Towards the spatial rectification of tower-based eddy-covariance flux observations B53A-0172

Ke Xu[1](kxu35@wisc.edu), Stefan Metzger[2], Natascha Kljun[3], Jeffrey R. Taylor[2], Ankur R. Desai[1]

[1]{University of Wisconsin Madison, Department of Atmospheric and Oceanic Sciences, Madison, Wisconsin, United States of America} [2]{National Ecological Observatory Network, Fundamental Instrument Unit, Boulder, Colorado, United States of America} [3]{University of Colorado, Boulder, Colorado, United States of America} [4]{Swansea University, Department of Geography, Swansea, Wales, United Kingdom}

Objectives

- Extract the environmental response functions (ERFs) between flux response and environmental state variables
- Upscaling turbulent exchange from small transient tower footprint to large predefined target area

Methodology and Results

US-PF 447 m tall tower Measurement height: 122 m

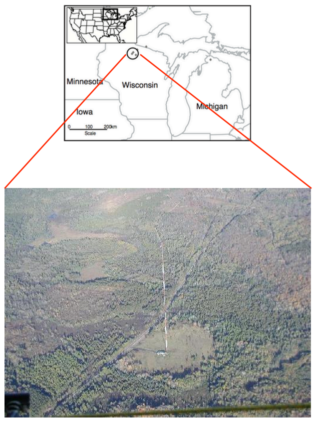

Fig. 1. Location of US-Park Fall in Wisconsin, northern U.S.A. Bottom is a picture of Park Fall tower

Wavelet decomposed turbulent flux and footprint weighted biophysical surface drivers

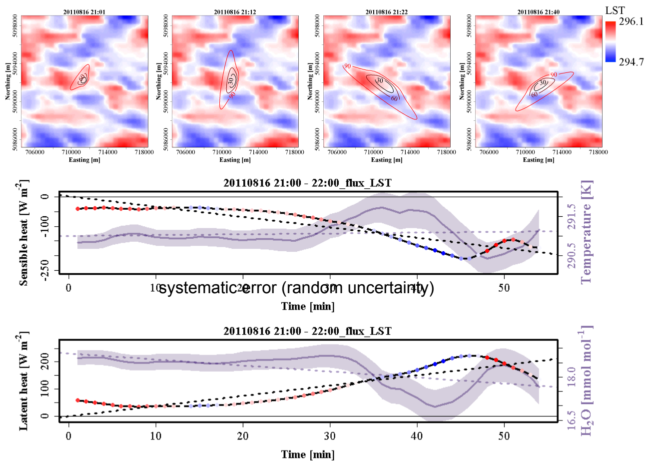

Fig. 2. 1 min composite 30%, 60% and 90% footprint maps superimposed over land surface temperature (LST). Bottom plot shows time series of LST in the footprint of 1 minute observation and wavelet decomposed high temporal flux

Environmental response functions extracted from machine learning

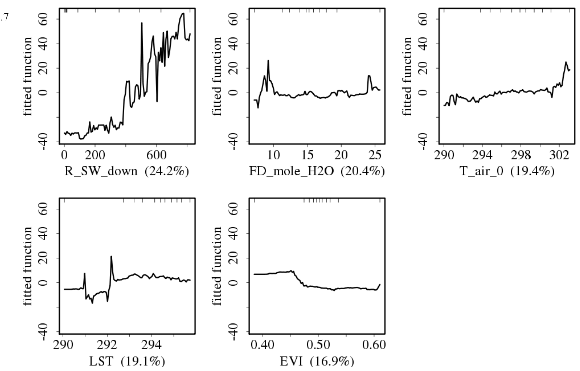

Fig. 3. Cross-related multi-dimensional partial dependence plots show the effect of each individual variable on the sensible heat flux (W m-2) . The chosen sensible heat flux drivers are short wave incoming radiation, dry mole fraction of water vapor, air potential temporature, LST and enhanced vegatation index (EVI).

Projected sensible heat flux grids

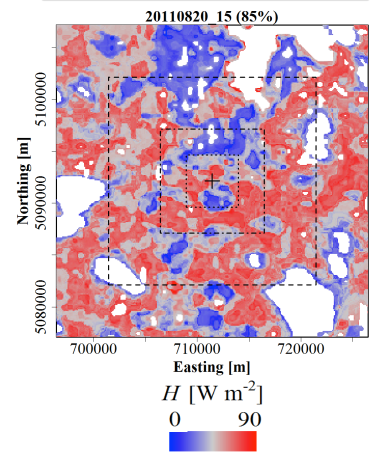

Fig. 4. Projected sensible heat flux grids August 20th, 2011, 15:00-16:00 CST, tower is located at the center, boxes represent 5 km x 5 km, 10 km x 10 km, 20 km x 20 km target areas.

Uncertainty budget

systematic error (random uncertainty)

Source of uncertainty	Instrumentation and hardware	Turbulent sampling	ERF state variables	ERF unstratified cross validation	ERF stratified cross validation	ERF projection interval
Sensible heat	0.89 W/m^{-2}	1% (45%)	1% (49%)	0% (4%)	**-15% (103%)**	0% (46%)
Latent heat	1.23 W/m^{-2}	1% (78%)	0% (57%)	0% (10%)	**-19% (208%)**	0% (47%)

Conclusion and outlook

- When ERF is applied, tower spatial coverage is expanded from footprint area to 70-100% of the 400 km^2 target area around the tower.
- The largest uncertainty systematic error of tower ERF is limited by 15%, 19% for sensible heat and latent heat flux, which are bound to energy balance closure. Random uncertainty drops rapidly with expansion of sample size.
- The resulting flux grids can be integrated into probability density function (PDF). Our **companion talk B32B-08 by Stefan Metzger** further elaborated how PDF enables direct assimilation into mechanic models and the evaluation of tower observations.
- Our future work is to prove the applicability of ERF procedure to different climate and ecological environments to upscale flux to regional scales.

Reference:

1.Metzger, S., Junkermann, W., Mauder, M., Beyrich, F., Butterbach-Bahl, K., Schmid, H. P., and Foken, T.: Eddy-covariance flux measurements with a weight-shift microlight aircraft, Atmos. Meas. Tech., 5, 1699-1717, doi:10.5194/amt-5-1699-2012, 2012.

1. Metzger, S., et al. (2013), Spatially explicit regionalization of airborne flux measurements using environmental response functions, Biogeosciences, 10(4), 2193-2217.
2. Kljun, N., P. Calanca, M. W. Rotach, and H. P. Schmid (2004), A Simple Parameterisation for Flux Footprint Predictions, Boundary-Layer Meteorology, 112(3), 503-523.

Acknowledgements: This project is sponsored by the National Ecological Observatory Network, WLEF tall tower operations/analysis supported through funding by National Science Foundation (DEB-0845166 and DBI-1062204), tower operations by Educational Communications Board (J. Ayers), and technical assistance from D. Baumann, USGS, A. Andrews and J. Kofler of NOAA, and K. Davis at Penn State. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.