Landbúnaðarháskóli Íslands
Agricultural University of Iceland

UNIVERSITY OF ICELAND

SPECTRAL REFLECTANCE MEASUREMENTS OF ABSORBING IMPURITIES ON SNOW

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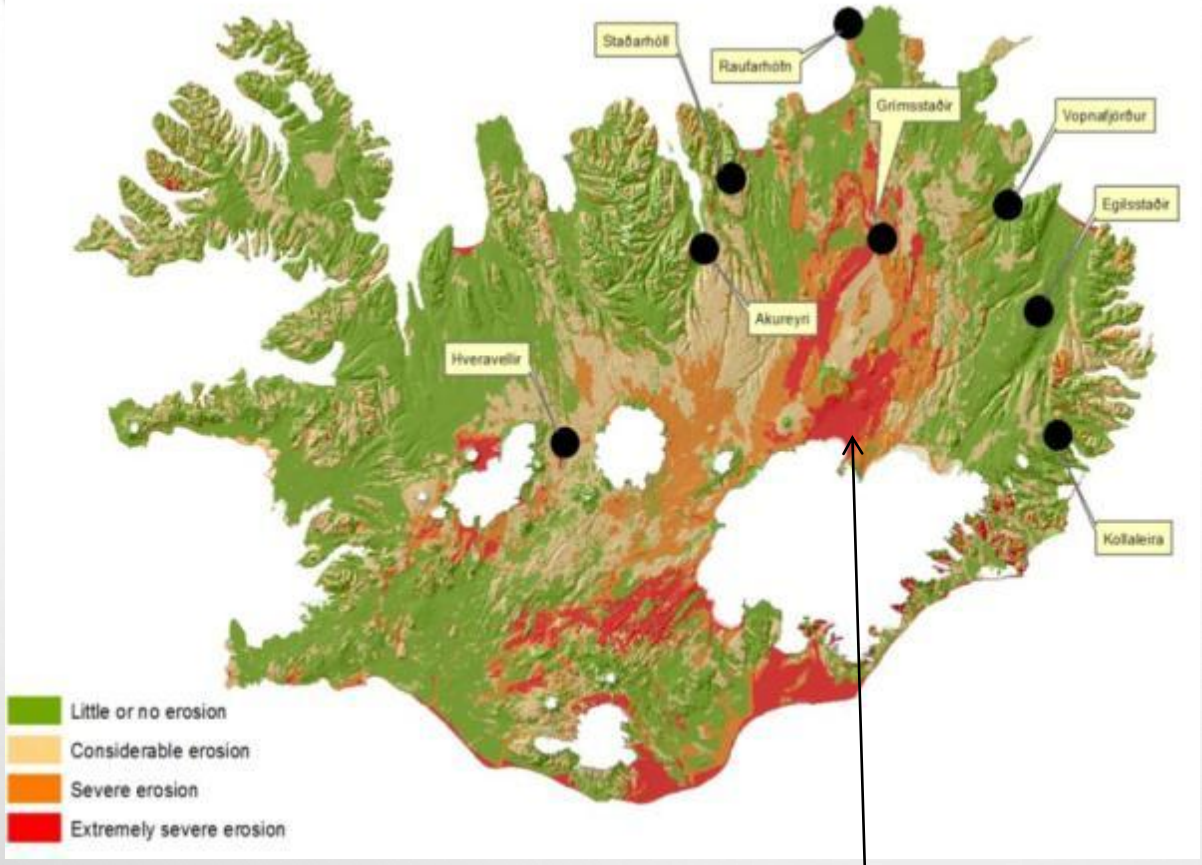
REYKJAVIK UNIVERSITY, FEBRUARY 28TH, 2017

ICELAND AND SOURCES OF AIR POLLUTION

- ABOUT 11% OF THE COUNTRY ARE GLACIERS
- ABOUT 22 % OF THE COUNTRY ARE VOLCANIC SANDY DESERTS AND > 40 % ARE DESERT AREAS WITH SEVERE EROSION

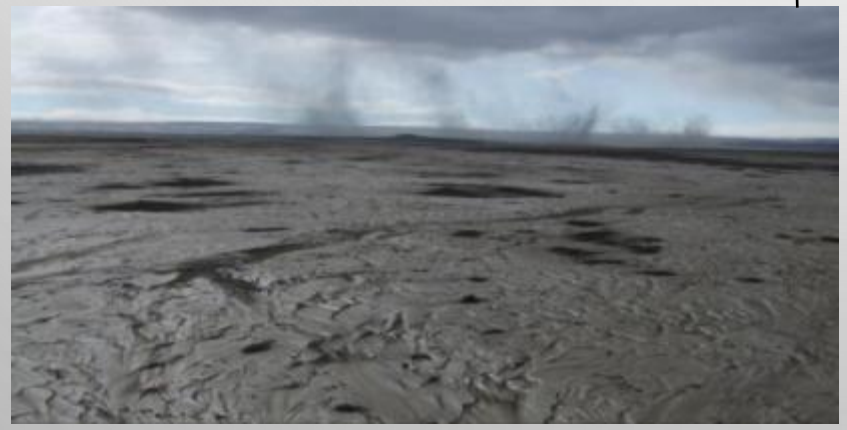
=> THE LARGEST DESERT IN THE ARCTIC AND EUROPE

- FREQUENT VOLCANIC ERUPTIONS
- FREQUENTLY STRONG WINDS



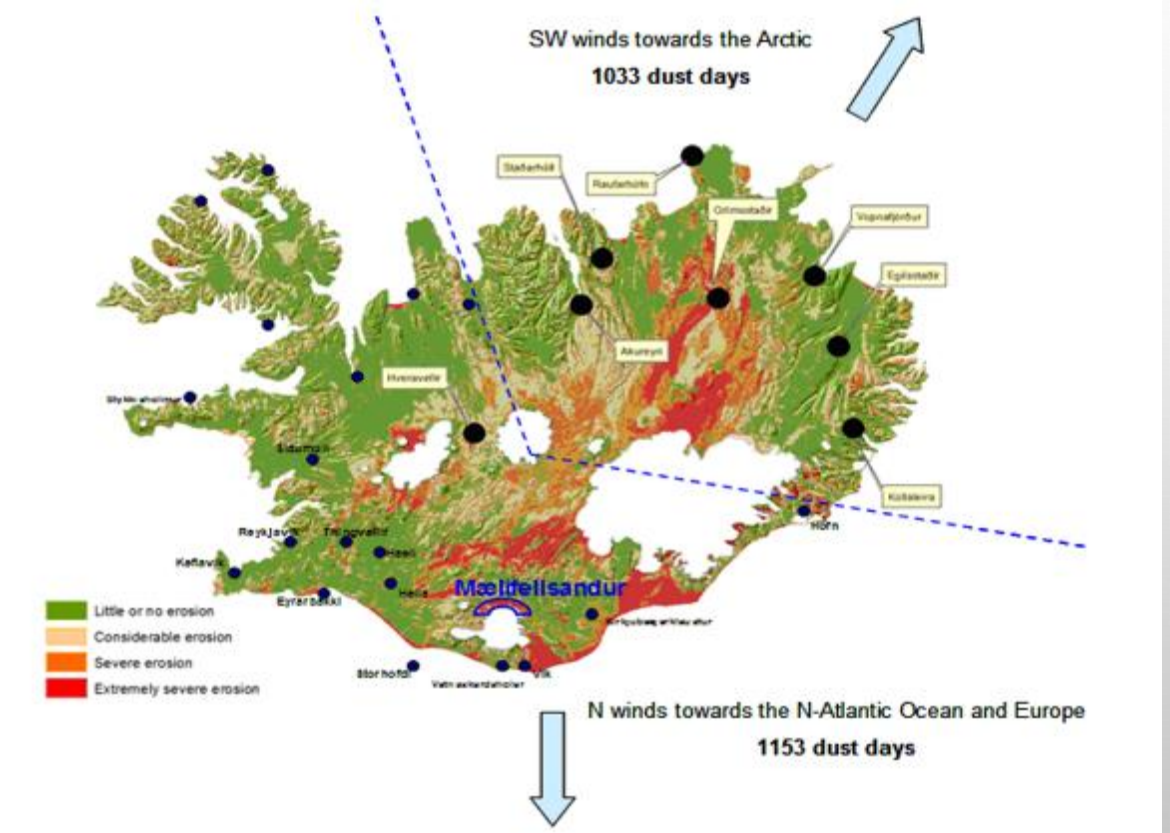
volcanic sandy deserts (21%)

glacial riverbeds and ice-proximal areas



FREQUENCY OF DUST EVENTS AND ESTIMATION OF AMOUNTS OF DUST DEPOSITION

- METHODS: A NETWORK OF 30 WEATHER STATIONS IN ICELAND (1949-2011)



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

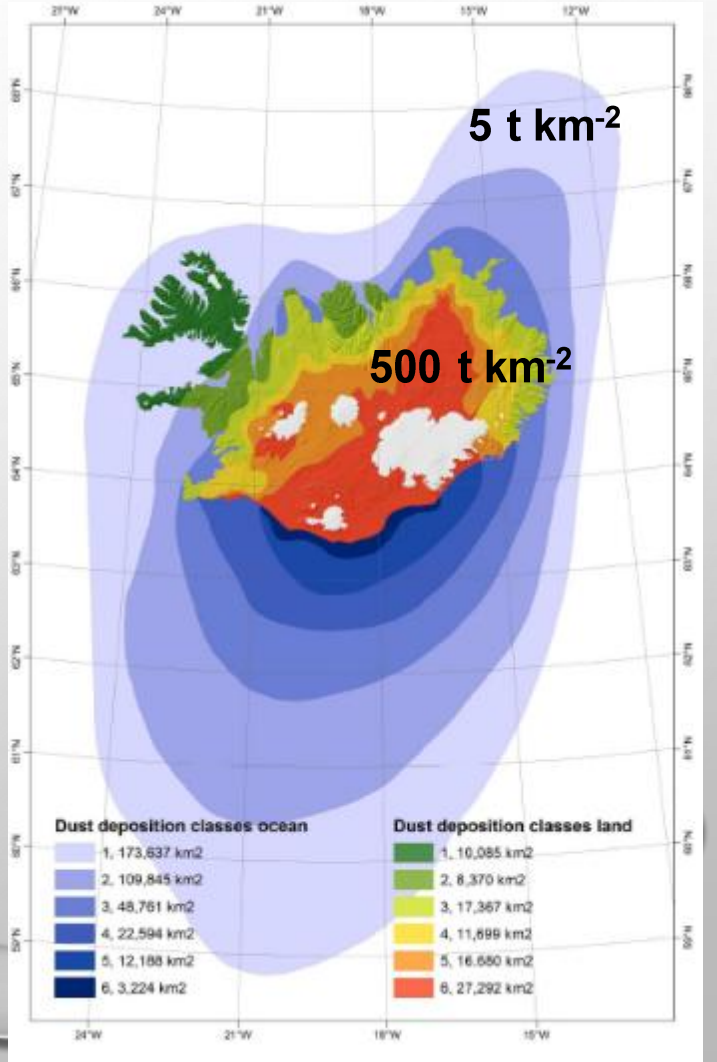
BUT **135** DUST DAYS PER YEAR INCLUDING

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

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

AVERAGE DISTRIBUTION OF DUST DEPOSITION

- TOTAL EMISSIONS RANGE FROM **30.5 TO 40.1** MILLION T
- TWO APPROACHES: 1. DUST EVENT BASED CALCULATION
  2. DEPOSITION RATES (ARNALDS, 2010)
- LAND DEPOSITION: 25-26 MILLION TONS
- OCEAN DEPOSITION: 5.5 TO 13.8 MILLION TONS
- CALCULATED IRON DEPOSITION: 0.56 TO 1.4 MILLION T
- ICELANDIC **GLACIERS: 4.5 MILLION TONS ANNUALLY**



This is not Eyjafjallajokull volcanic plume!

This is a dust plume!

HVALFJÖRÐUR SUSPENDED DUST, MARCH 24, 2012

REYKJAVÍK HAZE, SEPTEMBER 11, 2011

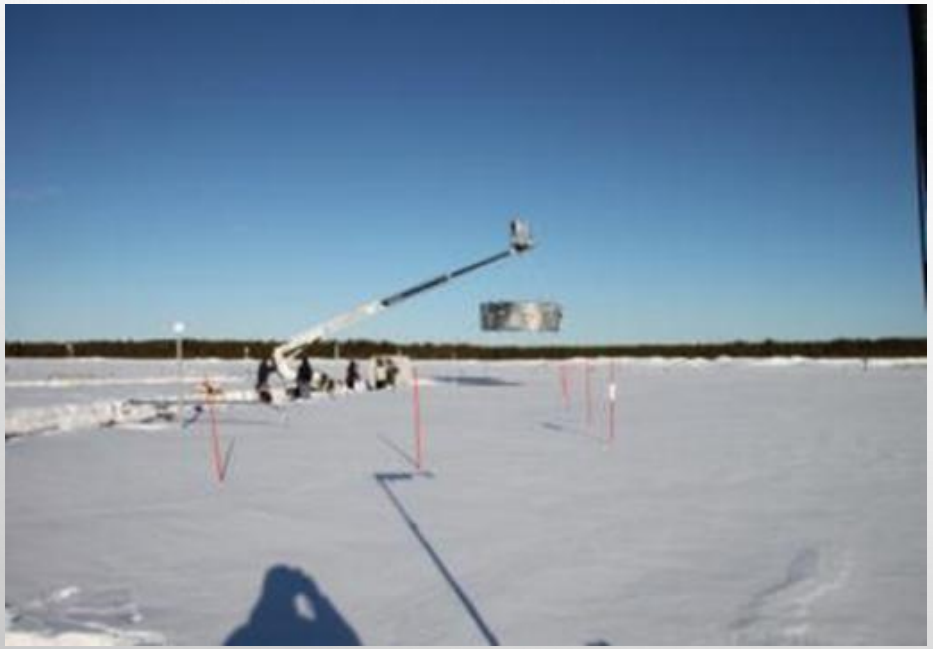
IMPURITIES ON SNOW

BC

Algae

Dust

SOOT ON SNOW PROJECT IN LAPLAND
SOS 2013



ILMATIETEEN LAITOS
METEOROLOGISKA INSTITUTET
FINNISH METEOROLOGICAL INSTITUTE

CRAICC

LANDBÚNAÐARHÁSKÓLI ÍSLANDS

UNIVERSITY OF ICELAND

FINNISH GEODETIC INSTITUTE

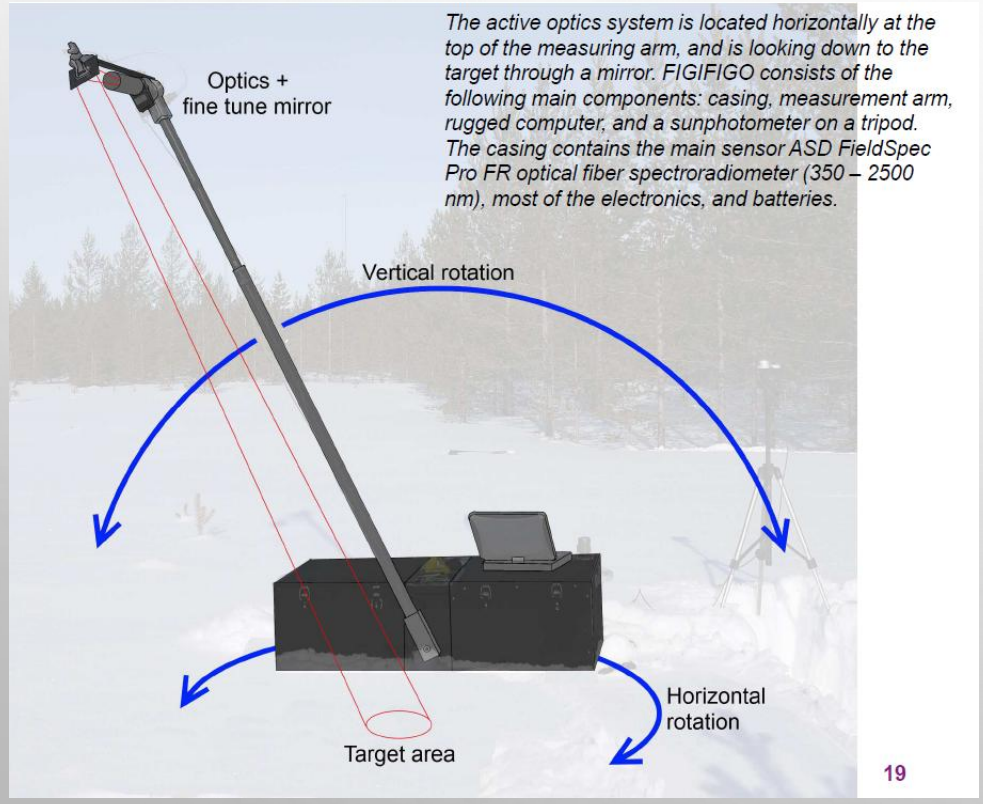
HELSINGIN YLIOPISTO
HELSINGFORS UNIVERSITET
UNIVERSITY OF HELSINKI

THE SPECTRAL REFLECTANCE OF MELTING SNOW AND DUST IN LABORATORY WAS MEASURED

- THE ANALYTICAL SPECTRAL DEVICE (ASD) SPECTROMETER FOR 325-1075 NM
- THE GONIOSPECTROMETER FIGIFIGO

- SPECTRAL REFLECTANCE OF SNOW WAS MEASURED FIRST DAYS OF THE DEPOSITION (FIGIFIGO) AND TWO WEEKS AFTER THE DEPOSITION (ASD).

THE FINNISH GEODETIC INSTITUTE FIELD GONIOSPECTROMETER FIGIFIGO



- THIS INSTRUMENT USES MULTIANGULAR REFLECTANCE TO MEASURE THE ALBEDO AND POLARIZATION, HEMISPHERICAL DIRECTIONAL REFLECTANCE FACTOR (HDRF), AND OTHER SNOW PROPERTIES

Key measurement components:

1. Snow

Primarily component for the experiment. Natural snow pack at Sodankylä airport. Begining of April, 2013

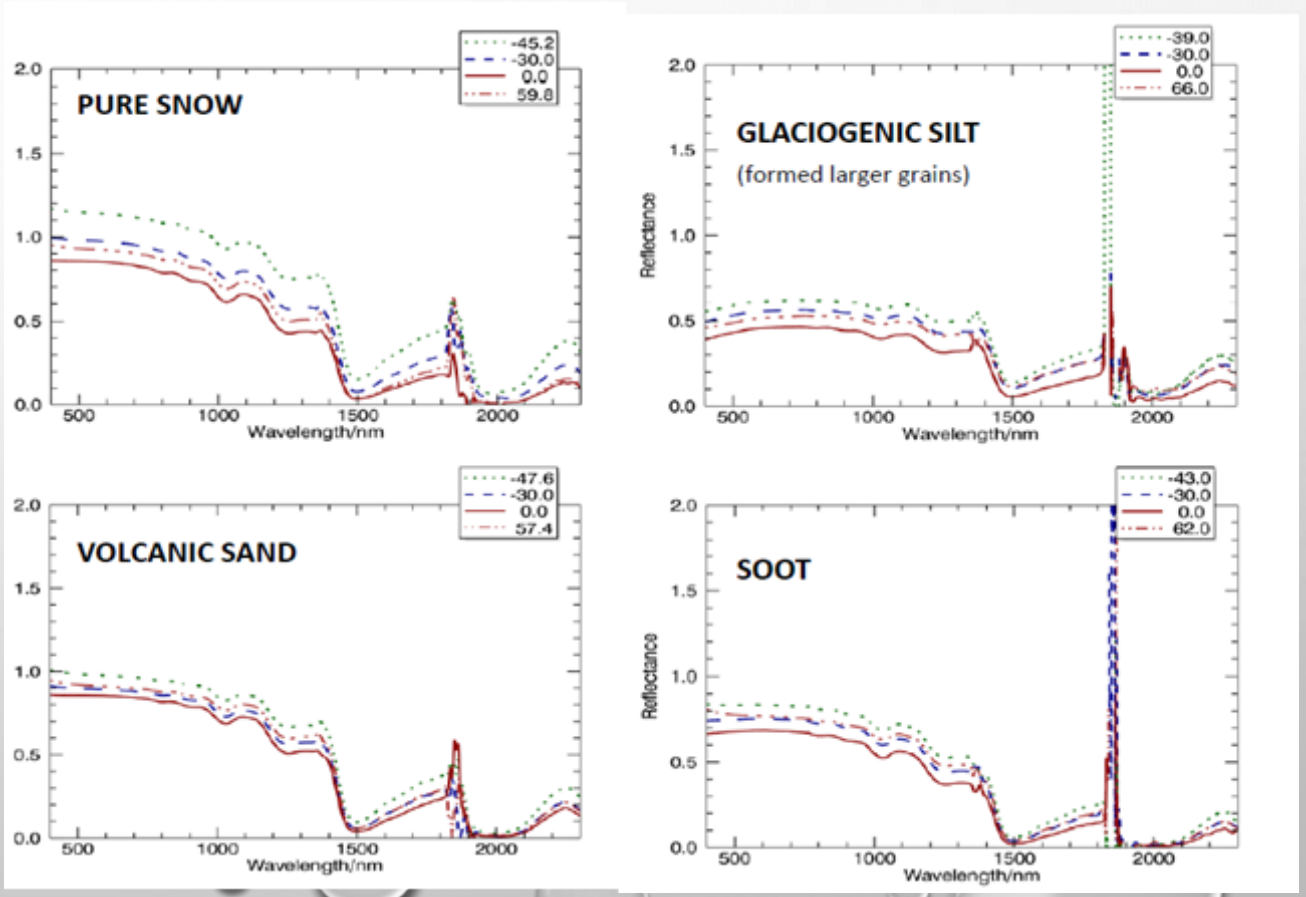
2. Volcanic sand

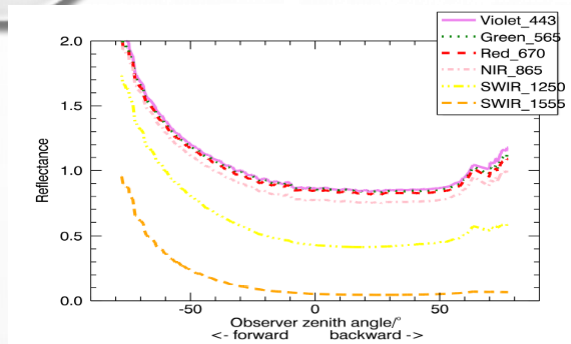
A near black mixture of the volcanic ash of glaciofluvial nature. Origin: under the Myrdalsjokull glacier

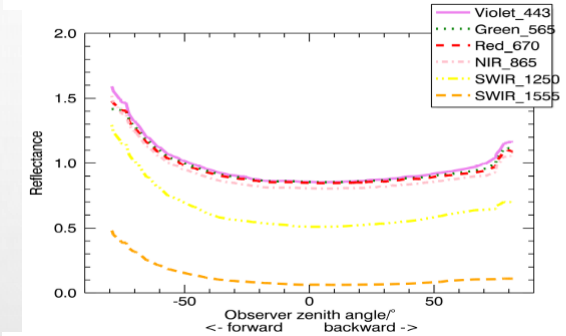
3. Glaciogenic silt

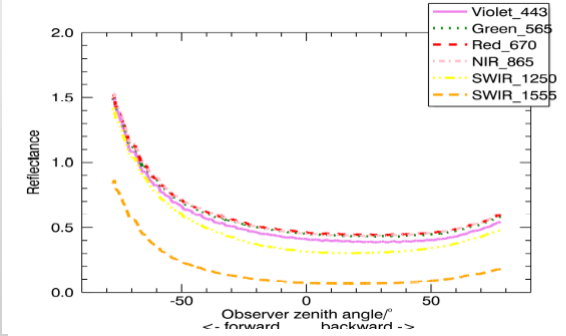
Collected from the glacial river Mulakvisl, it consists mainly of silt and some coarse clay sized particles

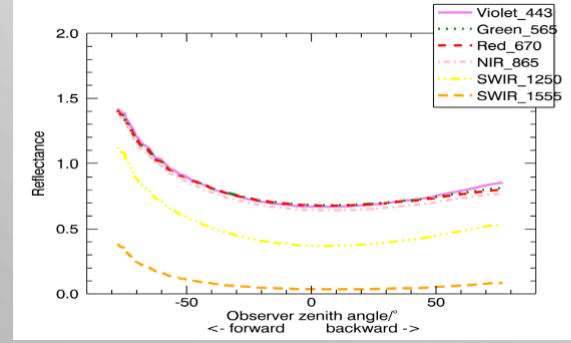
SPECTRAL REFLECTANCE AT THE TIME OF THE DEPOSITION




Violet_443
Green_565
Red_670
NIR_865
SWIR_1250
SWIR_1555
Reflectance
Observer zenith angle/°
<- forward backward ->
PURE SNOW
-45.2
-30.0
0.0
59.8
Wavelength/nm
Principal zenith angle /°
Cross zenith angle/°


Violet_443
Green_565
Red_670
NIR_865
SWIR_1250
SWIR_1555
Reflectance
Observer zenith angle/°
<- forward backward ->
VOLCANIC SAND
-47.6
-30.0
0.0
57.4
Wavelength/nm
Principal zenith angle /°
Cross zenith angle/°


Violet_443
Green_565
Red_670
NIR_865
SWIR_1250
SWIR_1555
Reflectance
Observer zenith angle/°
<- forward backward ->
GLACIOGENIC SILT
(formed larger grains)
-39.0
-30.0
0.0
66.0
Wavelength/nm
Principal zenith angle /°
Cross zenith angle/°


Violet_443
Green_565
Red_670
NIR_865
SWIR_1250
SWIR_1555
Reflectance
Observer zenith angle/°
<- forward backward ->
SOOT
-43.0
-30.0
0.0
62.0
Wavelength/nm
Principal zenith angle /°
Cross zenith angle/°

CLUMPING MECHANISM

SILT

Only artificial deposition?

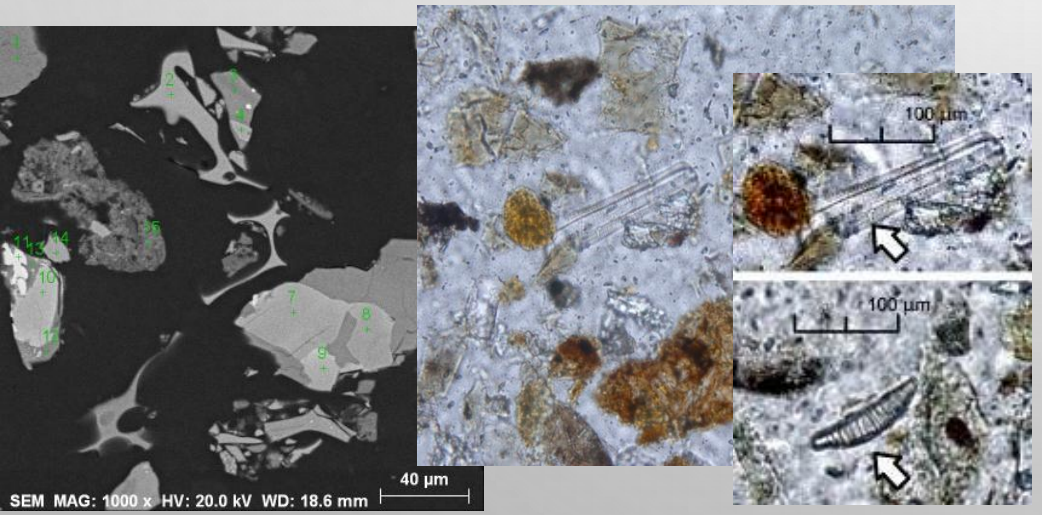
SOOT

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



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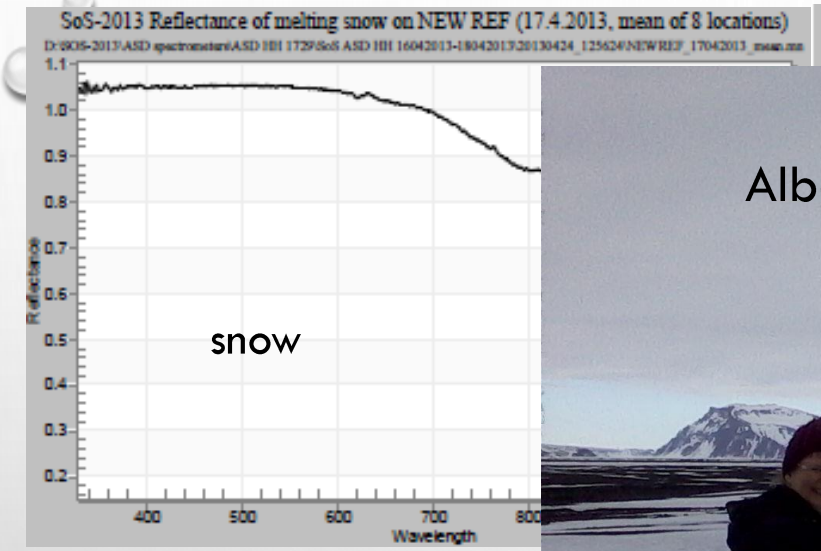
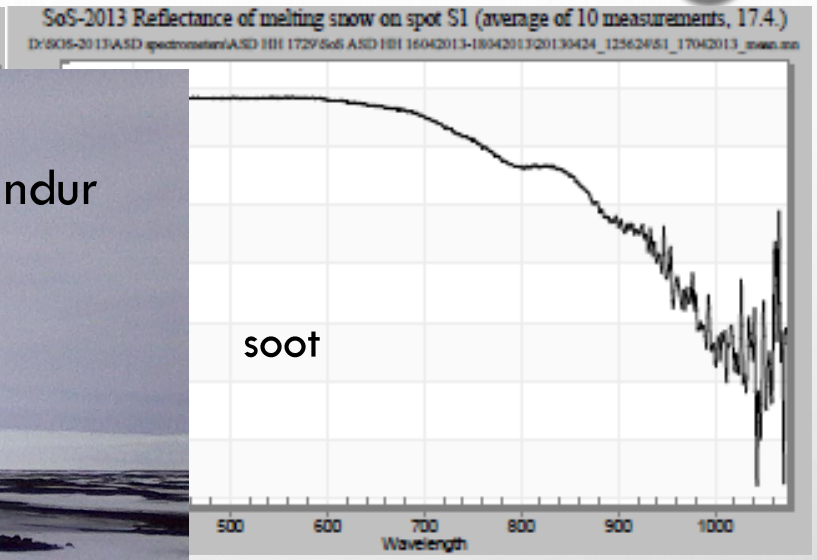
Snow–Dust Storm: Unique case study from Iceland, March 6–7, 2013

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]

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

REFLECTANCE MEASUREMENTS 2 WEEKS AFTER THE DEPOSITION





CONCLUSIONS

- FIELD EXPERIMENTS SHOWED THAT VOLCANIC DUST DECREASES SNOW ALBEDO SIMILARLY AS BC
- LABORATORY EXPERIMENTS SHOWED THAT VOLCANIC DUST IS AN EXTREMELY ABSORBING AEROSOL
- CLUMPING MECHANISM OF THE IMPURITIES CAN BE OBSERVED IN NATURAL CONDITIONS
- MORE IN SITU MEASUREMENTS ARE NEEDED

THANK YOU FOR YOUR ATTENTION!

MODIS IMAGE, WINTER DUST, JAN 12 2016