

III. Climate Reconstructions from Proxy Data

AIT: "...the so-called global warming skeptics often say that global warming is really an illusion reflecting nature's cyclical fluctuations." (*AIT*, p. 64)

Comment: Some so-called skeptics doubt that the current warming is entirely or mainly driven by rising CO₂ levels. That does not mean they view global warming as an "illusion."¹

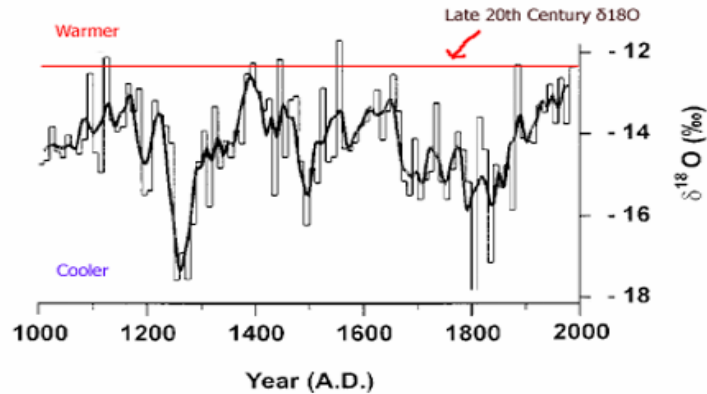
AIT: "To support their view, they [the skeptics] frequently refer to the Medieval Warm Period. But as Dr. [Lonnie] Thompson's thermometer [analysis of the ratio of oxygen-16 to oxygen-18 in ice cores] shows, the vaunted Medieval Warm Period (the little red blip from the left, below) was tiny compared to the enormous increase in temperatures of the last half-century (the red peaks at the far right of the chart)." (*AIT*, p. 64)

Comment: Thompson analyzed the isotopic oxygen ratios in three Andean and three Tibetan ice cores. The graph Gore presents on page 63—and again on pages 64-65—appears in Thompson's study, but it is not the graph of Thompson's composite ice core data. Rather, Gore's graph (Figure 7d of Thompson's paper) is the Hockey Stick reconstruction of Northern Hemisphere climate history (about which, more presently), which Thompson included for purposes of comparison.²

More importantly, contrary to Gore's assertion, Thompson's study does not prove that the Medieval Warm Period was "tiny" compared to the late 20th century warming.

To begin with, not all scientists accept Gore's characterization of Thompson's "thermometer" as "highly accurate." Ramirez et al. (2003) argue that, "in low latitudes empirical evidence linking temperature and the stable water isotopes in modern precipitation breaks down and instead, precipitation amount dominates the signal."³ In other words, isotopic oxygen records from the tropical Andes may chiefly reflect changes in precipitation rather than changes in temperature.⁴

Even if Thompson's "thermometer" is accurate, the conclusion that Gore draws from it is questionable. Of the three Tibetan ice cores Thompson examined, the Dunde and Guliya sites actually depict several decadal periods of the past that were as warm as or warmer than the last few decades of the 20th century. See the Figure below on the Guliya ice core.⁵



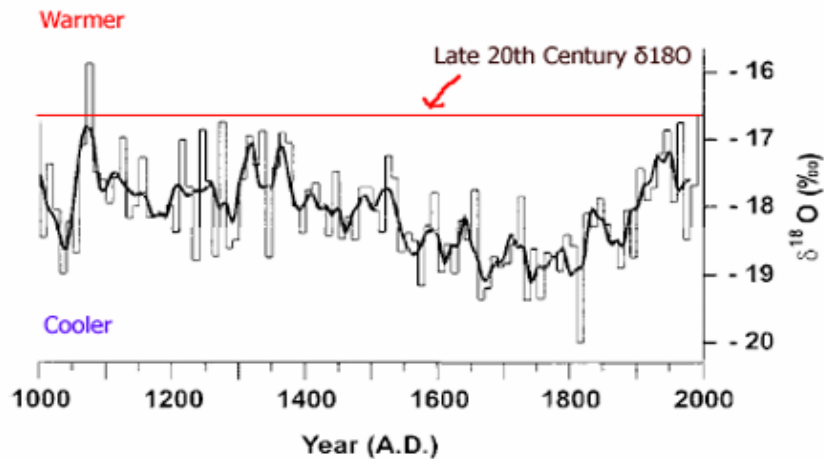
Decadally-averaged $\delta^{18}\text{O}$ records from the Guliya ice core over the past millennium. The darker, smooth curve is a 3-decade running mean. Adapted from Thompson et al.

Guliya ice core

Source: Center for the Study of Carbon Dioxide

Because the Dasuopo site shows a much more dramatic difference in the opposite direction, it rules the average result. This is the correct way to average, but averaging would not be necessary if a reliable reconstruction could be derived from a single site. Without many additional observations, it is impossible to know whether Thompson's average is truly representative or is skewed by a single dataset.

Similarly, of the three Andean ice cores Thompson examined, the Quelccaya and Sajema sites show greater warming in past centuries than in the 20th century. See the Figure below on the Quelccaya ice core.



Decadally-averaged $\delta^{18}\text{O}$ records from the Quelccaya ice core over the past millennium. The darker, smooth curve is a 3-decade running mean. Adapted from Thompson et al.

Quelccaya ice core

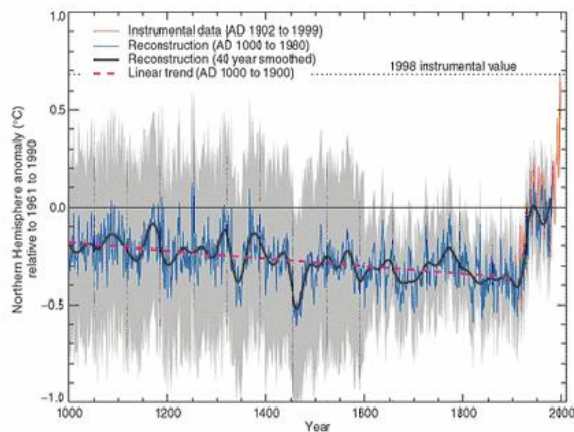
Source: Center for the Study of Carbon Dioxide

In short, only two of Thompson's six sites show recent temperatures to be greater than earlier temperatures.

Developing an accurate temperature history of past millennia requires many results from all around the world using many types of proxy data. Numerous records indicate that the Medieval Warm Period and the earlier Roman Warm Period were as warm as or warmer than the current warm period. The Center for the Study of Carbon Dioxide and Global Change has reviewed literally scores of such studies. A survey conducted by Sallie Baliunas and Willie Soon of the Harvard-Smithsonian Center for Astrophysics found 79 studies in which proxy data from various locations “show periods of at least 50 years [during the past millennium] which were warmer than any 50 years period of the 20th century.”⁶ As noted earlier, a 2006 study by Polissar and colleagues indicates that the Andes region was warmer during the Medieval Warm Period than it is today. Bao et al. (2003), analyzing isotopic oxygen ratios and other proxy data, found that each part of the Tibetan Plateau (northeastern, southern, and western) had at least one 50-year period during the last 2000 years when the mean temperature was warmer than it was during the last 50 years.⁷

AIT: “Those global warming skeptics...launched a fierce attack against another measurement of the 1,000-year correlation between CO₂ and temperature known as “the hockey stick,” a graphic image representing the research of climate scientist Michael Mann and his colleagues [Raymond Bradley and Malcolm Hughes]. But in fact, scientists have confirmed the same basic conclusions in multiple ways—with Thompson’s ice core record as one of the most definitive.” (AIT, p. 65)

Comment: The “fierce attack”—actually nothing more than due diligence to check Mann’s data and methods—was entirely appropriate. In its *Third Assessment Report* (2001), the IPCC presented the hockey stick in the Summary for Policymakers, the Technical Summary, twice in Chapter 2 (“Observed Climate Variability and Change”), and again in the *Synthesis Report*. The hockey stick was the basis for the IPCC’s claim (Summary for Policymakers, p. 3) that “the 1990s [likely] have been the warmest decade and 1998 the warmest year of the millennium.” Unsurprisingly, the hockey stick (see the Figure below) became an instant poster child for global warming alarmism and pro-Kyoto advocacy.



The Hockey Stick

Source: IPCC

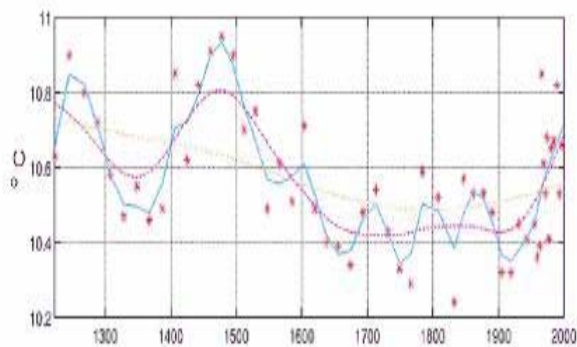
The hockey stick reconstruction depicted a relatively stable climate with a slight cooling trend from 1000 A.D. to 1900, and then a sharp upward spike in the 20th century. Two Canadians, Stephen McIntyre and Ross McKittrick (M&M), published two critiques of the hockey stick in *Energy & Environment* in 2003 and a third critique in *Geophysical Research Letters* in 2005.⁸ Among other weaknesses, M&M found that Mann, Bradley, and Hughes (MBH) “de-centered” their proxy data, picking a mean that inflates the importance of data generating hockey stick shapes.⁹

At the request of the House Energy and Commerce Committee, Dr. Edward J. Wegman of George Mason University’s Center for Computational Statistics assembled a team of statisticians to assess M&M’s critique of MBH’s data and methods.¹⁰ The Wegman team found that:

- “The net effect of this decentering using the proxy data in MBH98 and MBH99 is to produce a hockey stick shape.”
- “In general, we found the writings of MBH98 and MBH99 to be somewhat obscure and incomplete and the criticisms of M&M03/03a/05a to be valid.”
- “Overall, our committee believes that the MBH99 assessment that the decade of the 1990s was likely the hottest decade of the millennium and 1998 was likely the hottest year of the millennium cannot be supported by their analysis.”

Gore suggests that MBH’s analytic shortcomings do not matter, because other scientists have confirmed their results. But as M&M pointed out, and as Wegman confirmed, those other scientists often work with Mann, and tend to use the same datasets. Because of these connections and shared proxies, the other studies might not be as independent as they appear to be.

Far from being settled that the Medieval Warm Period was tiny compared to the current warming, a recent reconstruction of Northern Hemisphere climate history shows a pronounced Little Ice Age preceded by a Medieval Warm Period that is warmer than the present.¹¹ See the Figure below.



Reconstruction of Northern Hemisphere temperature history from diatoms (plankton sediments)

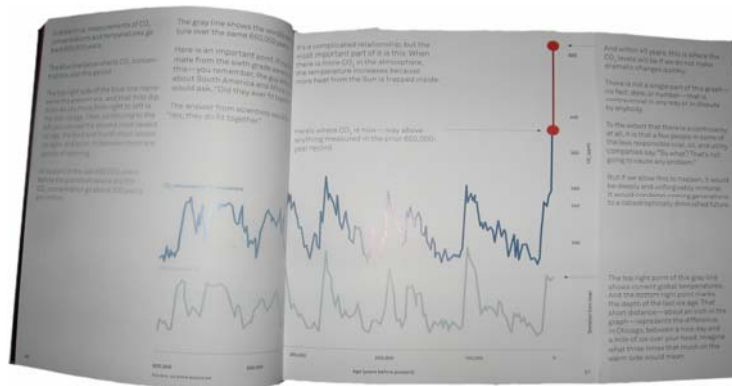
Source: Weckström et al. (2006)

AIT: “At no point in the last 650,000 years before the pre-industrial era did the CO₂ concentration go above 300 parts per million...CO₂ is now [380 ppm]—way above anything measured in the prior 650,000-year record.” (AIT, p. 66)

Comment: Both claims—that CO₂ concentrations “never” rose above 300 ppm in pre-industrial times, and that the current level is “way above anything” measured in the prior 650,000-year record—are questionable. Wagner et al. (1999), analyzing the stomatal frequency of birch tree leaves buried in peat deposits near Denekamp, in the Netherlands, estimate that CO₂ levels during the early Holocene exceeded 330 ppm for centuries, rising as high as 348 ppm—roughly the CO₂ level for 1987.¹² The Center for Carbon Dioxide and Global Change summarizes the Wagner team’s research:

Atmospheric CO₂ concentrations 10,000 years ago were determined to be between 260 and 265 ppm. Thereafter, they rose to a value near 330 ppm over the course of a century. Concentrations remained in the 330 ppm range over the next 300 years, whereupon they declined to about 300 ppm. A second sharp increase in atmospheric CO₂ concentration to a maximum value of 348 ppm followed, with concentrations hovering between 333 and 347 ppm for the duration of the record.

AIT: “It’s a complicated relationship,” writes Gore, referring to a two-page graph showing CO₂ levels rising and falling along with global temperatures during the past 650,000 years, “but the most important part of it is this: When there is more CO₂ in the atmosphere, the temperature increases because more heat from the Sun is trapped inside.” (AIT, p. 67)



AIT's graph of CO₂ levels and global temperatures over the past 650,000 years

Comment: The foregoing statement is carefully parsed. Gore does not actually say that changes in CO₂ levels caused the alternation between ice ages and warm interglacial periods, but he allows or even encourages readers (or viewers) to draw that conclusion. In reality, global temperature changes preceded changes in CO₂ levels by hundreds to thousands of years.¹³

The causality is very nearly the opposite of what Gore insinuates. When ocean temperatures fall, seawater retains more dissolved CO₂, and the expansion of polar sea ice further limits sea-to-air CO₂ flux. Conversely, when the oceans warm, more dissolved CO₂ outgases into the air.¹⁴ At most, changes in the air's CO₂ content had an amplificatory effect on climate changes already under way.¹⁵

Ironically, Gore's 650,000-year graph of CO₂ levels and global temperatures shows that each of the previous four interglacial periods was warmer than the one in which we are now living, even though CO₂ levels were lower. Gore makes no mention of this, but it is well established in the scientific literature.¹⁶ For example, during the peak of the last interglacial period, roughly 130,000 to 127,000 years ago, various proxy data indicate that summer surface temperatures in Arctic Canada and Greenland were 4-5°C warmer than the present, and large portions of Siberia were 4-8°C warmer.¹⁷ Multiple ice cores indicate that East Antarctica was 2.5°C-5°C warmer than the present.¹⁸

In short, Gore exaggerates CO₂'s importance in Earth's climate history. Over the past several hundred thousand years, changes in CO₂ levels were chiefly the effect rather than the cause of changes in global temperature, the Earth was warmer than it is today during previous interglacial periods when CO₂ levels were lower, and significant evidence indicates that the Medieval Warm Period was warmer than the current warm period.

¹ Wm. Robert Johnston, "Falsehoods in Gore's *An Inconvenient Truth*."

² I am grateful to Wm. Robert Johnston for bringing this information to my attention in a personal communication, September 3, 2006.

³ Ramirez, E., G. Hoffmann, J.D. Taupin, B. Francou, P. Ribstein, N. Caillon, F.A. Ferron, A. Landais, J.R. Petit, B. Pouyaud, U. Schotterer, J.C. Simoes, and M. Stievenard. 2003. A New Andean Deep Ice Core from Nevado Illimani (6,350 m), Bolivia. *Earth and Planetary Science Letters* 212: 337-50

⁴ For further discussion on Thompson's use of the isotopic oxygen "thermometer," see Steve McIntyre's blog, <http://www.climateaudit.org/?p=739>.

⁵ The Center for the Study of Carbon Dioxide and Global Change provides graphs of all six ice core reconstructions, see Medieval Warm Period Records of the Week from Vol. 9, No. 25, 21 June 2006, http://www.co2science.org/scripts/CO2ScienceB2C/issues/v9/v9n25_co2science.jsp.

⁶ Sallie Baliunas and Willie Soon, *Lessons & Limits of Climate History: Was the 20th Century Unusual?* George C. Marshall Institute, 2003, p. 13, <http://www.marshall.org/pdf/materials/136.pdf>.

⁷ Reviewed by the Center for the Study of Carbon Dioxide and Global Change, "A 2000-Year Record of a Second 'Big Chunk' of China," 26 November 2003, <http://www.co2science.org/scripts/CO2ScienceB2C/articles/V6/N48/EDIT.jsp>.

⁸ These papers and much other fascinating commentary and debate on the hockey stick are available at Stephen McIntire's Web site, www.climateaudit.org.

⁹ For a non-technical explanation, see Ross McKittrick, "What Is the Hockey Stick Debate About?" Paper presented to the Australian APEC Study Group, April 4, 2005, <http://www.uoguelph.ca/~rmckitri/research/McKittrick-hockeystick.pdf>.

¹⁰ Testimony of Edward J. Wegman, "Questions Surrounding the 'Hockey Stick' Temperature Reconstruction: Implications for Climate Change Assessments," House Energy and Commerce Subcommittee on Oversight and Investigations, July 20, 2006, <http://energycommerce.house.gov/108/Hearings/07192006hearing1987/Wegman3108.htm>.

¹¹ Weckström, J., A. Korhola, P. Erästö, and L. Holmström. 2006. Temperature patterns over the past eight centuries in Northern Fennoscandia inferred from sedimentary diatoms. *Quaternary Research*, **66**, 78–86.

¹² Wagner, F., S.J.P. Bohncke, D.L. Dilcher, W.M. Kurschner, B. van Geel, and H. Visscher. 1999. Century-scale shifts in early Holocene atmospheric CO₂ concentration. *Science* 284: 1971–1973, reviewed by the Center for the Study of Carbon Dioxide and Global Change, <http://www.co2science.org/scripts/CO2ScienceB2C/articles/V2/N16/C2.jsp>.

¹³ H. Fischer, M. Wahlen, J. Smith, D. Mastroianni, and B. Deck, "Ice Core Records of Atmospheric CO₂ around the Last Three Glacial Terminations," *Science* 283 (1999): 1712–14, reviewed by the Center for the Study of Carbon Dioxide and Global Change, <http://www.co2science.org/scripts/CO2ScienceB2C/articles/V2/N8/C3.jsp>.

¹⁴ B. B. Stephens and R. F. Keeling, "The Influence of Antarctic Sea Ice on Glacial-Interglacial CO₂ Variations." *Nature* 404 (2000): 171–74, reviewed by the Center for the Study of Carbon Dioxide and Global Change, <http://www.co2science.org/scripts/CO2ScienceB2C/articles/V3/N7/C1.jsp>.

¹⁵ Center for the Study of Carbon Dioxide and Global Change, "Ice Core Studies Prove CO₂ Is Not the Powerful Climate Driver Climate Alarmists Make It Out to Be," 25 June 2003, <http://www.co2science.org/scripts/CO2ScienceB2C/articles/V6/N26/EDIT.jsp>.

¹⁶ Petit, J.R., J. Jouzel, D. Raynaud, N.I. Barkov, J.-M. Barnola, I. Basile, M. Bender, J. Chappellaz, M. Davis, G. Delaygue, M. Delmotte, V.M. Kotlyakov, M. Legrand, V.Y. Lipenkov, C. Lorius, L. Pepin, C. Ritz, E. Saltzman, and M. Stievenard. 1999. Climate and Atmospheric History of the Past 420,000 Years from the Vostok Ice Core, Antarctica. *Nature* 399: 429–36, reviewed by the Center for the Study of Carbon Dioxide and Global Change, <http://www.co2science.org/scripts/CO2ScienceB2C/articles/V2/N12/C1.jsp>.

¹⁷ Otto-Bliesner, B.L., S. J. Marshall, J.T. Overpeck, G.H. Miller, and A. Hu. 2006. Simulating Arctic Climate Warmth and Icefield Retreat in the Last Interglaciation. *Science* 311: 1751–53.

¹⁸ Overpeck, J.T., Otto-Bliesner, B.L., Miller, G.H., Muhs, D.R., Alley, R.B., Kiehl, J.T. 2006. Paleoclimate Evidence for Future Ice-Sheet Instability and Rapid Sea-Level Rise. *Science* 311: 1747–50.