Atmos. Chem. Phys. Discuss., 9, C9498–C9502, 2010
www.atmos-chem-phys-discuss.net/9/C9498/2010/

Atmospheric Chemistry and Physics Discussions

Interactive comment on "Solar cycle signals in sea level pressure and sea surface temperature" *by* I. Roy and J. D. Haigh

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Received and published: 8 January 2010

January 6, 2009

Review for Atmos. Chem. Phys. Discuss.

"Solar cycle signals in sea level pressure and sea surface temperature"

By I. Roy and J.D. Haigh

General comments

This paper presents a multiple regression analysis of reconstructed sea level pressure and sea surface temperature datasets, along with stratospheric aerosols, the sunspot cycle, and Nino3.4 time series. The authors show, for peaks in the solar cycle, positive

sea level pressure anomalies in the North Pacific, thus re-confirming results from other studies, but the story for SST is somewhat more complicated. This level of complexity with regards to the timing of forcing and response, shown in detail in a number of previously published papers, has been missed by the authors in the present paper. However, the fundamental aspect of this timing is actually described by the authors as noted below, and needs to be clarified.

Though the authors state that their Fig. 2 shows "a weak El Nino-like pattern", what Fig. 2 actually shows is no consistent signal across the equatorial Pacific. The very small anomalies of about +/- 0.1 K show no coherent pattern in the equatorial Pacific. There are negative values close to South America, weak positive values from about 90 to 130W, small negative values from 140W to 170W, and very small positive values west of the Dateline. In my view this is not El Nino-like or La Nina-like, but a mixed neutral pattern. The reason these SST anomalies are neither El Nino- or La Nina-like is summarized best by the authors themselves in section 25844, and this accurate insight goes to the crux of the solar forcing/response problem and probably should be the main result of the paper: "peak years tend to occur very soon after the solar cycle becomes more active...at least a year before... the peak of a broader decadal variation". My guess is that the multiple regression is picking up this broader peak (as did White's filtering). Therefore, the early La Nina-like response is blurred into the subsequent El Nino-like pattern a year or two later, producing virtually no distinguishable pattern from the multiple regression.

Since the work by van Loon, Meehl, Arblaster, White, Liu and others have shown an oscillatory response to solar forcing in the equatorial Pacific, timing is everything. It would appear that the initial response to the ramp-up of solar forcing leading to the peak would be a La Nina-like response as documented for two mechanisms (one working top-down, the other bottom-up) that produces such a response in observations and models (Meehl et al., Science, 2009, not referenced in the present paper). Then the system responds to that impulse (working on the timescale of ENSO, namely months,

ACPD
9, C9498–C9502, 2010

as shown in detail by Meehl and Arblaster, 2008) since coupled ocean-atmosphere ENSO-like dynamics are involved, to produce a lagged El Nino-like response. Again, this was shown for observations and models by Meehl and Arblaster, 2008 (the text states erroneously that study only showed model results), as well as by Meehl et al. (2009). Thus the multiple regression is picking up an intermediate time period in the broad decadal peak as the system is transitioning from the initial La Nina-like response (as documented in their Fig. 3b) to the more El Nino-like pattern a year or two later, but still in the broad decadal maximum.

Specific comments

Section 25840:

Line 5: Meehl and Arblaster (2009) was a combined modeling and observational study, not just a modeling study as stated here; the combination of two observational datasets and two models makes a strong case for the oscillatory response of the tropical Pacific to solar forcing; also note this reference is cited with incorrect authors in the reference list

Line 13: Meehl et al (Science, 2009) is not cited here, but should be, since it makes a process-oriented argument for two mechanisms that would work in the same sense to produce the initial La Nina-like response, which stimulates the coupled dynamics documented in Meehl and Arblaster (2009) that transitions to an El Nino-like pattern along the equatorial Pacific a year or two later

Section 25841:

Line 13: Vecchi et al is apparently cited incorrectly; in the reference list it is Vecchi and Soden. Additionally, the authors need to cite Vecchi et al (2008) who provide an enlightening discussion of inconsistencies of the various SST reconstructions in the equatorial eastern Pacific that provide different results between the NOAA and HadISST data.

ACPD

9, C9498–C9502, 2010

Section 25842:

Line 6: Meehl et al (2008) provide compelling evidence that convective heating anomalies associated with the SST anomalies in the tropical Pacific force the SLP pattern characterized by anomalous high pressure over the North Pacific with peaks in the solar cycle

Line 15: Actually, the biggest and most dominant signal in the observations shown by van Loon et al (2007) is exactly the positive SLP anomalies in the North Pacific shown here again, though the authors do not mention this

Line 27: White et al show a much more consistent El Nino-like pattern than that shown in Fig. 2 of the present paper which shows basically no consistent pattern in the equatorial Pacific

Section 25843:

Near line 20: The authors have identified, in another way, what van Loon and coauthors have shown in multiple papers, that the response to peaks in solar forcing resemble weak La Nina conditions; however, the authors should mention that van Loon and Meehl (2008, in the reference list) showed that the peak solar conditions are different from La Nina events in the Southern Oscillation mainly in the equatorial stratosphere, where the latter have the opposite sign zonal wind anomaly compared to the former

Line 24: I would argue that the pattern in Fig. 2 is not a "weak WE-like response", it's more of a neutral response; see discussion in general comments above

Section 25844:

Lines 9-15: I suggest that this could be the main result of this paper with regards to timing and the oscillatory response of the equatorial Pacific to solar forcing

Line 28: The authors have presented no results regarding physical processes; they

ACPD

9, C9498–C9502, 2010

only present statistical results from a multiple linear regression

Section 25845

Lines 1-5: As shown in great detail in Meehl and Arblaster (2009) and discussed above, the timescale of the response to peak solar in the equatorial Pacific is the same as ENSO dynamics, namely a timescale of months, certainly not centennial to millennial!

Line 10: Indeed a limitation of the observations is a finite number of solar cycles, but results from two different global coupled models shown by Meehl et al (2008), using multiple ensemble members from 20th century simulations and thus on the order of 40 to 50 realizations of peak solar forcing for each model, show a similar pattern to the shorter observational record, and Meehl et al (2008, 2009) provide mechanisms to explain it

Lines 15-18: the Meehl et al (2009) paper uses versions of models with both the top-down stratospheric ozone mechanism and the bottom-up coupled ocean-atmosphere mechanism to demonstrate how the two mechanisms mentioned in the comment above could work

References

Meehl, G.A., J.M. Arblaster, K. Matthes, F. Sassi, and H. van Loon, 2009: Amplifying the Pacific climate system response to a small 11 year solar cycle forcing, Science, 325, 1114-1118.

Vecchi, G.A., A. Clement, and B. J. Soden, 2008: Examining the tropical Pacific's response to global warming. Eos Trans. AGU, 89, 9, doi:10.1029/2008EO090002

Interactive comment on Atmos. Chem. Phys. Discuss., 9, 25839, 2009.