

# Assessing sensitivity of soil water–heat transport simulations to frozen soil parameterizations in Noah-MP

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November 18, 2022

## Abstract

Water-heat transport in frozen soil impacts the hydrological processes in cold region through its influences on the surface energy budget and water storage. In this study, sensitivities of soil water-heat transport simulations to parameterizations of soil permeability, supercooled water and freezing temperature threshold that determines phase change criteria were assessed in the Noah with multi-parameterization (Noah-MP) land surface model. The results showed that Noah-MP well reproduce the seasonal variations in soil temperature and moisture in the freeze-thaw (FT) process, while it still involves biases in soil temperature and moisture simulations with RMSE of 4.35 and 0.068 mm<sup>3</sup>/mm<sup>3</sup> at shallow layer during soil thawing period. Performances of Noah-MP in soil water-heat transport simulations are not very sensitive to the optional combinations of soil permeability and supercooled water parametrizations. Nevertheless, instead of constant freezing temperature, a virtual temperature implemented to redefine the phase change criteria improves soil moisture simulations in the FT process evidently by about 20%–50% bias reduction, especially during soil thawing period, and the simulated soil water–heat coupling relation is consistent with the observations. Global simulations further validate the improvements of implemented frozen soil parameterizations in Noah-MP. Results in this study emphasize the importance of phase change criteria choice in land surface model for frozen soil hydrothermal regime simulations.