The Land-Atmosphere Feedback Experiment (LAFe)

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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:

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

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

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

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

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

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

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

Monin-Obukhov Similarity Theory

Richardson Number Approach

Lee and Buban, JAMC, submitted
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.