The Land-Atmosphere Feedback Experiment (LAFE)

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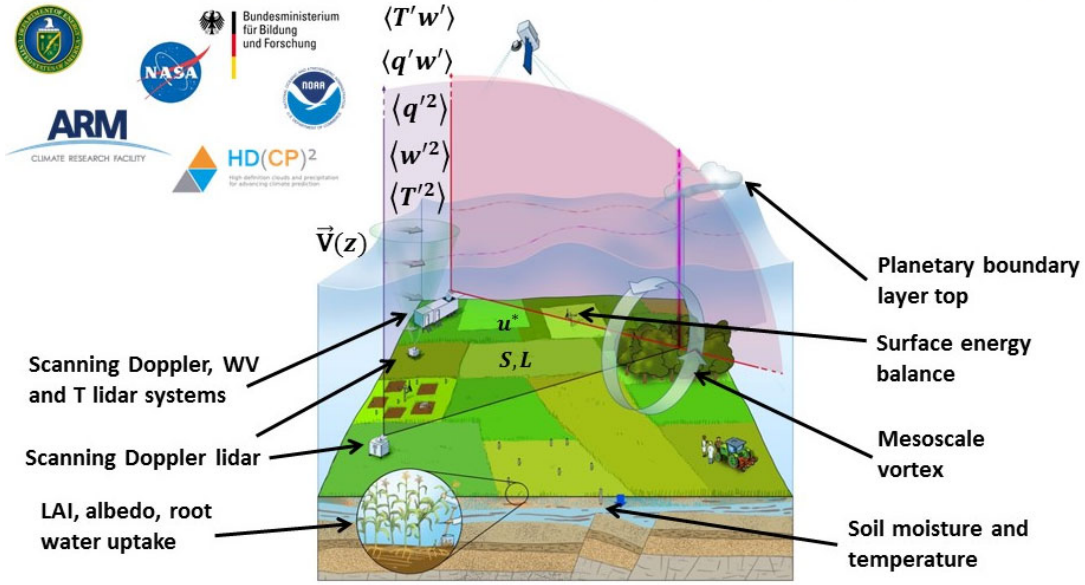
LAFE Measurement Synergy and Concept (Southern Great Plains Site, USA, August 2017)



Further infos:

- ***Wulfmeyer et al. BAMS 2018***
- ***Wulfmeyer et al.: this session***
- ***Turner et al.: Warm Boundary Layer Processes***
- ***Turner et al.: Poster Session B1***
- ***Wulfmeyer et al.: Poster Session B1***

LAFE Objectives and Realization

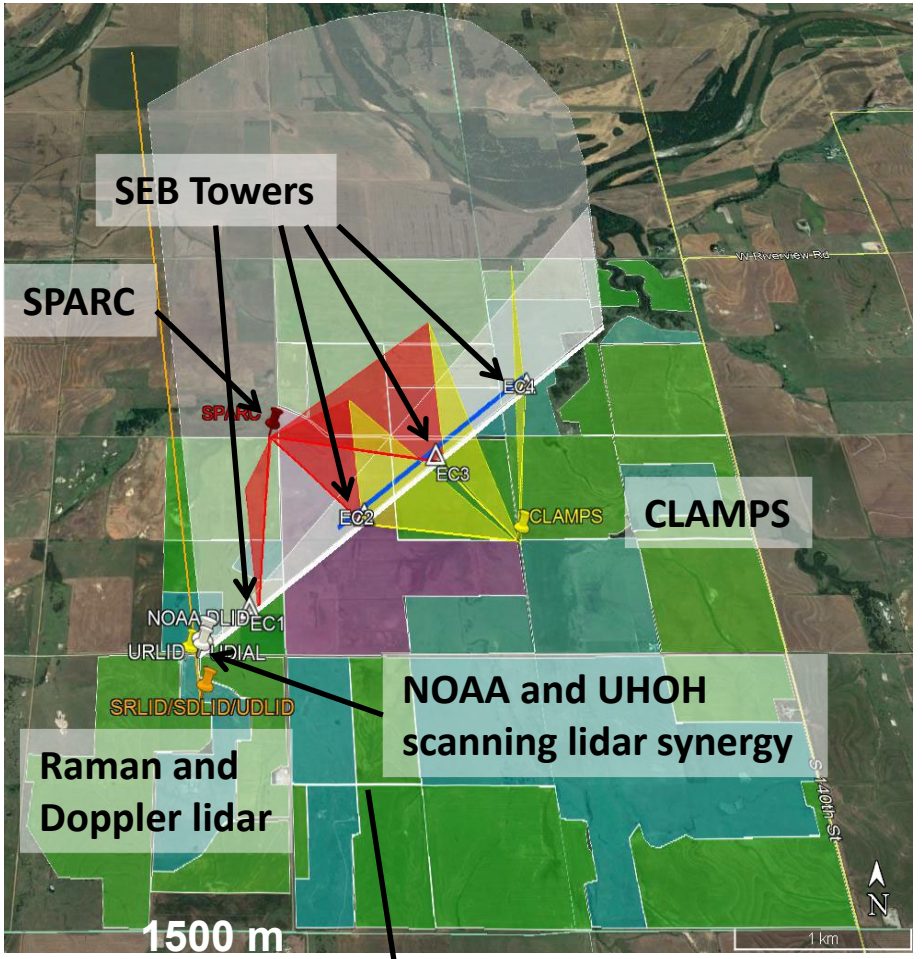
The objectives of LAFE are to:

I. **Determine turbulence profiles and investigate new relationships among gradients, variances, and fluxes**

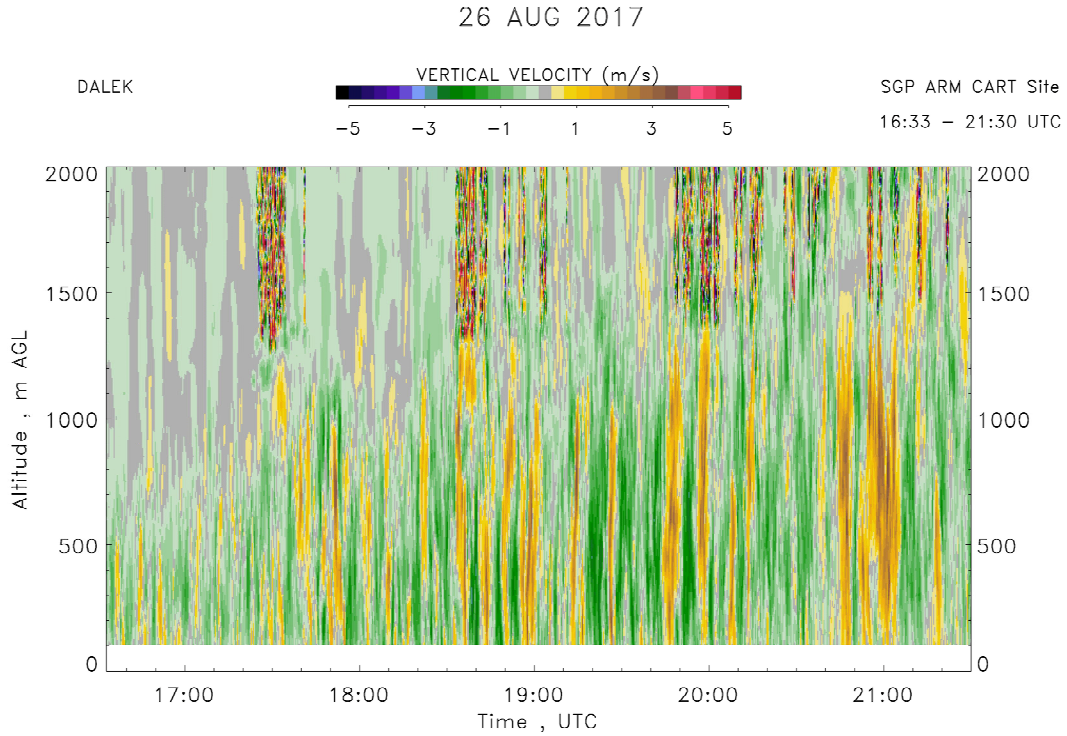
II. **Map surface momentum, sensible heat, and latent heat fluxes using a synergy of scanning wind, humidity, and temperature lidar systems**

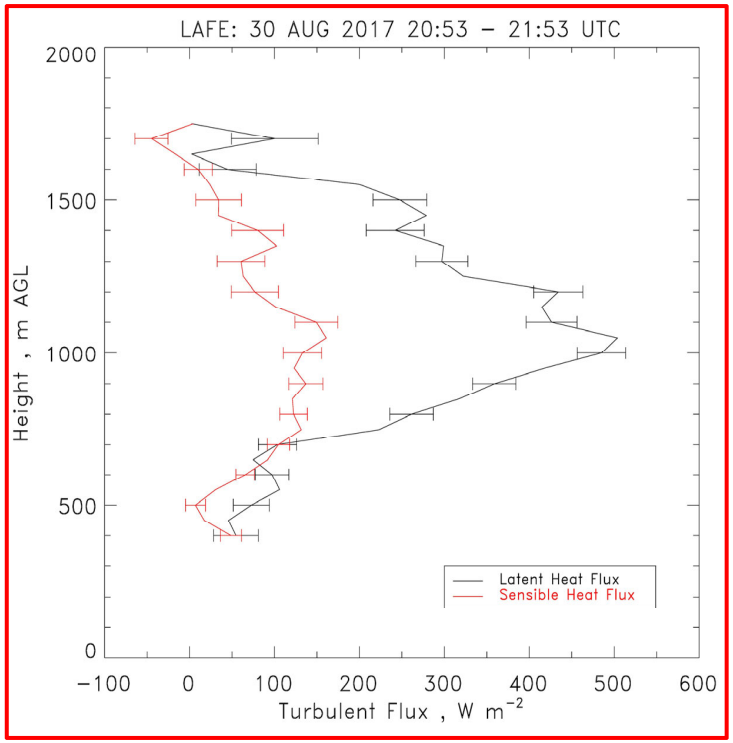
III. **Characterize land-atmosphere feedback and the moisture budget at the SGP site via the new LAFE sensor synergy**

IV. **Verify large-eddy simulation model runs and improve turbulence representations in mesoscale models.**



I) Entrainment Fluxes and Variances





Similarity relationship for water-vapor entrainment flux Q_I:

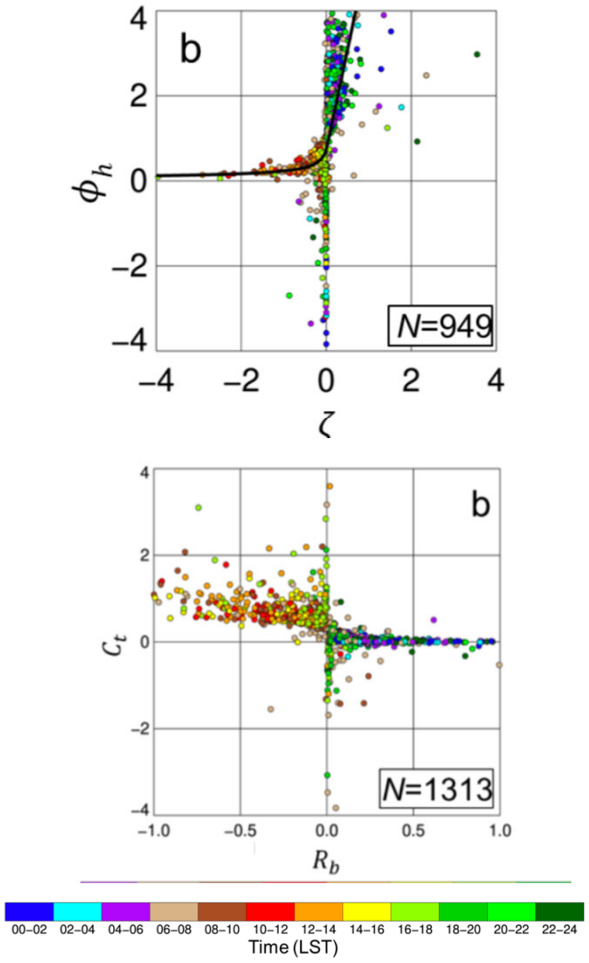
$$Q_I \approx -C_F S_w S_q = -C_F \left(w^*\right)^2 \frac{g_I}{N_I} f_Q(Ri_I)$$

For water-vapor variance:

$$\left\langle q'^2 \right\rangle_I \approx C_{q^2} S_{q^2} = C_{q^2} \left(w^*\right)^2 \left(\frac{g_I}{N_I}\right)^2 f_{q^2}(Ri_I)$$

Wulfmeyer et al. BLM 2010, Turner et al. JTECH 2014, Wulfmeyer et al. JAS 2016, Osman et al. JGR in review 2019

II) Surface Layer Studies



$$\phi_h = \alpha_h (1 - \beta_h \zeta)^{-\frac{1}{2}}$$

$$\frac{\partial \bar{\theta}}{\partial z} \frac{u_* \kappa z}{H} = \phi_h(\zeta)$$

Monin-Obukhov Similarity Theory

$$C_\theta = \alpha_\theta (1 - \beta_\theta R_b)^{\frac{1}{3}}$$

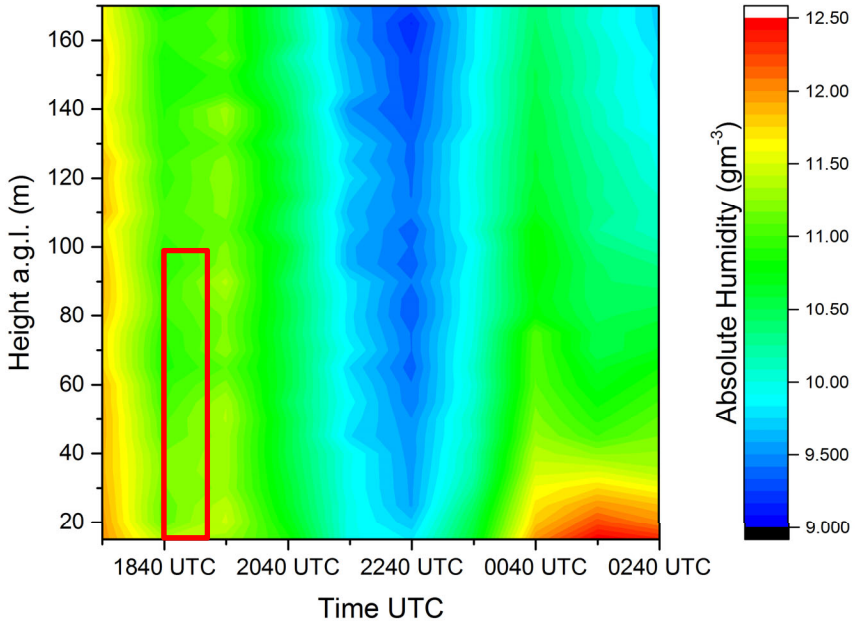
Richardson Number Approach

$$C_\theta = \frac{\theta_*}{(\theta_v - \theta_{vs})}$$

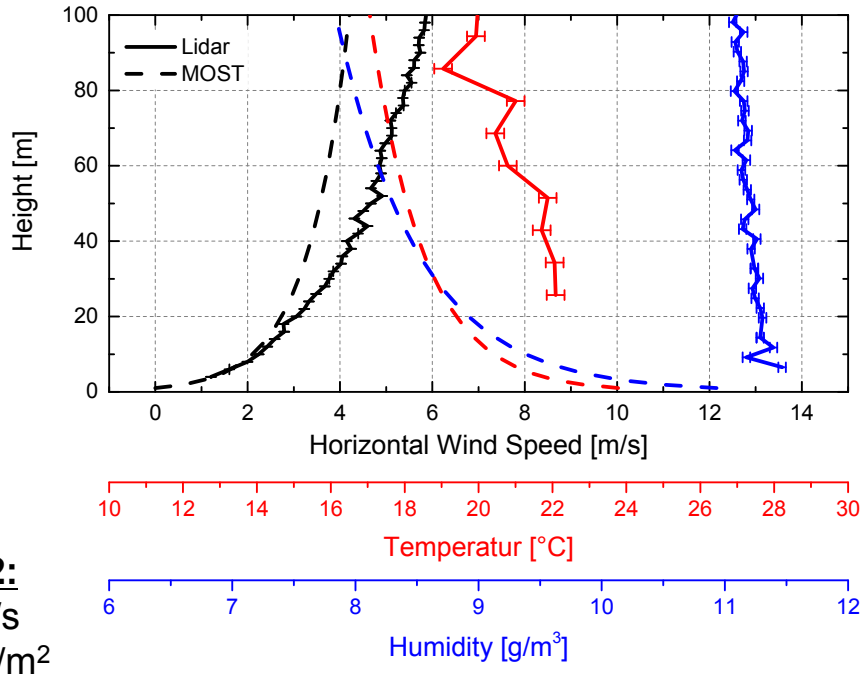
Lee and Buban, JAMC, submitted

Considerably better agreement achieved with Richardson number approach, also in other regions.

II) Surface Layer Studies



18:40 – 19:30 UTC (13:40 – 14:30 LT)



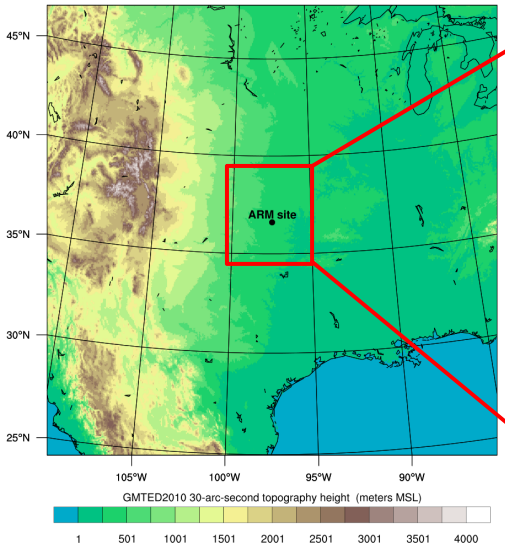
EBC Data Tower 2:

u*	=	0.365 m/s
H_{EBC}	=	244.0 W/m^2
E_{EBC}	=	245.0 W/m^2
T_{EBC}	=	27.14 K
q_{EBC}	=	10.93 g/m^3
z_0	=	1 m

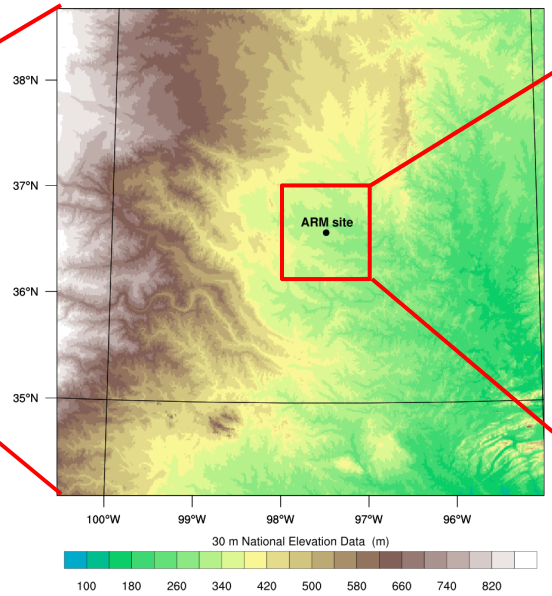
Δz_{DL} = 2 m
Δz_{TRRL} = 10 m
Δz_{DIAL} = 3 m

Observations question the validity of Monin-Obukhov theory. Advanced parameterizations of surface fluxes in complex terrain necessary?

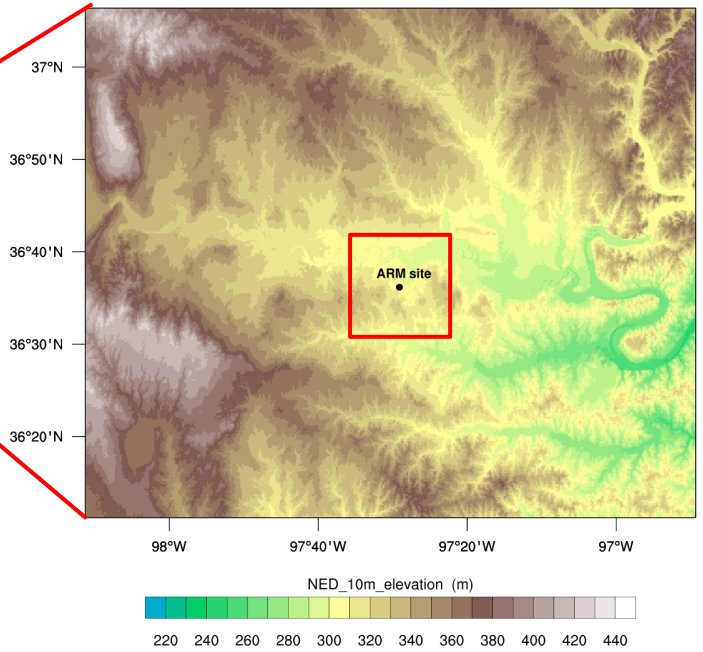
IV) Simulation of LAFE Cases



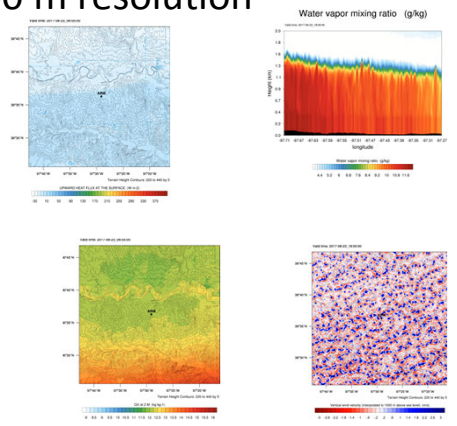
1000x1000 grid points,
2500 m resolution



1001x1001 grid points,
500 m resolution



1201x1001 grid points,
100 m resolution



- **Forced by ECMWF analyses**
- **DA cycle possible using 3DVAR RUC**
- **NOAHMP LSM**
- **100-m soil and land cover data**
- **Current par. set:**
  RRTMG, MOST a la Jimenez et al.,
  advanced YSU, Thompson cloud microphys.

Summary

- LAFE processed further to address all four scientific objectives
- First simultaneous measurement of sensible and latent heat flux profiles
- Test and development of new relationships between variances, fluxes, and gradients
- MOST questioned by LAFE observations, Richardson number approach seems to work much better
- Water-vapor budget analyses ongoing (not shown)
- Nested model configuration for simulations down to the turbulence-permitting scale available
- Results will be used to verify LES and turbulence parameterizations as well as to develop new ones.
- Great opportunity for process studies and collaborations merging observationalists and modelers.