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Representing subgrid snow cover and snow depth variability in a global land model: offline validation

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Seasonal snow cover is a key variable in the global climate system because of its large impact on surface temperature and surface energy and water budgets. In the present study, we incorporated a subgrid snow cover parameterization, SSNOWD (Liston, 2004), into a land surface model, MATSIRO (Takata et al., 2003). SSNOWD assumes that the subgrid snow water equivalent (SWE) distribution follows a lognormal distribution function, accounting for the physical processes that produce subgrid SWE variability. Two sets of 29-year offline simulations were performed: one with and one without SSNOWD. The simulations were forced with a global meteorological dataset (Kim et al., 2009) which combined the JRA25 atmospheric reanalysis data (Onogi et al., 2007) with 5 observed-precipitation datasets. The simulated monthly snow cover fractions were compared with satellite-based MODIS snow cover fraction data (Hall et al., 2006). For the Northern Hemisphere, daily snow-covered area was also validated using the IMS snow analysis (National Ice Center, 2008). Both of these comparisons show that the original MATSIRO underestimates the snow cover fraction, especially for the accumulation season and/or the regions with relatively small amounts of snowfall. In contrast, the inclusion of SSNOWD improved the spatial pattern of snow cover fraction. The SSNOWD simulation agrees well with the IMS snow analysis and led to an improved seasonal cycle of snow-covered area in the Northern Hemisphere. This is because SSNOWD formulates snow cover fraction differently for accumulation season and ablation season, and represents the hysteresis of snow cover fraction for different seasons. The effects of incorporating SSNOWD on surface energy fluxes and hydrological properties were also examined using 5 ensemble runs with different precipitation forcing.