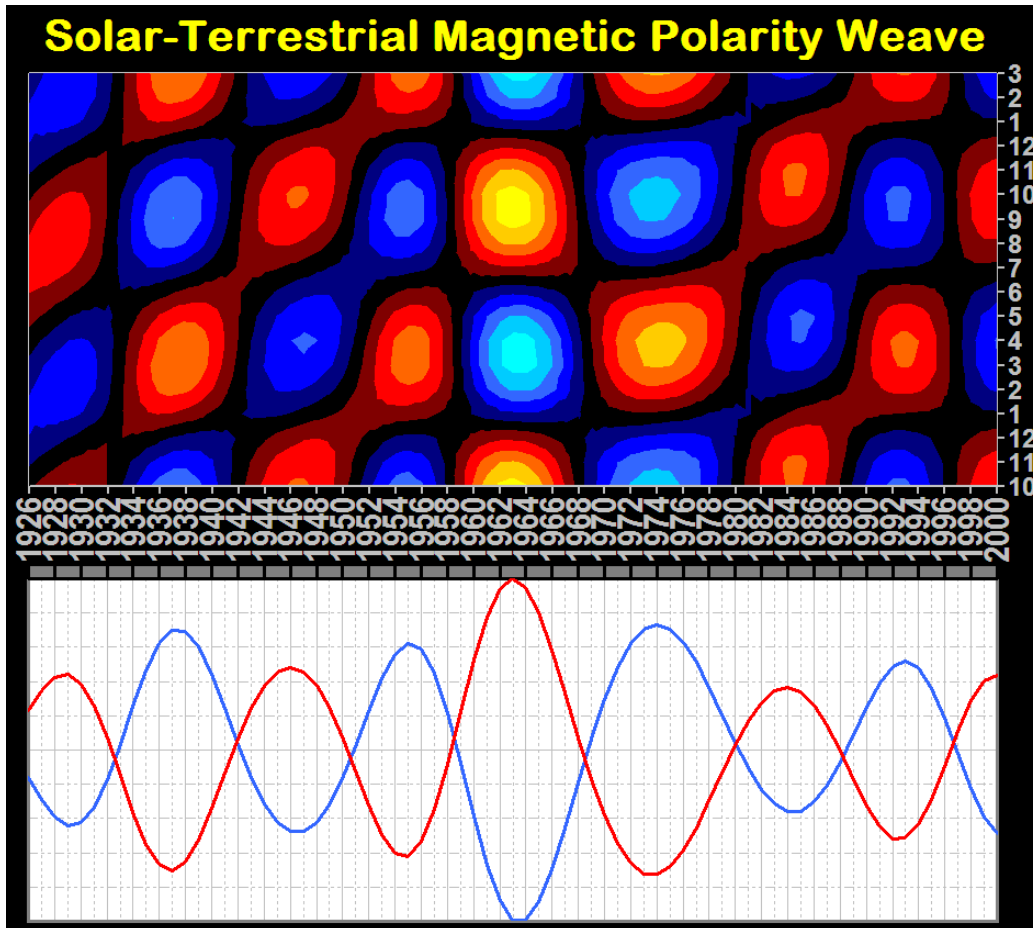# Solar-Terrestrial Volatility Weaves

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## Quasicyclic Multiscale Solar-Terrestrial Volatility Weaves

Extremes – in contrast with just means – have become a popular topic in climate discussions. We can take a simple lesson from econometrics:

Volatility Clustering
http://www.riskglossary.com/link/volatility_clustering.htm

If the clustering has cyclic grain & extent, the attractor of the mean extreme envelope is easy to map with tuned multi-extent complex wavelets due to Central Limit Theorem.

A comparison of 2 simple wavelets clarifies the meaning of *grain & extent* (useful terms adopted from the landscape ecology literature on aggregation fundamentals), neither of which should be confused with *resolution*:

resolution = 1 day	resolution = 1 month
extent = 11 years	extent = 48 years
grain = 1 year	grain = 8 years
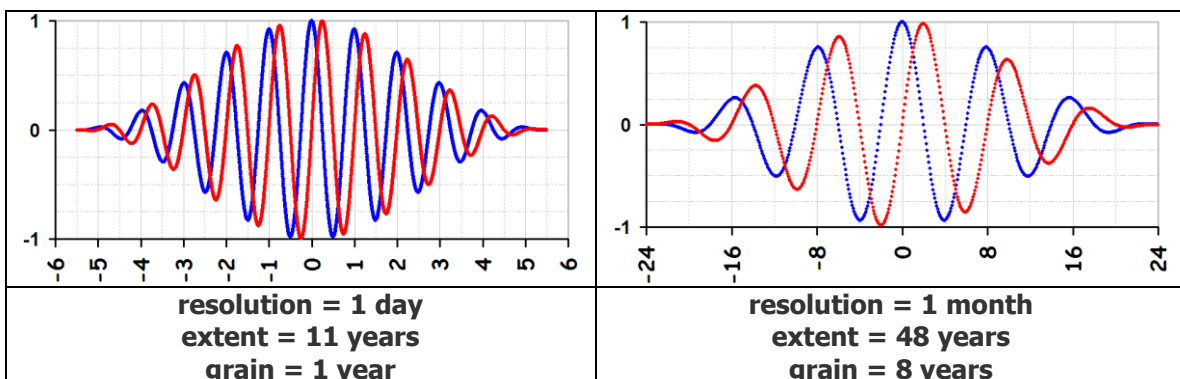
Hierarchically structured quasistationary cyclic volatility summarized in Figure 3's middle panel can be further crystallized (see graph on previous page) with a combination of gaussian central differencing and tuned multi-extent complex wavelets:

Mursula, K.; & Zieger, B. (2001). Long-term north-south asymmetry in solar wind speed inferred from geomagnetic activity: A new type of century-scale solar oscillation? Geophysical Research Letters 28(1), 95-98.
http://spaceweb.oulu.fi/~kalevi/publications/MursulaAndZieger2001.pdf

Another seminal paper highlighting cyclic heteroskedasticity is the following:

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.

Applying a similar method (as was applied above to geomagnetic aa index) to semi-annual terrestrial length of day – an indicator of semi-annual midlatitude zonal westerly circulation mean amplitude/latitude – results in the following decadal dynamic central limit attractor summaries:
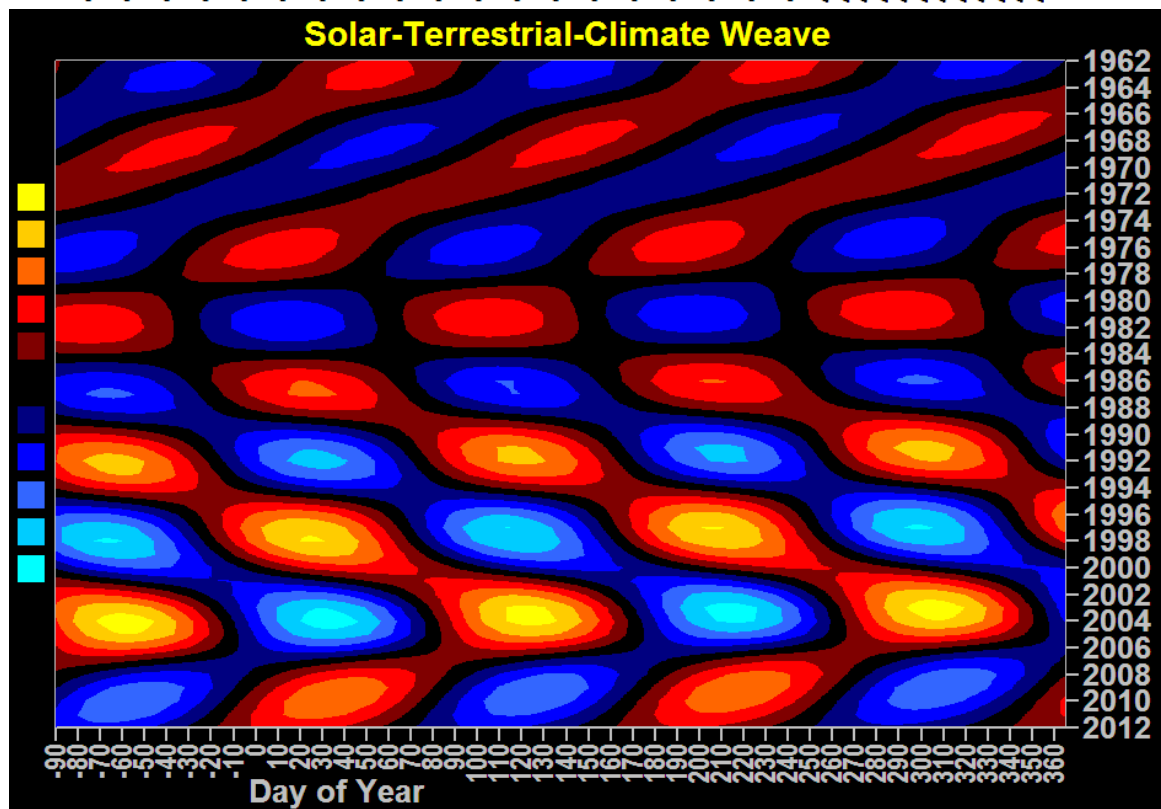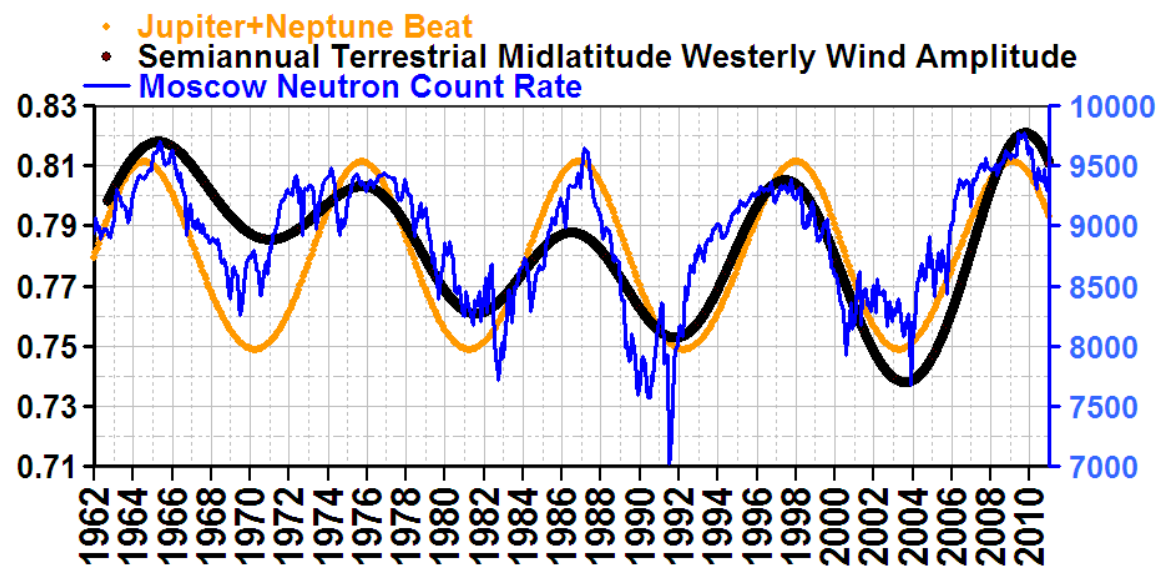
These extrema attractors are rigidly well-constrained by the Laws of Large Numbers & Conservation of Angular Momentum.

How do these decadal circulatory pulses integrate into ocean memory multidecadally?...

Volatility Weave Rate Shifts

Measuring the changing rate of twist on these hierarchically nested multiscale amplitude weaves with complex multi-extent wavelets is a simple exercise that highlights multidecadal solar throttling of aggregate meridional equator-pole heat & water pumping:
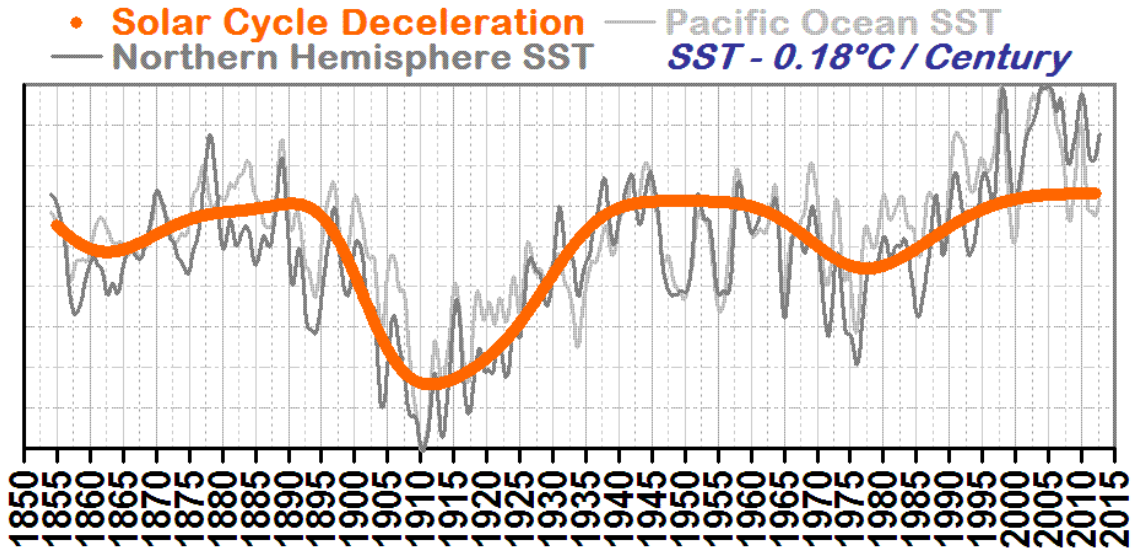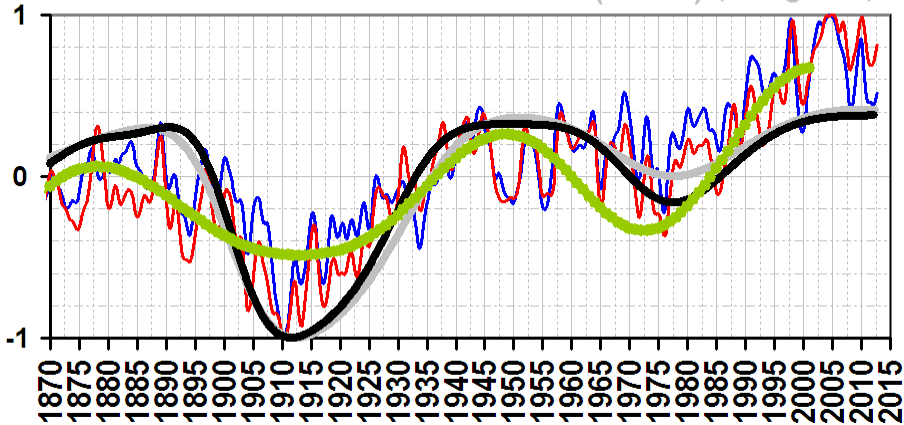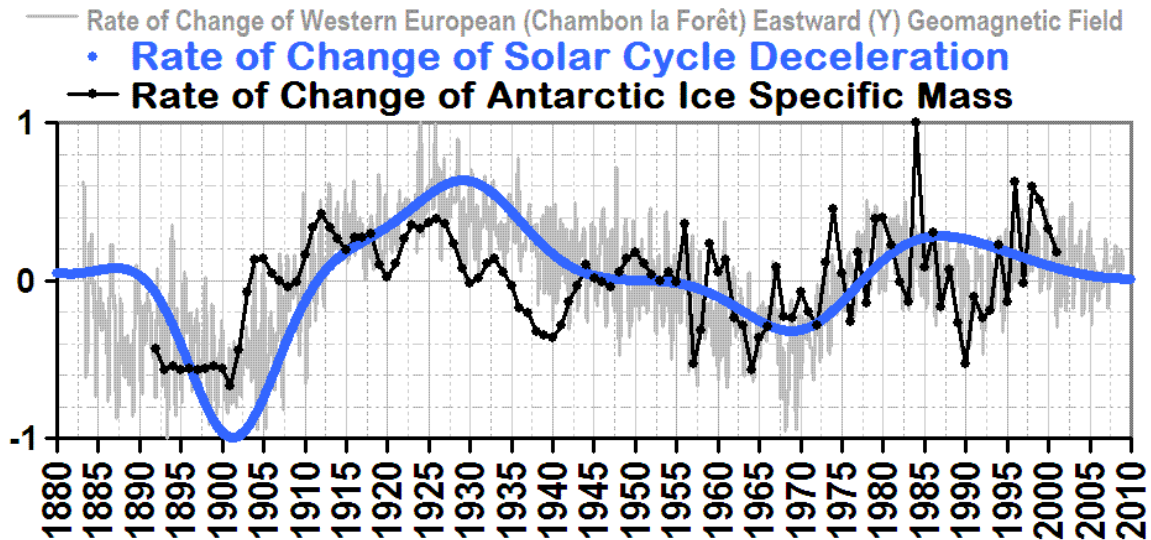

[Jean Dickey (NASA JPL)](#) emphasizes that spatiotemporal *temperature, mass, & velocity* variations are *coupled*.
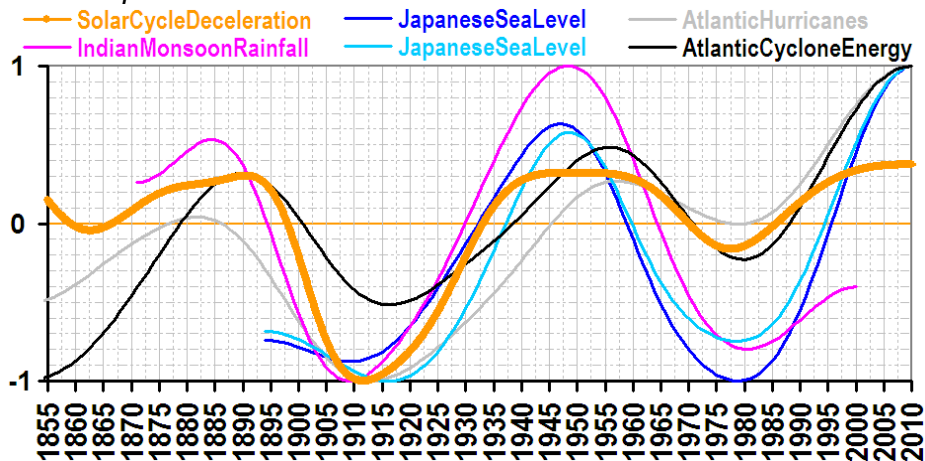
Geophysical phenomena showing coherence with SCD's derivative include PDO & the following:


See Figure 4 from the following for deep insight:

Wyatt, M.G.; Kravtsov, S.; & Tsonis, A.A. (2011). Atlantic Multidecadal Oscillation and Northern Hemisphere's climate variability. Climate Dynamics. doi: 10.1007/s00382-011-1071-8.

Phase Residuals & Envelope Decomposability

Interannual Indo-Pacific warm pump phenomena show up in decadal-extent semiannual LOD phase discontinuities, making it clear that semiannual LOD envelope decomposition into decadal & interannual components – complete with the potential for simple, sensible statistical inference – is feasible:
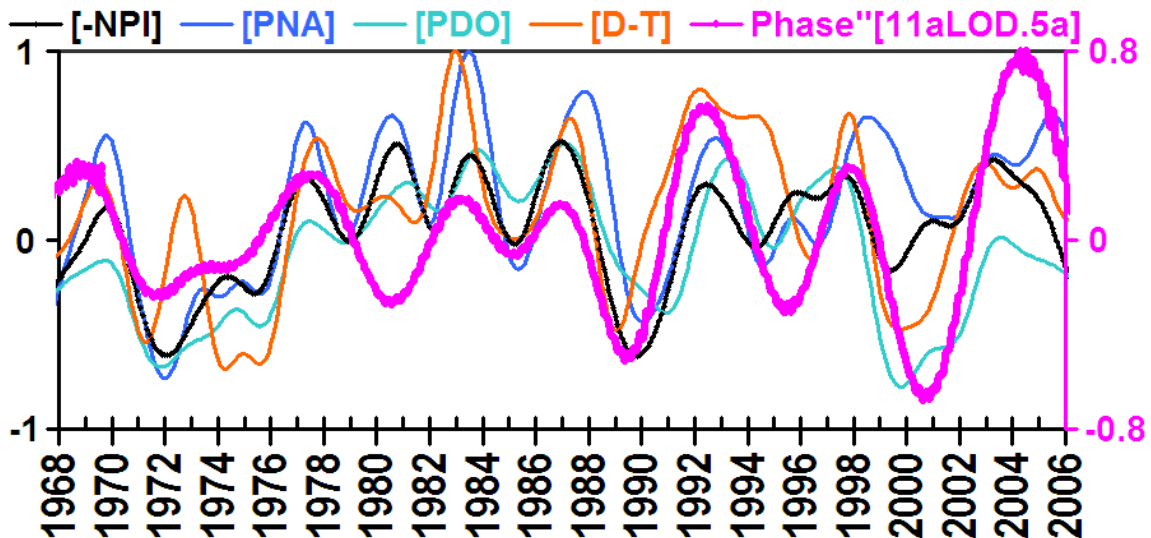
D = Darwin SLP; T = Tahiti SLP; -SOI = D-T; SLP = sea level pressure; NPI = North Pacific Index; PNA = Pacific North America index; PDO = Pacific Decadal Oscillation; LOD = Length of Day

This will be no surprise to anyone who has appreciated and understood the figures in the following article:

Dickey, J.O.; & Keppenne, C.L. (1997). Interannual length-of-day variations and the ENSO phenomenon: insights via singular spectral analysis.
http://trs-new.jpl.nasa.gov/dspace/bitstream/2014/22759/1/97-1286.pdf

The possibility should be considered that the decadal/interannual decomposition is also latitudinal/longitudinal.

Supplementary material:

Dickey, J.O.; Marcus, S.L.; & Chin, T.M. (2007). Thermal wind forcing & atmospheric angular momentum: origin of the Earth's delayed response to ENSO. Geophysical Research Letters 34, 7.

Dickey, J.O.; Marcus, S.L.; & de Viron, O. (2003). Coherent interannual & decadal variations in the atmosphere-ocean system. Geophysical Research Letters 30(11), 1573. http://trs-new.jpl.nasa.gov/dspace/bitstream/2014/11255/1/02-3203.pdf

Appendices

Supplementary, peripheral, & evolving new material is shared here to expand the scope of discussion.

Appendix A: The Other Side of the Coin

The high frequency boundary conditions of solar system oscillatory phenomena are set by the highest & lowest frequency Jovian planets, Jupiter & Neptune, respectively.

J + N	J - N
~11.1 years	~12.8 years

Details of the harmonic framework are sketched here.

Here's a look at the other decadal feature graphically highlighted by Dickey & Keppenne (1997):
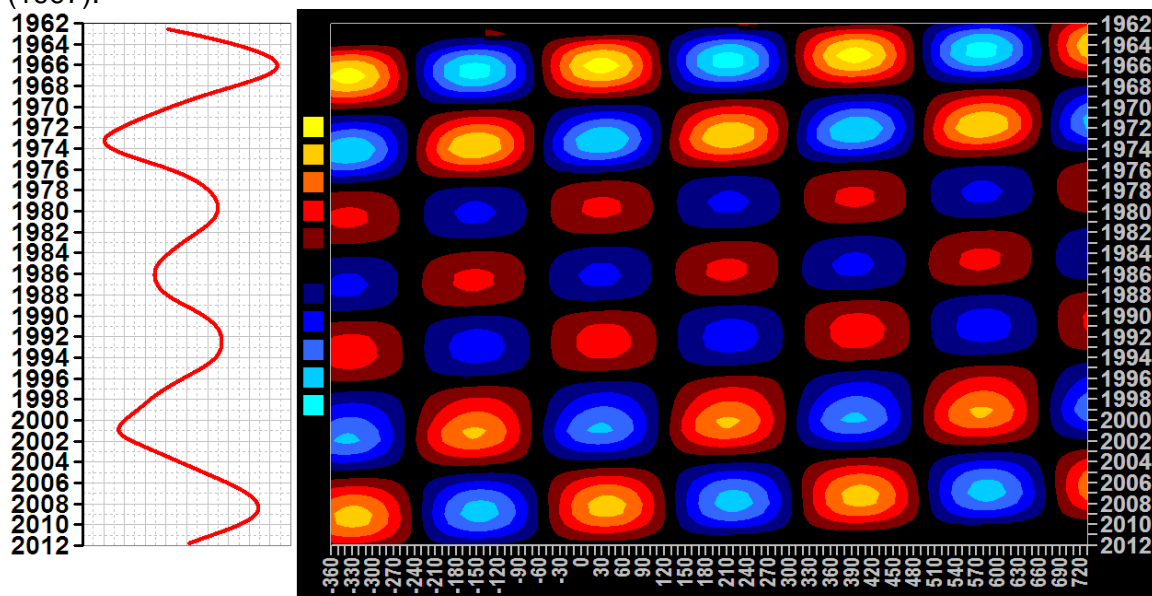
Weave detail has been filtered out of the preceding wavelet summary of decadal amplitude of annual LOD to ease visual perception of lattice-like structure, but a recent complementary analysis of the weave detail using gaussian central differencing suggests the 12.8 year periodicity (hierarchically downstream echo of Jupiter-Neptune beat via terrestrial planets, & Earth-Moon orbital relations) may be stable with relatively constant phase over the entire record. A few more years worth of LOD data should be enough to draw a decisive conclusion using attractor-detecting methods that are resistant to the cumulative edge effect that's a known hazard of the recursive algorithm that was used to sharply focus the lattice-like framework in the preceding graph (a method that was *not* used on any of the other summaries in this document).
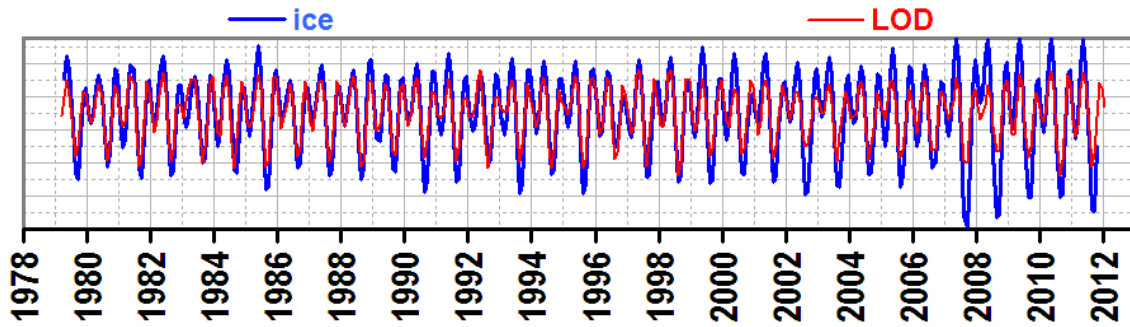
Appendix B: Resonant Solar-Terrestrial Seasonal Excitation Persistence

The following preliminary results summarize complementary seasonal persistence of resonant solar-terrestrial excitation at semi-annual & annual timescales:
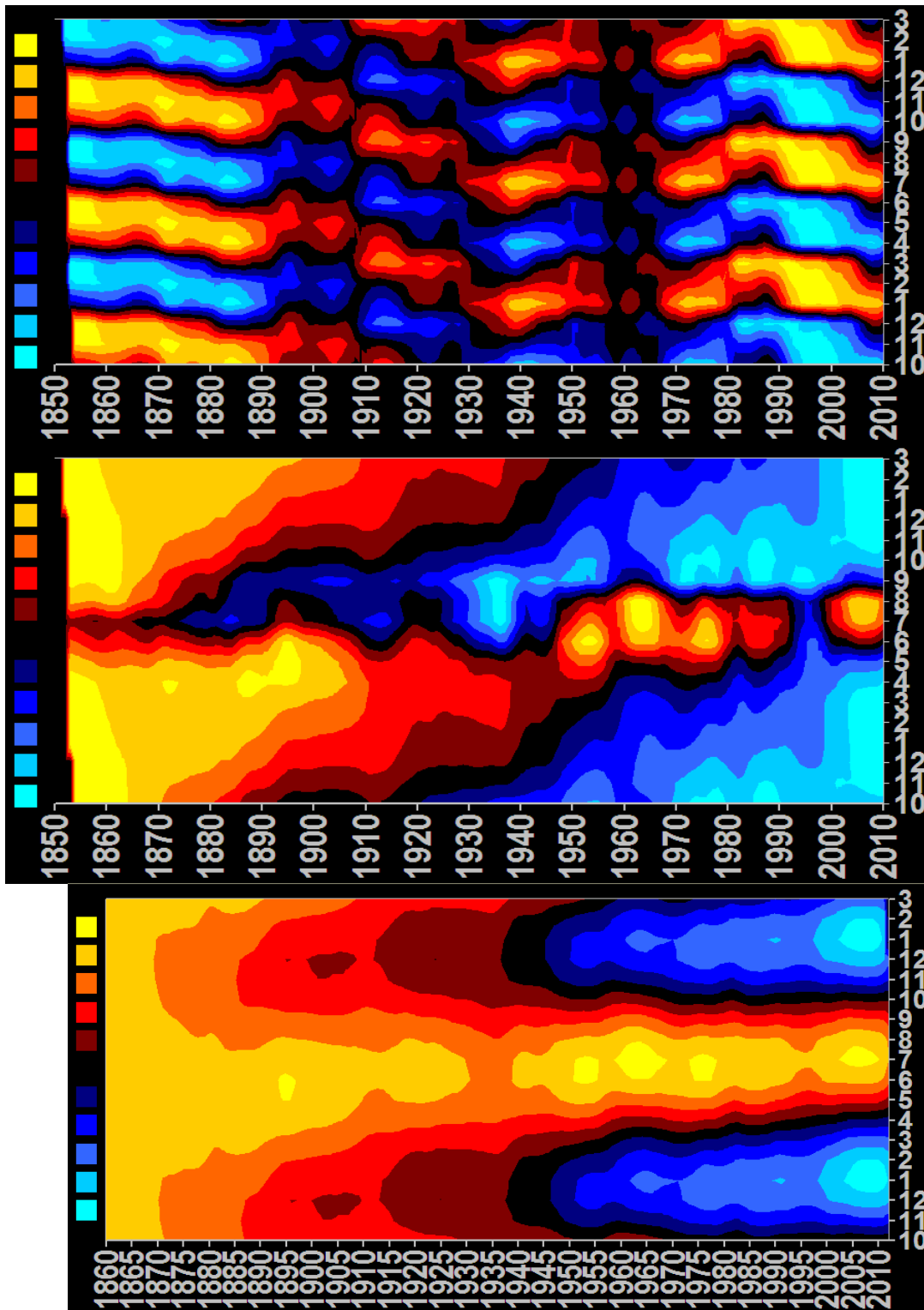
The changepoints & track-shifts in these simple **sunspot** persistence summaries coincide with climate & geophysical regime shifts, including the Chandler wobble phase reversal, the 1940s & 1970s climate shifts, and the recent arctic sea ice dynamical regime shift to high amplitude cycles with low multi-year ice inertial damping.

Here's a glimpse of a new metric of interhemispheric global sea ice contrast that emphasizes the reality of the recent nonlinear shift in ice dynamics:

For background on the Chandler wobble phase reversal, see the following:
Solar-terrestrial resonance, climate shifts, & the Chandler wobble phase reversal

More details will follow at a later date.

Appendix C: Hierarchically Clustered 28 day & Annual Persistence of Resonant Solar-Terrestrial Excitation

Much of the solar rotation literature focuses on 27 day components, but when integrated *by day within year* heliomagnetic field (HMF) persistence (as observed *at Earth*) shows clear 28 day and 1 year components:
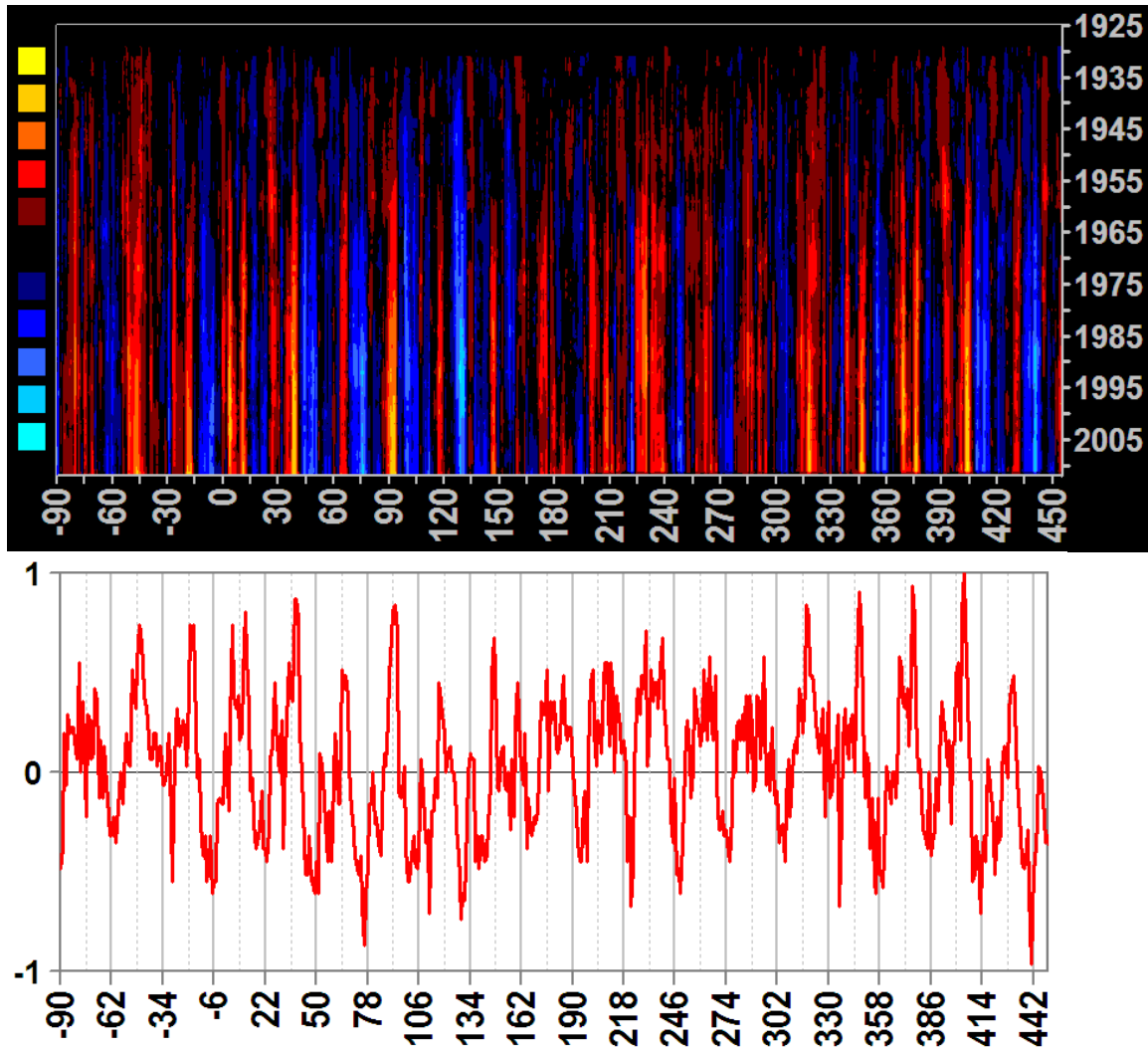
There's lots more to illustrate about the fascinating nuances of HMF structure. This is a fun time series to explore. There are visually evident volatility structures that are *not* emphasized in the literature, so when time & resources permit, a focus will be trying to design concise summary metrics.

Appendix D: Recurrence Plots

Nonstationary solar phase recurrence & nonlinear solar scaling cross-recurrence:
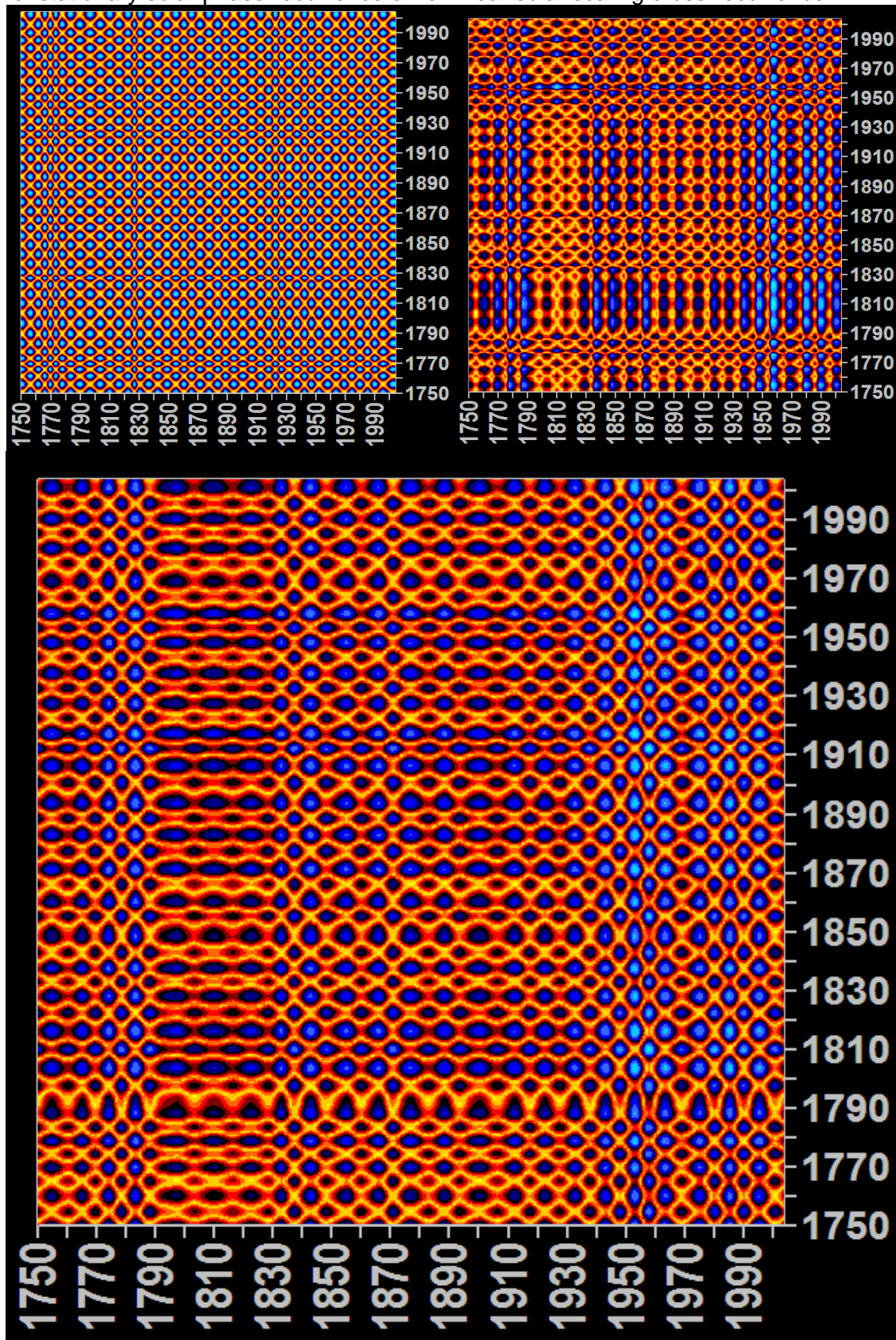
Details that will help with interpretation of recurrence changepoints will be conveyed moving forward. Also, multivariate recurrence methods can be adapted to extend Tsonis, Swanson, & Kravtsov's (2007) network synchronization work. Time & resource permitting, this will be another future focus.

Recurrence Plots at a Glance
http://www.recurrence-plot.tk/glance.php

Appendix E: Decadal & Interannual Column Ozone Components

Not decadal global column ozone but rather *the **rate of change*** of decadal global column ozone is coherent with solar activity & mean decadal midlatitude zonal circulation amplitude/latitude:
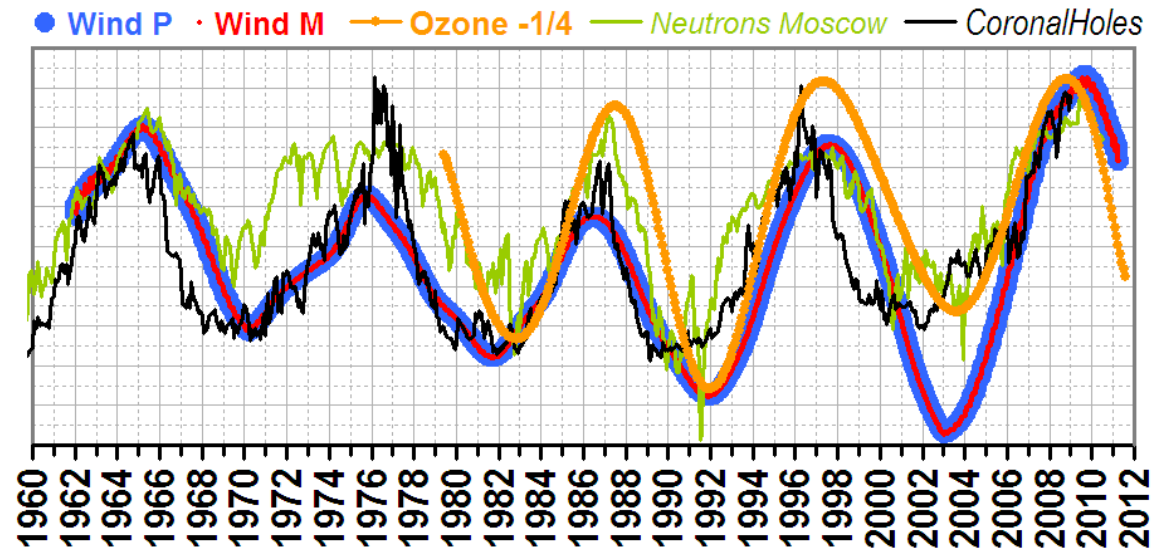
Westerly wind wavelet specs: P = Paul & M = Morlet.

Ozone -1/4 indicates ***rate of change*** of decadal ozone. By comparison with the following, note the relative 1/4 cycle phase roll inside the constraining envelope:

Ozone	
Component	%
Secular	33
Solar	13
QBO	7
annual	41
semi-annual	6
Total	100
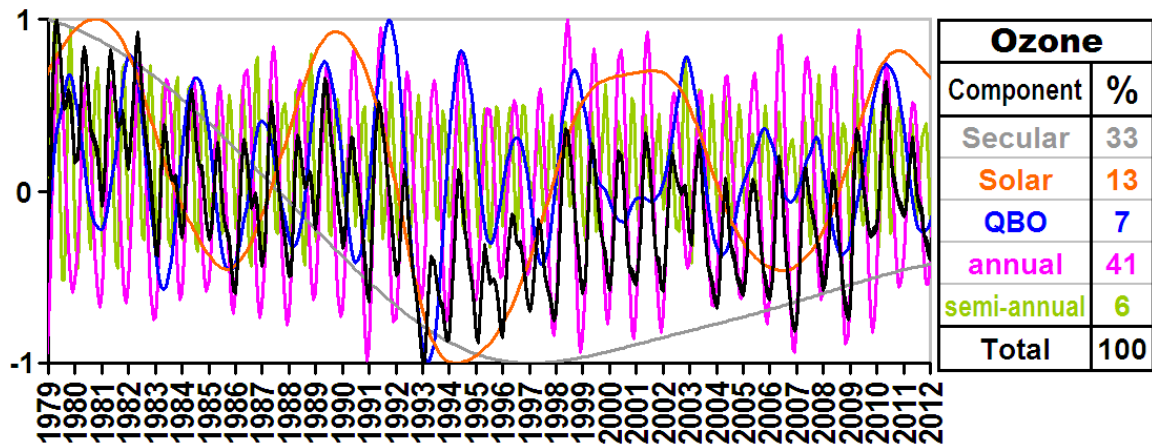
Tropospheric column ozone follows ENSO:
http://acd-ext.gsfc.nasa.gov/Data_services/cloud_slice/gif/enso10.gif
http://acd-ext.gsfc.nasa.gov/Data_services/cloud_slice/#oei