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On the use of data assimilation methods to quantify uncertainty in model physics parameterizations

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Model physics (e.g., cloud microphysics, convection, and radiation) parameterizations represent an important source of uncertainty in climate models. Much of this uncertainty is associated with specification of parameters that control the rates and/or characteristics of physical processes. Ensembles of simulations and stochastic variation of parameters are increasingly proposed as methods with which to address parameter variability, however, to do so properly requires knowledge of which parameters have the greatest effect on model results, as well as the characteristics of the relationship between model output and changes to parameters. In this presentation, nonlinear data assimilation algorithms are used to quantify the functional relationship between model parameters and model output for cloud microphysics and radiation packages in a cloud resolving model and a GCM. In the process, we demonstrate how data assimilation techniques can be used to (1) map the functional relationship between changes in model physics parameters and changes in model output, (2) identify which parameters have the most significant effect on various model output fields, and (3) describe the nature of nonlinearity in the parameter-state relationship.