# Investigation of the influence of temperature inversions and turbulence on land-atmosphere exchange for irrigated farmland in rolling terrain

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## Motivation

Surface energy fluxes are exchanged between the earth's surface and the atmosphere and impact weather, climate, and air quality. The radiation from the sun triggers the surface-atmosphere interaction during the day as heat is transmitted to the surface and the surface heats the air directly above generating wind known as thermal turbulence that transports heat, moisture and momentum in the atmospheric boundary layer. This process is impacted by greenhouse gases such as; water vapor, carbon dioxide and other trace gases that absorb heat emitted by the earth's surface and radiates it back to the ground thereby altering atmospheric boundary layer dynamics and surface energy balance. Temperature inversions are associated with weak winds that raise pollutants to unhealthy levels within the boundary layer. Most boundary layer models break down on complex terrain especially during stable atmospheric conditions as these models are designed for flat terrain.

## Objectives

- Quantify surface fluxes during one week in September 2014 from a monitoring site in Echo, Oregon
- Provide a better understanding of surface fluxes and mixing, particularly during stable conditions

## Study Site

Figure 1. Study site showing the irrigated farmland nearby

## Method

- Calculate surface fluxes using eddy-covariance technique
- Measure atmospheric turbulence using a fast response 3D sonic anemometer (three components of wind speed and temperature at 10Hz, CSAT-3 Campbell Scientific)
- Measure water vapor and carbon dioxide concentrations using a fast response open-path infrared gas analyzer (10Hz, EC150 Campbell Scientific)
- Wilczak planar fit for sonic tilt correction
- Mean removal with 15min linear detrend
- Fluxes calculated with 30min average
- Sensors at four heights: 1.1m, 2.7m, 4.8m, and 7.7m
- Center pivot irrigated farmland with over 100 wind turbines

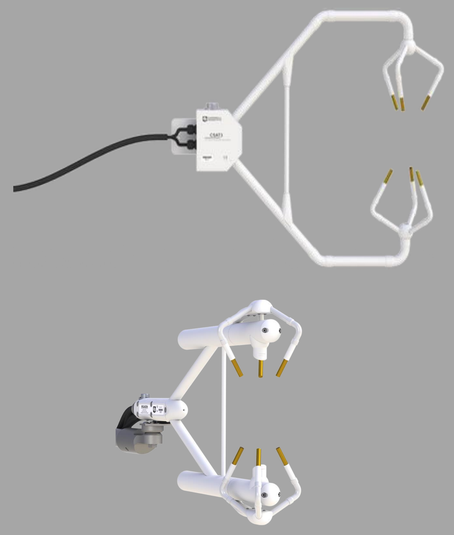
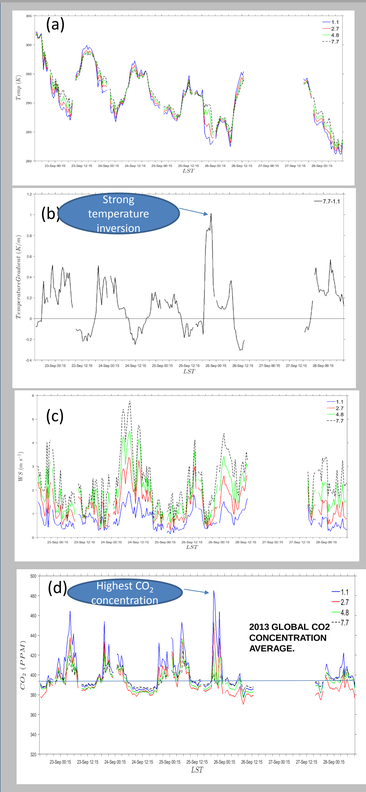
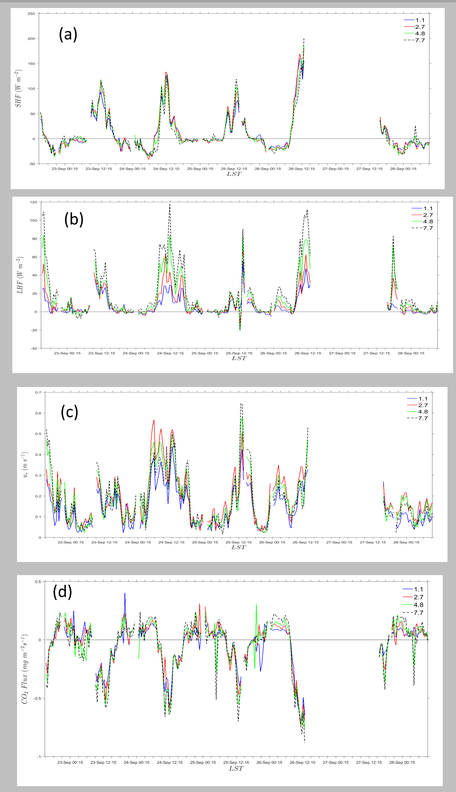


Figure 2. Image showing CSAT-3 sonic anemometer (top) and EC150 open path infrared gas analyzer (bottom)

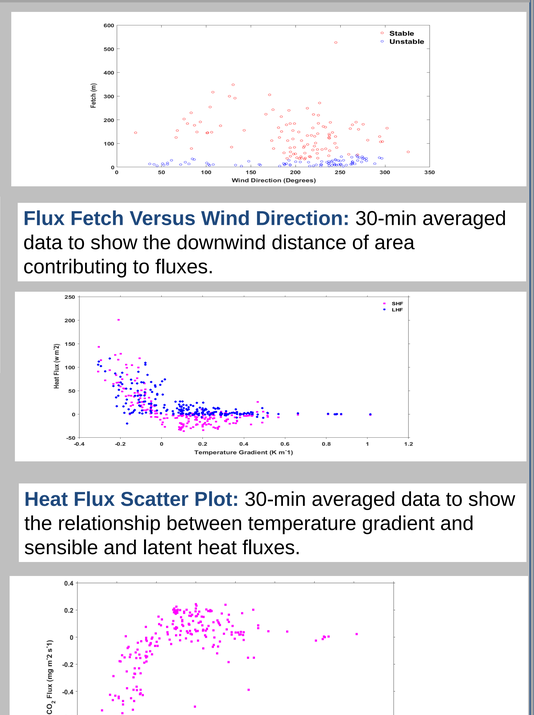
## Results




**Meteorology Observations:** 30-min averaged data from 23-28 Sep 2014. (*a*) sonic temperature, (*b*) temperature gradient, (*c*) wind speed, and (d) $CO_2$ concentration.

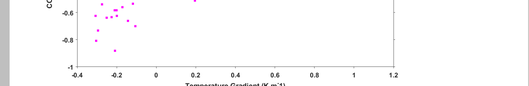



**Turbulence Observations:** 30-min averaged turbulent fluxes from 23-28 Sep 2014. (*a*) sensible heat flux, (*b*) latent heat flux, (*c*) friction velocity, and (d) $CO_2$ flux.




**Flux Fetch Versus Wind Direction:** 30-min averaged data to show the downwind distance of area contributing to fluxes.

**Heat Flux Scatter Plot:** 30-min averaged data to show the relationship between temperature gradient and sensible and latent heat fluxes.




$CO_2$ **Flux Scatter Plot:** 30-min averaged data to show the relationship between temperature gradient and sensible and latent heat fluxes.

## Summary

- The surface fluxes of heat, moisture, momentum and $CO_2$ have a significant amount of temporal variability and strong diurnal variation
- Temperature inversions impact the turbulent exchanges between the surface and the atmosphere
- $CO_2$ concentrations are greatest at night due to respiration by plants/soil, shallow boundary layer, and reduced turbulent mixing in the stable nocturnal boundary layer
- Negative $CO_2$ flux during daytime is due to turbulent mixing and photosynthesis, positive at night due to respiration by plants and soil
- Turbulence enhances evaporation by continuously removing water vapor away from the surface leading to high daytime latent heat flux

## Acknowledgement

- The Oregon field experiment was done in collaboration with Dr. Chad Higgins and his group at Oregon State University (http://newag.bee.oregonstate.edu/home)