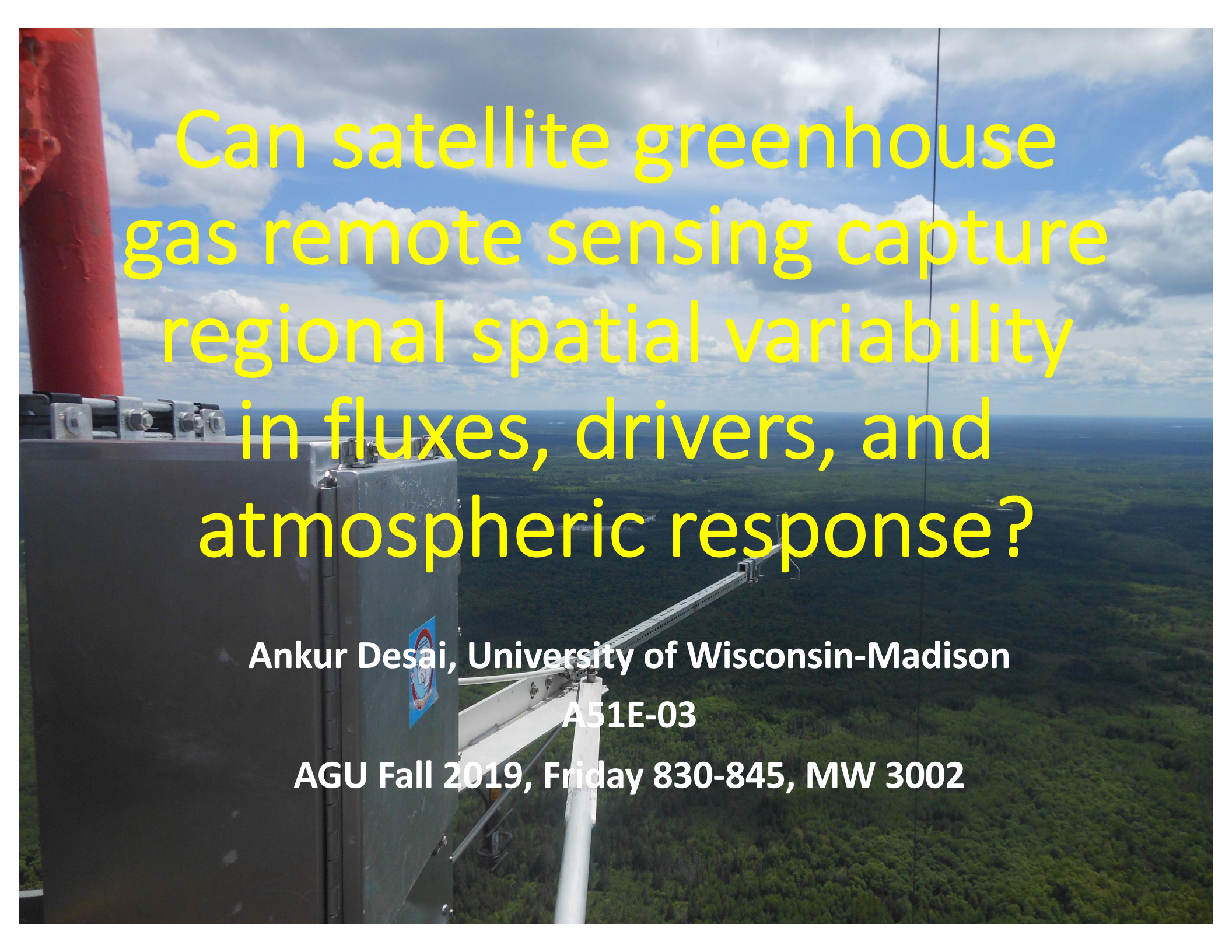




Can satellite greenhouse gas remote sensing capture regional spatial variability in fluxes, drivers, and atmospheric response?

Ankur Desai, University of Wisconsin-Madison

A51E-03

AGU Fall 2019, Friday 830-845, MW 3002

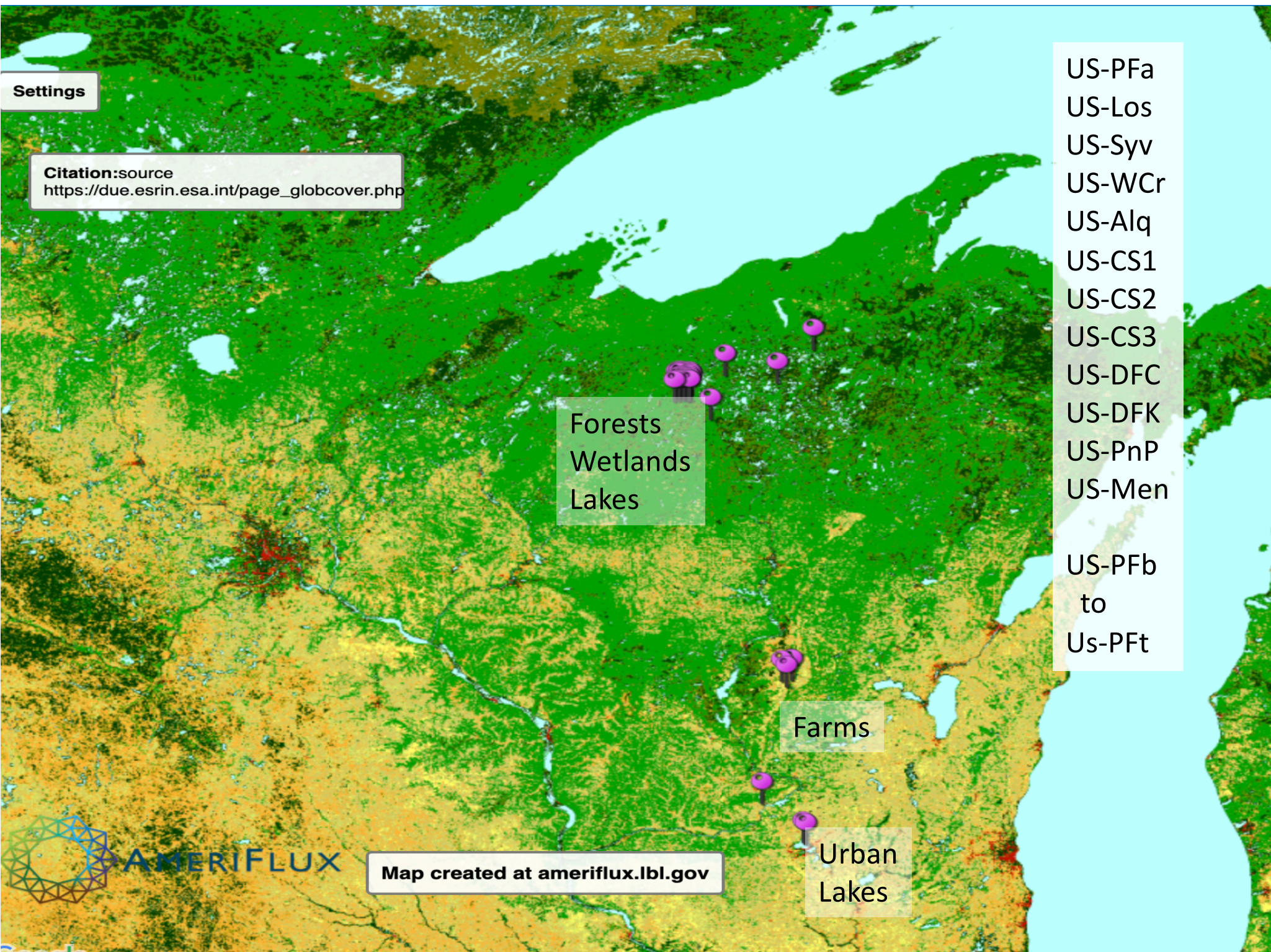
Acknowledge

- Bill Brown, Steve Oncley (NCAR)
- Brian Butterworth, Ryan Clare, James Mineau (UW)
- Erik Olson, Tim Wagner (UW SSEC)
- Phil Townsend, Ting Zheng, Erin Wagner (UW Forest Ecology)
- Aronne Merrelli (UW SSEC)
- Peter Somkuti (CSU/CIRA)
- Hannes Vogelmann (KIT IMK-IFU)
- Annmarie Eldering, Ryan Pavlick, Josh Fisher (NASA JPL)
- Coleen Roehl, Paul Wennberg (Cal Tech)
- David Reed, Jeralyn Poe (MSU)
- Zhien Wang (CU-Boulder) and UWKA team (U Wyoming)
- Arlyn Andrews, Colm Sweeney, Kathryn McKain (NOAA)
- NSF CHEESEHEAD AGS-1822420
- DOE Ameriflux Network Management Project
- DFG (Germany), NOAA, NASA

Is regional spatial variation in fluxes captured in satellite remote sensing?

US-PFa
WLEF

Photo: B. Butterworth



Settings

Citation:source
https://due.esrin.esa.int/page_globcover.php

Forests
Wetlands
Lakes

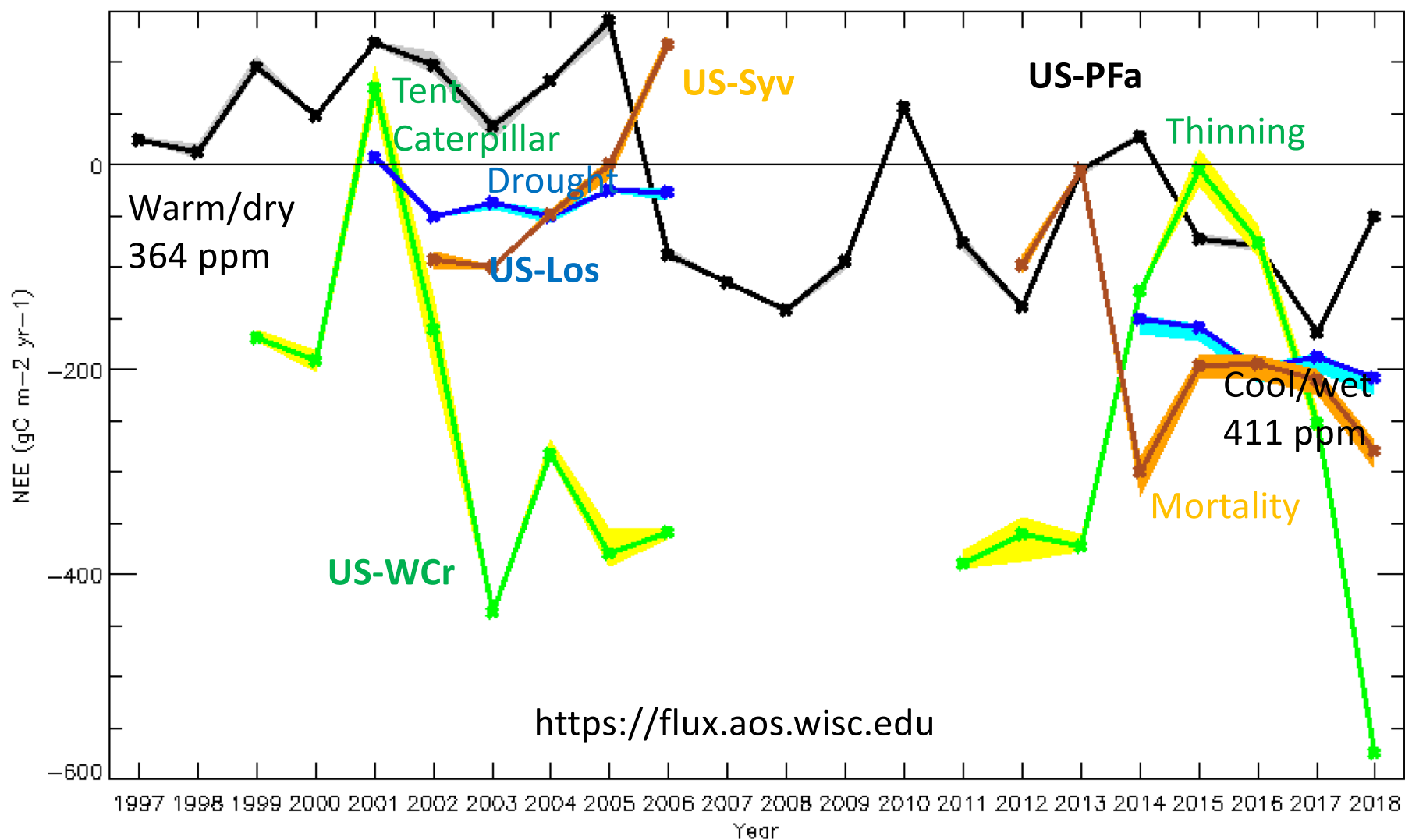
Farms

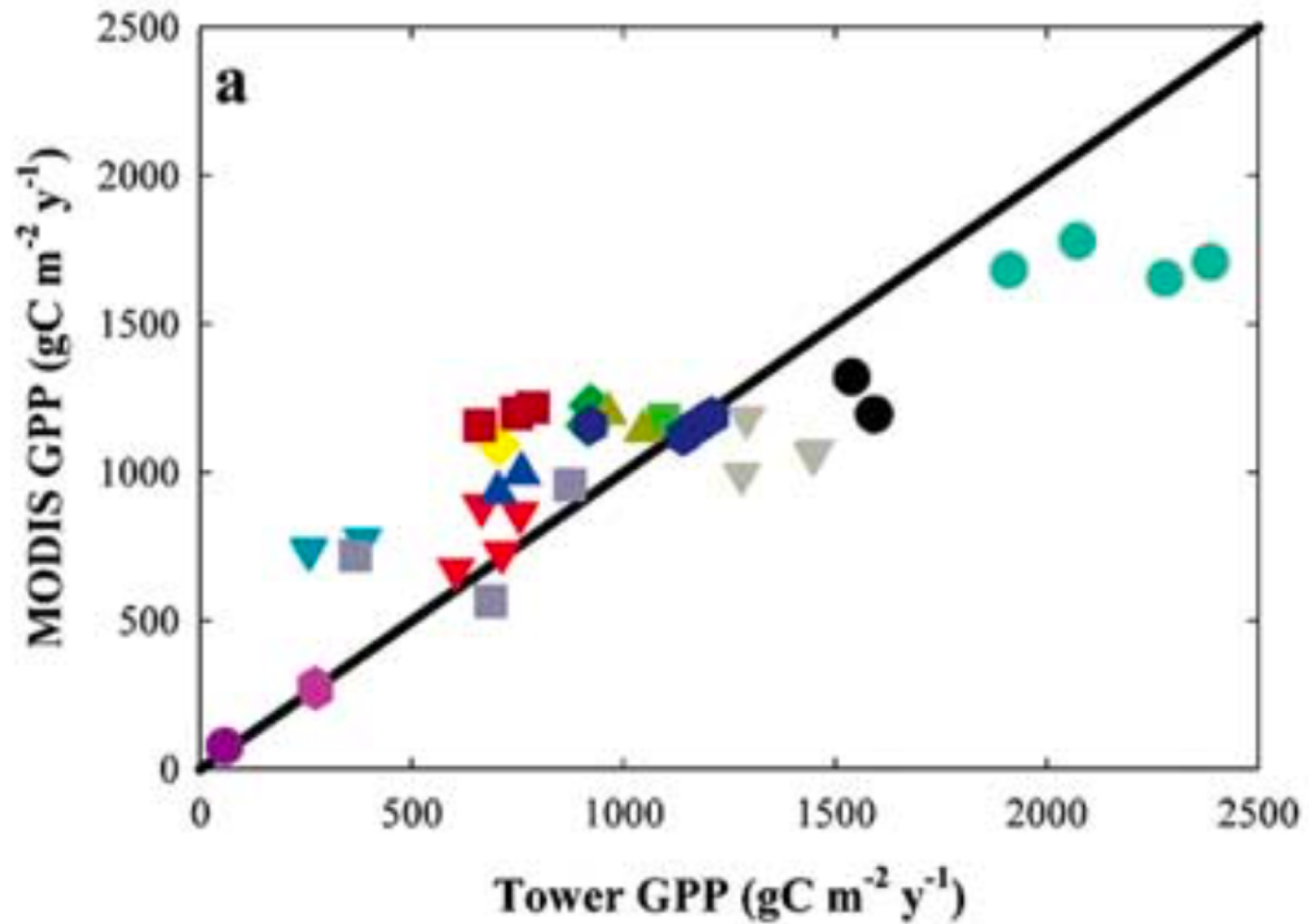
Urban
Lakes

- US-PFa
- US-Los
- US-Syv
- US-WCr
- US-Alq
- US-CS1
- US-CS2
- US-CS3
- US-DFC
- US-DFK
- US-PnP
- US-Men
- US-PFb
to
Us-PFt



Map created at ameriflux.lbl.gov





Chequamegon Heterogeneous Ecosystem Energy-balance Study Enabled by a High-density Extensive Array of Detectors (CHEESEHEAD19)



https://www.eol.ucar.edu/field_projects/cheesehead

Ankur R Desai, U. Wisconsin-Madison (PI)

Grant Petty, U. Wisconsin-Madison (co-PI, UW Ultralight)

Phil Townsend, U. Wisconsin-Madison (co-PI, UW SpecEx)

Mark D Schwartz, U. Wisconsin-Milwaukee (co-PI, Phenology)

Stefan Metzger, NEON/Battelle (co-PI, ERF, NEON Assets)

Matthias Mauder, Karlsruhe Institute of Technology (co-I, LiDAR/LES)

Rose Pertzborn, U. Wisconsin-Madison (co-I, K-12 outreach)

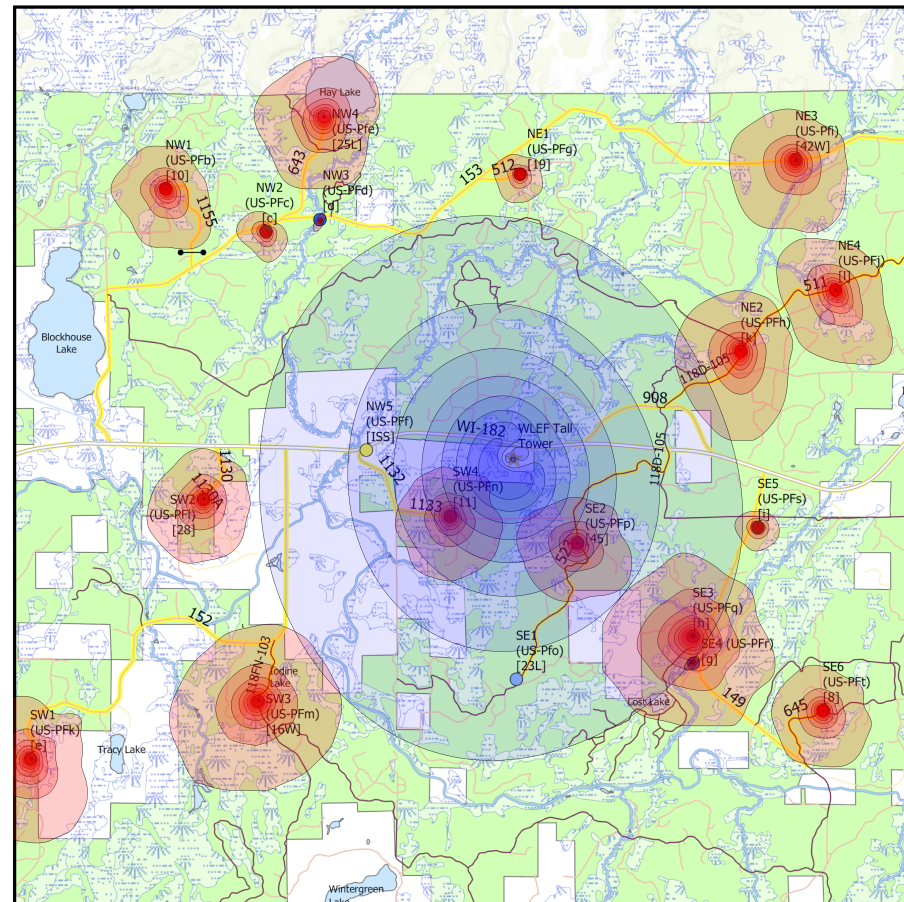
Paul Stoy, Montana State University (co-I, towers + being rarely wrong)

+Instrument PIs: Al Rodi (U Wyoming King Air), Steve Oncley (NCAR ISFS), Bill Brown (NCAR ISS), Tim Wagner (SSEC SPARC), Eric Kruger (UW, Biometry), Joel McCorkel (NASA GSFC, CAMSIS)

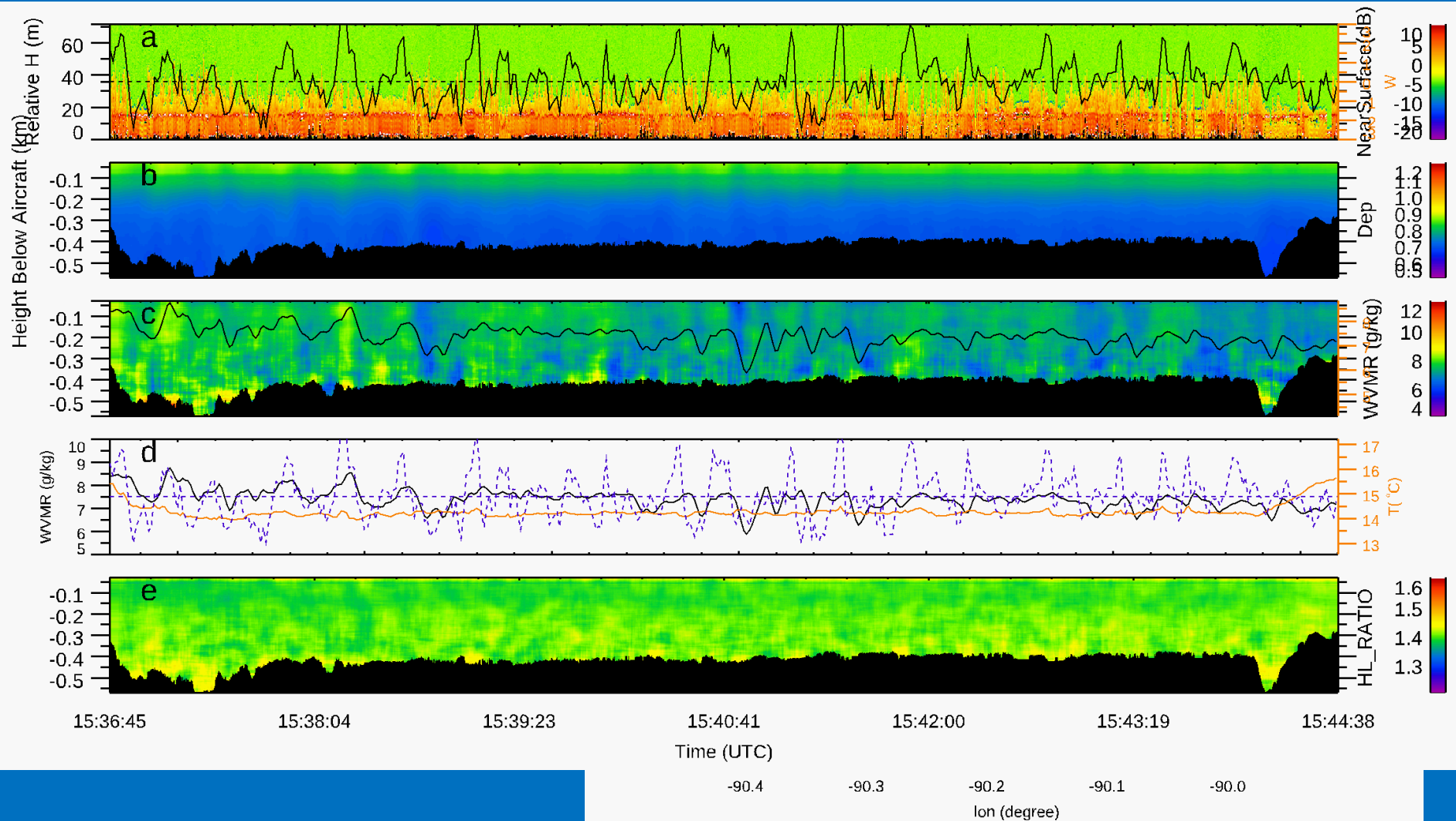
NSF, Physical and Dynamic Meteorology, #AGS-1822420

Spatial variability was name of the game in CHEESEHEAD19

- 20 flux towers in one 10x10 km area
- Centered at WLEF / US-Pfa tall flux tower / GHG profile / TCCON site

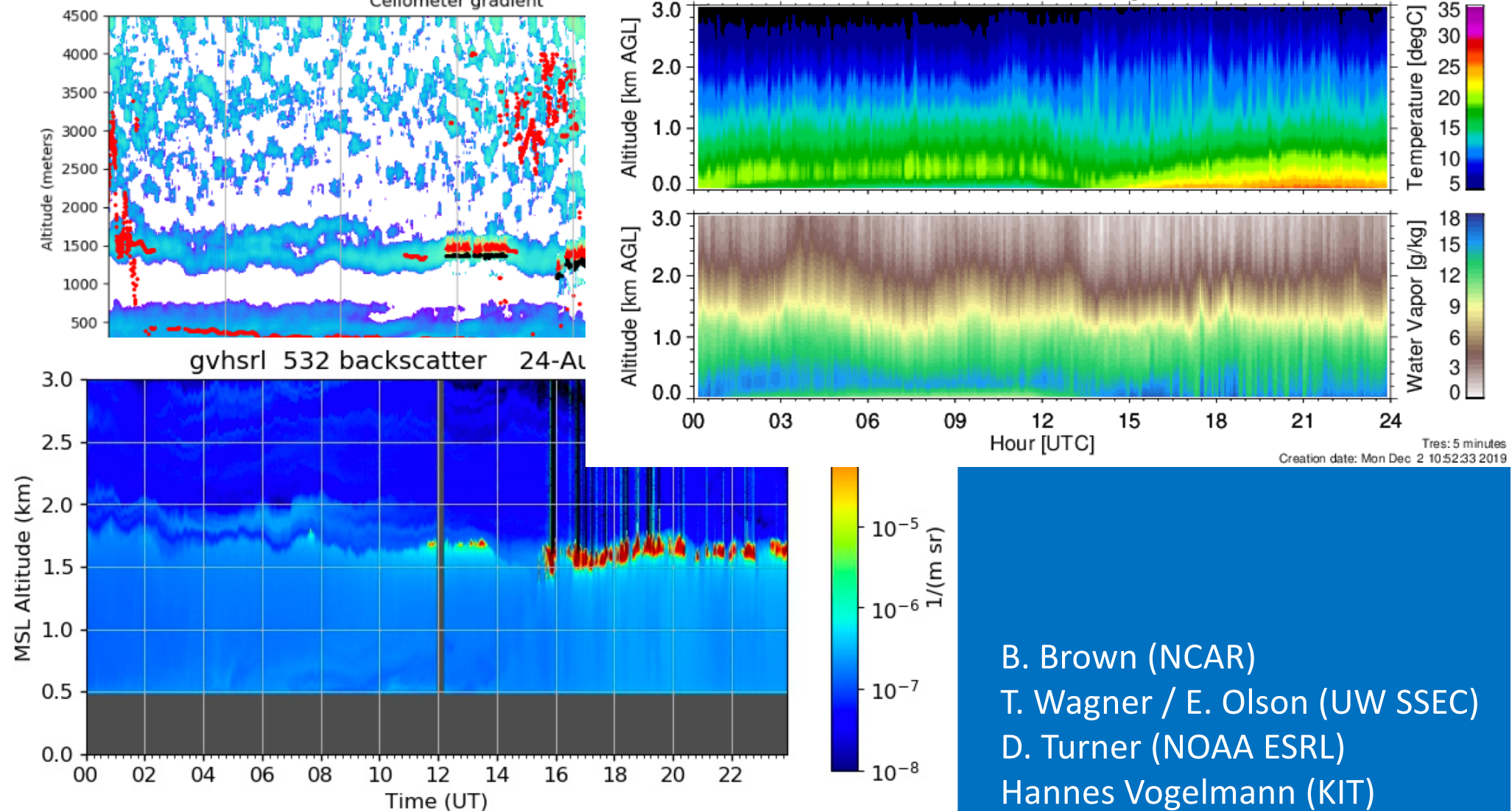


Three intensives with airborne sampling of surface fluxes

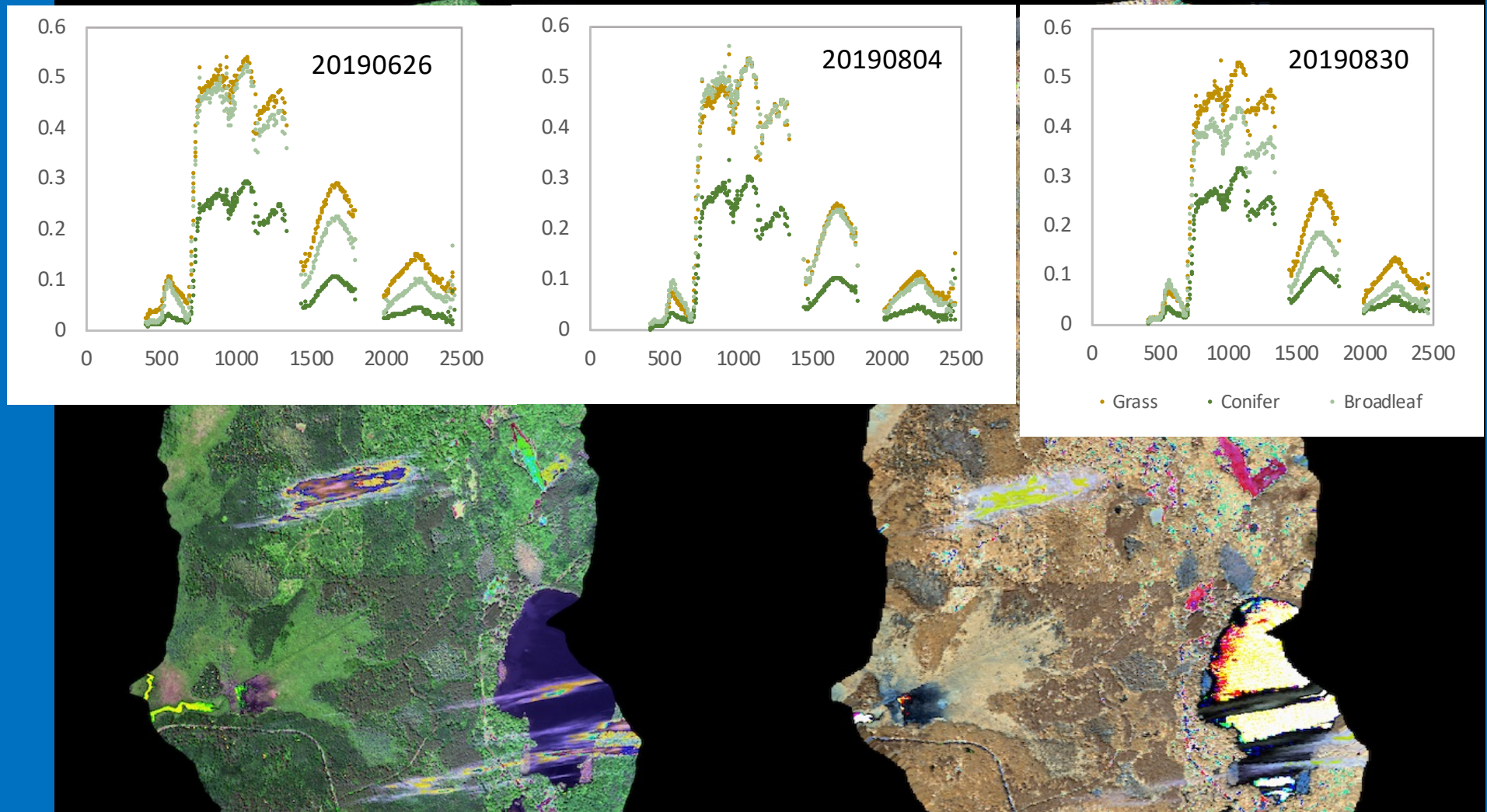


Serious PBL atmospheric profiling
by NCAR, NOAA, SSEC, KIT

MWRoe, Prentice, 17 August 2019

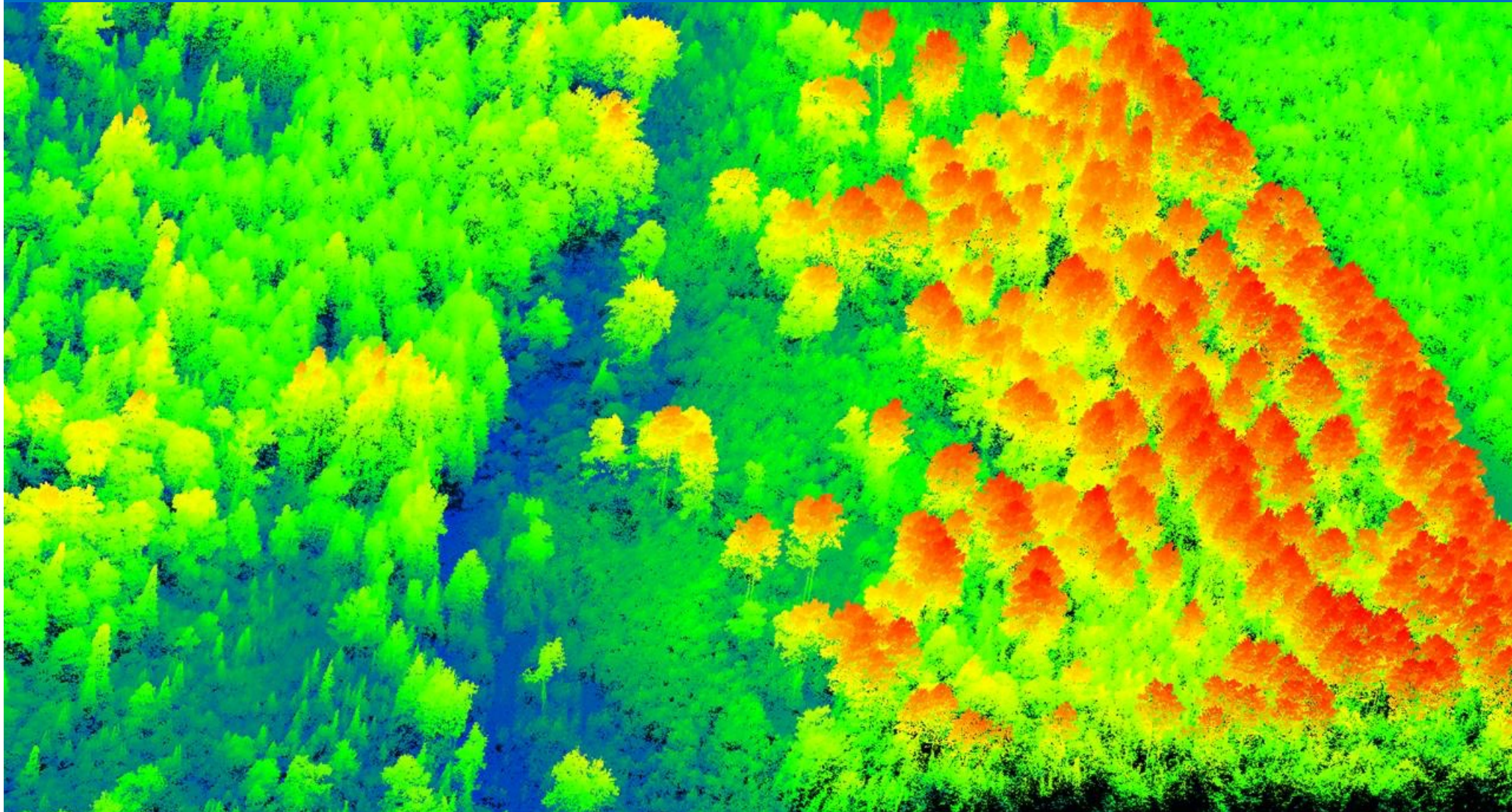


Surface characterization by aircraft and ground (HySpex)

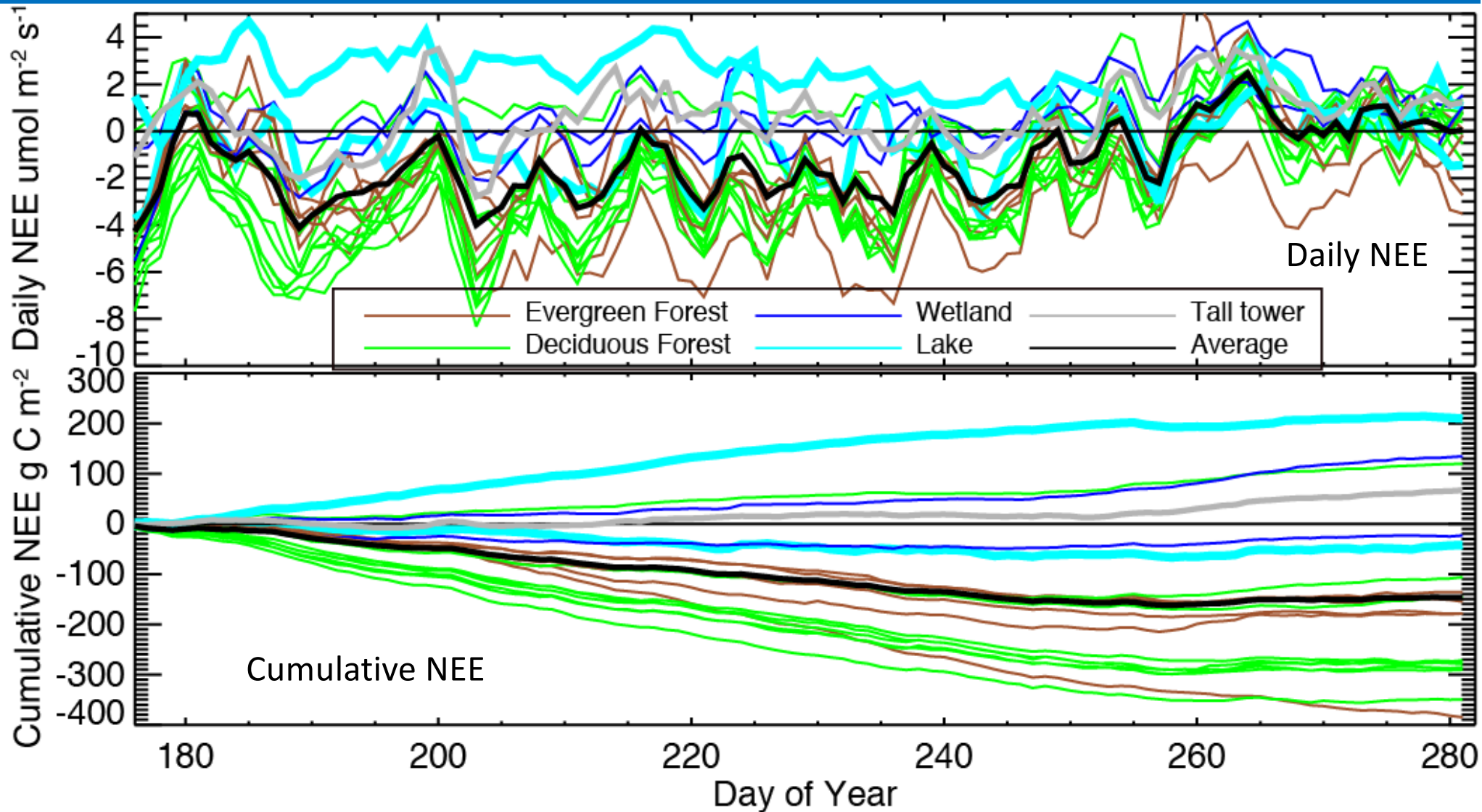


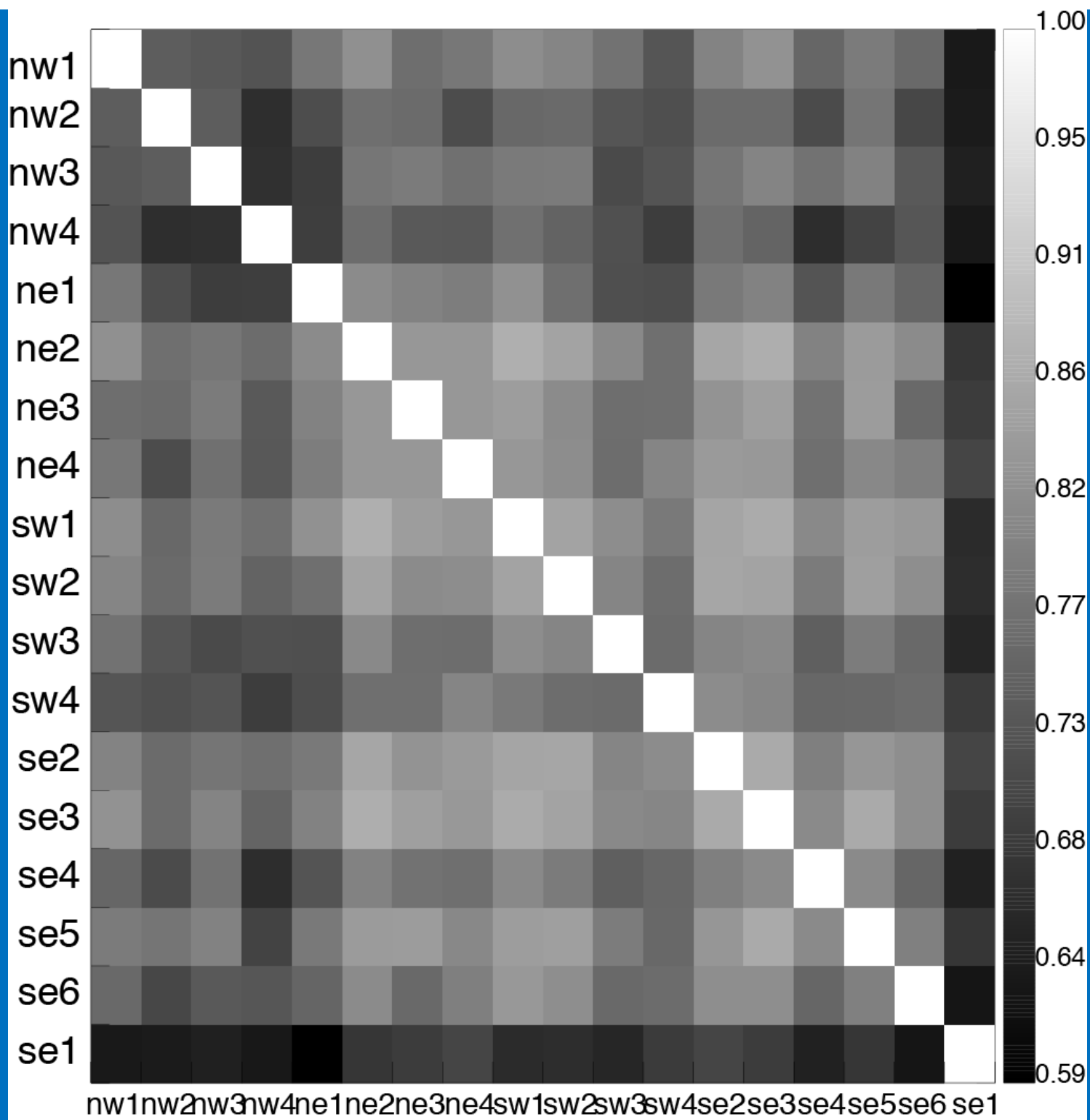
Drones, too!

C. Andresen (UW)

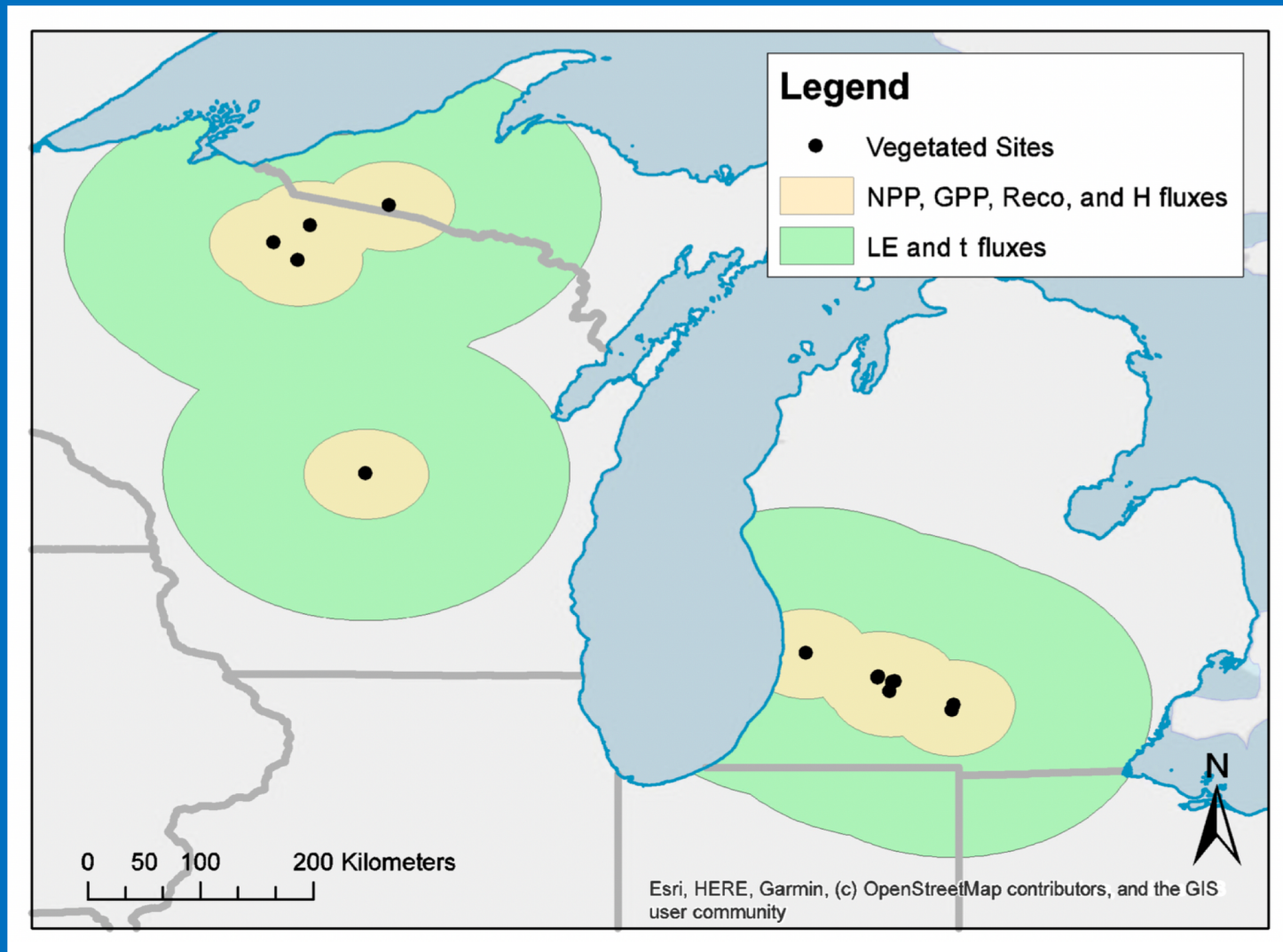


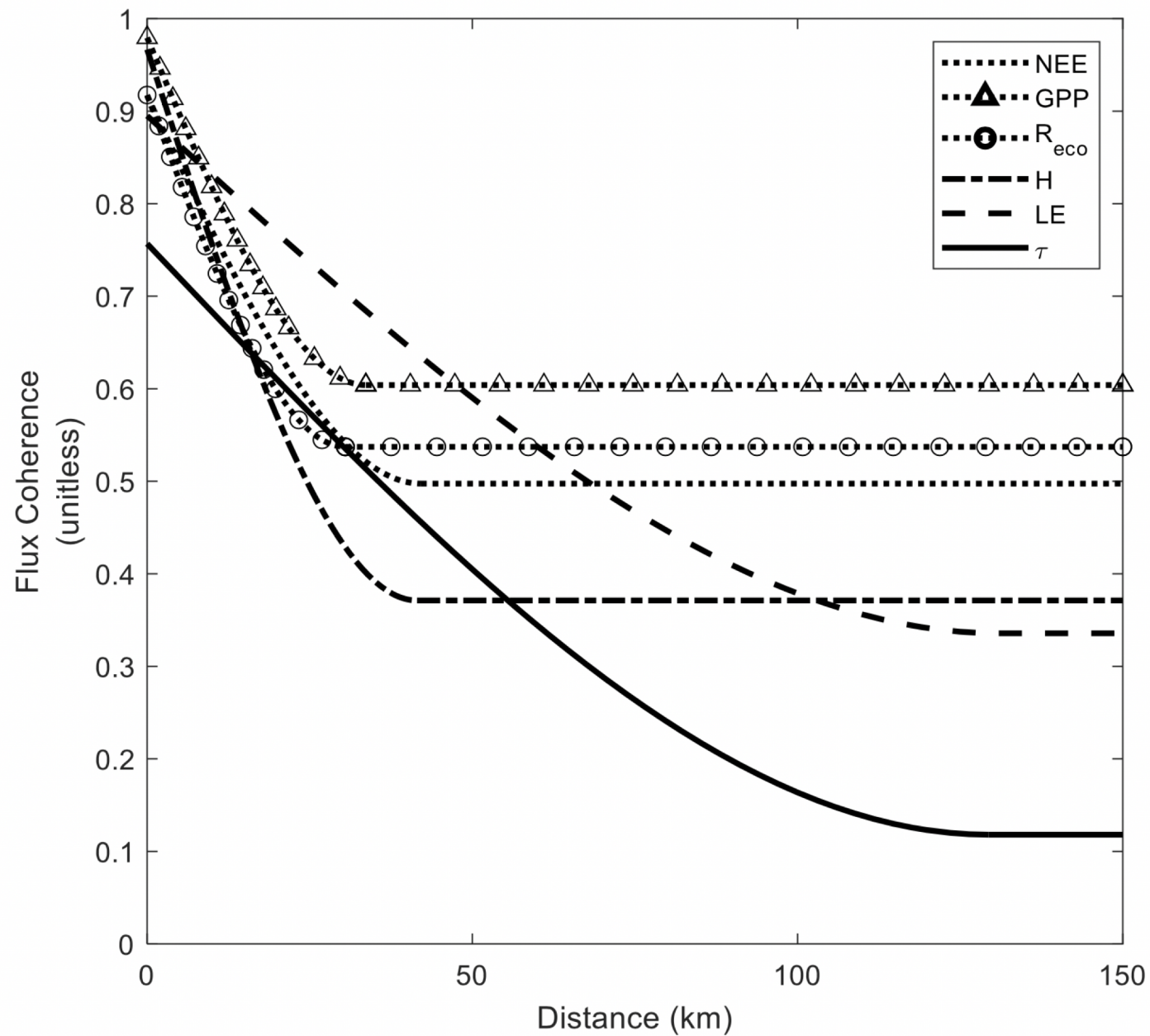
So, what have we learned so far about spatial variability?





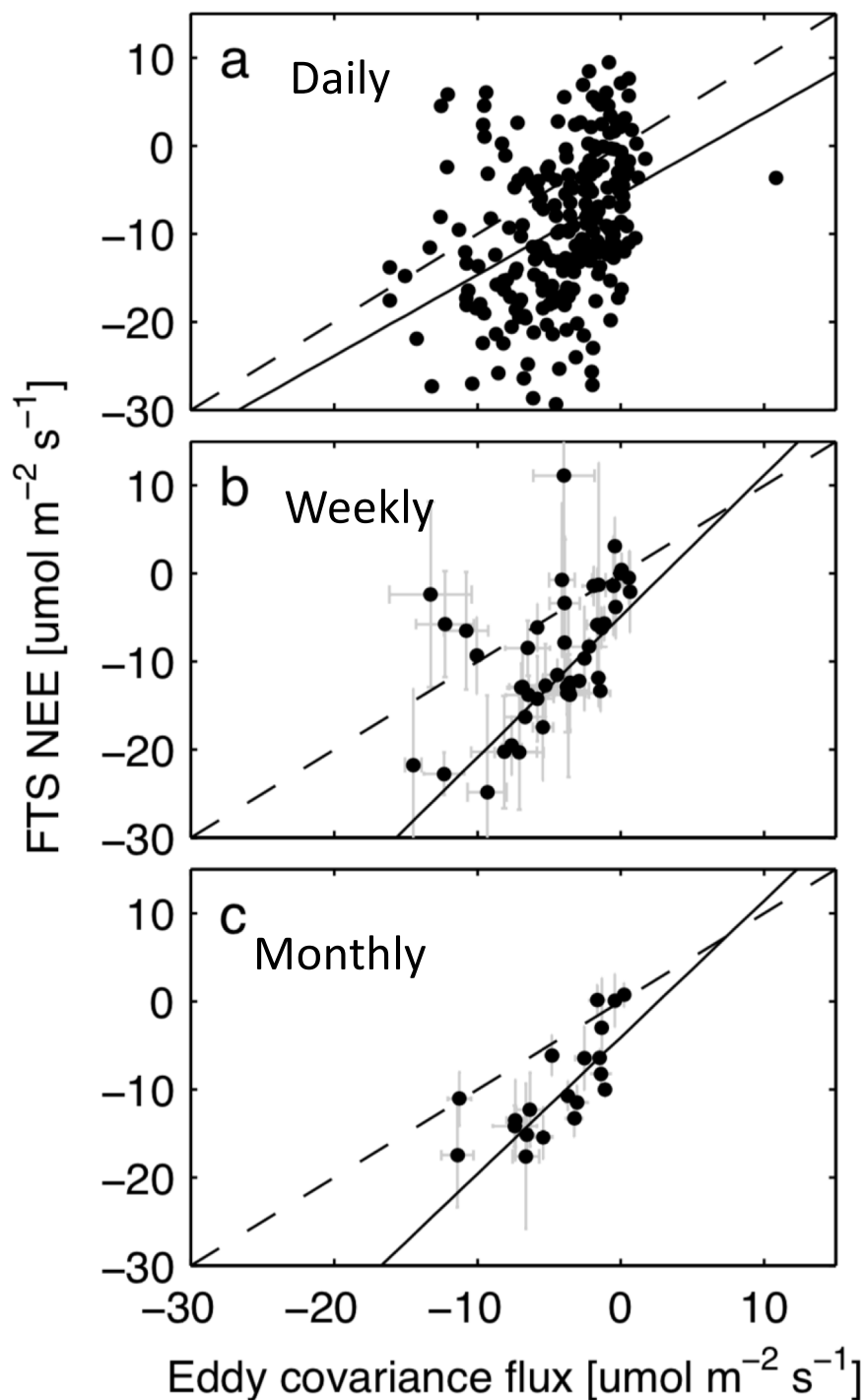
Spatial coherence can now be done with flux tower clusters to improve top-down inversions





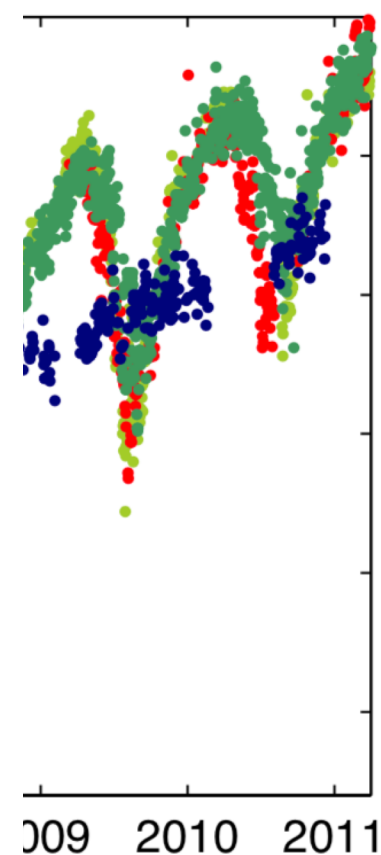
The impact of the column

G. Keppel-Aleks¹,
J.-F. Blavier⁴,
B. B. Stephens¹



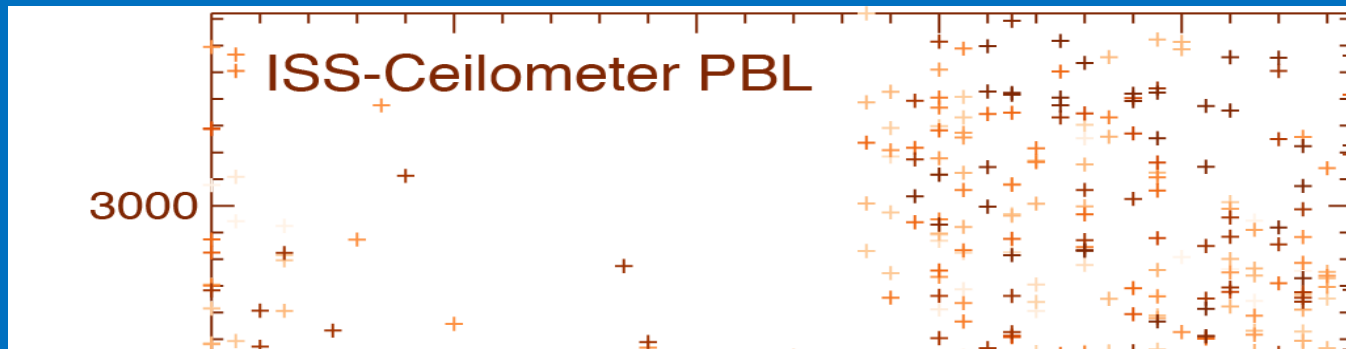
Impact on variations in total

F. Schneider¹, G. C. Toon⁴, R. J. Andres³,
J. Notholt⁸, C. M. Roehl¹, V. Sherlock⁹,

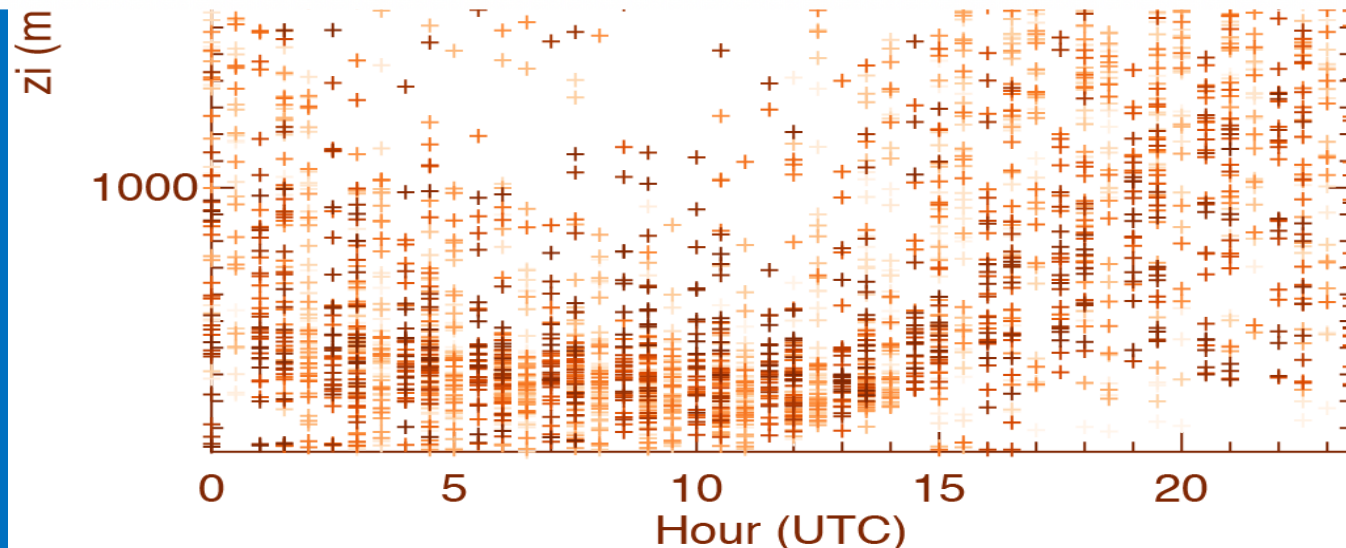


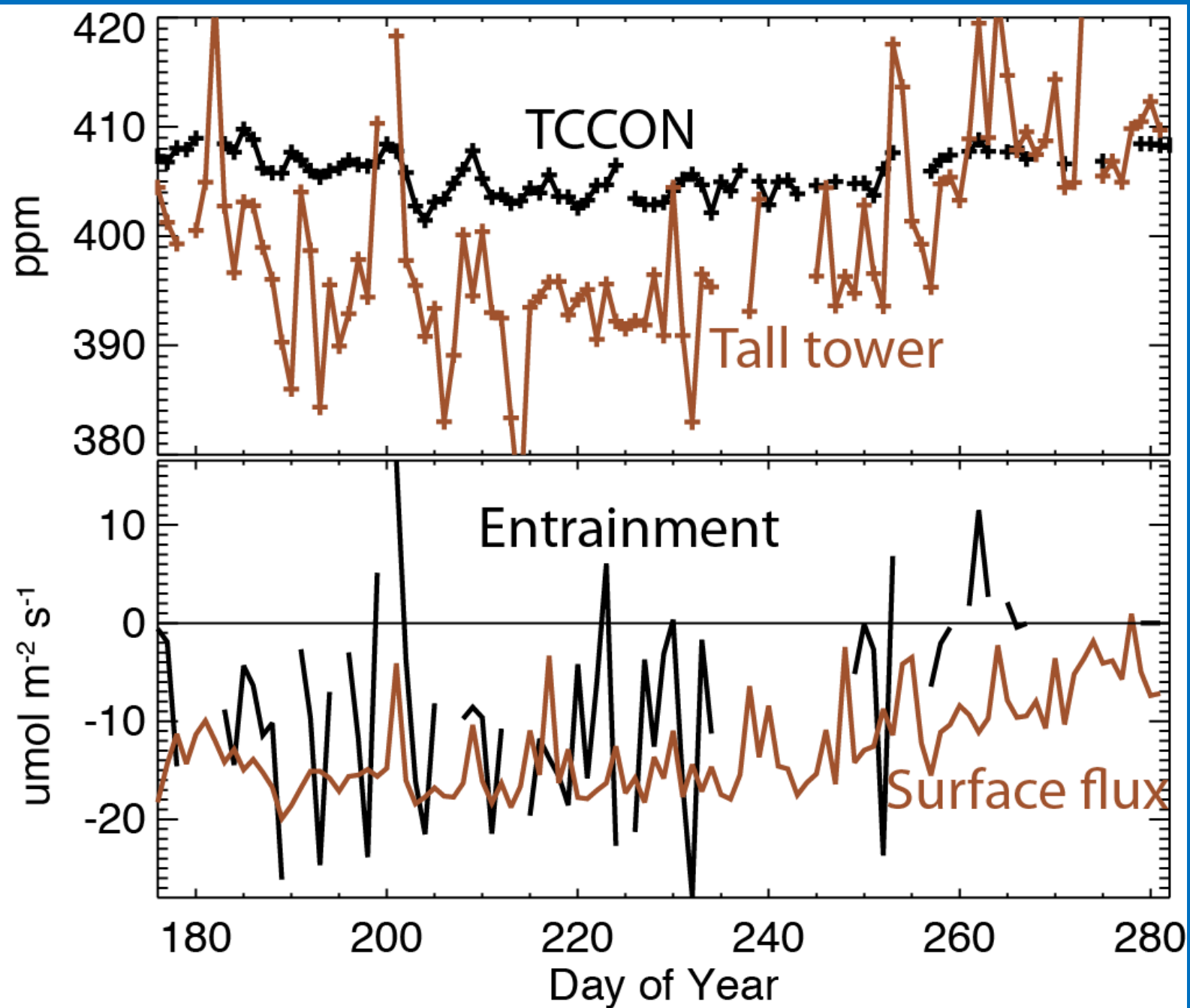
Biogeosciences, 9, 875–891, 2012
www.biogeosciences.net/9/875/2012/
[doi:10.5194/bg-9-875-2012](https://doi.org/10.5194/bg-9-875-2012)

Adding PBL depth information to TCCON or XCO₂ can help differentiate surface and advected influence on concentrations

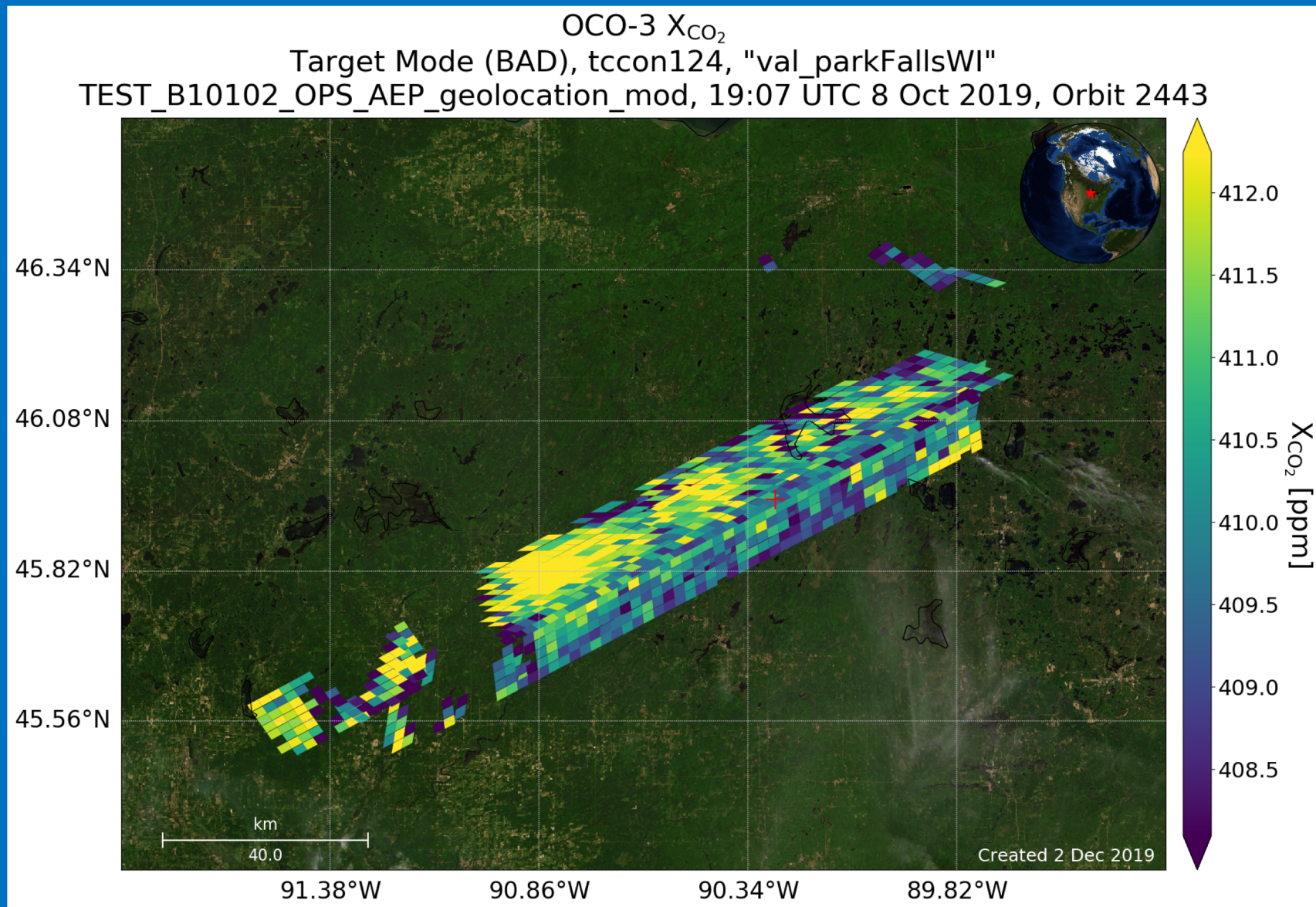


$$\frac{dC}{dt} = \overline{w'c'_{sfc}} - \overline{w'c'_{z_l}} = \text{Flux towers} - w_e \Delta C^+ = \text{Flux towers} - \frac{dz_i}{dt} (C_{TCCON} - C_{PBL})$$

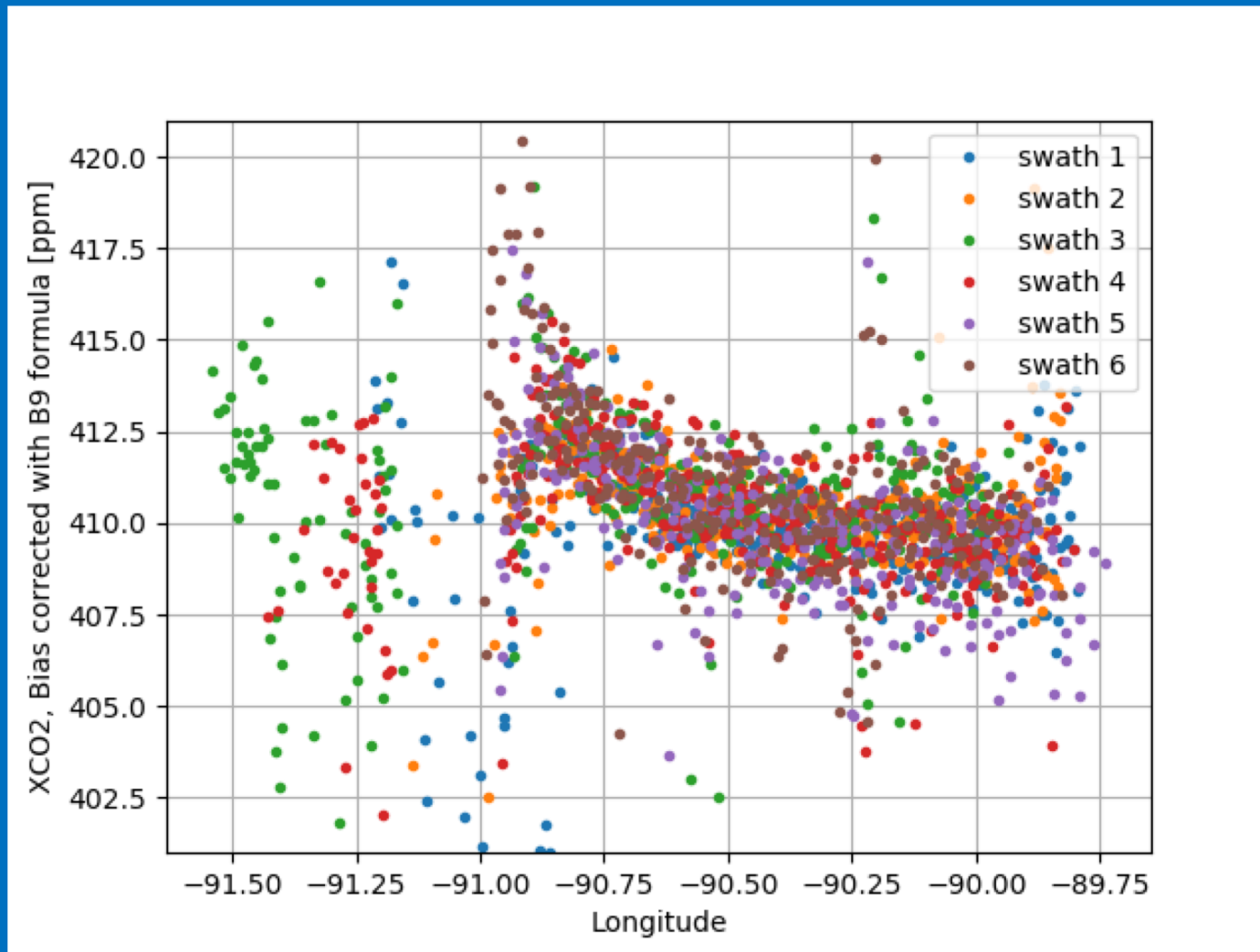




Moving to satellite GHG remote sensing



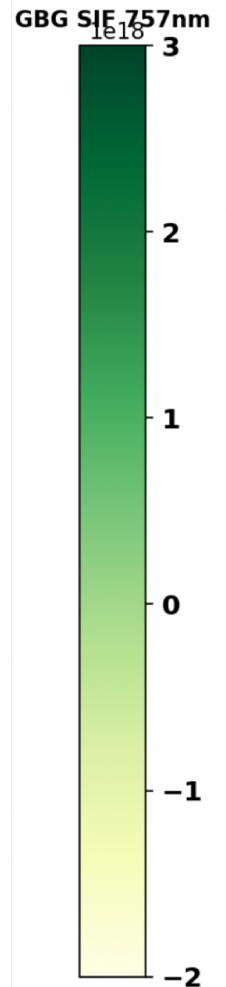
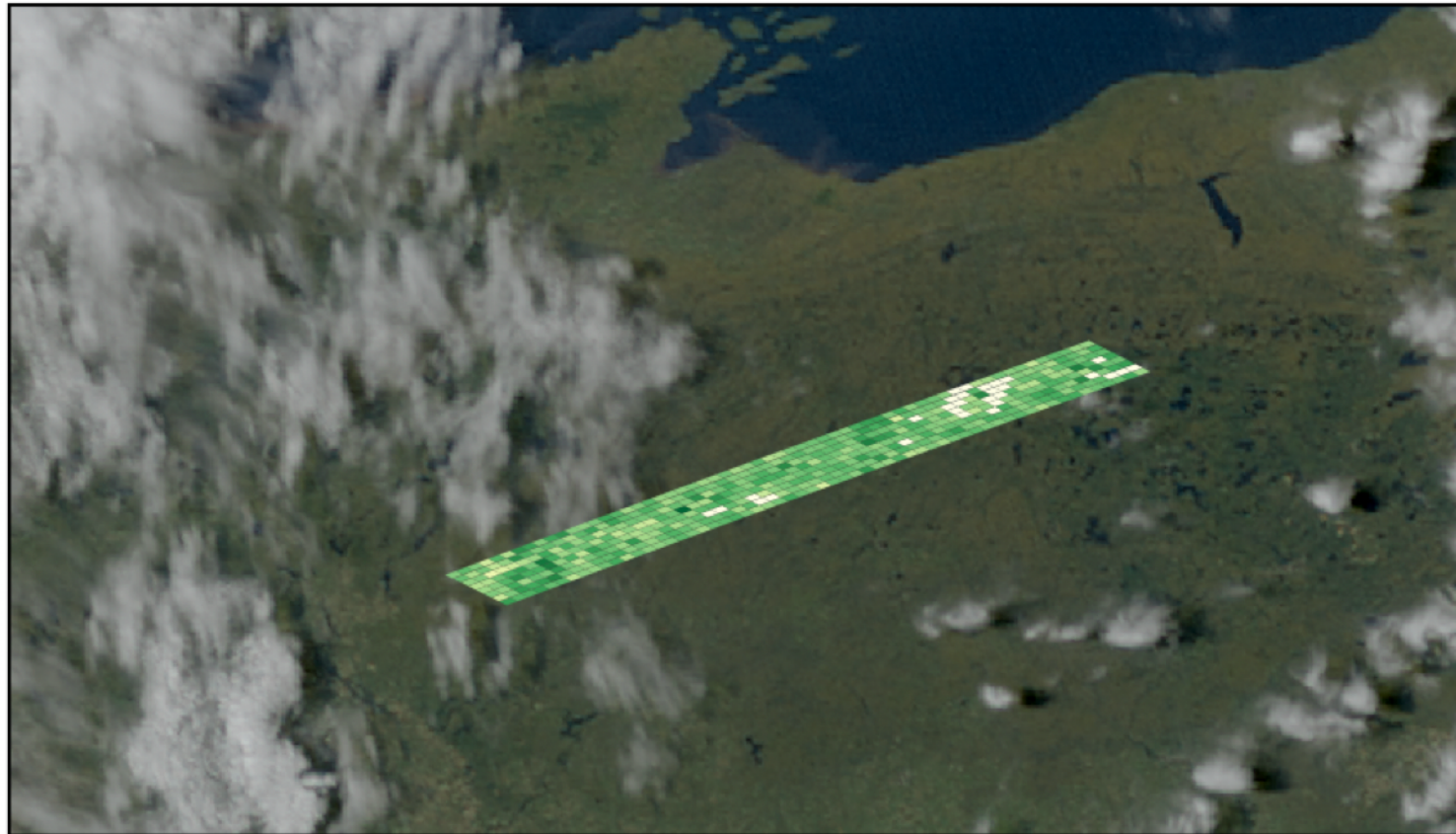
Small-scale spatial gradients link to transport and spatial flux variation



Aronne Merrelli (UW SSEC) / Annmarie Eldering and Rob Nelson (NASA JPL)

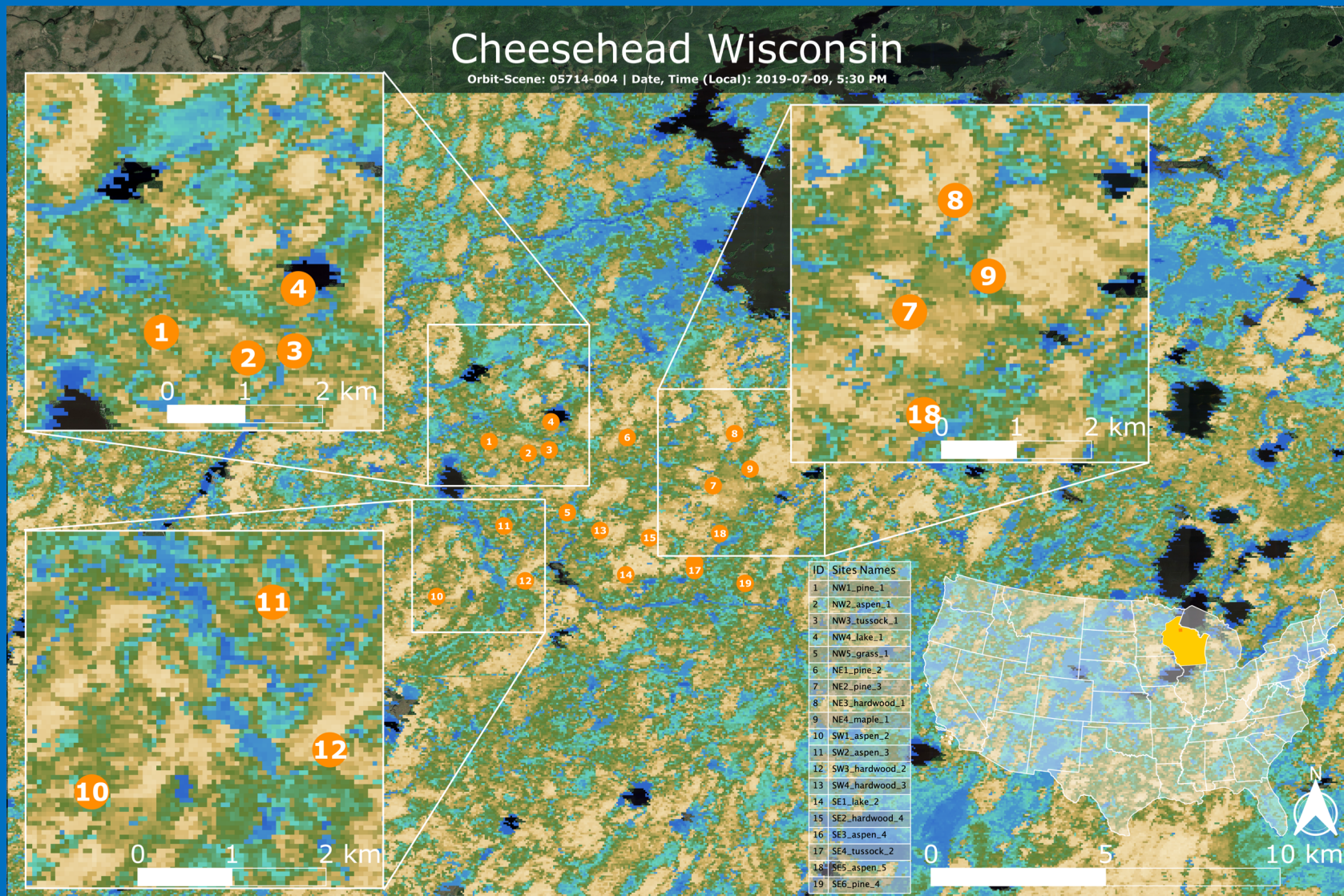
SIF is intriguing...

Overlay data from oco3_L2GBG_02443a_191008_B10100_ratio_geolocation_mod_B10102_OPS_AEP_geomod_merge.h5
Background from OR_ABI-L1b-RadC-M6C02_G16_s20192811906259_e20192811909032_c20192811909084.nc,
Overlay time = 2019-10-08 19:08:46, mean time offset = 2.1 min., plot created on 2019-12-02

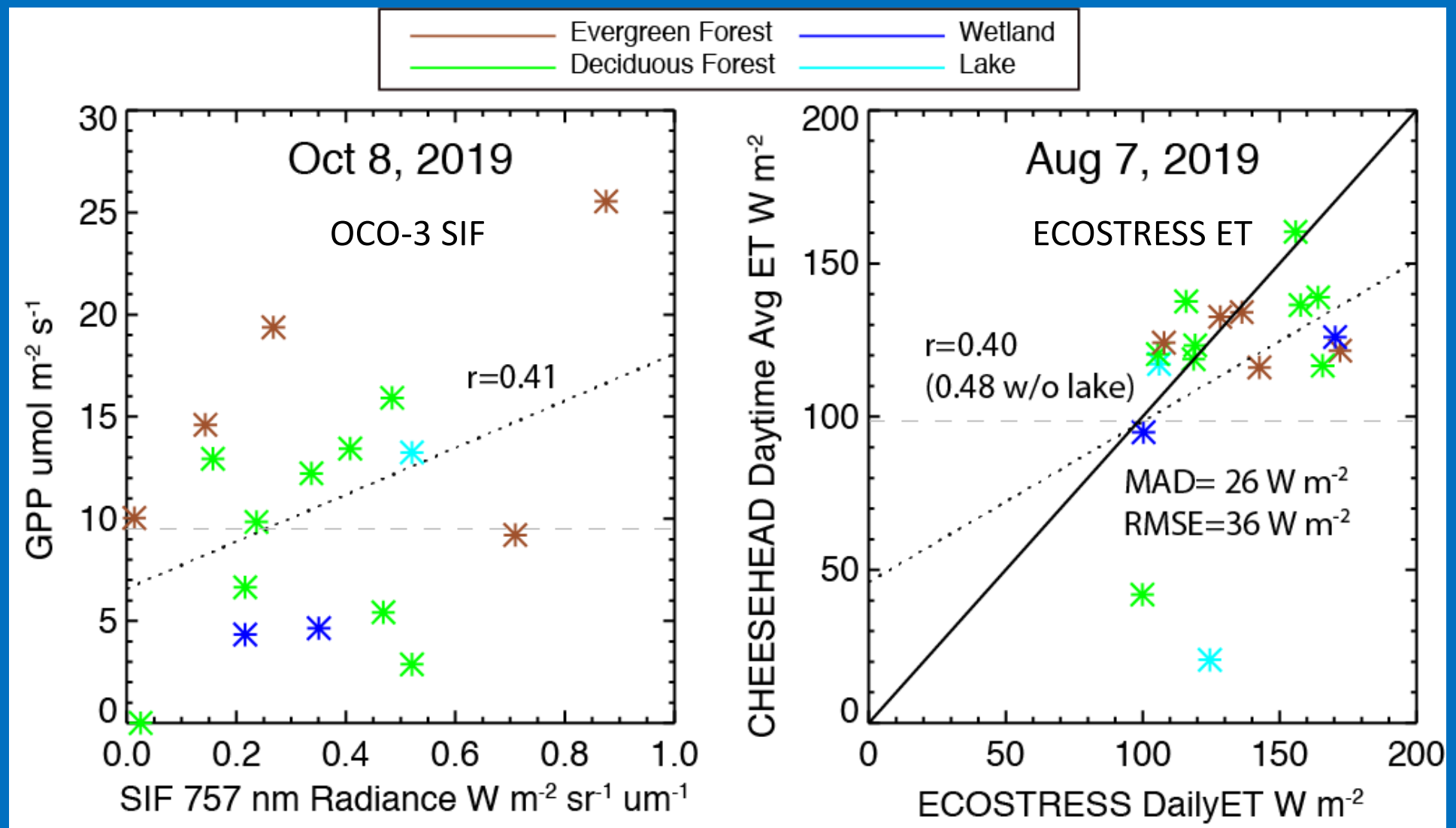


Aronne Merrelli (UW SSEC) / Peter Somkuti (CIRA) /
Annamarie Eldering and Rob Nelson (NASA JPL)

ECOSTRESS, too...

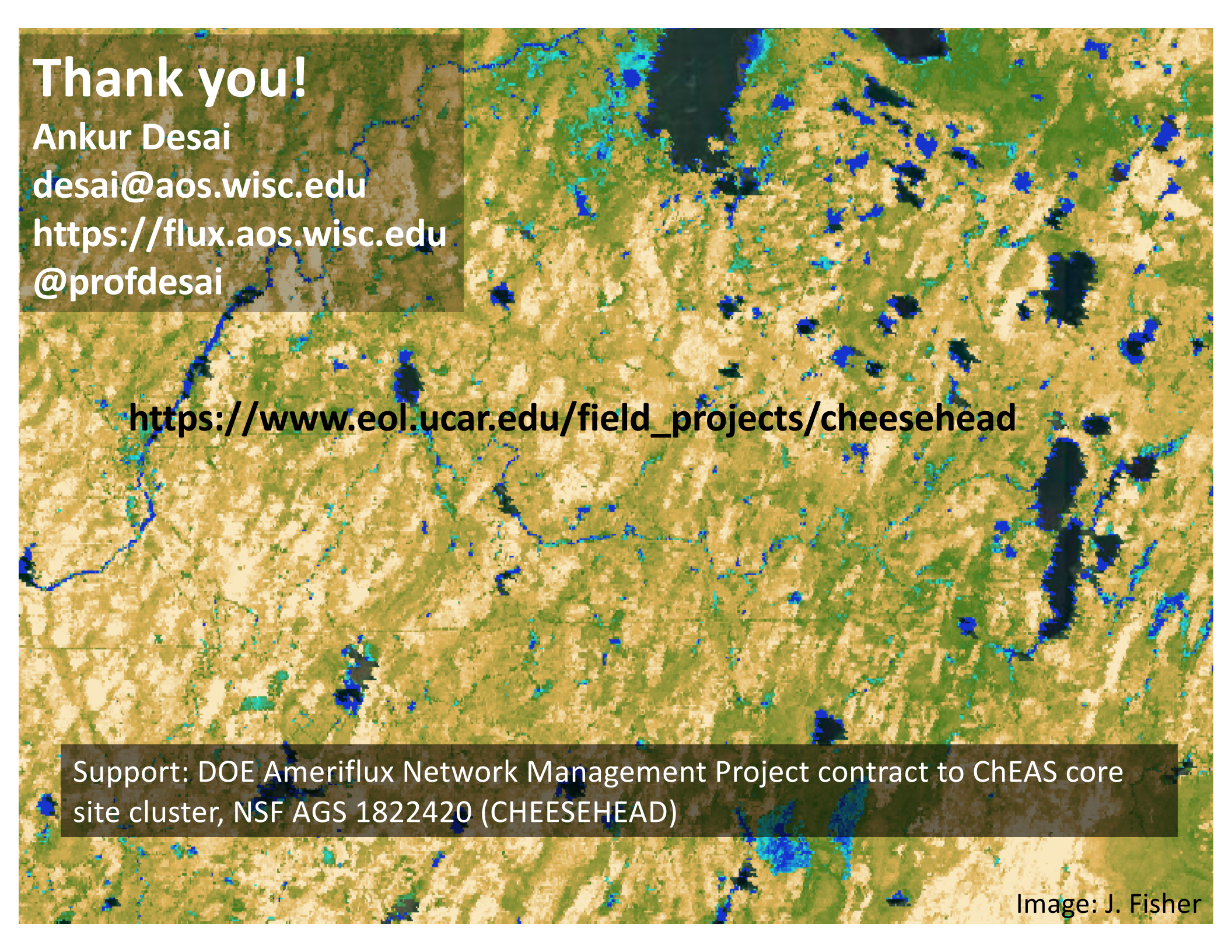


Next generation surface and atmospheric GHG remote sensing has potential to retrieve fine-scale details



Final thoughts

- Satellite remote sensing has revolutionized how we understand global variation and drivers of GHG fluxes and emissions
- However, less confidence in how well they capture regional scale GHG sources and sinks, especially in heterogenous regions
- CHEESEHEAD19 and similar experiments provide surface and atmosphere benchmarks and critical PBL profile and flux data to improve on this
- Next-generate satellites (OCO-3, ECOSTRESS, Hypsiri) provide significant potential to retrieve regional fluxes



Thank you!

Ankur Desai

desai@aos.wisc.edu

<https://flux.aos.wisc.edu>

@profdesai

https://www.eol.ucar.edu/field_projects/cheesehead

Support: DOE Ameriflux Network Management Project contract to ChEAS core site cluster, NSF AGS 1822420 (CHEESEHEAD)

Image: J. Fisher