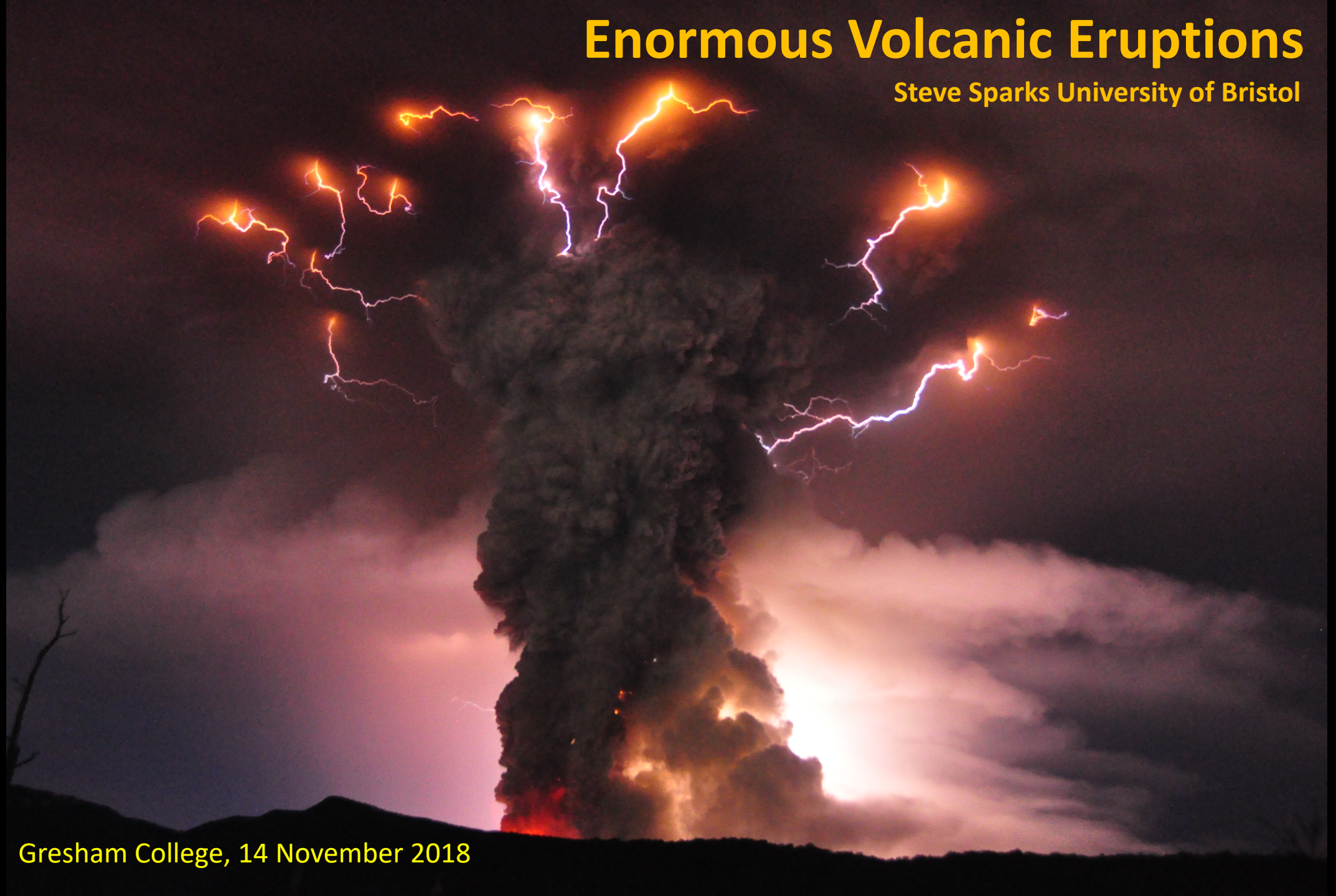
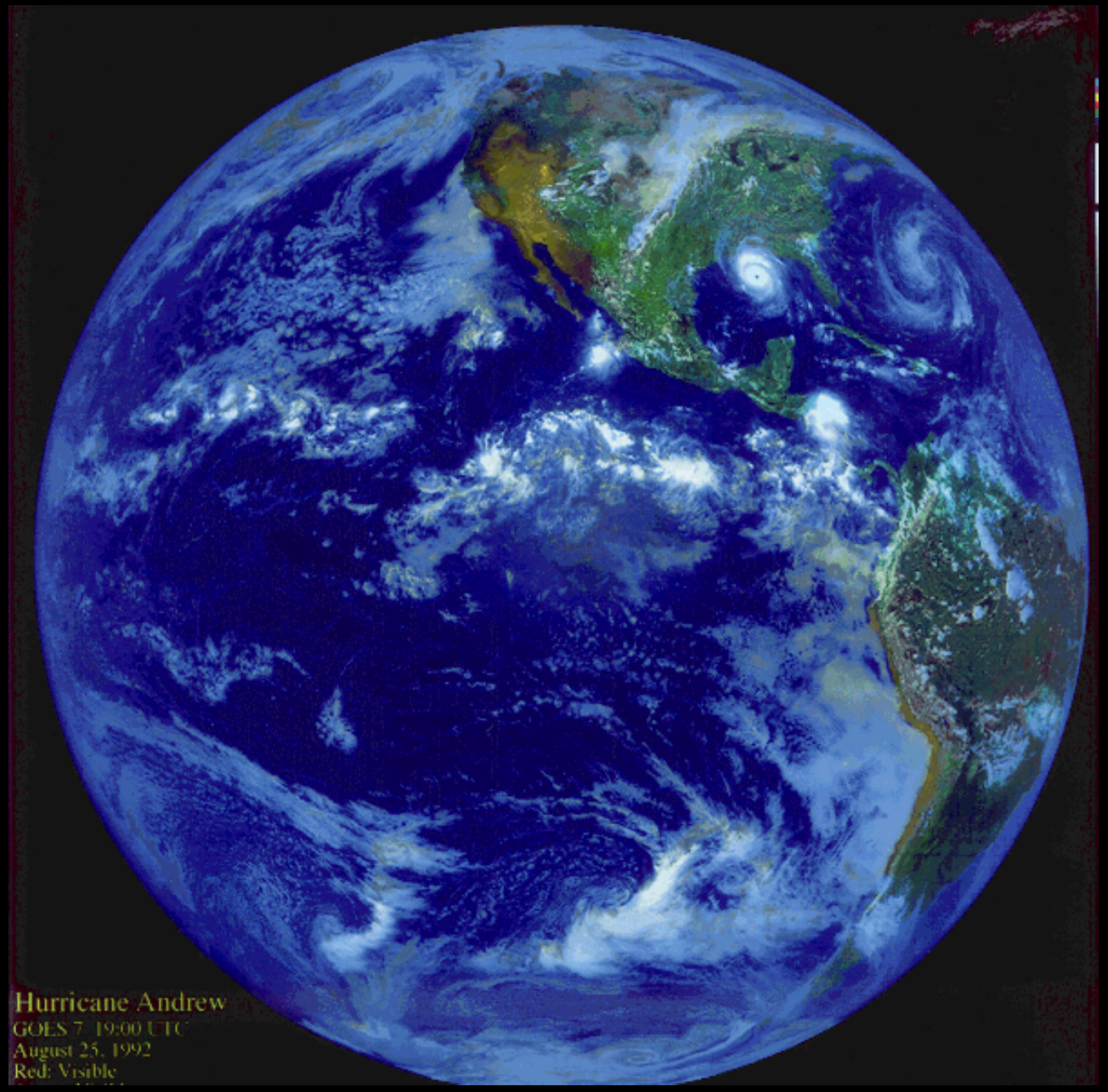
Enormous Volcanic Eruptions

Steve Sparks University of Bristol



Gresham College, 14 November 2018

Global Volcanism



551 historically active volcanoes
(Sinabung 2010, Indonesia)

~ 1554 Quaternary volcanoes

~ 50 eruptions per year

~ 1 volcano erupts every 2 years
with no historic eruption

Economic costs high locally

Large eruptions effect global climate

Global vulnerability increasing
(population growth, infrastructure)

How do we measure size of volcanic eruptions?

Amount erupted (Magnitude)

Volume (cubic kilometres)
Mass (m) erupted (kilograms)

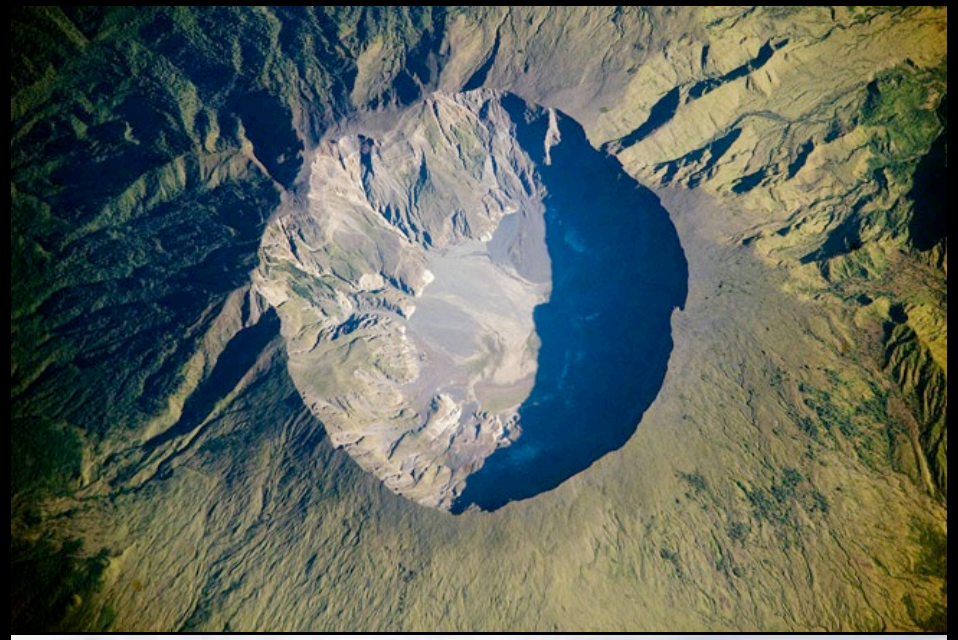
Rate of eruption (intensity)

Volume per second
Mass per second

$$M = \text{Log}_{10} m + 7$$

Super-eruption is magnitude 8 or greater

Tambora 1815 45 km³ M = 7

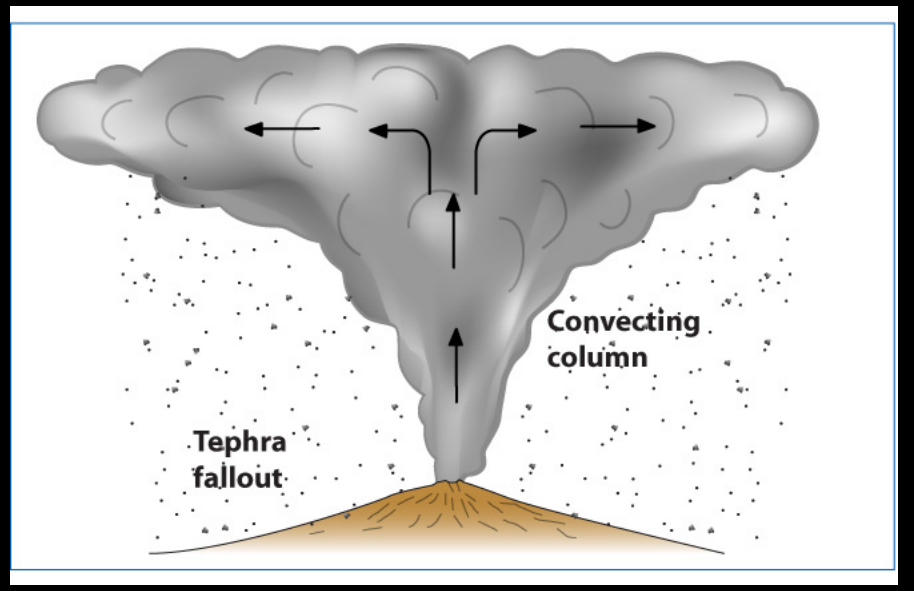


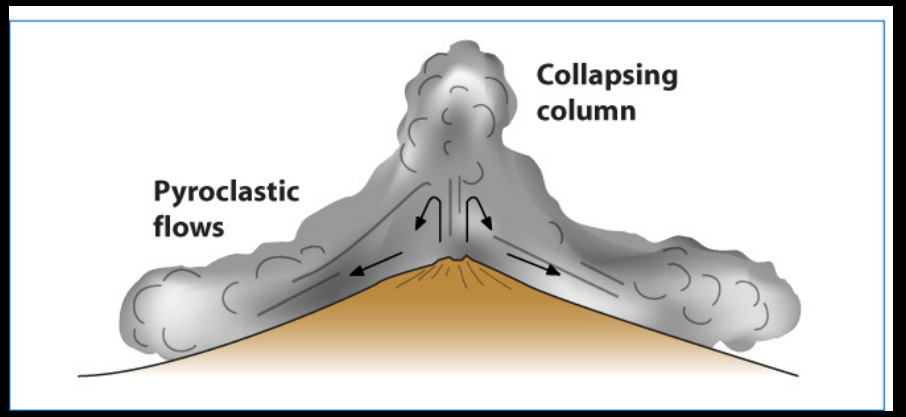
Pinatubo 1991 5 km³ M = 6.5

Toba 74,000 years ago 3500 km³ M = 9

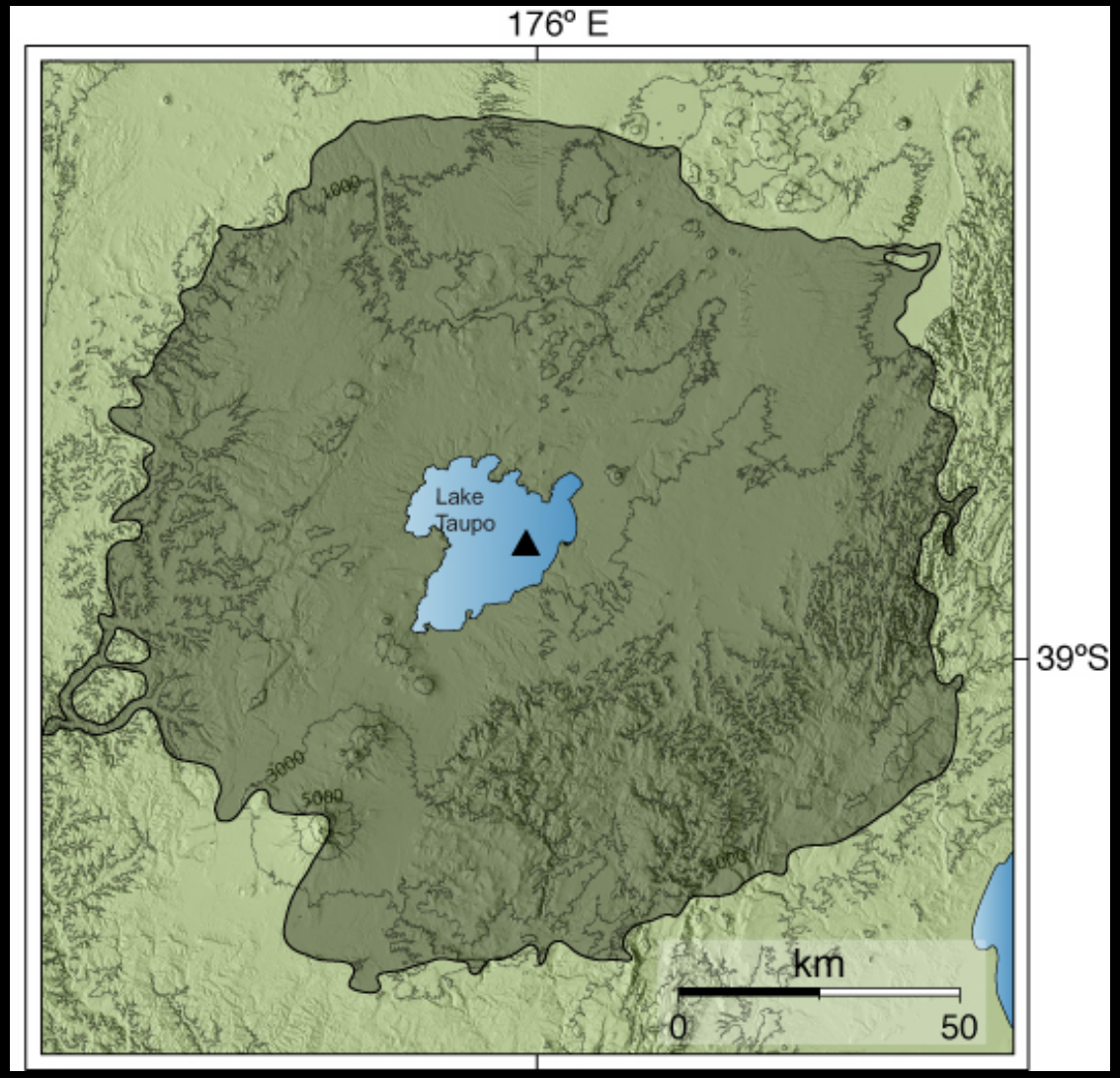
Intensity and style of explosive eruptions

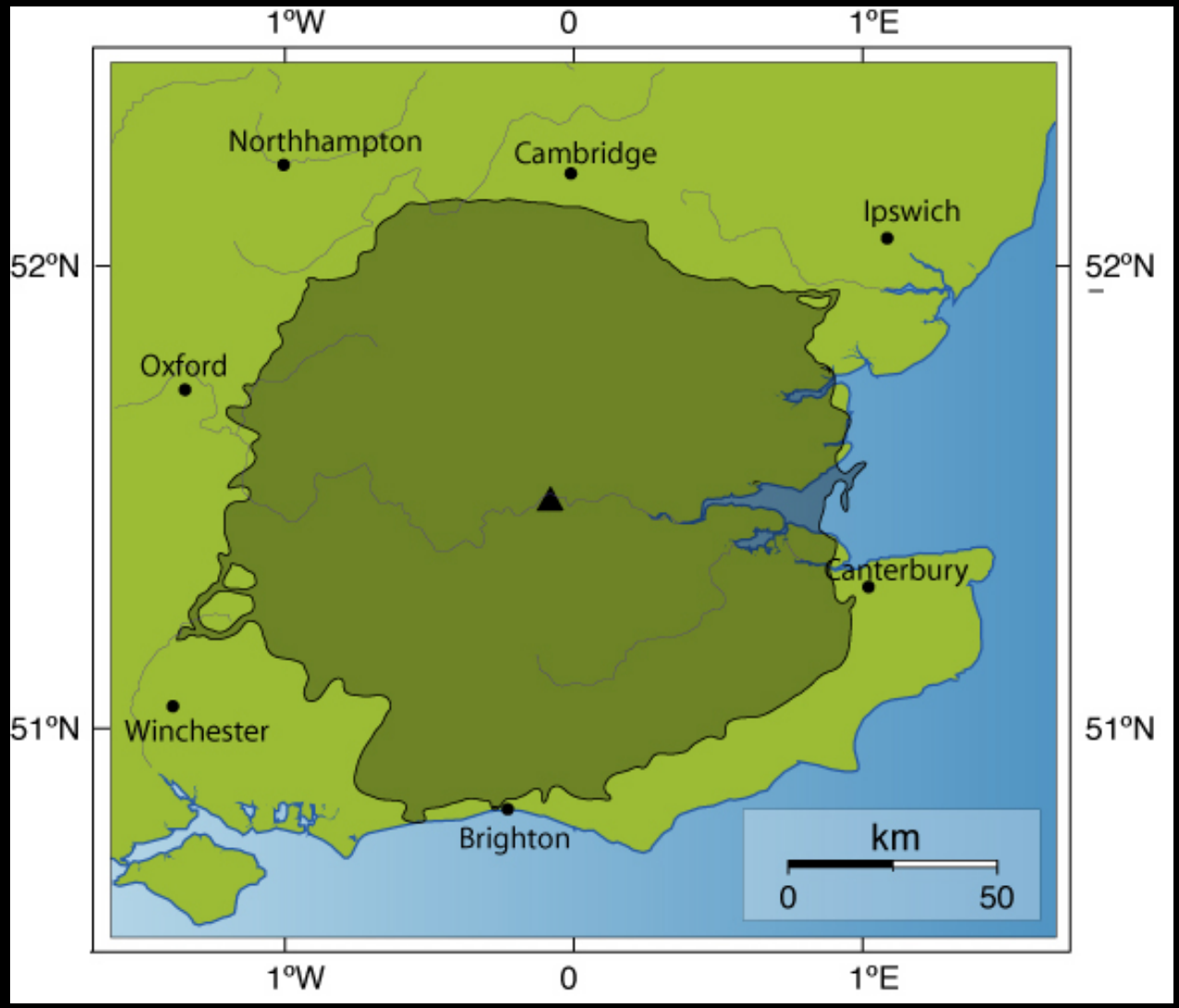
Mount St Helens 1980
10,000 cubic metres per second
0.2 km^3 over several hours





Taupo, New Zealand 180 AD: the most violent eruption known

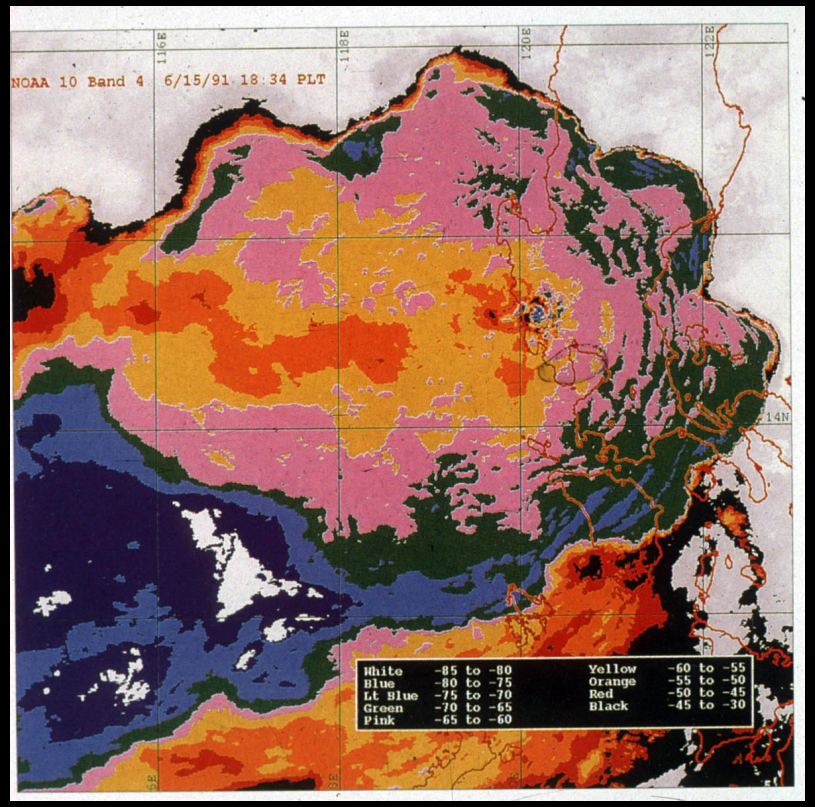


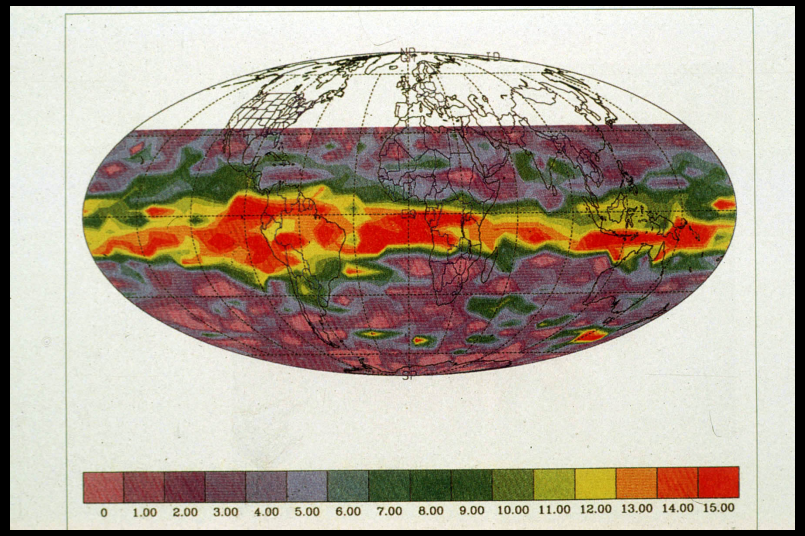


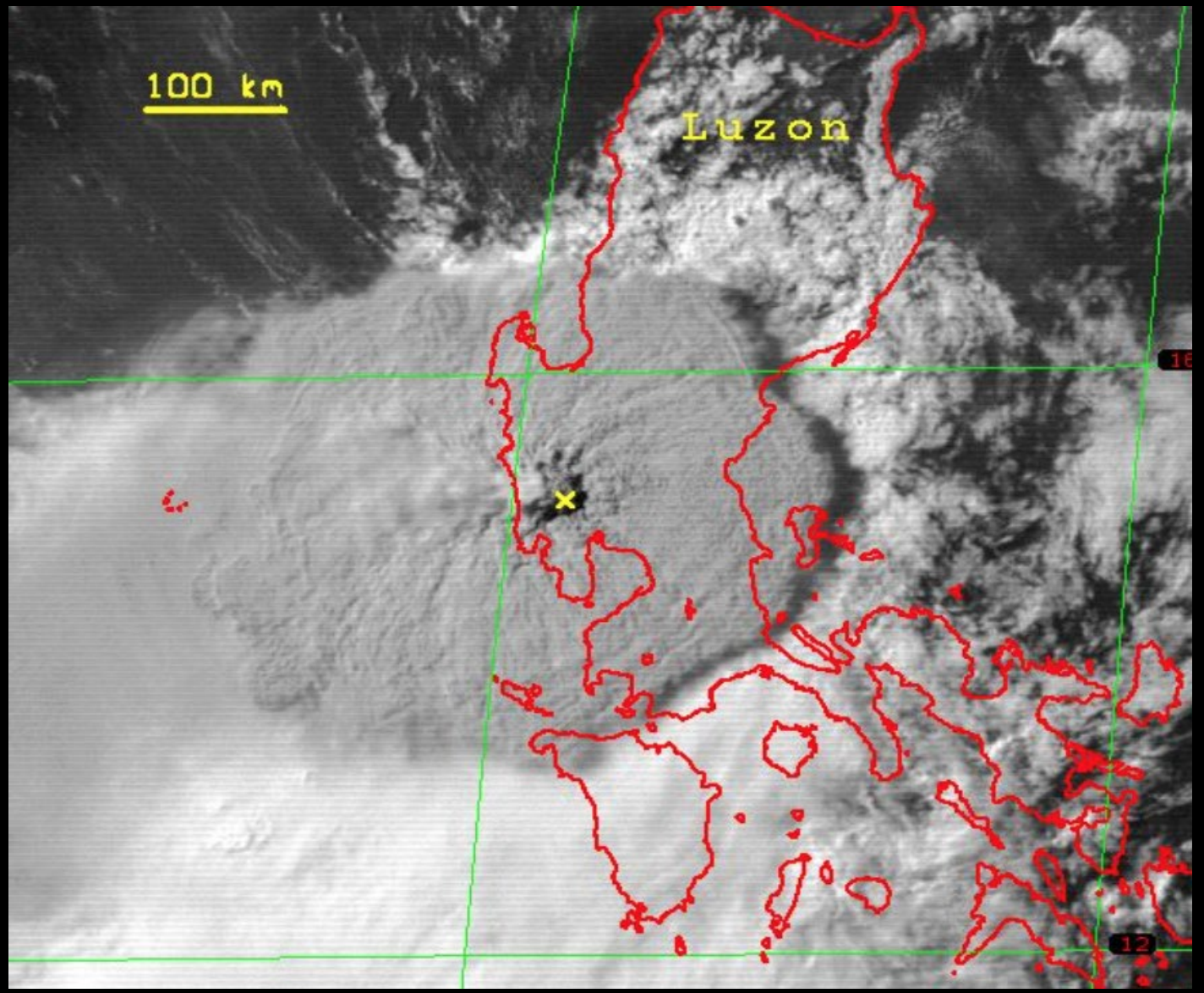
15 km³ in 15 minutes
20 million cubic metres per second

Flow speed about 800 kph

Pinatubo, Phiilipines (5 km^3) from space







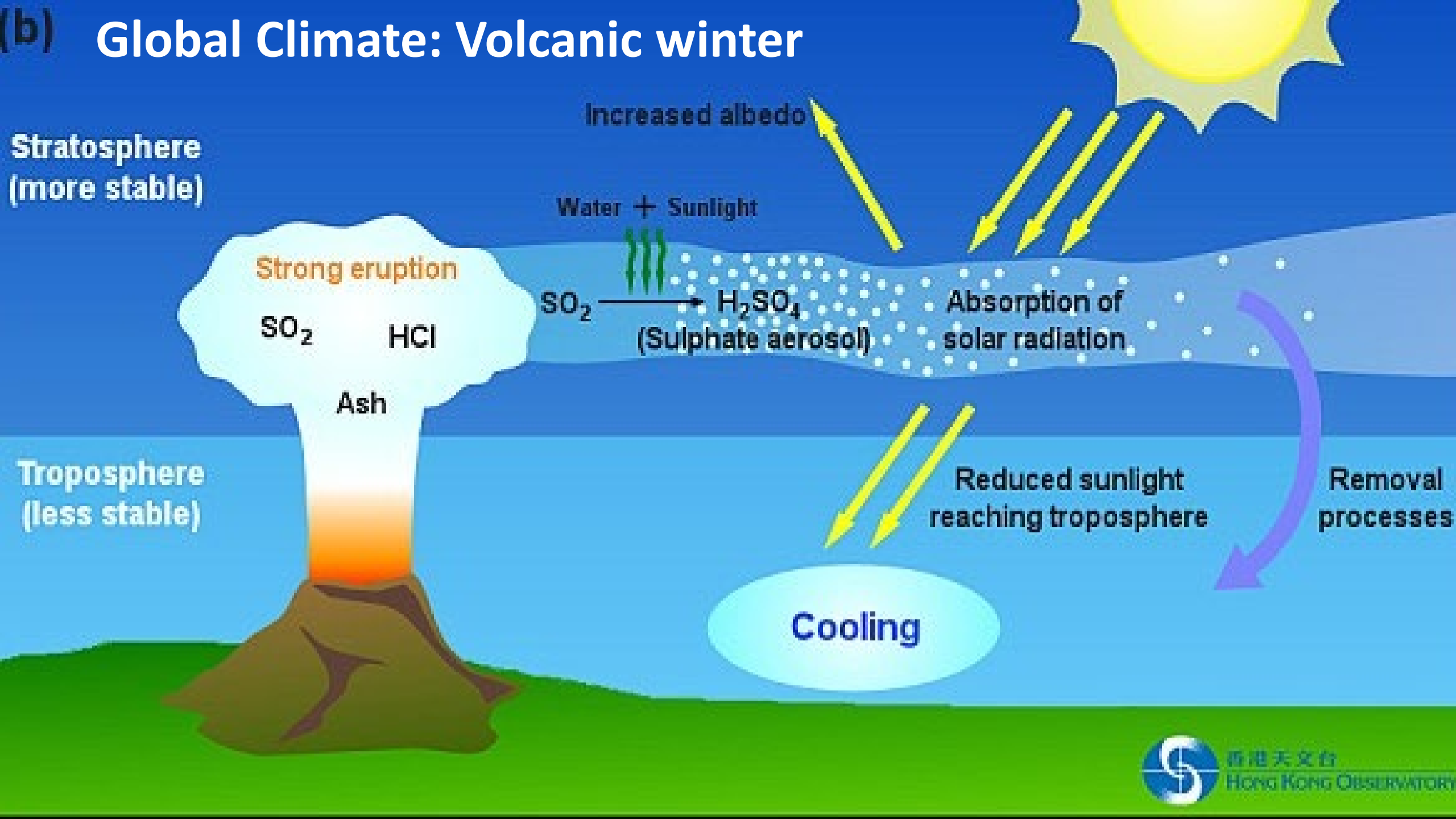
Atmospheric pollution; global scale

1815 eruption of Tambora, Indonesia ~ 45 km³

60,000 deaths directly and famine

1816: The year without a summer

(b) Global Climate: Volcanic winter



香港天文台
Hong Kong Observatory

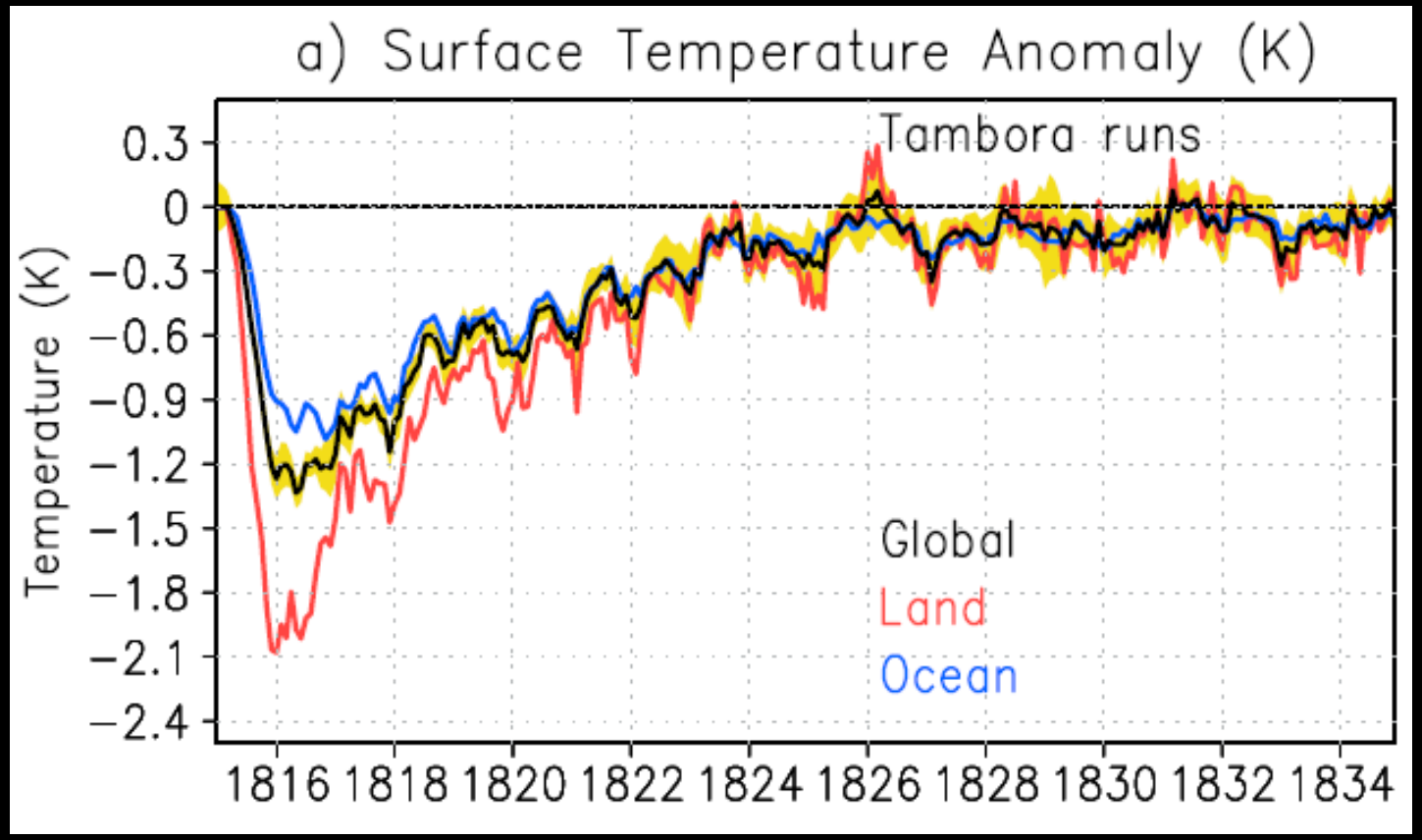
Great Famine of 1816

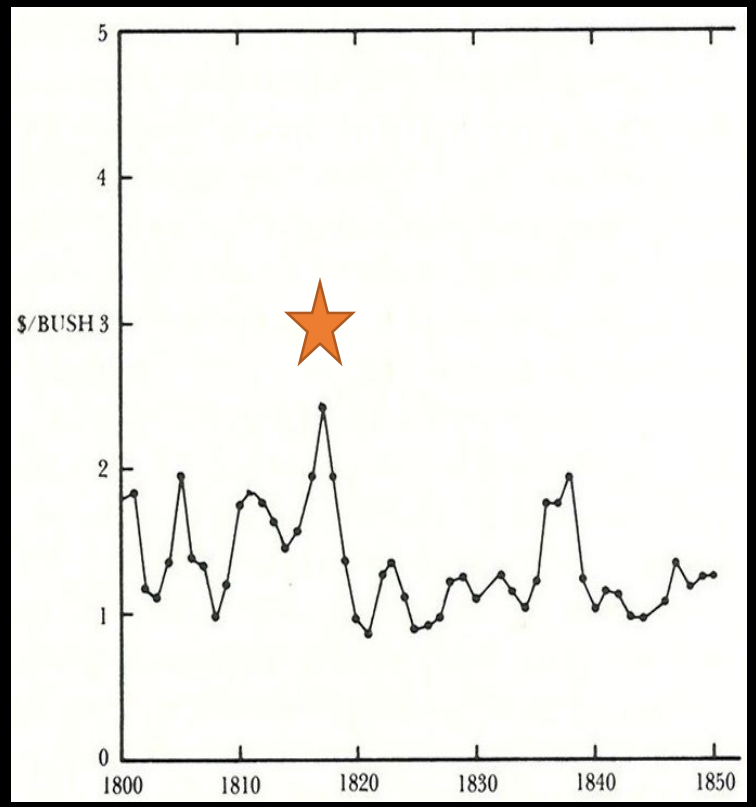
'Coldest July in a 192 years record.' (Lancashire Plain, UK)

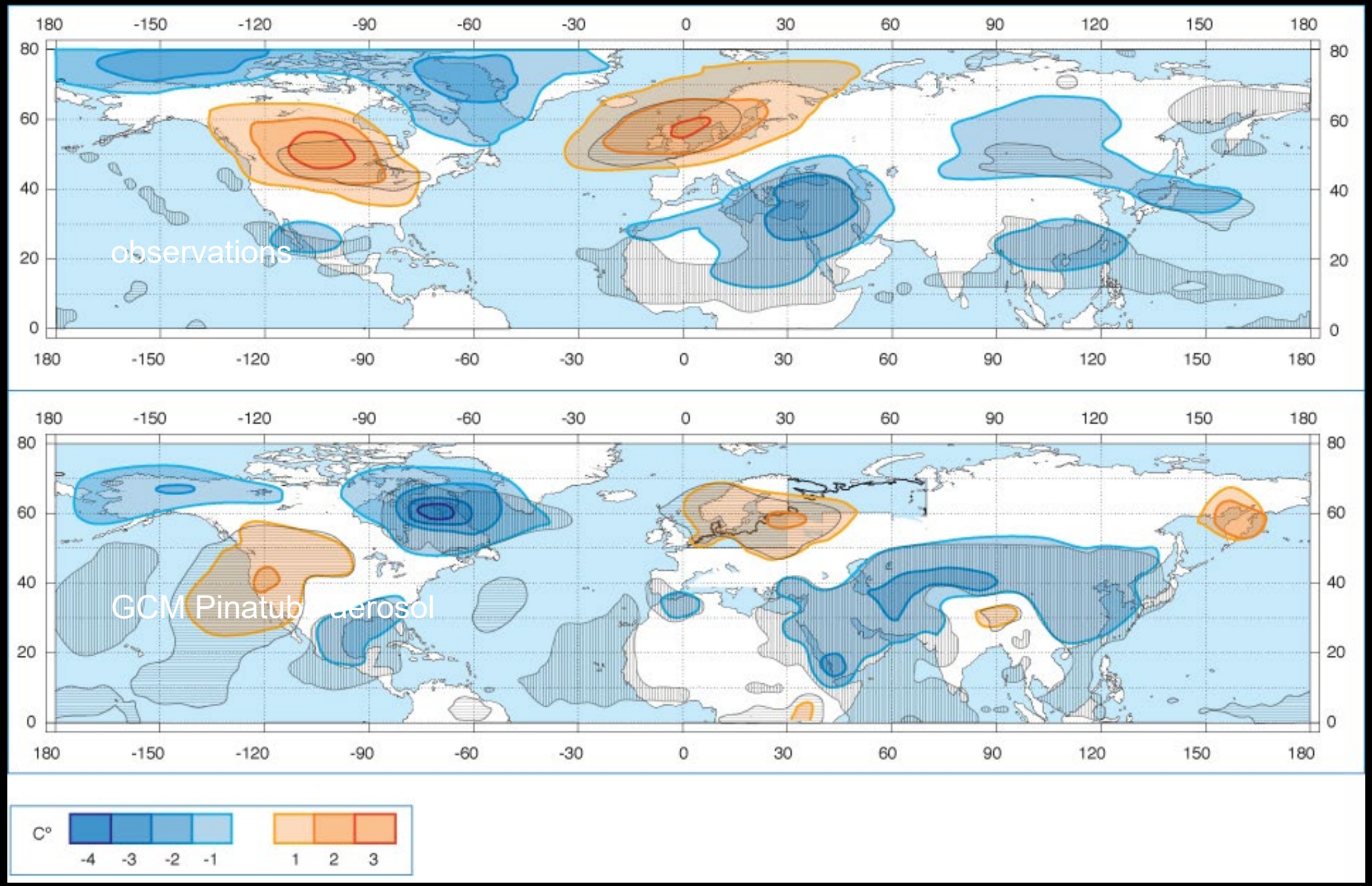
'Coldest summer in 1753-1960.' (Geneva, Switzerland)

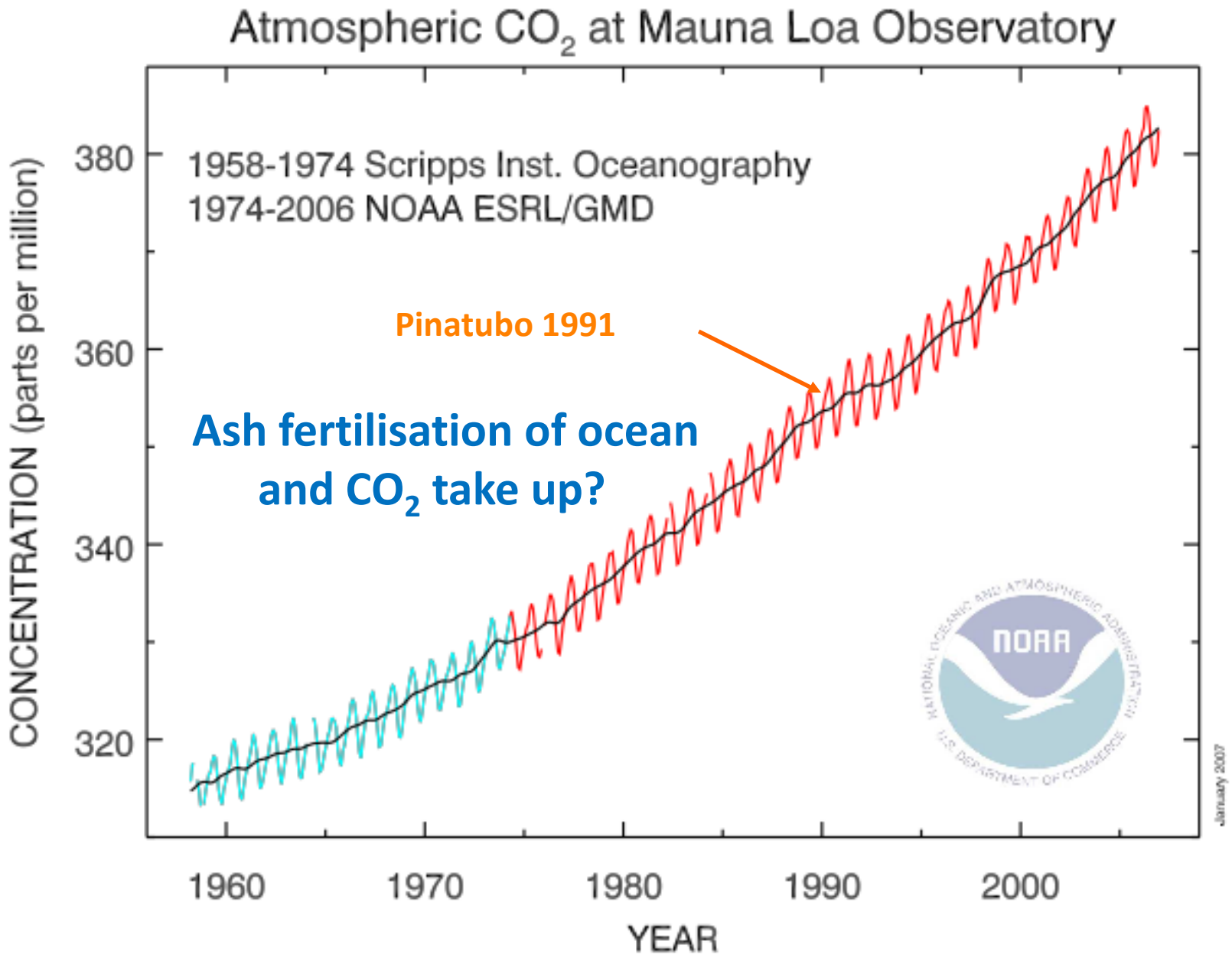
' 'In July ice froze as 'thick as window glass". (Maine, USA)

'..for the harvest entirely failed from the badness of the weather.' (Ireland)

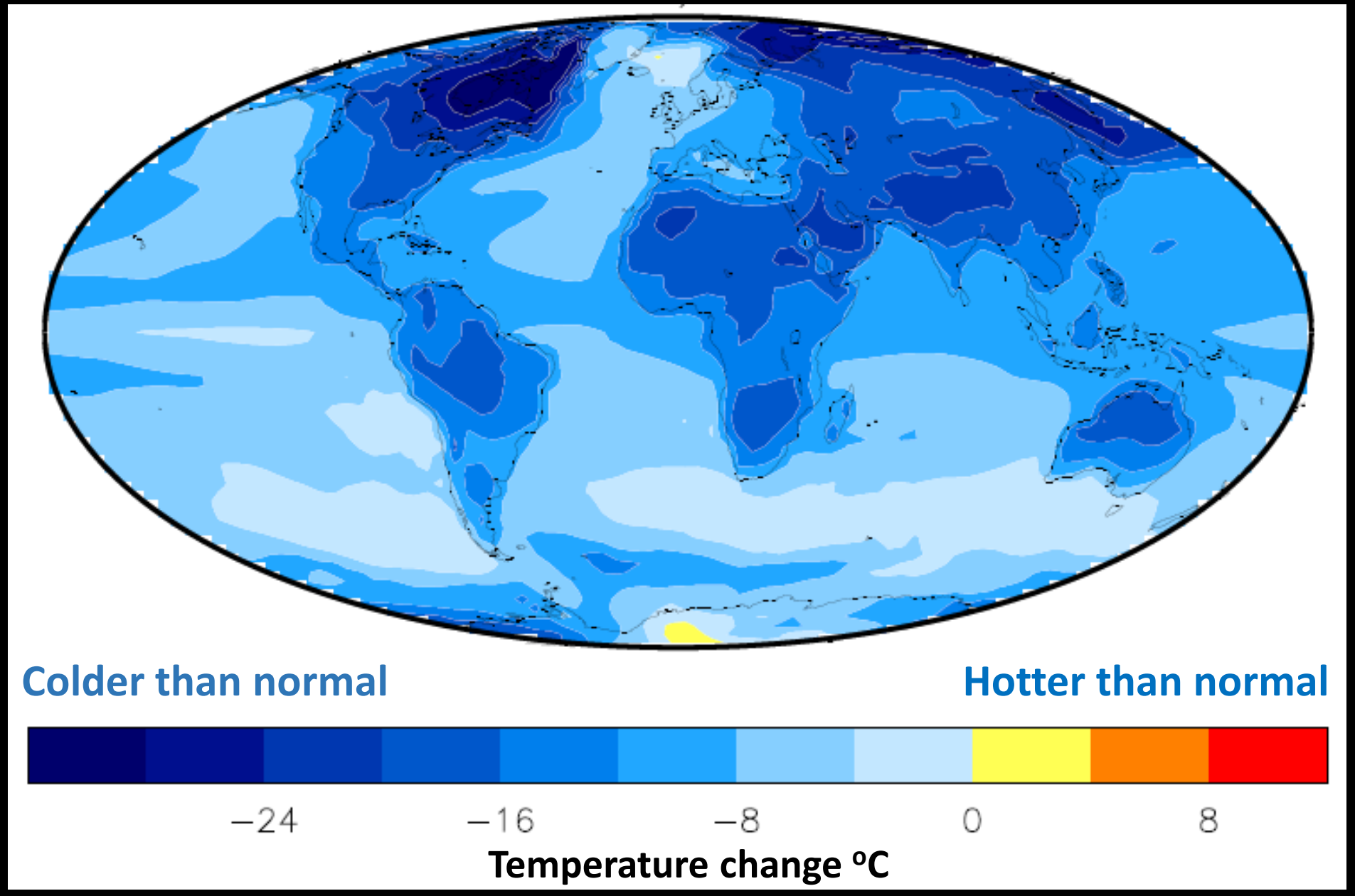




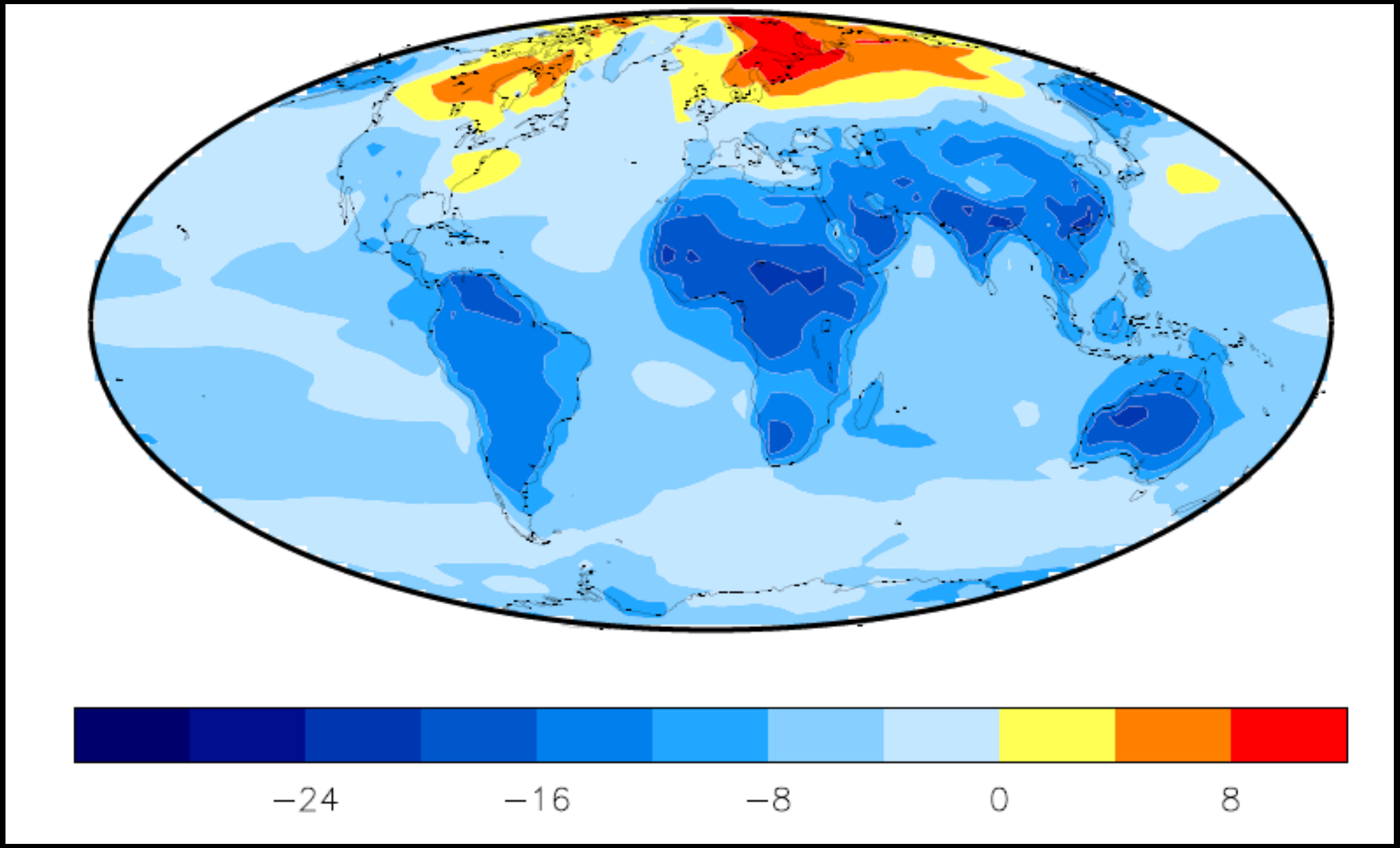

observations
GCM Pinatubo aerosol
C°
-4 -3 -2 -1
1 2 3


Atmospheric CO_2 at Mauna Loa Observatory
1958-1974 Scripps Inst. Oceanography
1974-2006 NOAA ESRL/GMD
Pinatubo 1991
Ash fertilisation of ocean and CO_2 take up?
CONCENTRATION (parts per million)
380
360
340
320
1960
1970
1980
1990
2000
YEAR
NOAA
January 2007

Predicted temperature changes during the Northern Hemisphere summer



Predicted temperature changes during the Northern Hemisphere winter



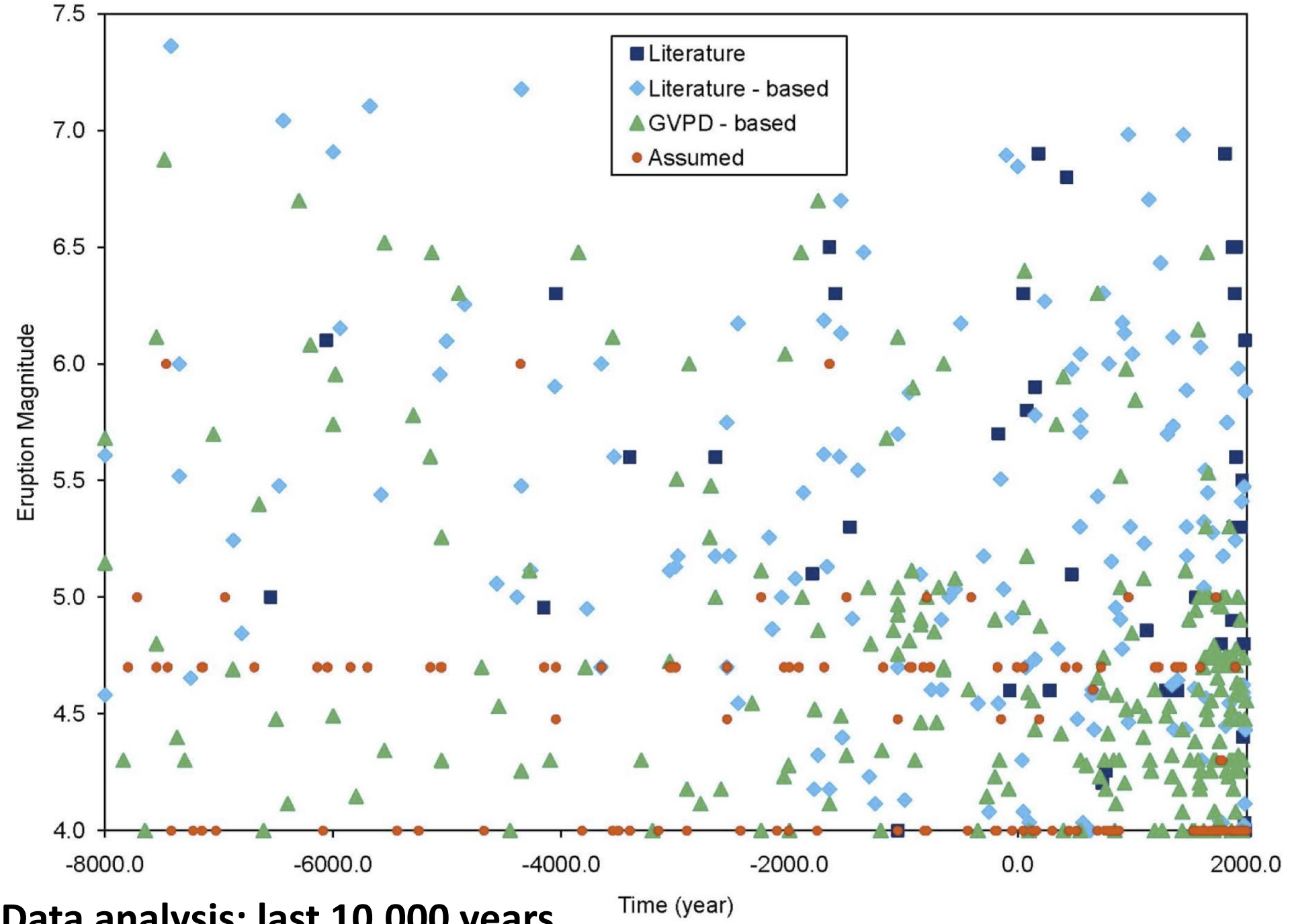
Large Magnitude Explosive Volcanic Eruption database (LaMEVE)

Global database on Quaternary Large Magnitude Explosive Eruptions of M = 4 or greater (LaMEVE)

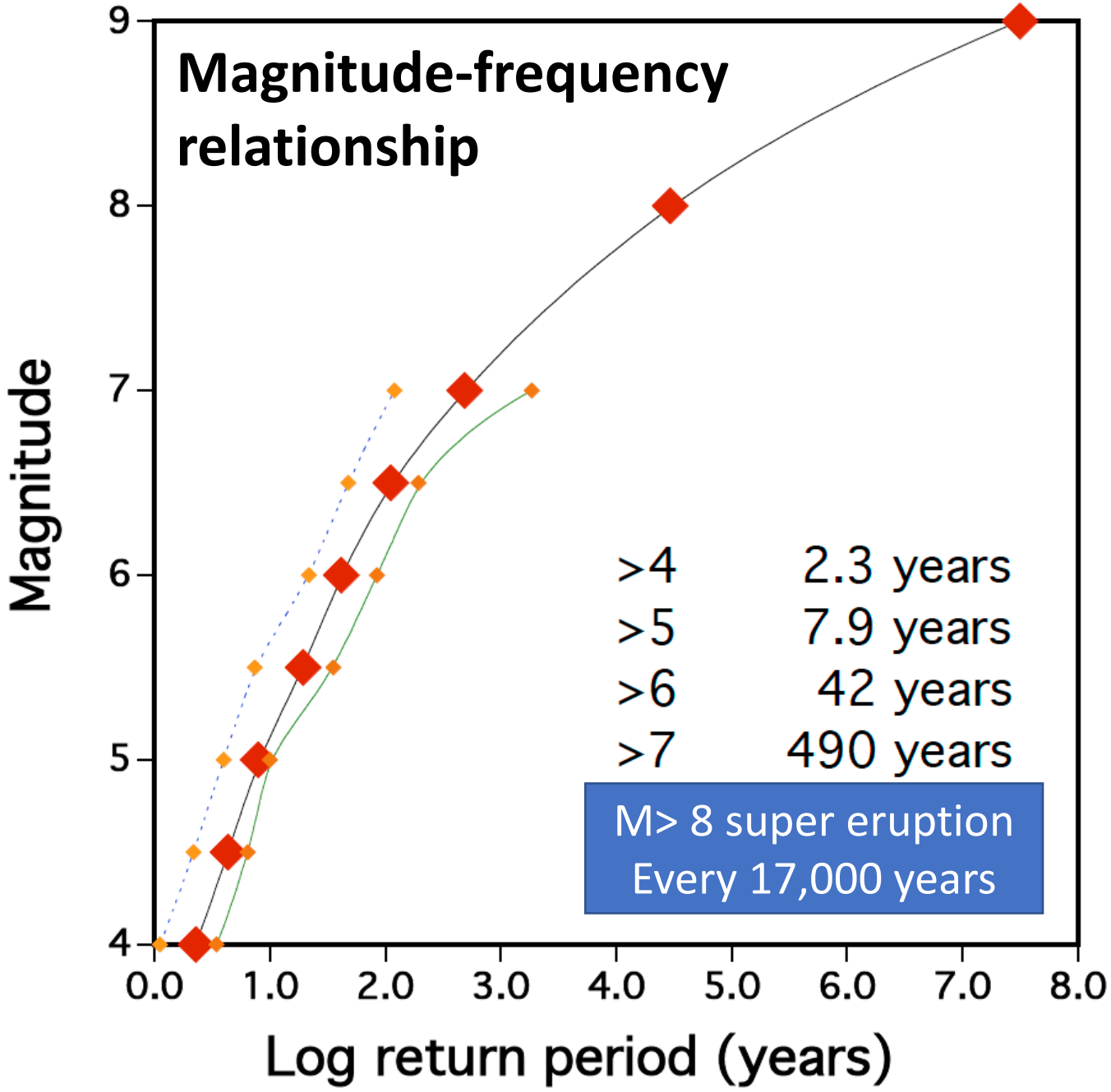
1929 entries from 481 Quaternary volcanoes

Analysis of recurrence rates of different magnitude eruptions and completeness of eruptive records

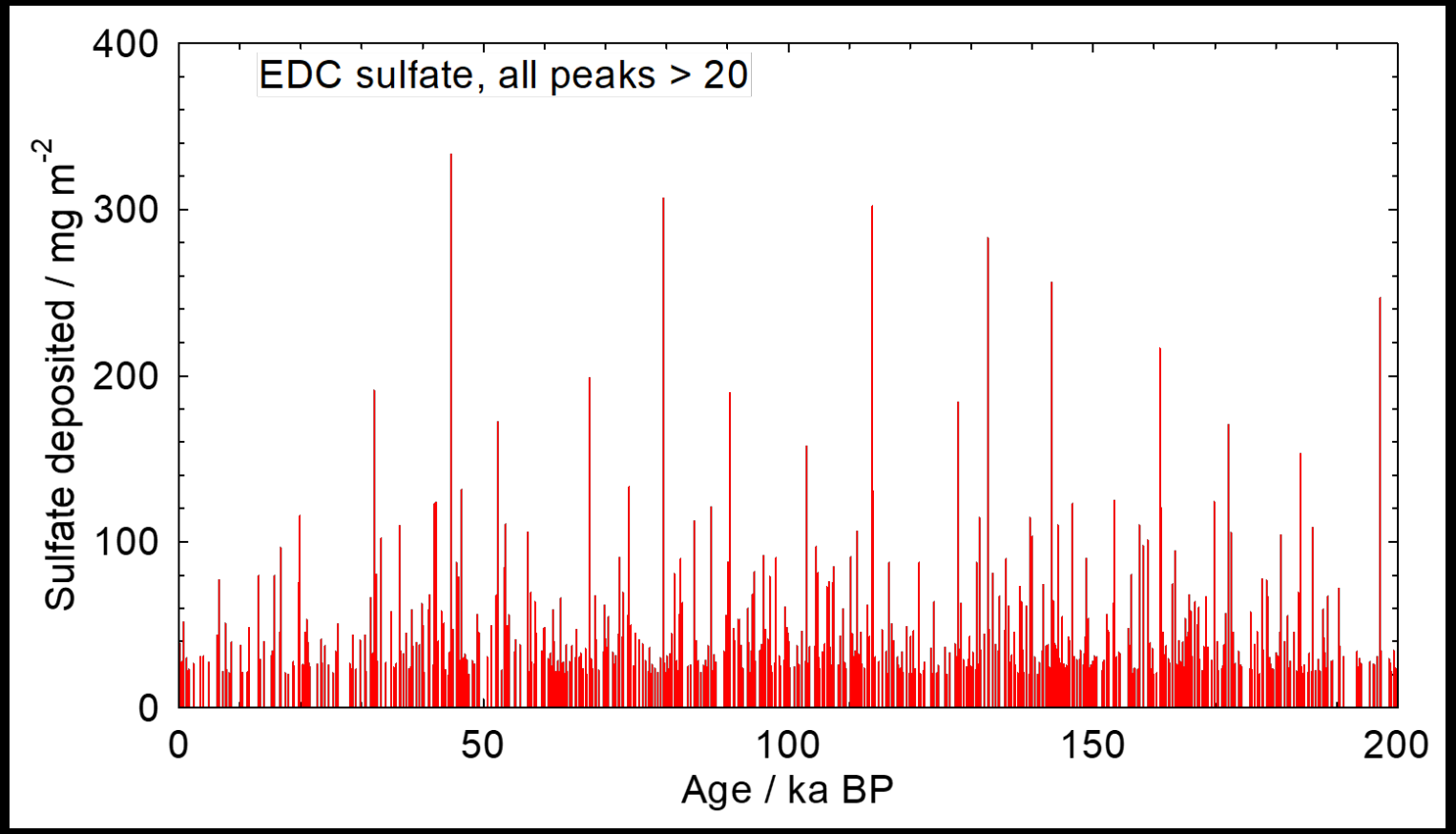
Source, uncertainty, reliability, multiple records, ranking



Data analysis: last 10,000 years

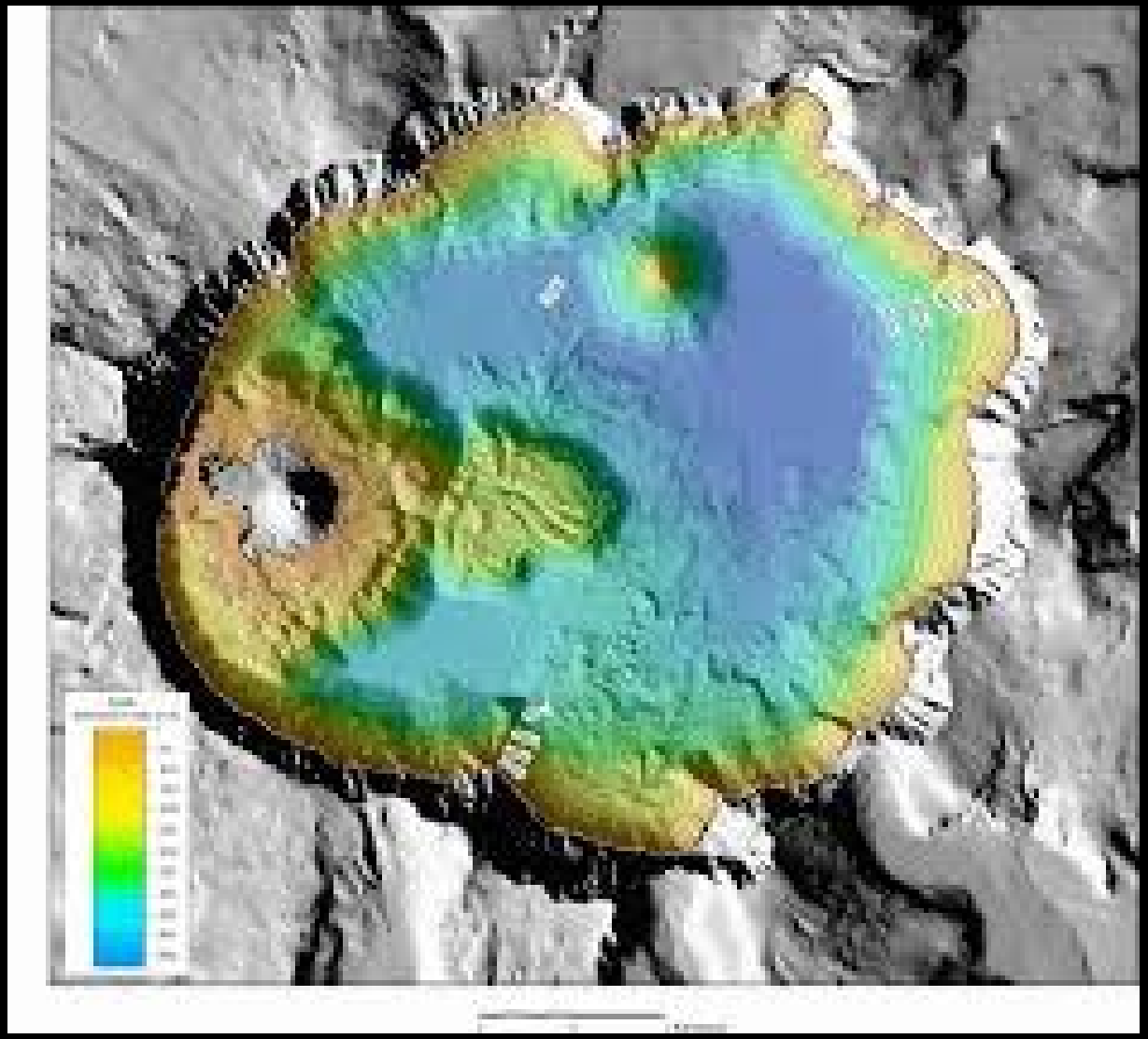

Magnitude-frequency relationship
Magnitude
9
8
7
6
5
4
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
Log return period (years)
>4 2.3 years
>5 7.9 years
>6 42 years
>7 490 years
M> 8 super eruption
Every 17,000 years

Ice core Records of volcanism



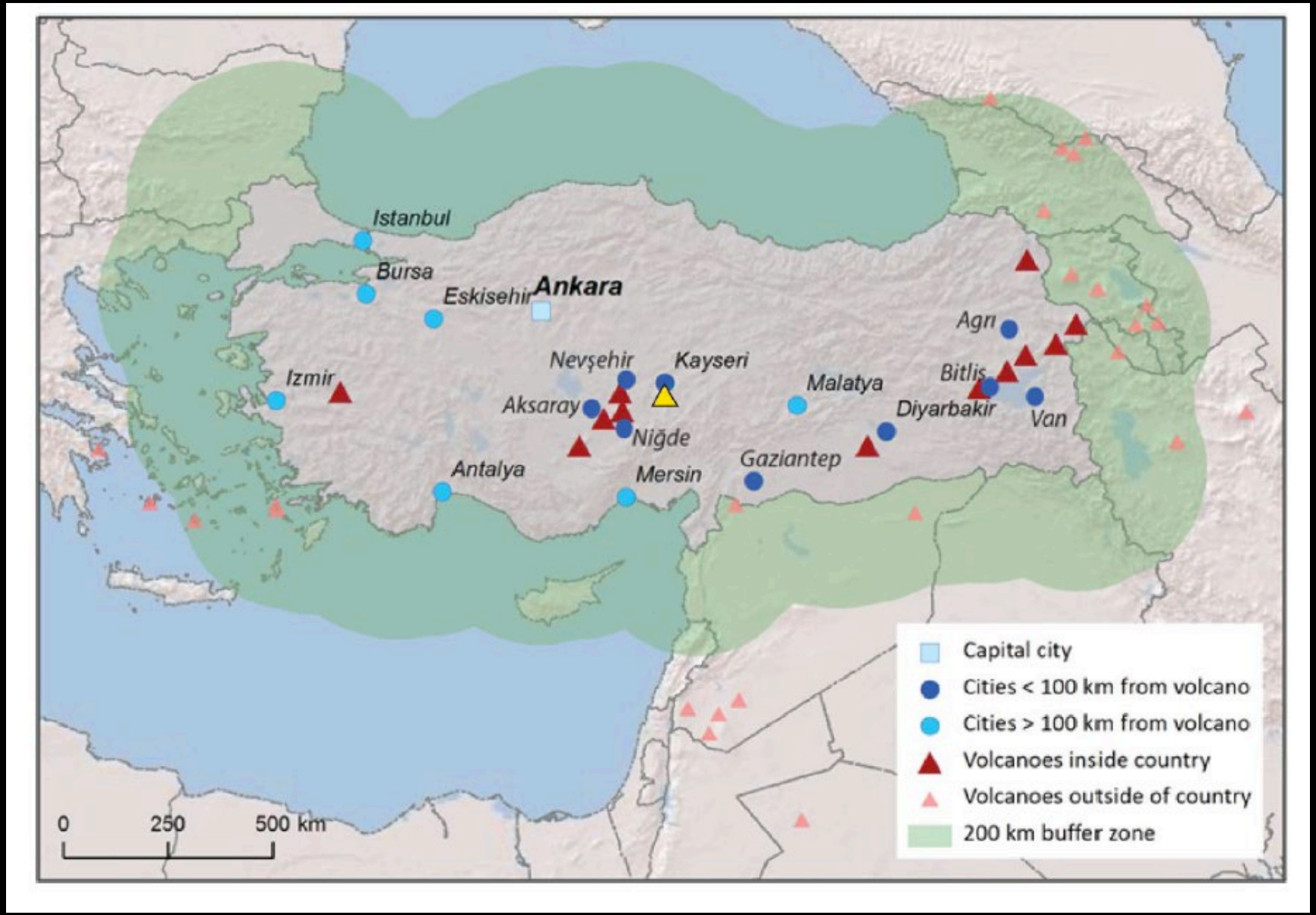
What do caldera volcanoes look like before caldera-forming eruptions?

Mount Mazama Magnitude 7.3 eruption
6,700 years BP

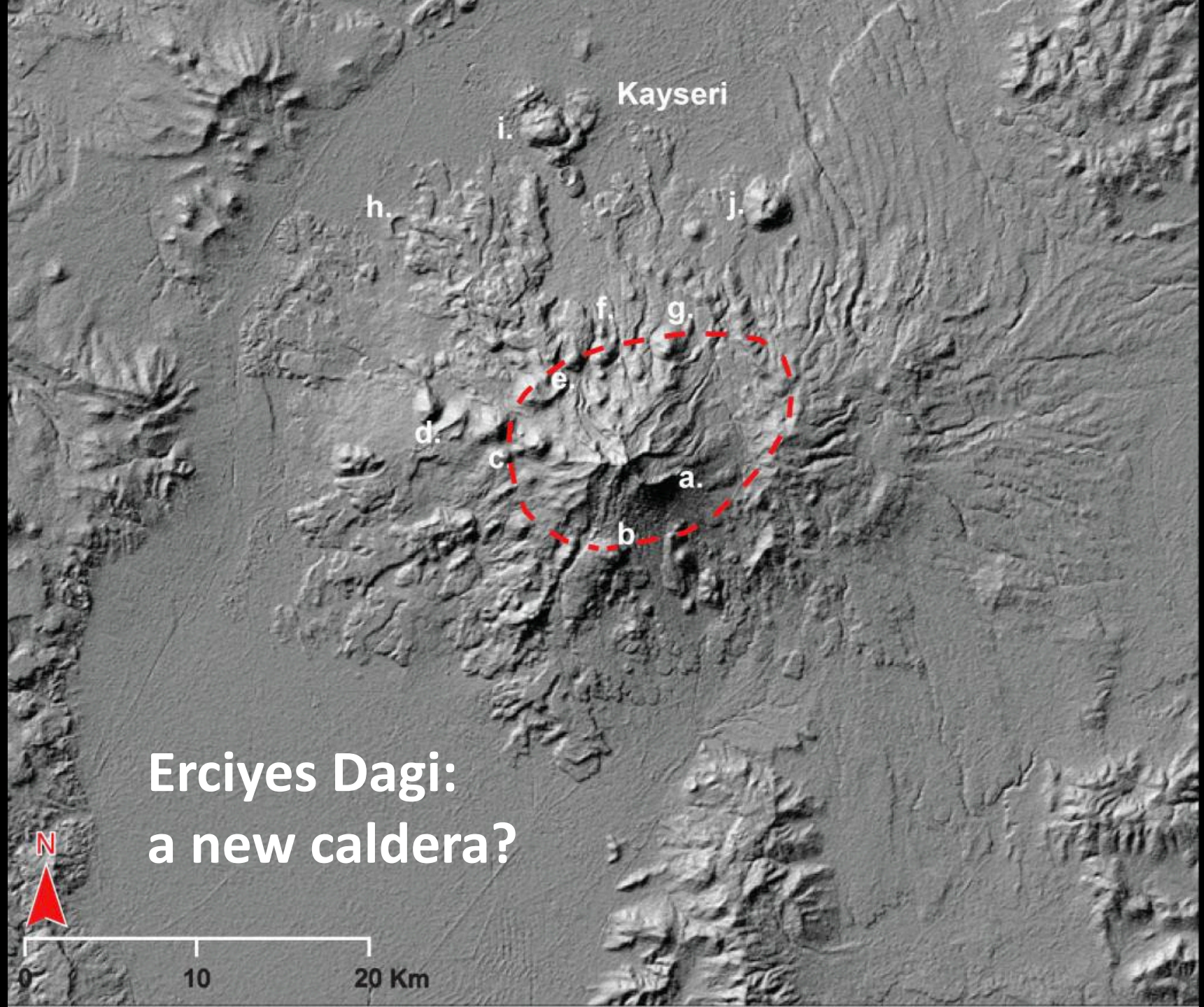


Crater Lake, Oregon (now)

Active Volcanoes of Turkey




Erciyes Dagi

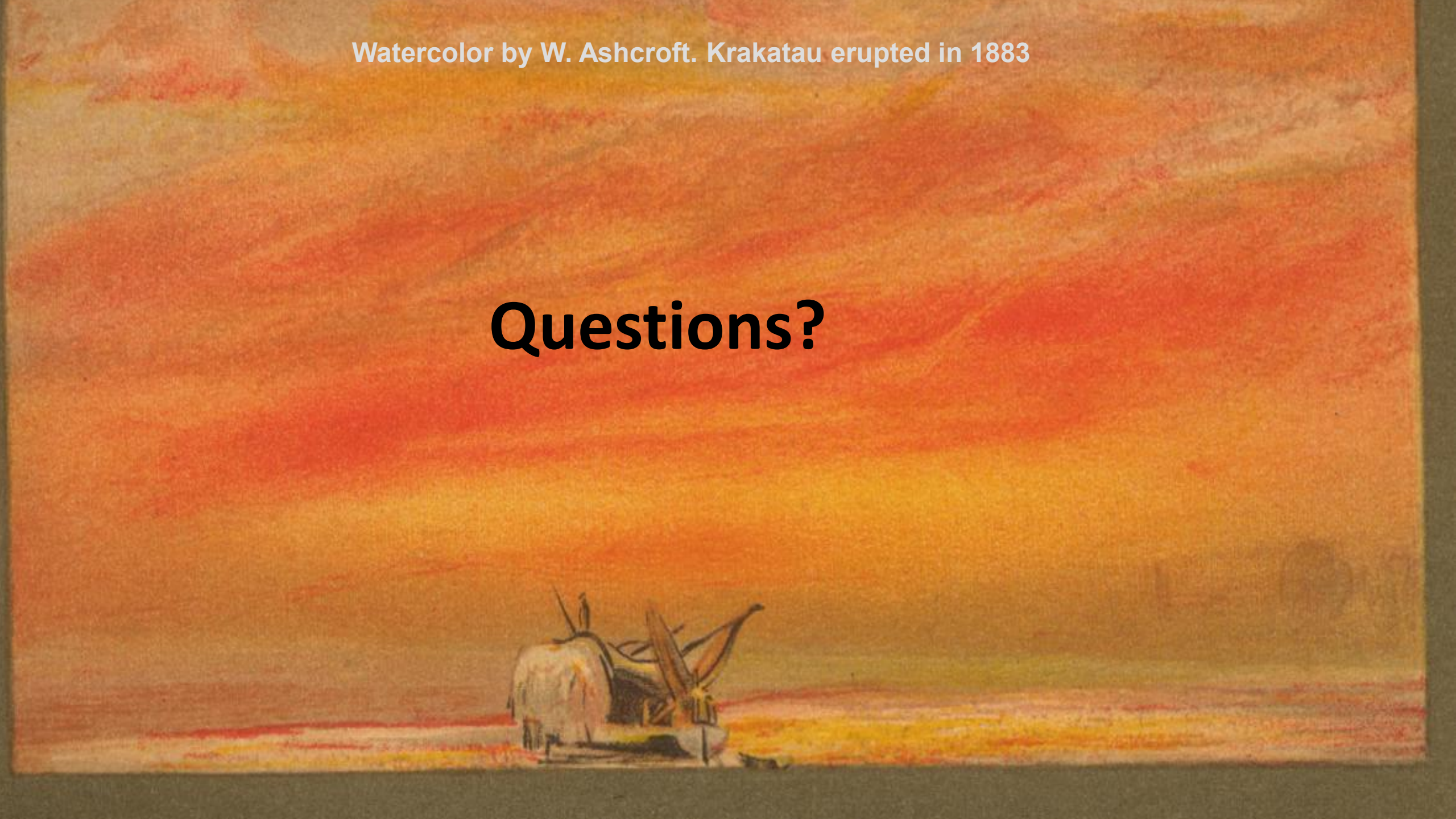

Kayseri
i.
h.
j.
f.
g.
e.
d.
c.
a.
b.
Erciyes Dagi:
a new caldera?
N
0
10
20 Km


Deverli town (100,000 people)
built on pyroclastic flow fan

Kayseri (1.2 million people)
growth 5% per year

Huge industrial estate

New build on young pyroclastic flows


Watercolor by W. Ashcroft. Krakatau erupted in 1883
Questions?