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# Impact of the hard-coded parameters on the hydrologic fluxes of the land surface model Noah-MP

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Land surface models incorporate a large number of processes, described by physical, chemical and empirical equations. The process descriptions contain a number of parameters that can be soil or plant type dependent and are typically read from tabulated input files. Land surface models may have, however, process descriptions that contain fixed, hard-coded numbers in the computer code, which are not identified as model parameters.

Here we searched for hard-coded parameters in the computer code of the land surface model Noah with multiple process options (Noah-MP) to assess the importance of the fixed values on restricting the model's agility during parameter estimation. We found 139 hard-coded values in all Noah-MP process options, which are mostly spatially constant values. This is in addition to the 71 standard parameters of Noah-MP, which mostly get distributed spatially by given vegetation and soil input maps. We performed a Sobol' global sensitivity analysis of Noah-MP to variations of the standard and hard-coded parameters for a specific set of process options. 42 standard parameters and 75 hard-coded parameters were active with the chosen process options. The sensitivities of the hydrologic output fluxes latent heat and total runoff as well as their component fluxes were evaluated. These sensitivities were evaluated at twelve catchments of the Eastern United States with very different hydro-meteorological regimes.

Noah-MP's hydrologic output fluxes are sensitive to two thirds of its standard parameters. The most sensitive parameter is, however, a hard-coded value in the formulation of soil surface resistance for evaporation, which proved to be oversensitive in other land surface models as well.

Surface runoff is sensitive to almost all hard-coded parameters of the snow processes and the meteorological inputs. These parameter sensitivities diminish in total runoff. Assessing these parameters in model calibration would require detailed snow observations or the calculation of hydrologic signatures of the runoff data.

Latent heat and total runoff exhibit very similar sensitivities towards standard and hard-coded parameters in Noah-MP because of their tight coupling via the water balance. It should therefore be comparable to calibrate Noah-MP either against latent heat observations or against river runoff data. Latent heat and total runoff are sensitive to both, plant and soil parameters. Calibrating only a parameter sub-set of only soil parameters, for example, thus limits the ability to derive realistic model parameters.

It is thus recommended to include the most sensitive hard-coded model parameters that were exposed in this study when calibrating Noah-MP.