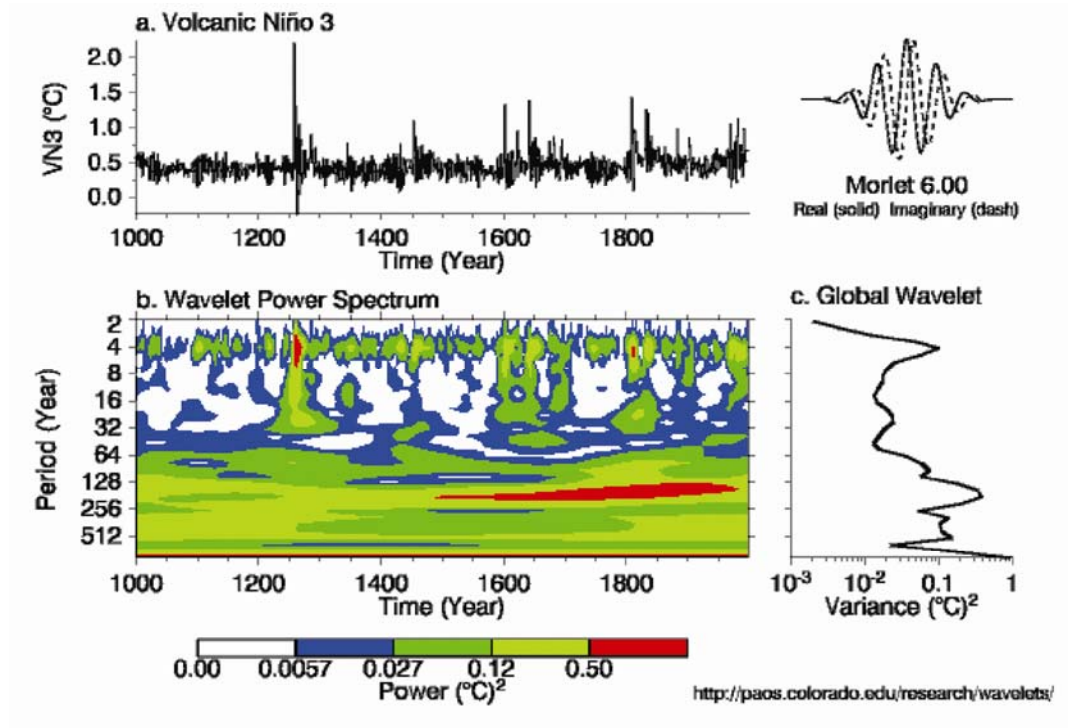


## SUPPLEMENTARY INFORMATION

There is a complementary study about El Niño Southern Oscillation (ENSO). In this study the response of ENSO to volcanic (only) radiative forcing over the past millennium is reanalyzed and extrapolated (M05). Preliminary results suggest two main oscillations: a persistent oscillation with a period around 176 years, and an oscillation of around 1000 years (See Figure S1).

A decomposition of volcanic ENSO in low and high frequency components has put forward the existence of around millennium and 176 yr scale oscillations, and a non-linear oscillation that changes to higher frequencies (from centennial to multidecadal periods) (See Figures S2). This decomposition could suggest an explanation for the last 1000 years of volcanic ENSO variability, and provide an experimental forecast of volcanic ENSO conditions for the next century.

These long-term oscillations have put forward several interesting aspects of ENSO: a) although most of the time, volcanic eruptions are found to be too small to significantly affect ENSO statistics, the cumulative effects are important and shows a periodic component possibly associated with astronomical phenomena, b) the non-linearity of a component of volcanic ENSO climate, and c) a possible centennial scale forecast, which confirms an ENSO trend toward La Niña conditions for the next century.



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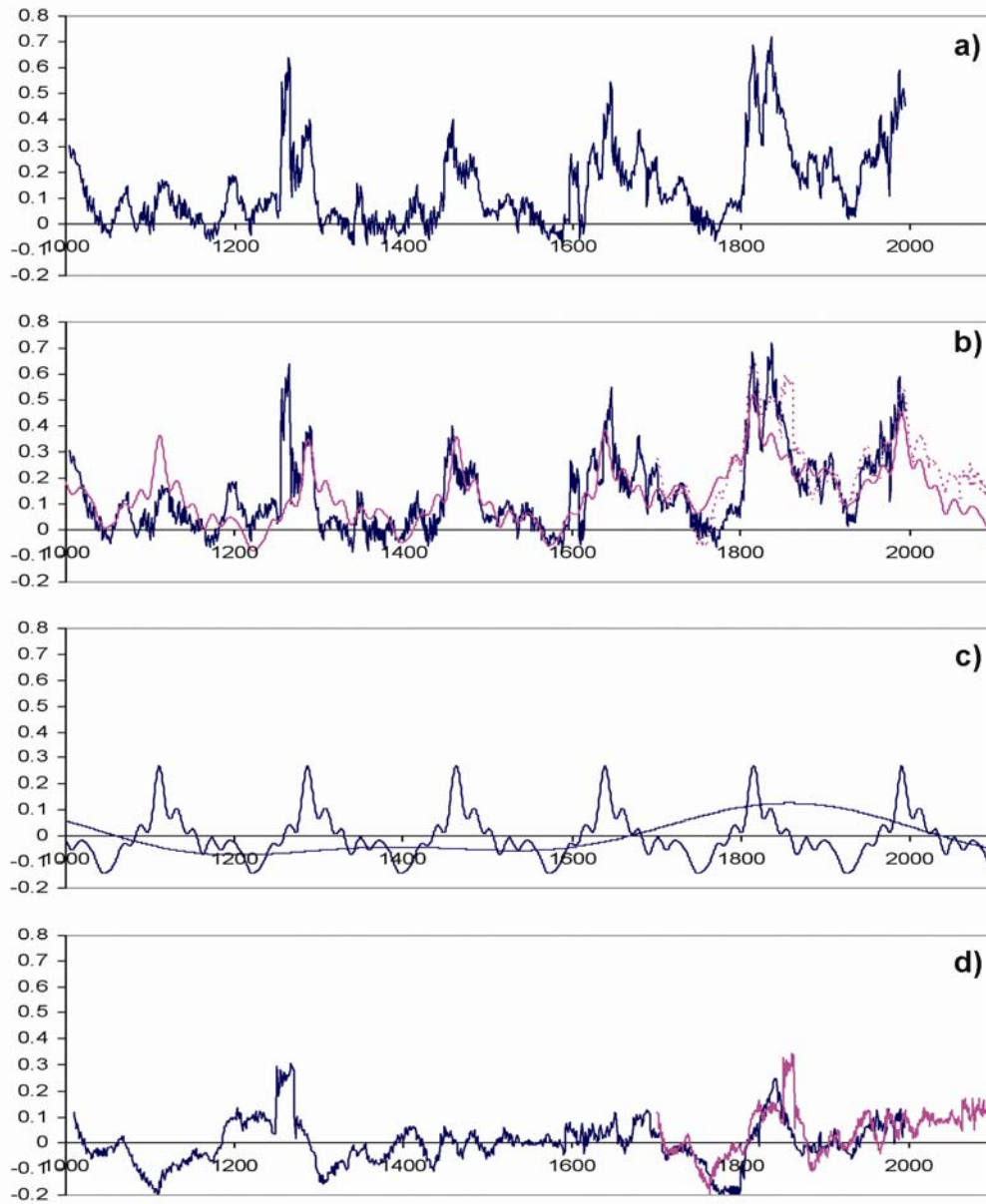
21 **Figure S1:** (a) Annual mean simulated Volcanic Niño3 (VN3) simulated indexes,  $VN3_s$ , in  $°K$ . (b)

22 Wavelet power spectrum. The contour levels are chosen so that 75%, 50%, 25%, and 5% of the wavelet  
23 power is above each level, respectively. Black contour is the 10% significance level, using a red-noise

24 (autoregressive lag1) background spectrum. (c) Global wavelet power spectrum (black line). The dashed

25 line is the significance for the global wavelet spectrum, assuming the same significance level and

26 background spectrum as in (b) (Torrence and Compo, 1998).



27

28 **Figure S2** Comparison of volcanic N3 (VN3) annual average records. (a) Simulated, 1000-1999 AD, with  
 29 ZC model (M05) (nEnsemble); (b) modeled obtained from the two Fourier series components model, VS1  
 30 and VS2, with and without the non-linear residue model, VN3S1+VN3S2+R (dark red dotted) and  
 31 VN3S1+VN3S2 (dark red), respectively; (c) the two Fourier series components model, VN3S1 and  
 32 VN3S2; and (c) the residual component, R, and its non-linear model (dark red).