A. Introduction

- We integrated a Bayesian inference technique within the Surface Energy Balance System (SEBS) model to quantify the influence of uncertainties in input meteorological forcing with respect to the estimation of the sensible heat flux.
- The Bayesian approach allows for an explicit quantification of the observational uncertainties, which are often ignored in flux estimation techniques.
- Results highlight the importance of characterizing input uncertainty to enable improved reproduction of observed fluxes.
- The advantages of a stochastic simulation of heat fluxes over a more traditional deterministic reproduction of fluxes, is recognized through improved statistical agreement with eddy covariance based observations.

B. Data

- Study area is the Walnut Creek watershed (centered at 41.96°N, 93.6°W) located near Ames, Iowa in the United States.
- Meteorological and flux data for the study area were measured across 12 eddy covariance towers during June and July 2002 as part of the Soil Moisture–Atmospheric Coupling Experiment (SMACEX) and the Soil Moisture Experiment 2002 (SMEX02) campaigns.
- Meteorological and heat flux data were averaged to 30 minutes. The measured sensible heat flux data are used without any closure correction. All records were filtered for rain events and are limited to the daytime period from 0730 AM to 1800 PM local time.

C. Surface Energy Balance System

- SEBS (Su 2002) is based on the flux gradient functions of the Monin-Obukhov Similarity Theory.
- Air temperature, land surface temperature, wind speed, and roughness length parameters are the most important terms.

D. Bayesian uncertainty analysis

- SEBS model is formulated in the likelihood function.
- Only the land surface temperature, air temperature, and wind speed are assumed uncertain and formed the priors using normal distributions with:
  - Observed values as mean for normal probability density function (PDF).
  - Standard deviation of normal PDF calculated based on the values of all towers.

E. Bayesian inference

- Slice sampling method is used for MCMC simulations to get posterior values of input variables.

F. Results

- Bayesian inference significantly improved estimation of the sensible heat flux in all towers.
- Bayesian inferred air temperatures and wind speeds are generally consistent with those observed at the towers, suggesting that local observations of these variables were spatially representative.
- Uncertainties in the land surface temperature have the strongest effect on the mismatch between observed and estimated sensible heat flux (Fig. 8), with Bayesian inferred values varying by up to ±5 °C from observed data.
- As a consequence, the footprint of the in-situ measured land surface temperature is not representative of the larger scale variability, suggesting that local measurements of the land surface temperature need to be used with caution in the calculation of surface heat fluxes.

G. Conclusion

- Bayesian inference approach provides an appropriate tool for stochastic evaluation of process-based evapotranspiration models.
- Amongst the uncertain input forcing, the in-situ land surface temperature has the greatest uncertainty and requires caution when used to estimate surface heat fluxes directly.

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