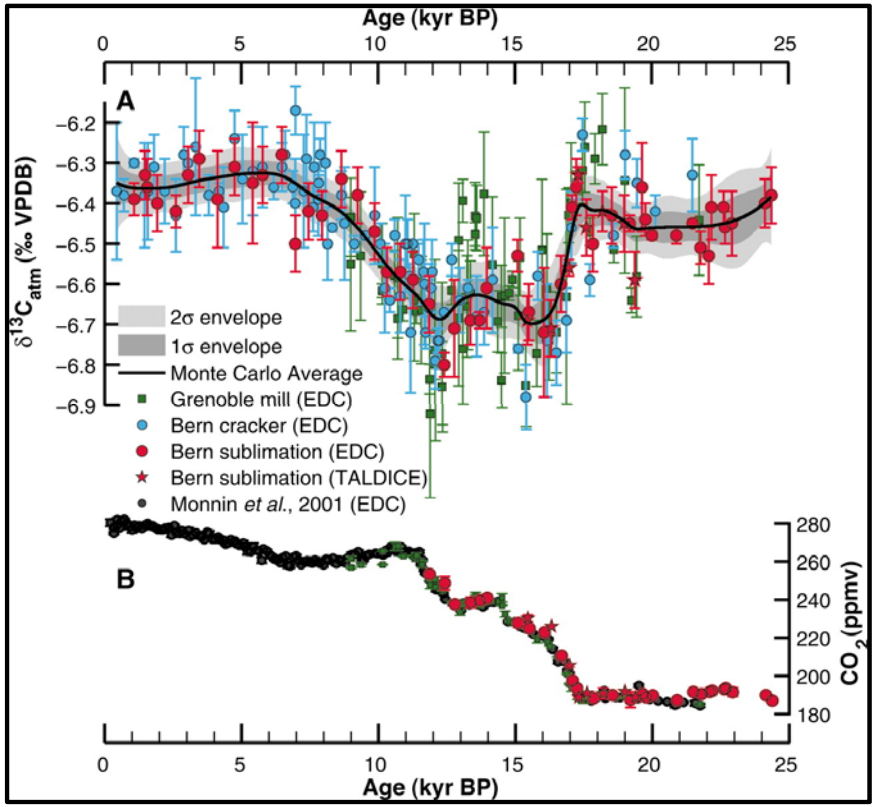
Proposed Effects of Early Agriculture on Current Climate

Elise Reed 570 Vincent Hall October 21st, 2014

The Early Anthropogenic Hypothesis

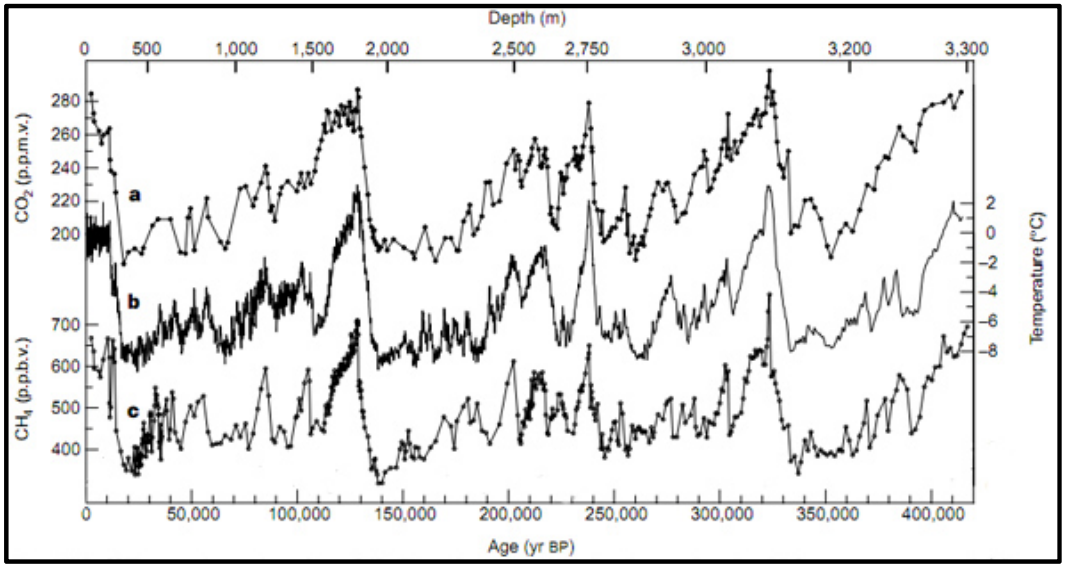
- Proposed by paleoclimatologist William Ruddiman in 2001
- Contends that the Anthropocene began about 8,000 years ago, not in the 1800s as is widely agreed upon
- Supported by the evidence of departure from regular Milankovitch cycle trends
- Also supported by the timeline of development of human agriculture



Schmitt, J., R. Schneider, J. Elsig, D. Leuenberger, A. Lourantou, J. Chappellaz, P. Kohler, F. Joos, T. F. Stocker, M. Leuenberger, and H. Fischer. "Carbon Isotope Constraints on the Deglacial CO2 Rise from Ice Cores." *Science* (2012): 711-14. Print.

Milankovitch Cycles and the Overdue Glaciation Hypothesis

- In past interglacial states, there was a never a late-deglacial CO_2 max
  - Holocene followed this trend up until 8,000 years ago, when we see an anomalous rise
- Most models agree that new glaciers would be forming by now, if human effects were ignored
  - 23,000 year cycle predicts max CO_2 ~10,000 years ago then decrease to present
  - 41,000 year cycle predicts CO_2 decrease starting ~3,500 years ago
  - 100,000 year cycle predicts CO_2 max ~13,500 years ago, with a following long-term decrease
- Ruddiman claims that this anomaly is caused by human activities

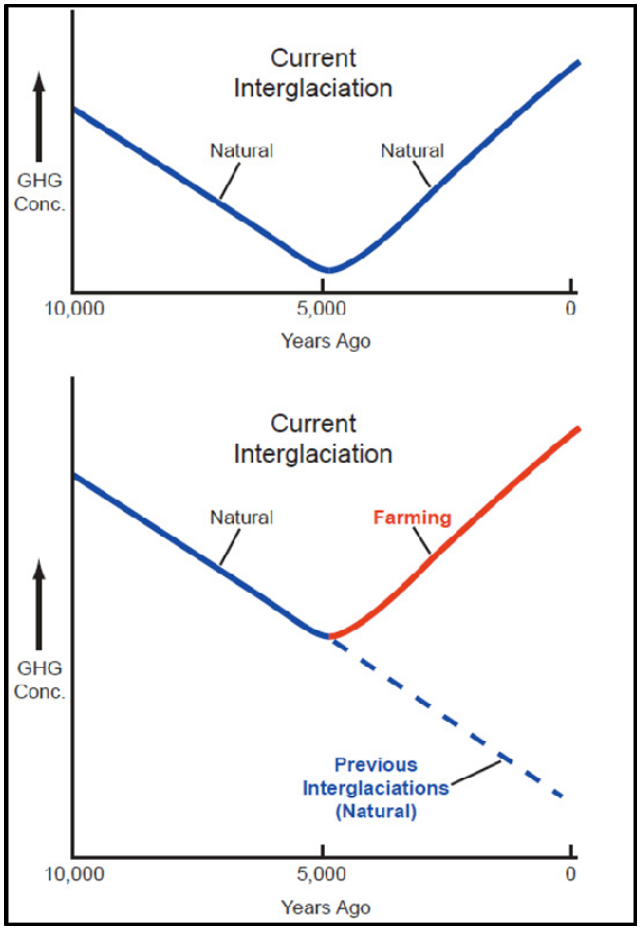


http://www.aip.org/history/climate/cycles.html

Causes of Deviation: Why do we think humans caused this cyclic anomaly?

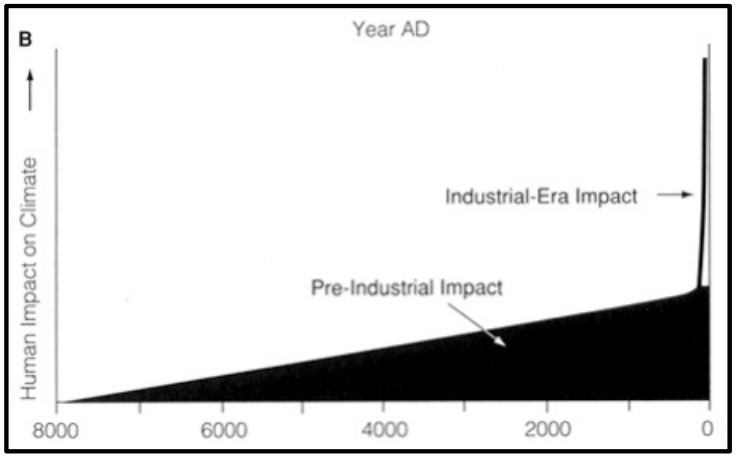
- Deforestation
  - Burning trees or hacking trees and leaving them to decay releases large amount of CO_2 from the terrestrial biosphere to the atmosphere
  - We would see an increase of CO_2 from the beginnings of agriculture (about 10,000 years ago) about 2,000 years later
    - We see this rise beginning at 8,000 years ago, as needed
- Primitive Agriculture
  - Beyond the deforestation that happened in order to start planting, the agriculture practiced during the Neolithic Revolution was extremely inefficient
    - Practices included flooding large areas as well as overworking soil, these effects are most obvious in methane proxy data

http://www.realclimate.org/index.php/archives/2011/04/



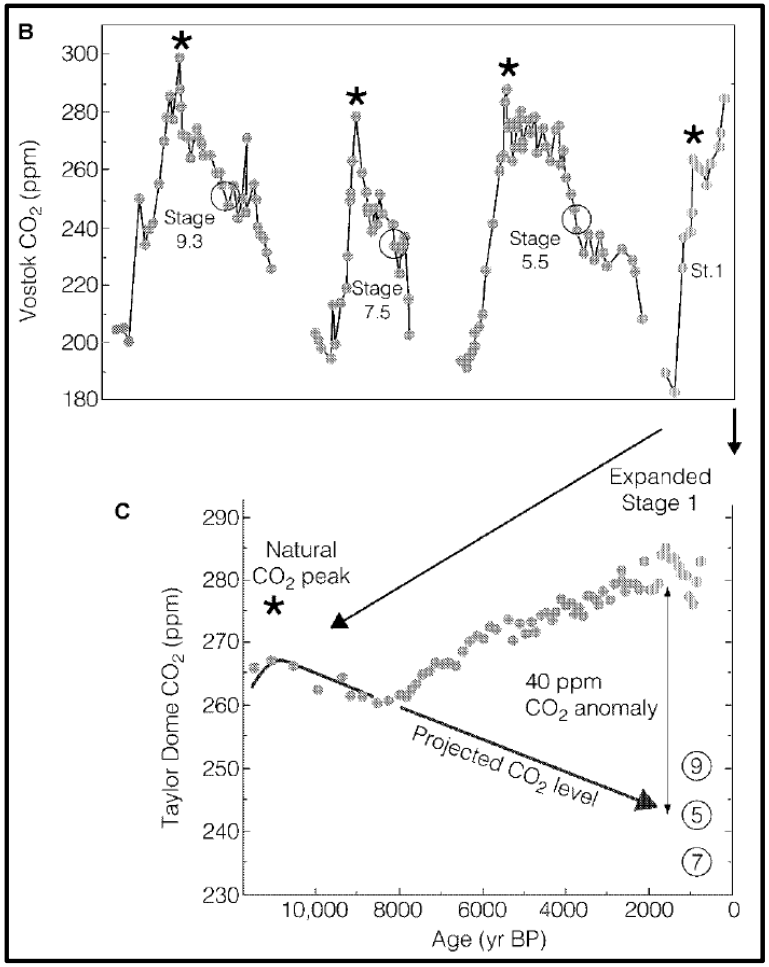
Full Effect of Holocene CO2 Anomaly

- Approximately 40 ppm
  25 ppm observed increase + 15 ppm expected decrease
- Industrial Era View
  200 years x 0.8 GtC/yr = 160 GtC total
- Pre-Idustrial “Tortoise” View
  7800 years x 0.04 GtC/yr = 320 GtC total



http://www.scienceagogo.com/forum/ubbthreads.php?ubb=showflat&Number=52779

http://www.webpages.uidaho.edu/envs501/GCCnews2010.html



Arguments against the Early Anthropocene

- There is not yet a way to prove that such relatively small groups of people at the times being considered could have had such a dramatic effect
- Natural Loss of Terrestrial Biomass
  - The best model of the land release/ocean uptake hypothesis would require a loss of ~200 GtC between 7,000-10,000 years ago
  - No model supports such a large natural loss
- Changes in Ocean Carbonate Ion Chemistry
  - 8,000 years ago, forests started expanding into newly ice-free area → forests extract CO_2 from ocean and atmosphere → ocean becomes less acidic → higher deposition of $CaCO_3$
    - When the forests stopped expanding, the deposits would have dissolved and cause the observed increase in CO_2
  - This hypothesis is weak because we would have seen this activity in past interglaciations

Other Effects of Human Activity

- Mass extinctions in Australia and Southeast Asia
  - Popular hypothesis assert that the mass extinctions of mammals occurring about 12,500 years ago were caused by climate change
    - Ruddiman believes that widespread extinctions over a wide variety of habitats points to a different explanation
  - Overkill Hypothesis: human hunting caused extinctions
  - Or, humans manipulating landscapes with fire and/or clearing of ground cover lead to maladaptation to habitat

Barriers to Determining Validity

- Proxy data such as, $\delta^{18}O$ and $\delta^{13}C$ values
  - Proxy data is affected by more variables than just the ones we are concerned with
  - Records are sparse, especially before 500 years ago
  - Most proxy data is regional, and regional trends often do not match global trends
- Population data is not accurate pre-modern times
- Hard to estimate full effects of deforestation and inefficient agriculture on carbon stores and isotopic signatures

Ruddiman, W.F. *Earth's Climate: Past and Future.* New York: W.H. Freeman, 2001. Print.

Ruddiman, William F. "The Anthropogenic Greenhouse Era Began thousands of Years Ago". *Climate Change.* 61.3(2003). 261-293. *Springer Link.* Web.