Interannual Terrestrial Oscillations

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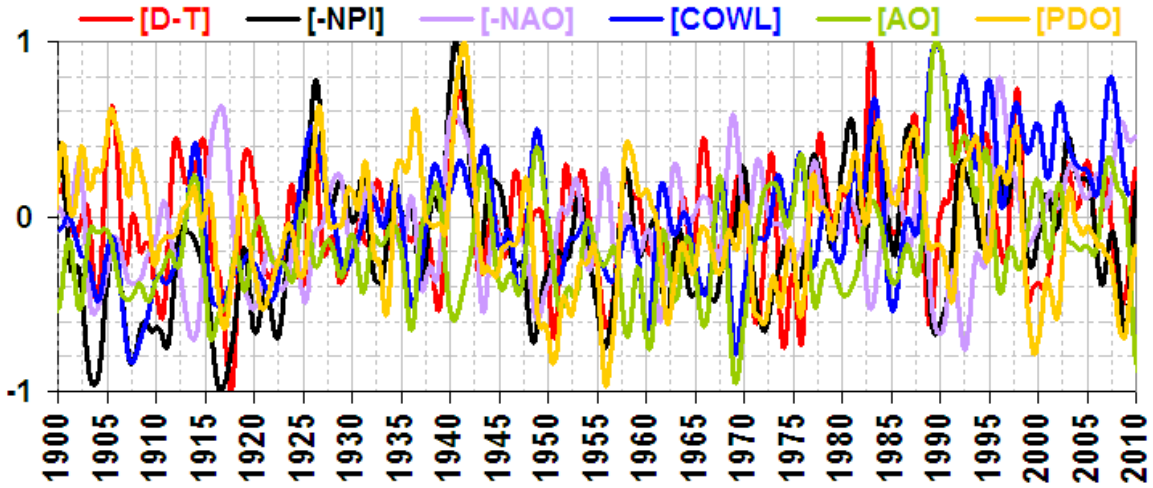
Lack of widespread awareness of the spatiotemporal nature of interannual terrestrial oscillations is perhaps the most paralyzing bottleneck in the climate discussion.

Data & Symbols

' indicates rate of change
[ ] indicates time-integration
AAM = Atmospheric Angular Momentum
AAO = AntArctic Oscillation
ABC = Agassiz, British Columbia (west coast of Canada near USA border)
AO = Arctic Oscillation
COWL = Cold Ocean, Warm Land index
D-T = -SOI = - Southern Oscillation Index = pressure difference between Darwin & Tahiti (an indicator of El Nino / La Nina cycling)
ENSO = El Nino / Southern Oscillation
i = interannual
LOD = Length Of Day
NAO = North Atlantic Oscillation
NPI = North Pacific Index
PDO = Pacific Decadal Oscillation
PNA = Pacific North America index
PPT = PreciPiTation
QBO = QuasiBiennial Oscillation
SAM = Southern Annular Mode
SOI = Southern Oscillation Index
T = Temperature (°C)
V = solar wind speed
x = extreme

North Pacific Pivot

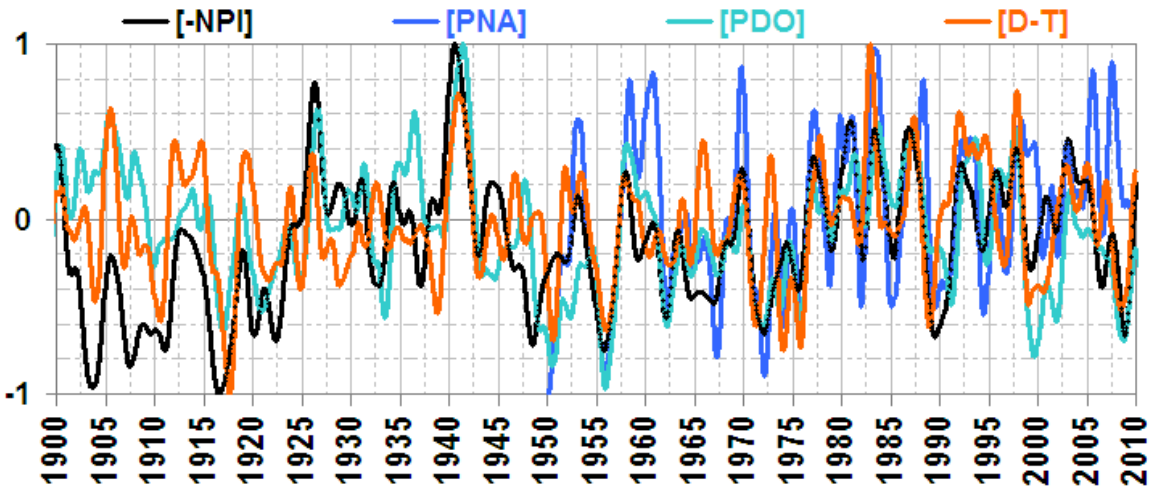
Elegant factor analyses by Trenberth, Stepaniak, & Smith (2005) concisely chart the limits of linear climate exploration, providing strong clues that the North Pacific is a *globally pivotal* intersection.



Most are well-acquainted with Tsonis, Swanson, & Kravtsov (2007). Recently Wyatt, Kravtsov, & Tsonis (2011b) shared the following on Dr. Pielke Senior's blog:

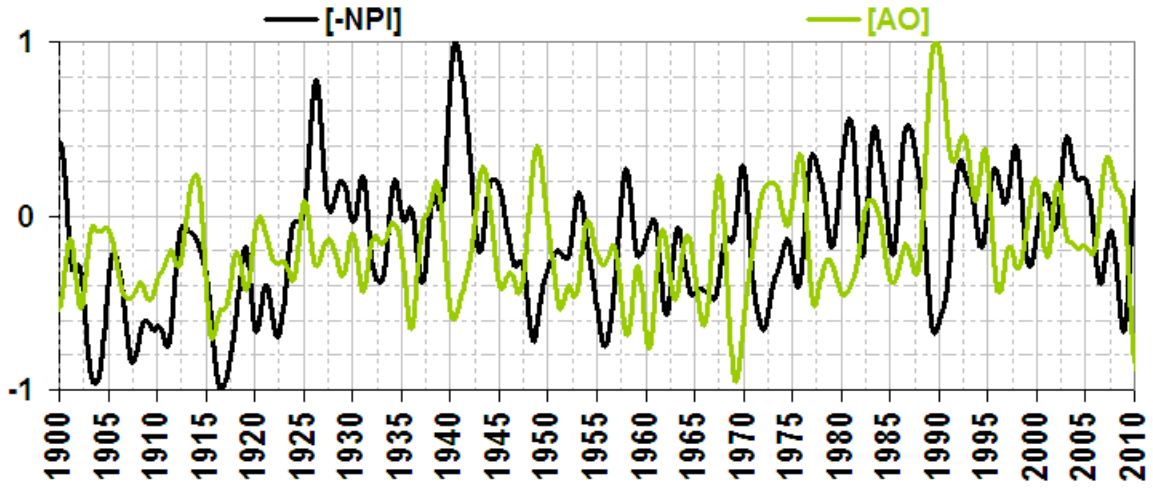
> *"PNA participates in all synchronizations."*

Orientation for ENSO- & PDO-centric readers:

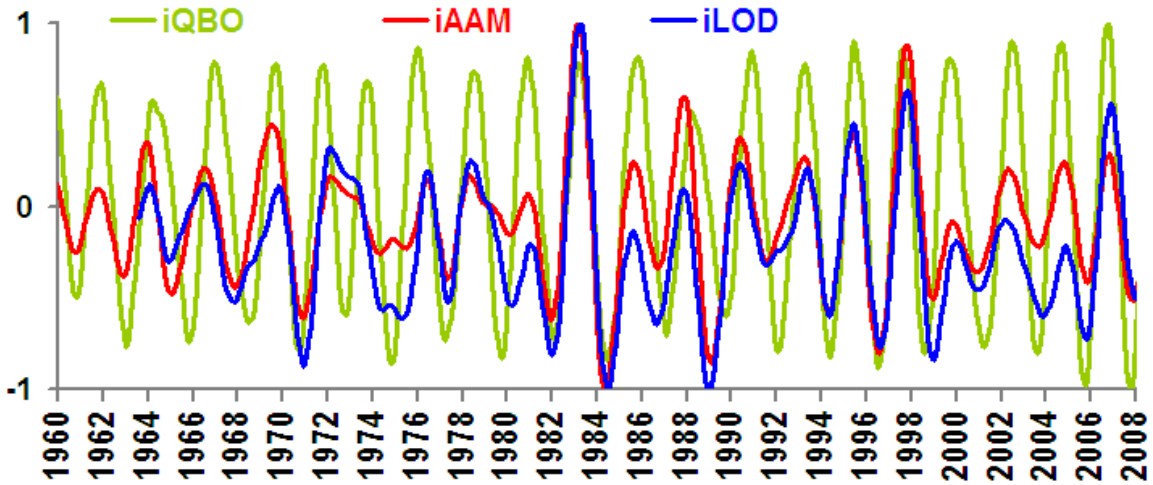


Complex Correlation

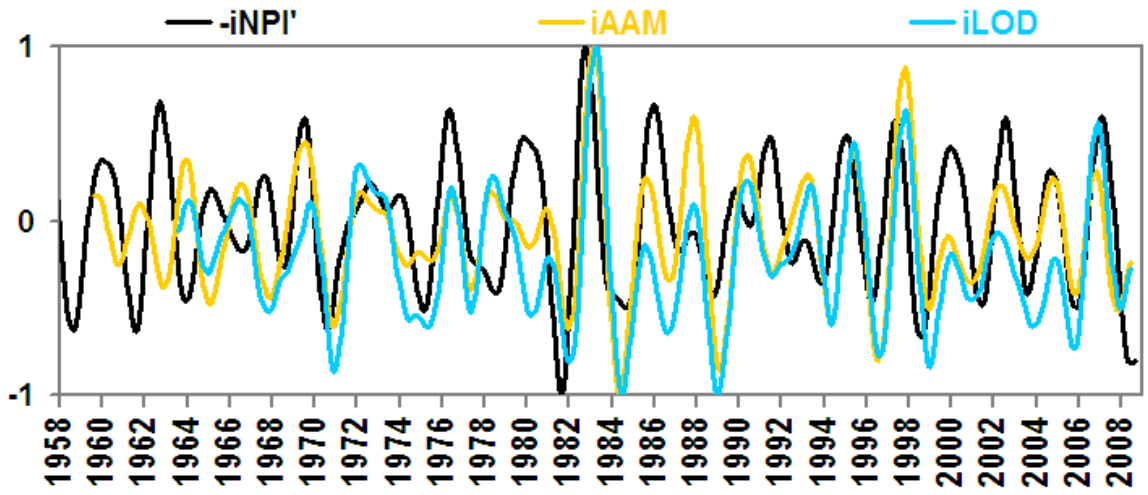
Simple linear correlation can do a *part-way* decent job of summarizing the preceding intrabasin relations, but properties of interbasin & interhemispheric multiscale spatiotemporal relations clarify the need for *complex* summaries. For example:



Limitations of linear methods are emphasized by Maraun & Kurths (2005). A mainstream audience might not appreciate their beautifully concise section **3** primer, but there's a simple way to look at interannual spatiotemporal phasing.



The ~2.37 year signal which is so prominent in the equatorial stratosphere is also easily detected in the troposphere, but there's clearly "something else" contributing to interannual tropospheric variation.

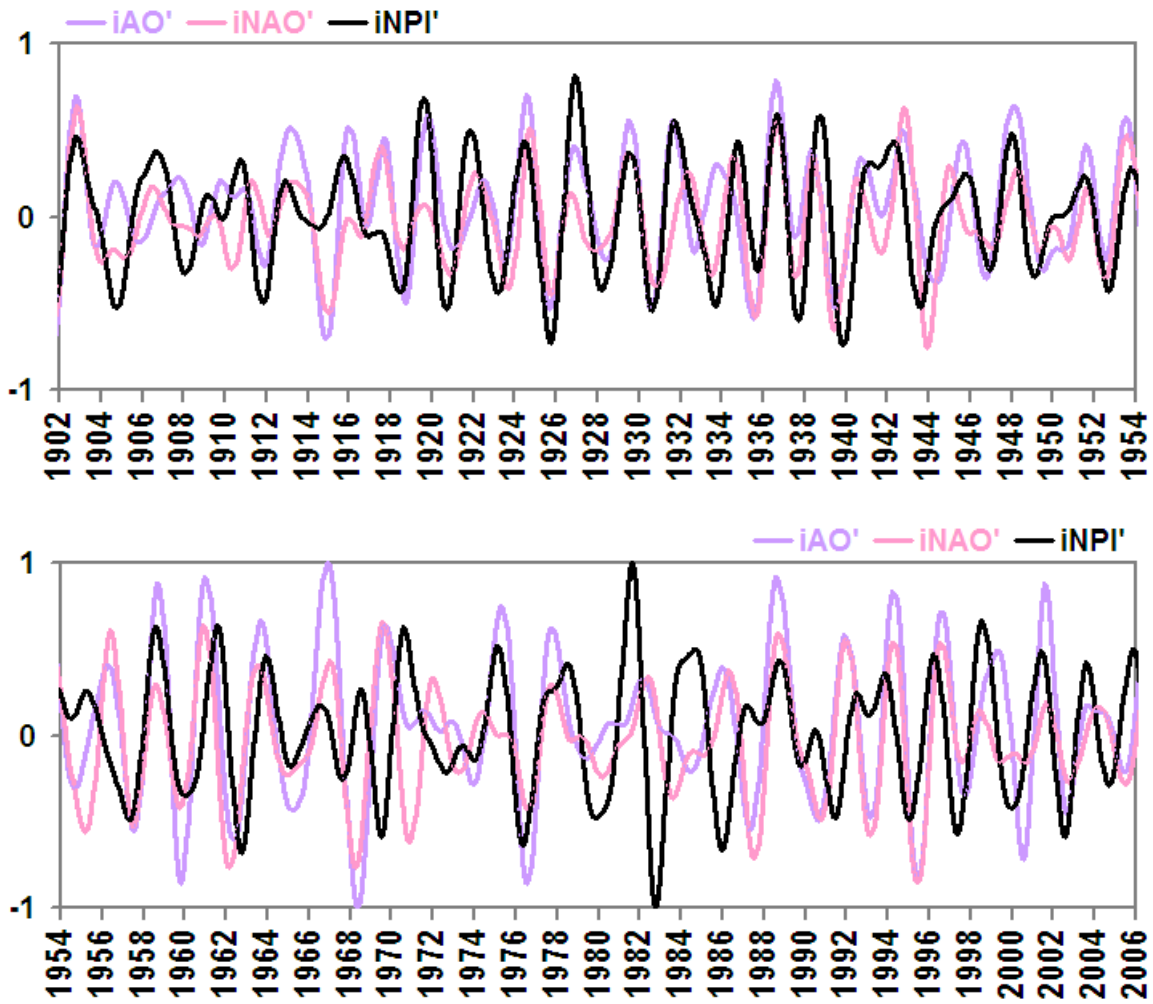


Note that when iNPI' doesn't "go with" iAAM & iLOD, it "goes against" them, much like a switch that is either "off" or "on". Specialists like Maraun & Kurths might speak of coherence and illustrate the nonrandom distribution of phase differences.

Multiscale complex correlation (for example using adjacent derivative based complex empirical wavelet embeddings) can measure complex nonstationary relations where simple linear correlation fails catastrophically. Naive investigators unknowingly encounter Simpson's Paradox by falsely assuming independence and blindly running linear factor analyses (such as PCA, EOF, & SSA) without performing the right diagnostics.

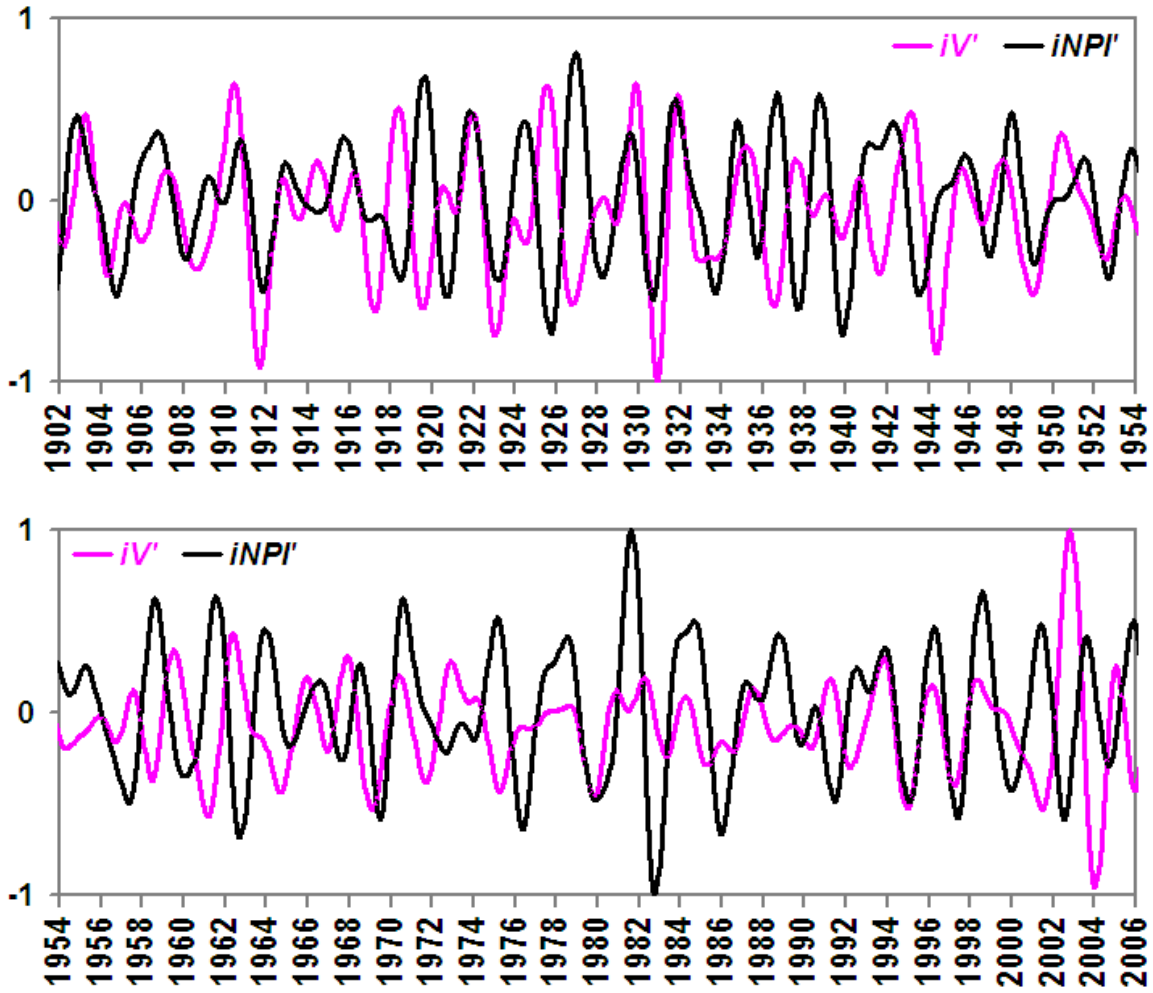
Northern Hemisphere Inter-Basin Interannual Coherence

Nonrandom phase relations explored by Schwing, Jiang, & Mendelssohn (2003):



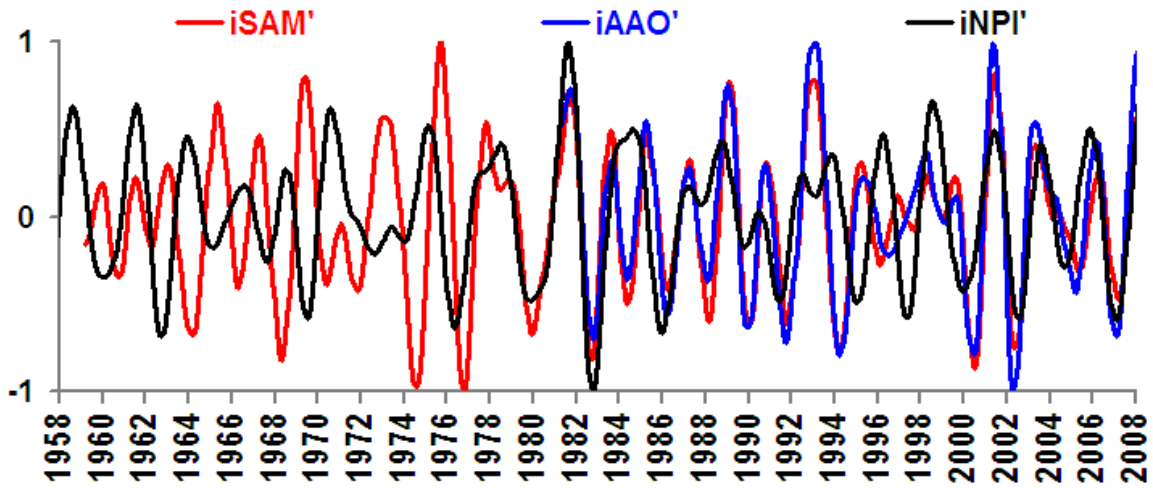
Interannual Solar-Terrestrial Phase-Relations

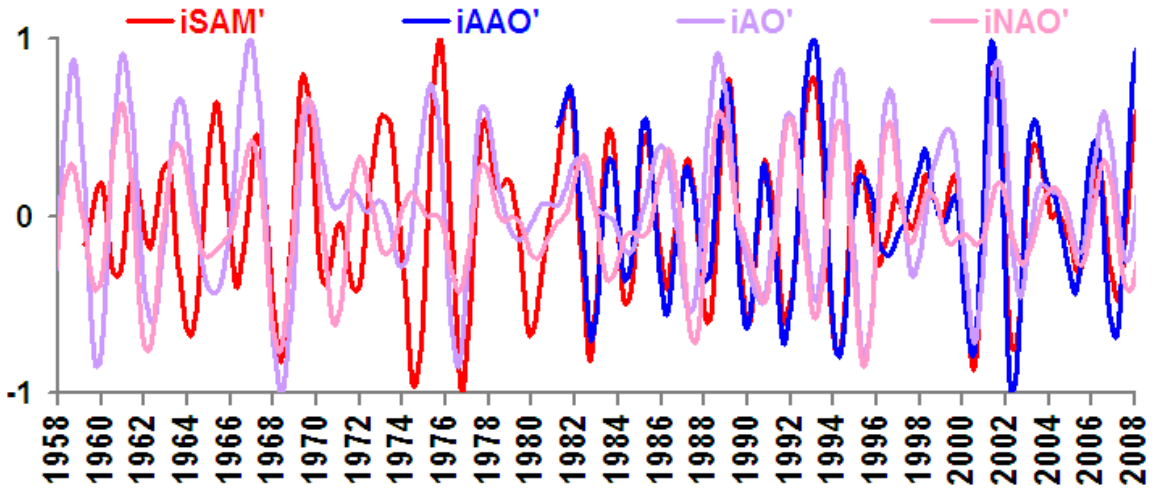
Terrestrial phase relations with interannual [*not to be confused with decadal*] rates of change of solar variables, including solar wind speed (iV'), are nonrandom:



Inter-Hemispheric Interannual Phase-Relations

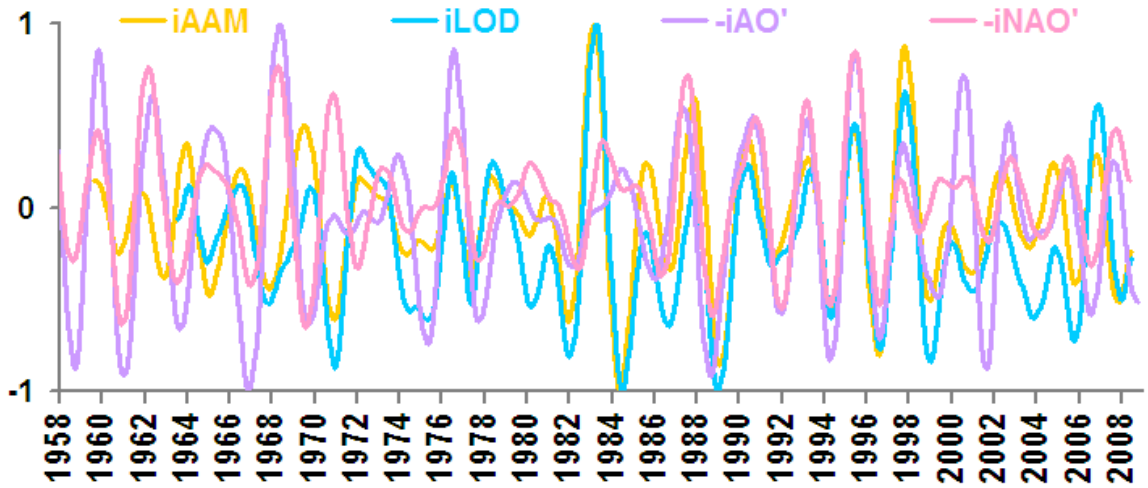
For those wondering how AAO & SAM fit in:





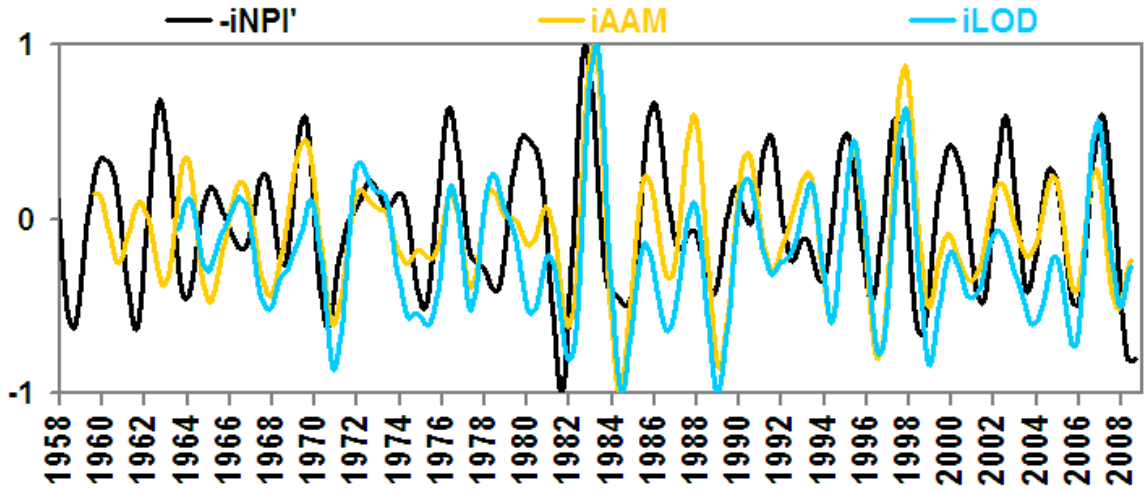
Global Synchronicity

Synchronicity's the norm. Orientation, configuration, amplitude, & extent of *globally constrained & coupled* jets & gyres are *pressured* while network monitoring remains *stationary*. Regional *temporal* phase summaries are *intermittently flipped by the stationary spatial geometry* of monitoring networks in the turbulent global context.



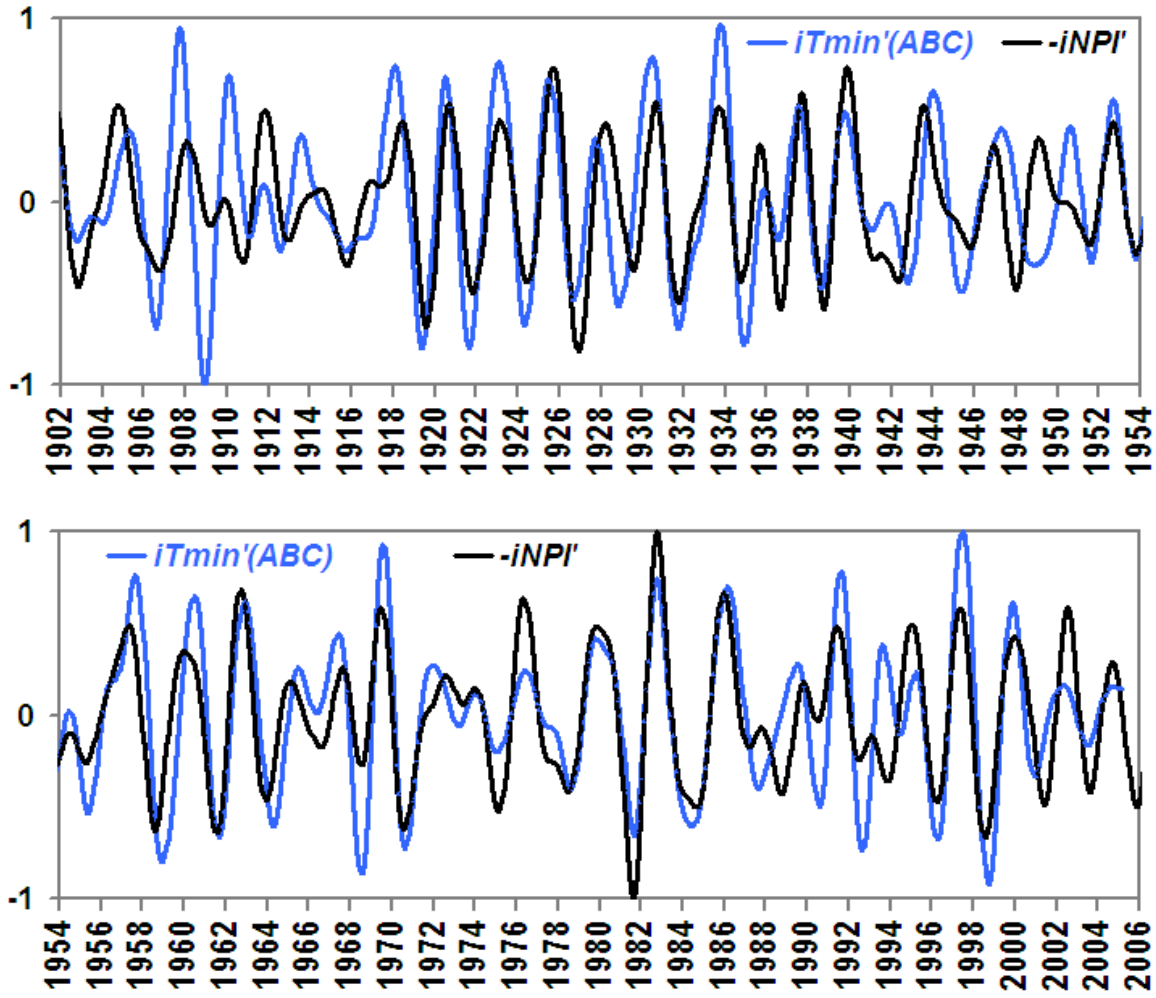
Note particularly (in the last 2 graphs) the strong & stable interannual synchronicity of northern annular, southern annular, & global modes for the decade beginning ~1988. The commencement of the pattern coincides with concurrent abrupt changes in Arctic ice flow (e.g. Rigor & Wallace (2004) Figure 3) and European temperature (e.g. Courtillot (2010)).

Repeated from above for easy comparison:



Local Connection

Here's how NPI relates to minimum temperatures at my local weather station:



Concluding Speculation

Terrestrial geostrophic balance is affected by the concert of ***changes in:***

a) interannual (*not to be confused with decadal*) solar variations.
b) decadal amplitude of *semi-annual* Earth rotation variations - [see Vaughan (2011) & links therein].
c) solar cycle length - [see links in Vaughan (2011)].

Nipping Potential Misunderstandings in the Bud

"So you're claiming the North Pacific controls global climate?"

No.

Why do I hear the same places mentioned every rush hour on the traffic report? Bottlenecks are easy places to detect *changes in* pressure & flow (whether global &/or locally intersecting), even using the simplest methods. Methods such as those suggested by Schwing, Jiang, & Mendelssohn (2003); Maraun & Kurths (2005); and Tsonis, Swanson, & Kravtsov (2007) help expand our vision towards the rest of the network. We have a lot of work to do (both exploratory & methodological).

Further Reading

Everything written by Tomas Milanovic at Dr. Judith Curry's blog Climate Etc.

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/

Referenced Above

Courtillot, V. (Dec. 2010). *YouTube Video* (~30min)*:* Berlin Conference Presentation. http://www.youtube.com/watch?v=IG_7zK8ODGA

Maraun, D.; & Kurths, J. (2005). Epochs of phase coherence between El Nino-Southern Oscillation and Indian monsoon. Geophysical Research Letters 32, L15709. doi10.1029-2005GL023225.
http://www.cru.uea.ac.uk/~douglas/papers/maraun05a.pdf

Rigor, I.; & Wallace, J.M. (2004). Variations in the age of Arctic sea-ice and summer sea-ice extent. Geophysical Research Letters 31. doi: 10.1029/2004GL019492.
http://iabp.apl.washington.edu/research_seaiceageextent.html

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.

Trenberth, K.E.; Stepaniak, D.P.; & Smith, L. (2005). Interannual variability of patterns of atmospheric mass distribution. Journal of Climate 18, 2812-2825.
http://www.cgd.ucar.edu/cas/Trenberth/trenberth.papers/massEteleconnJC.pdf

Tsonis, A.A.; Swanson, K.; & Kravtsov, S. (2007). A new dynamical mechanism for major climate shifts. Geophysical Research Letters 34, L13705.
http://www.nosams.whoi.edu/PDFs/papers/tsonis-grl_newtheoryforclimateshifts.pdf

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.

Since (to my knowledge) there's not yet a free version, see the conference poster and the guest post at Dr. R.A. Pielke Senior's blog for the general idea:

a) Wyatt, M.G.; Kravtsov, S.; & Tsonis, A.A. (2011a). *Poster:* Atlantic Multidecadal Oscillation and Northern Hemisphere's climate variability.
https://pantherfile.uwm.edu/kravtsov/www/downloads/WKT_poster.pdf

b) Wyatt, M.G.; Kravtsov, S.; & Tsonis, A.A. (2011b). *Blog:* Atlantic Multidecadal Oscillation and Northern Hemisphere's climate variability.
http://pielkeclimatesci.wordpress.com/2011/04/21/guest-post-atlantic-multidecadal-oscillation-and-northern-hemisphere%E2%80%99s-climate-variability-by-marcia-glaze-wyatt-sergey-kravtsov-and-anastasios-a-tsonis/

Important Note: While Wyatt, Kravtsov, & Tsonis (2011) are likely to stimulate a lot more discussion *once a free version of their paper becomes available*, it needs to be pointed out assertively & clearly that the cross-correlation approach, while informative, is *patently insufficient* for determining the full nature of terrestrial spatiotemporal phase relations.

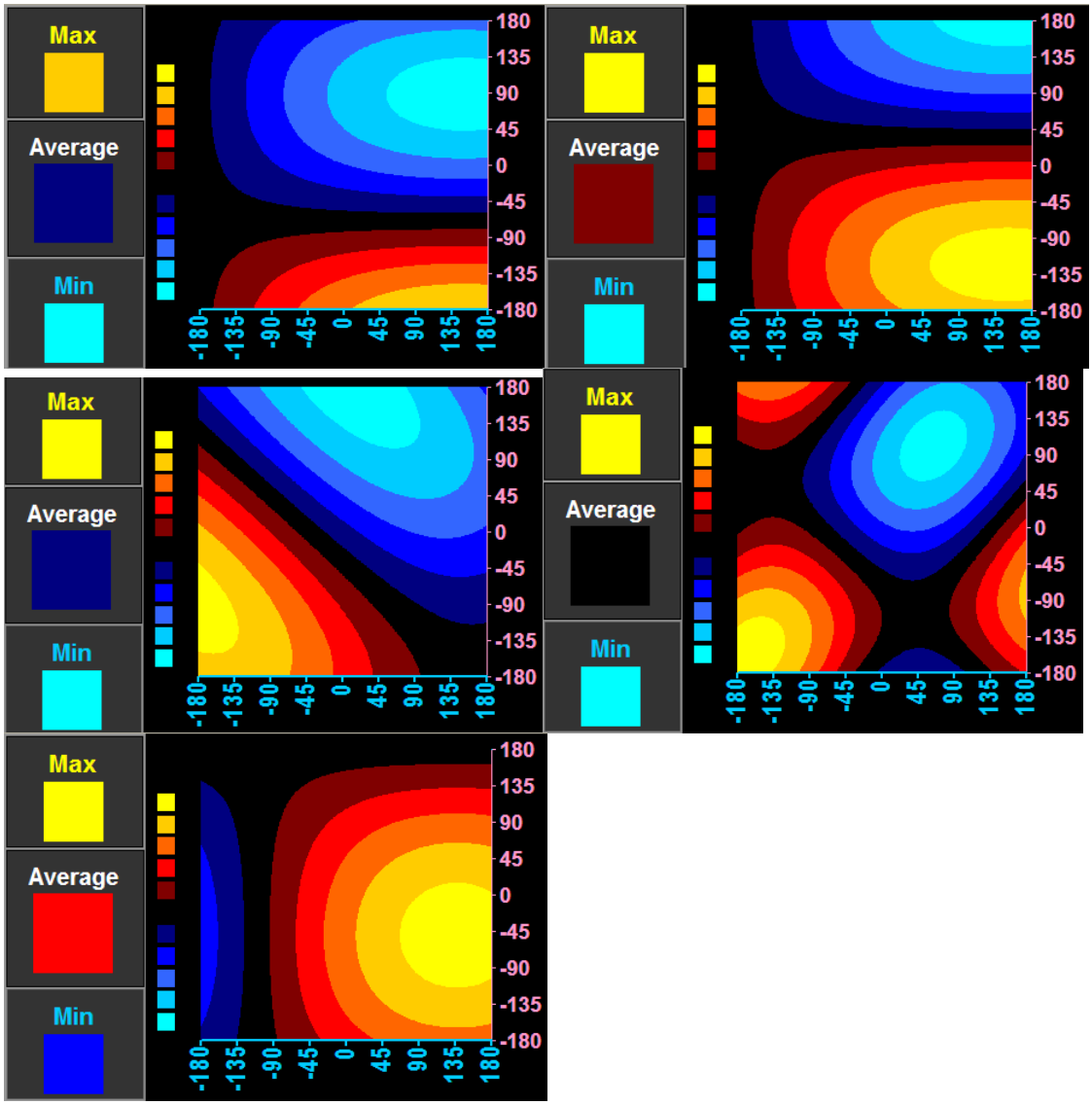
Appendices

In the appendices that follow, attention is concisely drawn to key items that are consistently underappreciated in climate discussions.

Appendix A: Spatial Influence on Phase - Important

Nonrandom phase relations demand careful focus on the spatial dimension. Temporal evolution isn't the only thing driving apparent phase.

If features *grow, shrink, rotate, change shape, reflect, or move* relative to the *stationary* windows in which they are measured, phase is affected.



The effect on summaries is plain & simple. (Anyone previously puzzled by *"integration across spatiotemporal harmonics"* might now get the *general* idea.)

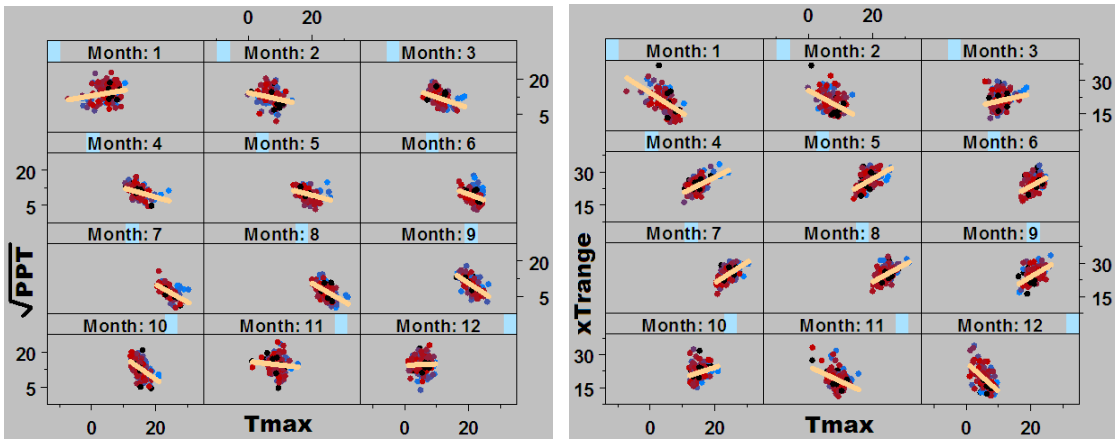
Appendix B: Reversals in Temperature-Precipitation Relations

Blink between winter & summer panels of Figure **6**:

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

Temperature-precipitation relations are a function of *absolutes*, ***not*** anomalies. This is *fundamentally* important.

Insight from my local (ABC) example:



Appendix C: Global Distribution of Continental-Maritime Contrast

High-amplitude regional variance leverages global summaries, but multidecadal variations often draw misguidedly narrowed focus to the North Atlantic Ocean when it is the *global distribution of continental-maritime contrast (in relation to flow patterns)* that should be attracting the attention. Noting the position of the relatively small North Atlantic *in this broader context*, carefully compare:

1. http://icecap.us/images/uploads/AMOTEMPS.jpg

2. Figure **10** here:

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

Concluding Remarks

Just getting started...