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

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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!
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
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
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 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 than CO₂, especially in growing season
• Flux footprint models and land cover maps hint at a wetland influence for CH₄ 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 CH₄ flux – seeking advice!
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