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MAGMATIC VOLATILES as an AMPLIFIER for CENTRIFUGAL VOLCANISM

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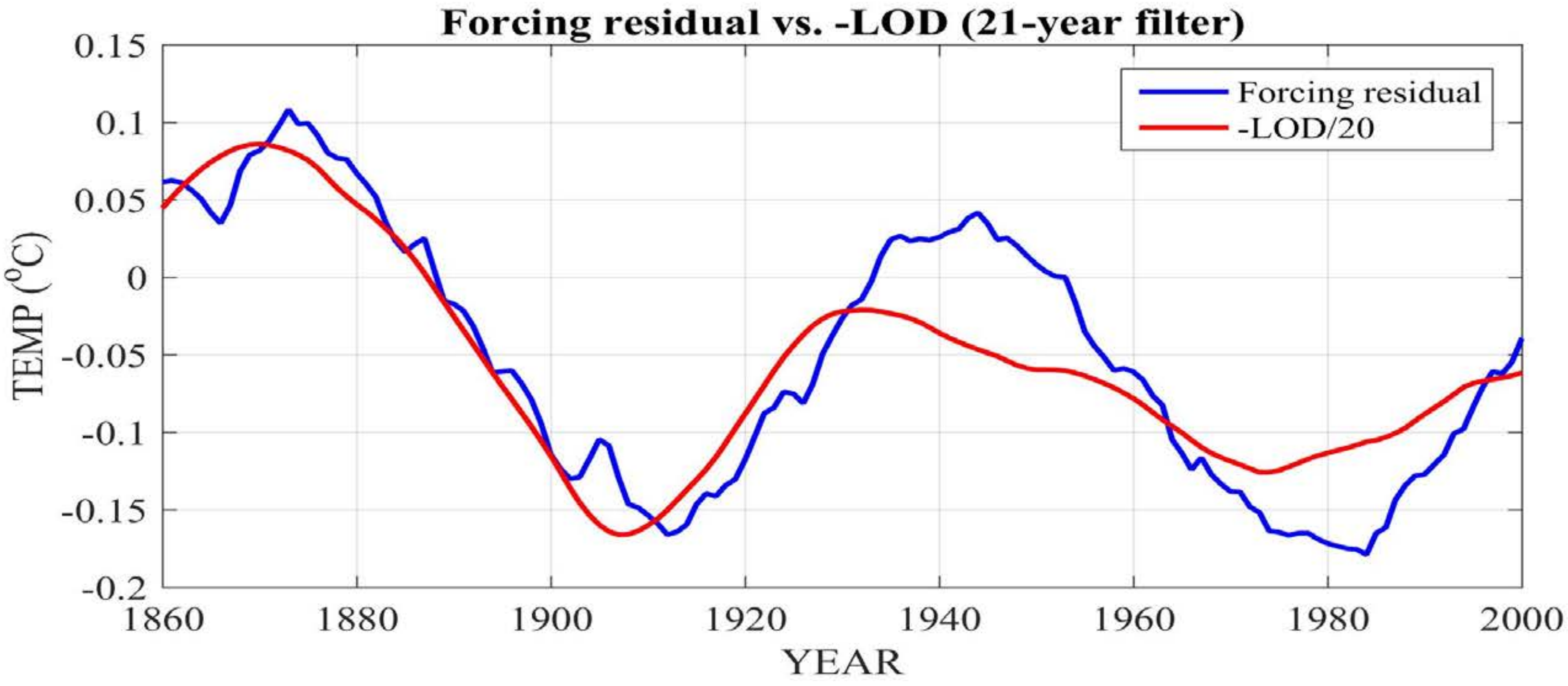
1. SUMMARY

- *Observed effect*: Shorter Length of Day (LOD) warms the Earth. (Atlantic Multidecadal Oscillation?)
- *Hypothesis* (VP AGUFM16): Cause of effect: rising magma. (Centrifugal volcanism hypothesis)
- *Problem*: Δ LOD too small for this effect.
- *Factor*: Magmatic volatiles as amplifier. (Same mechanism as for supervolcanoes)
- *Next 3 slides*: Our previous work. [7]

2. MAIN ARGUMENT FROM AGUFM2016

In this plot, the blue curve is the residual after removing from HadCRUT4 the expected effects of CO_2 forcing, TSI, and periodicities of 21 years and shorter using a 21-year moving average filter.

The red curve is −LOD with *amplitude* scaled to match.



Agreement in both *phase* and *frequency* is strong evidence for a causal relation. We propose **magma ejected by spin**.

3. MAIN PROBLEM: ΔLOD TOO SMALL

During the 30 years 1880-1910, LOD increased by 4 ms. [6][3] This lengthened the sidereal day of 86164.2 seconds to 86164.204 seconds, an increase of 50 ppb.

Angular velocity ω therefore decreased from $\omega = 2\pi/86164.2 =$ 72.9210660 μrad/sec to $\omega' = 2\pi/86164.204 =$ 72.9210625 μrad/sec, a decrease of 50 ppb. Centrifugal acceleration $a = \omega^2 r =$ .03385214087 m/s^2 or about 0.34% of Earth's gravity (9.8 m/s^2) decreasing to 0.03385213772 m/s^2 over 30 years, a decrease of 3.15×10^{-9} m/s^2 (315 nanogals) and therefore an equal increase in gravity at the equator.

Assuming the additional magma heats only the oceanic mixed layer, OML,[1] and not the deep ocean, we calculated the power sufficient to account for the multidecadal fluctuations in HadCRUT4 at 5 TW, for which 5×10^{5} kg/s of magma would suffice. Can ΔLOD deliver that?

4. IS THERE ENOUGH MAGMA TO WARM THE OML?

5 TW is less than 20% of the 30 TW of geothermal flux at the ocean floor, which therefore need vary only between 25 and 35 TW. A variation in flow of magma of $\pm 5\times10^5$ kg/s, sustained over 30 years or a billion seconds, can be accounted for as retention of 5×10^{14} kg of magma, 1500 Kilaueas [2][4][5], during the 1880-1910 slowing, followed by its release during the 20 years 1910-1920.

If only two-thirds of the magma retained over 30 years is released over 20 years, the additional warming of the OML during 1930-1940 might be due to the release of the rest of those 5×10^{14} kg.

Mass of crust (top 30 km) is 4×10^{22} kg. Hence the requisite mass of magma is less than 0.000000013 of the crust. There is therefore surely far more than enough magma in the crust to account for the observed 63-year fluctuation in sea surface temperature, aka the AMO.

5. FORCE NEEDED TO DRIVE THE MAGMA

In the current presentation we address two questions.

- 1. Are the LOD-induced fluctuations in gravity down in the noise compared to other sources of gravity fluctuations such as the passage of the Sun and Moon overhead?
- *Answer*. Yes, when frequency is ignored. When frequency is taken into account those bodies flash by far too quickly to have any perceptible impact on magma back-and-forth.

- 2. Is a third of a μgal sufficient to drive magma at the requisite rate?
- *Answer*. While we are unable as yet to quantify this, magmatic volatiles may make the centrifugal volcanism hypothesis more plausible.

6. GRAVITATIONAL “NOISE” FROM MOON & SUN

- The point of Earth nearest the Moon experiences a stronger pull towards the Moon than the furthest (antipodal) point. The variation is the derivative of Gm/r^2 or $-2Gm/r^3$. For the Moon this is −170 picogal/km and for the Sun, −83 pgal/km at perihelion and −75 pgal/km at aphelion 6 months later. These variations constitute 12-hour oscillations about a zero mean. (Earth’s orbital eccentricity contributes only to the *amplitude* of the Sun’s contribution and not to its *mean*.[8])
- The effect at the surface of the Earth is that times the radius of the Earth, namely ±110 µgal for the Moon, or *300 times that of the LOD fluctuation*, and about half that for the Sun.
- However the respective periods are 0.5 days for the Moon and the Sun, vs. 46,000 days for the 63-year LOD period, *a factor of nearly 100,000!* The effect of a 110 µgal pull sustained over 6 hours is overwhelmed by that of a 0.315 µgal pull over 31 years.

7. MAGMATIC VOLATILES: THEIR NATURE & ROLE

- Magmatic volatiles are liquids such as water that dissolve in magma under sufficient pressure. They boil out under either a reduction in pressure or an increase in temperature. When this happens near the surface the pressure reduces so quickly as to create a huge positive feedback capably of ejecting entire mountains into the stratosphere.
- The slight influence of LOD fluctuations is felt *throughout all* 4×10^{22} *kg of the 30-km-thick crust,* most of which is far enough from the surface not to experience a catastrophic depressurization.   Instead the very slight decrease in pressure acts to disturb the prevailing equilibrium, thereby boiling out enough liquid to amplify the force driving the magma upwards. However the “lid” does not blow off and the increase in pressure then acts to limit the amplification, though not enough to reduce it to nothing.

8. REFERENCES

1. Murton, B.J. et al, Detection of an unusually large hydrothermal event plume above the slow-spreading Carlsberg Ridge: NW Indian Ocean. Geophysical Research Letters, 33, L10608, doi:10.1029/2006GL026048, 2006
2. Parks, M.M. et al, Evolution of Santorini Volcano dominated by episodic and rapid fluxes of melt from depth. Nature Geosc. 5, 749–754 (2012) doi:10.1038/ngeo1562
3. Hide, R., D.H. Boggs and J.O. Hickey (2000), Angular momentum fluctuations within the Earth's liquid core and torsional oscillations of the core–mantle system, Geophysical Journal International, 143:3, 777-786.
4. Di Genovaa, D., Romanoa, C., Giordanoc, D. & Alletti, M., Heat capacity, configurational heat capacity and fragility of hydrous magmas. Geochimica et Cosmochimica Acta, Volume 142, 1 October 2014, Pages 314–333
5. Lin , G. et al, Seismic evidence for a crustal magma reservoir beneath the upper east rift zone of Kilauea volcano. Geol., Jan. 10, 2014. doi: 10.1130/G35001.1.
6. Schlesinger, M.E. & Ramankutty, N., An oscillation in the global climate system of period 65–70 years. Nature 367, 723-726 (1994) | doi:10.1038/367723a0
7. Pratt, V.R., A Centrifugal Volcanism Mechanism for the Atlantic Multidecadal Oscillation, Global Environmental Change session GC13G (December 12), American Geophysical Union (AGU) 2016 Fall Meeting, San Francisco, California.
8. Lambert, S.B., de Viron, O., & Marcus, S.L., LOD-climate links: The 2015-2016 El Niño, Earth’s Rotation,, and Possible Rotational Forcing of Multidecadal Temperature Changes, American Geophysical Union (AGU) 2016 Fall Meeting, San Francisco, California.