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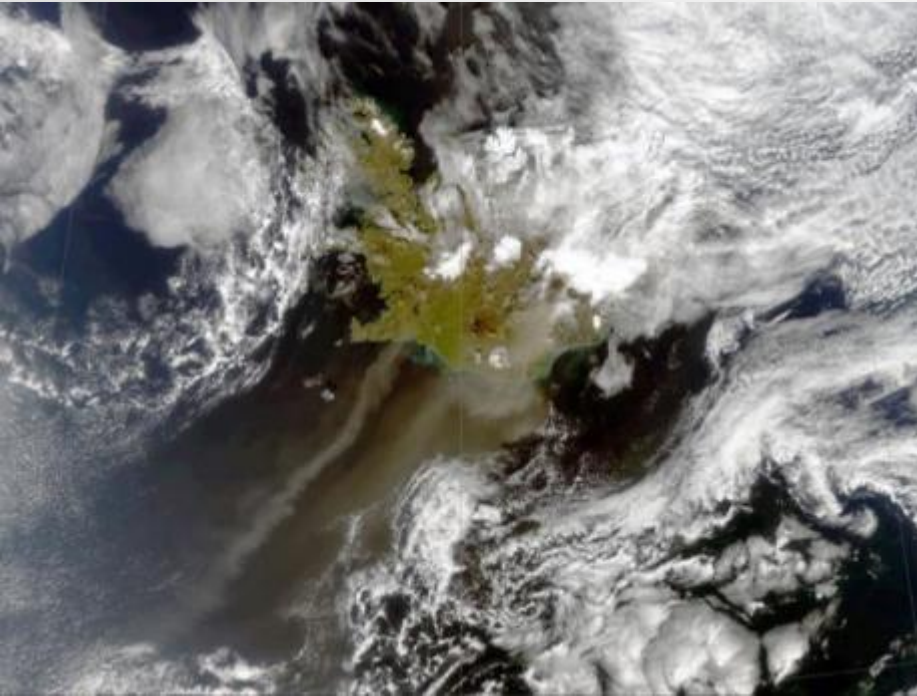
FINNISH GEODETIC
INSTITUTE



UNIVERSITY OF ICELAND



WINTER DUST STORMS IN THE ARCTIC



PAVLA DAGSSON WALDHAUSEROVA

O. ARNALDS, H. OLAFSSON, O. MEINANDER, J-B RENARD, J. HLADIL,
L. CHADIMOVA, J. KAVAN, B. MORONI, D. DJORDJEVIC, D. URUPINA,
AND MORE

EGU2020

4TH MAY 2020

TALK OUTLINE

- HIGH LATITUDE DUST SOURCES (HLD) AND DUST IN THE ARCTIC
- ICELAND AS A MAIN CONTRIBUTOR OF HLD AREAS
 - LONG-RANGE TRANSPORT OF ICELANDIC DUST
 - ANNUAL VARIABILITY IN DUST FREQUENCY IN ICELAND
 - SNOW-DUST STORMS
 - VERTICAL PROFILES OF DUST STORMS DURING THE ARCTIC WINTER
 - IMPACTS ON ATMOSPHERIC CHEMISTRY AND ROAD SAFETY
- ICELANDIC AEROSOL AND DUST ASSOCIATION (ICEDUST)

HIGH LATITUDE DUST AREAS

Updated paper on HLD sources in progress by Meinander et al.

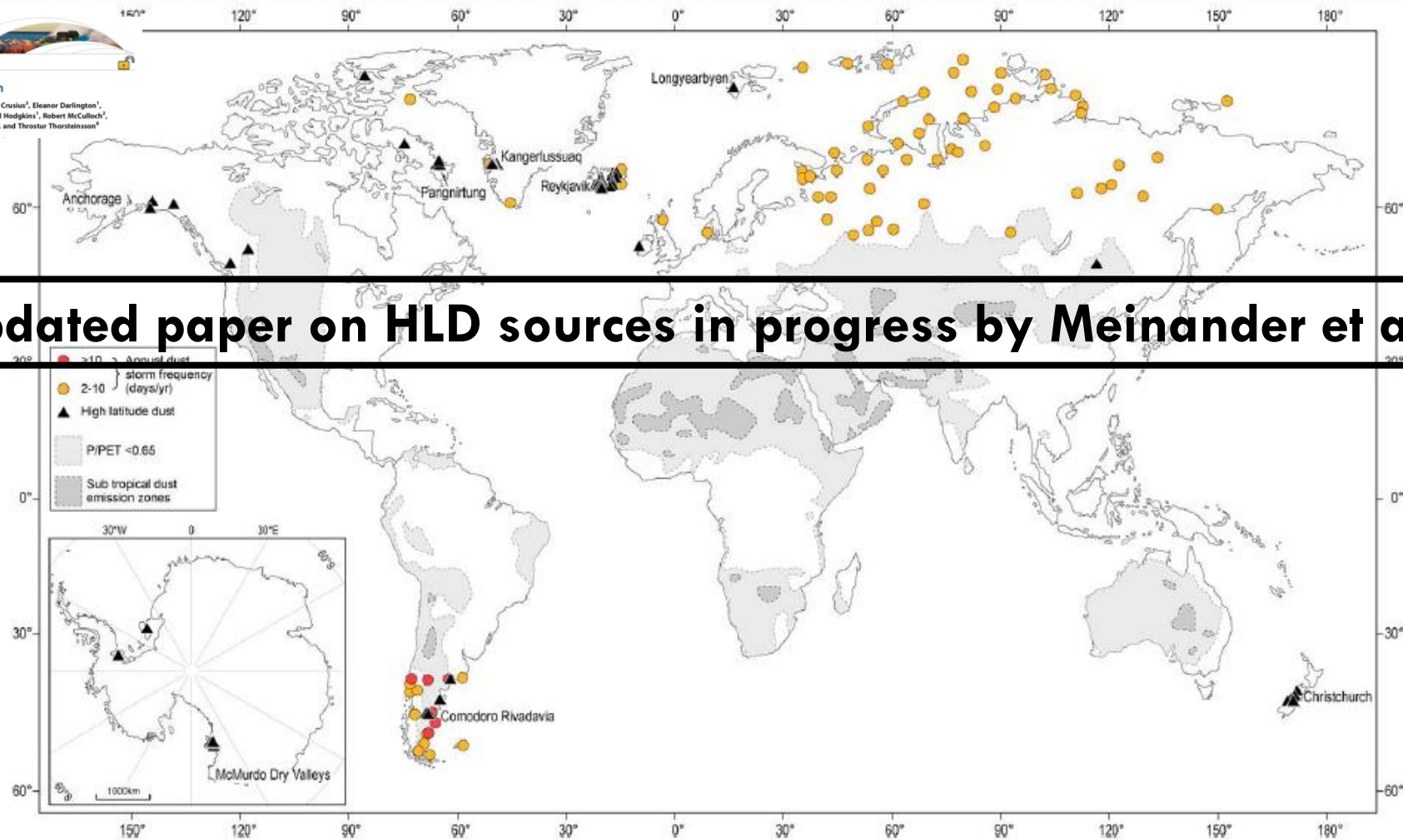


Figure 3. Global observations of high-latitude dust where filled circles indicate dust storm frequency based on visibility data, and black triangles indicate georeferenced published observations of dust storms (see text for details). Areas where the precipitation: potential evapotranspiration ratio < 0.65 (aridity index) [United Nations Environment Programme, 1997] and subtropical dust emission zones are included for reference.

NORTHERN HLD SOURCES AND THEIR CONTRIBUTION IN THE ARCTIC

~ 3% of global dust emission from HLD sources

Total atmospheric dust loads in the Arctic:

Asia (~38%)

Africa (~32%)

HLD (27%)

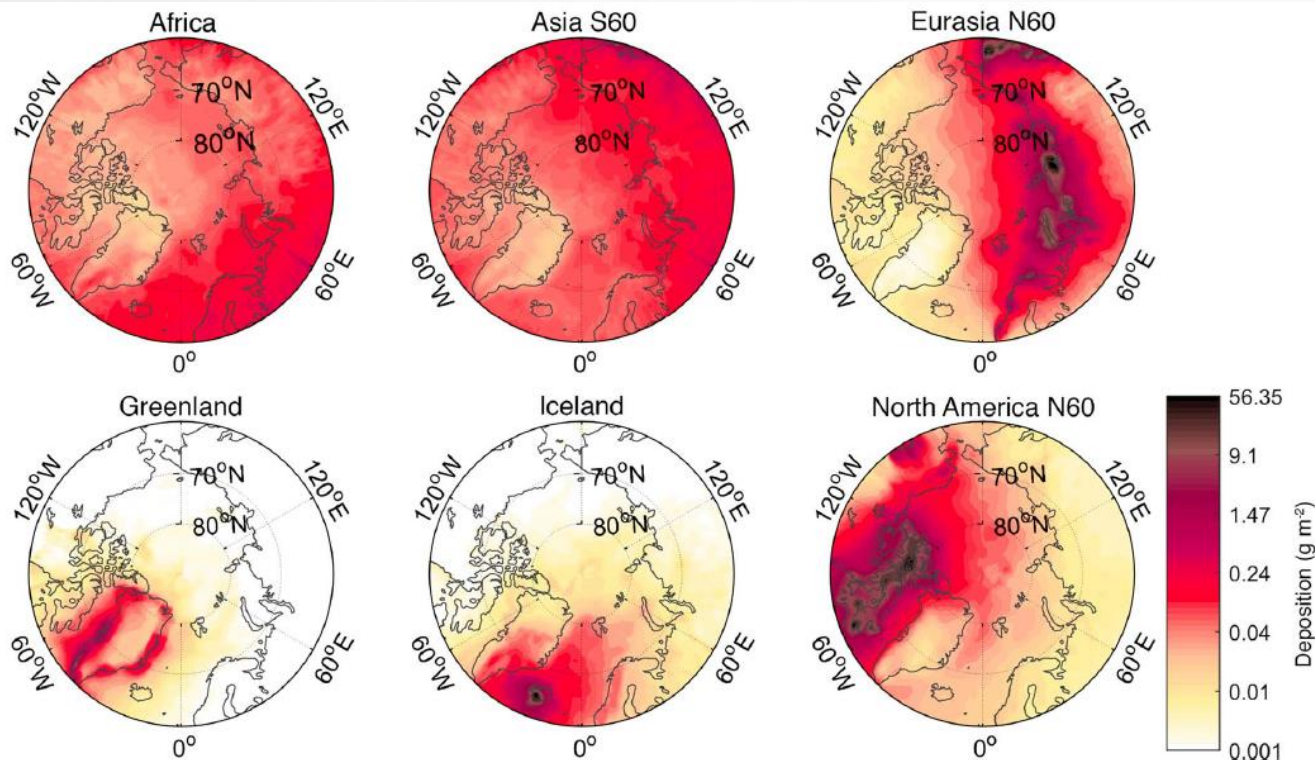


Figure 11. Simulated annual mean deposition of dust (g m^{-2}) in the near Arctic originating from different source regions averaged for years 2010–2012. Deposition is here given as the sum of dry and wet deposition.

Surface measurements are crucially needed as shown in Antarctica.

PM10 in Antarctica similar to North Europe!

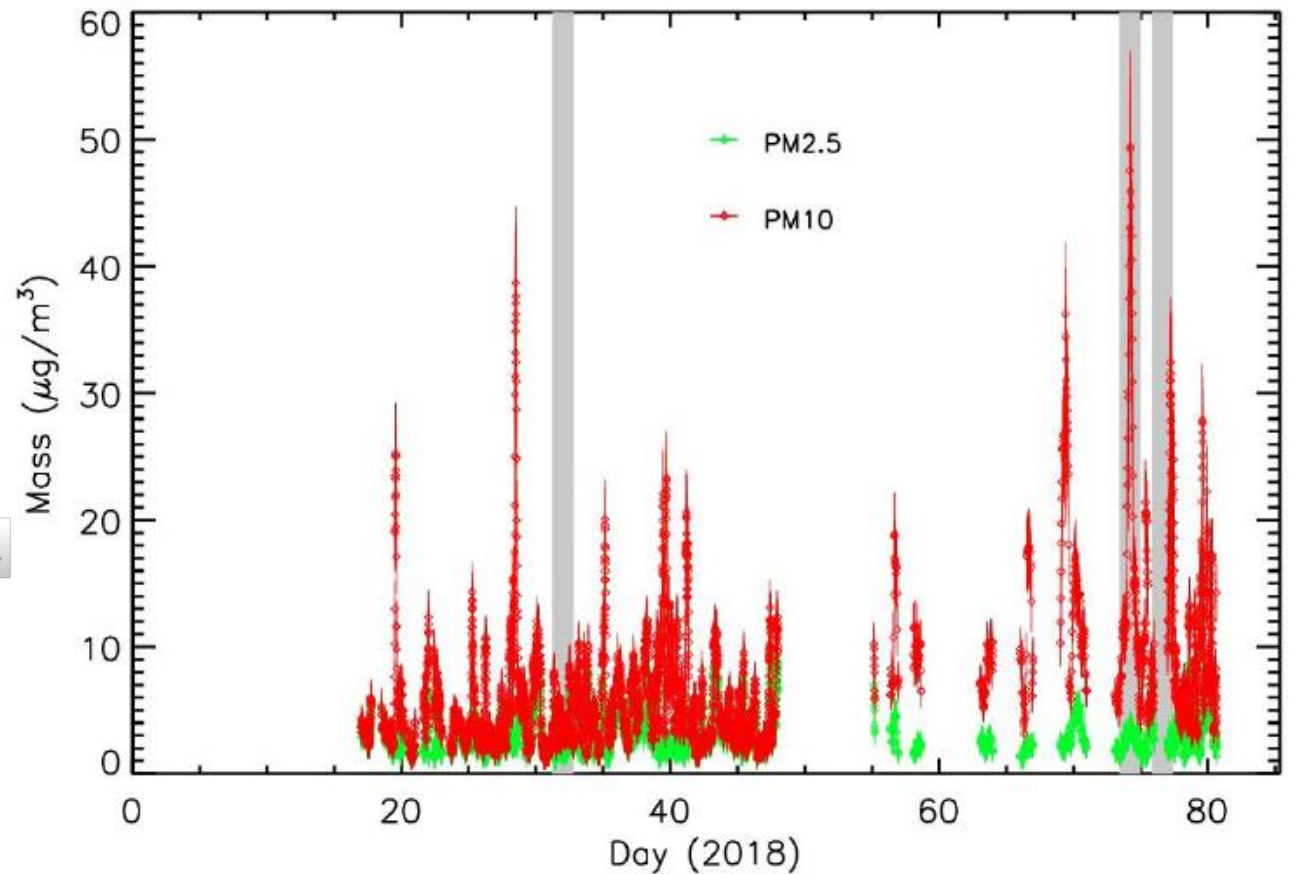


Mean (median) mass concentrations:

PM_{10} were 6.4 ± 1.4 (3.9 ± 1) $\mu g m^{-3}$

$PM_{2,5}$ were 3.1 ± 1 (2.3 ± 0.9) $\mu g m^{-3}$

for the period January-March 2018



ORIGINAL RESEARCH ARTICLE

Front. Earth Sci., 03 December 2018 | <https://doi.org/10.3389/feart.2018.00207>

Aerosol Concentrations in Relationship to Local Atmospheric Conditions on James Ross Island, Antarctica

Jan Kavan^{1*}, Pavla Dagsson-Waldhauserova^{2,3}, Jean Baptiste Renard⁴, Kamil Láška¹ and Klára Ambrožová¹

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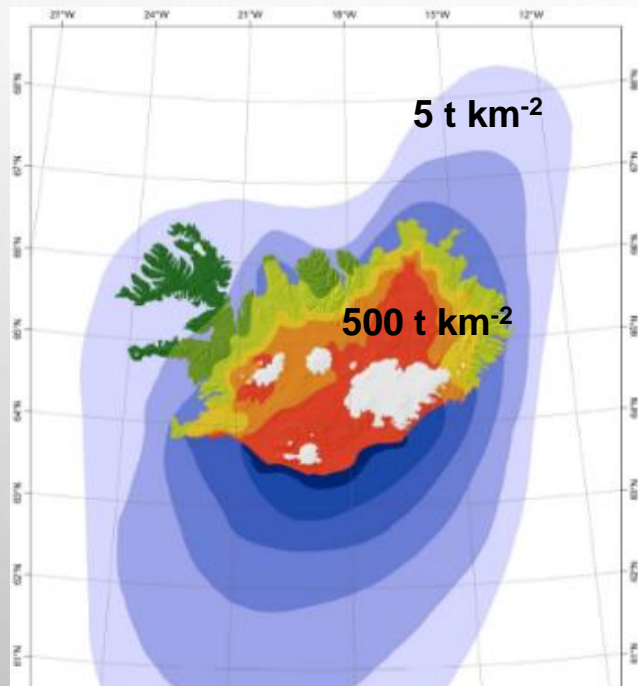
DUST DEPOSITION FROM ICELAND

Quantification of iron-rich volcanogenic dust emissions and deposition over the ocean from Icelandic dust sources

O. Arnalds¹, H. Ólafsson^{1,3,4}, and P. Dagsson-Waldhauserova^{1,2}

Temporal and spatial variability of Icelandic dust emissions and atmospheric transport

Christine D. Groot Zwaaftink¹, Ólafur Arnalds², Pavla Dagsson-Waldhauserova^{2,3,4}, Sabine Eckhardt¹, Joseph M. Prospero⁵, and Andreas Stohl¹



• TOTAL EMISSIONS: 4.3 ± 0.8 TG

• TOTAL EMISSIONS: 30.5 TO 40.1 MILLION T

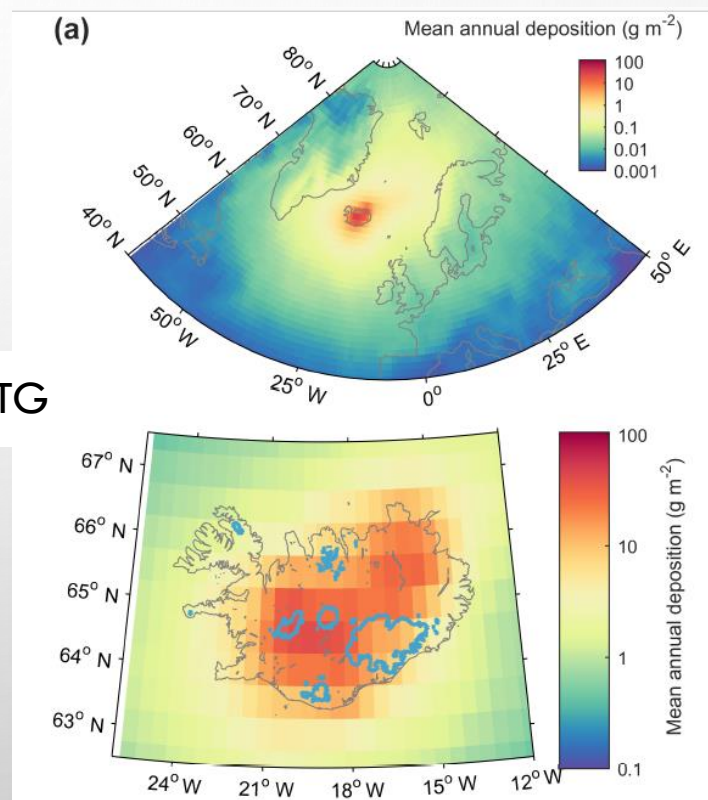
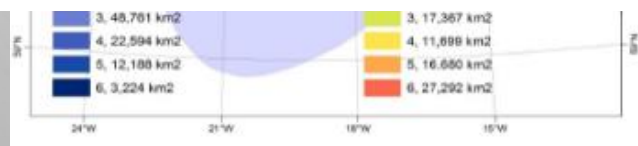


Figure 10. Mean annual dust deposition (g m^{-2}) simulated with FLEXPART in years 1990–2016 for the North Atlantic region (a) and Iceland (b). Maximum values are lower in the upper panel than in the lower panel as this figure shows averages over larger areas. The blue lines in the bottom figure are glacier outlines.

IS THERE ANY EVIDENCE THAT ICELANDIC DUST HAS REACHED SVALBARD OR EUROPE?

ORIGINAL RESEARCH ARTICLE

Front. Earth Sci., 05 November 2018 | <https://doi.org/10.3389/feart.2018.00187>



Mineralogical and Chemical Records of Icelandic Dust Sources Upon Ny-Ålesund (Svalbard Islands)

Beatrice Moroni^{1*}, Olafur Arnalds², Pavla Dagsson-Waldhauserová^{2,3}, Stefano Crocchianti¹, Riccardo Vivani⁴ and David Cappelletti¹

Yes, in Svalbard

Yes, in Ireland



Contents lists available at ScienceDirect

Atmospheric Environment

journal homepage: www.elsevier.com/locate/atmosenv



Volcanic sulphate and arctic dust plumes over the North Atlantic Ocean

J. Ovadnevaite^{a,b,*}, D. Ceburnis^a, K. Plaускаite-Sukiene^b, R. Modini^c, R. Dupuy^a, I. Rimselyte^b, M. Ramonet^d, K. Kvietkus^b, Z. Ristovski^c, H. Berresheim^a, C.D. O'Dowd^a

Source: GRID-Arendal, 2005. Barentswatch Atlas.

Dominating air currents



Central industrial areas

Volcanic dust travelled > 3000 km

ORIGINAL RESEARCH ARTICLE

Provisionally accepted

The full-text will be published soon. [Notify me](#)

Front. Earth Sci. | doi: 10.3389/feart.2019.00142

Can volcanic dust resuspended from surface soil and deserts of Iceland be transferred to central Balkan?

Dragana S. Dordević^{1*}, Ivana Tosić², Sanja Sakan³, Srđan Petrović¹, Jelena Đuričić-Milanković¹, David C. Finger³ and Pavla Dagsson-Waldhauserová⁴

¹Institute of Chemistry, Technology and Metallurgy, University of Belgrade, Serbia

²University of Belgrade, Serbia

³Reykjavik University, Iceland

⁴Agricultural University of Iceland, Iceland

Yes, in Serbia

In this work we use chemical fingerprints as characteristics ratios of specific crustal elements Ca/Al, Fe/Al, K/Al, Mg/Al, Mn/Al, Ca/Fe and Mg/Fe to investigate the long-range transport of volcanic aerosols which are entering the atmosphere in suspended and resuspended processes from Icelandic deserts and hot spots in remote areas in Iceland and transmitted to the central Balkan area (Belgrade). For this purpose, backward trajectories from Belgrade ($\square=44^{\circ}48'$; $\square=20^{\circ}28'$) in 2012 and 2013, simultaneous with atmospheric aerosols measurements, were calculated by using the Hybrid Single-Particle Lagrangian Integrated Trajectory (HYSPLOT) model. We found that about 17% of air masses passed over Icelandic territory and arrived to Balkan area. In almost all of these episodes ratios of some investigated elements in suburban aerosols of Balkan area corresponded to the ratios of elements investigated in surface soil of the Rangárvellir area - South Iceland in the vicinity of volcanoes. We identified several episodes, such as 6 – 8 August 2012, 2 – 6 June 2013, 26 – 28 June 2013, and 18 – 20 September 2013, with the characteristic ratios of the highest number of investigated elements in atmospheric aerosol of central Balkan corresponding to ratios from Icelandic soil material. This study provides evidence that Icelandic dust can travel long distances showing the importance of High Latitude Dust sources.

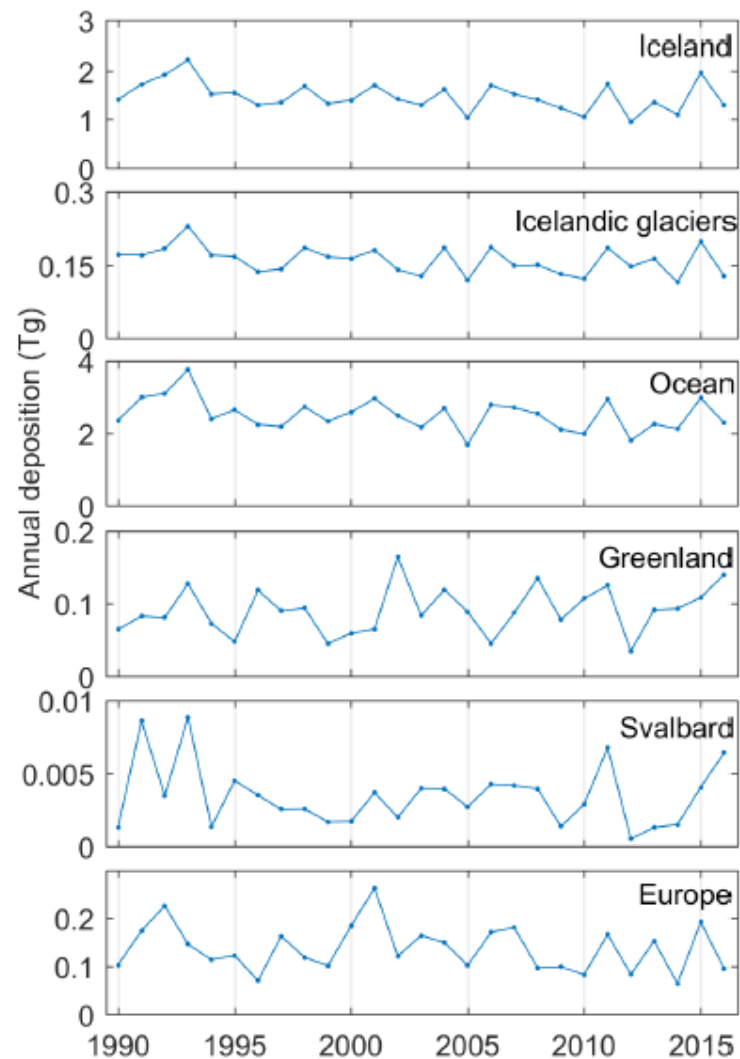


Figure 12. Time series (1990–2016) of modelled dust deposition (Tgyr^{-1}) in specific regions. Note that Iceland also includes deposition on Icelandic glaciers.

Where does the Icelandic dust travel?

- Ocean deposition was on average 2.5 Tg or 58% of annually emitted dust
- Smaller fractions of emitted dust ended up in Greenland (2 %) and Svalbard (< 0,1 %)
- About 7% of emitted dust is deposited in the high Arctic ($> 80^\circ \text{N}$)
- Europe deposition (3% of emitted dust)

Atmos. Chem. Phys., 17, 10865–10878, 2017
<https://doi.org/10.5194/acp-17-10865-2017>
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Atmospheric
Chemistry
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EGU

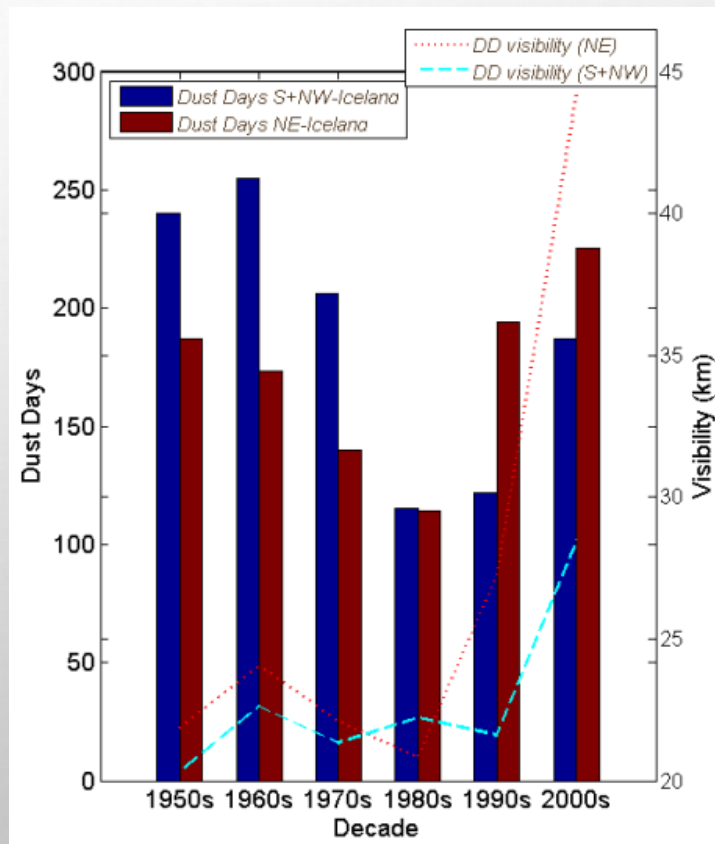
Temporal and spatial variability of Icelandic dust emissions and atmospheric transport

Christine D. Groot Zwaaftink¹, Ólafur Arnalds², Pavla Dagsson-Waldhauserova^{2,3,4}, Sabine Eckhardt¹, Joseph M. Prospero⁵, and Andreas Stohl¹

Long-term variability of dust events in Iceland (1949–2011)

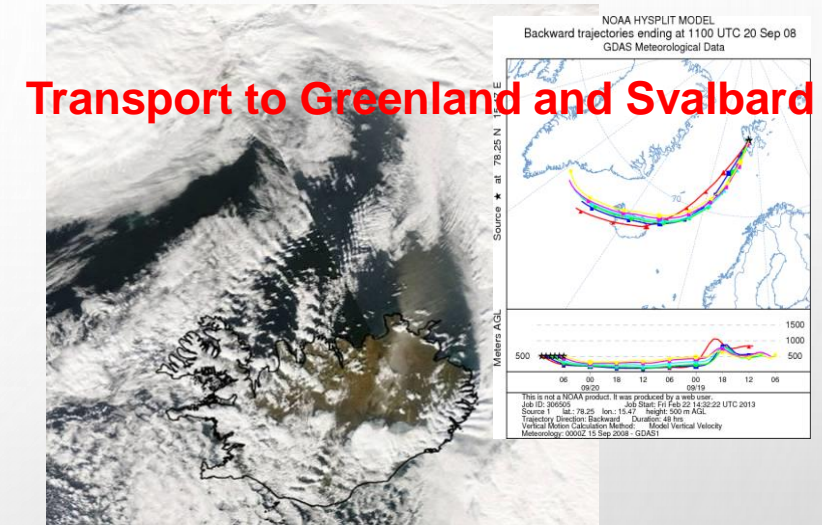
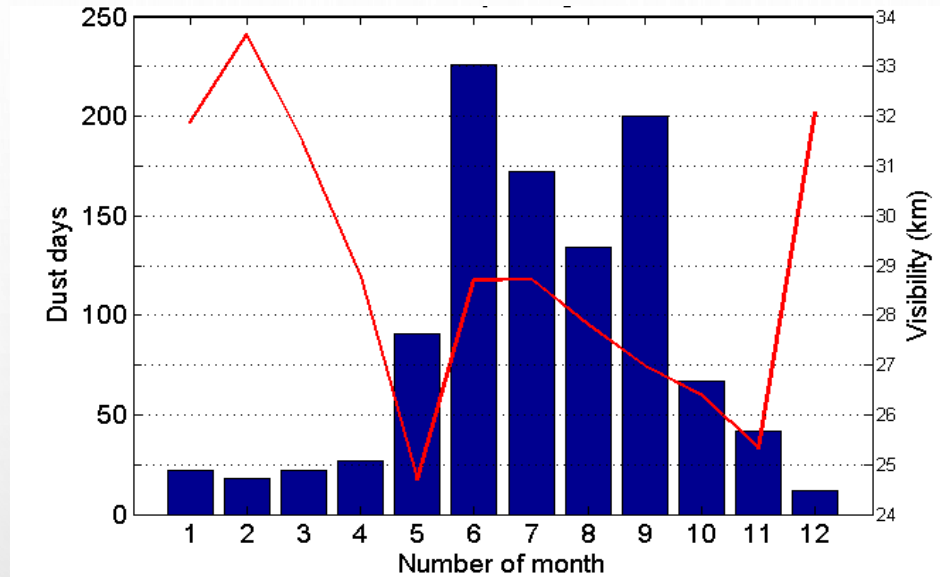
- METHODS: A NETWORK OF 30 WEATHER STATIONS IN ICELAND (1949-2011)
- AN AVERAGE OF 34.4 DUST DAYS PER YEAR, BUT **135** DUST DAYS PER YEAR INCLUDING CODES “VISIBILITY REDUCED BY VOLCANIC ASHES” + “DUST HAZE”

‘DUST DAY’ IS DEFINED AS A DAY WHEN AT LEAST ONE STATION RECORDED AT LEAST ONE DUST

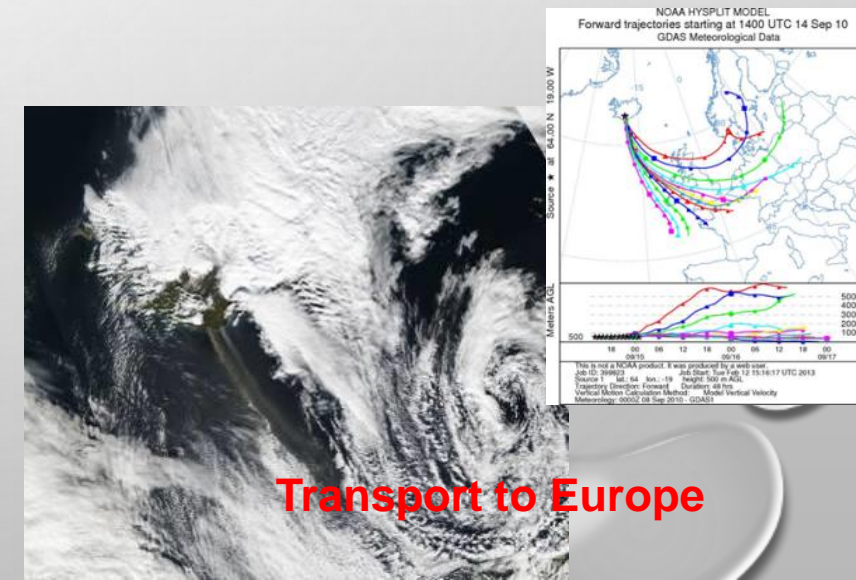
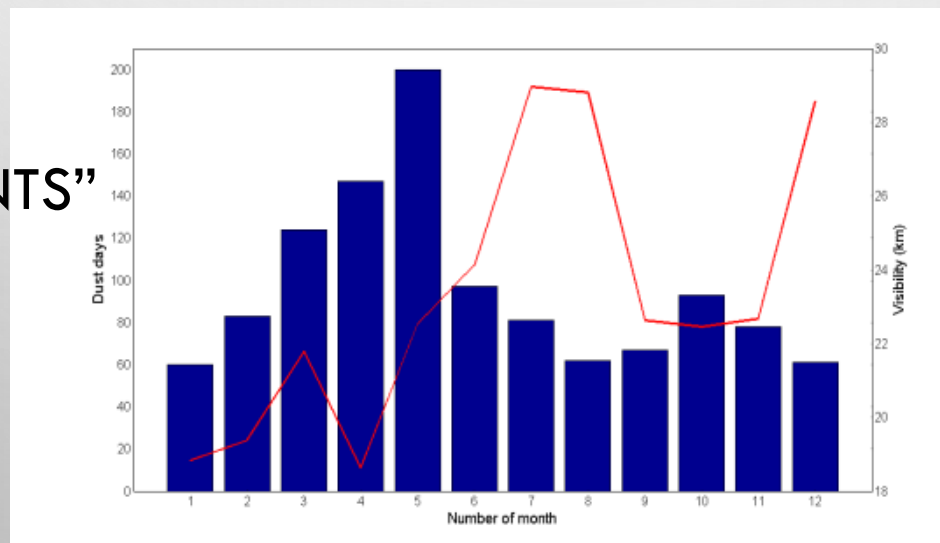


SEASONAL VARIABILITY OF DUST EVENTS

- NE ICELAND
“ARCTIC DUST EVENTS”
SUMMER



- S ICELAND
“SUB-ARCTIC DUST EVENTS”
WINTER-SPRING



AN EXAMPLE OF WINTER DUST STORM



Snow-Dust Storm



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Aeolian Research

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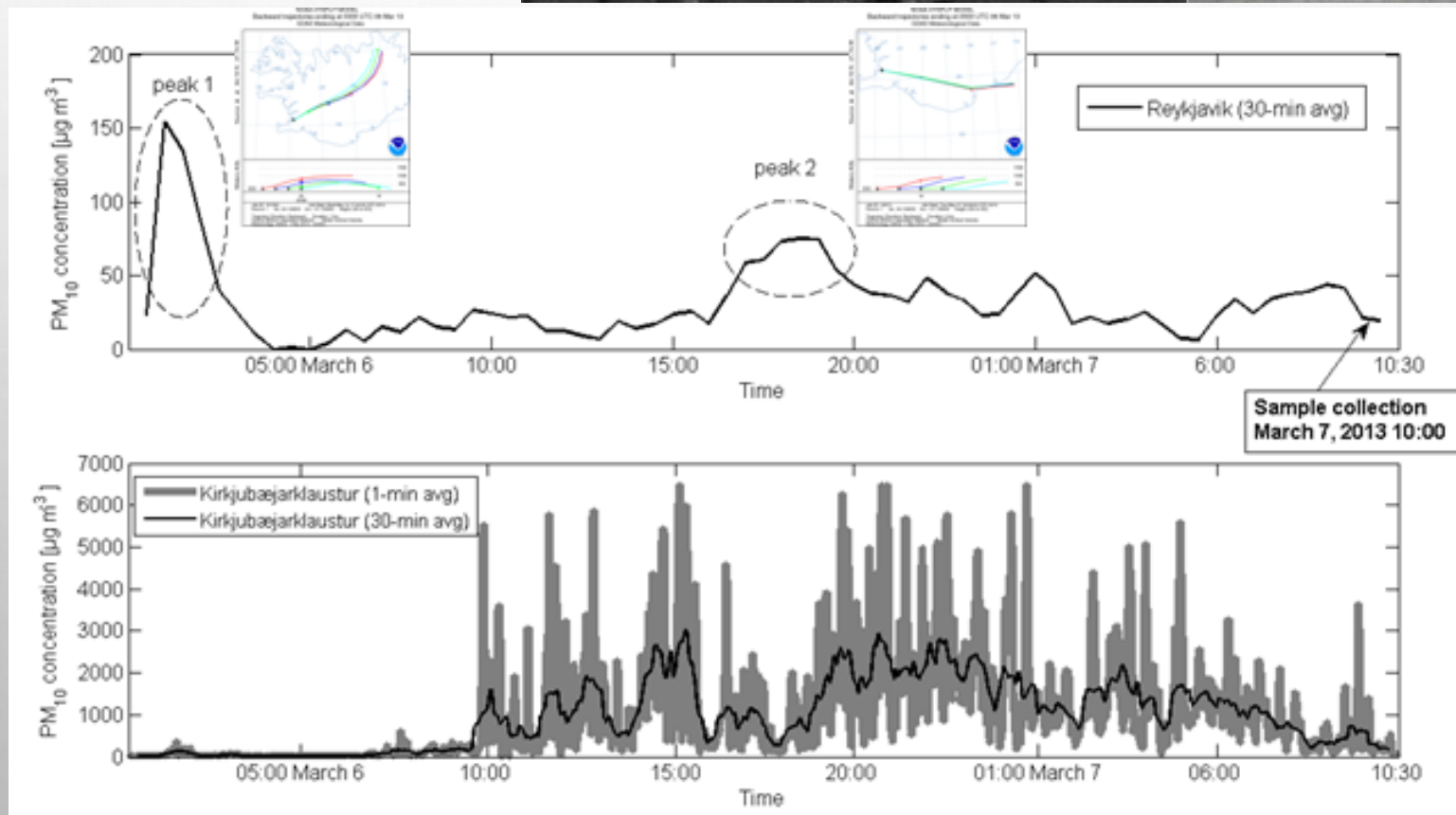
Snow-Dust Storm: Unique case study from Iceland, March 6–7, 2013

Pavla Dagsson-Waldhauserova^{a,b,g,*}, Olafur Arnalds^a, Haraldur Olafsson^{b,c,d}, Jindrich Hladil^e, Roman Skala^e, Tomas Navratil^e, Leona Chadimova^e, Outi Meinander^f



A SNOW-DUST STORM

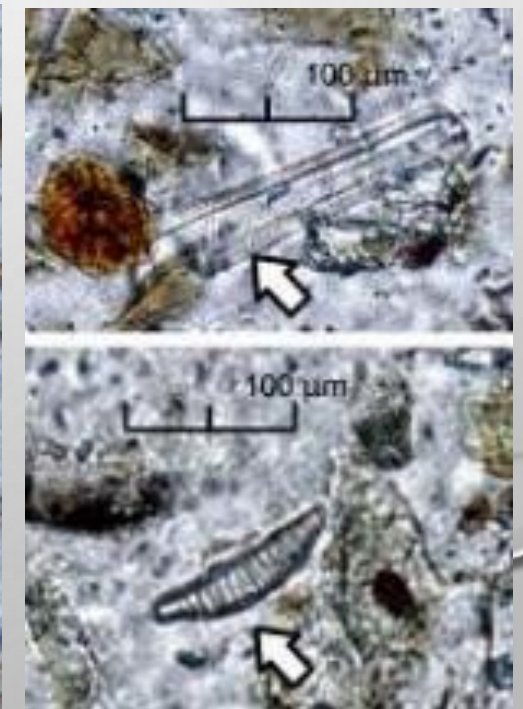
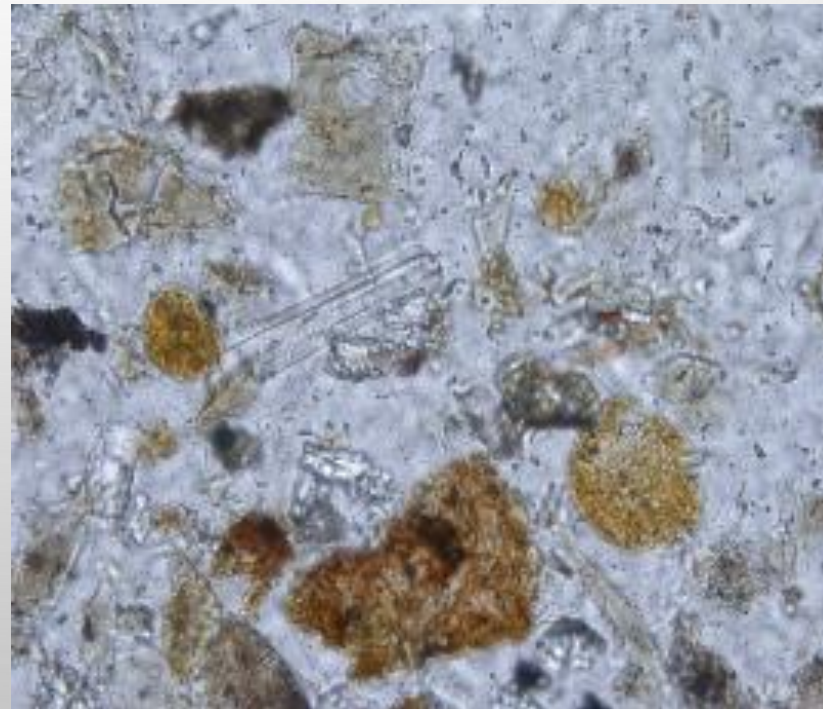
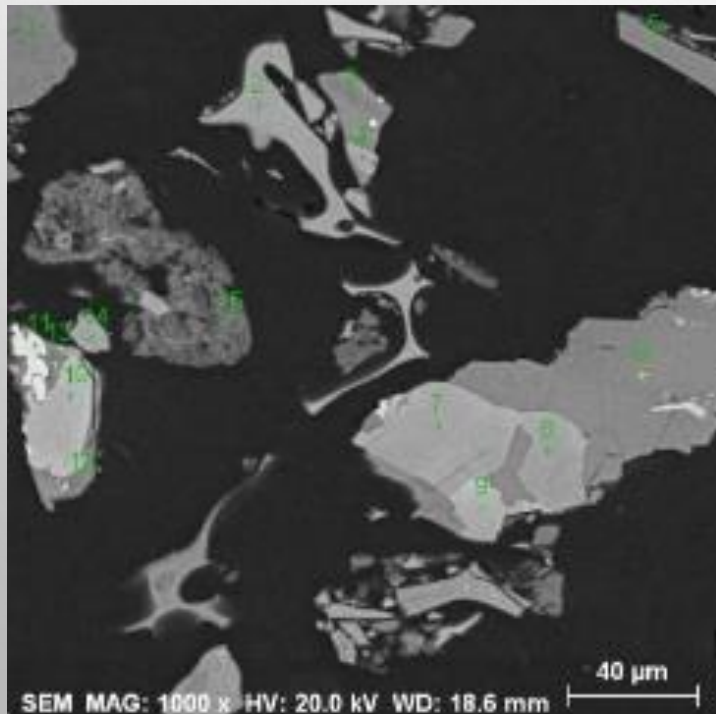
- Mean (median) PM_{10} concentration during 24-hour storm $\sim 1,281$ ($1,170$) $\mu g\ m^{-3}$
- Max one-minute PM_{10} concentration $\sim 6500\ \mu g\ m^{-3}$



A SNOW-DUST STORM

Mineral and geochemical composition:

- 75% ~ volcanic glass
- SiO_2 45%, FeO 14.5%, TiO_2 3.5%
- high proportion of organic matter and diatoms
- very fine pipe-vesicular structures of glasses



A SNOW-DUST STORM



Clumping mechanism of particles on snow
the first observation reported from natural conditions



Clumping mechanism during SoS experiments in 2013

Soot On Snow (SOS) 2013



Soot on Snow experiment: bidirectional reflectance factor measurements of contaminated snow

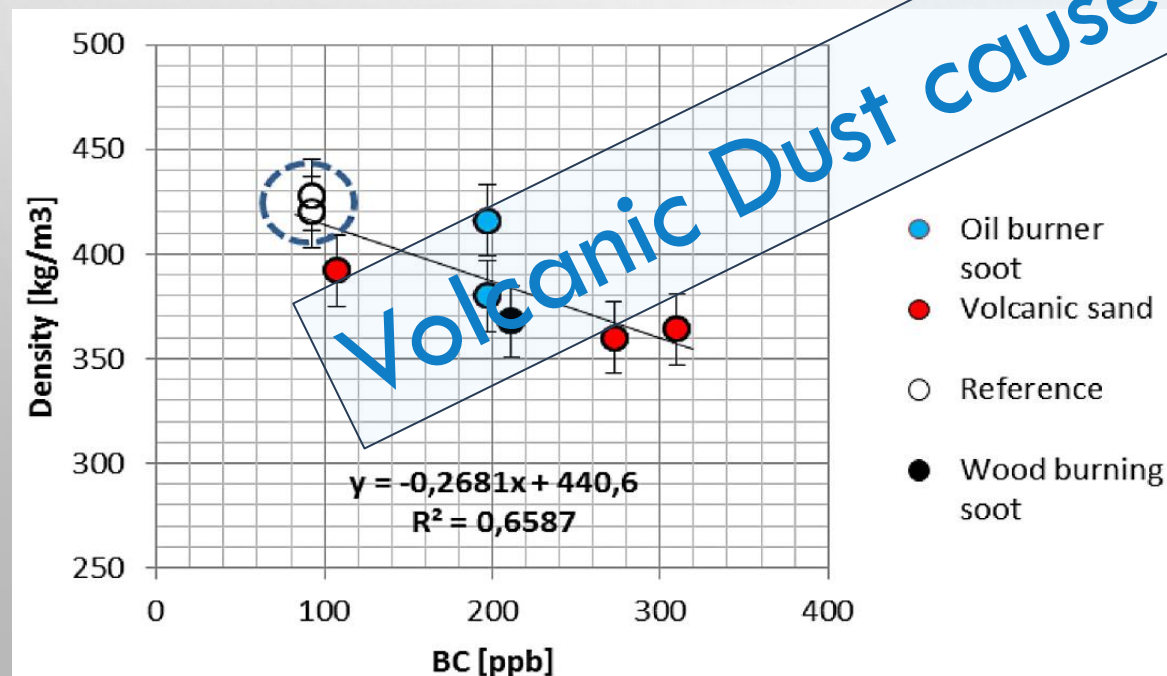
J. L. Peltoniemi^{1,2}, M. Gritsevich^{1,2,8}, T. Hakala¹, P. Dagsson-Waldhauserová^{5,6,7}, Ö. Arnalds⁹, K. Anttila^{1,3}, H.-R. Hannula⁴, N. Kivekäs³, H. Lihavainen³, O. Meinander³, J. Svensson^{3,9}, A. Virkkula³, and G. de Leeuw^{2,3}

The Cryosphere, 8, 991–995, 2014
www.the-cryosphere.net/8/991/2014/
doi:10.5194/tc-8-991-2014
© Author(s) 2014. CC Attribution 3.0 License.

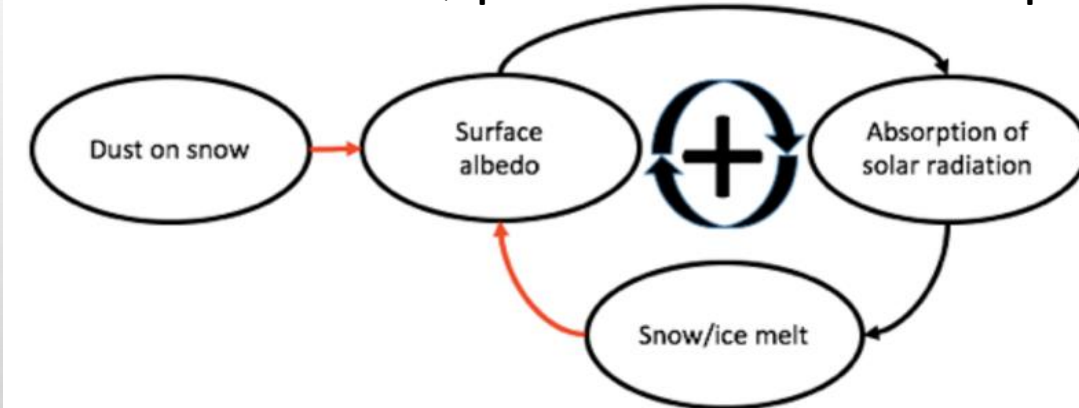
Brief communication: Light-absorbing impurities can reduce the density of melting snow

O. Meinander¹, A. Korhonen², A. Virkkula³, A. Arola⁴, J. Backman¹, P. Dagsson-Waldhauserová^{4,5}, O. Järvinen⁶, T. Manninen¹, J. Svensson^{3,9}, G. de Leeuw^{1,8}, and M. Leppäranta⁶

- VOLCANIC DUST DECREASES SNOW ALBEDO SIMILARLY AS BLACK CARBON
- SOOT DECREASES WATER RETENTION CAPACITY AND DENSITY OF SNOW



‘Dust-albedo effect’ → positive feedback for Arctic amplification



Atmos. Chem. Phys., 19, 2015–2061, 2019
https://doi.org/10.5194/acp-19-2015-2019
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Interactions between the atmosphere, cryosphere, and ecosystems at northern high latitudes

Michael Boy¹, Erik S. Thomson², Juan-C. Acosta Navarro³, Olafur Arnalds⁴, Ekaterina Batchvarova^{5,6}, Jaana Bäck⁷, Frank Berninger⁸, Merete Bilde⁹, Zoé Brasseur¹, Pavla Dagsson-Waldhauserová^{1,8,10}, Dimitri Castarède¹,

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DUST IMPAIRS AIR QUALITY AT HIGH ATMOSPHERIC ALTITUDES DURING ARCTIC WINTER

www.nature.com/scientificreports/

Jan 13 2016

100 km

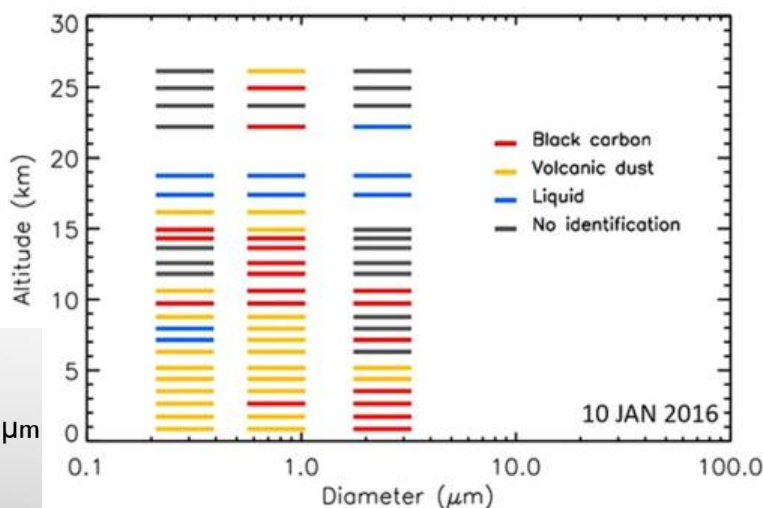
MODIS

Clean profiles PNC < 5 particles cm⁻³

Clean Arctic conditions

Polluted profiles PNC > 250 particles cm⁻³

Dirty Saharan dust layer



Particle sizes

Surface	up to 20 μm
900 m	submicron + few 10 μm
3,5 km	< 5 μm
6 km	submicron



Loftið mjög tært þegar komið var í 1.000 metra hæð

**SCIENTIFIC
REPORTS**
nature research

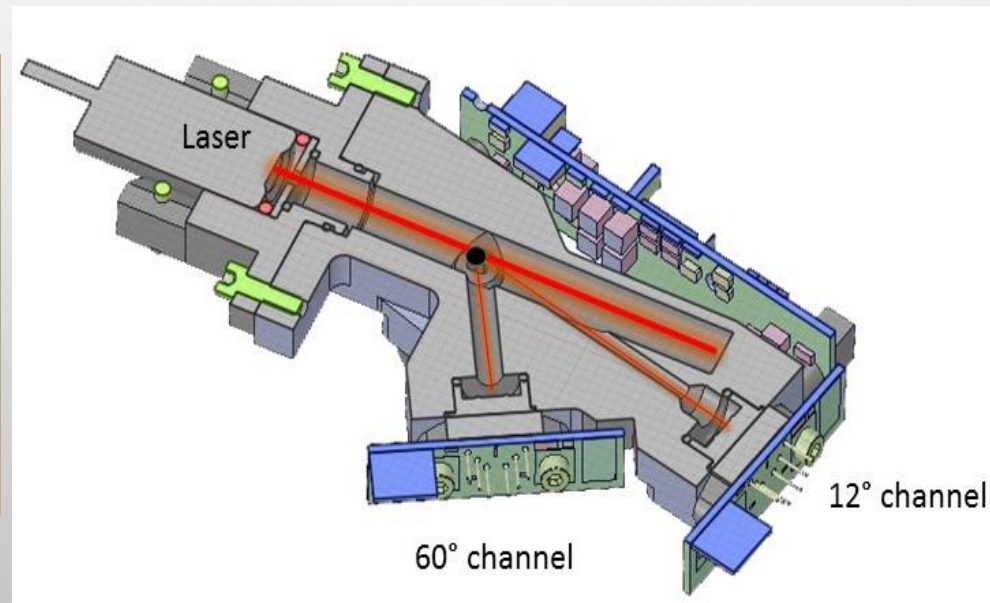
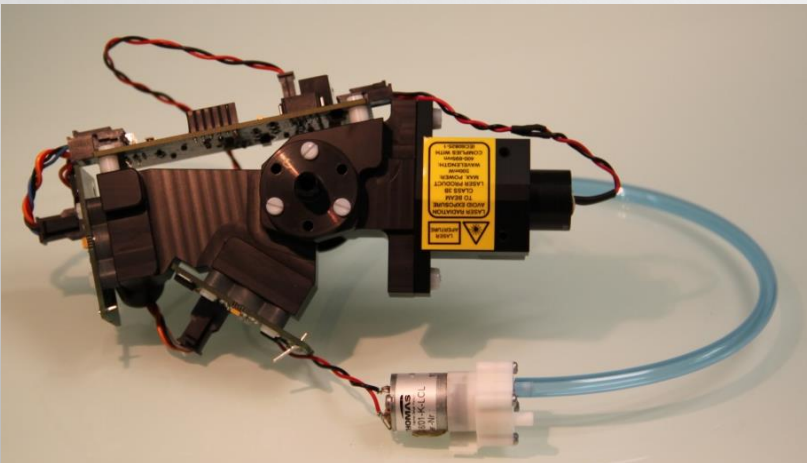
Vertical distribution of aerosols in dust storms during the Arctic winter

Pavla Dagsson-Waldhauserova^{1,2*}, Jean-Baptiste Renard³, Haraldur Olafsson^{4,5}, Damien Vignelles³, Gwenaél Berthet³, Nicolas Verdier⁶ & Vincent Duverger³

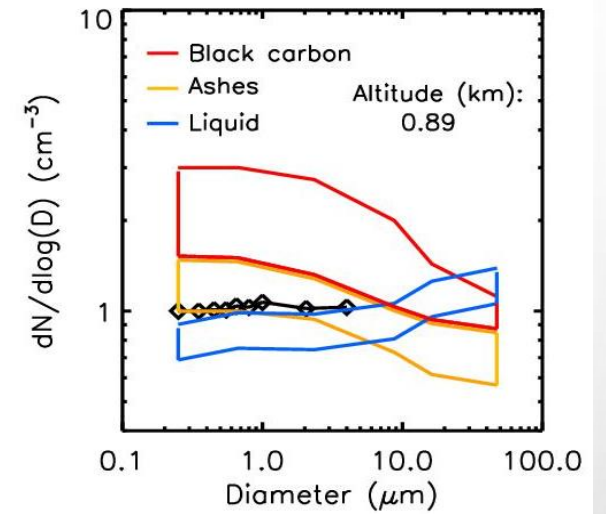
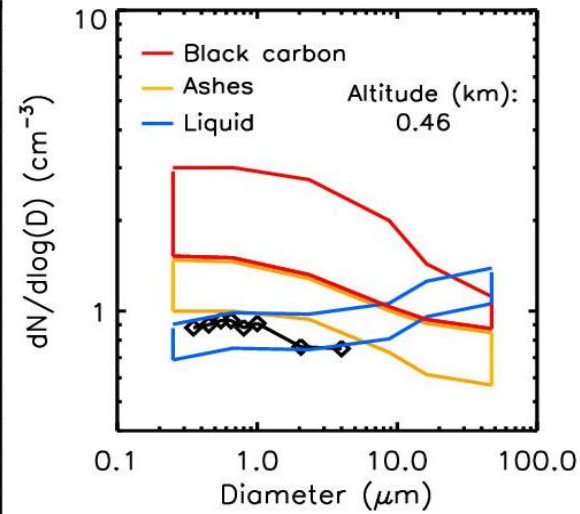
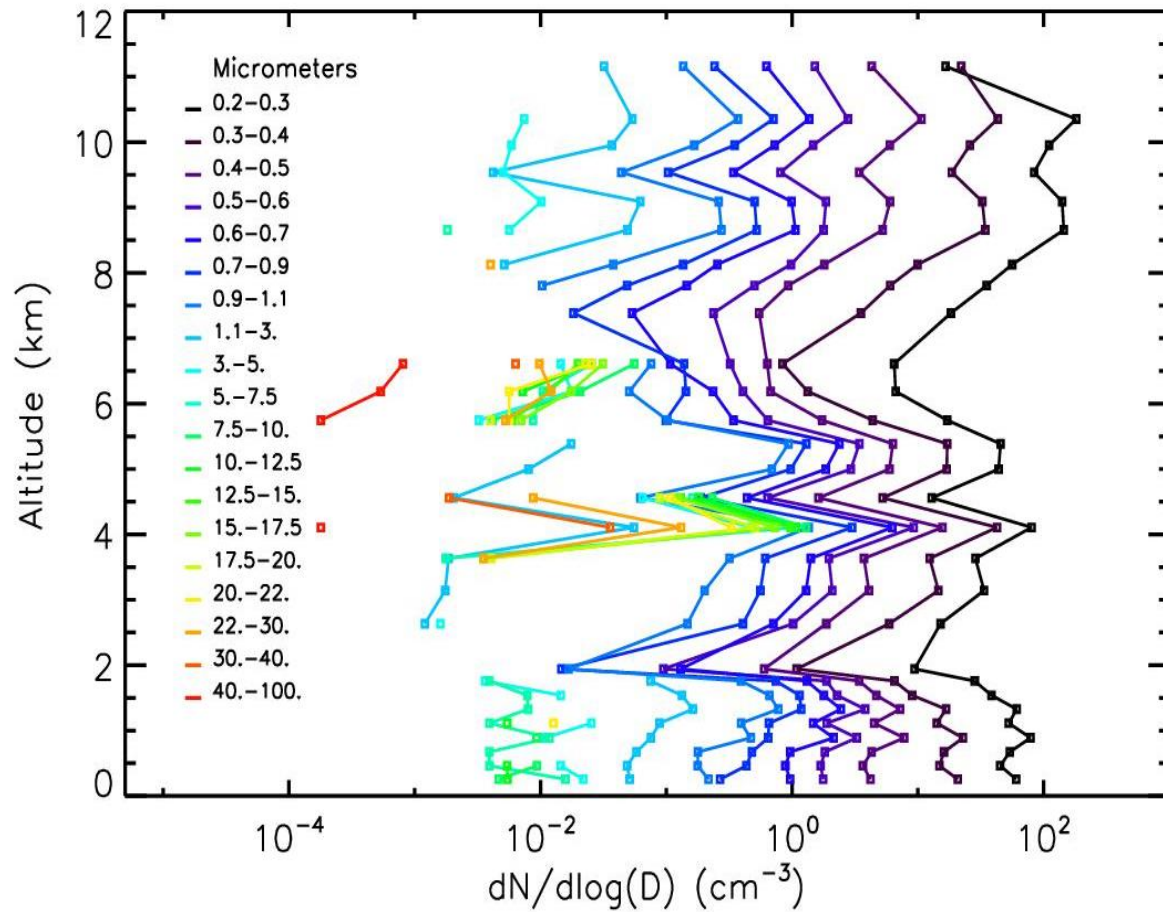
AIR BORNE MEASUREMENTS WITH LOAC 2013-2016

(LIGHT OPTICAL AEROSOL COUNTER)

- **LOAC** can determine **aerosol concentrations** in **19 size classes** (**0.2 and 100 μm**) and to **estimate their typology** (Renard et al., AMT, 2016)
- **Measurements at 2 scattering angles :**
 - $\sim 12^\circ$, insensitive to refractive index of the particles (mainly diffraction) \Rightarrow accurate size determination and counting
 - $\sim 60^\circ$, strongly sensitive to the refractive index of the particles \Rightarrow indication of the nature of the particle (typology)

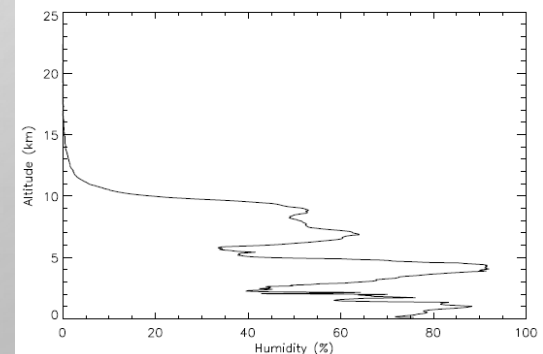
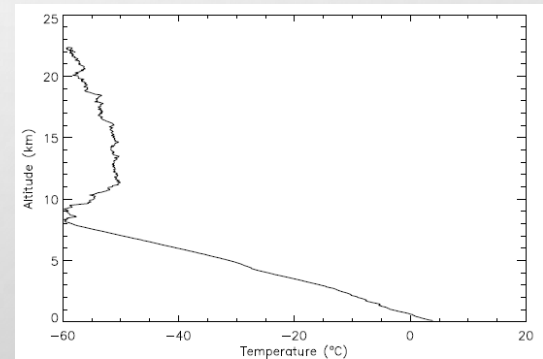


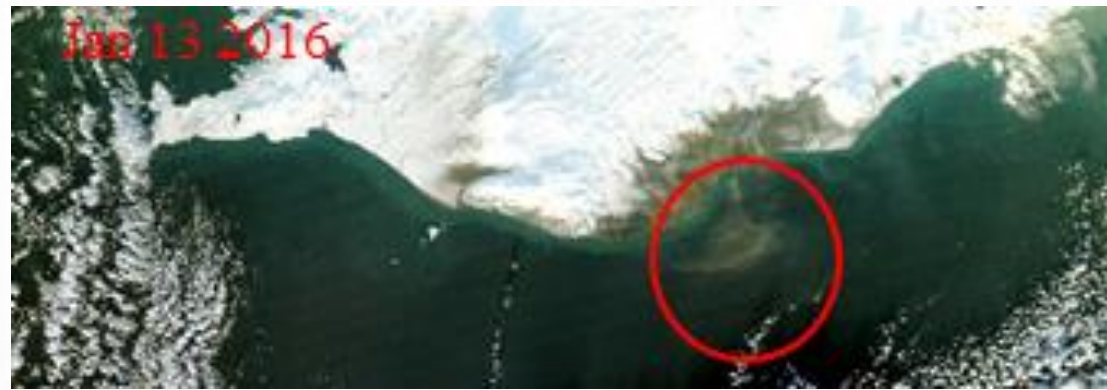
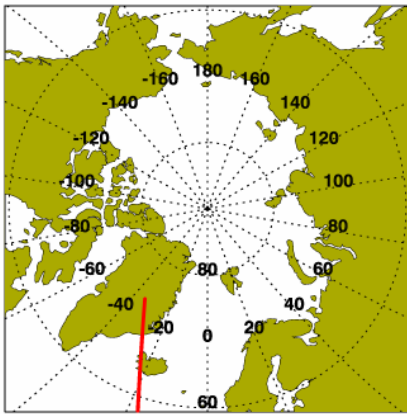
7 NOV 2013



Surface wind 8 ms^{-1} , surface $\text{PM}_{10} > 100 \mu\text{m}^{-3}$, mixed showers

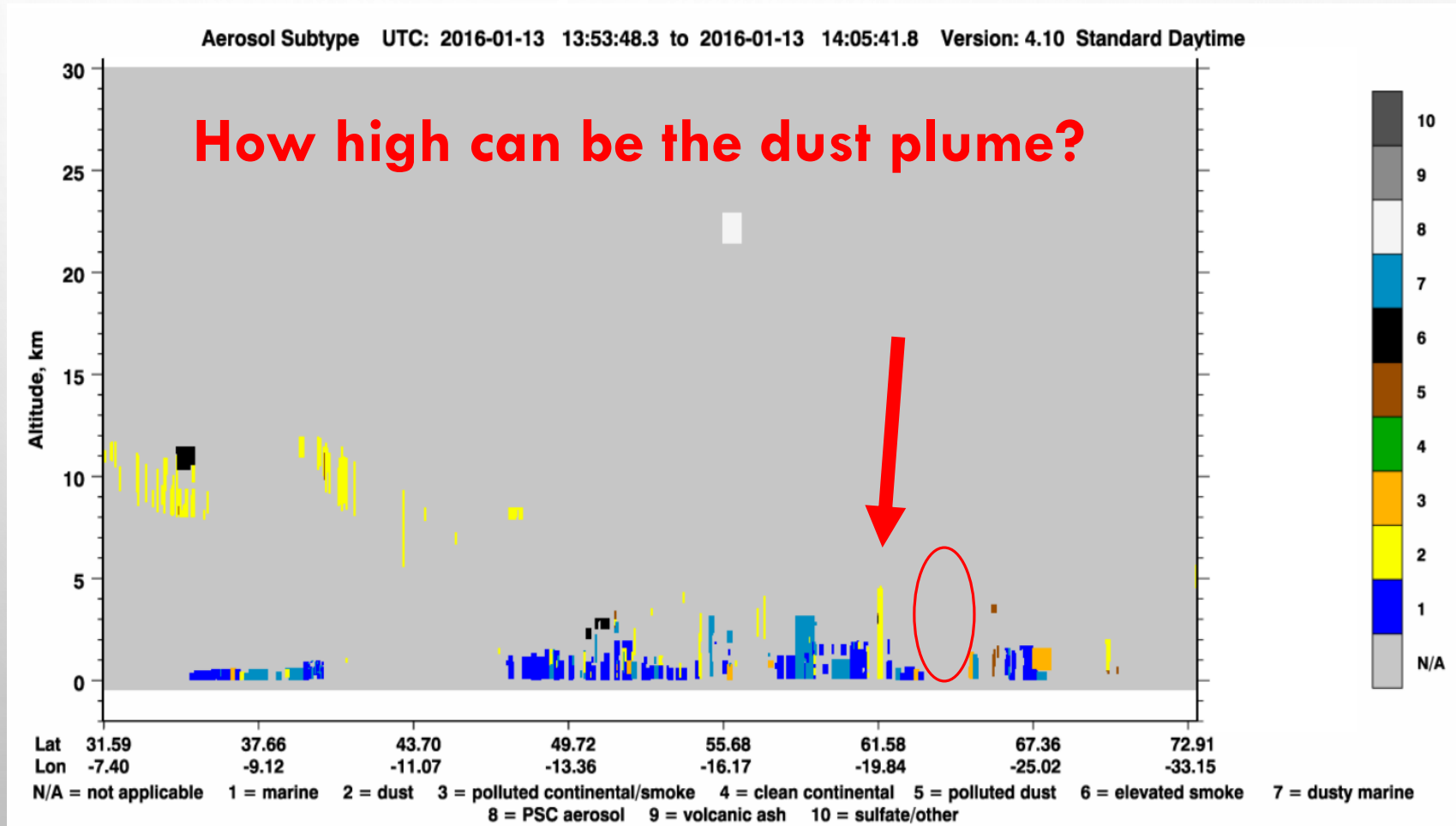
- The number concentration exceeded $40 \text{ particles cm}^{-3}$ ($10 \mu\text{g m}^{-3}$) at altitude of 1 km
- Liquid particles at 500 m





Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations (CALIPSO)

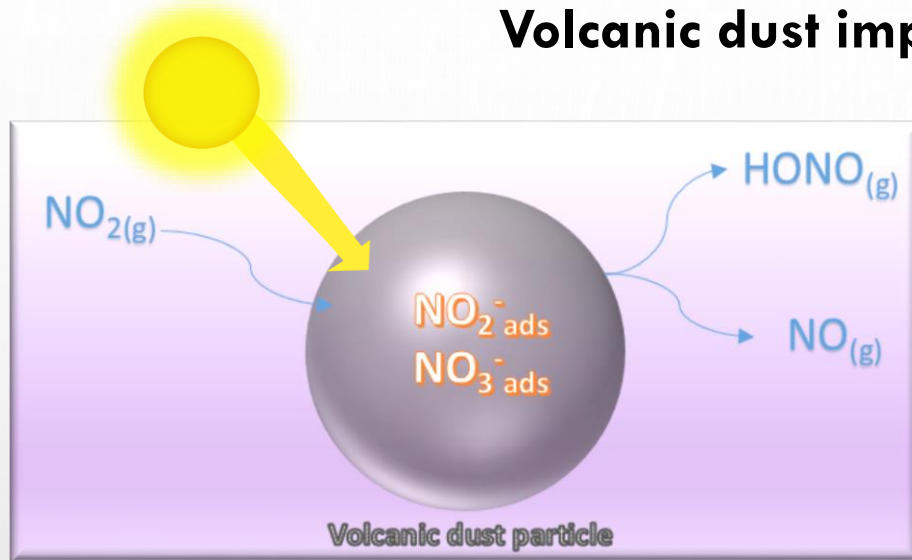
Cloud-Aerosol Lidar with Orthogonal Polarization (CALIOP) instrument that operates at two wavelengths (532 nm and 1064 nm)



TALK OUTLINE

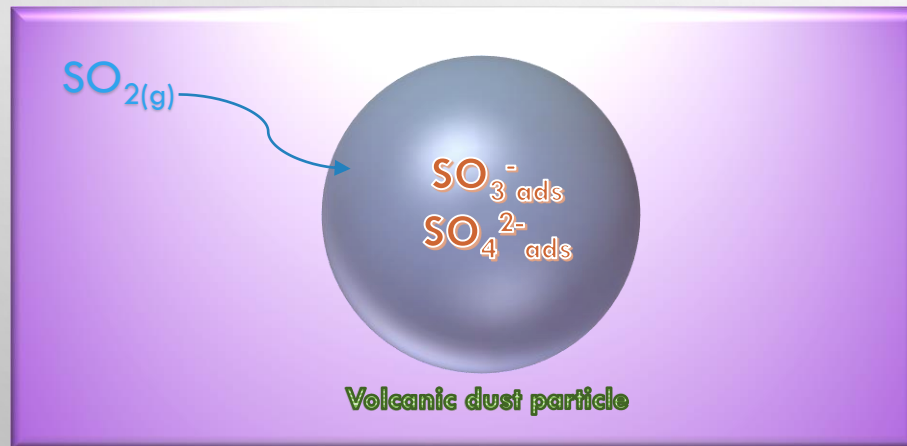
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Volcanic dust impacts on atmospheric chemistry



Dust particles scavenge efficiently NO_2 acting as transported media of surface nitrites and nitrates. Dust particles convert NO_2 to HONO (nitrous acid), a very important precursor of OH radicals (HONO is photolysed during day time producing OH and NO)

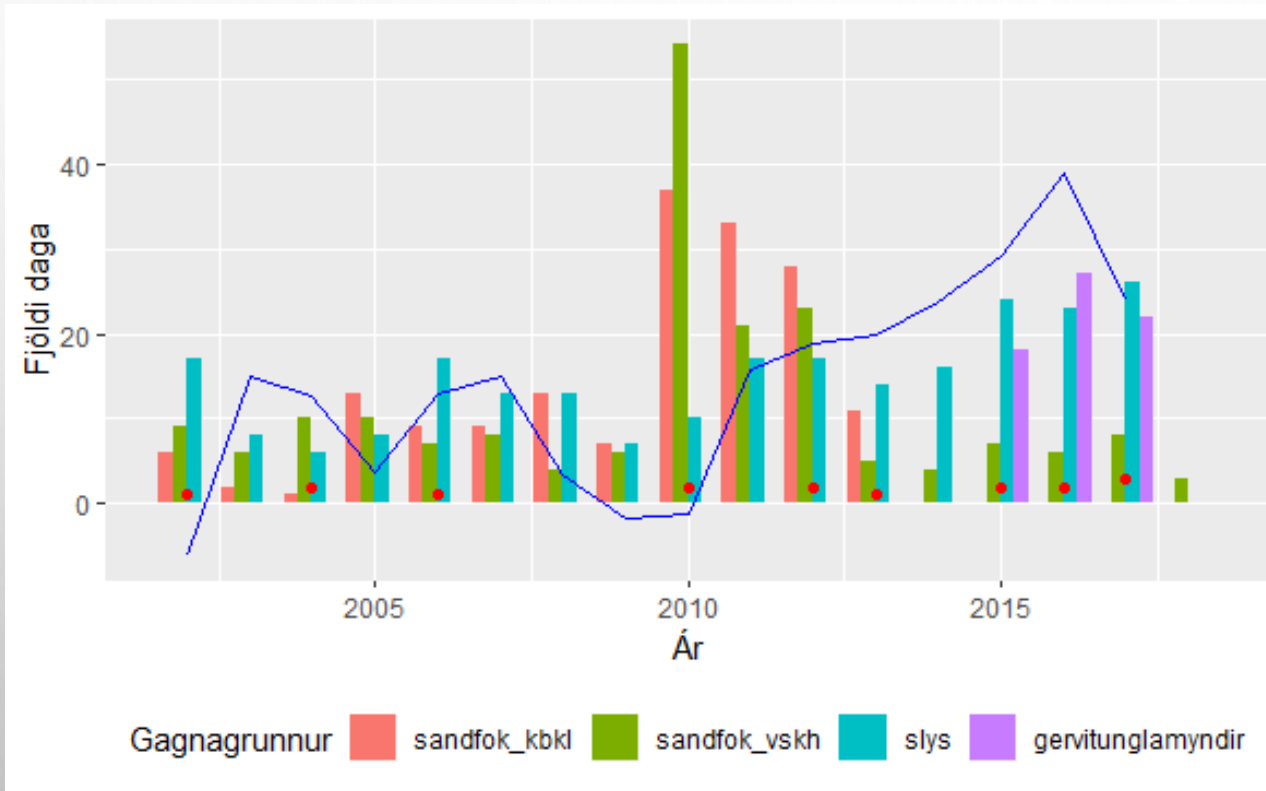
Romanias et al., submitted J. Env. Sci.



SO_2 is scavenged very efficiently on dust particles to form sulfites and sulfates. Therefore, the acidity of the particles can change as well as the hygroscopic and optical properties.

Urupina et al. (2019)

SANDSTORMS AND TRAFFIC SAFETY IN SOUTH ICELAND



Accidents due to dust weather reported by police



Sandfok
og umferðaröryggi

Esther Hlíðar Jensen, Ingibjörg Jónsdóttir, Haraldur Sigþórsson,
Einar Sveinbjörnsson og Pavla Dagsson Waldhauserová

First HLD operational forecast under WMO SDS-WAS

Officially launched in 2020

Log in

NORTHERN AFRICA-MIDDLE EAST-EUROPE (NA-ME-E) REGIONAL CENTER
WMO Sand and Dust Storm Warning Advisory and Assessment System (SDS-WAS)

World Meteorological Organization
GOBIERNO DE ESPAÑA
AEMET
BSC Barcelona Supercomputing Center

WMO SDS WAS || Asia Regional Center || America Regional Center

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Dust forecasts

by admin — last modified Mar 16, 2020 04:53 PM

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Serbian WMO MeteoWorld contribution about Australian SDS
Apr 09, 2020

New Forecast Product: Icelandic Dust
Mar 17, 2020

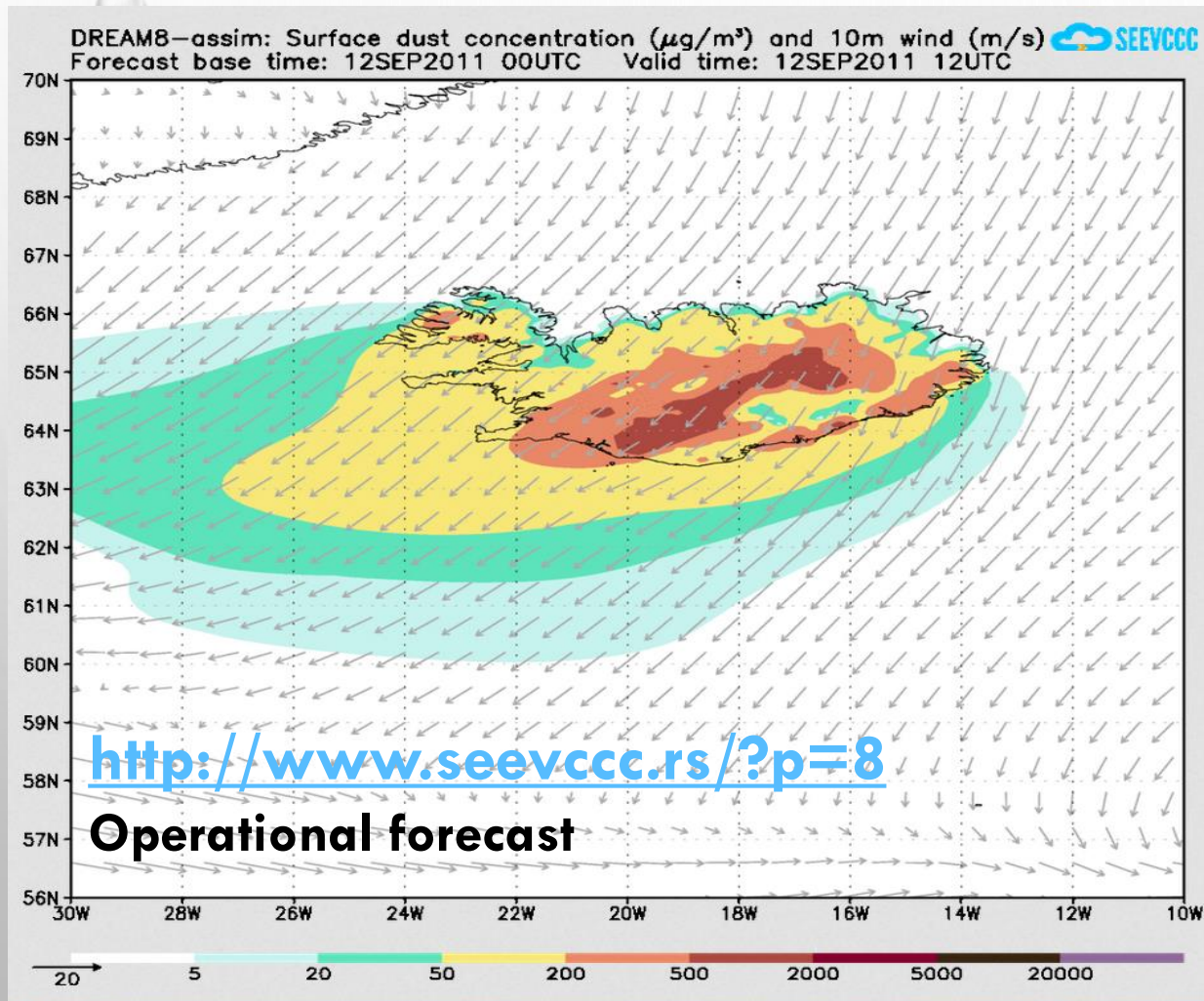


inDust

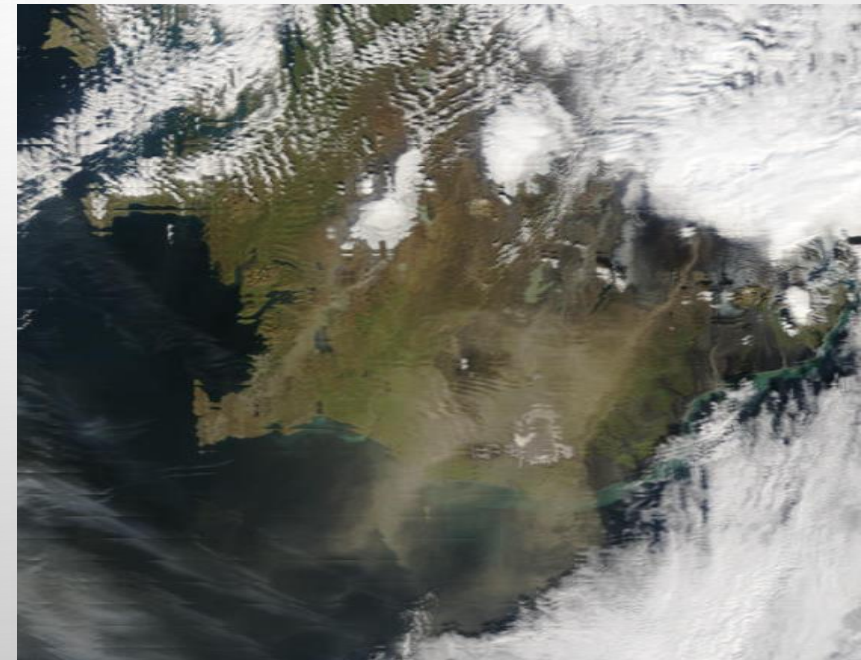
The **International Network to Encourage the Use of Monitoring and Forecasting Dust Products**

DREAM Iceland (Dust Regional Atmospheric Model)

- See poster of Cvetkovic, Nickovic et al.




Soon part of the WMO Sand/Dust Storm forecasts




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 Icelandic Aerosol and Dust Association
(IceDust)
Rýkrannsóknafélag Íslands (RvkiS)

Home About Who we are? Past events **Publications** Contact Open positions


Witnessed dust storm?



NOVEMBER 30, 2019
Workshop on Effects and Extremes of High Latitude Dust (HLD Workshop), Reykjavik, 13-14 Feb 2020



OCTOBER 4, 2019
Open call for travel grants to the Workshop on Effects and Extremes of High Latitude Dust (Reykjavik, 13-14 FEB 2020)




SEPTEMBER 26, 2019
'Dust is climate driver in Polar Regions' says the new IPCC report

Search for topic on IceDust


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Upcoming Dust Events


- High Latitude Dust Workshop February 13, 2020
- High Latitude Dust Workshop February 14, 2020




AUGUST 21, 2019
Doctoral defense on Icelandic dust




OCTOBER 31, 2018
Effects and Extremes of High Latitude Dust, IASC Workshop, Reykjavik, 13-14 Feb 2019




AUGUST 27, 2018
Short guest lectures at the Agricultural University of Iceland



JANUARY 18, 2018
THE 2nd ICEDUST WORKSH OP



NOVEMBER 29, 2017
The Frontiers open new Research Topic on Aerosol in cold regions and cryosphere - Call for papers



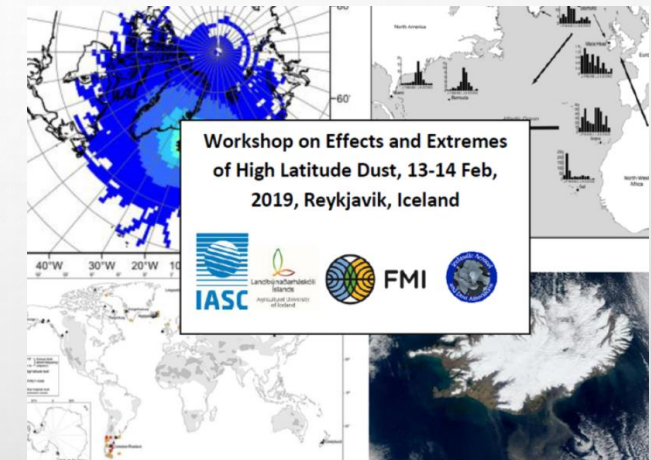
JUNE 7, 2017
International conference on High Latitude Dust in Reykjavik



HLD Workshop V

February 10-11 2021

-free entrance, everybody welcome!



Thank you for your attention!
pavla@lbhi.is



European Geosciences Union
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IE1.1/CR1.14/AS4.21/BG9.66 **Media**

Atmosphere - Cryosphere interaction in the Arctic, high latitudes and mountains: Transport and deposition of aerosols, eScience and ensemble methods (co-organized)

Convener: Pavla Dagsson Waldhauserova

Co-Conveners: Biagio Di Mauro, Marie Dumont, Andreas Stohl, Alberto Carrassi, Helmut Neukirchen, Ignacio Pizzo

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