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Improving ecophysiological representations through numerical sensitivity analysis: Determining controls on stomatal conductance in an invasive species

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Ecophysiological processes are modeled in a variety of ways depending on the scales and questions examined, and representations of newly discovered or analyzed processes tend to encourage greater numbers of model parameters. We look at representations of stomatal and plant conductance in a soil-vegetation-atmosphere transfer model, and examine how leaf water potential plays a critical role in governing fluxes between plants and the atmosphere. Sensitivity analysis of this model reveals the circumstances in which the number of parameters can be reduced, raising the model's overall parsimony. Recent advances in the traditional generalized likelihood uncertainty estimation (GLUE; Beven and Binley, 1992) have allowed a more targeted approach to parameter reduction by using the results of a numerical optimal parameter search. The dynamically dimensioned search – approximation of uncertainty (DDS-AU) method developed by Tolson and Shoemaker (2008) is used to analyze the sensitivity and correlation of model parameters governing stomatal conductance. This heuristic approach starts with a global search algorithm that progressively becomes more local as the number of model iterations approaches a pre-determined maximum number of desired iterations, and has been shown to be more efficient than the uniform random sampling approach used in most GLUE applications.

These results are presented in the context of an invasive species infestation in California's Sacramento River-San Francisco Bay Delta region, which is a critical component of California's water distribution system and agriculturally important in its own right. The parameter search algorithms are used to evaluate the SVAT model's output results against eddy covariance estimates of water and carbon fluxes as well as predawn and midday field leaf water potential measurements. This multi-objective approach to calibration and sensitivity analysis is required for accurately weighting the mixture of physical processes that potentially control leaf-level carbon assimilation and evapotranspiration. We compare the sensitivity of modeled stomatal conductance to plant hydraulic conductance and to atmospheric controls such as vapor pressure deficit and temperature. We examine recent improvements to representations of stomatal conductance and show that for this high temperature-adapted invasive species, improvements in representing the response to vapor pressure deficit have limiting returns. We also show where parameter pairs give correlated improvements to model fitness, and so are targets for parameter reduction efforts. We believe that numerical exercises tied to field measurements can improve ecophysiological process representation and can offer parsimonious mechanistic descriptions for use in larger scale land surface modeling efforts.

References:

Beven, K. and Binley, A., 1992. The future of distributed models: model calibration and uncertainty prediction. Hydrological Processes, 6(3).

Tolson, B.A. and Shoemaker, C.A., 2008. Efficient prediction uncertainty approximation in the calibration of environmental simulation models. Water Resources Research, 44(4).