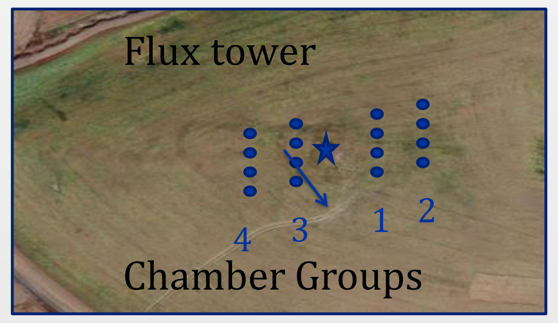
Eddy covariance tower set-up.



Location of five eddy covariance towers in the REACCH study area.

Methods

N_2O Monitoring: Chambers and Flux Gradient



- N_2O emissions have high spatial and temporal variability (hot spots and hot moments).
- Using chamber and tower-based measurements together optimizes our ability to monitor accurately: the chambers can detect very low fluxes and can measure continuously, and the tower measures at a field-integrated scale.
- The chamber and tower-based N_2O measurements are designed to share one N_2O analyzer.

Chamber flux calculation:

$$F_{N_2O} = \frac{\Delta C}{\Delta t} * \frac{V}{A}$$

C = gas concentration
t = time
V = chamber volume
A = chamber surface area

Tower flux calculation:

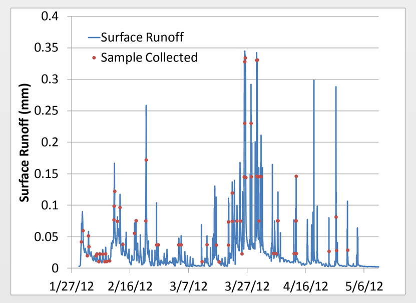
$$F_{N_2O} = -K * \Delta N_2O$$

ΔN_2O calculated by measuring N_2O concentration at two heights
K = coefficient determined via similarity theory or a tracer

Sediment and carbon losses by Water

Annual carbon and soil loss are determined through event-based water sampling and continuous discharge measurements.

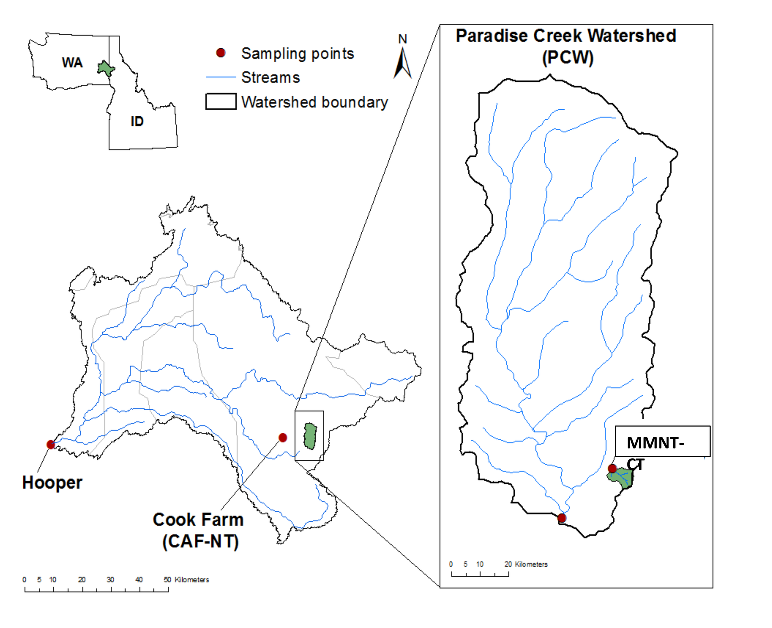
Surface runoff measurement at the 14 ha Moscow Mtn. conventional tillage (MMNT-CT) site



Event based water sampling at the MMNT-CT site during 2012

Measurement of subsurface drainage from an artificial drain line at the Cook Agronomy Farm no tillage (CAF-NT) site

Measurements are made four locations to assess the effects of tillage management and scale

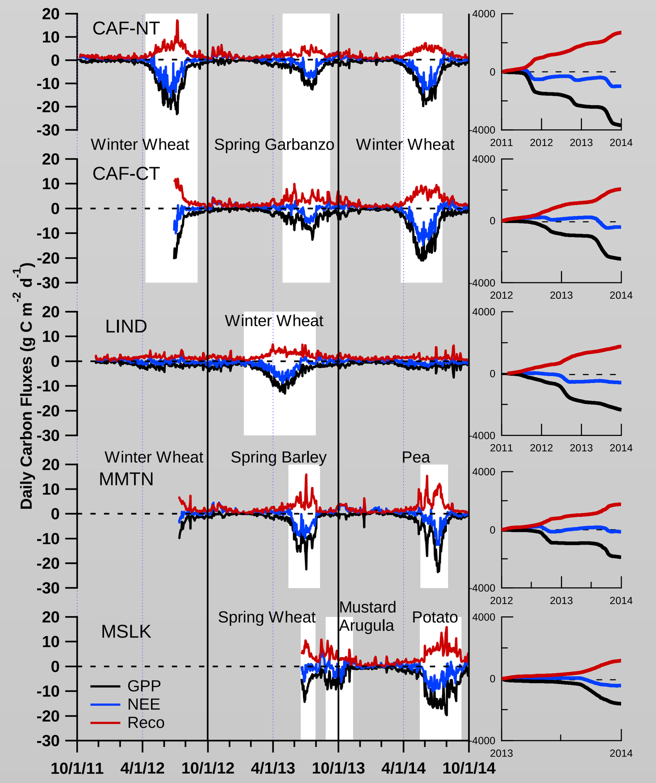


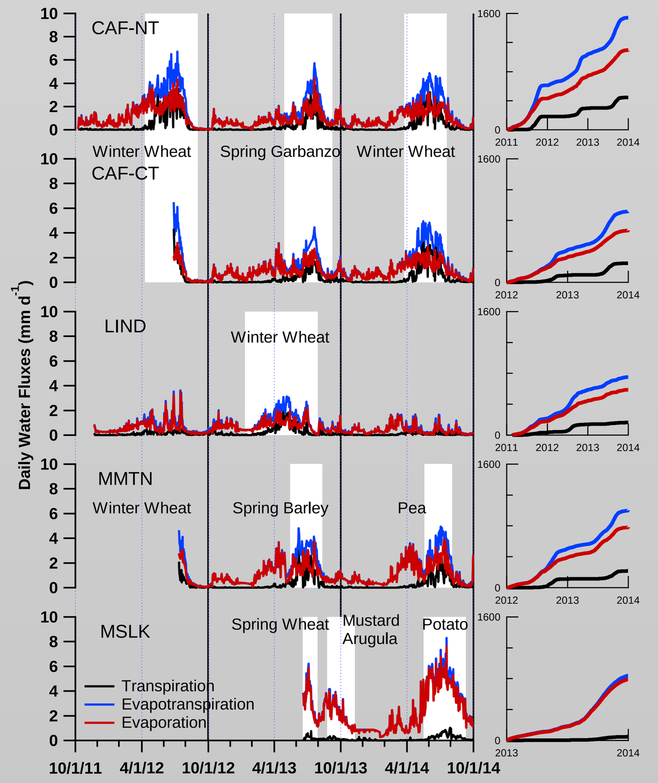
Map of sites

Results

Carbon and Water Fluxes

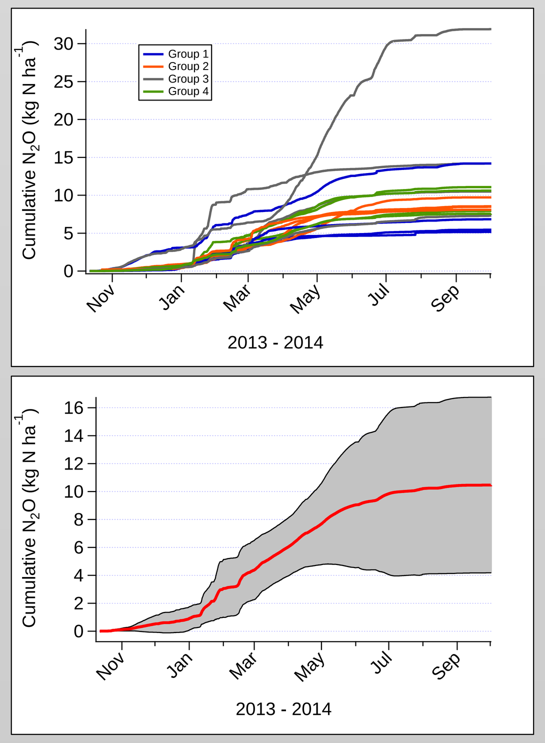
Net ecosystem exchange of CO_2 (*NEE*) is partitioned into gross primary productivity and total ecosystem respiration (R_{eco}): $NEE = GPP - R_{eco}$
Evapotranspiration (*ET*) is partitioned into plant transpiration (*T*) and soil water evaporation (*E*): $ET = T + E$



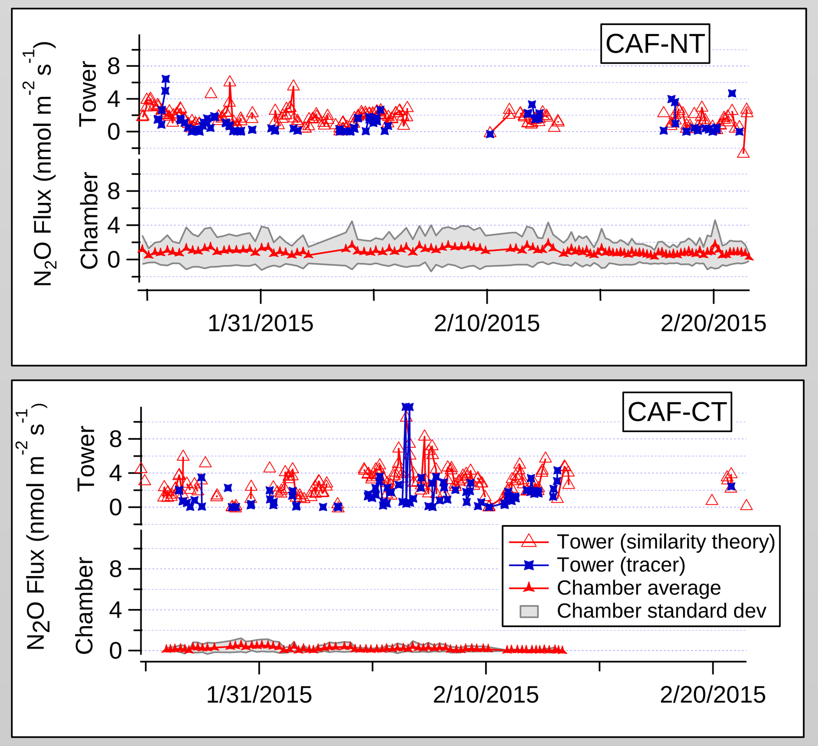


Daily and cumulative carbon and water fluxes at five flux tower sites. Highlighted areas are main growing seasons. Sign convention: fluxes from the atmosphere to the surface are negative, vice versa.

N_2O fluxes



Cumulative N_2O emissions over the 2014 crop year at CAF-NT (winter wheat) for individual chambers (top) and the chamber average (bottom). The annual emissions were 10± 6 kg N2O-N ha^{-1} yr^{-1}.



Plots of the tower-measured fluxes (red and blue markers on upper portion of plots) and the average chamber flux results (solid red markers with gray area showing one standard deviation of the mean). At CAF-NT, the results are comparable, while at CAF-CT, the tower fluxes are elevated both compared to the chambers and to the CAF-NT tower results. The spike in emissions at CAF-CT coincides with a rainfall event.

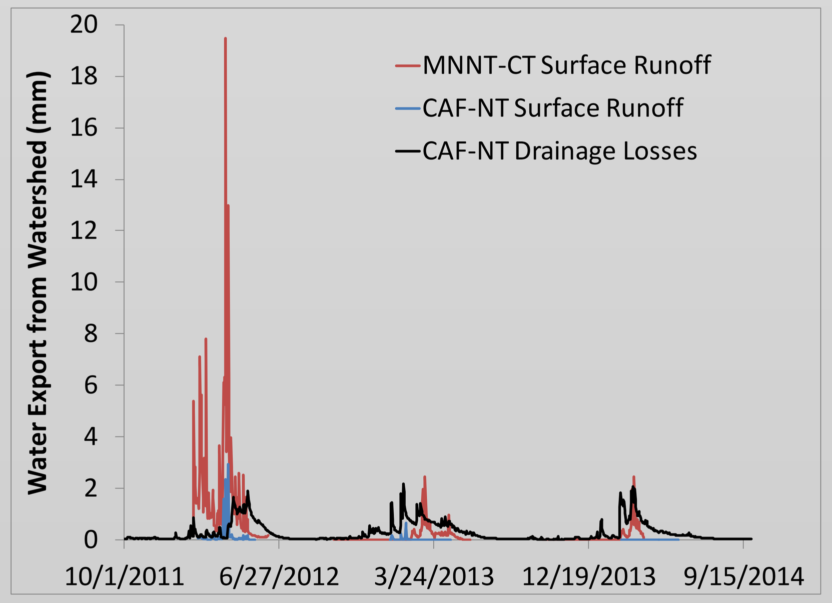
Water losses

- Total sediment/carbon loss from conventional tillage 100x greater than no-tillage
- Surface runoff losses from the conventional tillage site are 20x greater than at the no-till site
- When water loss from artificial subsurface drainage is considered, there is **more** water loss from the no-tillage site than the conventional tillage site

Measured sediment and carbon transport from the no-tillage (CAF-NT) and conventional tillage (MMNT-CT) sites during 2012-2014 water years (Suspended Sediment Concentration (SSC), Dissolved Organic Carbon (DOC), Particulate Organic Carbon (POC), Organic Carbon (OC)).

Site	Water year	Average Concentrations ($mg\ L^{-1}$)			Annual Yield ($kg\ ha^{-1}$)			
		SSC	DOC	POC	Sediment	Total OC	DOC	POC
Hooper	2012	775 ± 3047	7 ± 7	NA	2953 ± 5	26 ± 17	6 ± 5	21 ± 12
	2013	59 ± 41	4 ± 2	0 ± 0	34 ± 2	4 ± 4	4 ± 4	0 ± 0
PCW	2012	260 ± 457	6 ± 2	NA	547 ± 0	20 ± 8	16 ± 5	4 ± 3
	2013	198 ± 437	6 ± 2	1 ± 2	70 ± 0	7 ± 2	7 ± 2	1 ± 0
MMNT-CT	2012	4018 ± 5304	4 ± 1	NA	5617 ± 1995	69 ± 29	11 ± 3	59 ± 26
	2013	596 ± 1132	6 ± 1	8 ± 17	114 ± 42	4 ± 0	3 ± 0	1 ± 0
CAF-NT*	2012	634 ± 399	10 ± 5	NA	73 ± 1	2 ± 1	1 ± 1	1 ± 0
	2013	226 ± 279	11 ± 2	2 ± 2	3 ± 0	0 ± 0	0 ± 0	0 ± 0

*Only carbon losses through surface runoff losses listed here.



Water export from watershed at each site.

Measured water loss from the no-tillage (CAF-NT) and conventional tillage (MMNT-CT) sites during 2012-2014 water years. Daily totals above; annual totals below.

Water Year	CAF-NT: Subsurface Drain	CAF-NT: Surface Runoff	MMNT-CT: Surface Runoff
2012	90.0	13.1	228.0
2013	113.4	1.9	30.0
2014	86.4	0.0	21.0
2012-2014 Avg. =	**96.6**	**5.0**	**93.0**

Conclusions

- All five sites were net CO_2 sink over the measurement periods (1-3 crop years), with cumulative NEE ranging from -126 (MMTN) to -983 g C m^{-2} (CAF-NT).
- The higher rainfall site (MMTN) had the largest averaged T/ET ratio (0.38) during the spring barley main growing season in 2013, while the irrigated site (MSLK) had the lowest.
- Largest sediment and carbon transport was observed at the conventional tillage site.
  - Artificial drainage losses at the no-till site are significant and equivalent in magnitude to the reduction in surface runoff observed at the no-tillage site relative to the conventional tillage site.
    - N_2O emissions for CAF-NT over the 2013 crop year were higher than the IPCC Tier 1 estimate of 1% of fertilizer N. The IPCC estimate would yield emissions of 1-2 kg N_2O-N ha^{-1} yr^{-1}, while the measurements show 10±6 kg N_2O-N ha^{-1} yr^{-1}.
      - Ongoing paired tower-chamber results will help to understand why we see elevated emissions.

"Regional Approaches to Climate Change for Pacific Northwest Agriculture" is funded through award #2011-68002-30191.