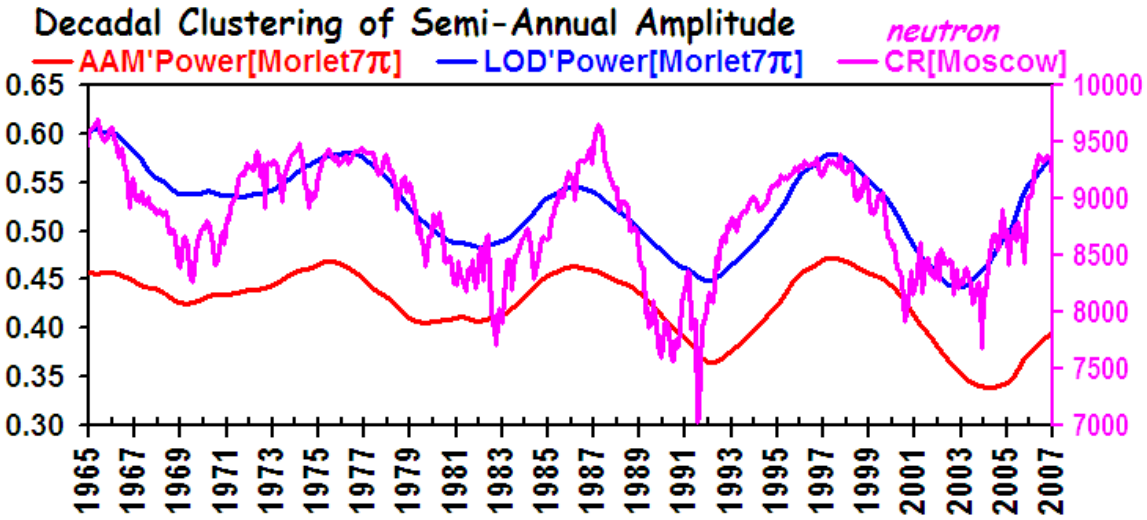
Shifting Sun-Earth-Moon Harmonies, Beats, & Biases

Paul L. Vaughan, M.Sc. – October 2011



Motivation

One purpose of this article is to direct the attention of sensible observers to a serious oversight in the mainstream quest for understanding of multidecadal solar-terrestrial relations (section **I**).

Another is to ask the community to start thinking carefully about what can be learned from rotating multivariate lunisolar spatiotemporal phase relations shared by Earth Orientation Parameters (EOP) and terrestrial climate records, while seizing the same opportunity to highlight critical omissions in "classic" works on alleged solar-barycentric terrestrial influences (section **II**).

These data exploration notes are volunteered in support of ongoing publicly collaborative multidisciplinary research.

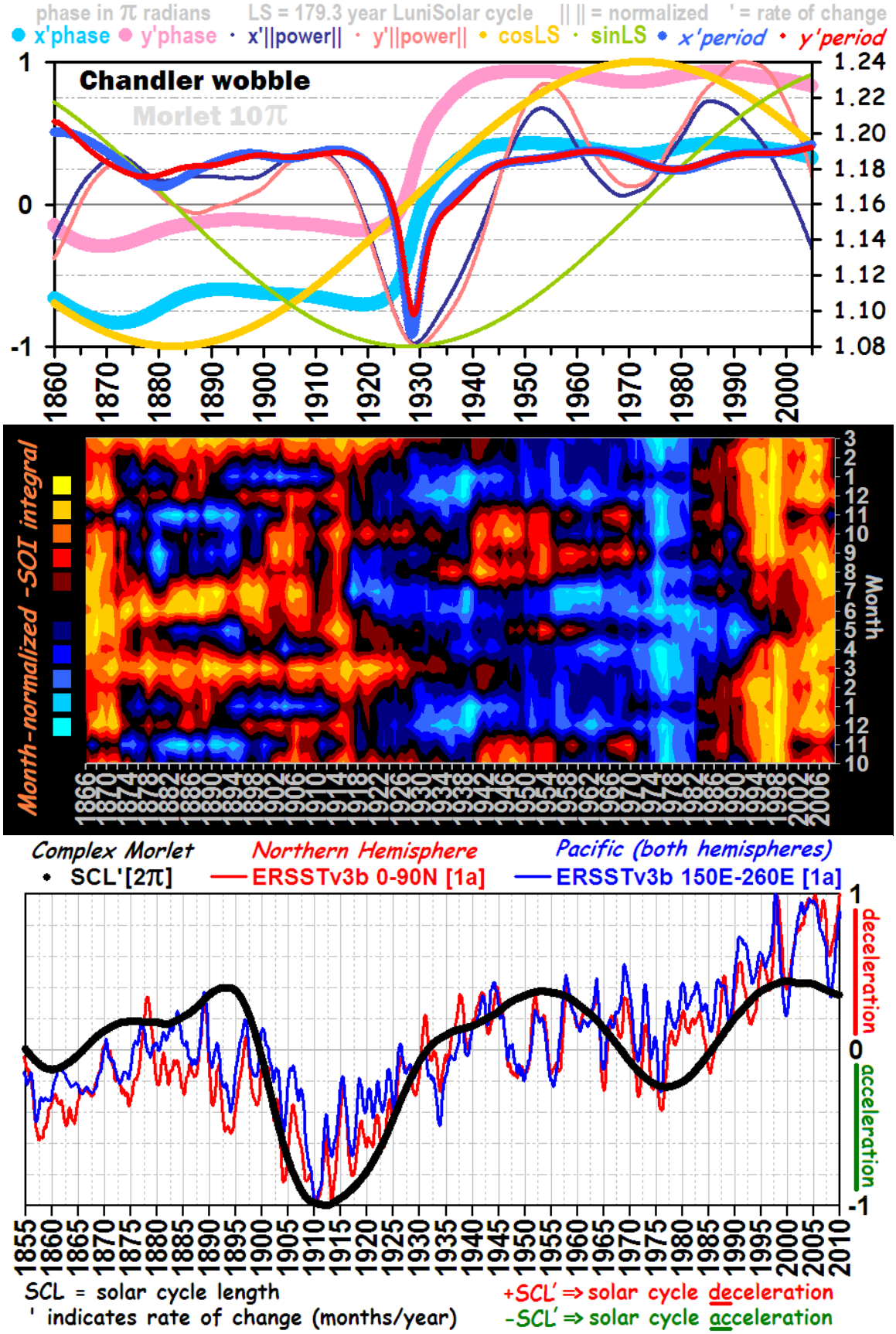
Audience

The diverse audiences addressed might not be the ones preferred by some readers. Addressing rotates priority across a spectrum of functional numeracy & orientation.

Format

Volunteer time & resources are limited, so presentation is skeletal & informal.

Visual Abstract



I.

Multidecadally Shifting Asymmetric Solar-Terrestrial Annual Pump Amplifier

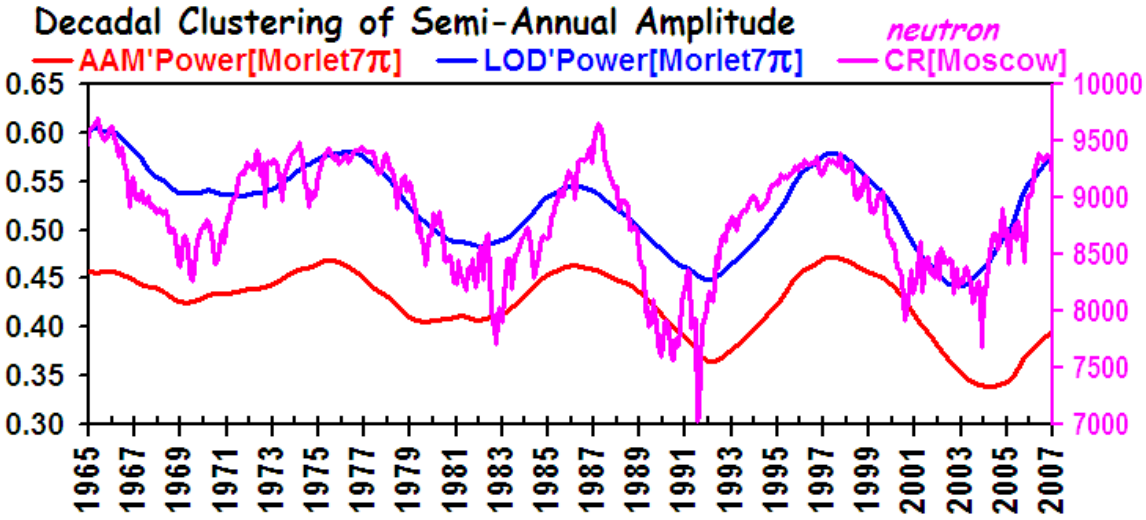
What the mainstream appears to have overlooked:

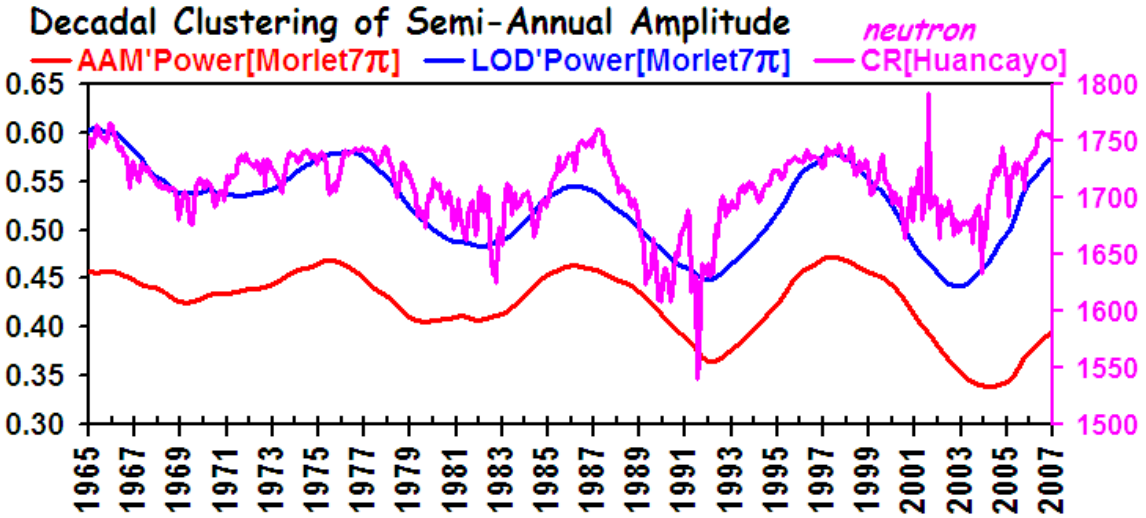
1. Solar cycle phase modulates equator-pole pumping variations annually & regionally.
2. The *changing* frequency of differential modulation controls multidecadal oscillations.

This occurs naturally.

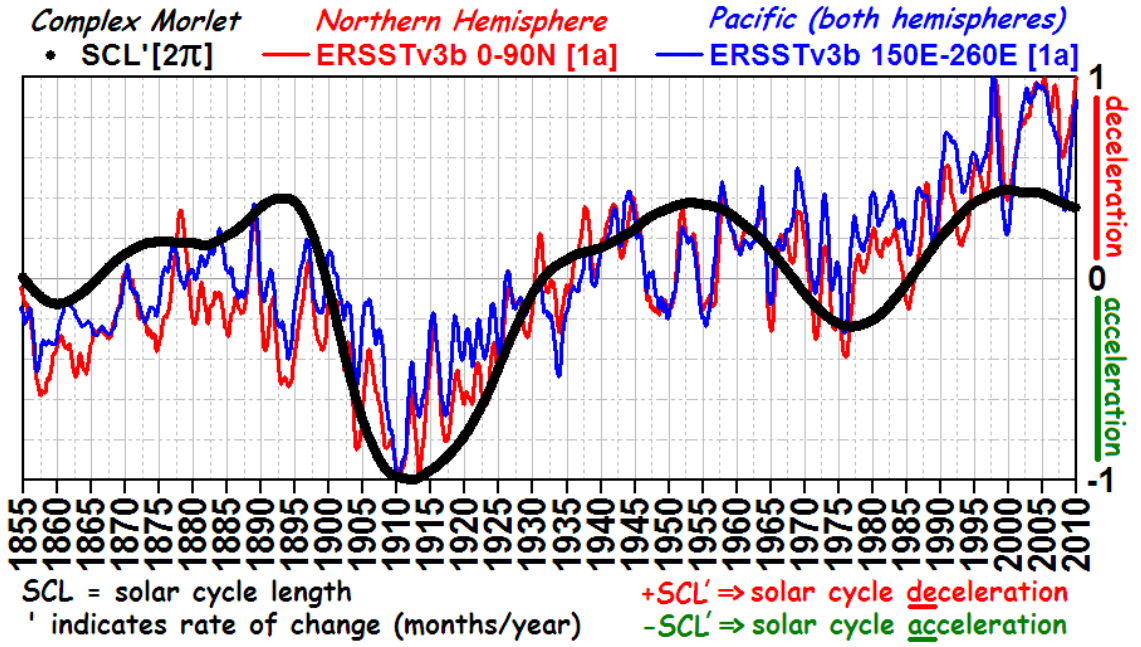
Illustrated elaboration:

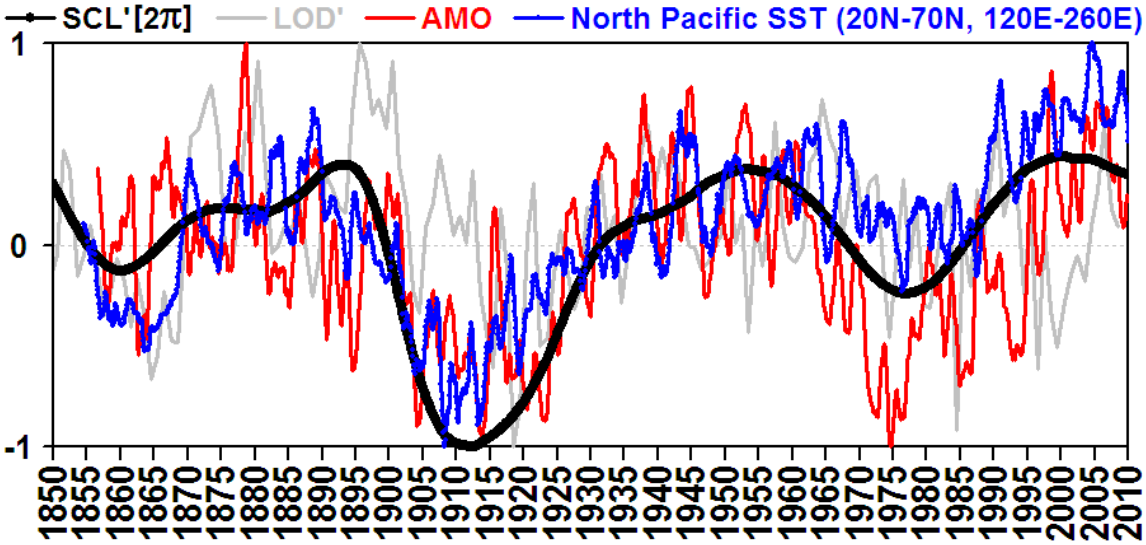
1) Solar max attenuates and solar min amplifies semi-annual terrestrial gradient & flow variations.

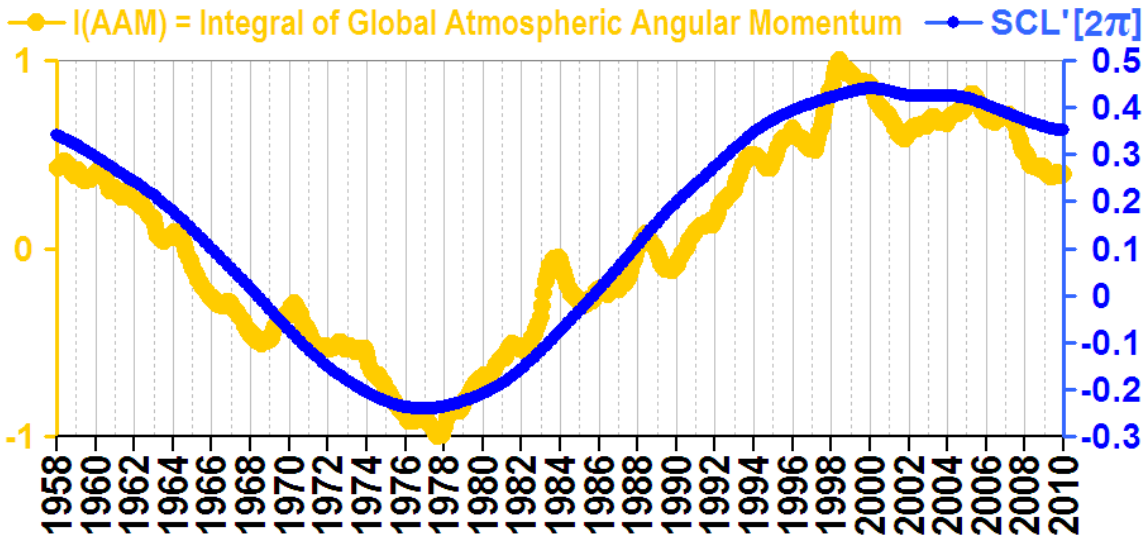




2) Multidecadal terrestrial oscillations arise cumulatively from gradient & flow shifts aliased differentially from solar pulse position by dominant terrestrial cycles (e.g. year & QBO) and spatial heterogeneities (e.g. north-south asymmetry & ocean-continent heat-capacity contrast).



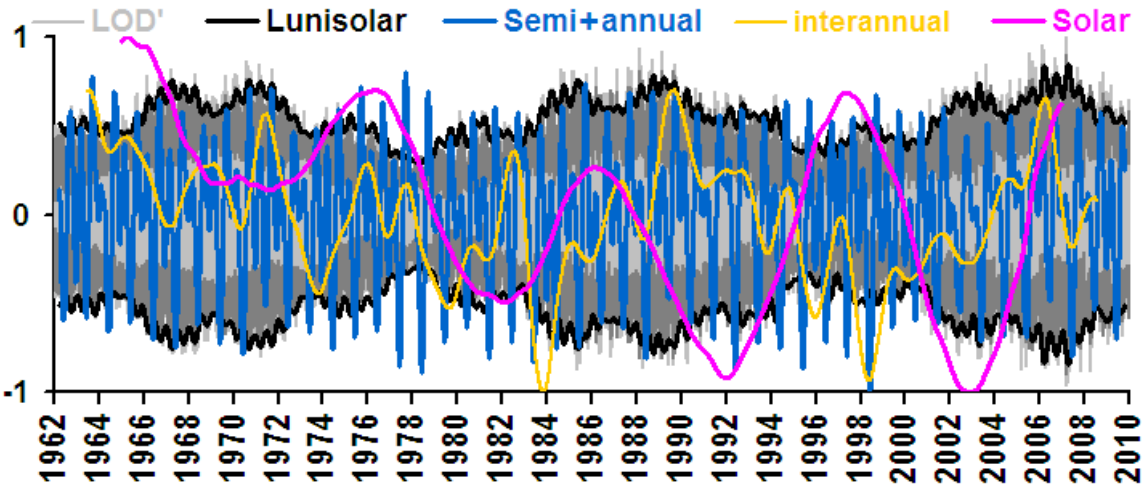




What mechanisms?

Gravitational & spatiotemporal insolation tides. The surfaces of Earth's shells wrap on themselves, putting constraints of solar & lunisolar origin on global summaries.

On the following graph, every curve is a *simple* summary of the grey LOD' curve:



How do the mechanics work?

10 steps to understanding:

1. See particularly the exposition of p. 433 [pdf p.10] and more generally this whole paper:

Sidorenkov, N.S. (2005). Physics of the Earth's rotation instabilities. Astronomical and Astrophysical Transactions 24(5), 425-439.
http://images.astronet.ru/pubd/2008/09/28/0001230882/425-439.pdf

2. Study Figures 8, 11, 13, & 15 comparatively to *very carefully "spot the differences"* between pictures & hemispheres, consulting the associated text for reinforcement:

Leroux, Marcel (1993). The Mobile Polar High: a new concept explaining present mechanisms of meridional air-mass and energy exchanges and global propagation of palaeoclimatic changes. Global and Planetary Change 7, 69-93.
http://ddata.over-blog.com/xxxyyy/2/32/25/79/Leroux-Global-and-Planetary-Change-1993.pdf

Supplementary: (a) http://www.seafriends.org.nz/issues/global/global52.jpg , &
(b) http://upload.wikimedia.org/wikipedia/commons/d/d7/ITCZ_january-july.png

3. See the following seminal 2010 paper:

Le Mouël, J.-L.; Blanter, E.; Shnirman, M.; & Courtillot, V. (2010). Solar forcing of the semi-annual variation of length-of-day. Geophysical Research Letters 37, L15307. doi:10.1029/2010GL043185.

This paper provided the crucial missing link I needed to make sense of and gain full confidence in shared patterns I had noticed months earlier. It cannot be overstated how beautiful & crucial these findings are. The contribution stands out as the most towering landmark in the history of solar-terrestrial relations. It has been misunderstood by critics, evidently as an unfortunate result of functional numeracy deficiencies.

4. See the extension of (3) here:

Vaughan, P.L. (2010). Semi-annual solar-terrestrial power. http://wattsupwiththat.com/2010/12/23/confirmation-of-solar-forcing-of-the-semi-annual-variation-of-length-of-day/

No variable in the OMNI2 database [http://omniweb.gsfc.nasa.gov/] fits semi-annual power better than neutron count rate (nCR). When time & resources permit, there are a number of ways to further refine the analysis to further underscore coherence.

5. See supplementary notes providing foundations for (4) here:

Vaughan, P.L. (2011). Solar, terrestrial, & lunisolar components of rate of change of length of day. http://wattsupwiththat.com/2011/04/10/solar-terrestrial-lunisolar-components-of-rate-of-change-of-length-of-day/

6. To supplement (1), see:

Sidorenkov, N.S. (2003). Changes in the Antarctic ice sheet mass and the instability of the Earth's rotation over the last 110 years. International Association of Geodesy Symposia 127, 339-346.

Excerpts:

a) *"The purpose of this paper is to call attention to a close correlation of the decade variations in the Earth rotation with the mass changes in the Antarctic ice sheets."* [Compare with decadal variations of -NPI.]

b) *"The redistribution of water masses on the Earth entails changes in the components of the Earth's inertia tensor and causes the motion of poles and changes of the Earth's rotation speed."*

c) *"Apart from all other reasons, the parameters of the geoid depend on the distribution of water over the planetary surface."*

Note that the same material is addressed in section 3 (*"Nature of the decades-long variations in the Earth's rotation"*) of (1).

7. See figure 10:

Carvalho, L.M.V.; Tsonis, A.A.; Jones, C.; Rocha, H.R.; & Polito, P.S. (2007). Anti-persistence in the global temperature anomaly field. Nonlinear Processes in Geophysics 14, 723-733. http://www.icess.ucsb.edu/gem/papers/npg-14-723-2007.pdf

Compare with the following to develop awareness of low-heat-capacity *high-variance-leverage* (that *misleads* those lacking adequate conceptualization of the role of *aggregation criteria* in spatiotemporal summaries): **http://icecap.us/images/uploads/AMOTEMPS.jpg**

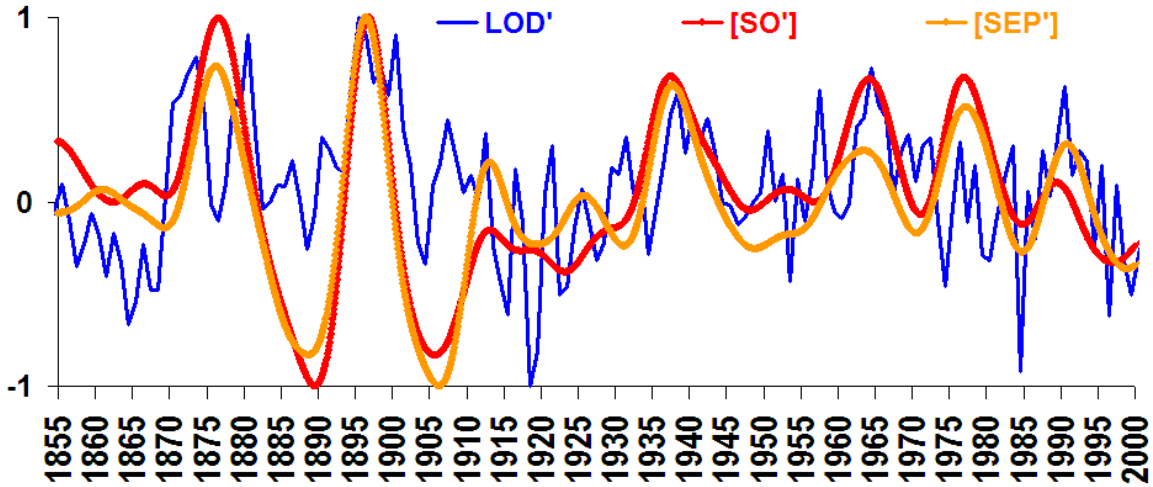
A comparison of the 2 similarly-patterned maps emphasizes that academic complexity-reducing efforts should neither be centered on nor limited to a single ocean basin (e.g. North Atlantic, which seems to attract the lion's share of multidecadal attention) at the expense of attention to *north-south-asymmetric global maritime-continent contrasts* more generally.

Carefully note the *north-south-asymmetric longitudinal variance* (west-east land-ocean-land-ocean alternations for a fixed latitude) [bearing in mind that much of the Arctic Ocean is "continental" for most of the year from an atmospheric perspective] of **multivariate** climatologies: http://ds.data.jma.go.jp/gmd/jra/atlas/eng/atlas-tope.htm (deserves a few ***hours*** of attention)

Longitudinal spatial oscillations of climatologies are not rigidly nonstationary at multidecadal timescales. Solar & lunisolar modulation is *spatially heterogeneous* due to contrasting land-ocean physical properties.

In the northern hemisphere, the alternating distribution of land & ocean (with rotation) results in multivariate isolines with relatively high length : area ratios. This topology implies that jet deflecting shifts in absolute gradient positions, orientations, & magnitudes affect a *relatively large* area, much of which has *low* heat-capacity. The meridional meandering differentially (in space) aggregates (in time) into multidecadal summaries.

8. Observed over a terrestrial rotation at a fixed latitude, the far south is *relatively uniform longitudinally* when contrasted with the violently alternating physical properties of the north. The powerful westerlies over the Southern Ocean's Antarctic Circumpolar Current (which have *minimal* land-ocean-land-ocean alternations) don't get the attention they deserve, so here's a reminder:



SO = Southern Ocean SST (ERSSTv3b) SEP = SouthEast Pacific SST (ERSSTv3b)
' indicates rate of change [ ] indicates dominant-peak-&-valley-location-preserving repeat 1-year smoothing

The average position of the multidecadal temperature-swing fulcrum is *not* located over the equator but rather the Antarctic Circumpolar Current of the Southern Ocean, a *sharp* discontinuity *caused by the current distribution of continents*.

See Figures 2a, 2b, & especially 4b here:

Svensmark, H. (2006). The Antarctic climate anomaly and galactic cosmic rays.
http://arxiv.org/PS_cache/physics/pdf/0612/0612145v1.pdf

For more details, see Figure 5 here:

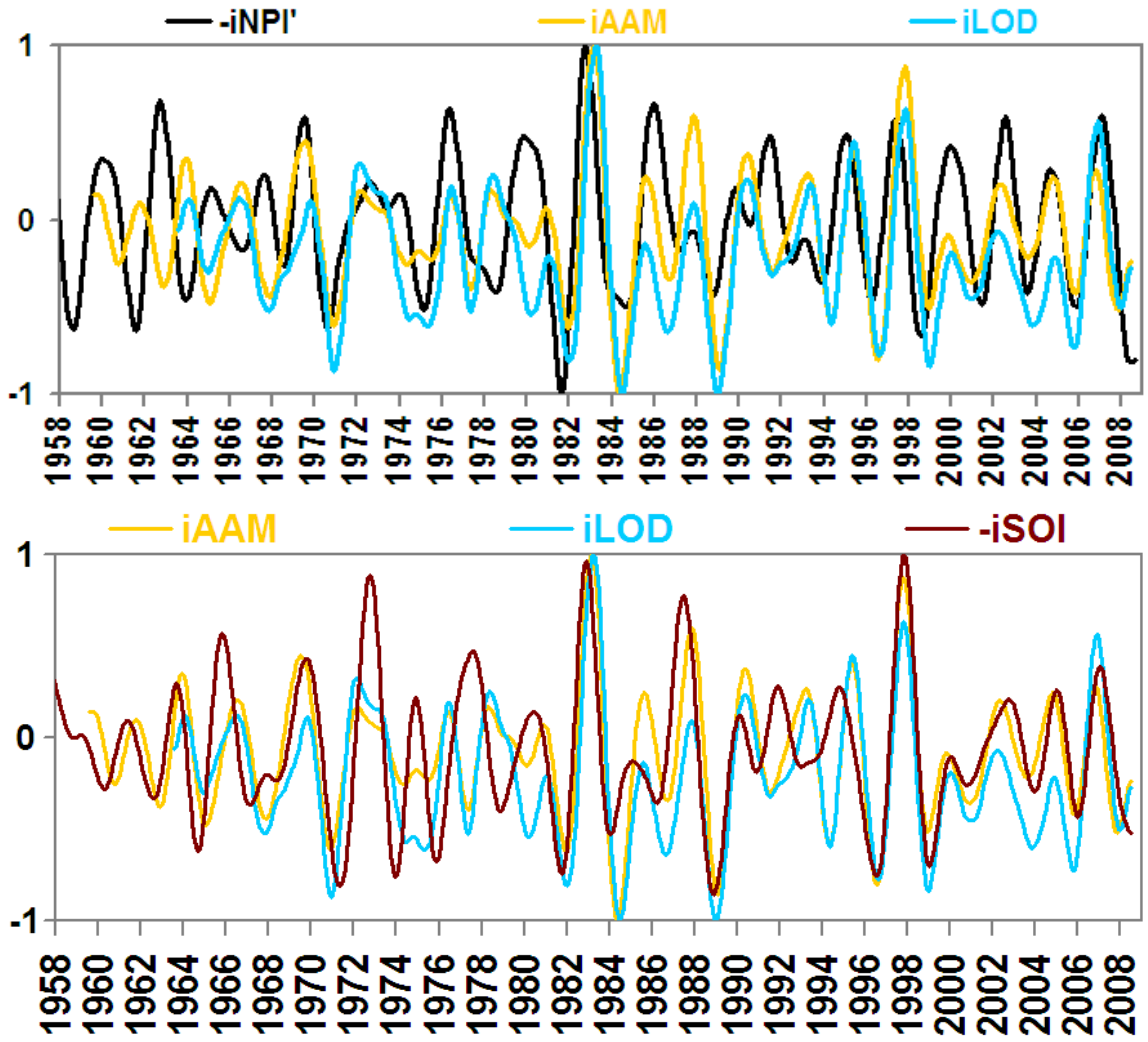
Pavolonis, M.J.; & Key, J.R. (2003). Antarctic cloud radiative forcing at the surface estimated from the AVHRR Polar Pathfinder and ISCCP D1 datasets, 1985-93. Journal of Applied Meteorology 42, 827-840.
http://journals.ametsoc.org/doi/pdf/10.1175/1520-0450%282003%29042%3C0827%3AACRFAT%3E2.0.CO%3B2

"On the monthly timescale, clouds were found to have a warming effect on the surface of the Antarctic continent for every month of the year, which means that the longwave effect of clouds is larger than the shortwave effect of clouds for every month. This result is in contrast to the globally averaged effect, in which clouds cool the surface on an annual basis [...]" / "Over the ocean poleward of 58.758S, clouds were found to have a warming effect on the surface from March through October in the ISCCP-derived dataset and from April through September in the APP-x dataset."

9. The spatiotemporal version of Simpson's Paradox has a *vice-like* grip on widespread, *deeply entrenched misconceptions* of interannual regional terrestrial interrelations, thus precluding the possibility of sensible conception of multidecadal variations for all but an extraordinarily rare few climate discussion participants.

One of topography's effects on externally governed flow
[e.g. http://upload.wikimedia.org/wikipedia/commons/6/67/Ocean_currents_1943_%28borderless%293.png]
is interannual relations that are*n't* linear (interannual "spatiotemporal chaos" according to *potentially* seriously misleading labeling applied by some, which is potentially of at least *transient* utility in the climate discussion until mainstream conceptualization is adjusted to achieve consistency with observation).

For example:



More graphs emphasizing the complexity (as in complex numbers), a prominent feature of which is *reversing* phase-relations, accompany links to related research articles here:

Vaughan, P.L. (2011). Interannual terrestrial oscillations.
http://wattsupwiththat.files.wordpress.com/2011/05/vaughan-p-l-2011-interannual-terrestrial-oscillations.pdf

[Speculation (a) in that article is under revision/refinement following new insights arising from multivariate multiscale complex correlation and precisely-targeted temporal-framework input from Piers Corbyn.]

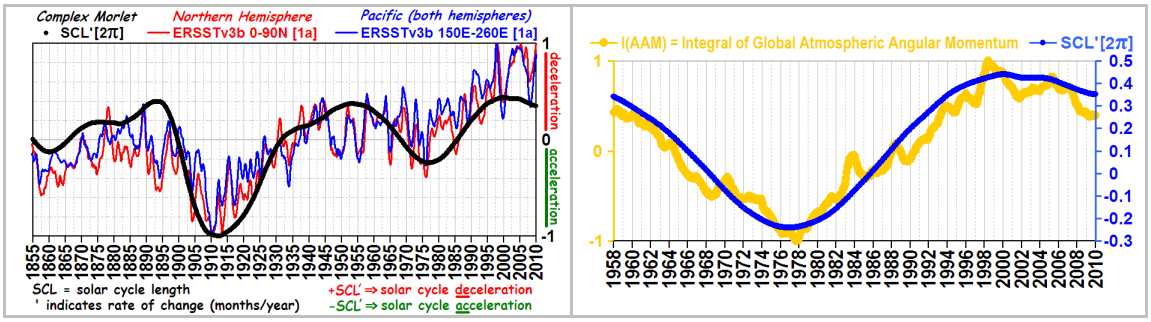
Related: Tomas Milanovic revealed the primary, fundamental mainstream misconception motivating his entry into the climate discussion while responding to my comments here:
http://judithcurry.com/2011/03/07/phase-locked-states/#comment-54749

10. Changing nonstationary beats with natural internal oscillations are *generalizable*. The generalizability *includes* natural oscillations with *irregular* periods. It's no different than anchoring 2 ends of an accordion along a graduated yardstick and distorting the uniform spacing of the folds relative to the tick-marks. Even if there are several adjacent sets of tick-marks, some of which might be irregularly spaced (say to represent nonstationary processes in different ocean basins or to demark *whatever* one considers important internal-oscillation transition-points), the effect of the shifting accordion folds is *generalizable*.

P'(s,t) =
({ |A(t)-B(s,t)| * [A(t)*B'(s,t) + B(s,t)*A'(t)] }
- { [A(t)*B(s,t)] * [(A(t)-B(s,t)) * (A'(t)-B'(s,t)) / |A(t)-B(s,t)|] })
/ (A(t)-B(s,t))^2

A(t) ≠ B(s,t)
A = solar cycle length nearest-harmonic
B = a given internal cycle period
P = beat period
s = space ' indicates rate of change
t = time ^ indicates exponentiation

It's important to recognize that the effect of changing solar cycle frequency is generalizable *even with incomplete knowledge* of Earth's internal cycles. This point cannot be stressed enough for audience members struggling to understand the mechanics & the nonstationary (**not** "60 year") multidecadal coherence.



Both solar cycle acceleration & deceleration dial *& step-jump* nearest-harmonics with dominant natural internal modes of variability (such as the terrestrial year, QBO, ENSO, etc.) Dalton Minimum is an example of a time when there was *rapid* dialing & step-jumping through nearest-harmonics due to both deceleration & acceleration. The dialing & jumping was so rapid that disentangling the effect from other sources of interannual variability would be a challenging exercise given *current* levels of understanding of climate. However, in *recent times*, solar cycle acceleration & deceleration have been *slow enough* to allow us to see a clear & simple multidecadal pattern *despite* interannual (so-called "spatiotemporal chaos") variability.

The observed *differential* pulse-position modulation can produce step-changes *both up and down*. Important: It's *not* the deviation of solar cycle frequency from average solar cycle frequency that's of practical significance *from a terrestrial perspective*. Earth, the receiver, has no clock locked to the average solar cycle length, so the pulse-position modulation is *differential*.

Cautionary Notes

We lack reliable geophysical records of satisfactory spatiotemporal resolution for periods such as Maunder Minimum, so we might be terribly ill-advised to extrapolate phase-based relations into future periods of low amplitude solar activity. And surely nature has *many* other lessons to teach us about *qualitative* shifts in *conditional* multivariate relations.

Concluding Remarks

Nonstationary multidecadal terrestrial variations are synchronized with *changes in* the spacing of decadal clusters of terrestrially-asymmetric semi-annual equator-pole flow-hammering amplitude.

Hydrology's a function of *absolutes*, *not* anomalies. *"Apart from all other reasons, the parameters of the geoid depend on the distribution of water over the planetary surface."* -- Sidorenkov (2003).

The majority of recent multidecadal terrestrial variability is due to *natural* spatiotemporal aliasing of differential solar pulse-position by terrestrial topology over basic terrestrial cycles including the year.

Bear in mind that these variations are only *tenths* of a degree K.

Important: These observations depend on *neither* the success nor failure of CERN's CLOUD experiment.

Even though they appear to have fluked out somewhat in achieving sufficient focus to recognize the pattern with compoundly suboptimal focus, Le Mouël, Blanter, Shnirman, & Courtillot (2010) have supplied absolutely crucial help with their seminal observation of the beautiful missing link that bridges the lower & higher timescales.

Careful consideration of how & why the mainstream unacceptably overlooked the razingly plain simplicity might help educators determine what adjustments to education systems are necessary to prevent such unconscionably blind failures in the future. The 2 primary rotten functional numeracy roots of the collectively-compromising comprehension-bottleneck appear to be (1) severely inadequate common knowledge of cycle & phase relation fundamentals and (2) widespread mainstream failure to fundamentally differentiate *marginal* spatial & temporal distributions from *joint* spatiotemporal distributions **[spatiotemporal version of Simpson's Paradox]**.

In layman's terms:
It was right in front of their noses, but no one thought to bring the microscope *into focus*. Sounds ridiculously silly, yes, but this is literally analogous to what happened.

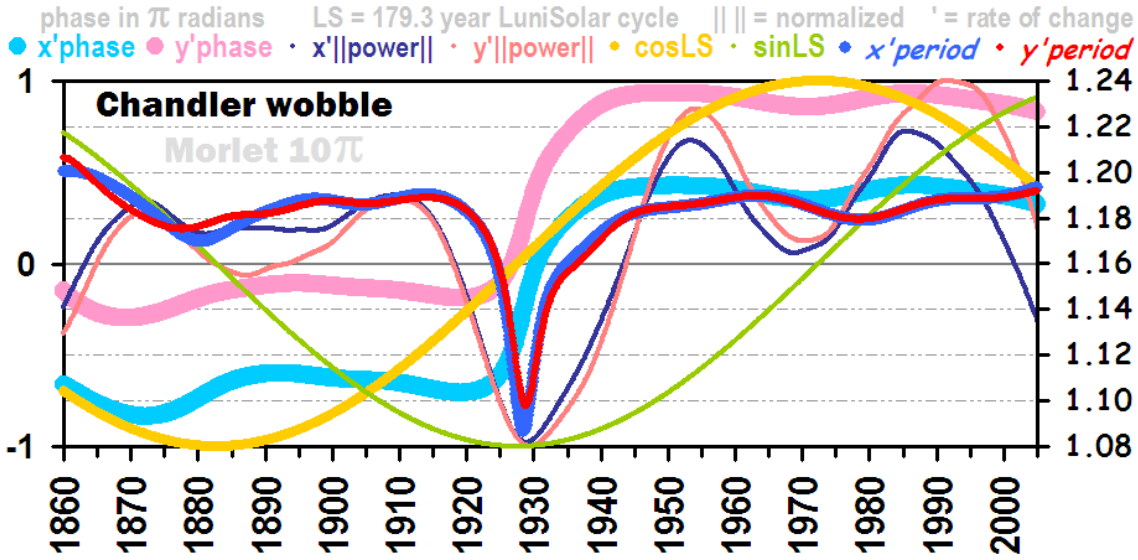
Disbelief, denial, ignorance, &/or mistrust of the sheer simplicity of what was overlooked may continue to be the dominating mainstream reaction in both the short & medium terms. For those who don't understand that complex (as in complex numbers, not as in complicated) resonators have adjustments analogous not only to magnification but also focal length, acceptance of the finding may be postponed *indefinitely*. Similarly, those lacking deep conceptual understanding of the role of aggregation criteria in summaries of spatiotemporal pattern may *never* possess sufficiently lucid cognizance of the potential to misinterpret spatial phase reversals as temporal evolution.

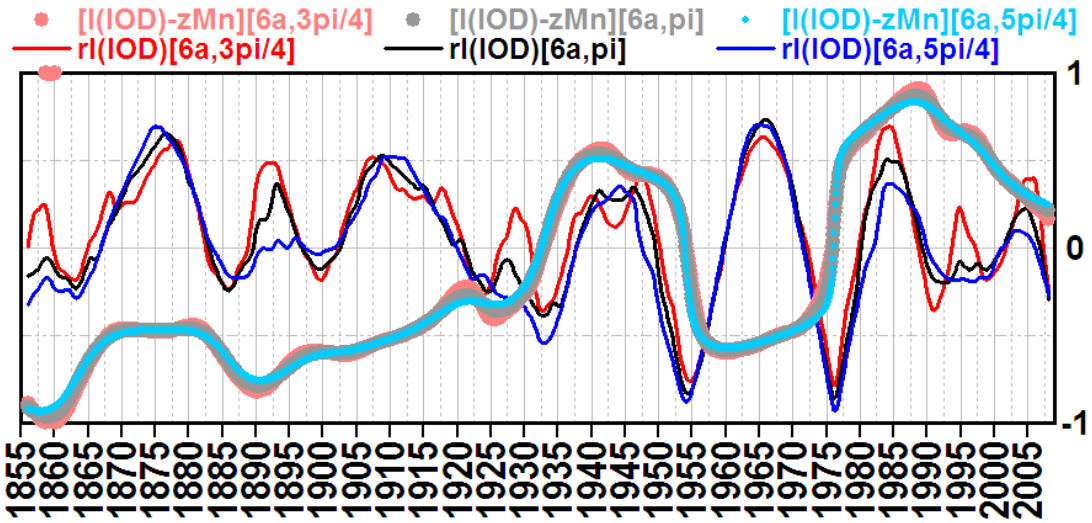
EOP, which are integrated & aliased *globally*, are the arbiters of terrestrial climate disputes. In light of the preceding observations, popular theories speculating that AMOC drives AMO (& so-called "60 year cycles" more generally) should be brought under scrutinizing review. Also, we now have a new basis (similar to the double-helix of DNA) for reframing & refining our spatiotemporal conceptions of interannual variability.

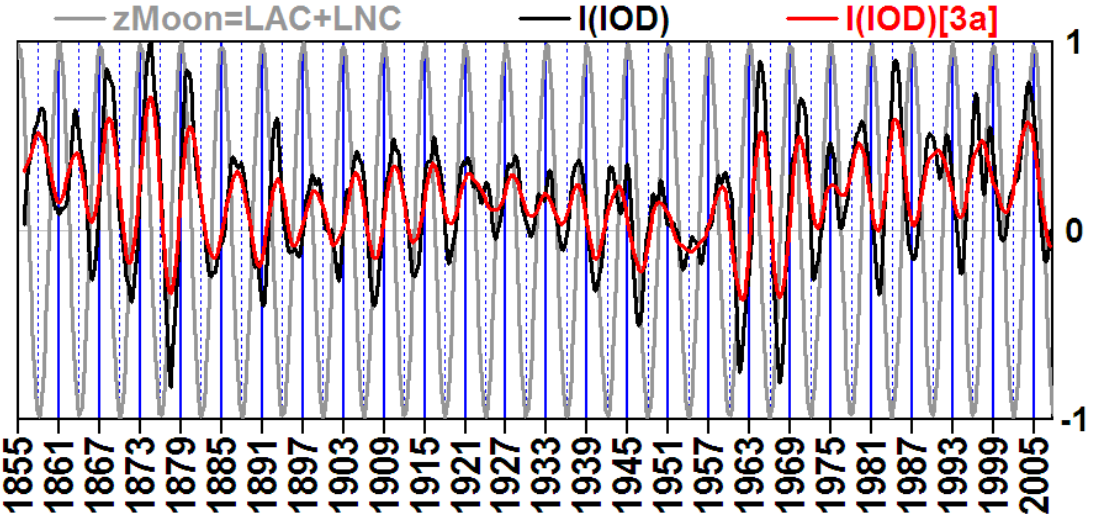
Best Regards to All,
Paul L. Vaughan, M.Sc.

II.

Lunisolar Components of Terrestrial Chandler Wobble, Quasibiennial Oscillation, & Polar Motion Envelope

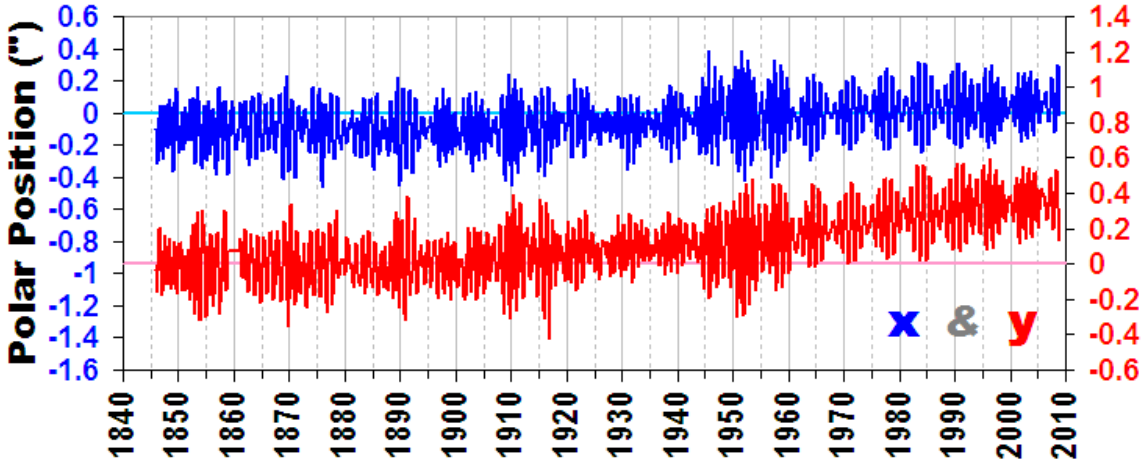




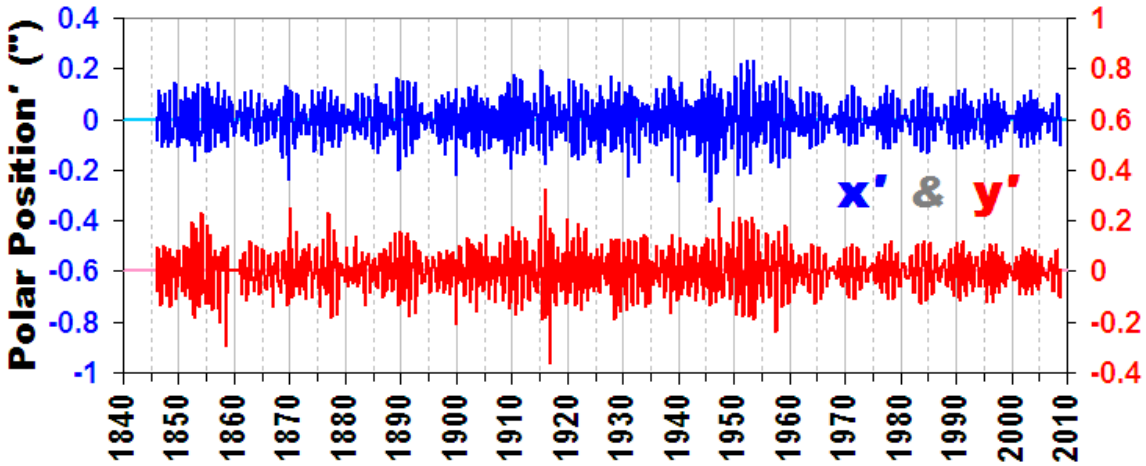


Background

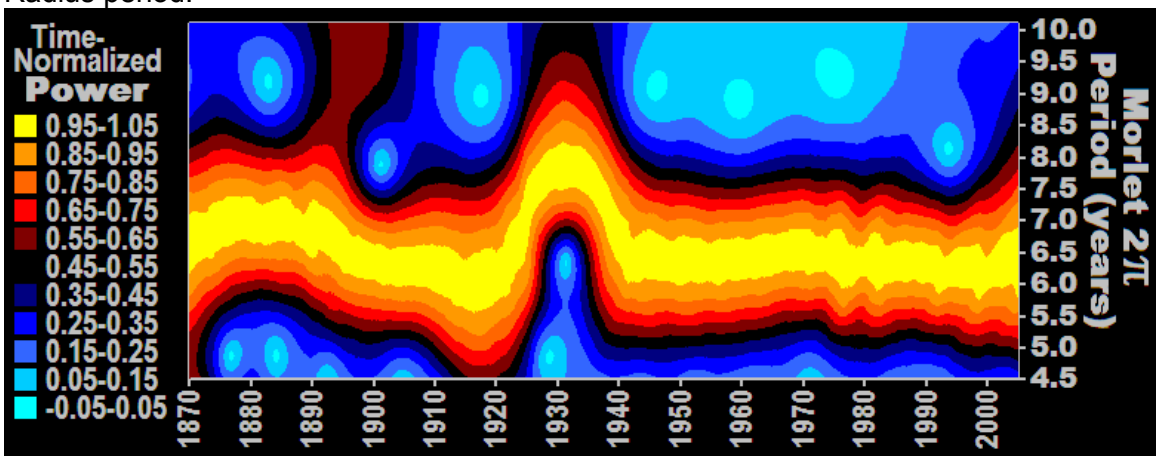
The terrestrial polar motion record represents the motion of the surface of the geoid relative to the rotation axis (not to be confused with the motion of the rotation axis relative to a celestial framework).



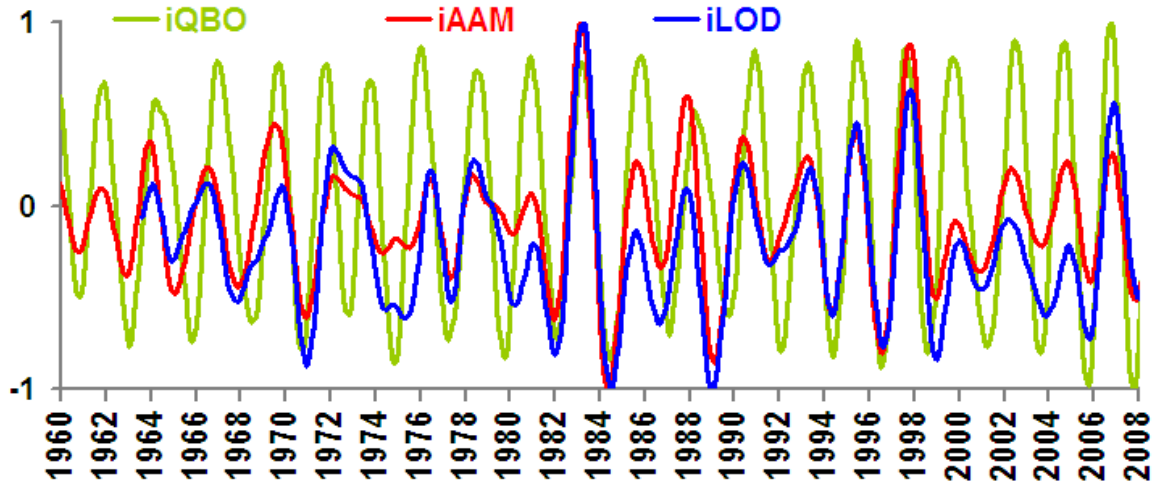
Rate of change:



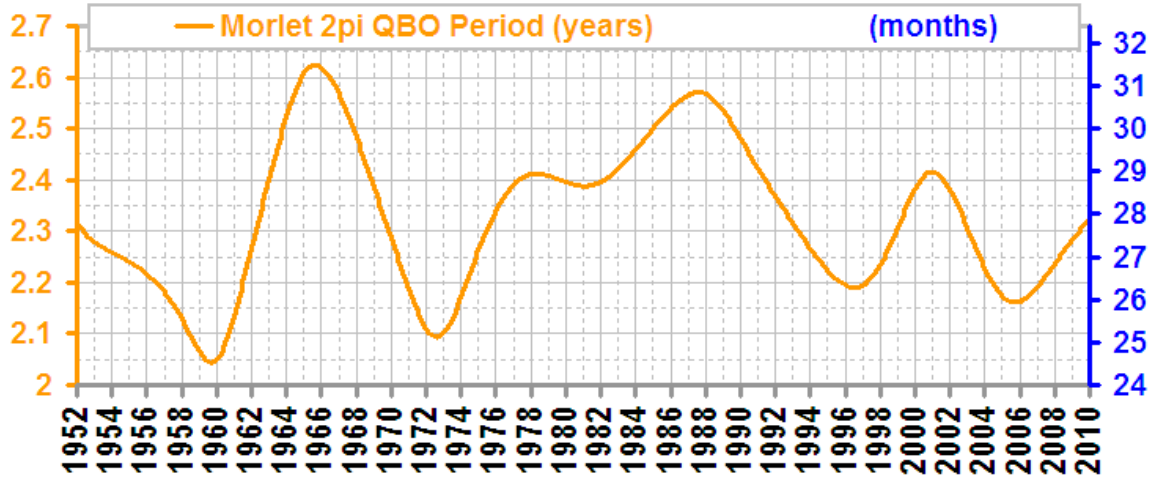
Radius period:



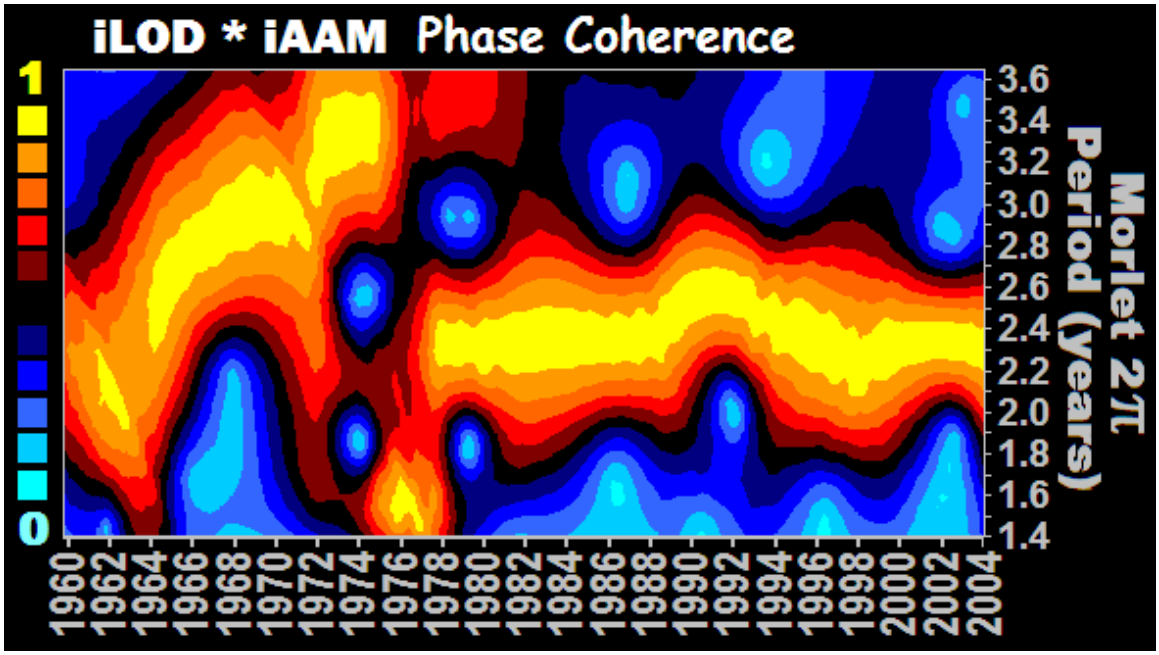
Interannual quasibiennial oscillation (QBO), atmospheric angular momentum (AAM), & length of day (LOD):



QBO period:



Coherence of interannual LOD & AAM:



Beats

Terrestrial Tropical Year = 365.24219 days

Earth has 2 hemispheres:

Semi-Annual Oscillation = Tropical Year / 2 = 365.24219 / 2 = 182.621095 days
(time between equinoxes = time between solstices)

1. Lunar Draconic Month = 27.212221 days
(time between node-crossings in *same* direction)

Nearest harmonic of tropical year = 365.24219 / 13 = 28.09555308 days

(28.09555308)*(27.212221) / (28.09555308 - 27.212221)
= 865.5209286 days = **2.369717826 years**

2. Lunar Draconic Month / 2 = 27.212221 / 2 = 13.6061105 days
(time between node-crossings [in *either* direction])

a) Nearest harmonic of tropical year = 365.24219 / 27 = 13.52748852 days

(13.6061105)*(13.52748852) / (13.6061105 - 13.52748852)
= 2341.031097 days = **6.409530885 years**

b) Nearest harmonic of semi-annual oscillation = 182.621095 / 13 = 14.04777654 days

(14.04777654)*(13.6061105) / (14.04777654 - 13.6061105)
= 432.7604643 days = **1.184858913 years**

Note that the beat of the tropical year with the Chandler wobble gives the polar motion envelope, as it should:

(1.184858913)*(1) / (1.184858913 - 1) = 6.409530885 years

Also note that the QBO period is the Chandler wobble period doubled:
2 * 1.184858913 = 2.369717826 years

(Earth has 2 hemispheres.)

Summary

Oscillation	**Period (years)**
Chandler Wobble	1.184858913
QBO	2.369717826
Polar Motion envelope	6.409530885

Phase-Confounding of Solar, Lunisolar, & Solar System Beats & Harmonies

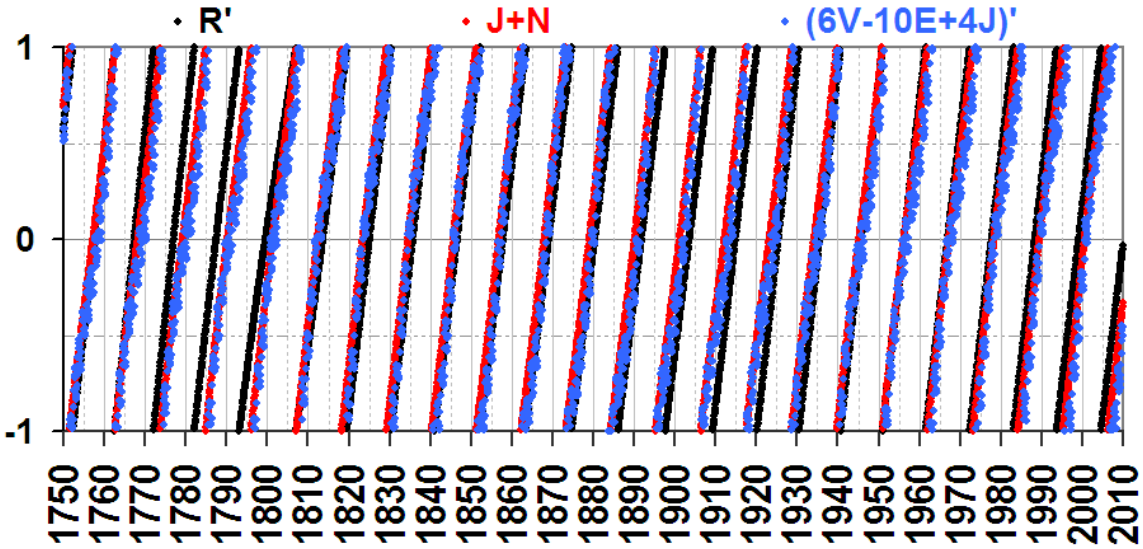
A. The highest-frequency high-amplitude solar system beats are set by the innermost & outermost jovian (gas giant) planets.

Position	Gas Giant	Period (years)
Innermost	Jupiter	11.8663089875917
Outermost	Neptune	164.888324956453

Sidebands:

1) J+N = (164.888325)*(11.86630899) / (164.888325 + 11.86630899)
= 11.06967194 years

Note the near-synchronicity with the solar Schwabe cycle & the Jupiter-Earth-Venus cycle:



Phase units: pi radians = 180 degrees = half-cycle.

J+N & R' have been out-of-phase by at most a quarter-cycle on 2 occasions (~1790 & ~1915), both of which occurred near a sunspot amplitude drop, which is also when R' phase is arguably least well-determined.

Equivalently, the solar Hale cycle appears synchronized with the harmonic mean of J & N over the full span of the sunspot record.

Near-synchronicity means phase-contrast cycles *slowly* – for example 6V-10E+4J (11.05497026 years) laps J+N in 8323.866665 years.

2) J-N = (164.888325)*(11.86630899) / (164.888325 - 11.86630899)
= 12.78649873 years

Alignments of the Sun, Neptune, & Jupiter define the dominant temporal mode of absolute solar barycentric radial acceleration: 12.78649873 / 2 = 6.393249363 years.

Some readers will also be aware of 6.4 year features of the Mayan calendar:

i. 4th Venus-Earth subharmonic:

(1)*(0.615172098) / (1 - 0.615172098) = 1.598564175 years
4 * (1.598564175) = 6.394256699 years

ii. 3rd Earth-Mars subharmonic:

(1.880851534)*(1) / (1.880851534 - 1) = 2.135265095 years
3 * (2.135265095) = 6.405795284 years

iii. Ma - 2E + V = (Ma-E) - (E-V)
= (2.135265095)*(1.598564175) / (2.135265095 - 1.598564175) = 6.359889012 years

This reminds us that the beat period of any 2 adjacent harmonics is the fundamental.

n	**6.4/n**	**6.4/(n+1)**	**Beat Period**
1	6.4	3.2	6.4
2	3.2	2.133333	6.4
3	2.133333	1.6	6.4
4	1.6	1.28	6.4

The acoustic identity is proven as follows:

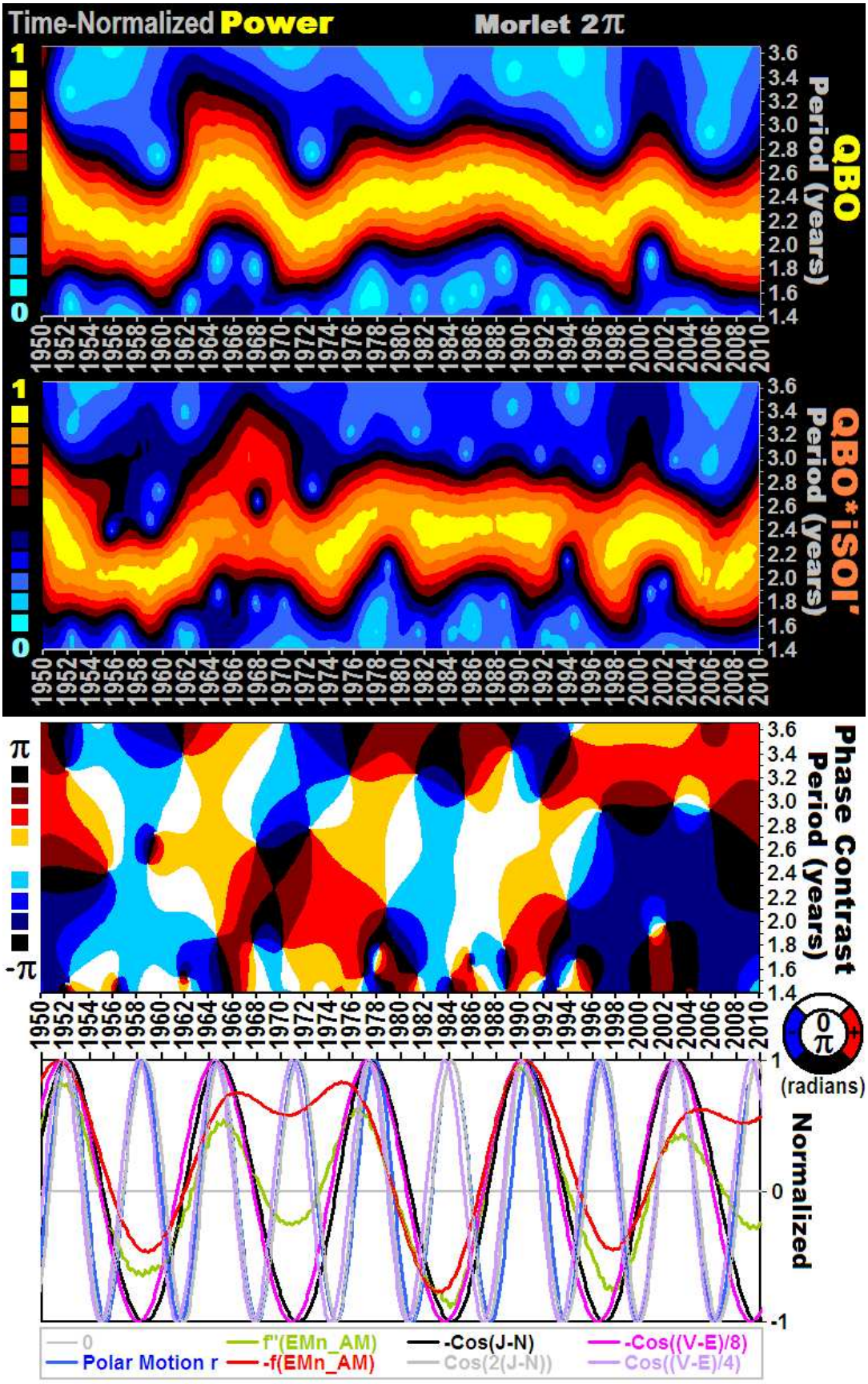
{ [x / n] * [x / (n+1)] } / { [x / n] - [x / (n+1)] }
= { [x^2] / [n(n+1)] } / { [x(n+1) - xn] / [n(n+1)] }
= x

where x represents the fundamental period & n indicates harmonics.

Near-synchronicities mean phase-contrasts cycle *slowly* – a few examples:

A	B	Beat = A*B / |A-B|
6.409530885	6.393249363	2516.824367
6.394256699	6.393249363	40582.39483

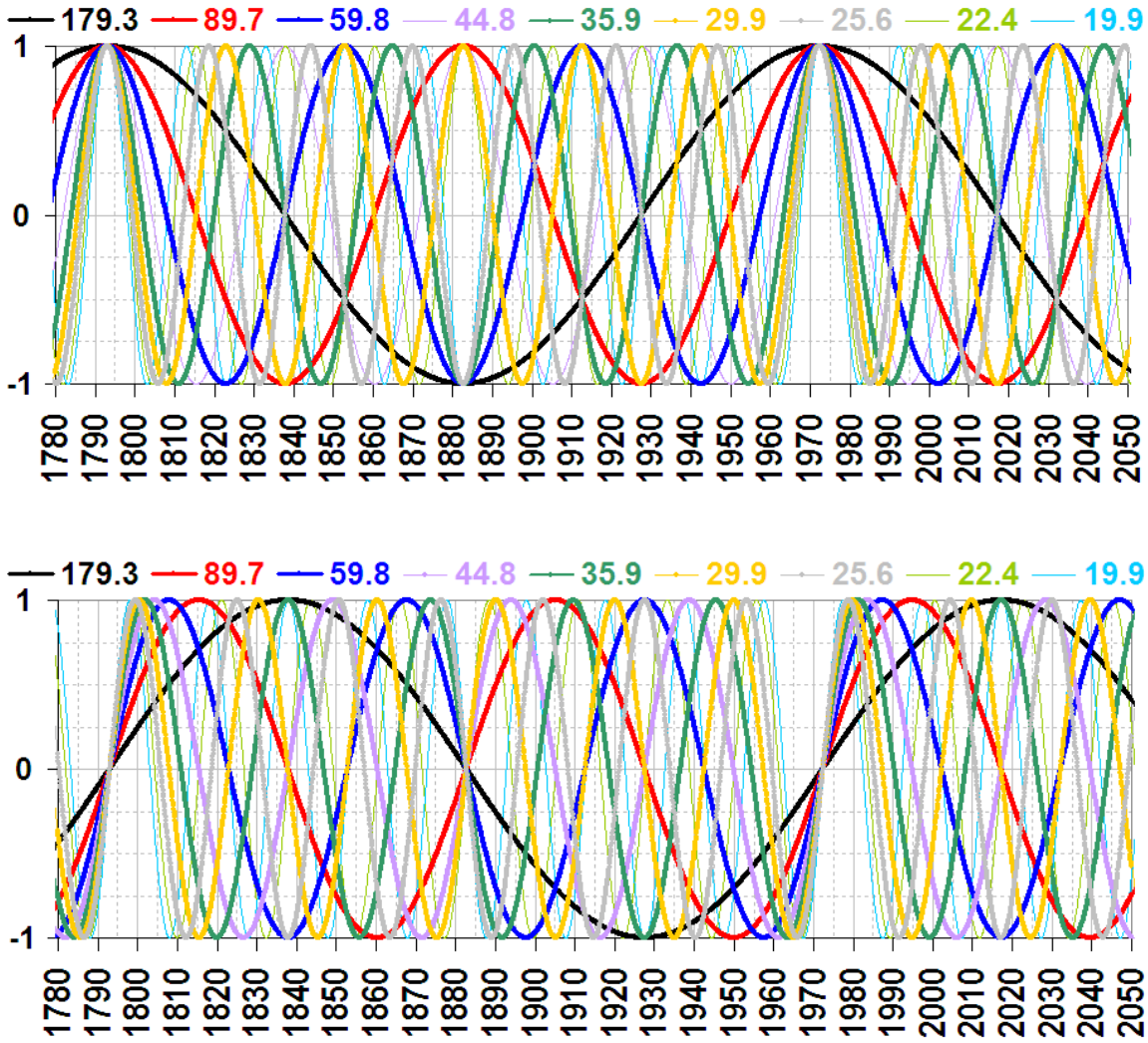
Richard Gross (NASA EOP expert) was the first to suggest a redirection of my focus from the solar system to lunisolar cycles. Physicist Piers Corbyn (WeatherAction.com) *efficiently* pointed *directly* at *specific* lunisolar cycles. Physicist Ian Wilson highlighted hierarchically-historic solar system shaping of lunisolar cycles. Their collective influence demystified coincidences (bottom-panel) on the following graph:


Time-Normalized Power
Morlet 2π
QBO
Period (years)
QBO*iSOI'
Period (years)
Phase Contrast
Period (years)
(radians)
Normalized
0
Polar Motion r
f'(EMn_AM)
-f(EMn_AM)
-Cos(J-N)
Cos(2(J-N))
-Cos((V-E)/8)
Cos((V-E)/4)

Confounding Summary:

Cycle	Pr'	~Chandler	~Chandler (d)	~QBO	~QBO (mo)
(J-N) / 2	6.393249363	1.185416978	432.9642932	2.370833957	28.45000748
4 * (V-E)	6.394256699	1.185382353	432.9516466	2.370764706	28.44917647
3 * (E-Ma)	6.405795284	1.184986657	432.8071219	2.369973315	28.43967978
Ma - 2E + V	6.359889012	1.186571027	433.3858007	2.373142055	28.47770466
Lunar Nodal	*years*	*years*	*days*	*years*	*months*
or Draconic	**6.409530885**	**1.184858913**	**432.7604643**	**2.369717826**	**28.43661392**

B. The complex (cos & sin) lunisolar harmonic spectrum (up to the ninth harmonic):



Average periods:

LNC = Lunar Nodal Cycle = 18.612948 years
LAC = Lunar Apse Cycle = 8.847358 years

(LNC/2)*(LAC) / (LNC/2 - LAC)
= (9.306474)*(8.847358) / (9.306474 - 8.847358)
= 179.3396597 years

Harmonics are found by dividing by n, where n = 1, 2, 3, ...

Summary of selected confounding:

					Jovian	Lunisolar	
U-N =	171.44	14*(J-N) =	179.01	5*(S-N) =	179.44	179.34	*years*
Technical Note: U-N defines an *envelope* in solar barycentric motion, but contributions of 5*(S-N) & 14*(J-N) make 179 years a commonly-observed *effective* cycle length.				S-U =	45.39	44.83	*years*
				S-N =	35.89	35.87	*years*
				S =	29.47	29.89	*years*
				2*(J-N) =	25.57	25.62	*years*
				2*(J+N) =	22.14	22.42	*years*
				J-S =	19.86	19.93	*years*
				J-U =	13.82	13.80	*years*
				J-N =	12.79	12.81	*years*
				(J-N)/2 =	6.39	6.405	*years*

Closing Comments on Confounding

The dominant lunisolar beats & harmonics cannot all be perfectly synchronized with solar system beats & harmonics due to competing frequency contrasts of opposing sign. Capable astrophysicists should be able to concisely overview coupling frameworks for nonphysics audiences and explain the balance of competing synchronizations for both the short & very long terms.

Did all of the pioneers of solar barycentric theories know about solar system phase confounding with solar & lunisolar cycles?

It seems implausible that the confounding would be completely overlooked, but the "barycenter classics" make no mention of it.

Early 20th Century: Natural Phase Shifts &/or Synchronized Bias?

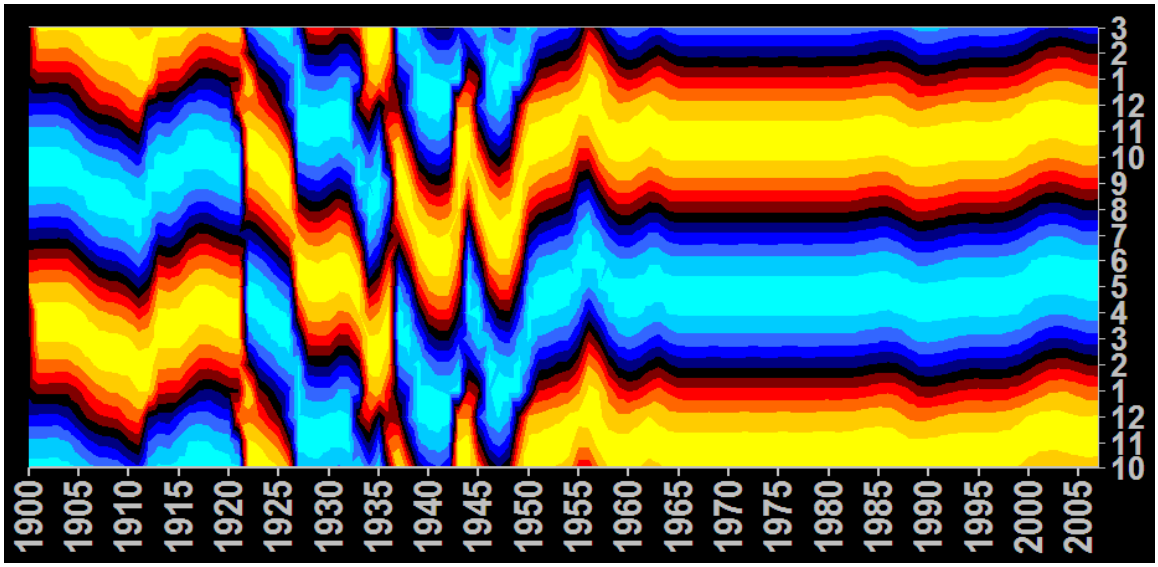
There are a number of known early 20th century data quality issues with largely coincident timing across multiple time series due to synchronizing factors such as world wars, changes in technology, and changes in record-keeping protocols. Such confounding makes data exploration & interpretation both interesting & challenging. With *careful* work, more can be learned about nature from existing records despite systematic biases.

One expert argument is that we cannot discern what caused the Chandler wobble phase reversal since atmospheric angular momentum records do not go back far enough in time. However, AAM is associated with a variety of other variables. Those longer records might, in concert, provide sufficient information to productively refine speculation.

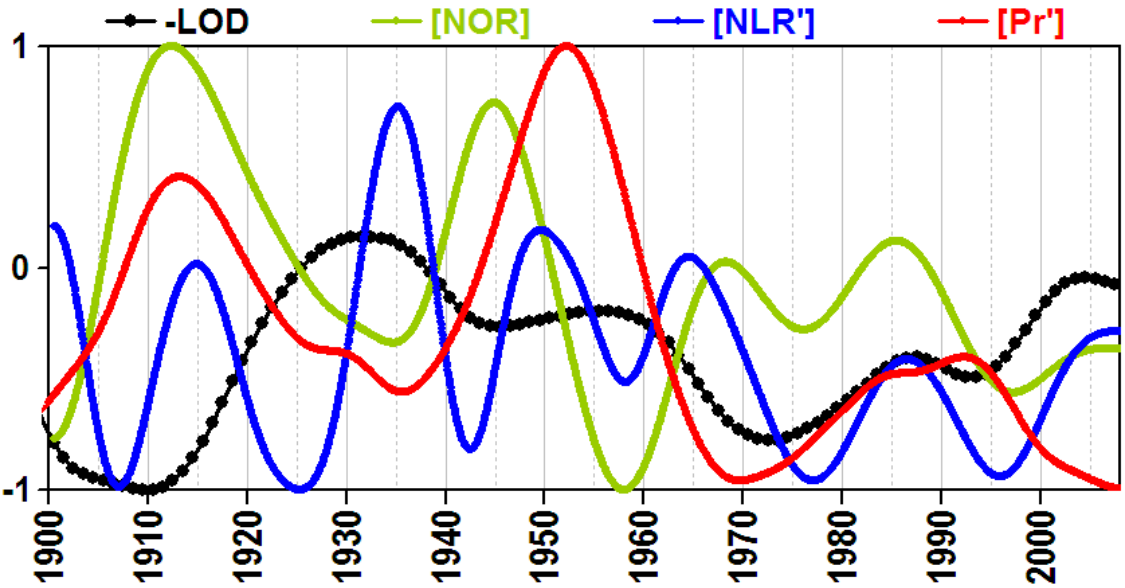
What other variables have interesting phase shifts early in the 20th century?

Southern Oscillation Index (SOI) and Central England Temperature (CET) for 2 prominent examples, but let's first consider 2 more EOP (Earth Orientation Parameter) examples that share characteristics with the early 20th century divergence of NPI & PDO.

Dislocation of the annual cycle in terrestrial nutation in obliquity residuals (NOR):

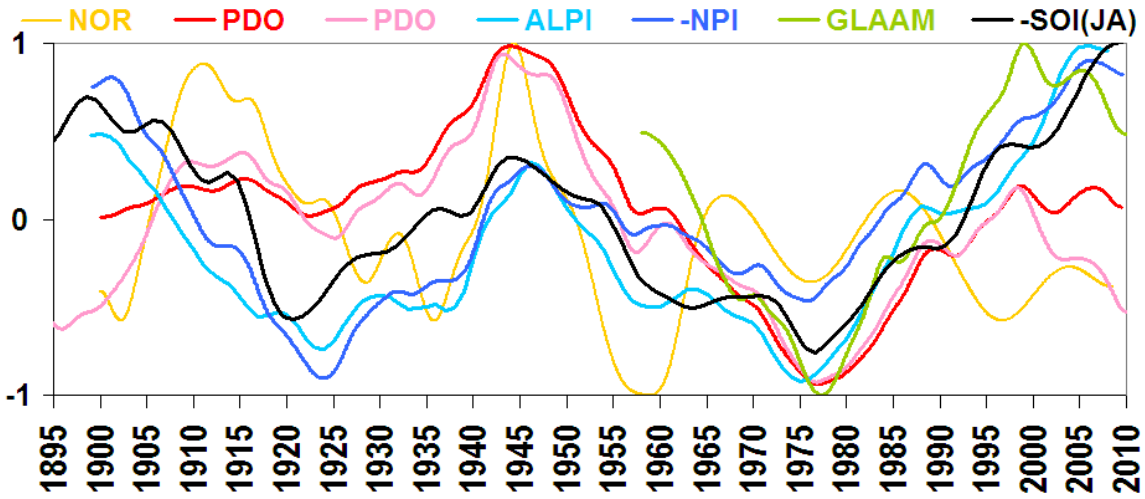


That was phase. Now note the inter-war wave apparent in amplitude:



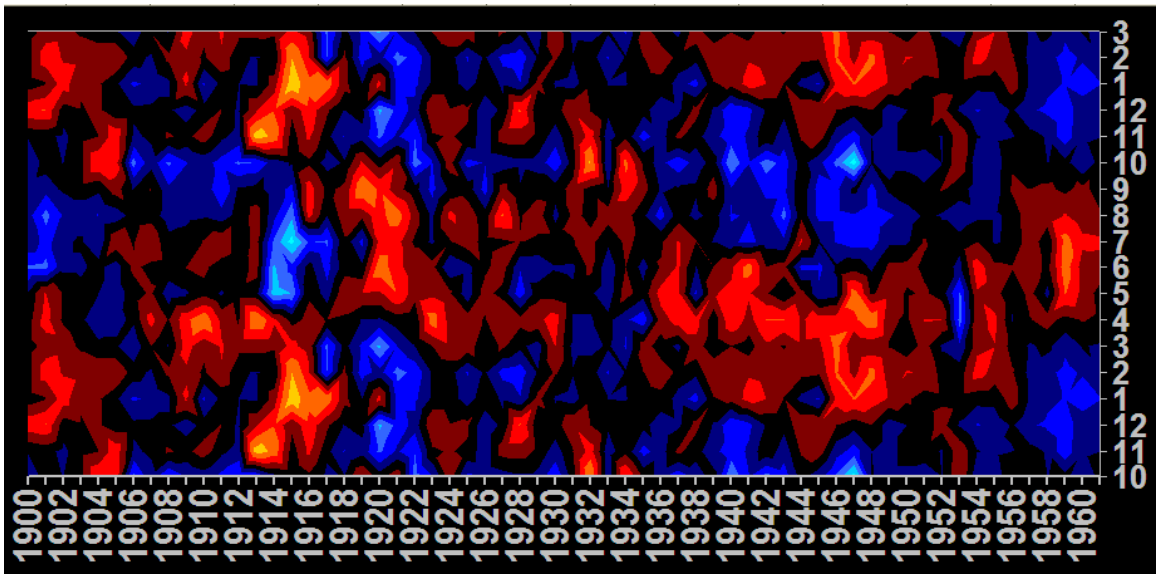
[*Exercise for capable readers: Isolate spatial* ***phase reversals*** *~1927 & ~1972 from the temporal multivariate* ***lunisolar*** *phase relations evident in this plot to the nonlinear eye. Pr = polar motion radius.*]

The maxima coincide with maxima of the integrals of PDO indices (~1910 & ~1945), highlighting a divergence of PDO & NPI ~1910 that should look familiar to those who study the evolution of climatologies & ENSO:



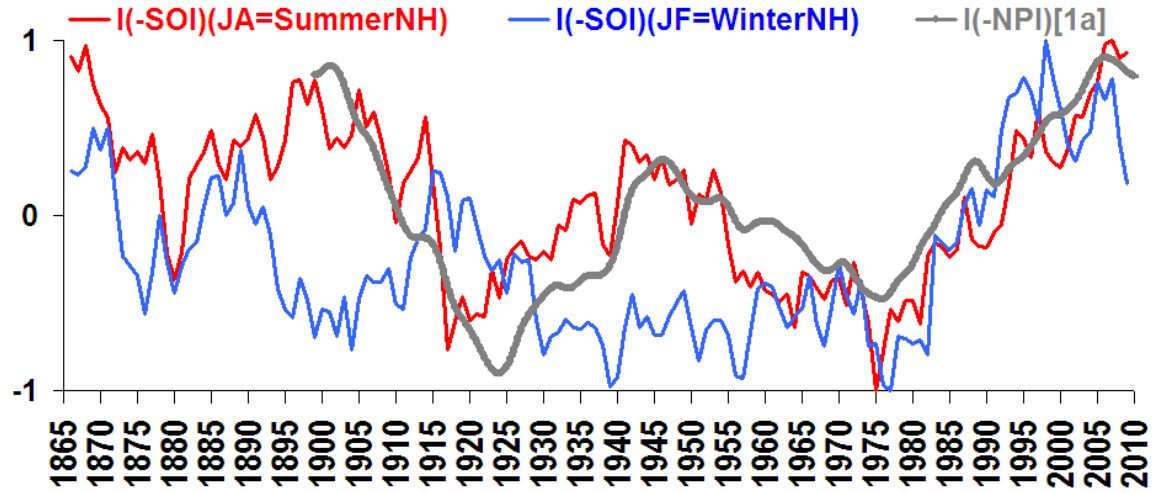
All curves are integrals except NOR. JA = July&August.

Note the concurrent inter-war swirl in nutation in longitude residual (NLR) extrema:



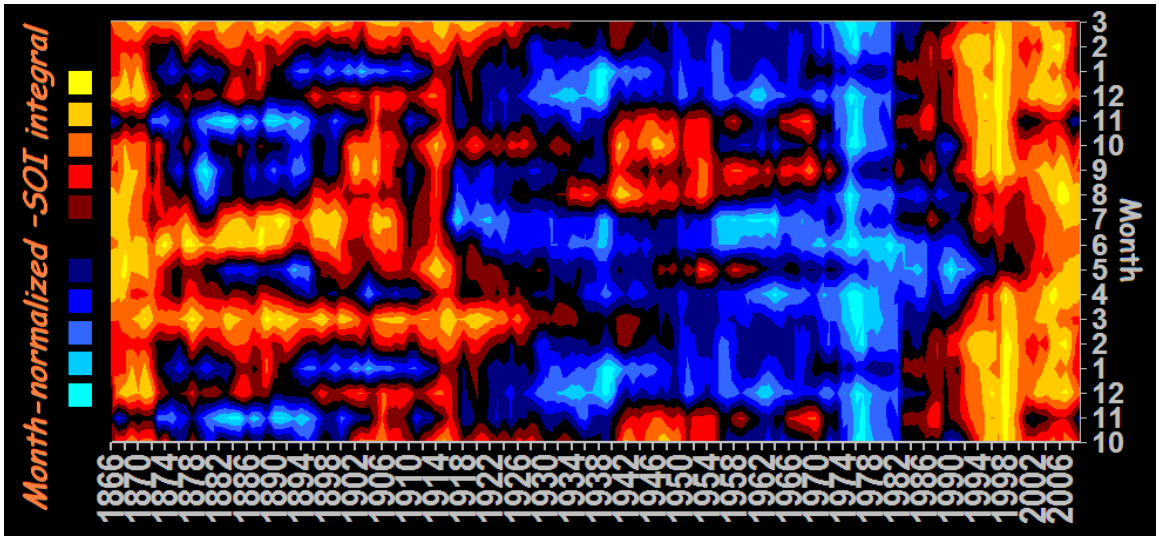
Also note the dates & seasons of the extrema (i.e. near & during the world wars and near the same time of year).

Integrals of seasonal -SOI suggest a related systematic early-record dialing of pressure anomalies within the year:



NH = Northern Hemisphere JA = July&August JF = January&February I = integral

Month-normalized -SOI integral:



Note particularly the antisymmetric seasonal clustering (near opposite equinoxes) of WWI & WWII maxima.

Also, the transition to increased uniformity across seasons in the late 1950s is perfectly coincident with the very striking qualitative shift in phase relations noted by Schwing, Jiang, & Mendelssohn (2003).

Schwing, F.B.; Jiang, J.; & Mendelssohn, R. (2003). Coherency of multi-scale abrupt changes between the NAO, NPI, and PDO. Geophysical Research Letters 30(7), 1406. doi:10.1029/2002GL016535.

See also:

1) Figure 2:
Trenberth, K.E. & Stepaniak, D.P. (2001). Indices of El Nino Evolution. Journal of Climate 14, 1697-1701.
http://www.cgd.ucar.edu/cas/Trenberth/trenberth.papers/tniJC.pdf

2) Figures 3-6:
Xue, Y.; Smith, T.M.; & Reynolds, R.W. (2003). Interdecadal Changes of 30-Yr SST Normals during 1871-2000. Journal of Climate 16, 1601-1612.
http://journals.ametsoc.org/doi/pdf/10.1175/1520-0442%282003%29016%3C1601%3AICOYSN%3E2.0.CO%3B2

A similar dialing can be found in other records, such as CET, suggesting that some key aspect of the annual cycle reversed phase, perhaps due to externally triggered shifts in seasonal interhemispheric mass balance or, according to some authorities, more likely due to synchronized record-keeping biases.

Shifts such as those depicted above for SOI, regardless of how they arise:

1) qualitatively alter summaries of terrestrial spatiotemporal interrelations, with substantial implications for diagnostic interpretation of factor analyses (such as PCA, EOF, SSA, etc.) that assume stationarity & linearity, even if analyses are broken down by season.

2) emphasize that tools such as cross-correlation analysis and uni-extent temporally-global nonspatial spectral analysis are insufficient & potentially seriously misleading approaches to frequency & phase relations exploration.

I want to suggest that capable mainstream climatologists such as Kevin Trenberth explore the possibility of working in consultation with Earth orientation experts such as Richard Gross to investigate what the divergence between early 20th century integrals of PDO & NPI indicates about the characterization of climate via anomalies & *non*-complex factor analyses (such as *linear* PCA, EOF, & SSA).

Hydrology's a function of *absolutes*, *not* anomalies. Informatively contrasting summer & winter panels of Figure 6 provide only the most *crudely preliminary* overview:

Trenberth, K.E. (2011). Changes in precipitation with climate change. Climate Research 47, 123-138. doi: 10.3354/cr00953.
http://www.int-res.com/articles/cr_oa/c047p123.pdf

"Apart from all other reasons, the parameters of the geoid depend on the distribution of water over the planetary surface." -- Sidorenkov (2003).

Selected literature figures to be considered in conjunction with the preceding:

1) Figures 16-25:
Zolotova N.V.; & Ponyavin D.I. (2005). Recurrence and cross recurrence plot analysis of natural time series, Educational and methodical materials. St. Petersburg University Press. (in Russian)
http://geo.phys.spbu.ru/~ned/ZP_methodology.pdf

2) All figures here:
Ponyavin, D.I.; & Zolotova, N.V. (2004). Nonlinear analysis of climatic time series with cross recurrence plots.
http://geo.phys.spbu.ru/~ned/Ponyavin_and_Zolotova_2004.pdf

3) Figure 3:
Keeling, C. D. & Whorf, T. P. (1997). Possible forcing of global temperature by the oceanic tides. Proceedings of the National Academy of Sciences of the USA 94(16), 8321-8328.
http://www.pnas.org/content/94/16/8321.full.pdf?ijkey=YjbRA3bMQaGic

Also see summary section 5 of the following:

Park, J.; & Mann, M.E. (1999). Interannual temperature events and shifts in global temperature: a “multiwavelet” correlation approach.
http://earth.geology.yale.edu/~jjpark/parkmann00.pdf

So what caused the Chandler wobble phase reversal and other early 20th century terrestrial phase shifts?

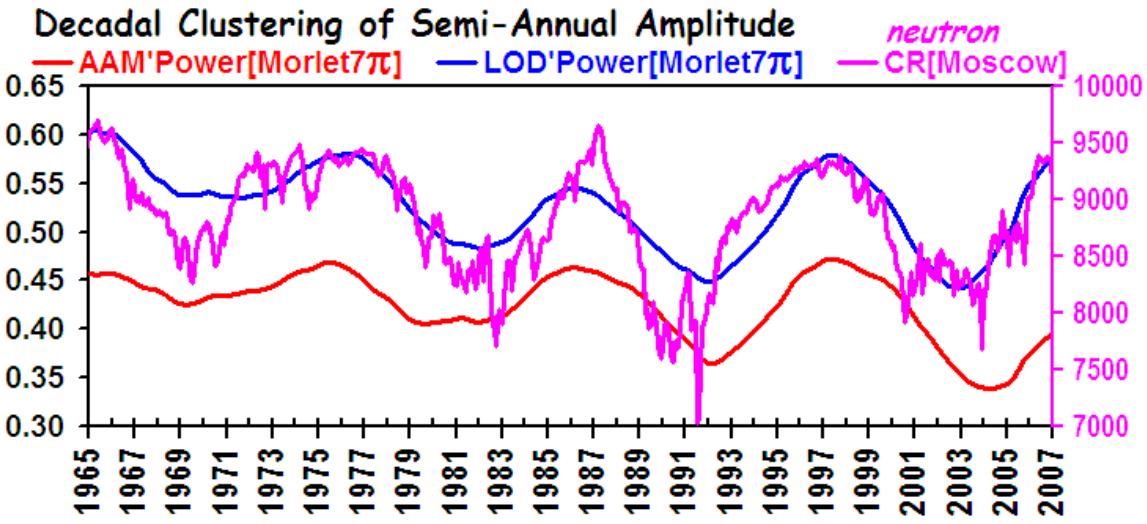
That's what I'm asking the community to think about.

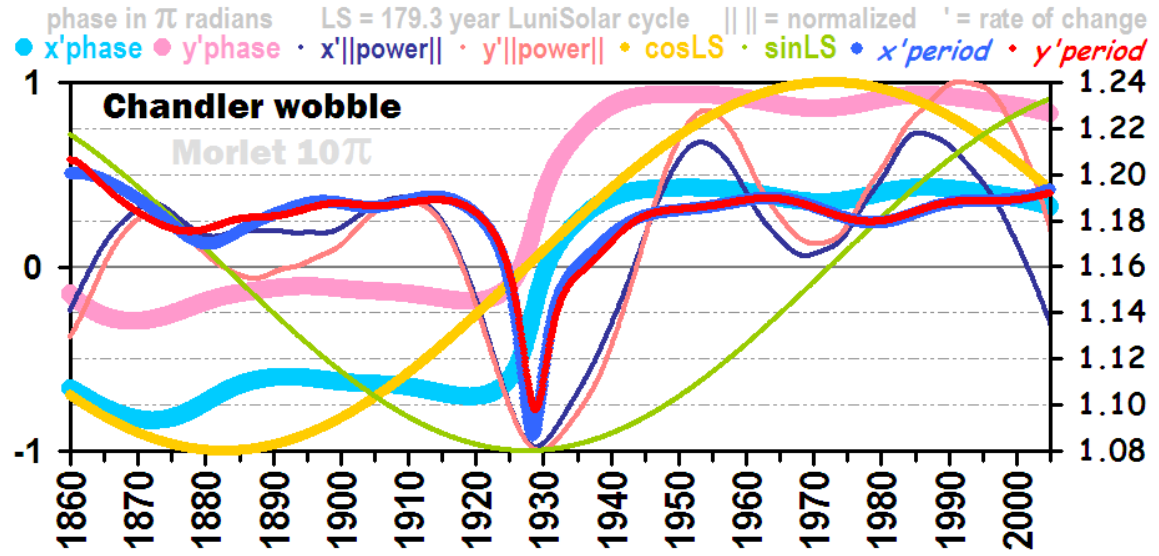
Who might suspect what?

a) Barycenter enthusiasts: Charvatova's early 20th century trefoil.
b) Lunisolar enthusiasts: Late 1920s critical point in 179 year lunisolar cycle.
c) Solar enthusiasts: dramatic early 20th century solar cycle amplitude &/or phase changes (possibly better described as 2 separate camps).
d) Anthro-enthusiasts: socio-economically/politically/technologically/etc.-synchronized errors &/or changes in human record-keeping (including spatiotemporal confounding of sampling intensity with seasons & regions).

My instinct is that the changes are of tidal (gravitational &/or thermal) origin & spatially-global scale. I suspect that sufficient information exists for capable parties to cooperate in a multidisciplinary effort to get a sufficient handle on (d) to discover physical mechanisms related to (b) &/or (c). I include (a) in the list both to raise awareness of confounding and to put hierarchical levels of spatiotemporal coupling frameworks in historical perspective.

Best Regards to All,
Paul L. Vaughan, M.Sc.




phase in π radians
LS = 179.3 year LuniSolar cycle
|| || = normalized
' = rate of change
x'phase
y'phase
x'||power||
y'||power||
cosLS
sinLS
x'period
y'period
Chandler wobble
Morlet 10π
1
0
-1
1.24
1.22
1.20
1.18
1.16
1.14
1.12
1.10
1.08
1860
1870
1880
1890
1900
1910
1920
1930
1940
1950
1960
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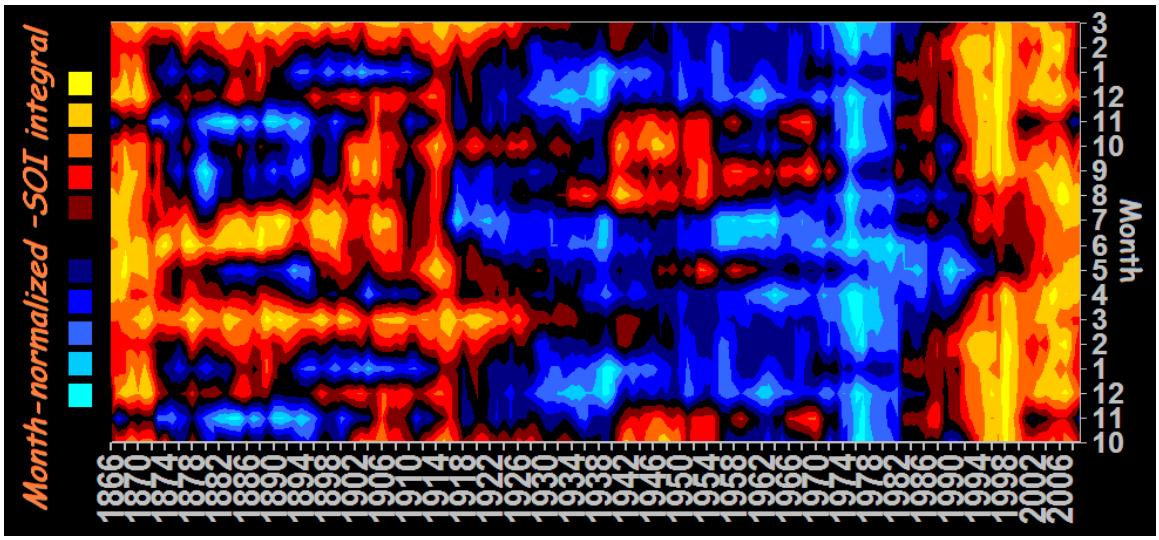
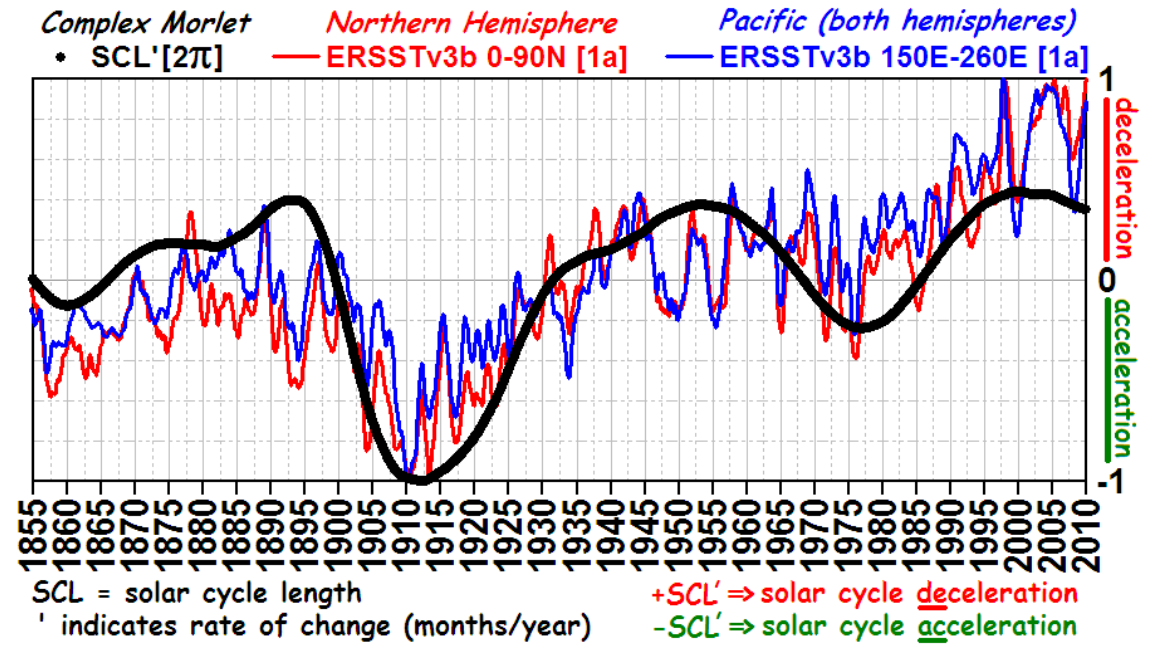
1980
1990
2000


Month-normalized -SOI integral
Month


Complex Morlet
SCL'[2π]
Northern Hemisphere
ERSSTv3b 0-90N [1a]
Pacific (both hemispheres)
ERSSTv3b 150E-260E [1a]
1
0
-1
deceleration
acceleration
1855
1860
1865
1870
1875
1880
1885
1890
1895
1900
1905
1910
1915
1920
1925
1930
1935
1940
1945
1950
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
SCL = solar cycle length
' indicates rate of change (months/year)
+SCL' ⇒ solar cycle deceleration
-SCL' ⇒ solar cycle acceleration