Polluted cloud tracks across spatial and temporal scales

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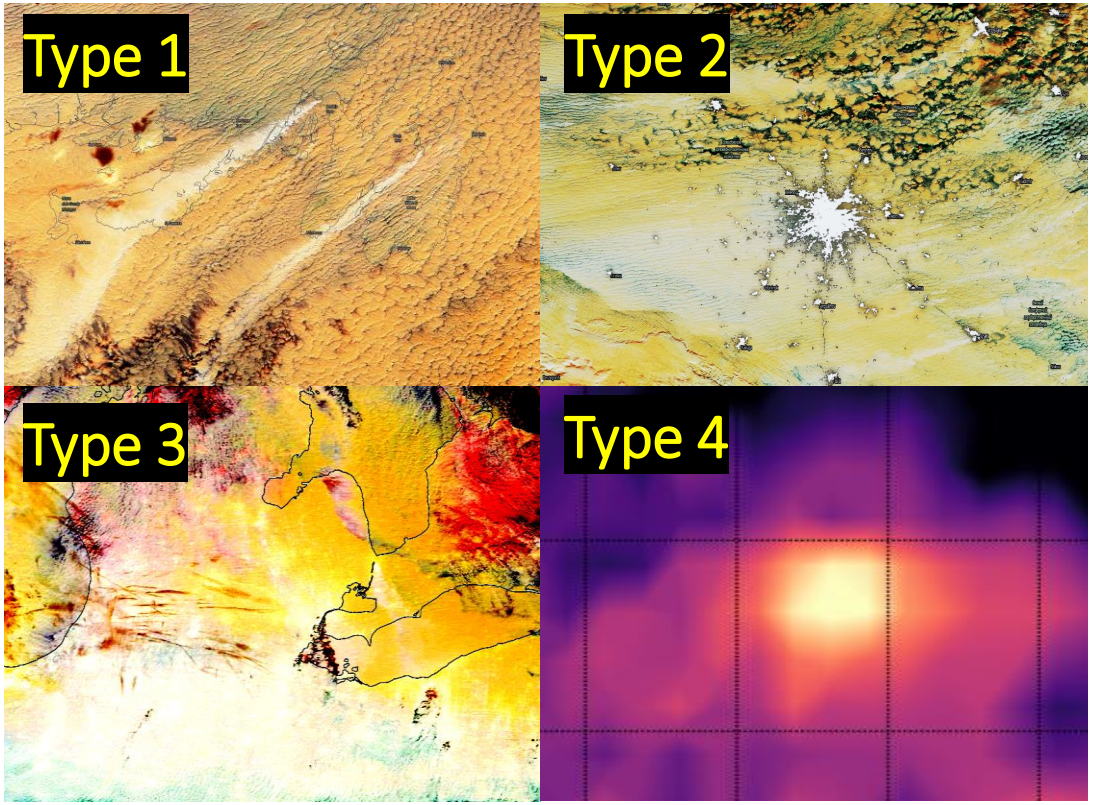

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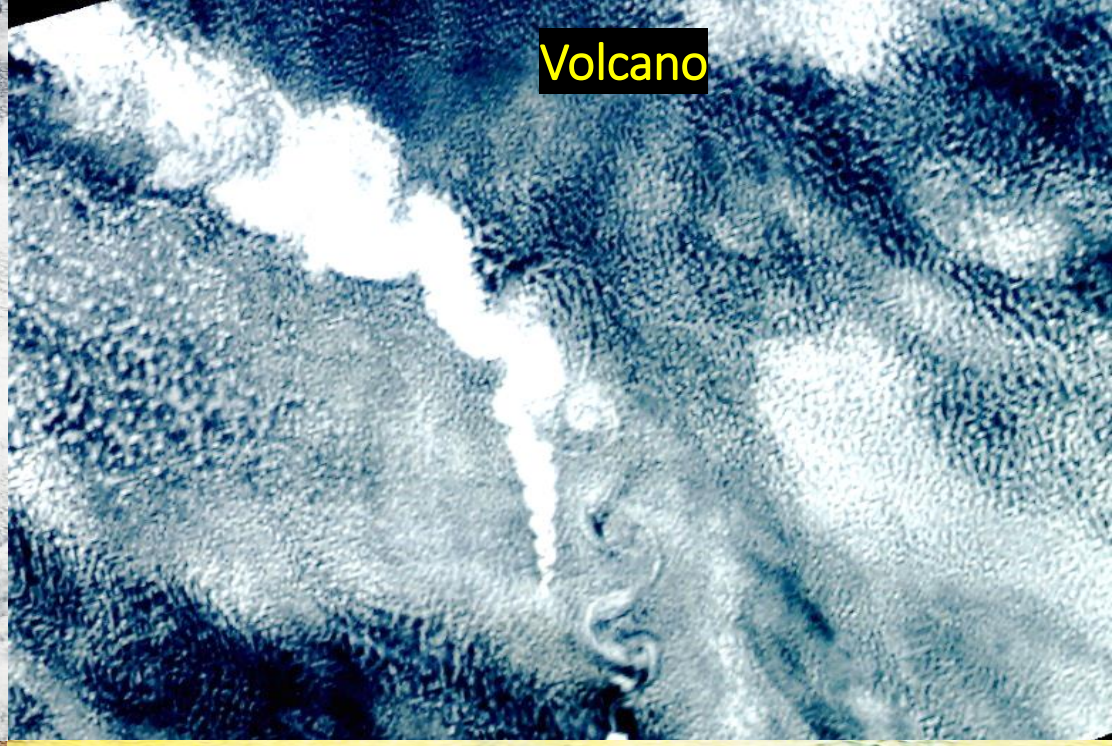
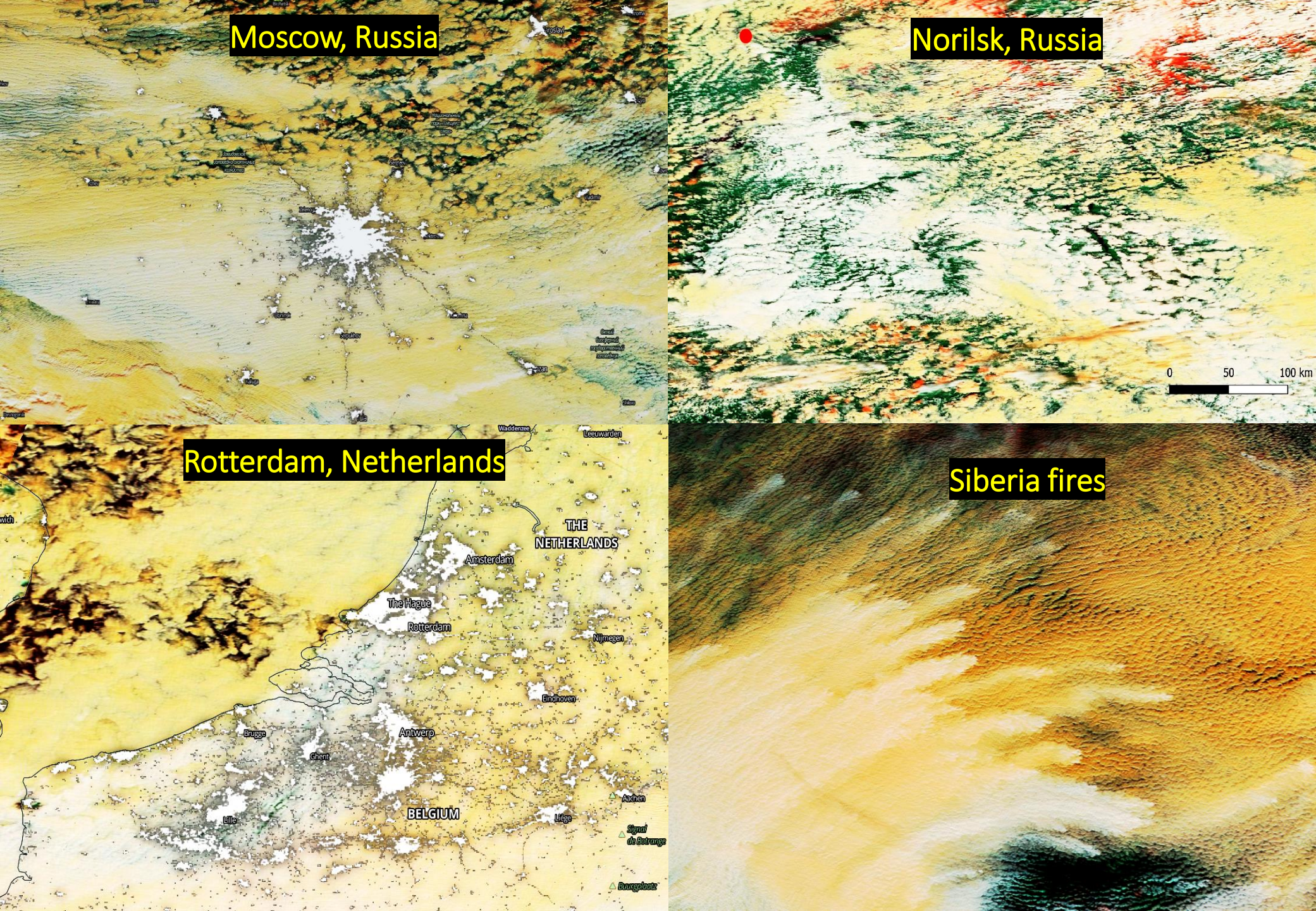
UNIVERSITY OF TARTU
Institute of Physics

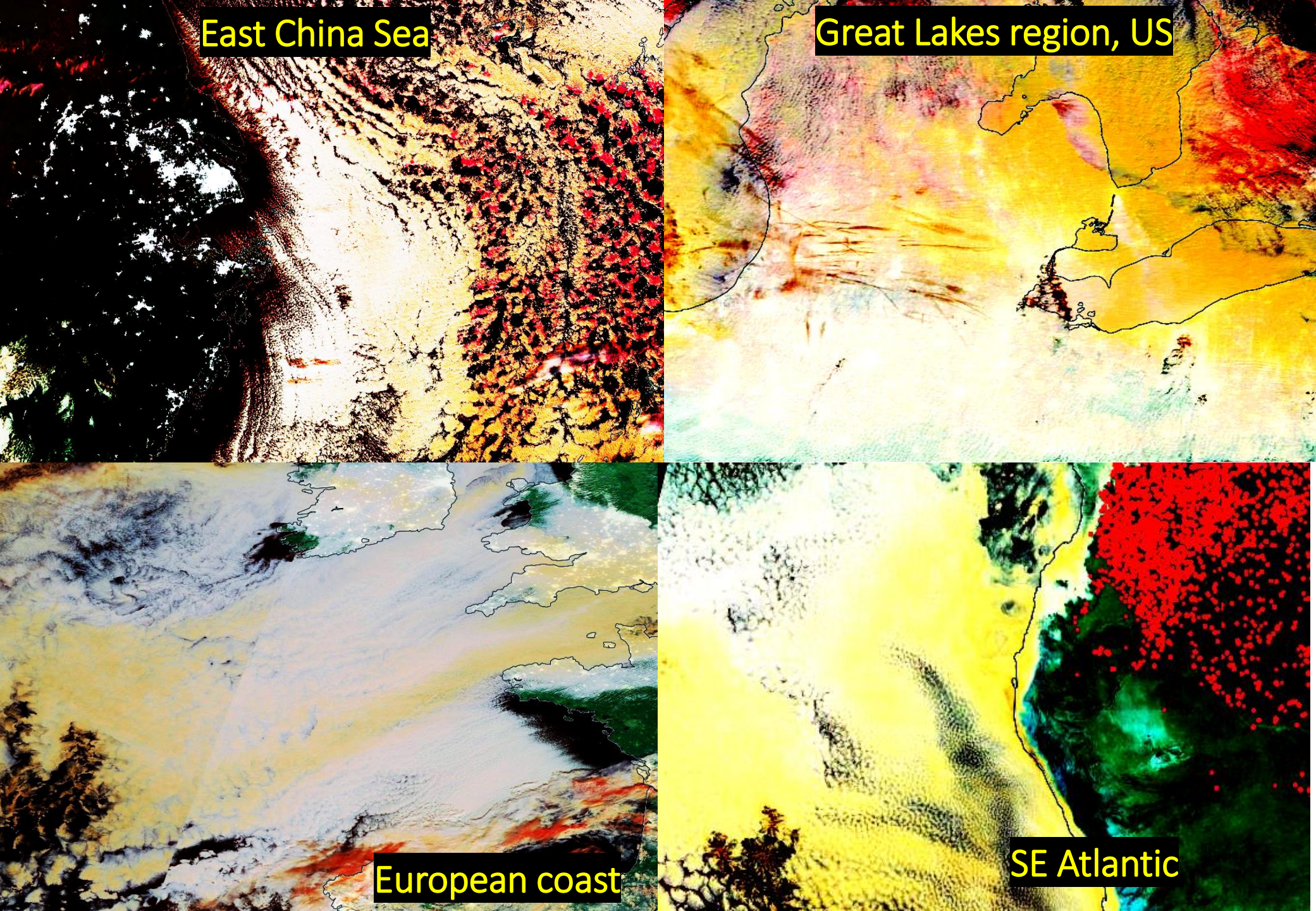

Ship


Volcano

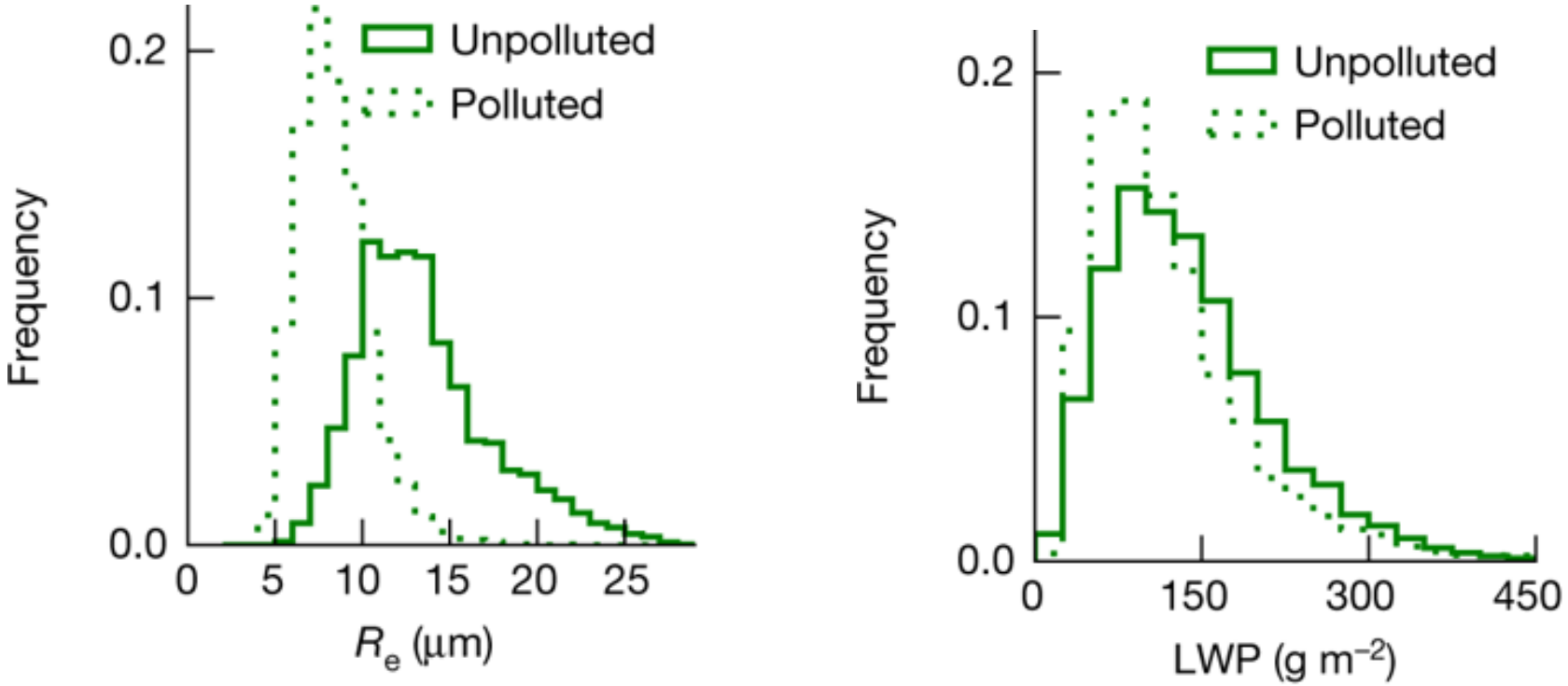

Industry


Fire
Bely Yar


Moscow, Russia
Norilsk, Russia
0
50
100 km
Rotterdam, Netherlands
Waddenzee
Leeuwarden
THE
NETHERLANDS
Amsterdam
The Hague
Rotterdam
Nijmegen
Eindhoven
Antwerp
Brugge
Ghent
Aachen
BELGIUM
Lille
Liège
Siberia fires


East China Sea
Great Lakes region, US
European coast
SE Atlantic

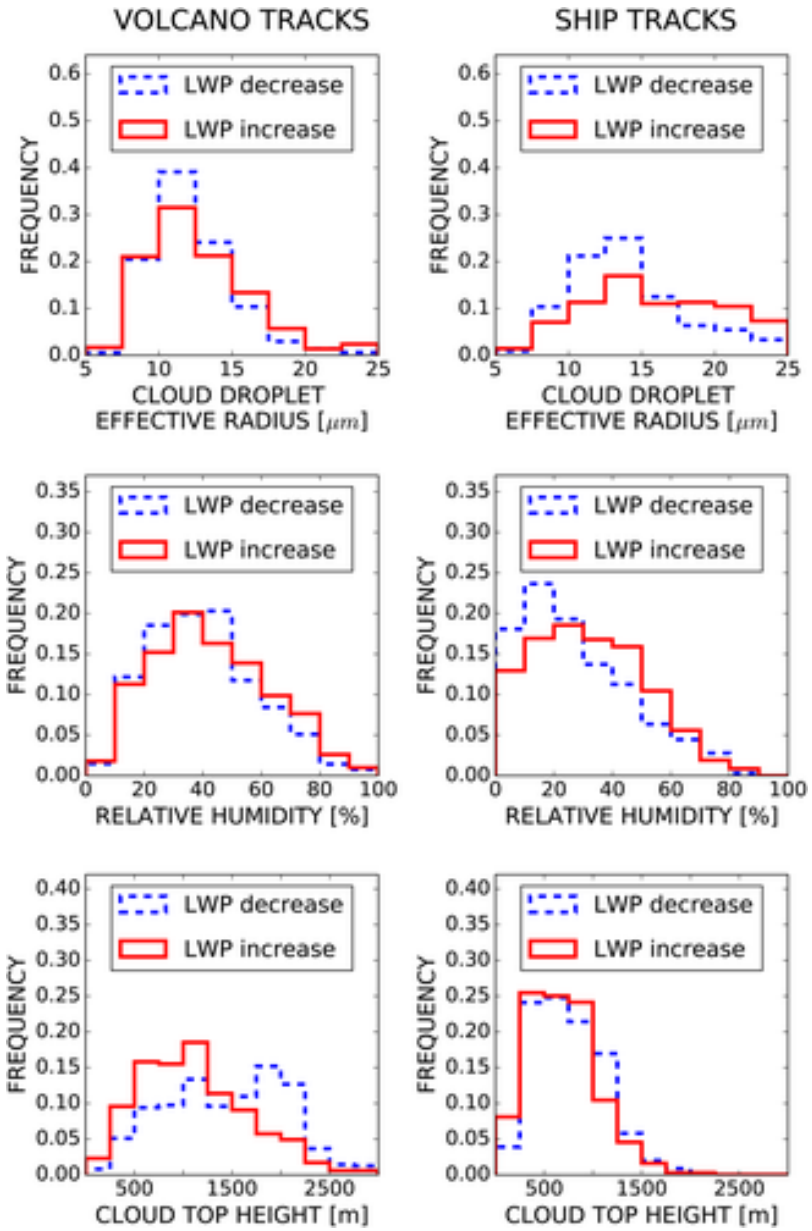
Cloud water increases are compensated by decreases



Comparison between polluted and unpolluted clouds

(Toll et al 2019 *Nature*)

Meteorological dependence of cloud water response



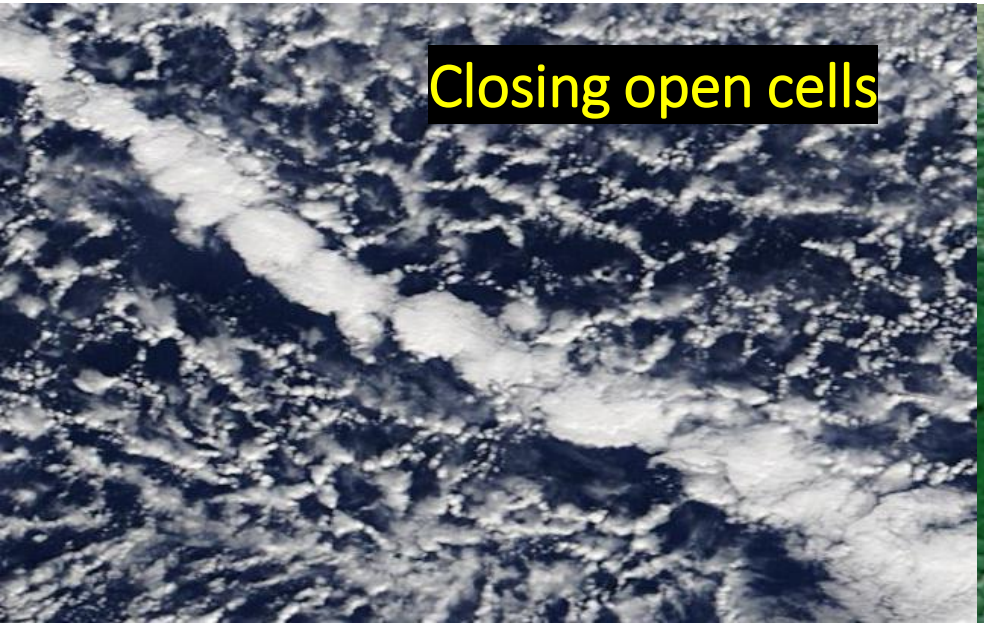
LWP response dependence on cloud droplet size supports suppression of precipitation.

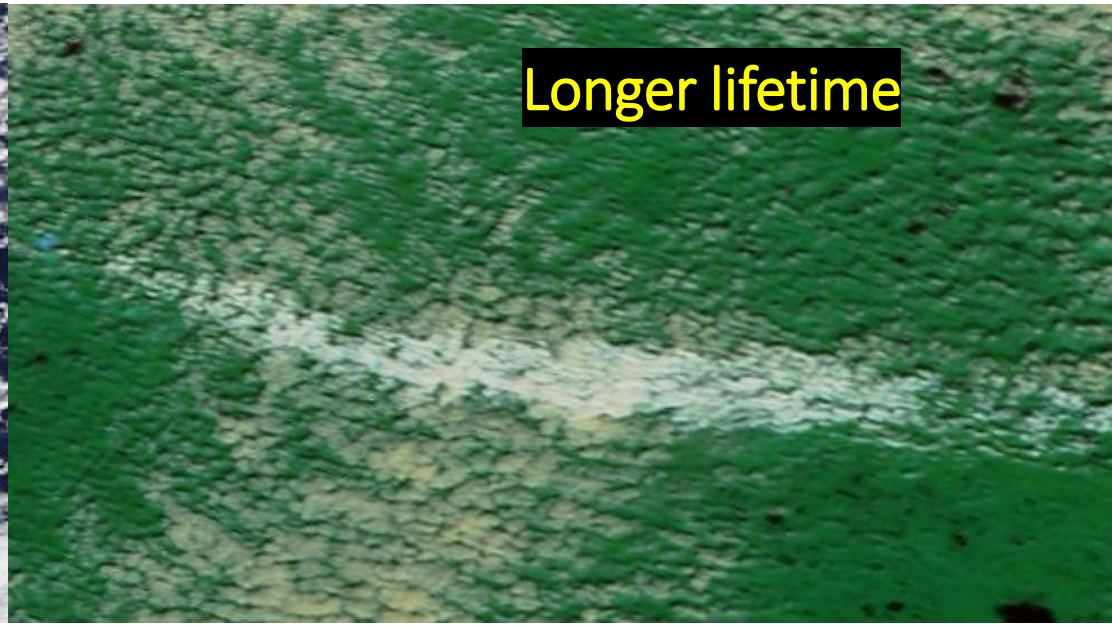
LWP response dependence on relative humidity supports aerosol-enhanced entrainment.

There is a lot of variability in the responses under all conditions: processes controlling LWP increases and decreases need to be better understood.

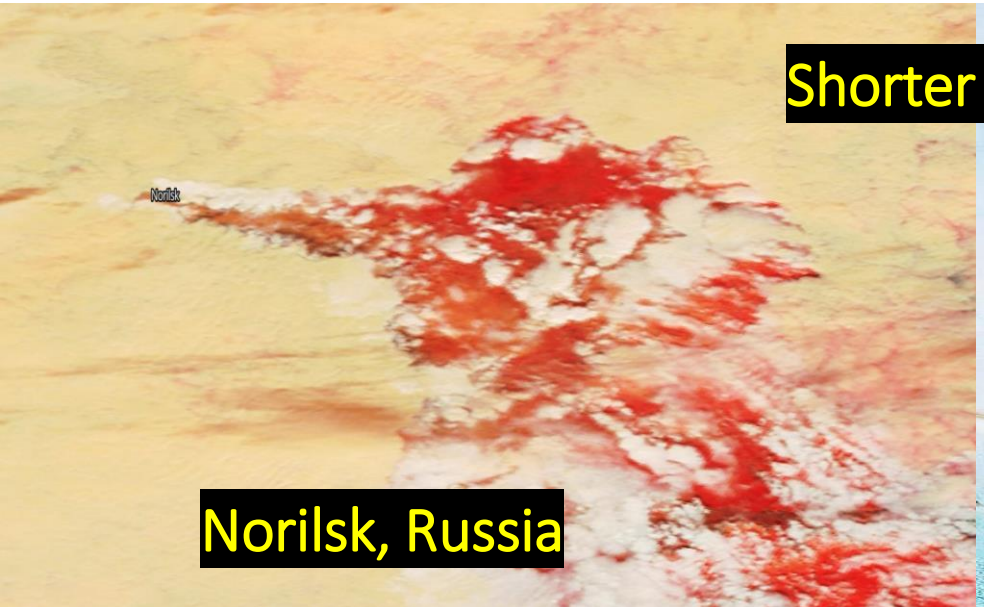
(Toll et al 2017 *GRL*)

Increased cloud fraction

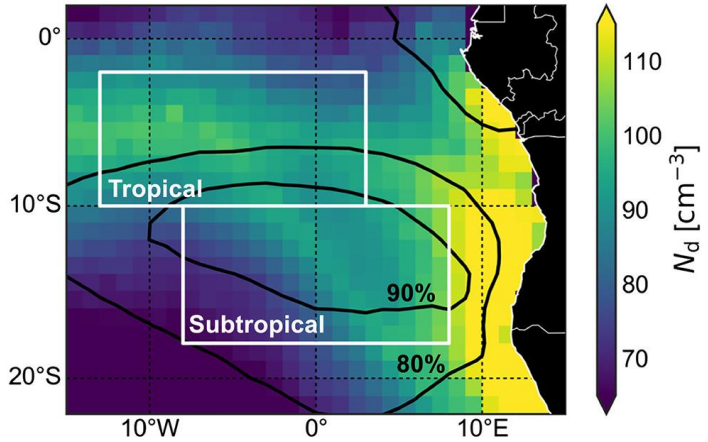




Decreased cloud fraction



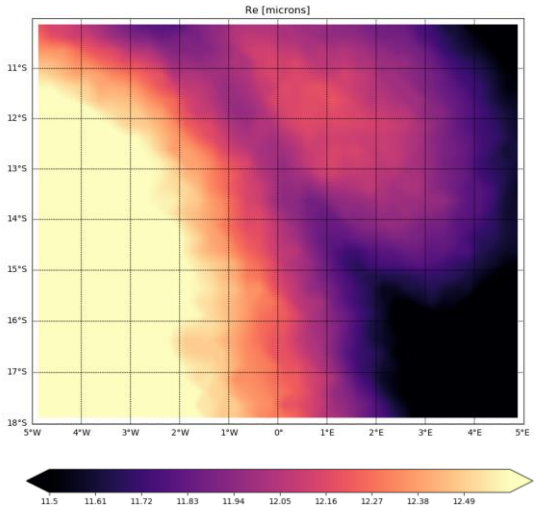
Polluted cloud tracks recorded in long-term average cloud properties



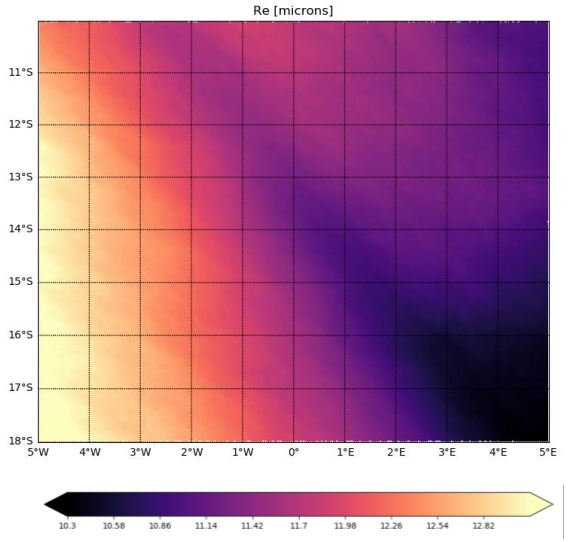
Shipping corridor seen in the South-East Atlantic MODIS CDNC,

1 deg resolution

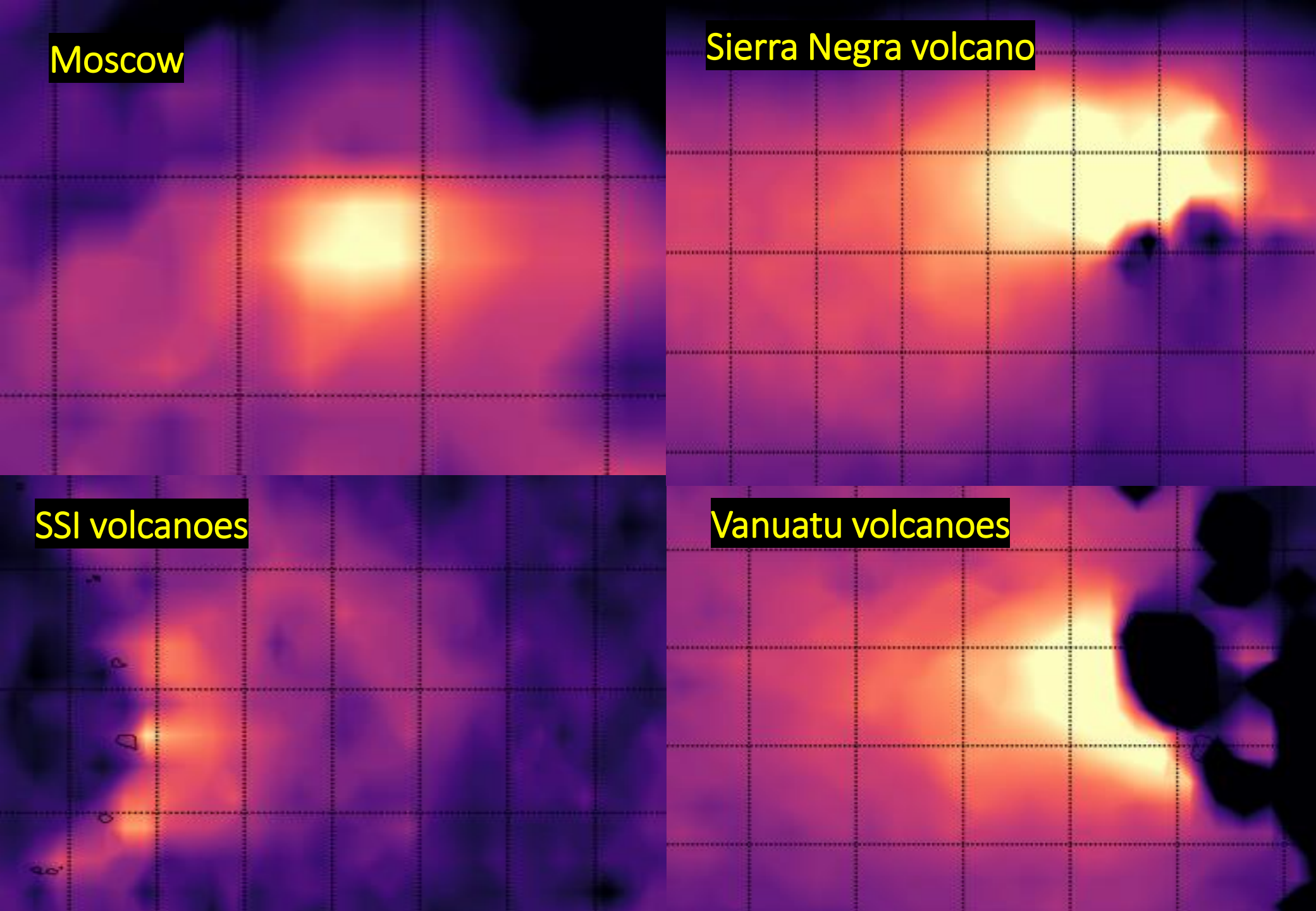
(Diamond et al 2020 *AGU Advances*)



AVHRR Re data 1982-2015, at 0.25 deg resolution



SEVIRI Re data 2004-2015, at 0.05 deg resolution


Moscow
Sierra Negra volcano
SSI volcanoes
Vanuatu volcanoes

What can polluted cloud tracks tell us?

1) Local CDNC response

$\Delta \ln(CDNC) / \Delta \ln(SO_4)$ Type 4

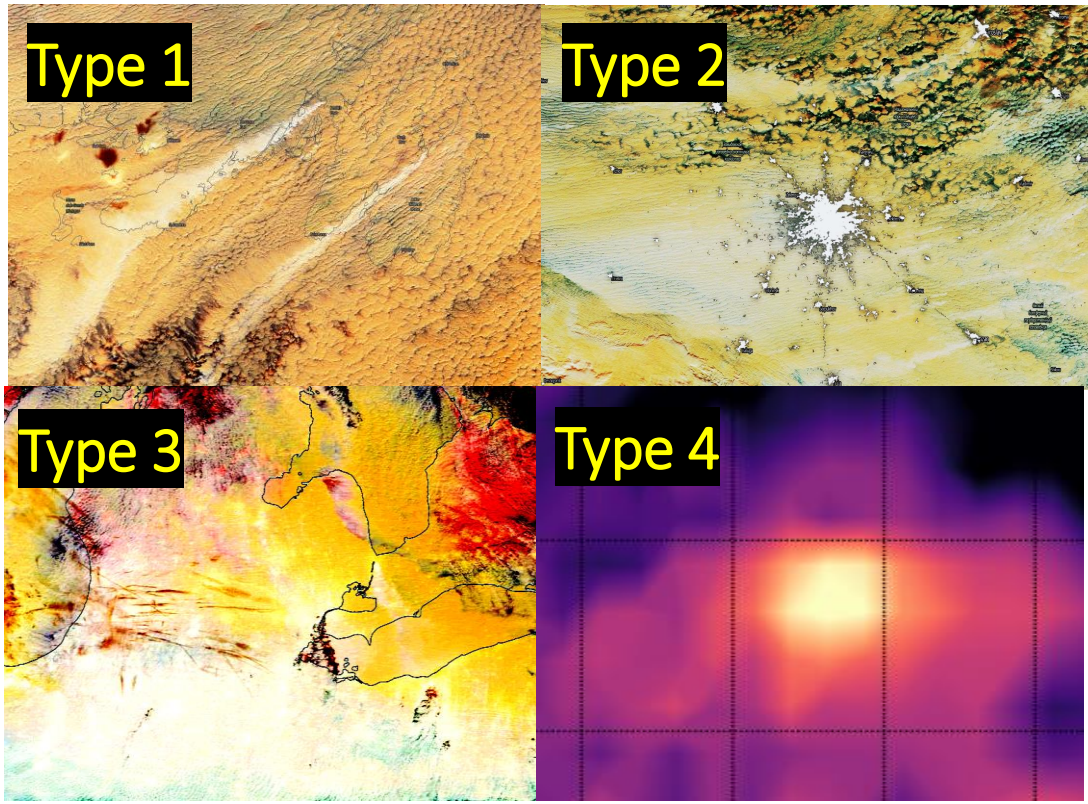
2) Local LWP, CF response

$\Delta \ln(LWP) / \Delta \ln(CDNC)$

$\Delta \ln(CF) / \Delta \ln(CDNC)$ Type 1,2,3,4

3) Meteorological dependence of aerosol indirect forcing, processes-level understanding Type 1,2

4) Additional ideas?



By sampling local cloud responses via natural experiments for many regions and cloud types (ocean, land, Sc, low-level Cu etc), we can estimate global aerosol indirect radiative forcing more reliably.