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Integrating 25 Years of surface and airborne observations to assess arctic NEE

Munger-03

Co-I's

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Collaborators

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AER, NOAA, NASA-JPL, Max Planck BGC

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Motivation

- Atmospheric mixing ratios integrate ecosystem exchange of CO_2 and CH_4
- *But,* interpretation of the signal requires definition of the region that has influenced the air mass and knowledge of what the upwind background was.
- By explicitly considering the influence area and atmospheric transport we distinguish the contributions from ecosystem processes and atmospheric transport to observed variation in mixing ratios at a receptor site. By accounting for variations in transport and defining a baseline ecosystem exchange we can use historical records of atmospheric carbon mixing ratio to identify and attribute anomalous emission or uptake. **Do vegetation changes lead to changes in carbon exchange?**

Science Questions & Objectives

- Tier 2 Science Questions: Carbon pools
  - Detect regional ecosystem changes by interpreting time series of CO_2 and CH_4 mixing ratios
- Tier 2 Science Objectives:
  - **Controls on Carbon Biogeochemistry :** associate anomalies with climate and vegetation changes

Modeling Approach

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- Lagrangian particle dispersion model transport, driven by Polar WRF modeled meteorology
- Input: NARR meteorology, MODIS vegetation
- Polar VPRM defines *a priori* estimate of vegetation functional response to temperature, light, snowcover, **and spatial patterns** – separately for major vegetation types. Adaptable to **any** gridded flux field.
- Inverse analysis to derive optimized parameters that represent a mean state for land-surface exchange
- Mixing ratio anomalies identify times/regions that differ from the mean response
- LPDM applied in forward mode to ecosystem model output allows receptor mixing ratios to be used as an integral constraint to challenge models.

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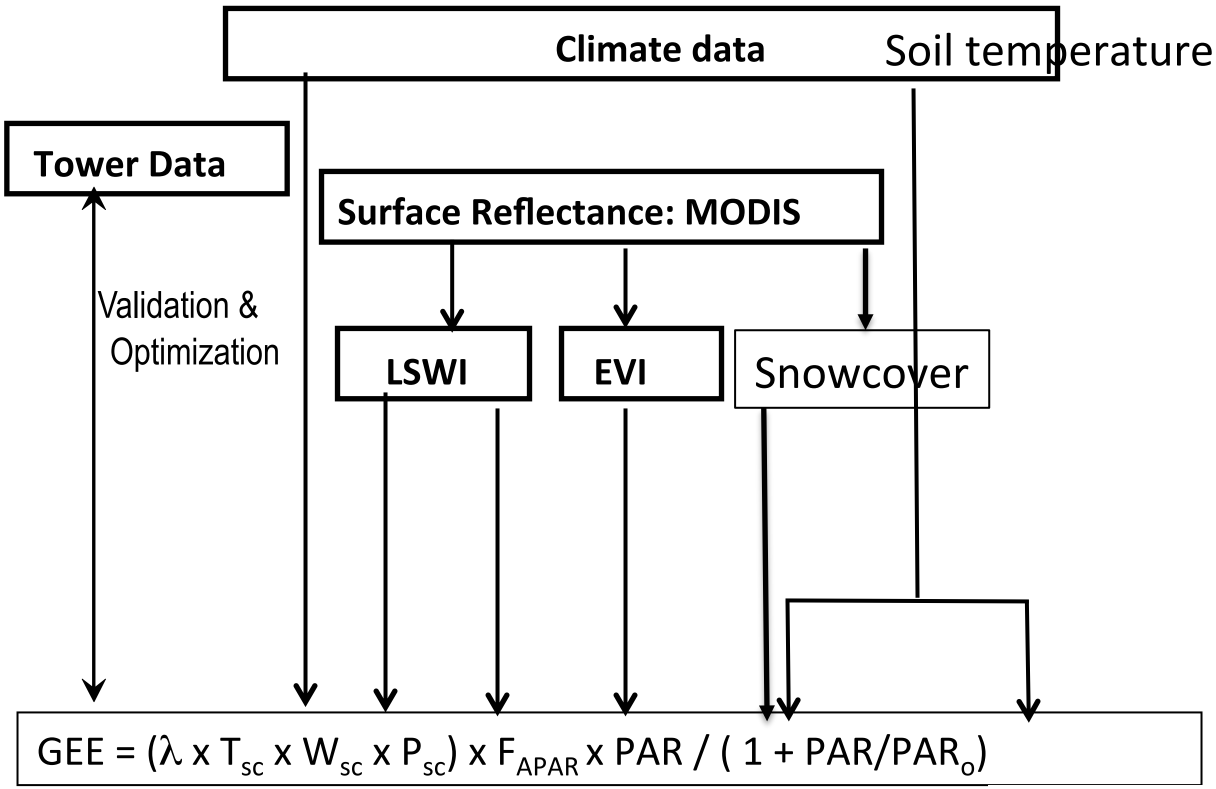
Data Assimilation Framework



$$Respiration = \alpha \times T_{air} + \beta$$

$NEE = -GEE + R$

"VPRM"

Pathmathevan et al. 2007

P-VPRM: time/space resolved CO_2 emission prior based on eddy flux and remote sensing

Mahadevan (2008); Luus, Lin 2013-15

Data Sources

Campaign	Time period	Spatial extent	Measurements
Airborne and surface concentrations to be simulated			
ABLE3A airborne	Summer 1988	Yukon-Kuskokwim River Delta	CH_4 concentrations
ARCTAS – airborne	Spring 2008	Fairbanks to North Slope	CO_2 concentrations
CARVE- airborne	Spring-Fall 2012	Interior and North Slope	CO_2, CH_4 concentrations
NOAA-GMD	Since 1971/1983 (B) and 1978/1983 (CB)	Barrow and Cold Bay	Flask and continuous CO_2 and CH_4
	Since June 1999	Poker Flats aircraft	CO_2, long-lived gases
	Since 1960	North Pole—South Pole difference	CO_2, CH_4, other gases
Land-surface data sources			
Landsat	~25 years	North America; 25m pixels	Landcover and vegetation indices
MODIS	Since 2001	North America 0.5km pixels	Vegetation indices
Circumpolar Active Layer Monitoring (CALM) Network	(1995-on)	Alaska and other arctic regions	Temperature Profiles in the active layer and subsurface permafrost
Surface flux data for parameterizing Vegetation model			
AmeriFlux sites	1992 - current	Individual tower sites	CO_2 flux & Concentrations meteorology and vegetation
Bonanza Creek LTER	1991-1994, 2003-2004	Bonanza Creek & Caribou Poker Creek watershed	CO_2 and CH_4 flux from chambers
ABLE3A-ground	Summer 1988	Yukon-Kuskokwim River Delta	CO_2 and CH_4 fluxes, ancillary met
Barrow- IBP and follow-on ecological studies	Since 1972	Barrow, Alaska	Fluxes, and vegetation data

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Geospatial Data Products

- Outputs
  - Meteorological fields
  - Transport footprints
  - Optimized flux fields constrained by atmospheric mixing ratio data and vegetation remote sensing
  - Identification of significant anomalies in ecosystem function
- Focus on north slope with additional analysis of interior Alaska where data allow.
- Format and gridding adaptable to needs
- Primarily 2000-present (MODIS availability)
- Tool for project synthesis and integration, model evaluation

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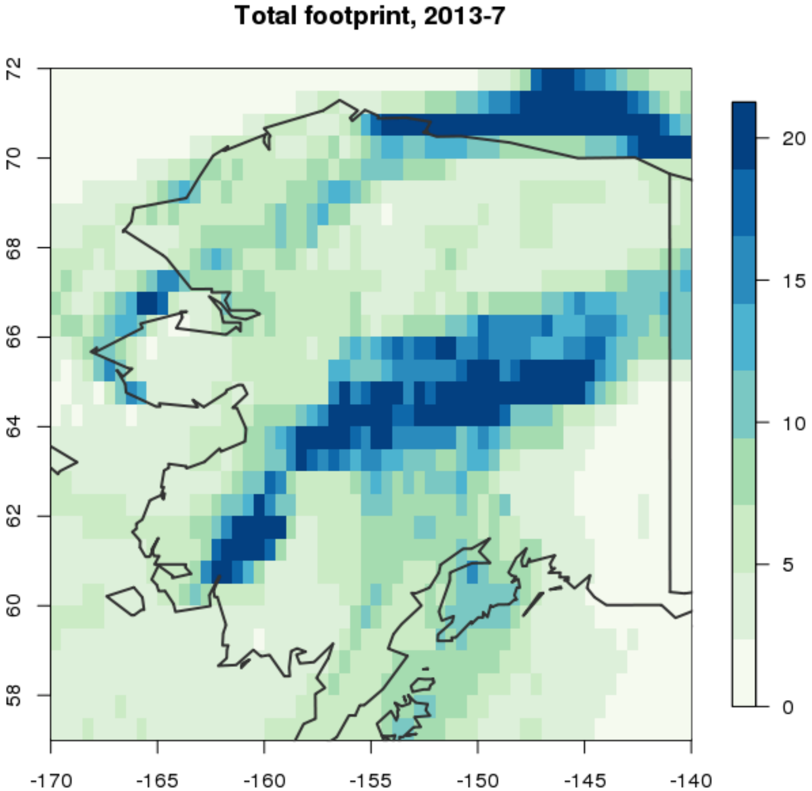
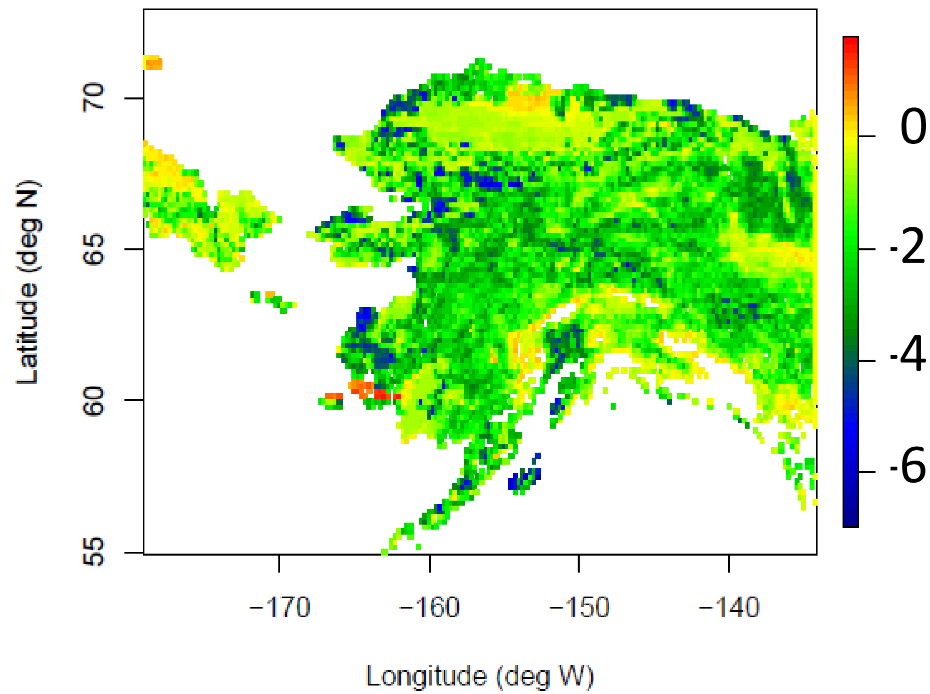
Receptor mixing ratio = Influence x Flux + *Background*

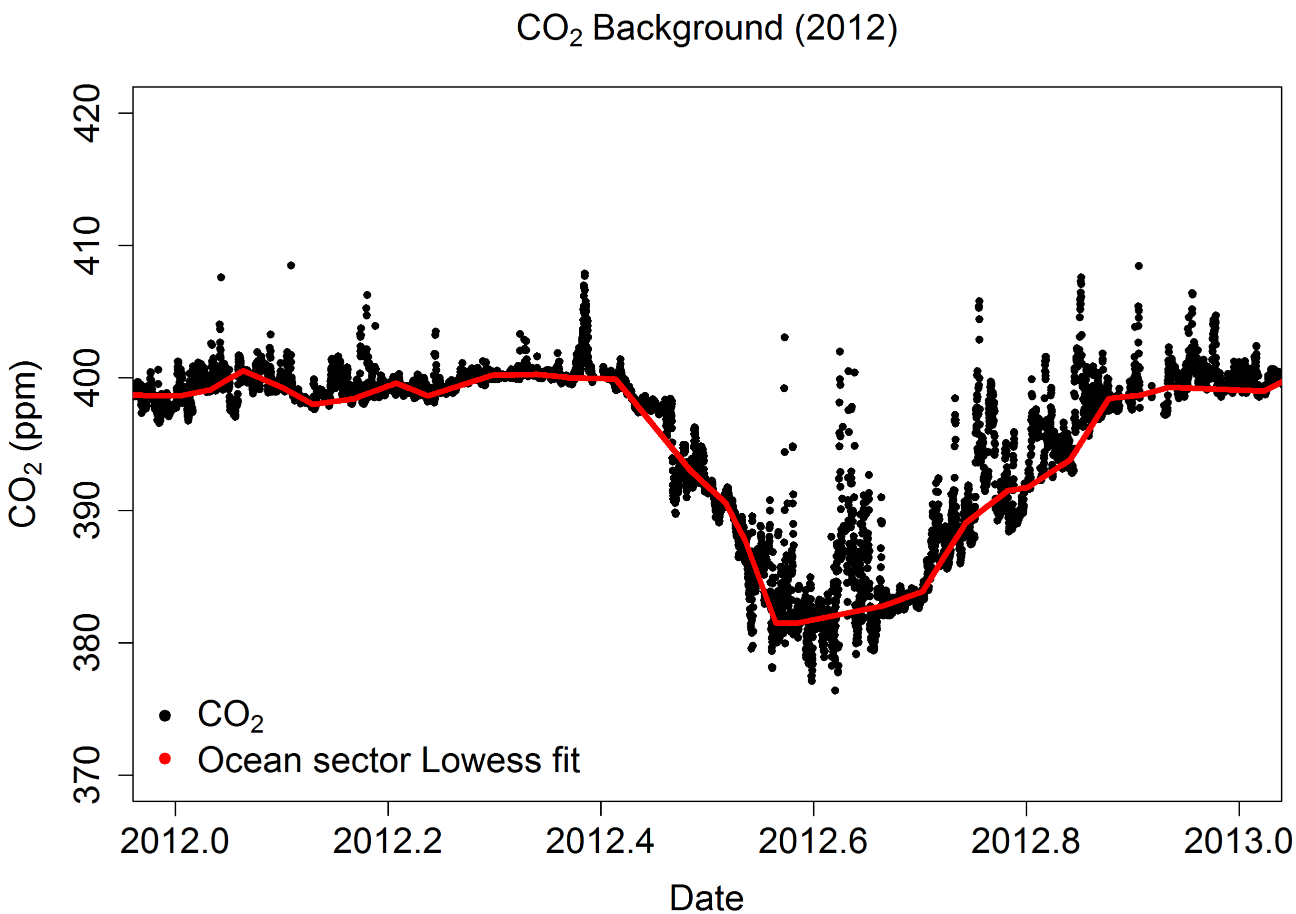


ppm/(μmole $m^{-2}s^{-1}$)

Polar VPRM NEE – July 2013 (μmole $m^{-2}s^{-1}$)



Example results: Barrow data



Example results: Barrow data

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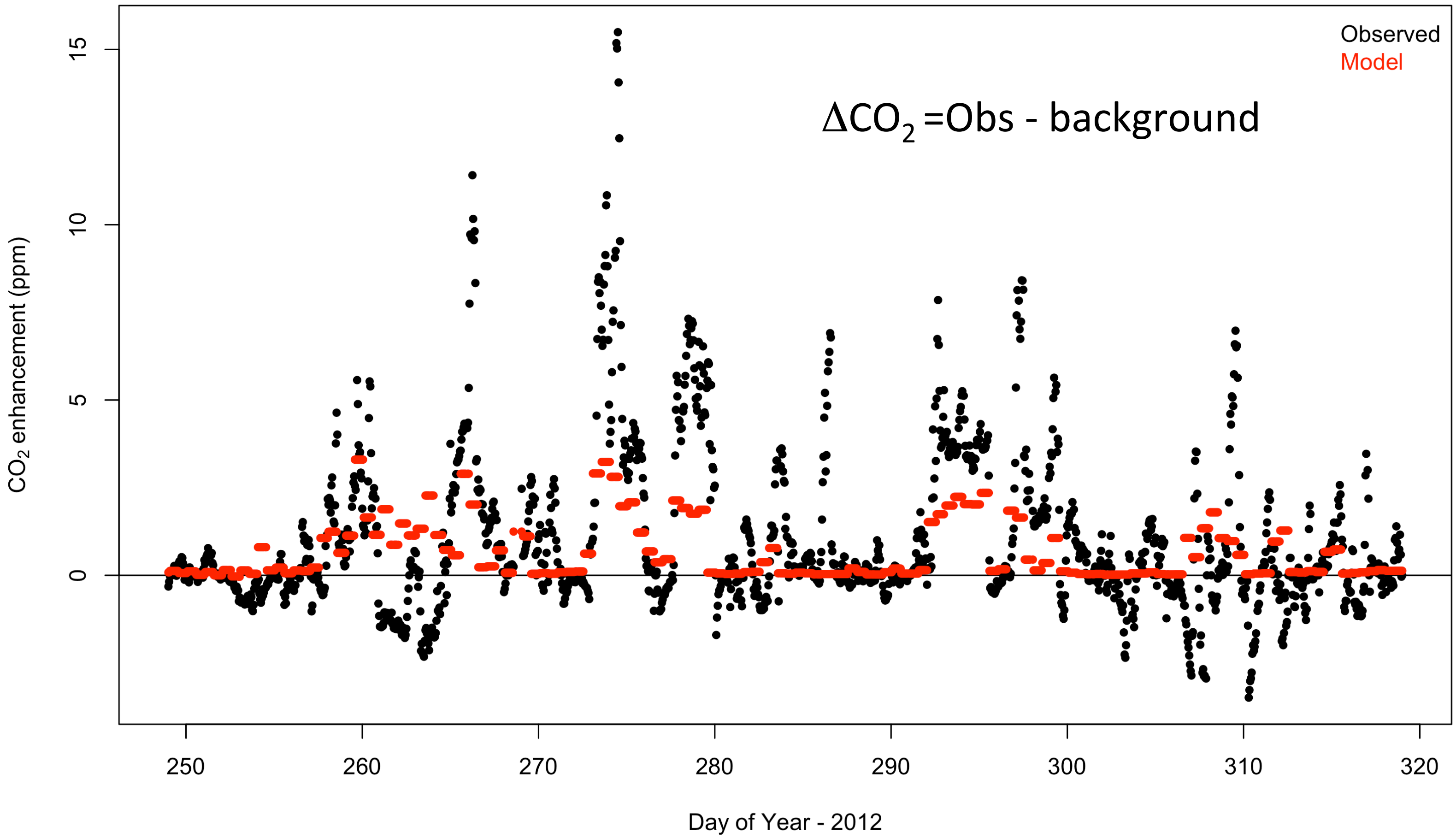
CO_2 efflux magnitude not accounted by *a piori* PVPRM



Example results: Barrow data

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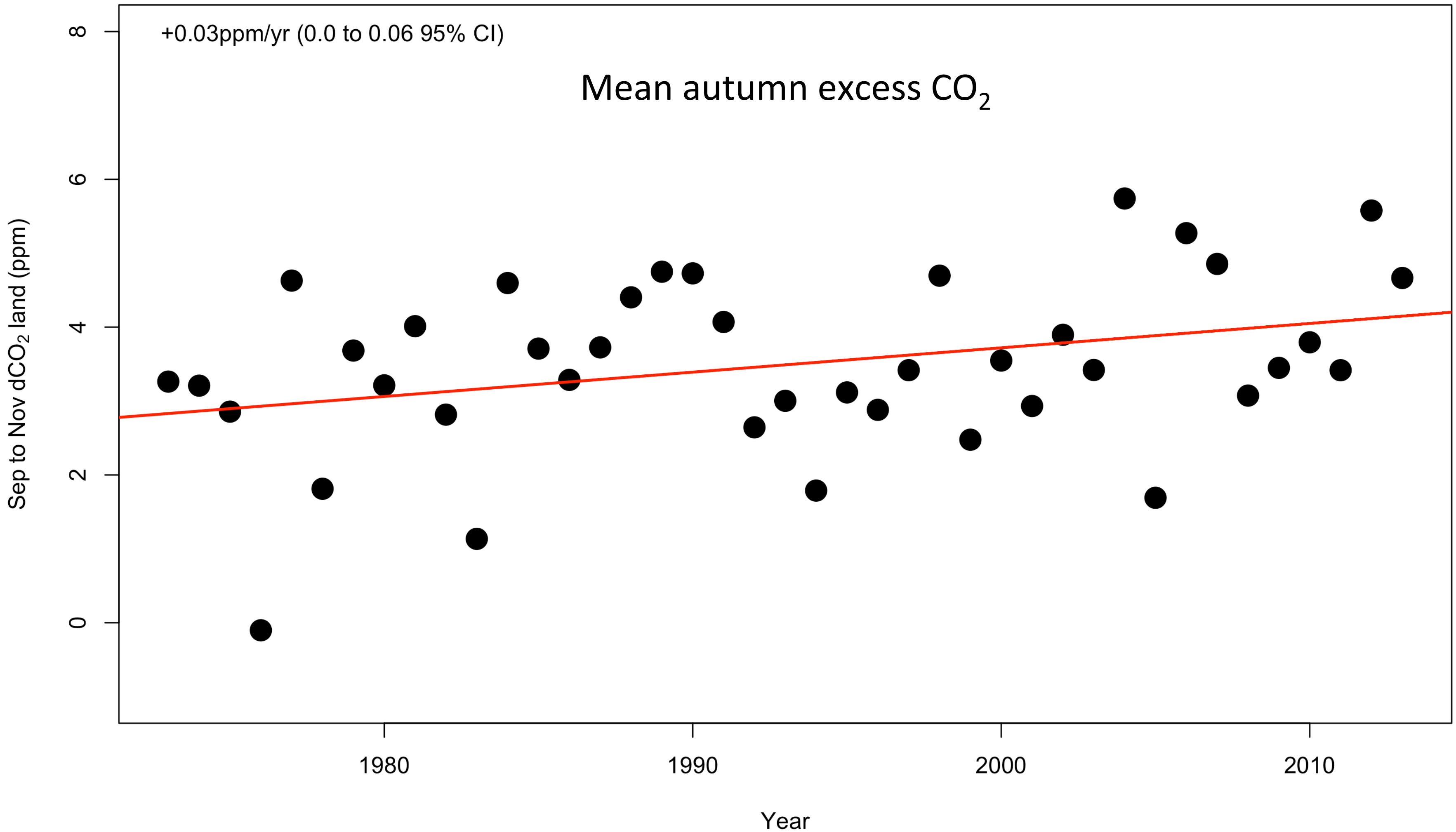

Example results: Carve Tower

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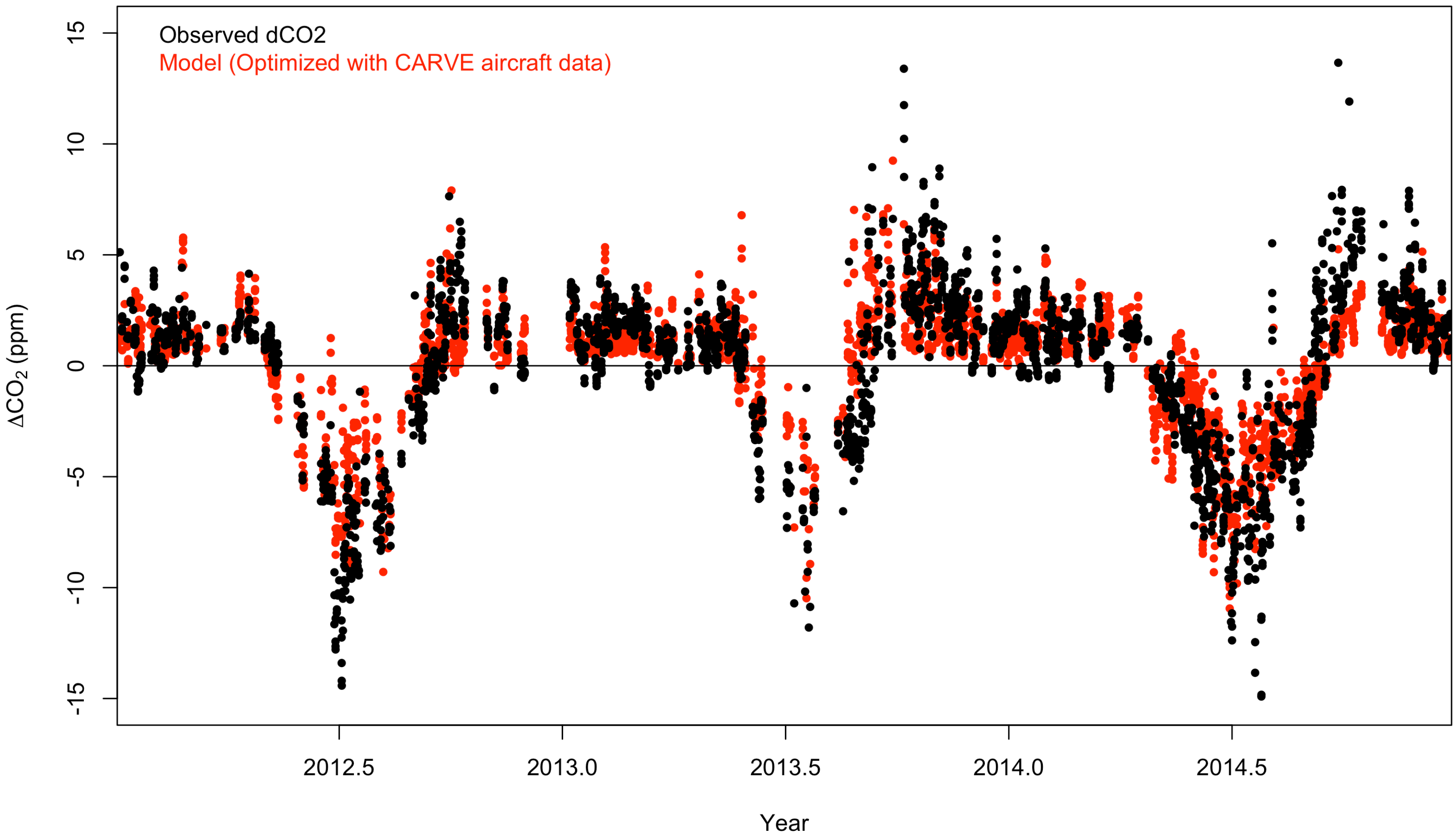

Highly promising results,
Demonstrates a potential to evaluate ecosystem models at an appropriate regional scale

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Take-home points

- Shoulder seasons are highly sensitive to environmental change and they can dominate annual budgets
- EVI-based algorithm predicts too much spring uptake:
  - airborne observations and flux tower (if year-round) quantify correction
- Autumn respiration evident at multiple sites
- Atmospheric observations, *carefully sited*, DO provide a useful integral constraint for regional carbon budget.