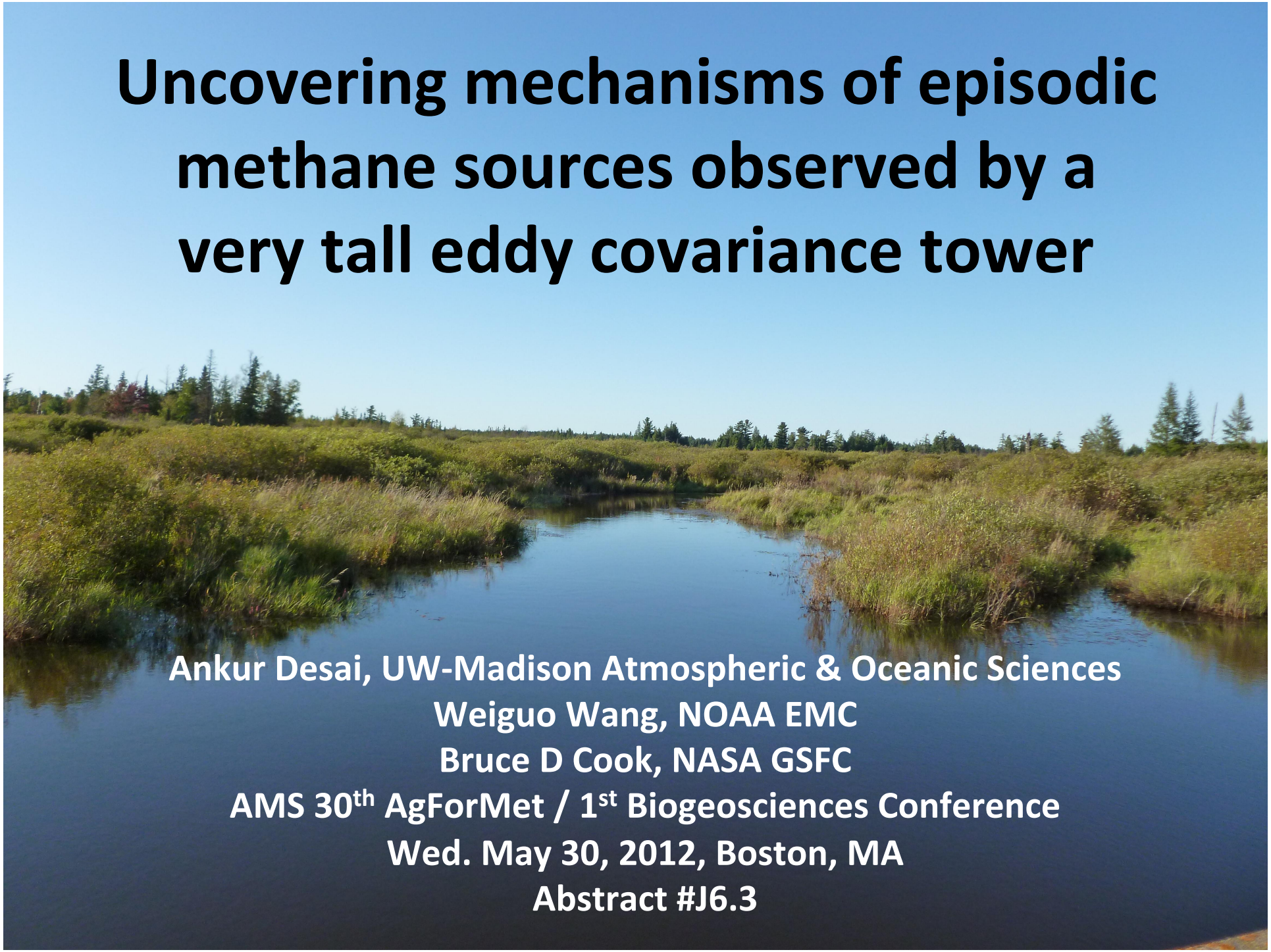
Uncovering mechanisms of episodic methane sources observed by a very tall eddy covariance tower



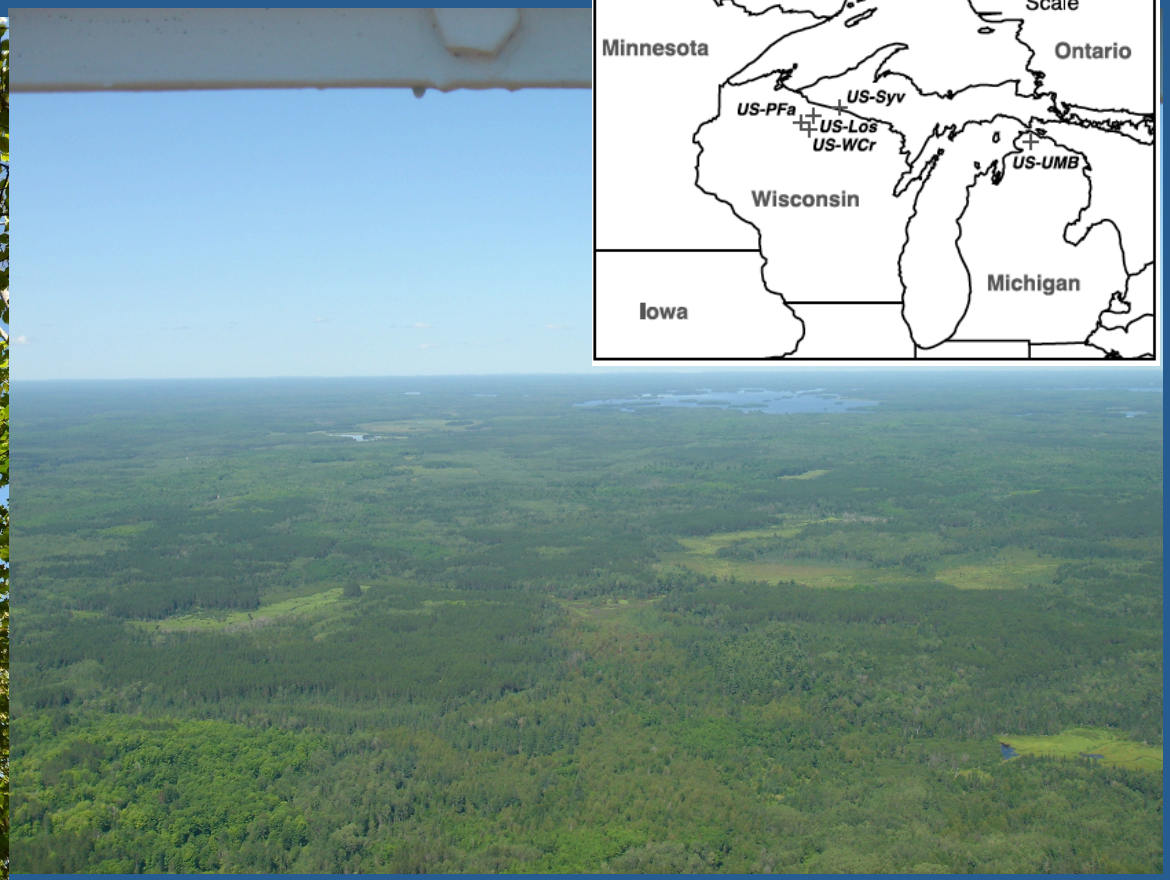
Ankur Desai, UW-Madison Atmospheric & Oceanic Sciences
Weiguo Wang, NOAA EMC
Bruce D Cook, NASA GSFC

AMS 30th AgForMet / 1st Biogeosciences Conference
Wed. May 30, 2012, Boston, MA
Abstract #J6.3

Why do we even have tall towers?

- Atmospheric and ecological research suffers from the "perfect site" bias
  - High signal to noise ratio
    - E.g., convection in southern great plains
  - Pretty site bias (infrastructure, homogeneity)
    - E.g., Even-aged homogenous flux towers
- Regional-scale flux measurements can address some of this bias

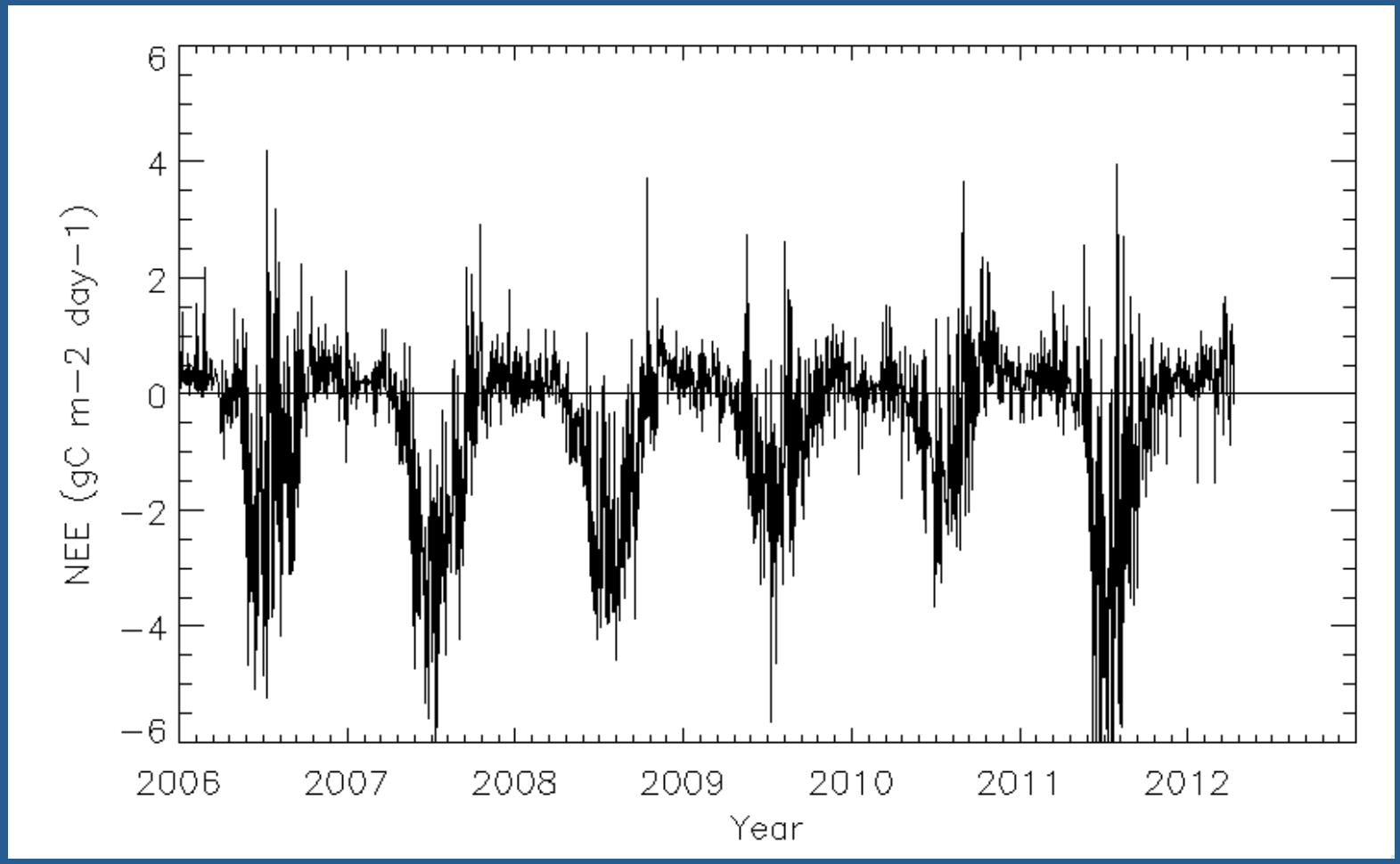
A very tall tower!



Pretty sites!

The reality

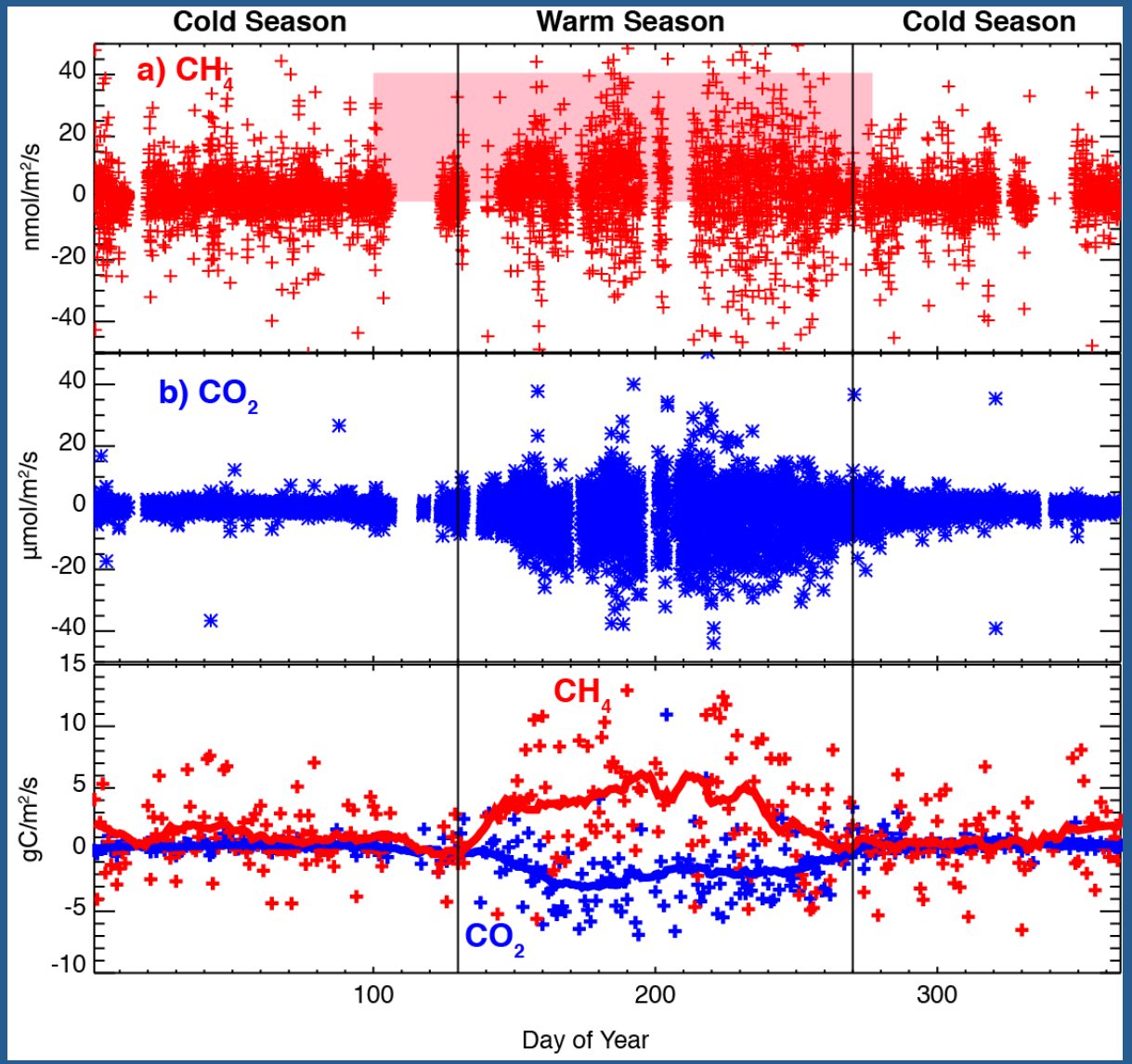
Long-term variability of CO_2 NEE



Methane is a real bugger

- In late 2010, we added fast response methane measurements to the long running Ameriflux US-PFa (WLEF) tower

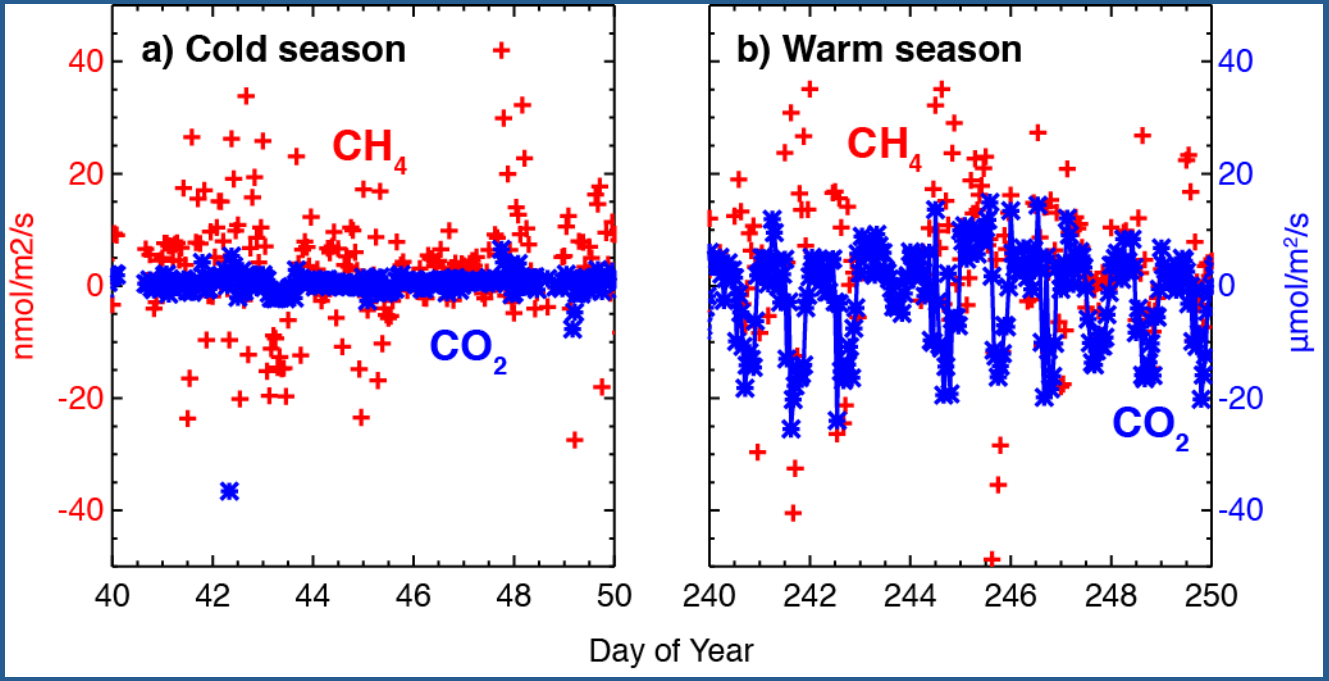
And it surprised us!



A. Desai J6.3

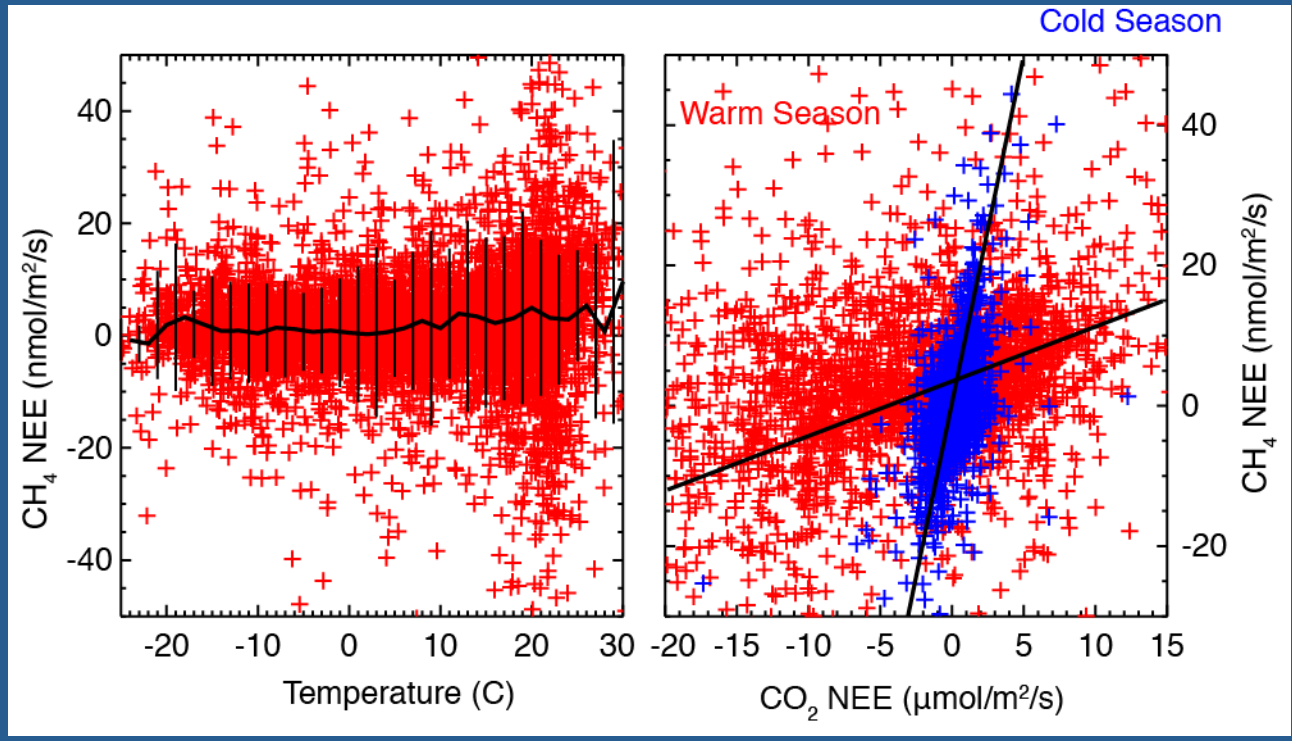
Different sources in winter and summer?

- Methane flux magnitudes do not change in magnitude from winter to growing season, but do change in quality.



Environmental controls not evident

- CH_4 emissions regionally are only weakly correlated to temperature, unlike at plot scale. Winter CH_4 fluxes strongly correlated to small magnitude CO_2 fluxes.

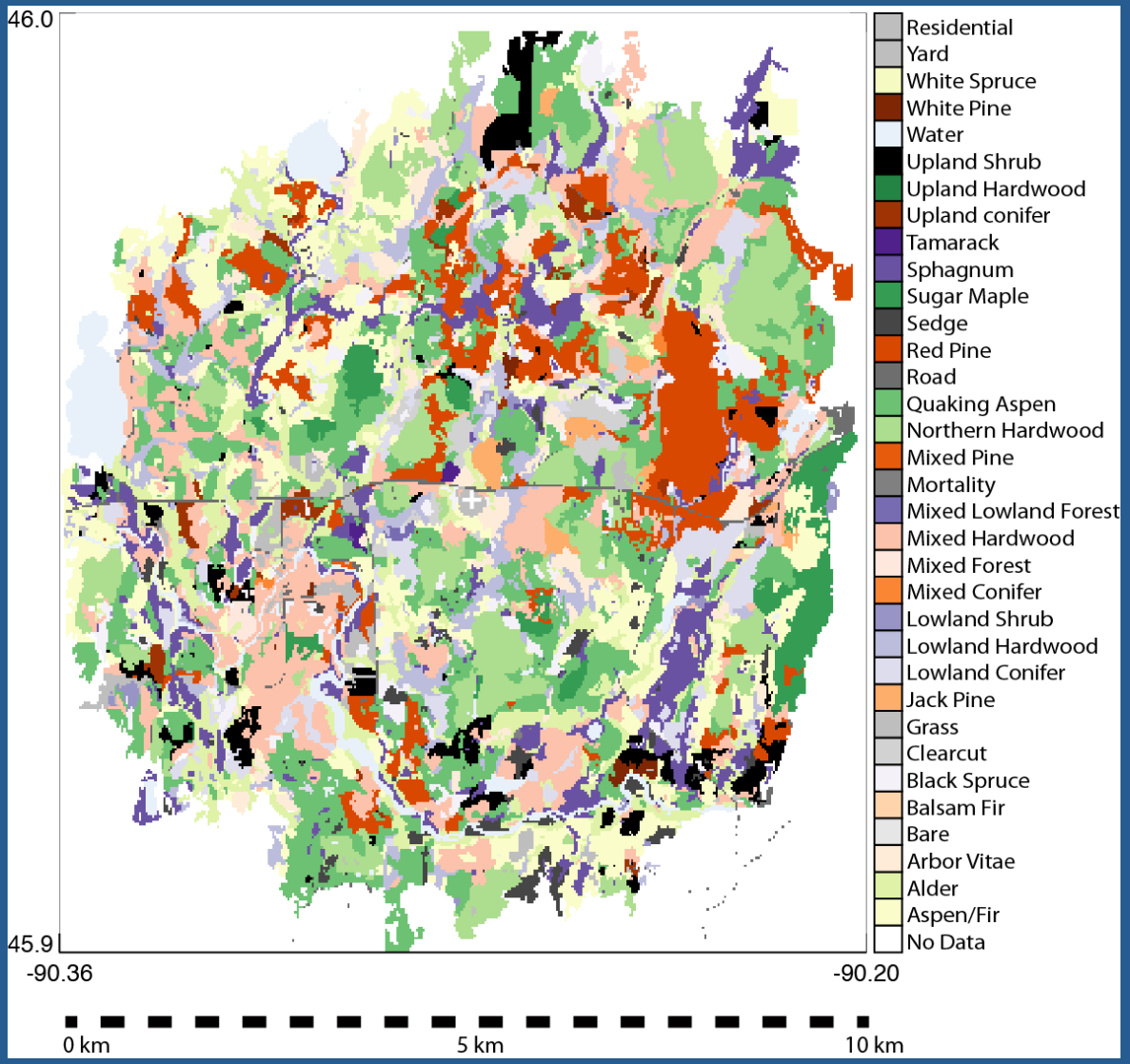


Questions

- Are there ecosystem-scale environmental controls on these relatively large bursts of methane inside and outside of the growing season?
- Which landscapes in the tower footprint are responsible for large CH_4 sources?
- Is there a shift in key regions for methane emission and consumption by season?

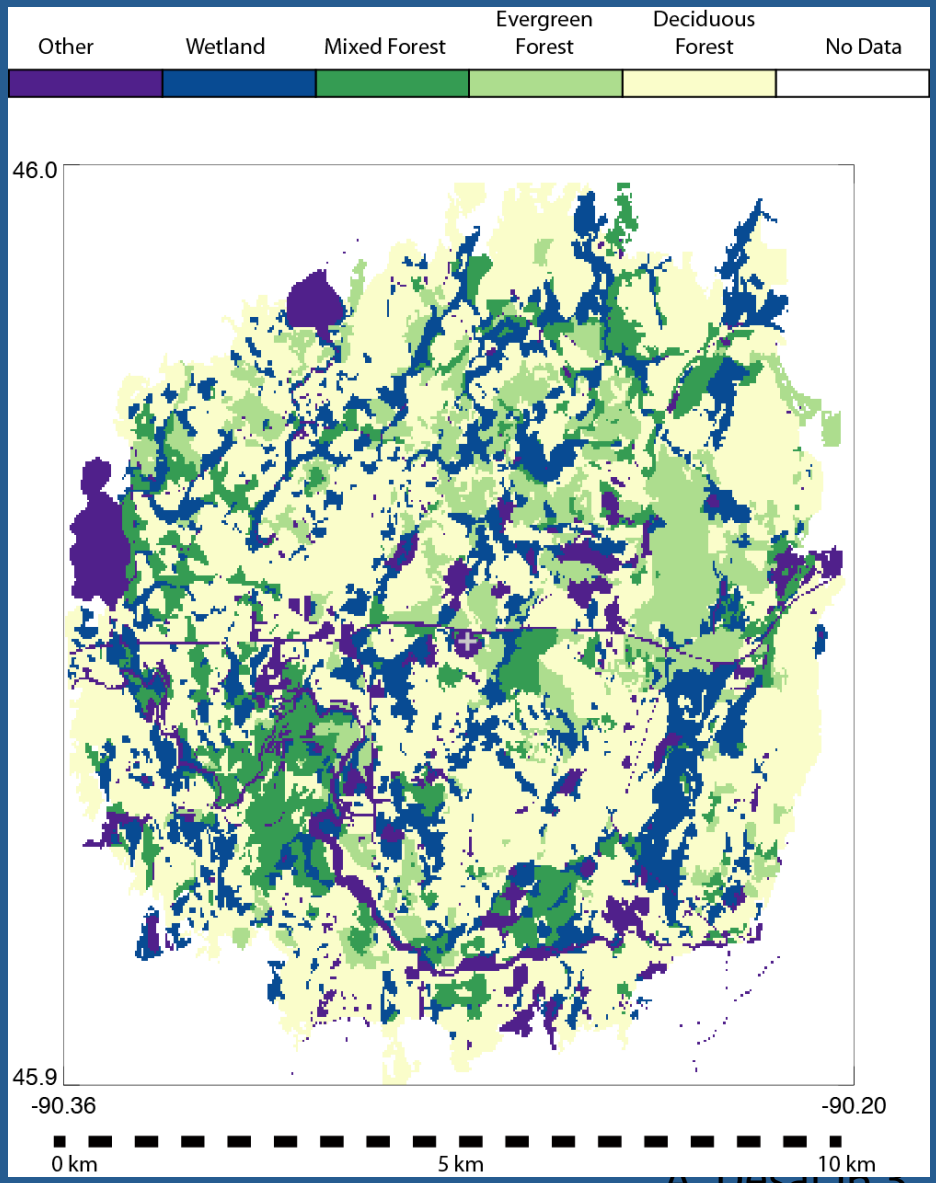
Where are the methane sources?

- 30 meter land cover derived from hand analysis and ground truthing of Quickbird imagery



Seeing more with less

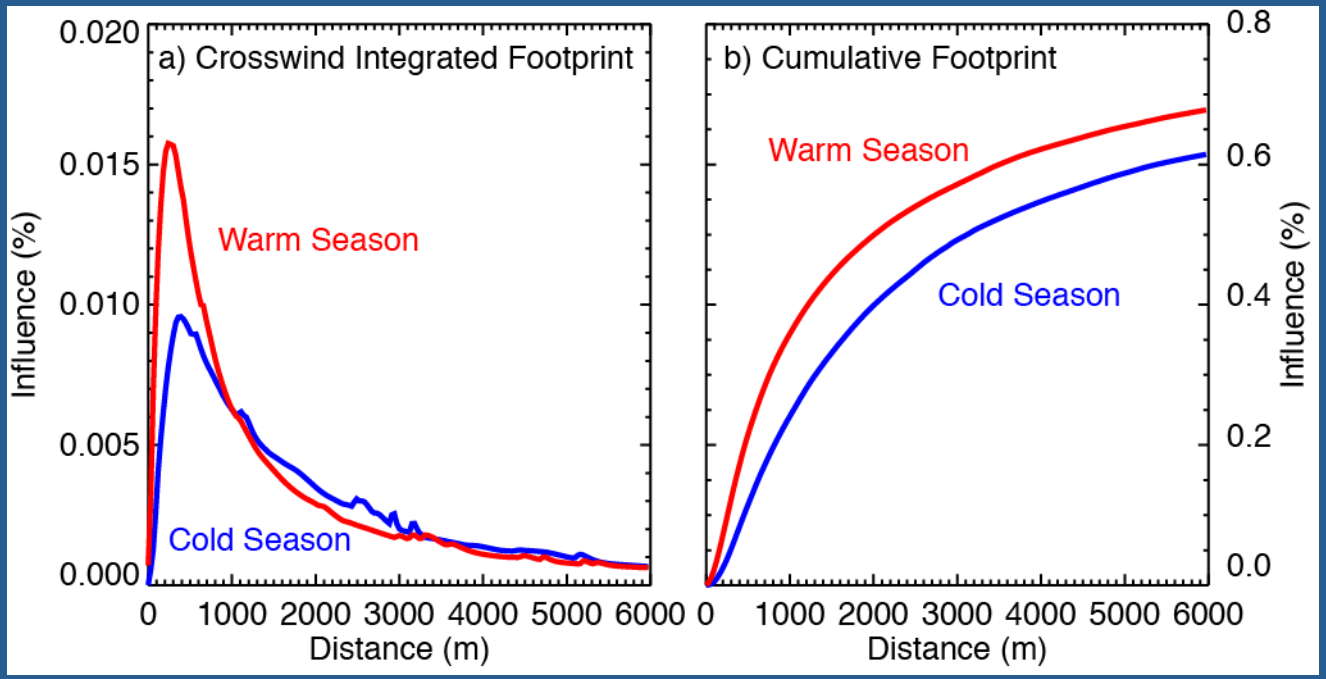
- Reclassification of 34 land covers reveals importance of small-scale wetlands and forest type across footprint



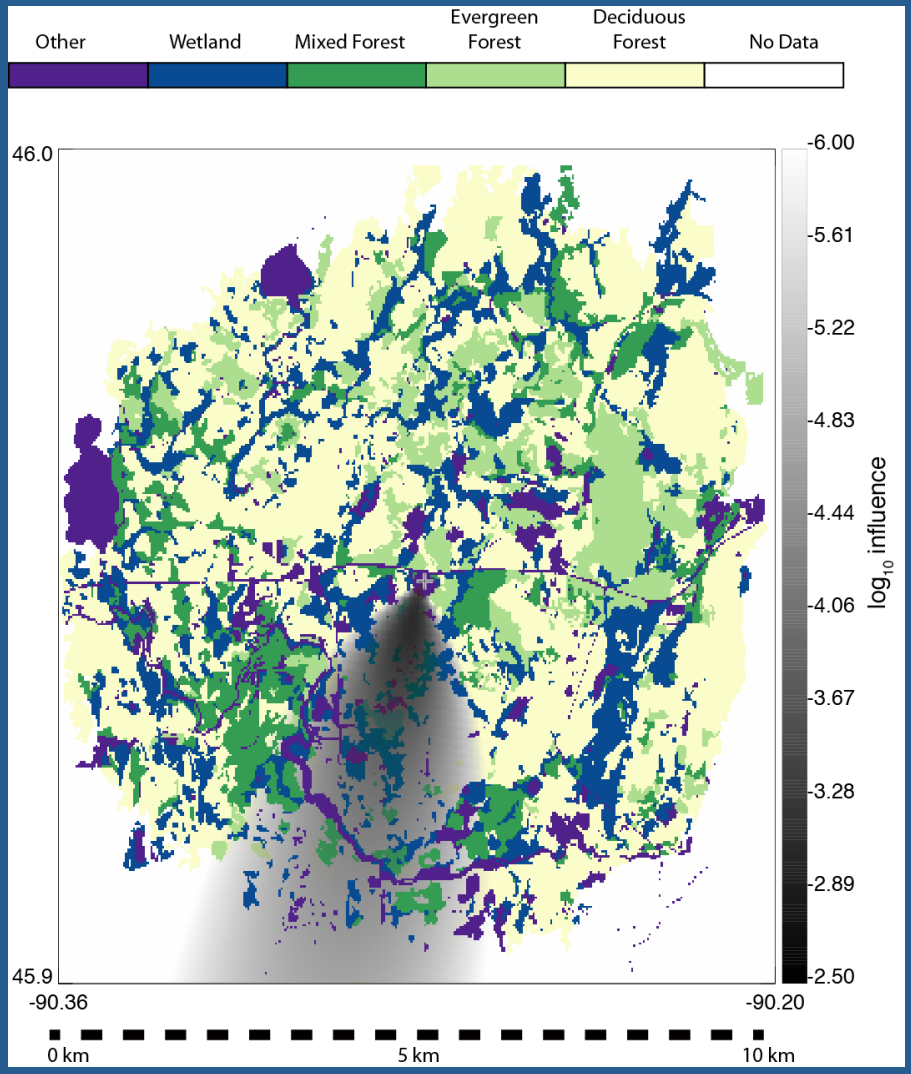
A. Desai 06.3

PBL footprint models required

- Surface-layer flux footprint models are not valid for tall towers
- Applied Wang et al. (2006) J. Atm. Ocean. Tech. CBL cross-wind integrated flux footprint model to one year at 122m measurement height at WLEF



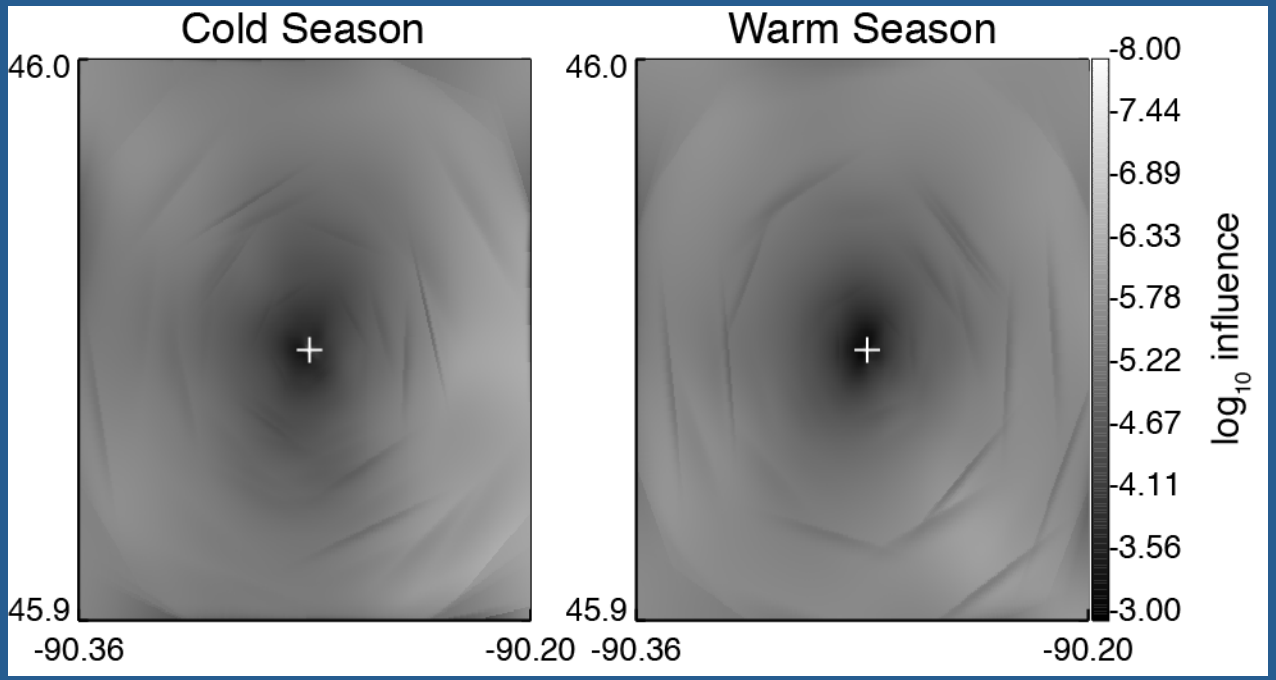
I see the forest and the swamp!



- Typical hourly flux footprint samples a wide range of wetland and forest types
- Variation with stability and wind direction allow us to evaluate sources

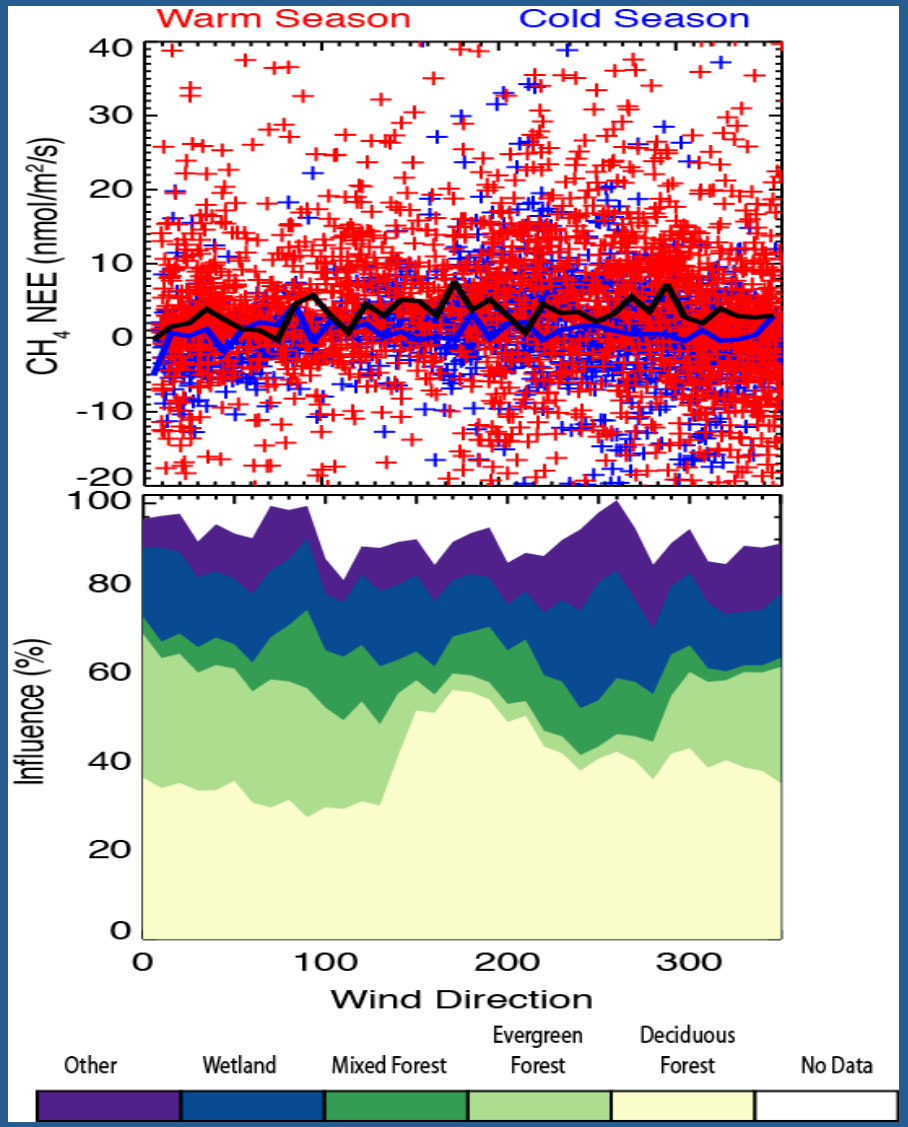
Footprint sample bias is small

- Surprisingly, long-term footprint biases are small, so we are confident that tower samples regional flux over long-time periods



No smoking gassy gun?

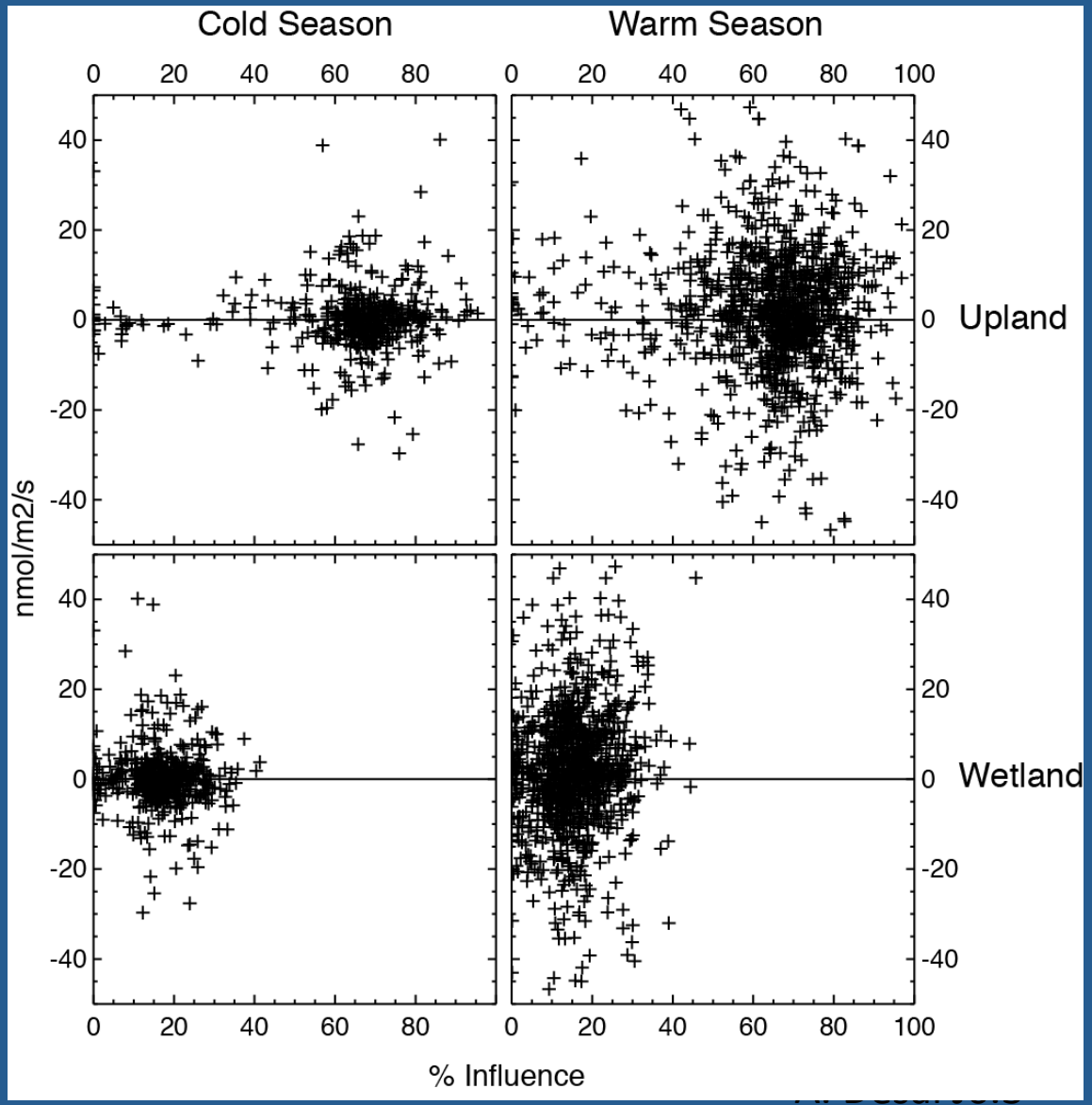
- Mean land cover by wind-direction segregated footprint hints but does not fully support strong CH4 sources from wetlands NW of tower



A. Desai J6.3

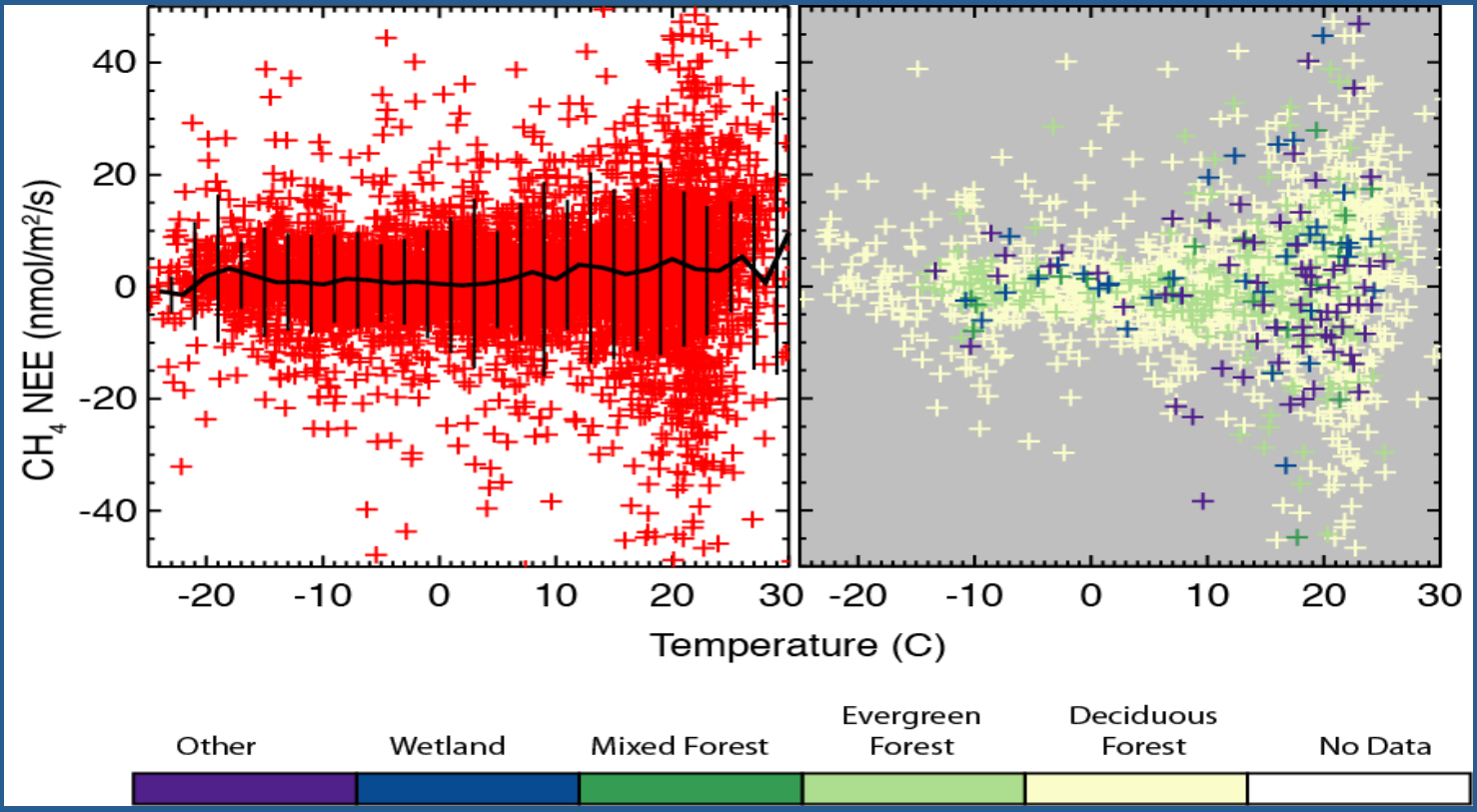
Maybe “pure” footprints help?

- However, high methane emissions occur both in footprints with mostly upland influence (top) AND mostly wetland influence (bottom)



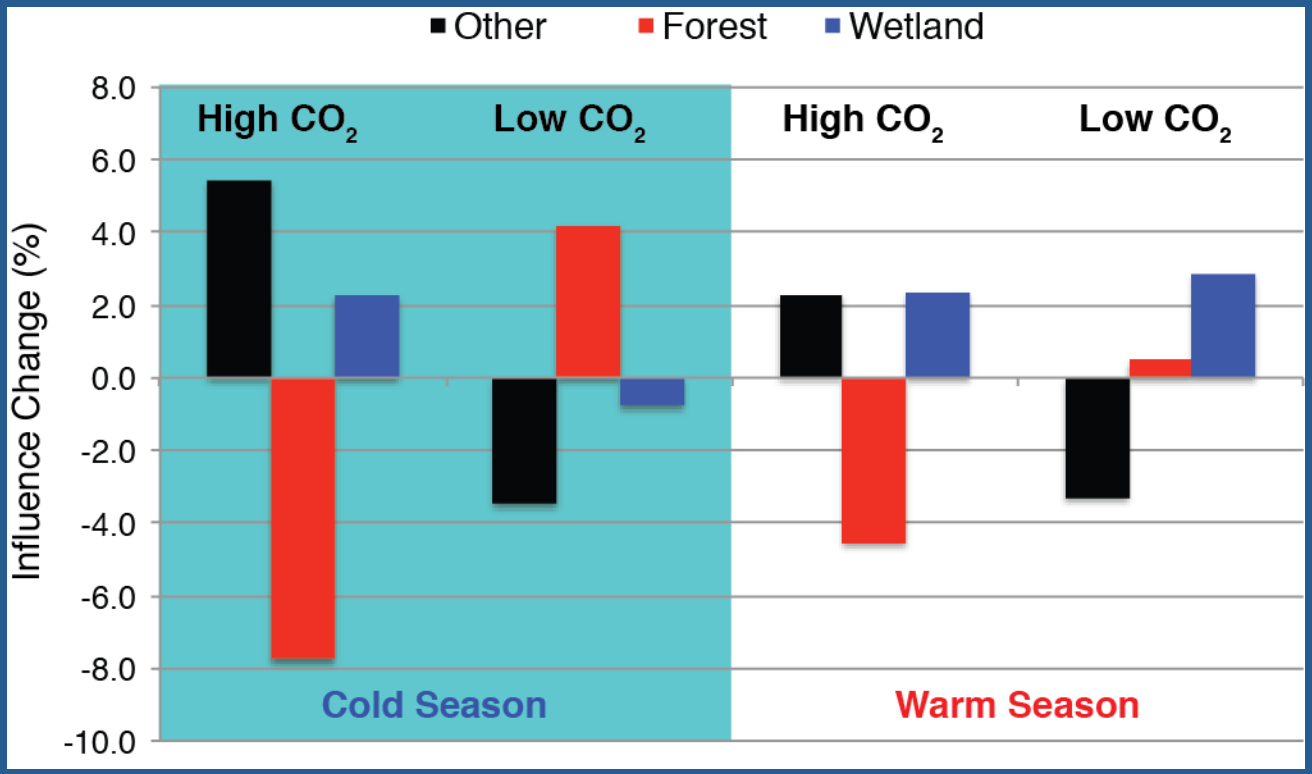
Forests may have CH_4 sources

- Temperature response segregated by “dominant” footprint land cover reveals high CH_4 emission by deciduous forest dominant footprints!



Coevolution of CO_2 and CH_4 sources?

- Alternative look – some consistencies in difference in land cover influence by periods with high CO2 and/or high CH4



Conclusions

- Regional fluxes arise from a a variety of "non-pretty" landscapes with "low signal-to-noise"
  - Requires a more robust sample design for scaling from stand to region
- Episodic methane sources influence regional methane flux budgets and have a different pace and mechanism then CO_2, especially in growing season
- Flux footprint models and land cover maps hint at a wetland influence for CH_4 emissions, but not clearly
  - Uncertainty in all three (flux, footprint, land cover) can be large and require evaluation
  - Upland sources of methane cannot be ruled out
  - Simple temperature response functions from the plot-scale do not necessarily pan out at the region -> implications for ecosystem model parameterization
  - Current plans include development of soil survey chamber for CH_4 flux – seeking advice!

Acknowledgments

- $$: NSF CAREER DEB #0845166
- WLEF/ Park Falls (US-PFa) tall tower research partners: NOAA ESRL (A. Andrews, J. Kofler), USFS NRS (M. Kubiske, D. Baumann), Penn State (K. Davis), WI ECB (J. Ayers) , Ameriflux, Picarro, Inc., Los Gatos Research, Inc., P Weishampel (Northland College)
- Desai lab at UW
  - Field site manager: Jonathan Thom
  - http://flux.aos.wisc.edu
  - desai@aos.wisc.edu
  - 608-218-4208