Skimming the trees: Benefits of the UW King Air for lower boundary layer characterization in CHEESEHEAD19

Ankur Desai, UW-Madison

UCAR FARE Workshop

Mon Sept 18

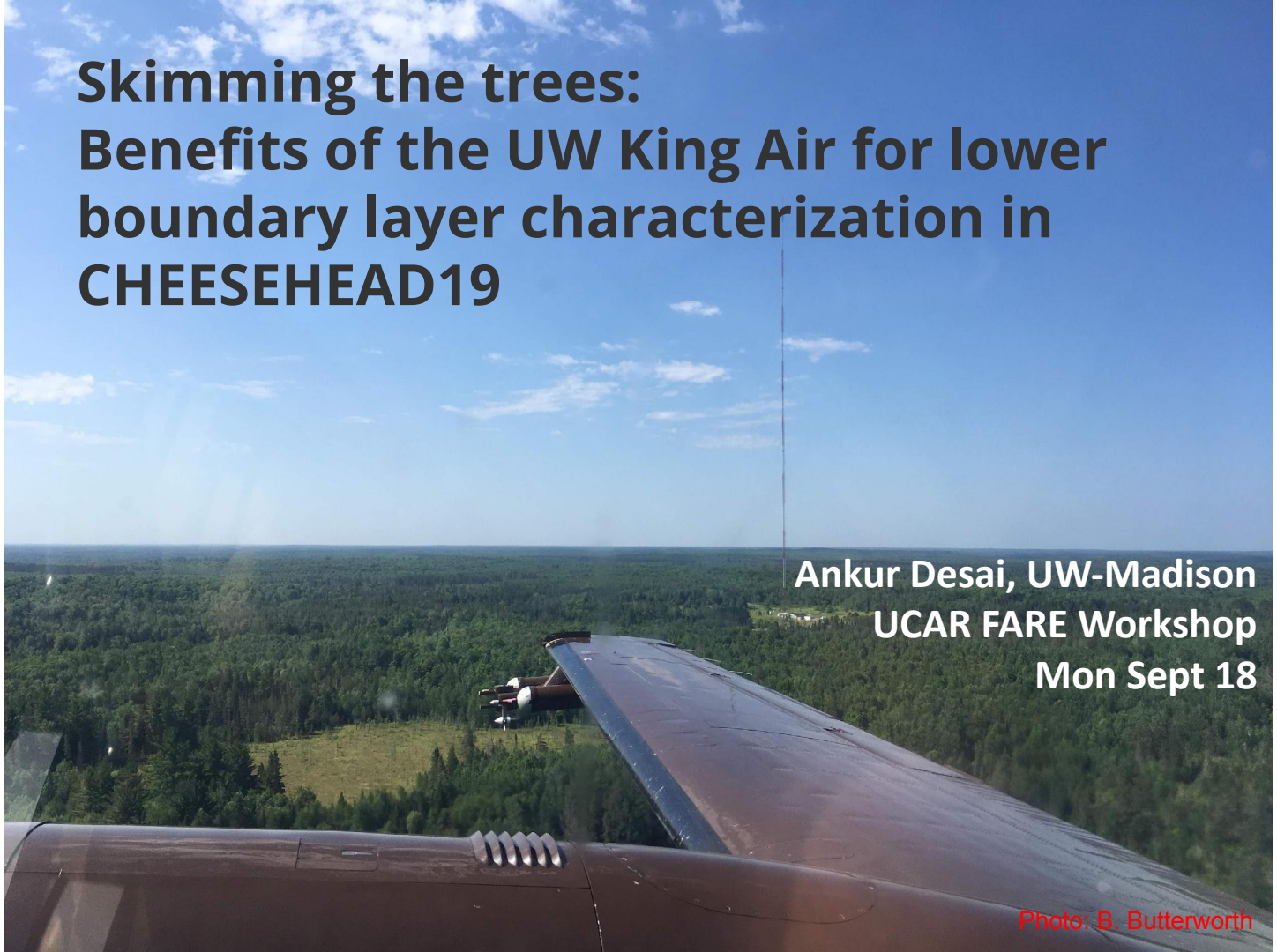
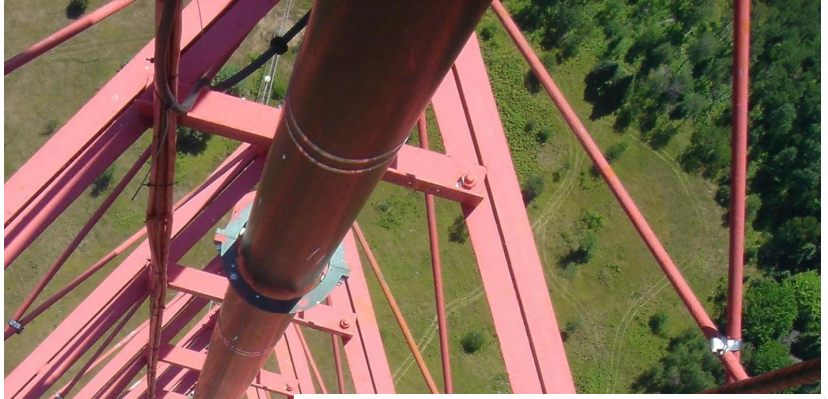
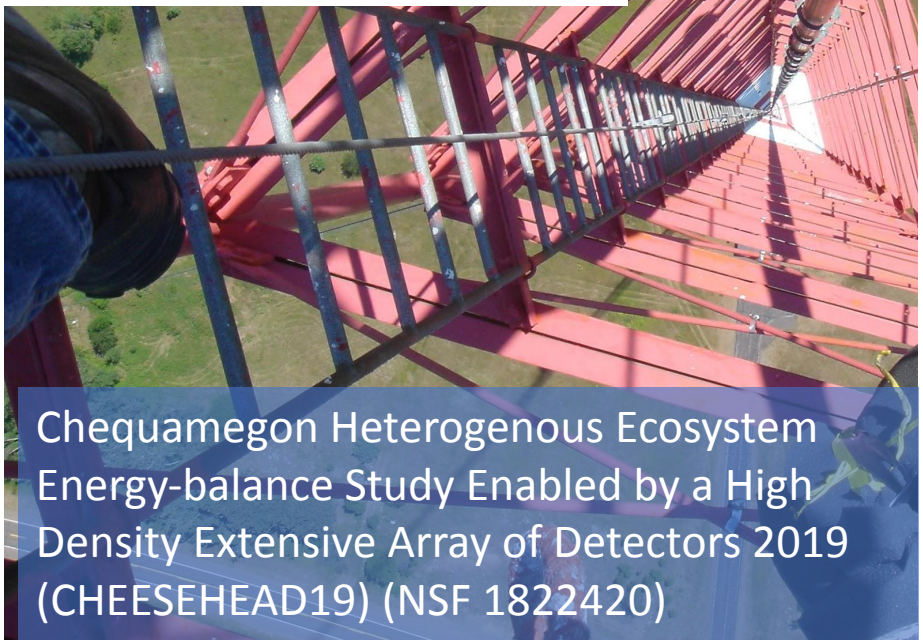


Photo: B. Butterworth

CHEESEHEAD 2019

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





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

Scientific Merit

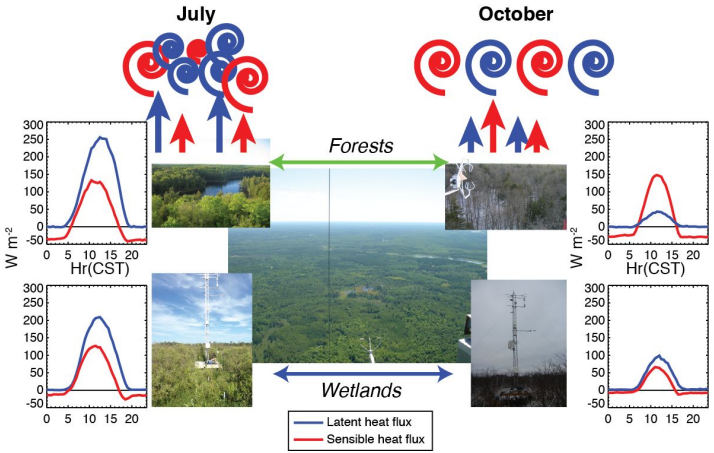
Overarching question: To what extent are land surface energy partitioning and atmospheric responses different than the sum of its individual components, and if so, how do they influence the atmosphere and how do we optimally observe and simulate it?

- *When and where does local surface heterogeneity drive local atmosphere circulations?*
- *How does the presence or absence of these circulations influence the reliability and representativeness of single-point eddy covariance flux tower measurements?*

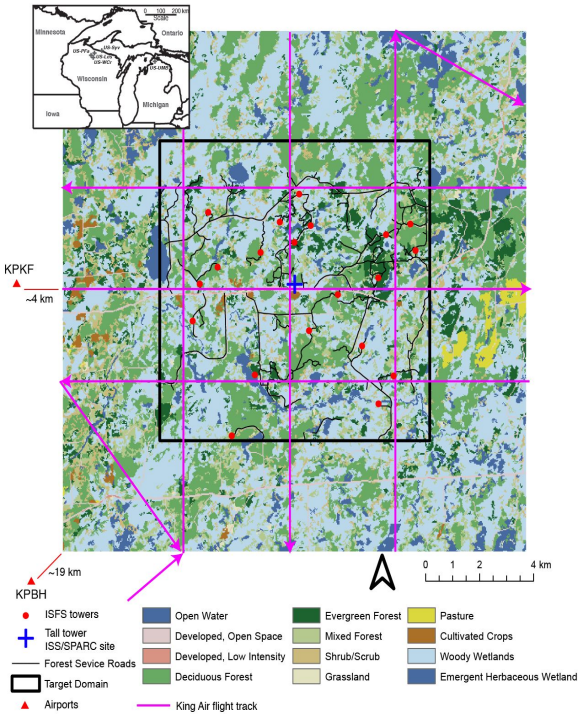
CHEESEHEAD was a 3-month experiment to intensively sample and scale surface energy balance, PBL response, and LES model parameterizations in a 10x10 km heterogeneous vegetated region (Chequamegon Forest) in Northern Wisconsin.

The experiment was proposed to be held from summer to early-fall, as the region switches from homogenous transpiration dominated to heterogeneous sensible heat dominated surface energy forcing.

July-October allows us to sample landscape as it evolves from homogenous LE (transpiration) driven, to patchier H and LE patterns depending on ecosystem



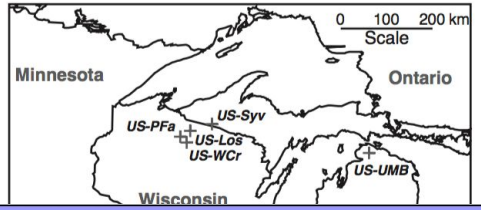
~15-20 “virtual” flux towers (red dots, right) appear to be needed in LES to close energy balance in domain around tower using published spatial eddy covariance technique

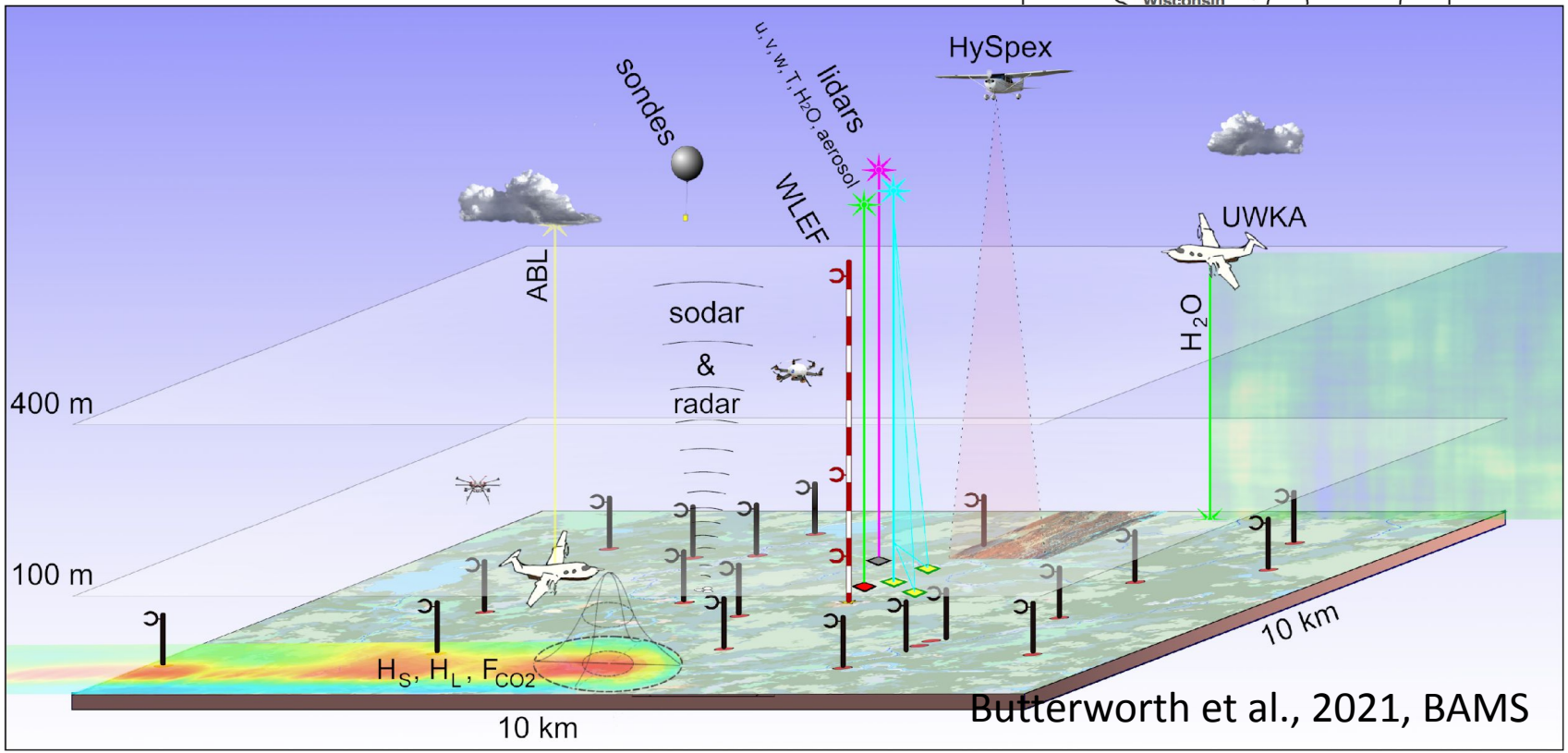


A long road…

- 2014 Research culminating in vision for field experiment. Whitepaper on idea while on sabbatical leave in Germany, shared with multiple groups, NSF, others, found some partners
- 2014 AGU - Meeting with Steve Oncley at NCAR to discuss ISFS capability, future plans
- 2015 Virtual studies on # of towers needed by PhD student
- 2015 Meetings with UWKA, SPARC, CRL, ISS, and other groups
- Summer to Fall 2015 – proposal and experimental design writing, meetings w/ USFS about permitting
- Jan 2016 – first proposal submission for 2017 or 2018 study
- Spring 2016 OFAP feasibility analysis, largely favorable, but science proposal had criticisms
- Fall 2016 Additional virtual studies on energy balance scaling
- Dec 2016 resubmission of proposal, but withdrew due to overlap with funded study
- Summer 2017 Internally funded deployment of SPARC at tall tower site for more experimental data in ABL
- Dec 2017 Resubmission of proposal for 2019 study, this time with parallel submission to DFG for German contribution
- May 2018 OFAP reviews, responses required
- Summer 2018 Successful funding, start of OSSE study for aircraft design
- Fall 2018 Site visit by Steve Oncley on site selection, discussions with UWKA on airport siting, permitting with USFS
- Fall 2018 Supplemental request for NSF and UWKA for change in IOP timing and days, addition supplemental request for REU participation from HBCU
- 2018-2019 Recruitment of staff, start of biweekly telecons, organization of planning material on TRELLO, open calls for participation at AGU/AMS
- 2019 Finalize OSSE study on flight design pattern, traceability matrix, review with pilots of UWKA
- 2019 EXPERIMENT!

Experiment Plan





Butterworth et al., 2021, BAMS

Why UWKA?

- Core, requestable NSF lower atmosphere facility, strong track record in delivering top quality measurements and science
- Fully outfitted aircraft for micrometeorology and eddy covariance
- Wyoming Cloud LiDAR and Compact Raman LiDAR provide ABL profiling capability
- Sufficient speed for sampling “flux” legs, and can fly close to ground, in large variety of conditions
- Investigators can see data in real-time, flying right seat
- Real-time chat and tracking on ground (M.S. student)
- Flight time limitations sufficient for our design (our need: 2 2-2.5 hour flights a day, 3 or 4 days in a row, 84 hours total)
- Available for public outreach, student tours at airport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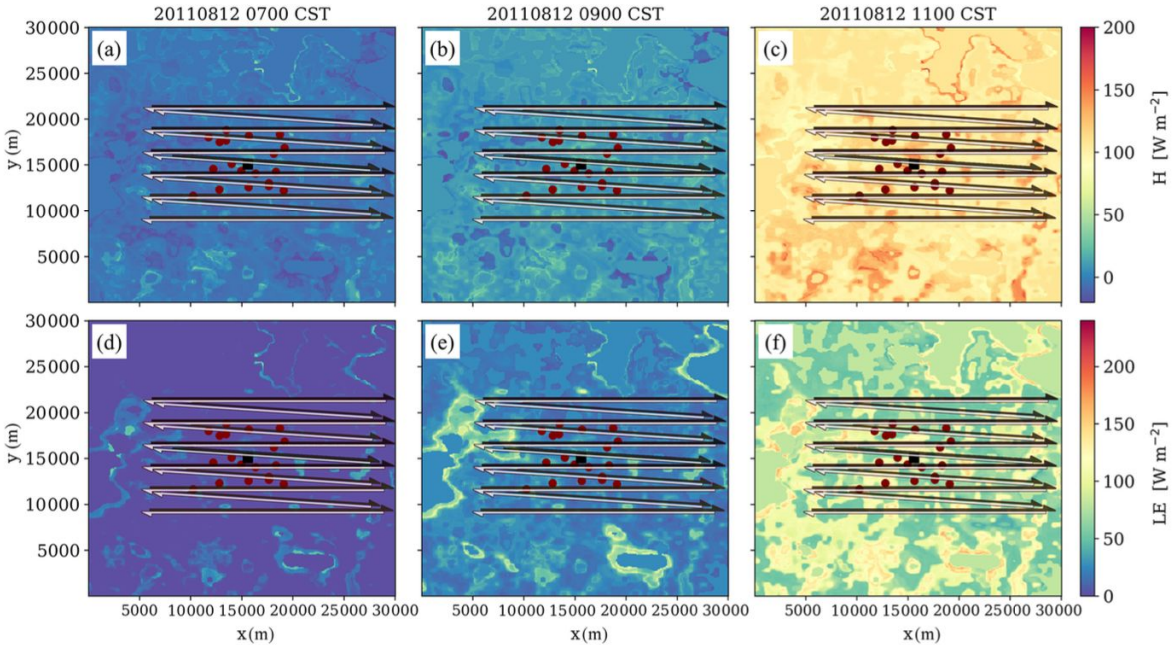
Atmos. Meas. Tech., 14, 6929–6954, 2021
https://doi.org/10.5194/amt-14-6929-2021

Atmospheric Measurement Techniques
Open Access
EGU

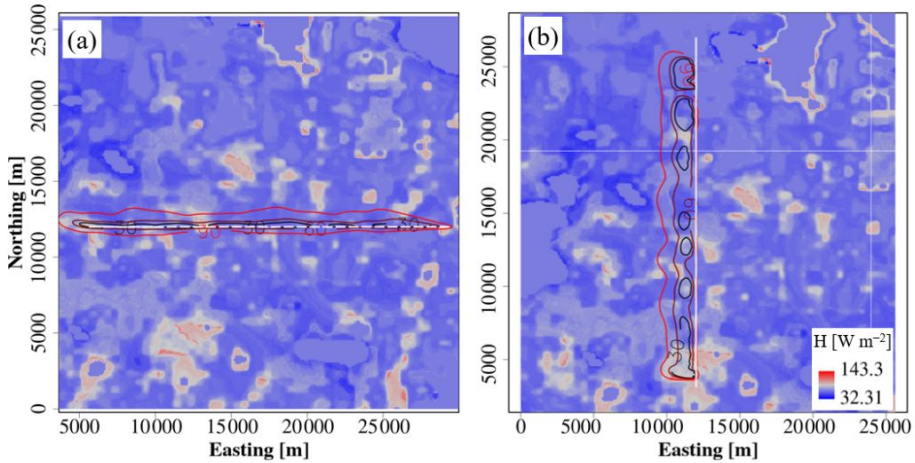
Novel approach to observing system simulation experiments improves information gain of surface–atmosphere field measurements

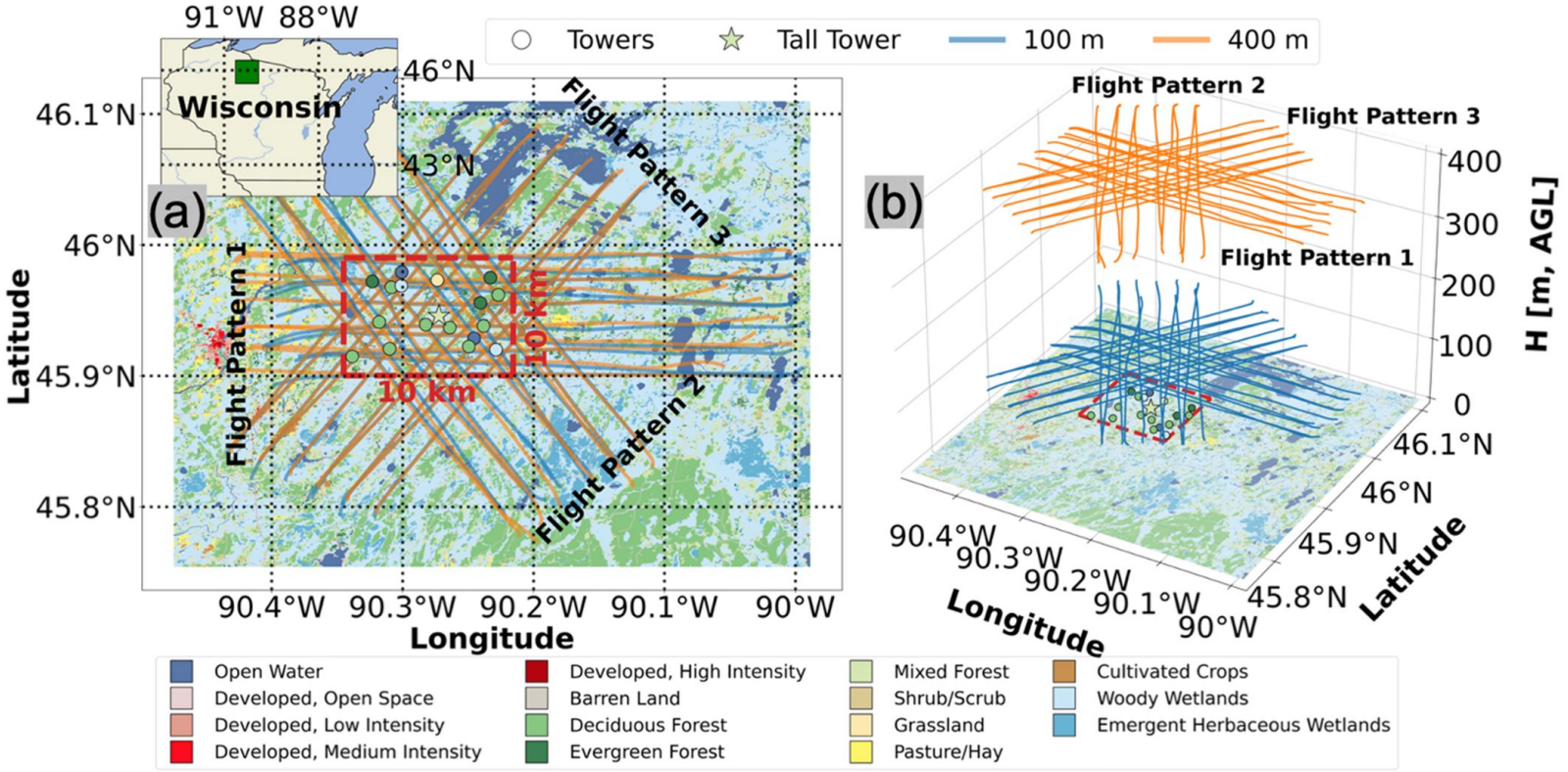
Stefan Metzger[1,2], David Durden[1], Sreenath Paleri[2], Matthias Sühring[3], Brian J. Butterworth[2], Christopher Florian[1], Matthias Mauder[4], David M. Plummer[5], Luise Wanner[4], Ke Xu[6], and Ankur R. Desai[2]

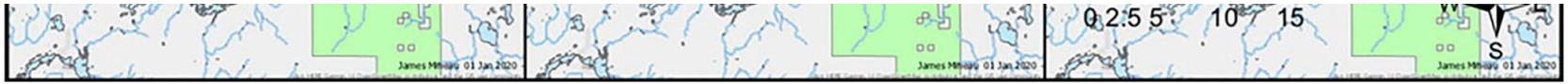


OSSE suggests perpendicular flight tracks

Optimality criterion	All angles	0°	**45°**	**60°**	**90°**
Spatial coverage	23.6 % ± 2.2 %	20.9 % ± 1.9 %	24.7 % ± 0.8 %	23.3 % ± 1.8 %	25.6 % ± 0.1 %
Energy balance ratio	6.8 % ± 5.3 %	1.7 % ± 1.4 %	**6.4 % ± 5.3 %**	**6.4 % ± 4.7 %**	**12.8 % ± 3.1 %**
Spatial patterning	23.2 % ± 11.7 %	13.7 % ± 9.2 %	**34.6 % ± 3.3 %**	**26.2 % ± 6.8 %**	**18.3 % ± 15.2 %**

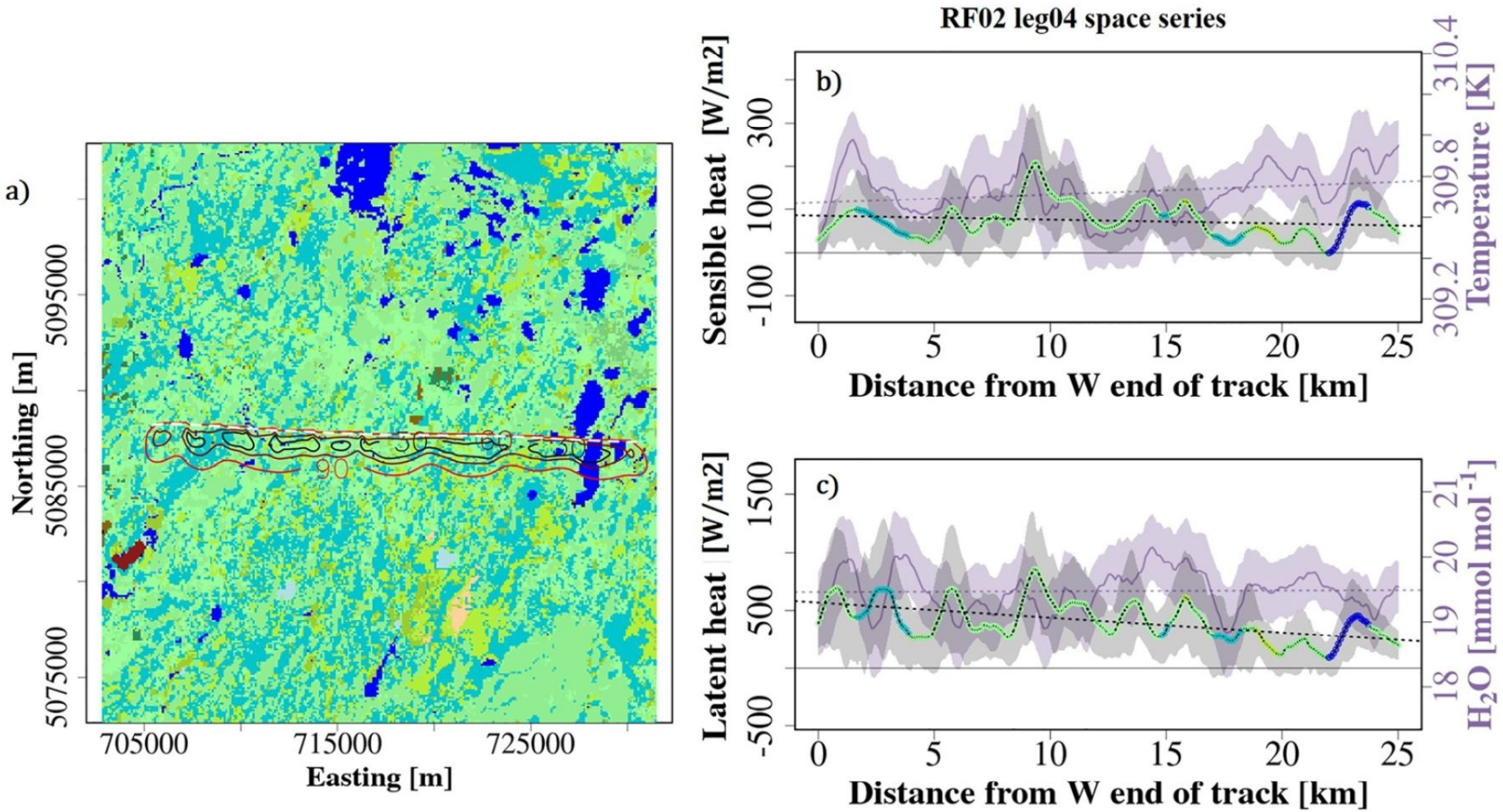






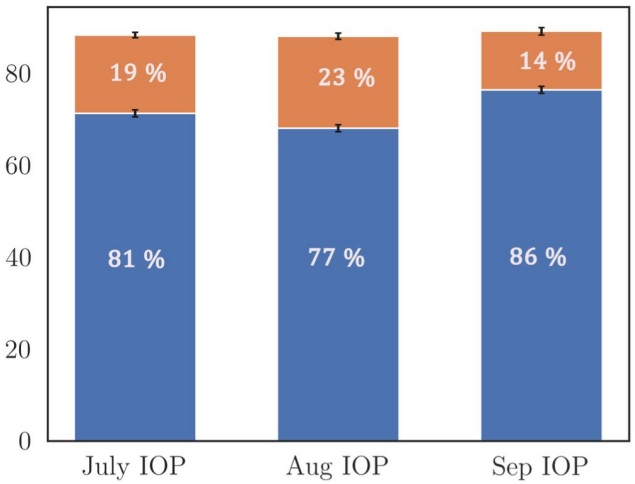
Paleri et al., JGR-D, 2022; Lin et al., in review

Off and away!

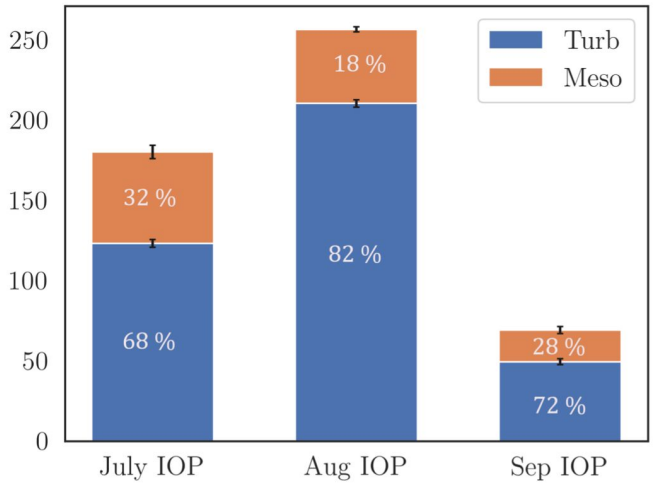


Paleri et al., 2022, JGR-Atmosphere

”Missing” energy found in the “mesoscale”



(a) Sensible heat flux $[Wm^2]$ at 100m

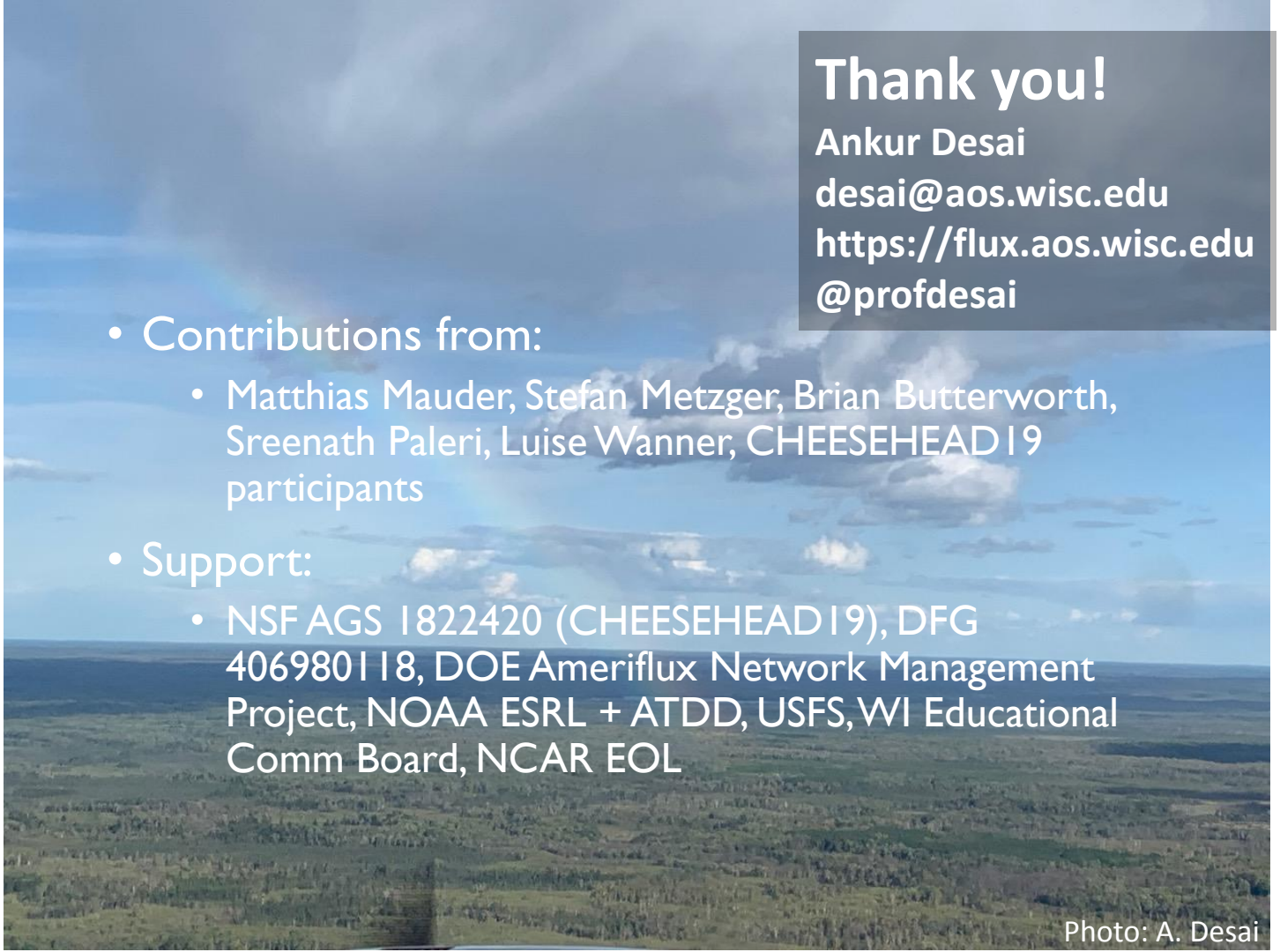


(b) Latent heat flux $[Wm^2]$ at 100m

S. Paleri, 2022, JGR-Atmos

Thoughts for Track 3 proposers

- Start early – good to line up availability, capability, science partners
  - Instrument and platform partners want to help!
- This took a few tries, either due to experimental design weaknesses, lack of preliminary science results, or overlap with other experiments
  - Be flexible on timing
  - Pre-experiment mini-experiments in situ or view model studies can help ground experimental design
  - Be ready to respond to OFAP review



Thank you!

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- Contributions from:
  - Matthias Mauder, Stefan Metzger, Brian Butterworth, Sreenath Paleri, Luise Wanner, CHEESEHEAD19 participants
- Support:
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Photo: A. Desai