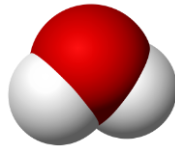


Are these GHG the **cause** of warming?

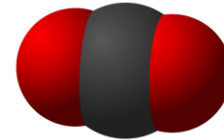
Are these GHG the **effect** of warming?

Are these GHG both the **cause *and* effect**?

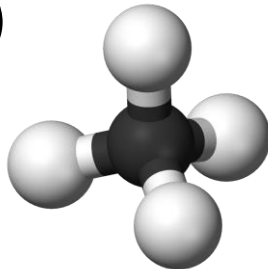
water vapor ( $\text{H}_2\text{O}$ )



carbon dioxide ( $\text{CO}_2$ )



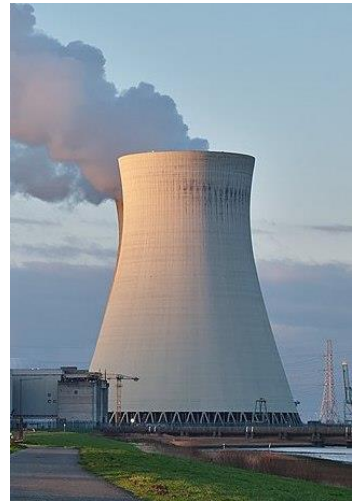
methane ( $\text{CH}_4$ )

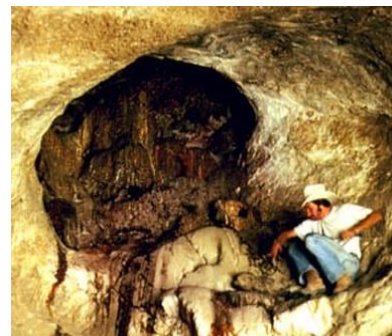








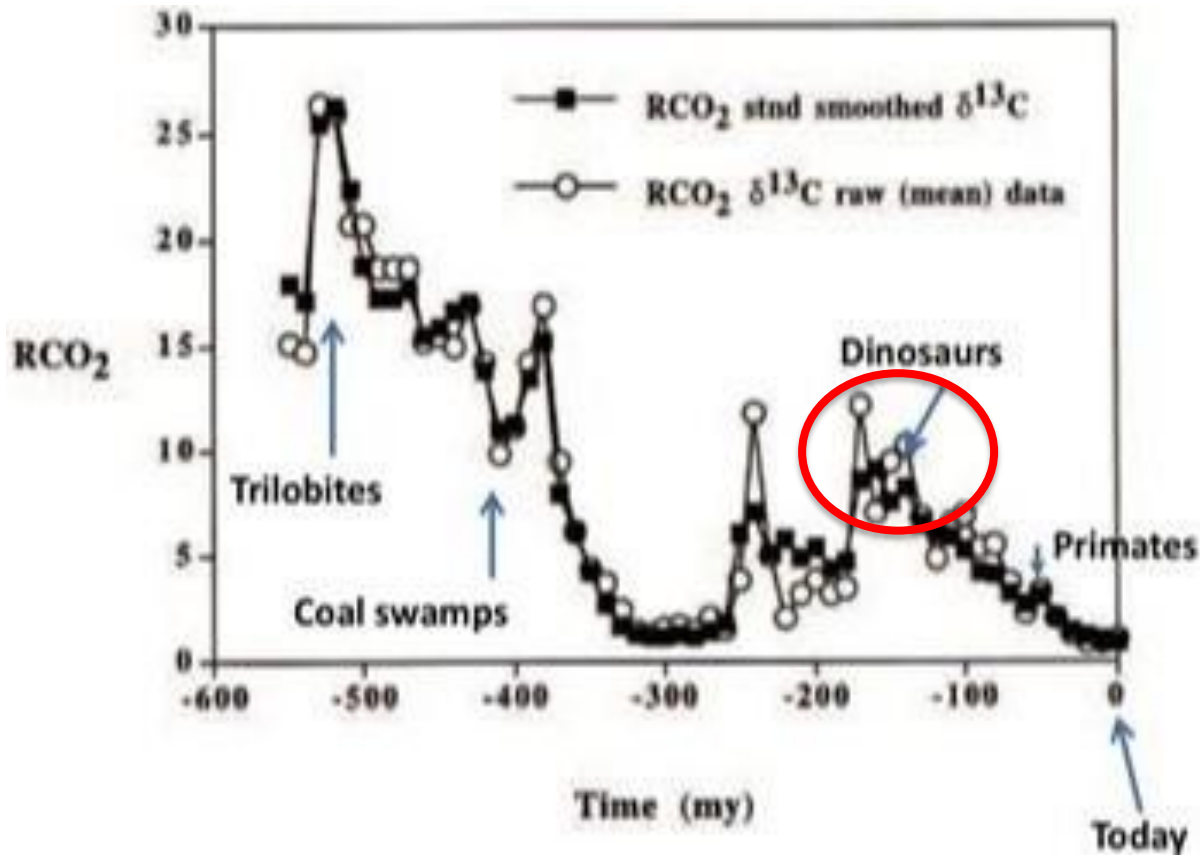




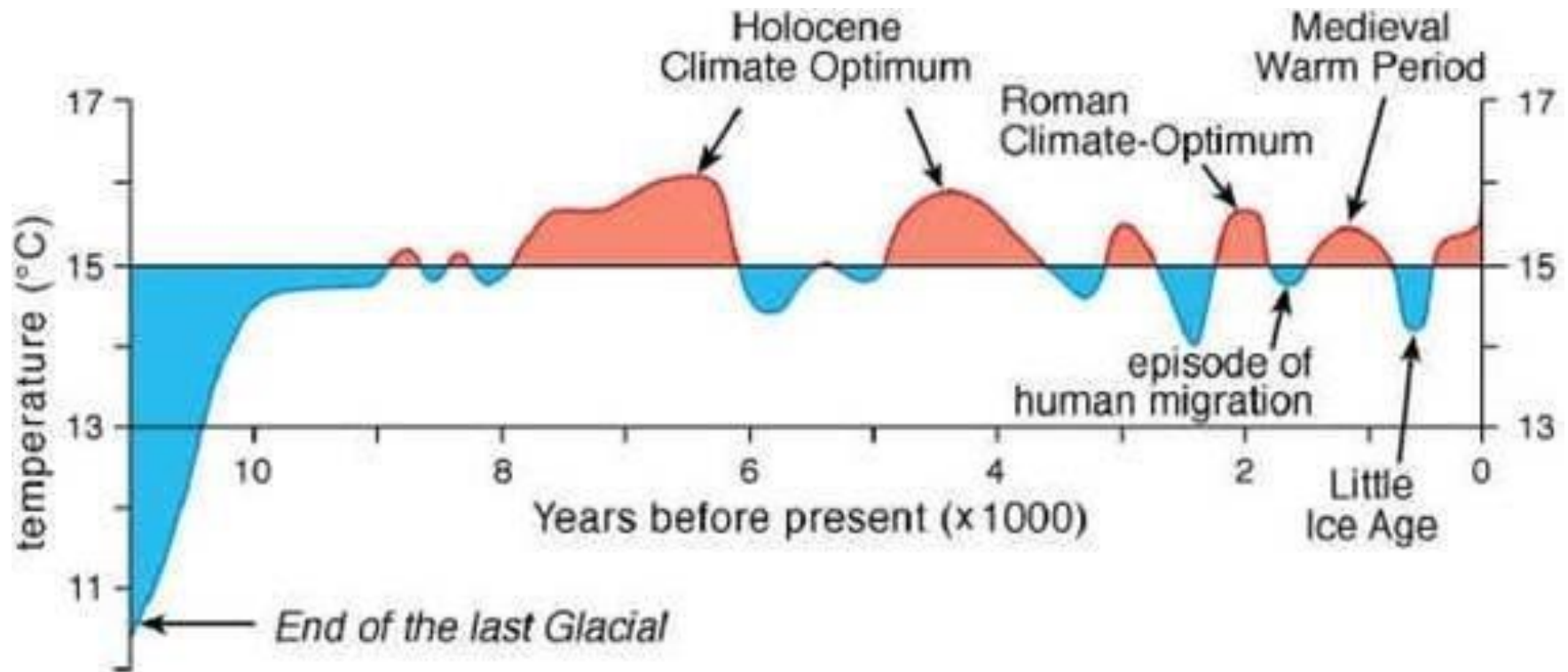


Nevertheless 150 million years ago, CO<sub>2</sub> levels may have far exceeded those of today

This is when dinosaurs roamed the land



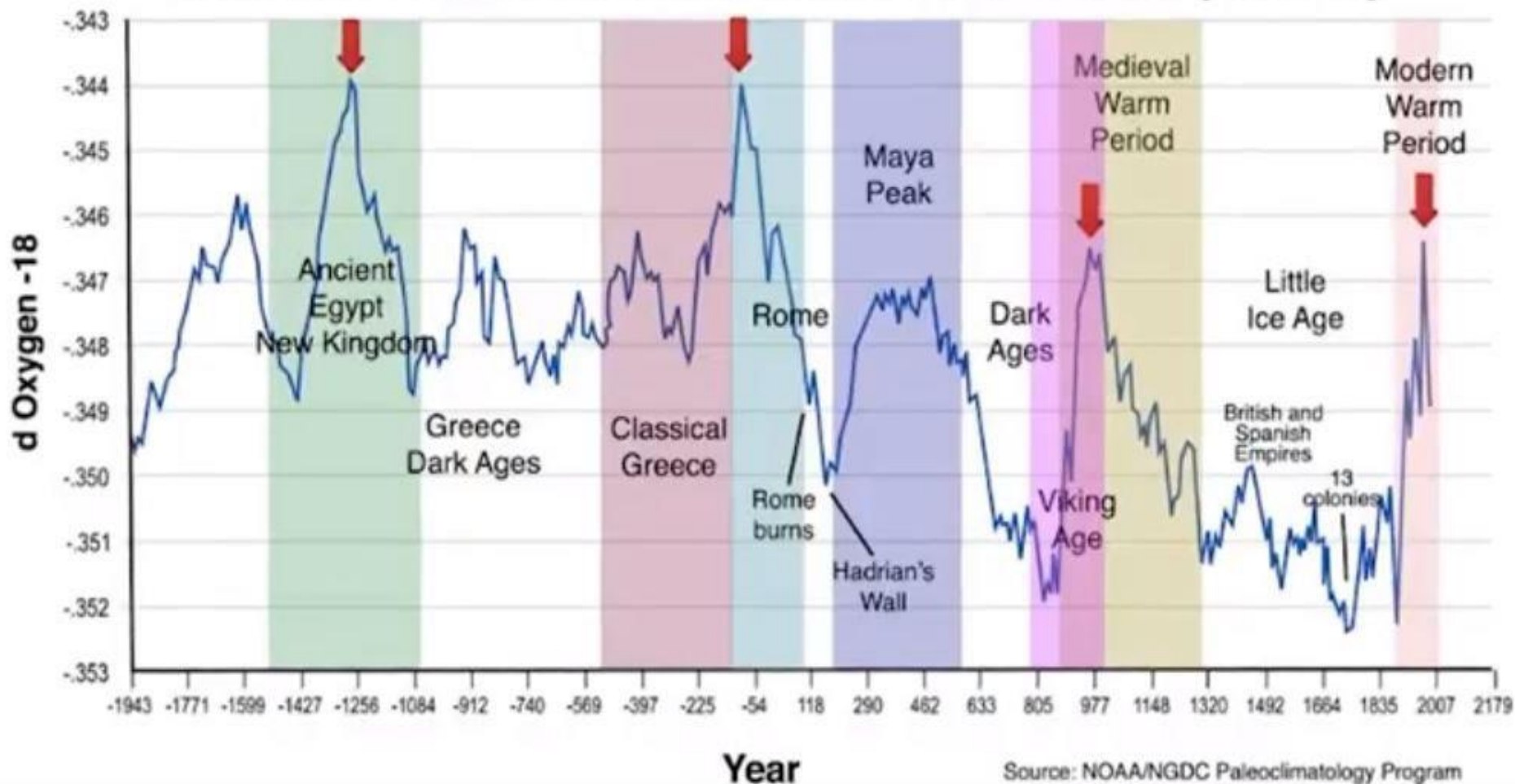
# Nevertheless, the Earth was slightly warmer during earlier periods of human history



*Average near-surface temperatures of the northern hemisphere during the past 11,000 years (after Dansgaard et al., 1969, and Schönwiese, 1995)*

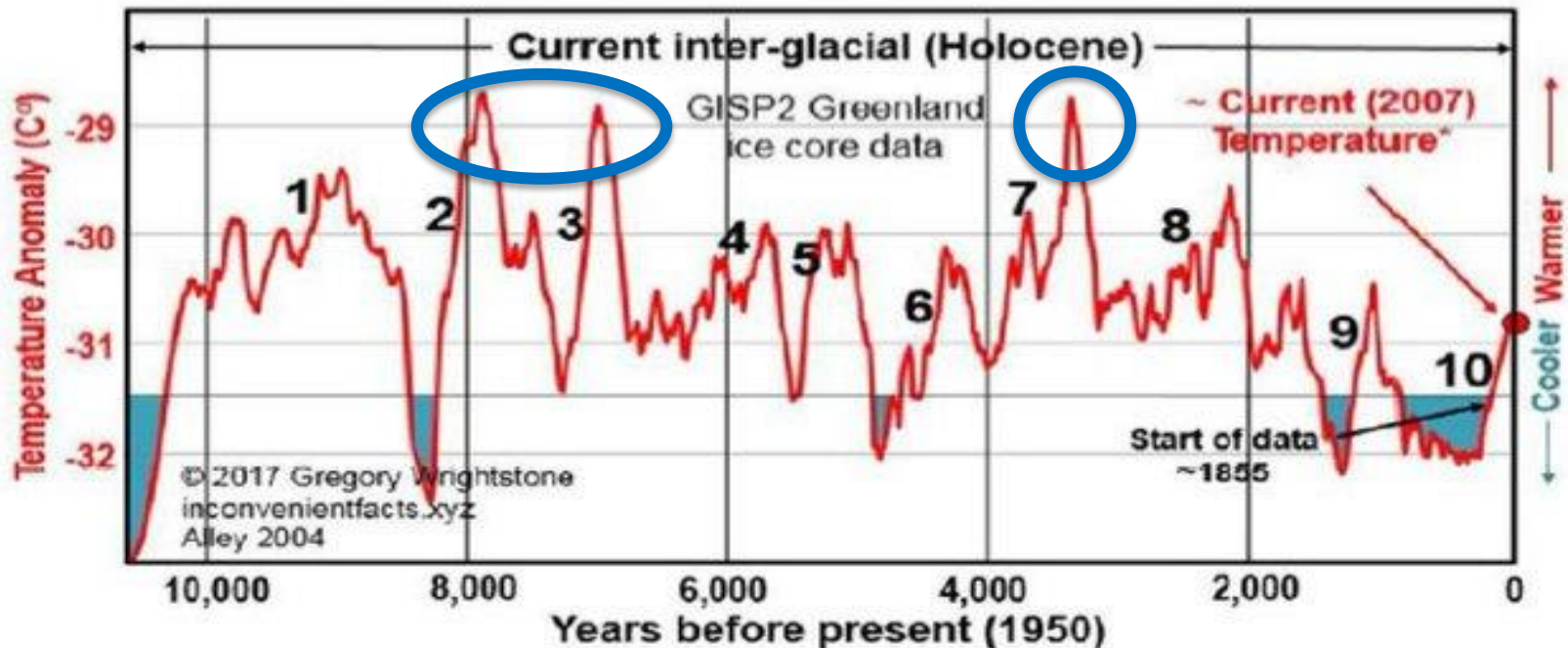
# Other measurements indicate that the Earth was even warmer during the Roman Empire

## Climate: Data from Greenland Ice Cores (GISP2)



# Some measurements indicate the Earth was much warmer during parts of the Stone Age ...and even during parts of the Bronze Age

**10,000 years and 9 warming periods remarkably similar to present-day warming (and all warmer)**



Alley, R.B., 2004. GISP2 Ice Core Temperature and Accumulation Data. IGBP PAGES/World Data Center for Paleoclimatology Data Contribution Series #2004-013. NOAA/NGDC Paleoclimatology Program, Boulder CO, USA.

\*Current Temp: Box JE, Yang L, Bromwich DH, Bai L (2009) Greenland Ice Sheet Surface Air Temperature Variability: 1840–2007\*. American Meteorological Society, Journal of Climate Vol 22, pp 4029 - 4049