The signature of the large 2015-2016 winter storms in Svalbard snowpacks

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INTRODUCTION

Long-term meteorological records from Svalbard indicate that the frequency of extreme cyclone events in this sector of the Arctic has steadily increased over recent decades, particularly in Nov-Dec., in step with a pronounced winter warming trend (Rinke et al., 2017: Environ. Res. Lett. 12, 094006). A large winter storm on 19 Dec. 2015 caused a deadly avalanche in Longyearbyen and was followed by an exceptionally large intrusion of southerly air on 30 Dec. associated with one of the five largest North Atlantic cyclones since 1958 (Kim et al., 2016: Sci. Report 7:40051). A campaign of coordinated observations of the physical, chemical and microbiological properties of seasonal snowpacks was carried out across Svalbard in April 2016 by the SnowNet research consortium. The data obtained in the SnowNet campaign provide a timely opportunity to examine how exceptionally large winter storms such as that in late December 2015 impact the terrestrial cryosphere in this sector of the Arctic.

SIGNATURE OF THE DECEMBER 2015 STORMS IN THE SNOWPACK

The late Dec. 2015 storm was associated with a major, sudden warming of up to 32°C in parts of Svalbard, and the warming was sustained for ~1 week into early Jan. 2016 (Fig. 1). The intense southerly atmospheric moisture flux that accompanied the storm (Fig. 2) resulted in a period of intensified precipitation recorded at most sites across Spitsbergen, but not on Nordauslandet (Fig. 3). Unlike the warming, the snowfall and snow accumulation during the storm period was quite variable (Table 1). At many sites, the enhanced melt that followed the warm air intrusion moderated the new snow accumulation, or even removed it. Remarkably, the snow strata deposited in late December did not show uniquely recognizable isotopic ($\delta^{18}$O, $\delta$) or ionic signatures (Na$^+$ or SO$_4^{2-}$).

**Table 1:** Air temperature rise ($\Delta T$), estimated cumulative total precipitation ($\Delta$ppt) and snow accumulation ($\Delta$sx) during the late Dec. 2015 stormy period at various sites across Svalbard.

**Fig. 1:** Daily records of air temperature, cumulative precipitation and snow depth at three permanent meteorological stations in Svalbard for the period 1 Sept. 2015 to 30 April 2016. The red shading identifies the stormy period in late Dec. 2015 and early Jan. 2016.

**Fig. 2:** 850-hPa level moisture flux (brown) and convergence (blue) in the Arctic on 30 Dec., 2015. Figure reproduced from Kim et al. (2016; Sci. Reports 7:40051).

**Fig. 3:** Surface meteorological observations from automated weather stations (AWS) on Svalbard glaciers and ice caps (left) and seasonal snowpack properties measured in snowpits excavated near the AWS sites in April 2016 (right). The middle panels above show cumulative snow water equivalent depths in snowpits (SWE; blue) and cumulative total precipitation at these locations, as inferred from downscaled ERA-interim data (red). The red shading identifies the stormy period in late Dec. 2015 and early Jan. 2016, and the strata in the seasonal snowpack associated with this period.

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