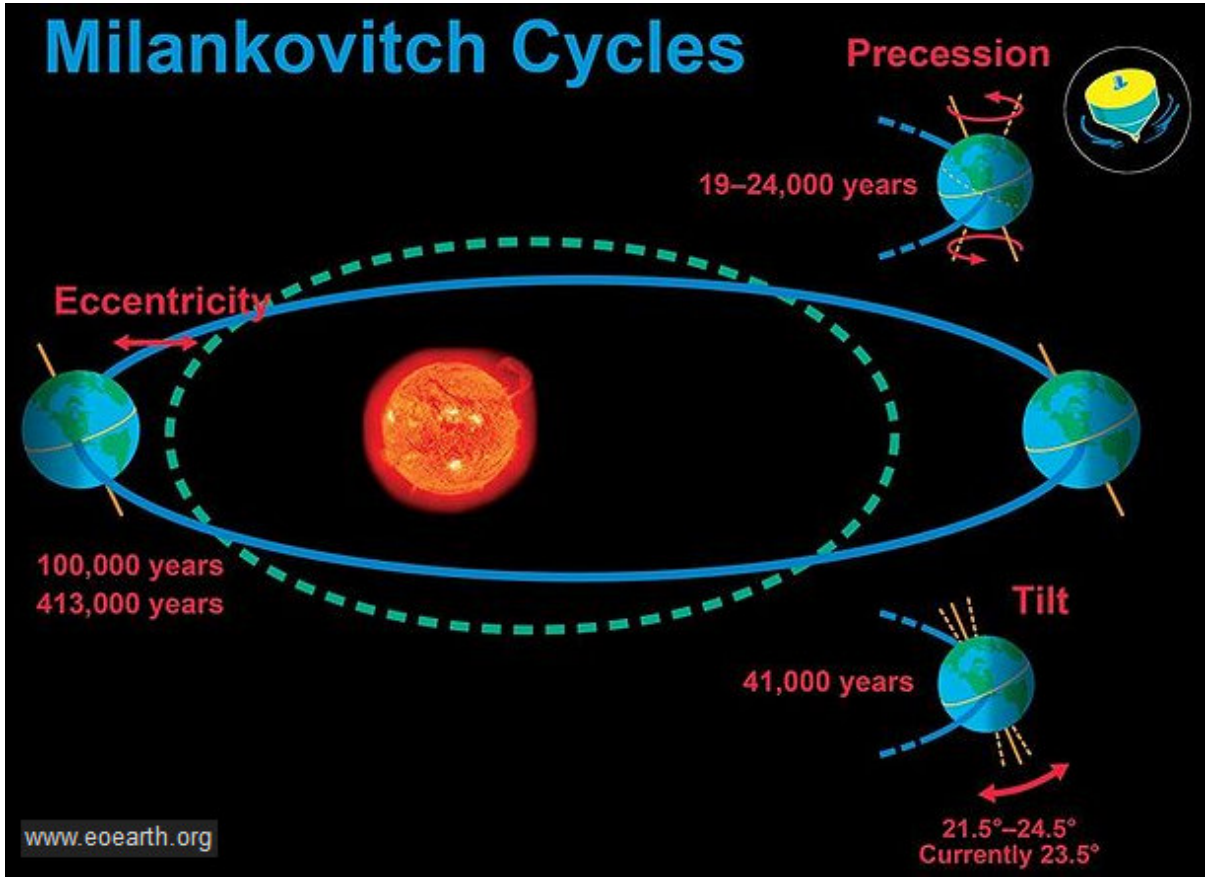
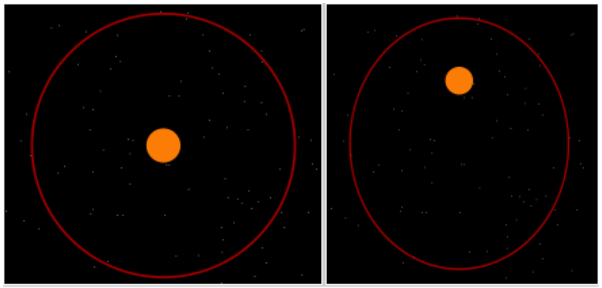
ORBITAL FORCING, CLIMATE CYCLES AND CHANGE



Sources: http://en.wikipedia.org/wiki/Milankovitch_cycles
http://commons.wikimedia.org/wiki/File:Phanerozoic_Climate_Change.png
Olsen, P.E., Kent, D.V., Cornet, Bruce, Witte, W.K., and Schlische, R.W., 1996, High-resolution stratigraphy of the Newark rift basin (early Mesozoic, eastern North America): Geological Society of America Bulletin, v. 108, no. 1, p. 40-77.

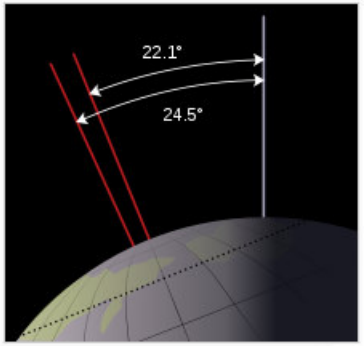
Milankavitch Theory

From Wikipedia, the free encyclopedia



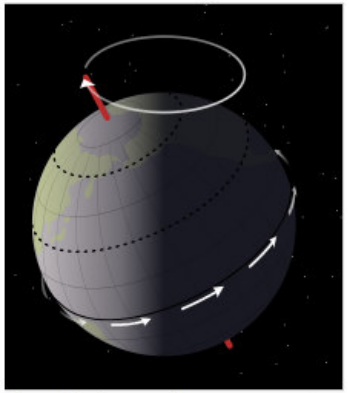
Circular orbit, no eccentricity. Orbit with 0.5 eccentricity.

Describes the collective effects of changes in the Earth's movements upon its climate, named after Serbian civil engineer and mathematician Milutin Milanković, who worked on it during First World War internment. Milanković mathematically theorized that variations in eccentricity, axial tilt, and precession of the Earth's orbit determined climatic patterns on Earth through orbital forcing.



22.1–24.5° range of Earth's obliquity.

The Earth's axis completes one full cycle of precession approximately every 26,000 years. At the same time the elliptical orbit rotates more slowly. The combined effect of the two precessions leads to a **21,000**-year period between the astronomical seasons and the orbit.



Precessional movement.

In addition, the angle between Earth's rotational axis and the normal to the plane of its orbit (obliquity) oscillates between 22.1 and 24.5 degrees on a **41,000**-year cycle. It is currently 23.44 degrees and decreasing.

Milankavitch Theory

From Wikipedia, the free encyclopedia

Orbital inclination - The inclination of Earth's orbit drifts up and down relative to its present orbit. Milankovitch did not study this three-dimensional movement. This movement is known as "precession of the ecliptic" or "planetary precession". More recent researchers noted this drift and that the orbit also moves relative to the orbits of the other planets. The invariable plane, the plane that represents the angular momentum of the solar system, is approximately the orbital plane of Jupiter. The inclination of Earth's orbit drifts up and down relative to its present orbit with a cycle having a period of about 70,000 years.

The inclination of the Earth's orbit has a **100,000** year cycle relative to the invariable plane. This is very similar to the 100,000 year eccentricity period. This 100,000-year cycle closely matches the 100,000-year pattern of ice ages.

The **400,000-year problem** is that the eccentricity variations have a strong 400,000-year cycle. That cycle is only clearly present in climate records older than the last million years. If the 100ka variations are having such a strong effect, the 400ka variations might also be expected to be apparent.

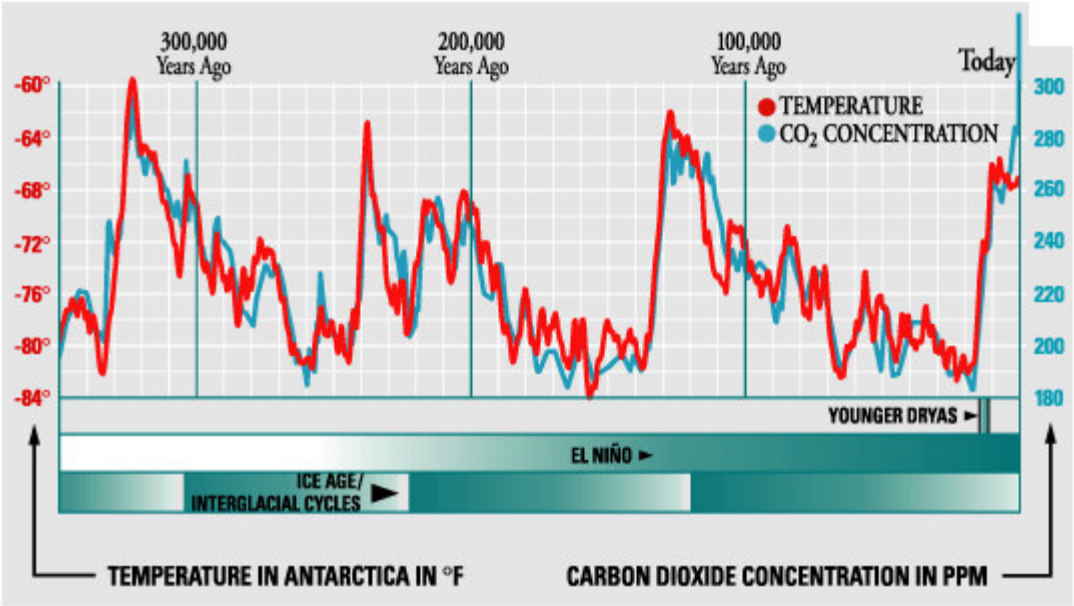
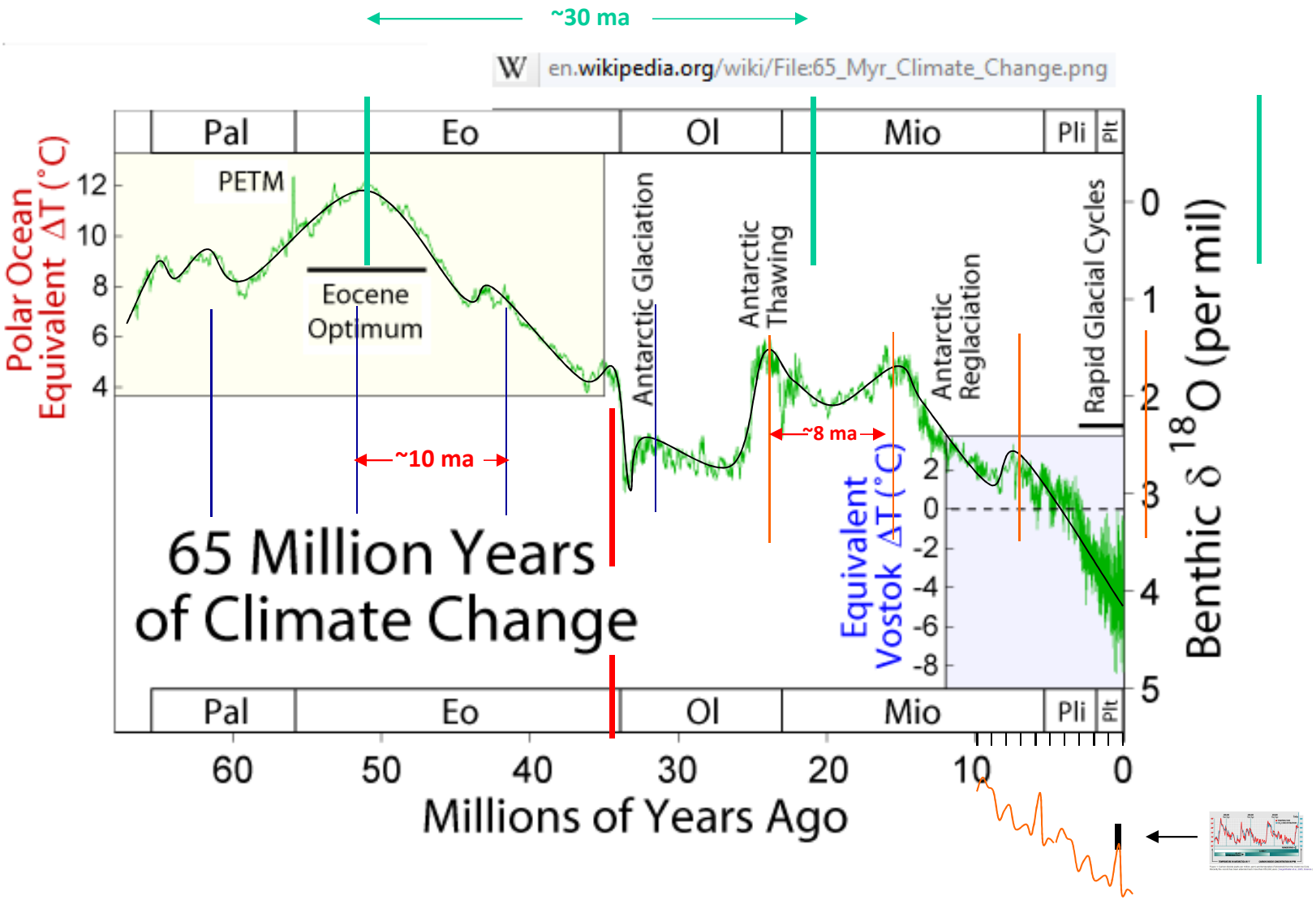
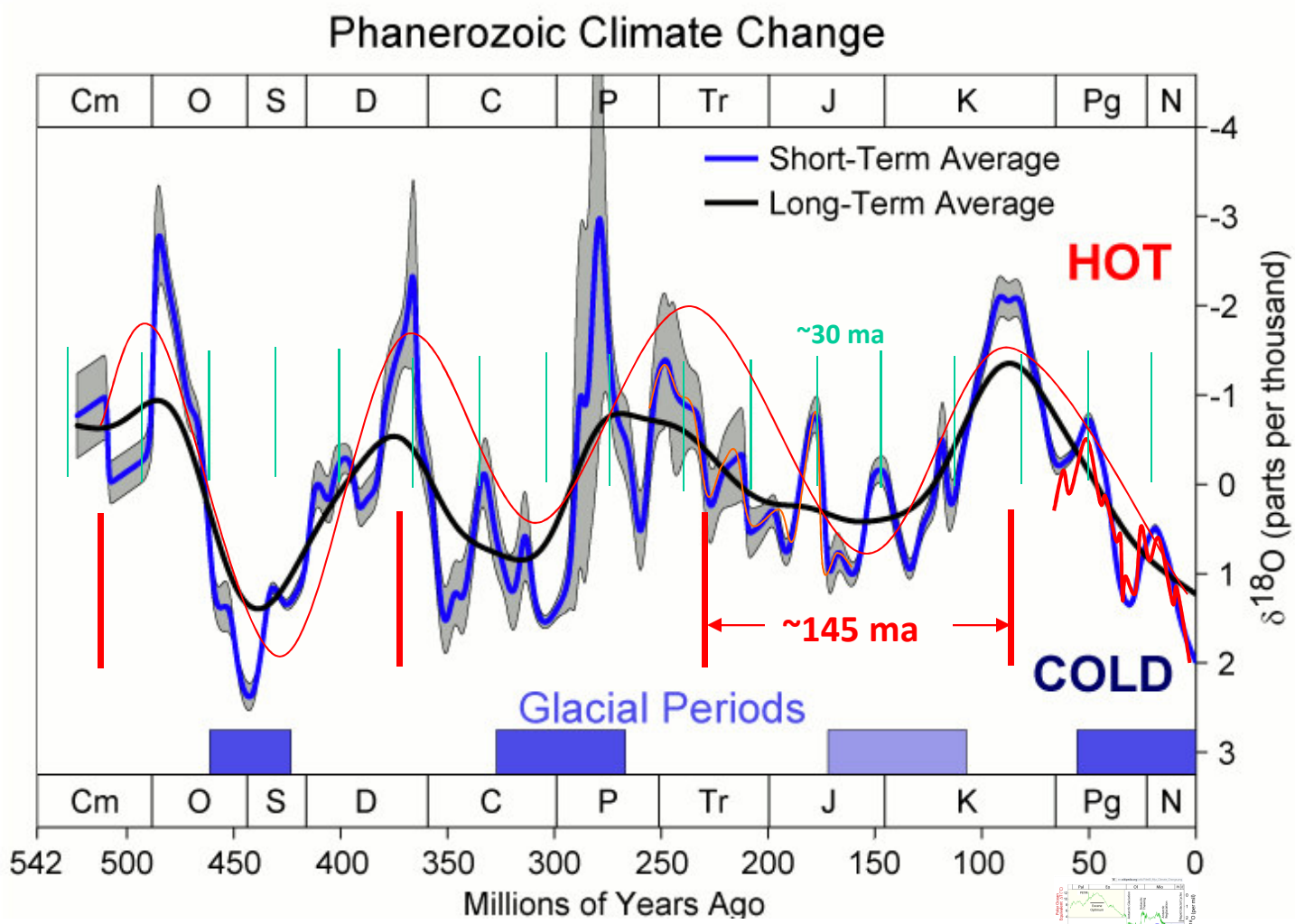


Figure 1: Carbon dioxide (parts per million, ppm) and temperature (Fahrenheit) from the Vostok Ice Core. Recently the record has been extended back more than 650,000 years (Siegenthalter et al., 2005, Science)

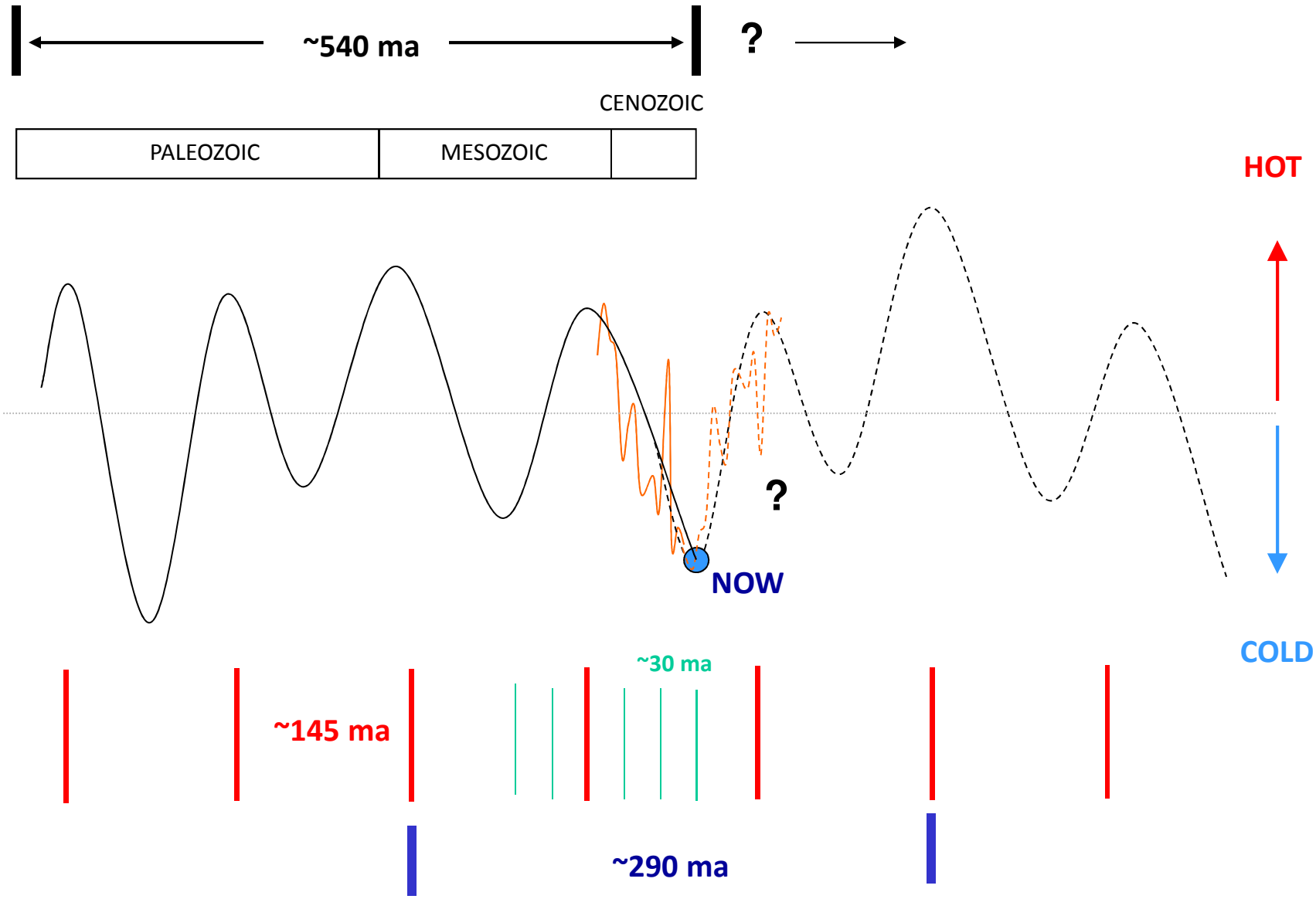


This figure shows climate change over the last 65 million years. The data are based on a compilation of oxygen isotope measurements ($\delta^{18}O$) on benthic foraminifera by Zachos et al. (2001) which reflect a combination of local temperature changes in their environment and changes in the isotopic composition of sea water associated with the growth and retreat of continental ice sheets

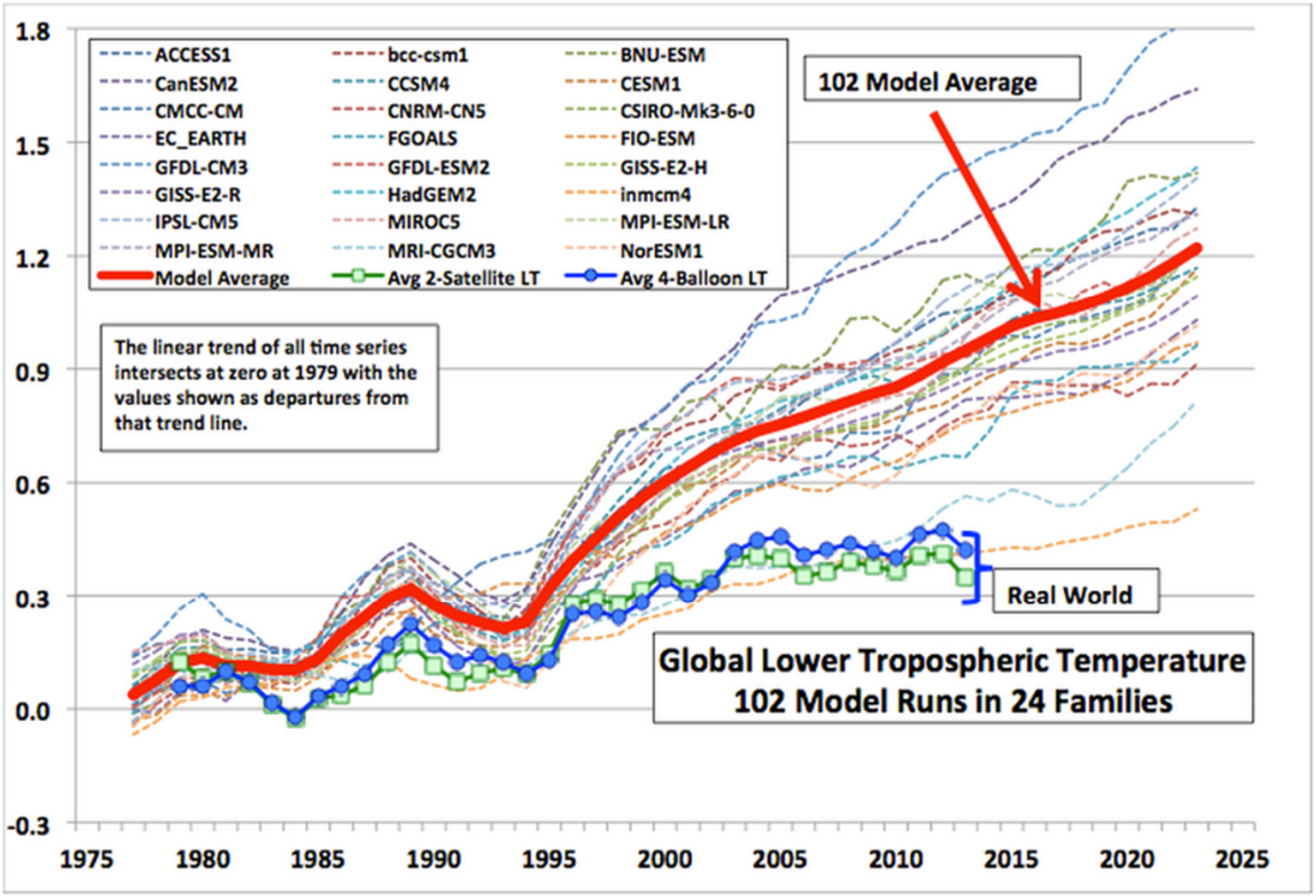
commons.wikimedia.org/wiki/File:Phanerozoic_Climate_Change.png

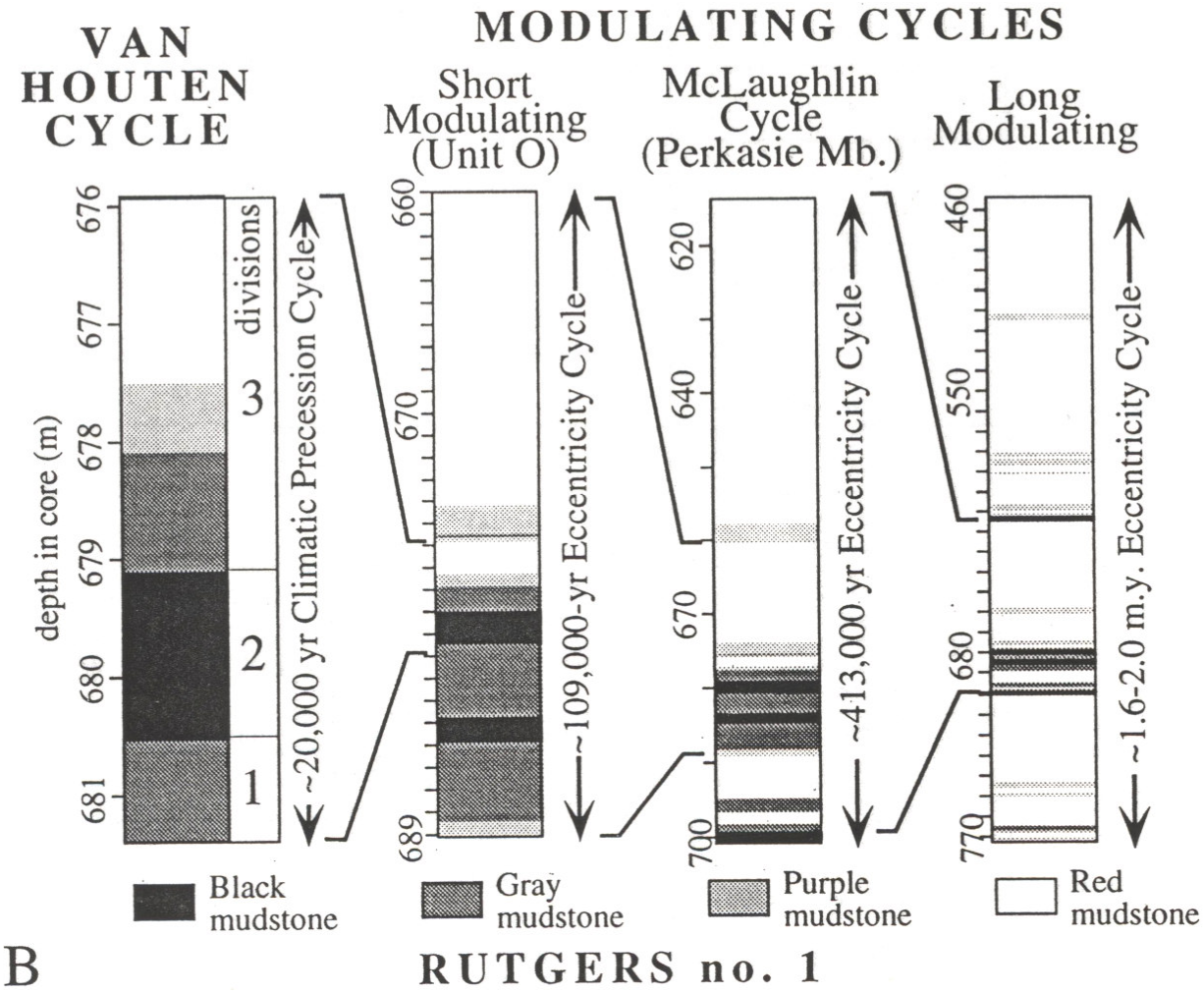


Veizer, J., Ala, D., Azmy, K., Bruckschen, P., Buhl, D., Bruhn, F., Carden, G.A.F., Diener, A., Ebneth, S., Godderis, Y., Jasper, T., Korte, C., Pawellek, F., Podlaha, O. and Strauss, H. (1999) 87Sr/86Sr, d^{13}C and d^{18}O evolution of Phanerozoic seawater. *Chemical Geology* 161, 59-88. The ~30 and ~145 Ma cycles are from eyeballing the trends.



Graphics games with geological time, the long-term climate record and powerpoint lines, arrow, and autoshapes.


1.8
1.5
1.2
0.9
0.6
0.3
0.0
-0.3
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020
2025
ACCESS1
bcc-csm1
BNU-ESM
CanESM2
CCSM4
CESM1
CMCC-CM
CNRM-CN5
CSIRO-Mk3-6-0
EC_EARTH
FGOALS
FIO-ESM
GFDL-CM3
GFDL-ESM2
GISS-E2-H
GISS-E2-R
HadGEM2
inmcm4
IPSL-CM5
MIROC5
MPI-ESM-LR
MPI-ESM-MR
MRI-CGCM3
NorESM1
Model Average
Avg 2-Satellite LT
Avg 4-Balloon LT
102 Model Average
The linear trend of all time series intersects at zero at 1979 with the values shown as departures from that trend line.
Real World
Global Lower Tropospheric Temperature
102 Model Runs in 24 Families



Olsen, and others, 1996