Clim. Past Discuss., 9, C1845–C1860, 2013
www.clim-past-discuss.net/9/C1845/2013/

Climate of the Past Discussions

CPD

9, C1845–C1860, 2013

Interactive Comment

Interactive comment on "Siple Dome shallow ice cores: a study in coastal dome microclimatology" *by* T. R. Jones et al.

T. Jones

tyler.jones@colorado.edu

Received and published: 27 August 2013

Detailed suggestions : - section 1.1 : you may want to explain and quantify using Rayleigh models how source and site temperature changes associated with ENSO and ASL changes are theoretically expected to affect water stable isotopes in Siple Dome ice cores.

ANSWER: We have decided to focus on the complexity of the water isotope signal, and list ENSO and ASL as a possible influence on the signal (see PCA discussion below).

- the order of sections is not logical. The site, measurements and dating methods should be introduced before a discussion of statistical methods (as in 1.2). I suggest to summarize the basis of isotope-temperature relationships in the introduction, and then have a section on Material and Methods.

ANSWER: Noted.

- I cannot understand why the authors use a Rayleigh open cloud model to quantify isotope-temperature relationships. What is the local spatial gradient? On which data is the unnumbered equation of line 20, page 2685 defined ?

ANSWER: The equation is from Dansgaard, 1964, but the Dansgaard delta-temperature relation is not valid in Antarctica. It will be removed.

- Page 2686 does not mention two key aspects : i) precipitation intermittency, and ii) wind scouring which both play a key role in signal to noise variability in shallow ice core records. The uncertainties on the isotope-temperature relationships from Jouzel et al (2003) are only valid for glacial-interglacial changes. Several studies have challenged the use of spatial gradients for temporal variations in coastal Antarctica.

ANSWER: Agreed.

- Section 3.2 should introduce the accuracy on deuterium excess measurements. The dating method should be described together with the associated uncertainty. This aspect is crucial for the rest of the paper.

ANSWER: We have decided to remove the deuterium excess measurements from the paper since the measurement uncertainties prevent any conclusions about a water isotope source signal.

The dating of the ice cores was performed using visual stratigraphy on a light table over fluorescent tubes (after the core had been sectioned longitudinally). Indicators were used to determine how obvious dating choices were: 3=clear indication, 2=fair indication, 1=poor indication, 0.5=something present but not picked as a summer, 0=interpolated where visible examination too difficult for choices (as in badly fractured core).

For the B Core, sixteen ‘poor indications’ are given within the first 17 meters (age

CPD
9, C1845–C1860, 2013

interval 1995-1920). For the age interval 1995-1920 for Core C, D, E, F, G, H, twenty-four 'poor indications' are given, seven 'poor indications' are given, twenty-three 'poor indications' are given, nine 'poor indications' are given, fourteen 'poor indications' are given, and nine 'poor indications' are given, respectively.

The dating of the shallow cores makes temporal analysis difficult. For this reason, we focused on averaged values of accumulation and water isotopes for the period 1920-1995. We also include standard deviation of delta-D as a measure of the strength of signal.

The file "SipleDome_ShallowCore_AnnualLayers.txt" is included as a supplement for further reference. There is also .txt documents for isotopes and density.

- Table 2 should include error bars on average stable isotope and accumulation ratios, based on standard deviations. This would allow to check if differences between sites are significant or not.

ANSWER: A graph is presented with error bars for average stable isotopes, which are based on mass spec uncertainty using repeated measurements of water isotope standards. Error bars for accumulation are not presented, but an indication of uncertainty is given in the supplemental file "SipleDome_ShallowCore_AnnualLayers.txt".

- Section 3.3 is not properly placed. How much does the hypothesis of a constant phase with SOI affect the chronology ? The discussion of isotopic diffusion is useless C1487 if this effect is not corrected for identifying annual layers and correcting measurements.

ANSWER: For Core B, the assumption of constant phase with the SOI requires a shift in the dating a maximum of 3.5 years. It is agreed that diffusion is not useful in terms of identifying annual layers since there is considerable uncertainty in the annual layer interpretations.

- The result section must be reorganised. I suggest to discuss first the spatial gradients and to combine Figures 8, 9, 10 into one single figure showing for the transect : (i) ele-

CPD
9, C1845–C1860, 2013

vation, (ii) temperature, including temperature estimated from elevation effects only, (iii) accumulation rates, (iv) 18O (including 18O expected from a linear fit to accumulation) and (v) deuterium excess.

ANSWER: See new plots.

- A plot of excess as a function of 18O could be useful in order to identify if the points align or not on a single distillation line. The deuterium excess signals from the different ice cores should be shown somewhere (is there any coherency between the different shallow ice cores or not ?). On Figure 10, the authors show a decreasing trend, while I see two groups of points with different mean values (like a step function).

ANSWER: There appears to be little coherency between the different shallow ice core water isotope and accumulation measurements (see plots). This may be related to post-depositional snow movement.

- I am not convinced that the fits shown in Figs 8-10 do reflect spatial gradients. It seems that only site F is an Â′n outlier ÂËŹz with respect to the other ones. Could dome shadow effects explain the differences ? Why are there two points Â′n H ÂËŹz in the graphs ?

ANSWER: Your observation is correct that site F is the outlier. It is possible that shadow effects could explain the difference.

- Figures 3-4 bring no useful information. They could be replaced by a cross spectral analysis to look at the coherency between the various ice core records and the SOI, in order to check in which frequencies you have a common signal. If the dating uncertainty is 3.5 years as mentioned in the caption of Fig 5, then I am afraid that it is not possible to discussion the link with SOI.

ANSWER: Yes, re-dating Core B to the SOI introduces a maximum shift in the dating of 3.5 years. Due to the difficulty in dating the Core B ice core (sixteen ‘poor indications’ are given within the age interval 1995-1920), we include the graph to show that Core B water isotopes show common structure with the SOI (given re-dating only, which may or may not be valid due to dating uncertainty).

A new graph is presented showing cross-spectral analysis of Core B delta-D compared with accumulation, Nino 3.4, and SAM. Core B delta-D shares power with accumulation in the 2-3 year range, with Nino 3.4 in the 3-7 year range, and with SAM in the 1-3 year range. Core B delta-D and accumulation also share power in the 3-8 year range, but the power is not significant at 95% AR(1) red noise assumption. Note the different age scales for the cross-spec graphs. The major conclusion from this figure is that ENSO and accumulation patterns influence the Core B delta-D record in the 2-7 year ENSO variability range. It cannot be said with confidence whether one or both are playing the strongest role.

- I suggest to replace Figs 5-6 by an analysis of the common signal in all the ice cores through a Principal Component Analysis, and then look at the link between the first PC and SOI. The signal to noise ratio could also be calculated and discussed.

ANSWER: A new graph is presented showing the PCA of the 7 shallow ice cores. The first five components of the PCA explain 22%, 17%, 16%, 14%, and 13% of the total variance. The signal is complex. A plot of component 1 vs. component 2 is shown in the bi-plot. For component 1 on the horizontal axis, Core F and Core H (Inland) have negative coefficients, and Cores E, G, D, C, and B (Pacific and Summit) have positive coefficients. For component 2 on the vertical axis, Core B and Core E have negative coefficients, and Cores G, C, D, H, and F have positive coefficients. The bi-plot shows a fundamental difference in the Inland vs. Summit/Pacific for component 1, but component 2 does not support the difference. The complexity of the signal may partially result from the uncertainty in dating.

A plot of the first 5 principal components and the relation to Nino 3.4 and the SAM is shown. There is no agreement between any of the components and the climate oscillations. This suggests that post-depositional snow processes may play a significant role

CPD
9, C1845–C1860, 2013

in the higher frequencies of the water isotope record, and that the records would have to be smoothed considerably to reach agreement. But again, caution must be taken in this statement as the dating of each ice core also has considerable uncertainty.

- Sections 4.2 and 4.3 should be rewritten in order to investigate the spatial gradients in elevation, temperature, accumulation, their coherency and what they imply for isotopes. Then the isotope spatial gradients should be described with respect to the previous C1488 information. In the last paragraph of page 2690, please check if such small temperature differences are significant or not.

ANSWER: The temperature differences are not significant.

- Page 2695 : this is very speculative and not quantified. An option could be to select years with specific known climate anomalies (large Nina events, or large SST anomalies) and see if there is a specific isotopic spatial pattern for these given years, compared to the other years.

ANSWER: Based on dating, there is no specific isotopic spatial pattern for large El Nino/La Nina years. A graph is presented showing strong El Nino years (red lines) and strong La Nina years (blue lines) defined as 5 consecutive months greater than or less than 1.5 degree Celsius sea surface temperature anomalies for the Nino 3.4 region, respectively. There is no agreement amongst the shallow cores. Again, dating of the ice cores may prevent an accurate comparison.

- Links between modes of variability and local micro climate : couldn't atmospheric reanalyses or regional models be used to estimate what spatial structures are expected in this area ? The discussion is very speculative, and gives the impression that the authors have a theory, and want the observations to be consistent with this theory, without really testing it. Figure 11 shows the large scale atmospheric circulation but not the magnitude of the climate signals associated with it. This Figure could replace the schematic representation of Figure 1.

ANSWER: We plan to modify the paper to suggest ENSO-ASL as a possible influence on the water isotope record, but not the sole theory.

- Section 5.2 is very speculative.

ANSWER: We plan to modify the paper to suggest ENSO-ASL as a possible influence on the water isotope record, but not the sole theory.

- From this paper, one expects to discuss the representativity of a given shallow ice core record in terms of spatial and temporal scale of climate signals which are archived. This is somehow missing and the conclusion is quite vague. It is a pity due to the huge analytical effort conducted here and the fact that very few comparable studies have been conducted.

ANSWER: The dating uncertainty of the shallow ice cores introduces difficulty in analyzing spatial and temporal scale climate signals. Our goals are to show that the shallow ice cores present a complex climate signal that must be considered at longer time scales (1920-1995) due to dating uncertainties. Within the water isotope signal we find frequencies that match classical ENSO variability (2-7 years), and Core B can be re-dated with a maximum temporal shift of 3.5 years to match the structure of the SOI. Cross-spectral analysis shows that both Nino 3.4 and Core B accumulation share power with Core B delta-D in the 2-7 year band. However, plots of all shallow ice core delta-D and accumulation shows no common pattern when compared with strong El Nino and La Nina events (greater than 1.5 C SST anomalies in the Nino 3.4 region). PCA analysis show a complex signal, and none of the principal component reconstructions show common structure with Nino 3.4 or SAM.

It is evident that water isotope standard deviation and average accumulation (1920-1995) decrease from north (Pacific Flank) to south (Inland Flank), and Core F is isotopically lighter than the other shallow ice cores. Borehole temperature measurements show that the Pacific Flank is warmer than the Inland Flank. These effects occur on a relatively flat dome (7.2 m/km) over 60 km and show that a microclimate exists on Siple

Dome.

Post-depositional snow movement or microclimate effects may be convoluting the high-frequency climate signal, making the original goal of ENSO reconstruction using the Siple Dome ice core difficult. But, ENSO frequencies are still evident in the shallow ice cores. We suggest that detection of a high-frequency signal (2-7 years) can be utilized over long time scales (100-500 year windows) in the deep ice core to infer whether ENSO-type frequencies were operating in the West Antarctic climate system. This information can inform ENSO climate models. (The WAIS Divide ice core is higher resolution that Siple Dome, and will be more useful for high-frequency studies.)

Please also note the supplement to this comment:
http://www.clim-past-discuss.net/9/C1845/2013/cpd-9-C1845-2013-supplement.zip

---

Interactive comment on Clim. Past Discuss., 9, 2681, 2013.

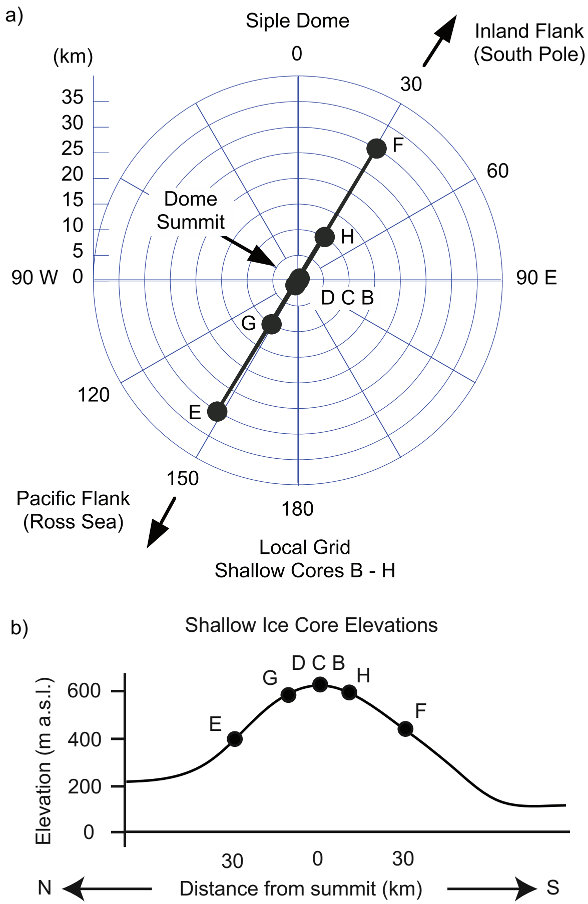

Fig. 1. Shallow ice core locations and elevation above sea level.

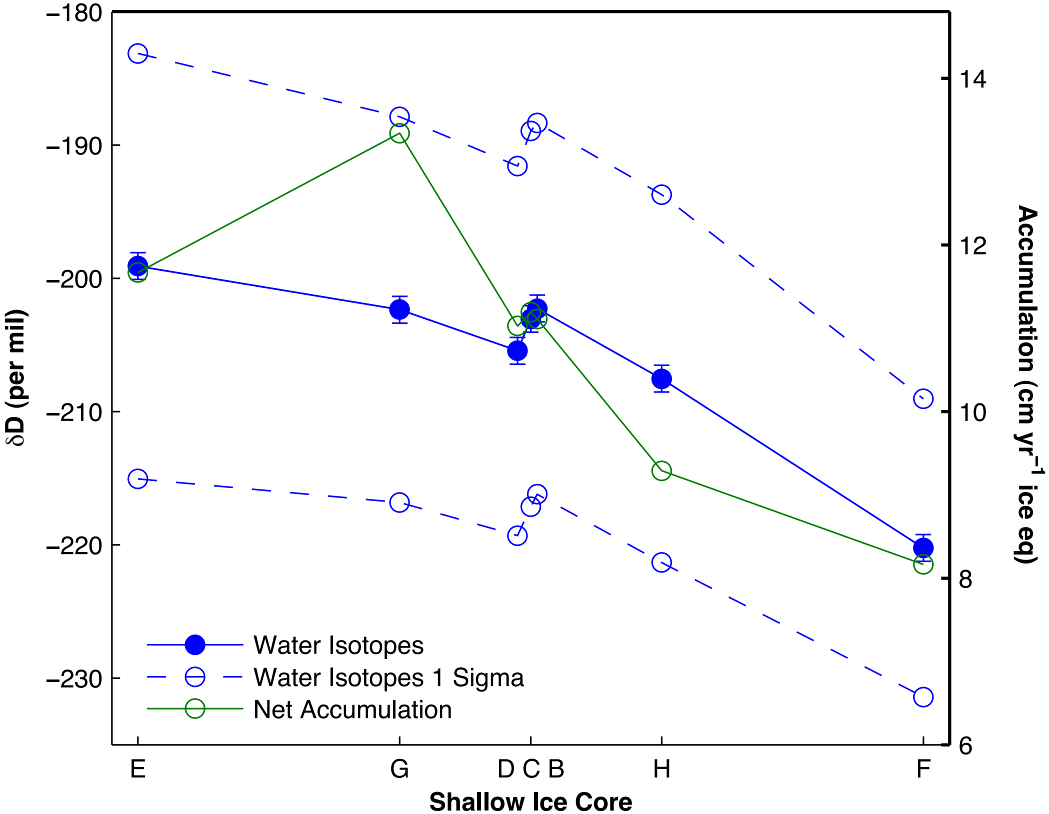

Fig. 2. Delta-D and Accumulation averages (1920-1995).

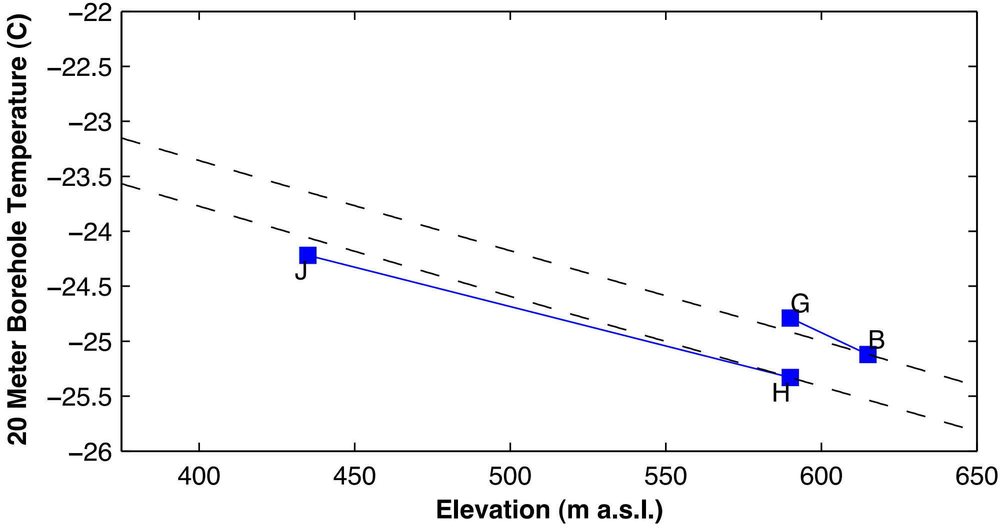

Fig. 3. Twenty-meter borehole temperatures.

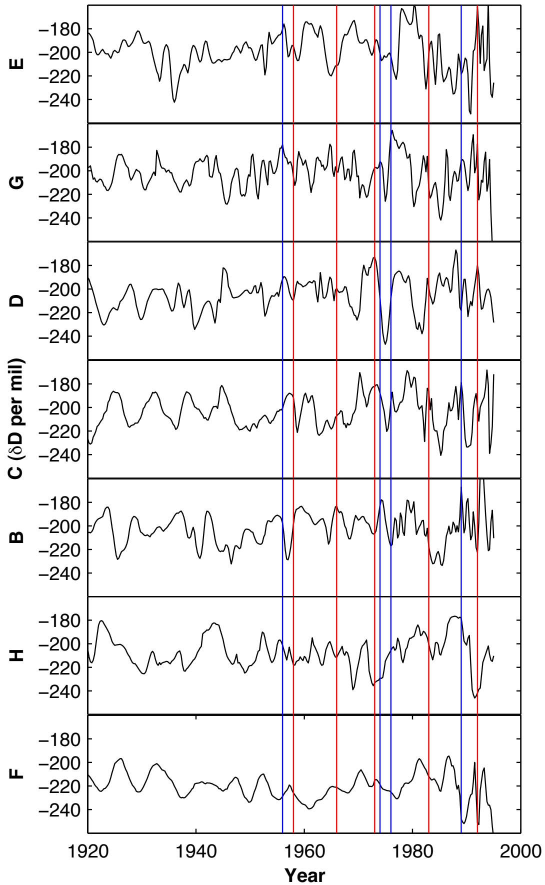

Fig. 4. Shallow ice core water isotope records compared with strong El Nino years (red) and strong La Nina years (blue), Nino 3.4 SST, and the SAM.

CPD
9, C1845–C1860, 2013

Interactive Comment

Full Screen / Esc

Printer-friendly Version

Interactive Discussion

Discussion Paper

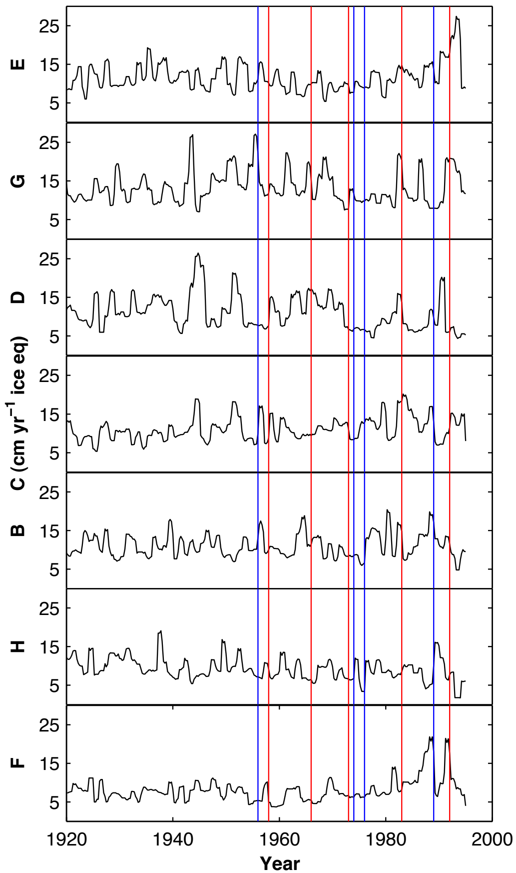

Fig. 5. Shallow ice core accumulation records compared with strong El Nino years (red) and strong La Nina years (blue), Nino 3.4 SST, and the SAM.

CPD
9, C1845–C1860, 2013

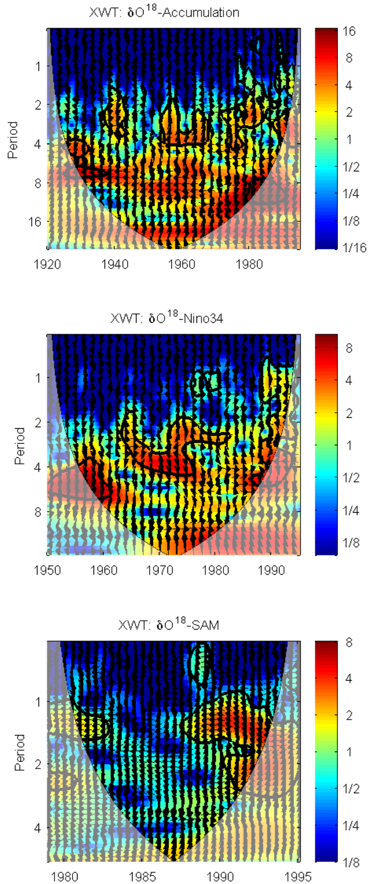

Fig. 6. Cross-spectral analysis of Core B delta-D compared with Core B accumulation, Nino 3.4, and SAM. Black contours enclose regions of 95% statistical significance (AR1 red noise estimate).

CPD
9, C1845–C1860, 2013

CPD
9, C1845–C1860, 2013

Interactive Comment

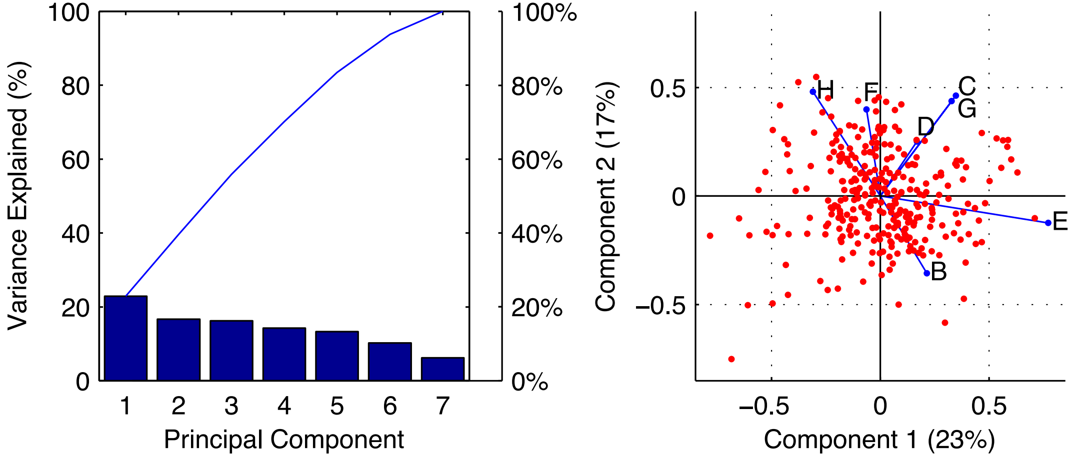

Fig. 7. PCA analysis of Siple Dome shallow ice cores, including the variance explained by each component, and a bi-plot of component 1 and 2.

Full Screen / Esc
Printer-friendly Version
Interactive Discussion
Discussion Paper

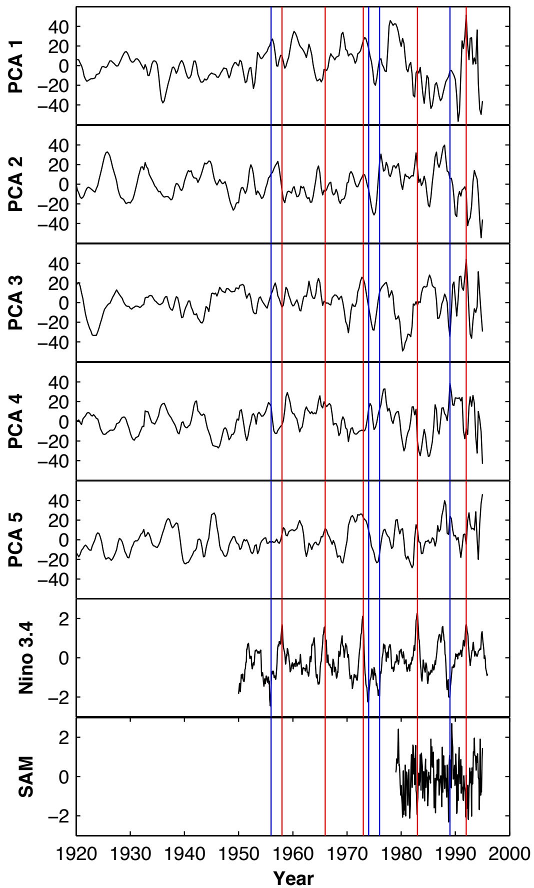

Fig. 8. First 5 principal components compared with strong El Nino years (red) and strong La Nina years (blue), Nino 3.4 SST, and the SAM.

CPD

9, C1845–C1860, 2013