Sand and Dust Storms and the Arctic: local sources, pollution modelling and combating methods

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WEATHER CLIMATE WATER
TEMPS CLIMAT EAU

WMO OMM
World Meteorological Organization
Organisation météorologique mondiale

High Latitude Dust Workshop 2021
Reykjavík, 10-11 Feb 2021

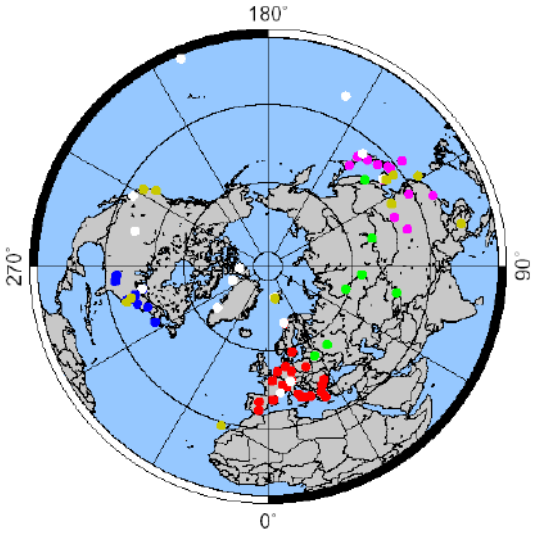
WMO Global Atmosphere Watch Programme

Provides international leadership in research and capacity development in atmospheric composition observations and analysis through:

- *maintaining and applying long-term systematic observations of the chemical composition and related physical characteristics of the atmosphere,*
- *emphasizing quality assurance and quality control,*
- *delivering integrated products and services related to atmospheric composition of relevance to users.*

WMO GAW: Atmospheric composition observation network

GALION: GAW Aerosol Lidar Observation Network



GAW

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GAW builds on partnerships involving contributors from **100** countries

WMO Sand and Dust Storm Warning Advisory and Assessment System (SDS-WAS)

The WMO SDS-WAS, which is a global federation of partners, endorsed by the 15th WMO Congress and organized around regional nodes & centers (NAMEE: Barcelona, Asia: Beijing, Americas: Barbados), integrates research and user communities

Atmospheric Aerosol Eddies NASA Animated Map: 10km Geodetic Earth Orbiting Satellite (GEOS-5) AOD: Red colour – Dust Aerosols
http://geo-pickmeup.com/atmospheric-aerosol-eddies-nasa-animated-map/

SDS - meterological phenomena - effects on:

- Climate Change & cryosphere
- Human Health (asthma, infections, meningitis in Africa, valley fever in the America's)
- Agriculture (negative & positive impacts)
- Marine productivity
- Aviation (air disasters)
- Ground Transportation
- Infrastructure and industry (Energy, Semi-conductor, Tourism, etc)

WMO SDS-WAS NAMEE Node Multi-model ensemble

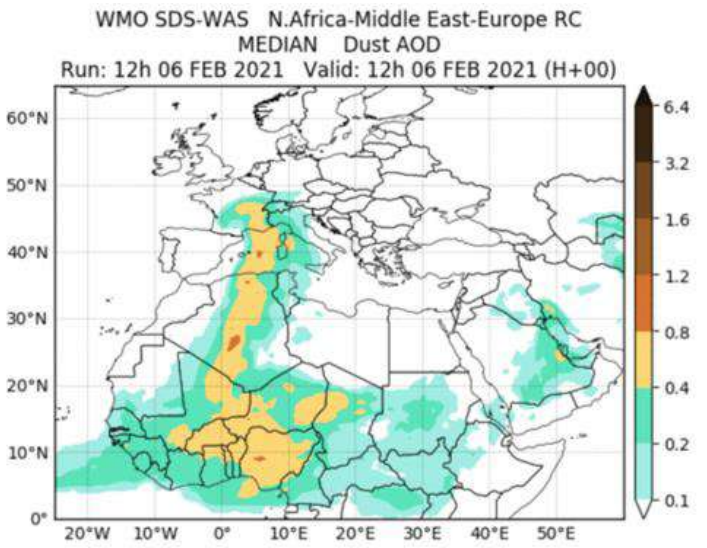
Sand and dust storm hits Europe on 6-7 February 2021

http://sds-was.aemet.es/

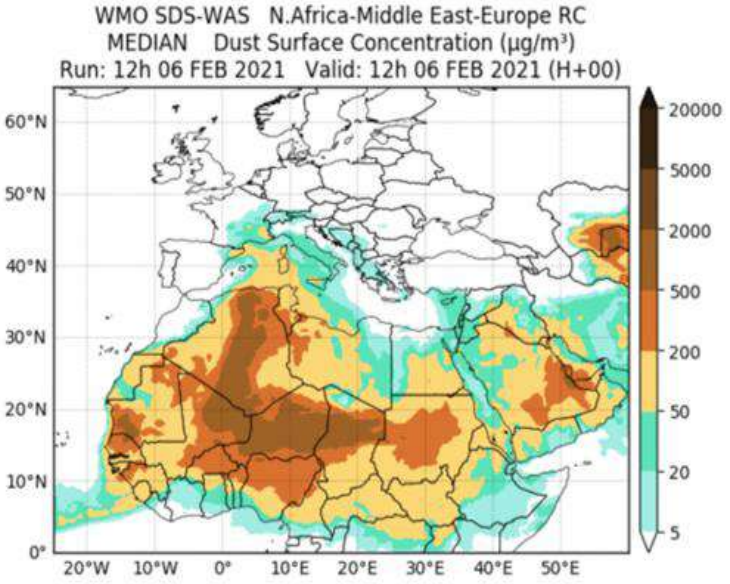
Model ensemble

15 Global – Regional models
(from ~ 100 to 10 km)

Dust column-load, DOD



Surface concentration



Basart et al., 2021

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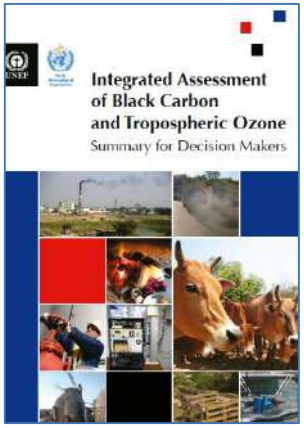
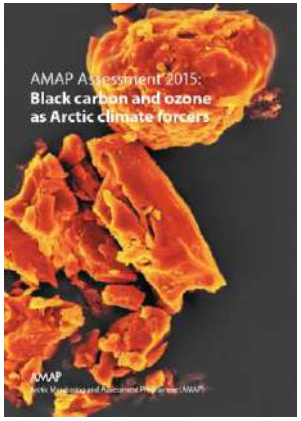
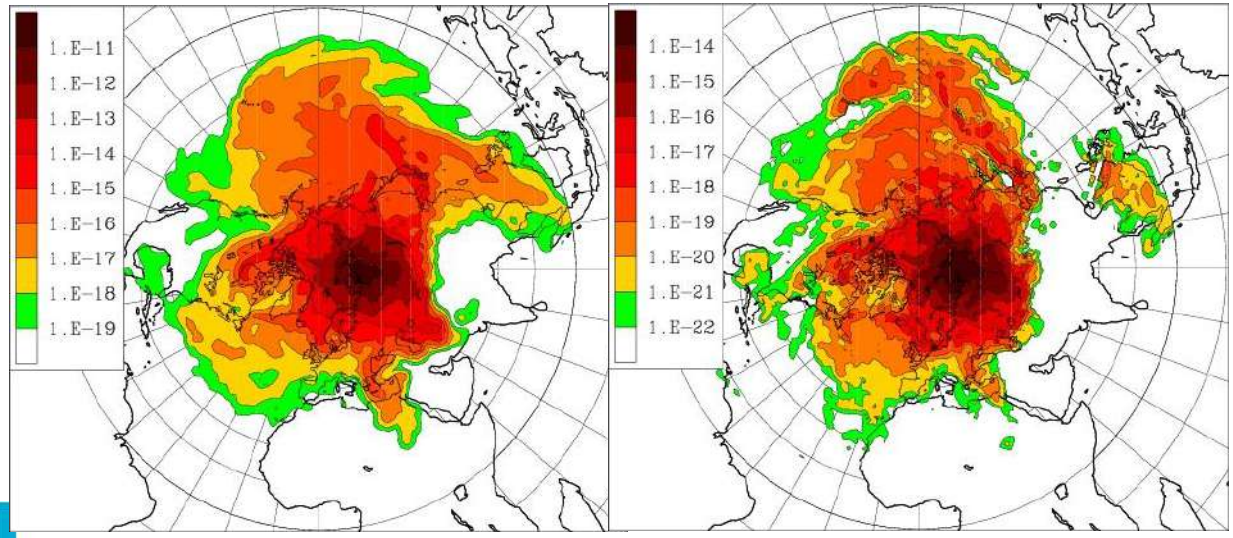


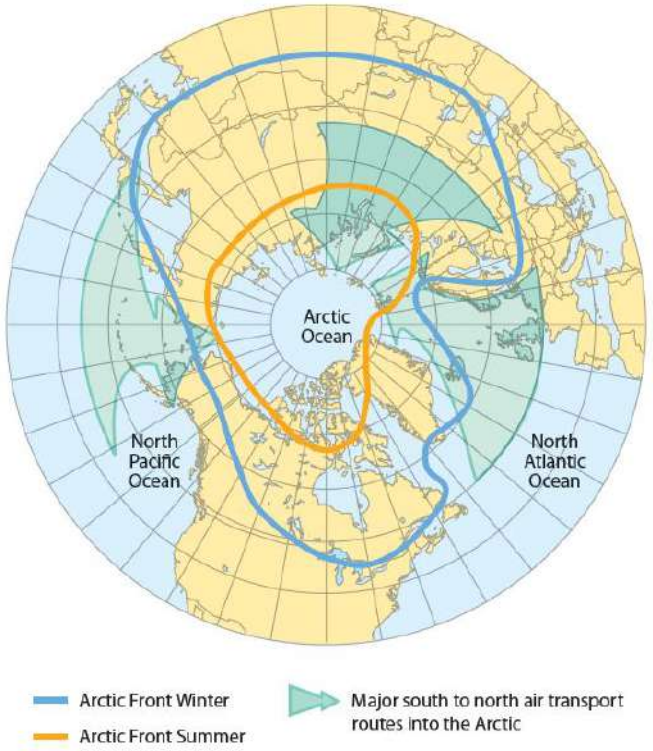
Middle & high latitude sources effecting the Arctic environment



Results of long-term dispersion modelling by DERMA model: annual **time integrated air concentration** & **wet deposition** patterns



for normalise aerosol source from the **Norilsk nickel plant**
Mahura, Baklanov et al., 2014



AMAP BC & O3 Report, 2015

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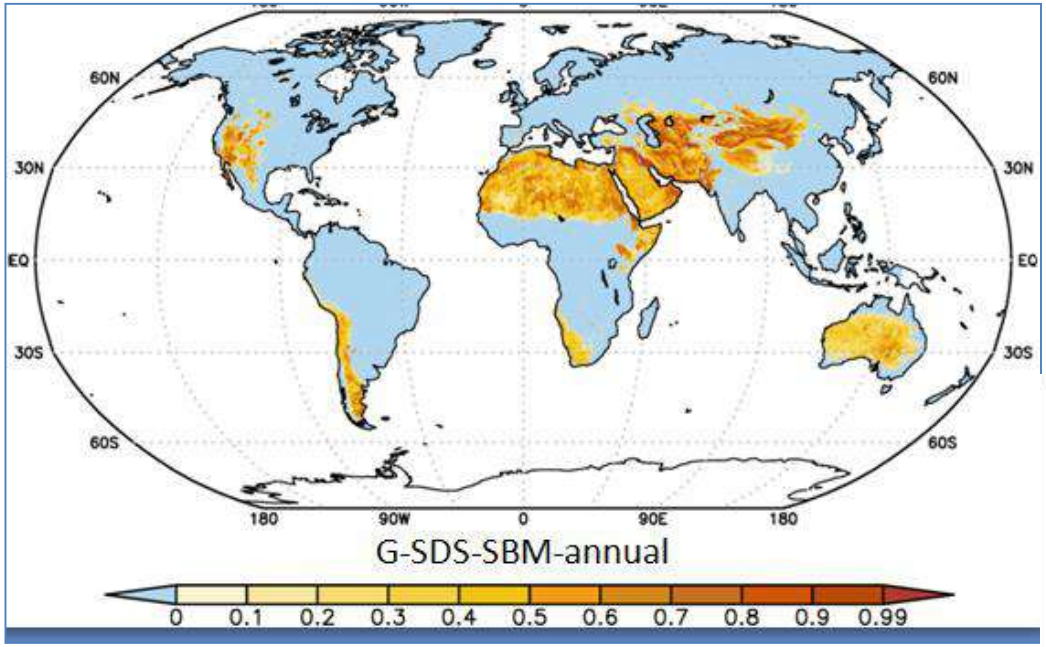
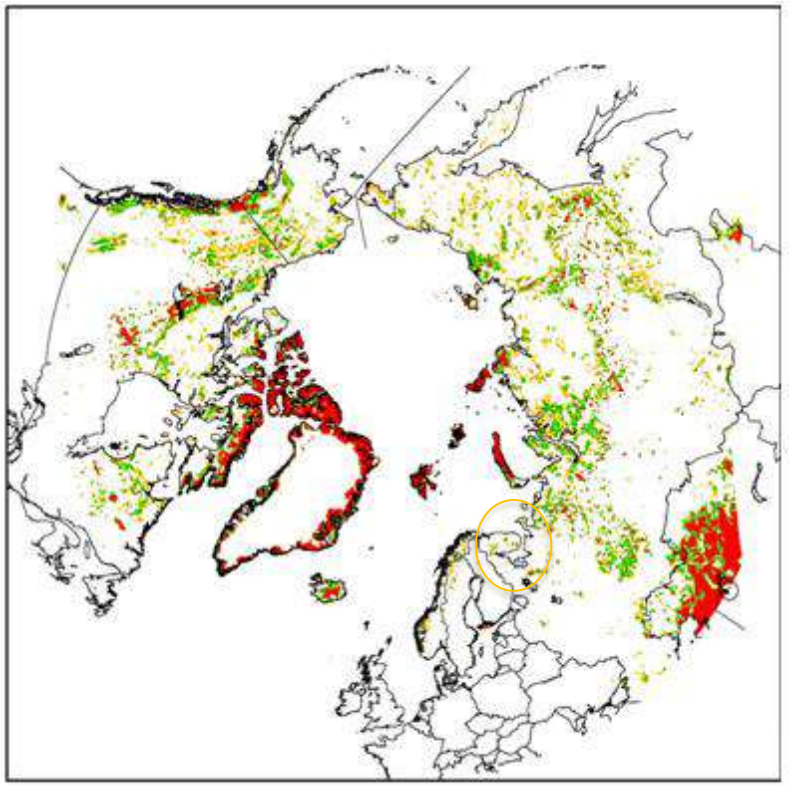
Sand & Dust Storm Source Mapping

https://maps.unccd.int/sds/



UNCCD 1km global dust mask (Ana Vukovic, 2019)

Dust sources in high latitudes



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NATURAL & TECHNOGENIC DUST SOURCES FROM MINING WORKS & TAILING DUMPS, ALSO IN THE ARCTIC

Works on opencasts & coalmines

<= Land degradation & desertification

Dusting from tailing dumps

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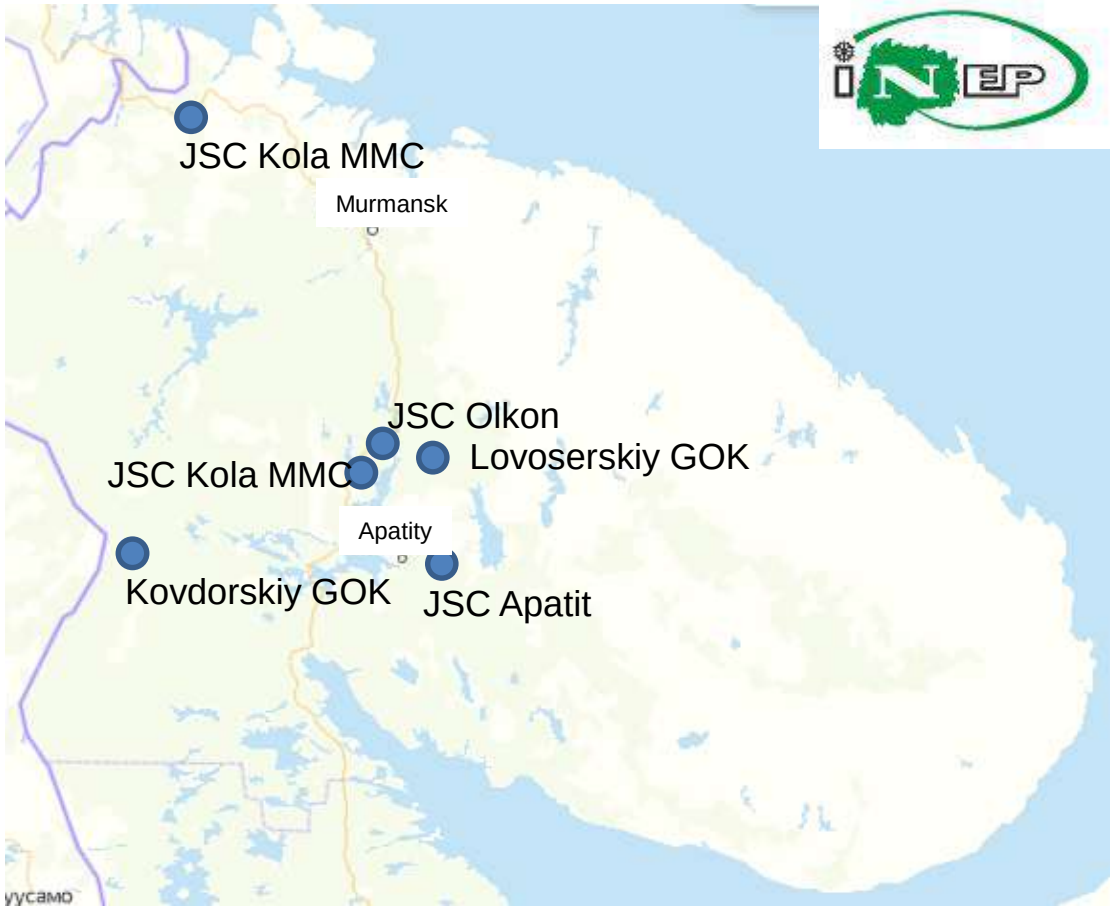
Technogenic dust storm sources in the Kola Arctic, Russia

- Several mining enterprises operate in the region and act as backbone enterprises for the cities of Apatity, Kirovsk (JSC Apatit, North-western phosphorus company), Zapolyuarnyi, Nikel and Monchegorsk (JSC Kola MMC), Olenegorsk (Olkon JSC), Kovdor (JSC Kovdorskiy GOK; LLC Kovdorslyuda), Revda (LLC Lovozerskiy GOK).



Map of the location of mining enterprises

- About 30% of all suspended matters are released from the mining enterprises into the atmosphere due to wind-induced dusting of beaches and slopes of tailings dumps (Masloboev et al., 2016).

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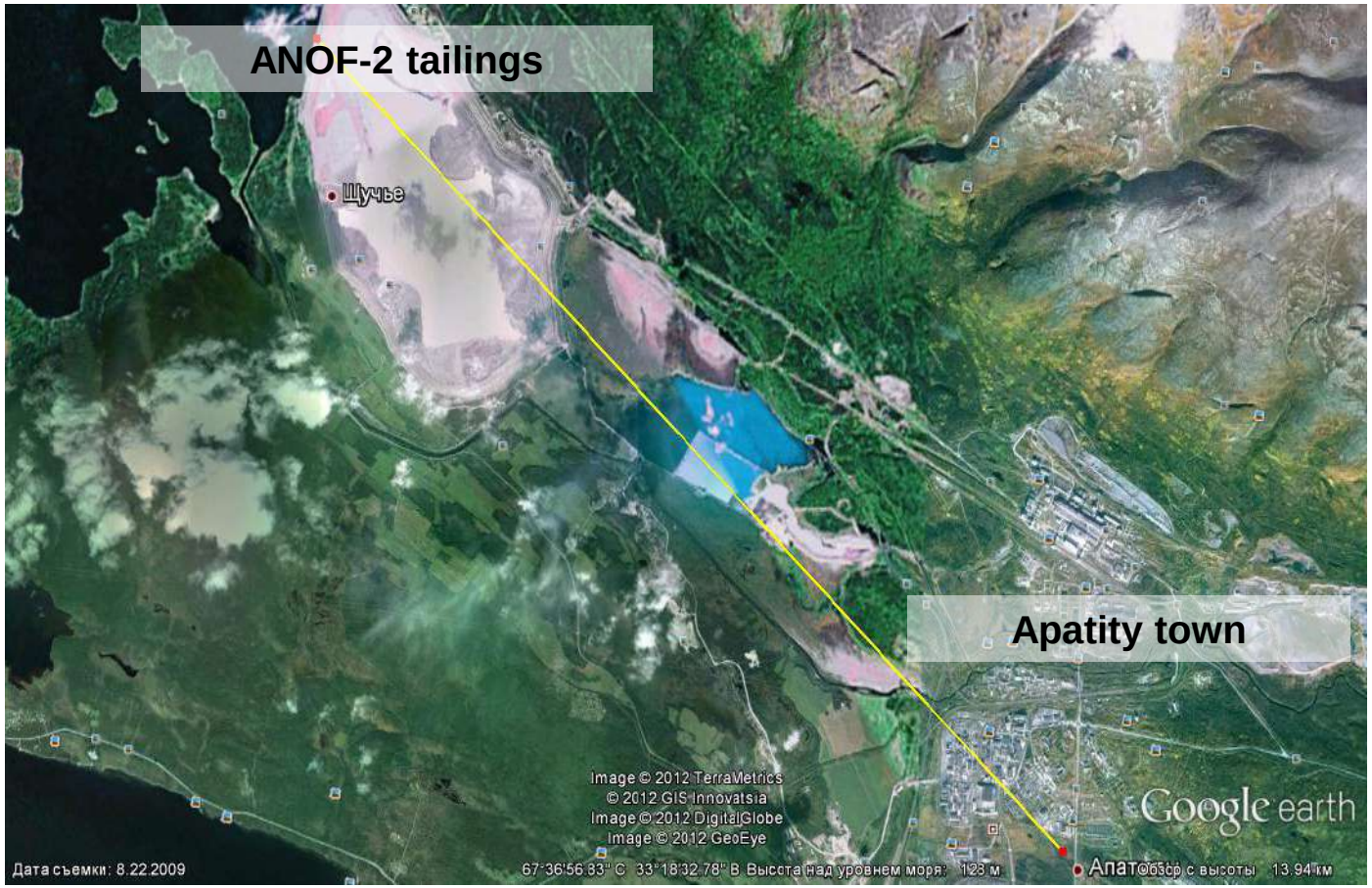
Characteristics of tailing ponds

(Masloboev, Makarov, Baklanov, Amosov, Seleznev, IMPC, 2016)

No.	Object	Exploitation period	Total area, ha	Resource, (M) t
1	Tailing pond of processing plant no. 1 of the Pechenganickel works, JSC Kola MMC	1945 - 1994	1033	~220
2	Tailing pond of processing plant no. 2 of the Pechenganickel works, JSC Kola MMC	1965 - present time		22.4
3	Tailing pond of processing plant of the Severonikel works, JSC Kola MMC	1935 - 1978	No data	5.3
4	Dumps of granulated slag of the Pechenganickel works, JSC Kola MMC	1945 - present time	80	47
5	Tailing pond No 1 and No 2 of crushing and processing plant, JSC Olkon	1954 - present time	1400	~300
6	Tailing pond of apatite-nepheline processing plant no.1 (ANOF-1), JSC Apatit	1957 - 1963	120	24.4
7	Tailing pond of apatite-nepheline processing plant no. 2 (ANOF-2), JSC Apatit	1963 - present time	1652	~550
8	Tailing pond of apatite-nepheline processing plant no. 3 (ANOF-3), JSC Apatit	1988 - present time	1158	~250
9	Tailing pond of JSC Kovdorskiy GOK, (field no. 1)	1962 -1980	330	53.8
10	Tailing pond of JSC Kovdorskiy GOK, (field no. 2)	1988 - present time	900	80
11	Tailing pond of LLC Lovoserskiy GOK	1951 - present time	No data	12
12	Tailing pond of LLC Kovdorslyuda	1959 - present time	35	6

Dust Storms from Tailing Damps polluting the Town of Apatity



Area "ANOF-2 tailings – Apatity town" [GOOGLE EARTH]

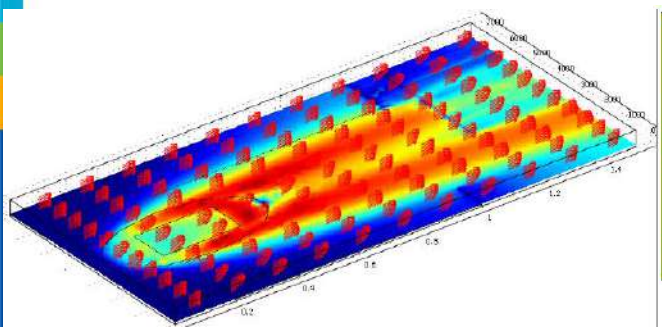
Number of cases of exceeding the MPC (for dust) in the atmosphere of Apatity town

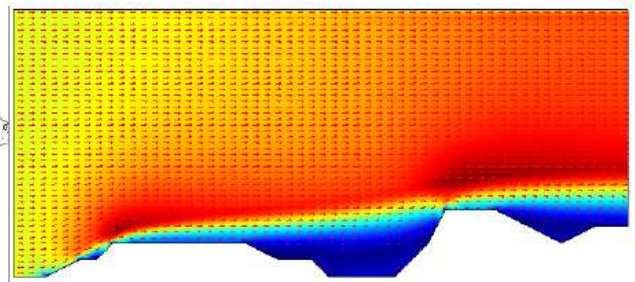
Year	2014	2015	2016	2017	2018
Number	18	3	14	10	13

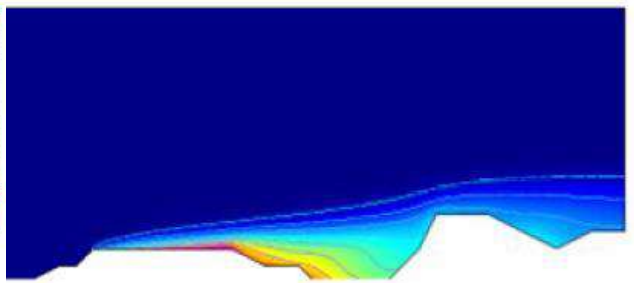
According to the FBGU "Murmansk UGMS»

Study Area and Methods

- Based on multi-years measurements and **CFD model (RANS and LES modes) simulations** of different dust storm events the intensity and conditions of dust blowing and emissions are analyzed.
- The study examines the following factors and conditions: *wind velocity, humidity and other meteorological parameters, material moister content, size and shape of particles*, **efficiency of dust catching, height and geometry of tailing dumps, etc., as well as specific measures to reduce dusting, e.g. protecting fences**.
- The study presents also results of numerical simulations of atmospheric flow and dust transport and influence of tailing dumps on potential contamination of the atmospheric environment in different conditions.

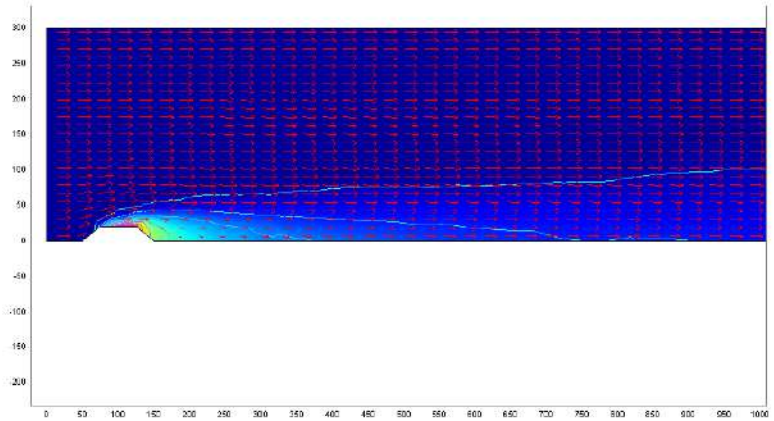




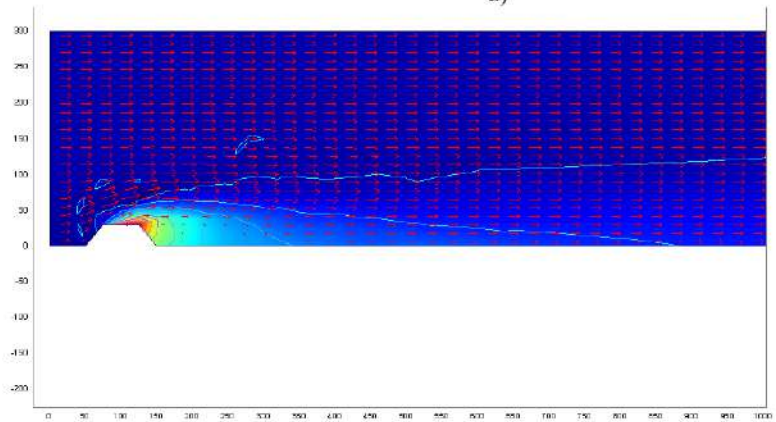


Dust pollution at various tailing dump heights:

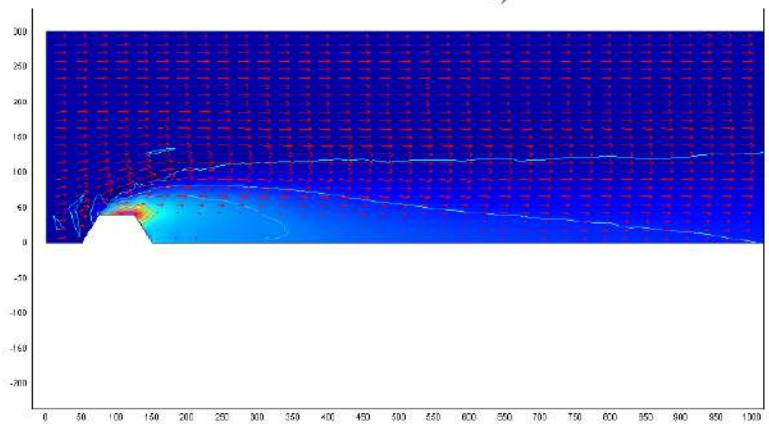
a) 20 m; b) 30 m; c) 40 m



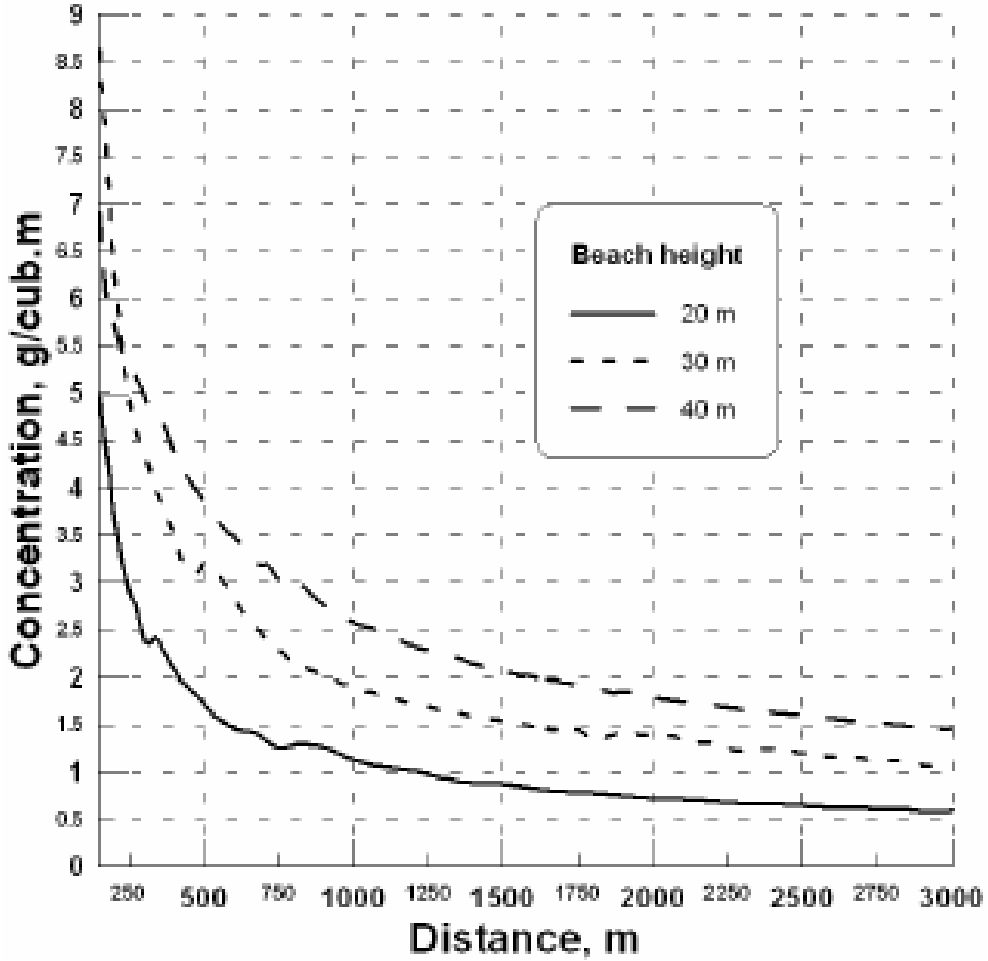
a)



b)

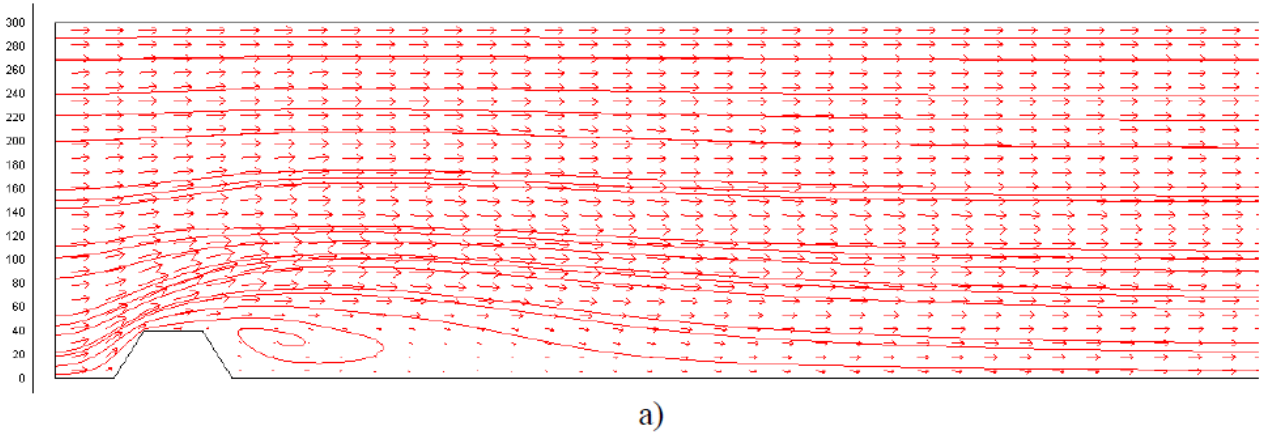


c)

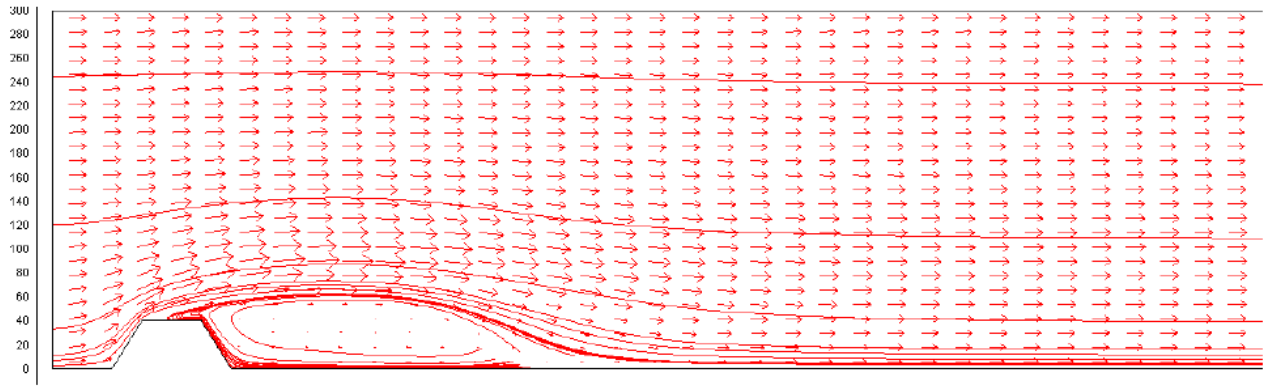


Concentration for variations of tailing dump heights

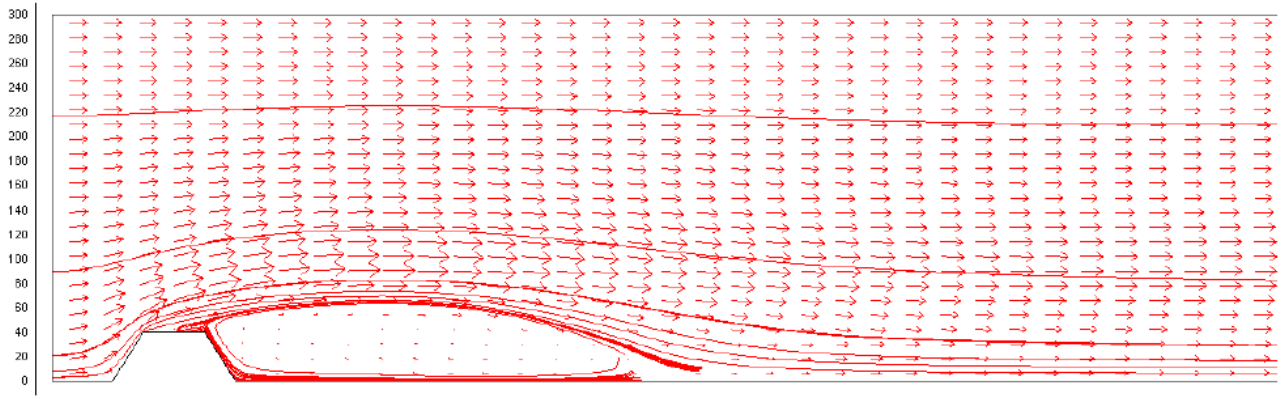
Study of protection barrier effects on wind flows and dusting intensity



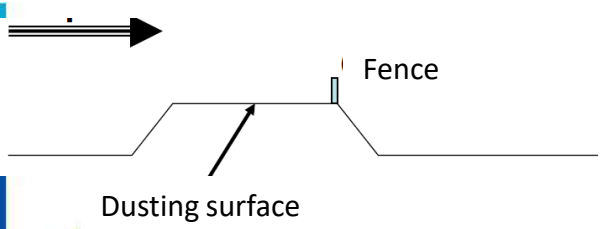
а)



б)



a – 0.0 m;
b – 0.5 m;
c – 1.0 m;



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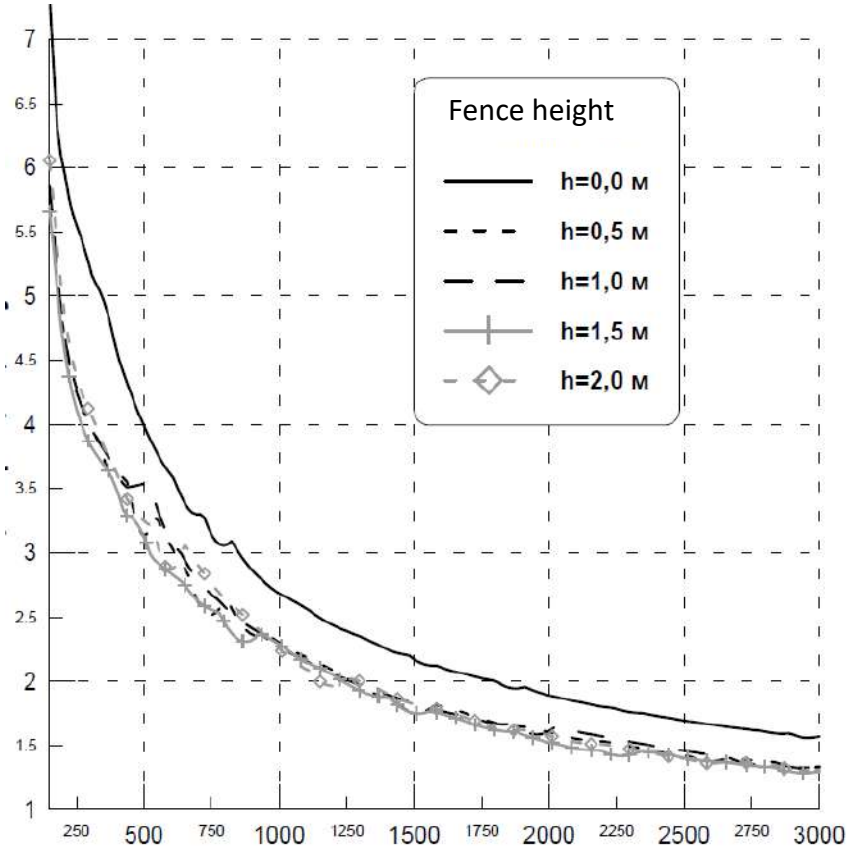
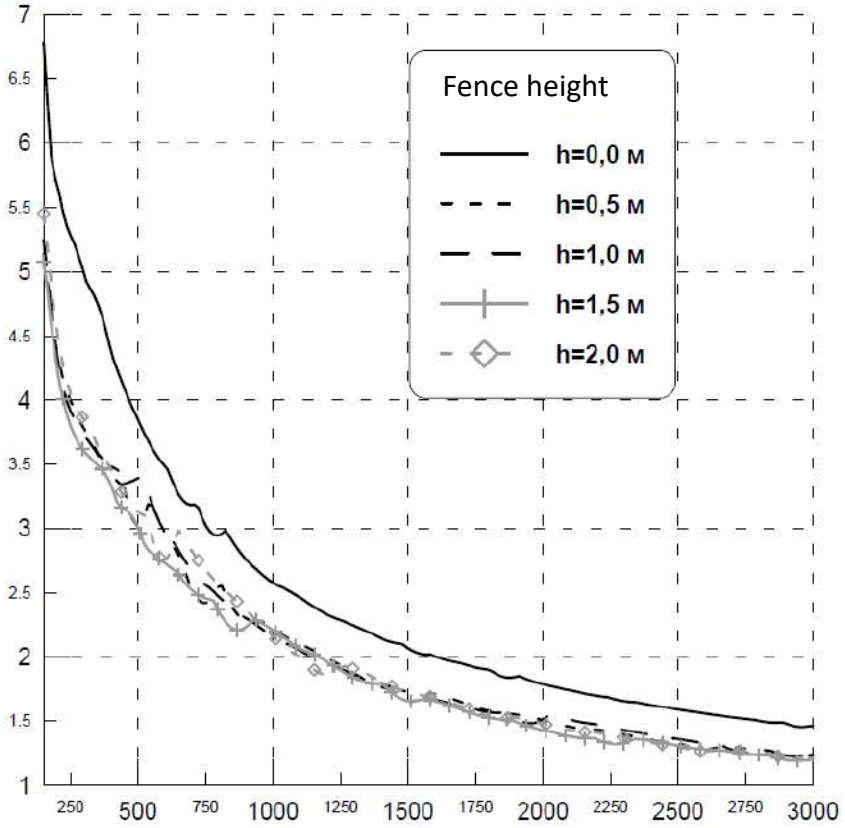
Dust concentration vs fence height



Wg = 0.05m/s



Wg = 0.01m/s

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Local Dust Storms over Greenland

One example of a source of dust storm over Nuussuaq, Greenland, detected from satellite image, 1 October 2020:
https://www.flickr.com/photos/pierre_markuse/50447335522/

Several observation and modelling groups are starting simulations of this episode for local, meso and regional scales. Welcome to join the study!

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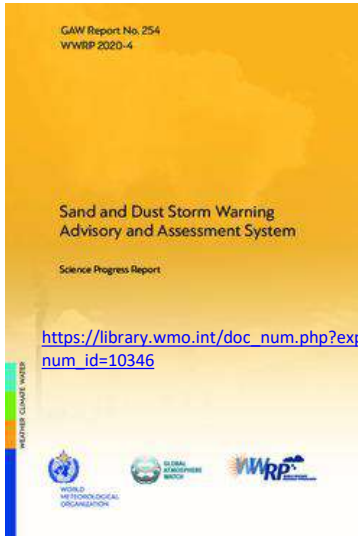
Conclusions

- WMO SDS-WAS considers HLD as an important source of air pollution and forcer for Arctic climate and welcomes the Icelandic Aerosol and Dust Association (IceDust) to join SDS-WAS.
- CFD or LES type of models enables studying the influence of the height and geometry of tailing dumps on changing the airflows above them, as well as effectiveness of different measures of combating SDS.
- Increase of dumps height leads to drastic increase of dusting intensity and dust air concentrations down wind.
- This mechanism is non-linear and the most intensive on the first phase when the dump left the wind shadow zone and reaching the highest wind-shear zone.
- Study of protection barrier effects showed that the maximum positive effect is predicted at a protection barrier's height of 1.5 m.
- For atmosphere pollution prevention at distances of 1 km and more, protection barriers of 0.5 m height are recommend (cost-benefits).
- Local Dust Storms over Greenland are important for further observation and modelling studies.

SDS-WAS Outreach Activities and Capacity Building



No1 (2017):: https://library.wmo.int/opac/index.php?lvl=bulletin_display&id=3902

No 2 (2018):: https://library.wmo.int/opac/doc_num.php?explnum_id=4572

No3 (2019): https://library.wmo.int/index.php?lvl=bulletin_display&id=3972#.X4sMtkBuI2w

No4 (2020): https://library.wmo.int/doc_num.php?explnum_id=10317

WMO SDS-WAS web-sites and reports:

http://www.wmo.int/sdswas

https://public.wmo.int/en/our-mandate/focus-areas/environment/sand-and-dust-storm

SDS-WAS Regional Nodes and Operational Forecasts:

for Northern Africa, Middle East and Europe: http://sds-was.aemet.es;
for Asia: http://eng.nmc.cn/sds_was.asian_rc;
for the Americas: http://sds-was.cimh.edu.bb/
Operational Barcelona Center: http://dust.aemet.es/

SDS-WAS Training Courses, Conferences and Materials:

https://sds-was.aemet.es/materials/training