

Declining summer snowfall in the Arctic: causes, impacts and feedbacks

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Recent changes in the Arctic hydrological cycle are explored using in situ observations and an improved atmospheric reanalysis data set, ERA-Interim. We document a pronounced decline in summer snowfall over the Arctic Ocean and Canadian Archipelago. The snowfall decline is diagnosed as being almost entirely caused by changes in precipitation form (snow turning to rain) with very little influence of changes in total precipitation. The proportion of precipitation falling as snow has decreased as a result of lower-atmospheric warming. Statistically, over 99% of the summer snowfall decline is linked to Arctic warming over the past two decades. Based on the reanalysis snowfall data over the ice-covered Arctic Ocean, we derive an estimate for the amount of snow-covered ice. It is estimated that the area of snow-covered ice, and the proportion of sea ice covered by snow, have decreased significantly. We perform a series of sensitivity experiments in which inter-annual changes in snow-covered ice are either unaccounted for, or are parameterized. In the parameterized case, the loss of snow-on-ice results in a substantial decrease in the surface albedo over the Arctic Ocean, that is of comparable magnitude to the decrease in albedo due to the decline in sea ice cover. Accordingly, the solar input to the Arctic Ocean is increased, causing additional surface ice melt. We conclude that the decline in summer snowfall has likely contributed to the thinning of sea ice over recent decades. The results presented provide support for the existence of a positive feedback in association with warming-induced reductions in summer snowfall.