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Use of eigendecomposition in a parameter sensitivity analysis of the Community Land Model

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Sensitivity Analysis is a widely used tool for model identification and calibration, and to quantify model output uncertainty. This paper explores the use of eigendecomposition in a global sensitivity analysis of a complex land surface model, the Community Land Model CLM, revision 3.5, with respect to its parametrization. We use different fluxes from and to the atmosphere as target variables, namely the fluxes of latent and sensible heat, and photosynthesis. We identified 66 parameters in the stand-alone version of CLM3.5. The parameter sensitivity measures from global parameters are arranged in a sensitivity matrix S. The eigendecomposition of S^T S tells parameter importance while taking into account interactions between the parameters.
A main focus of sensitivity analysis is the selection of important parameters, e.g. for parameter estimations. We therefore examine existing ranking and selection methods to determine parameter importance from the sensitivity matrix S. We propose a new parameter importance ranking index which takes parameter interactions into account and determine its uncertainty with bootstrapping. Furthermore, we propose a new selection method working in concert with this index for detecting important parameters. The most elaborate selection method which we tested marks comparatively more parameters as relevant compared to the other methods. We show that our selection method performs very similar to the elaborate method. The number of important parameters detected with the new selection procedure depends on the amount of variability in the cost function one wants to conserve. It retains two thirds of the 66 parameters when conserving 99% and only 10 parameters when conserving 90% variability in the cost function when analyzing three model outputs simultaneously. But it can be shown that the sensible heat flux is the least sensitive model output compared to latent heat and photosynthesis when disentangling the three model outputs. The C3 evergreen vegetation type has less sensitive parameters compared to the both deciduous types with C3and C4 photosynthetic pathways since soil parameters play less a role during the year. The soil evaporation resistance description is over-sensitive to all analyzed fluxes and vegetation classes and is therefore excluded from the analysis. The parameters which determine V_{cmax} and the slope of the stomatal resistance model become very important if sensitivity is determined with respect to photosynthesis. The soil water parameters are important for the latent heat and C4 photosynthesis. We conclude that our new proposed parameter selection procedure can analyze sensitivities of more than one model output simultaneously, helps to identify important parameters while taking their interactions into account and is inexpensive compared to other.