Do Submarine Volcanoes Change Climate?

Presented by: Eur Ing Brian RL Catt CEng, CPhys, MBA

Abstract

I approach this as a physicist and engineer, not as a geologist. I apply published academic geophysics, and am advised by global subject experts. I follow deterministic scientific method. So I use only well reported data and basic physical laws and avoid consensual science. So its easy to check for yourself. And I hope you will.

My talk is especially for you, its a one off that attempts to explain the natural cyclic nature and the likely variable warming of the World's oceans by submarine volcanoes, poorly considered or ignored by "consensual science".

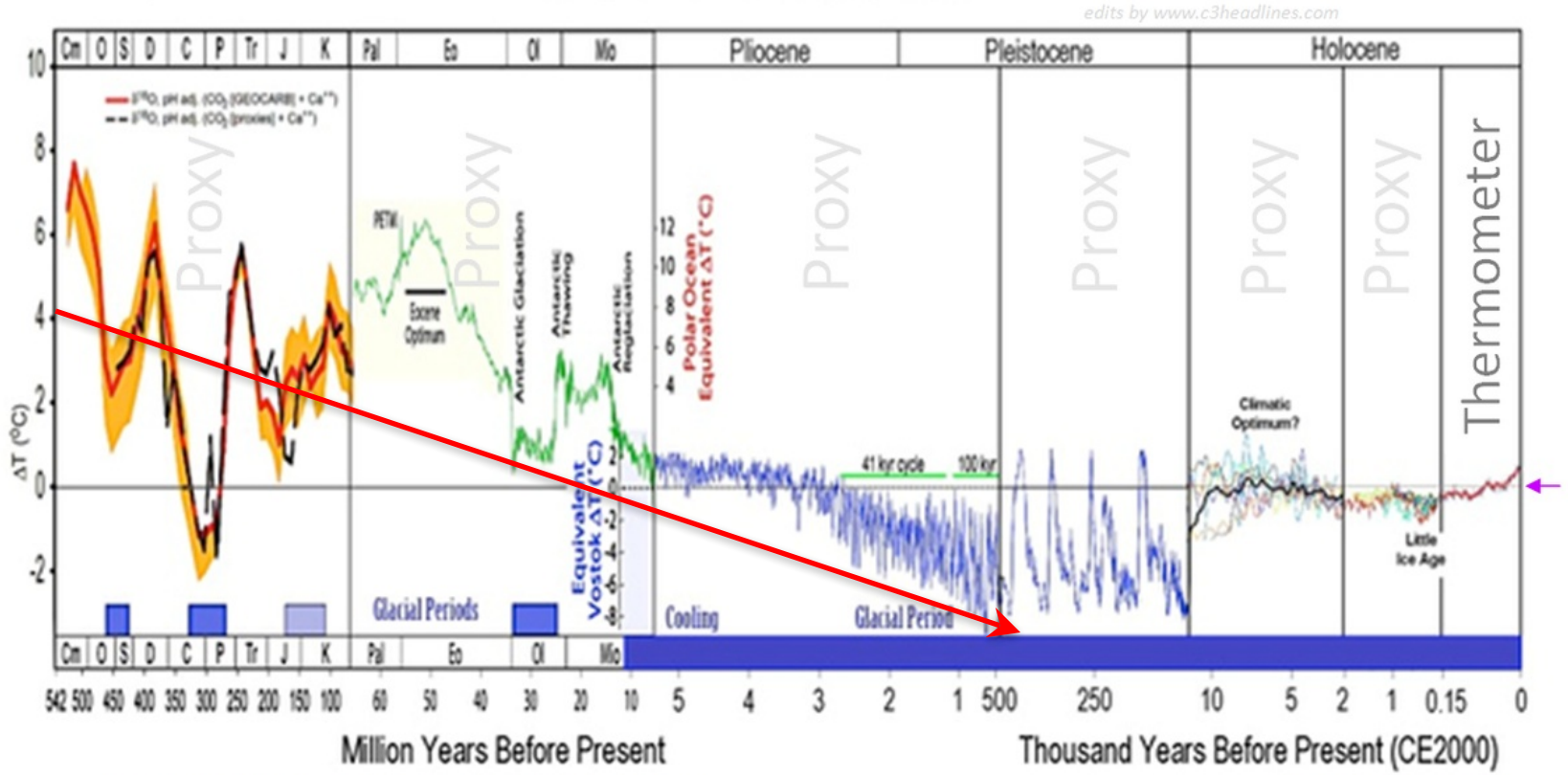
The breadth of this talk is such that many people WILL find something new to understand or facts to check later. I am happy to assist with independent sources for both.

I hope to introduce things that you simply didn't know before, that can be measured but never experienced. Because humans don't live long enough to notice statistically significant global changes, but like to believe they can. It makes them feel significant. So I also examples of include short term contributions to the longer term effects I discuss. This includes volcanoes.

Finally, while geology has good proxy data back 1 million years, and reasonable proxy data data before that, as regards temperature change, sea levels, crustal movements, etc., science does not know with any certainty HOW climate varies over geological time, or even over hundreds of years. But analysis does tells us that well controlled change happens naturally, on multiple time scales, and without human effect, over a relatively narrow range in absolute terms - but significant to today's humans. Much larger changes occur naturally on a far longer and well controlled time scale than the tiny changes humans now concern themselves with. For example, now is in fact a small part of the warming phase of a short multi-centennial interglacial cycle, superimposed on the longer term and larger range ice age cycle. A short warm interglacial that our civilisation might not survive to see the next example of, in 90,000 years time, but not because of any human effect on the climate .

500Million Years - Since Records REALLY Began

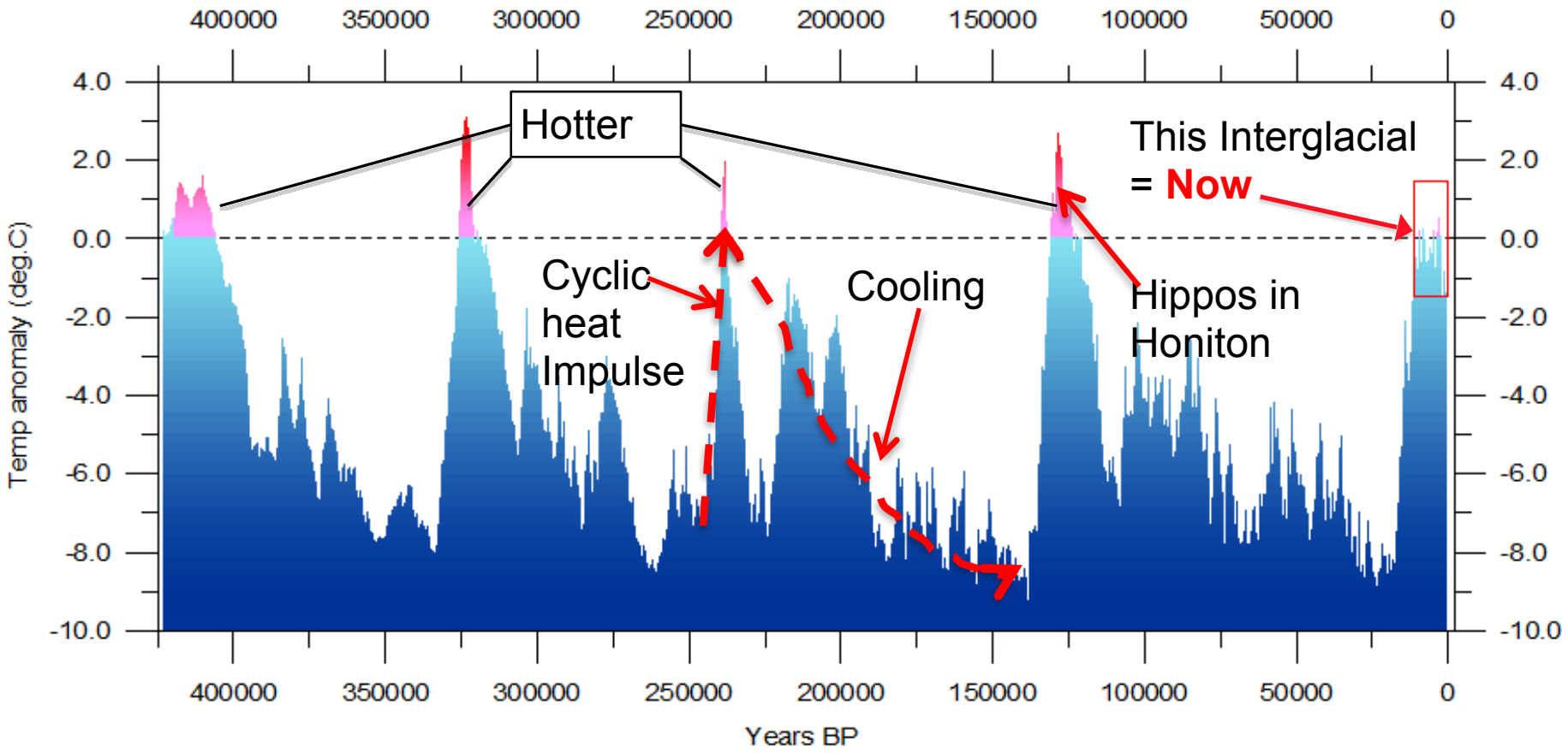
Comparison of Past Earth Temperatures Using Proxies vs. Modern Instrumental



Source: U.S. Dept. Energy's Lawrence Berkeley Laboratory

Relative changes in global average temperature for the past 550 million years based on various methods from various researchers. The time scale is vastly different for each of the five general time segments, going from hundreds of millions of years per segment, to millions of years, to thousands of years. Note that the Earth has generally been warmer than it is today, and that we have been in a cooling period for the last 10 million years, with glaciation the last 2.3 my.

500,000 Years of Ice Ages – Sawtooth Cycles



Current interglacial is cooler that last 4 - and nearly ended

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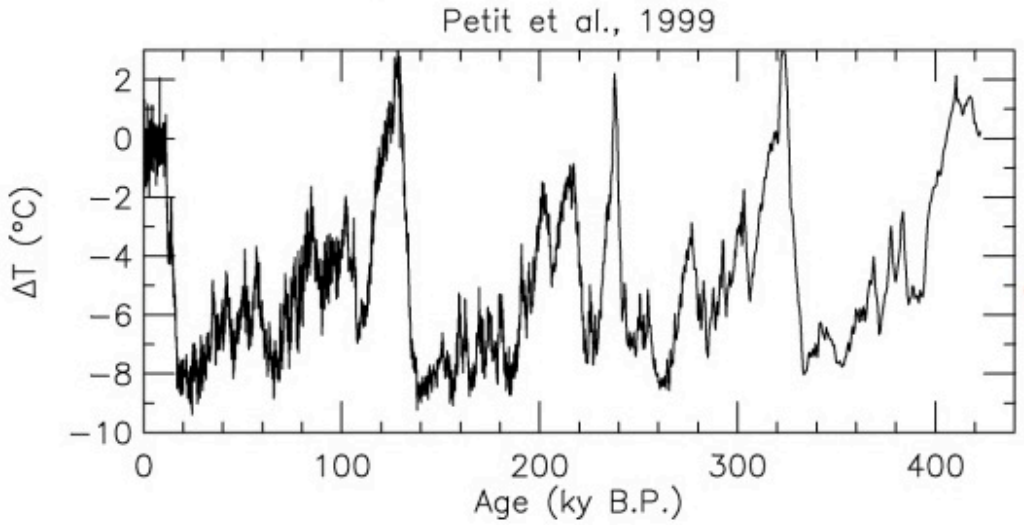
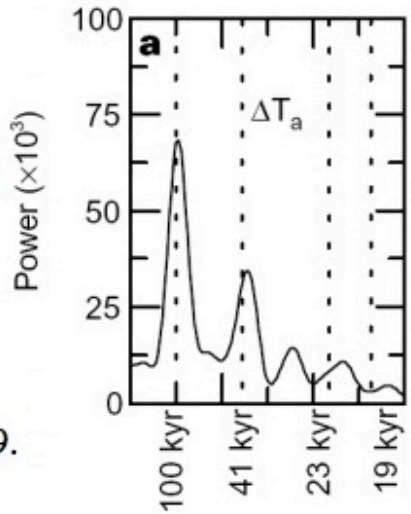
Detecting Frequencies of Natural Cycles

- Frequency analysis of Vostok Ice core
- Many interfering frequencies combined
- Need to separate notes from chords

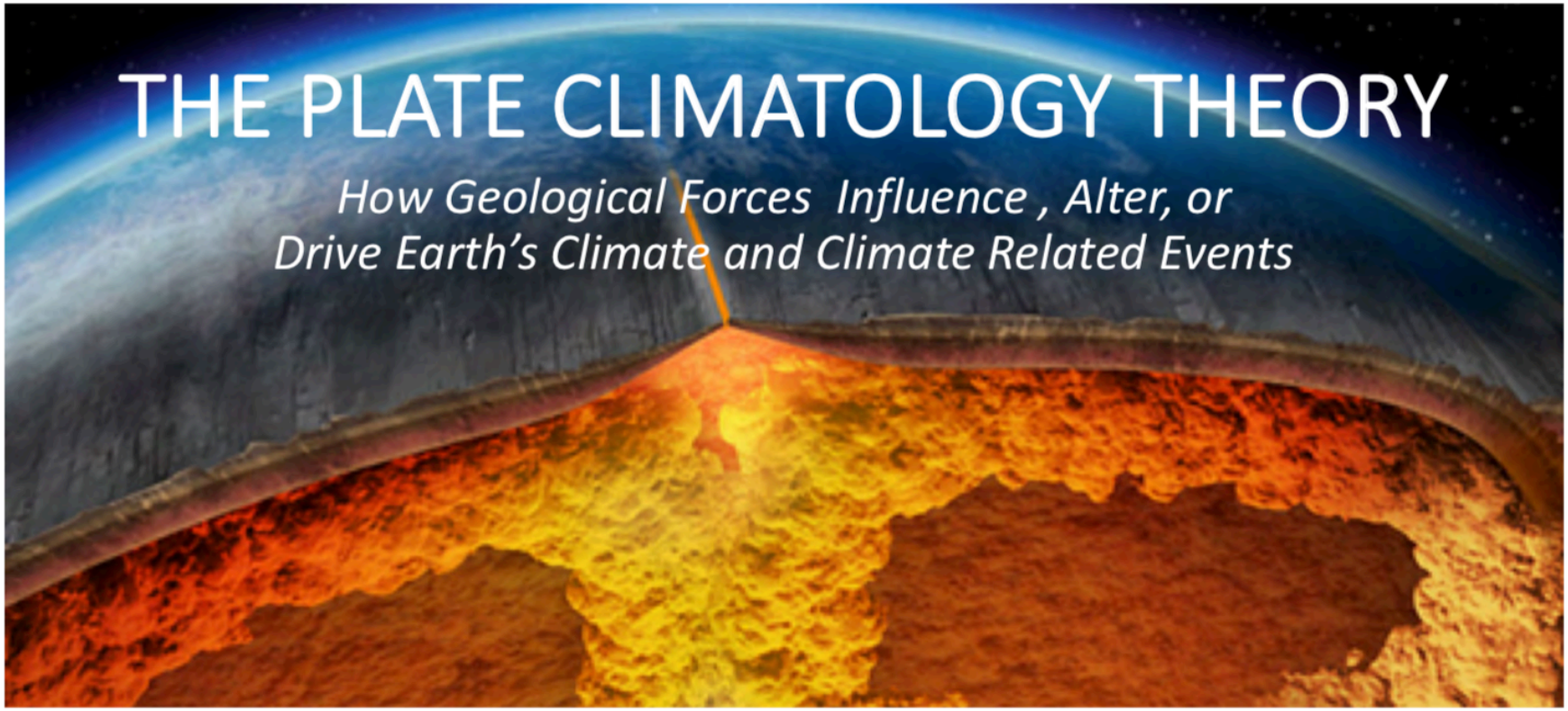


Deconvolved Chord



Petit *et al.*, *Nature*, 1999.

It’s been suggested before



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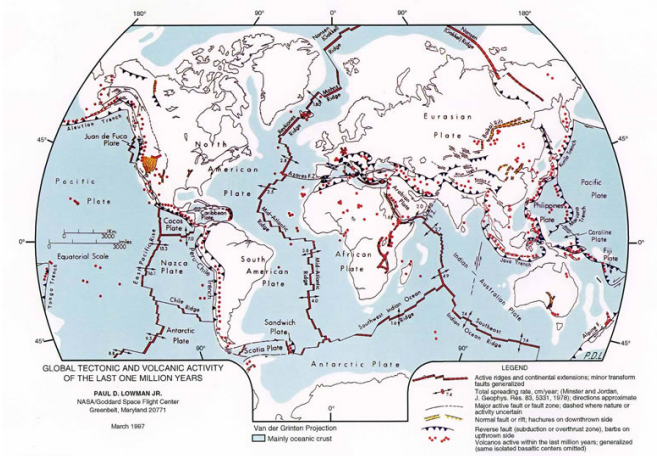
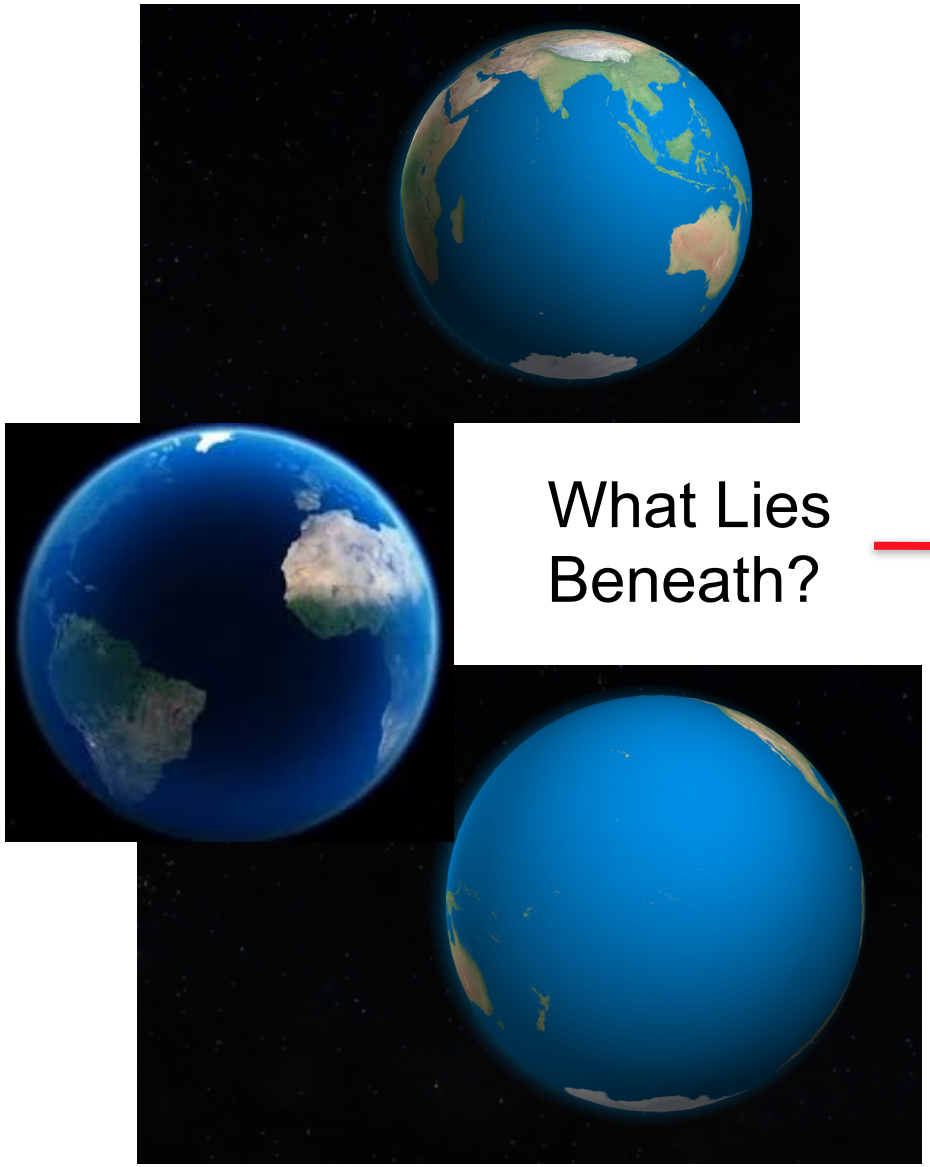
Some Facts About the Ocean Floor

- The Earths tectonic plates mainly diverge in the oceans, up to 24cm pa
- Ocean crust perhaps 7km thick while continents are 70km, depends who you ask.
- Continents effectively float over the denser basalt (2.8 vs. 2.9 kg/m^3)
- Thin, heavy, Oceanic plates are mostly subsumed by thicker lighter continents
- Older submarine volcanoes are continually subsumed by continental plates
- Oceanic basaltic crust is no more than 200 million years old anywhere

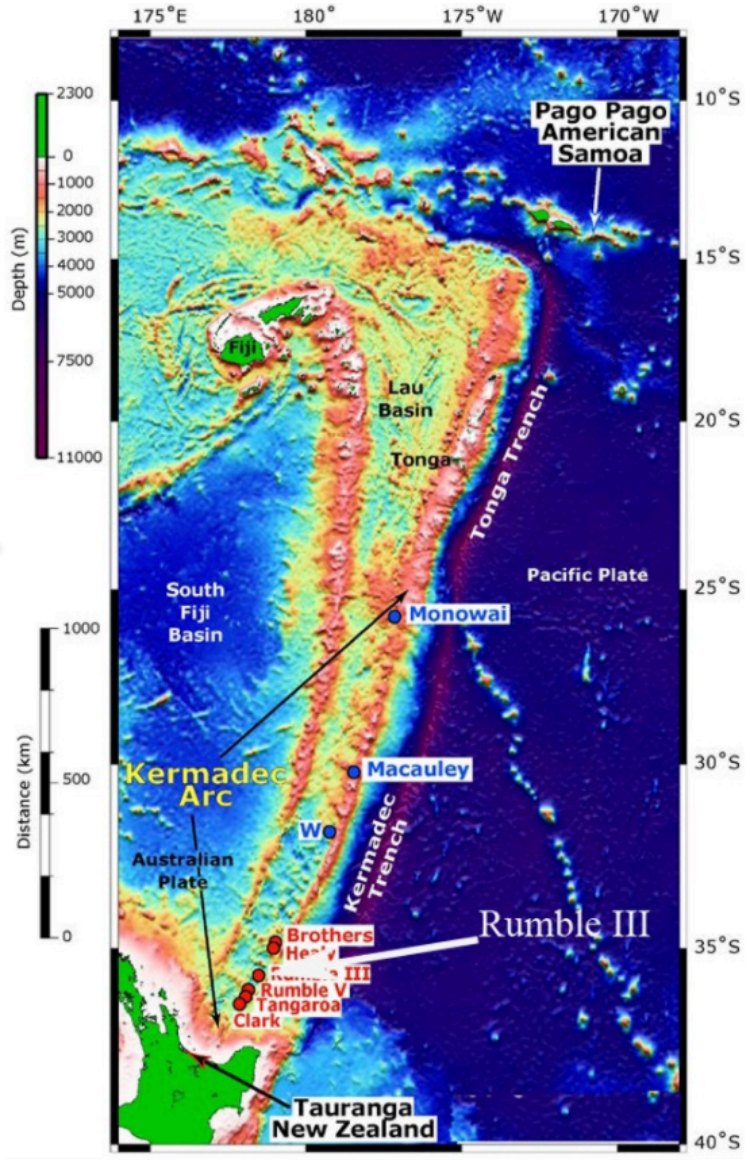


- The ocean is 70% of the Earth's surface
- The continents have 1,500 active volcanoes
- **The oceans should have at least 5,000**
  - Perhaps more, given the shorter pathway through which magma must force its way

Oceans are Big – 70% of the Surface



What Lies Beneath?



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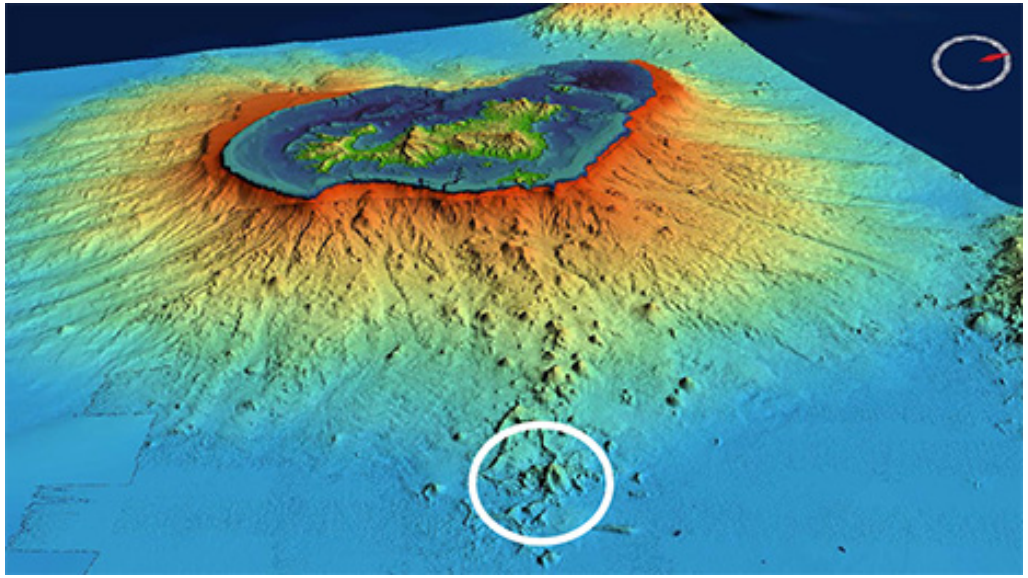
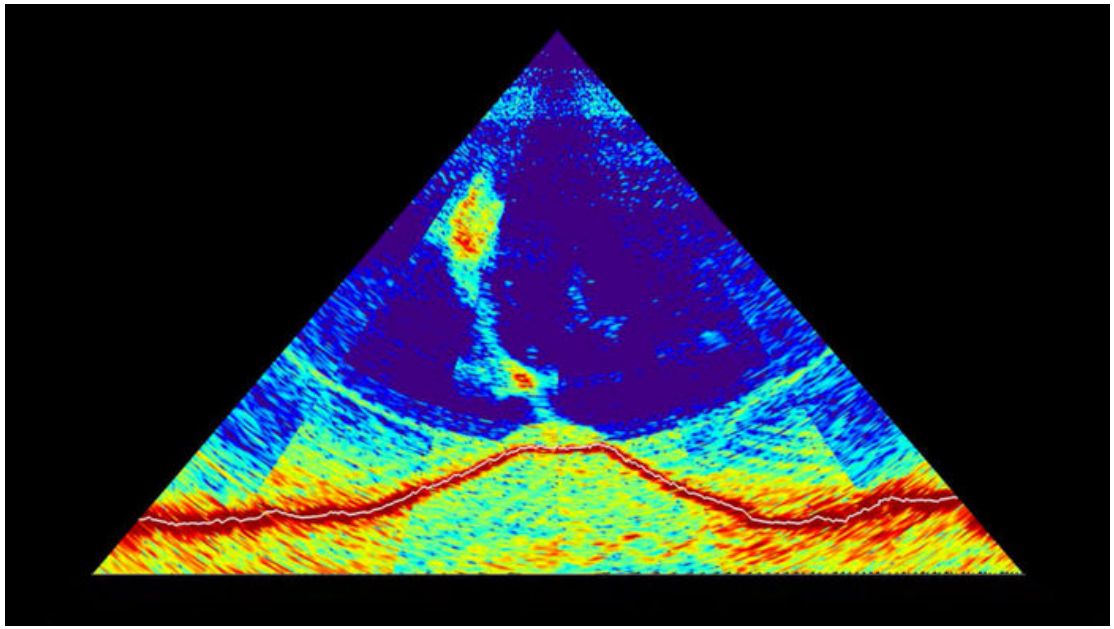
And...Mayotte

- Signalled globally
- LF Seismic signal
- Erupted Sept 2018
- 5km^3 in 6 months
- 15 Billion Tonnes

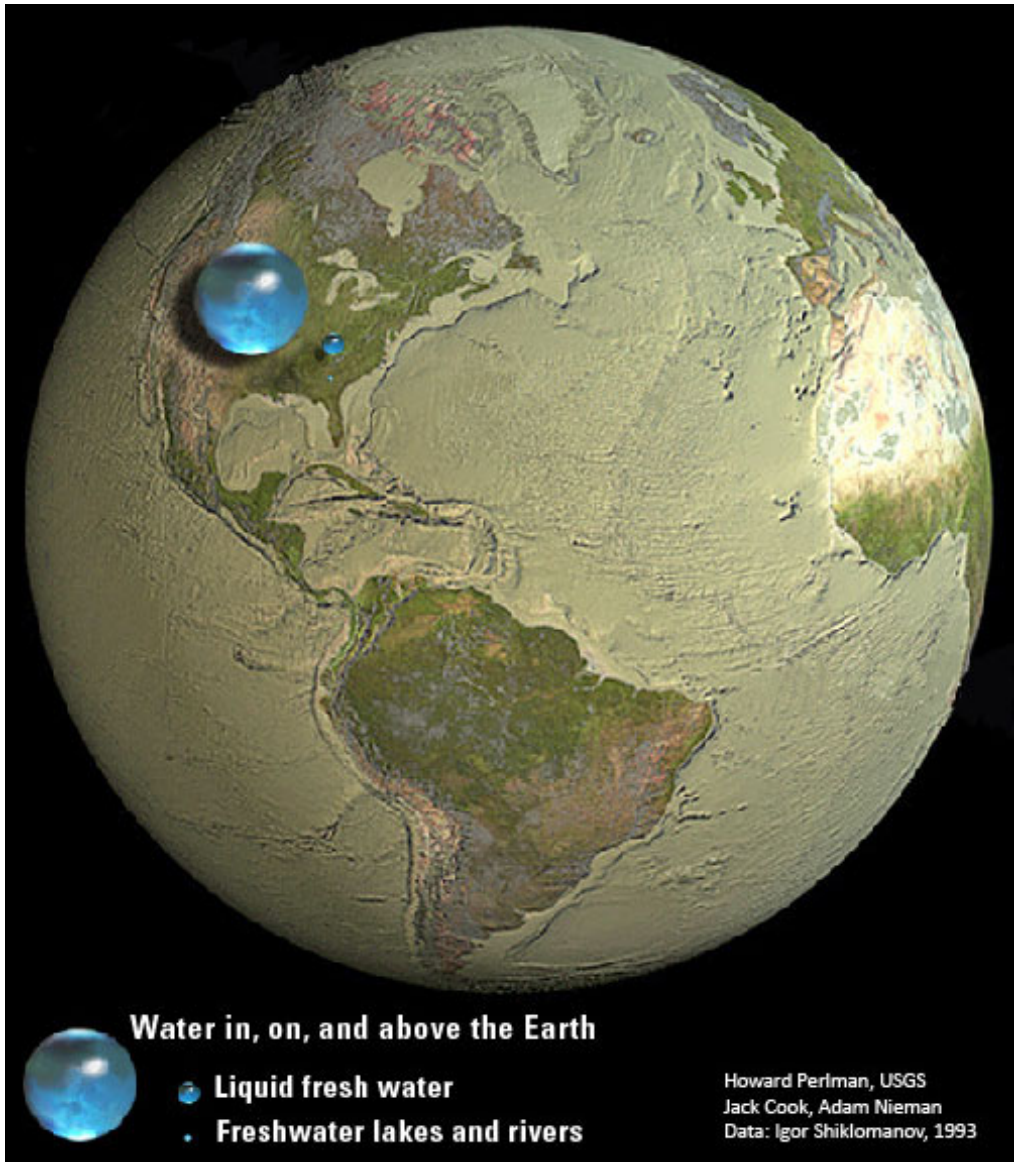




- 20 ExaJoules of heat added to ocean above 20x10^{18} EJ
- Possible impact on 2019 Hurricane Season in E.Africa

Convective Adiabatic Transfer: AKA Plume and Blob

It's Mostly Rock



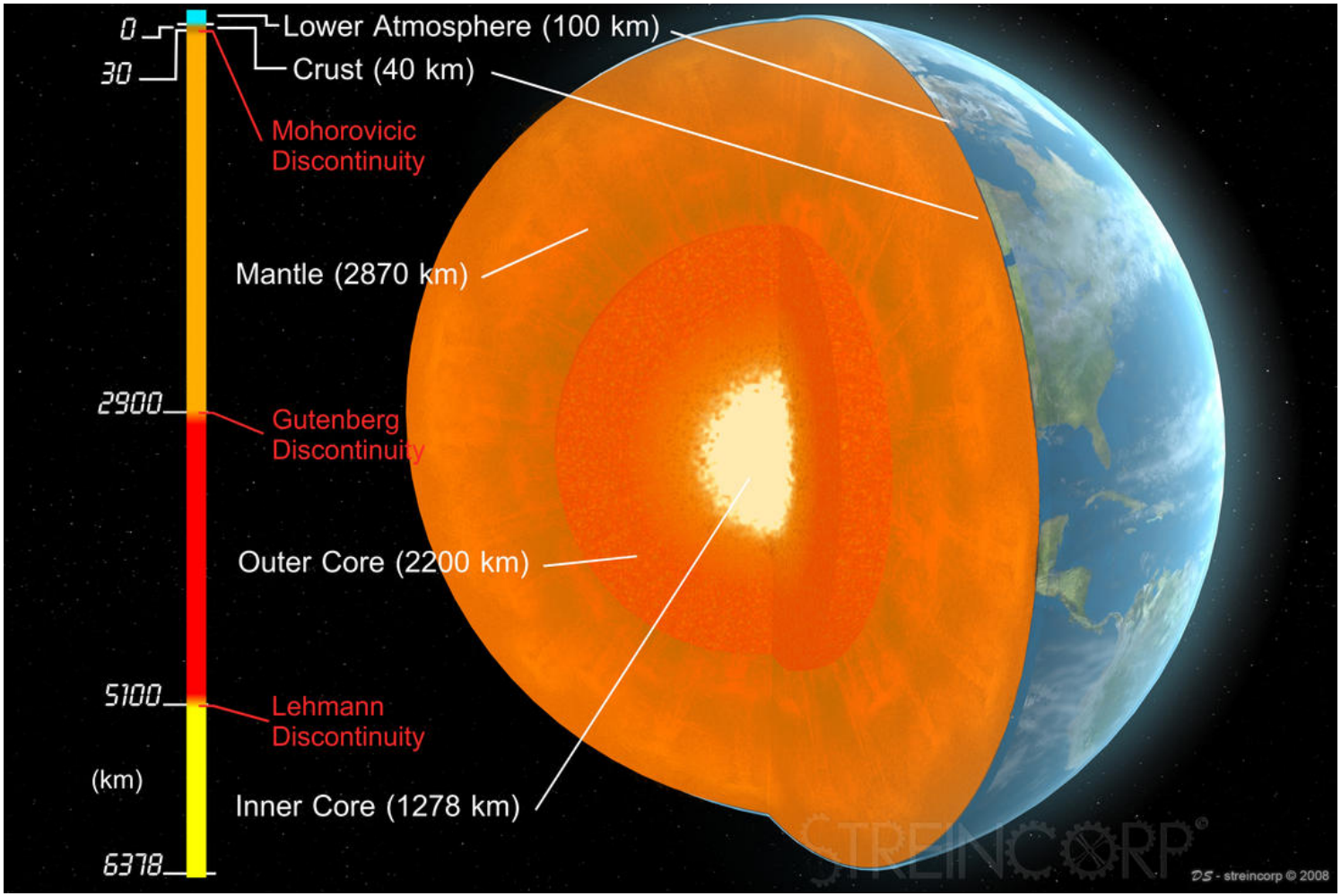
By Scale of weight:

- Rock is 4,000 x Water
- Rock is 1 Million x Air

Absolute:

- Rock is 5.9×10^{24} Kg
- Water is 1.4×10^{21} Kg
- Air is 5.1×10^{18} Kg

The Earth is not Solid



The crust 7km to 70 km thick - Both less than the thickness of a line

Gravity - Why the World is Smooth and Round'ish

- It isn't solid, gravity determines its shape dynamically
- Most of the Upper and Lower mantle are deformable/visco-elastic hot rock
  - Under high pressure at many thousand degrees temperature, but mobile
- "The Earth can be modelled as a liquid for collision purposes"
- Only the wafer-thin crust and Lithosphere is solid'ish - & the metal inner core.
  - Crust is too thin to draw here, or represent on a screen/sheet of paper as a line (Visual)
- The spinning planet is kept in oblate spheroid shape by gravity and CF
- The crust is held on by gravity, continually massaged by the mobile interior
- Magma pressure is 10-30,000 Atmospheres where it comes from, push, push....
  - Depth of oceans at exit has little effect (Deepest ocean pressures are 1,000 Bar)
- *The shape is constantly modulated* by the orbital forcing of the Sun and Moon
  - 55cm per day solid tide as well as liquid tides (nb: Direct effect >ocean loading effect)

Earth is a flexible Body Wrapped in a wafer thin crust by gravity
Orbital Forcing gravity continually distorts the planet

What all this means for Submarine Volcanoes

- The ocean floor that oceanic volcanoes must penetrate is thin
- The driving pressure is huge and unnaffected by the ocean above
- Path to the surface is 10% of the path of continental volcanoes
- Any crustal faults are continually massaged by gravitational solid tides
- The tidal modulation amplitude changes as orbital forcing changes
- Forcing is from daily Lunar orbit eccentricity to 100Ka Milankovitch cycles
- All help deliver an average output of 6.4 times that of surface volcanoes (*)
- Largest output I have found is Hawaiian hot spot at 100 Million m^3 pa
- **Average Output of a submarine volcano is about 28 million m^3 pa (*)**

* Scott White et al, 170 Volcano study of surface and submarine volcanoes

But does it vary?

How Much Warming is That? (Numbers at last!)

- $28x10^6 m^3$/pa per volcano x 5,000 volcanoes = **140 Km^3pa = 400 Billion tonnes pa**
- Greater than ANY consensus figure, larger than the 73,000km divergence in-fill

- **Unit heat content:**
  - 1000 deg x 1,000kg x 1,000 Joules/kg deg = $1x10^9$ Joules/tonne
  - Heat of crystallisation = $400x10^6$ Joules per tonne
  - **Total Unit heat content is 1.4 Giga Joules per tonne**

- **Hence Total Heat pa =5.5×10^{20} Joules per annum**
  - Can raise 1m of the ocean by 0.36 deg (= $5.5 \times 10^{20} / (1x362x10^{12}x1x10^3)x4.2x10^3$)
  - $0.034 W/m^2$ (0.1% of average solar insolation)

That's the average, but how does it vary - Volcanoes aren't "average"

Dec 2023

Yes it Does (Vary) – Kutterolf et al

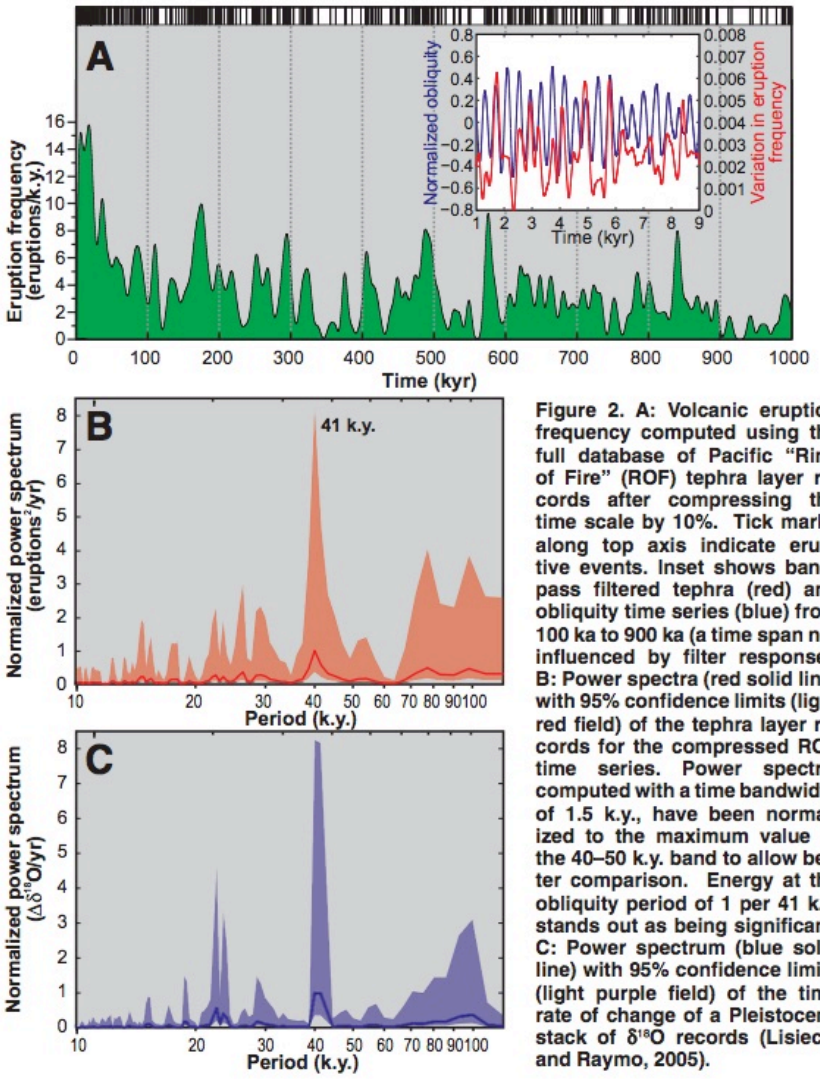


Figure 2. A: Volcanic eruption frequency computed using the full database of Pacific "Ring of Fire" (ROF) tephra layer records after compressing the time scale by 10%. Tick marks along top axis indicate eruptive events. Inset shows band-pass filtered tephra (red) and obliquity time series (blue) from 100 ka to 900 ka (a time span not influenced by filter response). B: Power spectra (red solid line) with 95% confidence limits (light red field) of the tephra layer records for the compressed ROF time series. Power spectra, computed with a time bandwidth of 1.5 k.y., have been normalized to the maximum value in the 40–50 k.y. band to allow better comparison. Energy at the obliquity period of 1 per 41 k.y. stands out as being significant. C: Power spectrum (blue solid line) with 95% confidence limits (light purple field) of the time rate of change of a Pleistocene stack of $\delta^{18}O$ records (Lisiecki and Raymo, 2005).

- Application of frequency analysis to deposition data from RoF
- A is time Series of event frequency
- B is period/frequency analysis of same eruptions using d18O proxy

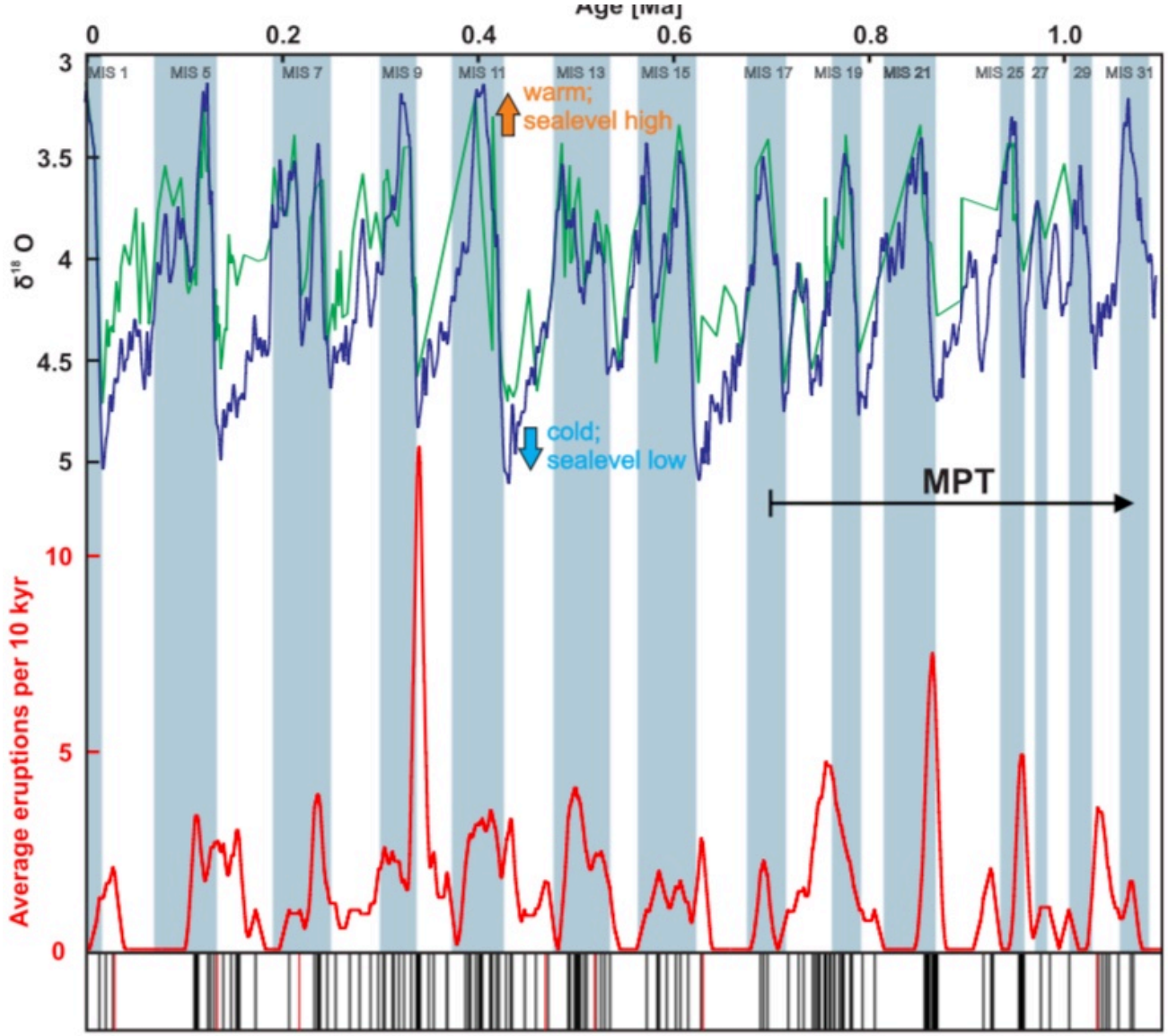
nb: Author has so far declined to quantify the likely increase in emissions at Milankovitch maximums, but they are clearly substantial in the hundreds of percent. Most sustained during the 100Ka eccentricity maximum, most intense at the 41Ka Obliquity maximum.

Ref: A detection of Milankovitch frequencies in global volcanic activity, Kutterolf et al 2012:

Volcanic maximums occur at Milankovitch orbital forcing maximums

www.gsapubs.org | February 2013 | GEOLOGY

A Second Look - Schindlbeck et al (incl. Kutterolf)



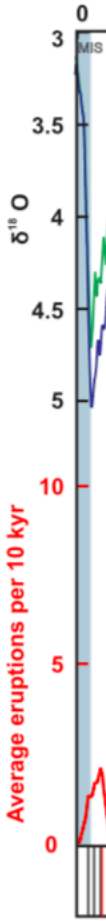


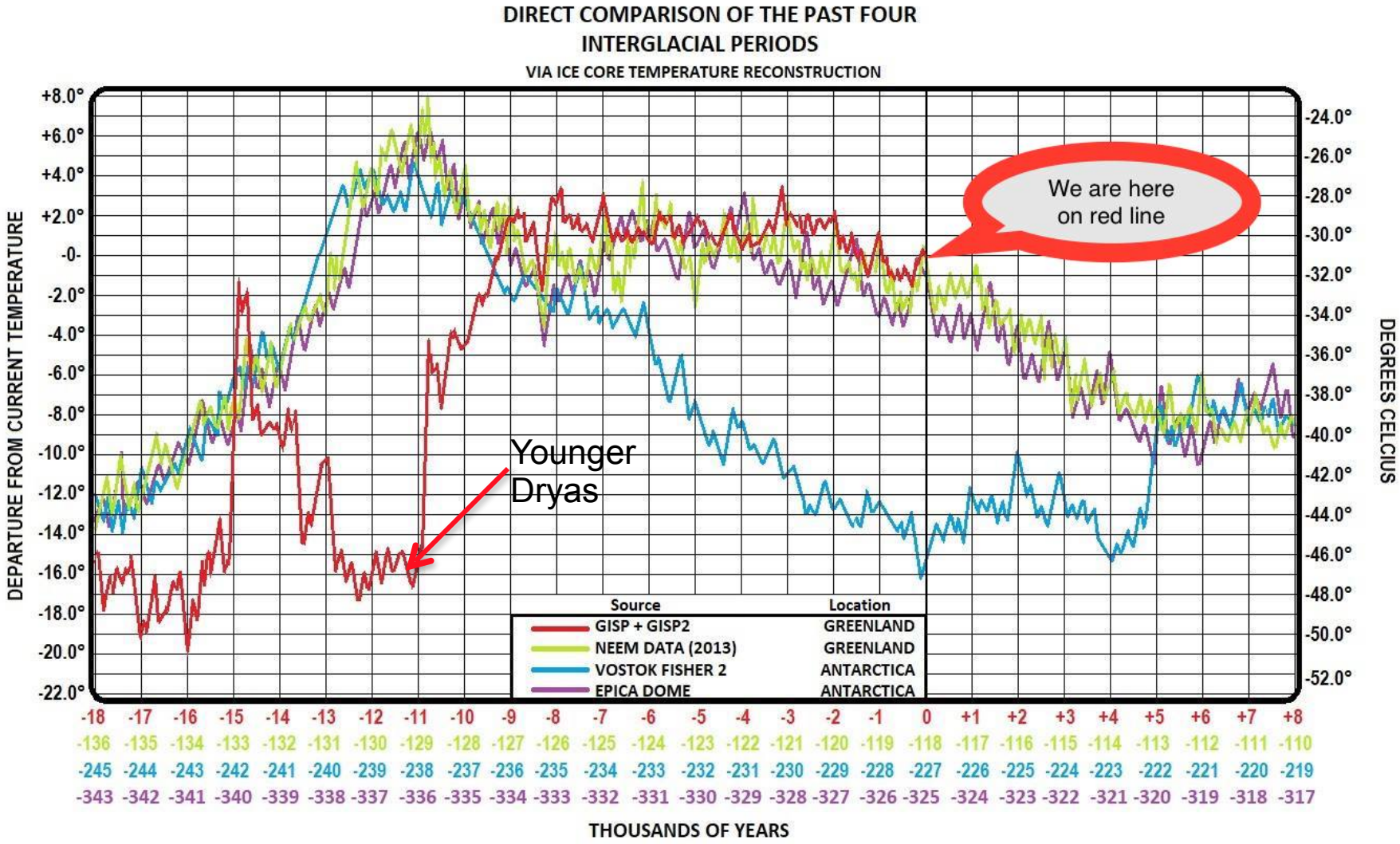
Figure 3 volcanic stack cur high sea Volcanic of 10 kyr one erup record of global LI

How Variable, Then? A Guestimate

- Allocate average between 20Ka peak periods, and 80Ka low minima.
- So highest max will be 5 times average over 20% of the time with 0% over 80% 0f the time.
- I have called that 4.6 times during 20% peak.
- So that increases peak value of volcanic heat pa to 2.2×10^{21} Joules pa over 20Ka
- $0.16 W/m^2$ max, by this measure

Anything else? The unquantifiables ….. what we don't know……..

Last 4 Interglacials - Featuring Holocene Younger Dryas Event



Recasting of the referenced data sets by James J Covington

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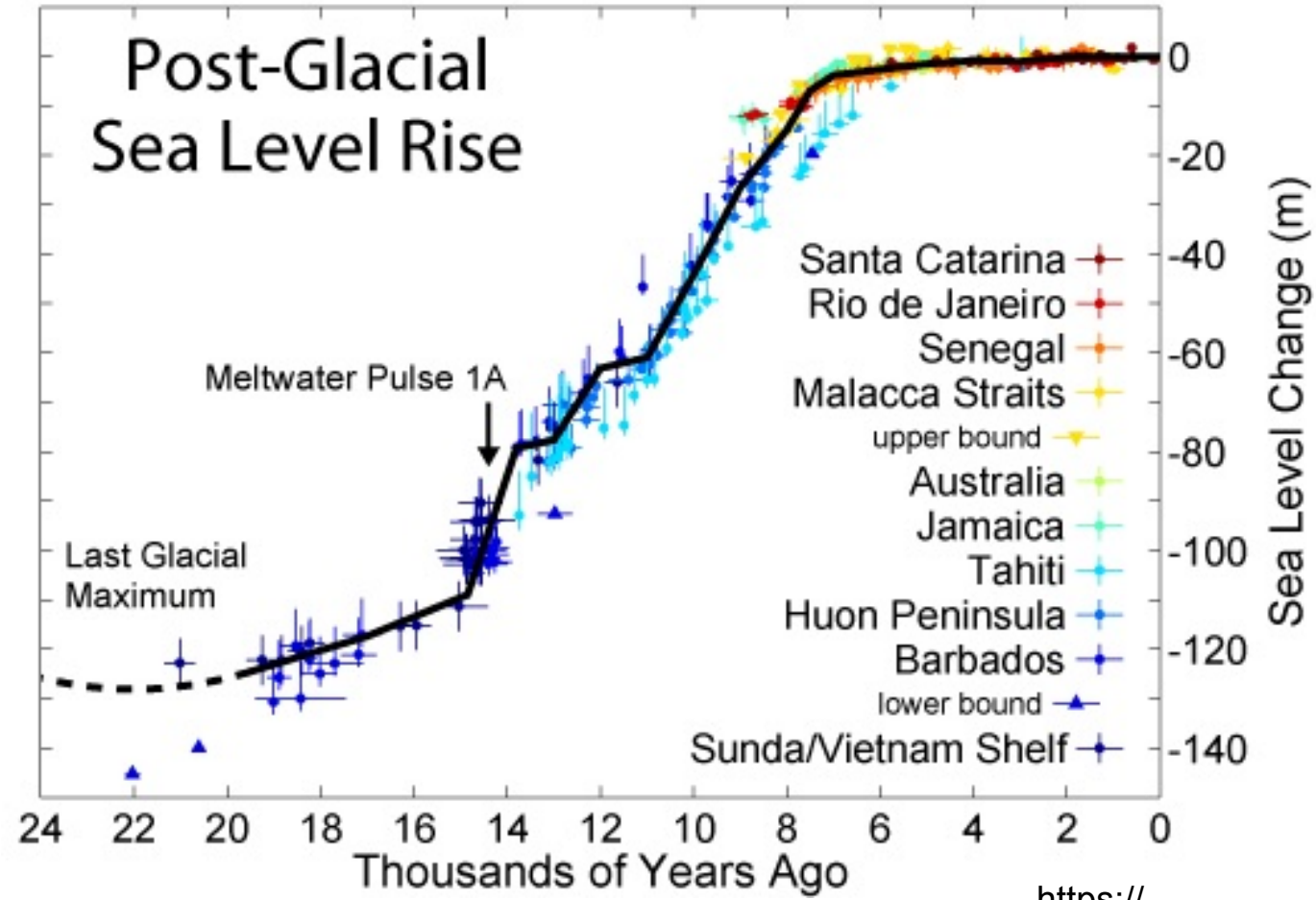
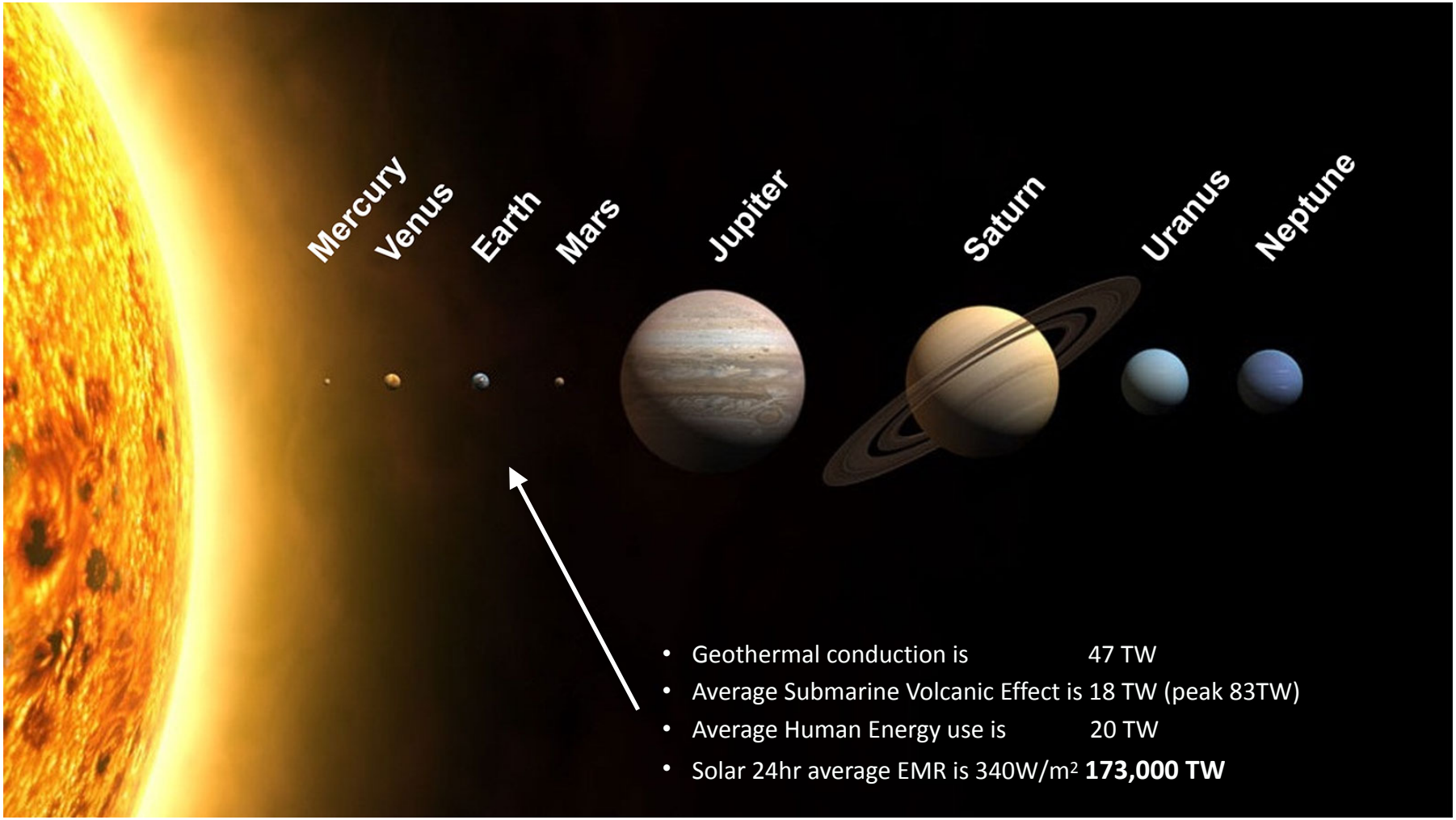
Interglacial Sea Level Rise - 18mm pa, non stop



No Dryas pause to ice sheet melt, where does the heat come from? Below? Still a mystery-outa time!

https://commons.wikimedia.org/wiki/File:Post-Glacial_Sea_Level.png

Relativity - Size and Energy Density



Geothermal is a Small Proportion of Total Surface Energy

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Do Submarine Volcanoes Change Climate?

Theories Tested	Observed Reality
Submarine Events are energetic enough to cause regional extremes.	Energy release to surface by single sea mount is at ExaJoule scale, so regionally significant
Total geothermal effect is constant & insignificant, 47TW conduction dominates	Volcanic activity is significant & variable on 3 Milankovitch cycles, (by gravitational effect?)
Does Dryas cooling events+steady sea level rise suggest interglacial cause part geothermal	Possibly. If these estimates are wrong. What better explanations?
Submarine volcanism can drive an interglacial	Estimated volcanic effect too small to deliver the heat required, acting alone. Orbital and planetary asymmetry effects may dominate
Magma “overflows” from divergent ridges are not large	Ignoring emissions from the divergent ridges may be a mistake, may vary with solid tides?
Volcanic effects are much more than believed by consensus, and highly variable	Submarine Volcano popn., total emissions & cyclic variability need better study

Little is known for sure, & whatever we believe must be tested by the independent observation of nature, not imposed by a “consensus of experts”

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THE END

- Thank you for your attention! Questions?

- Please send questions regarding the facts and the physics to brian.catt@deconfused.com