

METR 5223: Atmospheric Radiation

# Orbital Effects on Solar Radiation

Lecture for Spring 2009, v0.2

Prof. Brian H. Fiedler

*School of Meteorology, University of Oklahoma*

# Orbital Variations and the Ice Ages

- The position of Earth in its elliptical orbit can be given by a longitude angle.  $\Lambda$  is the *longitude of perihelion*, the longitude of closest approach to the sun, relative to the *longitude of vernal equinox*.
- The *eccentricity*  $\epsilon$  is a measure of the radius at aphelion  $r_a$  to the radius at perihelion  $r_b$ :

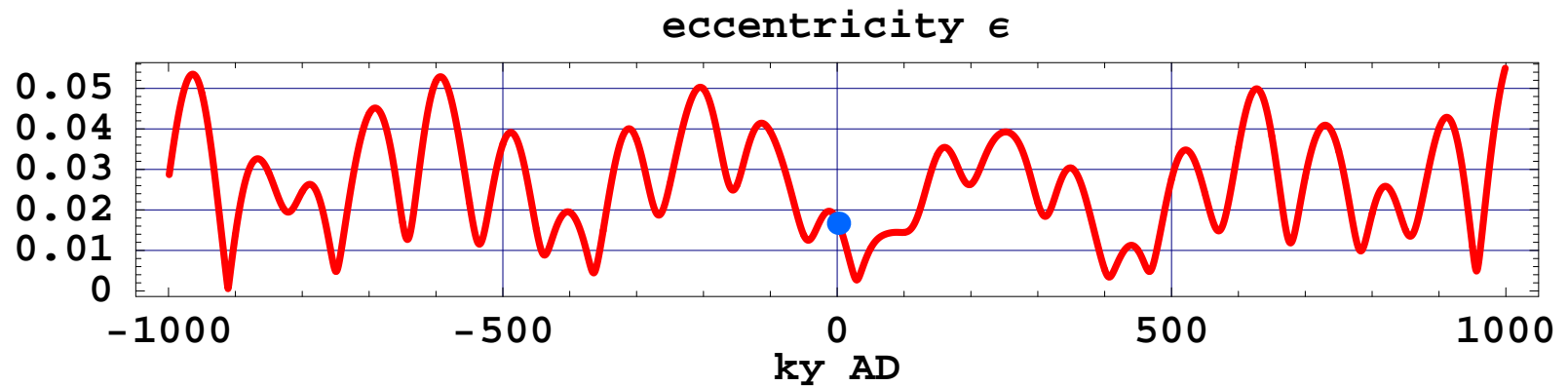
$$\frac{r_a}{r_b} = \frac{1 + \epsilon}{1 - \epsilon}$$

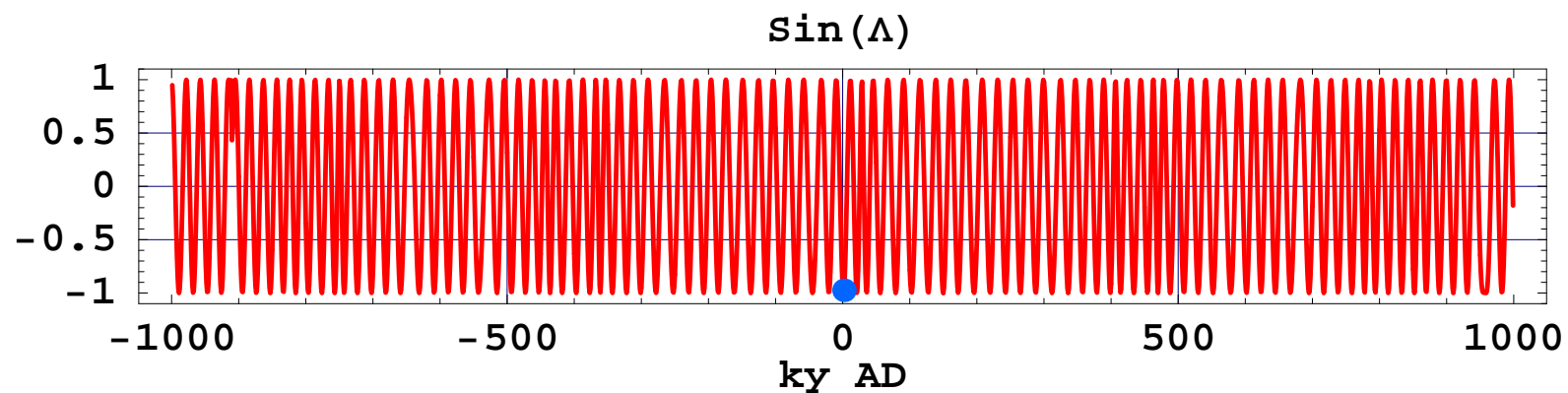
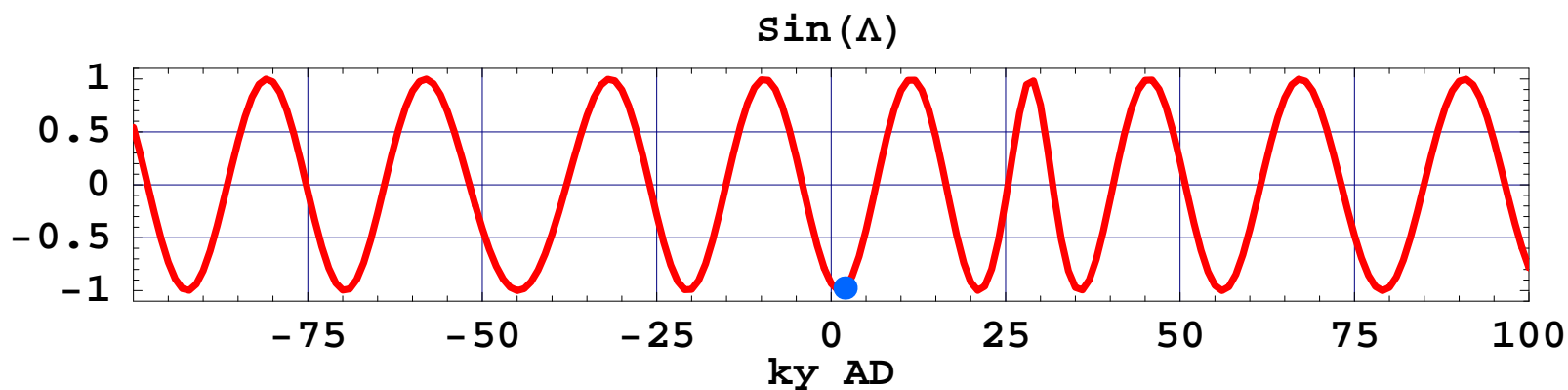
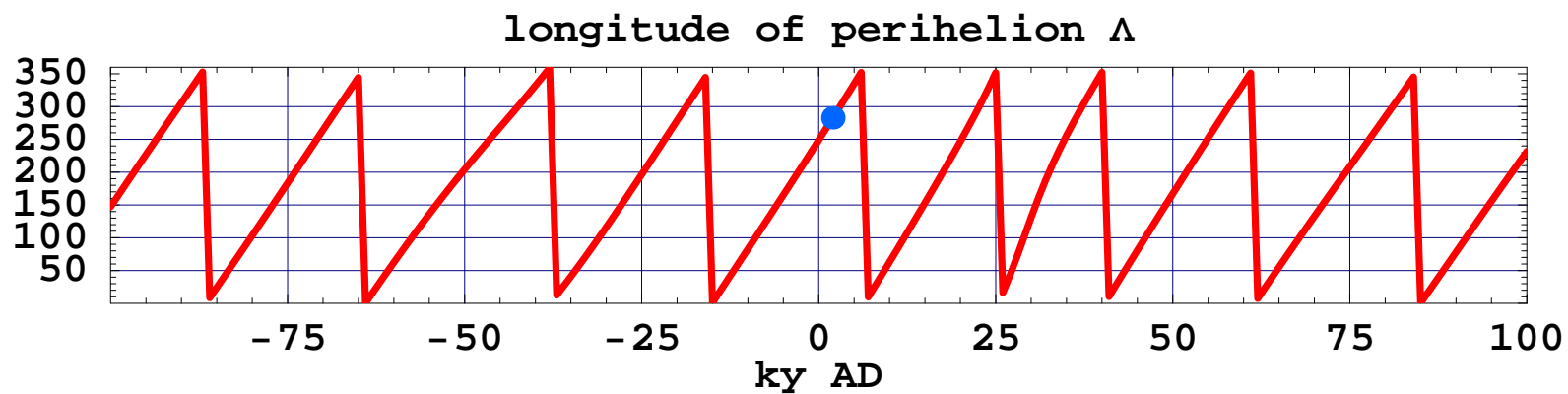
- The *obliquity* is a measure of the tilt of the axis of rotation of Earth, relative to the normal vector of the plane of the orbit.

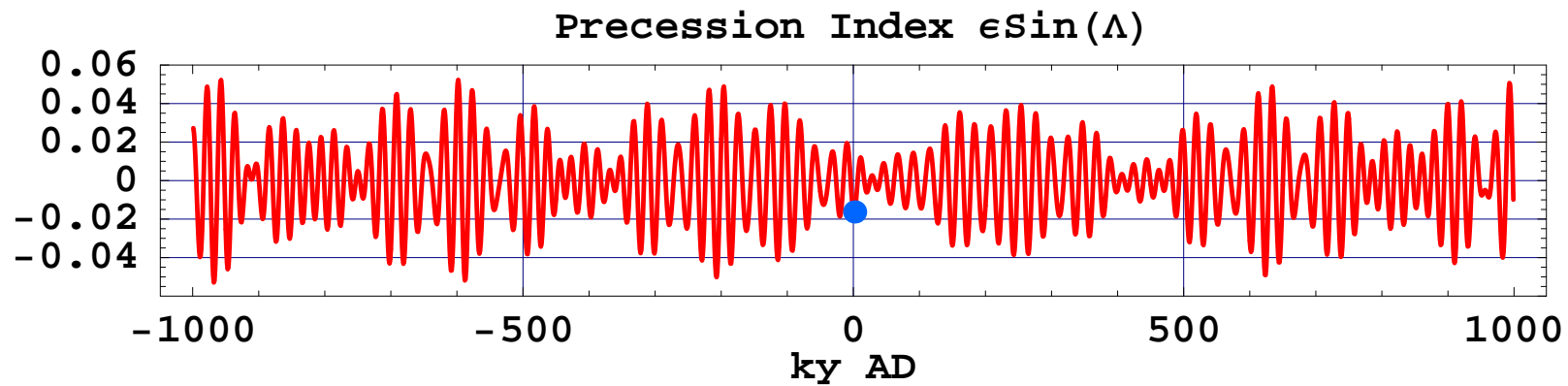
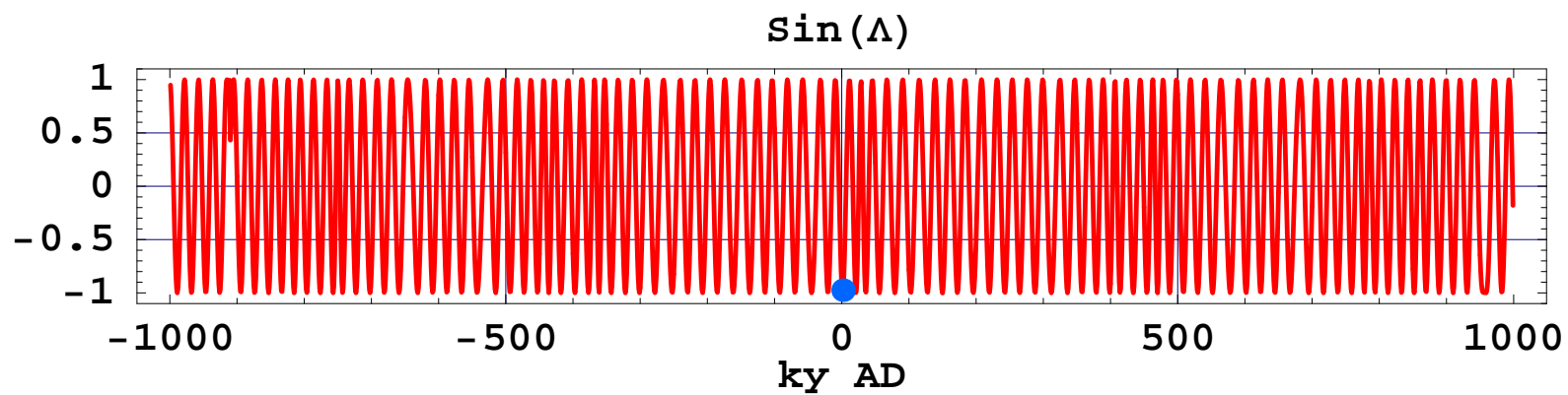
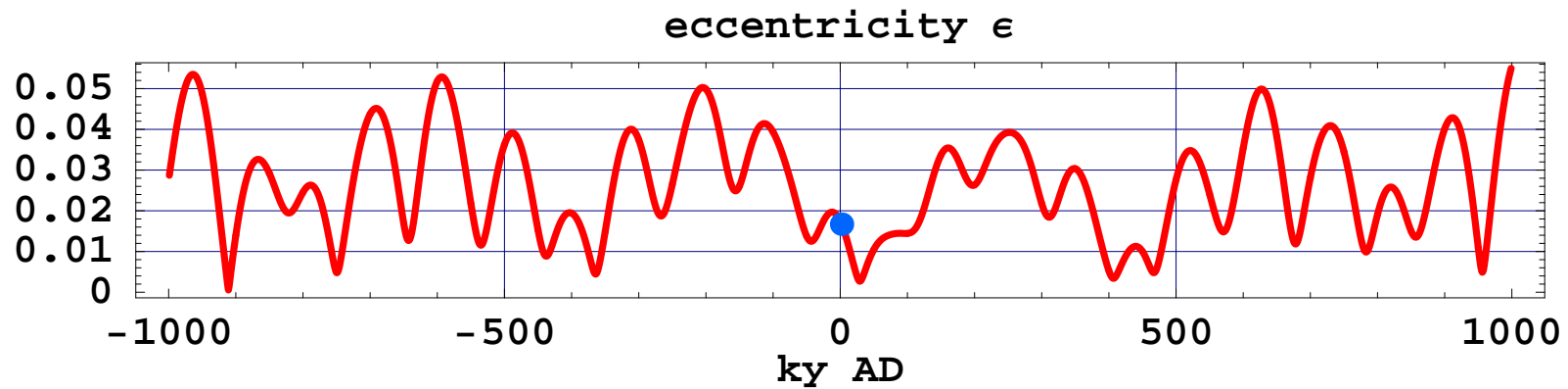
Here is the eccentricity  $\epsilon$ .

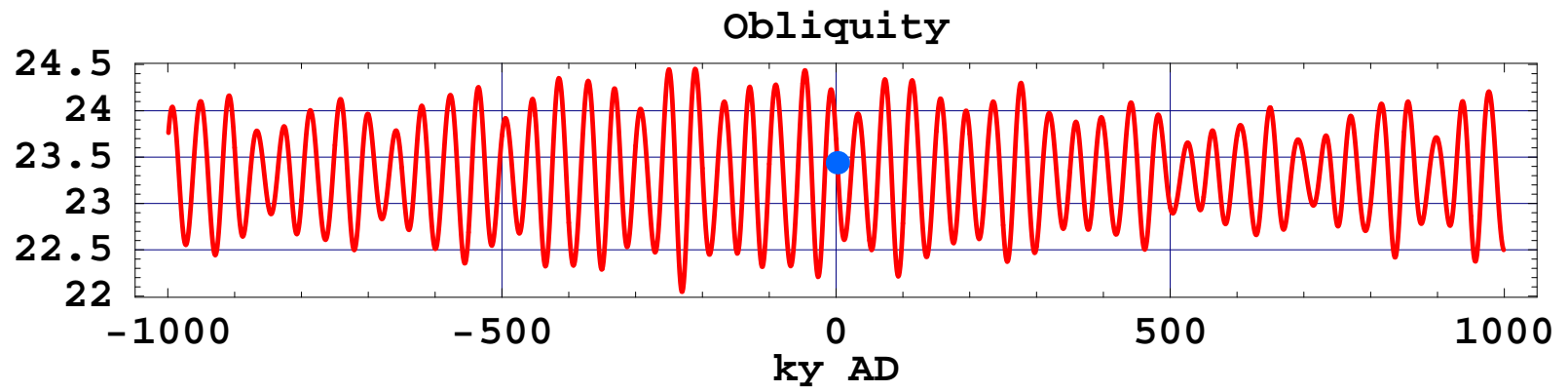
$\epsilon = 0$  would be a perfect circle.

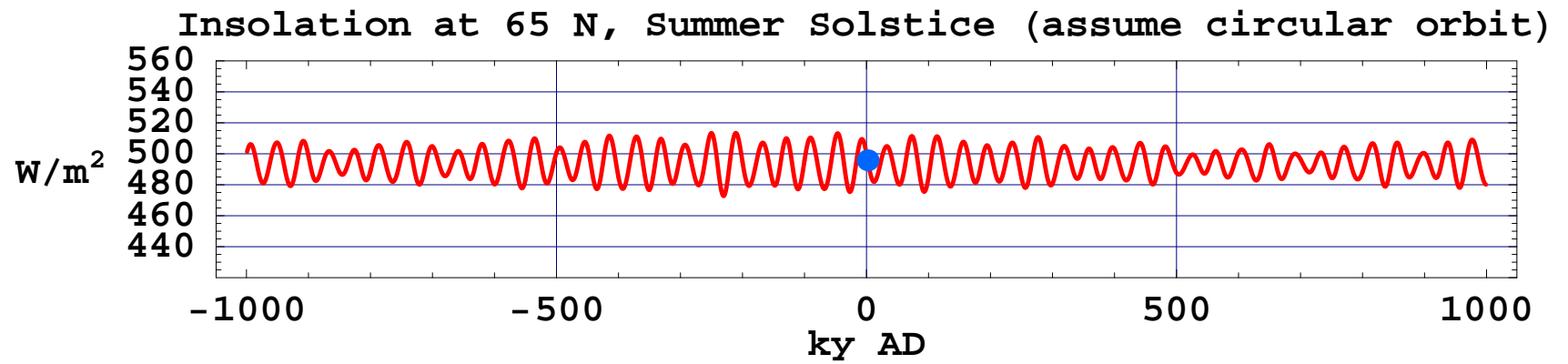
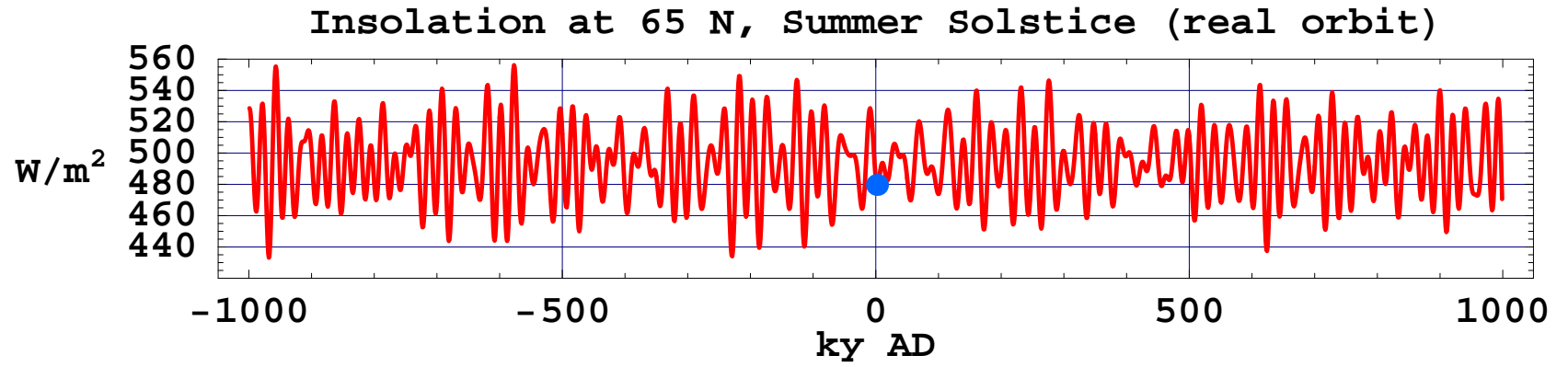
ky is kiloyears.



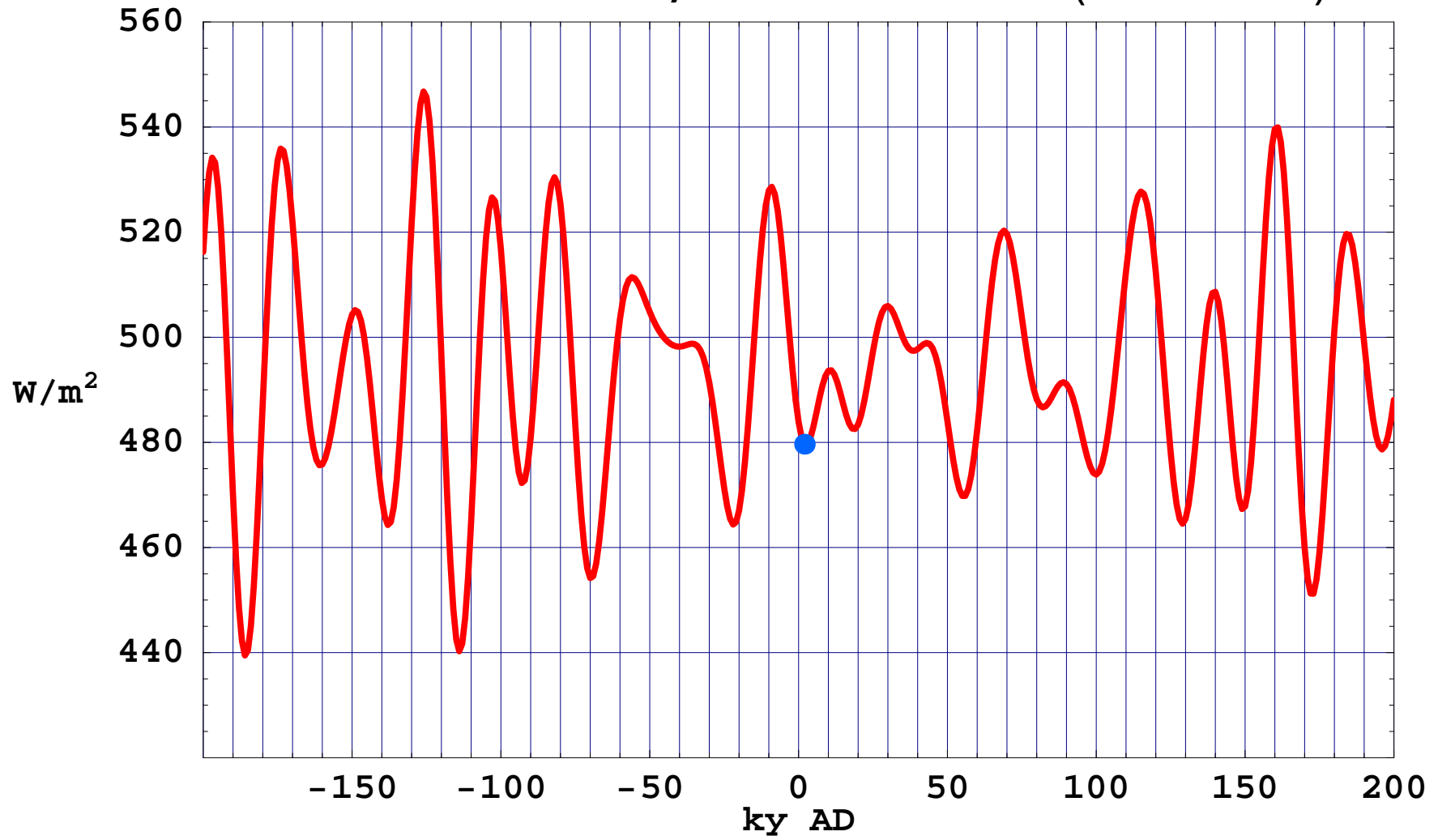




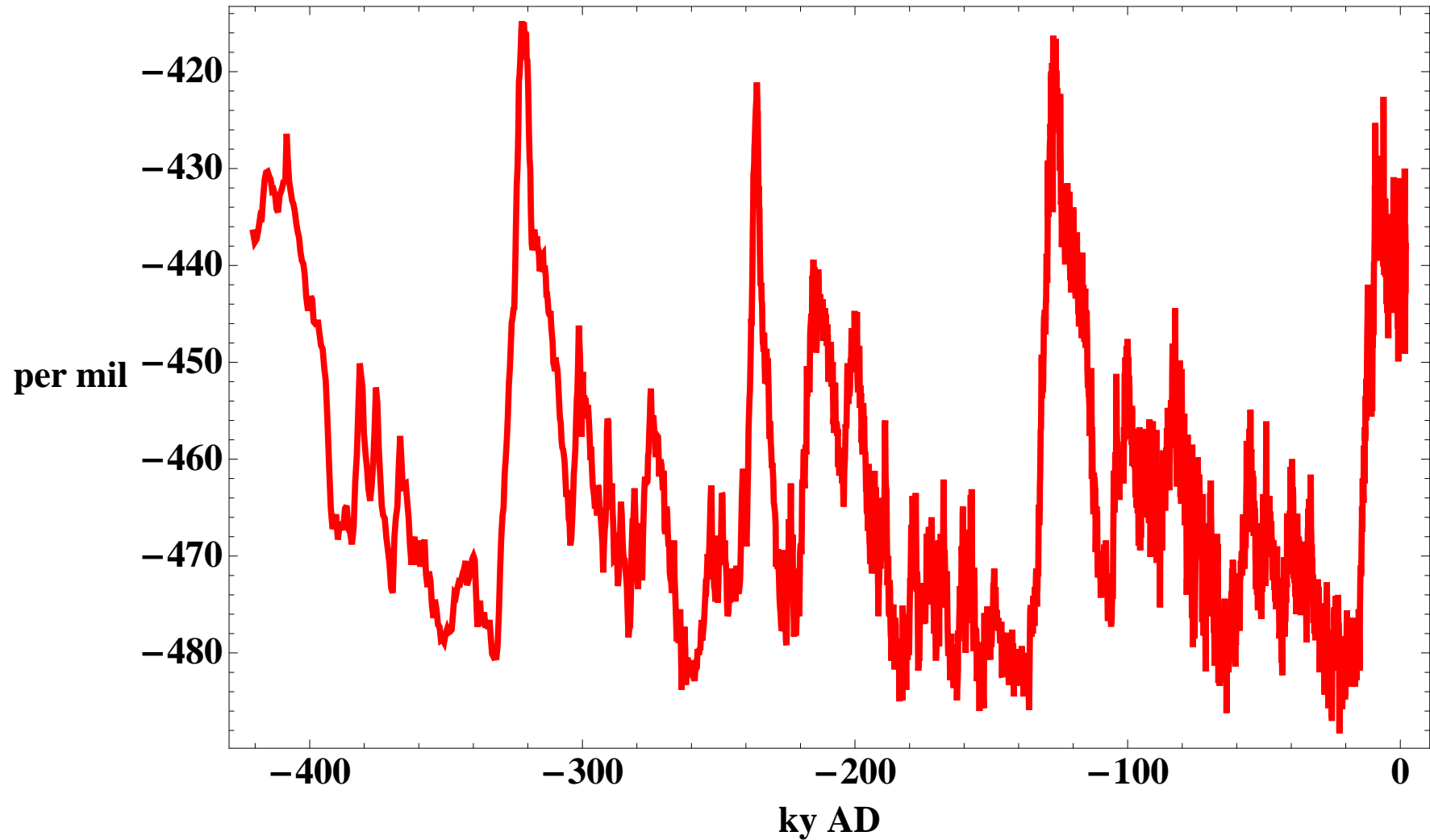




Insolation at 65 N, Summer Solstice (real orbit)

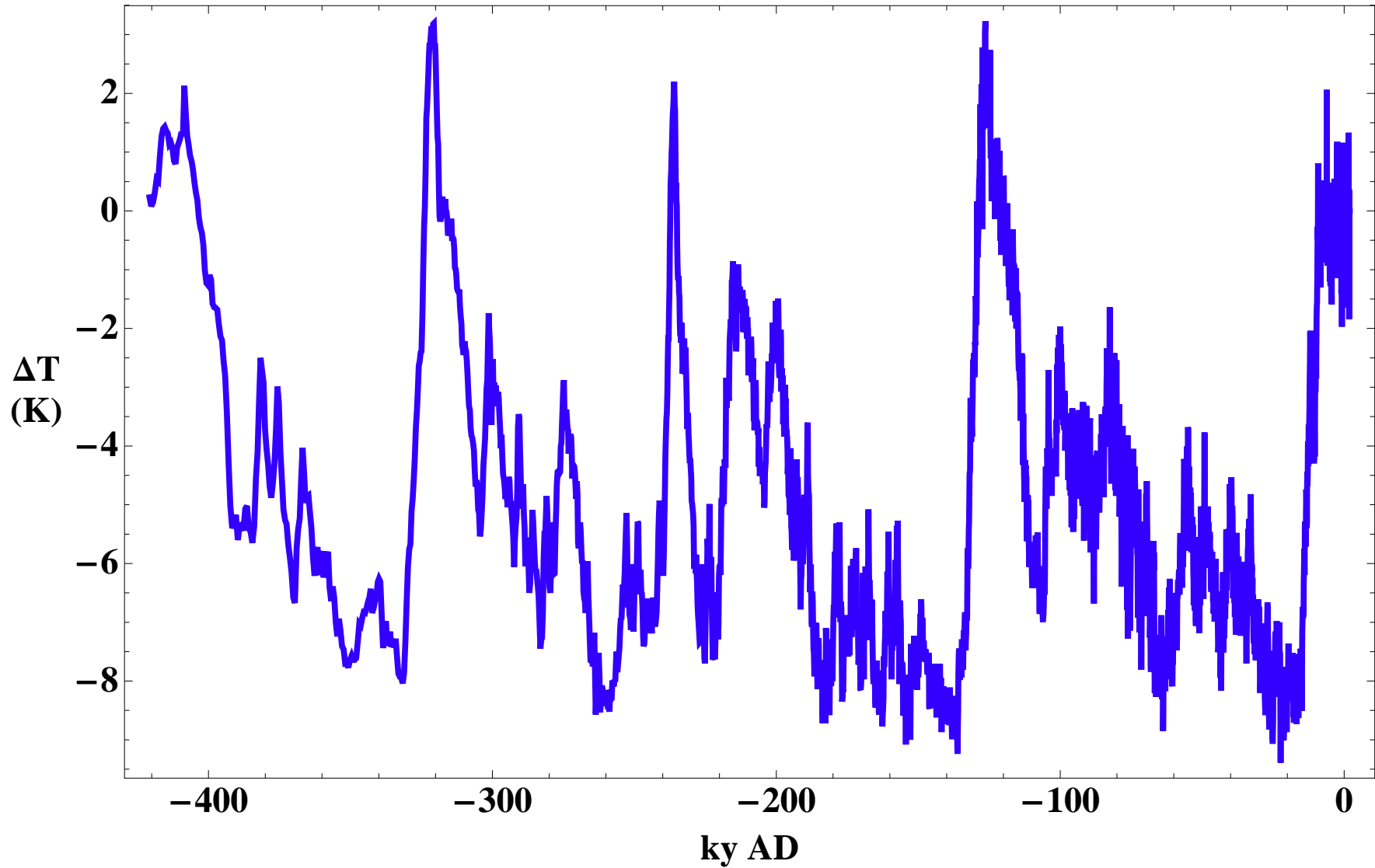


## Change in Deuterium in Ice Core from Standard Water



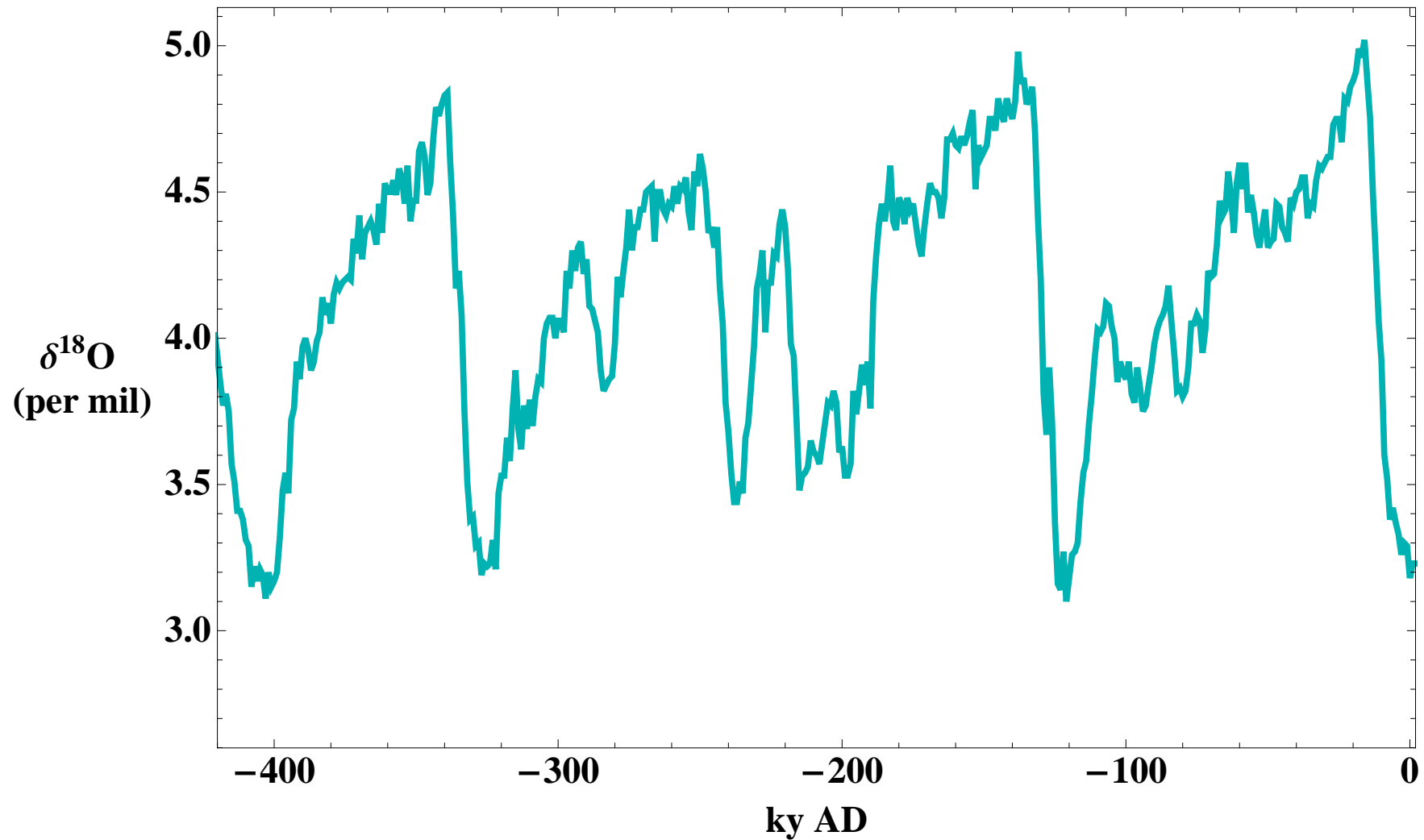
Deuterium is depleted when snow forms at colder temperatures.

## Temperature Change Reconstruction from Deuterium Data



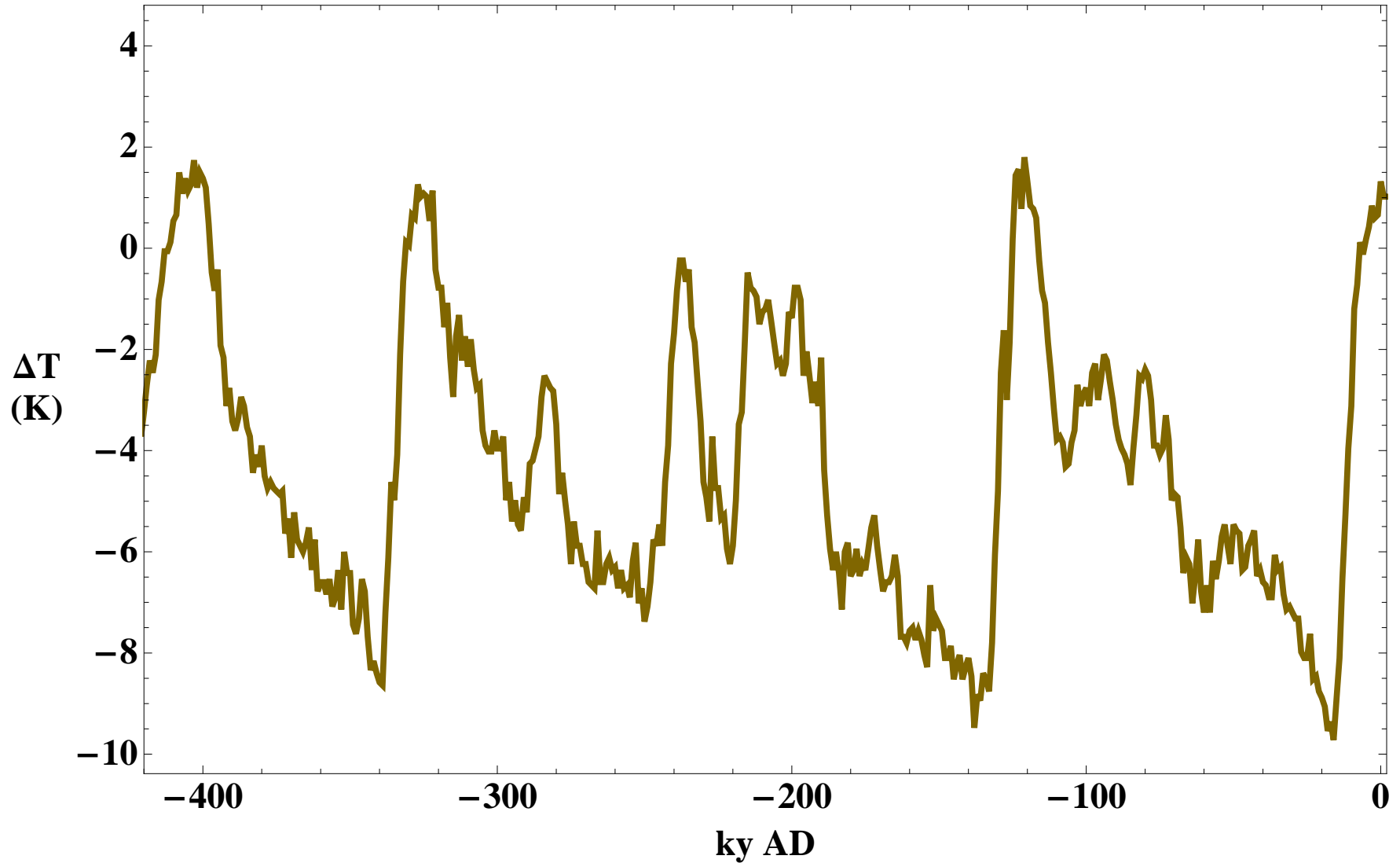
Temperature reconstruction from the deuterium depletion in the ice core.

## From Foraminefera Calcite in Ocean Core



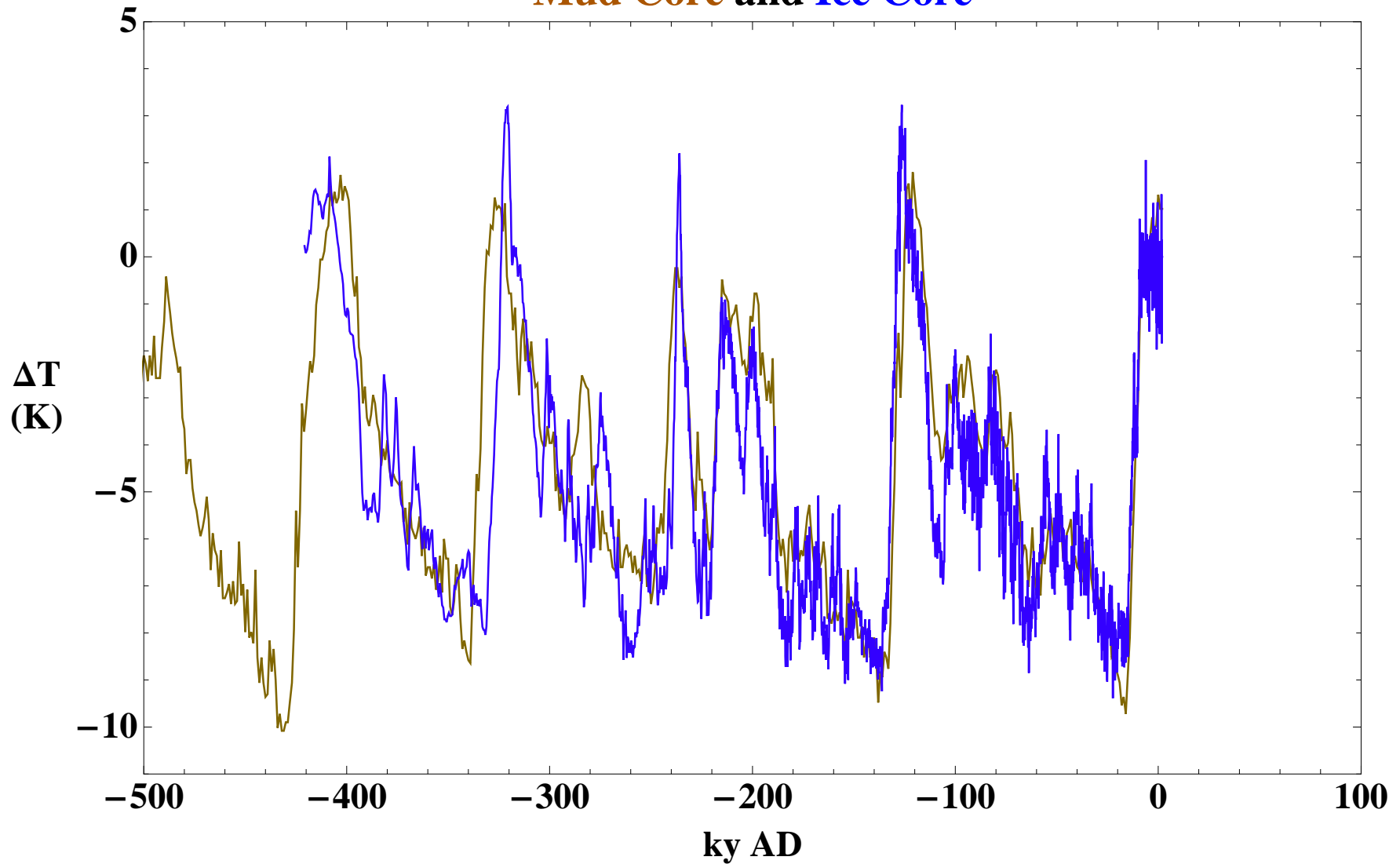
Heavy oxygen is depleted in fossil shells when sealevel is high.

## From Foraminefera Calcite in Ocean Core



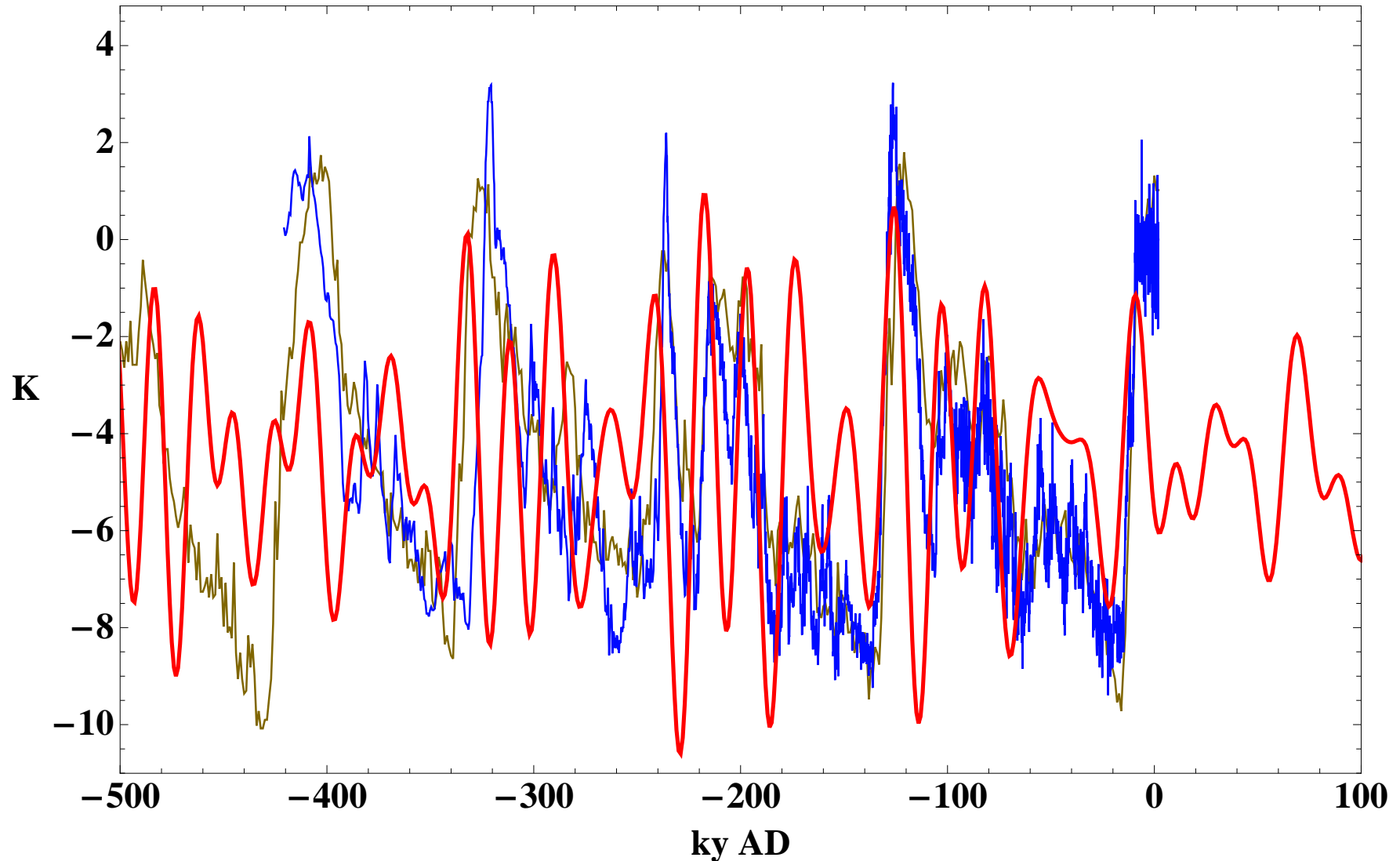
try:  $\Delta T = 6(3.4 - \delta^{18}O)$  for the temperature reconstruction from the depleted oxygen.

## Mud Core and Ice Core



Touchdown! That is really good agreement in the temperature reconstruction from two different sources of data.

## Mud Core and Ice Core and Simple Theory



try:  $\Delta T = (Q - 540)/10$ ,  $Q$  is summer solstice insolation at 65 N. The model does not completely reproduce the observations.