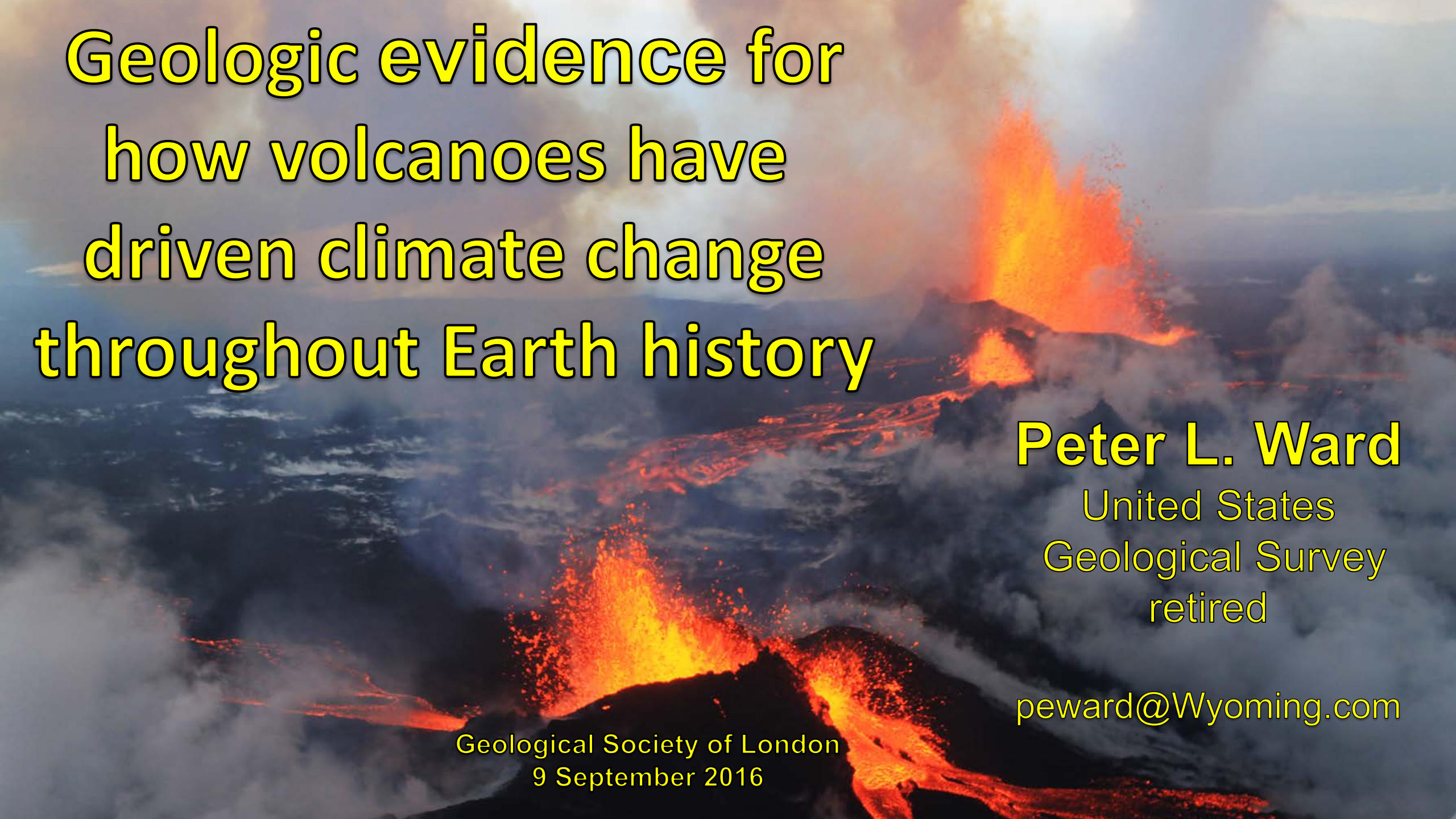
Geologic evidence for how volcanoes have driven climate change throughout Earth history



Peter L. Ward
United States Geological Survey
retired

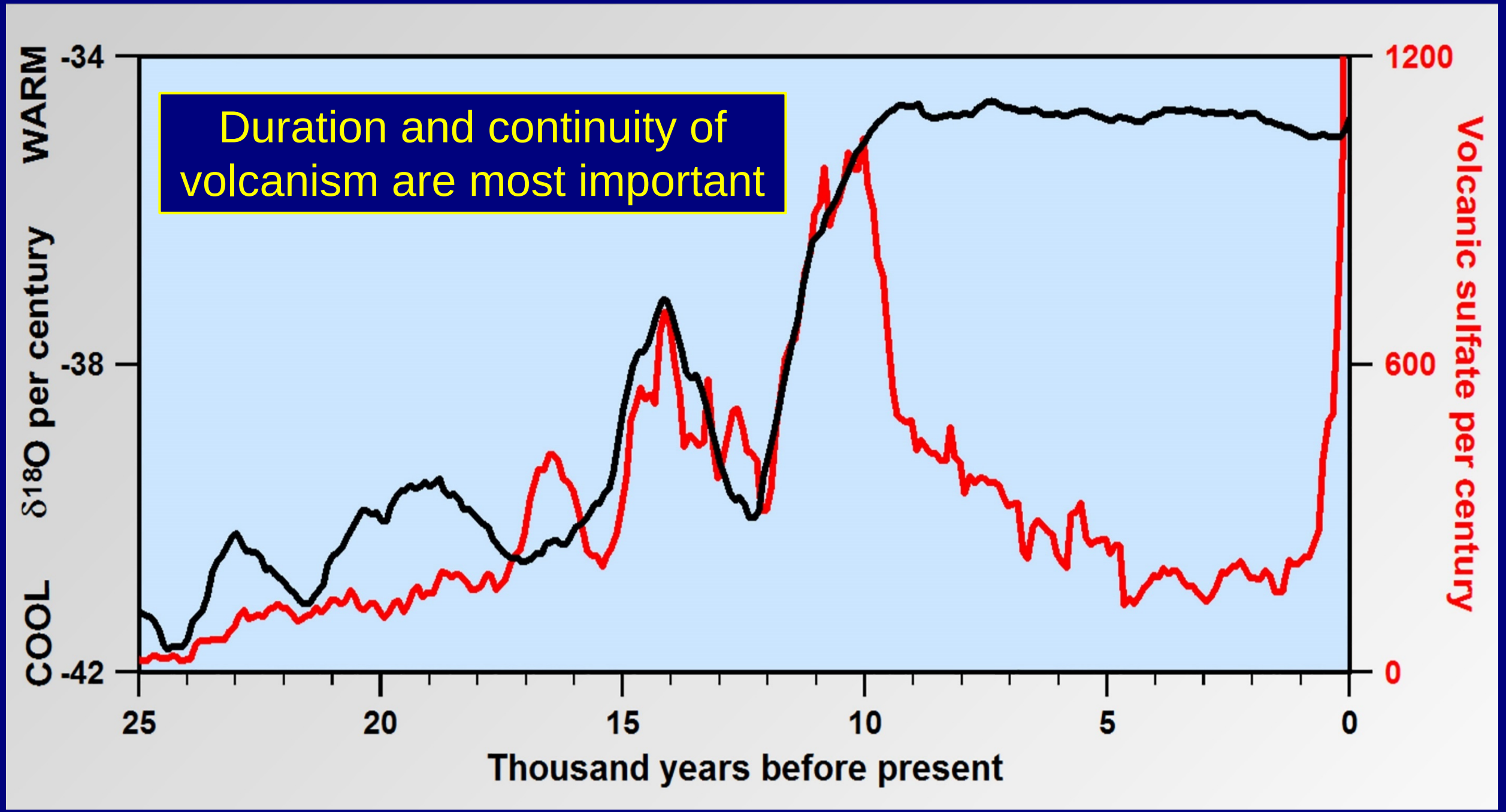
peward@Wyoming.com

Geological Society of London
9 September 2016

Greenland Ice Sheet Program Drill Hole 2 (GISP2)

1988 to 1993

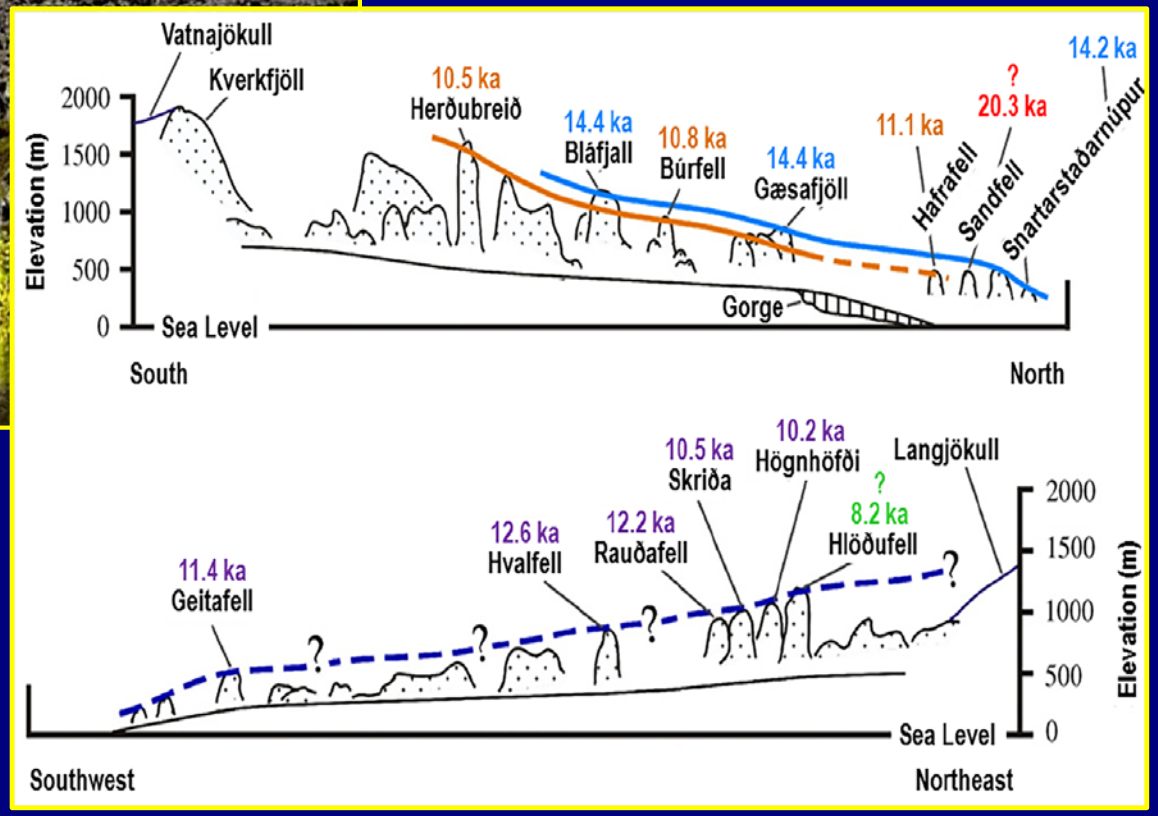
Mayewski et al., 1995



Zielinski et al., 1996

Evidence of sub-glacial volcanism in Iceland

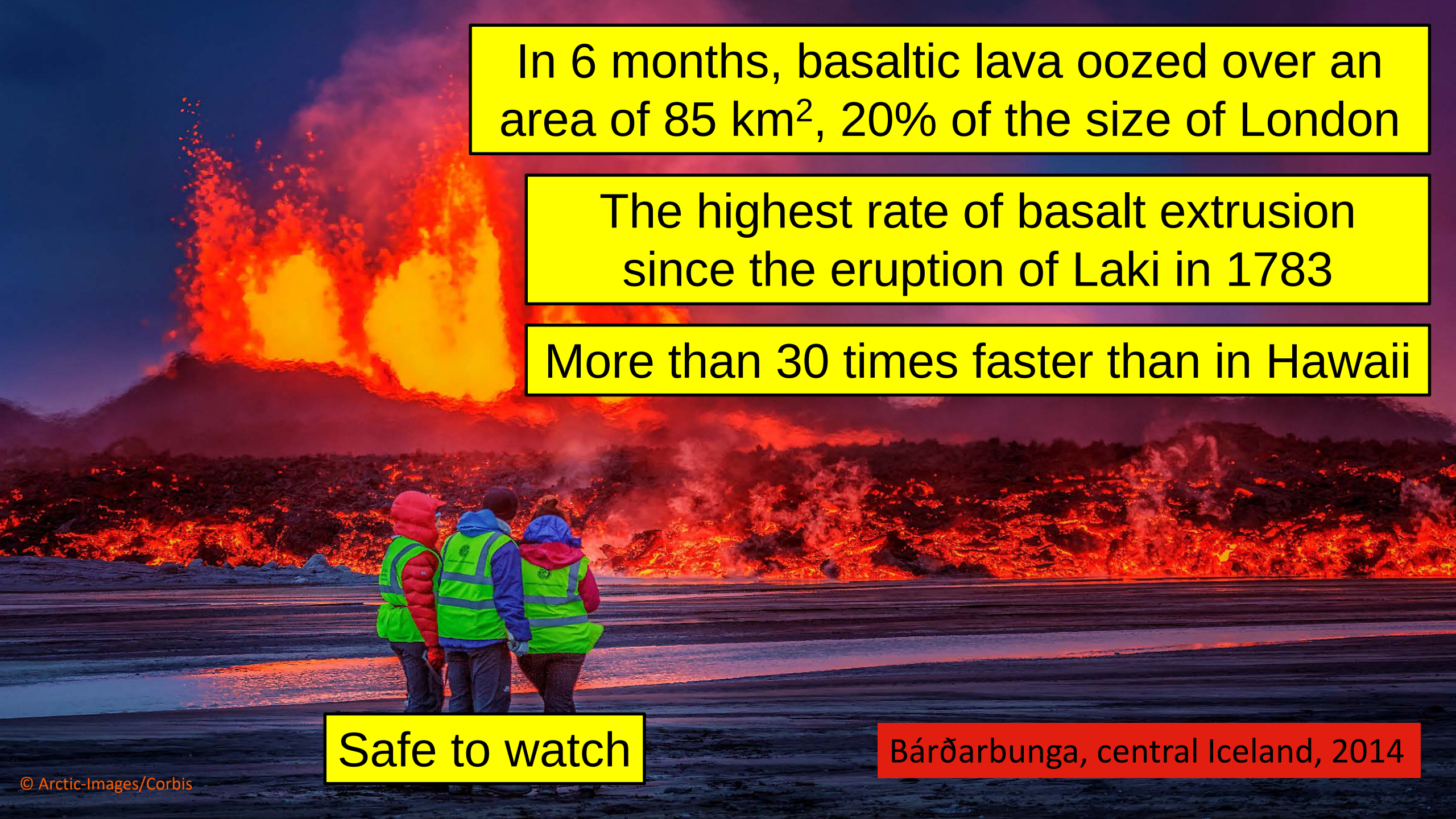
Herðubreið , a tuya in north-east Iceland (“broad shoulders”)



“From 12,000 to 7000 years ago, there was 2-6 times more volcanism that melted the ice sheet causing decompression of magma.”

Huybers and Langmuir, 2007

Licciardi et al., 2007



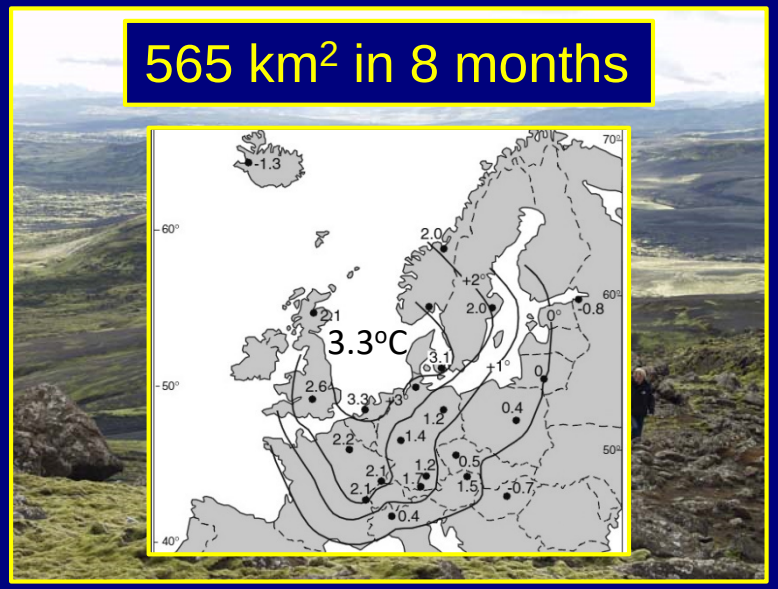
Major effusive volcanic eruptions

Extrude basaltic lava over large areas for months to hundreds of thousands of years

Do not eject much debris into the lower stratosphere to form aerosols

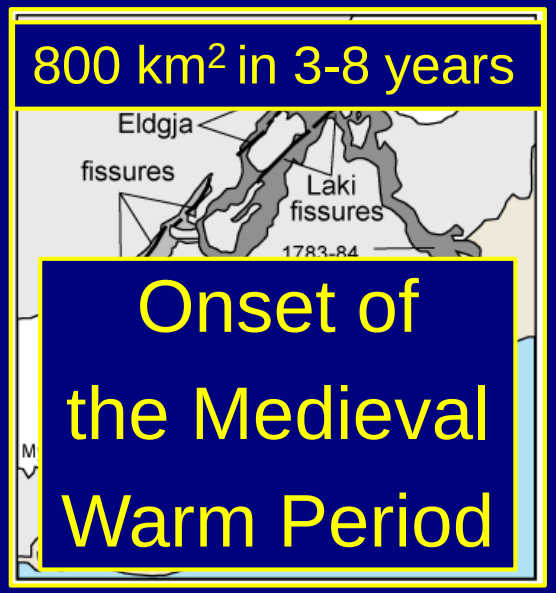
Warm the world out of ice ages when lasting for ~2000 years

Bárðarbunga 2014



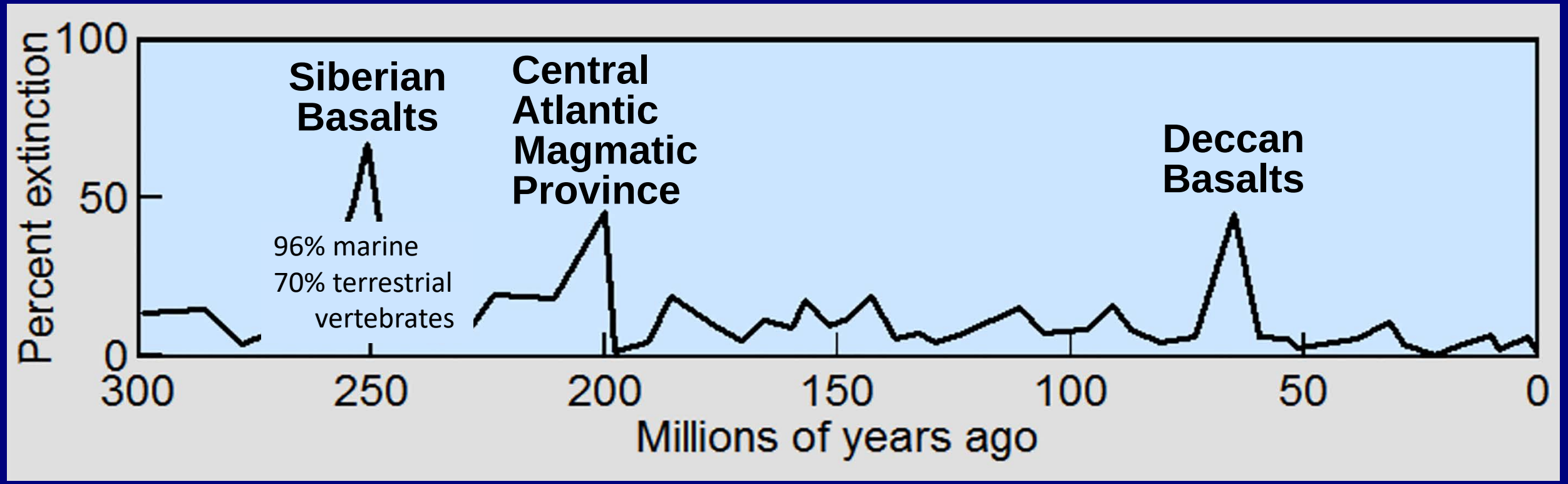
Laki 1783

Thordarson and Self, 2003

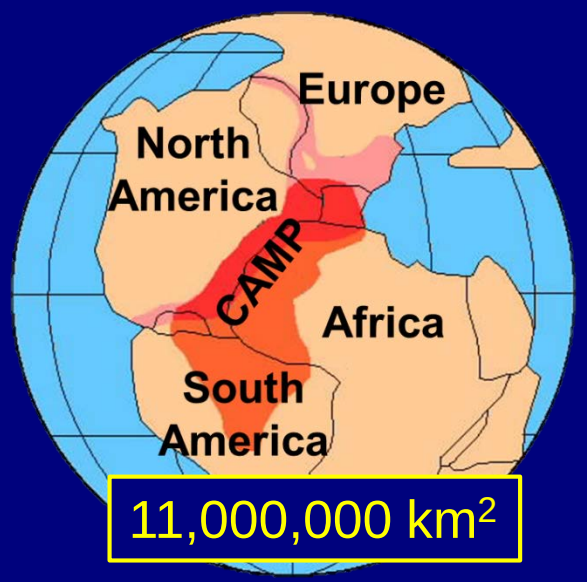


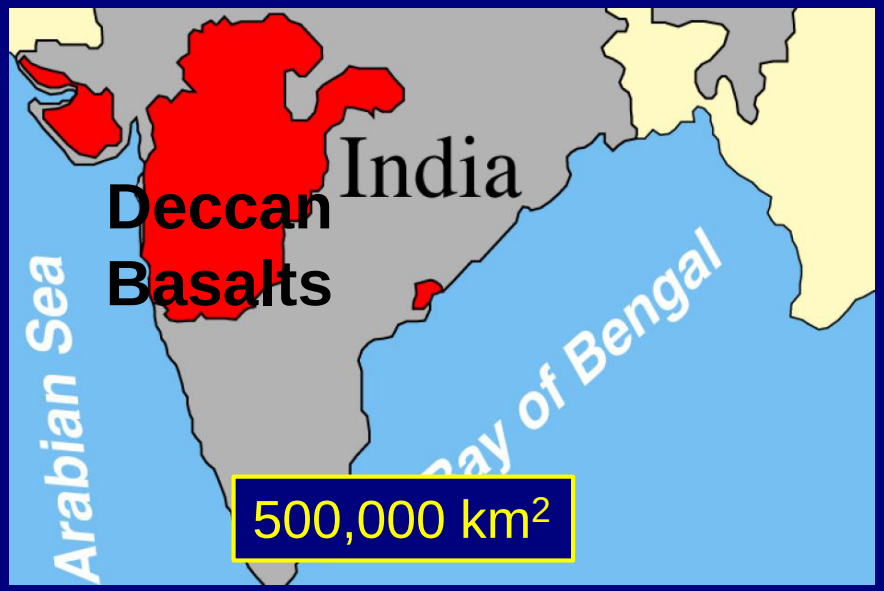
Eldgjá 935

volcano.oregonstate.edu

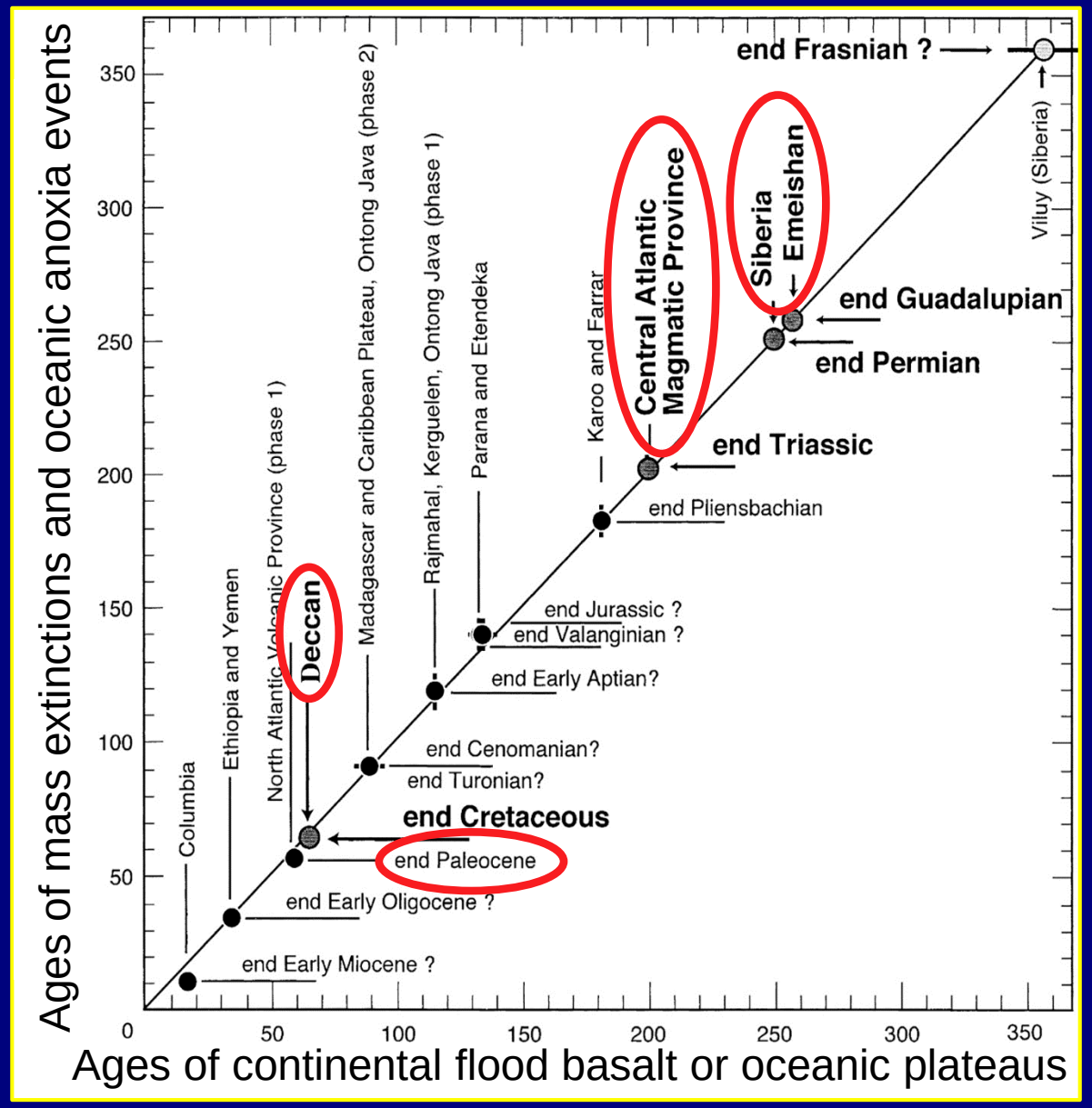

Percent extinction
100
50
0
Siberian Basalts
96% marine
70% terrestrial vertebrates
Central Atlantic Magmatic Province
Deccan Basalts
300
250
200
150
100
50
0
Millions of years ago


Arctic Ocean
Finland
Санкт-Петербург
Moscow
Волгоград
Caspian Sea
Sea of Okhotsk
Якутск
Lake Baikal
Siberian Basalts
7,000,000 km²


Europe
North America
CAMP
Africa
South America
11,000,000 km²


India
Deccan Basalts
Arabian Sea
Bay of Bengal
500,000 km²

Extinctions versus flood basalts

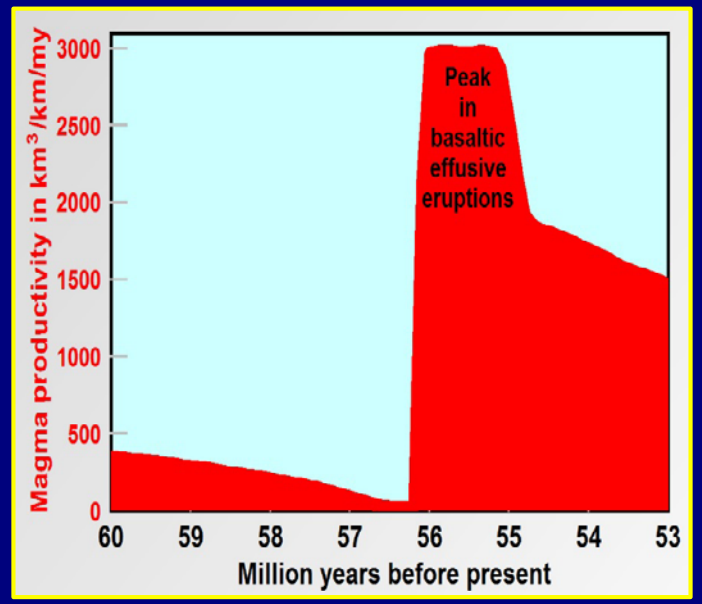


Courtillot and Renne 2003

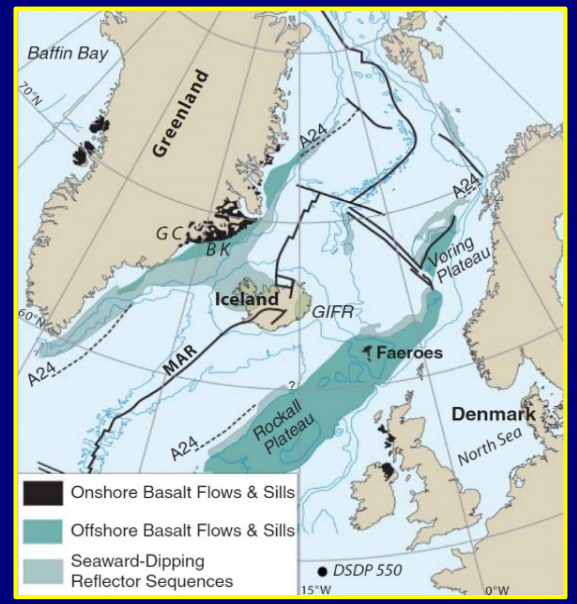
Paleocene Eocene Thermal Maximum

Extrusion of basaltic magma reached a peak 56 million years ago during the opening of the Greenland-Norwegian Sea

Sea surface temperatures rose 6°C



Storey et al. 2007



Effusive, basaltic, volcanic eruptions

Form over months to hundreds of thousands of years

Cover areas of tens to millions of square kilometers

Are contemporaneous with major global warming

Cause major ocean acidification though SO_2 forming sulfuric acid

Cause extinctions of as much as 83% of all genera at one time

Have occurred sporadically throughout earth history

Not particularly dangerous to watch

Recent warming caused by Bárðarbunga?

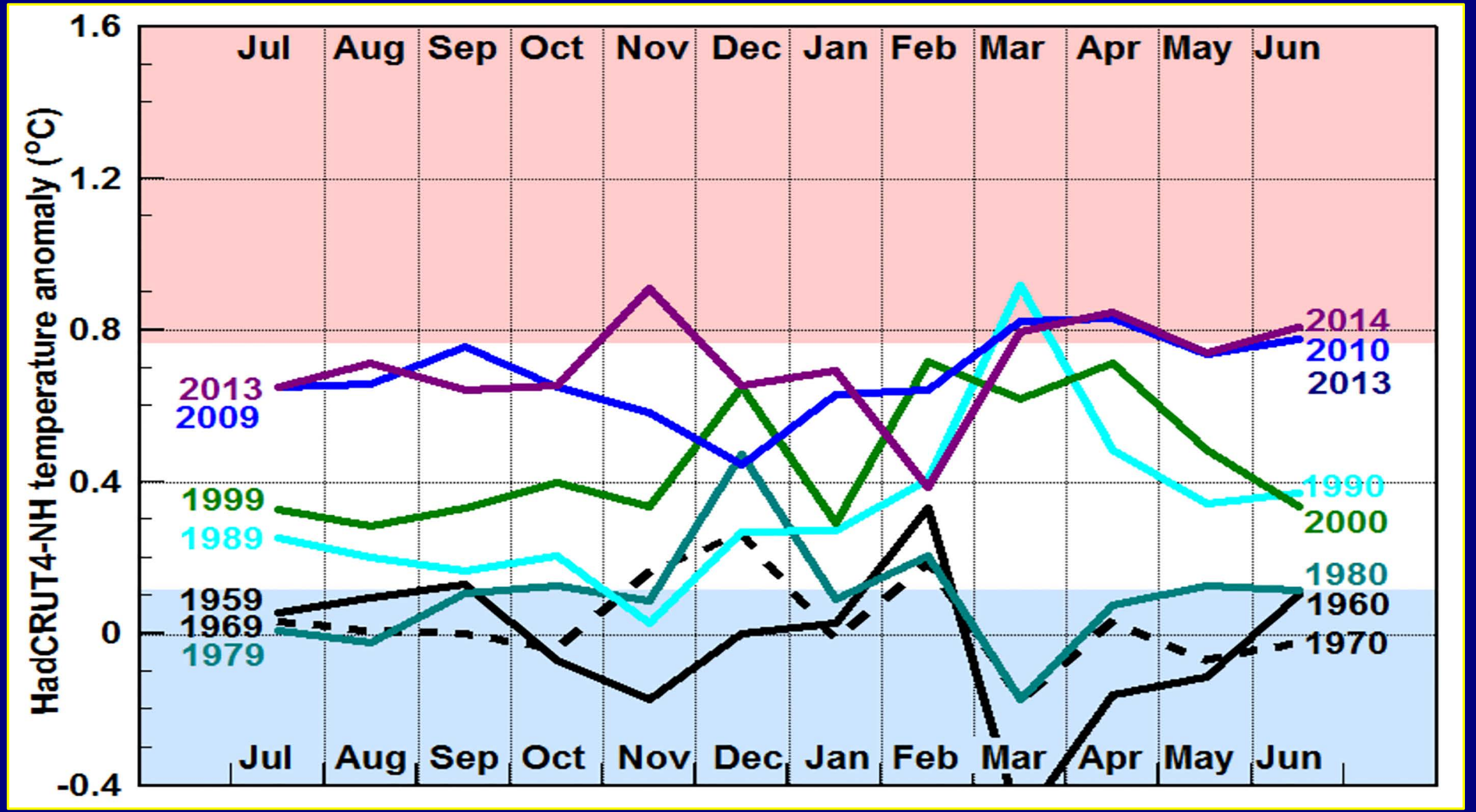
HadCRUT4-NH temperature anomaly (°C)

1.6
1.2
0.8
0.4
0
-0.4

Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr May Jun

1959
1969
1979

1980
1960
1970


HadCRUT4-NH temperature anomaly (°C)
1.6
1.2
0.8
0.4
0
-0.4
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar
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Jun
2014
2010
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2013
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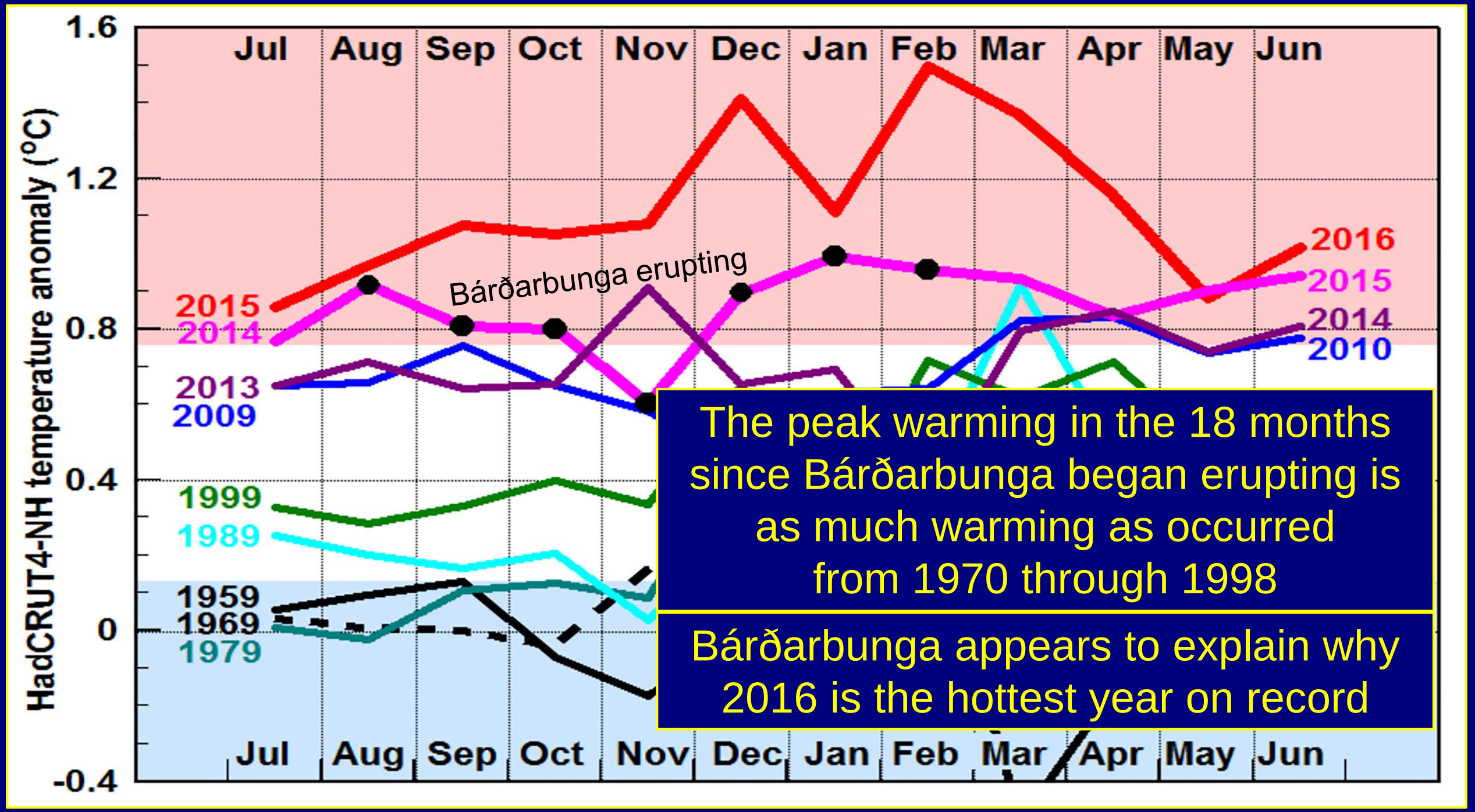
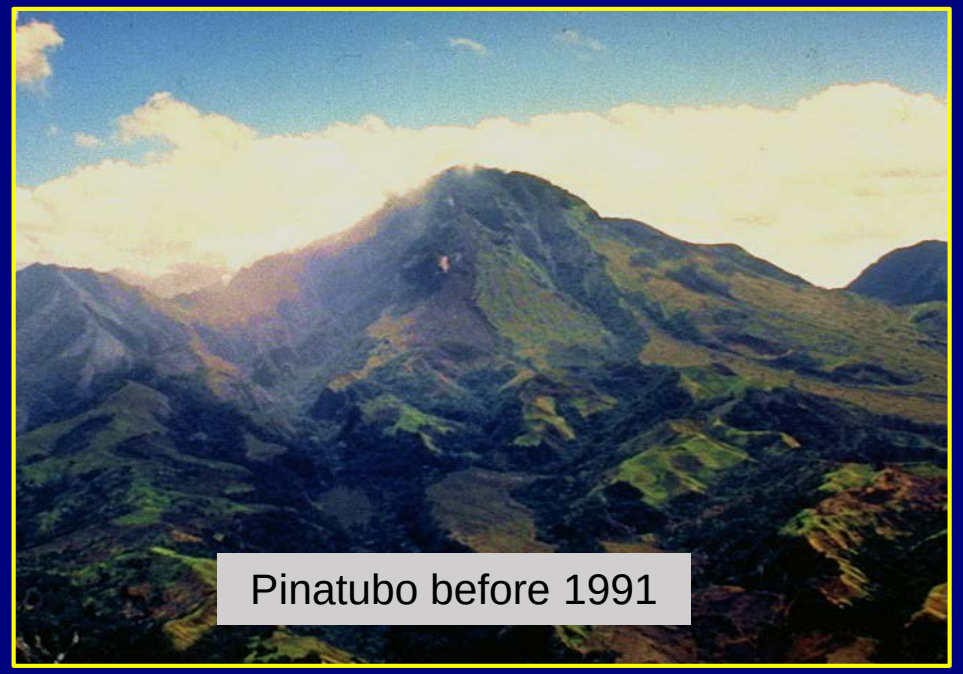
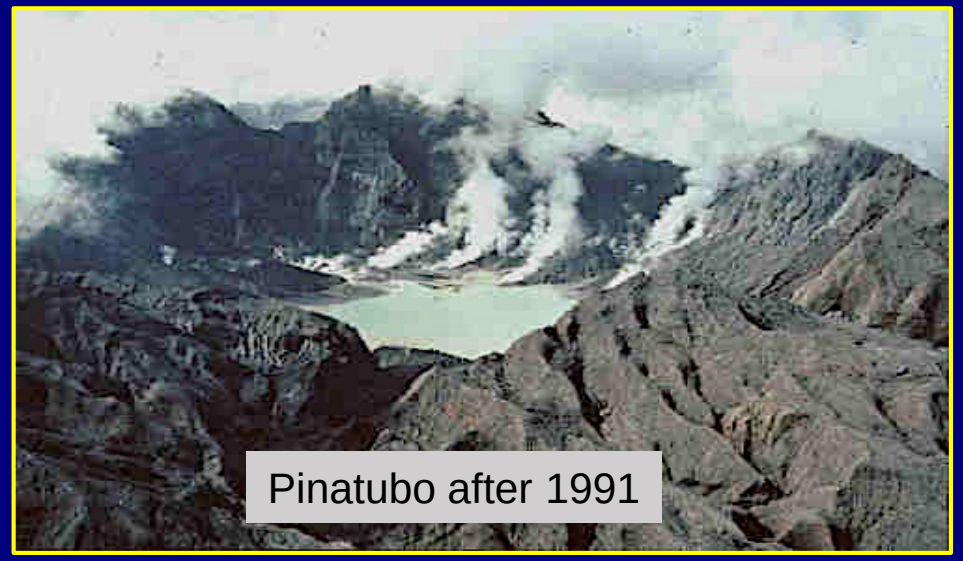
1999
1989
1990
2000
1980
1959
1969
1979
1960
1970


HadCRUT4-NH temperature anomaly (°C)
1.6
1.2
0.8
0.4
0
-0.4
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
2016
2015
2014
2010
2015
2014
2013
2009
1999
1989
1959
1969
1979
Bárðarbunga erupting
The peak warming in the 18 months since Bárðarbunga began erupting is as much warming as occurred from 1970 through 1998
Bárðarbunga appears to explain why 2016 is the hottest year on record

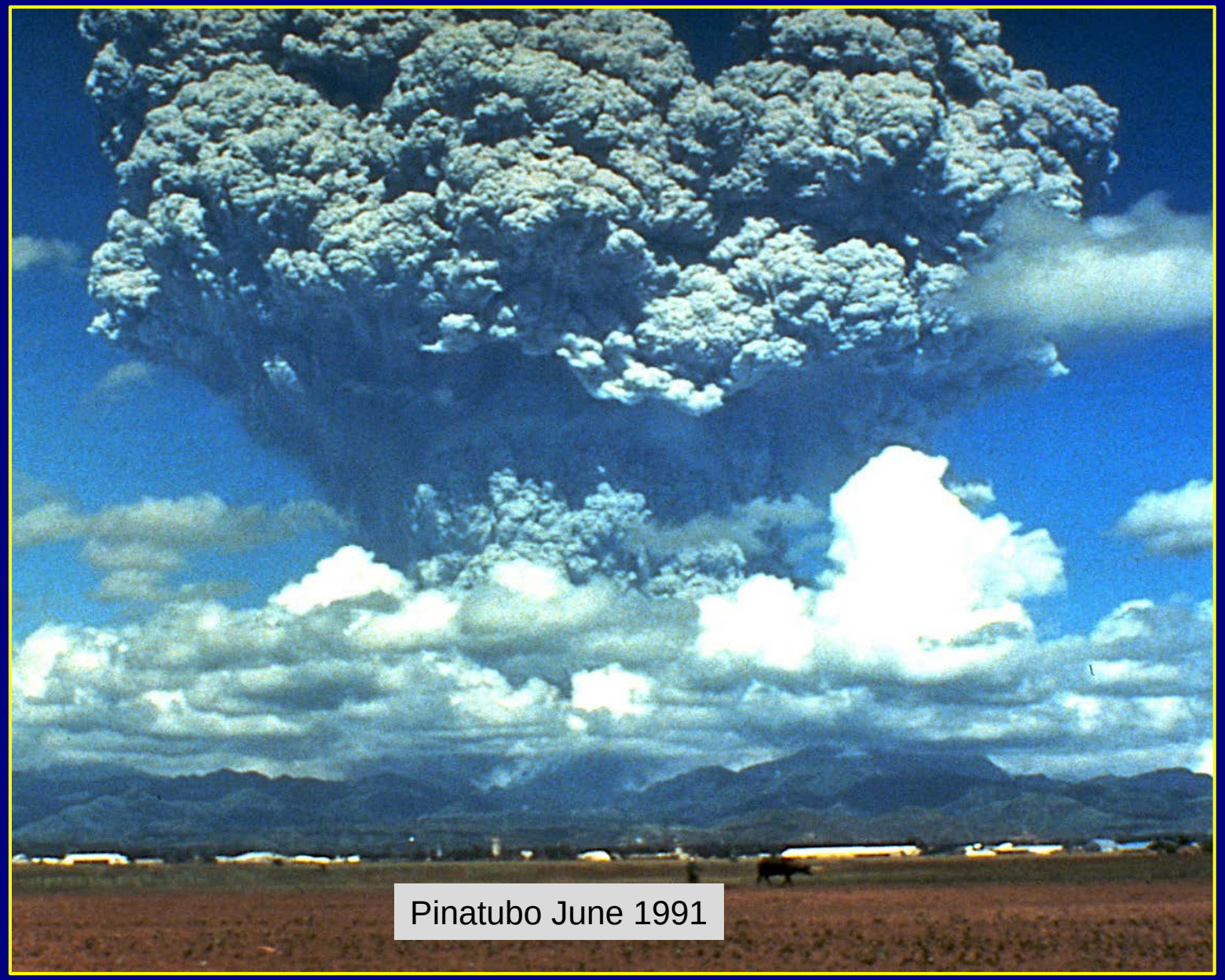
Major explosive volcanic eruptions



Pinatubo before 1991



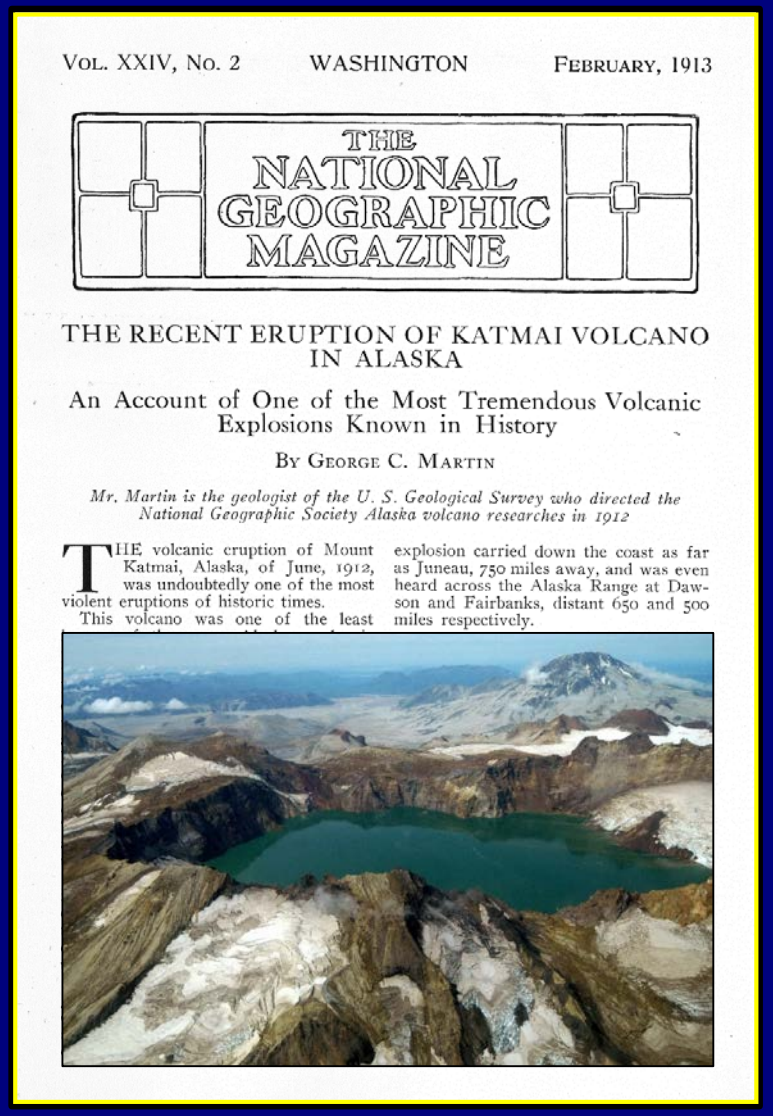
Pinatubo after 1991



Pinatubo June 1991

Major explosive volcanic eruptions cool earth

about 0.5°C for 2 to 3 years



VOL. XXIV, No. 2 WASHINGTON FEBRUARY, 1913

THE NATIONAL GEOGRAPHIC MAGAZINE

THE RECENT ERUPTION OF KATMAI VOLCANO IN ALASKA

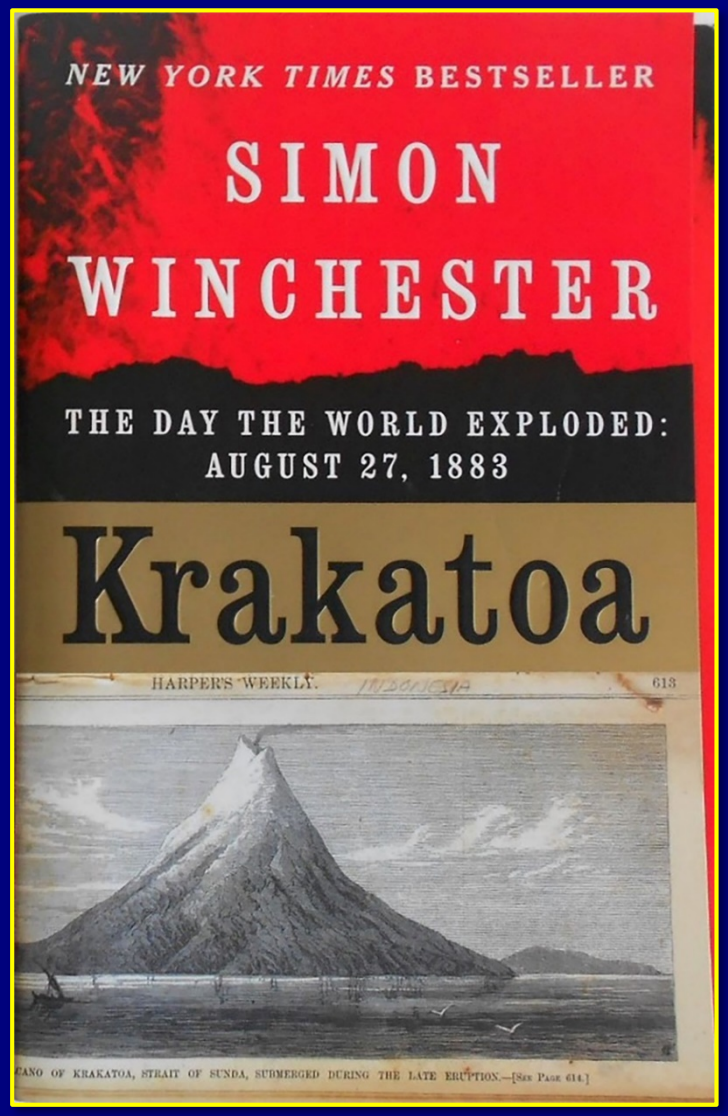
An Account of One of the Most Tremendous Volcanic Explosions Known in History

BY GEORGE C. MARTIN

Mr. Martin is the geologist of the U. S. Geological Survey who directed the National Geographic Society Alaska volcano researches in 1912

THE volcanic eruption of Mount Katmai, Alaska, of June, 1912, was undoubtedly one of the most violent eruptions of historic times. This volcano was one of the least explosion carried down the coast as far as Juneau, 750 miles away, and was even heard across the Alaska Range at Dawson and Fairbanks, distant 650 and 500 miles respectively.

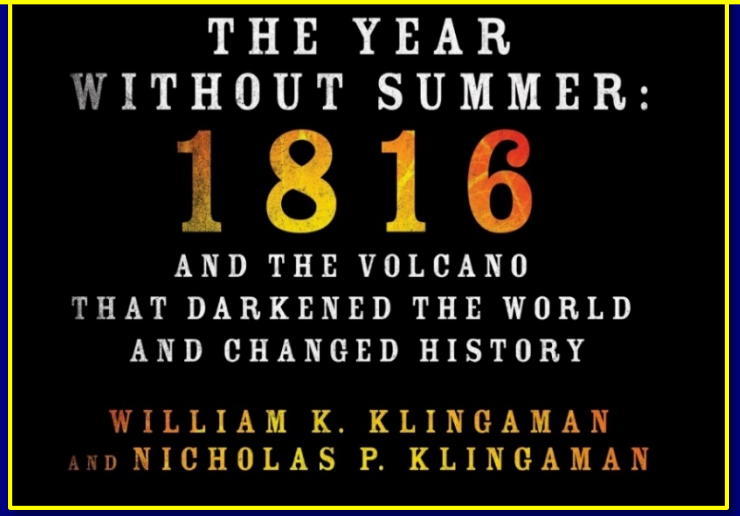
Katmai 1912



Krakatoa 1883

Largest since 1258 AD

>71,000 killed?
Worst famine in 19th century



Tambora 1815

Major explosive volcanic eruptions

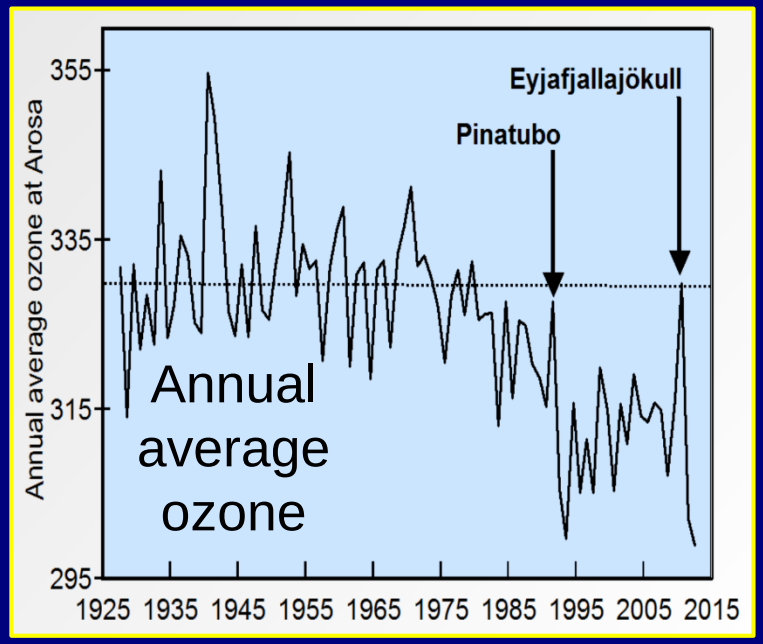
Erupt for days, may recur every 500 years or so

Eject debris more than 35 km

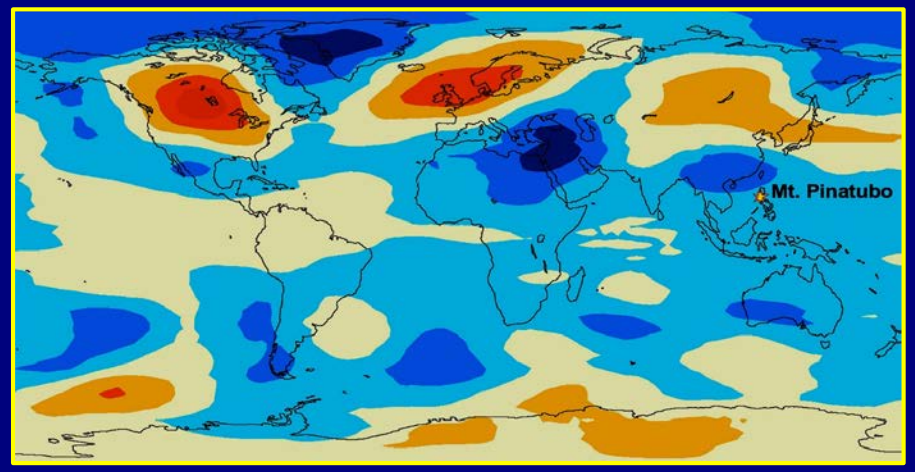
Form aerosols in the lower stratosphere at 15 to 25 km that last for 2 to 3 years

Deplete ozone causing short-term warming

Reflect solar energy, causing net global cooling

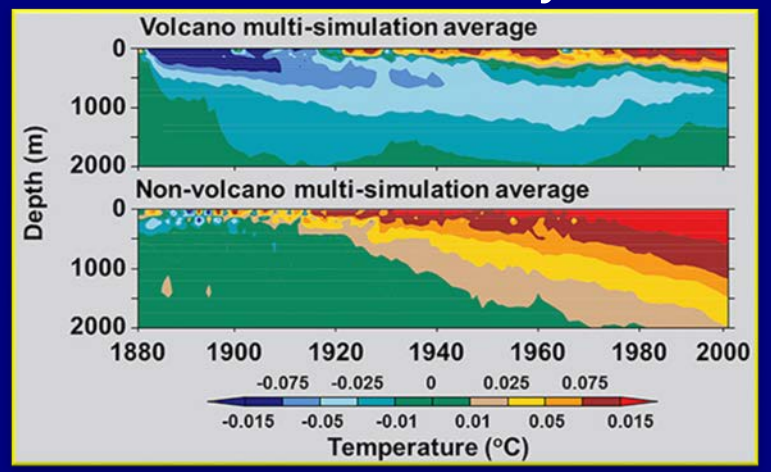


Warming 3.5ºC Dec to Feb



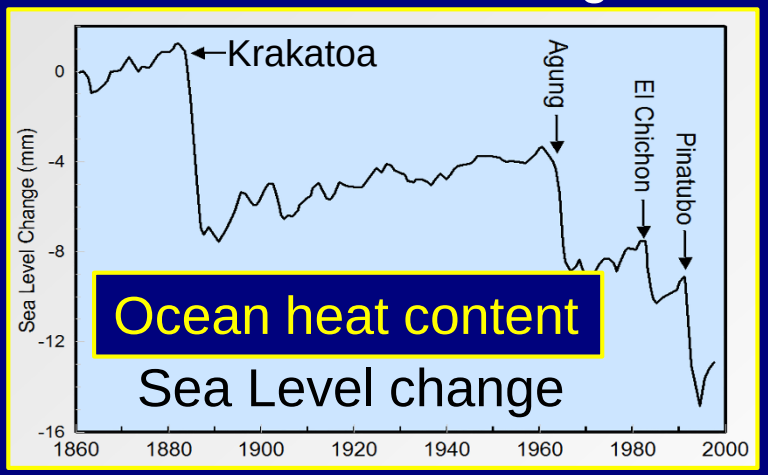
Robock, 2002

Krakatoa cooled ocean for more than 100 years

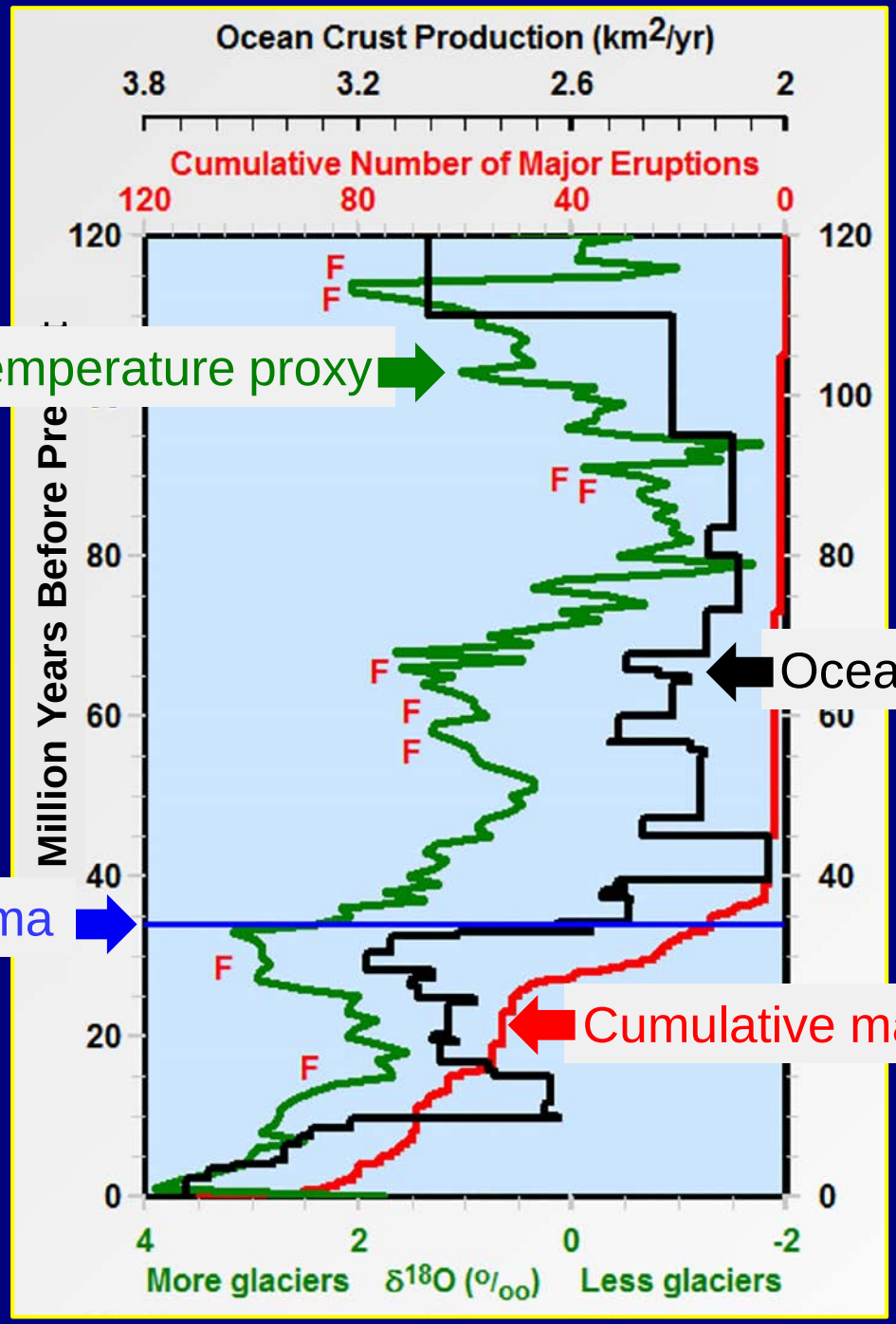


Gleckler et al., 2006

Multiple eruptions increment the world into ice age



Gregory et al., 2006



Temperature proxy

Ocean crust production

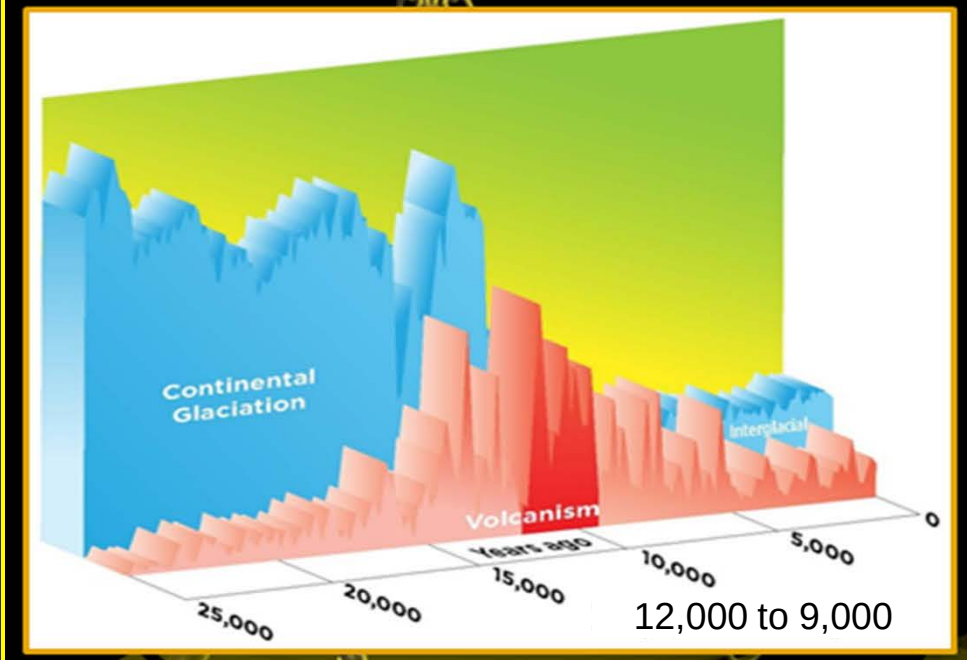
Onset of major ice in Antarctica 34 ma

Cumulative major volcanism

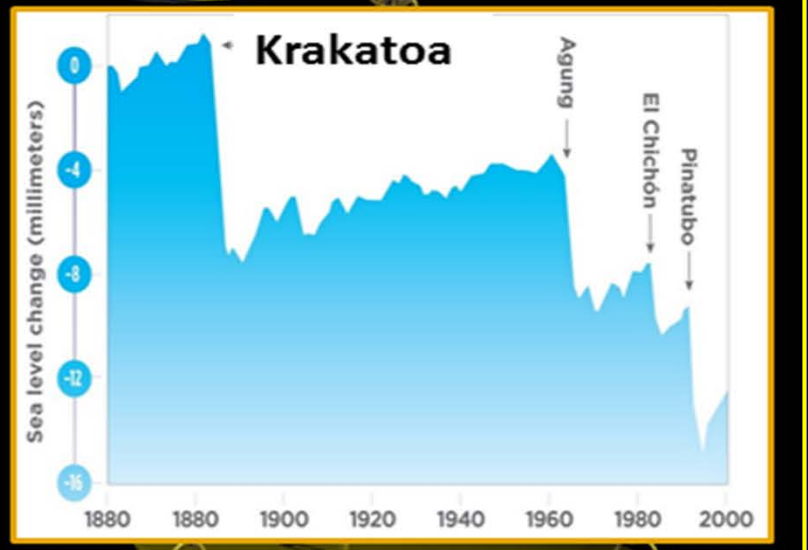
Veizer et al., 1999
Cogne et al., 2006
Coxall et al., 2005
Ward, 2009

Global Warming

Global Cooling



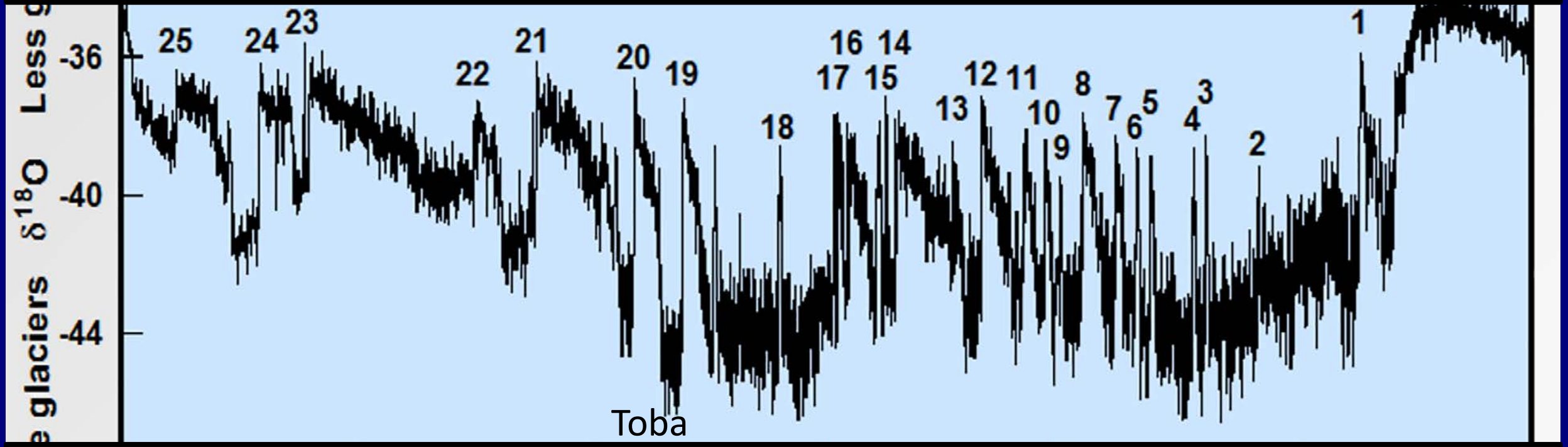
12,000 to 9,000



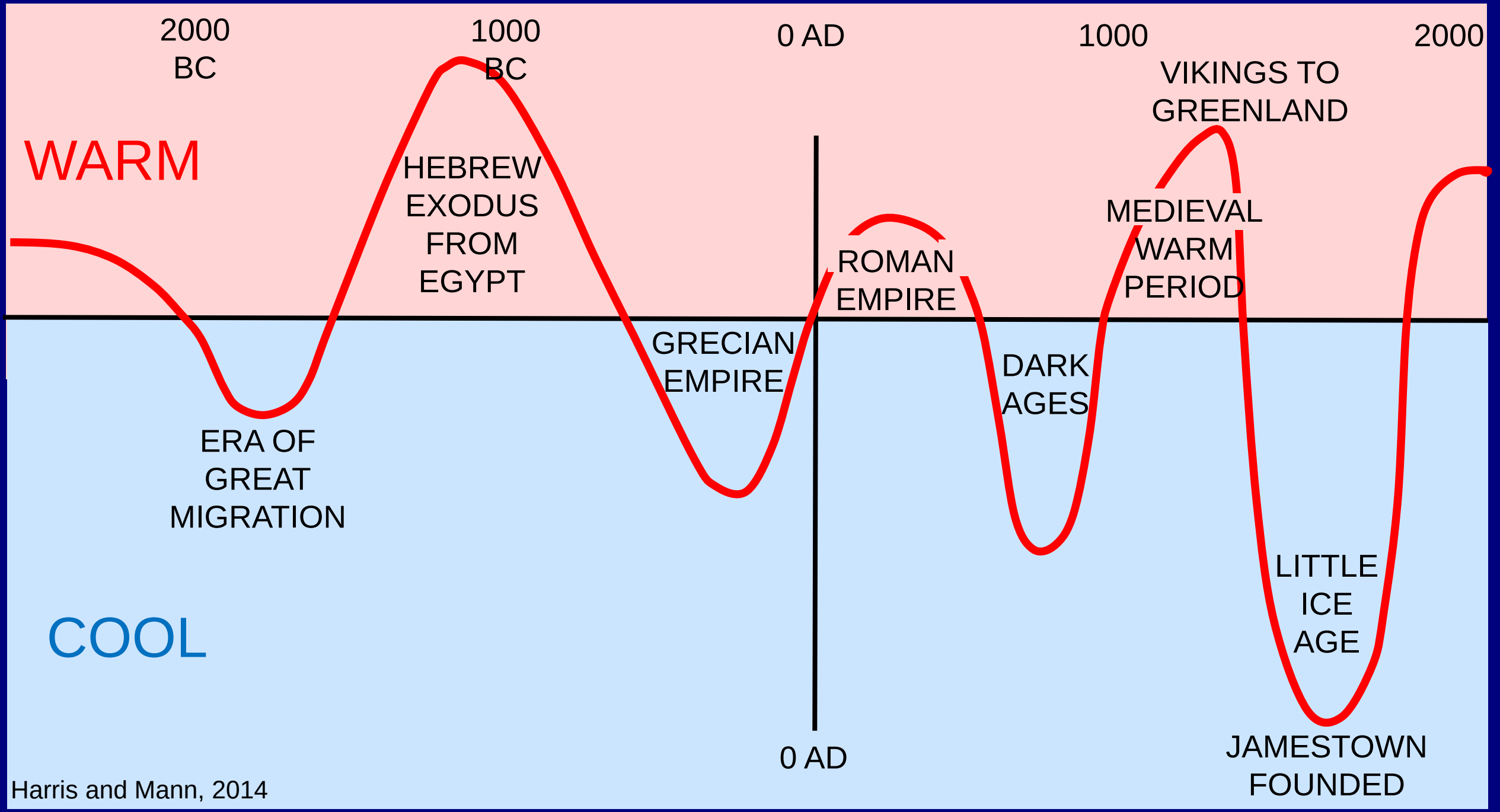
Duration of effusive volcanism

Frequency of explosive volcanism

The fundamental footprint of climate change is
erratic sudden major global warming within a few years
followed by cumulative cooling over centuries to millennia
where an average cycle lasts only a few thousand years



Any explanation for climate change must explain this cycling

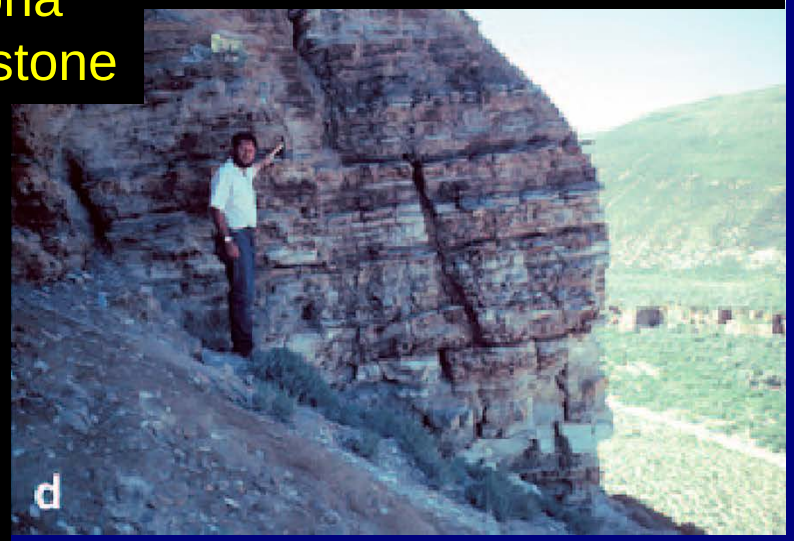

2000 BC
1000 BC
0 AD
1000
2000
WARM
COOL
HEBREW EXODUS FROM EGYPT
ERA OF GREAT MIGRATION
GRECIAN EMPIRE
ROMAN EMPIRE
DARK AGES
VIKINGS TO GREENLAND
MEDIEVAL WARM PERIOD
LITTLE ICE AGE
JAMESTOWN FOUNDED
0 AD
Harris and Mann, 2014

Eocene Green River Formation in Wyoming

53.5 to 48.5 million years ago

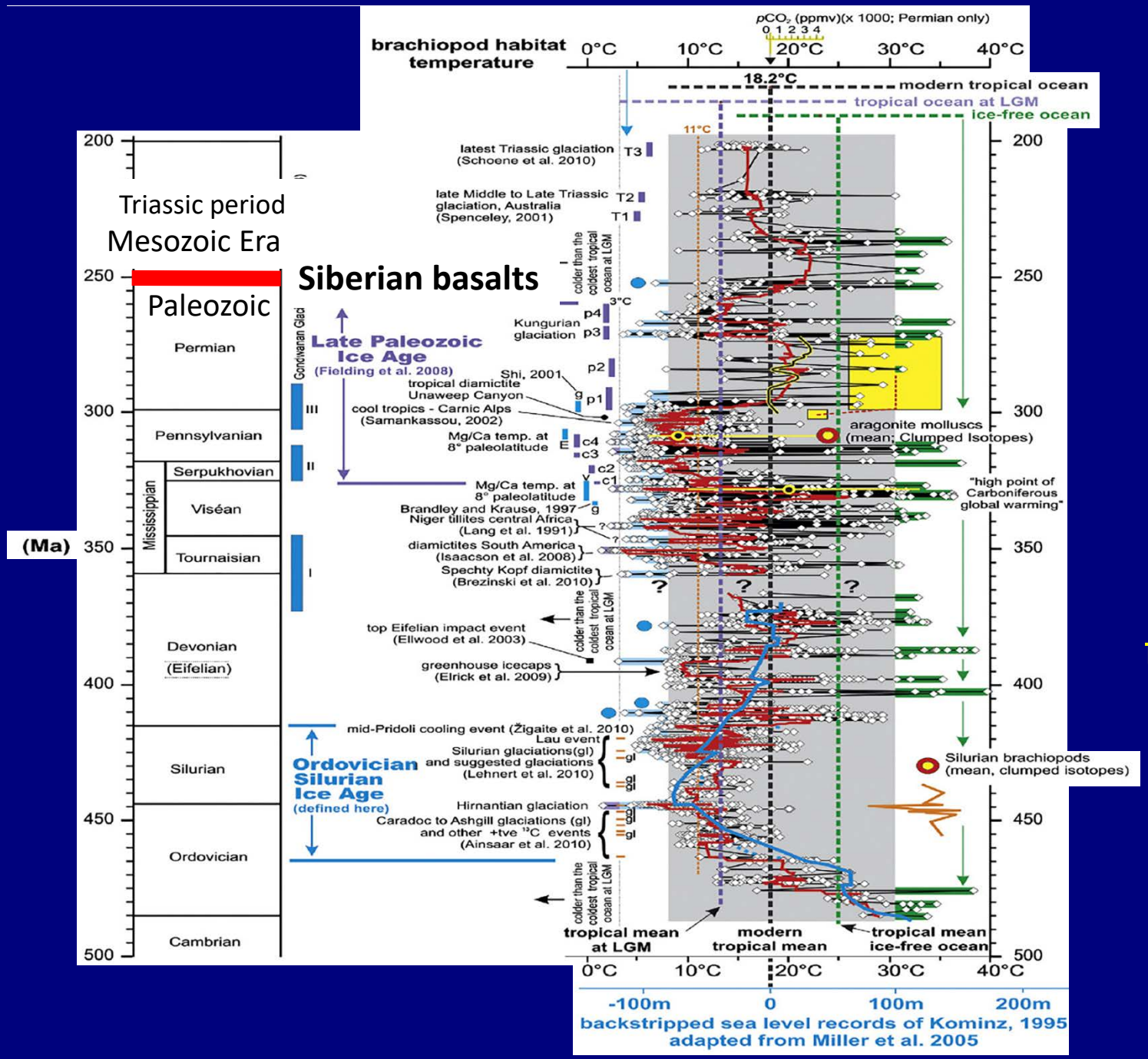
Ronald Surdam, 2013

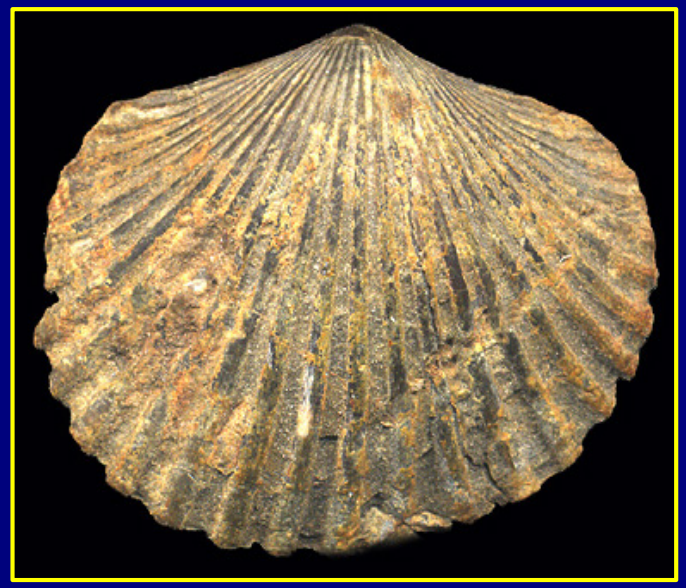
oil shale
trona
dolostone



Mud Lake
Florida
Oil shale

Lake Magadi,
Kenya, Trona

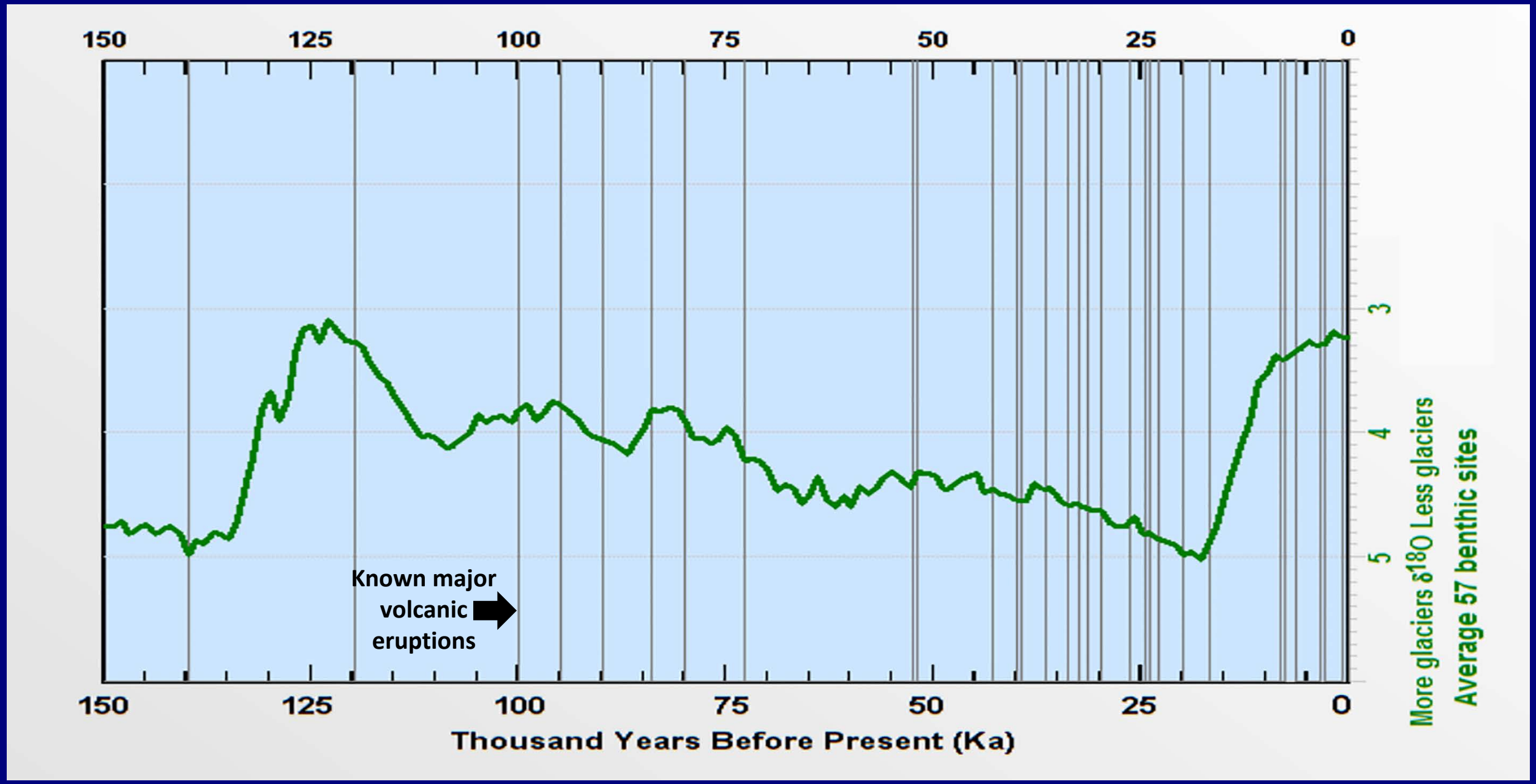




Low-latitude Ordovician to Triassic brachiopod habitat temperatures (BHTs) determined from $\delta^{18}O$[brachiopod calcite]

Peter Giles, 2012
Geological Survey of Canada

We have to be very careful about “cycles”



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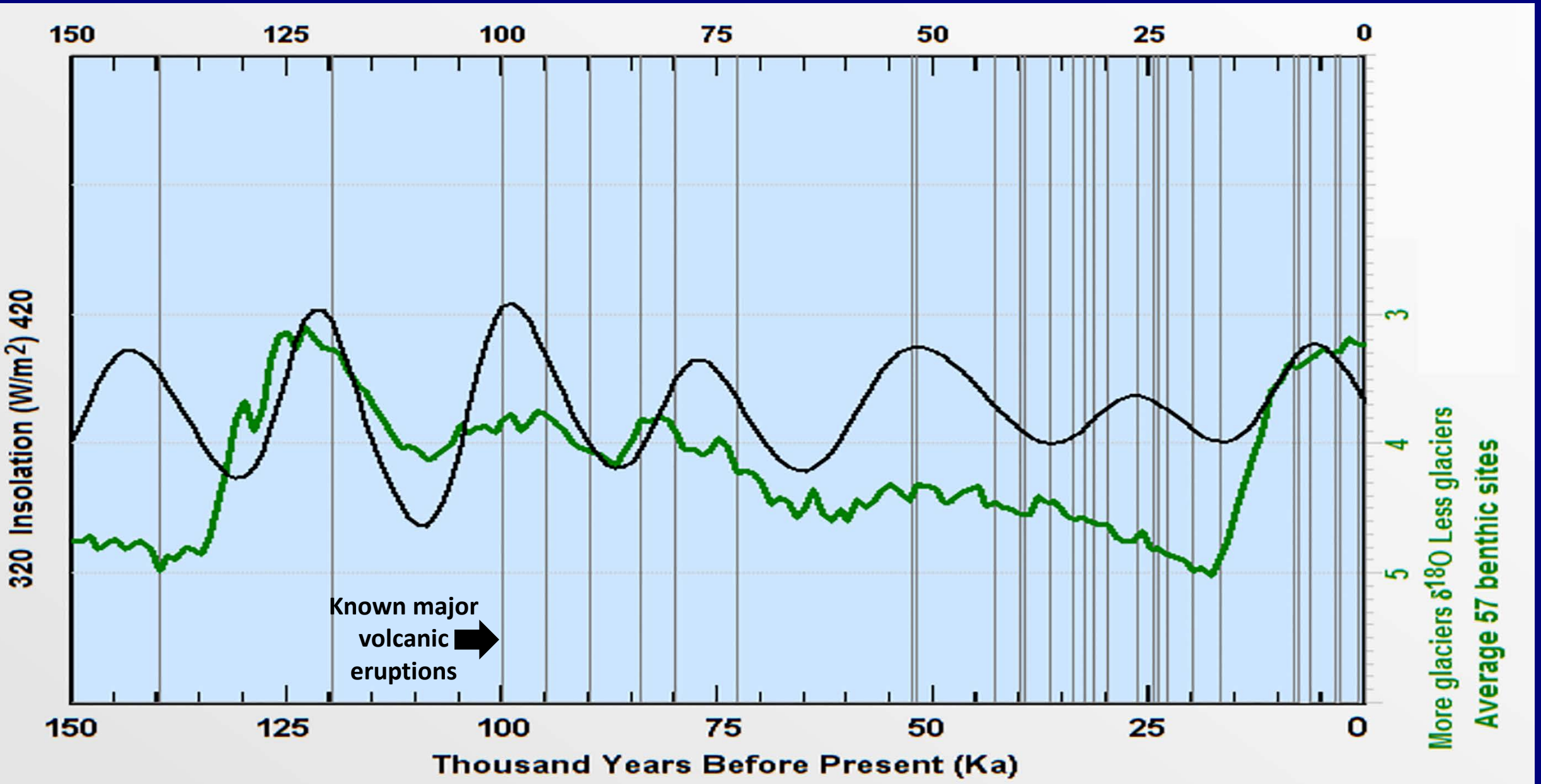
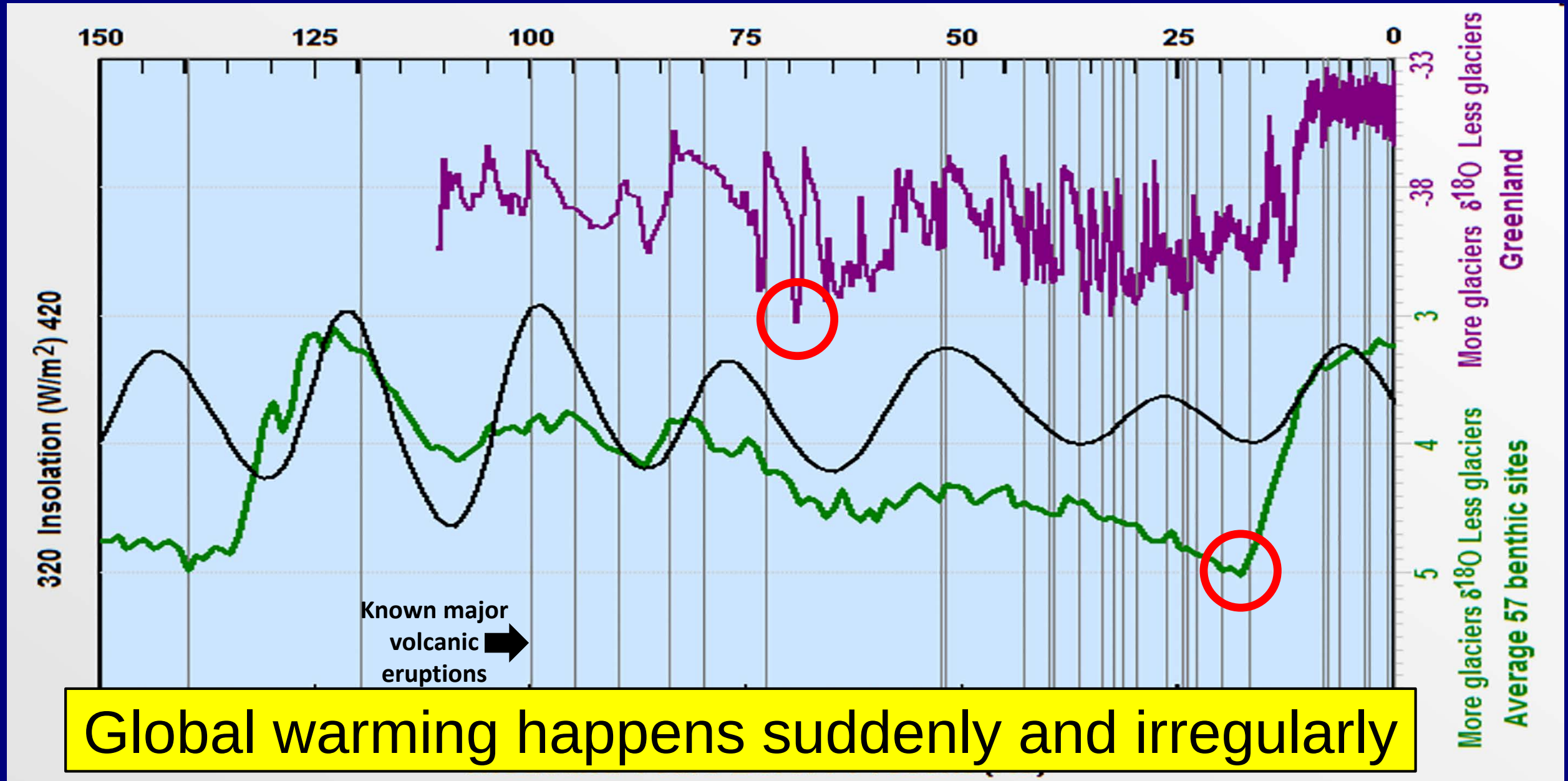


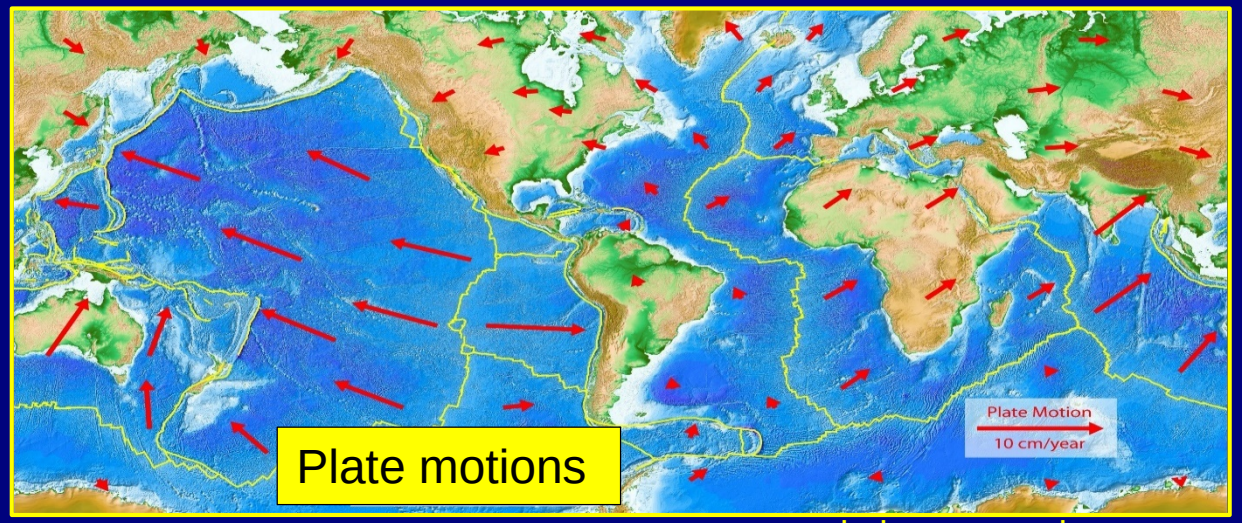
We have to be very careful about “cycles”

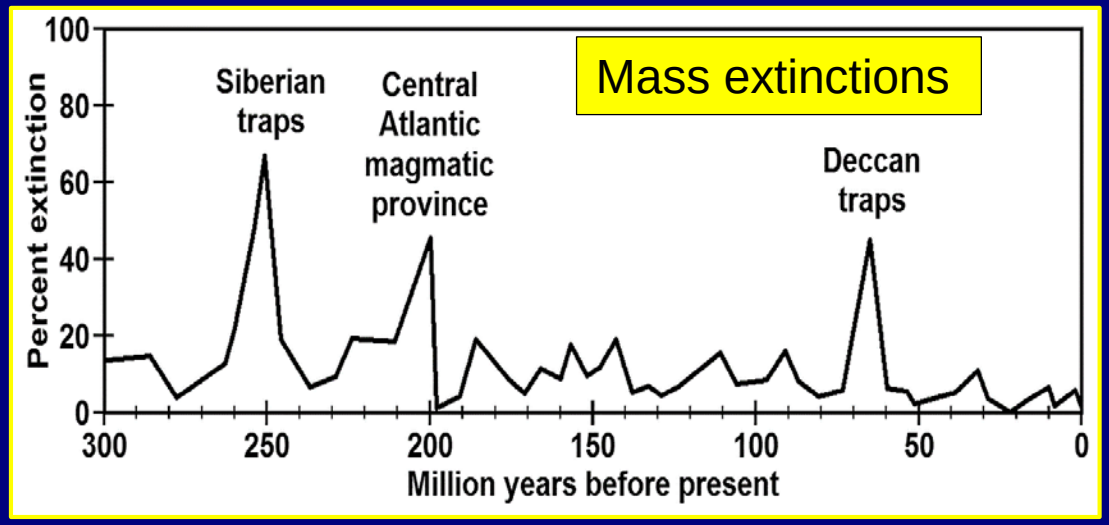


Global warming happens suddenly and irregularly

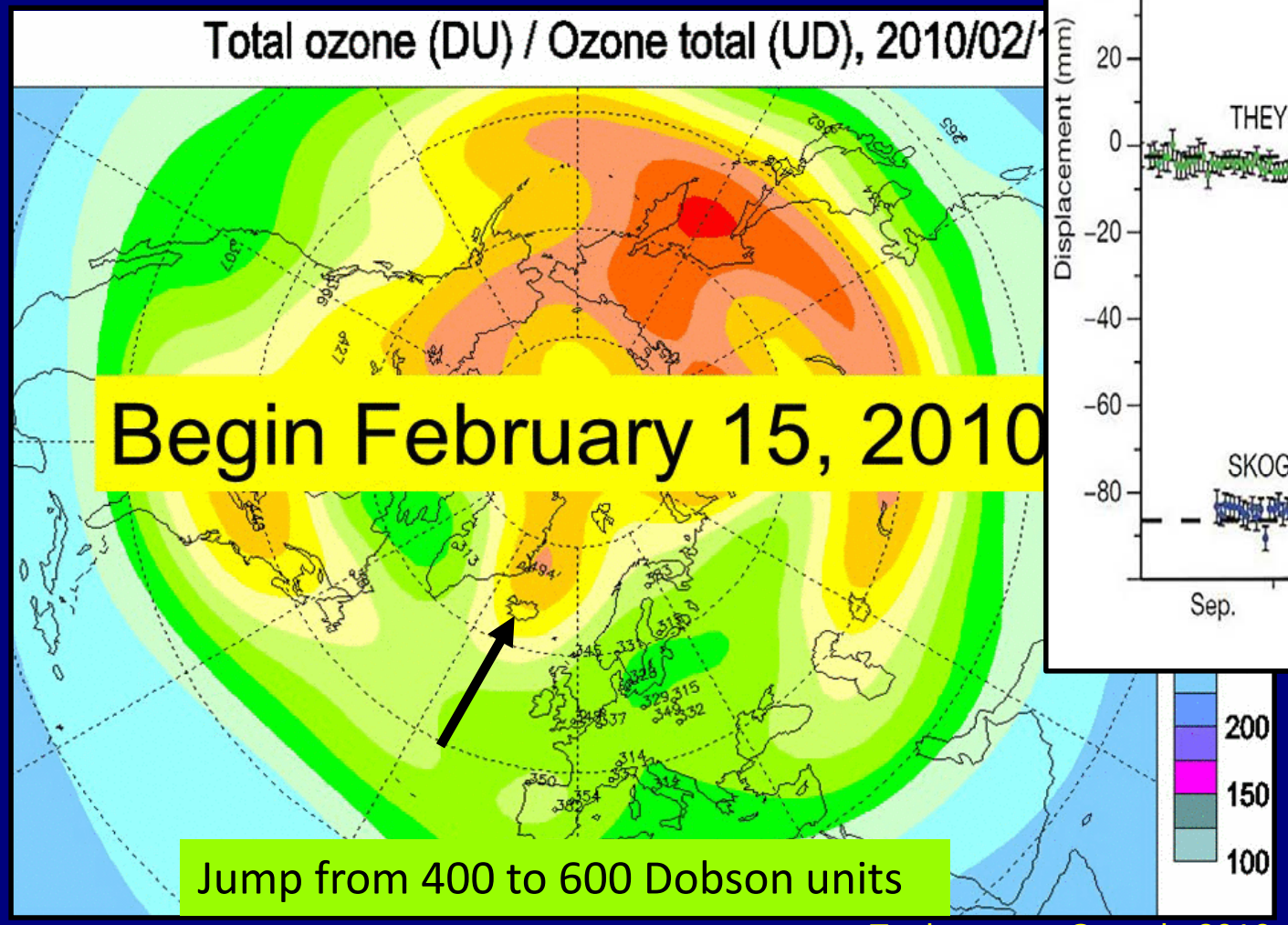
Volcanoes Rule

The balance between sudden explosive volcanic eruptions and long periods of effusive volcanic extrusions driven by tectonic plate motions provides the only clear explanation for why climate changes suddenly and irregularly throughout earth history, from small to gargantuan amounts.

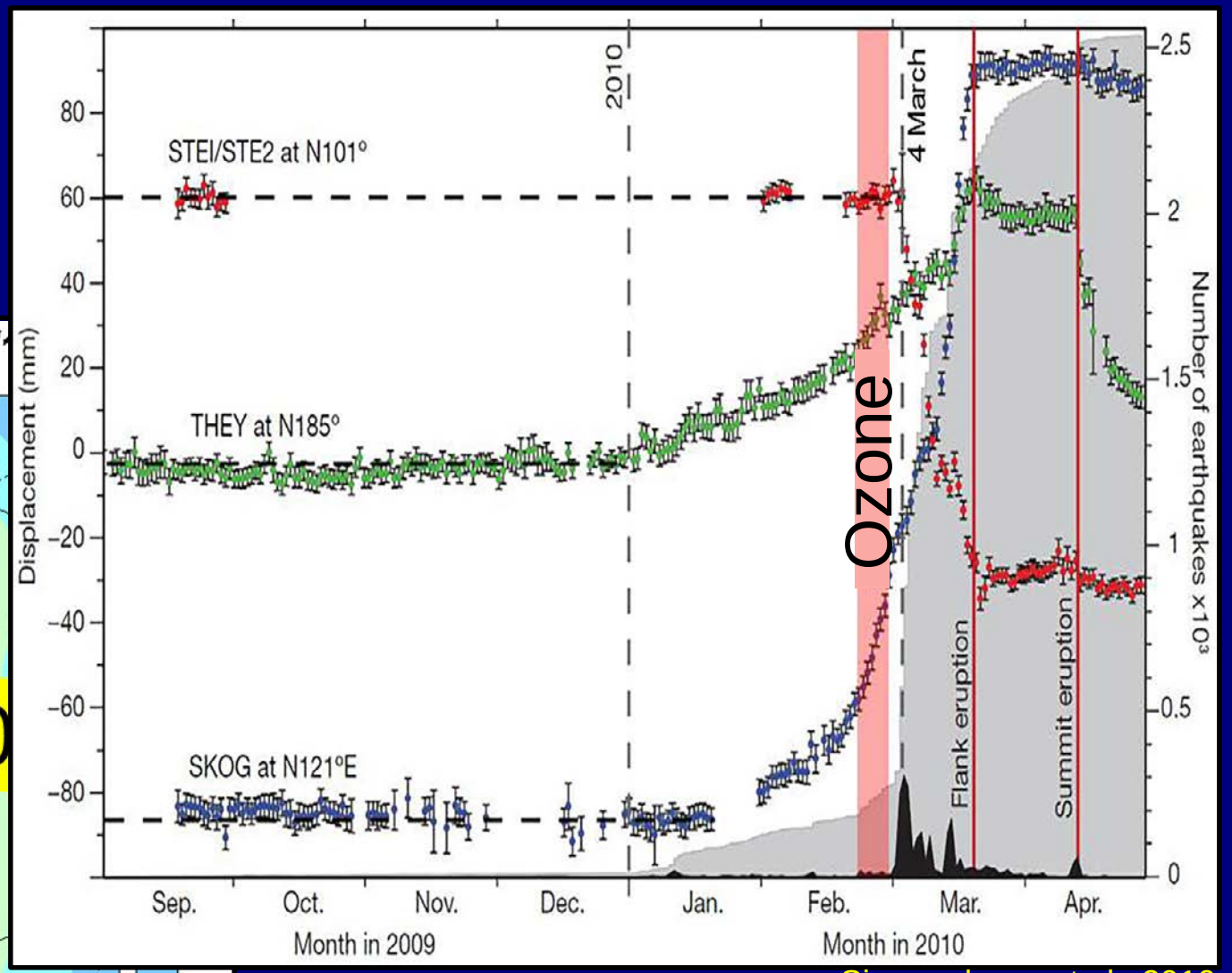




Release of ozone before the eruption of Eyjafjallajökull in Iceland



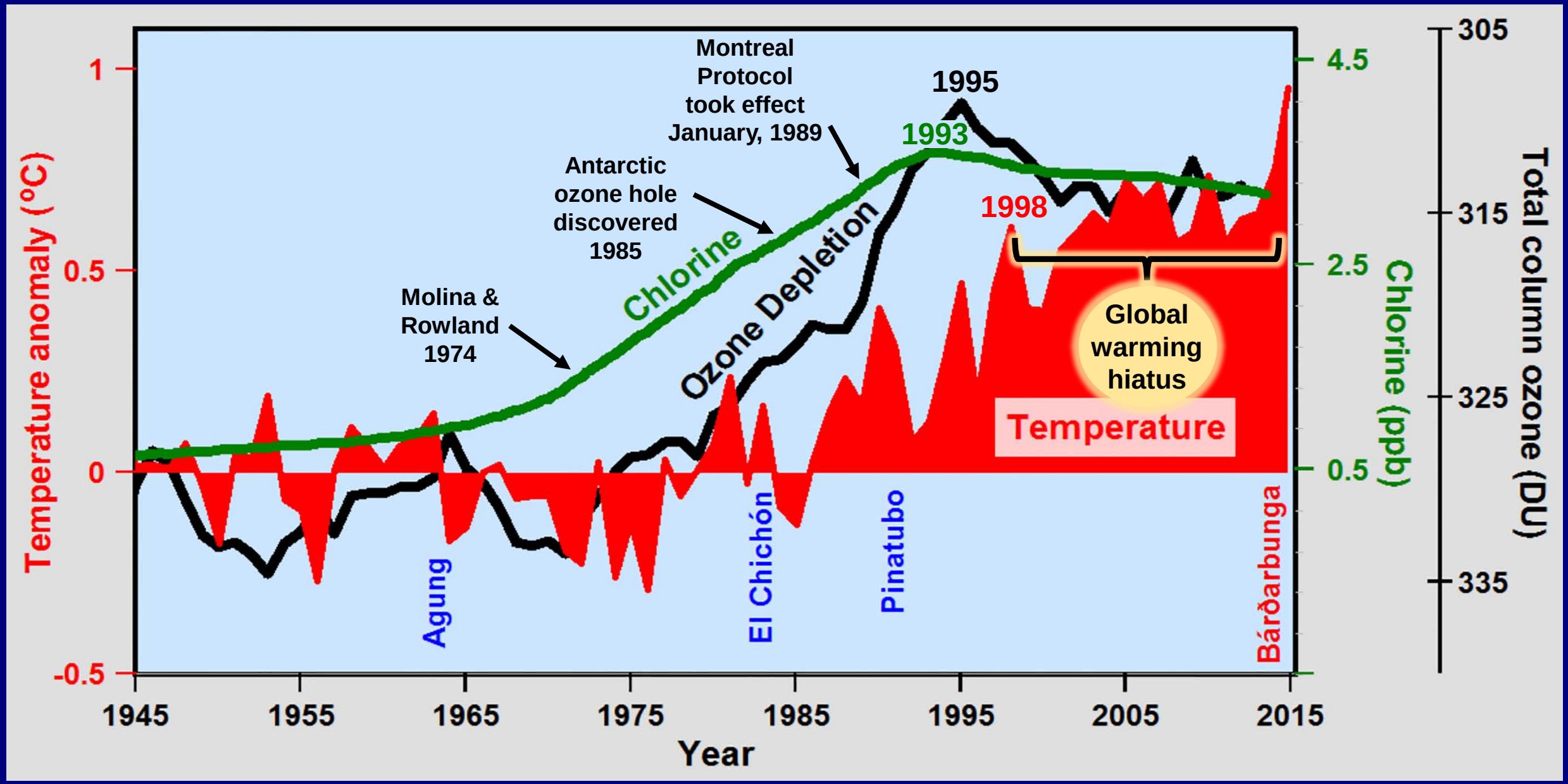
Environment Canada 2010



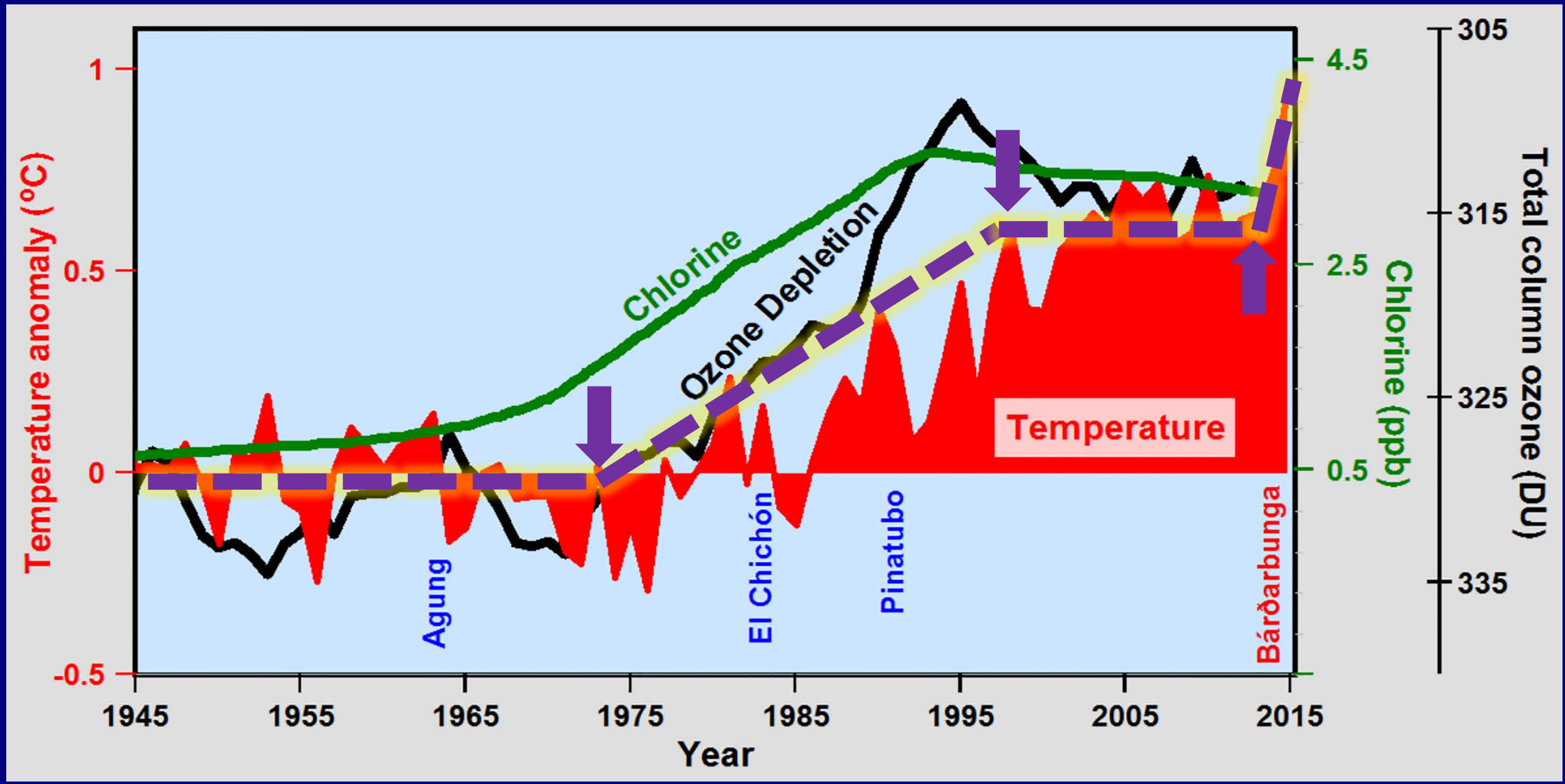
Sigmundsson et al., 2010

At the same time that fractures may have opened above a sill at a depth of 2.5 to 3.7 km

Warming from 1970 to 1998 appears caused by ozone depletion



It is hard for greenhouse-warming theory to explain inflection points

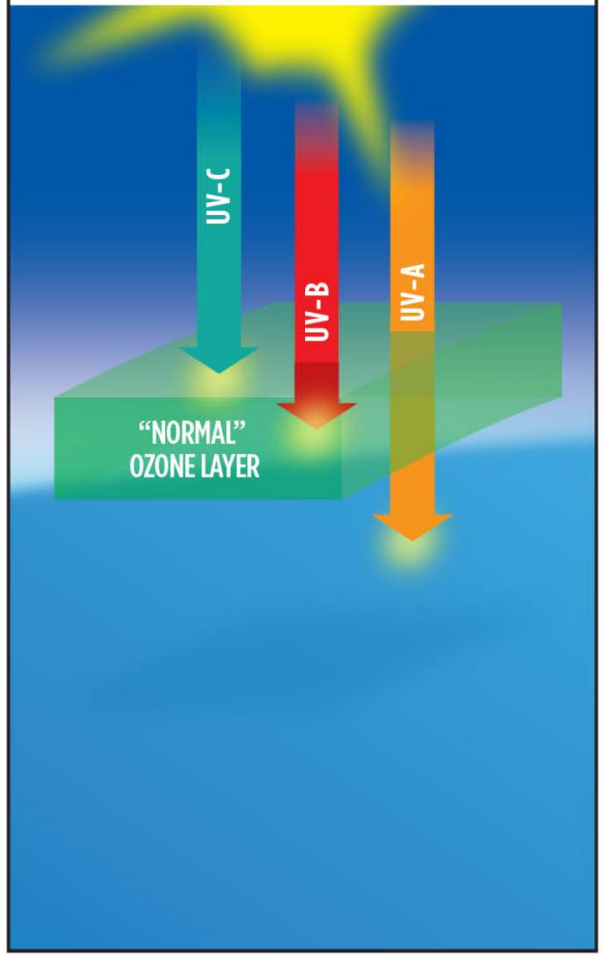


NORMAL CONDITIONS

UV-C keeps atmosphere warm

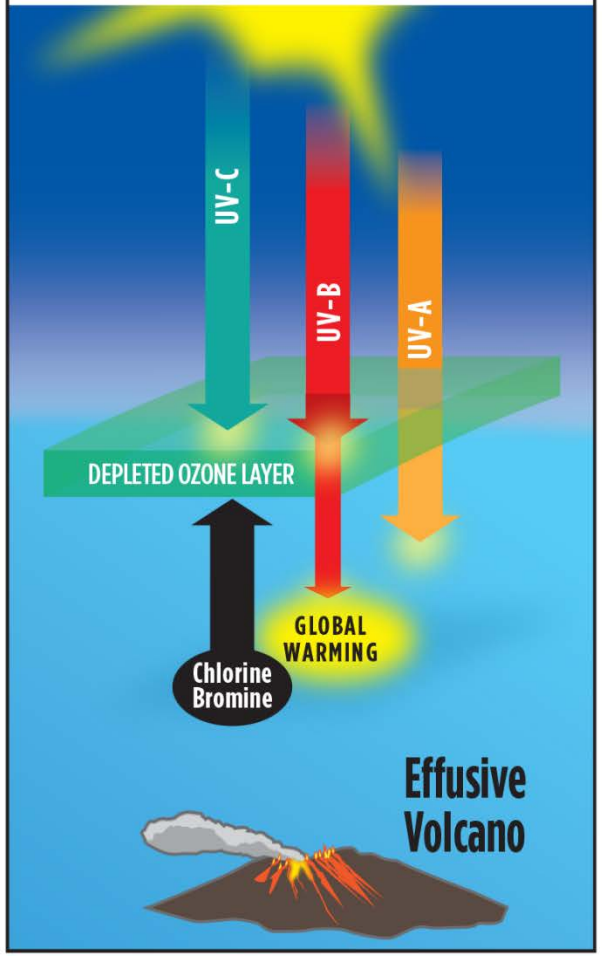
UV-B keeps ozone layer warm

UV-A & sunlight keeps Earth warm



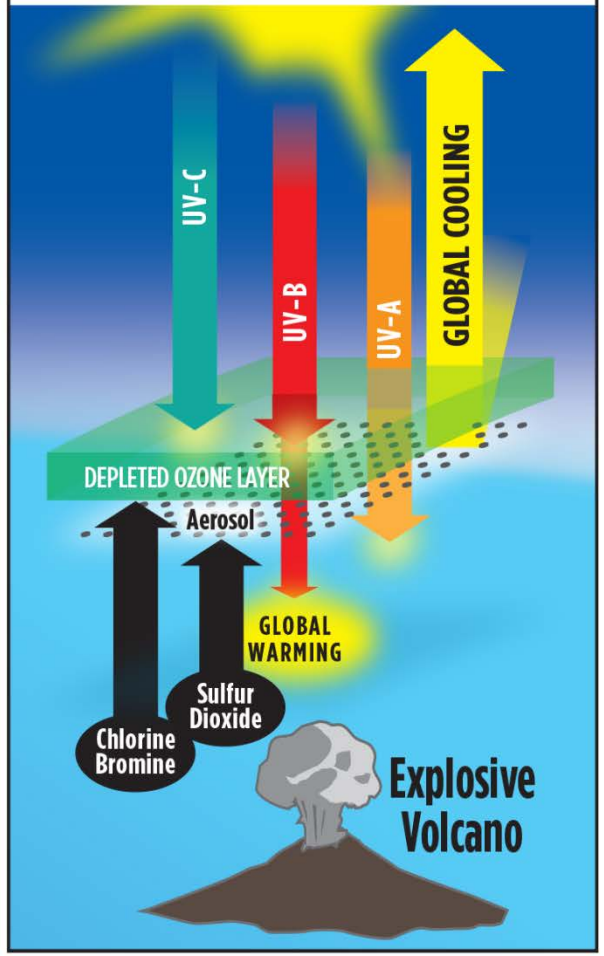
GLOBAL WARMING

Volcanoes release **Chlorine & Bromine**
depleting ozone
cooling ozone layer & warming Earth



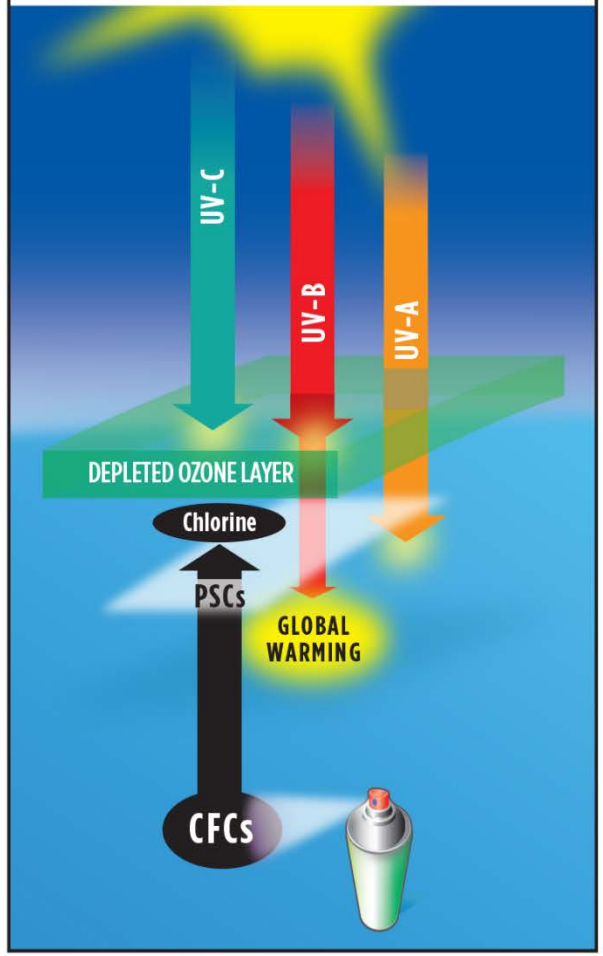
GLOBAL COOLING

Explosive volcanoes also eject
Sulfur Dioxide into stratosphere
forming aerosols that reflect & disperse
sunlight causing net cooling of Earth

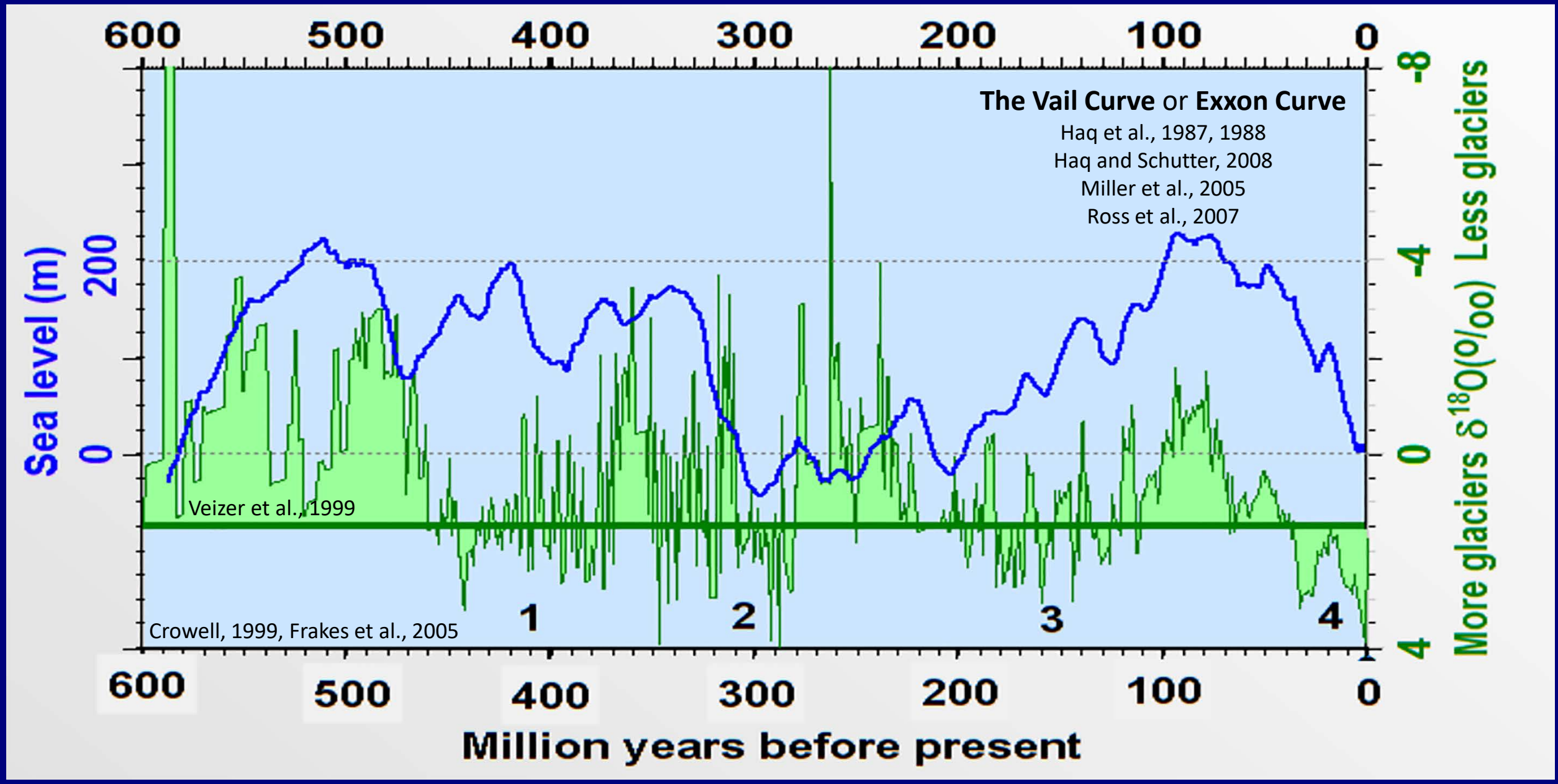


GLOBAL WARMING

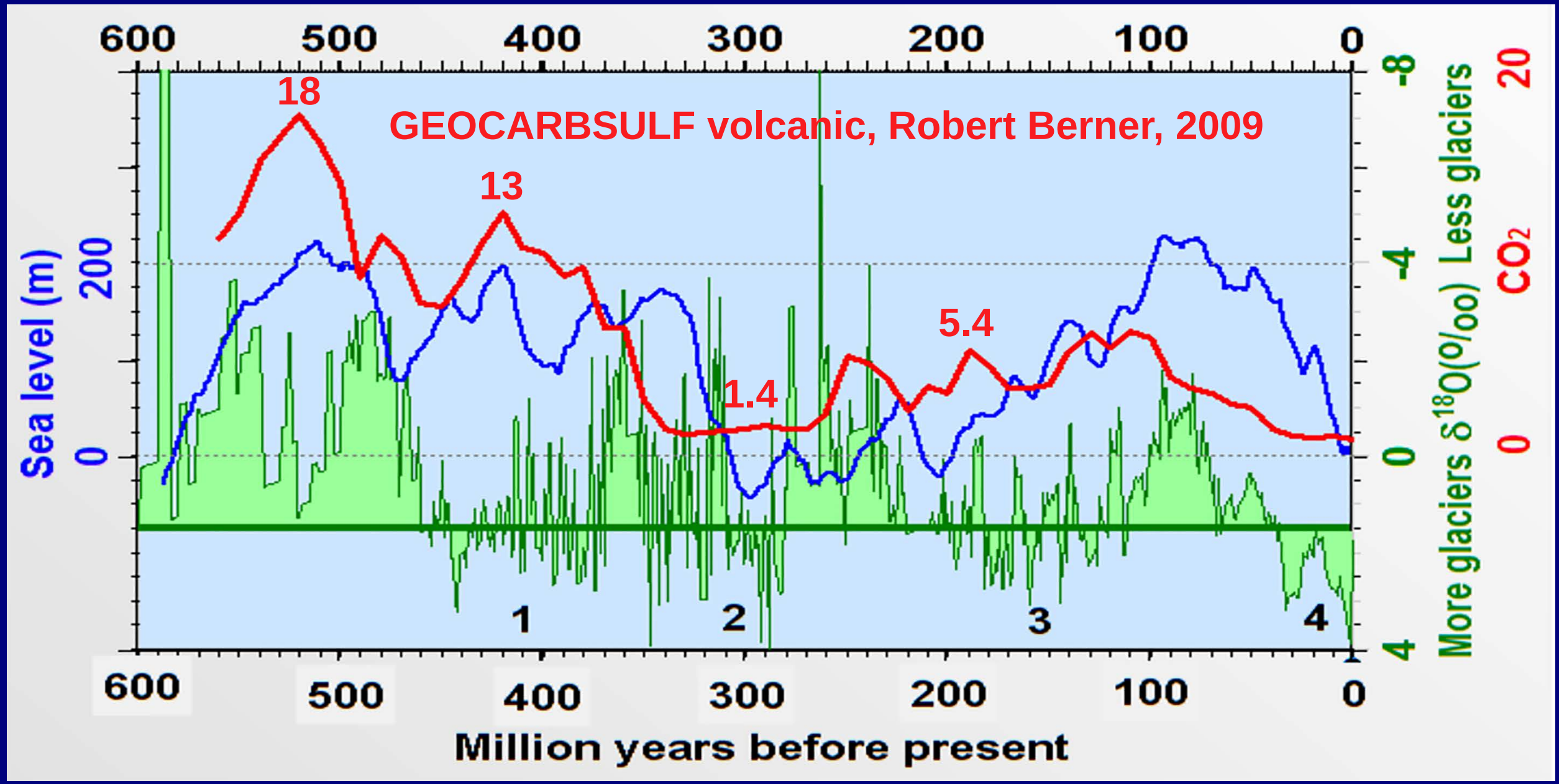
CFCs in polar stratospheric
clouds (PSCs) release chlorine
depleting ozone
cooling ozone layer & warming Earth



Global temperature, sea level, and ice ages



Global temperature, sea level, ice ages, and CO_2



Are we earth scientists absolutely sure that the hand of carbon dioxide fits the glove of reality?

It has never been shown experimentally that increasing concentrations of greenhouse gases actually cause air to warm significantly

Climate models have not predicted temperature correctly since 1998

All nations on earth are about to spend up to 10 trillion dollars to reduce greenhouse emissions

What if these expenditures have no effect on global warming?

This would be greatest economic and political crisis created by mistaken SCIENCE

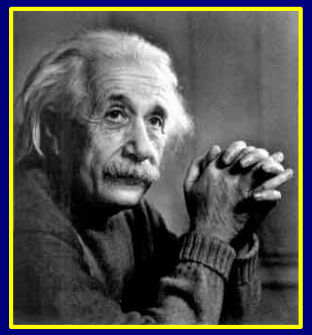
Scientists have worked hard to get political leaders to act. We have got to get this right!

Consensus is the stuff of politics, but debate is the stuff of science

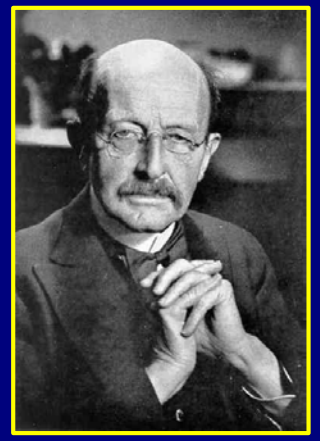
We need to bring genuine scientific debate back to climate change

Science is not done by consensus or by popular vote

“In science consensus is irrelevant. What is relevant is reproducible results. The greatest scientists in history are great precisely because they broke with the consensus.”

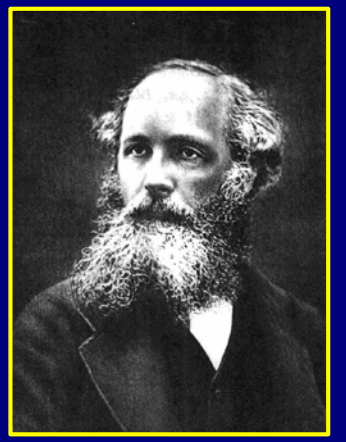


"Why one hundred? If I were wrong, one would have been enough."



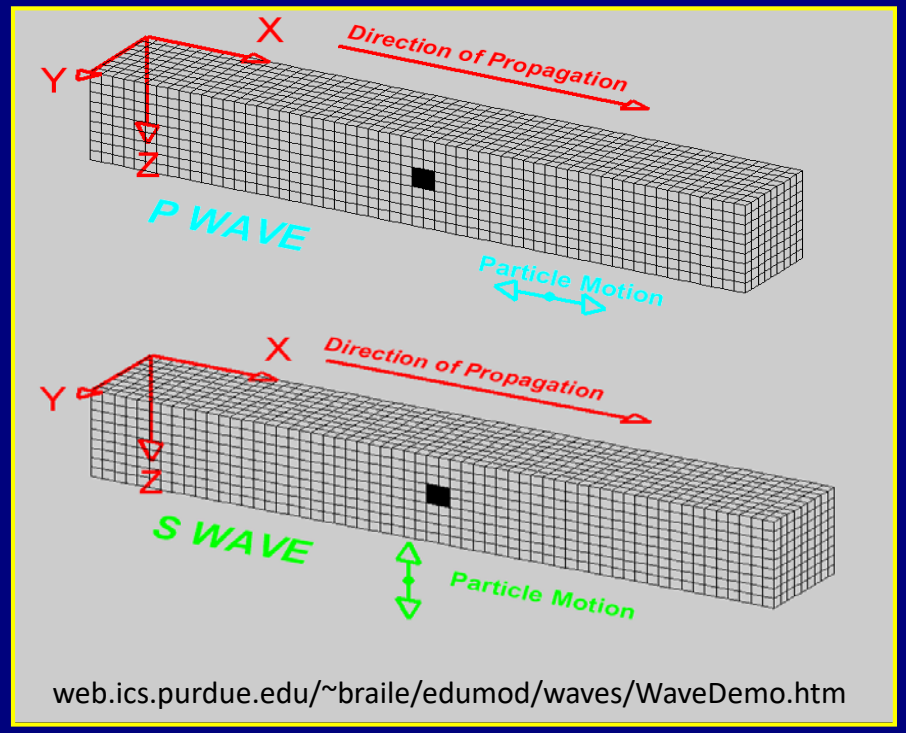
“New scientific ideas never spring from a communal body, however organized, but rather from the head of an individually inspired researcher who struggles with his problems in lonely thought and unites all his thought on one single point which is his whole world for the moment.”

The problem traces back to an assumption made in the 1850s by James Clerk Maxwell, the God of electromagnetism



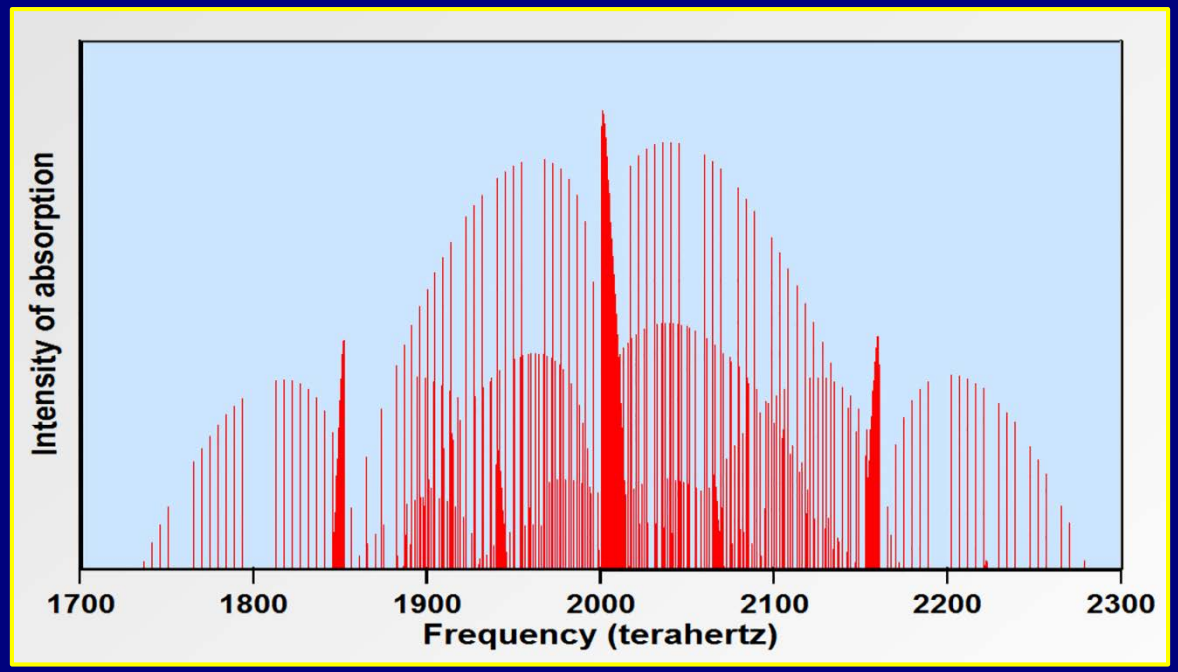
Natural philosophers and scientists have been arguing for 2500 years whether radiation travel as waves, particles, or wave-particle duality

Radiation cannot physically travel as waves

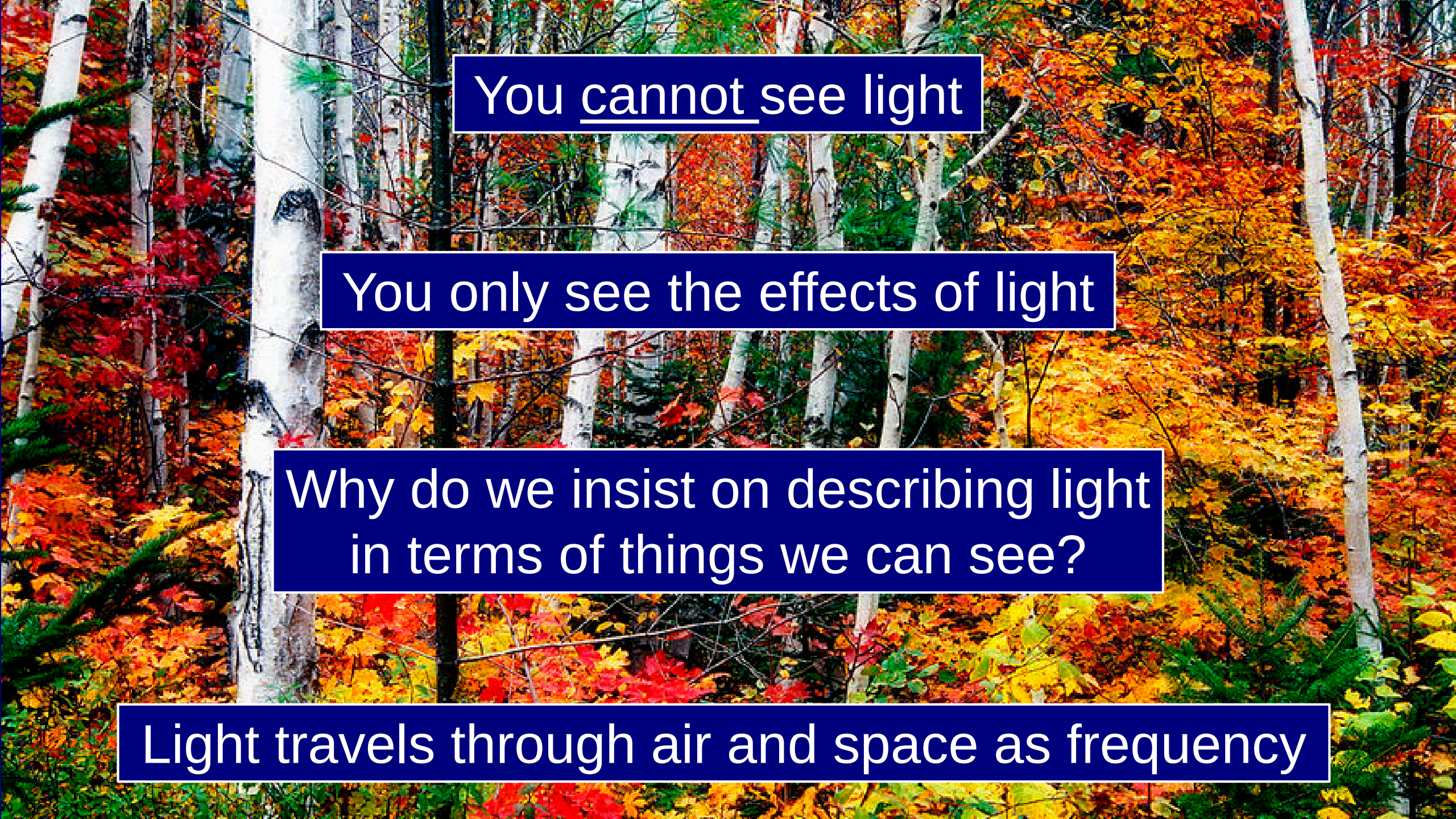


There is no luminiferous ether

Radiation cannot physically travel as particles



Energy absorbed is determined by resonant frequencies of the bonds holding the molecule together


You cannot see light
You only see the effects of light
Why do we insist on describing light in terms of things we can see?
Light travels through air and space as frequency

Thermal energy in radiation travels as frequency of oscillation

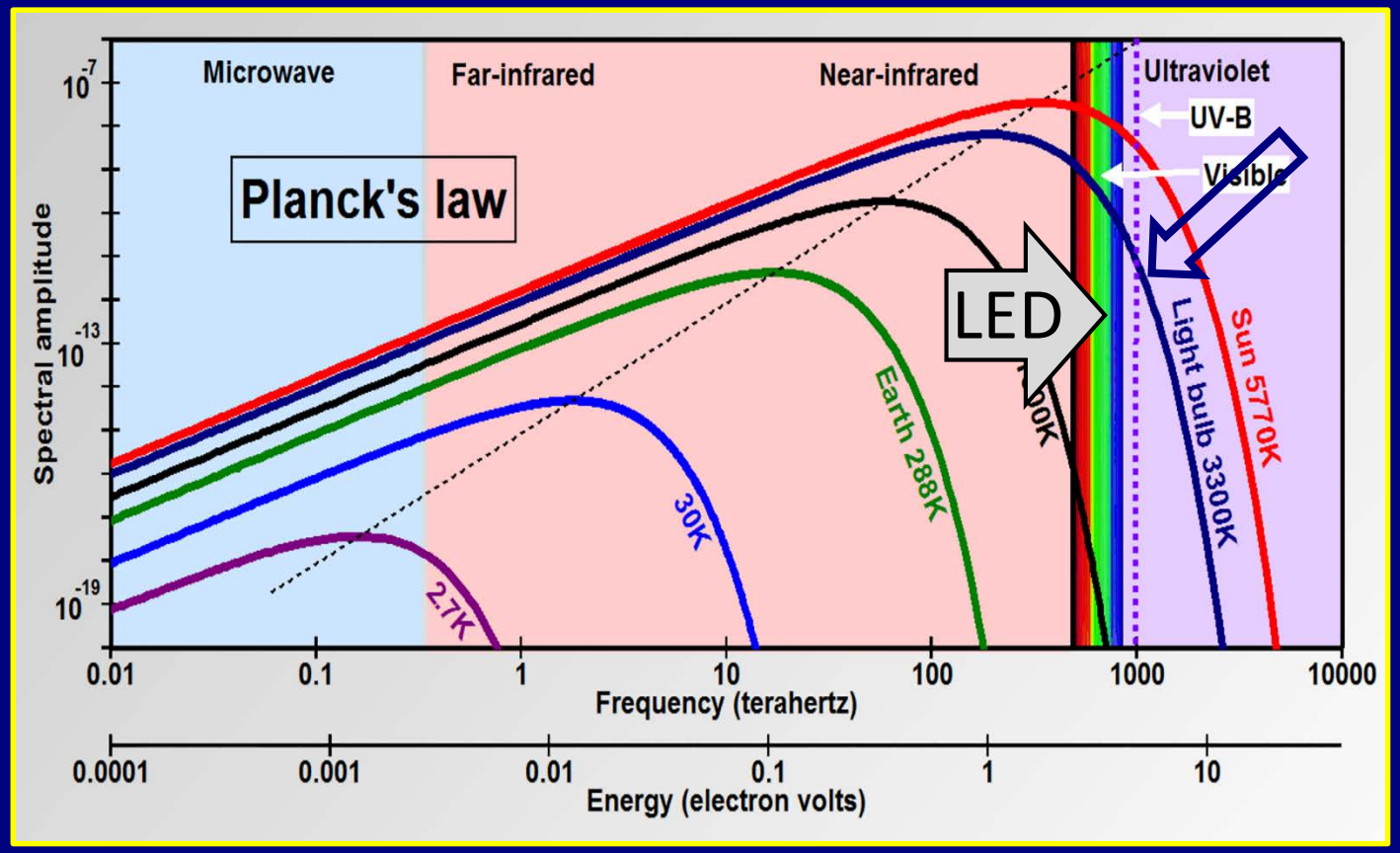
Thermal energy is a broad range of frequencies of

Radiation from Earth cannot physically warm Earth

The amplitudes at all frequencies are not high enough

This would be the thermodynamic equivalent of a perpetual motion machine!

The hotter the body of matter, the broader the range of frequencies radiated

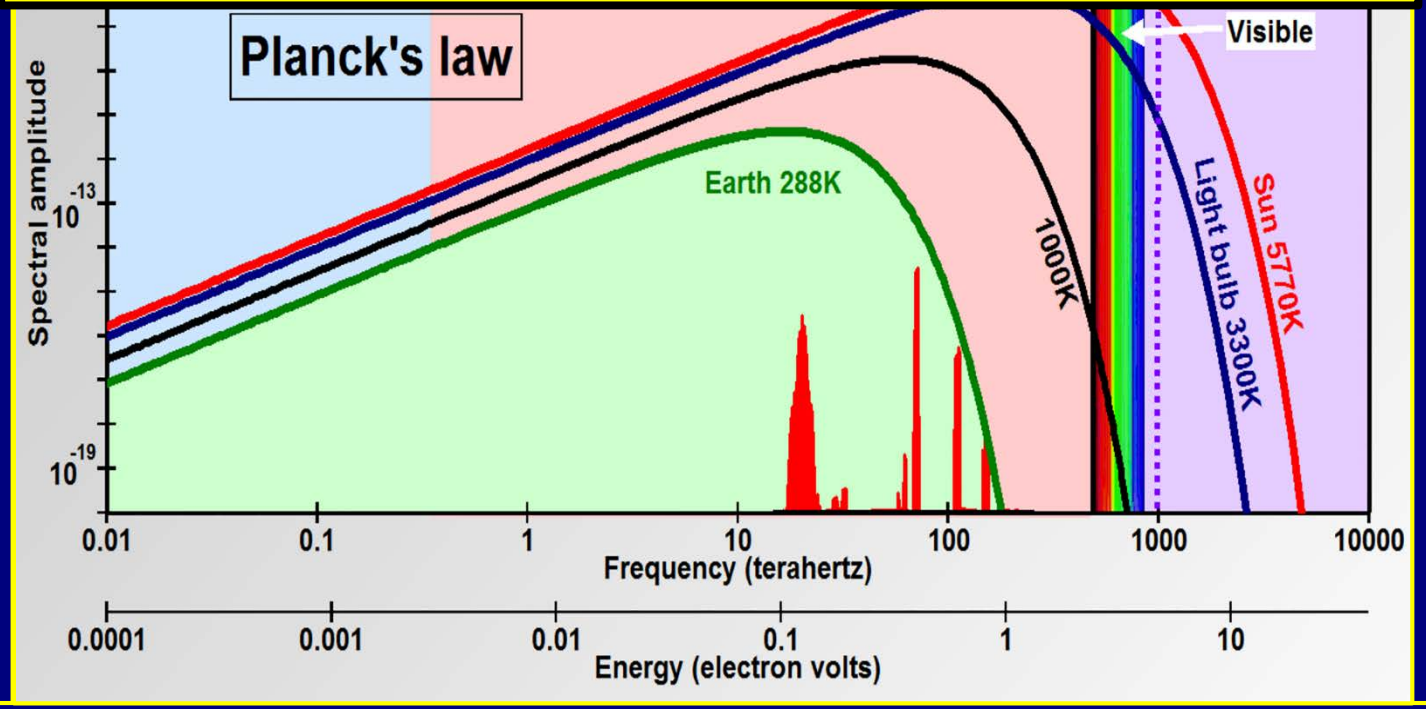


To increase the temperature of matter, you must increase the amplitudes of oscillation at every frequency and especially at the highest frequencies

Thermal energy in radiation travels as frequency of oscillation

Thermal energy is a broad range of frequencies of oscillation of all the bonds that hold matter together

Greenhouse gases simply do not absorb enough heat to warm Earth



Radiation from Earth cannot physically warm Earth

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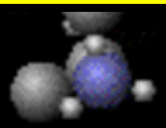
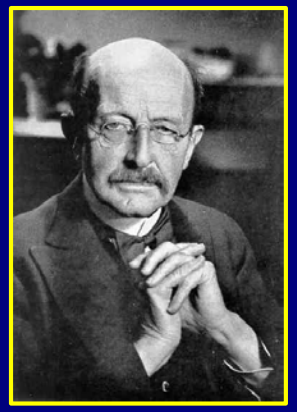


Trillions of cycles per second

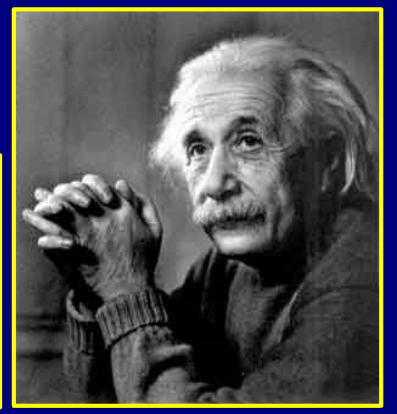
CO_2 makes up 0.04% of the gas molecules and each molecule absorbs only a limited number of frequencies

The Planck-Einstein Relation



In 1900, Max Planck postulated that for energy in radiation $E=h\nu$

In 1905, Albert Einstein studying photoelectric effect, suggested that $E=h\nu$ was a light quantum

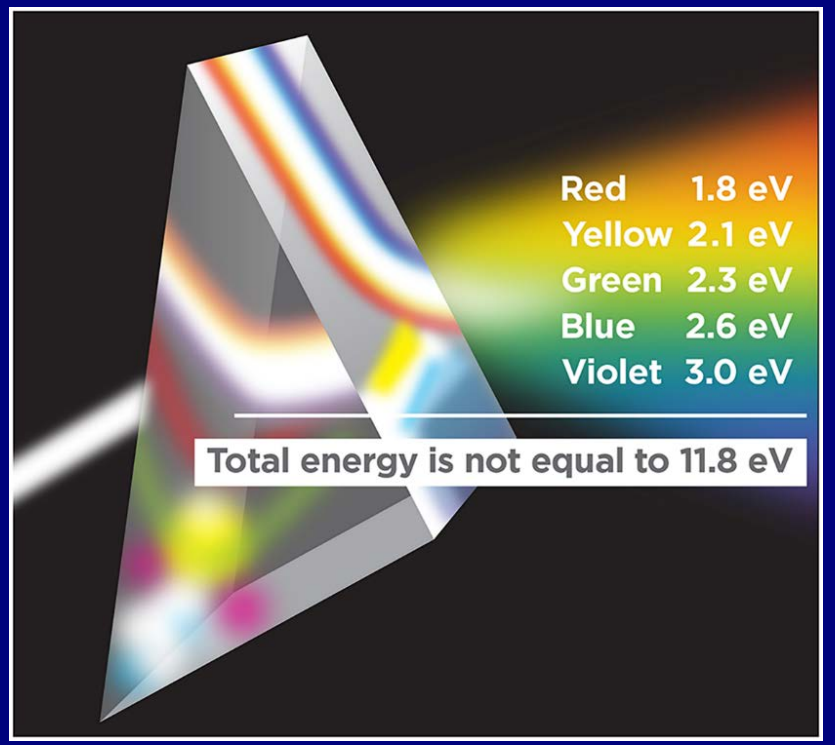


Frequency is a continuum.
Therefore, since $E=h\nu$ then energy must be a continuum.

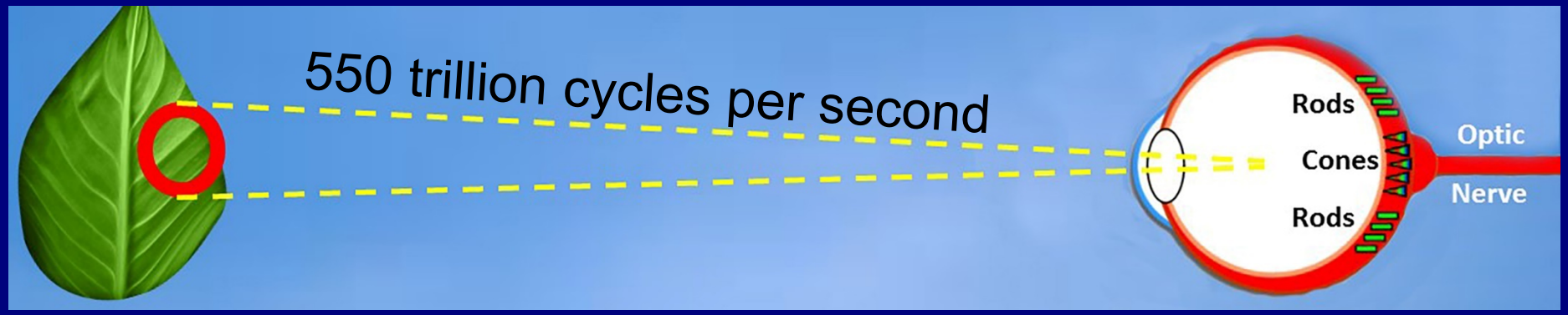
Radiant energy is not quantized until it interacts with matter.

You cannot say $E=h\nu_{red} + h\nu_{green} + h\nu_{blue} + \ldots$

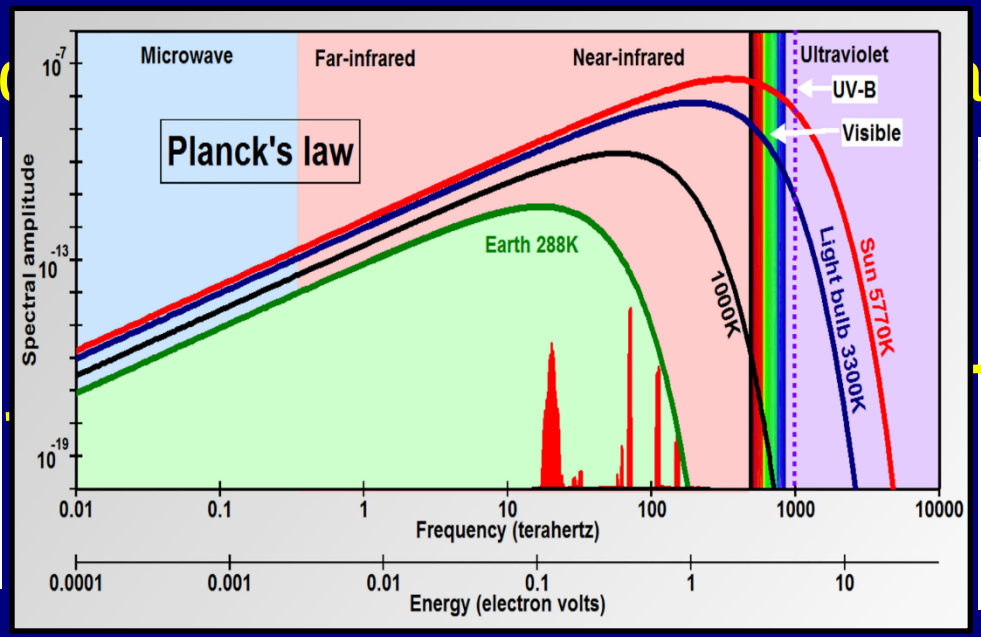
Furthermore, frequency is a continuum.
If $E=h\nu$, then energy must be a continuum.



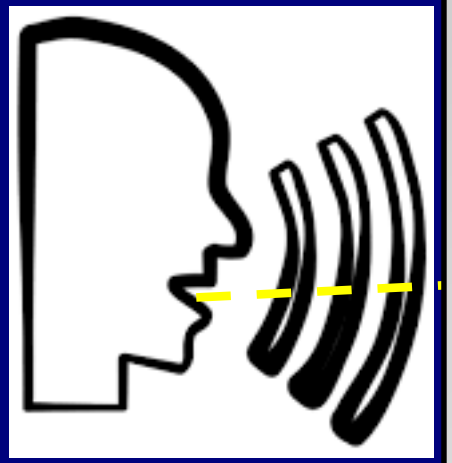
We cannot see frequency, but it is frequency that allows us to see

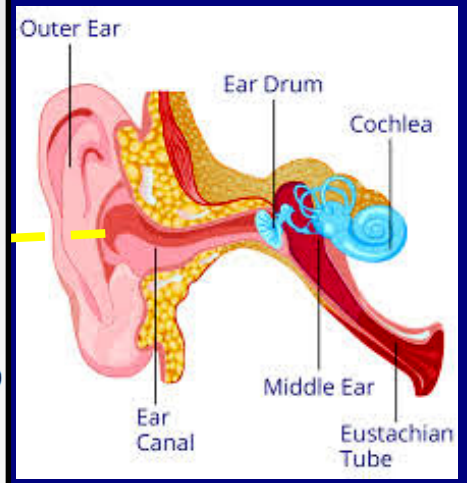


We cannot see fre



t allows us to hear

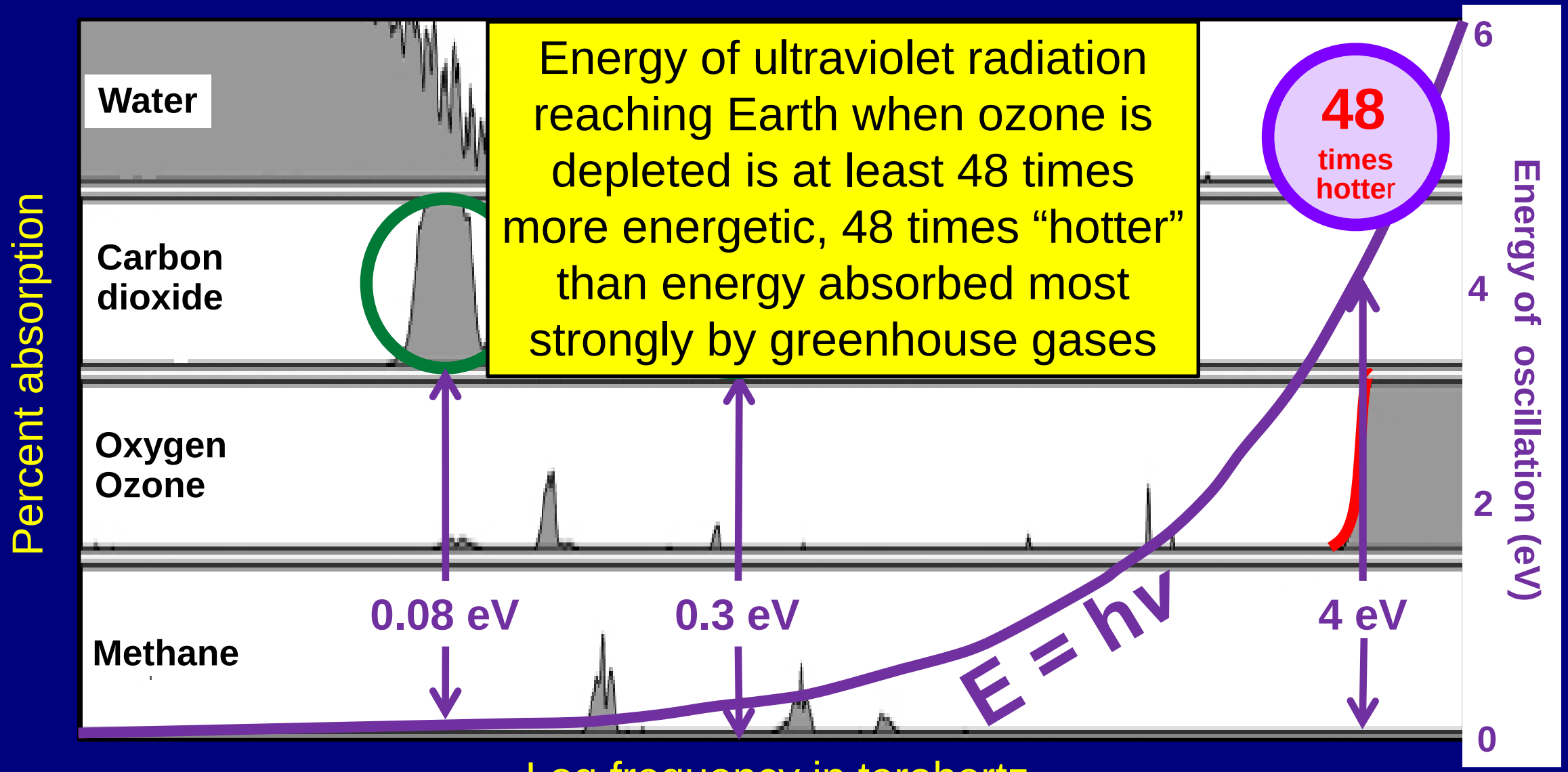




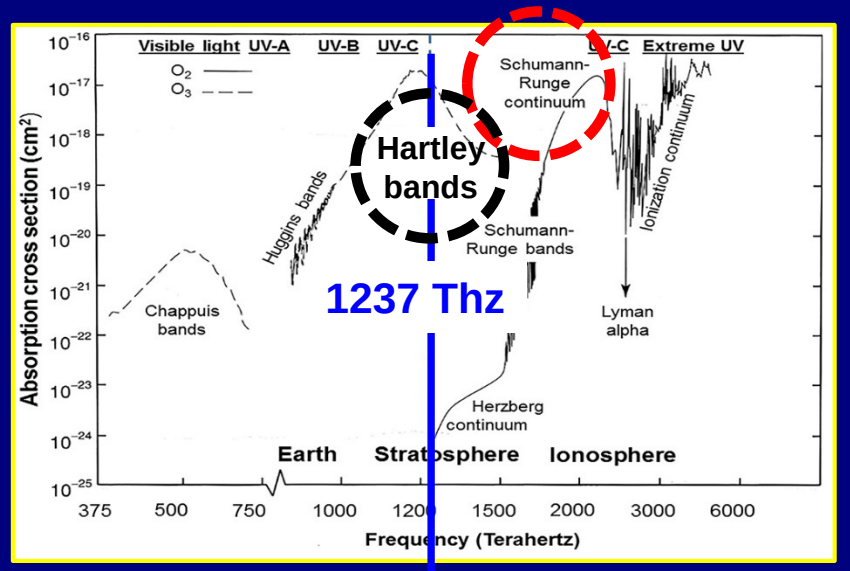
What we perceive as temperature is a broad spectrum of frequencies

We interact with each other and with the world via frequencies

How should we calculate radiant thermal energy?



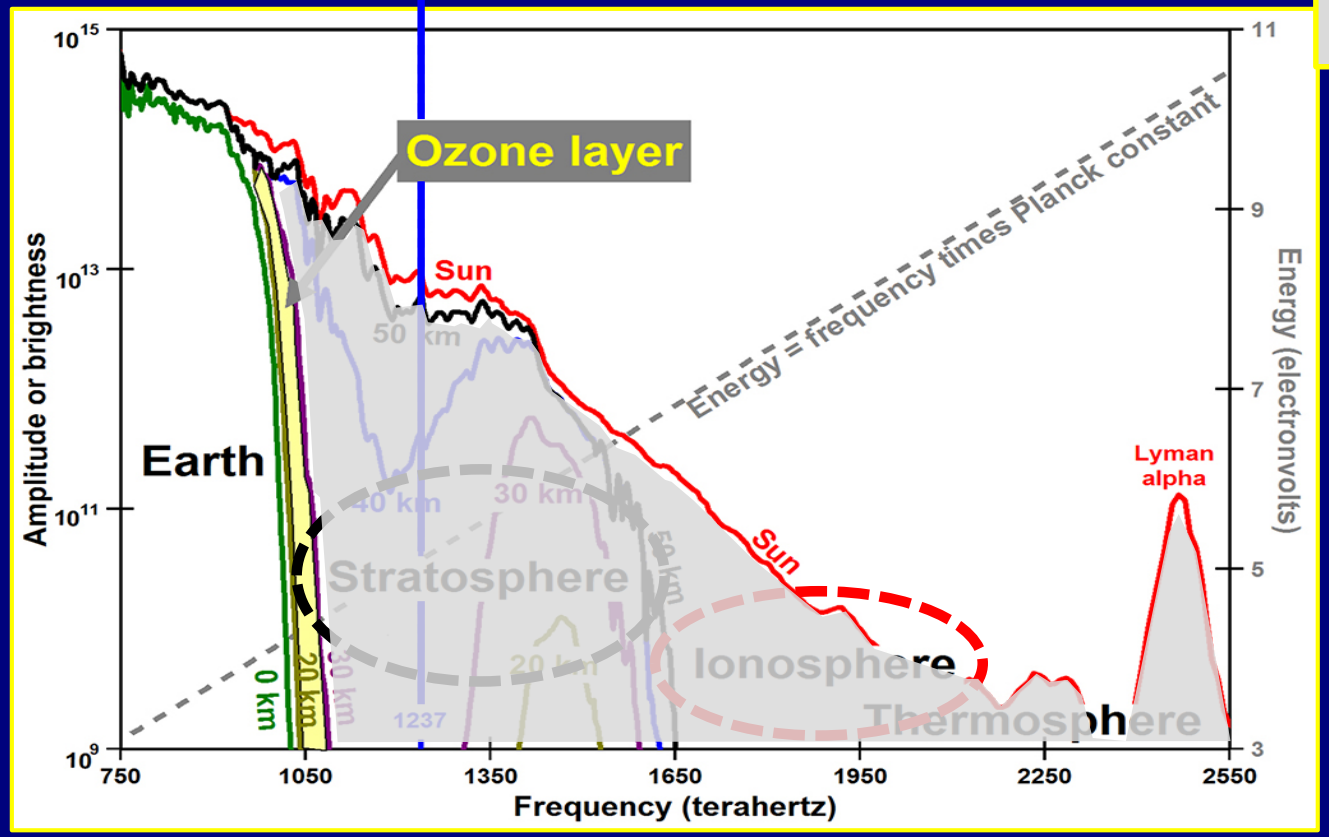
Thinking in terms of frequency, we can now understand the structure of Earth's atmosphere

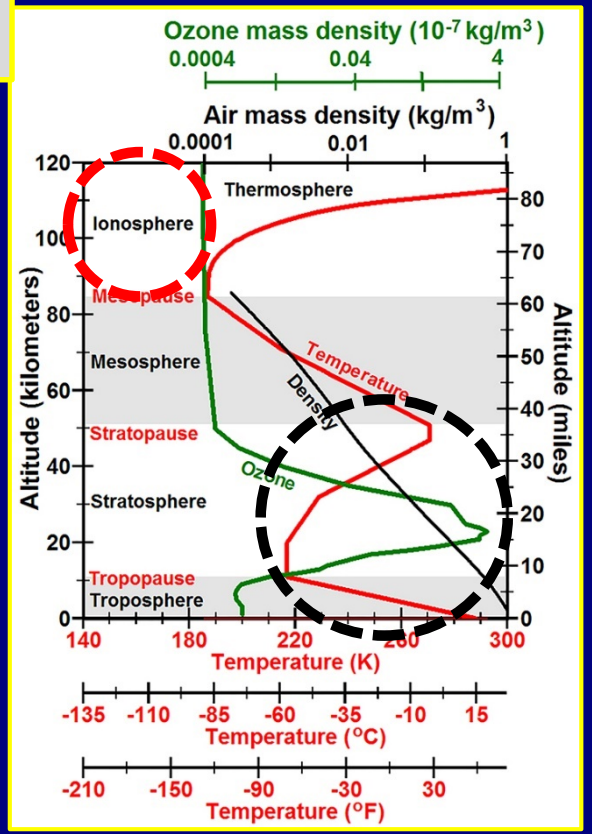


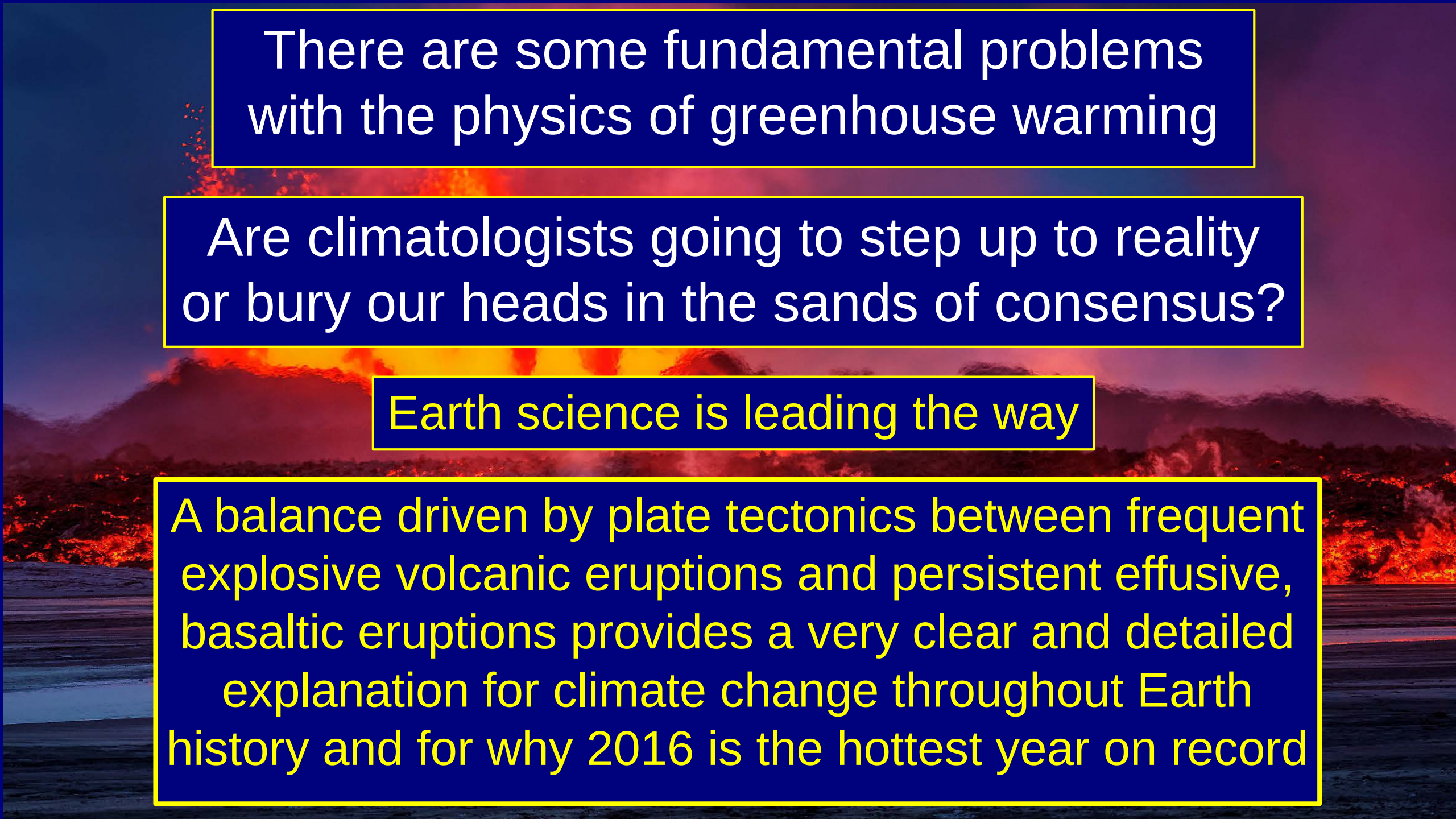
Schumann-Runge continuum forms ionosphere

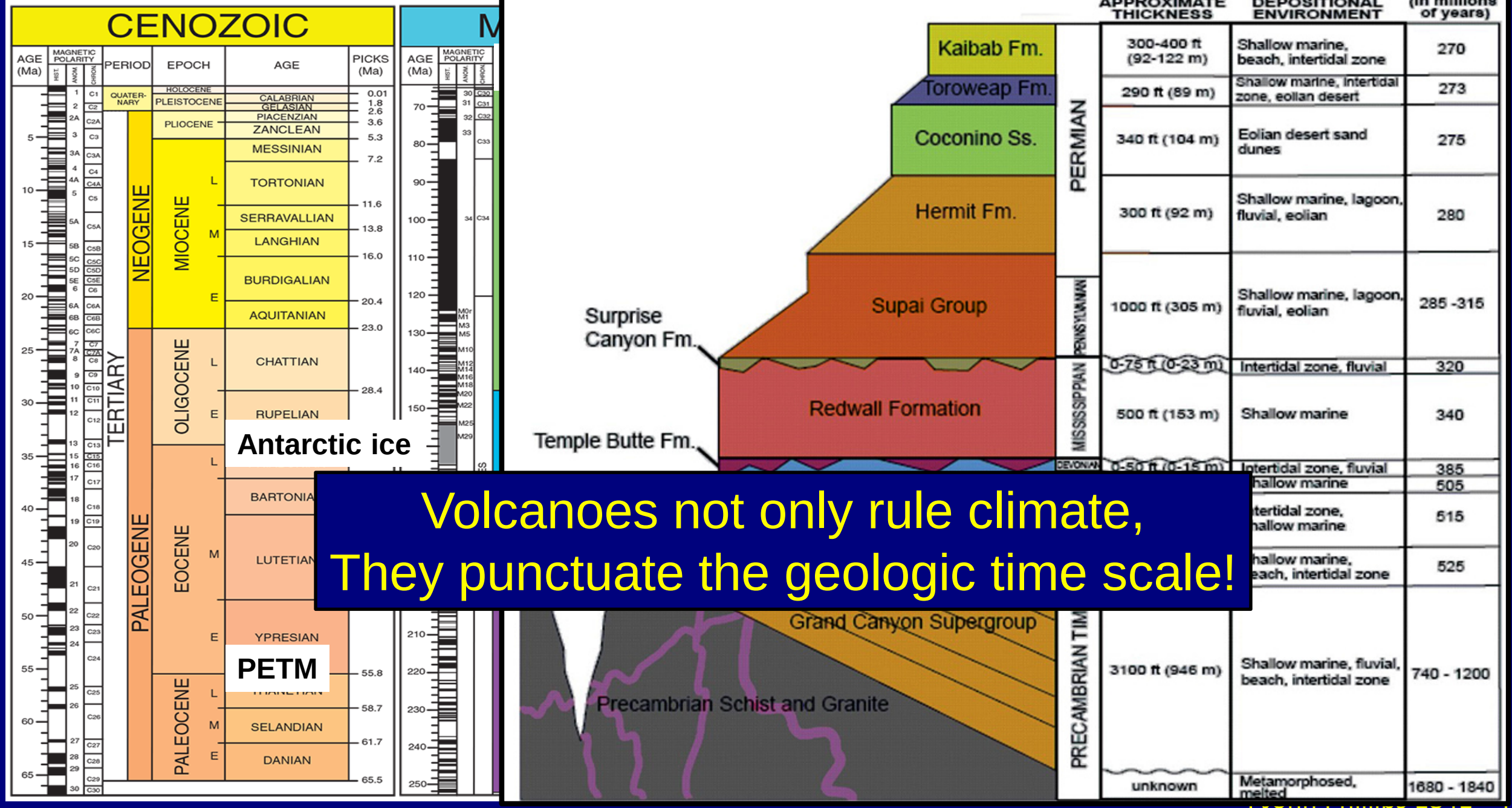
Hartley bands warm the stratosphere

Atmospheric structure has nothing to do with waves or photons





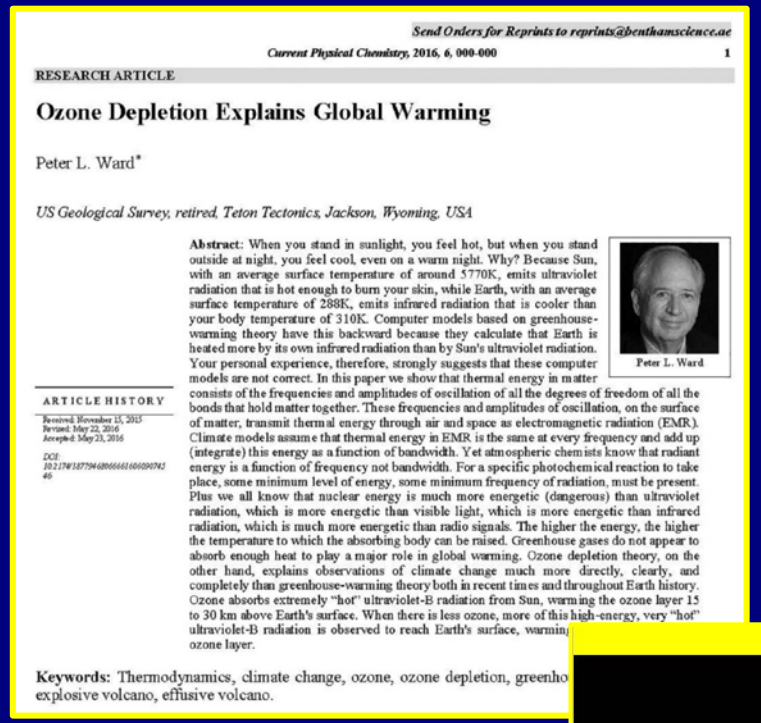

There are some fundamental problems with the physics of greenhouse warming
Are climatologists going to step up to reality or bury our heads in the sands of consensus?
Earth science is leading the way
A balance driven by plate tectonics between frequent explosive volcanic eruptions and persistent effusive, basaltic eruptions provides a very clear and detailed explanation for climate change throughout Earth history and for why 2016 is the hottest year on record



Geological Society of America Time Scale

Book

Peer-reviewed paper



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RESEARCH ARTICLE

Ozone Depletion Explains Global Warming

Peter L. Ward*

US Geological Survey, retired, Teton Tectonics, Jackson, Wyoming, USA

Abstract: When you stand in sunlight, you feel hot, but when you stand outside at night, you feel cool, even on a warm night. Why? Because Sun, with an average surface temperature of around 5770K, emits ultraviolet radiation that is hot enough to burn your skin, while Earth, with an average surface temperature of 288K, emits infrared radiation that is cooler than your body temperature of 310K. Computer models based on greenhouse-warming theory have this backward because they calculate that Earth is heated more by its own infrared radiation than by Sun's ultraviolet radiation. Your personal experience, therefore, strongly suggests that these computer models are not correct. In this paper we show that thermal energy in matter consists of the frequencies and amplitudes of oscillation of all the degrees of freedom of all the bonds that hold matter together. These frequencies and amplitudes of oscillation, on the surface of matter, transmit thermal energy through air and space as electromagnetic radiation (EMR). Climate models assume that thermal energy in EMR is the same at every frequency and add up (integrate) this energy as a function of bandwidth. Yet atmospheric chemists know that radiant energy is a function of frequency not bandwidth. For a specific photochemical reaction to take place, some minimum level of energy, some minimum frequency of radiation, must be present. Plus we all know that nuclear energy is much more energetic (dangerous) than ultraviolet radiation, which is more energetic than visible light, which is more energetic than infrared radiation, which is much more energetic than radio signals. The higher the energy, the higher the temperature to which the absorbing body can be raised. Greenhouse gases do not appear to absorb enough heat to play a major role in global warming. Ozone depletion theory, on the other hand, explains observations of climate change much more directly, clearly, and completely than greenhouse-warming theory both in recent times and throughout Earth history. Ozone absorbs extremely "hot" ultraviolet-B radiation from Sun, warming the ozone layer 15 to 30 km above Earth's surface. When there is less ozone, more of this high-energy, very "hot" ultraviolet-B radiation is observed to reach Earth's surface, warmin[g] ozone layer.

Peter L. Ward

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