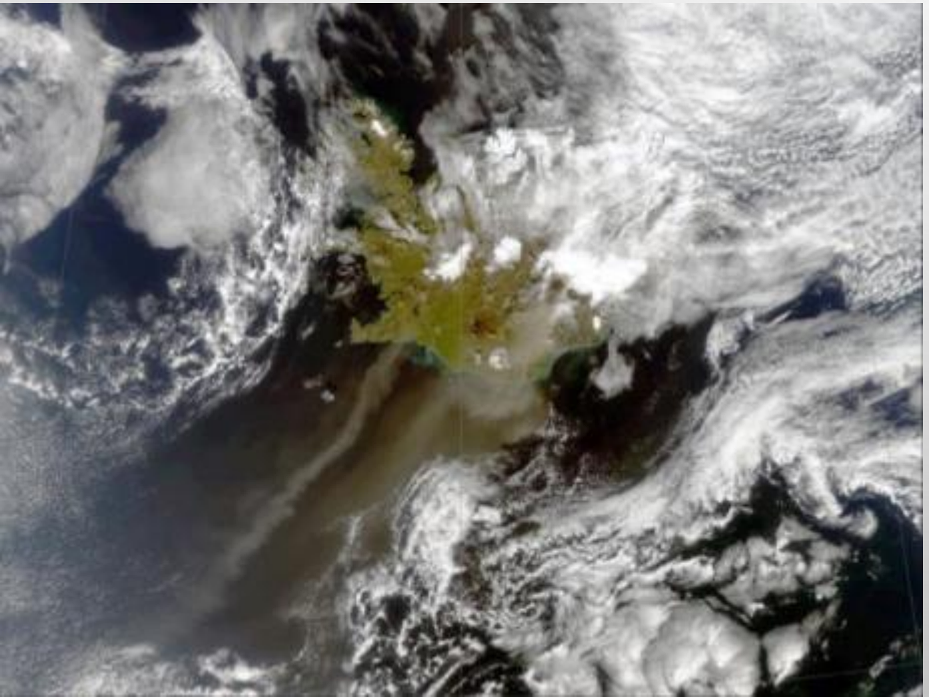
WINTER DUST STORMS IN THE ARCTIC



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

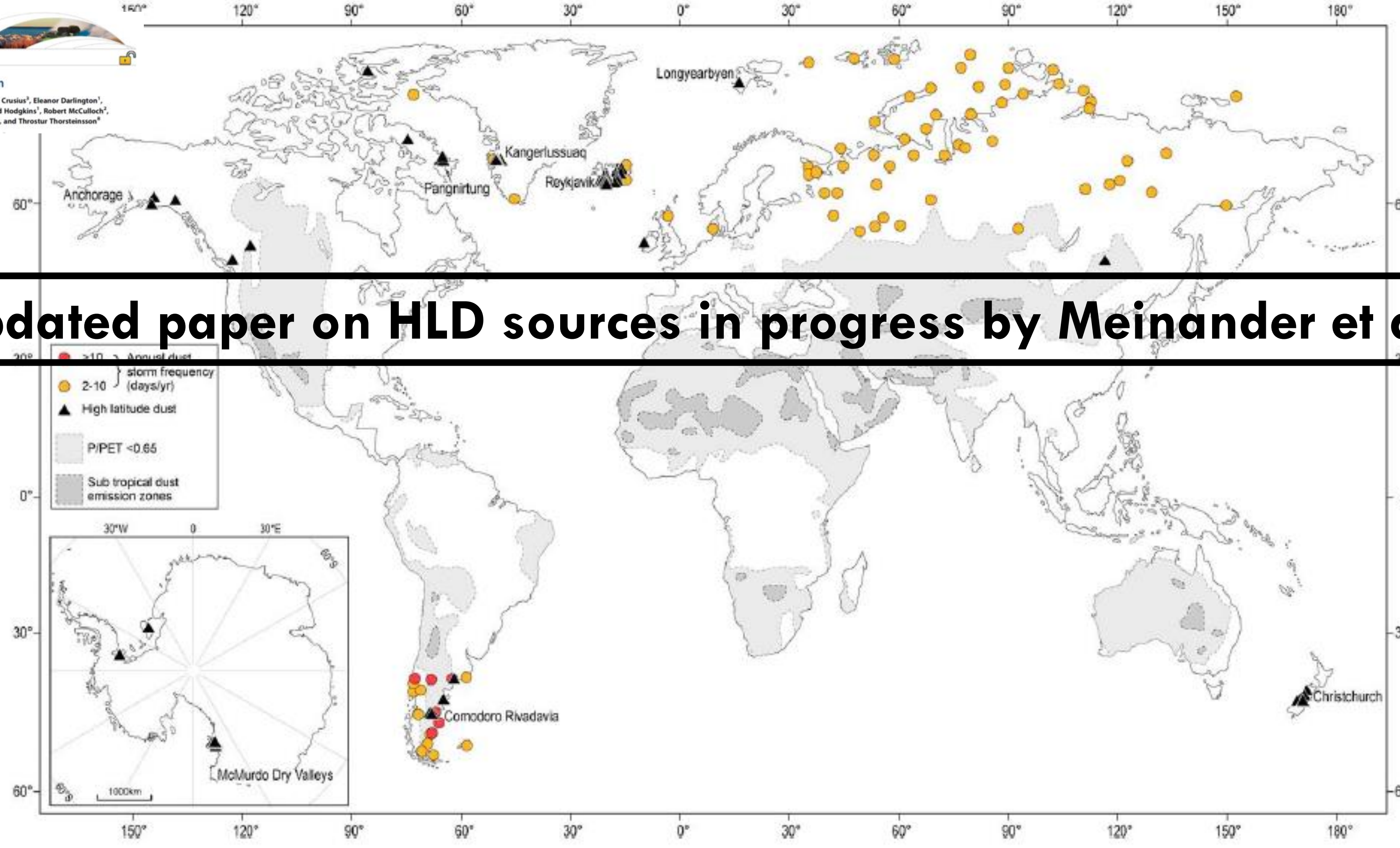
4TH MAY 2020

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 VARIABLITY 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


AGU PUBLICATIONS
Reviews of Geophysics
REVIEW ARTICLE
10.1002/2016RG000518
High-latitude dust in the Earth system
Joanna E. Bullard[1], Matthew Baddock[1], Tom Bradwell[2], John Crusius[3], Eleanor Darlington[1], Diego Gaiero[4], Santiago Gassó[5], Gudrun Gisladottir[6], Richard Hodgkins[1], Robert McCulloch[2], Cheryl McKenna-Neuman[7], Tom Mockford[1], Helena Stewart[2], and Throstur Thorsteinsson[6]



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

AGU PUBLICATIONS
JGR
Journal of Geophysical Research: Atmospheres
RESEARCH ARTICLE
10.1002/2016JD025482

Substantial contribution of northern high-latitude sources to mineral dust in the Arctic

C. D. Groot Zwaaftink[1], H. Grythe[1,2,3], H. Skov[4], and A. Stohl[1]

Key Points:
- High-latitude dust sources in the

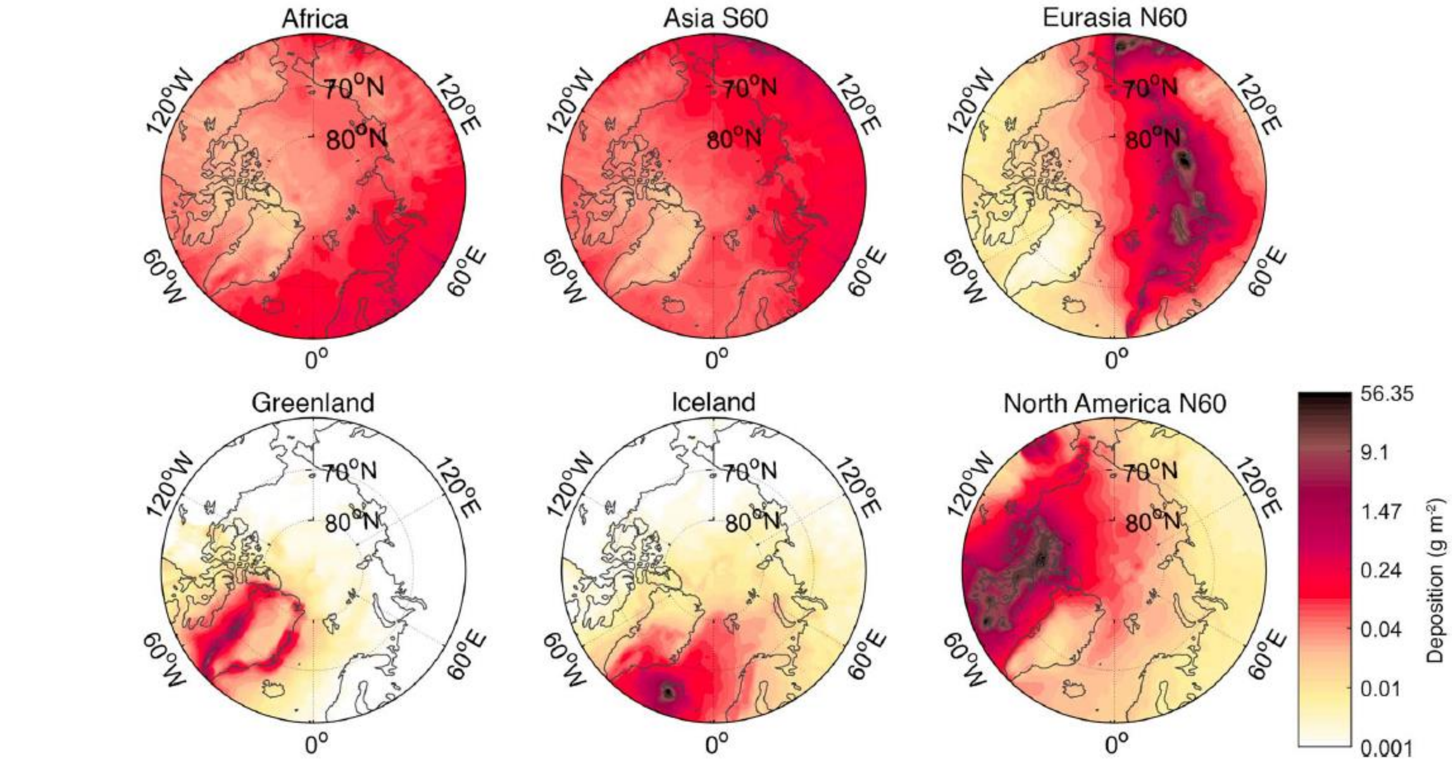


Figure 11. Simulated annual mean deposition of dust (g m^{-2}) in the near Arctic originating from different source regions averaged for years 2010–2012. Deposition is here given as the sum of dry and wet deposition.

~ **3% of global dust emission** from HLD sources

Total atmospheric dust loads in the Arctic:

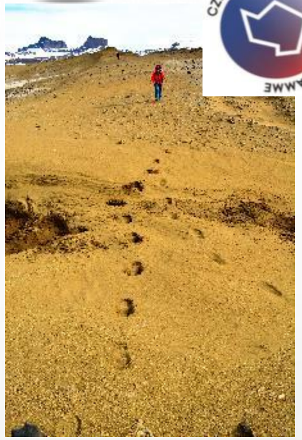
Asia (~38%)

Africa (~32%)

HLD (27%)

Surface measurements are crucially needed as shown in Antarctica.

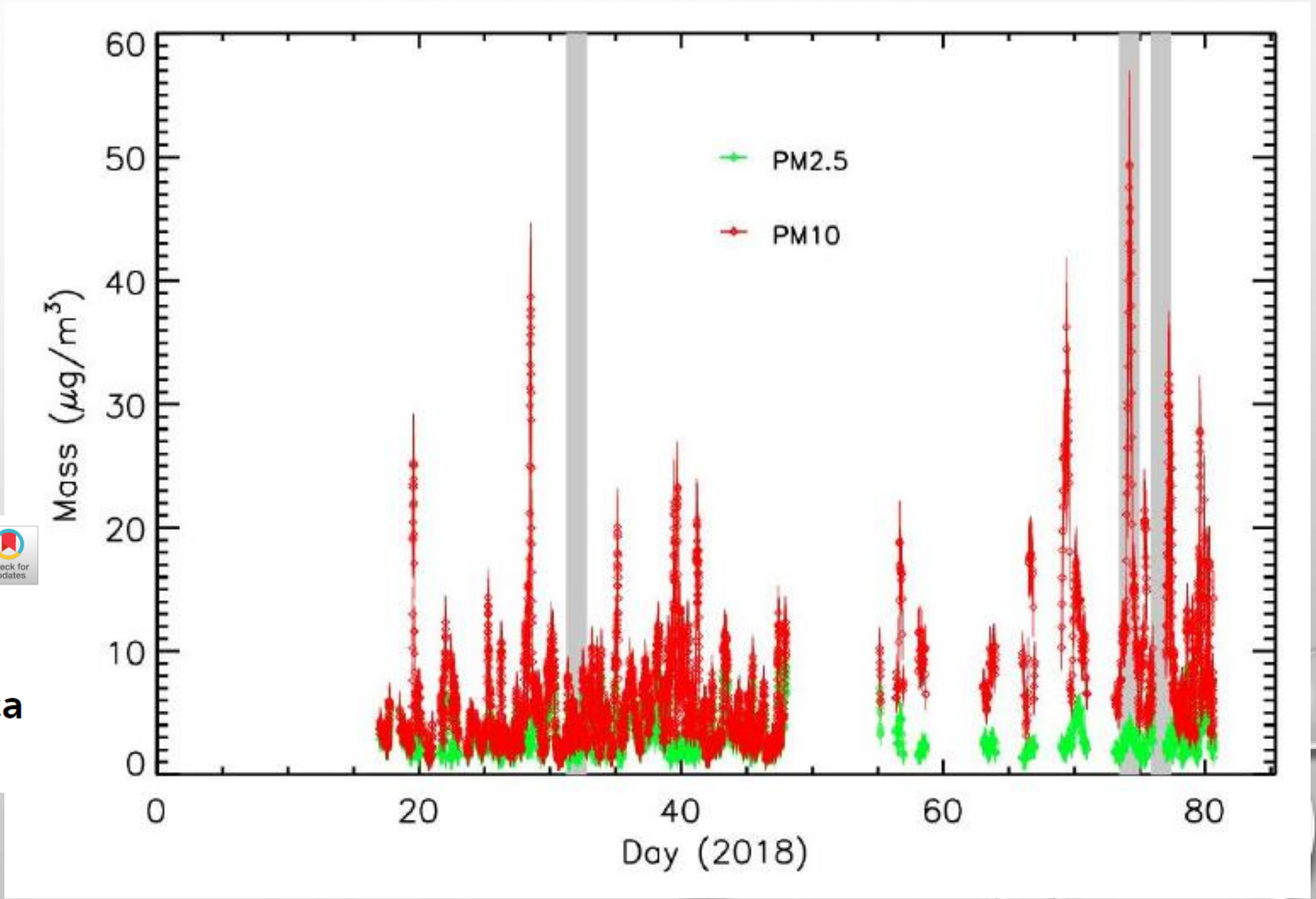
PM10 in Antarctica similar to North Europe!



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

Check for updates

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

Jan Kavan[1*], Pavla Dagsson-Waldhauserova[2,3], Jean Baptiste Renard[4], Kamil Láska[1] and Klára Ambrožová[1]

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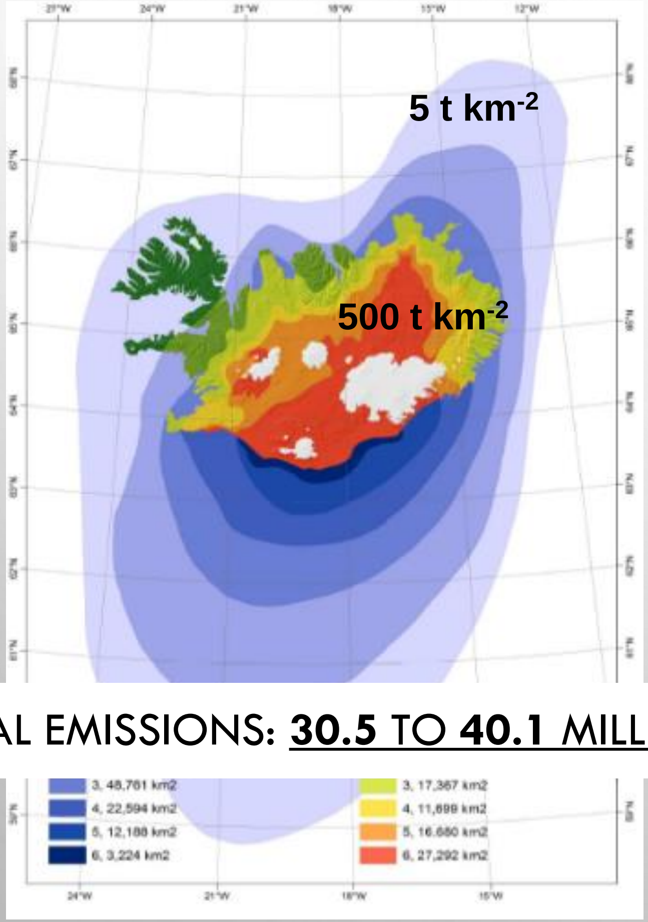
DUST DEPOSITION FROM ICELAND

Biogeosciences, 11, 6623–6632, 2014
www.biogeosciences.net/11/6623/2014/
doi:10.5194/bg-11-6623-2014

Biogeosciences Open Access

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

O. Arnalds[1], H. Olafsson[2,3,4], and P. Dagsson-Waldhauserova[1,2]



- TOTAL EMISSIONS: **30.5 TO 40.1 MILLION T**

Atmos. Chem. Phys., 17, 10865–10878, 2017
https://doi.org/10.5194/acp-17-10865-2017

Atmospheric Chemistry and Physics Open Access EGU

Temporal and spatial variability of Icelandic dust emissions and atmospheric transport

Christine D. Groot Zwaaftink[1], Ólafur Arnalds[2], Pavla Dagsson-Waldhauserova[2,3,4], Sabine Eckhardt[1], Joseph M. Prospero[5], and Andreas Stohl[1]

- TOTAL EMISSIONS: **4.3 ± 0.8** TG

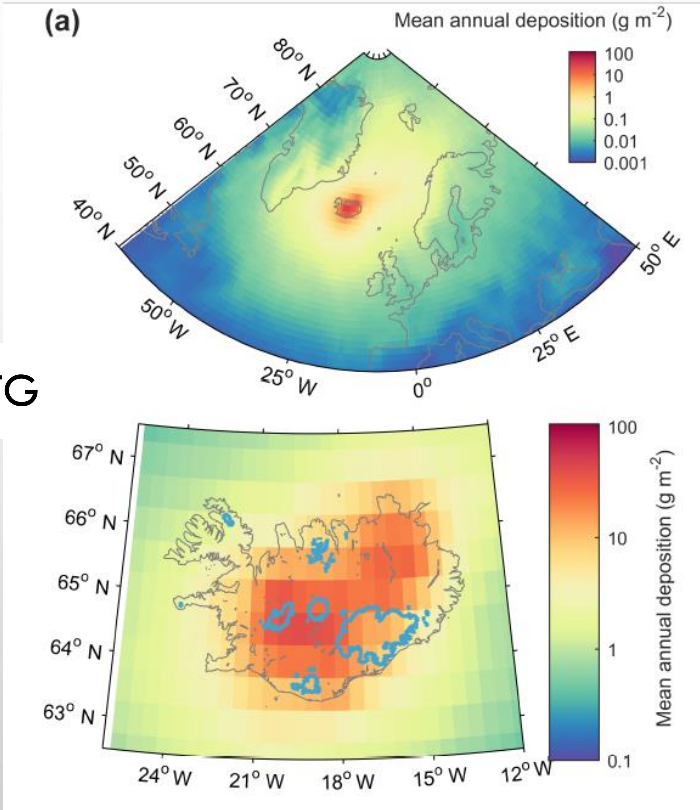


Figure 10. Mean annual dust deposition ($g\,m^{-2}$) simulated with FLEXPART in years 1990–2016 for the North Atlantic region **(a)** and Iceland **(b)**. Maximum values are lower in the upper panel than in the lower panel as this figure shows averages over larger areas. The blue lines in the bottom 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 Arnalds[2], Pavla Dagsson-Waldhauserová[2,3], Stefano Crocchianti[1], Riccardo Vivani[4] and David Cappelletti[1]

Yes, in Svalbard

Volcanic dust travelled > 3000 km

Yes, in Ireland

Contents lists available at ScienceDirect
Atmospheric Environment
journal homepage: www.elsevier.com/locate/atmosenv
ELSEVIER
ATMOSPHERIC ENVIRONMENT

Volcanic sulphate and arctic dust plumes over the North Atlantic Ocean

J. Ovadnevaite[a,b,*], D. Ceburnis[a], K. Plauskaite-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]

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. Đorđević[1*], Ivana Tosic[2], Sanja Sakan[1], Srđan Petrović[1], Jelena Đuričić-Milanković[1], David C. Finger[3] and Pavla Dagsson-Waldhauserova[4]

[1]Institute of Chemistry, Technology and Metallurgy, University of Belgrade, Serbia
[2]University of Belgrade, Serbia
[3]Reykjavík University, Iceland
[4]Agricultural 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 (□=44°48'; □=20°28') in 2012 and 2013, simultaneous with atmospheric aerosols measurements, were calculated by using the Hybrid Single-Particle Lagrangian Integrated Trajectory (HYSPLIT) 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.

Source: GRID-Arendal, 2005. Barentswatch Atlas.

Where does the Icelandic dust travel?

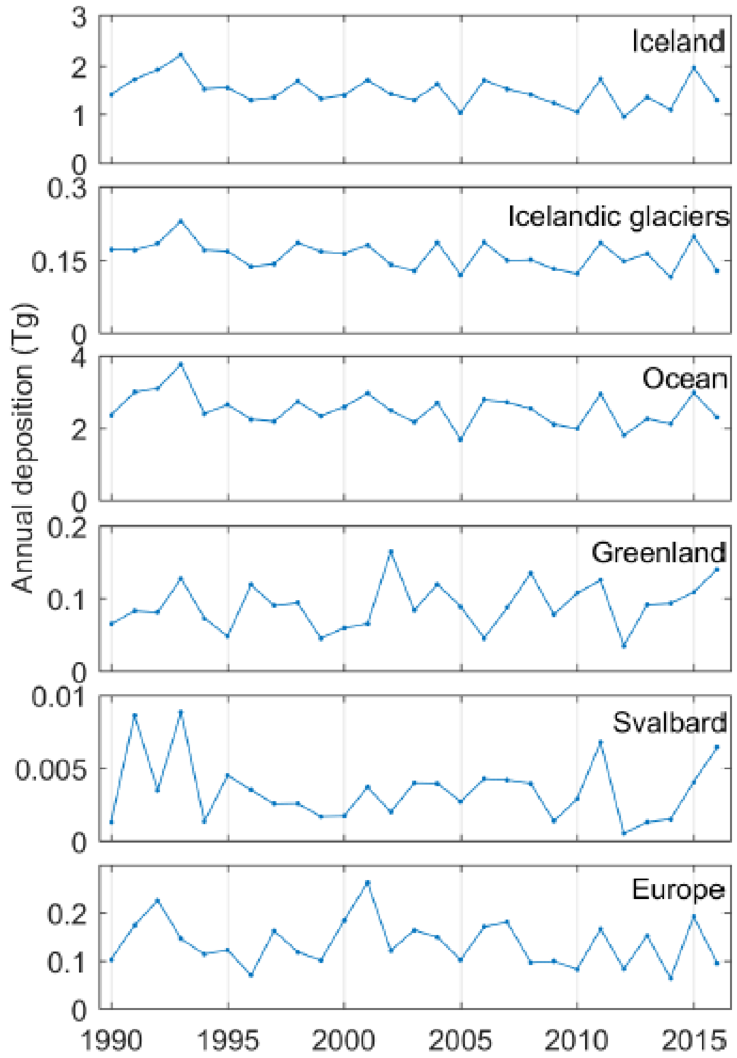


Figure 12. Time series (1990–2016) of modelled dust deposition ($Tg\,yr^{-1}$) in specific regions. Note that Iceland also includes deposition on Icelandic glaciers.

- 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° N)
- Europe deposition (3% of emitted dust)

Atmos. Chem. Phys., 17, 10865–10878, 2017
https://doi.org/10.5194/acp-17-10865-2017

Atmospheric Chemistry and Physics
Open Access
EGU

Temporal and spatial variability of Icelandic dust emissions and atmospheric transport

Christine D. Groot Zwaaftink[1], Ólafur Arnalds[2], Pavla Dagsson-Waldhauserova[2,3,4], Sabine Eckhardt[1], Joseph M. Prospero[5], and Andreas Stohl[1]

Atmos. Chem. Phys., 14, 13411–13422, 2014
www.atmos-chem-phys.net/14/13411/2014/
doi:10.5194/acp-14-13411-2014

Atmospheric Chemistry and Physics
Open Access

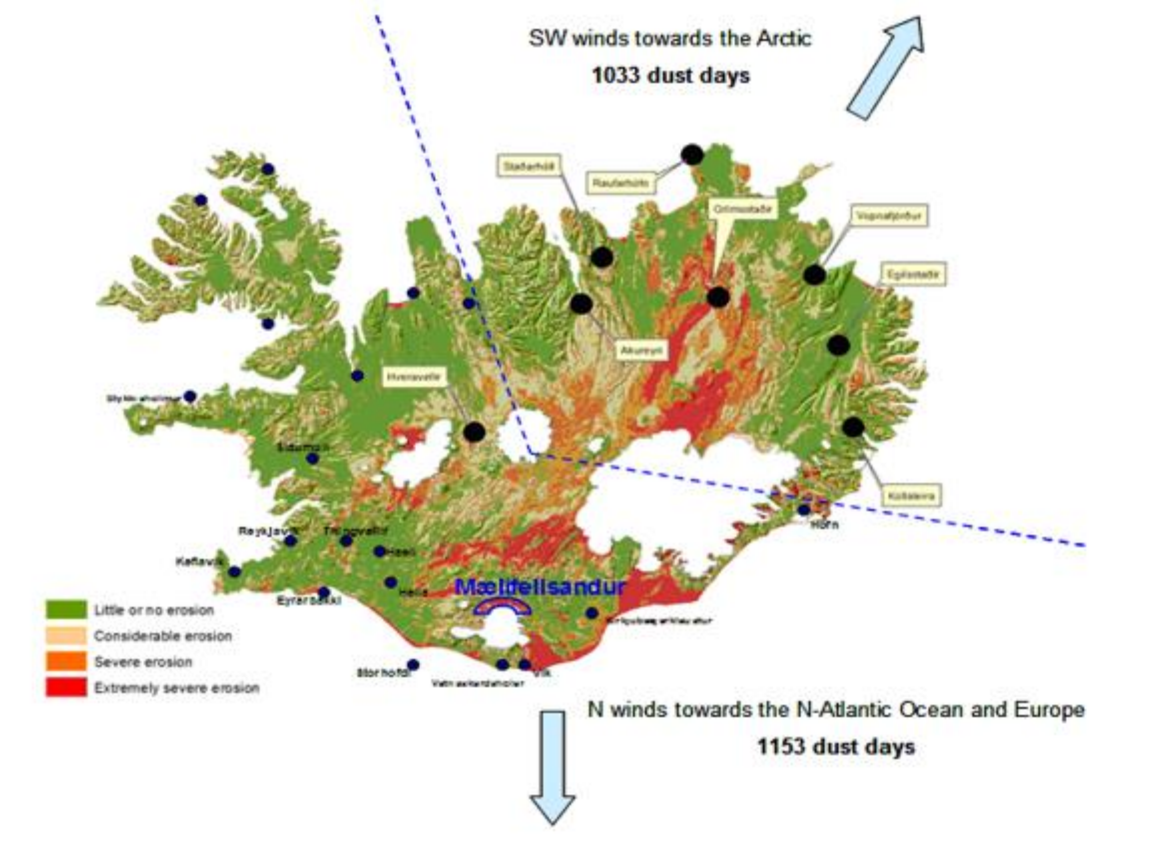
FREQUENCY OF DUST EVENTS

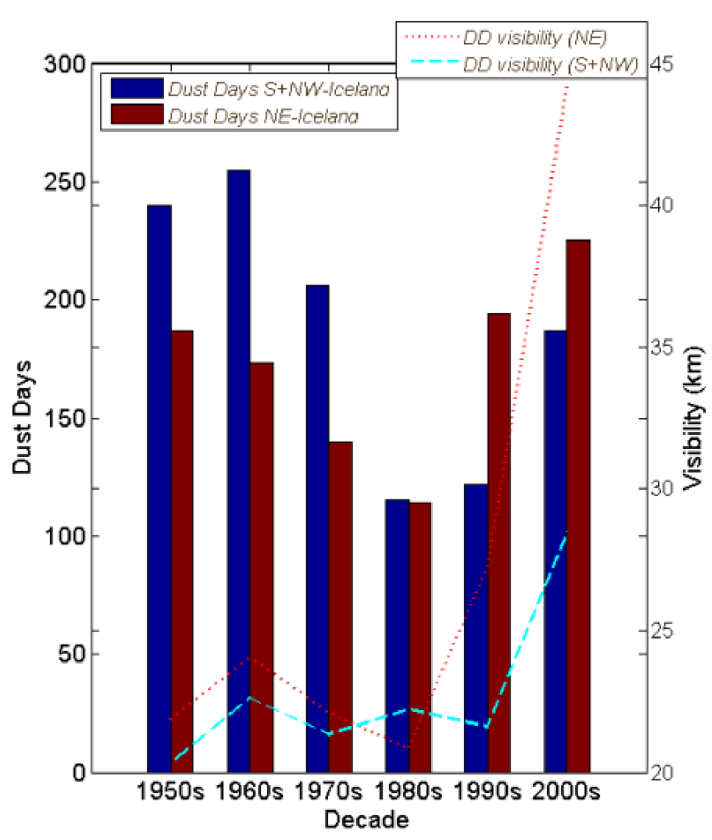
Long-term variability of dust events in Iceland (1949–2011)

P. Dagsson-Waldhauserova[1,2], O. Arnalds[1], and H. Olafsson[2,3,4]

- 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



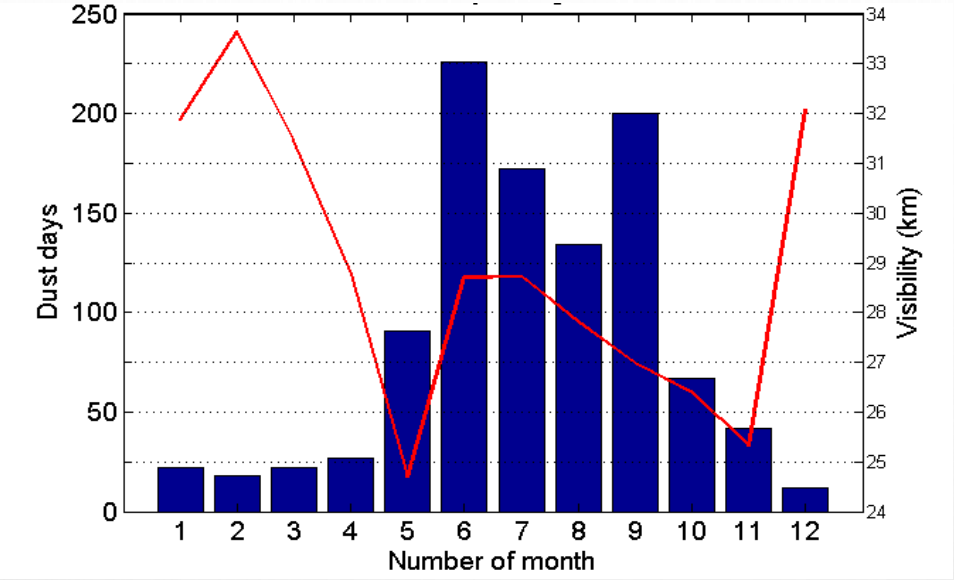


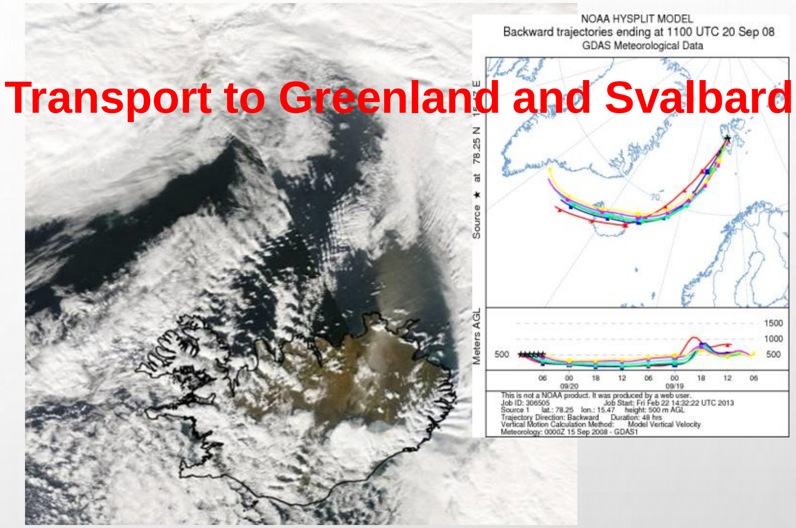
SEASONAL VARIABILITY OF DUST EVENTS

- NE ICELAND

"ARCTIC DUST EVENTS"

SUMMER

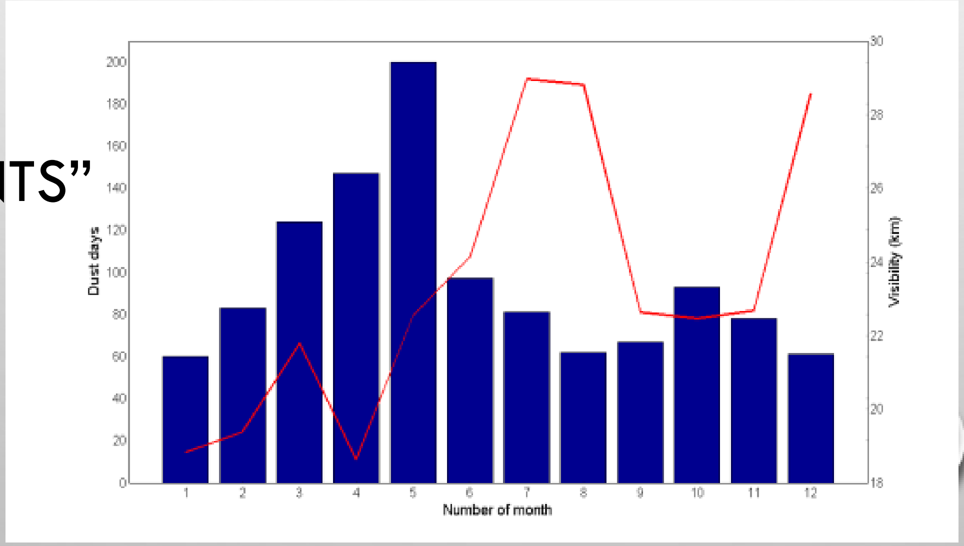


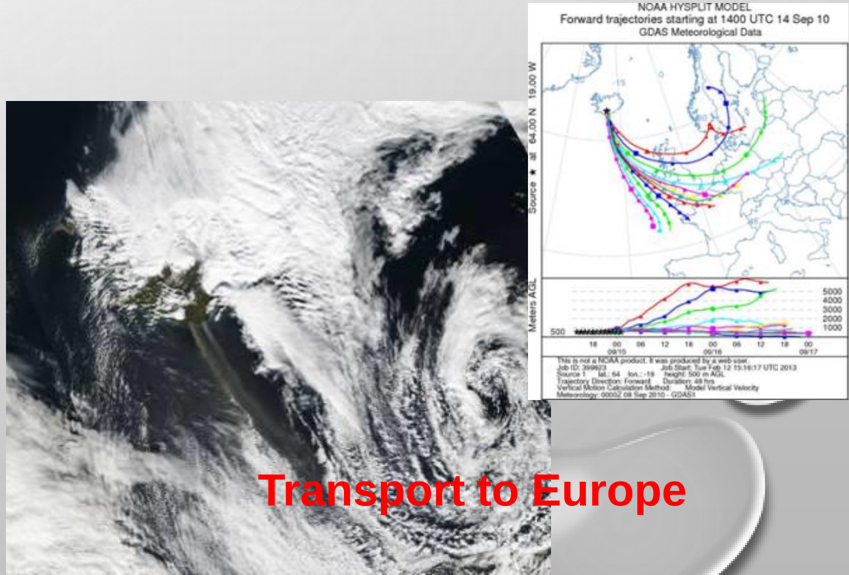


- S ICELAND

"SUB-ARCTIC DUST EVENTS"

WINTER-SPRING





AN EXAMPLE OF WINTER DUST STORM

Snow-Dust Storm

Contents lists available at ScienceDirect

Aeolian Research

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

ELSEVIER

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

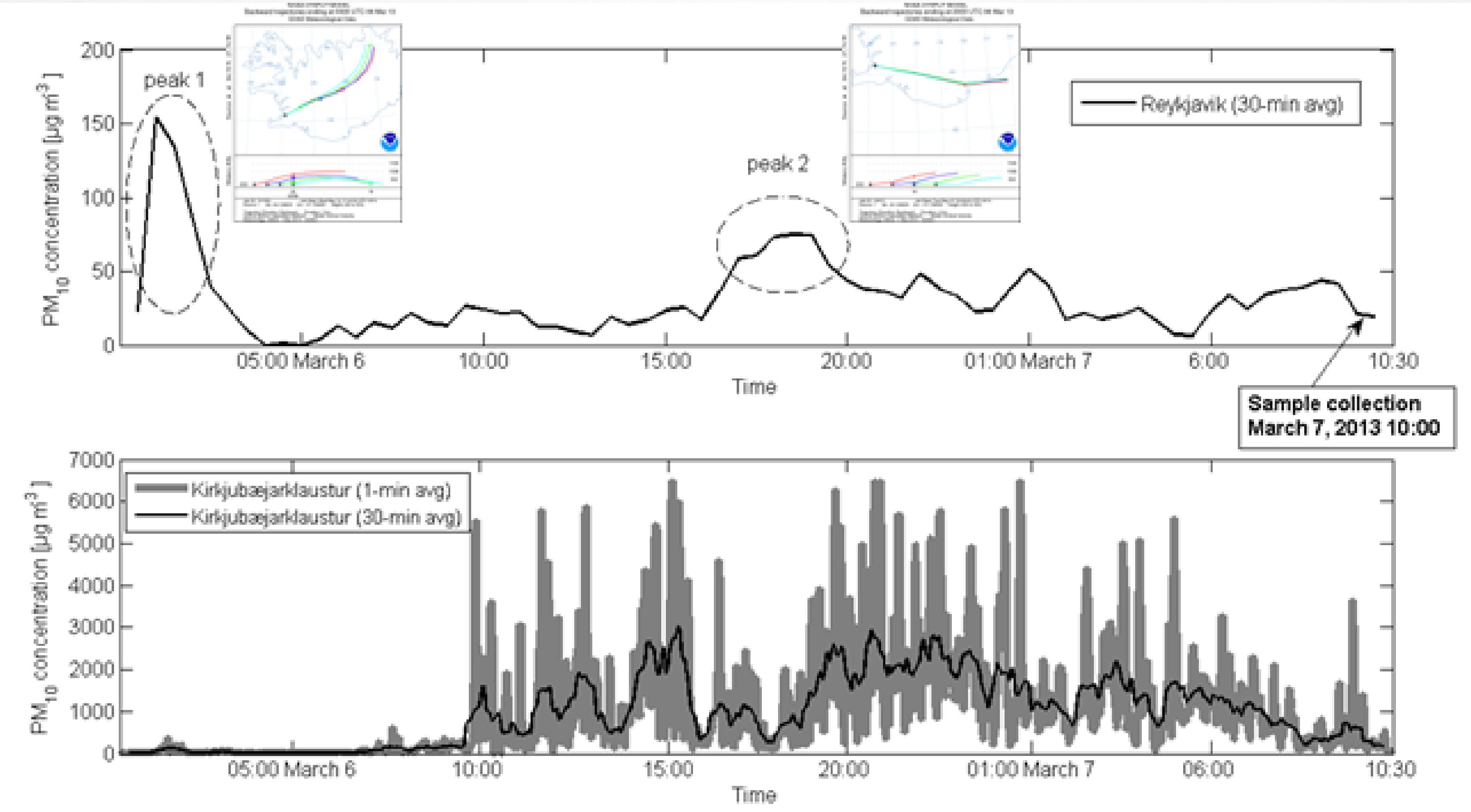
Pavla Dagsson-Waldhauserova [a,b,g,*], Olafur Arnalds [a], Haraldur Olafsson [b,c,d], Jindrich Hladil [e], Roman Skala [e], Tomas Navratil [e], Leona Chadimova [e], Outi Meinander [f]

A SNOW-DUST STORM

- Mean (median) PM_{10} concentration during 24-hour storm ~ 1,281 (1,170) µg m^{-3}
- Max one-minute PM_{10} concentration ~ **6500 µg m^{-3}**

Kirkjubæjarklaustur

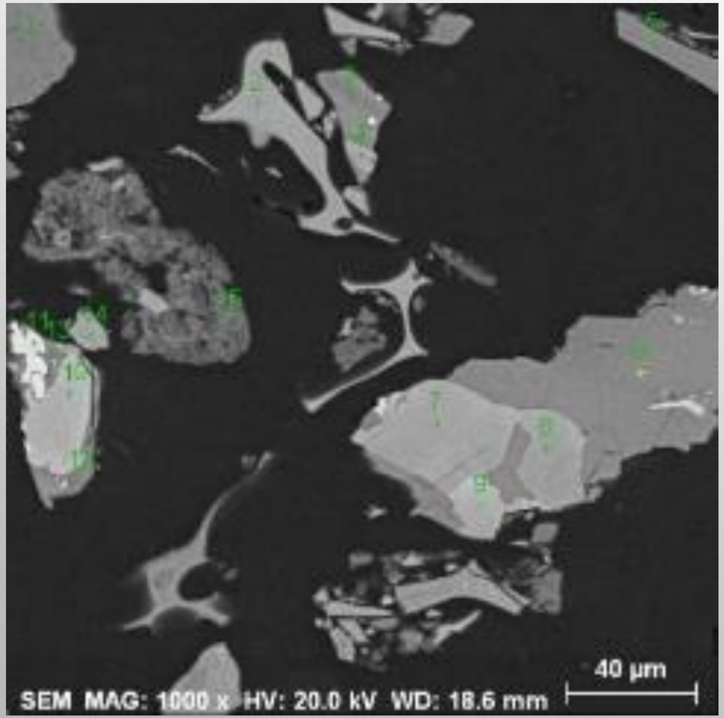
Reykjavík (250 km from the source)

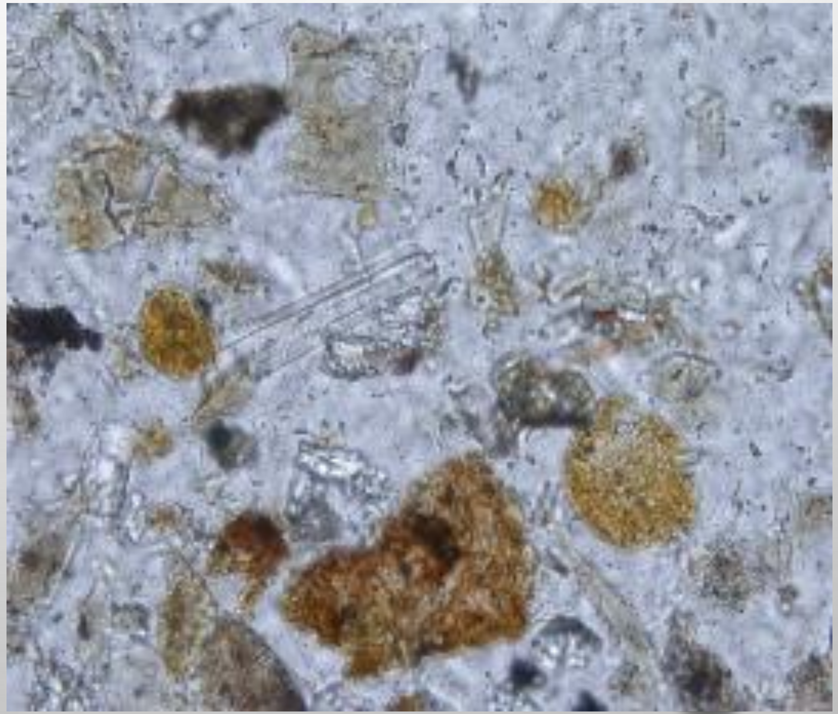


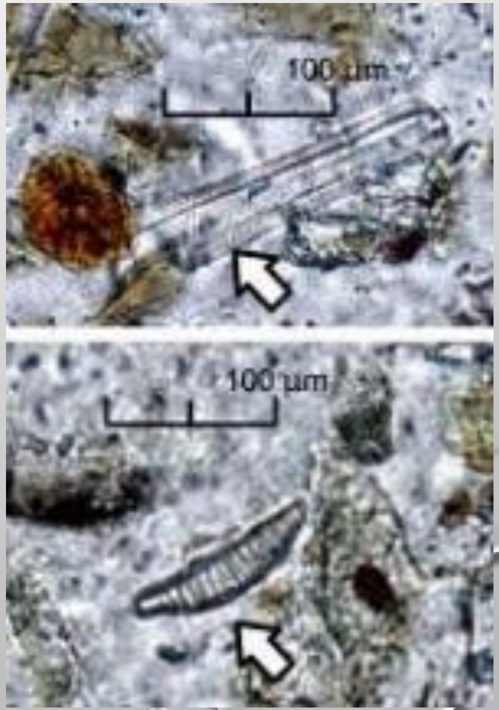
A SNOW-DUST STORM

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

The Cryosphere, 9, 2323–2337, 2015
www.the-cryosphere.net/9/2323/2015/
doi:10.5194/tc-9-2323-2015

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

J. I. Peltoniemi[1,2], M. Gritsevich[1,2,8], T. Hakala[1], P. Dagsson-Waldhauserová[5,6,7], Ó. Arnalds[6], K. Anttila[1,3], H.-R. Hannula[4], N. Kivekäs[3], H. Lihavainen[3], O. Meinander[3], J. Svensson[3,9], A. Virkkula[3], and G. de Leeuw[2,3]

Soot On Snow (SOS) 2013

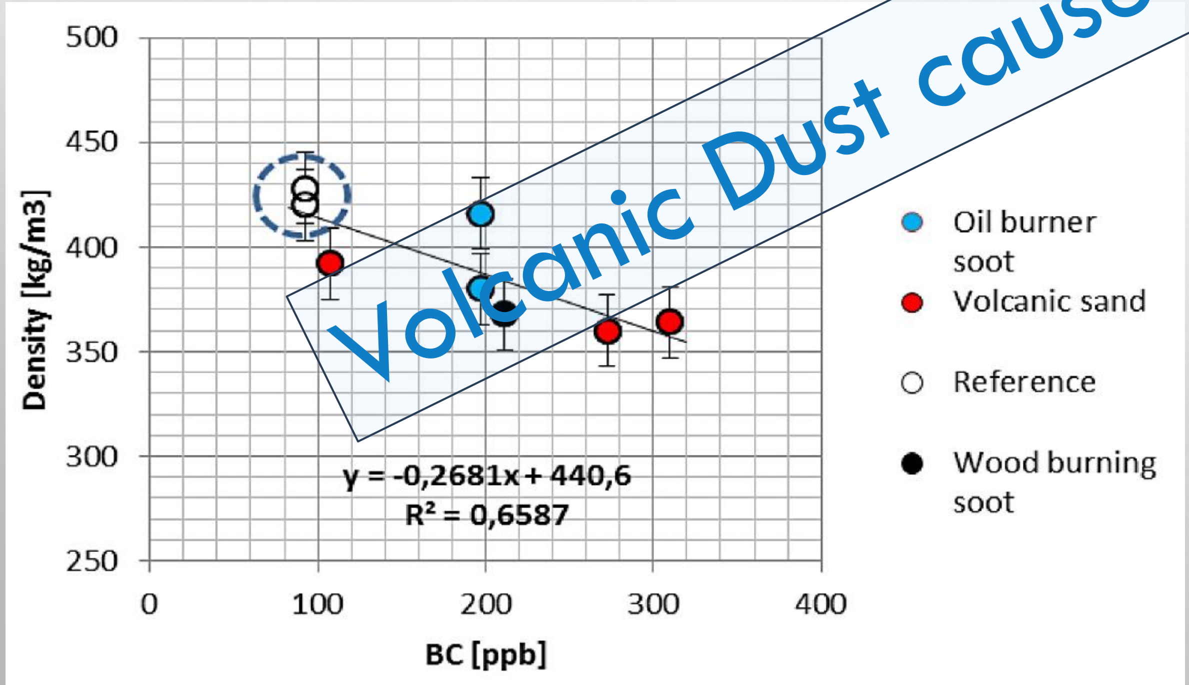
The Cryosphere, 8, 991–995, 2014
www.the-cryosphere.net/8/991/2014/
doi:10.5194/tc-8-991-2014

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

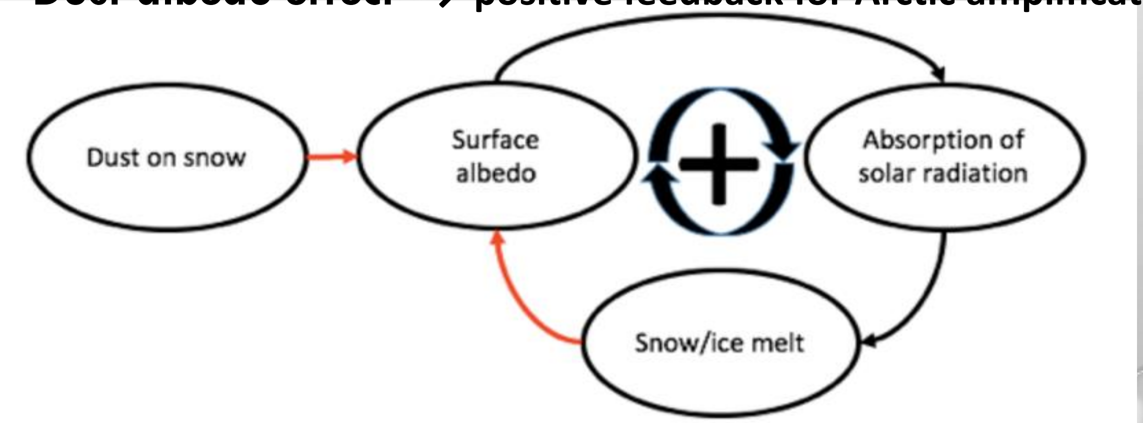
O. Meinander[1], A. Kontu[1], A. Virkkula[2], A. Arola[1], L. Backman[1], P. Dagsson-Waldhauserová[4,5], O. Järvinen[6], T. Manninen[1], J. Svensson[1], G. de Leeuw[1,6], and M. Leppäranta[6]

Volcanic Dust causes changes in cryosphere

- 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

Interactions between the atmosphere, cryosphere, and ecosystems at northern high latitudes

Michael Boy[1], Erik S. Thomson[2], Juan-C. Acosta Navarro[3], Olafur Arnalds[4], Ekaterina Batchvarova[5,6], Jaana Bäck[7], Frank Berninger[7], Merete Bilde[8], Zoé Brasseur[1], Pavla Dagsson-Waldhauserova[4,9,10], Dimitri Castarède[2],

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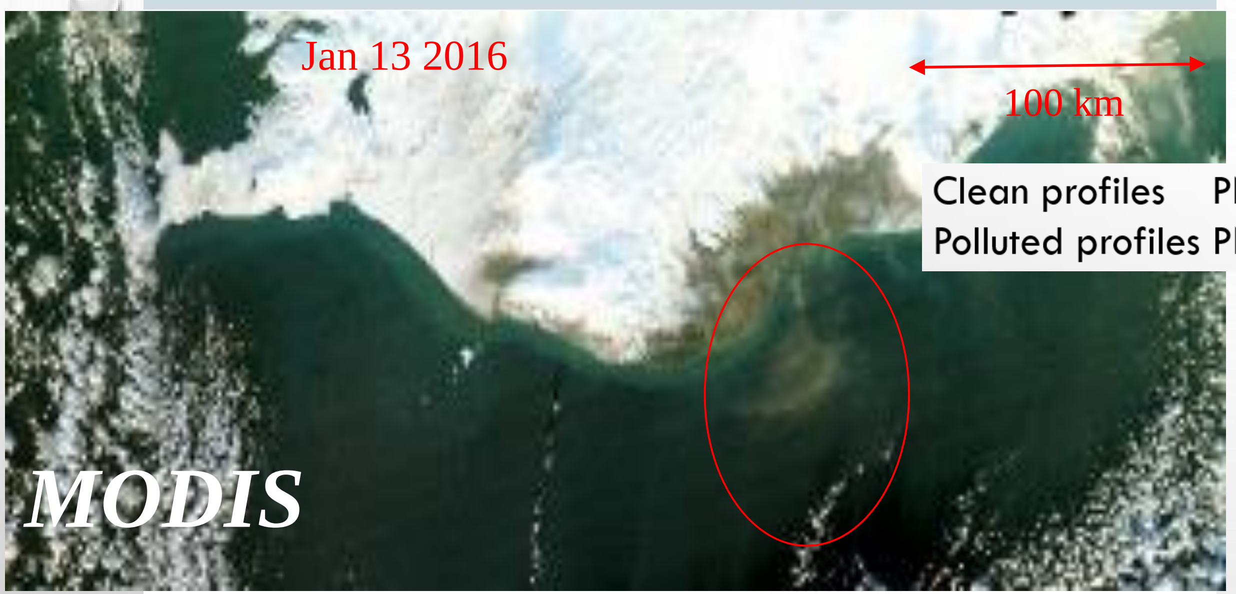
DUST IMPAIRS AIR QUALITY AT HIGH ATMOSPHERIC ALTITUDES DURING ARCTIC WINTER

www.nature.com/scientificreports/



Clean profiles PNC < 5 particles cm^{-3} Clean Arctic conditions

Polluted profiles PNC > 250 particles cm^{-3} Dirty Saharan dust layer


Morgunbladid

FÖSTUDAGUR 8. NÓVEMBER 2013

100 ÁRA

STOFNAÐ 1913

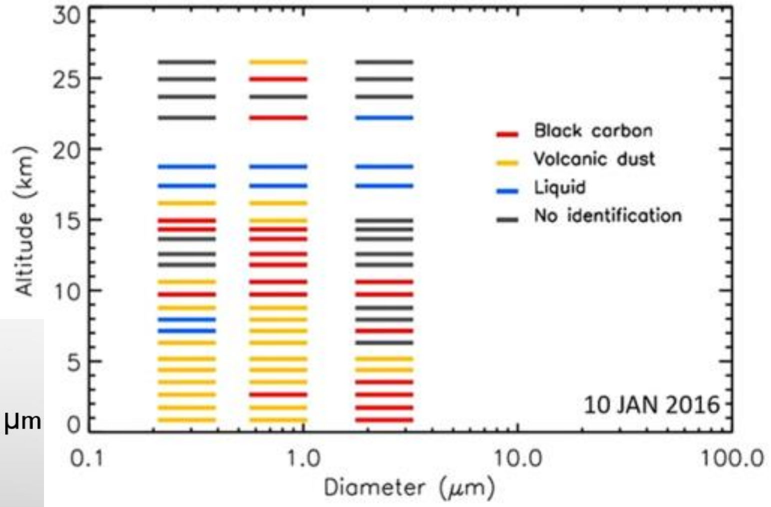
VILL DRAGA ÚR SYKURNEYSLU UNGS FÓLKS

ARNAR KVEÐUR ÞJÓÐLEIKHÚSIÐ FORMLEGA

BESTI SÖNGVARINN Í MÚSÍKTILRAUNUM FRÁ STOKKSEYRI

Loftbelgur ber tæki sem mælir agnir í andrúmsloftinu á leið hans upp í háloftin

Loftið mjög tært þegar komið var í 1.000 metra hæð



Particle sizes

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

SCIENTIFIC REPORTS

natureresearch

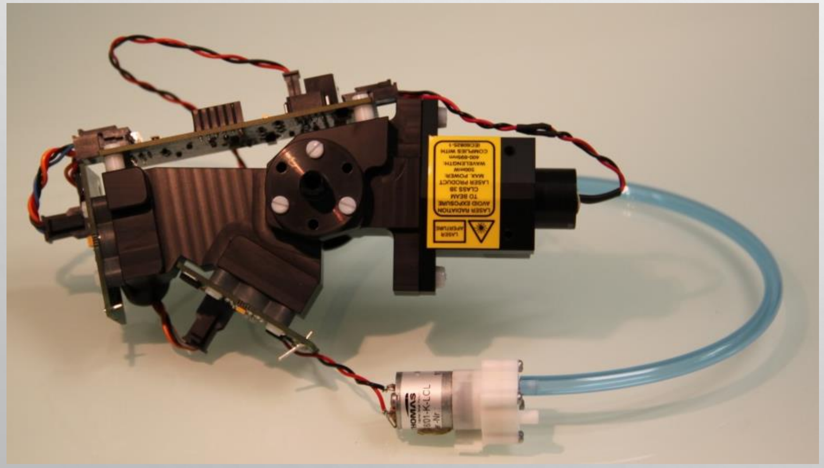
Vertical distribution of aerosols in dust storms during the Arctic winter

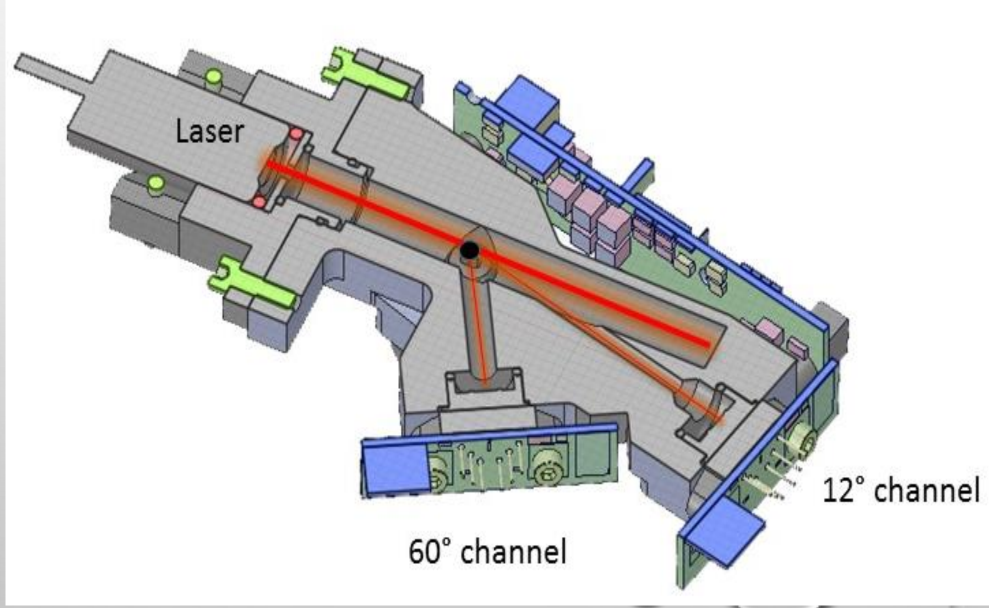
Pavla Dagsson-Waldhauserova[1,2*], Jean-Baptiste Renard[3], Haraldur Olafsson[4,5], Damien Vignelles[3], Gwenaël Berthet[3], Nicolas Verdier[6] & Vincent Duverger[3]

AIR BORNE MEASUREMENTS WITH LOAC 2013-2016 (LIGHT OPTICAL AEROSOL COUNTER)

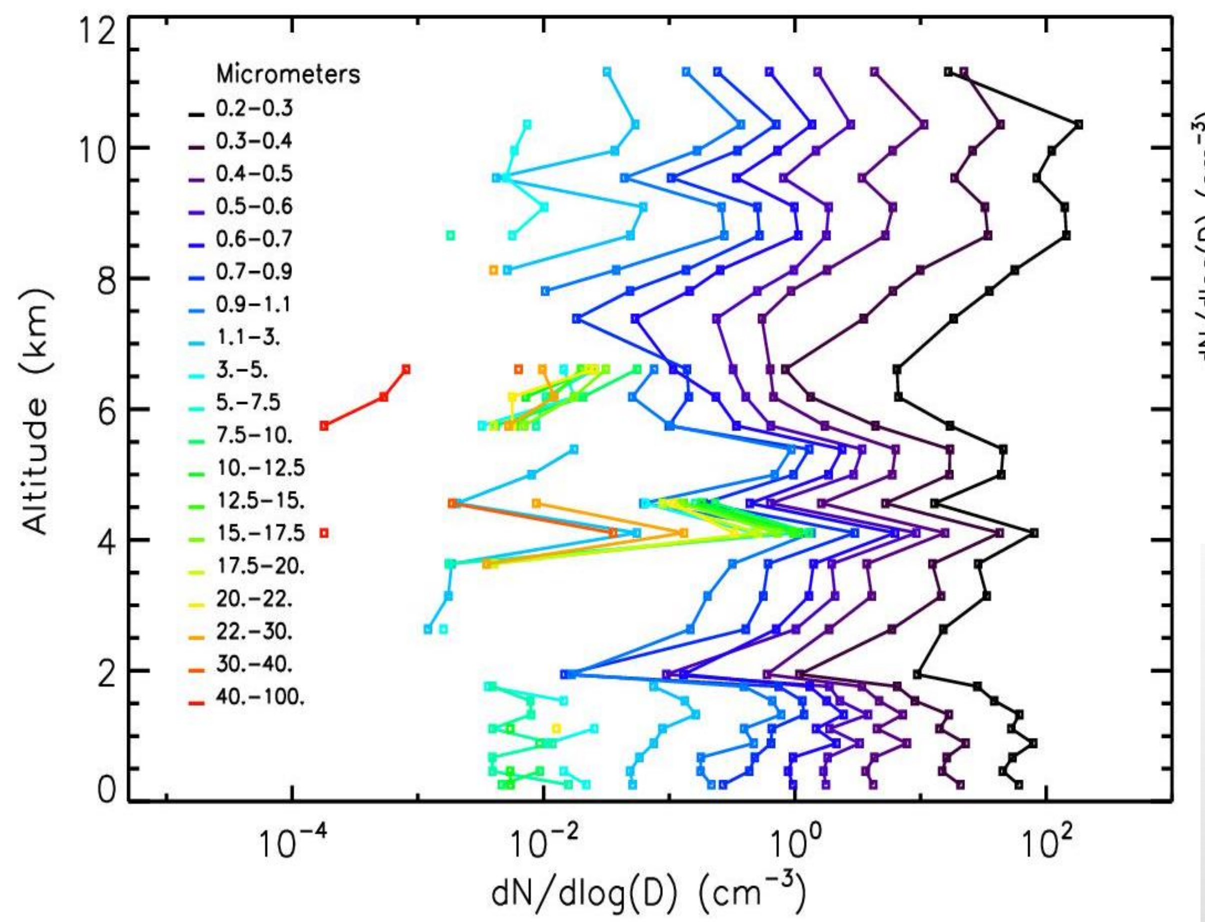
- **LOAC** can determine **aerosol concentrations in 19 size classes (0.2 and 100 μm) and to <u>estimate their typology</u> (Renard et al., AMT, 2016)**

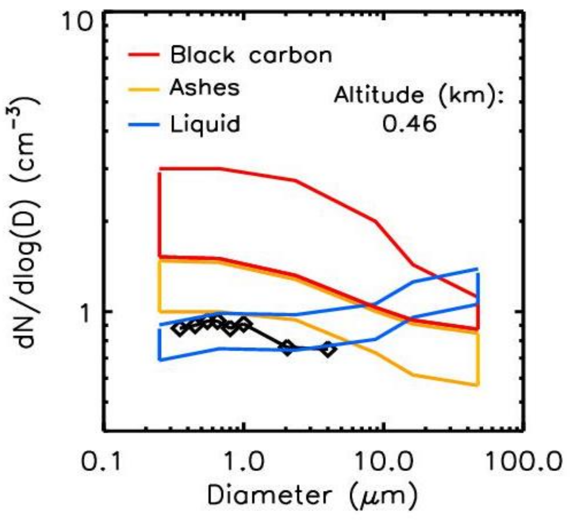
- **Measurements at 2 scattering angles :**
  ~12°, insensitive to refractive index of the particles (mainly diffraction) => accurate size determination and counting
  ~60°, strongly sensitive to the refractive index of the particles => indication of the nature of the particle (typology)

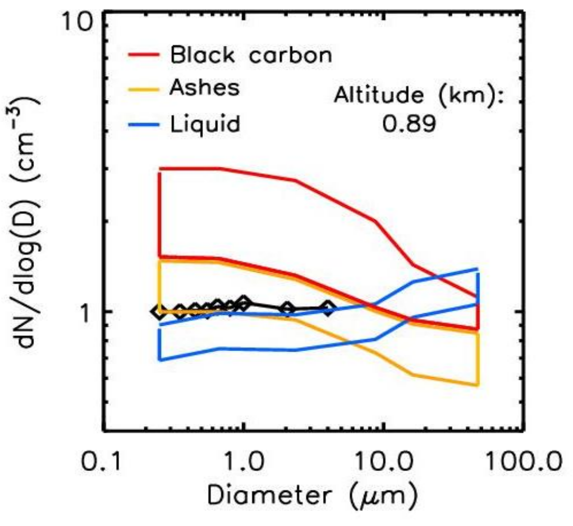


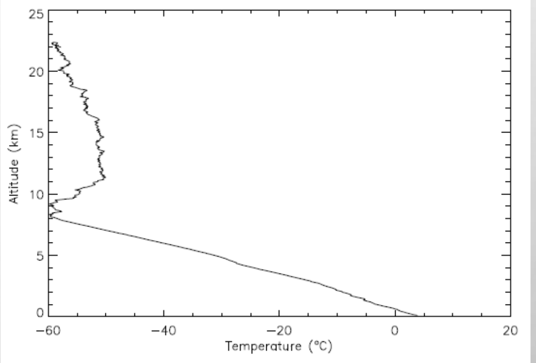


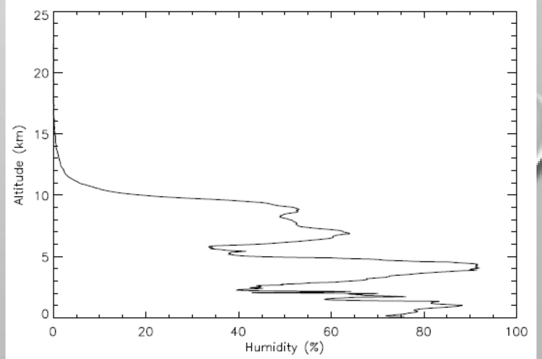
7 NOV 2013





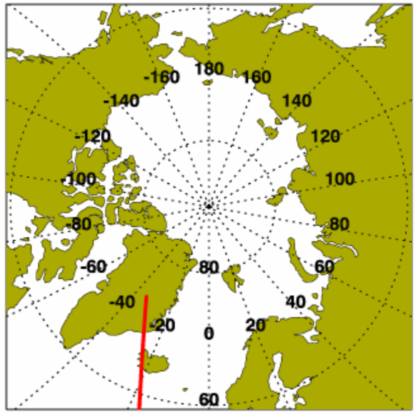






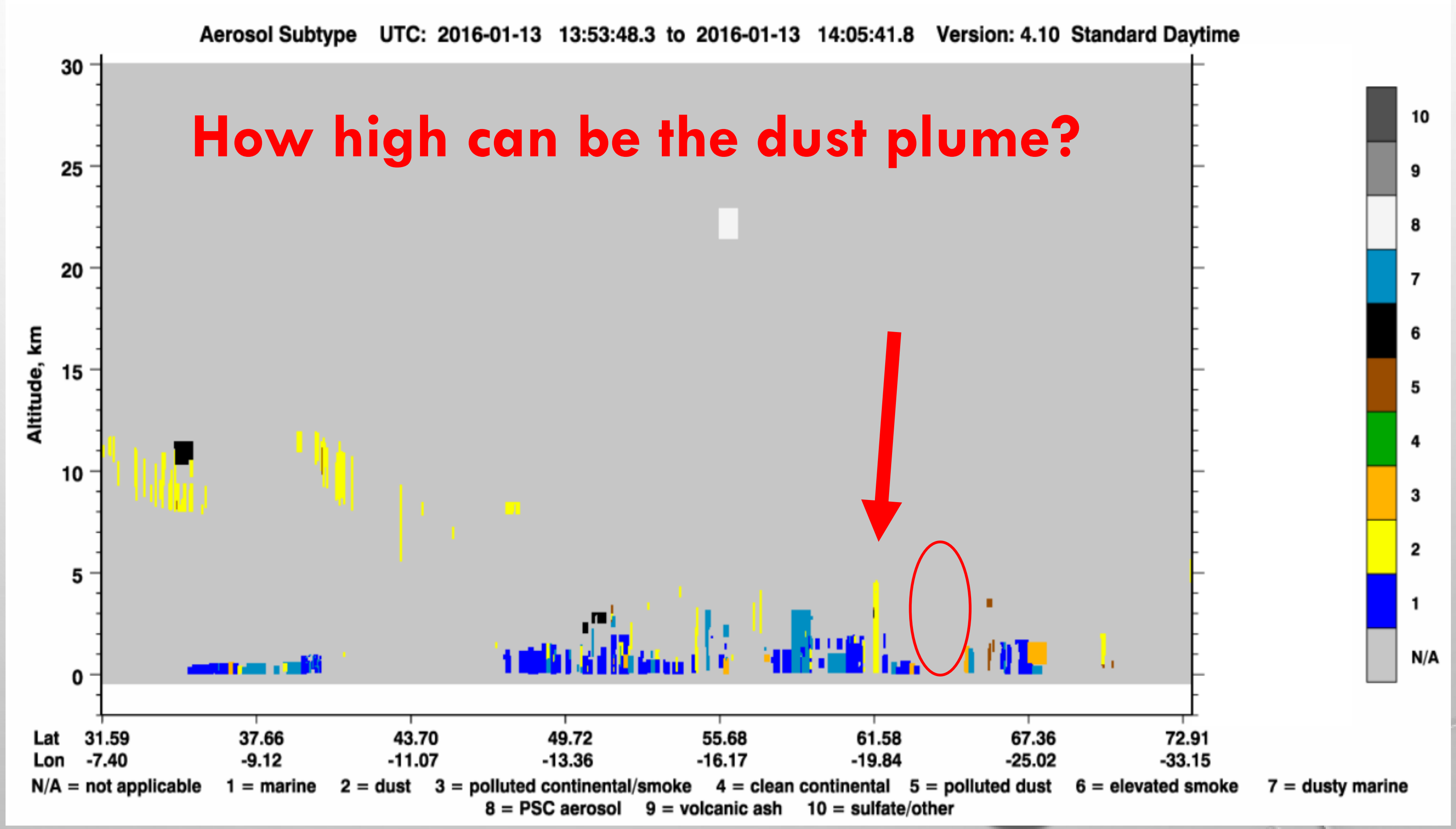
Surface wind 8 ms^{-1}, surface PM10>100μgm^{-3}, mixed showers

- **The number concentration exceeded 40 particles cm^{-3} (10 μgm-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)



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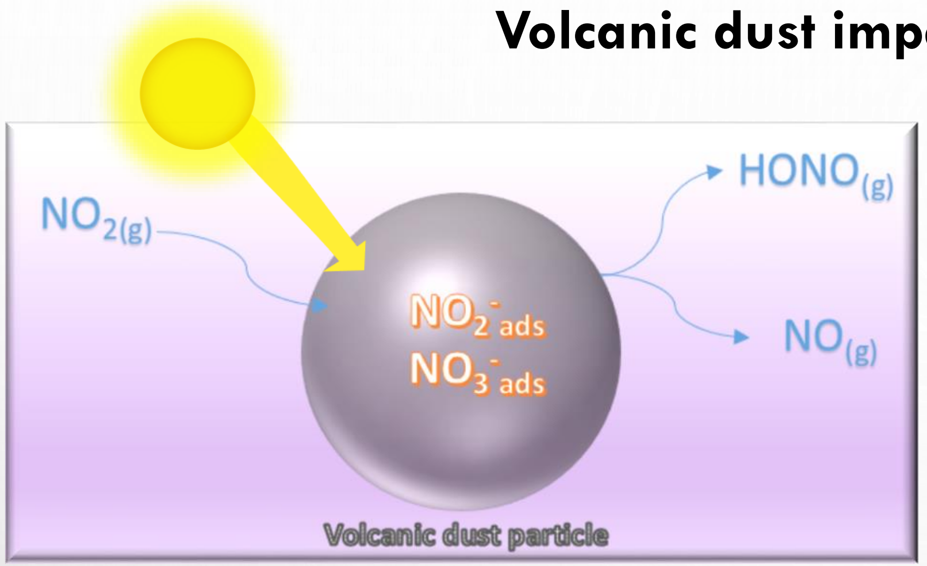
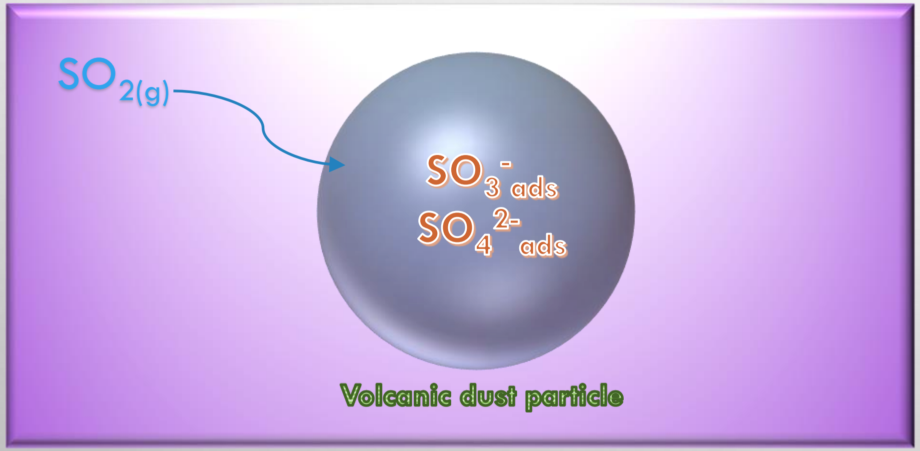
  - VERTICAL PROFILES OF DUST STORMS DURING THE ARCTIC WINTER
  - **IMPACTS ON ATMOSPHERIC CHEMISTRY AND ROAD SAFETY**
- ICELANDIC AEROSOL AND DUST ASSOCIATION (ICEDUST)

Volcanic dust impacts on atmospheric chemistry



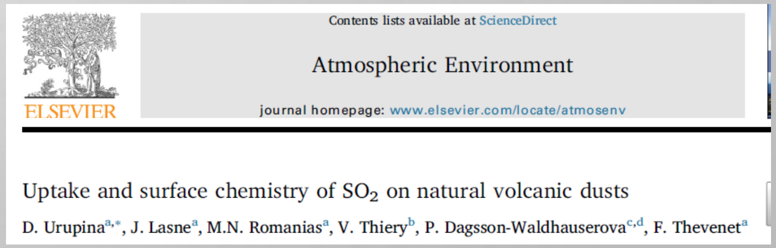
Dust particles scavenge efficiently **NO_2** acting as transported media of surface nitrites and nitrates.
Dust particles convert NO_2 to HONO (nitrous acid), a very important precursor of OH radicals (HONO is photolysed during day time producing OH and NO)

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)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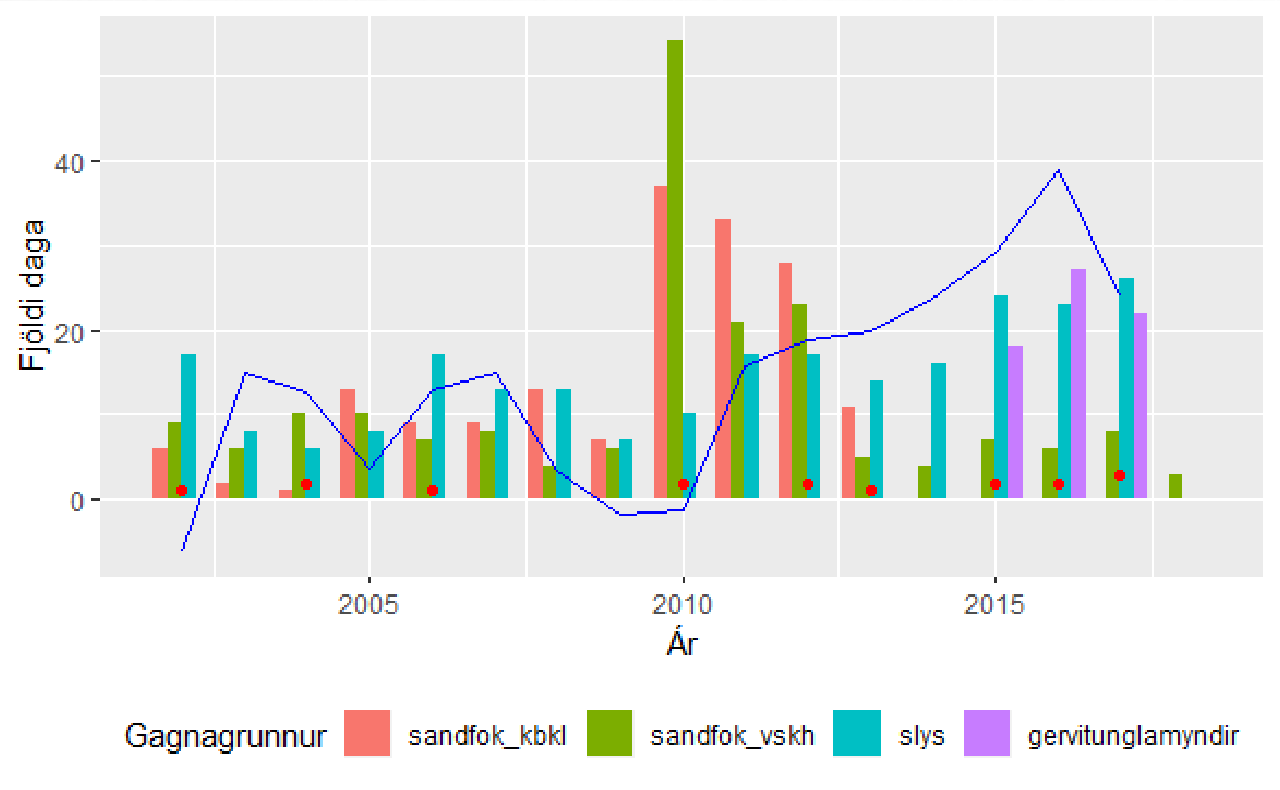
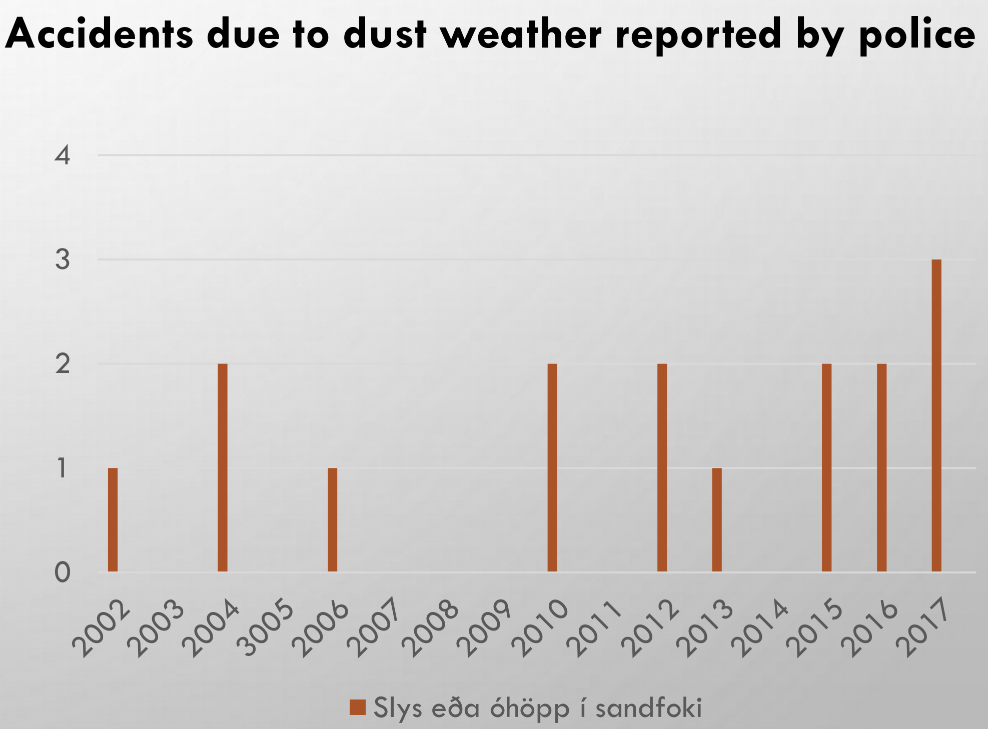
ELSEVIER

Uptake and surface chemistry of SO_2 on natural volcanic dusts

D. Urupina[a,*], J. Lasne[a], M.N. Romanias[a], V. Thiery[b], P. Dagsson-Waldhauserova[c,d], F. Thevenet[a]

SANDSTORMS AND TRAFFIC SAFETY IN SOUTH ICELAND





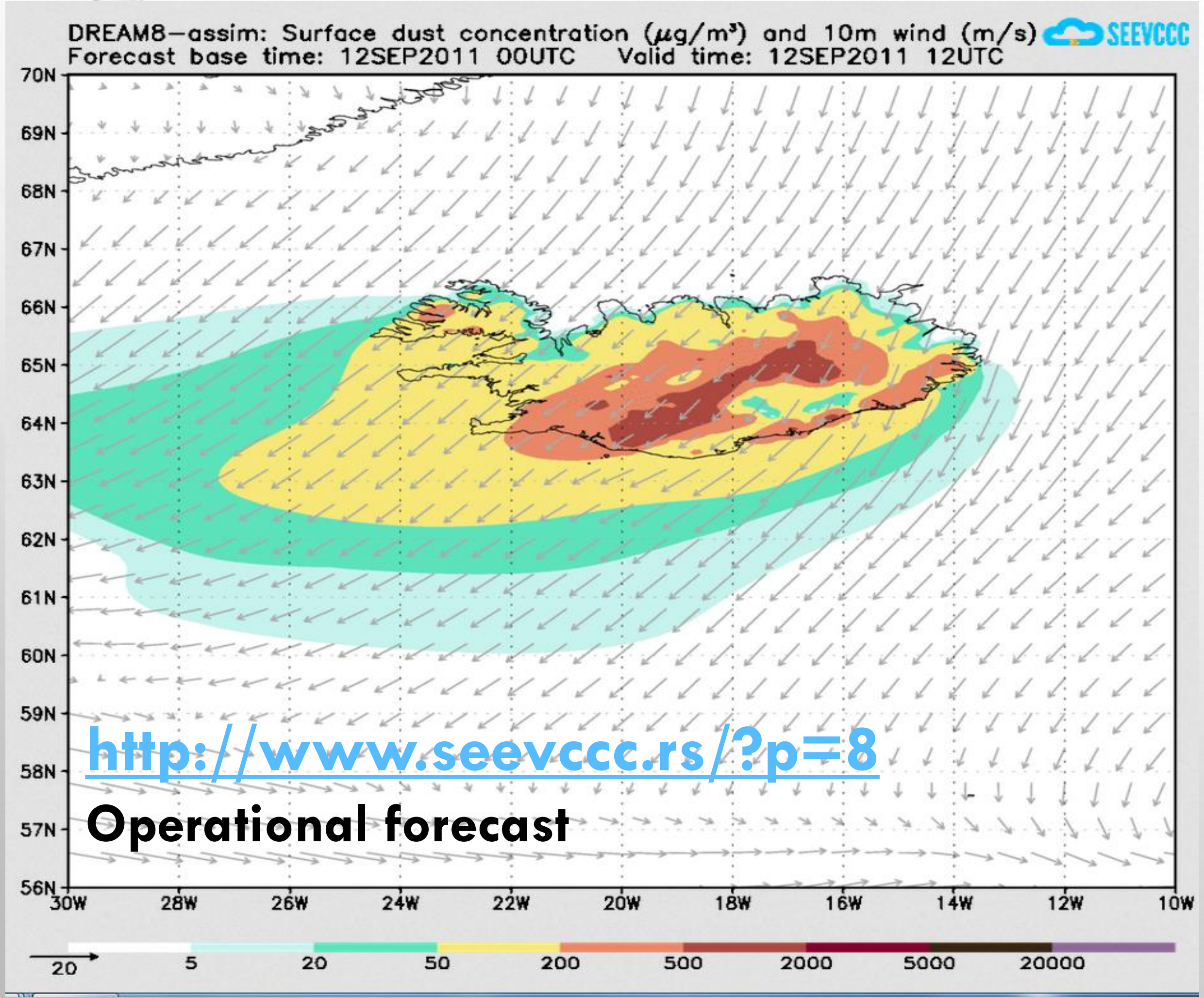
First HLD operational forecast under WMO SDS-WAS

Officially launched in 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.

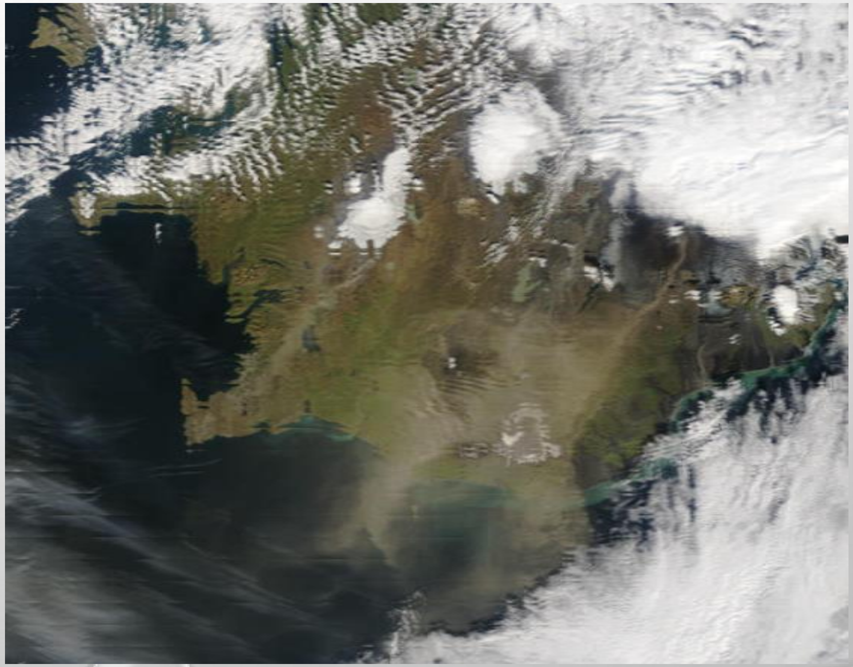


http://www.seevccc.rs/?p=8

Operational forecast

Nickovic et al., 2001

Soon part of the WMO Sand/Dust Storm forecasts



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 VARIABLITY IN DUST FREQUENCY IN ICELAND
    - SNOW-DUST STORMS
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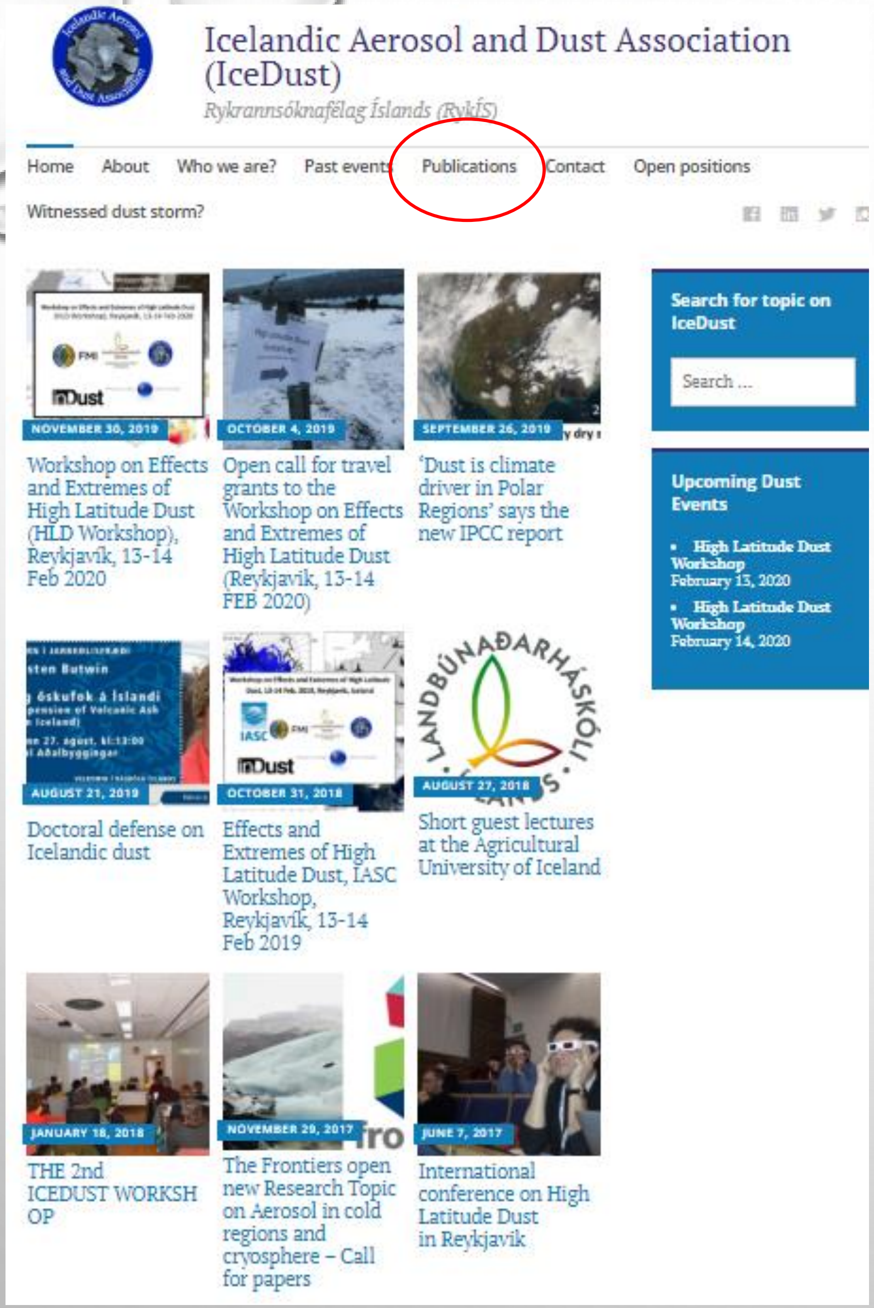
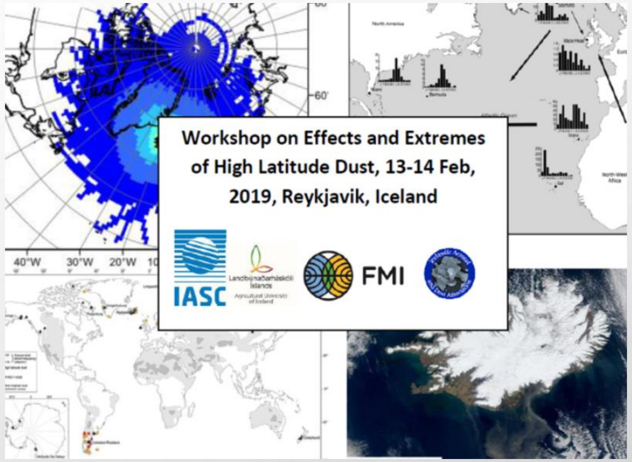


HTTPS://ICEDUSTBLOG.WORDPRESS.COM/

Dust Storms in Iceland
Public Group

HLD Workshop V
February 10-11 2021
-free entrance, everybody welcome!



Thank you for your attention!
pavla@lbhi.is

Orals IE1.1/CR1.14/AS4.21/BG9.66

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 Pisso