A Proposal to Establish and Operate a Surface Energy Flux Calibration Facility

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Why?

Surface Energy Balance:

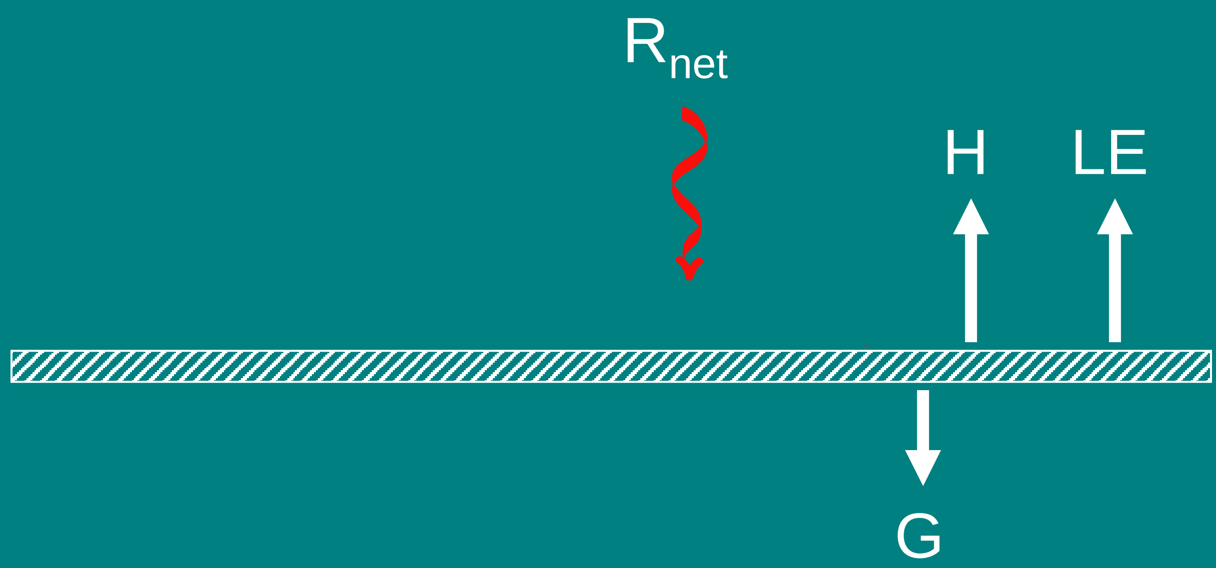
$$R_{net} = H + LE + G + \text{“other small stuff”}$$

R_{net} is net incoming solar radiation

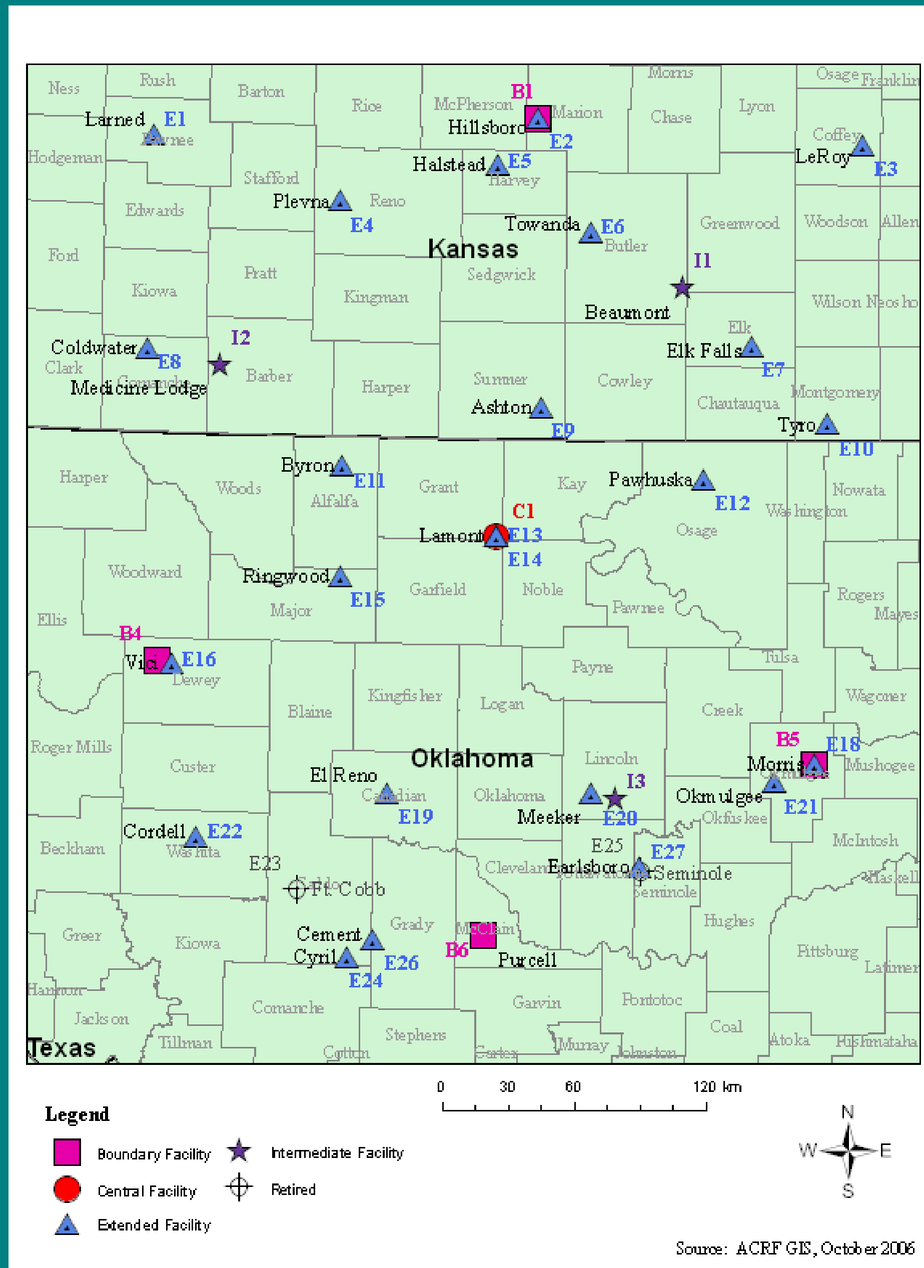
H is sensible heat flux (warms air… convection)

LE is latent heat flux (water vapor flux…. ET)

G is soil heat flux



ARM-SGP sites:



Surface Energy Components:

- ARM-SGP has 27 (at my last count) instrument systems installed to measure these components (H, LE, R_{net})
- Energy Balance/Bowen Ratio (EBBR) and Eddy Covariance (ECOR)
- One value of the wide spatial coverage of this data set is in its use to drive or validate regional models
- This data is also valuable in region-wide synthesis studies
- To be of maximal value, however, we would like to know the absolute and relative accuracy/precision of the data

System-wide errors and biases:

- Any measurement network has the potential for inter-system errors and biases
- This is especially true of systems where the data are derived from complex interactions between individual instruments like EBBR and ECOR systems
- We don’t have a tank of “flux” that we can use to calibrate individual systems
- Currently, ARM relies on “accuracy” parameters derived at each site to describe the entire flux network
- There are no inter-site linkages in these parameters
- The only viable way to calibrate flux system is through intercomparison
- This issue was first identified in FIFE and BOREAS.
- AmeriFlux took this to heart and established a roving intercomparison flux system

Goals and objectives:

- To build and operate an AmeriFlux-like flux intercomparison system within the ARM-SGP region
- To provide data users with a quantitative, defensible set of parameters that describe the relative errors and biases between individual instrument systems
- To identify and correct any malfunctions, mis-calibrations, or other instrument problems
- To quantitatively link the ARM and AmeriFlux data sets

How?

Operation:

- A single carefully calibrated and maintained portable eddy covariance flux tower (with a few other associated instruments) will be constructed
- This system will be deployed at each ARM EBBR and ECOR site for a period of 1 to 2 weeks, with the instruments "looking" at identical fetches. A regression analysis of the raw and processed data from these intercomparison periods will first be used to identify and diagnose instrument system "problems"
- After discussing the results with the instrument mentor and correcting any "fixable" issues, the regression data will be revised and made available to the user community

Expected results/products:

- A report to the instrument mentor on the current state/health of the tested instrument system and each of its components
- A continuously updated data base (to be housed with and linked to the EBBR/ECOR data in the archive) of site regression parameters

Instrumentation:

- LiCor LI-7500 CO_2/H_2O open-path IRGA
- Campbell Scientific CSAT3 sonic anemometer
- Kipp & Zonen CNR-1 4-component net radiometer
- Misc. instruments (barometer, T/RH sensor)
- Campbell Scientific data logger
- Eddy covariance control and data logging computer
- Portable tripod tower
- The system will be very un-obtrusive and will not interfere with normal system operations
- Experience has shown that this can be set up by one person in about 2 to 3 hours on-site (fits in the back of a small pickup or minivan

Other details:

- The facility will be operated from and housed at the University of Nebraska-Lincoln
- SGP Central Facility will not need to provide assistance
- Site visits will, however, be coordinated though SGP-CF and with the instrument mentor
- All instruments will be returned at the appropriate intervals to their manufacturers for maintenance and calibration
- The system will keep rotating through the sites and, new regression parameters will be added to the existing data set

Will this work? Does the effort have value?

- Yes! This is the same approach that AmeriFlux is currently using
- The instrument system design has been extensively tested and is being used in a number of Great Plains ecosystems
- A similar effort was done prior to the 2007 CLASIC field campaign. This identified and fixed several problems with 9 flux tower systems deployed

CLASIC intercomparison deployments at SGP Central Facility

Sample intercomparison results from CLASIC 2007

Parameter	Site 3		Site 4		Site 5		Site 6		Site 7		Site 8	
	Slope	Offset	Slope	Offset	Slope	Offset	Slope	Offset	Slope	Offset	Slope	Offset
F_{CO2} (μmol m^{-2} s^{-1})	0.8644	0.7742	0.9541	0.9886	0.9596	0.7792	**0.8493**	**1.0622**	1.030	-0.5619	1.100	-0.2008
LE (W m^{-2})	**0.8185**	0.6707	0.8923	2.538	0.8623	3.668	**0.7664**	5.385	**1.176**	**17.81**	**1.174**	**19.59**
H (W m^{-2})	**0.8366**	-3.032	0.9479	3.225	0.8810	-5.447	0.8717	0.9136	0.9767	5.109	0.9999	1.020
U* (m s^{-1})	0.9072	0.0147	0.9506	0.0099	0.9311	0.0167	0.8796	0.0224	0.8951	0.0307	0.9154	0.0259
Mean U (m s^{-1})	0.8833	0.0500	0.8701	0.0354	**0.8413**	**0.1145**	0.8663	0.0119	0.8752	-0.0183	0.8666	0.0569
Tsonic (C)	**1.402**	**-11.84**	**1.357**	**-11.27**	**1.411**	**-10.99**	**1.374**	**-11.16**	**1.268**	**-10.39**	**1.302**	**-8.710**
ρ_{CO2} (mg m^{-3})	1.087	**-52.54**	1.119	**-70.95**	1.078	**-46.79**	1.058	**-30.58**	1.027	-14.59	1.008	-0.8688
ρ_{H2O} (g m^{-3})	0.9430	0.0684	0.9544	-0.3162	0.9371	-0.2551	0.9729	-0.6475	0.9879	-0.2412	0.9322	0.4464
R sw-d (W m^{-2})	**0.4909**	-0.6891	**0.7470**	-0.6815	**0.8089**	-0.1045	**0.8052**	-1.458	0.9523	-1.910	1.010	-0.5669
R sw-u (W m^{-2})	**0.6196**	-6.123	0.9775	0.0486	1.036	0.4459	1.015	-1.017	0.9588	0.0260	1.018	0.8170
R lw-d (W m^{-2})	**1.296**	**-100.5**	**1.303**	**-106.5**	**1.315**	**-108.5**	**1.251**	**-85.16**	1.058	**-30.02**	1.087	**-41.71**
R lw-u (W m^{-2})	0.8721	**80.36**	1.005	3.926	1.015	5.260	1.006	6.889	1.119	**-44.51**	1.137	**-51.51**

Thanks for your time

- Questions?