Mid-Continent Intensive (MCI) Experiment Demonstrates Comparability between Bottom-Up and Top-Down Approaches for Carbon Dioxide Flux Estimation

Stephen M. Ogle[1], Kenneth Davis[2], Andrew Schuh[3], Tristram West[4], Thomas Lauvaux[2], Natasha Miles[2], Scott Richardson[2], Dan Cooley[5], F. Jay Breidt[5], Linda Heath[6], James Smith[6], Kevin Gurney[7], Jessica McCarty[8], Arlyn Andrews[9], Pieter Tans[9], Scott Denning[10]

[1] Natural Resource Ecology Laboratory and Department of Ecosystem Science and Sustainability, Colorado State University, Fort Collins, CO 80525

[2] Department of Meteorology, The Pennsylvania State University, University Park, PA 16802

[3] Cooperative Institute for Research in the Atmosphere and Natural Resource Ecology Laboratory, Colorado State University, Fort Collins, CO, 80525

[4] Joint Global Change Research Institute, Pacific Northwest National Laboratory and University of Maryland, College Park, MD 20740

[5] Department of Statistics, Colorado State University, Fort Collins, CO 80525

[6] USDA Forest Service, Northern Research Station, Durham, NH 03824

[7] School of Life Sciences, Arizona State University, Tempe, AZ 85287

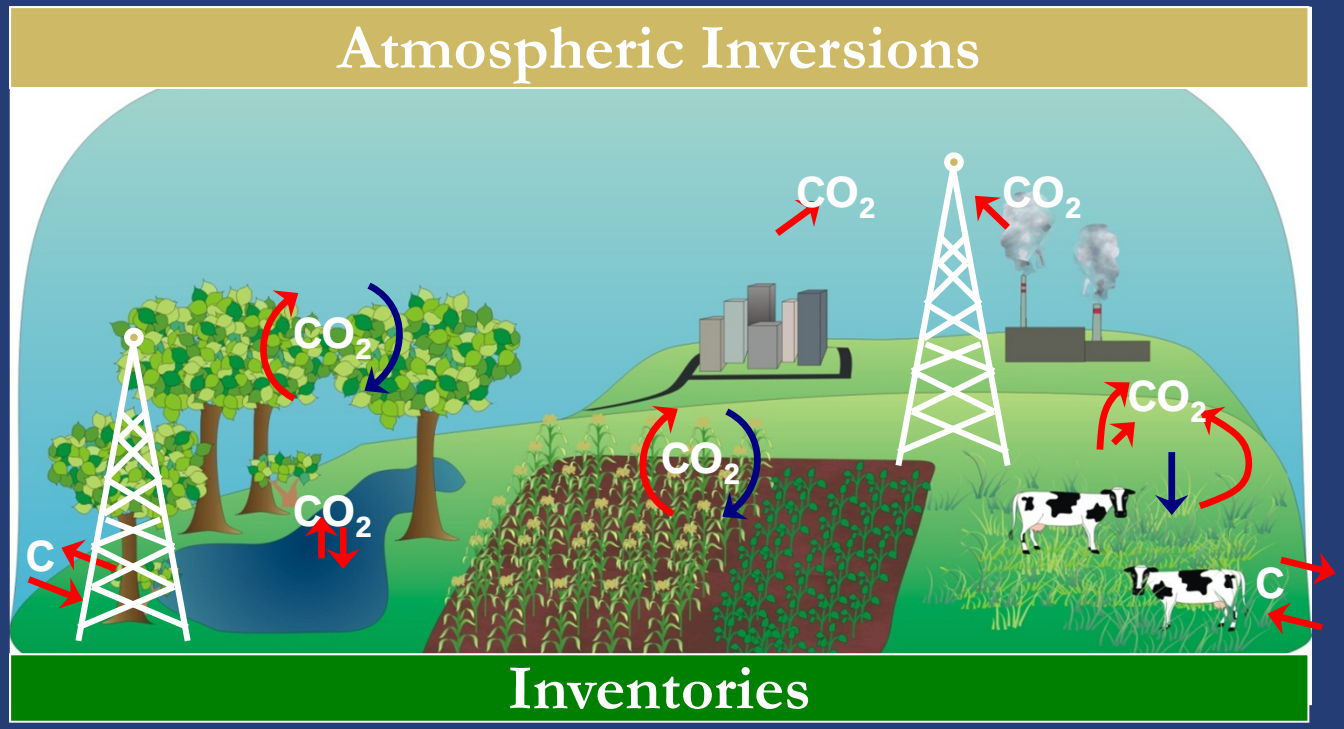
[8] Michigan Tech Research Institute, Ann Arbor, MI 481057

[9] Earth Systems Research Laboratory, NOAA, Boulder, CO 80305

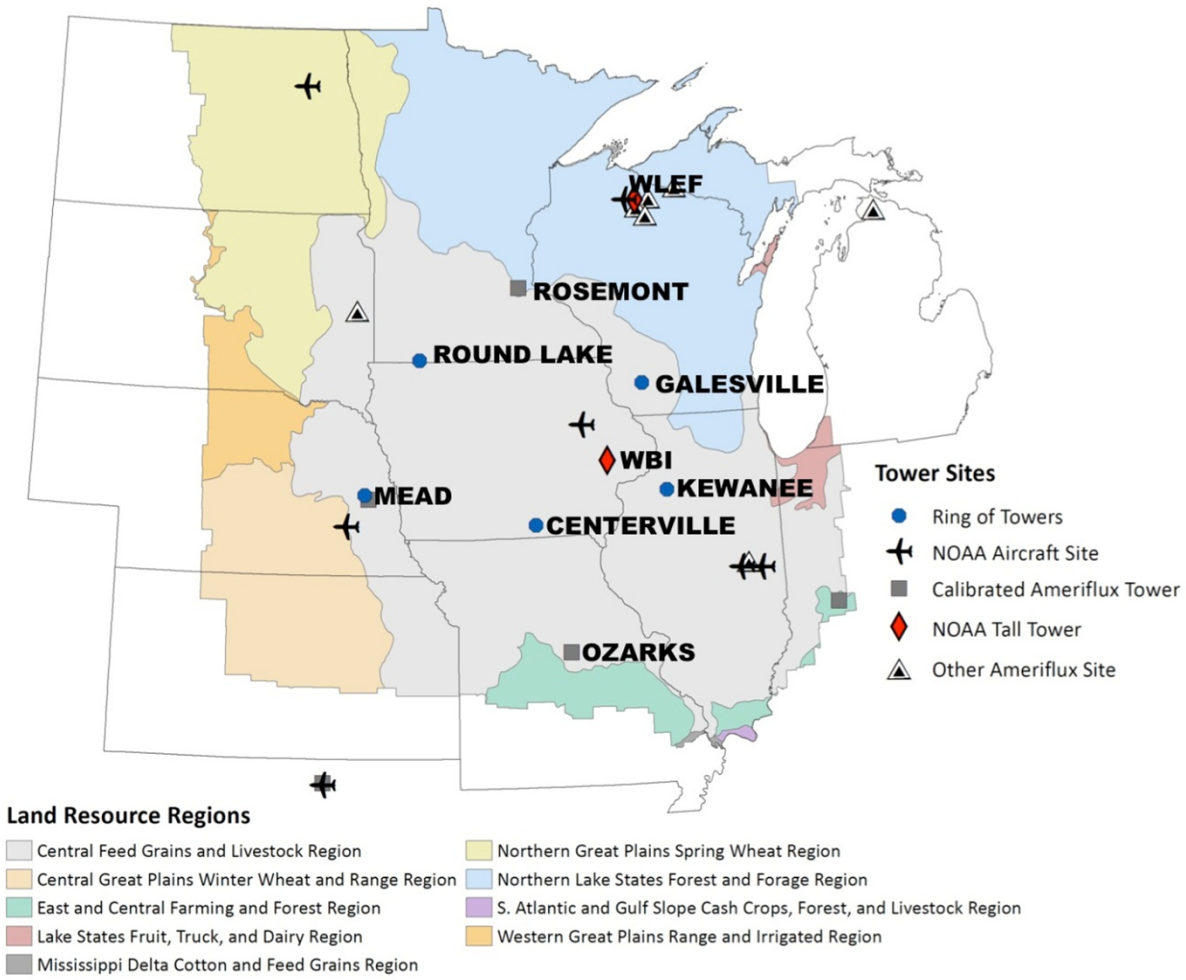
[10] Department of Atmospheric Sciences, Colorado State University, Fort Collins, CO 80525

MCI Study Objective

- NACP Mid-Continent Intensive (MCI) was a test-bed for comparing top-down and bottom-up methodologies that are used to estimate regional CO_2 fluxes. Focus year was 2007.



MCI Study Area



CO_2 Emissions Inventory

- Fossil and biofuel combustion (Gurney et al. 2009)
- Crop harvest, livestock respiration, and human respiration (West et al. 2011)
- Forest carbon and harvest (Smith et al. 2007, Heath et al. 2011)
- Cropland and grassland soil C (Ogle et al. 2010)
- Agricultural residue burning emissions (McCarty et al. 2009)
- Landfill decomposition (West et al., in prep)

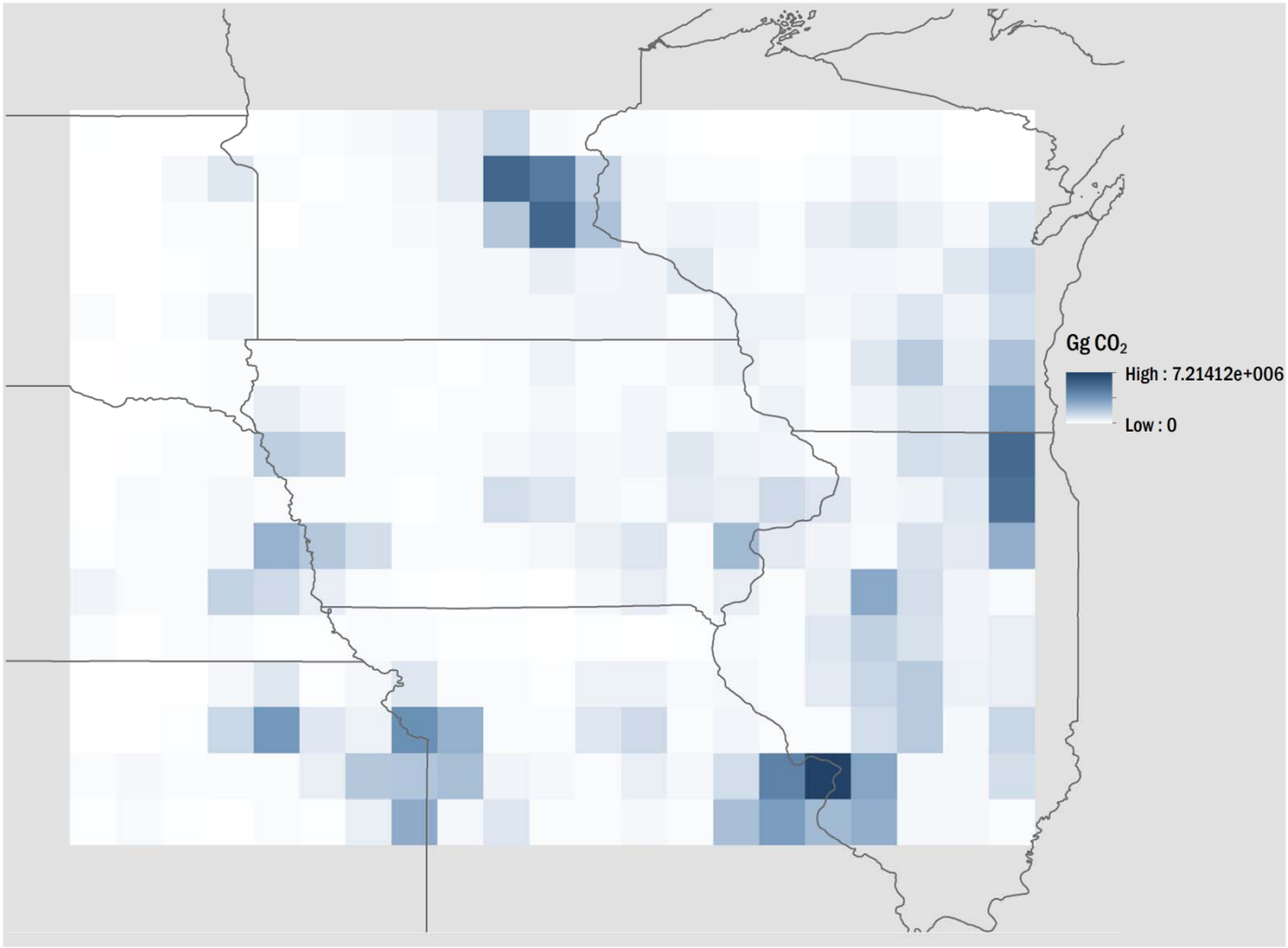
Emissions Inventory Uncertainty

- Estimating the sum of sources (t) for grid cells (i), and then summing those results to the region

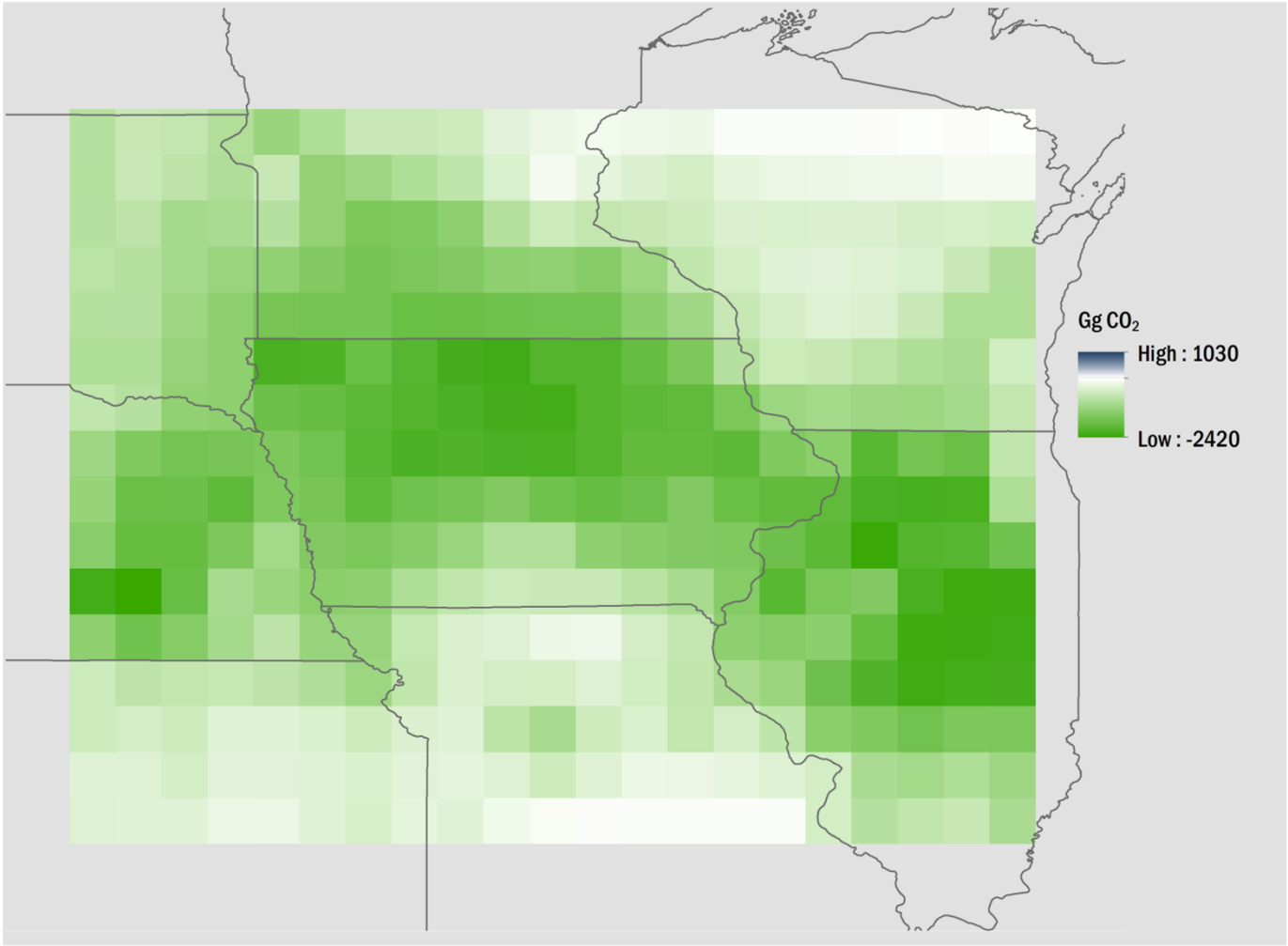
$$t_i = f_i + y_i + cl_i + gl_i + fl_i + w_i + lv_i + h_i + lf_i + b_i$$

- Monte Carlo Analysis
  - Each source has a 100 realizations for all grid cells in the MCI region
  - Uncertainty based on PDFs for key parameters and input data
- Spatial correlation represented within sources, but assumed to be independent between sources

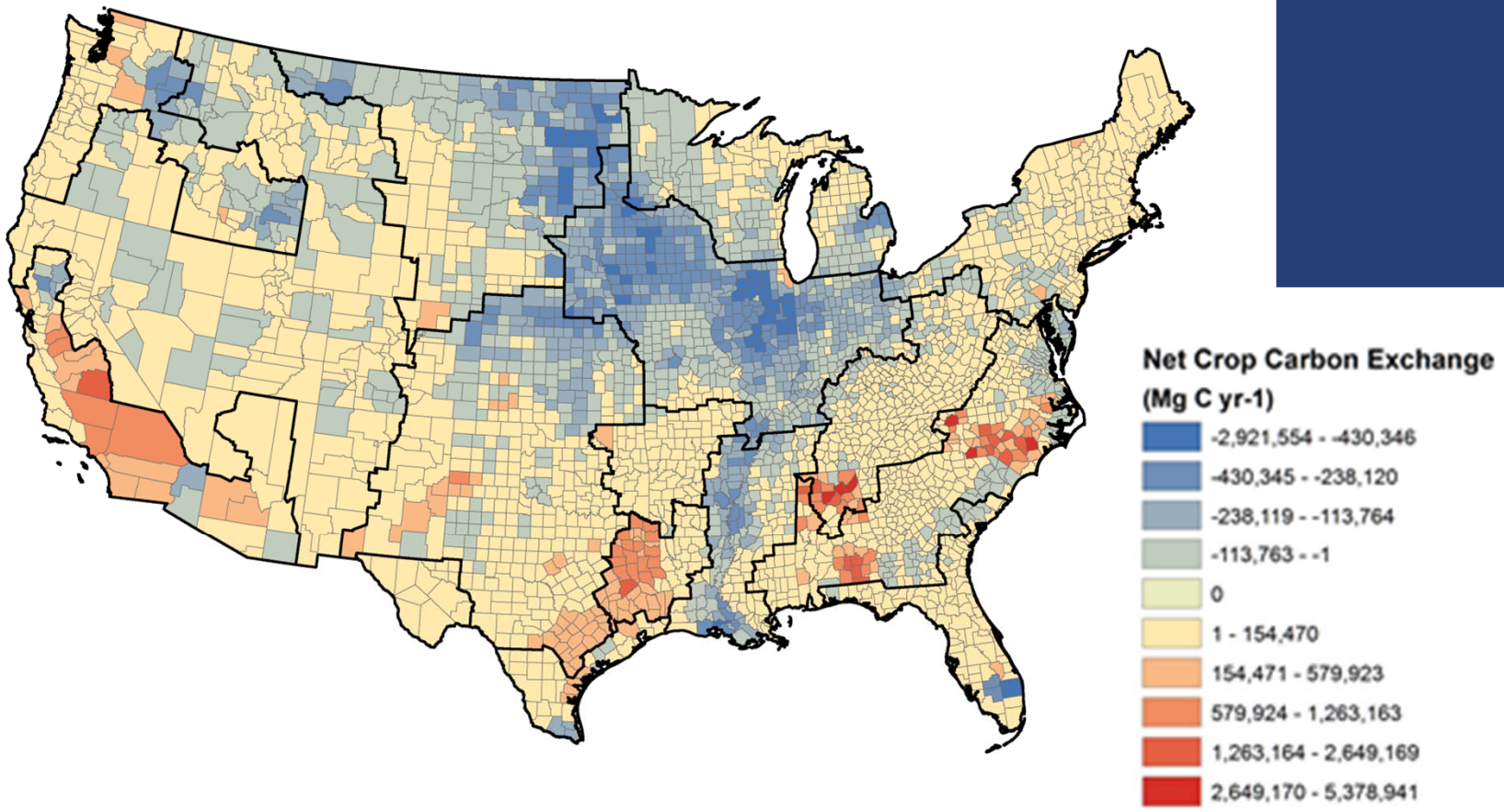
CO_2 Inventory: Fossil Combustion



CO_2 Inventory: Croplands

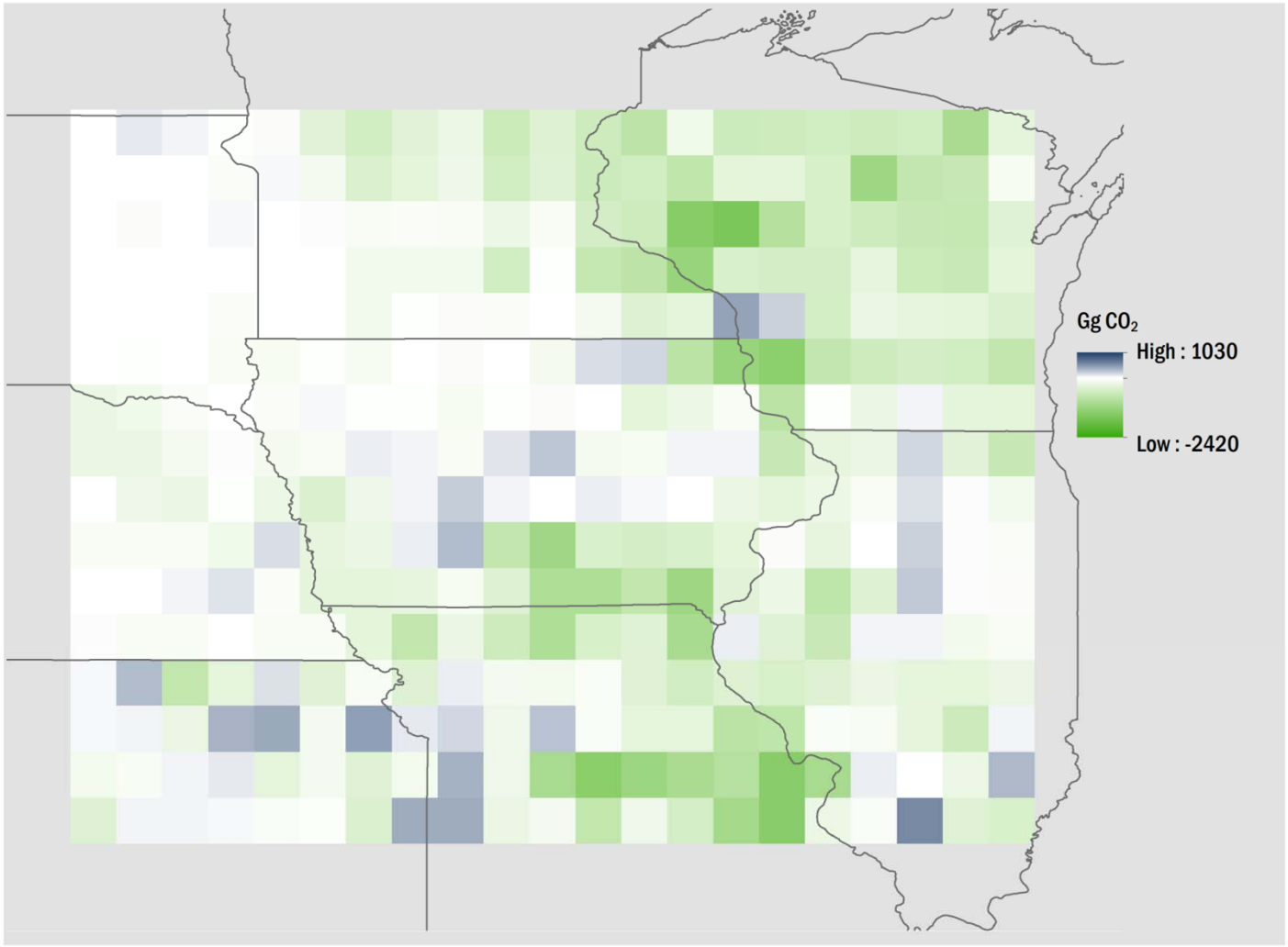


National Patterns: Cropland Carbon

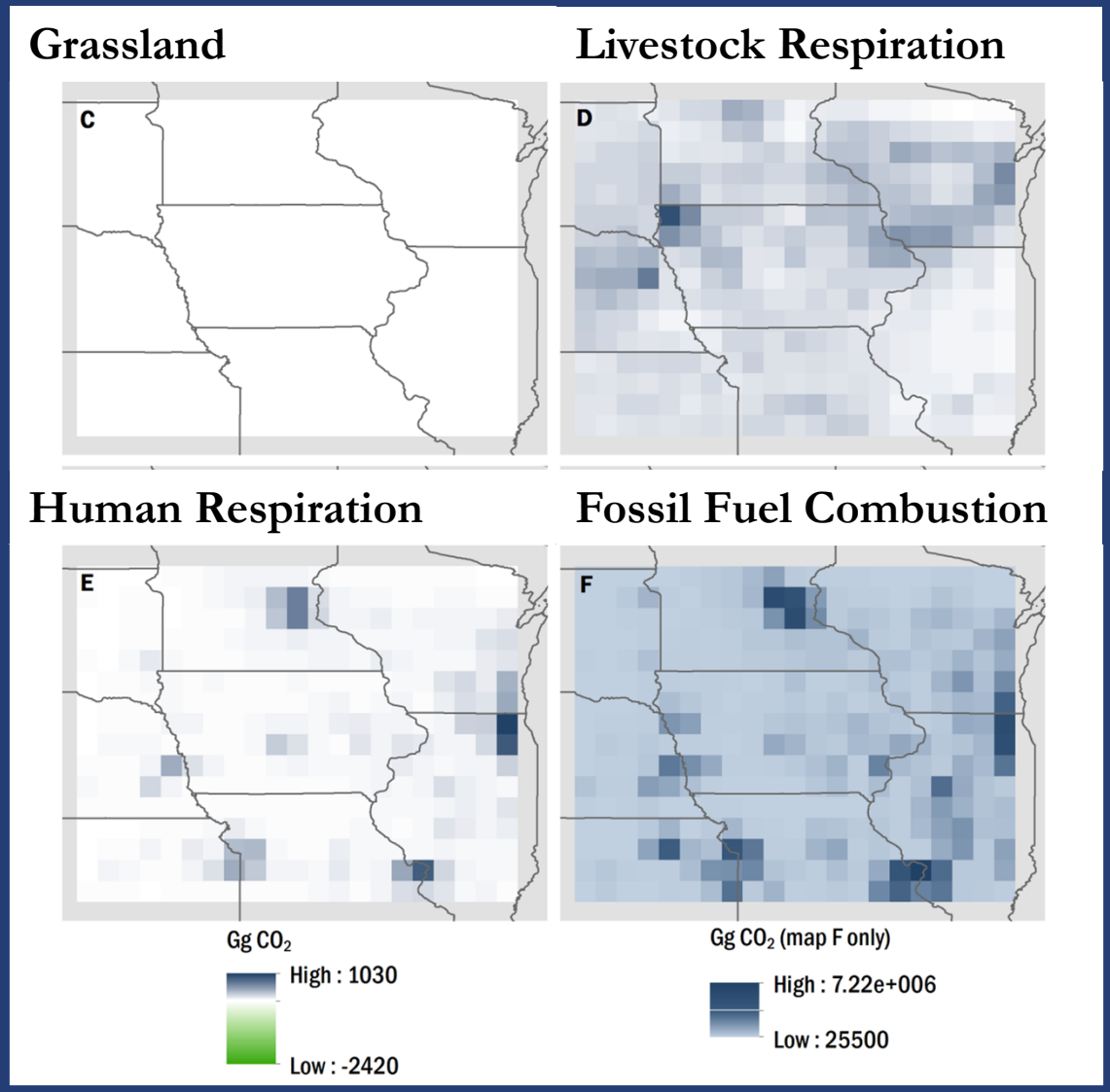


West et al. 2011, Biogeosciences

CO_2 Inventory: Forestland

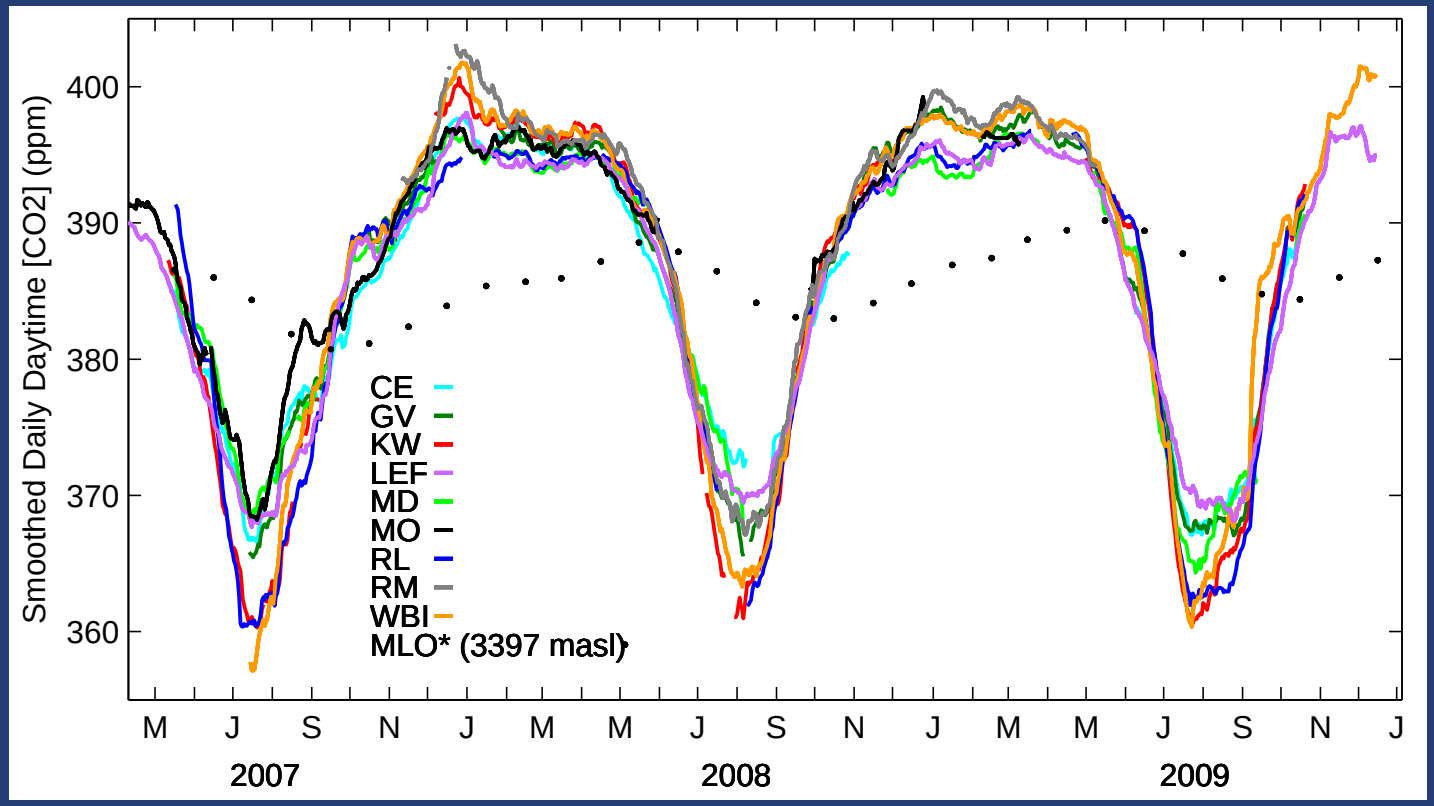


Other Inventory Sources



Atmospheric CO_2 Measurements

- CO_2 concentration data showing strong draw-down at all towers throughout MCI region

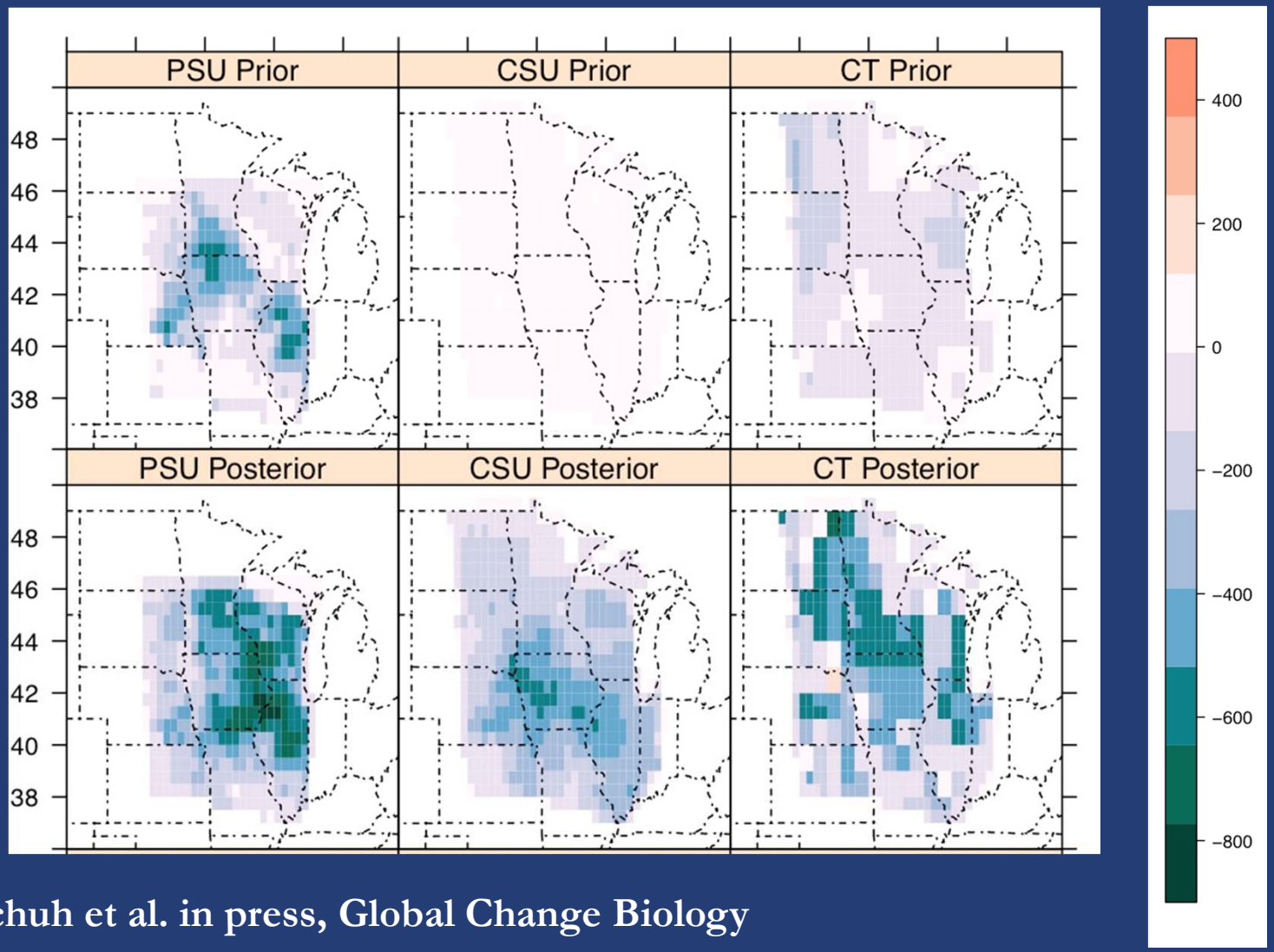


Miles et al. 2012, Journal of Geophysical Research

Atmospheric Inversion Models

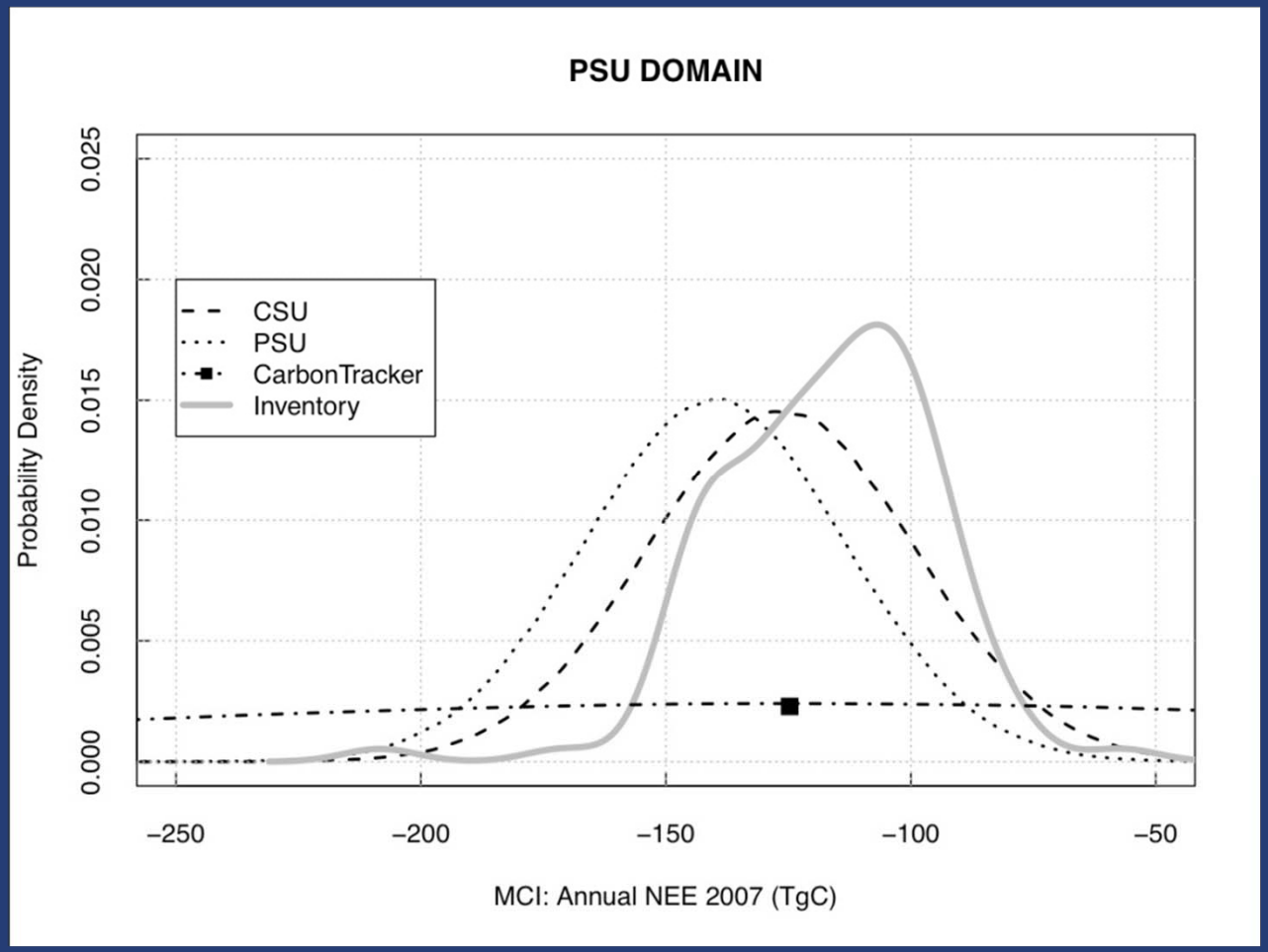
- Two meso-scale atmospheric inversion modeling systems
  - Colorado State University (Schuh et al. , in press)
  - Penn State University (Lauvaux et al. 2012)
- Included CarbonTracker for comparative purposes (Peters et al. 2007)
- Fossil emissions are treated as a known in the inversion
  - Comparison between inversion model results and non-fossil portion of CO_2 emissions inventory

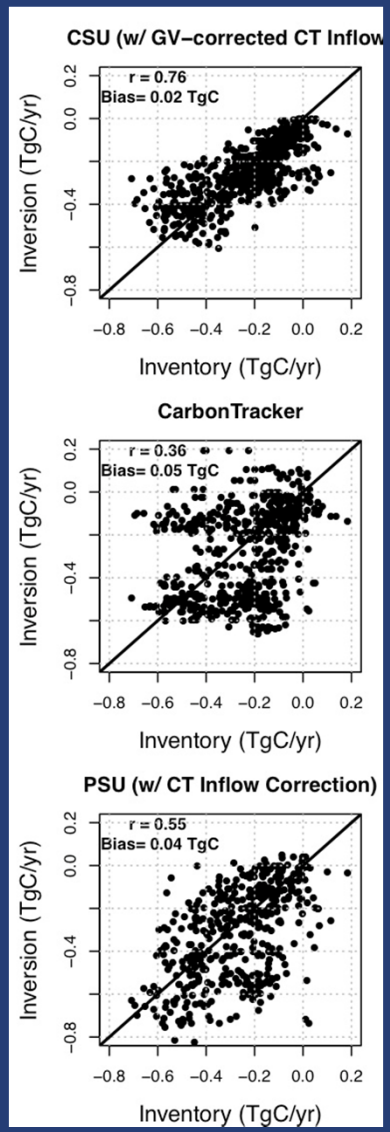
Atmospheric CO_2 Inversions



Schuh et al. in press, Global Change Biology

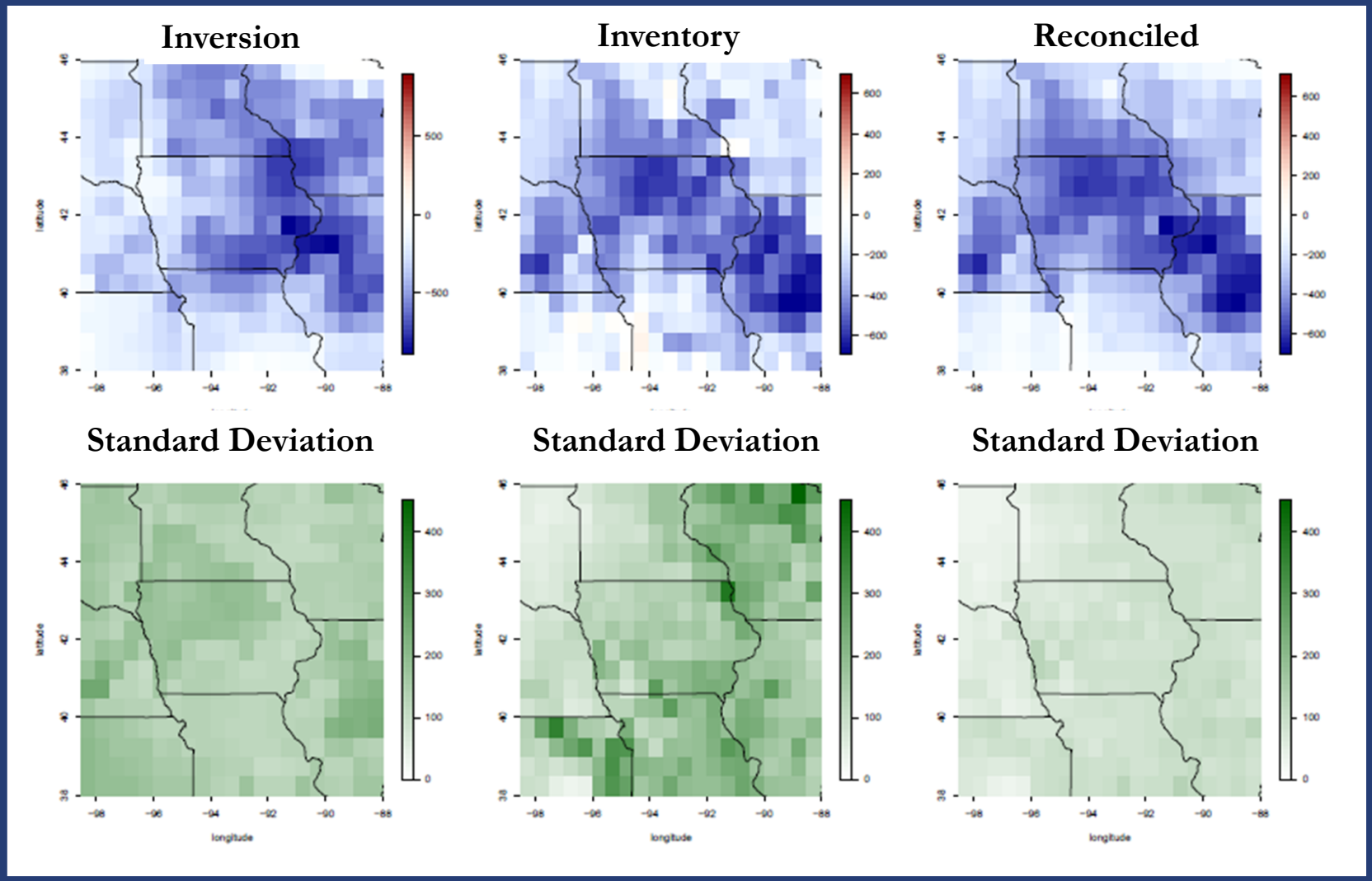
Comparison: Inventory and Inversion





Schuh et al. in press, Global Change Biology

Reconcile: Inventory and Inversion



Cooley et al. in press, Ecological and Environmental Statistics

Future Regional-Scale Research

- Meso-scale atmospheric measurement and inversion system needs to be tested in other regions
- Track lateral transport of carbon in commodities and CO_2 return as part of emissions inventories
  - Needed to compare inventory results with atmospheric CO_2 concentration measurements
- Can fossil emissions be included in the atmospheric inversion framework?
  - Indianapolis Flux Experiment, Megacities project
- Uncertainties have been reduced in regional CO_2 budget, but still room for improvement

Acknowledgements:

We are grateful to the MCI Science Team, in addition to the funding support from NASA, DOE, NOAA and USDA.

National Aeronautics and Space Administration