

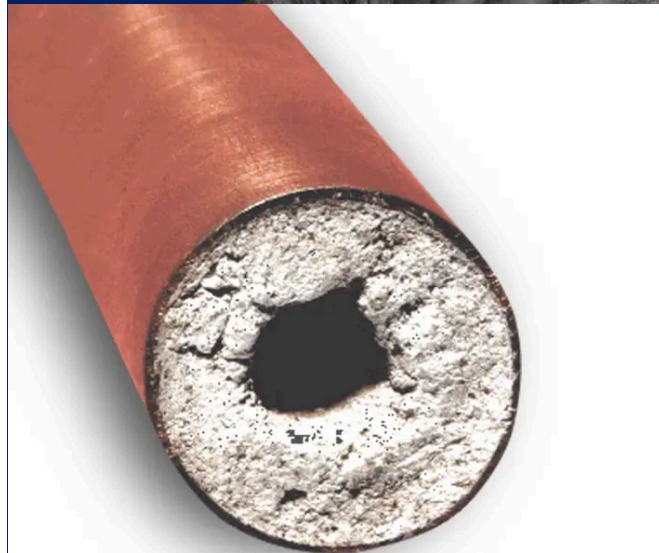
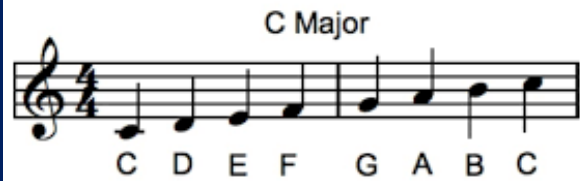
*Linking scales of motion in the
atmosphere to variation in the
surface below*

Ankur Desai, UW-Madison
AGU Fall 2021
H21C-03



Photo: B. Butterworth

What is scale?



<https://www.adeedo.com/how-to-prevent-scale-buildup-in-household-pipes/>



SCALE ISSUES IN HYDROLOGICAL MODELLING: A REVIEW

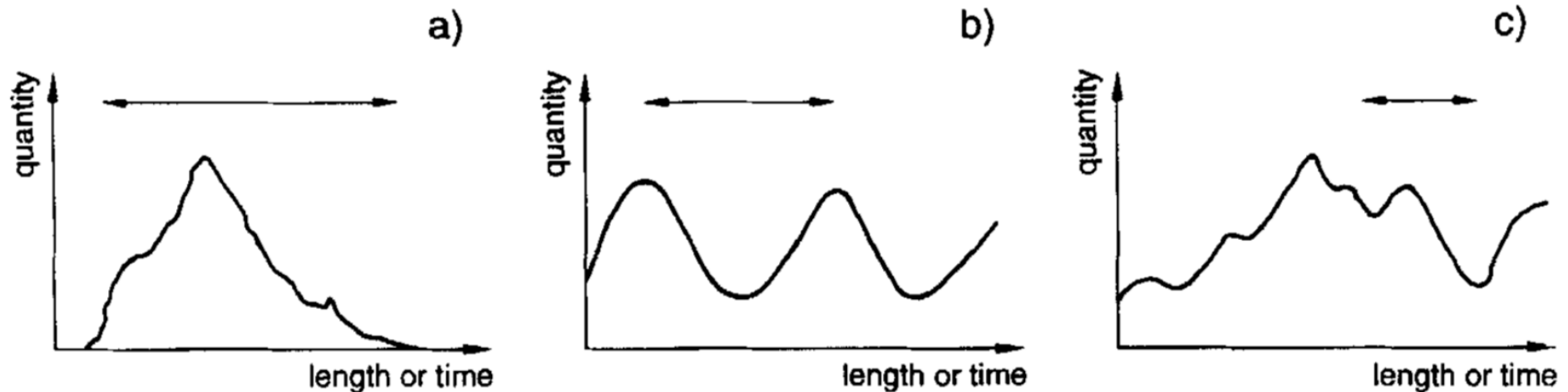
G. BLÖSCHL*

*Centre for Resource and Environmental Studies, The Australian National University, Canberra City,
ACT 2601, Australia*

AND

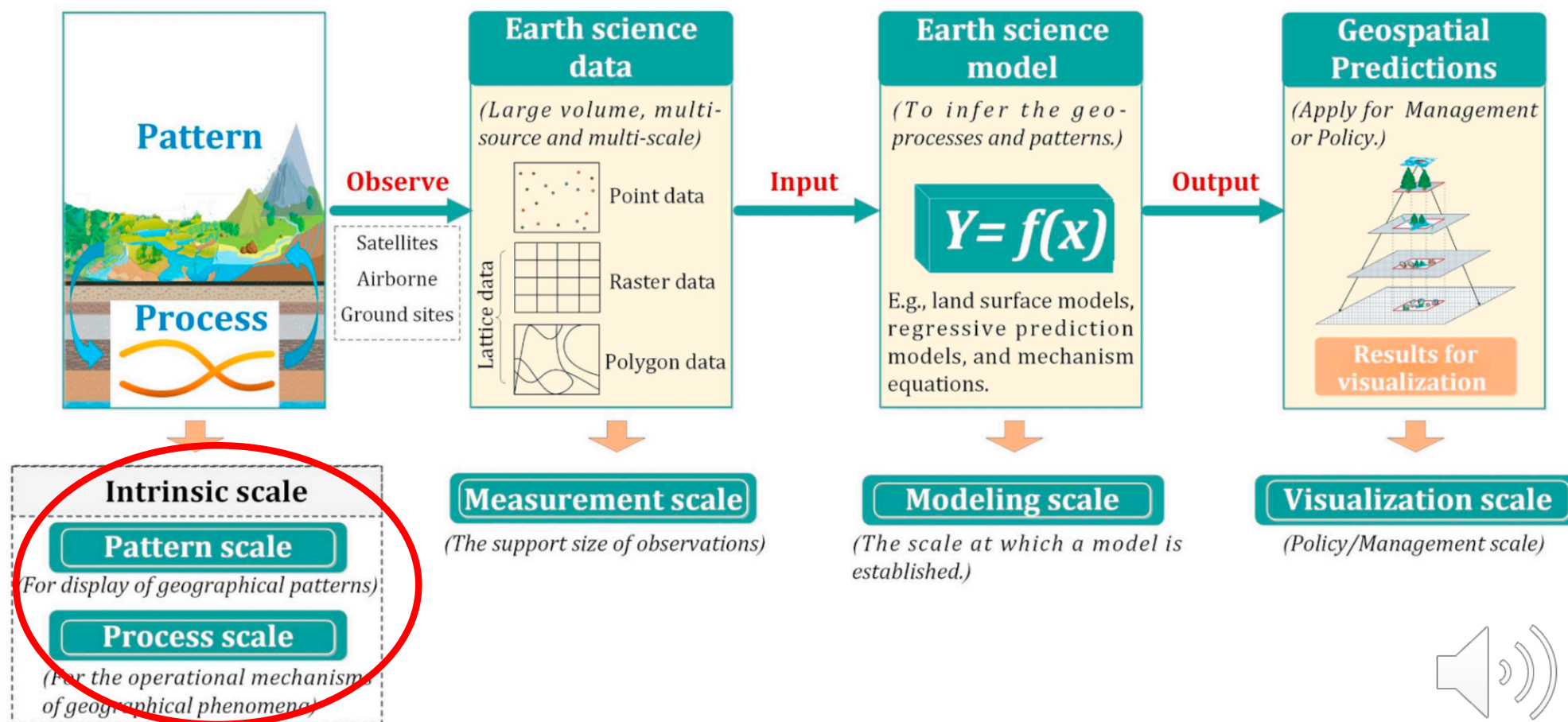
M. SIVAPALAN

*Centre for Water Research, Department of Environmental Engineering, University of Western Australia,
Nedlands, 6009, Australia*



Principles and methods of scaling geospatial Earth science data

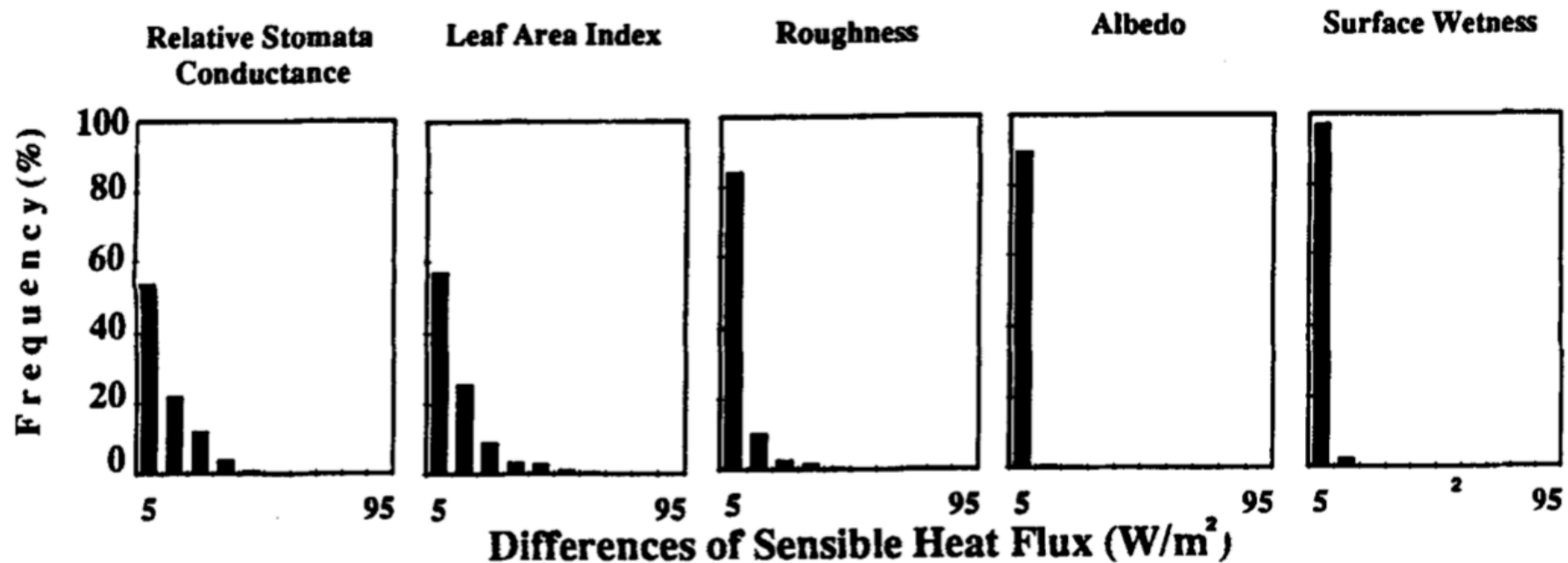
Yong Ge^{a,b,*}, Yan Jin^{c,d}, Alfred Stein^e, Yuehong Chen^f, Jianghao Wang^a, Jinfeng Wang^a, 2019
 Qiuming Cheng^g, Hexiang Bai^h, Mengxiao Liu^{a,b}, Peter M. Atkinsonⁱ



SCALING OF LAND-ATMOSPHERE INTERACTIONS: AN ATMOSPHERIC MODELLING PERSPECTIVE

RONI AVISSAR

Department of Meteorology and Physical Oceanography, Cook College, Rutgers University, New Brunswick, NJ 08903, USA

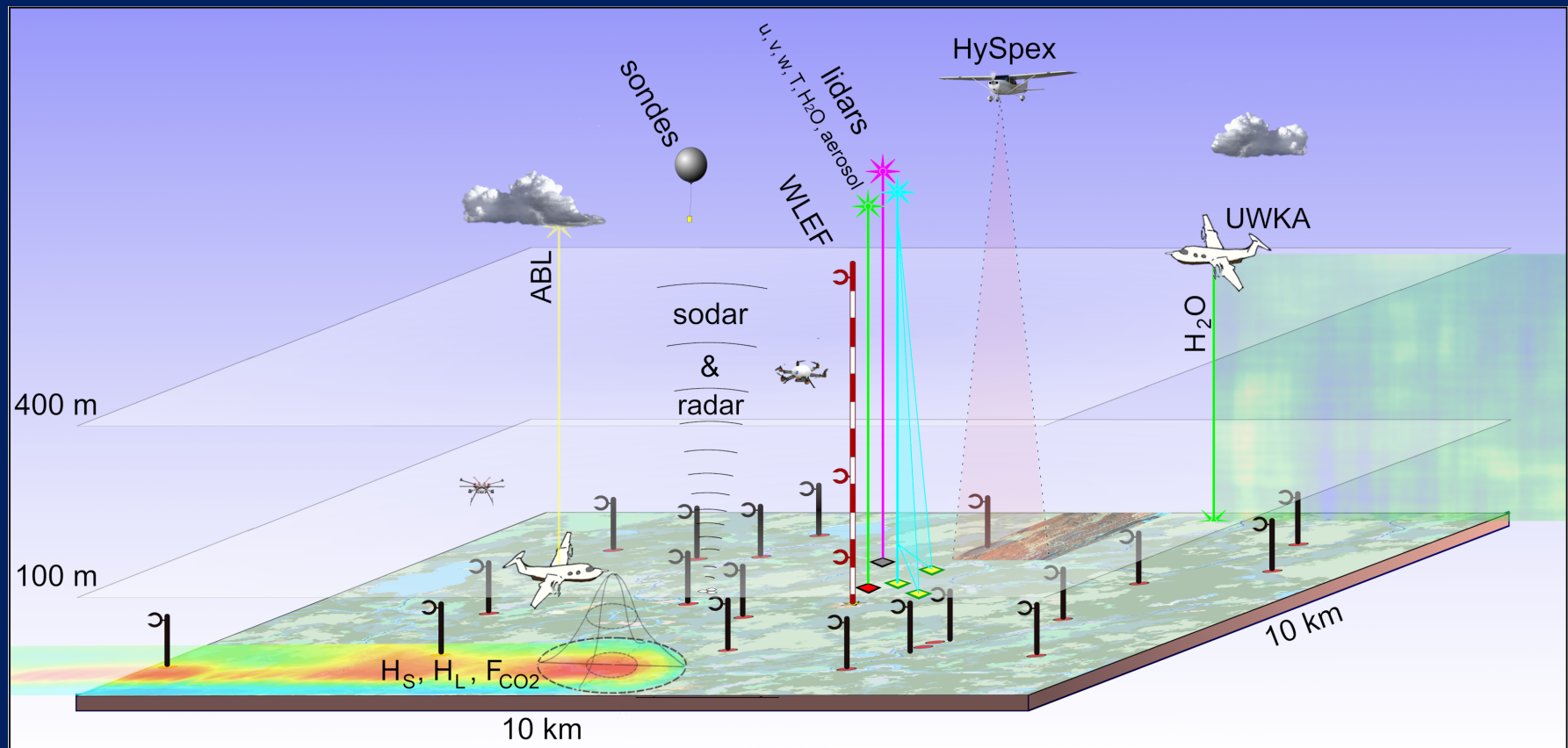


When does scale matter?



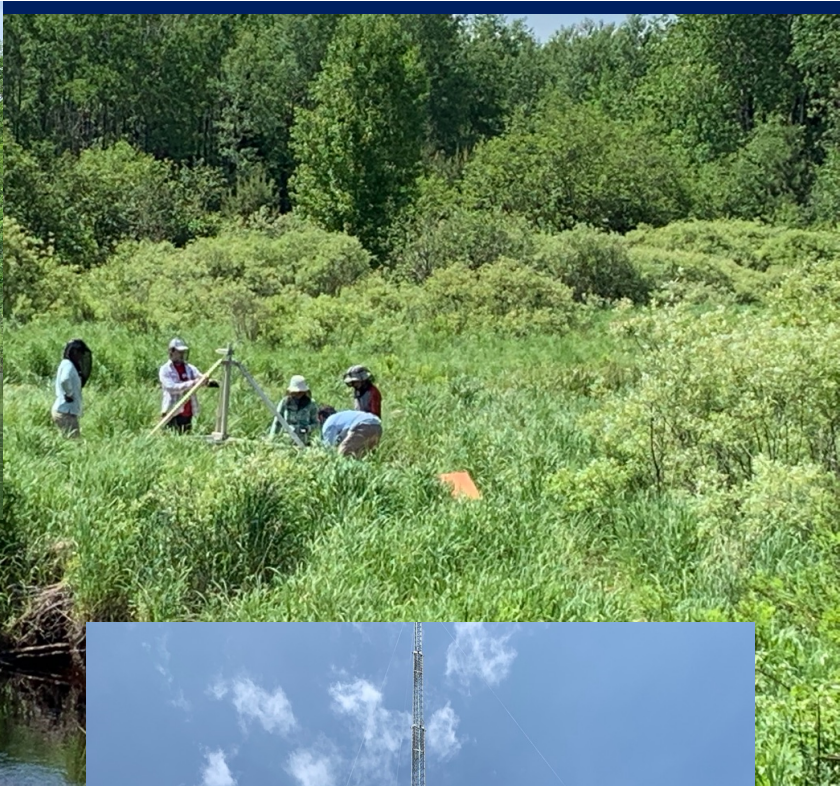
A good place as any to test

Chequamegon Heterogenous Ecosystem Energy-balance Study Enabled by a High Density Extensive Array of Detectors 2019 (CHEESEHEAD19) (NSF 1822420)

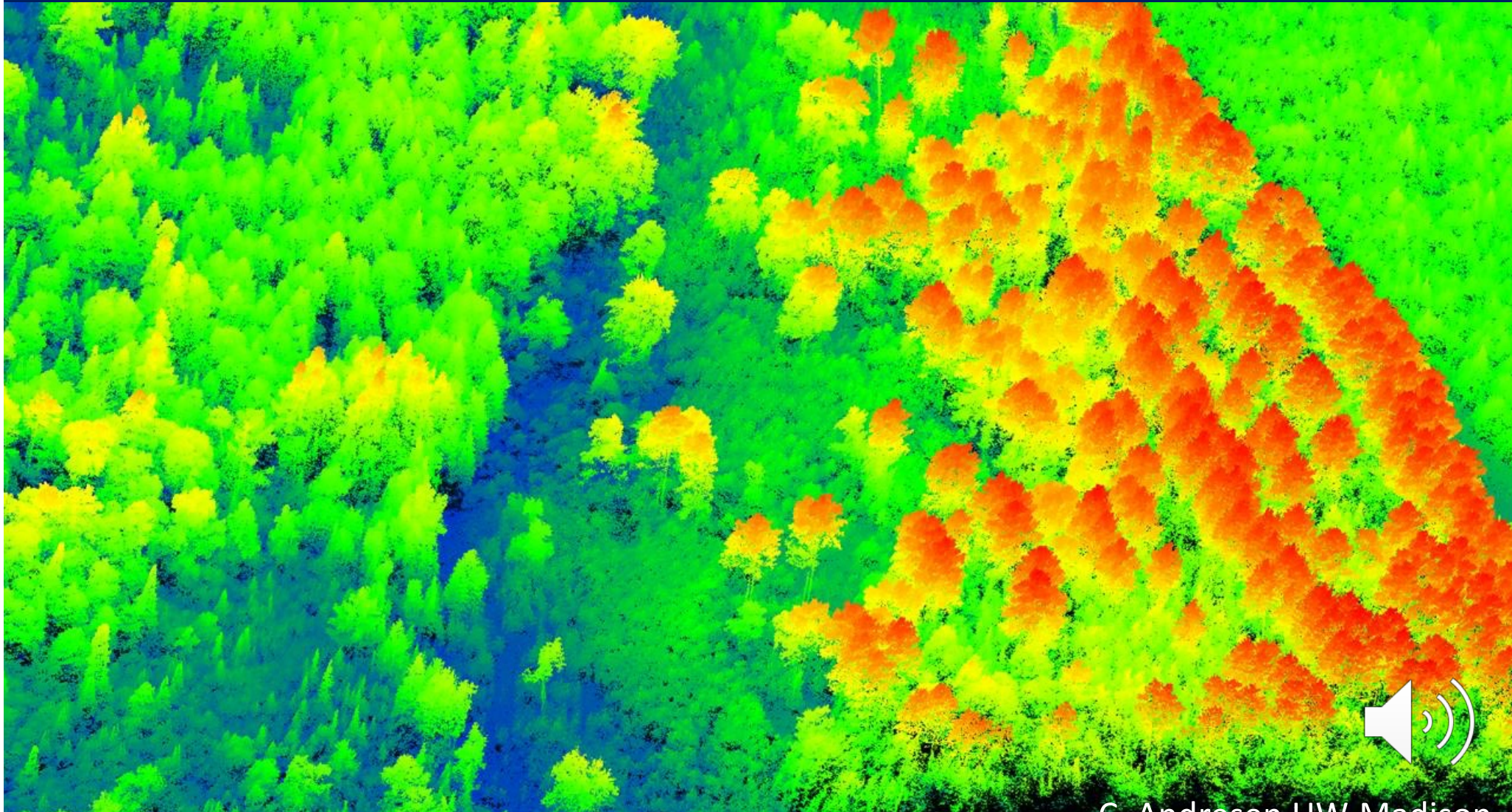


Butterworth et al., 2021, *Bulletin of the American Meteorological Society*





Scales of land surface temperature



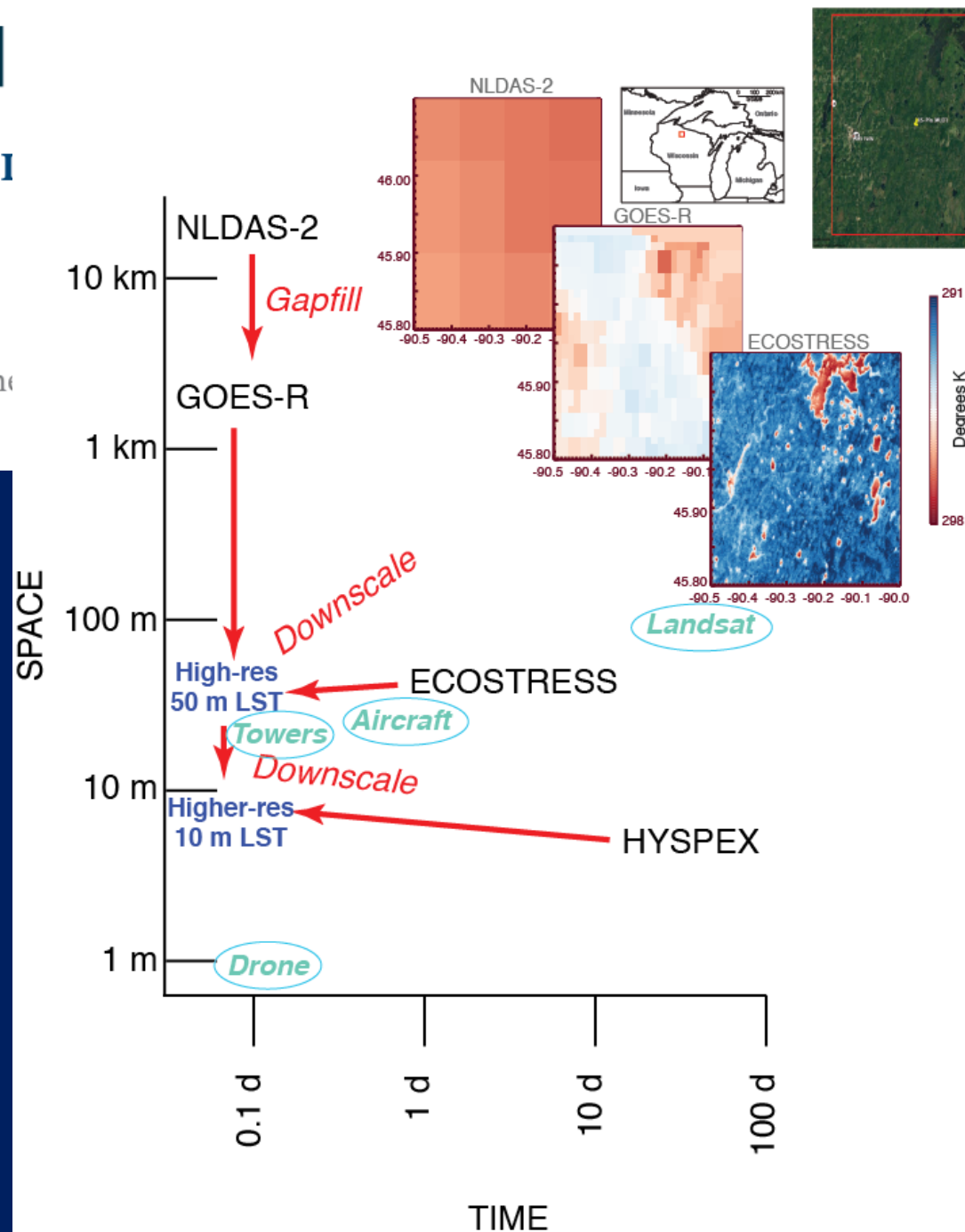
Earth and

RESEARCH ARTICLE

10.1029/2021EA001842

Special Section:

Advances in scaling and modeling of land-atmosphere interactions

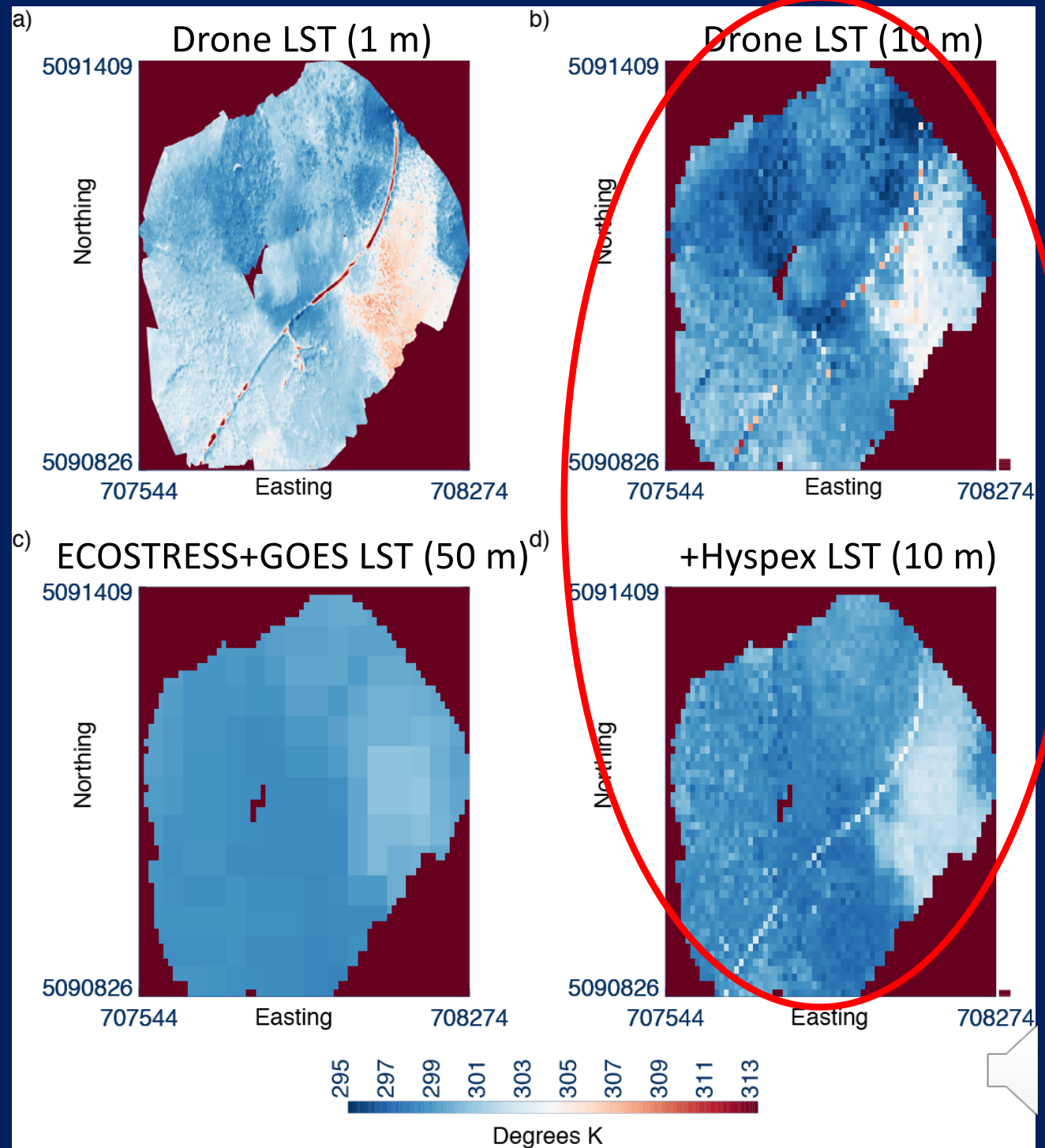


Space and Time

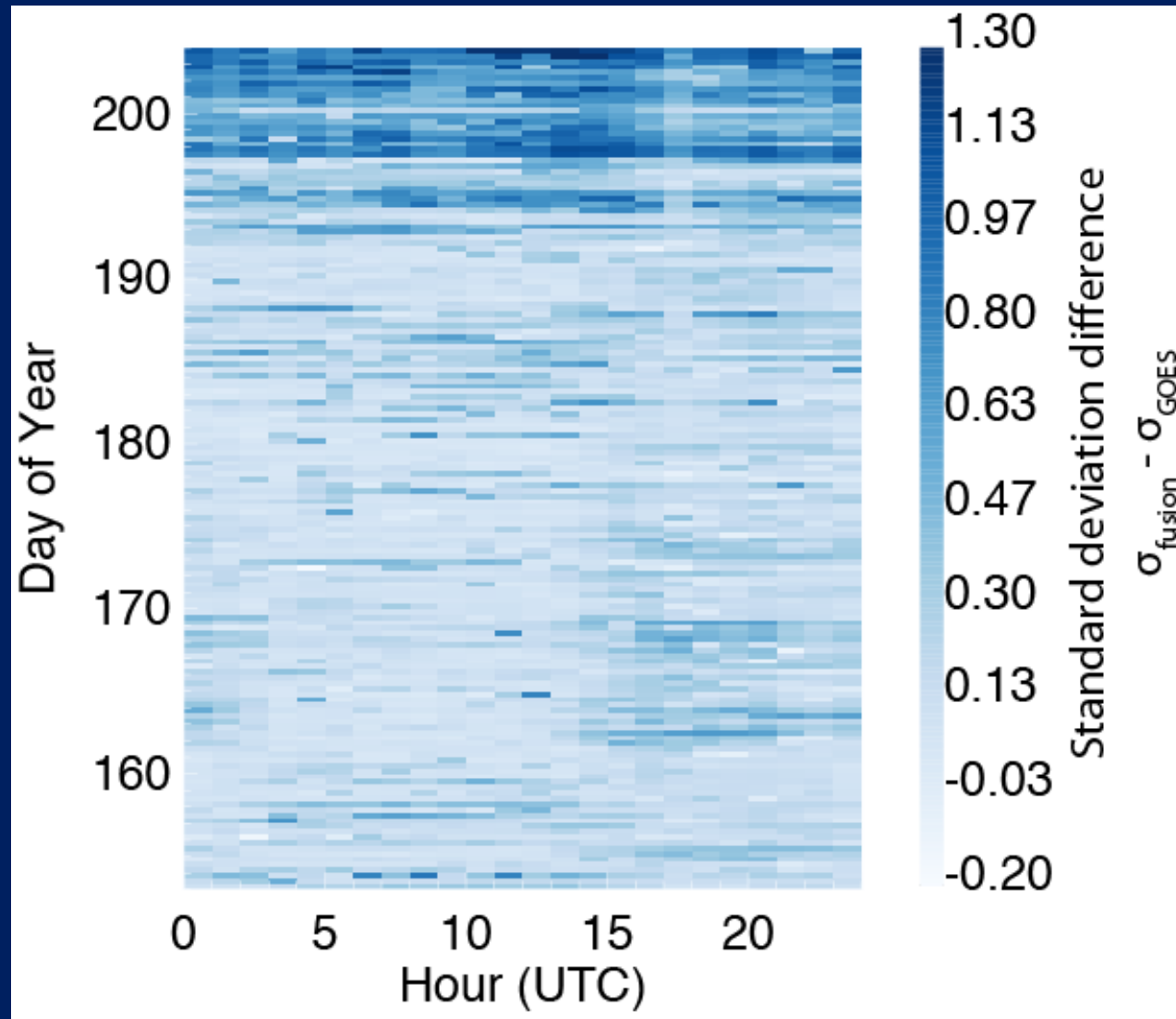
nath Paleri¹ ,
i , Glynn Hulley⁷ ,
aul Stoy⁹ , and



- Drone reveals fine structure of LST over one tower footprint
- A linear model captures basically all the main features with scale



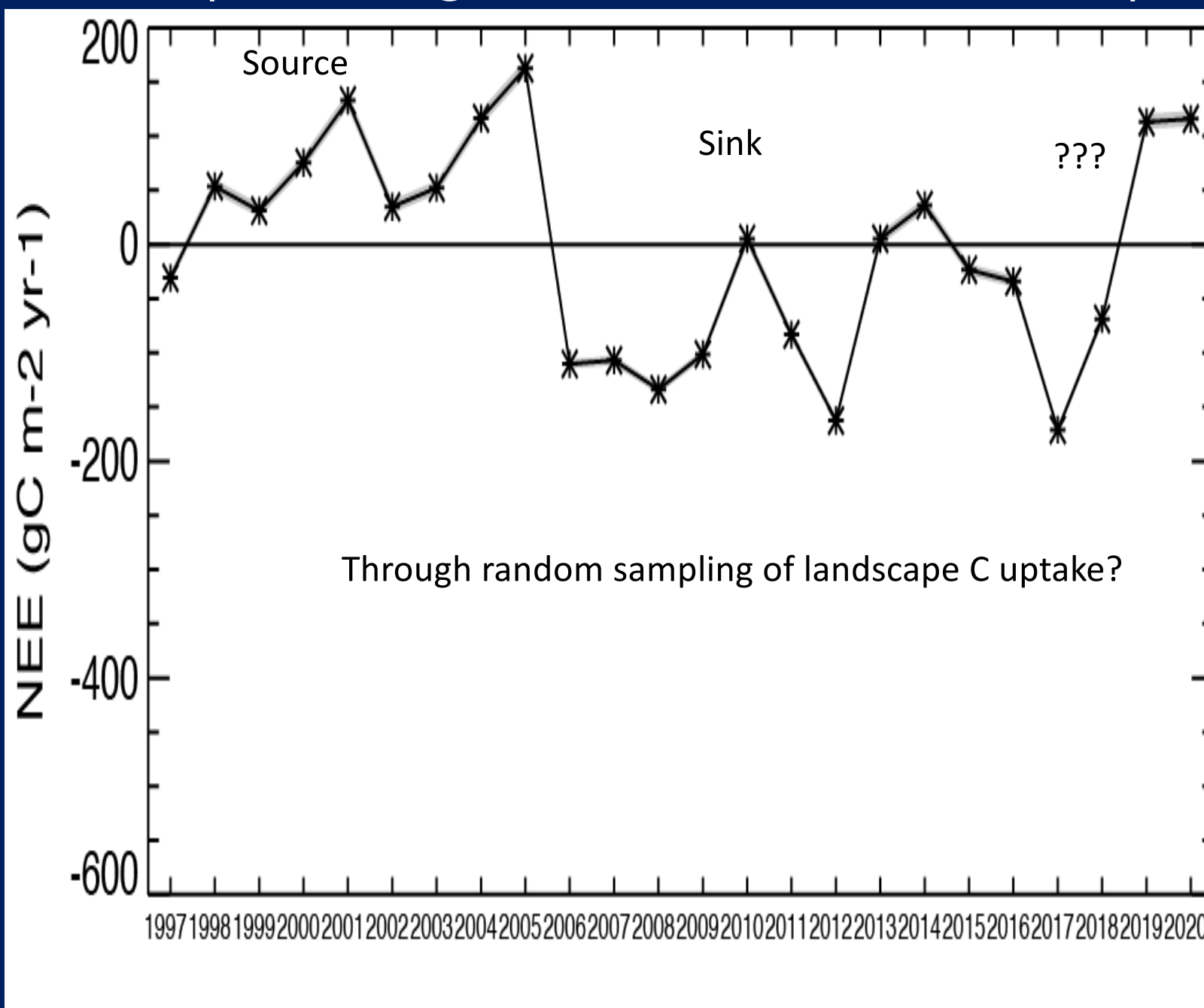
But we can still reveal features of spatial variance relevant for land-atmosphere interactions



Scales of carbon fluxes



Can we explain regional annual carbon uptake?



Legend

Type

- Conifer
- Grass
- Hardwood Deciduous
- Lake
- Tussock
- Tall Tower
- Gate
- Lake
- River
- Wetland
- NON-FS
- USDA FOREST SERVICE

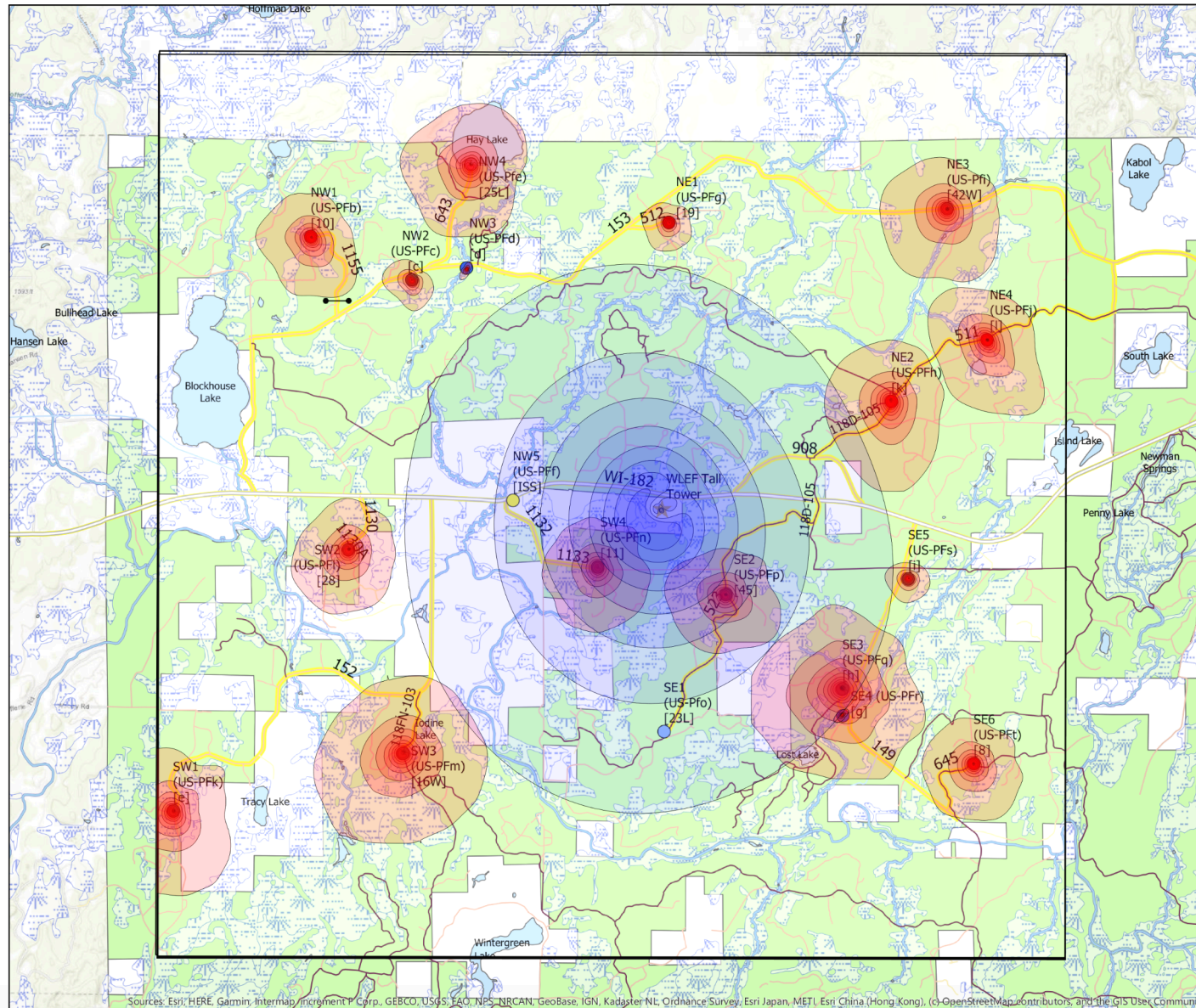
JURISDICTION

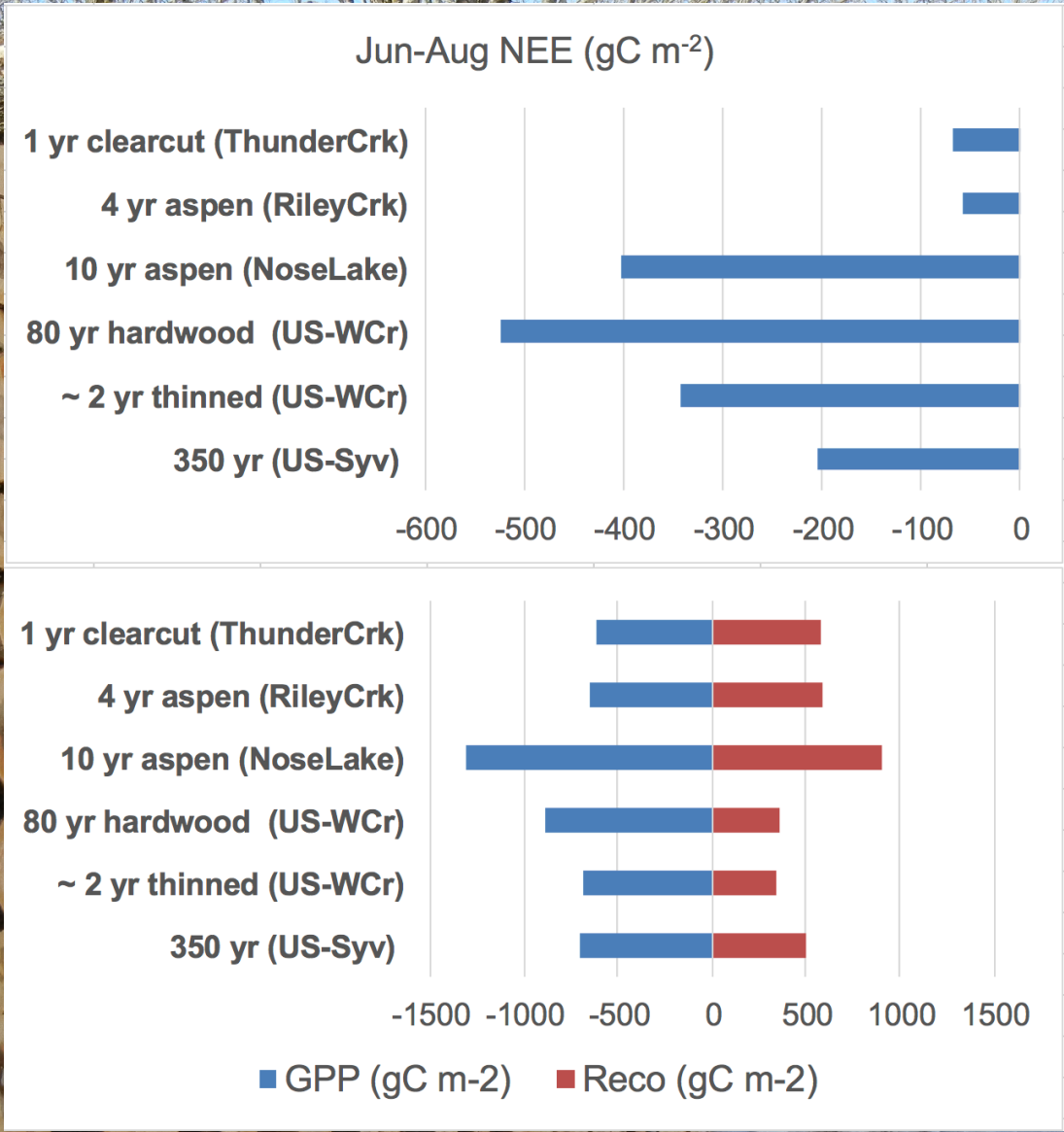
- FOREST SERVICE
- STATE
- LOCAL
- PRIVATE
- Trails
- Access Routes

James Mineau
2 June 2019

Kilometers
0 0.3 0.6 1.2 1.8 2.4

N
W E
S

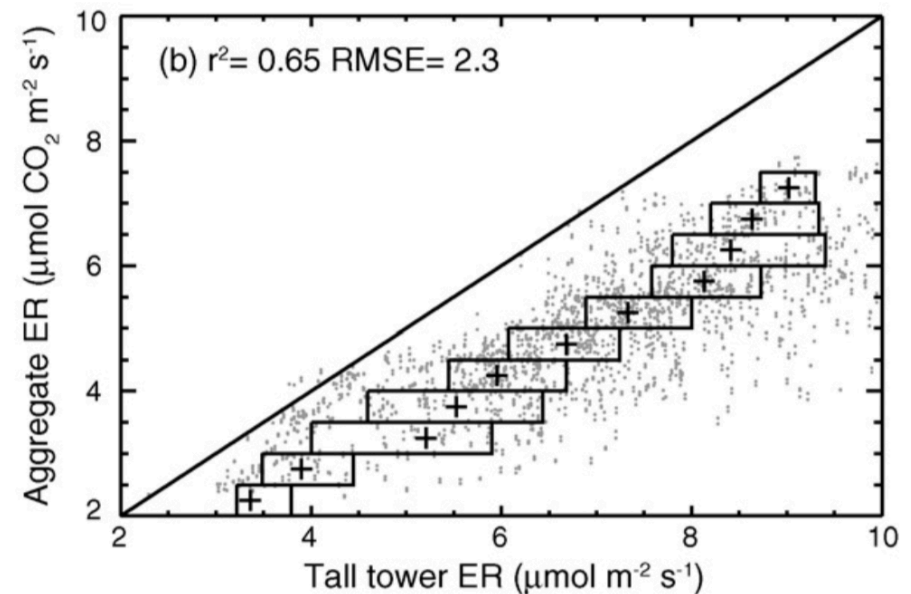
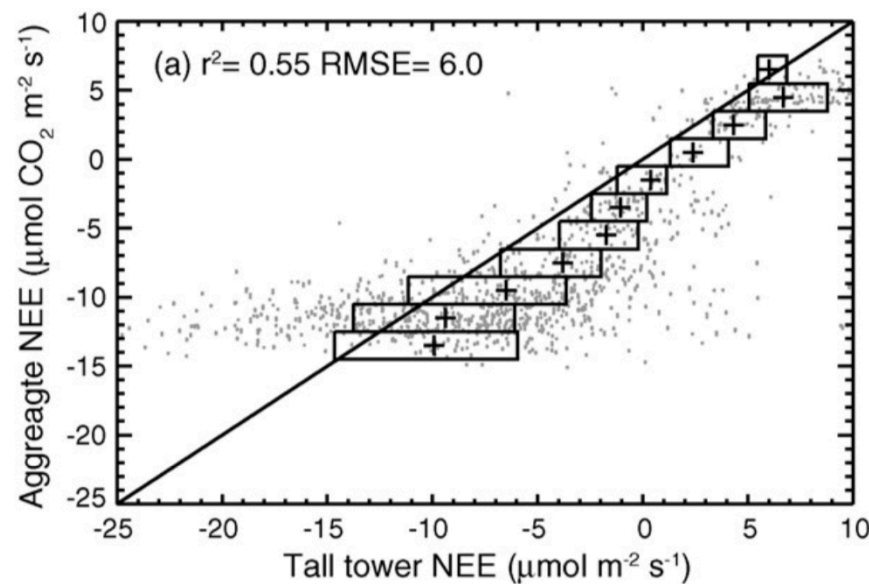




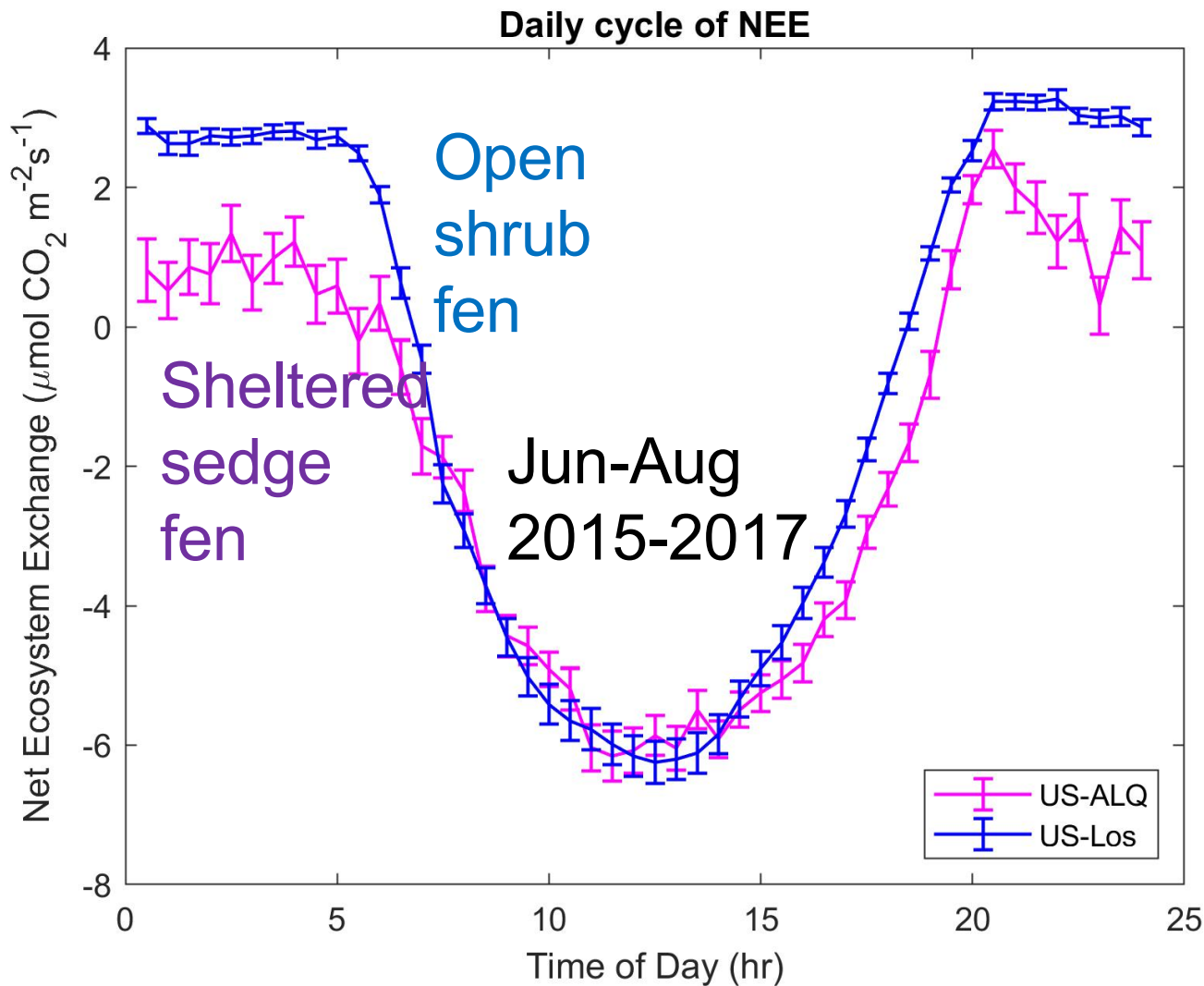
Influence of vegetation and seasonal forcing on carbon dioxide fluxes across the Upper Midwest, USA: Implications for regional scaling

Ag For Met, 2008

Ankur R. Desai^{a,*}, Asko Noormets^b, Paul V. Bolstad^c, Jiquan Chen^d, Bruce D. Cook^c, Kenneth J. Davis^e, Eugenie S. Euskirchen^f, Christopher Gough^g, Jonathan G. Martin^h, Daniel M. Ricciutoⁱ, Hans Peter Schmid^j, Jianwu Tang^k, Weiguo Wang^l

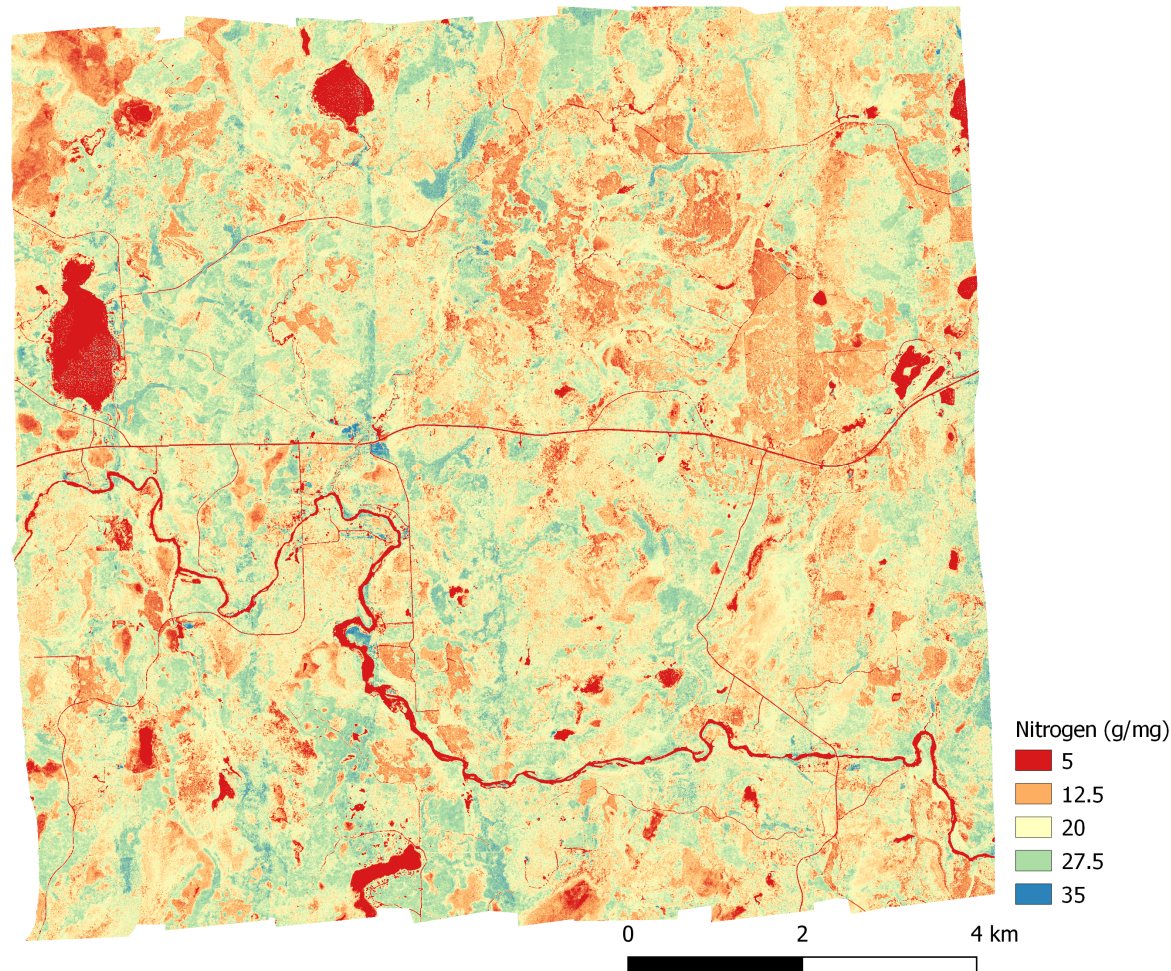


Wetlands: Scale matters



Hyperspectral imaging of leaf traits also reveals spatial scale dependency

Leaf
Nitrogen



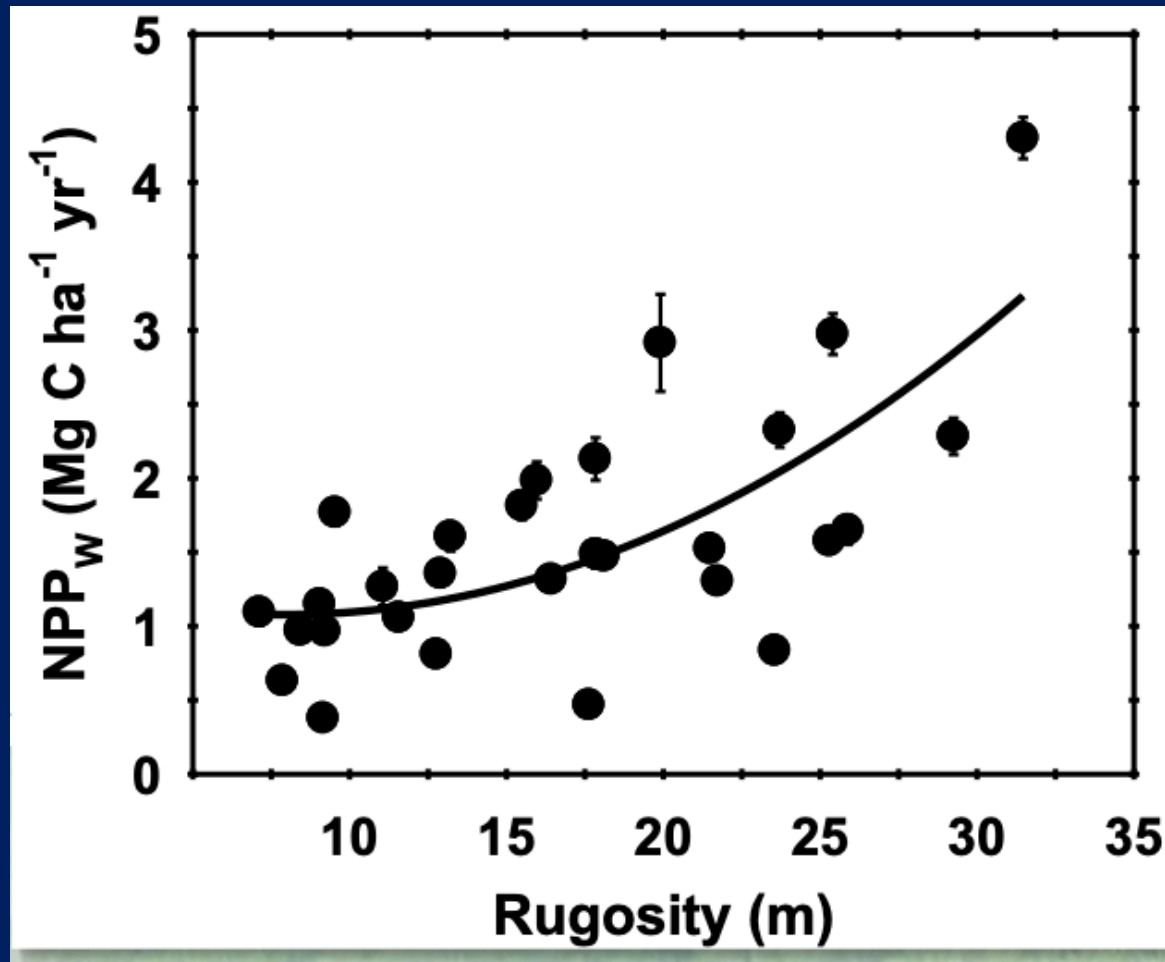


Scales of land-atmosphere energy budget



High rates of primary production in structurally complex forests

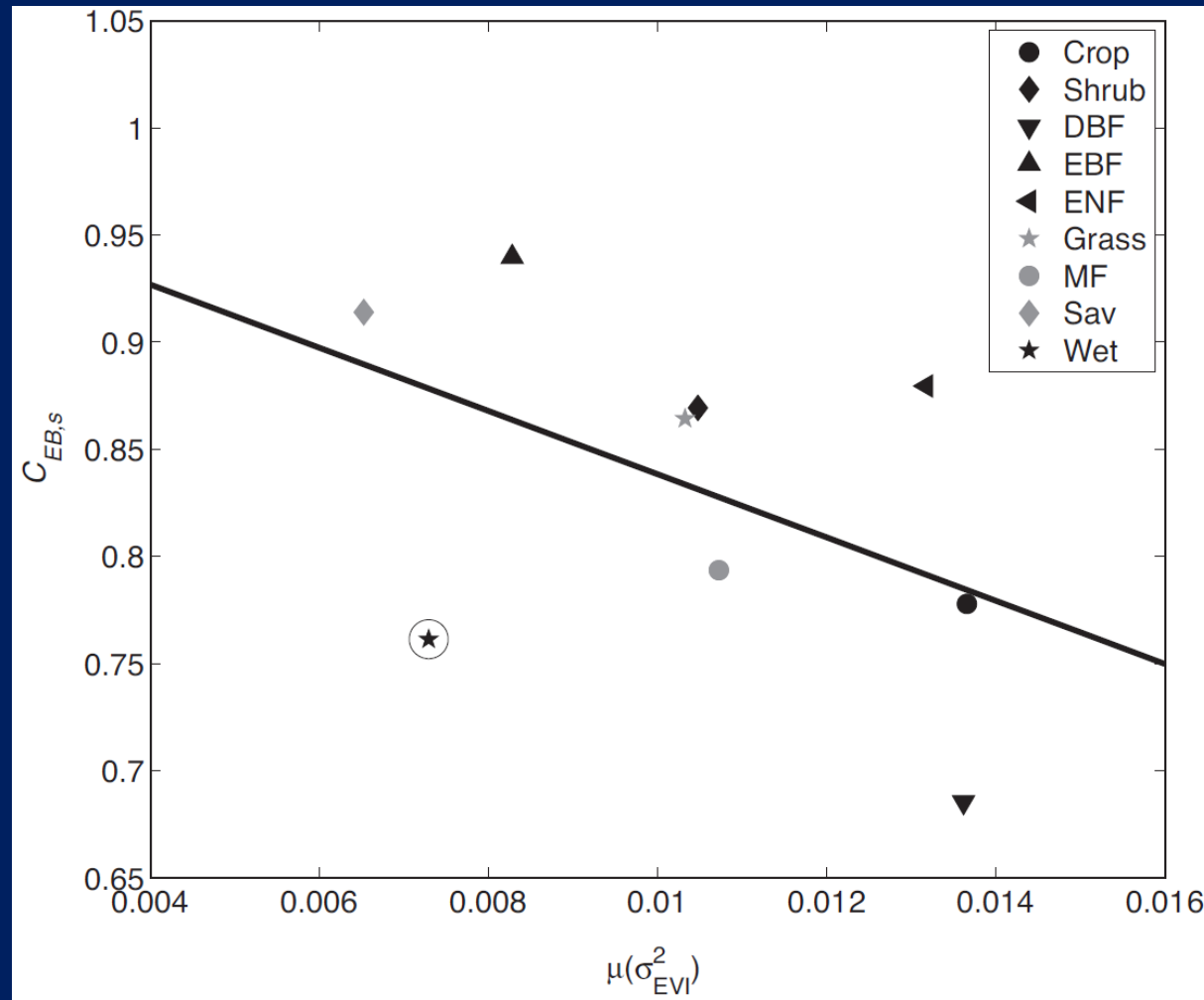
CHRISTOPHER M. GOUGH,^{1,4} JEFF W. ATKINS,¹ ROBERT T. FAHEY,² AND BRADY S. HARDIMAN³



Energy imbalance worsens with increased regional spatial heterogeneity

EBC=
H+Le

Rnet-G

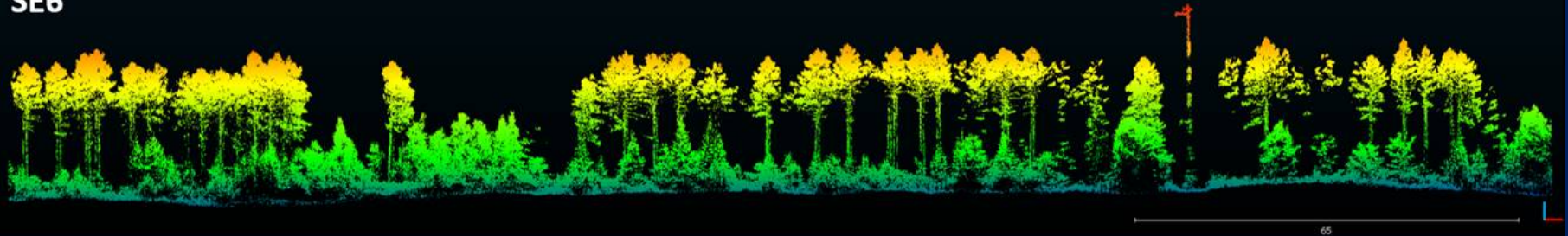


Greenness spatial variance

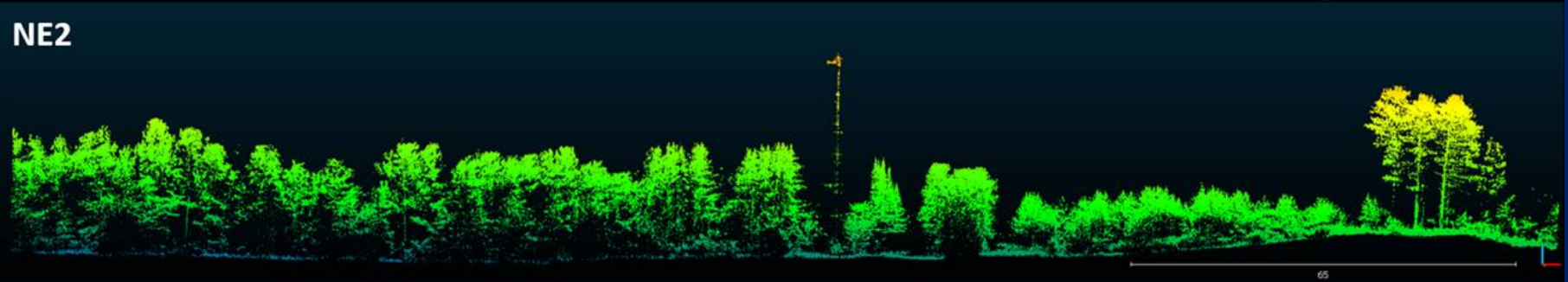
Stoy et al., 2013, 

Is it related to canopy structure?

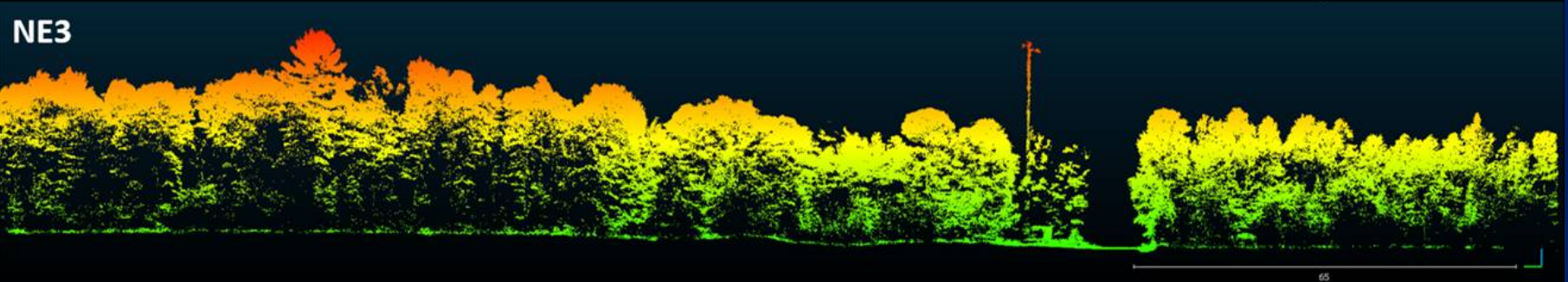
SE6



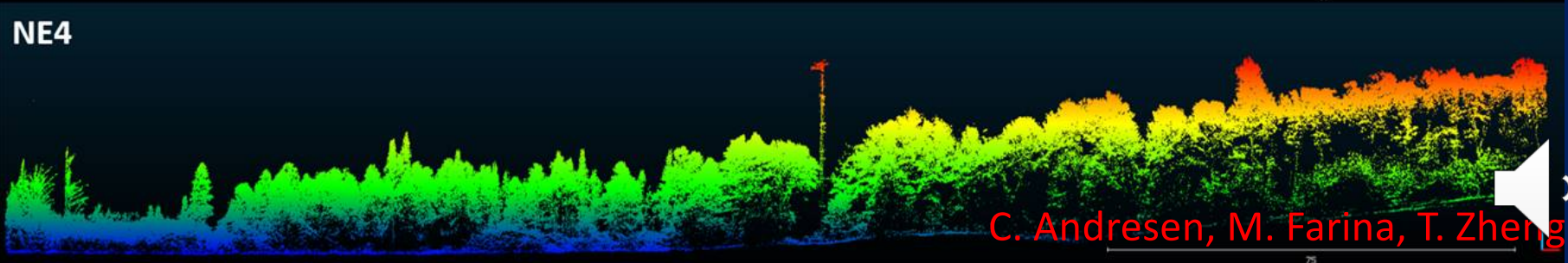
NE2



NE3



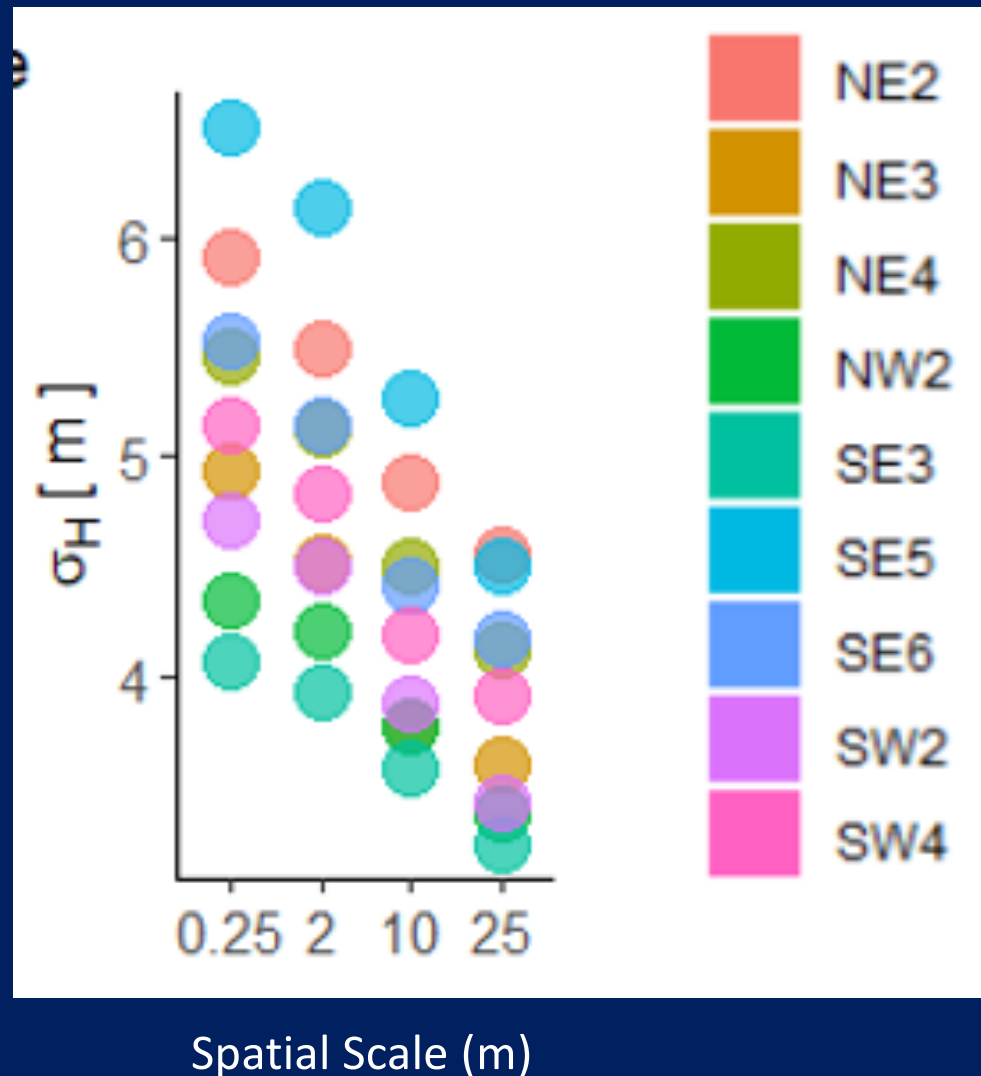
NE4

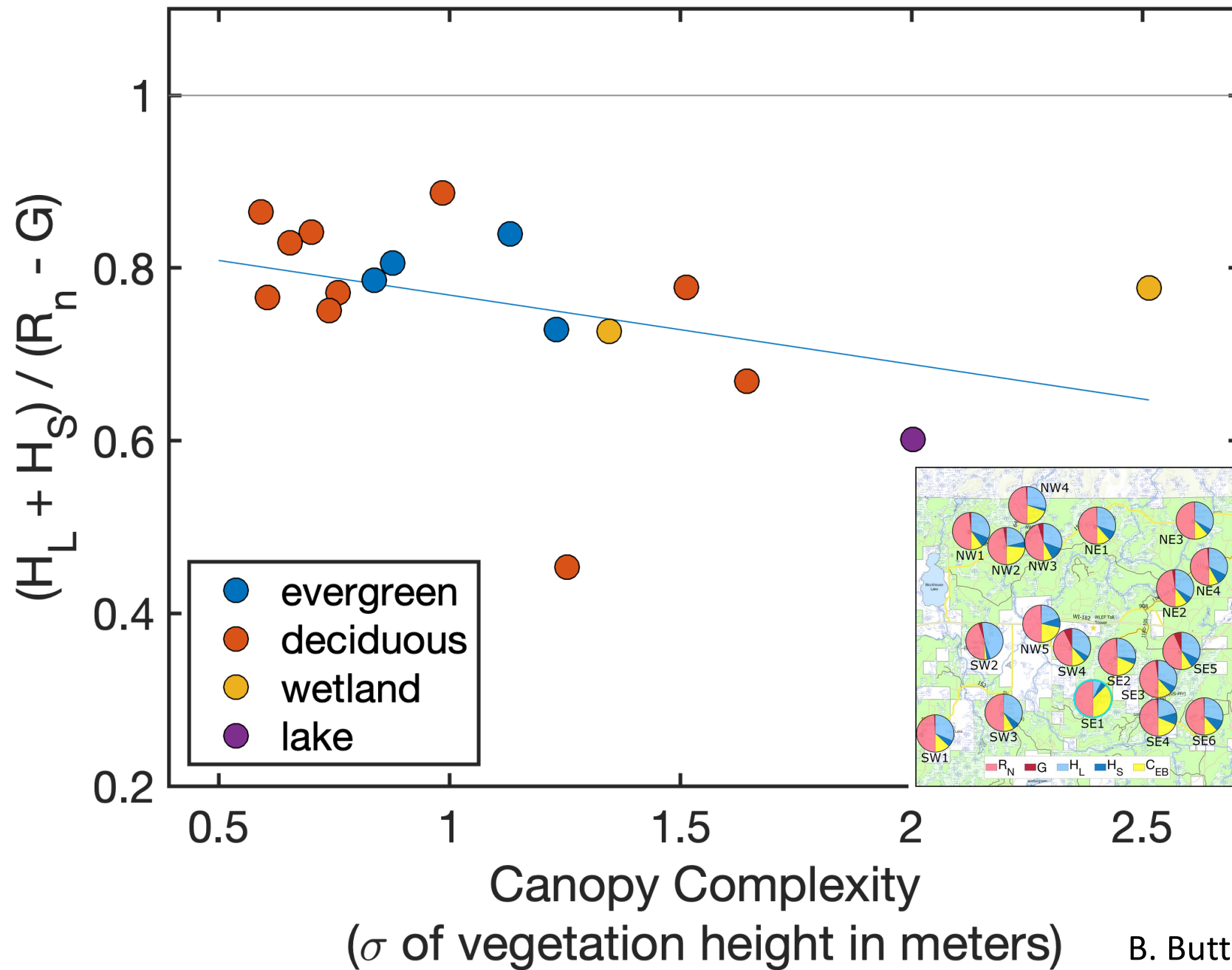


C. Andresen, M. Farina, T. Zheng

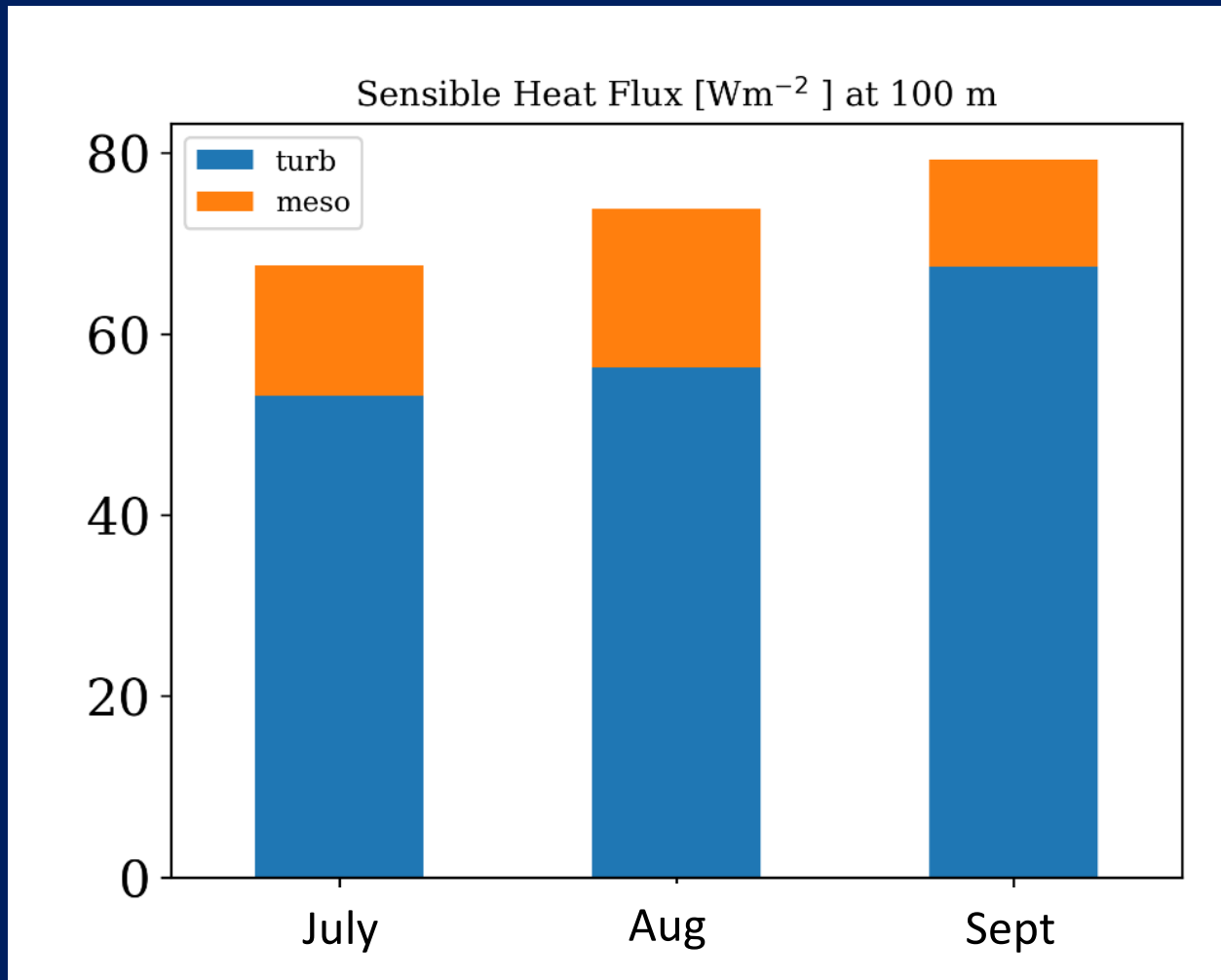


Canopy complexity varies with scale of sampling, but relative differences stay the same





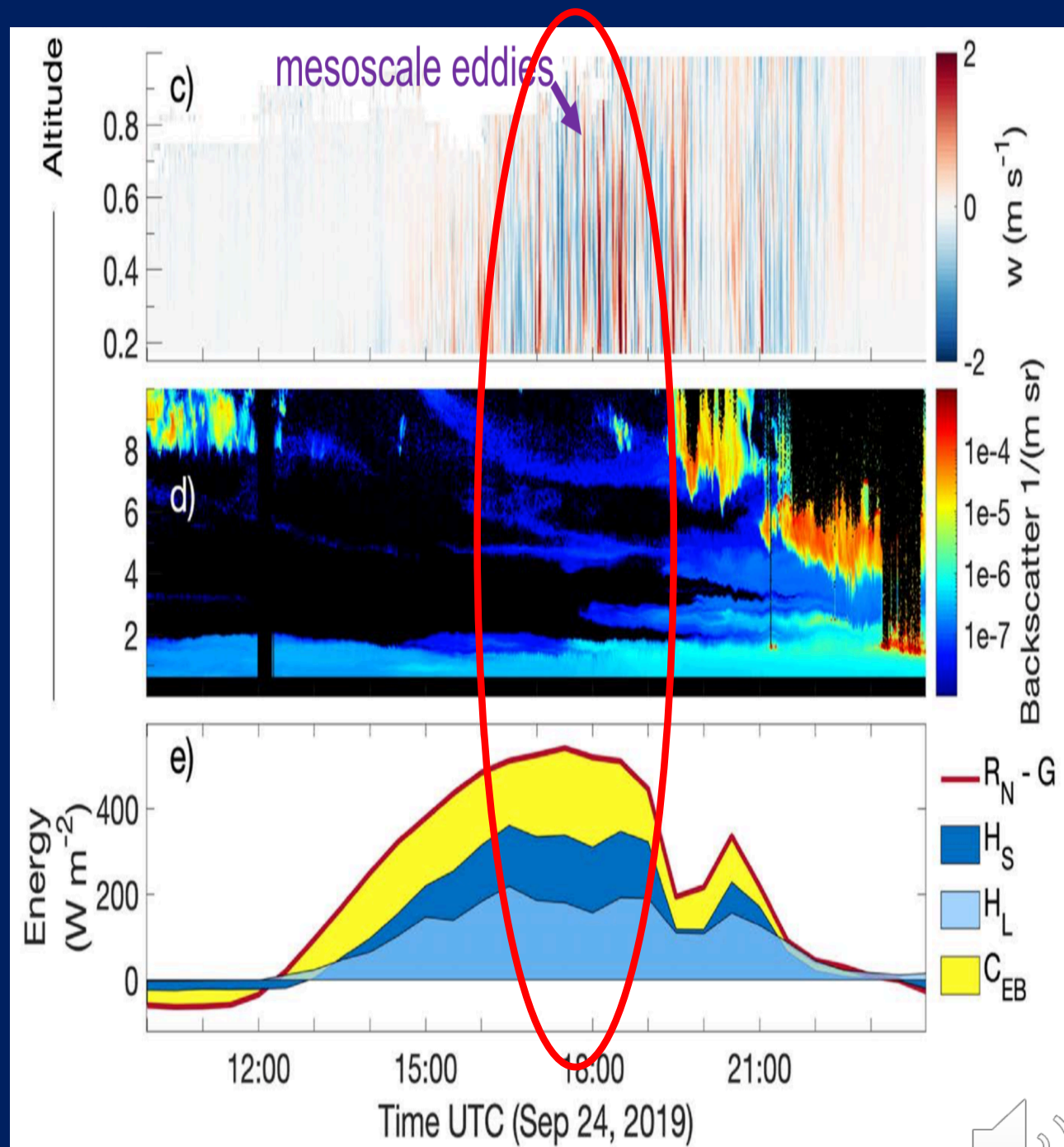
The missing energy is in the "mesoscale" according to flux aircraft



Vertical wind

Aerosol backscatter

Energy balance



L. Wanner, H. Vogelmann,
E. Eloranta, T. Wagner, E. Olson, B. Butterworth



Process and pattern scale matters sometimes

- Sometimes it is just linear (land surface temperature) – can randomly sample and average
- Sometimes it is conditioned on a variable (stand age on carbon fluxes) – conditionally sample
- Sometimes it is highly non-linear (mesoscale eddies from canopy variation) – requires new ways to sample or conceptualize system



AGU cross-journal special collection <https://bit.ly/2TIYtEh>

**Deadline
Extended
to end of
May 2022!**

Advances in Scaling and Modeling of Land-Atmosphere Interactions

Papers are invited for a new cross-journal special collection on insights in scaling land-atmosphere interactions from field experiments, data analyses, and modeling.

**Open in JGR-Atmos, JGR-Biogeo, Earth/Space
Sci, and J Advances Modeling in Earth Sys**



More at AGU:

- B11C-04 - Diagnosing the Effects of Surface Heterogeneity Induced Secondary Circulations from Large Eddy Simulations of Diurnal Cycles During the CHEESEHEAD19 Field Campaign (Paleri et al) MON 8:30 am
- B14D-08 - Exploring Natural Climate Solutions: Could flux towers be useful at industrial scales? (Metzger) MON 3:15 pm
- B15G-1515 - Modeling the Energy Balance Gap Based on Atmospheric Stability and Surface Heterogeneity (Wanner) MON posters
- H22B-01 - Partitioning evaporation and transpiration from 17 eddy covariance towers in a diverse forest landscape (Stoy) TUE 9:45 am
- B25I-1603 - Unravelling Forest Complexity: Resource Use Efficiency, Disturbance, and the Elusive Structure-Function Relationship (Murphy) TUE posters
- GC41D-10 - Merging eddy covariance and remote sensing models to facilitate high resolution spatiotemporal monitoring of agricultural greenhouse gas budgets (Wiesner) THU 8:45 am
- B55D-1234 - The Influence of Interannual Carbon Variability on Long-Term Carbon Sequestration in Proximate Northern Forests and Wetlands (Abyazani) FRI posters



Thank you!

Ankur Desai

desai@aos.wisc.edu

[@profdesai](https://flux.aos.wisc.edu)

- Contributions from:

- Stefan Metzger, Bailey Murphy, Sreenath Paleri, Luise Wanner, Jonathan Thom, Jess Turner, Ting Zheng, CHEESEHEAD19 participants, ChEAS Ameriflux and LTER participants

- Support:

- DOE Ameriflux Network Management Project contract to ChEAS core site cluster, NSF AGS 1822420 (CHEESEHEAD), NSF DEB 1440297 (NTL LTER), NOAA ESRL + ATDD, USFS, USGS, WI Educational Comm Board, WI Dept of Natural Resources, DFG, NASA, NCAR



Photo: A. Desai