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Improving the Fit of a Land-Surface Model to Data Using its Adjoint

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Land-surface models (LSMs) are crucial components of the Earth System Models (ESMs) which are used to make coupled climate-carbon cycle projections for the 21st century. The Joint UK Land Environment Simulator (JULES) is the land-surface model used in the climate and weather forecast models of the UK Met Office. In this study, JULES is automatically differentiated using commercial software from FastOpt, resulting in an analytical gradient, or adjoint, of the model. Using this adjoint, the adJULES parameter estimation system has been developed, to search for locally optimum parameter sets by calibrating against observations. We present an introduction to the adJULES system and demonstrate its ability to improve the model-data fit using eddy covariance measurements of gross primary production (GPP) and latent heat (LE) fluxes. adJULES also has the ability to calibrate over multiple sites simultaneously. This feature is used to define new optimised parameter values for the 5 Plant Functional Types (PFTS) in JULES. The optimised PFT-specific parameters improve the performance of JULES over 90% of the FLUXNET sites used in the study. These reductions in error are shown and compared to reductions found due to site-specific optimisations. Finally, we show that calculation of the 2nd derivative of JULES allows us to produce posterior probability density functions of the parameters and how knowledge of parameter values is constrained by observations.