Aerosol investigation during the Arctic Haze season 2018
Optical, Microphysical and Radiative properties

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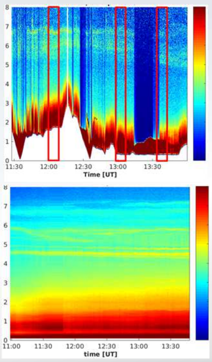
Motivation

Optical properties similar? + Radiative impact?



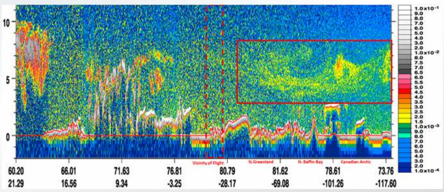


Fig 1: Lidar range-corrected signal at 532 nm (arbitrary units) measured over Fram Strait on 2nd April (top) and Svalbard on 5th April 2018(bottom) and total atten. Bsc. At 532 nm ($km^{-1}sr^{-1}$) by CALIOP (right) on 2nd April 2018.

Instrumentation

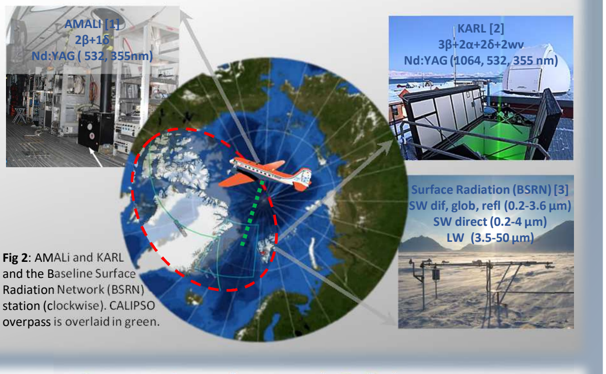


Fig 2: AMALi and KARL and the Baseline Surface Radiation Network (BSRN) station (clockwise). CALIPSO overpass is overlaid in green.

Optical and Microphysical properties [4],[5],[6],[7]

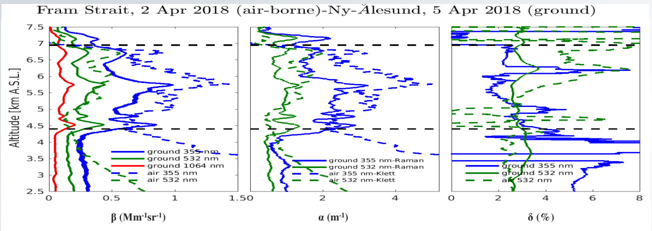


Fig 3: Aerosol optical properties from ground-based and air-borne Lidar systems.

$\overset{gr}{\beta}{}^{355} = 0.6 \pm 0.1\ Mm^{-1}sr^{-1}$
$\overset{gr}{\beta}{}^{532} = 0.3 \pm 0.06\ Mm^{-1}sr^{-1}$
$\overset{gr}{\beta}{}^{1064} = 0.1 \pm 0.03\ Mm^{-1}sr^{-1}$
$\overset{air}{\beta}{}^{355} = 1.3 \pm 0.4\ Mm^{-1}sr^{-1}$
$\overset{air}{\beta}{}^{532} = 0.4 \pm 0.08\ Mm^{-1}sr^{-1}$

$\overset{gr}{a}{}^{355} = 20 \pm 7\ Mm^{-1}$
$\overset{gr}{a}{}^{532} = 9 \pm 3\ Mm^{-1}$
$\overset{air}{a}{}^{355} = 33 \pm 19\ Mm^{-1}$
$\overset{air}{a}{}^{532} = 14 \pm 3\ Mm^{-1}$

$\overset{gr}{\delta}{}^{355} = 3 \pm 4\%$
$\overset{gr}{\delta}{}^{532} = 3 \pm 0.3\%$
$\overset{air}{\delta}{}^{532} = 5 \pm 2\%$

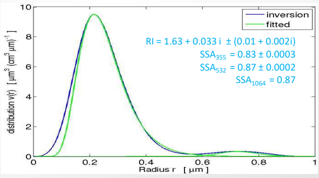


Fig 4: Inverted and fitted volume distribution.

Tab. 1: Retrieved microphysical properties for fine and coarse aerosol mode.

modal radius (µm)	0.17 ± 1.4	0.7 ± 1.1
effective radius (µm)	0.23	0.75
number conc. (cm^{-3})	50.3	0.04
surface conc. ($\mu m^2\ cm^{-3}$)	23.7	0.24
volume conc. ($\mu m^3\ cm^{-3}$)	1.8	0.06

- nearly **spherical** particles
- **higher β and α** over **Fram Strait** (air-borne obs)
- β_{355}, β_{1064} and LR_{355} similar to $Haze_{2014}$ but slight higher LR_{532}[8]

Aerosol typing and Origin

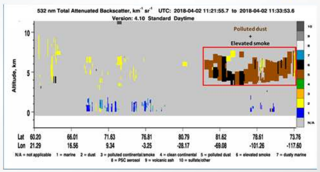


Fig 5: Aerosol type according to CALIPSO classification scheme.

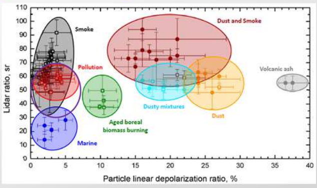


Fig 6: Aerosol typing at 355 nm based on the studies of Gross et al., 2011b, Gross et al., 2012, Baars et al. 2012; Kanitz et al., 2013. The purple ellipse indicates our dataset [9].

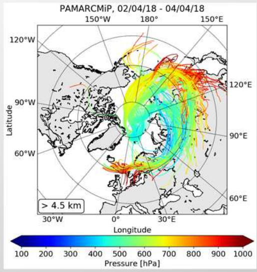


Fig 7: LAGRANTO 10 day back-trajectory (end >4.5 km) based on ECWMF analysis. *Courtesy of Daniel Kunkel and Oliver Eppers*

ground-based Lidar

mixture of smoke-pollution (LR_{532}= 51 sr, LR_{355}=50 sr) [9] or polluted continental [10]

CALIPSO

polluted dust-elevated smoke mixture [11]

LAGRANTO back-trajectories

two source regions → N Europe + NE Asia

- **fine domination** (smaller r_{eff}, 3xhigher fine to coarse number conc than 2014) [12]
- **high RI + low SSA** → slight **absorbing** particles
- lower SSA (compared to sea salt-sulfate of $Haze_{2014}$) [9,] [12]
- Indication of high BC by coordinated in-situ (2nd April 2018), contrary to $Haze_{2014}$

Nakoudi et al., 2020a: "Investigation of transport events in the Arctic by means of active and passive remote sensing"

Radiative characterization [3], [13]

$$F_{net}^{TOTAL} = (F_{dn}^{SW} - F_{up}^{SW}) + (F_{dn}^{LW} - F_{up}^{LW})$$

$$AF_{net}^{TOTAL} = F_{netE}^{TOTAL} - F_{netB}^{TOTAL} = (F_{netE}^{SW} - F_{netB}^{SW}) + (F_{netE}^{LW} - F_{netB}^{LW})$$

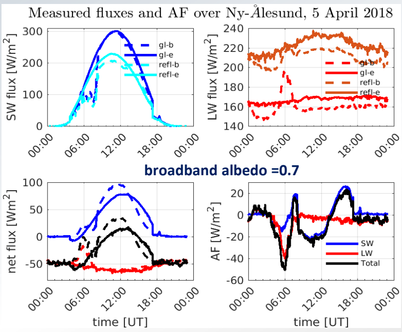


Fig 8: Measured fluxes and Aerosol Forcing (AF) at the surface of Ny-Ålesund compared to a clear day (5 April 2003).

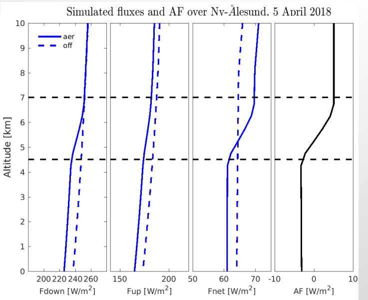


Fig 9: Spectrally integrated fluxes and AF simulated with SCIATRAN Rad. Transfer model at 200-1060 nm.

- + surf SW_{net} for sza < 73 °
- - surf LW_{net} → LW ↑ > LW ↓
- - surf $TOTAL_{net}$ → emission into the atm
  but $F_{net}^{TOTAL} = +12\ W/m^2$ for sza < 73 °
- compared to clear day
  - surf AF^{TOT} $(-15 W/m^2)$ 13-17 UT

Advanced aerosol case

- less flux↓ and flux↑
- - AF $(-5\ W/m^2)$ below layer and surface
- + AF $(+15\ W/m^2)$ upper layer and above
- more diffuse and less direct (not shown here)

Nakoudi et al., 2020b: "Radiative impact of transport events in the Arctic: observational and modelling perspectives"

Conclusions and Future Work

Ground-Airborne

similar intensive properties but **higher extensive over Fram Strait**

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Microphysical Inversion

slight absorbing particles

fine mode domination

Ground-Satellite

smoke-polluted continental aerosol

\+

Back-trajectories

N Europe - NE Asia origin

MOSAiC International Arctic Drift Expedition

similar microphysical and radiative properties?

- Lidar-photometer inversion

- airborne rad sensor - RTM comparison

- Further back-trajectories

airmass modification?

Radiation observations

surface → - $TOTAL_{net}$

but for high szas + $TOTAL_{net}$

surface → - AF

SCIATRAN with Lidar input:

surface & below layer → - AF

upper layer & above → + AF

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