Geophysical Research Abstracts
Vol. 20, EGU2018-9332, 2018
EGU General Assembly 2018

Snow-Dust Storm phenomenon: A case study from Iceland

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Presence of snow on deserts has been recently reported from low latitude areas such as Sahara, Israel or Oman. Deserts are, however, located also in high latitudes where dust interacts with snow, glaciers and sea ice. The best studied high latitude dust source is Iceland. Iceland is the largest desert in Europe and Arctic with >40,000 km2 of desert areas. The mean dust suspension frequency was 135 dust days annually in 1949-2011. The annual dust deposition was calculated as 31-40.1 million tons yr-1 affecting the area of >500,000 km2. Satelite MODIS pictures have revealed dust plumes traveling >1000 km at times.

About 50 % of the annual dust events in the southern part of Iceland take place at sub-zero temperatures or in winter, when dust may be mixed with snow. We investigated one particular winter dust event that occurred in March 2013. It resulted in a several mm thick dark layer of dust deposited on snow. Dust was transported over 250 km causing impurities on snow in the capital of Iceland, Reykjavik. Max one-minute PM10 concentration measured in Kirkjubæjarklaustur (20-50 km from the dust source) exceeded 6500 μgm-3 while the mean (median) PM10 concentration during 24-hour storm was 1,281 (1,170) μgm-3. Dust concentrations during the dust deposition in Reykjavik were only about 100 μgm-3, suggesting a rapid removal of the dust particles by snow during the transport. Dust sample taken from the snow top layer in Reykjavik after the storm showed that about 75 % of the dust deposit was a volcanic glass with $SiO_2\sim$ 45 %, FeO$\sim$14.5 %, and $TiO_2\sim$3.5. A significant proportion of organic matter and diatoms was also found. This case study showed that severe dust storms are related also to meteorological conditions, such as winter snow storms, and moist conditions. Small volcanic dust particles deposited on snow tend to form larger particles ("clumping mechanism") resulting in stronger light absorbance. This is one of the first reports on the "clumping mechanism" observed in natural conditions. Based on this case study, we defined such meteorological phenomenon as a Snow-Dust Storm.

Several field studies and observation of snow albedo and melting changes have been conducted since 2013 showing that Icelandic volcanic dust does reduce snow and ice albedo similarly to Black Carbon. Numerical modelling showed that about 7% of emitted dust from Iceland is deposited in the high Arctic (> 80° N) while about 3% contributes to deposition in Europe. The influence of Icelandic volcanic dust on the cryosphere in Iceland showed to be critical while the influence on snow, glaciers and climate in the high Arctic needs to be investigated.