Session: C16 Poster: T161A

Towards a formal benchmarking and evaluation framework for land surface models

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Model evaluation and verification are essential processes in the development and application of all simulation models. The process of systematic model evaluation and verification helps in the characterization of accuracy and uncertainty in model predictions and helps in developing tradeoffs between model complexity and performace. Quantitative measures of fidelity of model simulations are essential for improving the usage and acceptability of model outputs for real-world applications. Land surface models (LSMs), which are designed to represent the terrestrial water, energy and biogeochemical processes generate estimates of terrestrial and biosphere exchanges by solving governing equations of soil-vegetation-snowpack medium. Though there is a vast amount of literature on land surface model development, model simulation studies and multi-model intercomparison projects, the evaluation methods and metrics used in them tend to be specific for individual case studies and mostly deterministic. These studies have not typically converged on standard measures of model performance for evaluating different LSMs. In this presentation, we describe the development and capabilities of a formal system for land surface model evaluation called the Land surface Verification Toolkit (LVT). LVT is designed to provide an automated, consolidated environment for model evaluation and includes approaches for conducting both the traditional deterministic and probabilistic verification. LVT employs observational datasets in their native formats, enabling the continued use of the system without requiring additional implementation or data re-processing. Currently a large suite of in-situ, remotely sensed and other model and reanalysis datasets are implemented in LVT. Aside from the accuracy-based measures, LVT also includes metrics to aid model identification, such as entropy, complexity and information content. These measures can be used to characterize the tradeoffs in model performance relative to the information content of the model outputs. Finally, LVT also includes uncertainty and ensemble diagnostics based on Bayesian approaches that enable the quantification of predictive uncertainty in land surface model outputs. These capabilities provide novel ways to characterize LSM performance, enable rapid model evaluation efforts, and are expected to help in the definition and refinement of a formal benchmarking and evaluation process for the land surface modeling community. Results from the use of LVT for evaluating multi-decadal outputs from the North American Land Data Assimilation System (NLDAS) project will be presented.