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Sampling, filtering and analyzing procedures for thermal-optical OCEC analysis to determine black, organic and total carbon in Arctic snow, ice and water samples

Outi Meinander, Enna Heikkinen, and Minna Aurela
(firstname.lastname@fmi.fi)

We will be available during the EGU2020 chat on 4 May:

Twitter.com/FMI_Snow

Outi Meinander Enna Heikkinen

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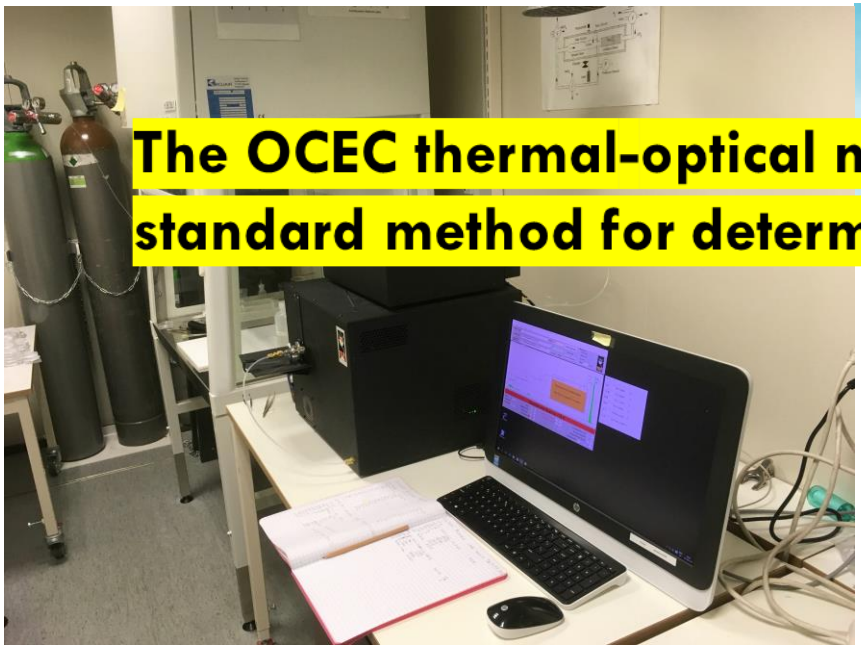
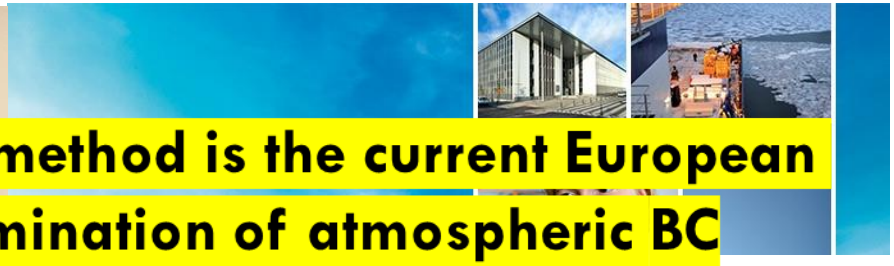
WE WELCOME COLLABORATION PROJECTS! Please contact: outi.meinander@fmi.fi

outi.meinander@fmi.fi

1. Who and what?

We and our OCEC analyzer are part of the ‘Aerosols and Climate’ –research group of the Finnish Meteorological Institute (www.fmi.fi), Helsinki, Finland (60.1°N)





The OCEC thermal-optical method is the current European standard method for determination of atmospheric BC

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Sampling, filtering and analyzing procedures for thermal-optical OCEC analysis to determine black carbon, organic carbon and total carbon concentrations in Arctic snow, ice and water samples

Outi Meinander, Enna Heikkinen, and Minna Aurela
Finnish Meteorological Institute, Research, Helsinki, Finland (outi.meinander@fmi.fi)

2. INTRODUCTION: BC IN SNOW AND ICE

Black carbon (BC) is mostly released in the atmosphere from human activities, but also from natural sources like forest fires.

Seemingly small amounts of black carbon (BC) in snow, of the order of 10–100 parts per billion by mass (ppb), have been shown to decrease its albedo by 1–5 %.

Due to the albedo-feedback mechanism, surface darkening accelerates snow and ice melt and contributes to Arctic warming.

OUR SAMPLES: ARCTIC, ANTARCTIC, MOUNTAIN REGIONS, SNOW, ICE, GLACIER ICE, RAIN, AND NATURAL WATER

ANALYSIS RESULT: BC, OC and TC [ppb] equals to [µg/kg] and [µg/L], determined as [µg-EC/L-H_2O]

3. OUR SAMPLES FOR OCEC ANALYSIS

Our Arctic samples include field and laboratory experiment samples and natural surface snow and snow profile samples, and ice and water samples collected at, e.g.:

North of the Arctic Circle at the Finnish Meteorological Institute **Arctic Space Center in Sodankylä,** Finland (67◦37 N, 26◦63 E), which is also a World Meteorological Institute's Global Atmospheric Watch station (**WMO GAW**).

H2020 EU-Interact stations of Faroes FINI, Iceland Sudurnes and UK Cairngorms.

Elsewhere from Iceland and Finland, including Helsinki Kumpula SMEAR-III station (60°12 N, 24°57 E, Station for Measuring Ecosystem-Atmosphere Relations, https://www.atm.helsinki.fi/SMEAR/index.php/smear-iii)

The most northern research catchment area of Pallas (68°N, about 130 km north from the Arctic Circle, https://blogs.egu.eu/divisions/hs/2019/06/19/featured-catchment-series-pallas/).

The BC concentrations in snow have been detected to vary according to the origin of the air masses and as a result of the post-depositional snow process (e.g., Meinander et al. 2013 and Meinander et al. 2020, see References at the end of this presentation).

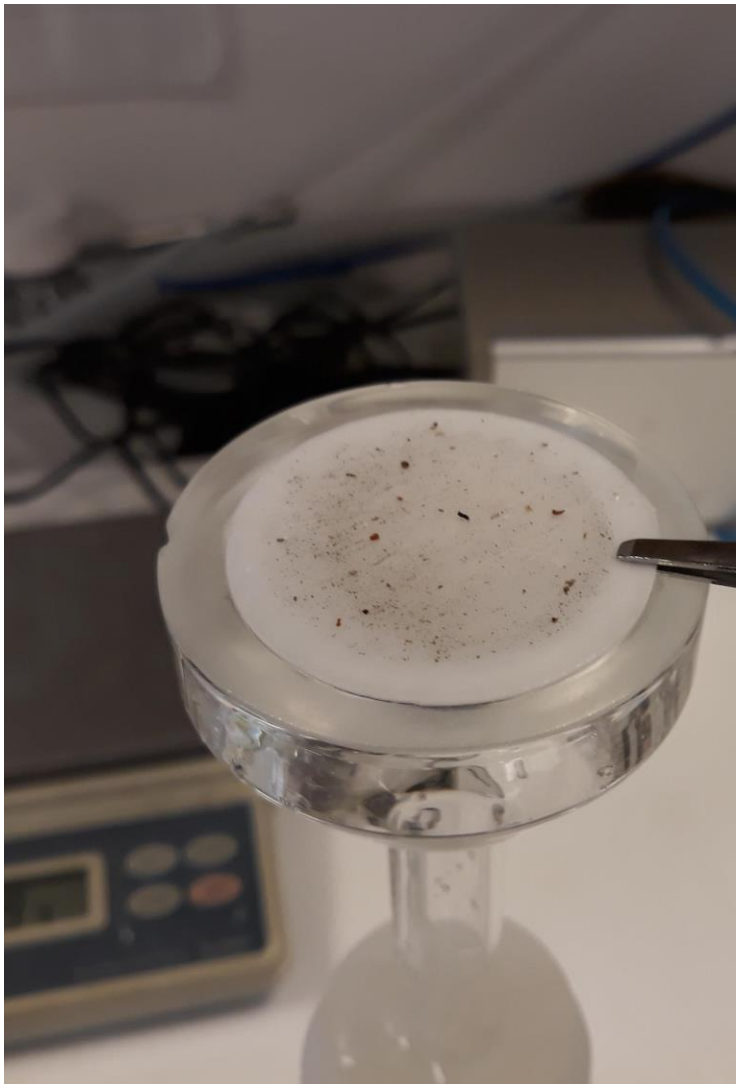
4. SNOW/ICE/WATER SAMPLING AND FILTERING USING QUARZ FILTERS (900 ^{0}C TEMPERATURES)

1. To avoid contamination, Snow/ice/water sample is collected using sterile plastic bags or glass containers, using stainless steel spatula.

2. Snow/ice is melted.

3. Water is filtered through sterile filters.

4. Particles are collected on a quarz-fiber filter and subjected to different temperature ramps following the protocols (e.g., NIOSH-870, EUSAAR2, or IMPROVE). Pyrolysis correction is by laser transmittance. Light transmittance through the filter is monitored during the collection phase to quantify BC (using transmission is more accurate than using reflectance).



5. THERMAL OPTICAL CARBON ANALYSIS

Basic principle:

- Filter piece is put into the sample oven and heated in two steps so that all the carbon or the filter is oxidized to carbon dioxide
- Carbon dioxide is reduced to methane whicl is measured using FID-detector
- Two-step heating separates organic carbon (OC) from elemental carbon (EC)
  - In the 1st heating step organic carbon is oxidized in pure helium atmosphere
  - In the 2nd heating step elemental carbon is oxidized in He/O_2-atmosphere
- The split point between OC and EC is determined using laser
  - Split point is the point where laser transmittance/reflectance returns to the starting value
  - Pyrolysis correction

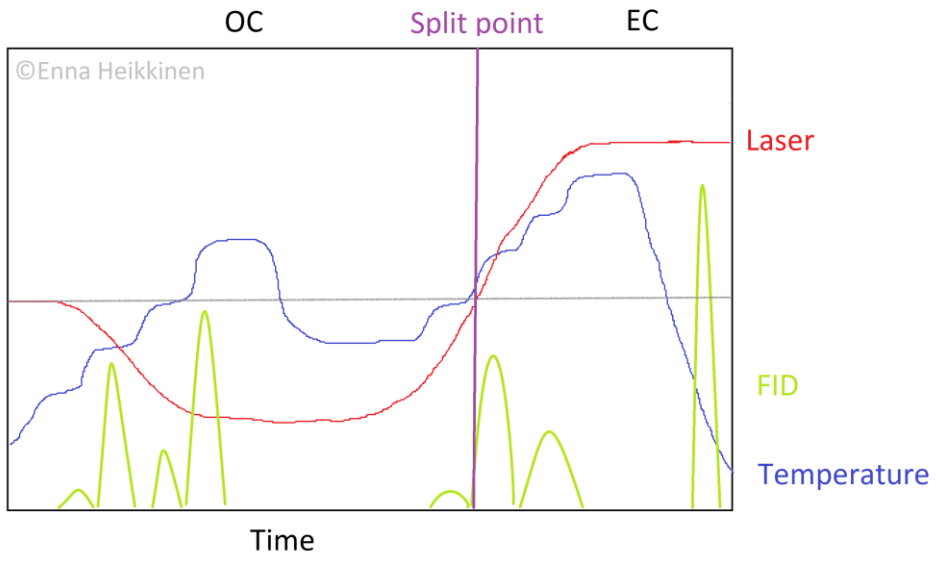


Figure 1. The thermogram.

6. PROTOCOLS

The most often used protocols are:

- EUSAAR 2
- NIOSH 870
- IMPROVE
- IMPROVE A

Different protocols give the same TC

The ratio of OC to EC varies

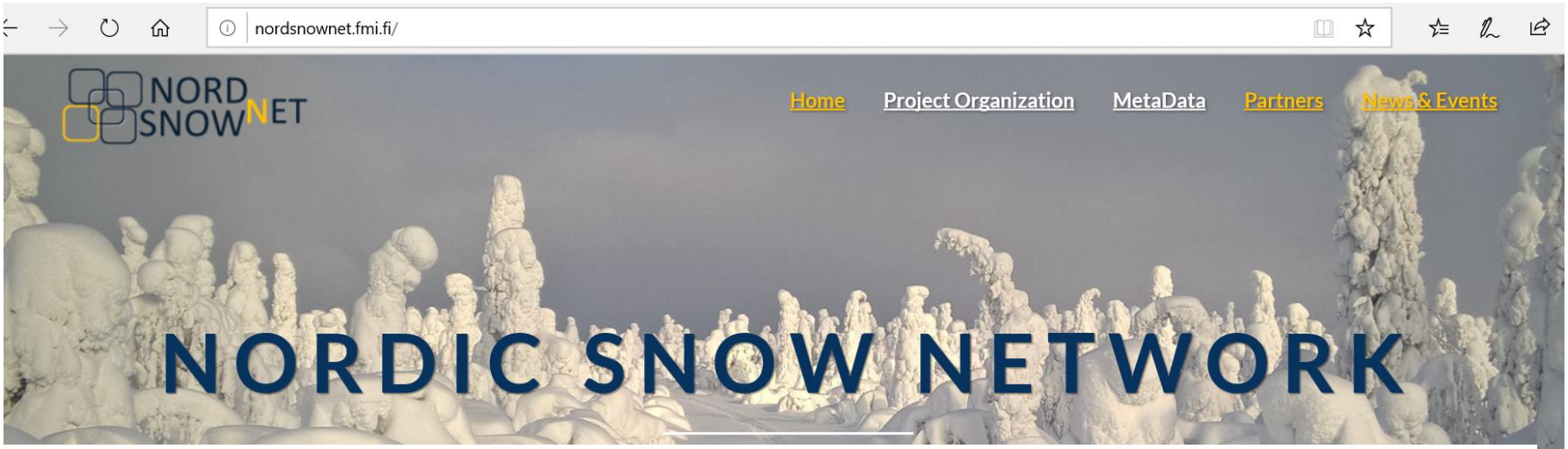
Table 1. The EUSAAR 2 protocol.

	EUSAAR 2	
Gas	Temperature (°C)	Time (s)
He	200	120
He	300	150
He	450	180
He	650	180
He	0	30
He/O_2	500	120
He/O_2	550	120
He/O_2	700	70
He/O_2	850	80
He/O_2	-	-
He/O_2	-	-

7a. Sodankylä SnowAPP campaign (2019-2020)

- NordSnowNet field campaign in 2020 in Sodankylä was planned to complete data set of SnowAPP campaign with measurements of spectral reflectance with hand held devices and measurements of spatial variability of snow properties
- Plan changed to support SnowAPP campaign measurements by locals due COVID-19
- Snow pit measurements were made twice per week in March-May, including NIR photos, density, SWE, liquid water content, stratigraphy, grain size and type, specific surface area, impurity, micro-CT sampling, and SnowMicroPen measurements
- Aim of SnowAPP project is to improve modelling of optical and microwave observations

7b. http://nordsnownet.fmi.fi

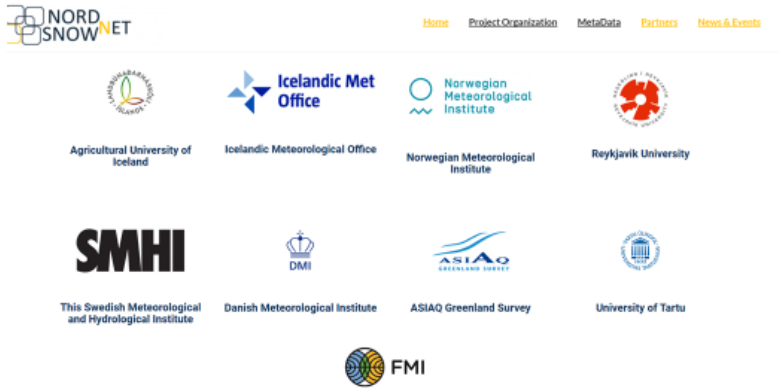


NordSnowNet Contact Persons

STEERING GROUP

Denmark:
•Kristian Pagh Nielsen
Estonia:
•Marko Kaasik
Greenland:
•Kirsty Langley
Iceland:
•Pavla Dagsson-Waldhauserova
Sweden:
•Patrick Samuelsson
Norway:
•Mariken Homleid
Finland:
•Outi Meinander
Project manager:
•Ali Nadir Arslan

Partners



7c. Soot on Snow campaigns (SoS) Sodankylä and AKA NABCEA-project

Home > Research & Development > Research and development projects > Projects >
Novel Assessment of Black Carbon in the Eurasian Arctic: From Historical Concentrations and Sources to Future Climate Impacts (NABCEA)

Novel Assessment of Black Carbon in the Eurasian Arctic: From Historical Concentrations and Sources to Future Climate Impacts (NABCEA)

Basic project information + Show information

MORE INFORMATION

Partners

FMI Finnish Meteorological Institute

UEF University of Eastern Finland

HY University of Helsinki

7d. Pallas catchment

https://blogs.egu.eu/divisions/hs/2019/06/19/featured-catchment-series-pallas/

EGU BLOGS GeoLog Network Divisions

EGU Blogs » Divisions » Hydrological Sciences » Featured catchment series: The North is not forgotten!

Featured catchment series: The North is not forgotten!

EGU Guest blogger · June 19, 2019 · Featured Catchment · No Comments

7e. EU-Interact Black-project in Sudurnes Iceland, Cairngorms UK, and FINI Faroes (with Arctic Research Blog)

7f. IBA-project as data user (https://en.ilmatieteenlaitos.fi/iba-project) (NordSnowNet collaborator)

IBA-project

Black carbon in the Arctic and significance compared to dust sources (IBA-FIN-BCDUST)

Funding: Ministry for Foreign Affairs of Finland (MFA of Finland)

Start: 12/2018

End: 12/2020

Workshops

WS1 ICELAND
In coperation with the IASC workshop on Effects and Extremes of High Latitude Dust (contact: Outi Meinander, FMI)

TIme: 13-14 February 2019

Place: Agricultural University of Iceland (AUI), Reykjavik, Iceland

More information, including agenda and preliminary book of abstract:
https://icedustblog.wordpress.com/20[illegible]and-extremes-of-high-latitude-dust-iasc workshop-in-co-operation-with-the-icedust-association-13-14-feb-2019-reykjavik-in-iceland/

WS2 RUSSIA
In co-operation with the University of Helsinki (contact: Hanna K Lappalainen University of Helsinki)

Time: September-October 2019

Place: Moscow, Russia

WS3 FINLAND

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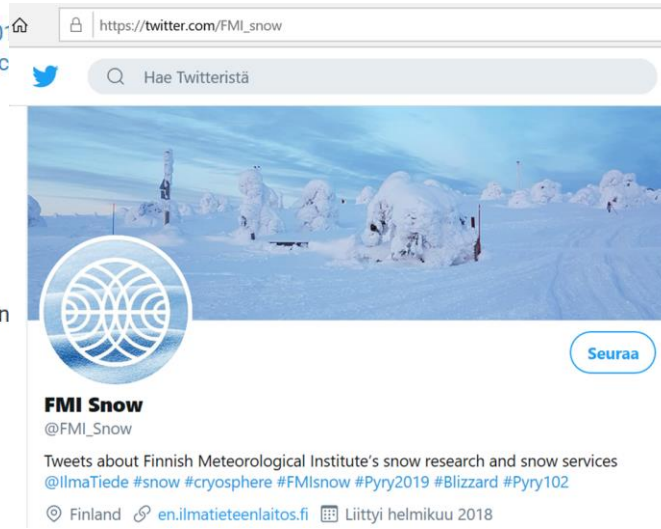

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