# Assessments of Carbon and Water Cycling in Multiple Agricultural Ecosystems in the Inland Pacific Northwest Using Eddy Covariance Flux Measurements and the CropSyst Micro-basin Model


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## Introduction

Local meteorology, crop management practices and site characteristics have important impacts on carbon and water cycling in agricultural ecosystems. This study focuses on carbon and water fluxes measured using eddy covariance (EC) methods and simulated using the CropSyst micro-basin model for sites in the inland Pacific Northwest (iPNW). The agricultural ecosystem is currently challenged by increasing pressure related to water resources as a consequence of multiple demands for water resources as well as impacts associated with different types of crop management. In addition, future climate projections for this region show a likely increase in temperature and significant reductions in precipitation that will affect carbon and water dynamics. Field scale measurements using micrometeorological techniques will enable us to understand how different management practices will improve adaptation to climate change. This work is part of the Regional Approaches to Climate Change (REACCH) program (https://www.reacchpna.org).

## Site Description

*Table 1: Eddy covariance flux sites in the iPNW region*

| Site | Temperature/ Precipitation* | Crop Rotation | Management Practices |
|---|---|---|---|
| MSLK | 11°C / 230mm | spring wheat-cover crops-potato | conventional tillage, irrigation |
| LIND | 10°C / 280mm | winter wheat-summer fallow | reduced tillage, fallow |
| CAF-NT | 9°C / 550mm | winter wheat-spring garbanzo | no-till |
| CAF-CT | 9°C / 550mm | winter wheat-spring garbanzo | conventional tillage |
| MMTN | 9°C / 680mm | winter wheat-spring crops | conventional tillage |

*Annual temperature and precipitation averaged from 1981 to 2010.

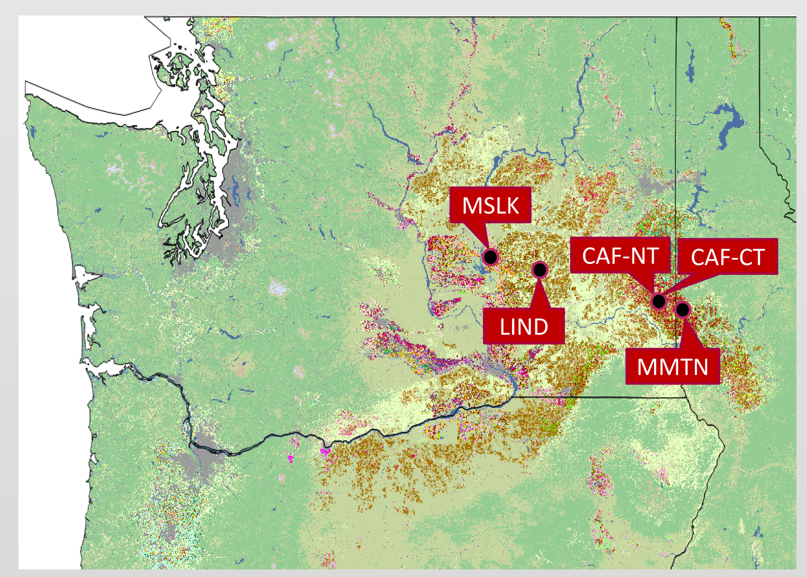


*Figure 1: Location of five eddy covariance towers in the REACCH study area.*

## 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 ($\rho'_c$) measured by a fast-response infrared gas analyzer:

$$NEE = \overline{w'\rho'_c}$$

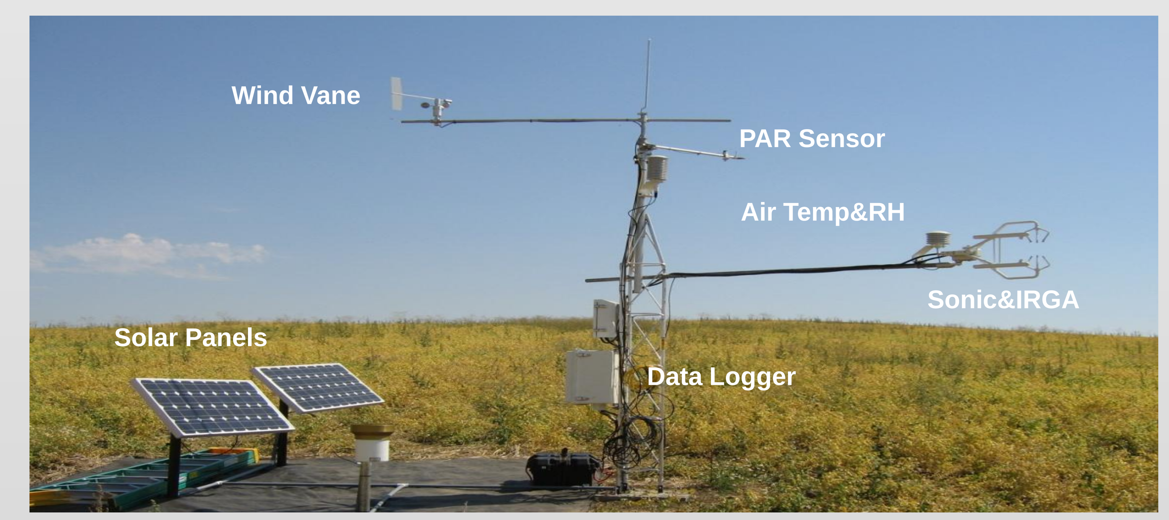


*Figure 2: Eddy covariance tower set-up. 3D sonic anemometer and infrared gas analyzer on lower boom, meteorological measurements on upper boom, and solar panels to provide power.*

### Micro-basin Model

The WSU CropSyst model was implemented in an integrated watershed grid framework for hourly time steps and 10 m x 10 m resolution. The model tracks vertical and lateral flows of water, nutrients and carbon over the landscape and small watersheds. The carbon flux is determined by Penning de Vries (1975) where the gross primary productivity (GPP), NEE, respiration of plant ($R_a$), residues ($R_r$) and soil ($R_s$) are modeled as:

$$GPP = \left(\frac{Biomass_{CS}}{Biosynthesis\ efficiency} + R_a\right) \times Yr$$

where:
$Biomass_{CS}$: biomass data from CropSyst model
$R_a$: maintenance respiration rate
Yr: biosynthesis coefficient

$$R_a = GPP \times mr$$

where
mr: maintenance coefficients, crop-dependent

$$R_{eco} = R_a + R_s + R_r$$

$$NEE = GPP - R_{eco}$$

## Eddy Covariance vs. CropSyst

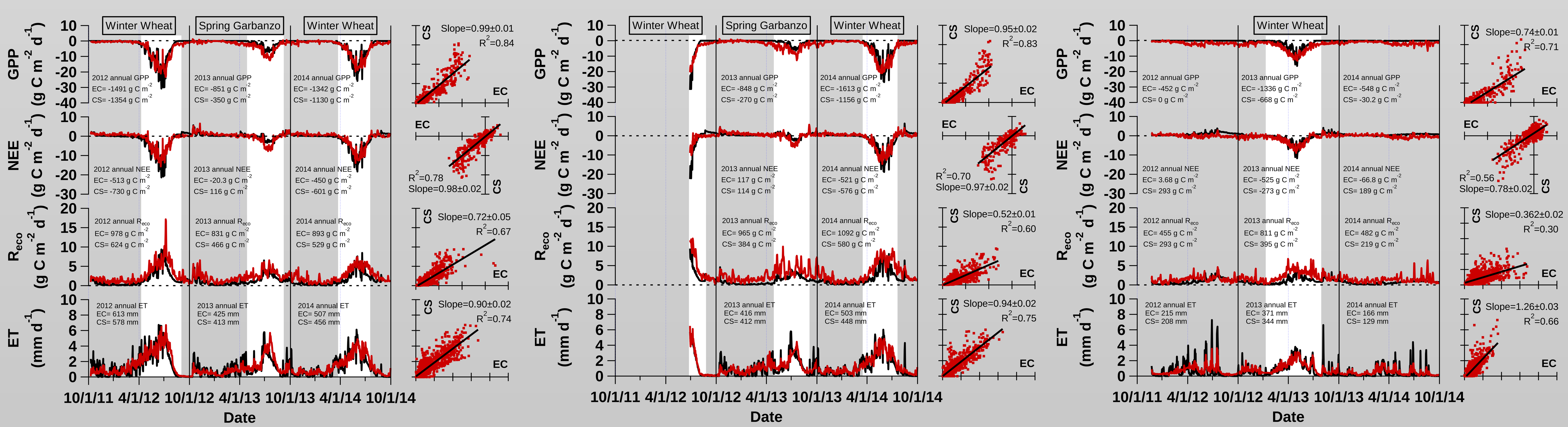


*Figure 3: Eddy covariance (EC, red lines) and modeled fluxes (CropSyst CS, black lines) for three sites under different management practices. GPP (gross primary productivity); NEE (net ecosystem exchange of $CO_2$); $R_{eco}$ (total ecosystem respiration); ET (evapotranspiration). NEE=GPP-$R_{eco}$*

## Annual Carbon and Water Budgets

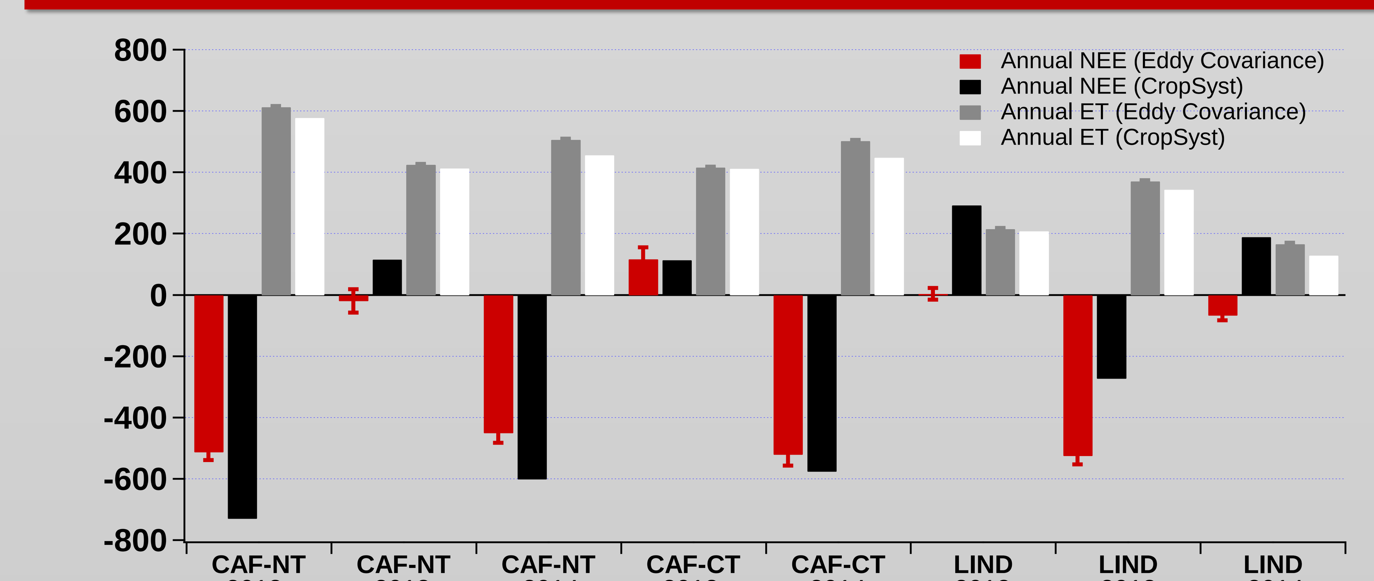


*Figure 4: Annual cumulative NEE and ET at each site from 2012 to 2014.*

## Conclusions

- All three sites were net carbon sinks for winter wheat growing years.
- The conventional tillage site (CAF-CT) was a net $CO_2$ source during 2013 with spring garbanzo, while CAF-NT was a small net $CO_2$ sink for the same year/crop.
- The reduced tillage-fallow site (LIND) was either a small $CO_2$ sink or source, depending on the weed population during 2012 and 2014 fallow years.
- During the winter wheat crop years, CAF-CT had the highest annual GPP and $R_{eco}$, followed by CAF-NT and LIND, due to the different tillage practices and meteorological conditions.
- Compared with eddy covariance measurements, the CropSyst micro-basin model had good agreement on GPP, NEE, and ET in terms of daily and annual sums for each site.
- The CropSyst micro-basin model captured most of the variations in GPP, NEE and ET at each site, with slope ranging from 0.74 to 0.99 and $R^2$>0.6.
- The CropSyst micro-basin model underestimated $R_{eco}$ by about 50% for each site.

## Reference


Penning de Vries, F.W.T, 1975. Use of assimilates in higher plants. In: Photosynthesis and productivity in different environment. Int. Biol. Progr., Vol.3, Cambridge Univ. Press.



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