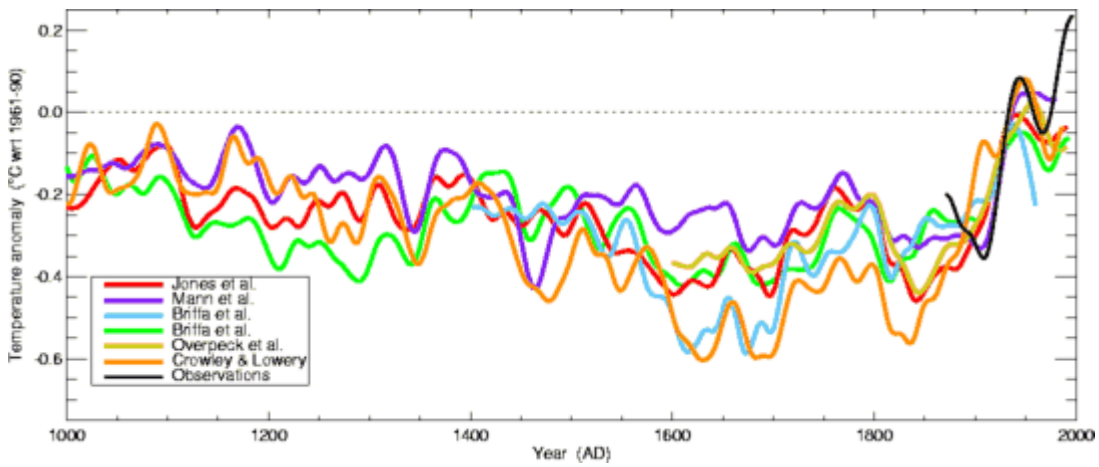
5: The Millennial Temperature Record

Phil Jones



(Also available as a PostScript file)

Considerable progress has been made in palaeoclimatology over the last twenty years. More information about the last millennium is now known from more locations and from more diverse proxies (trees, ice cores, corals, historical documents and some lacustrine and marine sediments). Much of this information provides annually resolved temperature evidence, principally for the growing season from many of the proxies.

Armed with all these series (most available from the National Geophysical Data Centre), groups in the UK and USA have begun producing spatial reconstructions of past temperatures and estimates of average temperatures for the Northern Hemisphere (NH). Figure 1 shows several of these series for the NH for the millennium. Evidence for the Southern Hemisphere is increasing also, but only about 5% of available proxy series come from this hemisphere.

How do these different compilations compare and what do they tell us? Agreement between the compilations is good, but much of the credit for this is because all contain many common series, so they can hardly be considered independent of each other. Methods of aggregation differ, some simply averaging some of the available series, others weighting the reconstructions according to their regressions with local temperatures.

The main feature of the series is the dramatic rise in temperatures during the 20th century, making it the warmest of the millennium. The 1990s are the warmest decade and 1998 the warmest year. Uncertainties are greater earlier in the millennium and we can only say that 1601 was *probably* the coldest year. The coolest centuries were the 17th and 19th with the former coldest over Europe and the latter coldest over North America. The first five centuries were warmer than the 16th to 19th but were clearer cooler than the 20th.

Reconstructions of this sort are important because proxy evidence provides our only means of estimating the levels of natural variability before meteorological instruments were used. Knowledge of this variability is vital in detection and attribution studies of recent climate change, which seek to explain the 20th century rise as a result of anthropogenic activities. Much of the record can be explained in terms of three mechanisms:

- changes in solar output
- changes in the number and severity of explosive volcanic eruptions
- changes in atmospheric composition as a result of human activities (increases in greenhouse gases and sulphate aerosols)

Natural forcing from the sun and volcanoes dominate the pre-1850 part of the record and only human activities appear to adequately explain the rise in temperature during the 20th century (Crowley, 2000). More work is required, however, to fully understand the variations in the series.

References and some other background material

- Bradley, R.S., 1999: *Paleoclimatology: reconstructing climates of the Quaternary*. Harcourt/Academic Press, San Diego, 610pp.
- Bradley, R.S. and Jones, P.D., 1993: 'Little Ice Age' summer temperature variations: their nature and relevance to recent global warming trends. *The Holocene* **3**, 367-376.
- Briffa, K.R.., 2000: Annual climate variability in the Holocene; interpreting the message of ancient trees. *Quaternary Science* **19**, 87-105.
- Crowley, T.J., 2000: Causes of climate change over the last 1000 years. *Science* (in press).
- Crowley, T. J. and Lowery, T., 2000: How warm was the Medieval Warm Period ? A comment on "Man-made versus Natural Climate Change". *Ambio* **39**, 51-54.
- Hughes, M.K. and Diaz, H.F., 1994: Was there a "Medieval Warm Period" and if so, where and when ? *Climatic Change* **26**, 109-142.
- Jones, P.D., Briffa, K.R., Barnett, T.P. and Tett, S.F.B., 1998: High-resolution palaeoclimatic records for the last millennium: interpretation, integration and comparison with General Circulation Model control run temperatures.*The Holocene* **8**, 455-471.
- Mann, M.E., Bradley, R.S. and Hughes, M.K., 1998: Global-scale temperature patterns and climate forcing over the past six centuries. *Nature* **392**, 779-787.
- Mann, M.E., Bradley, R.S. and Hughes, M.K., 1999: Northern Hemisphere temperatures during the past millennium: Inferences, uncertainties and limitations. *Geophys. Res. Letts*. **26**, 759-762.
- Overpeck, J., Hughen, K., Hardy, D., Bradley, R.S., Case, R., Douglas, M., Finney, B., Gajewski, K., Jacoby, G., Jennings, A., Lamoureux, S., Lasca, A., MacDonald, G., Moore, J., Retelle, M., Smith, S., Wolfe, A. and Zielinski, G., 1997: Arctic environmental change in the last four centuries. *Science* **278**, 1251-1256.

For further information on this subject please contact:
cru@uea.ac.uk