FLEXDUST module

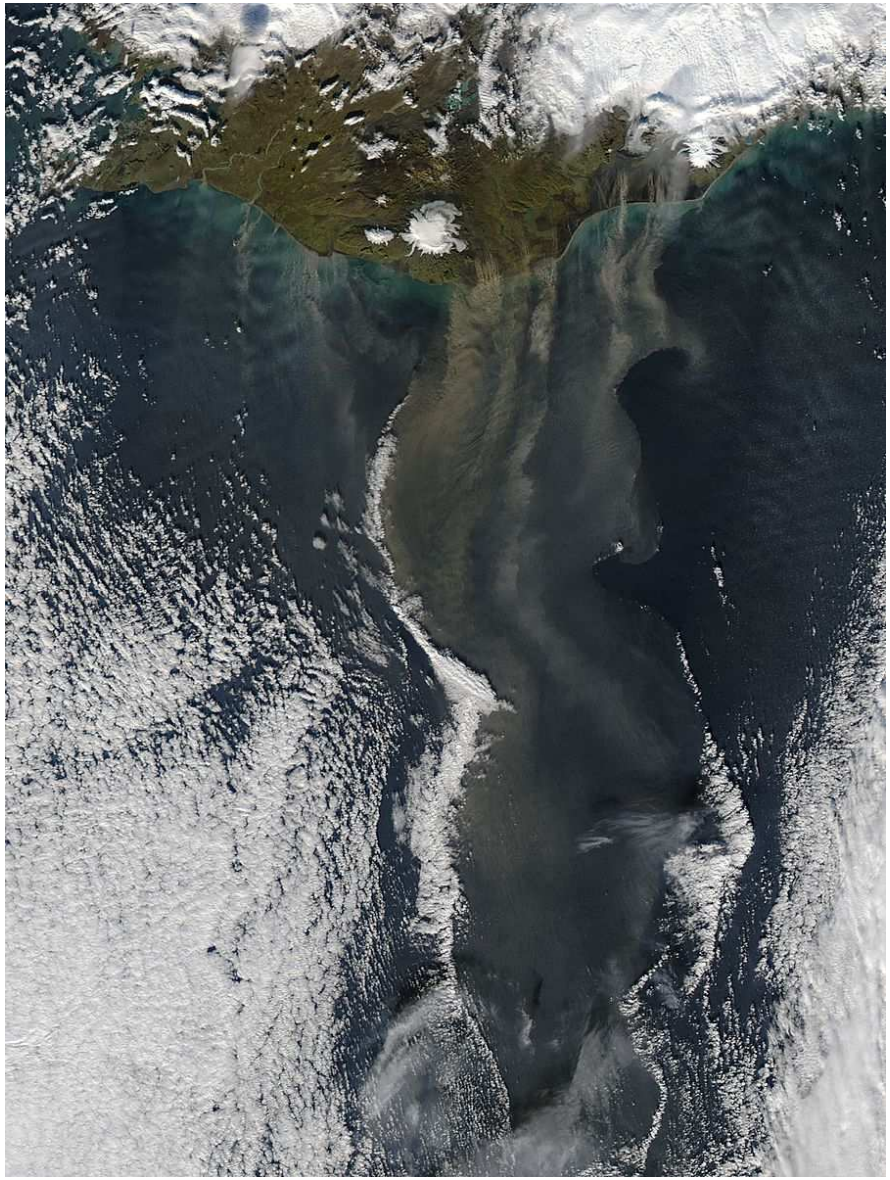
On behalf of Christine Groot Zwaaftink (NILU)

Groot Zwaaftink, C. D., Arnalds, Ó., Dagsson-Waldhauserova, P., Eckhardt, S., Prospero, J. M., and Stohl, A.: Temporal and spatial variability of Icelandic dust emissions and atmospheric transport, Atmos. Chem. Phys., 17, 10865-10878, https://doi.org/10.5194/acp-17-10865-2017, 2017.

FLEXDUST slides kindly provided by Christine Groot Zwaaftink (slides adapted)

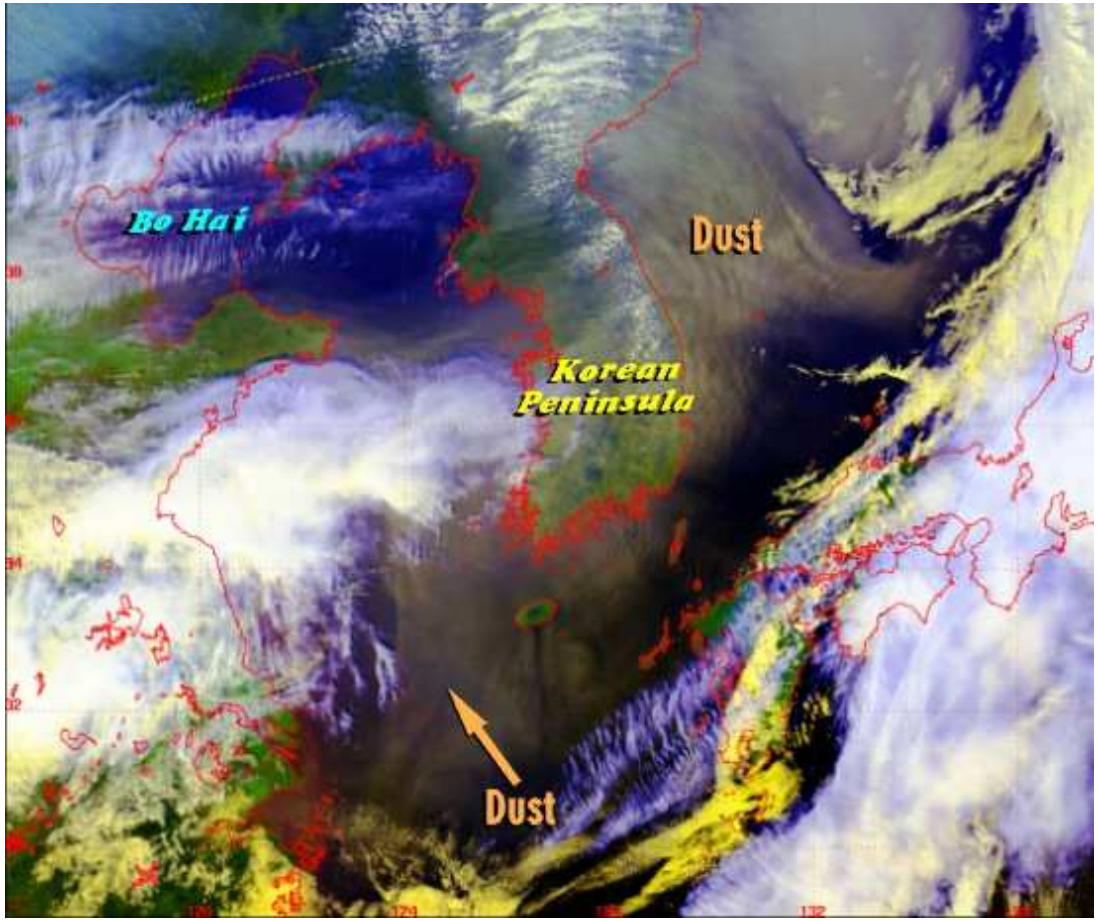
FLEXDUST : motivation

- Motivation: few studies on effects of dust in polar regions however those effects can be important in the radiation and energy balances.



FLEXDUST : motivation

- … what about Hong Kong?



Source: HKO, March 2002

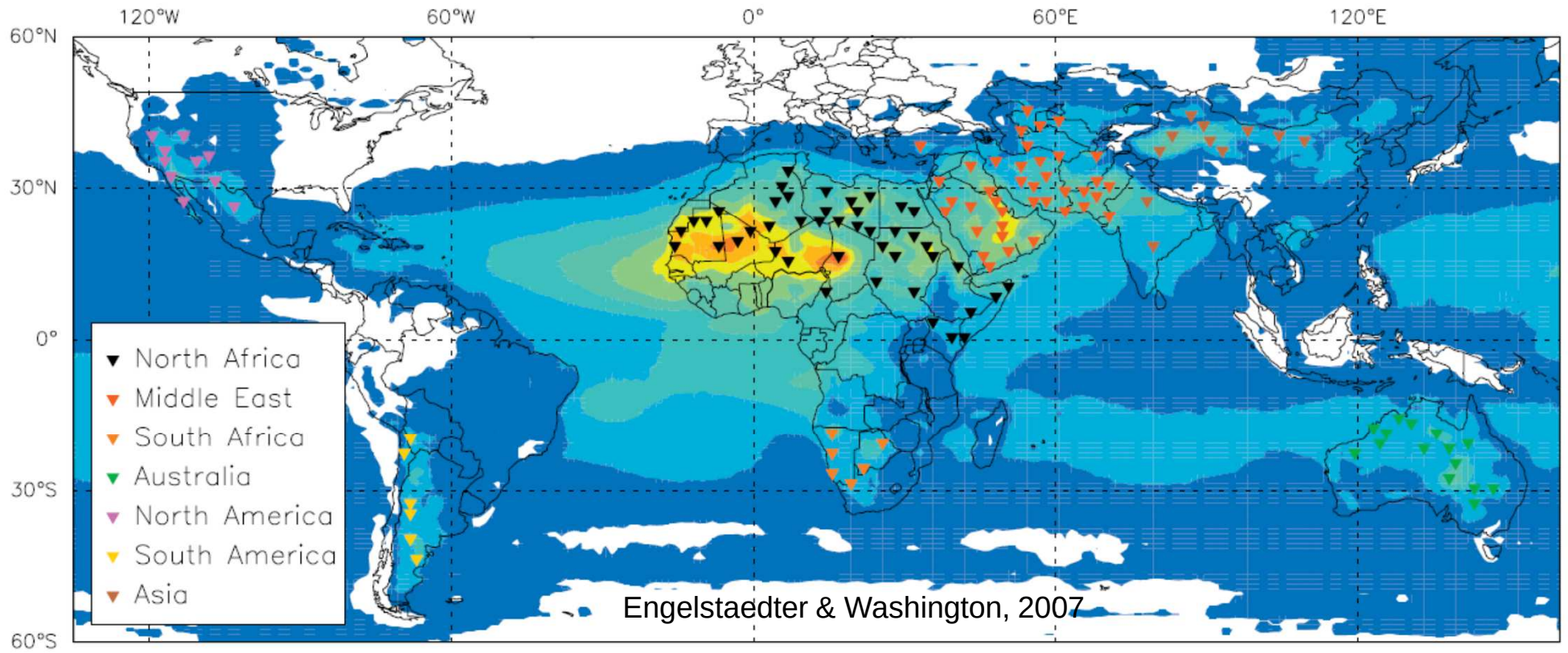
Superstorm

FLEXDUST : motivation

90° N

??

60° N



60° S

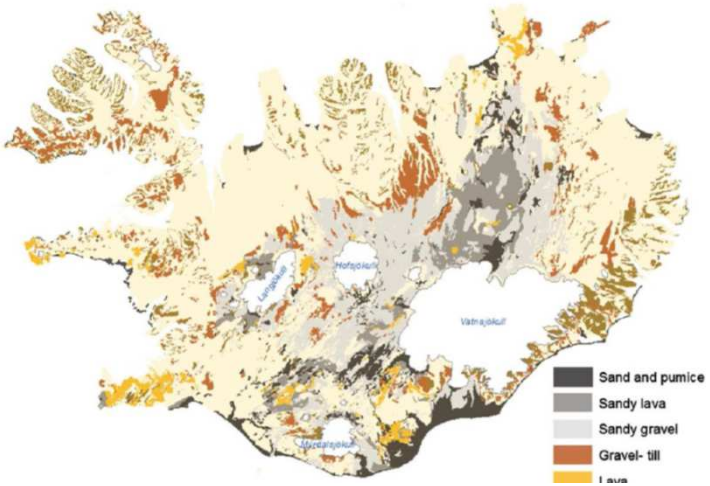
??

90° S

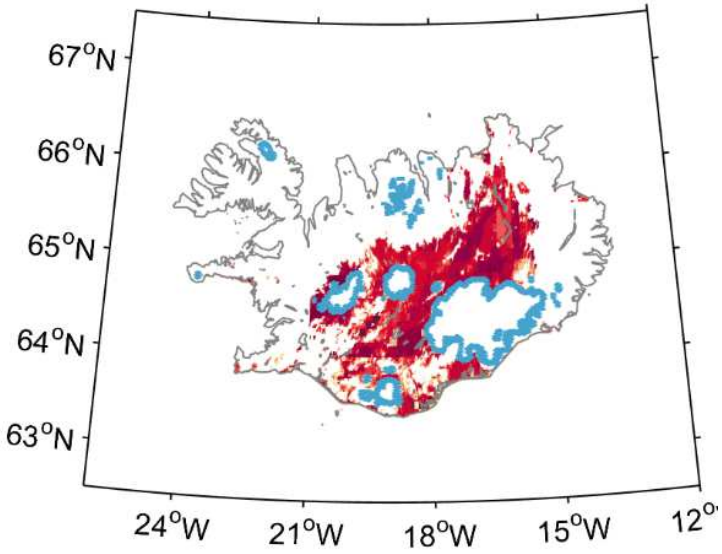
FLEXDUST : motivation

- Dominant source regions for dust in the Arctic
- What controls the seasonality of dust concentration and deposition?
- Icelandic dust?

FLEXDUST : approach



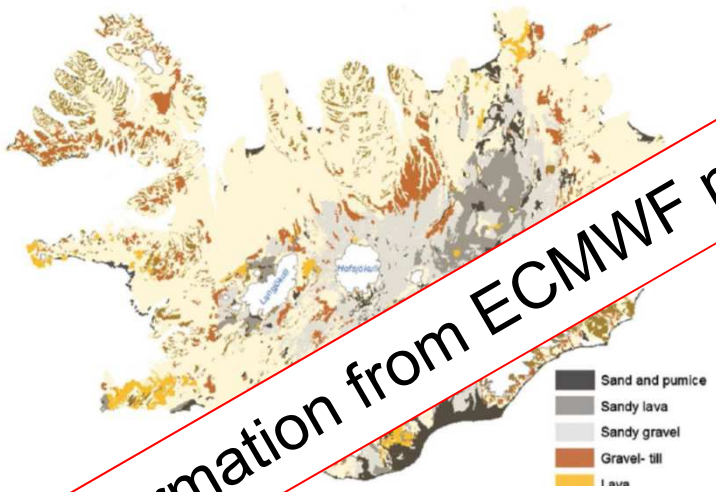
Bare soil fraction, soil properties, ECMWF analysis fields (wind, snow, precipitation,...)



FLEXDUST gridded and speciated dust emissions

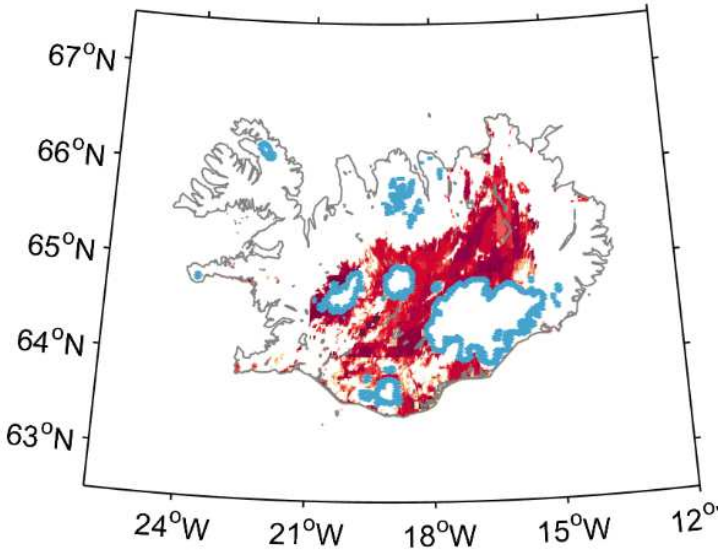
FLEXPART

FLEXDUST : approach



New information from ECMWF needed

oil fraction, soil properties,
CMWF analysis fields (wind,
snow, precipitation,...)



FLEXDUST gridded and speciated dust emissions

FLEXPART

FLEXDUST : emission scheme

- Find threshold of friction velocity for mobilization
  - Assume that sandblasting is dominant
  - Soil moisture can increase threshold friction velocity
  - Snow cover inhibits dust mobilization

Information from meteo fields

- Erodibility is influenced by topography

Sediments tend to gather in depressions

Obstacles are considered

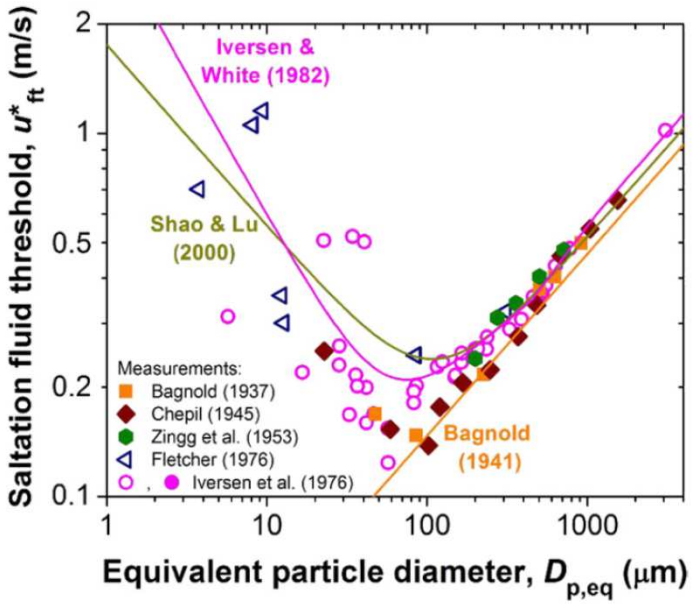
FLEXDUST : emission scheme

- Find threshold of friction velocity for mobilization
  - Assume that sandblasting is dominant
  - Soil moisture can increase threshold friction velocity
  - Snow cover inhibits dust mobilization
- Erodibility is influenced by topography
- Dust emission flux (Marticorena and Bergametti,1995):

$$Q_s = \frac{\alpha \rho u_*^3}{g}\left(1 - \frac{u_{*t}^2}{u_*^2}\right)\left(1 + \frac{u_{*t}}{u_*}\right)$$

Threshold friction velocity (influenced by soil moisture)

Sand blasting efficiency



Threshold friction velocity influenced by particle size distribution and sand and clay fractions

FLEXDUST : emission scheme

- Find threshold of friction velocity for mobilization
  - Assume that sandblasting is dominant
  - Soil moisture can increase threshold friction velocity
  - Snow cover inhibits dust mobilization
- Erodibility is influenced by topography
- Dust emission flux (Marticorena and Bergametti,1995):

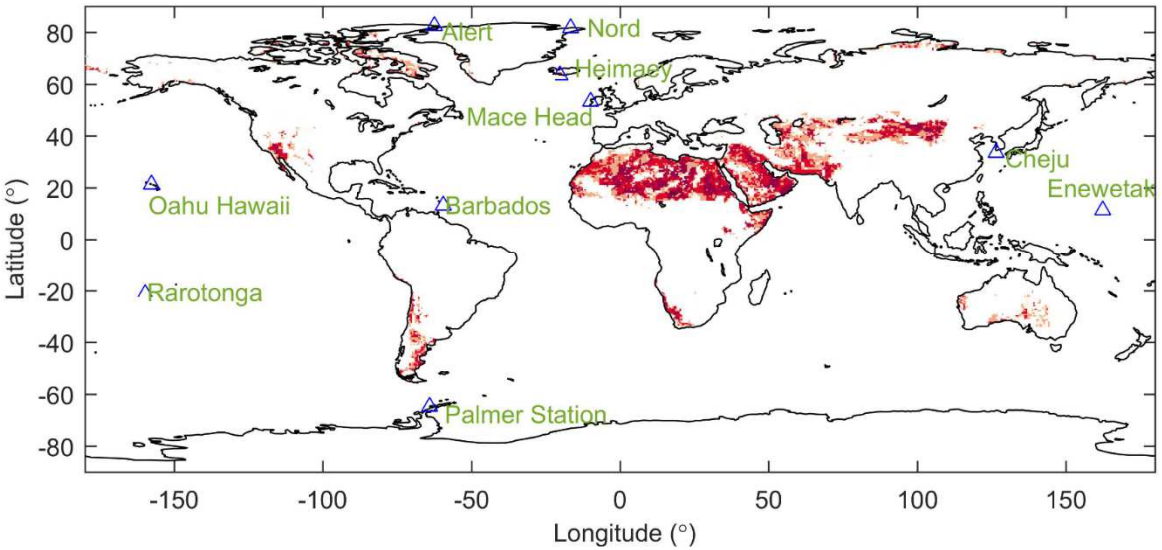
$$Q_s = \frac{\alpha \rho u_*^3}{g}\left(1 - \frac{u_{*t}^2}{u_*^2}\right)\left(1 + \frac{u_{*t}}{u_*}\right)$$

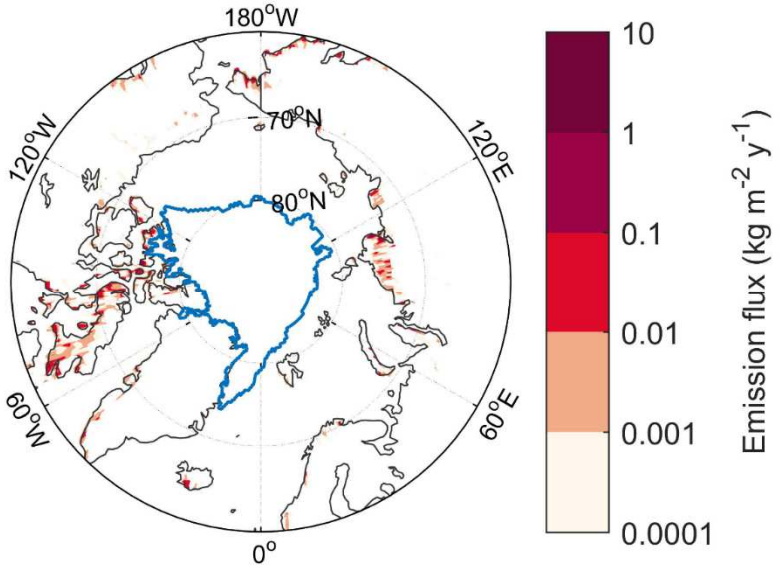
- Particle size distribution based on brittle fragmentation theory (Kok, 2011); 10 size bins, <20 µm.

Two more schemes are available, one simpler, based on work by Sodemann (2015) and another as well using friction velocity. Just the one here presented has been validated.

Species definition comprises particles with a **median diameter of 0.2, 0.5, 1.0, 1.5, 2.5, 5.0, 7.5, 12.5, 15.0 and 20 µm** having all an average density of 2500 kg/m3. (adaptation to Flexpart v 8.23 needed)

FLEXDUST - Annual emission



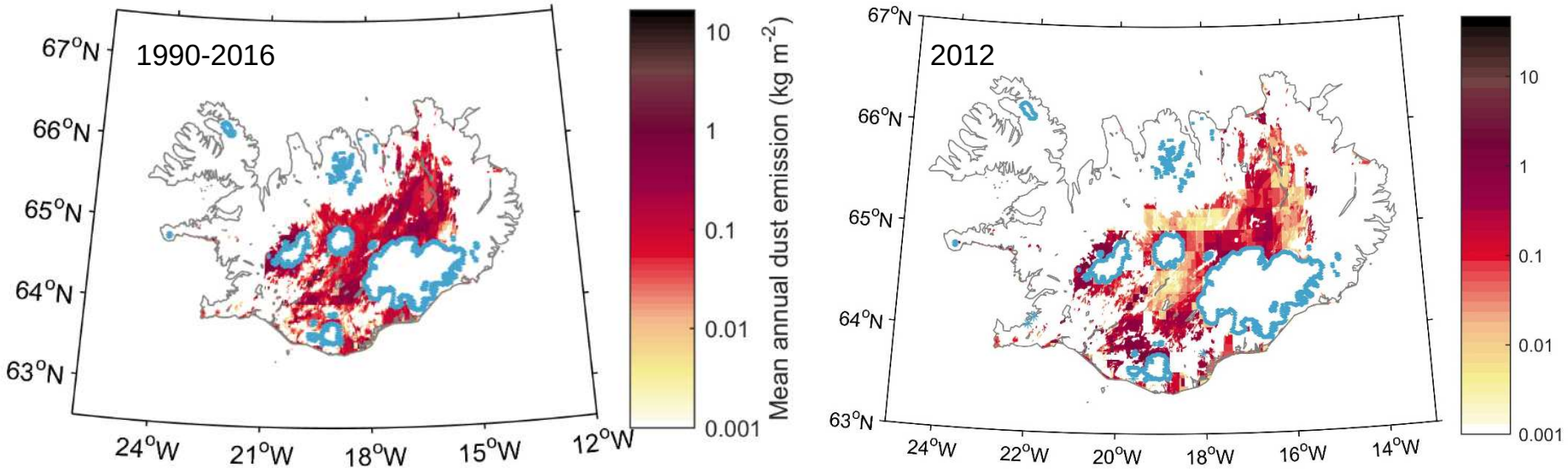


- Landcover data GLCNMO2 & high-resolution map Iceland
- FAO Sand & clay maps
- Meteorological data from ECMWF operational analysis fields
- Simulating years 2010 – 2012

- NOTE: Iceland – low amounts of dust BUT highly mobilized

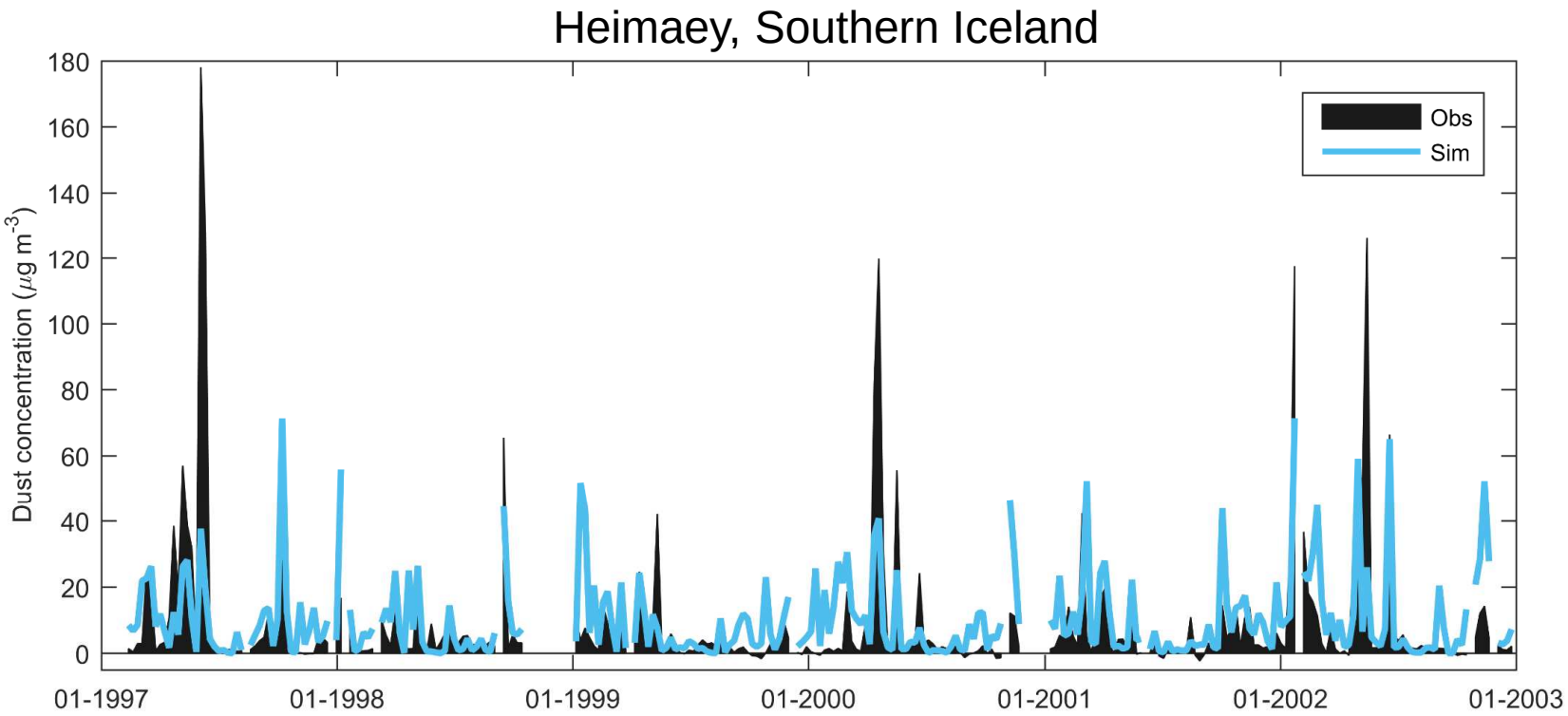
FLEXDUST – Icelandic emissions and relation to measurements

Era-Interim wind fields (1990-2016) and hourly 0.2° -ECMWF fields (2012)



Simulations 1990-2016:
Mean annual emission 4.3 Tg
50% emission occurs in 25 days

FLEXDUST – Icelandic emissions and relation to measurements



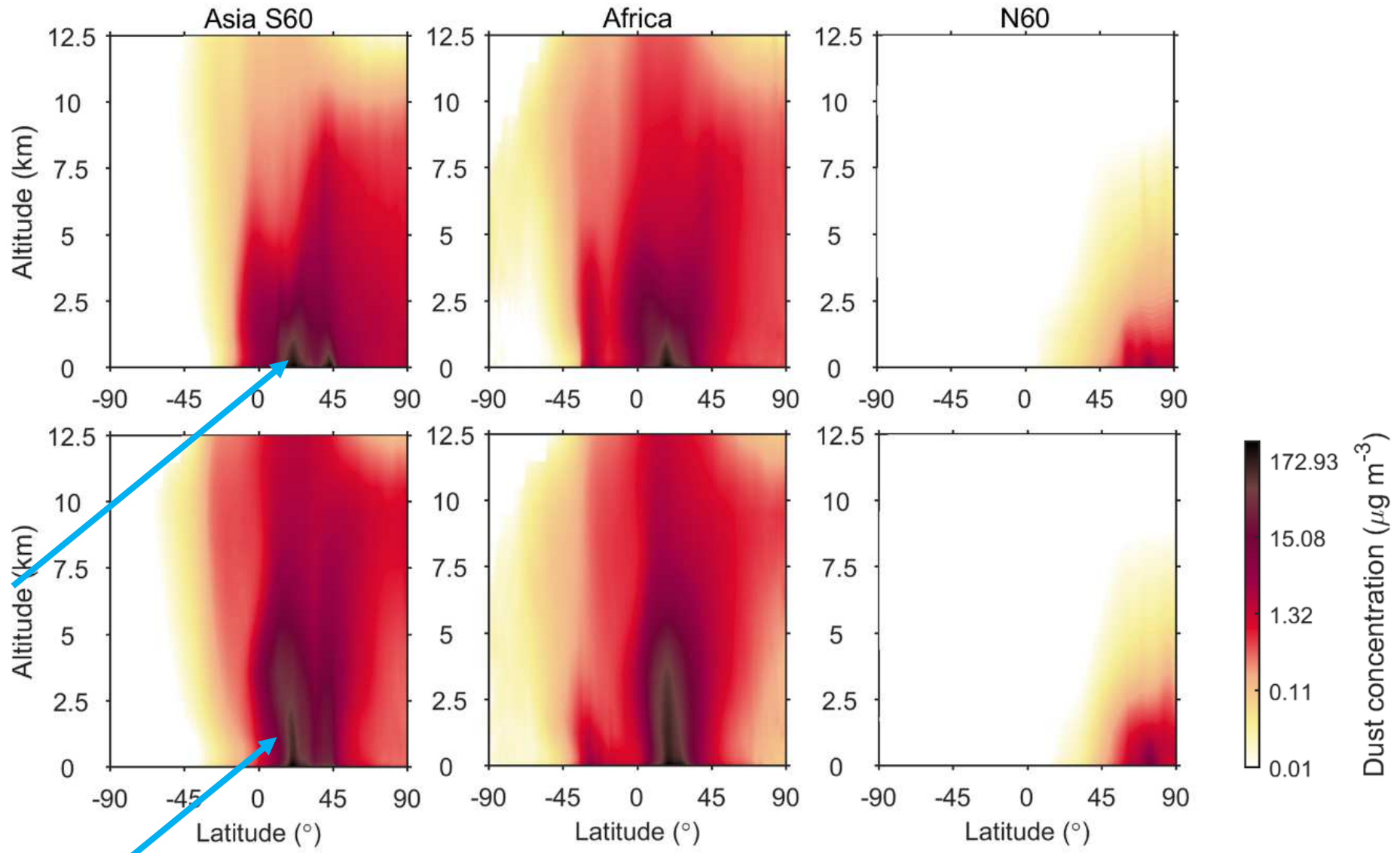
Timing of large events well captured

Underestimation partly related to flood events

FLEXDUST : regional distribution

Winter (DJF)

Summer (JJA)



Reaching high altitudes in the atmosphere - transport

FLEXDUST : data requirements

As a source for dust emission both land cover classes bare soil (sand) and partly vegetated areas are included. For partly vegetated areas, available soil fraction is determined by subtracting the vegetation cover fraction as used by the European Centre for Medium-Range Weather Forecasts (ECMWF, Boussetta et al., 2013). The following static input files are needed:

•If time dependent fields "*high vegetation cover*" (cvh) and "*low vegetation cover*" (cvl) are missing in FLEXPART ECMWF input files, a static vegetation cover from ECMWF should be used. Thus, file **Vegetation_ECMWF_2010** is currently in use. However, this implies that using this 1.0° file a global mother domain is a must and output fields must also be global. This is just a temporary solution in case the ECMWF fields are NOT available

•The routine that assigns bare land to the grid is based on the land use classes available in the Global Land Cover by National Mapping Organizations (GLCNMO; version 2, *Tateishi et al., 2014,* 15 arcsec pixel^{-1} resolution) map **landcover_GLCNMO_l.bin**.

•The clay and sand land cover files **clay.srf** and **sand.srf**

The code is in DEVELOPMENTAL stage still.

- The code is freely available to anyone.
- So far only NILU (developers) and ZAMG have tested it.
- Warning: some settings may NOT have been considered yet.
- Available at: https://git.nilu.no/christine/flexdust (tar file)
  - "git clone git@git.nilu.no:christine/flexdust.git" to get the code

Contact: Christine.Groot.Zwaaftink@nilu.no

Name	Last commit	Last update
INPUT	Added sand and clay files	2 years ago
src	Correction of wind field reading in case the start of the simulation ...	1 week ago
README	Updated README	8 months ago

FLEXDUST : data requirements