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Evaluation of the SMAP model-simulated snow internal physical properties at Sapporo, Japan from 2005 to 2015

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Temporal evolution of snow internal physical properties such as grain size, density, temperature, and water content are controlled by changes in meteorological conditions. On the other hand, in a snow covered area, surface atmospheric conditions are modulated in response to variations of snow albedo, which is affected by (optically equivalent) snow grain size as well as mass concentration of snow impurities such as black carbon and dust. Therefore, it is necessary for snowpack models incorporated in climate models to simulate realistic snow internal physical properties to perform accurate future climate prediction especially in the cryosphere.

In this study, we evaluated snow internal physical properties at Sapporo (43˚05'N, 141˚21'E, 15 m a.s.l.), Japan from 2005 to 2015 simulated with a 1-D multilayered physical snowpack model SMAP (Snow Metamorphism and Albedo Process). The model was driven by quality controlled 30-min averaged data for air temperature, relative humidity, wind speed, surface pressure, snow depth, downward and upward shortwave radiant flux, downward longwave radiant flux, and ground surface soil heat flux. Simulation results were compared against the data obtained from snow pit works performed twice a week at Sapporo.

First of all, the model-simulated column integrated SWE (snow water equivalent) were compared against in-situ measurements (273 data were available during the 10 winters). The results show that the model tends to underestimate SWE (mean error; ME was –19 mm); however, root mean square error (RMSE) was 34 mm, and these scores are better than those for simulations driven by not snow depth but precipitation (ME was less than –25 mm and RMSE was more than 40 mm). It suggests that the correction technique for precipitation measurements considering catch efficiency of a rain gauge is still insufficient. Next, the model-simulated profiles for snow density and snow temperature were compared against in-situ measurements. For this purpose, total 1688 and 2562 measurement data have been used for the former and the latter comparisons, respectively. The SMAP model tends to underestimate snow density (ME = –51 kg m^{-3}) and overestimate snow temperature (ME = 0.42 ^{o}C); however, RMSE for both properties were sufficiently small (88 kg $m^{-3}$and 1.62 ^{o}C, respectively). In order to permit higher precision of the model, it would be necessary to develop physically based schemes for new snow density and effective thermal conductivity of the snowpack.