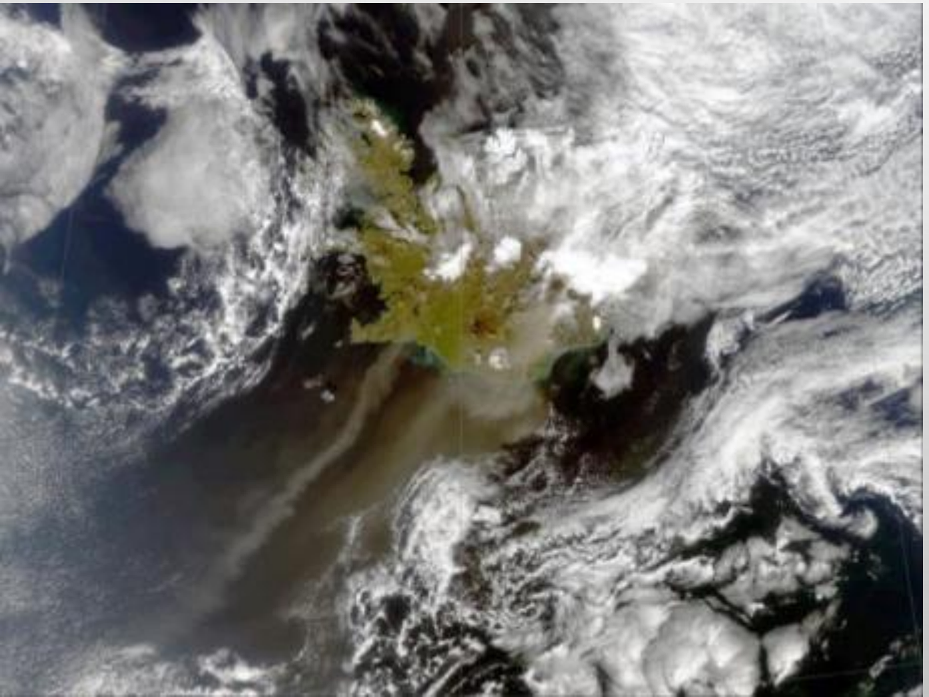
THREE EXTREME DUST STORMS IN ICELAND



PAVLA DAGSSON WALDHAUSEROVA

O. ARNALDS, H. OLAFSSON, O. MEINANDER, M. GRITSEVICH, J. PELTONIEMI, J-B RENARD, J. HLADIL, L. CHADIMOVA, AND MORE

THE 31ST NORDIC METEOROLOGICAL MEETING

REYKJAVÍK, 18.-20.6.2018

HIGH LATITUDE DUST AREAS

AGU PUBLICATIONS

Reviews of Geophysics

REVIEW ARTICLE

10.1002/2016RG000518

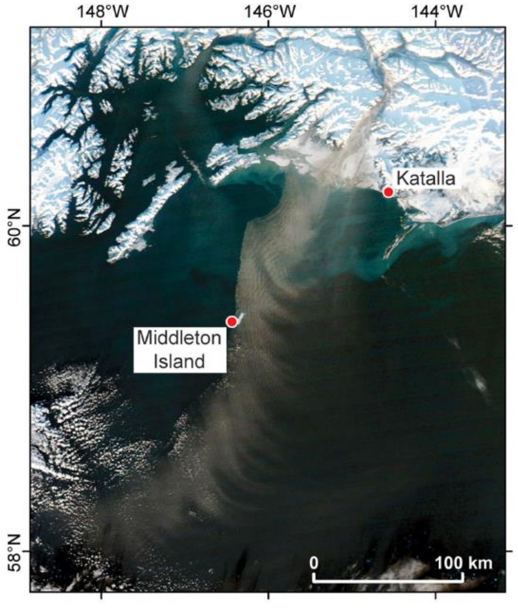
Key Points:

- High-latitude dust sources are located in paraglacial regions ≥50°N and ≥40°S

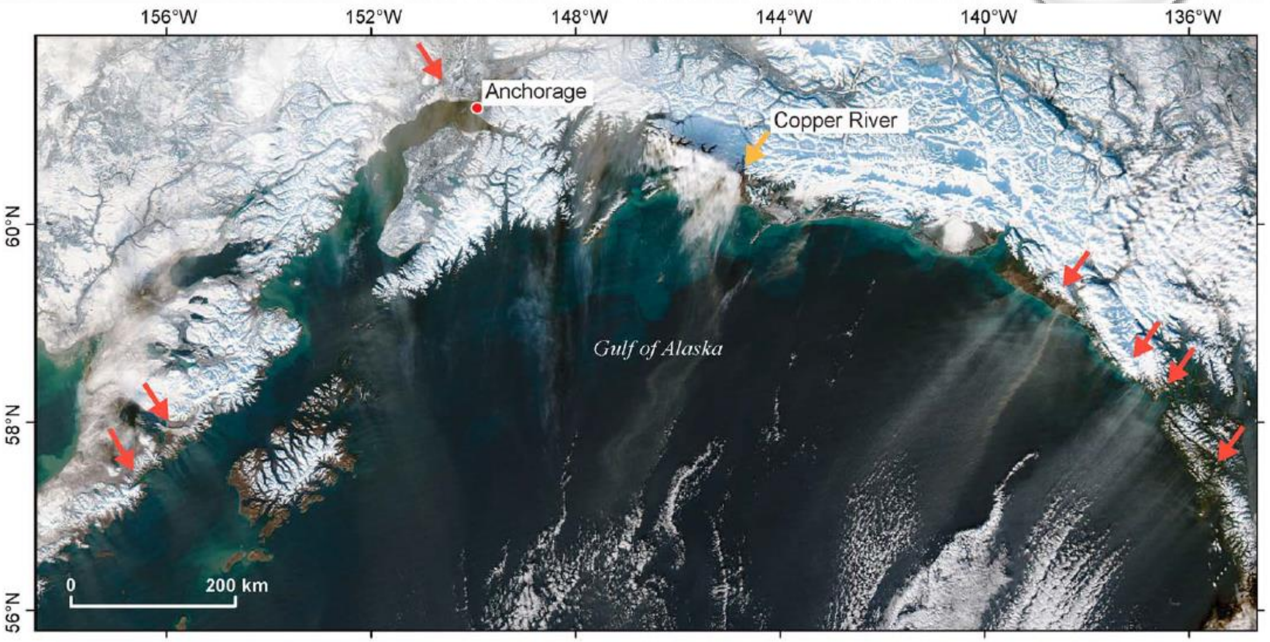
High-latitude dust in the Earth system

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[8]

- THE MAIN SOURCES OF DUST EMISSIONS IN THE NORTHERN (ALASKA, CANADA, GREENLAND, AND ICELAND) AND SOUTHERN (ANTARCTICA, NEW ZEALAND, AND PATAGONIA) HEMISPHERES
- HIGH-LATITUDE SOURCES COVER >500,000 KM^2
- CONTRIBUTION OF 80 – 100 TG YR^{-1} OF DUST TO THE EARTH SYSTEM (~5% OF THE GLOBAL DUST BUDGET)



MODIS Aqua image 4 December 2012 showing a major dust plume originating from the Copper River valley a



MODIS Terra image 26 February 2011 showing multiple dust plumes being transported over the Gulf of Alaska.

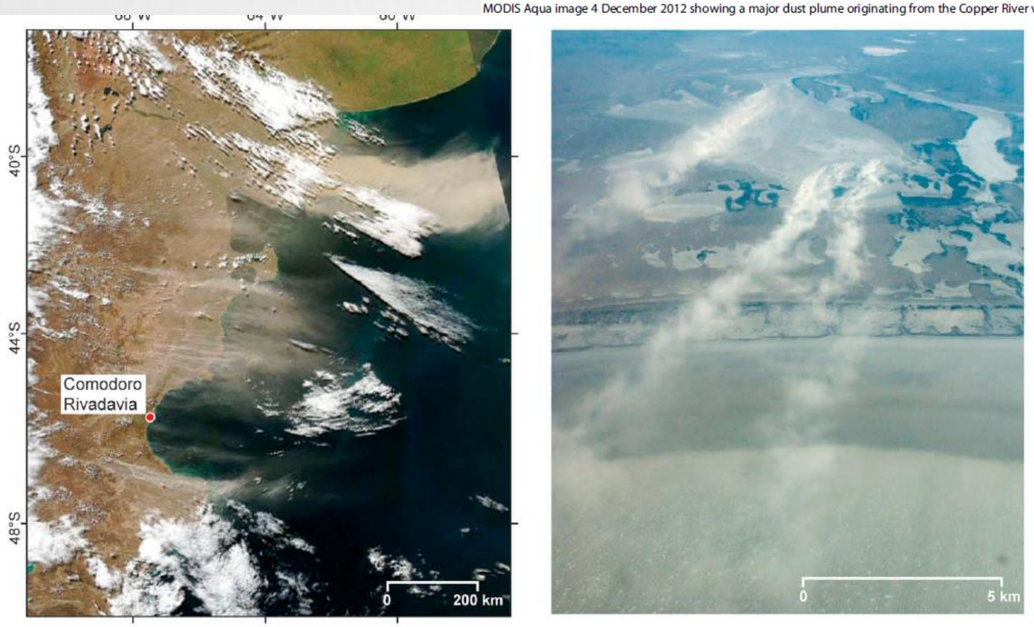


Figure 18. (left) MODIS Aqua image 28 March 2009 showing multiple dust plumes in Patagonia caused by strong westerly winds extending over the south Atlantic. The most dense plume originates from the Colorado and Negro River mouths in the north which were particularly active in 2009 due to combined drought and poor rangeland management. (right) Aerial photograph of dust storm in October 2004 caused by winds gusting to 29 m s^{-1} at San Sebastián Bay, Tierra del Fuego, 800 km south of Comodoro Rivadavia.

Figure 9. Dust event at Kangerlussuaq, SW Greenland, 1 July 2014. Phot

ICELAND AND SOURCES OF AIR POLLUTION

- TOTAL ICELANDIC DESERT AREAS COVER OVER 44,000 KM^2
- ICELAND IS THE LARGEST ARCTIC AS WELL AS EUROPEAN 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

Aeolian Research

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

ELSEVIER

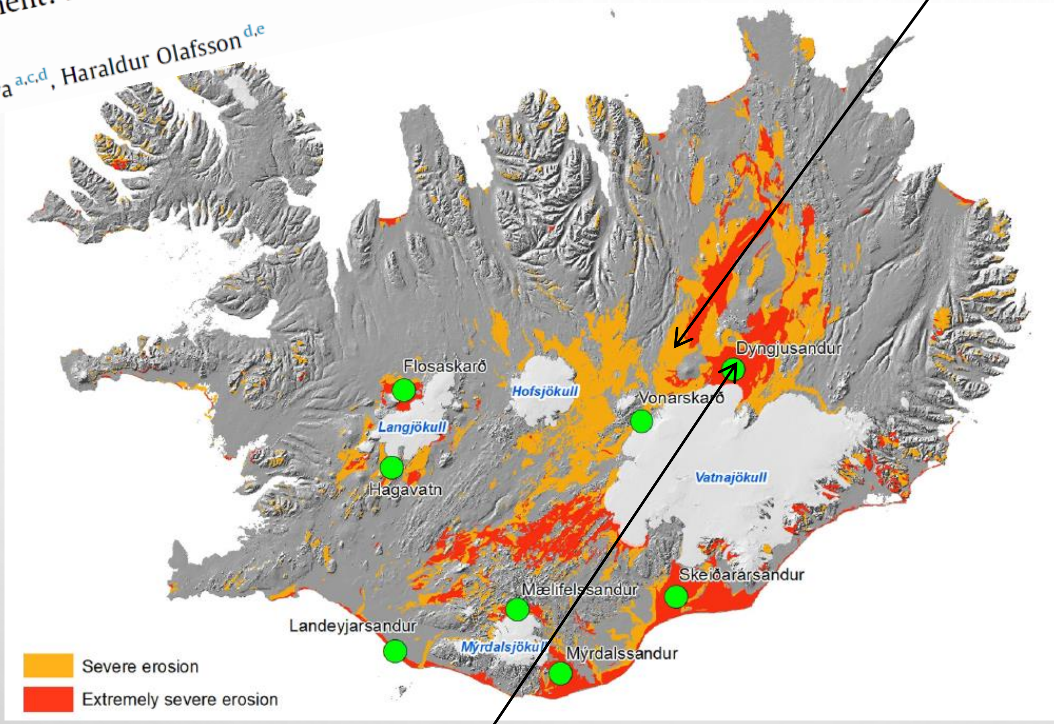
Review article

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

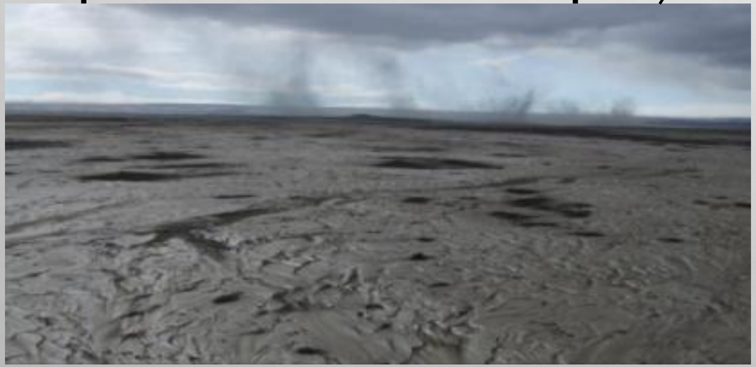
Olafur Arnalds[a,b,*], Pavla Dagsson-Waldhauserova[a,c,d], Haraldur Olafsson[d,e]

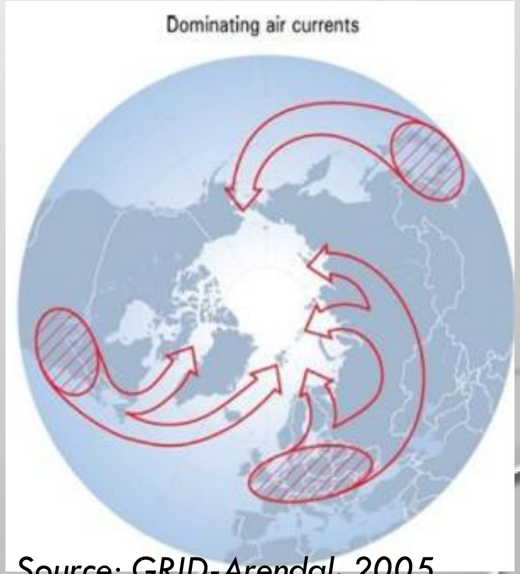

Aeolian Research 20 (2016) 176–195
Contents lists available at ScienceDirect
Aeolian Research
journal homepage: www.elsevier.com/locate/aeolia
ELSEVIER
CrossMark
Review article
The Icelandic volcanic aeolian environment: Processes and impacts — A review
Olafur Arnalds [a,b,*], Pavla Dagsson-Waldhauserova [a,c,d], Haraldur Olafsson [d,e]

volcanic sandy deserts (22% of Iceland)



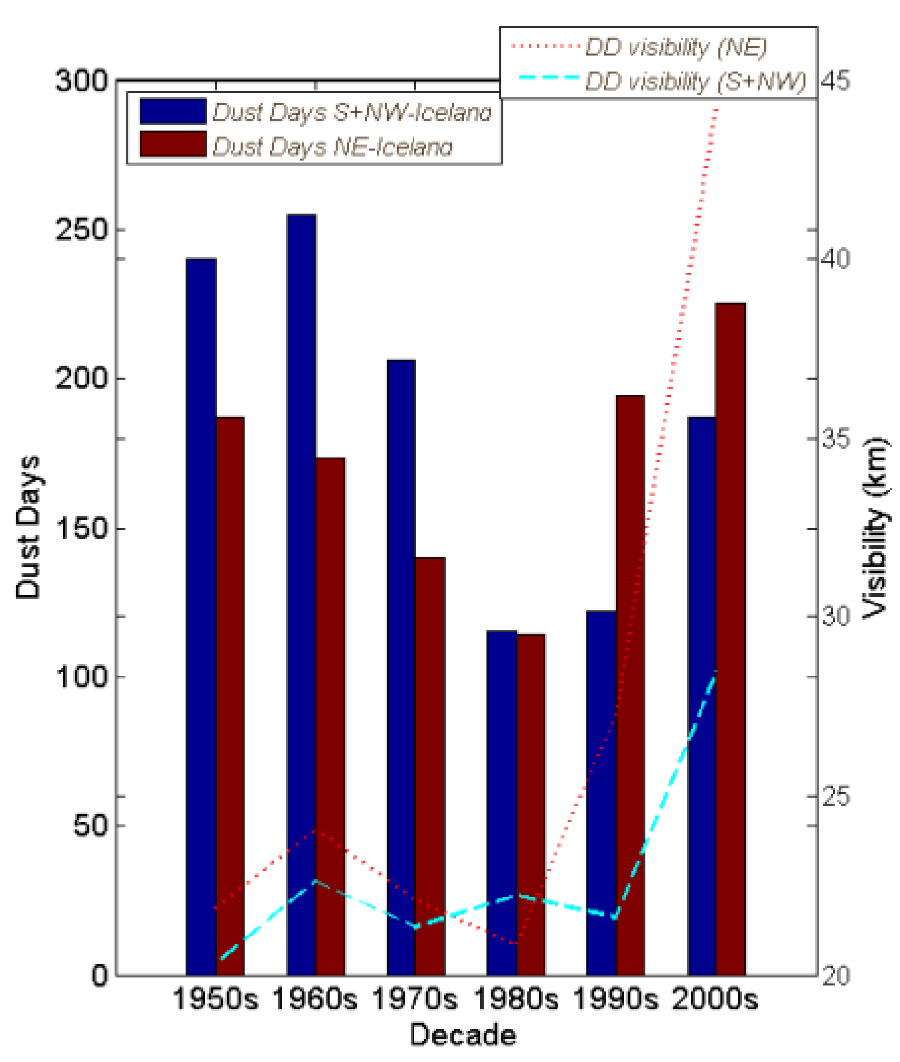
glacial riverbeds and ice-proximal areas = “dust hot spots”





Source: GRID-Arendal, 2005. Barentswatch Atlas.

FREQUENCY OF DUST EVENTS



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

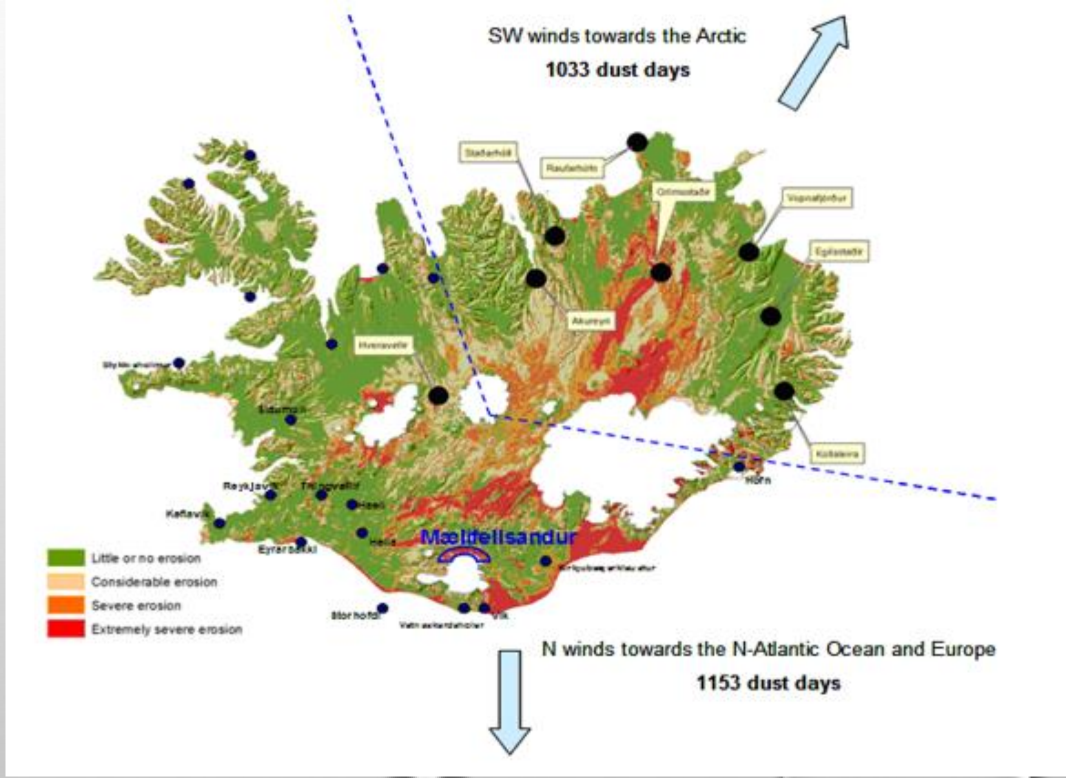
Long-term variability of dust events in Iceland (1949–2011)

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

AN AVERAGE OF **34.4** DUST DAYS PER YEAR,

BUT **<u>135</u>** <u>DUST DAYS</u> PER YEAR INCLUDING

"VISIBILITY REDUCED BY VOLCANIC ASHES" + "DUST HAZE"

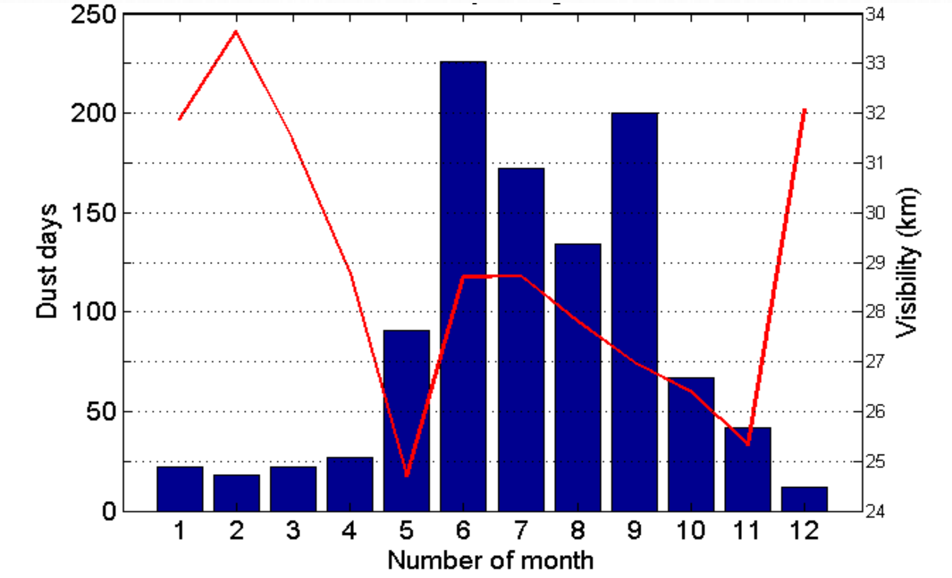


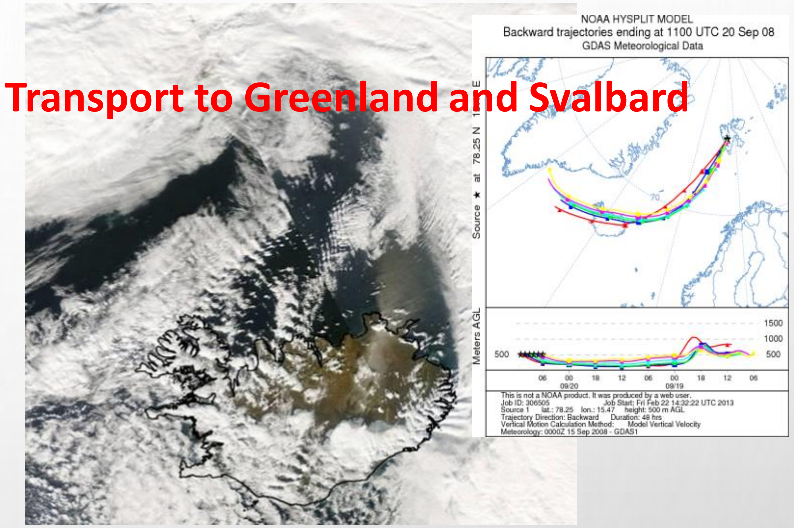
SEASONAL VARIABILITY OF DUST EVENTS

- NE ICELAND

"ARCTIC DUST EVENTS"

SUMMER

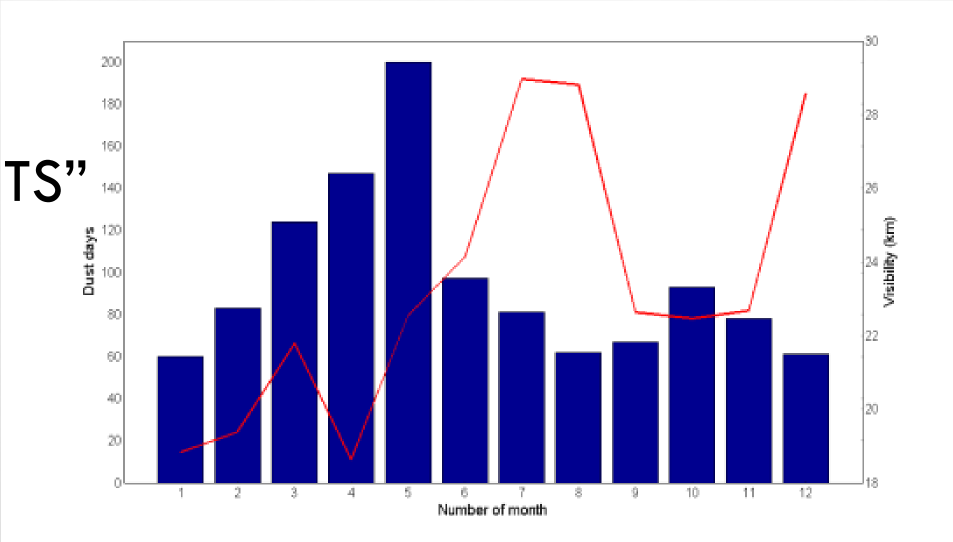


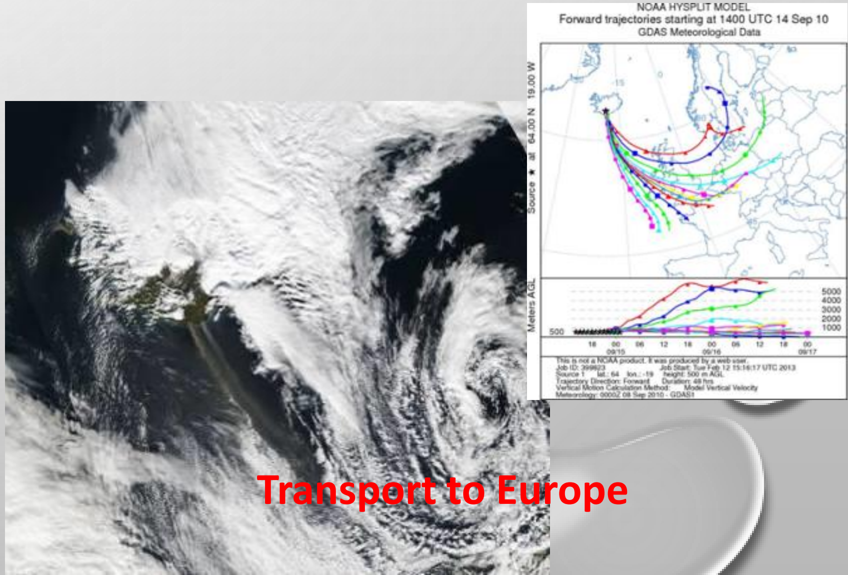


- S ICELAND

"SUB-ARCTIC DUST EVENTS"

WINTER-SPRING





DISTRIBUTION OF DUST DEPOSITION

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

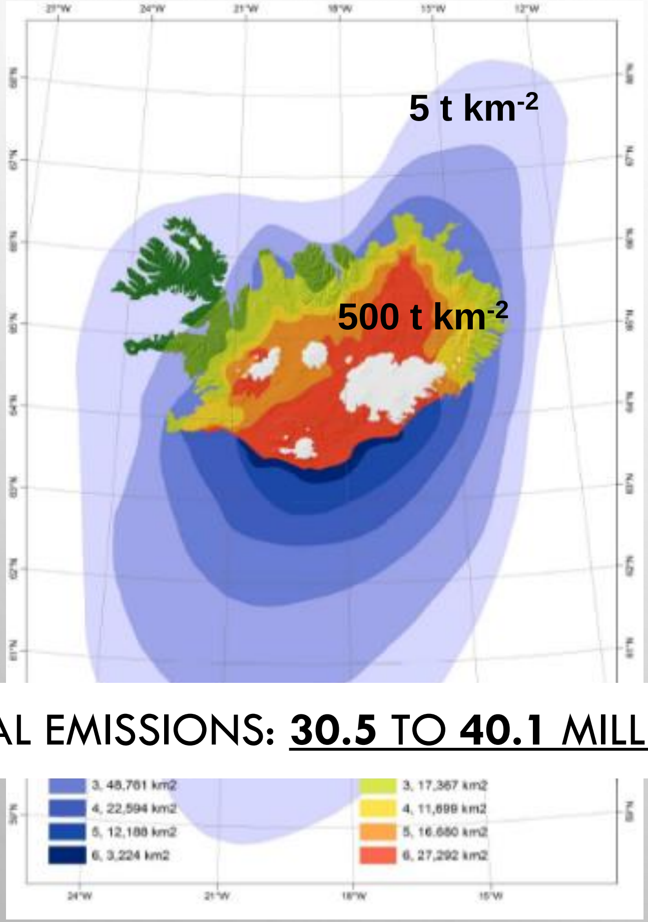
Quantification of iron-rich volcanogenic dust emissions and deposition over the ocean from Icelandic dust sources

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

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>

- TOTAL EMISSIONS: **4.3 ± 0.8** TG

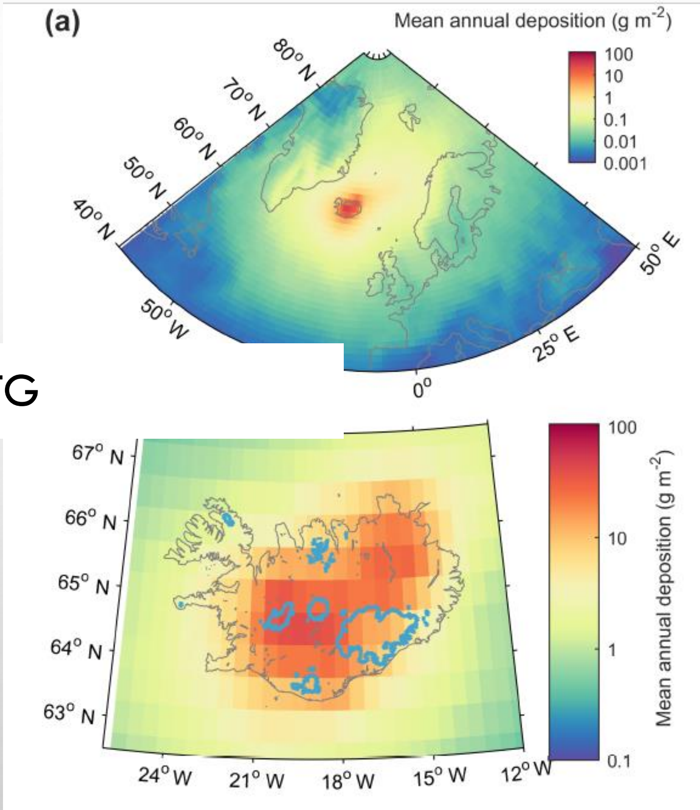


Figure 10. Mean annual dust deposition ($g\,m^{-2}$) simulated with FLEXPART in years 1990–2016 for the North Atlantic region **(a)** and Iceland **(b)**. Maximum values are lower in the upper panel than in the lower panel as this figure shows averages over larger areas. The blue lines in the bottom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

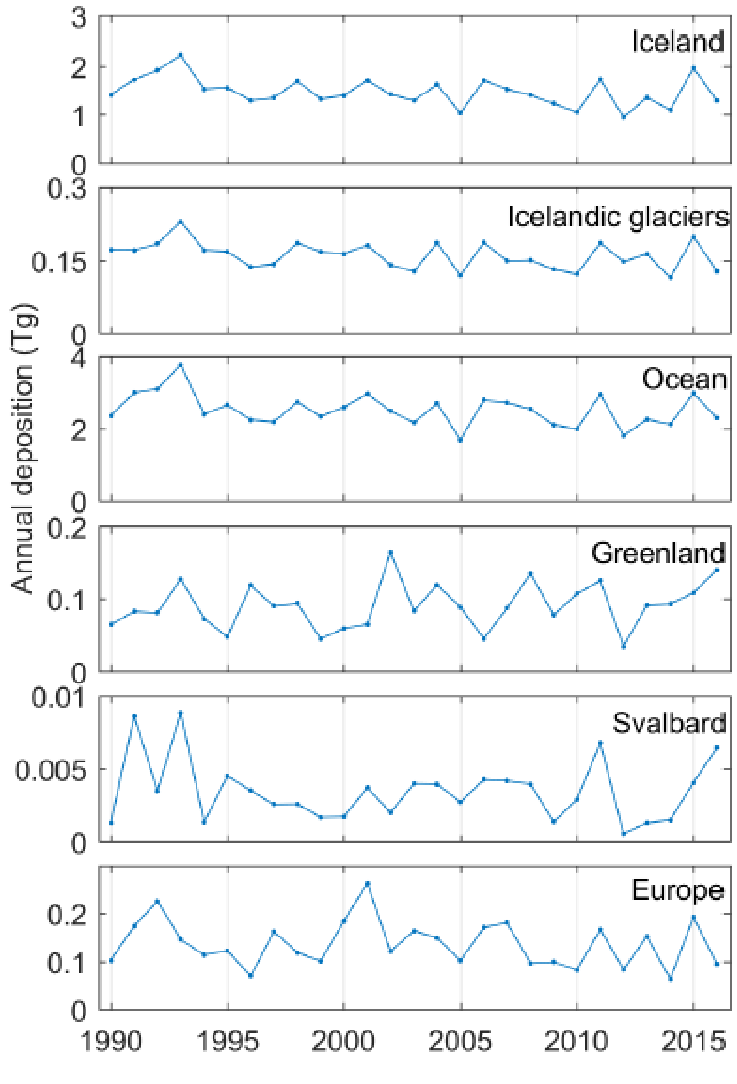


Figure 12. Time series (1990–2016) of modelled dust deposition ($Tg\,yr^{-1}$) in specific regions. Note that Iceland also includes deposition on Icelandic glaciers.

- 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)

ELSEVIER

Contents lists available at ScienceDirect

Earth and Planetary Science Letters

www.elsevier.com/locate/epsl

Pathways of high-latitude dust in the North Atlantic

Matthew C. Baddock[a,*], Tom Mockford[a], Joanna E. Bullard[a], Throstur Thorsteinsson[b]

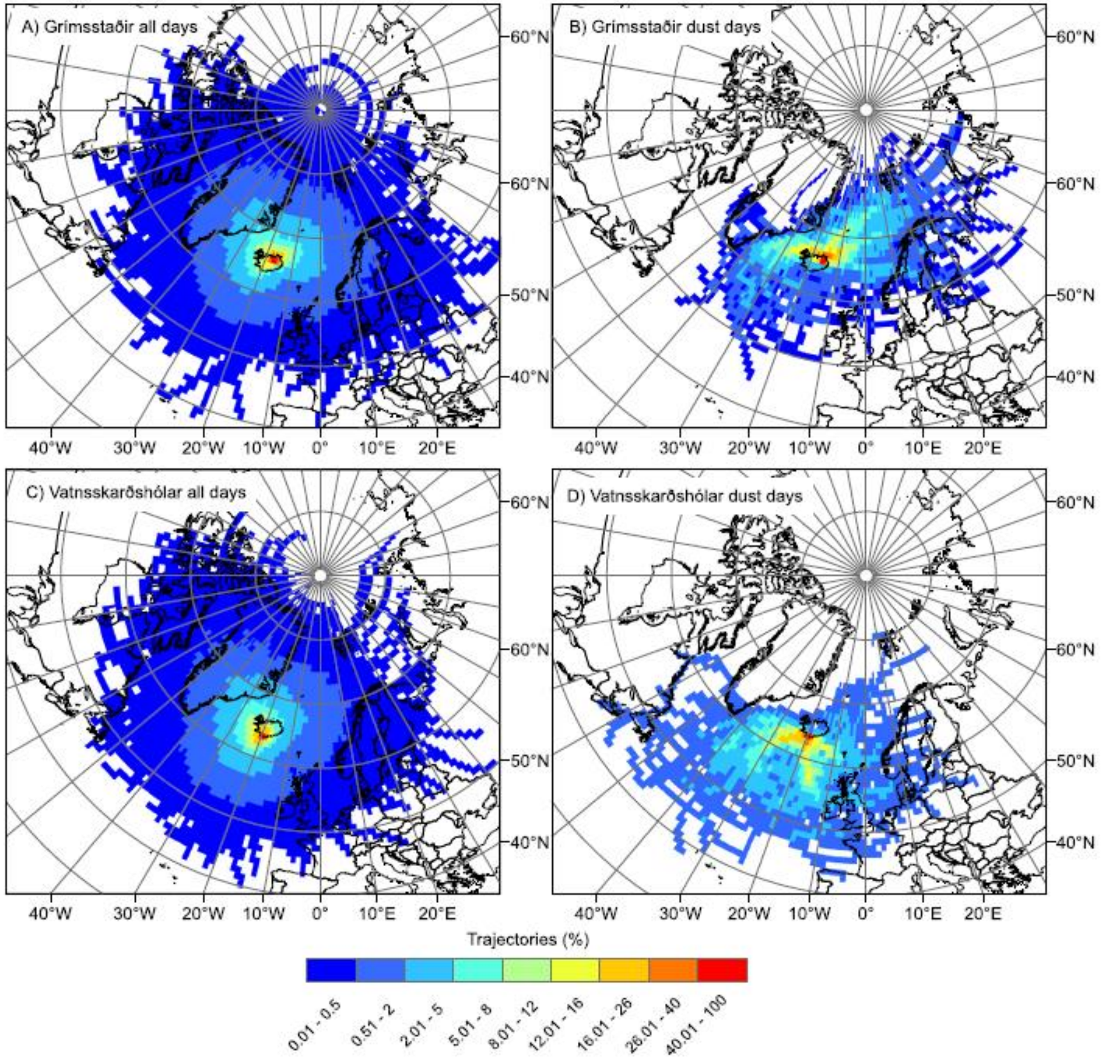
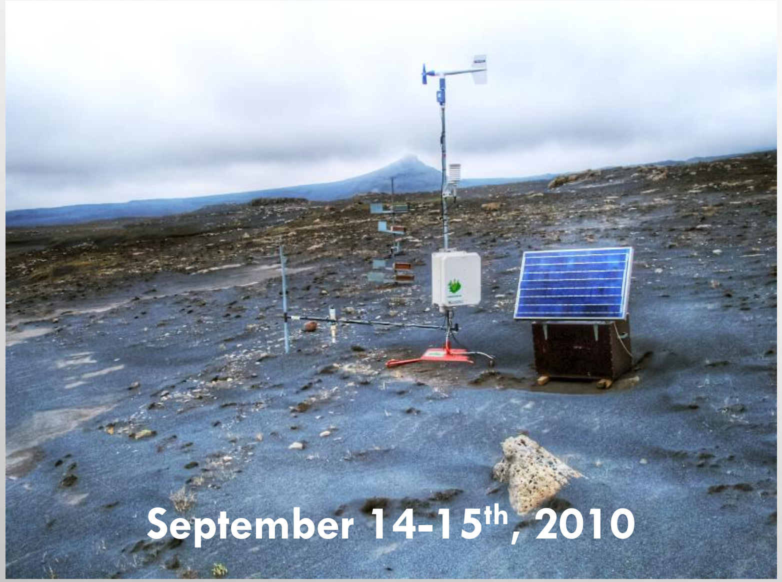


Fig. 2. Trajectory line density (% of trajectories per 1° × 1° cell) for 72 h simulations run at a 100 m start height from Grímsstaðir for all days 1992–2012 (A), and dust observation days only (B), from Vatnsskarðshólar for all days 1992–2012 (C), and dust observation days only (D). See Fig. 1 for trajectory start points.

THREE MOST UNUSUAL DUST EVENTS OBSERVED AND MEASURED

1. Extreme wind erosion event of Eyjafjallajökull volcanic ash



SCIENTIFIC REPORTS

OPEN

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

SUBJECT AREAS: ENVIRONMENTAL SCIENCES

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

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]

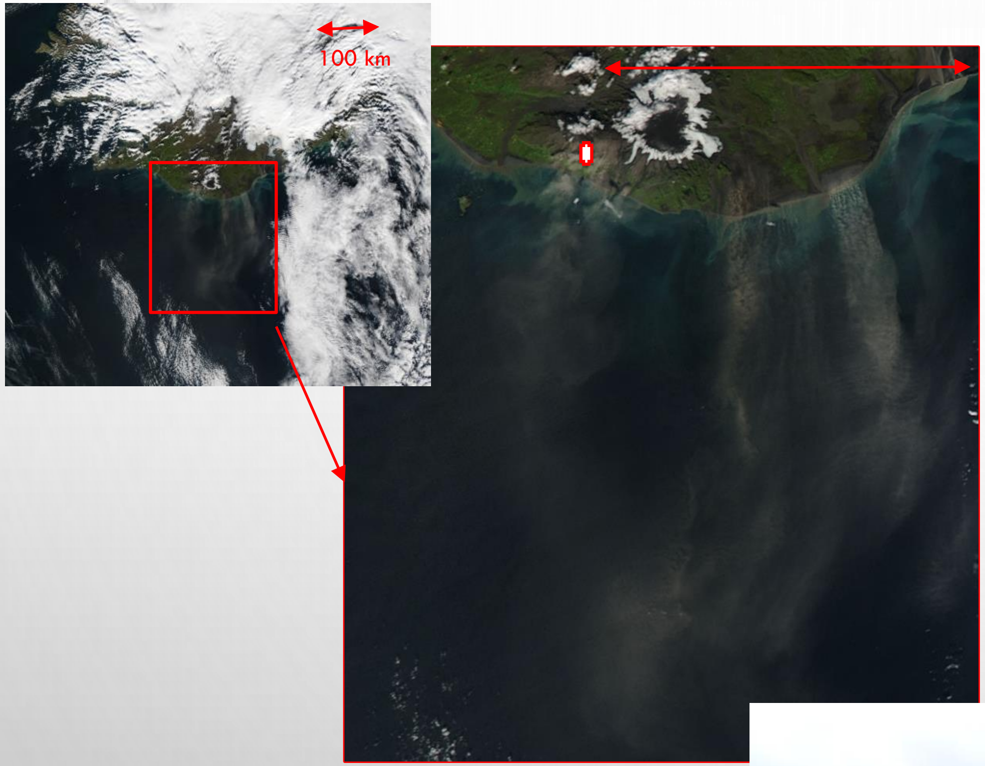
3. Suspended dust during moist and low wind conditions

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]

1. AN EXTREME WIND EROSION EVENT OF EYJAFJALLAJÖKULL VOLCANIC ASH IN 2010



- **AEOLIAN TRANSPORT** OVER ONE METER TRANSECT **> 11,800 KG M^{-1}**
- THIS STORM IS AMONG THE MOST EXTREME WIND EROSION EVENTS RECORDED ON EARTH
- FRESHLY DEPOSITED ASH PROLONGS IMPACTS OF VOLCANIC ERUPTIONS

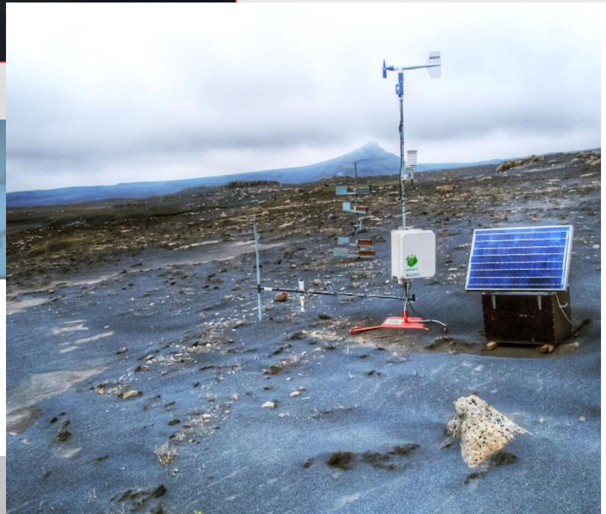

SCIENTIFIC REPORTS

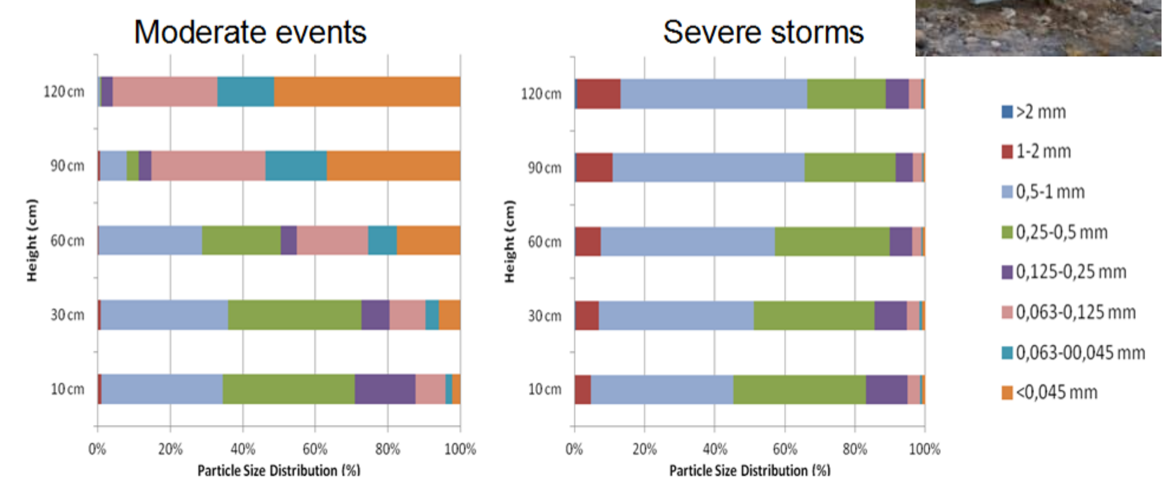
OPEN

SUBJECT AREAS: ENVIRONMENTAL SCIENCES

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

Olafur Arnalds, Elin Fjola Thorarinsdottir, Johann Thorsson, Pavla Dagsson Waldhauserova & Anna Maria Agustsdottir





Contents lists available at ScienceDirect
Aeolian Research
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Snow–Dust Storm: Unique case study from Iceland, March 6–7, 2013

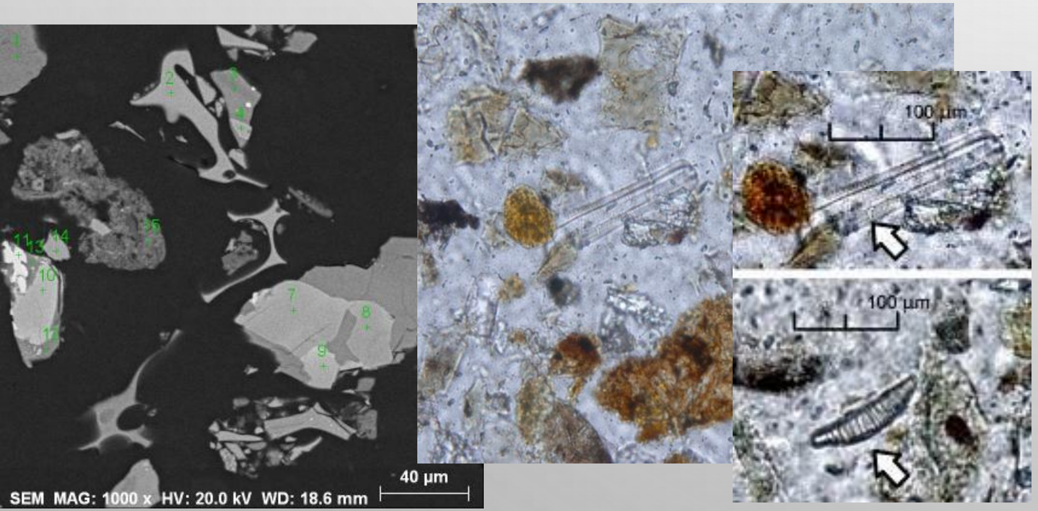
Pavla Dagsson-Waldhauserova [a,b,g,*], Olafur Arnalds [a], Haraldur Olafsson [b,c,d], Jindrich Hladil [e], Roman Skala [e], Tomas Navratil [e], Leona Chadimova [e], Outi Meinander [f]

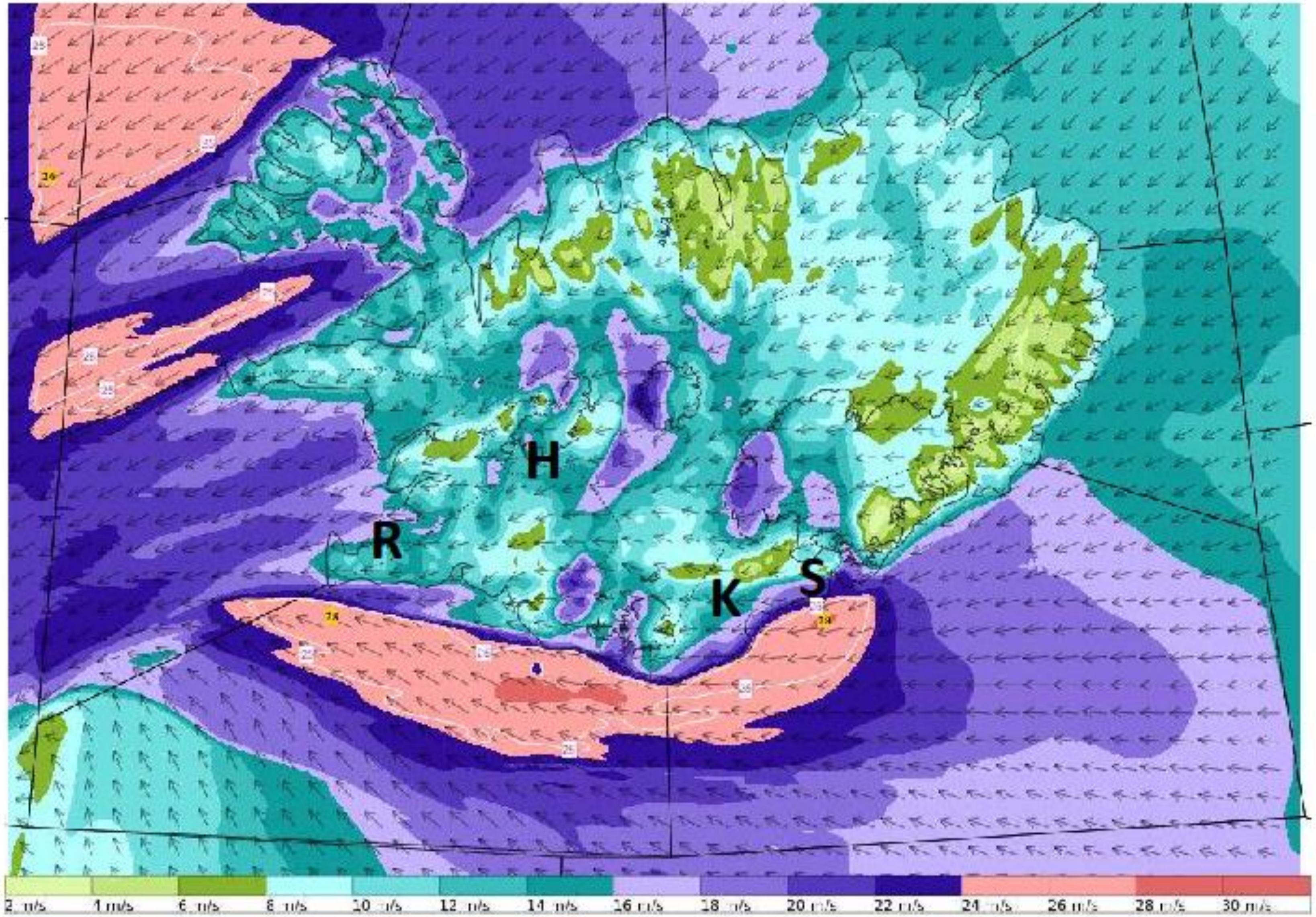
2. A SNOW-DUST STORM

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

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





H
R
K
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2 m/s
4 m/s
6 m/s
8 m/s
10 m/s
12 m/s
14 m/s
16 m/s
18 m/s
20 m/s
22 m/s
24 m/s
26 m/s
28 m/s
30 m/s

Soot On Snow (SOS) 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

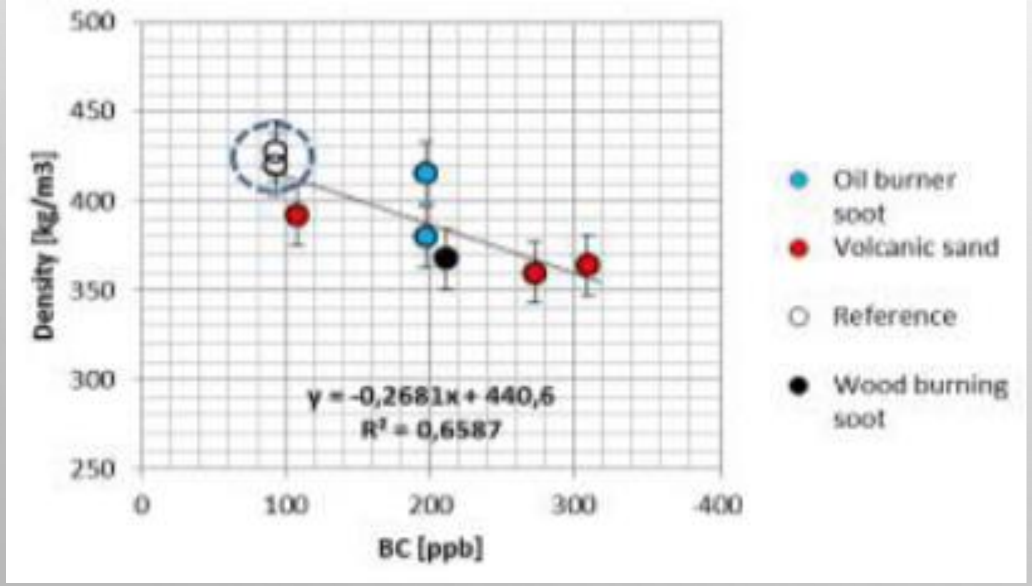
J. I. Peltoniemi[1,2], M. Gritsevich[1,2,8], T. Hakala[1], P. Dagsson-Waldhauserová[5,6,7], Ó. Arnalds[6], K. Anttila[1,3], H.-R. Hannula[4], N. Kivekäs[3], H. Lihavainen[3], O. Meinander[3], J. Svensson[3,9], A. Virkkula[3], and G. de Leeuw[2,3]

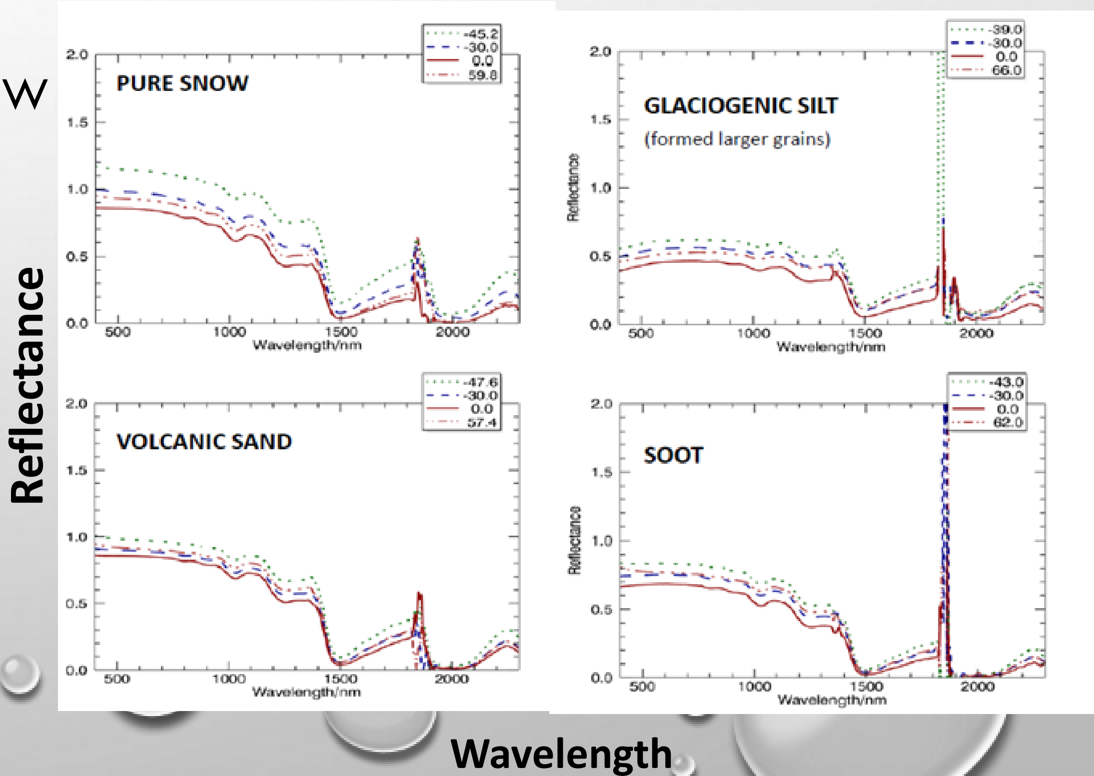
The Cryosphere, 8, 991–995, 2014
www.the-cryosphere.net/8/991/2014/
doi:10.5194/tc-8-991-2014

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

O. Meinander[1], A. Kontu[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[1,6], and M. Leppäranta[6]

- VOLCANIC DUST DECREASES SNOW ALBEDO SIMILARLY AS BLACK CARBON
- IN LAB, VOLCANIC DUST IS AN ABSORBING AEROSOL (SR=0.03)
- SOOT DECREASES WATER RETENTION CAPACITY AND DENSITY OF SNOW





3. SUSPENDED DUST DURING MOIST AND LOW WIND CONDITIONS

- DUST EVENT AS RESULT OF SURFACE HEATING IN AUGUST 2013
- Max particle number concentration (PM~0.3-10 µm) reached 149,954 particles cm^{-3} min^{-1} while mass concentration PM_{10} was 1757 µg m^{-3} min^{-1}
- THE PARTICLES WERE MAINLY OF THE CLOSE-TO-ULTRAFINE SIZE (highest number of particles in size range 0.3-0.337 µm)
- ~ 80 % of the glaciogenic dust is volcanic glass (with bubbles) rich in heavy metals
- WET DUST PARTICLES WERE MOBILIZED WITHIN < 4 HOURS

Mælifellssandur dust storm iniciation during dry summer 2012, © Oli Arnalds

L: The surface exposed to solar radiation for four hours **R:** Surface heating resulted in cloud formation and upward air motion

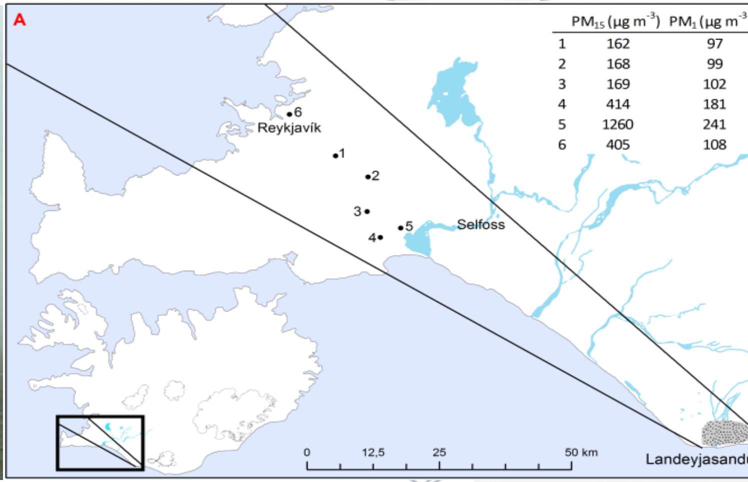
Source: Dagsson-Waldhauserova et al., 2014. **Physical properties of suspended dust during moist and low-wind conditions in Iceland**. Icelandic Agric. Sci. 27, 25–39.

atmosphere MDPI

Article

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

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



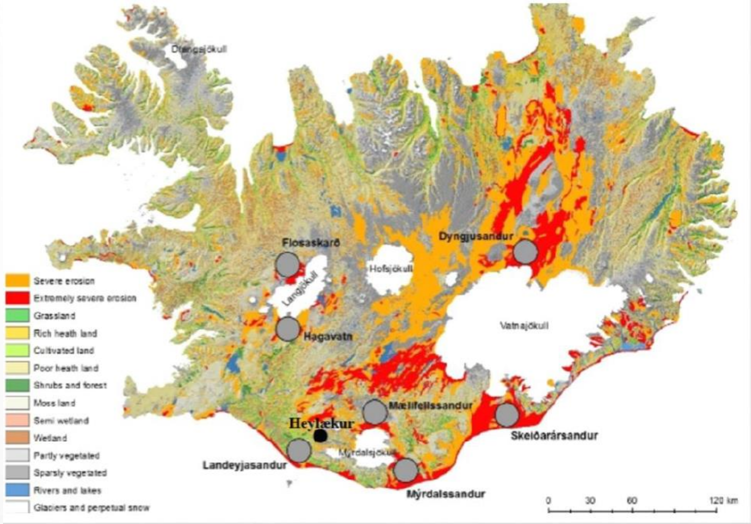
atmosphere

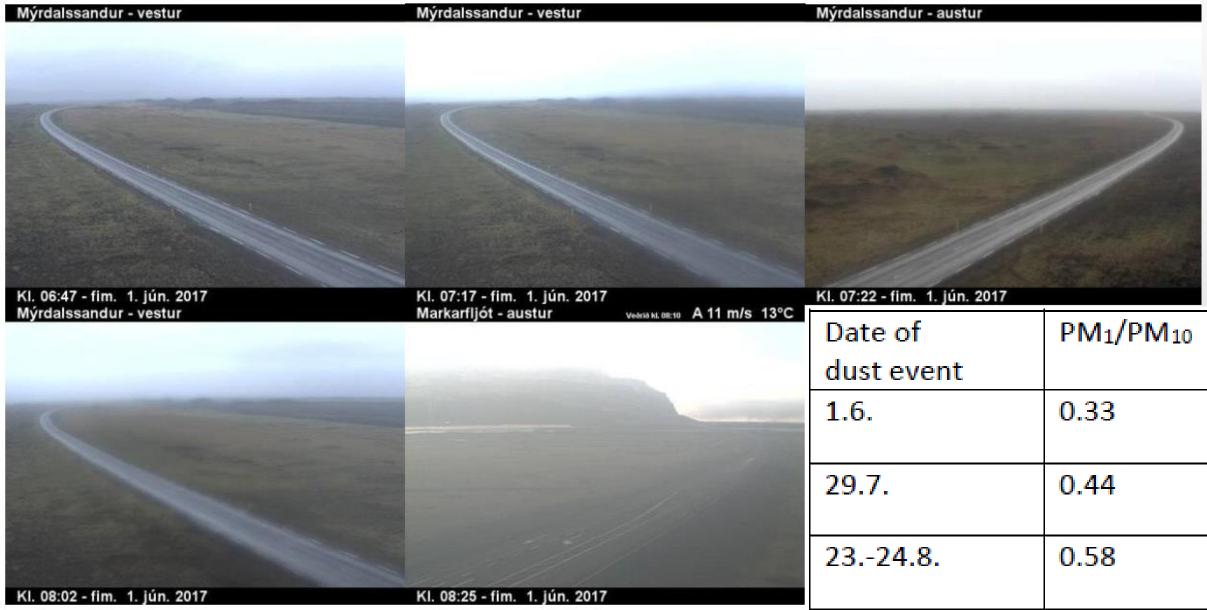
Table 1. Particulate matter concentrations $PM_{1\text{-}15}$ ($\mu g m^{-3}$) for both storms. Ratios between different PM values are given.

	PM_1 Average	$PM_{2.5}$ Average	PM_4 Average	PM_{10} Average	Total (PM_{15}) Average	PM_1/PM_{10} Ratio	$PM_{2.5}/PM_{10}$ Ratio	$PM_1/PM_{2.5}$ Ratio	PM_1/PM_4 Ratio	PM_4/PM_{10} Ratio	PM_{10}/PM_{15} Ratio
Storm 1											
1	97	109	130	158	162	0.61	0.69	0.89	0.75	0.82	0.98
2	99	110	130	158	168	0.63	0.70	0.90	0.76	0.82	0.94
3	102	114	137	163	169	0.63	0.70	0.89	0.74	0.84	0.96
4	181	201	248	354	414	0.51	0.57	0.90	0.73	0.70	0.86
5	241	263	322	583	1260	0.41	0.45	0.92	0.75	0.55	0.46
6	108	118	142	224	405	0.48	0.53	0.92	0.76	0.63	0.55
Storm 2											
1	11	12	14	29	71	0.48	0.53	0.92	0.76	0.63	0.55
2	4	4	5	7	10	0.38	0.41	0.92	0.79	0.48	0.41
3	12	13	16	29	42	0.57	0.57	1.00	0.80	0.71	0.70
4	57	61	74	162	383	0.41	0.45	0.92	0.75	0.55	0.69
5	164	174	206	486	1600	0.35	0.38	0.93	0.77	0.46	0.42
6	128	140	177	318	436	0.34	0.36	0.94	0.80	0.42	0.30
7	35	39	48	87	143	0.40	0.44	0.91	0.72	0.56	0.73

Frequency and origin of dust events in Fljótshlíð, South Iceland, in 2017

Lea María Lemarquis





Date of dust event	PM_1/PM_{10}	$PM_{2.5}/PM_{10}$	$PM_1/PM_{2.5}$	PM_1/PM_4
1.6.	0.33	0.35	0.93	0.76
29.7.	0.44	0.46	0.95	0.83
23.-24.8.	0.58	0.61	0.95	0.84
31.8.	0.46	0.47	0.96	0.79
31.10.-1.11.	0.41	0.41	0.99	0.90

Icelandic Aerosol and Dust Association (IceDust)

Rykrannsóknafélag Íslands (RykÍS)

Home | About | Who we are? | Past events | Publications | Contact | Open positions | Witnessed a dust storm?

JANUARY 18, 2018

THE 2nd ICEDUST WORKSHOP

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

Search for topic on IceDust

Search ...

Upcoming Dust Events

- **The 9th International Workshop on Sand / Dust storm and Associated Dustfall http://dustworkshop9.net/**

Dust Storms in Iceland

Public Group

European Geosciences Union General Assembly 2018

Vienna | Austria | 8–13 April 2018

EGU.eu

IE2.7/AS3.6/BG1.10/CL2.24/CR8.7 Media

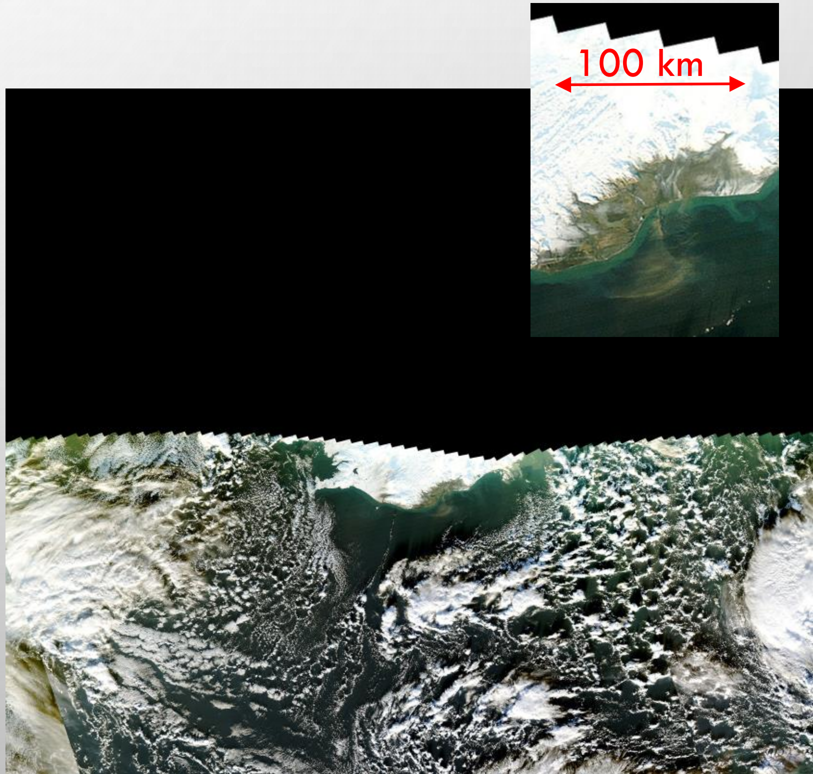
Atmosphere – Cryosphere interaction with focus on transport, deposition and effects of dust, black carbon, and other aerosols (co-organized)

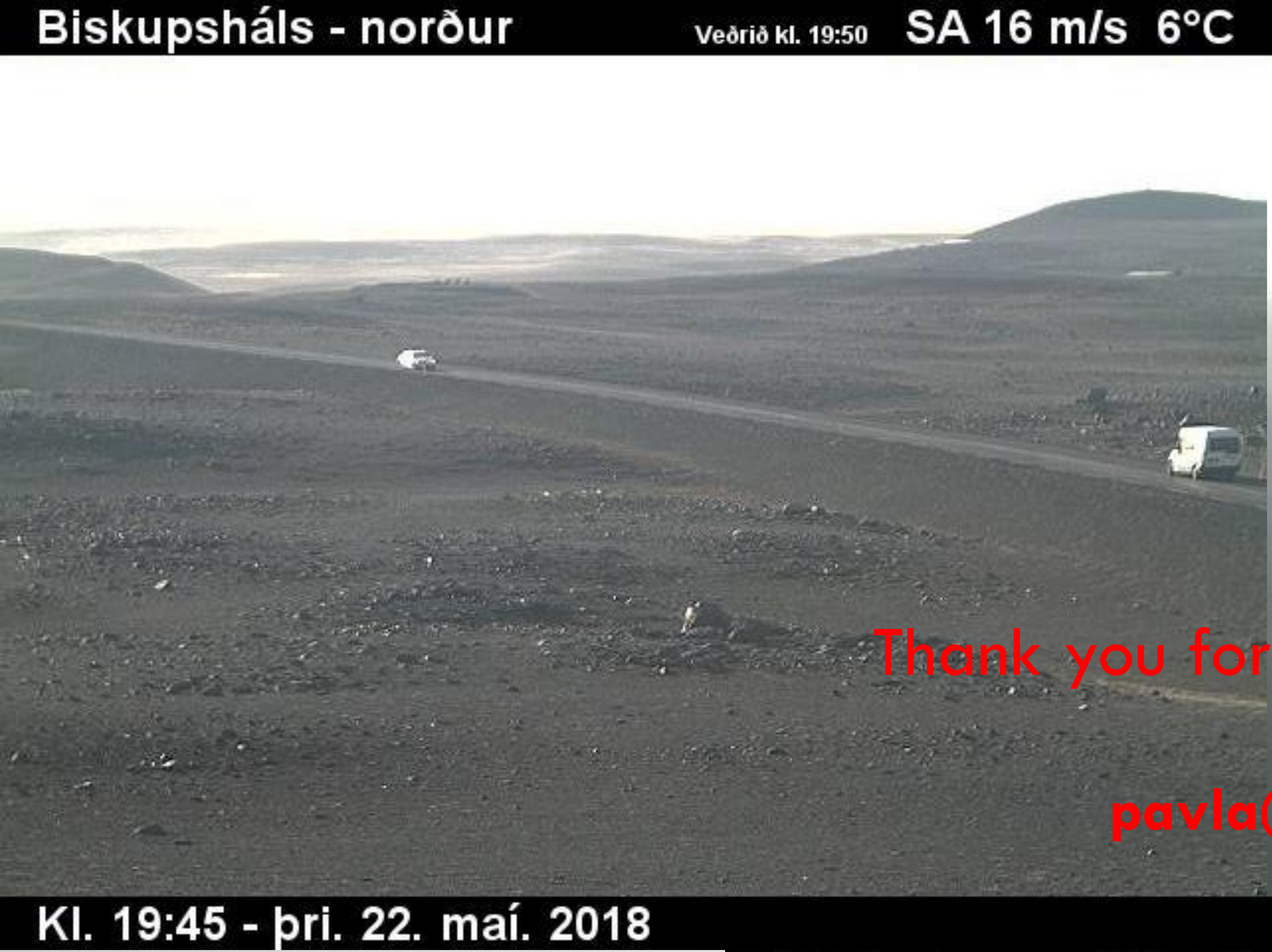
Convener: Pavla Dagsson Waldhauserova
Co-Conveners: Outi Meinander, Biagio Di Mauro, Marie Dumont, Chris Williamson, Krzysztof Zawierucha,

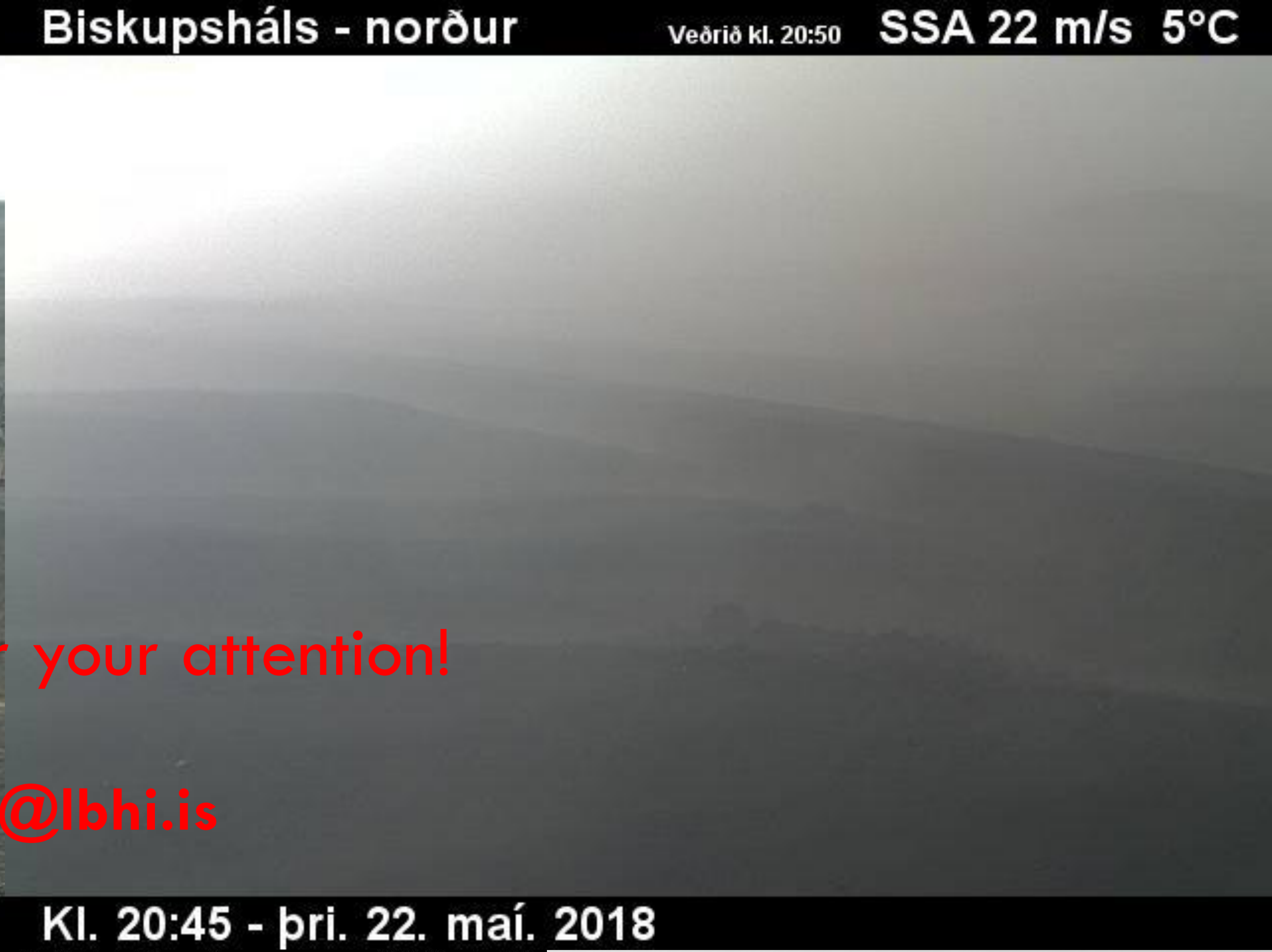
HTTPS://ICEDUSTBLOG.WORDPRESS.COM/

CONCLUSIONS

- ICELAND IS THE LARGEST EUROPEAN AND ARCTIC DESERT
- ICELANDIC DUST IS DIFFERENT TO CRUSTAL DUST
  - THE MOST EXTREME DUST EVENTS
  - OPTICAL PROPERTIES ARE SIMILAR TO BLACK CARBON
  - IT IS VERY FINE AND SHARP







Thank you for your attention!

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