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積雪変質モデルを用いた、2012 年夏期の北西グリーンランド SIGMA-A における急激な表面融解の解析
Assessing the extreme surface melt at SIGMA-A, northwestern Greenland during 2012 summer using a physical snowpack model

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It is reported that extreme surface (or near surface) melt occurred on the Greenland Ice Sheet (GrIS) across 98.6 % of its entire extent on around 12 July 2012. At the site SIGMA-A (78^{o}03'N, 67^{o}38'W, 1,490 m a.s.l.), which locates on northwest part of GrIS, we also observed near-surface melt, and accompanying rapid surface lowering especially during the latter half of our intensive field observation carried out from 26 June to 16 July. In this study we focus extreme near-surface melt occurred during 10 to 13 July at SIGMA-A. During the period average air temperature rose noticeably compared to the first half of the expedition period (30 June to 9 July) by about 1.6 ^{o}C, and we encountered heavy rain on snow event. Furthermore, near-surface mass concentrations of snow impurities (black carbon and dust) slightly increased to about 4.9 ppbw and 1327 ppbw, respectively.

In order to understand the detailed mechanism of the extreme near-surface melt, we employed a physically based 1-D snowpack model named Snow Metamorphism and Albedo Process (SMAP) forced by in-situ meteorological and snow data, and performed numerical sensitivity tests to assess relative contributions of temperature rise (Test-I), rain fall (Test-II), and snow impurities (Test-III), which can heat near-surface snowpack. SMAP with the default setting (CTL) was already tested using these data and we obtained reasonable results (root mean square errors for shortwave albedo and snow surface temperature were 0.024 and 0.373 ^{o}C, respectively) during 30 June to 14 July. In the Test-I input air temperature was reduced by 1.6 ^{o}C and downward longwave radiant flux was also modulated accordingly. For the Test-II we input no precipitation. Finally, in the Test-III we performed "pure snow" run where no snow impurities were input to drive SMAP.

Comparing each result by these sensitivity tests (Test-I, Test-II, Test-III) against that by CTL, and found average reductions in shortwave albedo (0.000, -0.003, and -0.013) and average increases in snow surface temperature (0.106 ^{o}C, 0.000 ^{o}C, and 0.002 ^{o}C) due to temperature rise, precipitation, and snow impurities, respectively during 10 to 13 July at SIGMA-A. These results indicate that albedo reduction is mainly caused by snow impurities, however, its extent is not sufficiently large to modulate surface energy balance dramatically. Instead, temperature rise increases net longwave radiant flux and sensible heat flux at the snow surface and heat the surface significantly, suggesting that temperature rise played an important role in the extreme surface melt at SIGMA-A during 10 to 13 July.
Keywords: Greenland, extreme melt event, snowpack model, snow albedo, snow surface temperature