GC13G-1265

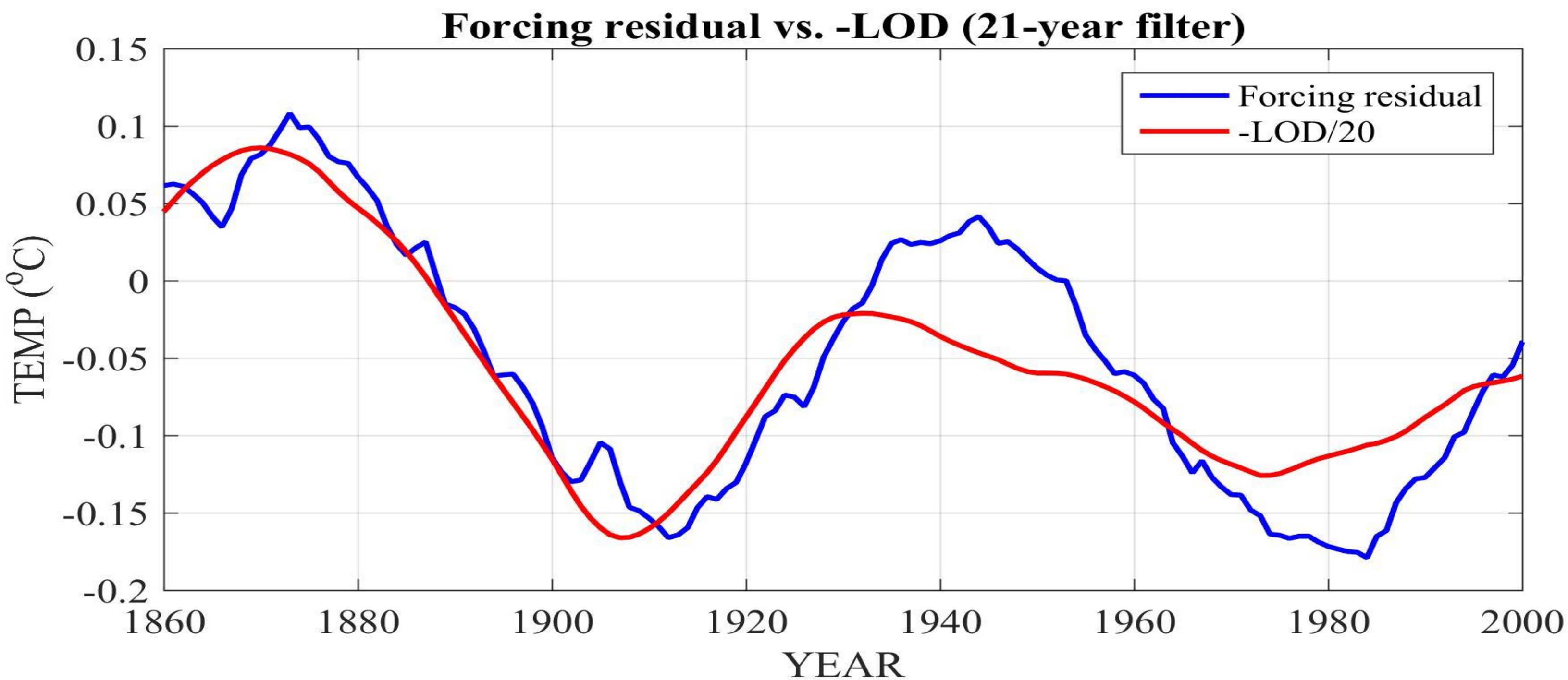
A CENTRIFUGAL VOLCANISM MECHANISM FOR THE ATLANTIC MULTIDECADAL OSCILLATION

Vaughan R. Pratt
Stanford University

December 30, 2015

1. THE ATLANTIC MULTIDECADAL OSCILLATION

Summary. After detrending global mean surface temperature (HadCRUT4) by the expected forcings—TSI, GHGs, and higher-frequency components—the residual bears a striking resemblance to Length Of Day inverted and suitably scaled (-LOD/20).



We propose to explain this correlation in terms of a *centrifugal volcanism mechanism*: more spin thrusts up more magma.

2. ARGUMENTS FOR AND AGAINST

For:

1) Excellent correlation up to 1930.

Against:

1) LOD fluctuation 1880-1910 is 0.1 ppm whereas a decrease of 10% in the 50 TW of geothermal flux is needed to account for a decline of 0.1 ℃ in 10^{19} kg of OML. Off by a million!
2) Thermals from the ocean floor have never been observed to reach the oceanic mixed layer (OML).
3) The correlation seems accidental. When LOD reversed in 1930, temperature continued to climb for another decade.
4) Furthermore when LOD amplitude weakened after 1930, temperature amplitude remained strong.

We respond to counterarguments 1-4 in the sequel.

3. QUALITATIVE SUMMARY OF RESPONSES

1) 45 TW measures the rate of magma *emission*, which is proportional to the *derivative* of magma volume. LOD influences the entire volume of magma, which may be many orders of magnitude larger than a decade's emission.
2) A 70 km thermal has recently been observed to come within a kilometer or so of the surface [1]. Such observations of thermals were not possible when the 1880-1930 LOD fluctuations were considerably larger than at present.
3) 1910-1930 inflated many magma balloons [2], which deflated during 1930-1940 while continuing to eject magma.
4) The lithosphere is colder and hence more elastic than the hotter mantle below (cf. the hot non-seismic surface of Venus). Oscillations of magma chambers excited by the LOD should therefore continue longer than the mantle oscillations excited by the core [3] and driving LOD.

4. QUANTITATIVE DETAILS OF RESPONSE 1

The heat content of magma relative to 0 °C at temperature T °C is $C_p T$, plus latent heat of crystallization when molten, where C_p is isobaric specific heat. Taking $C_p = 10^4$ J/kg/K and T = 1000 K [4] in round numbers and neglecting latent heat, this comes to 10^7 J/kg. Hence to heat the OML at 5 TW needs less than 5×10^5 kg/s of magma.

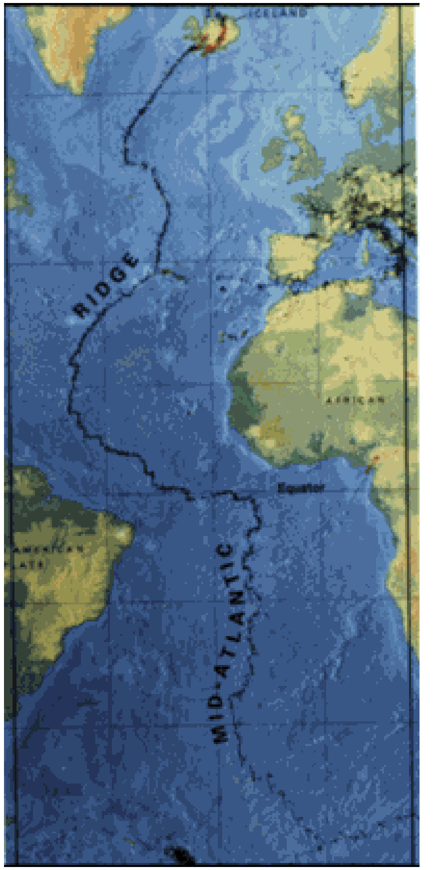
Earth's spin at the equator decreases tropical gravity by about 0.34%. An adjustment to LOD of 0.1 ppm (10^{-7}) would therefore change gravity there by about 0.3 μgal (3×10^{-9} m/s^2), Now gravity fluctuations will affect magma more than its relatively rigid chambers anchored to the crust. So depending on pressure, viscosity, available channels, etc., that change, if made to about 10^{15} kg of magma, could well yield the required fluctuation in flow of $\pm5\times10^5$ kg/s of magma.

The volume of magma below Kilauea is estimated at a cubic km [5] or about 10^{12} kg. Hence a mere thousand such magma chambers would already suffice. But the global magmatic volume is surely much more than that, permitting LOD to impact OML temperature noticeably.

5. WHERE TO LOOK FOR SUCH LEAKAGE

One obstacle to observing large thermals rising and heating the OML today is that spin-induced gravity fluctuations aren't as strong as they were at the turn of the last century. Although a remarkably large thermal was observed recently, over 70 km long, 4540 km^3, and rising some 1400 m [1], larger thermals may have been created by increased magma emissions during 1910-1940.

A promising place to look for evidence of such might be in the historical record of sea surface temperatures during that period, especially near mid-ocean ridges. To that end we have started examining the 23 million SST readings on file with ICOADS at NCAR/UCAR for that period and hope to be able to report in due course on any interesting patterns we find there.



6. MOTIVATIONS AND CONCLUSIONS

Starting with [6], the past two decades have seen a considerable body of literature describing what has come to be called the AMO and proposing one or another mechanism. Besides the obvious motivation of scientific curiosity, another motivation is the extent to which the AMO masks global warming. In particular it raises the question of how to apportion the rise in global mean surface temperature during 1970-2000 between the expected impact of greenhouse gases during the last third of the century and a putative repeat of the 1910-1940 AMO. How people tend to estimate this intuitively has for some time now been strongly correlated with where they stand on the extent to which humans might be responsible for the 1970-2000 rise, making it important to estimate both heat sources more precisely. Our focus here has been on the AMO.

Proposed mechanisms broadly divide into radiative and internal, the mechanism here being in the latter camp. As it is clear that radiative forcing (RF) due to greenhouse gases cannot have played much of a role before 1940 or even 1970, attributions to RF have largely been limited to aerosols of either volcanic or human origin.

7. MOTIVATIONS AND CONCLUSIONS (cont.)

Now even if the mechanism presented here is eventually found plausible, it does not rule out a correlation with volcanic aerosols, since both thermals and aerosols could have the same centrifugally driven origin. In that case however the aerosols would need to be of the warming rather than cooling kind associated with volcanic eruptions jetted into a cold stratosphere. But this is what would be expected of any centrifugally driven aerosols, which would tend to seep rather than jet.

In a previous AGU presentation [7] we exhibited evidence, independent of the above considerations, against radiative forcing as the dominant mechanism driving the three main rises in HadCRUT4 , namely during 1860-1880, 1910-1940, and 1970-2000. We observed that land minus sea temperature trended down strongly in the first, less so in the second, and up in the third. The first two would not have happened had aerosols contributed more warming than mechanisms internal to the ocean. We therefore inferred that the first two rises were dominated by internal effects while greenhouse RF dominated the third. It follows that any such seeping aerosols cannot be the dominant contributor to the AMO.

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., Reconciling multidecadal land-sea global temperature with rising CO2. AGU FM 2013, SWIRL Session GC53, December, 2013.