

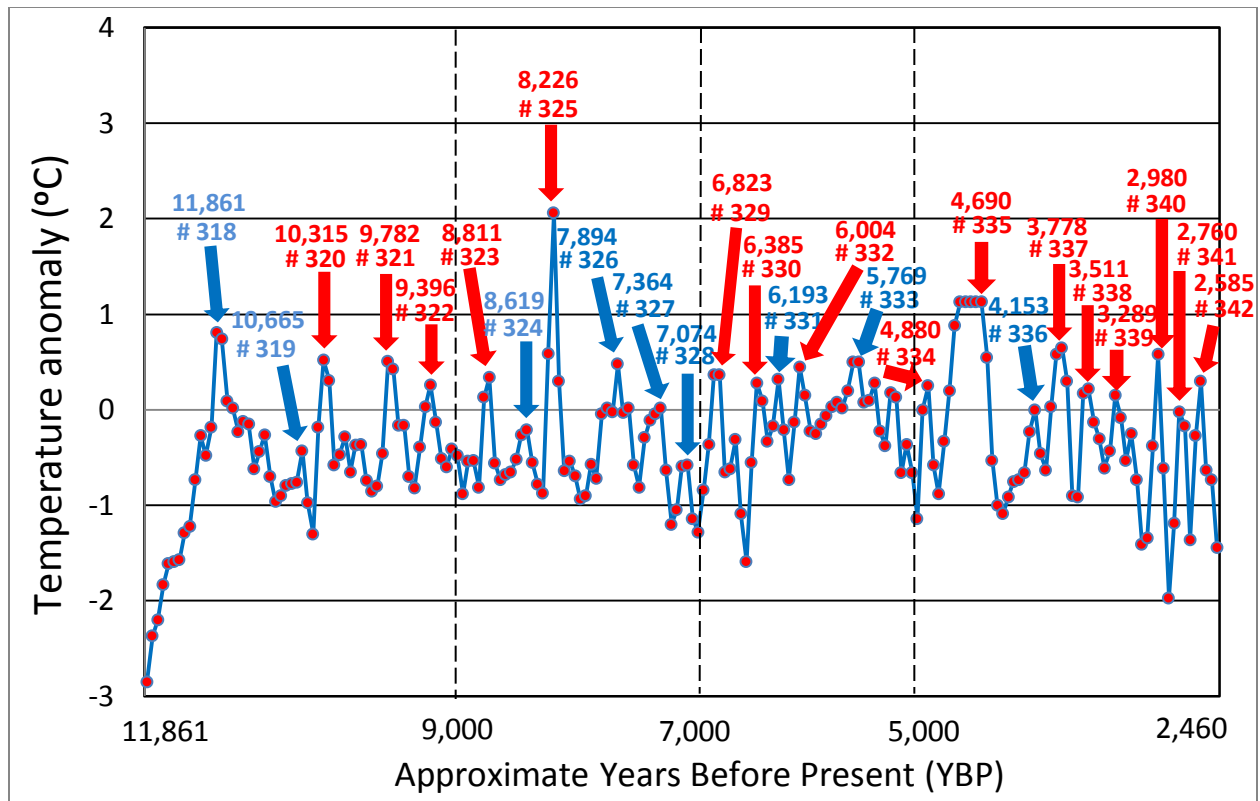
## Does the Current Global Warming Signal Reflect a Recurrent Natural Cycle?

We were delighted to see the paper published in *Nature* magazine online (August 22, 2012 issue) reporting past climate warming events in the Antarctic similar in amplitude and warming rate to the present global warming signal. The paper, entitled "*Recent Antarctic Peninsula warming relative to Holocene climate and ice-shelf history*" and authored by Robert Mulvaney and colleagues of the British Antarctic Survey (*Nature*, 2012, doi:10.1038/nature11391), reports two recent natural warming cycles, one around 1500 AD and another around 400 AD, measured from isotope (deuterium) concentrations in ice cores bored adjacent to recent breaks in the ice shelf in northeast Antarctica.

Public media in the U.S., including National Public Radio (NPR), were quick to recognize the significance of this discovery. The past natural warming events reported by Mulvaney et al. are similar in amplitude and duration to the present global warming signal, and yet the past warmings occurred before the industrial revolution and therefore were not caused by anthropogenic greenhouse gases. The present global warming cycle lies within the range of these past natural warming cycles, suggesting that the present global warming cycle may be of natural origin and not caused by human activity--as climate skeptics have been arguing for some time.

A couple of years ago we performed a similar but more extensive analysis of the historical temperature record from the ice core data obtained from the Vostok site in the Antarctic, not far from the ice core evaluated in the recent Mulvaney et al. *Nature* paper. We defined a NWE as a monotonic increase in temperature encompassing at least three consecutive Vostok temperature data points and terminated by at least one temperature data point less than the peak reached during the NWE. We found 342 natural warming events (NWEs) corresponding to this definition, distributed over the past 250,000 years at apparently irregular intervals (though we have not analyzed for subtle regularities, which may exist). The 342 NWEs we identified by this method are reminiscent of the two more recent NWEs reported in the Mulvaney et al. paper.

The 342 NWEs contained in the Vostok ice core record are divided into low-rate warming events (LRWEs;  $< 0.74^{\circ}\text{C}/\text{century}$ ) and high rate warming events (HRWEs;  $\geq 0.74^{\circ}\text{C}/\text{century}$ ) (Figure). Warming rates of NWEs were calculated as the peak amplitude ( $^{\circ}\text{C}$ ) divided by the duration (centuries). The threshold for HRWEs of  $0.74^{\circ}\text{C}/\text{century}$  is useful because this is the estimated rate of the current global warming event according to the Intergovernmental Panel on Climate Change (IPCC). Of the 342 NWEs in the Vostok record, 46 are high-rate warming cycles (HRWEs). The mean warming rate of these recurrent HRWEs is approximately  $1.2^{\circ}\text{C}$  per century, the mean amplitude is  $1.62^{\circ}\text{C}$ , and the mean duration of the warming phase is 143.8 years. For comparison, the current warming rate estimated by the IPCC is about  $0.74^{\circ}\text{C}/\text{century}$ , the current amplitude so far is about  $1^{\circ}\text{C}$ , and the current duration to date is 197 years. The current global warming signal is therefore the slowest and among the smallest in comparison with all HRWEs in the Vostok record, although the current warming signal could in the coming decades yet reach the level of past HRWEs for some parameters. The figure shows the most recent 16 HRWEs in the Vostok ice core data during the Holocene, interspersed with a number of LRWEs. Note the highest rate of warming beginning at 8,226 YBP, near the beginning of the agricultural revolution (taking into account the north-to-south hemispheric phase lag or climate see-saw).



**Figure:** Time series showing temperature anomaly (temperature difference from the recent past) during the final segment of the Vostok paleoclimate ice core record (the Holocene) in which conterminous proxy temperature and carbon dioxide measurements are available. Each arrow designates the peak temperature reached during a natural warming event (NWE). Blue arrows and font identify the peaks of low-rate warming events (LRWEs;  $< 0.74^{\circ}\text{C}/\text{century}$ ), while red arrows and font designate the peaks of high-rate warming events (HRWEs;  $> 0.74^{\circ}\text{C}/\text{century}$ ). In each case the first number associated with each arrow is the exact YBP at which the indicated NWE began, while the symbol # designates the number of the NWE in ascending chronological order, which permits cross-referencing of each peak with corresponding data in the accompanying table.

Each of the 46 HRWEs contained in the 400,000-year Vostok temperature record is shown in the Table along with its time of onset, peak amplitude, duration, and mean warming rate. The 16 HRWEs shown in the Figure can be cross-referenced to the corresponding Table entries using the time of HRWE onset. The original Vostok temperature data are accessible to anyone with internet access, and can be downloaded free of charge from the World Paleoclimatology Data Center website operated by the National Oceanic and Atmospheric Administration of the U.S. (NOAA). The easiest and quickest way to confirm our results is to select any HRWE in the Table, locate the corresponding time in the published Vostok temperature record, and measure the subsequent warming event using the operational definition of NWEs we adopted. Cross-referencing the Figure with the Table provides such confirmation for the most recent 16 HRWEs.

**Table:** Compendium of all high-rate natural warming (HRWEs) events in the Vostok temperature record, in descending chronological order. A natural warming event (NWE) is defined here as a temperature increase of at least 0.38°C consisting of at least three consecutive increases in temperature followed by at least one decline in temperature from the peak reached.

Natural Warming Event # (HRWE)	Time of HRWE Onset (Years Before Present)	Amplitude of HRWE (°C)	Duration of HRWE (Years)	Warming Rate (°C/century)
1	234,984	4.99	573	0.871
2	131,506	2.60	256	1.016
3	129,486	3.09	162	1.907
4	126,851	1.33	102	1.304
5	122,064	0.96	113	0.850
6	119,221	0.89	120	0.742
7	118,796	1.46	120	1.217
8	103,205	1.17	132	0.886
9	102,942	1.22	130	0.938
10	102,117	0.89	65	1.369
11	98,712	1.24	140	0.886
12	97,439	1.11	145	0.766
13	94,164	1.72	138	1.246
14	93,615	1.17	147	0.796
15	92,897	1.14	138	0.826
16	90,128	1.99	155	1.284
17	87,482	1.37	140	0.979
18	82,352	2.31	139	1.662
19	81,381	1.16	141	0.823
20	80,173	2.72	153	1.778
21	79,557	1.17	155	0.755
22	78,437	2.97	160	1.856
23	74,651	2.18	167	1.305
24	71,905	1.32	162	0.815
25	45,315	1.47	176	0.835
26	44,800	1.29	166	0.777
27	43,619	1.26	155	0.813
28	28,420	1.33	173	0.769
29	24,363	1.52	177	0.859
30	12,323	1.41	179	0.788
31	12,087	0.90	114	0.789
32	10,315	1.82	97	1.88
33	9,782	1.36	147	0.93
34	9,396	1.08	144	0.75
35	8,811	1.15	95	1.21
36	8,226	2.93	91	3.22
37	6,823	1.65	146	1.13
38	6,385	1.87	98	1.91
39	6,004	1.18	95	1.24
40	4,880	1.39	94	1.48
41	3,778	1.28	132	0.97
42	3,511	1.13	89	1.27
43	3,289	0.76	88	0.86
44	2,980	1.99	133	1.50
45	2,760	1.95	90	2.17
46	2,585	1.66	84	1.98

We submitted these findings sequentially to *Science Magazine*, *Nature*, and *Nature Climate Change*. The editor of *Science Magazine* replied that the results were not of sufficient general interest, suggested we submit the work to a specialty journal, and declined to proceed with external scientific review. *Nature* also rejected the paper without external scientific review, for reasons that we considered spurious. *Nature Climate Change* initially rejected the paper, but after some discussion the paper was assigned to a senior editor and reviewed by two anonymous reviewers. Given the context of their comments, both reviewers appeared to be climate modelers.

The *Nature Climate Change* reviewers concluded that the natural warming cycles we identified in the Vostok record could not possibly be real or significant, but instead represented irrelevant statistical "noise" in the temperature record. We replied respectfully that the warming events we detected and measured are similar to or larger than many well-accepted temperature fluctuations in ice core records, including Dansgaard-Oeschger oscillations, Heinrich events, and Antarctic Temperature Maxima. Indeed, the Vostok HRWEs are similar to or larger than the present global warming signal. These arguments were ignored by the reviewers, however, and the paper was rejected by the chief editor of *Nature Climate Change*.

As written in our rejected paper two years ago, if the current global warming event has the same underlying cause as the 342 previous similar NWEs spread over the preceding 250,000 years--and we can think of no obvious scientific reason to think otherwise--then based on the statistical properties of all natural warming events in the Vostok record, the current global warming event will reverse by 2032 with 68% probability and by 2105 with 95% probability. If the current warming event is homologous with a HRWE, climate reversal and global cooling are already overdue. Here is how we put it in our rejected paper.

*"...the estimated rate of contemporary global warming (0.74°C/century)<sup>2</sup> lies well within the range of temperature increases exemplified by NWEs in the Vostok paleoclimate record. More than 13% of Vostok NWEs exceeded this estimated contemporary warming rate. The mean warming rate over all Vostok HRWEs ( $\bar{x}$  = 1.195°C/century, Table) exceeded the estimated contemporary global warming signal<sup>2</sup> by nearly two-thirds (61.5%), while the highest rate of natural warming (3.22°C/century; 8,226 to 8,135 YBP) exceeded the rate of the current warming signal by 435%. Most of the Vostok HRWEs occurred during recent warm periods when temperature was similar to the contemporary global temperature. Therefore, the properties of the contemporary global warming signal<sup>2</sup> are consistent with a natural climate variation homologous to the Vostok HRWEs. In this case, and assuming that the contemporary period of global warming began in 1815<sup>30</sup>, global temperature is projected with 68.2% confidence to peak and begin declining toward pre-industrial levels by 2032 (1,815 years + mean HRWE duration of 144 years + 1 s of 73 years, Table; confidence limit associated with 1 s), and is projected with 95.4% confidence to peak and begin to decline by 2105 (1,815 + mean HRWE duration + 2 s, Table; confidence limit associated with 2 s)." [reference 2 is to the IPCC's Fourth Assessment Report, while reference 30 is to the NOAA website.]*

In the middle of the editorial review by *Nature Climate Change*, the senior editor in charge of our paper abruptly and inexplicably ceased working for the journal. We were notified of this change by an automated "no longer working here" response to a routine e-mail from us. We were advised later that responsibility for our paper had been transferred to the Chief Editor of *Nature Climate Change*, who issued the final rejection. A few weeks later, the climate journalist Christopher Booker wrote an opinion piece in the *Sunday Times* of London to the effect that *Nature* magazine continues to reject scientific findings if they contradict the prevailing anthropogenic global warming hypothesis. We have no way of knowing whether or how the departure of the *Nature Climate Change* editor or the *Sunday Times* article was related to the rejection of our paper.

We hasten to disclose that the central thrust of our paper dealt with climate (temperature) sensitivity to atmospheric carbon dioxide, and not with natural warming cycles, which we used simply as a tool to explore climate sensitivity. We developed a new method for analyzing climate (temperature) sensitivity to atmospheric carbon dioxide based on analysis of NWEs and their responses to naturally-varying atmospheric carbon dioxide levels, and found that the climate (temperature) sensitivity to atmospheric carbon dioxide is far less than currently-accepted estimates. The *Nature Climate Change* reviewers rejected this conclusion for the same reason as above, however, namely their assertion that the NWEs we identified are irrelevant climate "noise."

It is encouraging that in light the Mulvaney et al. paper the editors and reviewers of the Nature Publishing Group apparently no longer consider these natural warming events in ice core records as irrelevant climate "noise." Among other implications, this change in editorial interpretation and practice opens a new avenue for analysis of ice core data and a new method for demonstrating that in historic terms, the current global warming cycle is far from exceptional. It appears to us that the current global warming signal lies well within natural limits. In this case, it seems to us difficult to argue that the current global warming signal is the result of human activity.

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