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The effect of snow density on modelled seasonal evolution of snow depth on the Arctic sea ice

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Due to its high surface albedo, strong thermal insulation and complex temporal and spatial distribution, snow on top of sea ice plays an important role in the air-ice-ocean interaction in polar regions and high latitudes. Accurate snow mass balance calculations are needed to better understand the evolution of sea ice and polar climate. Snow depth is affected by many factors, but in thermodynamic models many of them are treated in a relatively simple manner. One of such factors is snow density. In reality, it varies a lot in space and time but a constant bulk snow density is often used to convert precipitation (snow water equivalence) to snow depth. The densification of snow is considered to affect snow depth mainly by altering snow thermal properties rather than directly on snow depth.

Based on the mass conservation principle, a one-dimensional high-resolution ice and snow thermodynamic model was applied to investigate the impact of snow density on snow depth along drift trajectories of 26 sea ice mass balance buoys (IMB) deployed in various parts of the Arctic Ocean. The ERA-Interim reanalysis data are used as atmospheric forcing for the ice model. In contrast to the bulk snow density approach, with a constant density of 330 kg/m^3 (T1) or 200kg/m^3 (T2), our new approach considers new and old snow with different time dependent densities (T3). The calculated results are compared with the snow thickness observed by the IMBs. The average snow depth observed by 26 IMBs during the snow season was 20±14 cm. Applying the bulk density (T1 and T2) or time dependent separate snow densities (T3), the modelled average snow depths are 16±13 cm, 22±17cm and 17±12cm, respectively. For the cases during snow accumulate period, the new approach (T3) has similar result with T1 and improved the modelled snow depth obviously from that of T2.