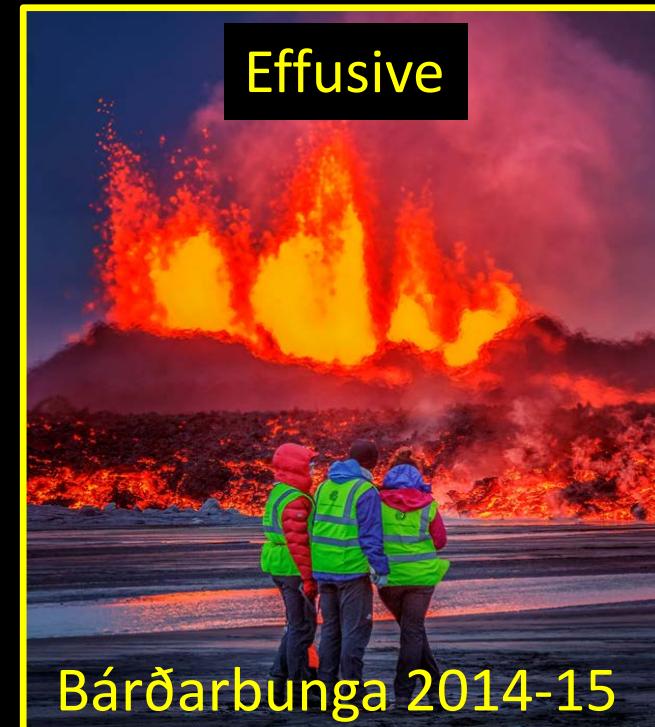


How Explosive Volcanic Eruptions Cause Global Cooling

While

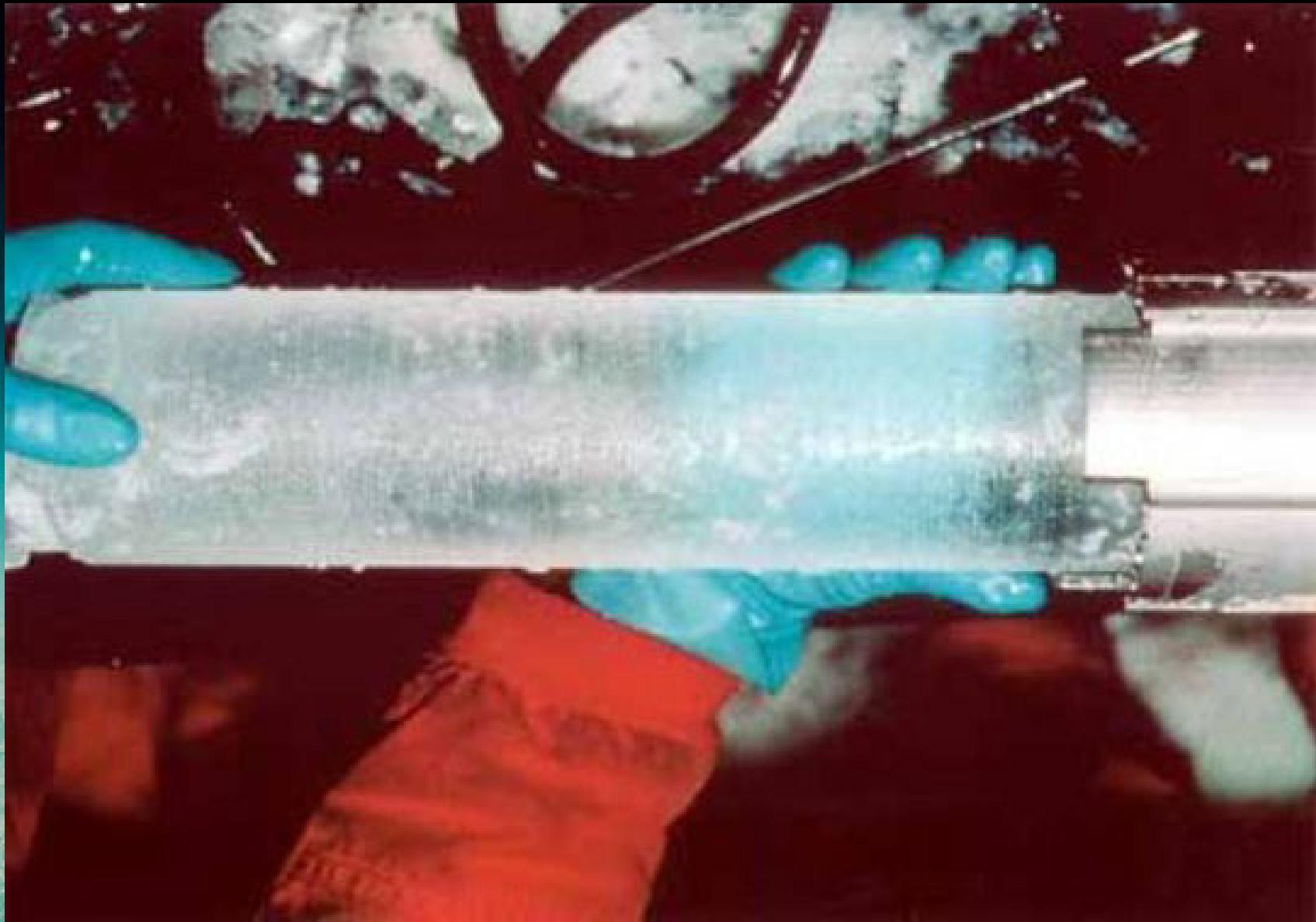
Effusive Basaltic Eruptions Cause Global Warming

Peter L. Ward, U.S. Geological Survey, retired
peward@wyoming.com

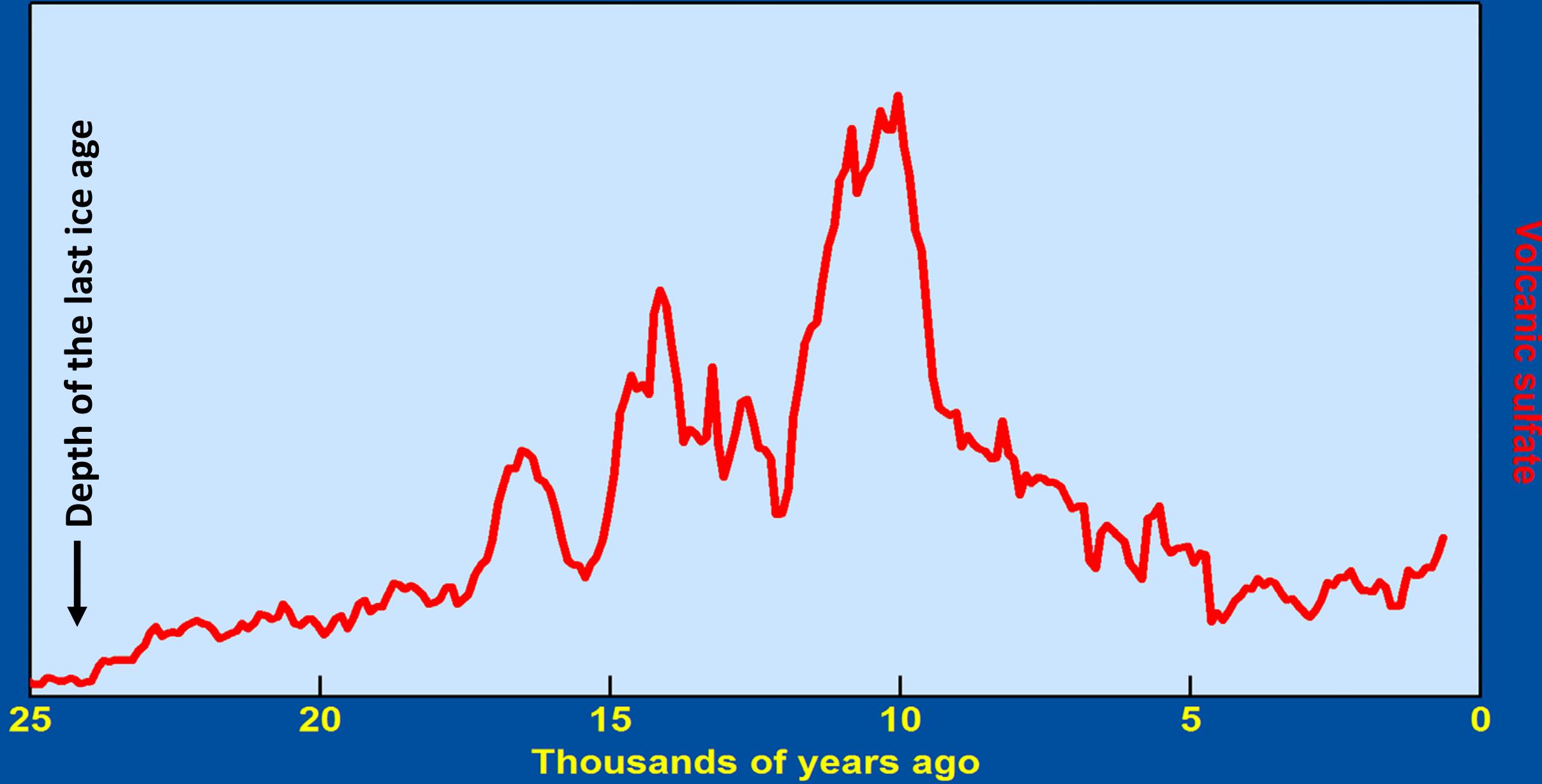


Greenland Ice Sheet Program Drill Hole 2 (GISP2)

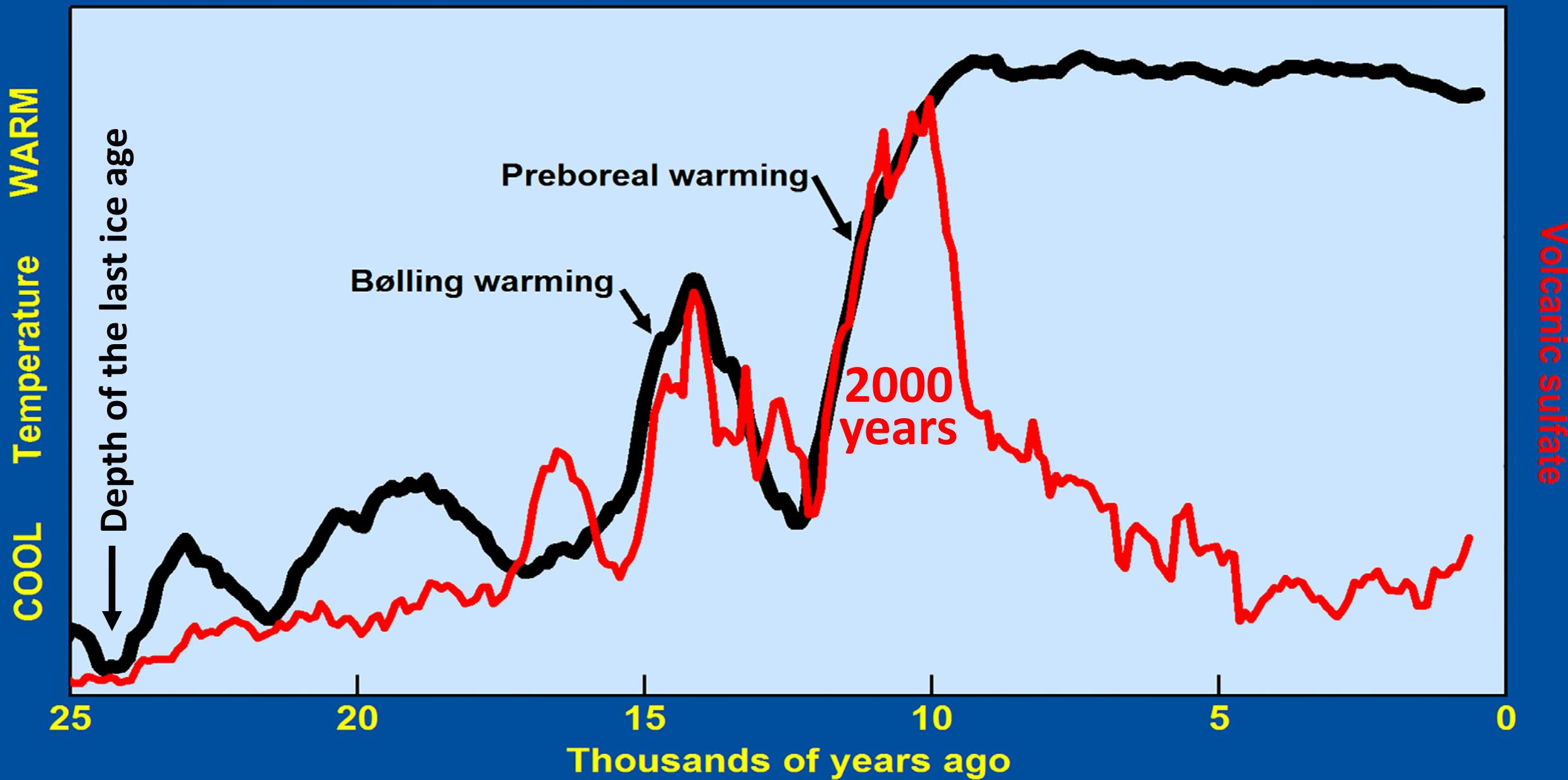
Summit Greenland



Volcanic Sulfate per Century (GISP2)



Temperature and Volcanic Sulfate per Century (GISP2)

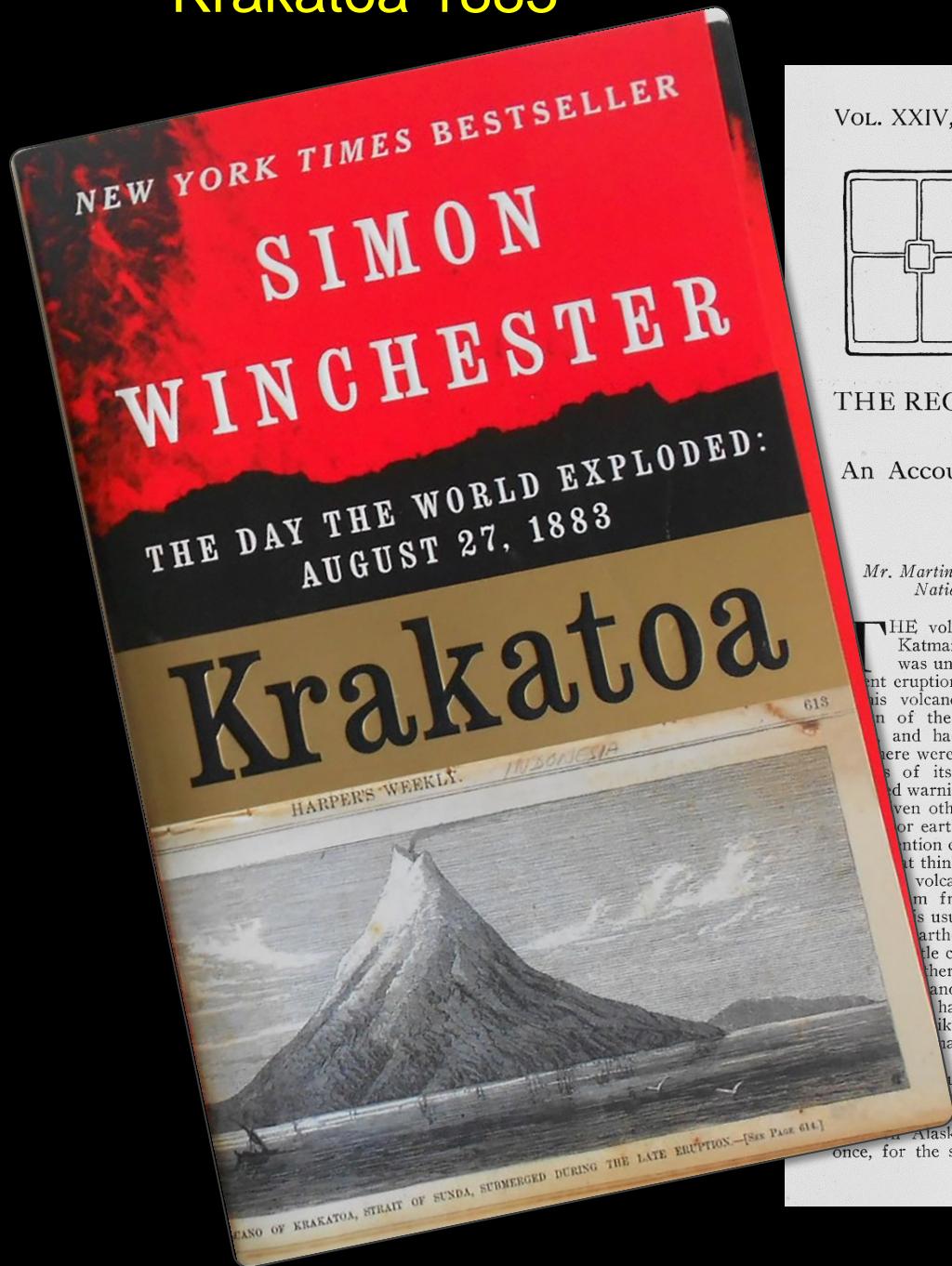


Mt. Pinatubo

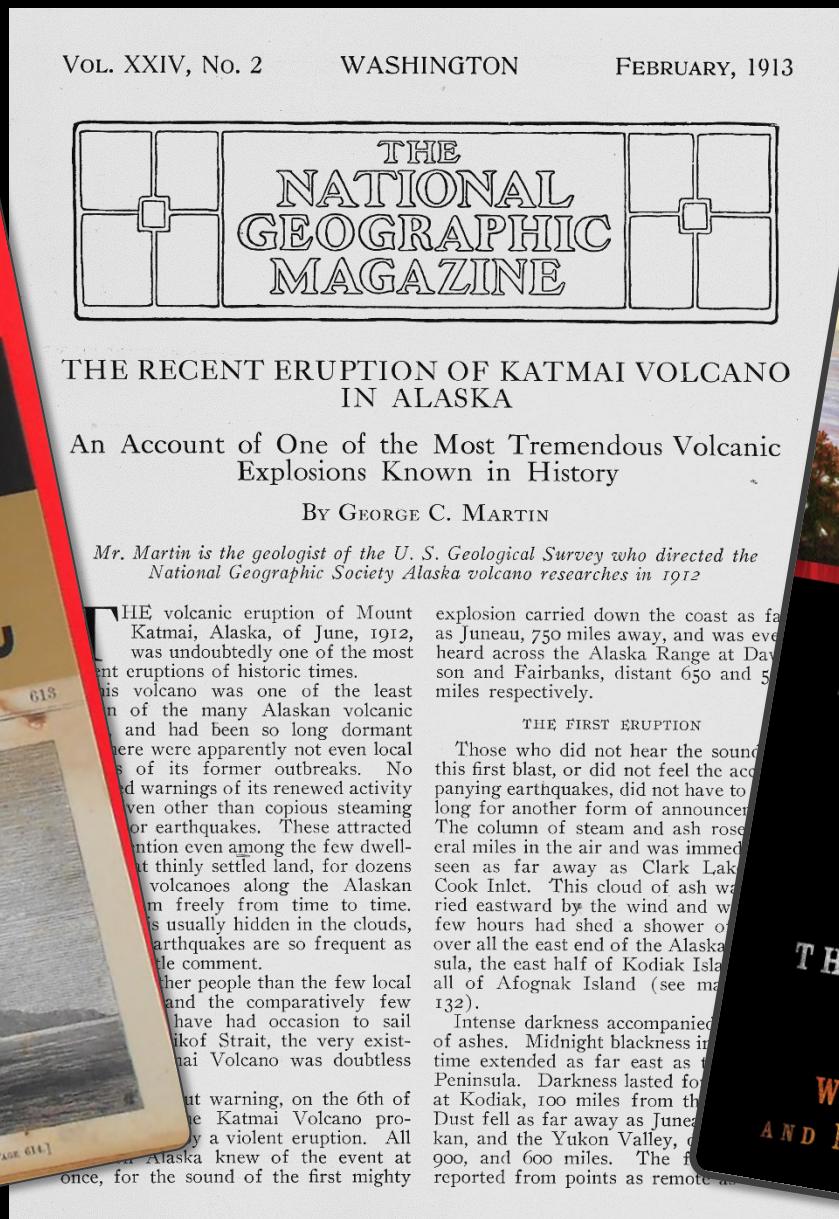


June 1991

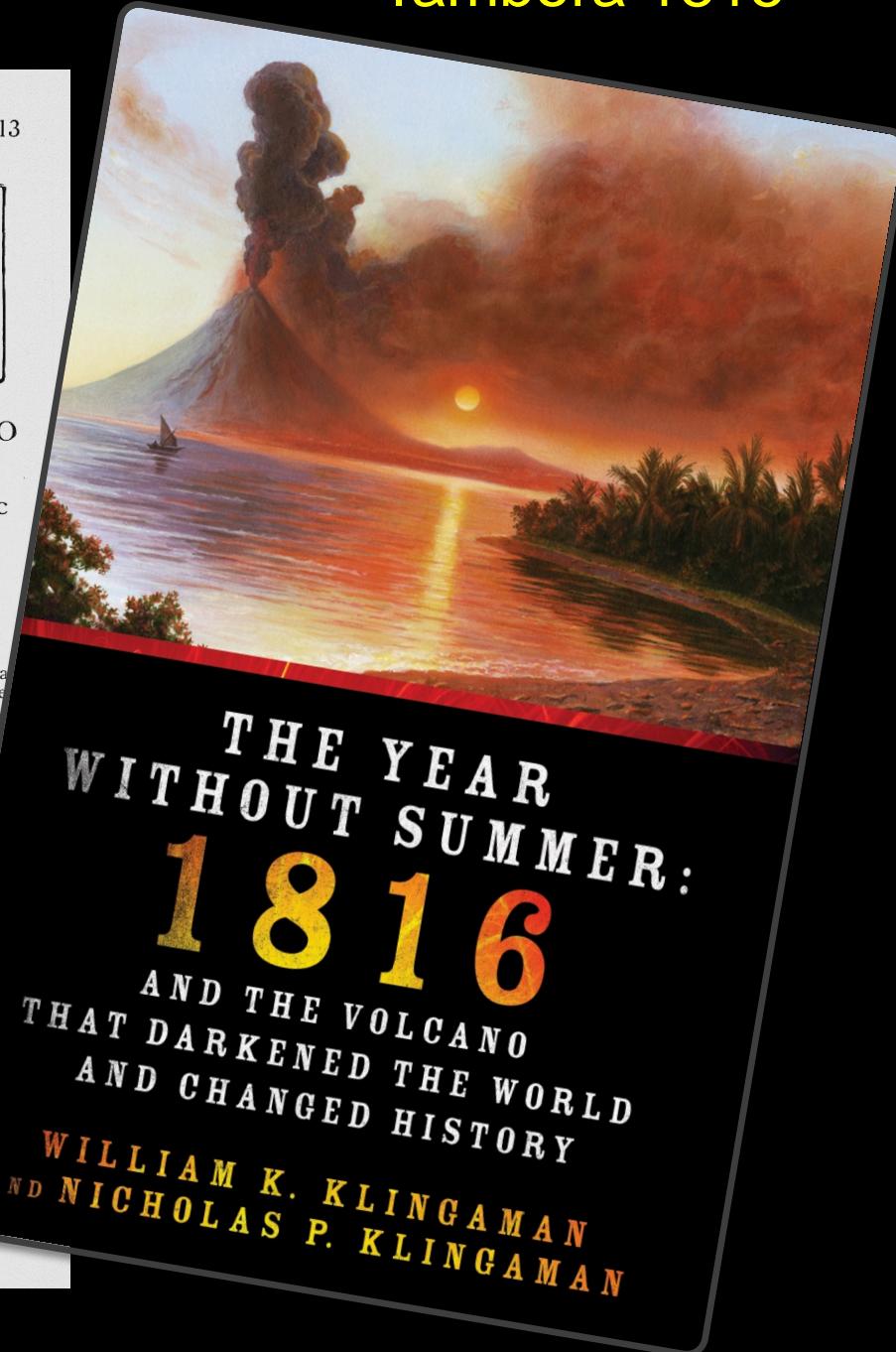
Krakatoa 1883

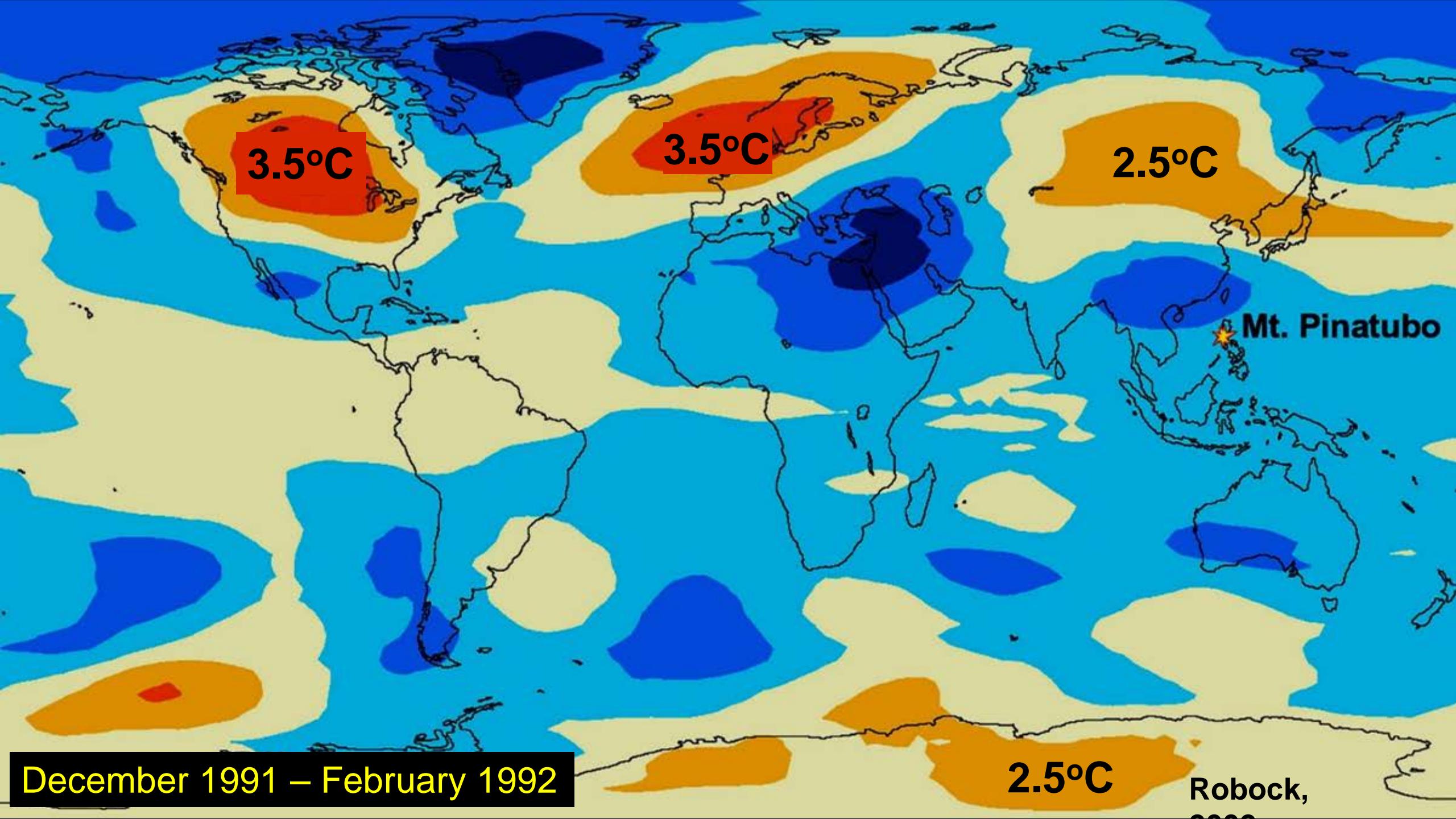


Katmai 1912

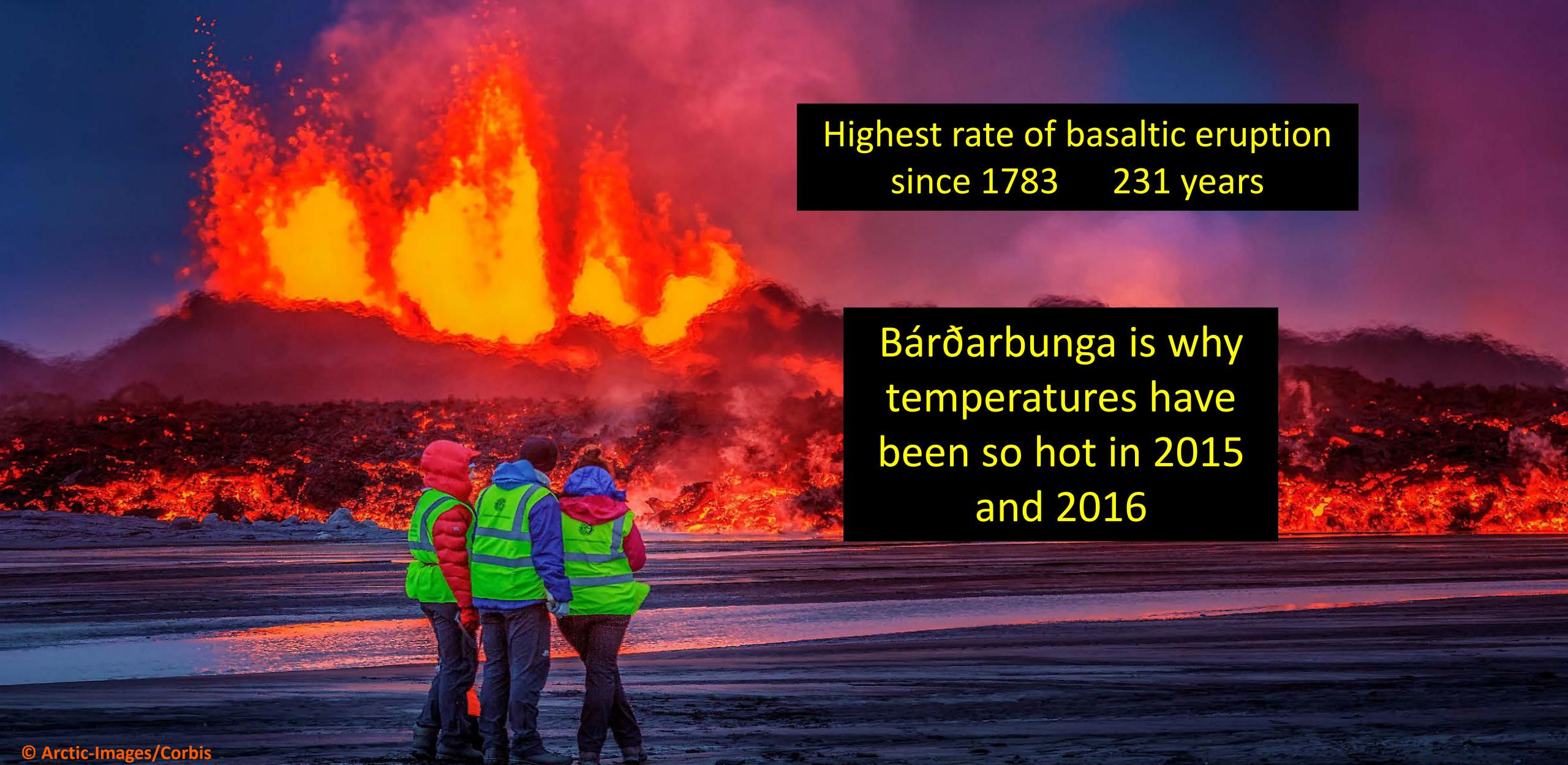


Tambora 1815





Bárðarbunga volcano, Iceland, August 2014 – February 2015



Highest rate of basaltic eruption
since 1783 231 years

Bárðarbunga is why
temperatures have
been so hot in 2015
and 2016

Pinatubo, 1991



Explosive eruption

Lasts for hours

Forms aerosols in the lower stratosphere

Causes net global cooling

Bárðarbunga, 2014-2015



Effusive eruption

Lasts for months

Does not form aerosols in the lower stratosphere

Causes net global warming



Herðubreið - a tuya or table mountain in Iceland

Temperature Proxy

Warm

Cold

120

100

80

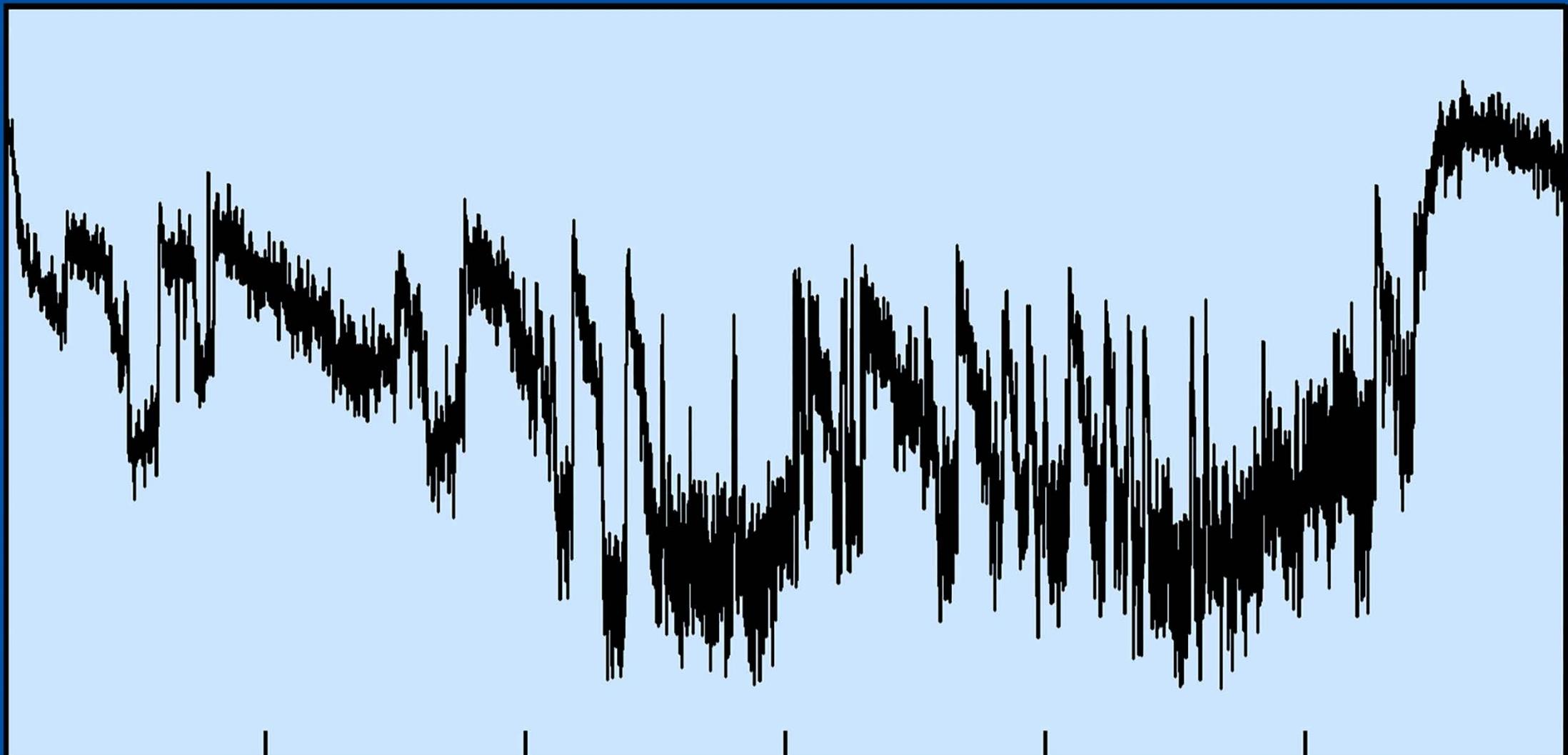
60

40

20

0

Thousands of years ago



Dansgaard-Oeschger Sudden Warmings

Warm

Preboreal warming
Bølling warming

Cold

120

100

80

60

40

20

0

Thousands of years ago

25
24
23

22
21
20
19

16
14

17
15
13
12
11

2

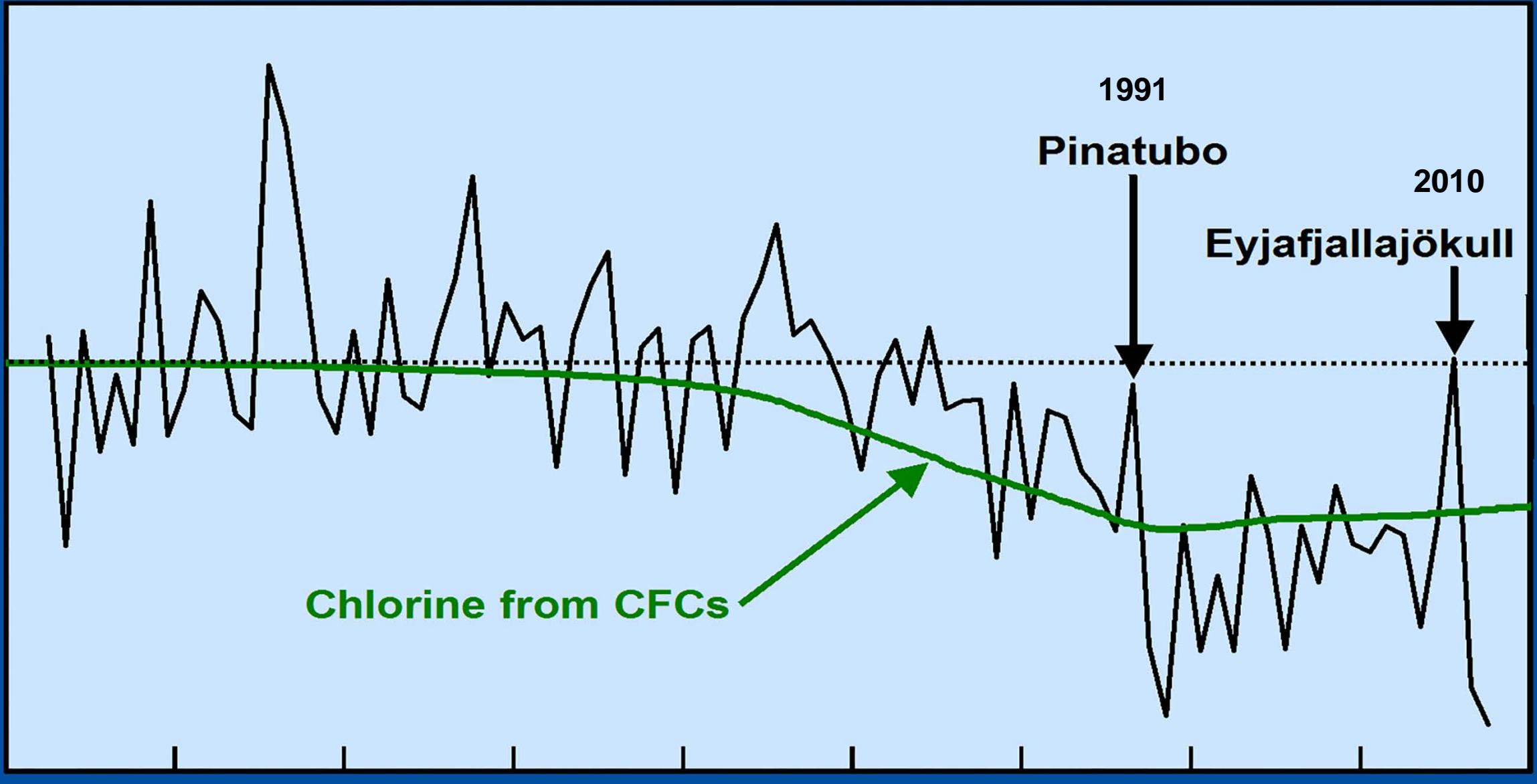
10
9
8

7
6
5
4

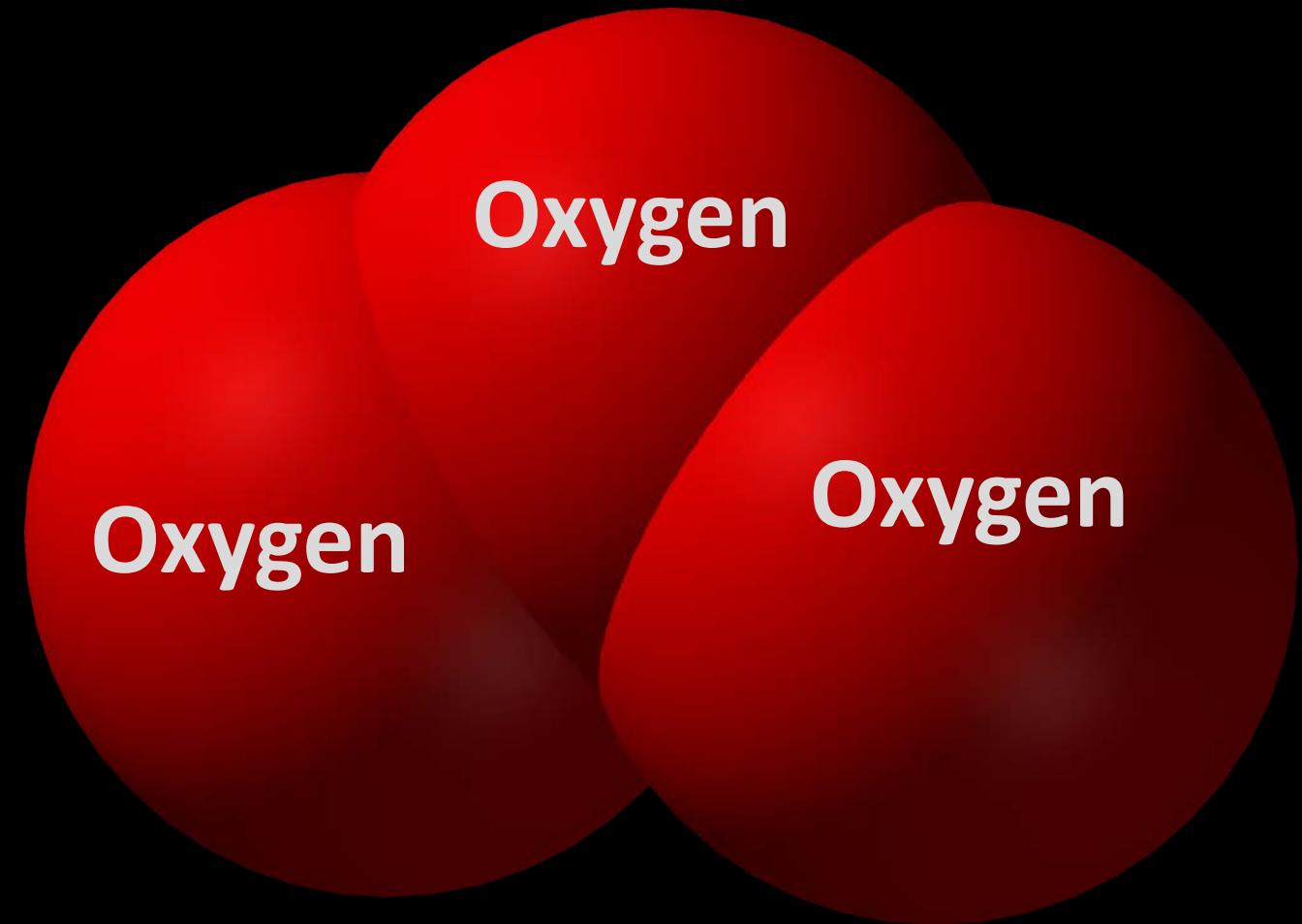
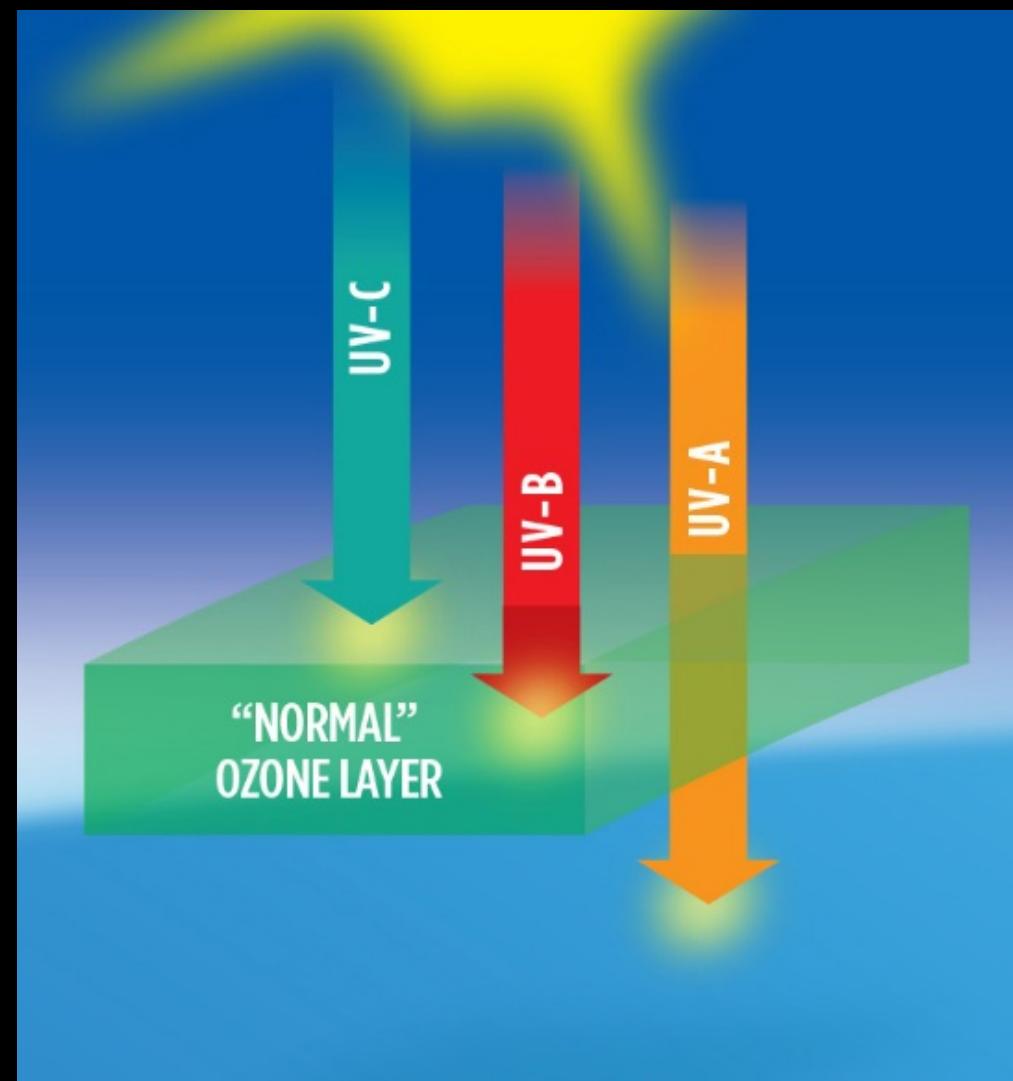
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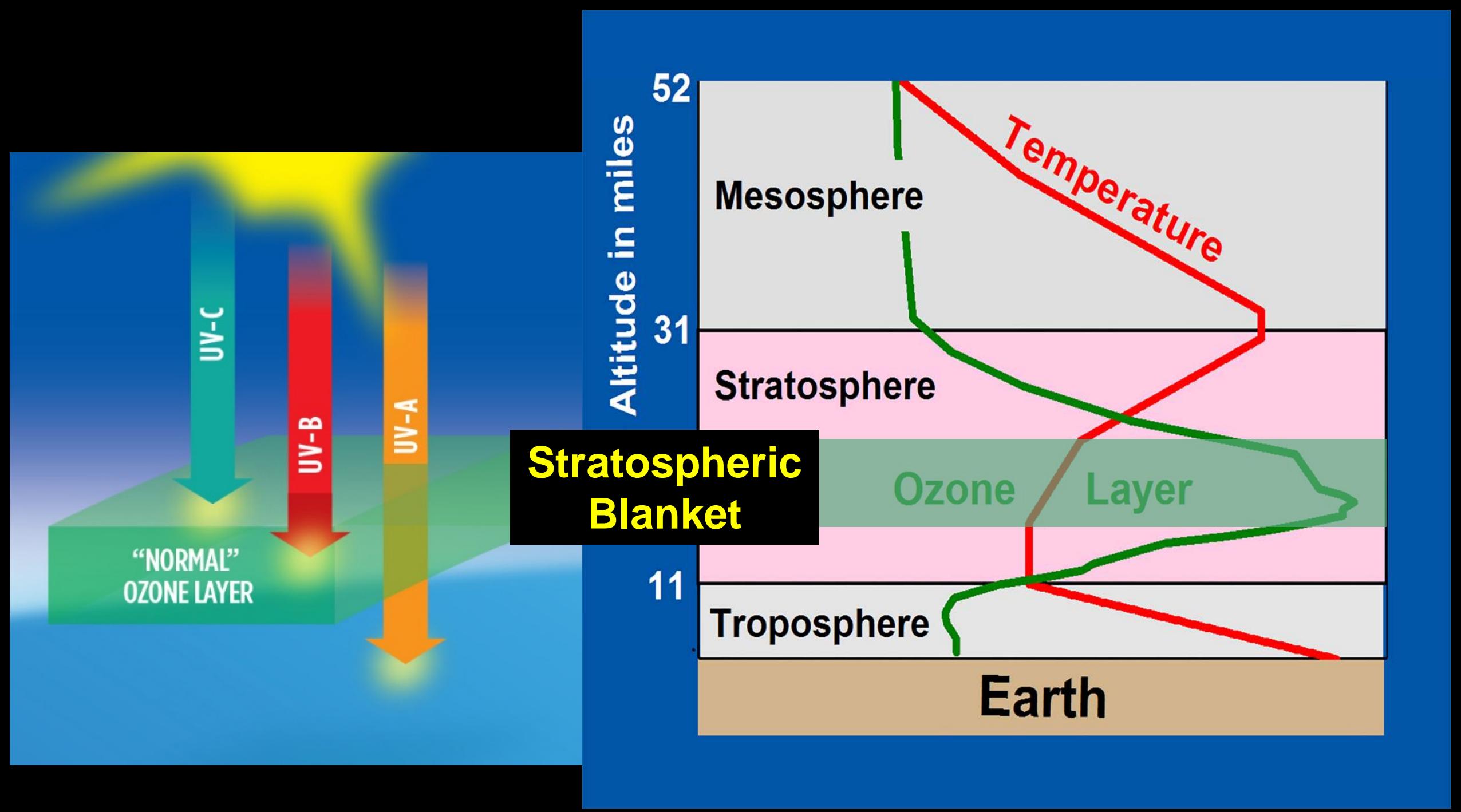
Annual Average Ozone, Arosa Switzerland

Annual average ozone at Arosa



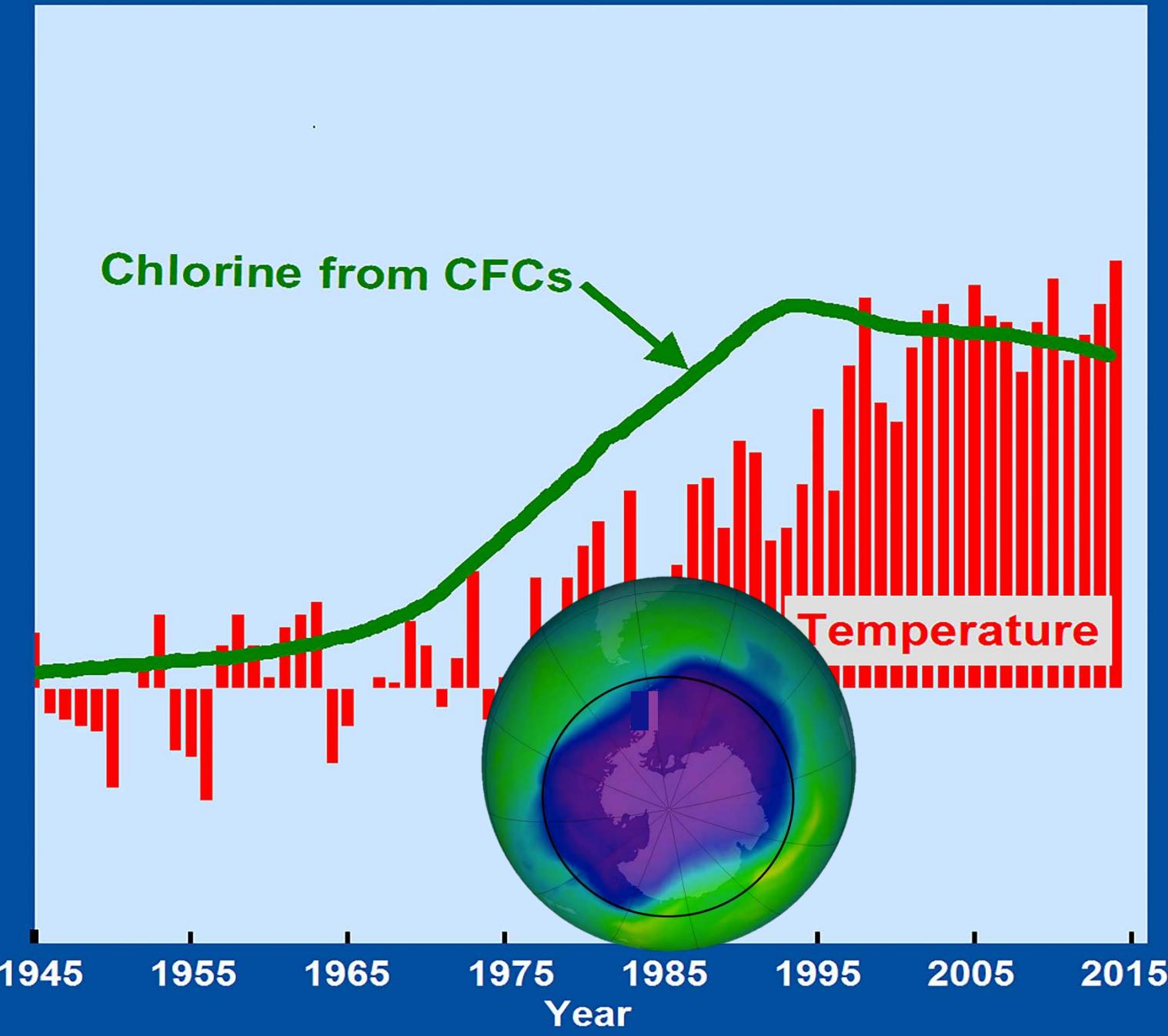
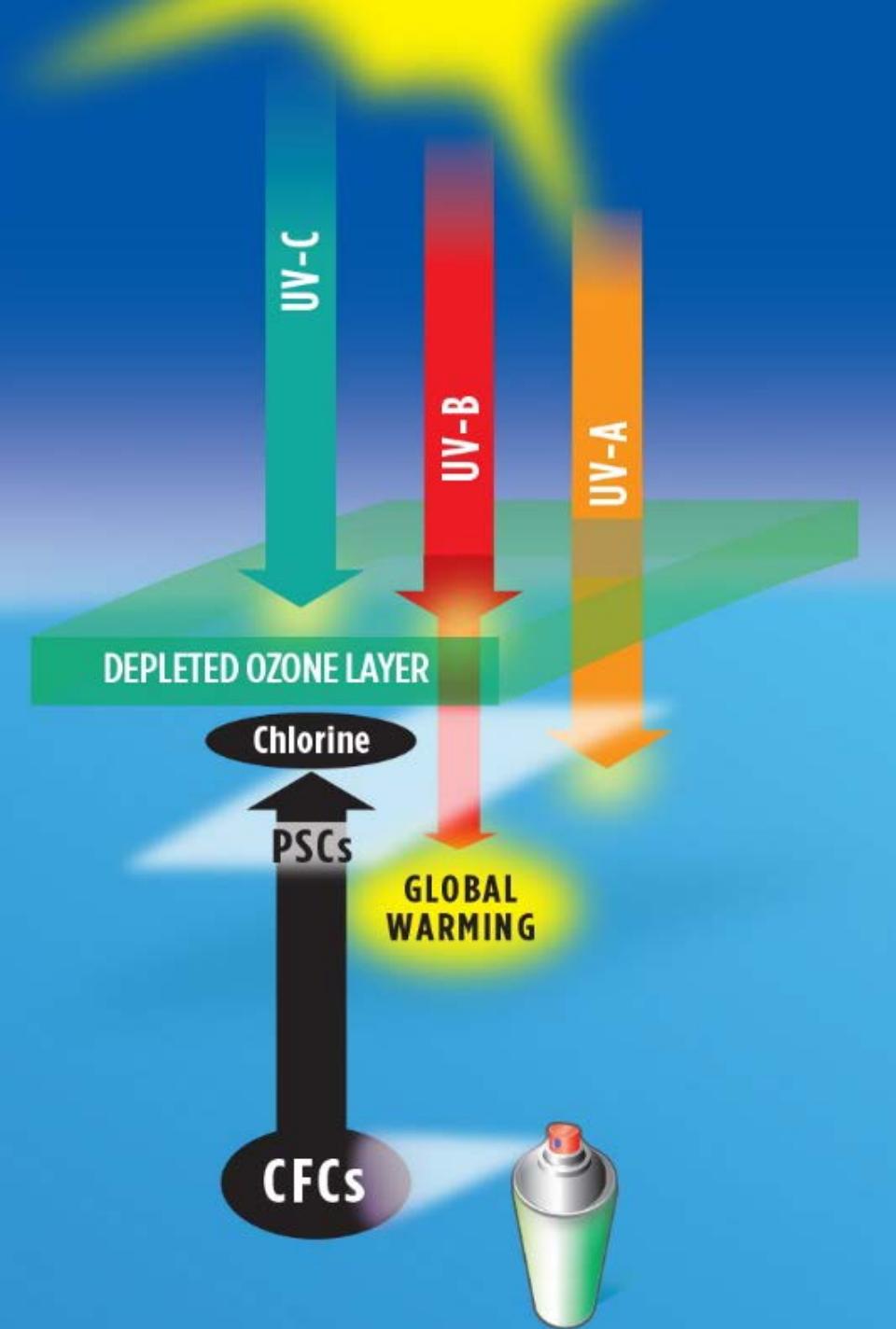
1925 1935 1945 1955 1965 1975 1985 1995 2005 2015

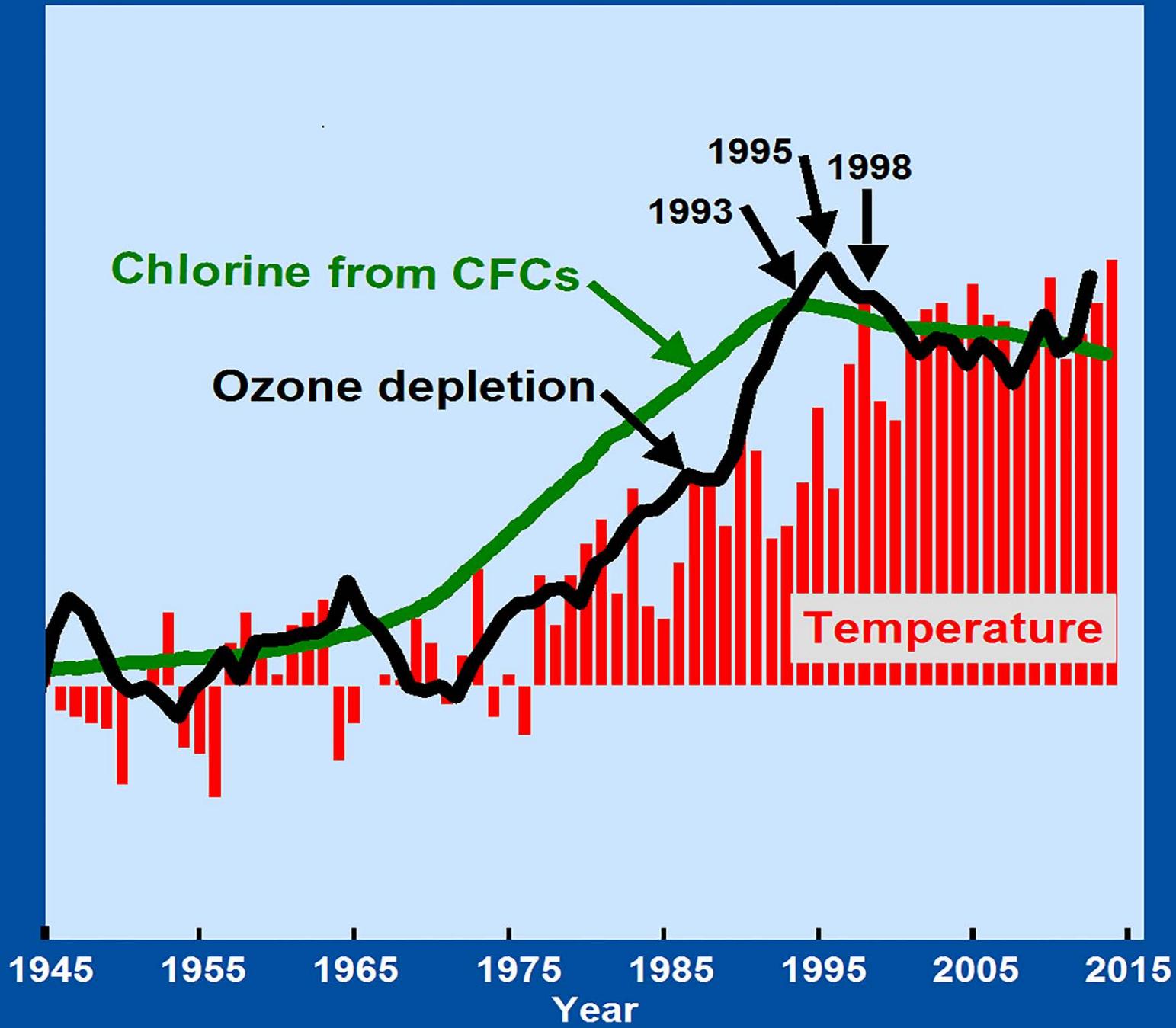
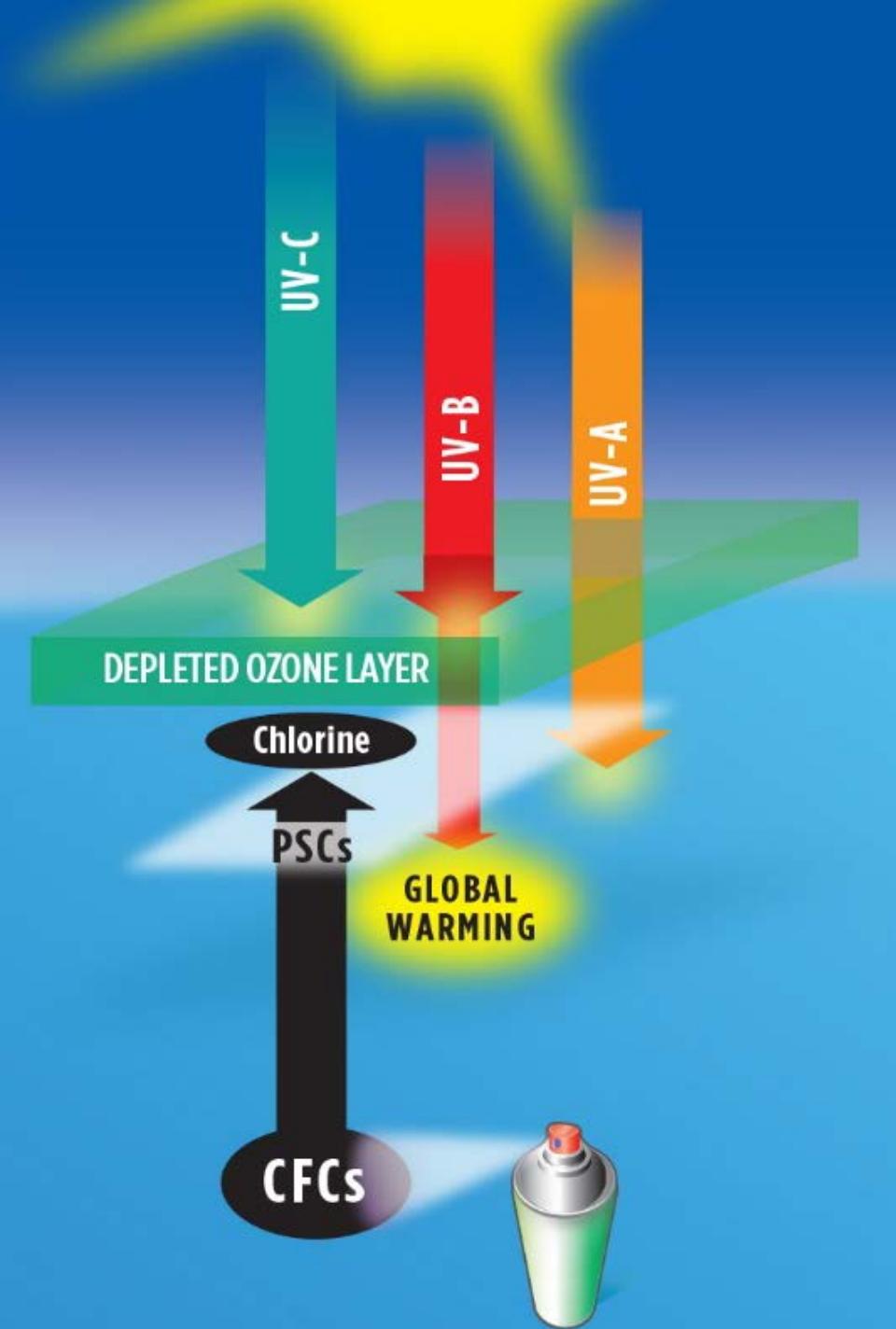


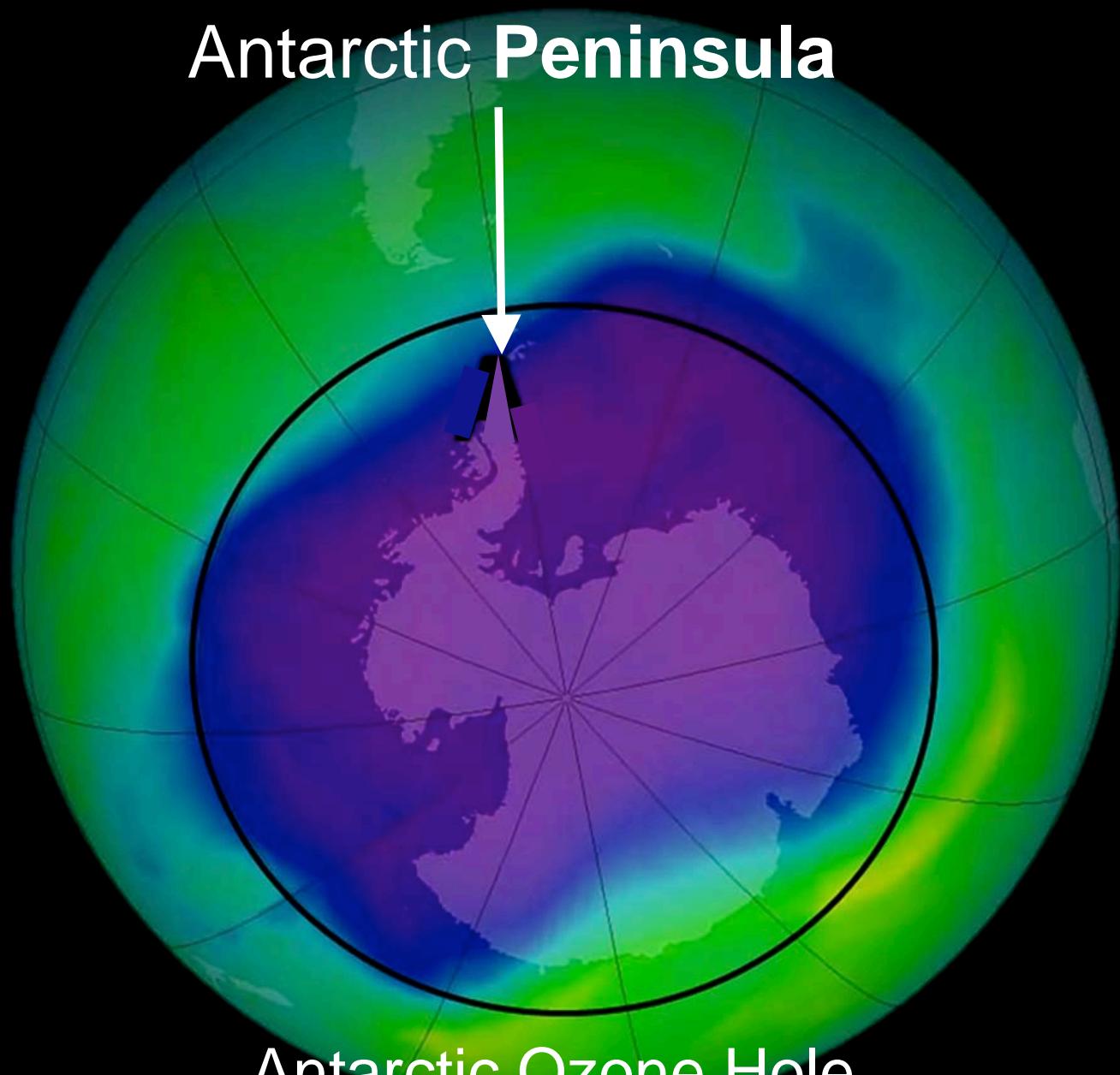


CFCs







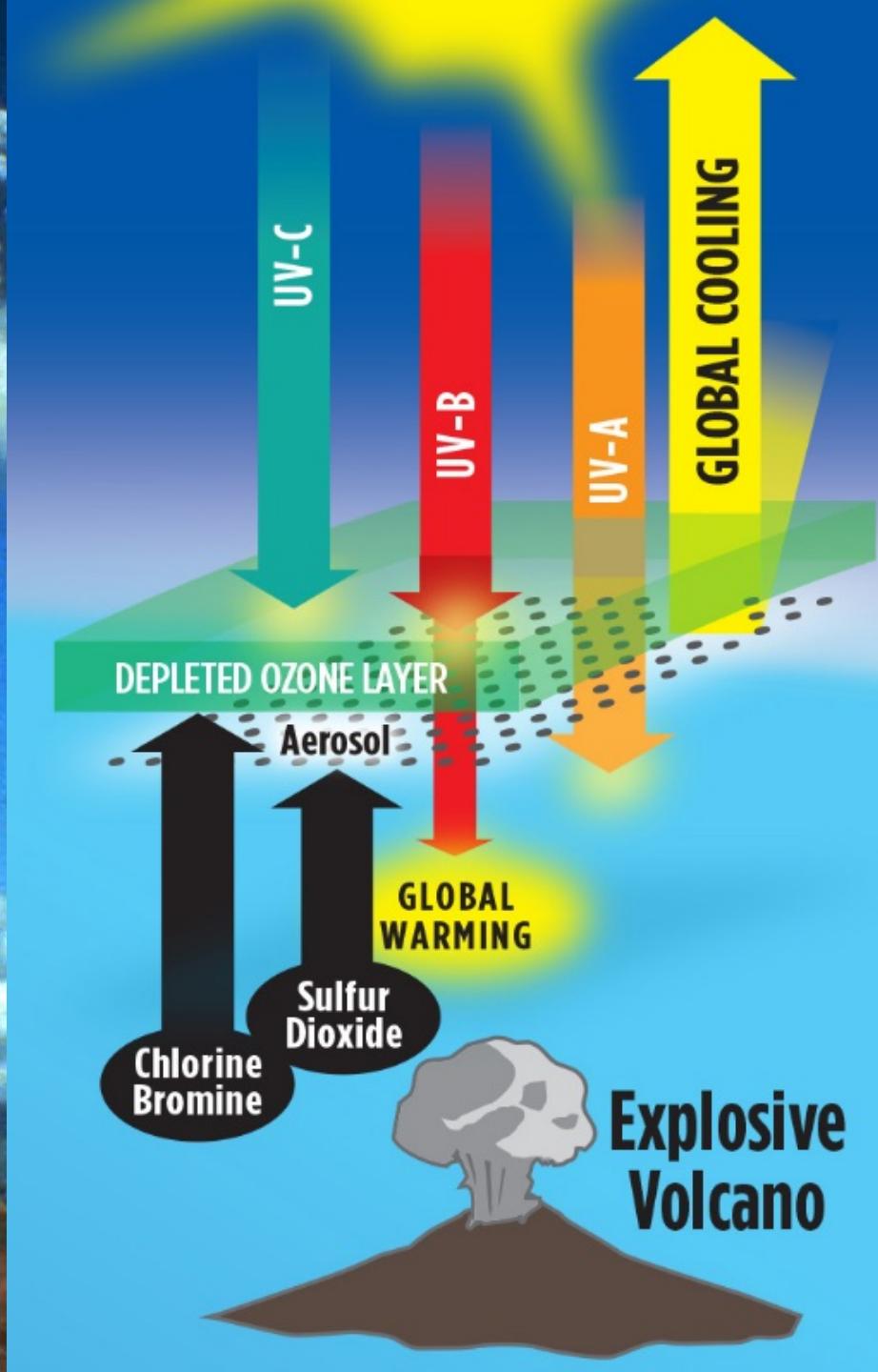


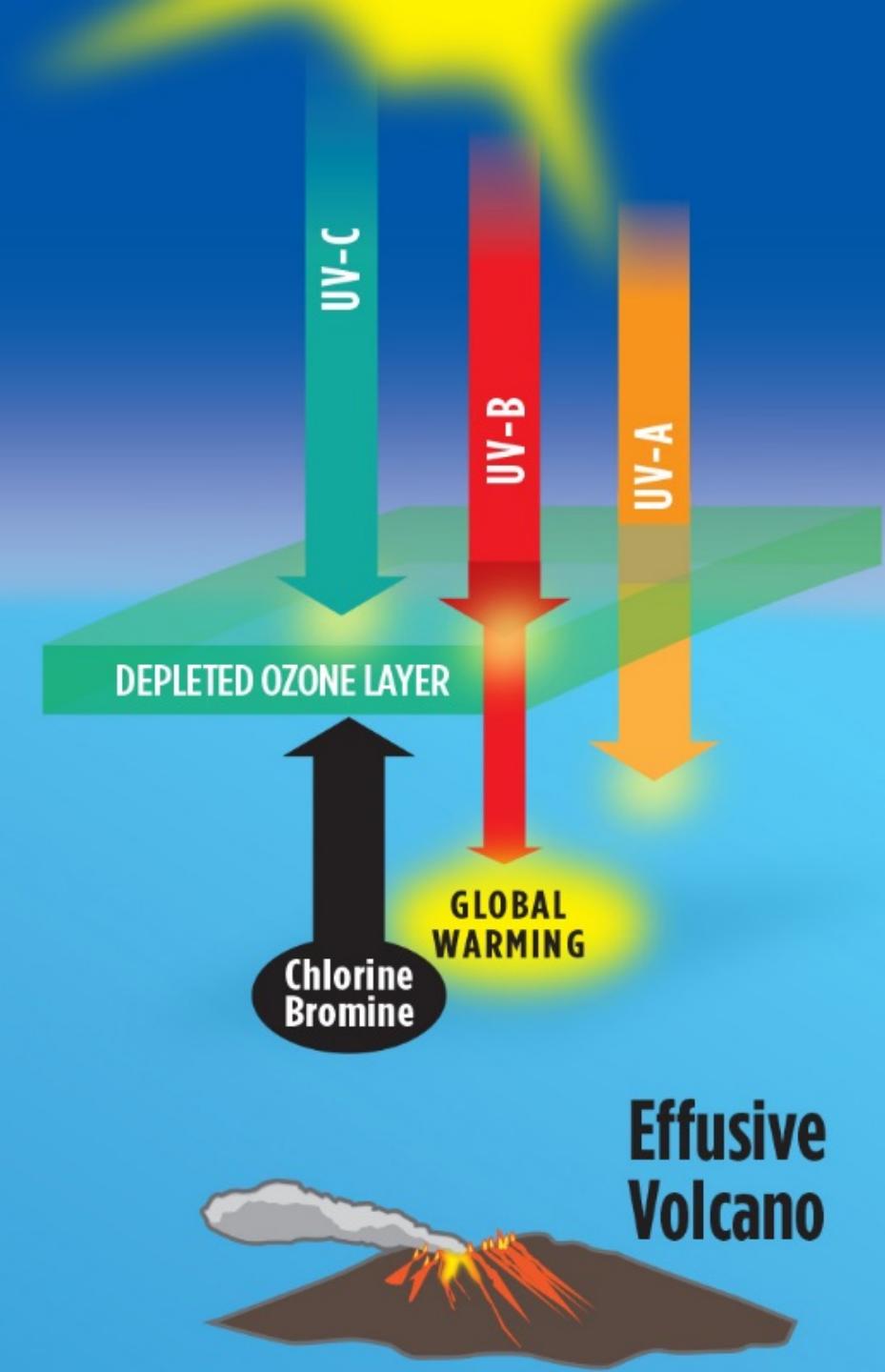
Minimum monthly temperatures rose 6.7°C from 1976 to 2000

Greatest warming in 1800 years

Winter sea ice decreased 10% per decade

Southern oceans warmed at twice the global rate





Pinatubo, 1991



Explosive → Cooling

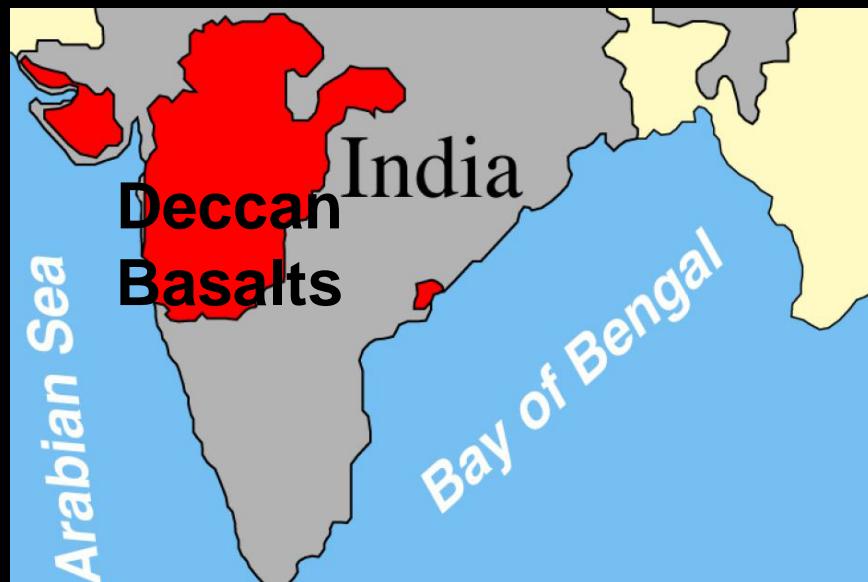
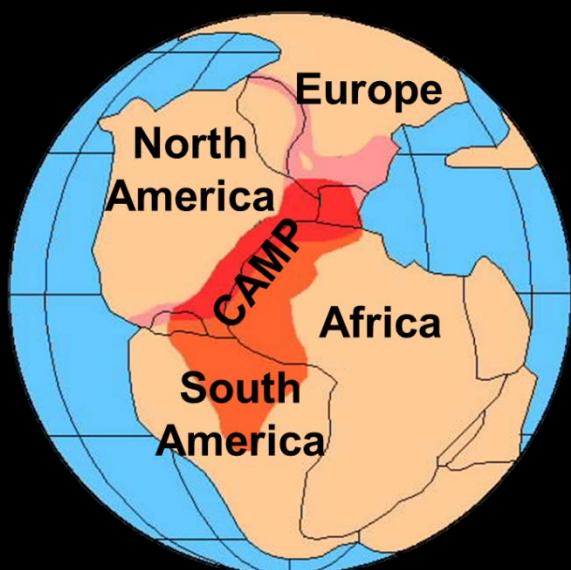
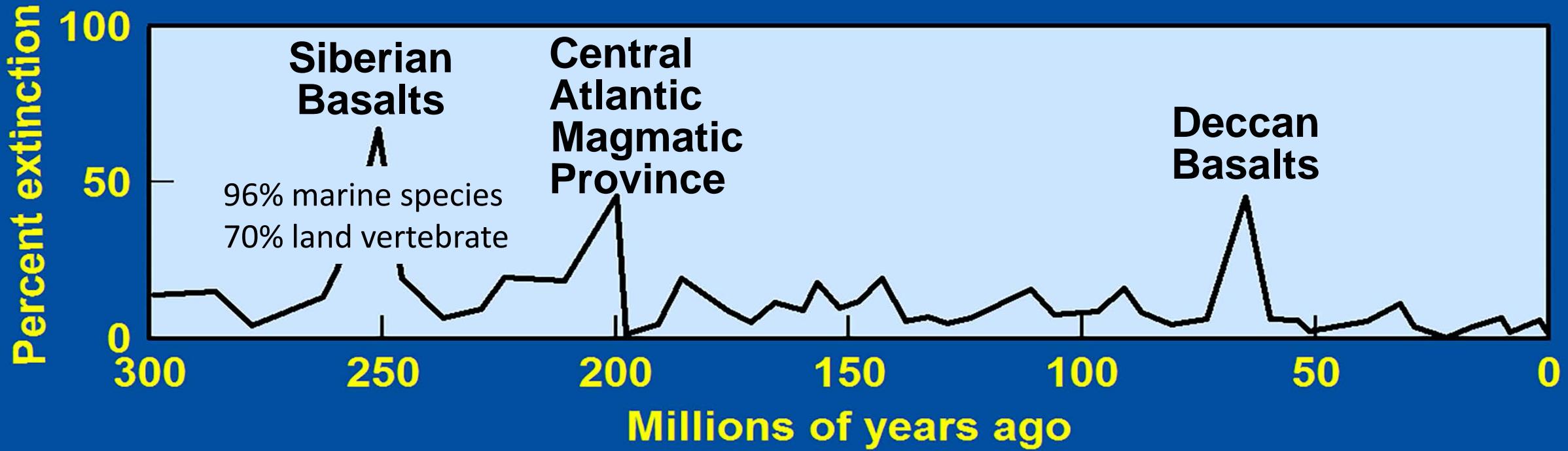
Aerosol formation

Bárðarbunga, 2014-2015



Effusive → Warming

No aerosol formation

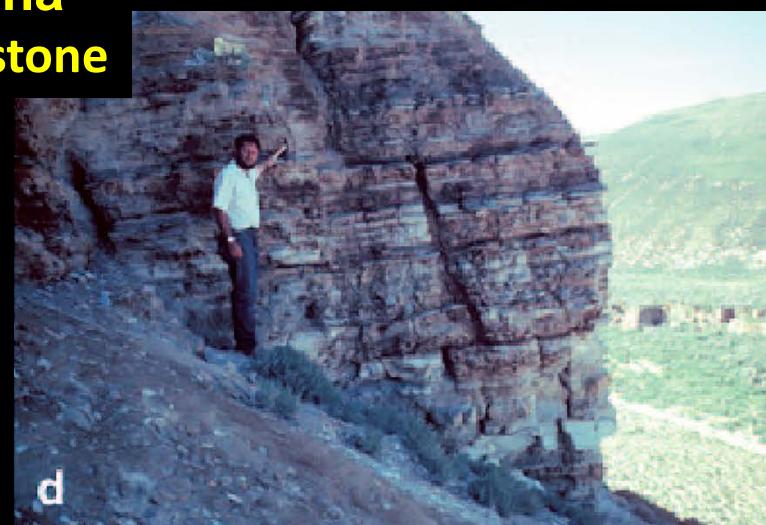


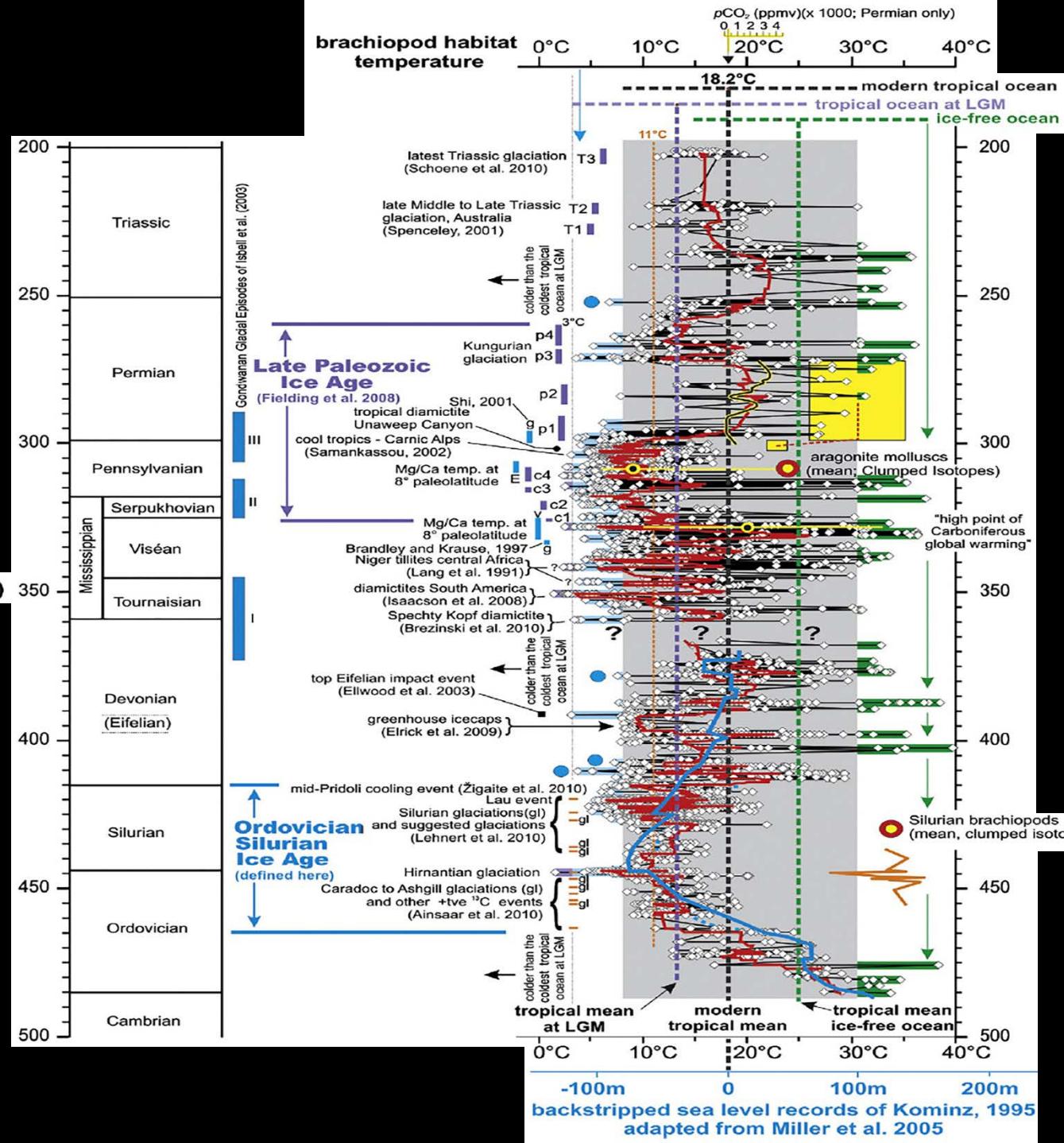
Eocene Green River Formation in Wyoming

Ronald C. Surdam, 2013, Geological Observations
Supporting Dynamic Climatic Changes, in
Geological CO₂ Storage Characterization, Springer.



oil shale
trona
dolostone

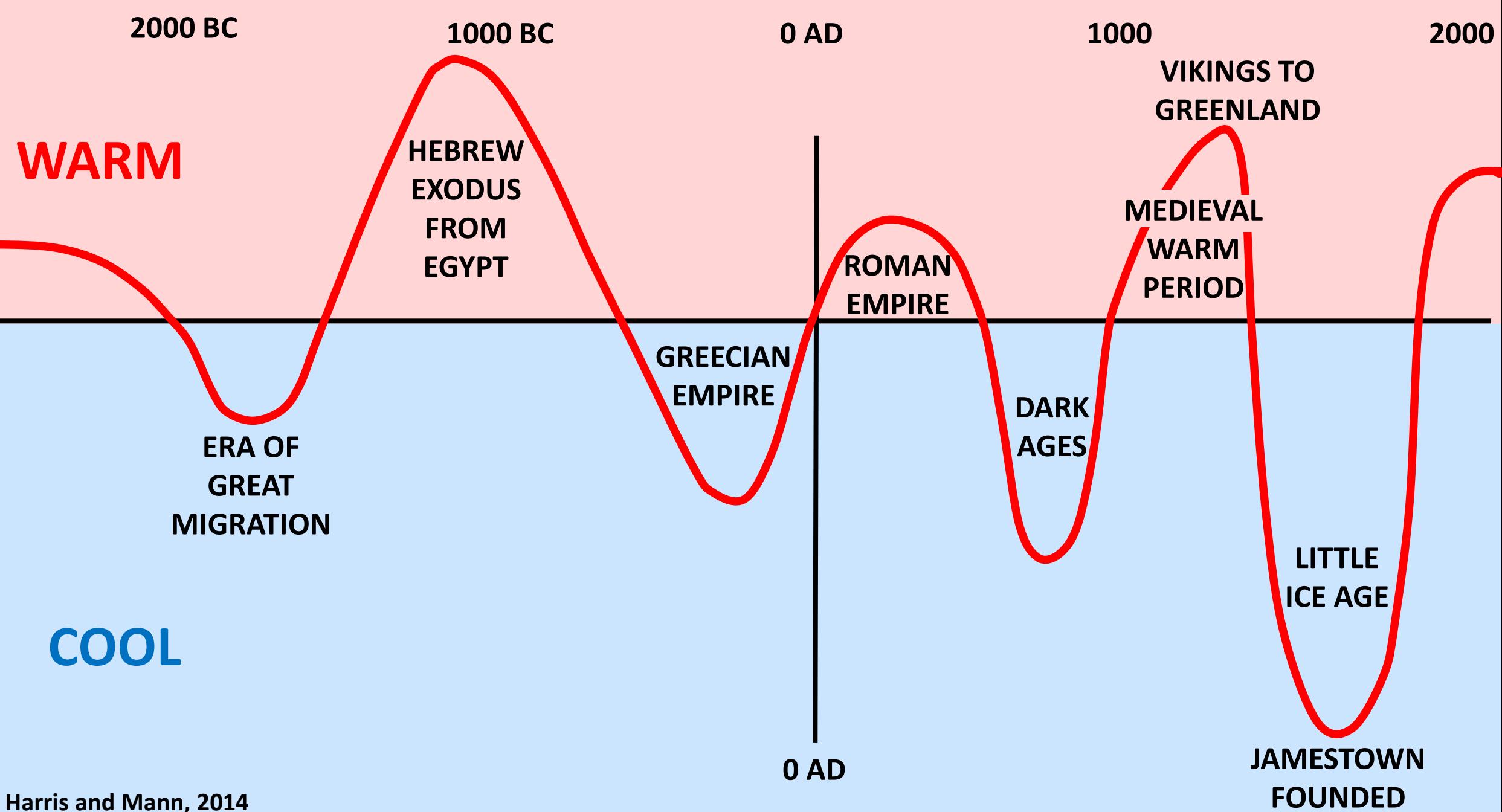




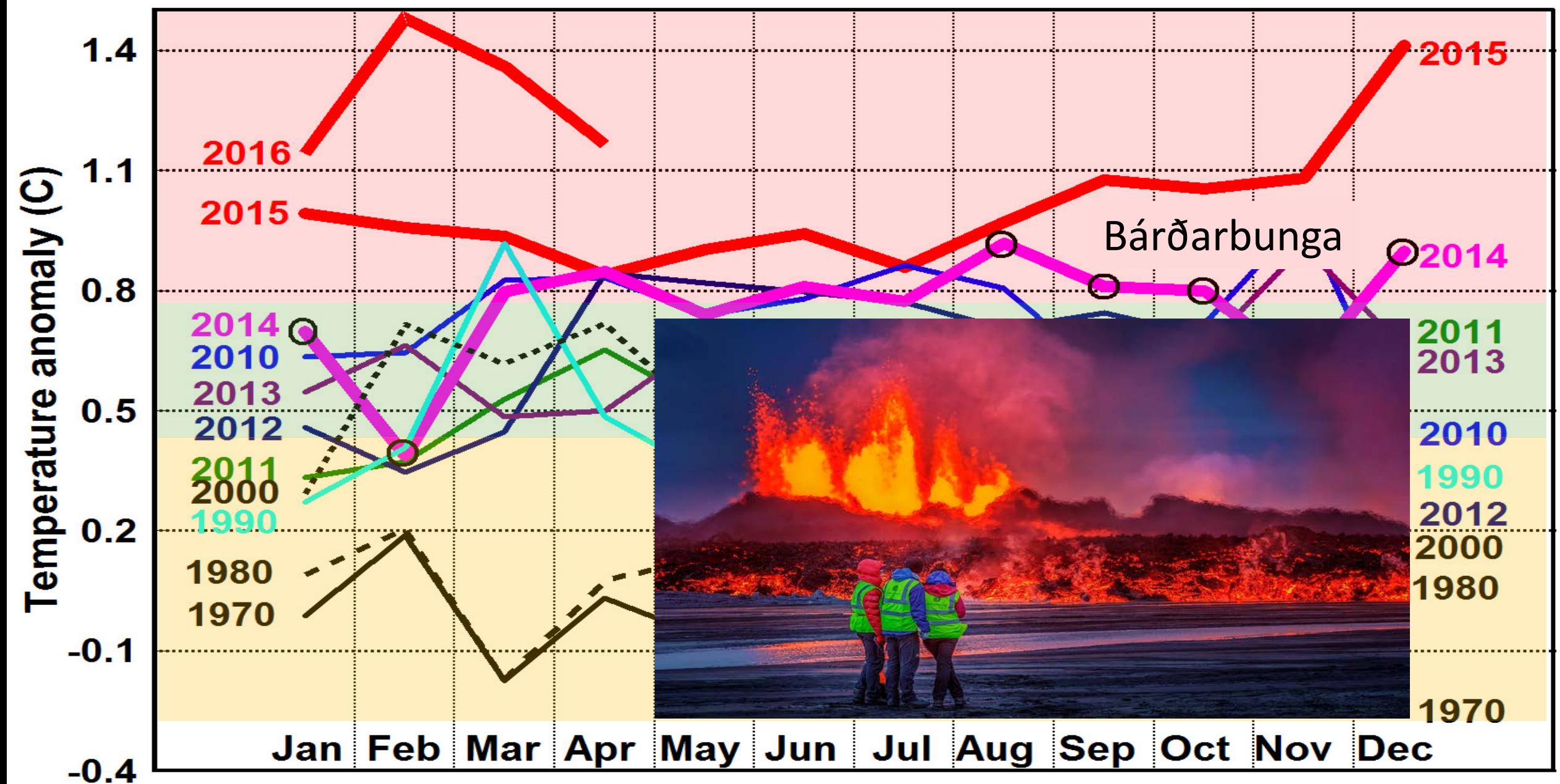
Peter S. Giles, 2012

**Low-latitude Ordovician to Triassic
brachiopod habitat temperatures
(BHTs) determined from
 $\delta^{18}\text{O}$ [brachiopod calcite]: A cold hard
look at ice-house tropical oceans**

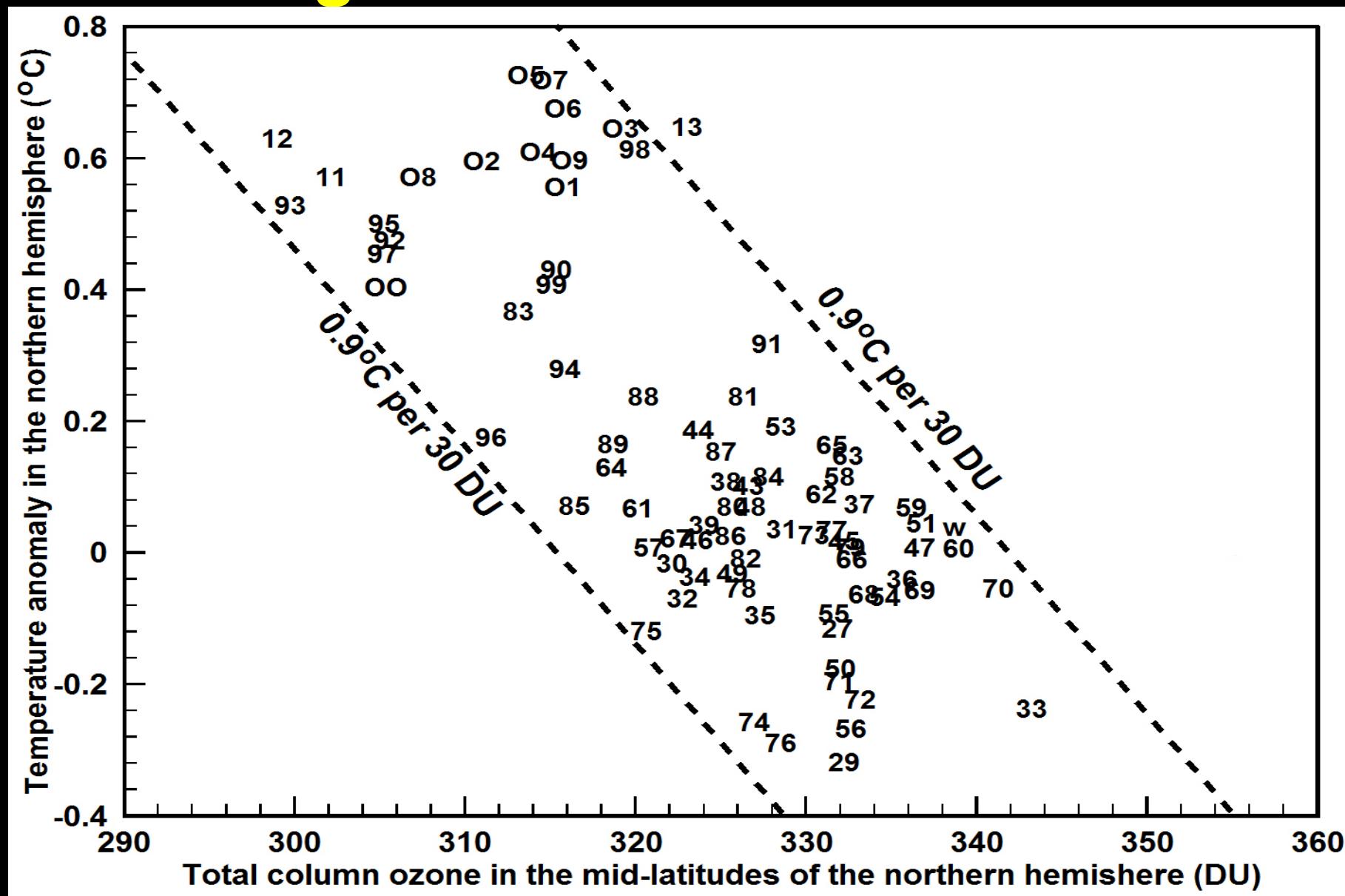
**Palaeogeography, Palaeoclimatology,
Palaeoecology, v. 317-318, p. 134-152.**



Major Temperature Increase Since December 2014



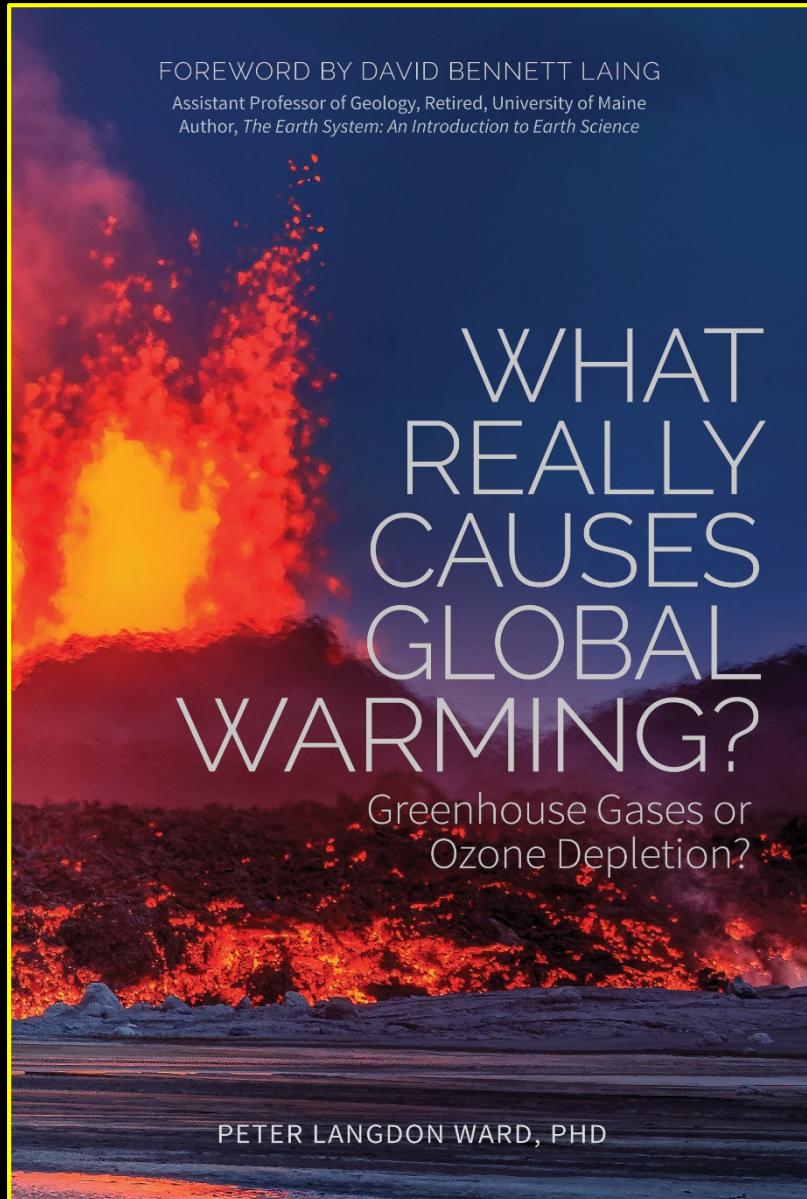
Average Annual Temperature as a Function of Average Annual Ozone Each Year



Ozone depletion caused by volcanic eruptions and CFC gases provides a clear and sufficient explanation for warming over the past 100 years and for warming throughout all of geologic time.

What role did greenhouse gases play?

For more information:



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