# Soot on Snow (SoS) measurement campaigns 2011-2013

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Soot consists mainly of light absorbing carbon. When deposited on snow, it decreases the snow albedo, increases the absorption of radiation in snow and thereby enhances melting. This process has been studied for decades (e.g. Clarke and Noone, 1985) and it has been recognized to be one of the major sources of warming in the Arctic regions (Flanner et al., 2007). The link between soot, snow albedo, and climate change is still not known in enough detail for quantitative analysis (Hansen and Nazarenko, 2004). To provide more insight into these connections, the Finnish Meteorological Institute and Helsinki University have started a series of Soot on Snow (SoS) measurement campaigns during years 2011-2013. In these campaigns soot is deposited on snow in the beginning of the melting season and then the properties of the snow pack are measured throughout the whole melting season until the snow is gone (Kivekäs et al., 2012).

The first experiment, SoS-2011 was conducted on a farming field at Nurmijärvi, Southern Finland some 40 km outside Helsinki. The soot was produced by burning rubber and firewood in a portable stove. The smoke was led through a pipe, cooled by snow surrounding the pipe, and led into a garage tent that was built on top of the snow. The smoke drifted out from the other end of the garage tent that was left open. This method produced a clear gradient (in both concentration and particle size) of soot on the snow.

We measured albedo and melting of the snow at the area with most soot and at a reference area with no added soot. After the soot was deposited the albedo of the dirty snow was roughly 0.4 and that of the reference area roughly 0.8. After snowfall the albedos were equal, but 1-2 days the albedo of the dirty snow had decreased to about 0.1 lower than that of the clean snow. The dirty snow also melted earlier than the clean one and the melting rate was faster.

SoS-2012 was conducted on an agricultural field outside the meteorological observatory of Jokioinen in southern Finland, about 100 km from Helsinki. This time we used soot collected by chimney cleaners from residential fire places in eastern parts of Helsinki. The soot was deposited on the snow by blowing it through a cyclone removing particles larger than about 3 μm into a specially manufactured cylindrical tent. This method produced a more uniformly distributed soot layer on the surface of snow. Three spots with different amounts of soot and one reference spot were produced.

This time the results were not so clear. A snowfall with high winds covered the spots with 10 cm of new snow soon after the measurements were started. After that all spots had very similar albedos, and the melting time of the snow depended mostly on the amount of snow in each spot. In later snow sample analysis it was also found that the wind had possibly blown away the top layer of snow, containing the added soot.

SoS-2013 is planned to take place at the old airport of Sodankylä in Northern Finland north from the Arctic Circle. The conditions there represent better those on the Arctic. There is more snow, and the melting of the snow continues further to the spring, making solar radiation a more prominent forcer in melting the snow.

The soot will be deposited similarly to the method in 2012, but with some improvements to be able to produce more homogenous soot spots with better controlled concentrations of soot. This time we will also make some spots with volcanic dust. Our planned time window for depositing the soot is two weeks, allowing us to time the experiment better related to weather. The snow albedo will be measured continuously, and the snow depth daily. Also snow samples will be taken weekly throughout the melting season to understand better how the soot is penetrating through the snow. Results from this experiment are to be analysed before the EAC conference in September 2013.

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