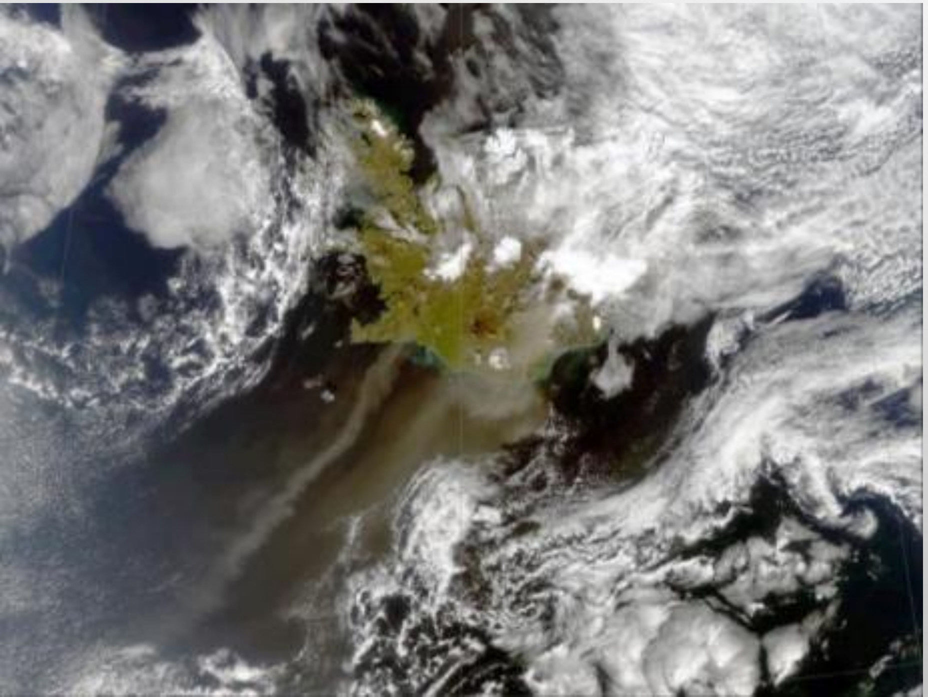
SNOW-DUST STORM: A CASE STUDY FROM ICELAND



PAVLA DAGSSON WALDHAUSEROVA

O. ARNALDS, H. OLAFSSON, O. MEINANDER, JINDRICH HLADILE, ROMAN SKALA E, TOMAS NAVRATIL E, LEONA CHADIMOVA

SNOW – AN ECOLOGICAL PHENOMENON

SMOLENICE, SLOVENSKO, 19-21 SEPTEMBER 2017

OBJECTIVES

- HIGH LATITUDE DUST SOURCES - ICELAND AS MAIN DUST SOURCE
- UNUSUAL DUST EVENTS FROM ICELAND
- OPTICAL PROPERTIES OF VOLCANIC DUST PARTICLES COMPARED TO BLACK CARBON

ICELAND AND SOURCES OF AIR POLLUTION

- TOTAL ICELANDIC DESERT AREAS COVER OVER 44,000 KM^2
- ICELAND IS THE LARGEST <u>ARCTIC</u> AS WELL AS <u>EUROPEAN</u> DESERT
- > 40 % OF ICELAND IS CLASSIFIED WITH CONSIDERABLE TO VERY SEVERE EROSION

WHAT MAKES ICELANDIC DUST SOURCES SO ACTIVE?

- FREQUENT VOLCANIC ERUPTIONS (+GLACIAL OUTBURST FLOODS "JÖKULHLAUP")
- FREQUENT STRONG WINDS


Aeolian Research 20 (2016) 176–195

Contents lists available at ScienceDirect

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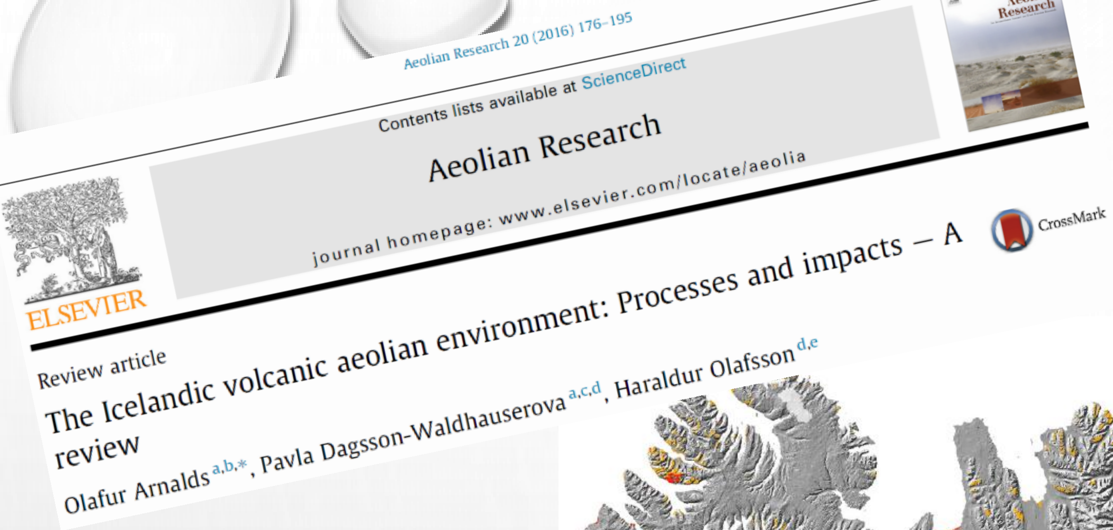
journal homepage: www.elsevier.com/locate/aeolia

Review article

The Icelandic volcanic aeolian environment: Processes and impacts — A review

Olafur Arnalds [a,b,*], Pavla Dagsson-Waldhauserova [a,c,d], Haraldur Olafsson [d,e]


Aeolian Research 20 (2016) 176–195

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Review article

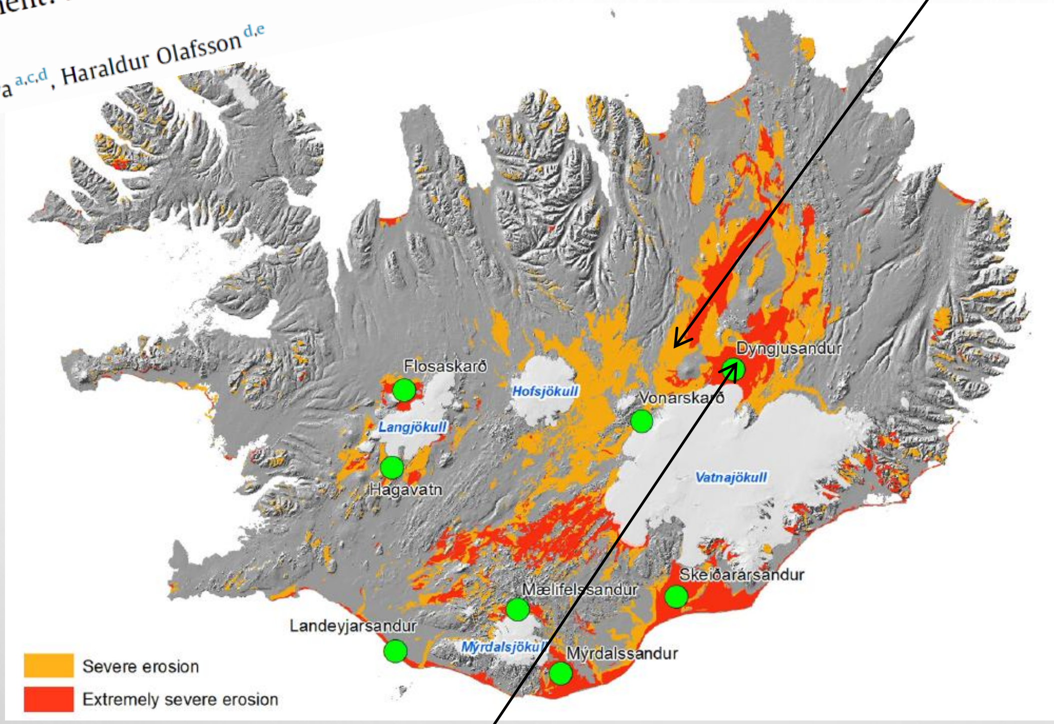
The Icelandic volcanic aeolian environment: Processes and impacts — A review

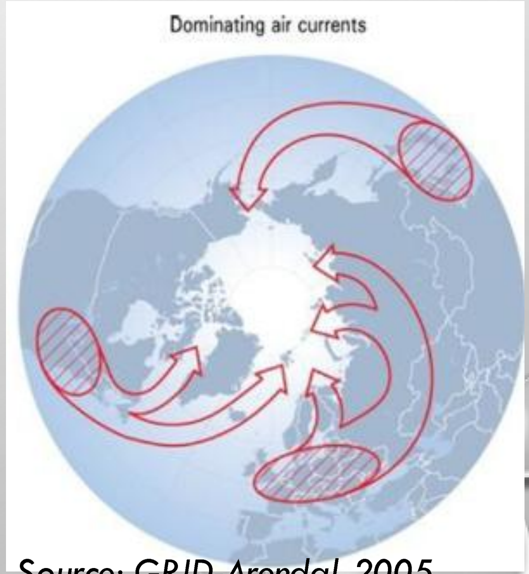
Olafur Arnalds[a,b,*], Pavla Dagsson-Waldhauserova[a,c,d], Haraldur Olafsson[d,e]

volcanic sandy deserts (22% of Iceland)

Total Icelandic desert areas cover over 44,000 km^2

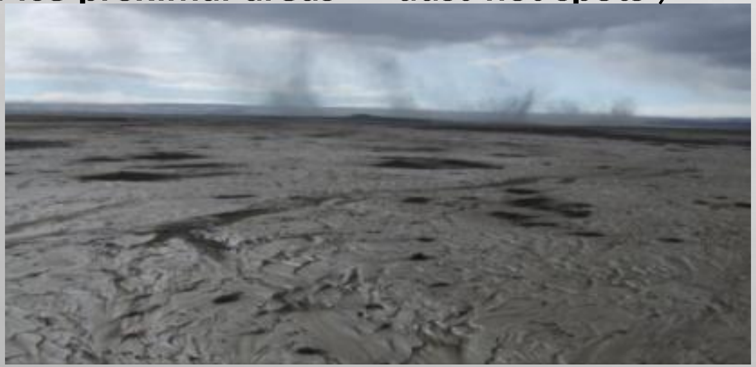
Almost like Slovakia!!





Source: GRID-Arendal, 2005. Barentswatch Atlas.

glacial riverbeds and ice-proximal areas = “dust hot spots”



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

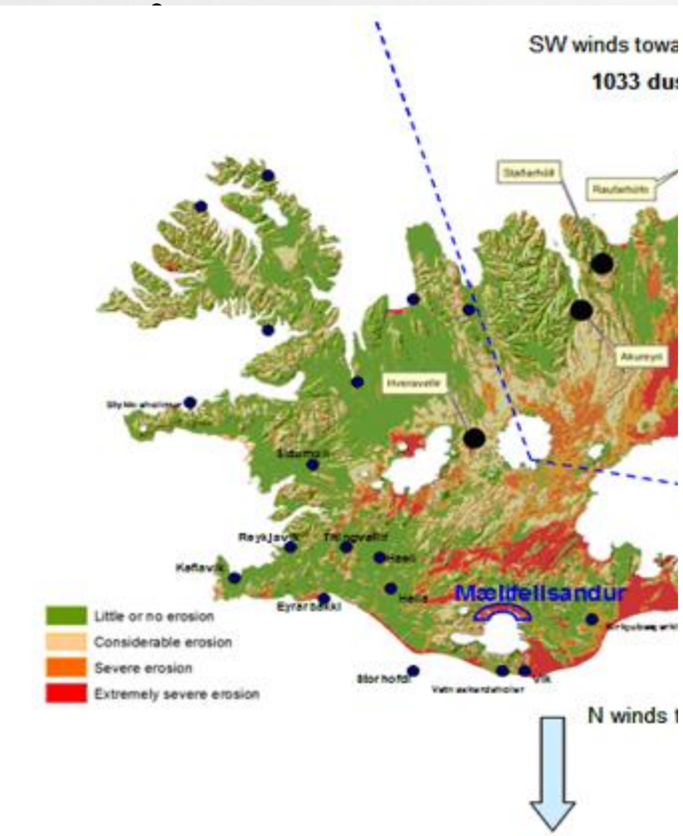
Atmospheric Chemistry and Physics

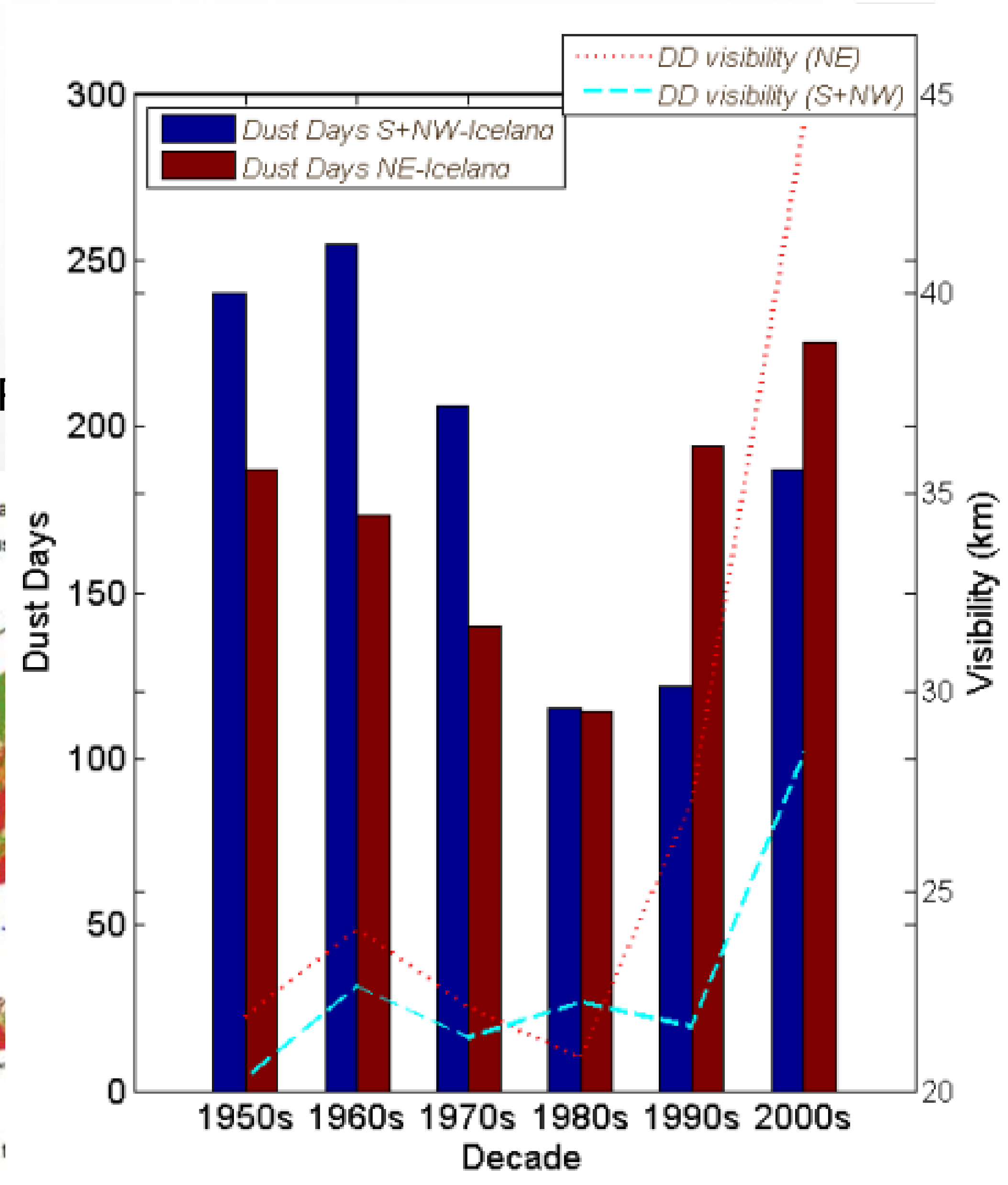
variability of dust events in Iceland (1949–2011)

...userova[1,2], O. Arnalds[1], and H. Olafsson[2,3,4]

FREQUEN

- METHODS: A NETWO... 9-2011)





UST DAYS PER YEAR,

YEAR INCLUDING

C ASHES” + “DUST HAZE”

IED AS A DAY WHEN AT LEAST ONE STATION

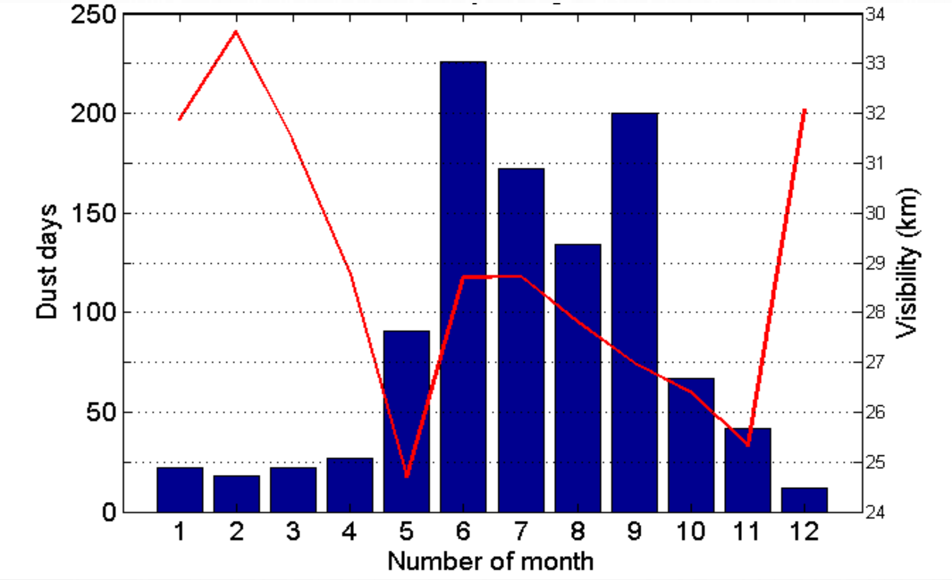
CORDED AT LEAST ONE DUST OBSERVATION

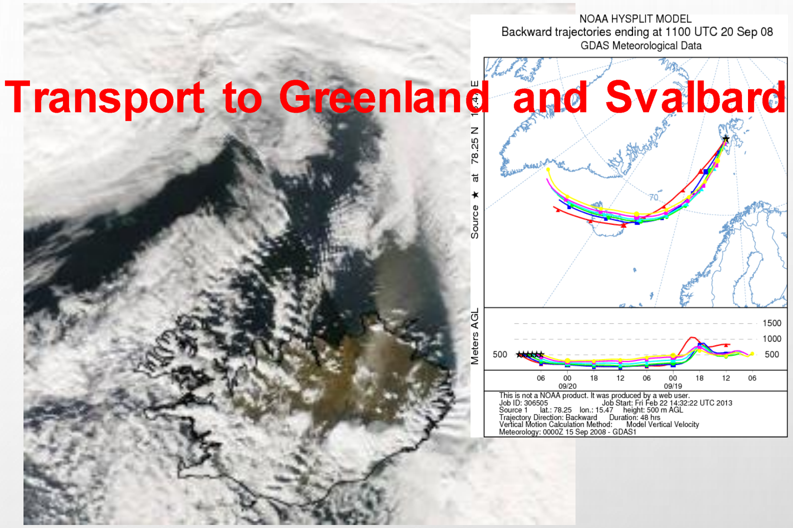
SEASONAL VARIABILITY OF DUST EVENTS

- NE ICELAND

“ARCTIC DUST EVENTS”

SUMMER

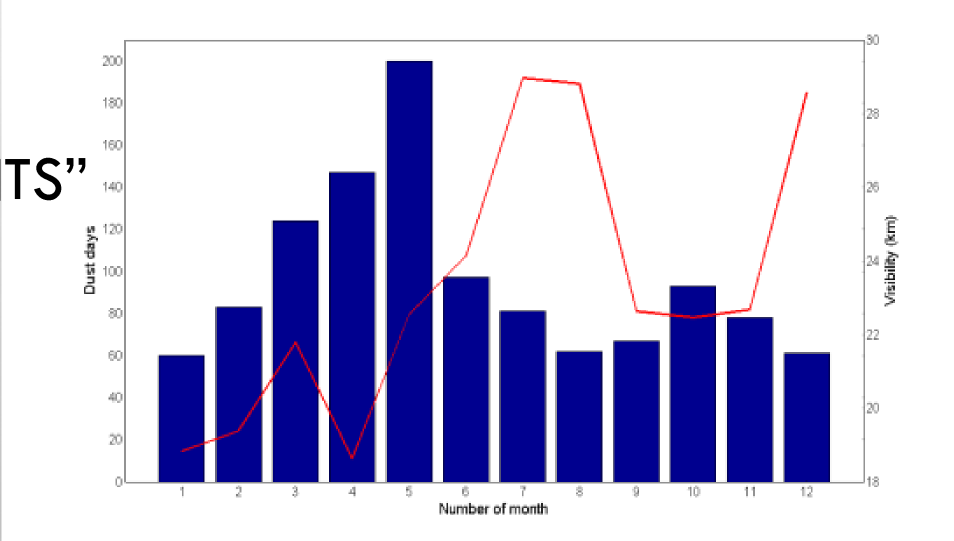


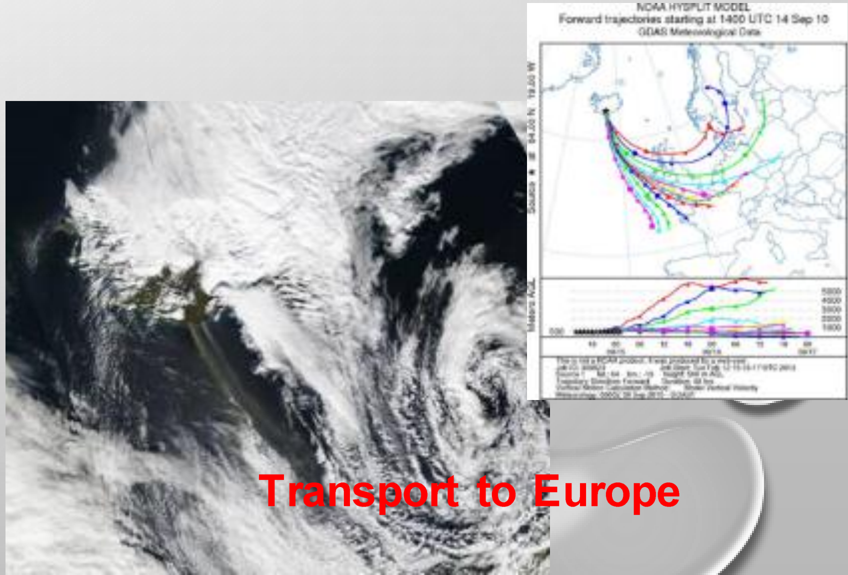


- S ICELAND

“SUB-ARCTIC DUST EVENTS”

WINTER-SPRING





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

Biogeosciences Open Access

DISTRIBUTION OF DUST DEPOSITION

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

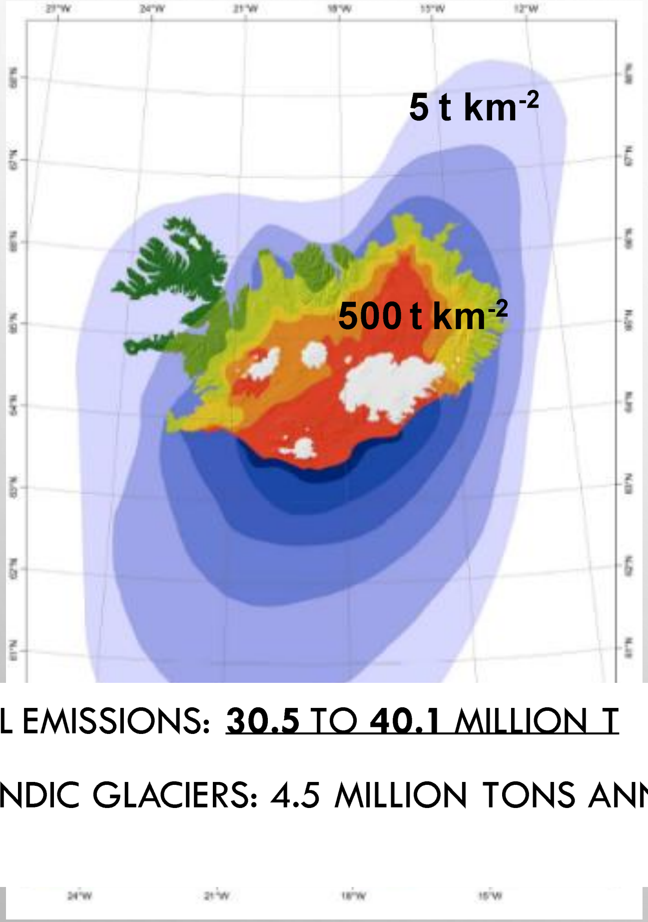
O. Arnalds[1], H. Olafsson[2,3,4], and P. Dagsson-Waldhauserova[1,2]

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: <u>**30.5** TO **40.1** MILLION T</u>
- ICELANDIC GLACIERS: 4.5 MILLION TONS ANNUALLY

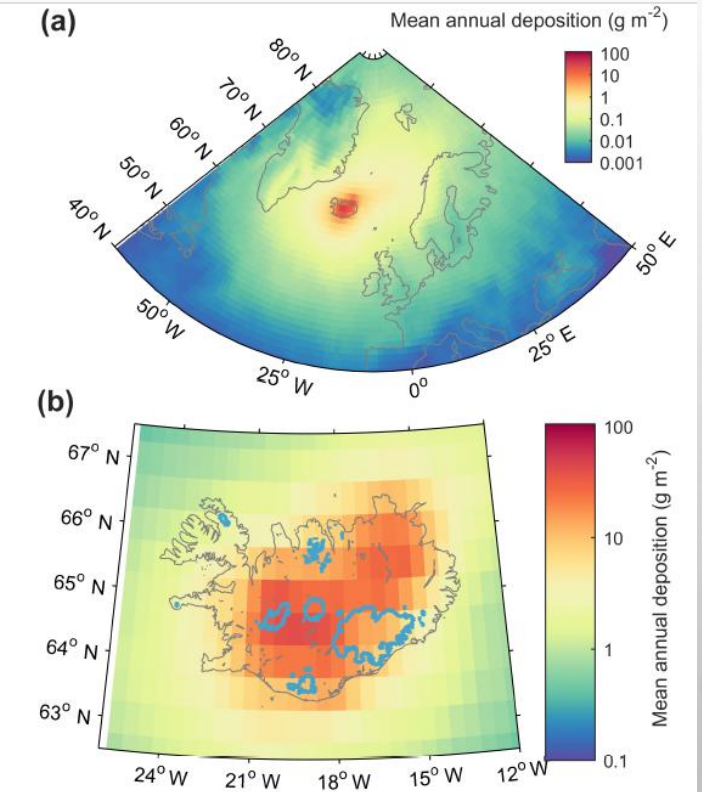


Figure 10. Mean annual dust deposition ($g\,m^{-2}$) simulated with FLEXPART in years 1990–2016 for the North Atlantic region **(a)** and Iceland **(b)**. Maximum values are lower in the upper panel than in the lower panel as this figure shows averages over larger areas. The blue lines in the bottom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

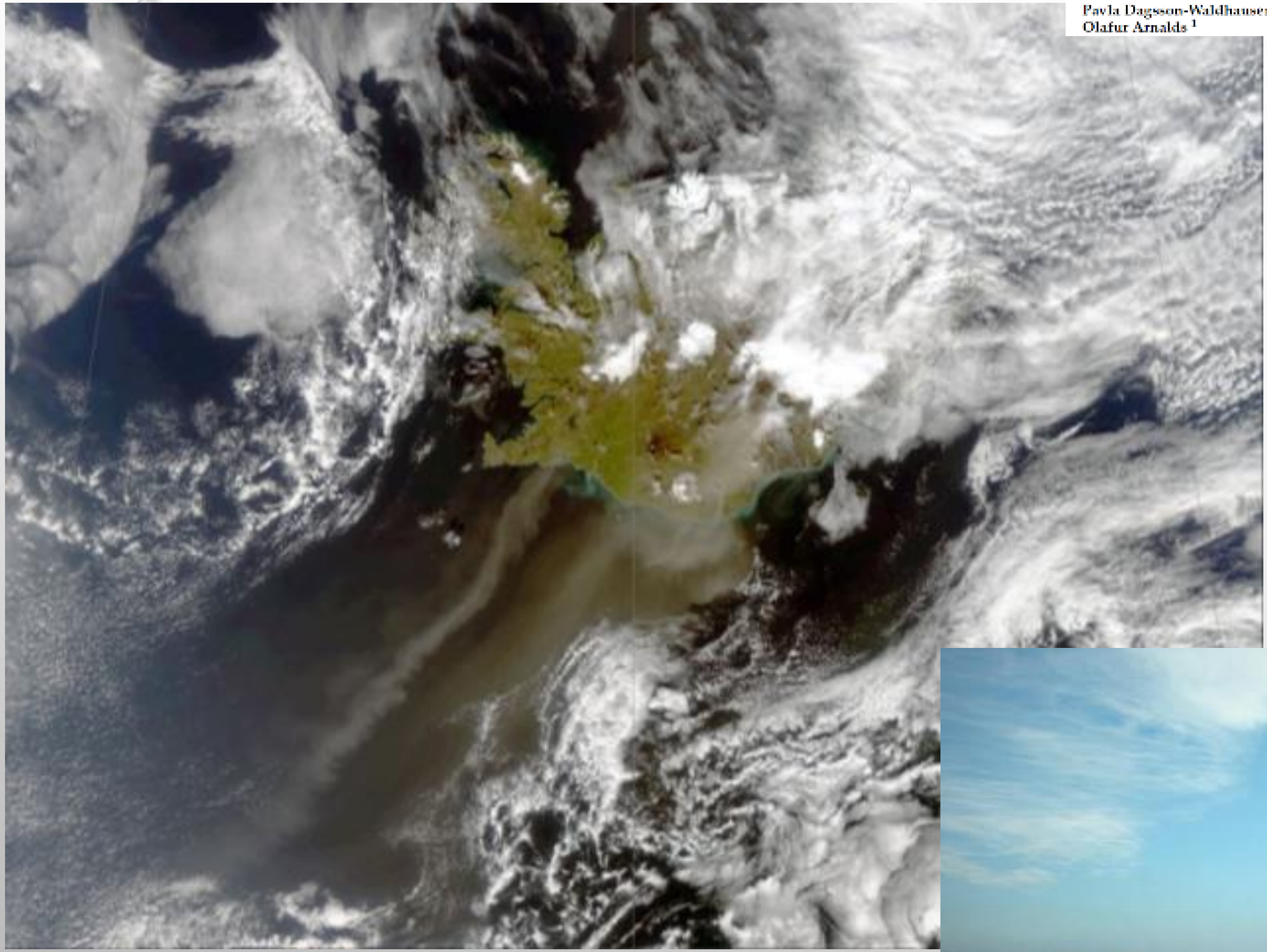
The Spatial Variation of Dust Particulate Matter Concentrations during Two Icelandic Dust Storms in 2015

atmosphere

MDPI

Article

Pavla Dagsson-Waldhauserova [1,2,3,*], Agnes Ösp Magnusdottir [1], Haraldur Olafsson [2,4] and Olafur Arnalds [1]



DUST FRONT ABOVE HVERAGERÐI, JUNE 15, 2015

REYKJAVÍK HAZE, SEPTEMBER 11, 2011

HVALFJÖRÐUR SUSPENDED DUST, MARCH 24, 2012

THREE MOST UNUSUAL DUST EVENTS OBSERVED AND MEASURED

1. Extreme wind erosion event of Eyjafjallajökull volcanic ash

SCIENTIFIC REPORTS

OPEN

SUBJECT AREAS: ENVIRONMENTAL SCIENCES

An extreme wind erosion event of the fresh Eyjafjallajökull 2010 volcanic ash

Olafur Arnalds[1], Elin Fjola Thorarinsdottir[2], Johann Thorsson[2], Pavla Dagsson Waldhauserova[1,3] & Anna Maria Agustsdottir[2]

2. Snow-Dust Storm

Contents lists available at ScienceDirect
Aeolian Research
journal homepage: www.elsevier.com/locate/aeolia
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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]

3. Suspended dust during moist and low wind conditions

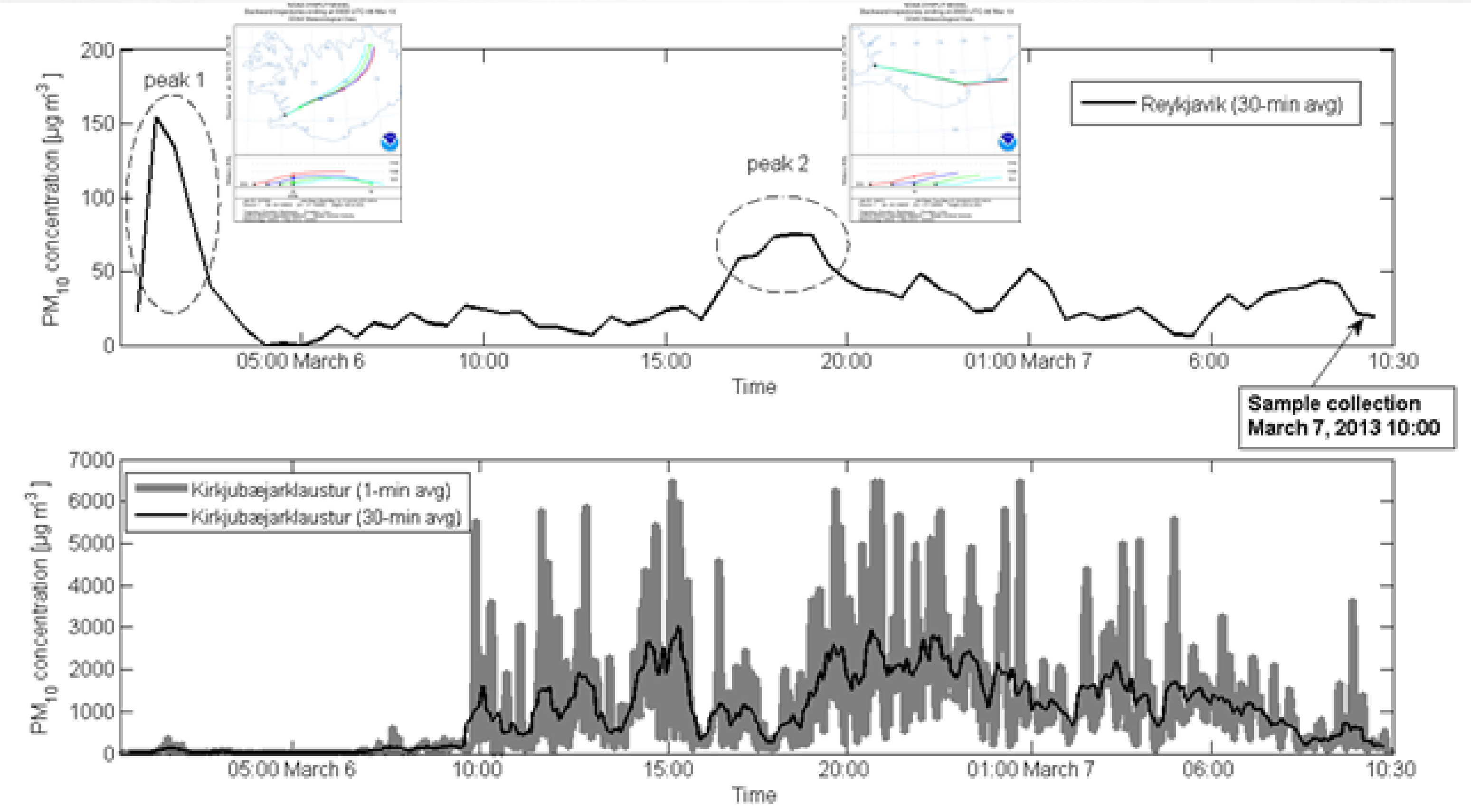
ICEL. AGRIC. SCI. 27 (2014), 25-39

Physical properties of suspended dust during moist and low wind conditions in Iceland

PAVLA DAGSSON-WALDHAUSEROVA,[1,2] OLAFUR ARNALDS,[1] HARALDUR OLAFSSON,[1,3,4] LENKA SKRABALOVA,[5] GUDMUNDA MARIA SIGURDARDOTTIR,[1,3] MARTIN BRANIS,[5] JINDRICH HLADIL,[6] ROMAN SKALA,[6] TOMAS NAVRATIL,[6] LEONA CHADIMOVA,[6] SIBYLLE VON LOWIS OF MENAR,[3] THROSTUR THORSTEINSSON,[7] HANNE KRAGE CARLSEN,[8] AND INGIBJORG JONSDOTTIR[7]

A SNOW-DUST STORM

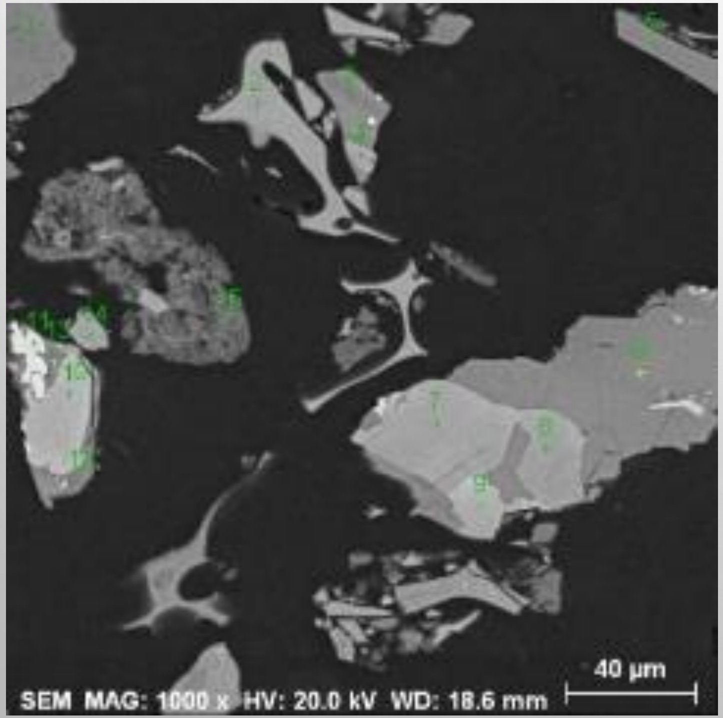
Mean (median) PM_{10} concentration during 24-hour storm ~ 1,281 (1,170) µg m^{-3}

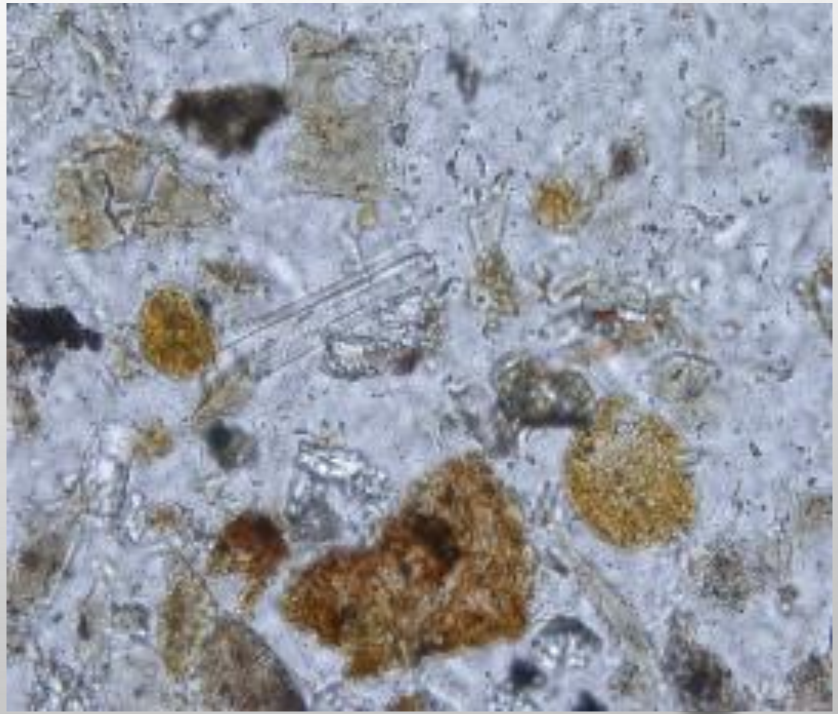


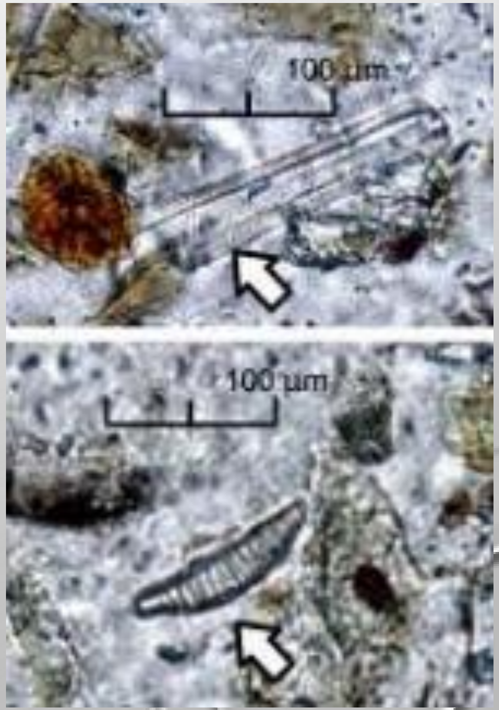
A SNOW-DUST STORM

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





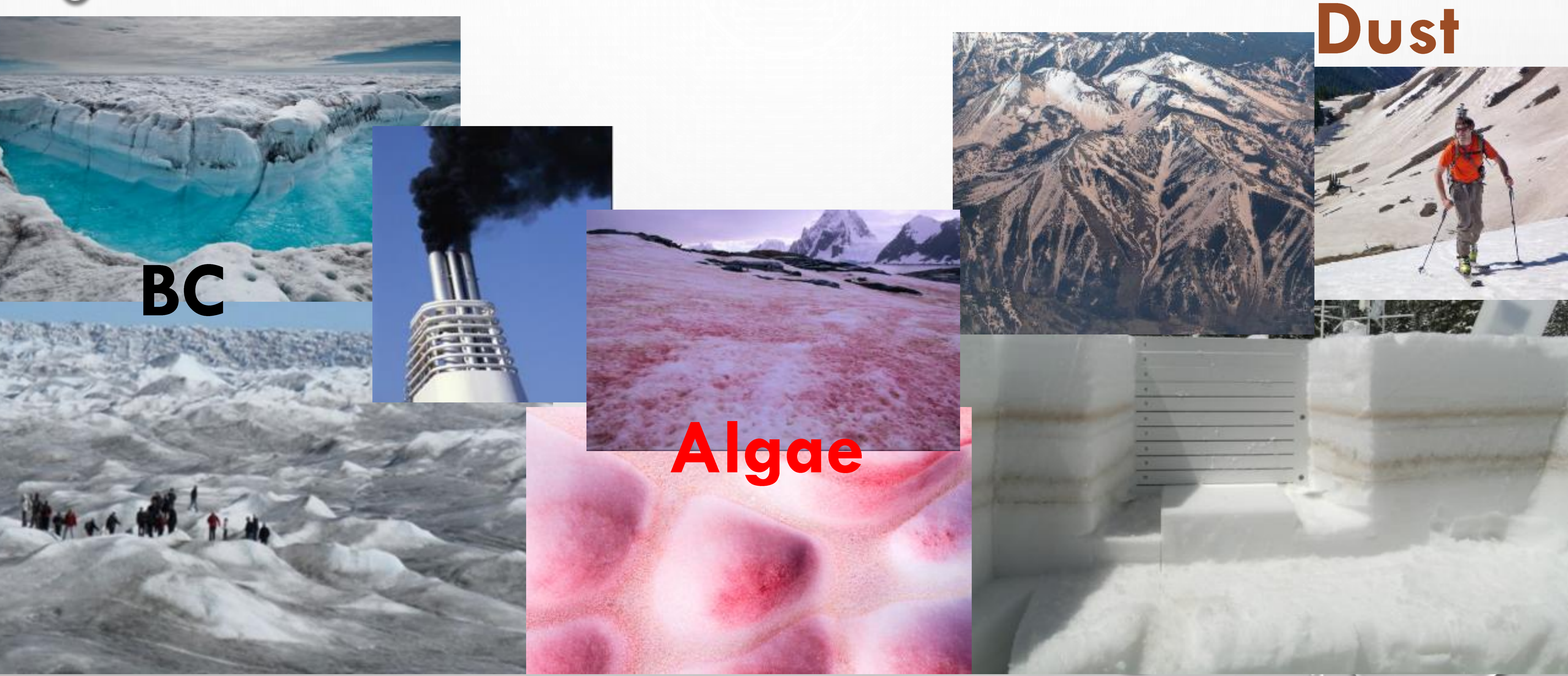


A SNOW-DUST STORM

Clumping mechanism of particles on snow

the first observation reported from natural conditions

IMPURITIES ON SNOW



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

The Cryosphere

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[1,2], 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

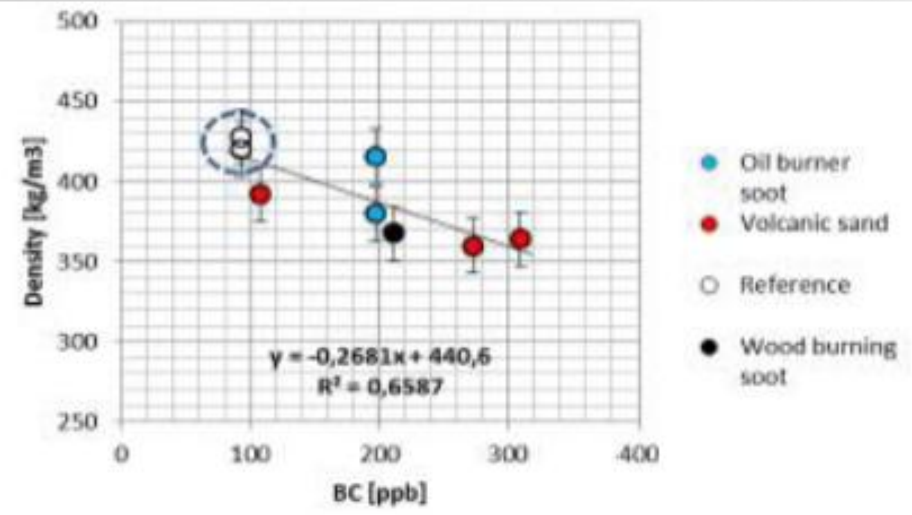
The Cryosphere, 8, 991–995, 2014
www.the-cryosphere.net/8/991/2014/
doi:10.5194/tc-8-991-2014

The Cryosphere

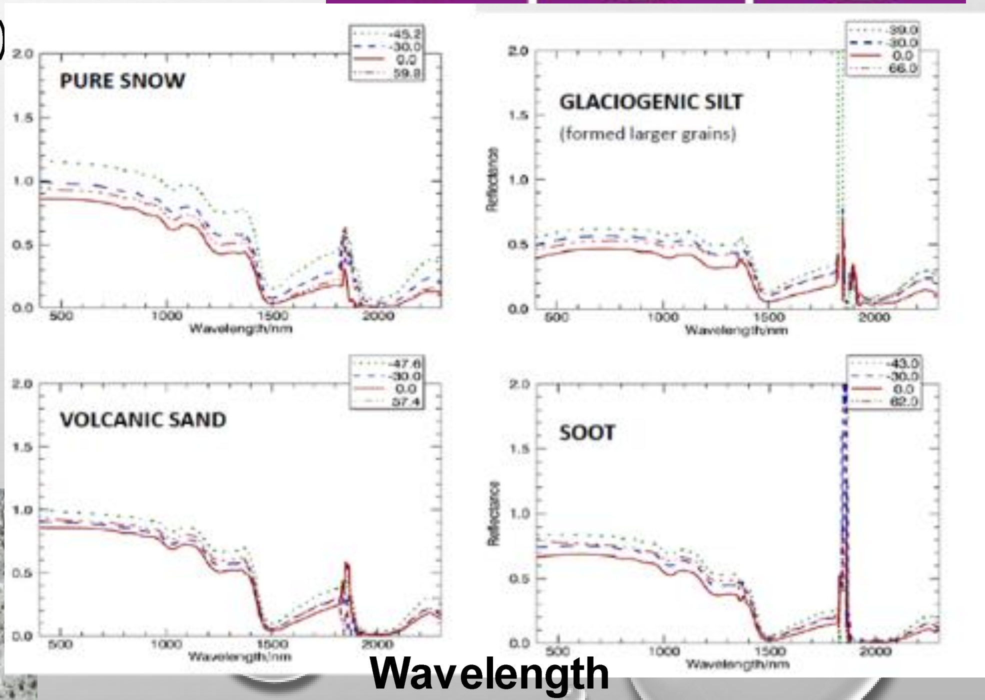
Brief communication: Light-absorbing impurities can reduce the density of melting snow

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

- FIELD EXPERIMENTS COMPARING THE ABSORBING IMPURITIES DEPOSITED ON SNOW
- **RESULTS: VOLCANIC DUST DECREASES SNOW ALBEDO SIMILARLY AS BLACK CARBON!**
- IN LAB, VOLCANIC DUST IS AN EXTREMELY ABSORBING AEROSOL (SR=0.03)
- SOOT DECREASES WATER RETENTION CAPACITY AND DENSITY OF SNOW



Clumping mechanism of fine silt



Landbúnaðarháskóli Íslands
Agricultural University of Iceland

UNIVERSITY OF ICELAND

CONCLUSIONS

- HIGH LATITUDE DUST SOURCES DUE TO GLACIER AND SNOW RETREAT
- ICELANDIC DUST IS INTERACTING WITH THE CRYOSPHERE
  - THE MOST EXTREME DUST EVENTS REPORTED FROM THE ARCTIC
  - SNOW DUST STORMS CAN OCCUR
  - OPTICAL PROPERTIES ARE SIMILAR TO BLACK CARBON

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

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Aeolian Research 20 (2016) 176–195
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journal homepage: www.elsevier.com/locate/aeolis

Review article

The Icelandic [illegible] aeolian environment: Processes and impacts – A review

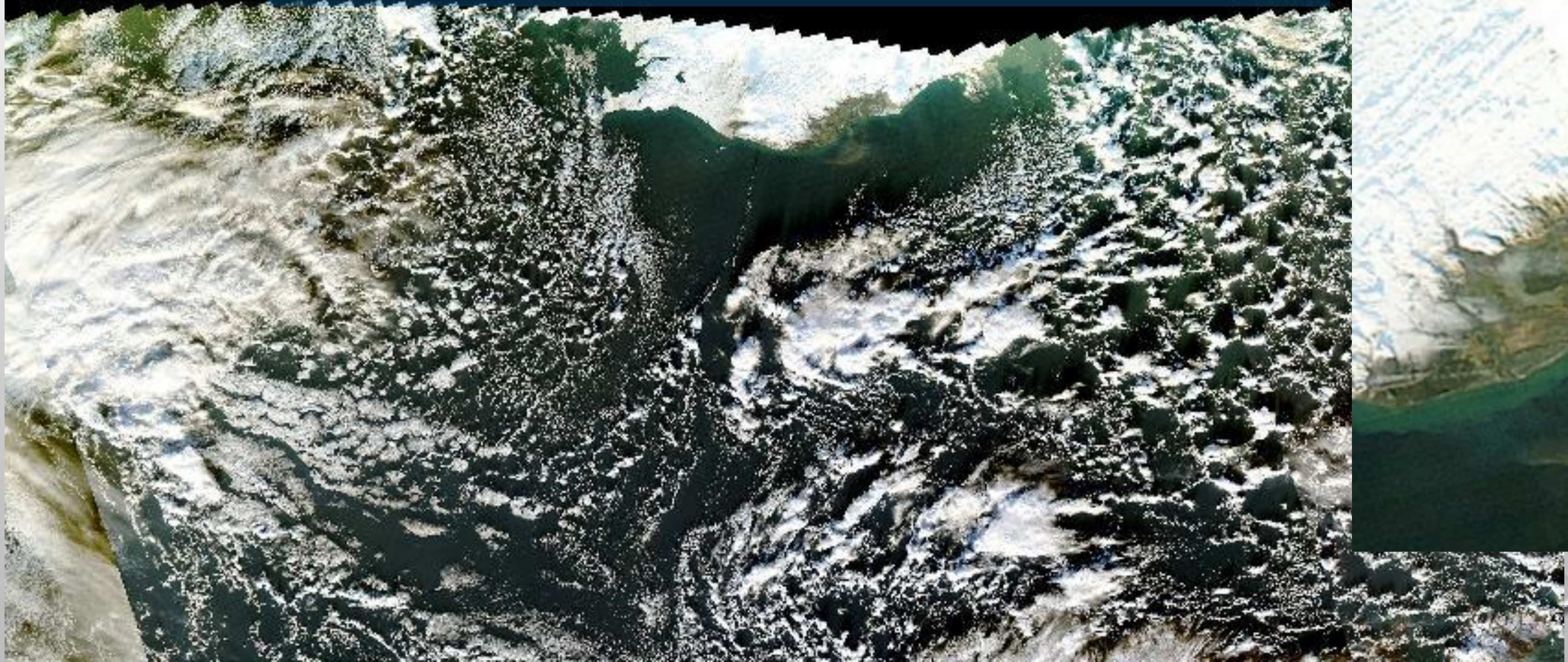
Olafur Arnalds[a,b,*], Pavla Dagsson-Waldhauserova[a,c,d], Haraldur Olafsson[d,e]

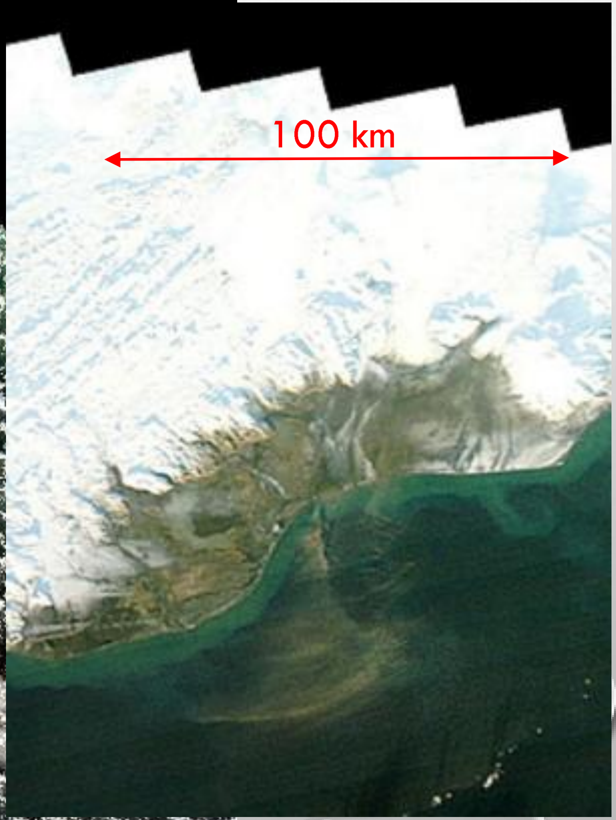
The largest desert in Europe and Arctic is ... ?

THANK YOU FOR YOUR ATTENTION!

pavla@lbhi.is

Snow does not give limitations for dust suspension!
Cold times, dusty times!
MODIS Aqua, S Iceland, January 13, 2016





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

The Cryosphere
Open Access

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

O. Meinander[1], A. Kontu[2], A. Virkkula[1], A. Arola[3], 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]

1. *A semi-direct effect of absorbing impurities*. Absorbing impurities would cause melt and/or evaporation from the liquid phase and sublimation from the solid phase of the surrounding snow, resulting in air pockets around the impurities, and thus lower snow density. We have empirical observations, where impurities (both organic and inorganic) in the snow have been surrounded by air pockets.

2. *BC effect on the adhesion between liquid water and snow grains*. If BC reduces adhesion, the liquid-water holding capacity decreases. For linear warming the influence on the density of wet snow is then max 5 % (at this level water flow starts in natural snow). However, with daily cycles, warm days and cold nights, the weaker adhesion may push liquid water down more day-by-day and then the influence to the density would be larger. This way also melt–freeze metamorphosis would produce less dense snow.

3. *BC effect on the snow grain size*. Absorbing impurities would increase the melting and metamorphosis processes, resulting in larger snow grains, which would lower the water retention capacity. Earlier, Yamaguchi et al. (2010) have suggested that the water retention curve of snow could be described as a function of grain size using soil physics models. Here our data showed some slight indication for the possibility of soot in snow to result in larger snow grain sizes via increased melt and metamorphosis, and our data did not show clear evidence against this possibility.