Willie Soon and Sallie Baliunas (2003), "Was the 20th Century Climate Unusual?", George Marsall Institute, p.6-10: *As quoted in* **Donald Rapp (2008), Section 1.1.1,** ***Assessing Climate Change***

*[Phrases and sentences removed by Rapp are shown in **~~bold strileout~~**. Also, all footnotes and accompanying references were removed, and so these are also shown **~~in bold strikeout~~**.]*

Tree Rings (Rapp 1.1.1, p. 3-4; Soon & Baliunas, p. 6-7)

~~As Bradley points out,~~ tree growth, and hence the width and density of tree rings, depends on many factors, including the tree species and age, the availability of stored food in the tree and nutrients in the soil, the full range of climatic variables (sunshine, precipitation, temperature, wind speed, humidity); and their distribution throughout the year.**~~[15]~~**

Of these factors, precipitation is probably the most important, since low water availability will lead to low tree growth, even at high temperature. Research has shown that the density of the wood in individual tree rings is a better indicator of average temperature in the growing season than the width of the tree ring, and most recent proxy temperature studies use this approach.**~~[16]~~** **~~Also, most tree ring studies use multiple samples from each tree and a number of trees to minimize the effect of variations within and between trees.~~**

Once tree ring width and/or density data have been collected, they have to be calibrated against climate variables, typically temperature and precipitation. Temperature and precipitation effects can be separated only if more than one measure of tree growth is available. In the typical situation, both tree ring width and density might be available for 500 years, but data for temperature and precipitation might be available for only 100 years. For that 100 years, standard regression analysis techniques can be used to separate the effects of annual (or growing season) average temperature and precipitation on tree growth. The resulting information can be used to estimate annual (or growing season) average temperature and precipitation for the remaining 400 years.

While the approach described above seems simple and mechanical, it is neither. Several problems arise. First, for the same weather conditions, young trees grow faster than older trees. The effects of this early growth must be removed statistically. The statistical approaches used smooth the year-to-year variability due to weather from the growth record when the tree was young,**~~[17]~~** and even the true year-to-year variability of weather may be lost through the procedure. Next, average values from the multiple samples per tree and multiple trees in the study must be calculated. This can further decrease the size of year-to-year variability in the final results. Also, the steady rise of atmospheric carbon dioxide (CO2) concentration is a complicating factor in interpreting tree ring data. Plants grow better at higher CO2 concentration, and there is growing evidence that this has already begun to affect trees growing natural conditions.**~~[18]~~** Since CO2 concentration has been rising for the same period as weather data are available to calibrate tree ring data, a non-linear error of unknown size has been introduced. Finally, since few trees yield good data for many centuries, it is usually necessary to combine data from several trees to get a multi-century record. The statistical techniques used to combine data filter out the century-scale climate variability. The effect of all of these problems is to make tree growth studies highly suspect as a continuous recorder of temperature histories over many centuries or as long as a millennium.

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13. **Bradley, R.S. (1999):** *Paleoclimatology: Reconstructing Climates of the Quaternary.* International Geophysics Series, Vol. 64, Harcourt Academic Press, 610 pp.
15. *Ibid.*, Pg. 398-399. [*Refers to 13, not 14 which is an unrelated ref. to Huang on boreholes*]
16. For example, see Briffa, K. R., *et al.* (2001): "Low-frequency temperature variations from a northern tree ring density network." *Journal of Geophysical Research*, 106: 2929-2941.
17. Cook, E. R., *et al.* (1990): "Tree-ring standardization and growth-trend estimation." In *Methods of Dendrochronology: Applications in EnvironmentalSciences*, 104-123. **Cited in Bradley, R.S. (1999)**: *op. cit.* Pg. 408.
18. Jarvis, P.G. , ed. (1998): *European Forests and Climate Change: The LikelyImpacts of Rising* CO_2 *and Temperature.* Cambridge University Press.

Ice cores (Rapp 1.1.1.2 p. 5-6; Soon & Baliunas, p. 8)

The ice sheets that cover Antarctica, Greenland, the islands north of Canada and Russia, and the tops of some mountainous areas, represent the accumulation of as much as several hundred thousand years of snow fall. In very cold, dry areas, such as the interior of Greenland and Antarctica, the record is particularly good because there is little year-to-year evaporation or melt, and snow compresses into annual layers of ice. The thickness of these layers is an indication of the amount of precipitation that fell at that location during the year the layer was deposited, and the isotopic make-up of the water in the ice can provide a proxy for temperature. ~~**As discussed above, oxygen exists in three stable forms, 16O, 17O, and 18O. Hydrogen exists in two stable forms, 1H and 2H. 1H is designated H, while 2H is known as deuterium, and designated by the symbol D. Almost all water is H2 16O, but two heavier forms, HDO and H2 18O, are present in sufficient quantities to provide a basis for a proxy temperature record. Both the**~~ [H]eavier HDO and $H^{2}\,{}^{18}O$ molecules will condense more quickly than $H^{2}\,{}^{16}O$. The concentration of D and ${}^{18}O$ in the ice sample is a measure of the temperature at which the snow that formed that ice fell. As more precipitation falls, the water vapor in the atmosphere becomes depleted in D and ${}^{18}O$, so the last snow to fall will have a different D and ${}^{18}O$ concentration than the first snow that fell. In areas of heavy snowfall this can cause significant differences in proxy temperature estimates.[23]

Ocean sediments (Rapp 1.1.1.3 p. 6; Soon & Baliunas, p. 8)

Ocean sediments contain the skeletons of a variety of invertebrates. Variations in the ${}^{18}O$ content in their shells can be used to establish a proxy temperature record using many of the same techniques as are used for corals. There are, however, several additional complications. Corals grow at the ocean surface, but the invertebrates deposited in ocean sediments live at different depths in the oceans. Water temperature changes rapidly with depth in the first few hundred feet below the ocean surface, so the knowledge of the depth at which the invertebrate species lived is of critical importance. Also, not all families of invertebrates concentrate ${}^{18}O$ with the same efficiency, a fact that must be taken into account when calibrating ocean sediment proxy data.[22]

Corals (Rapp 1.1.1.6 p. 9; Soon & Baliunas, p. 7)

Coral reefs do not exhibit the finely defined layers trees do, but their growth varies with sea water temperature; the higher the sea water temperature, the more dense the coral. As is the case with tree rings, many other factors also affect the density of coral reefs. However, several attempts have been made to develop a proxy record from the growth layers in coral reefs..[19] A proxy temperature approach makes use of the fact that corals extract calcium carbonate (CaCO3) from sea water to form their reefs. In the atmosphere, oxygen exists in three stable isotopes.[20]: 99.76% is ${}^{16}O$, 0.04% is ${}^{17}O$, and 0.2% is as ${}^{18}O$, and these are the typical proportions that are also present in CaCO3 in sea water. The calcium carbonate that corals extract is slightly enriched in ${}^{18}O$ compared with sea water, with the degree of enrichment decreasing as temperature increases. However, the relationship between the amount of ${}^{18}O$ in corals and temperature is not simple because the amount of ${}^{18}O$ in sea water is not constant. Rainwater is depleted in ${}^{18}O$, so heavy rainfall will lower the concentration of ${}^{18}O$ at the surface of the ocean. Conversely, a long dry period, with high evaporation rates, can raise ${}^{18}O$ concentration at the ocean's surface. Despite these difficulties, several reconstructed temperature records have been developed based on 18O in coral reefs.[21]

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19. Bradley, R.S. (1999): *op. cit.*, Pg. 249.
20. *Ibid.*, Pg. 129.
21. *Ibid.*, Pg. 250-252.
22. *Ibid.*, Pg. 200.
23. *Ibid.*, Pg. 129.