



# Teacher Earth Science Education Programme PARTNERS

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**Australian Government**  
**National Water Commission**



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# Teacher Earth Science Education Programme

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### SILVER

- The Australian National University
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### BRONZE

- Anglo Coal
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- Great Artesian Basin Coordinating Committee
- Hot Dry Rocks
- Macquarie University
- Sandy Menpes
- Monash Energy
- Museum Victoria
- Our Water Our Future, Vic
- Petroleum Geo-Services
- Primary Industries and Resources SA
- Stanwell Corporation
- Velseis
- ZeroGen



## Teacher Earth Science Education Programme

# RIDING THE CLIMATE ROLLER COASTER GEOLOGY OF CLIMATE

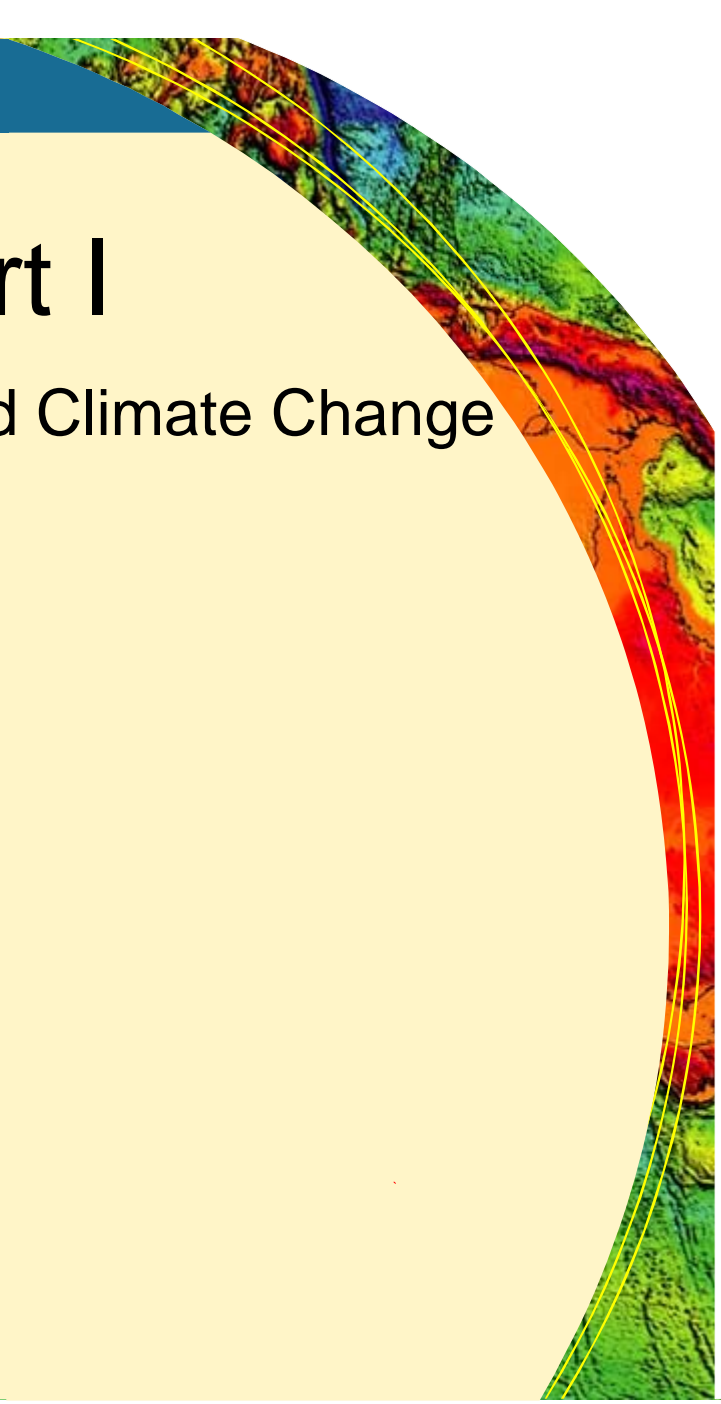
Greg McNamara

TESEP  
Executive Officer

# The Roller Coaster Part I

## The Geological Record of Climate and Climate Change

- Define
  - Climate
  - Weather
  - Geological time
- Examine
  - Known climate changes
  - Sources of geological information
  - Drivers of climate change
  - Specific climatic events



# Climate

What do we mean by climate?

- Weather averaged over time
  - 30 years usual but...
- Time is an important factor
  - Generational
    - » Granddad's day
  - Historical
    - » The dark ages
  - Geological
    - » The dinosaurs

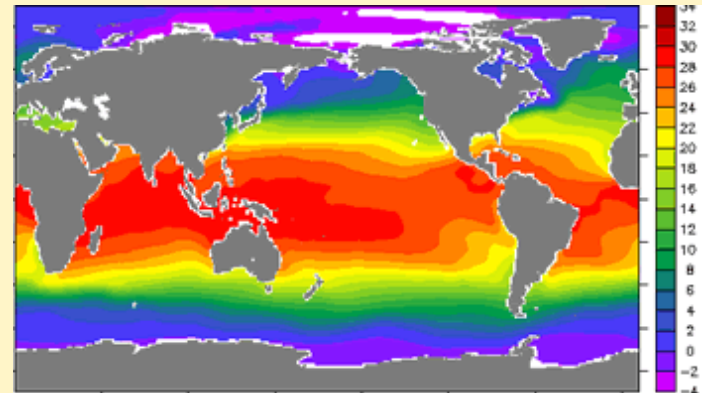
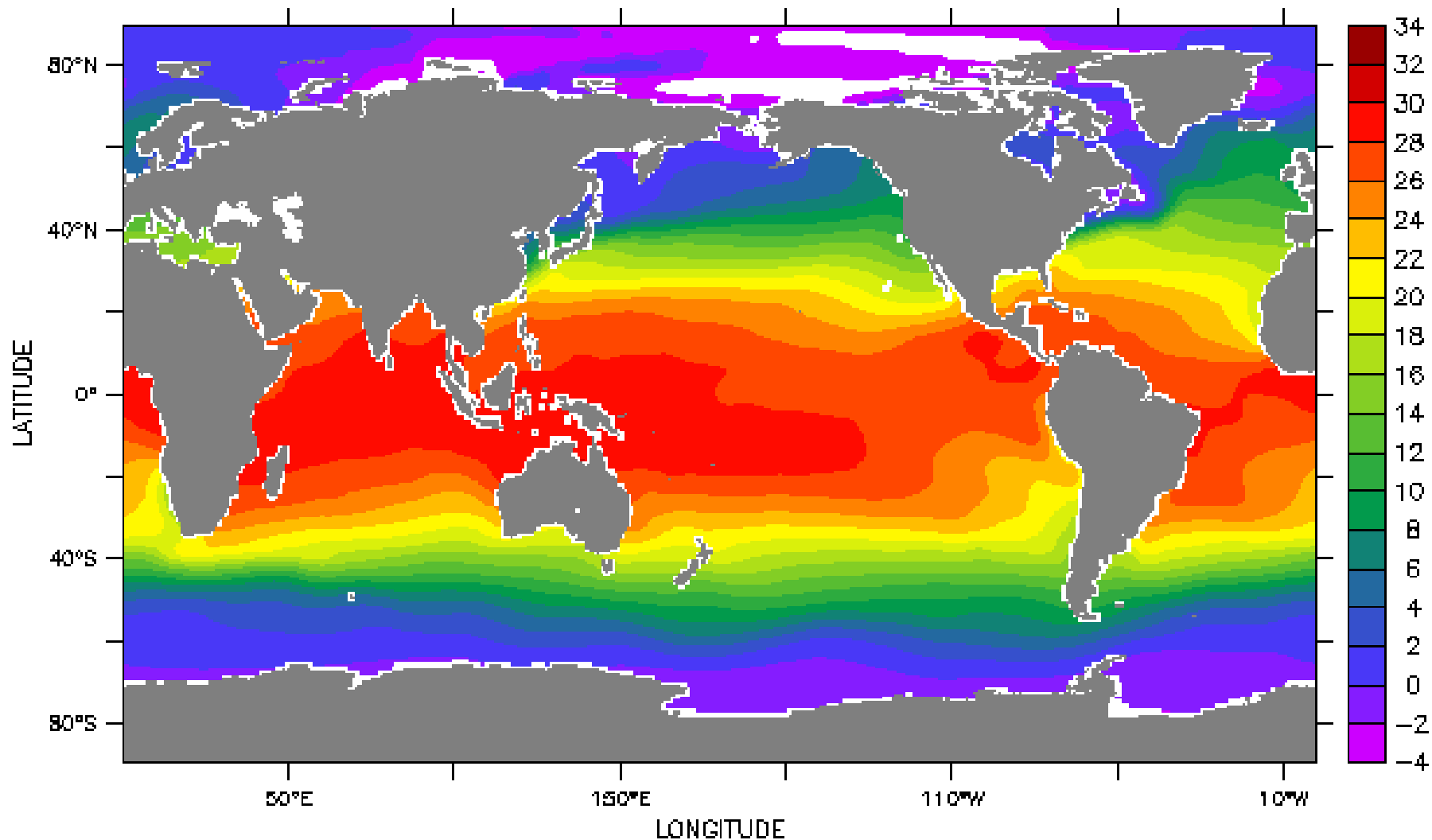


Image: NOAA Courtesy of Windows to the Universe  
[http://www.windows.ucar.edu/tour/link=/earth/climate/cli\\_define.html&edu=high](http://www.windows.ucar.edu/tour/link=/earth/climate/cli_define.html&edu=high)



TIME : 16-MAR-2004

DATA SET: sst\_regrid



## Monthly climatological mean SST

Image: NOAA Courtesy of Windows to the Universe

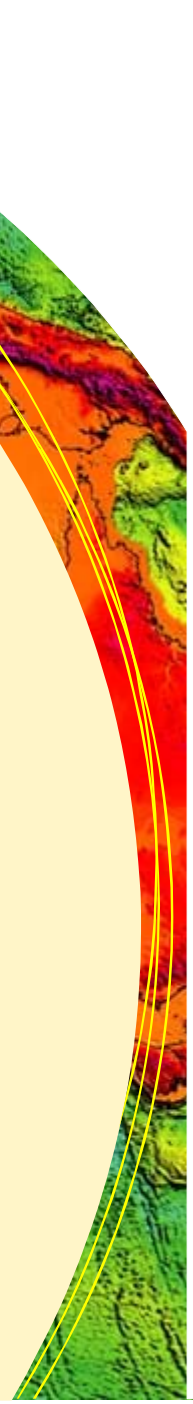
[http://www.windows.ucar.edu/tour/link=/earth/climate/cli\\_define.html&edu=high](http://www.windows.ucar.edu/tour/link=/earth/climate/cli_define.html&edu=high)

# Weather

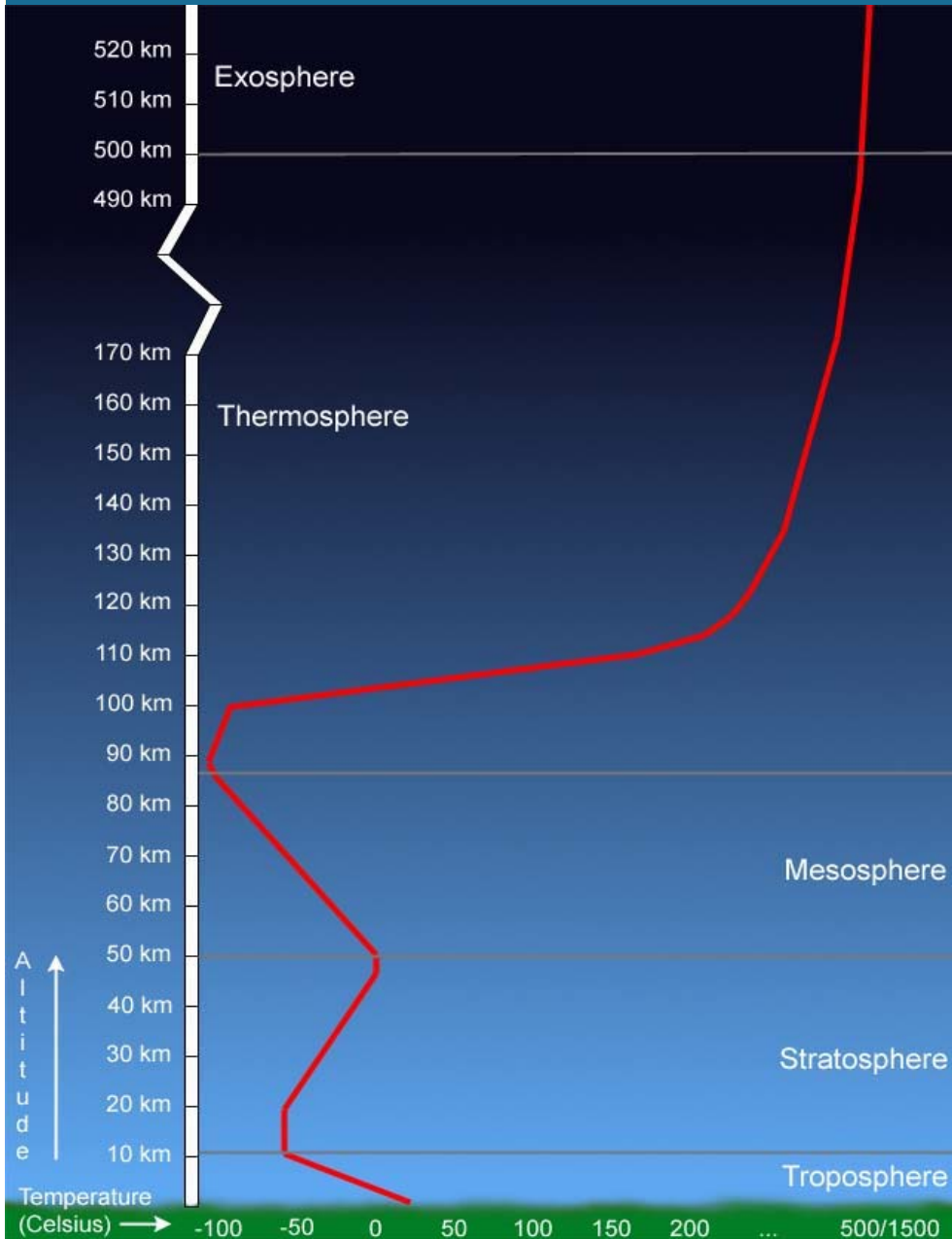


What is weather?

- Natural processes and events
  - In the atmosphere
  - Over a short period of time
    - Hours
    - Days
    - Week



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99% of atmosphere  
in bottom 32km

Ozone layer

Most weather  
75% of  
atmospheric gas

Image Courtesy of  
Windows to the Universe

[http://www.windows.ucar.edu/tour/link=/earth/images/profile.jpg\\_image.html](http://www.windows.ucar.edu/tour/link=/earth/images/profile.jpg_image.html)



# Deep time

What is geological time?

- The age of planet Earth
  - Close to 4.6 billion years
    - Absolute dates based on
      - Based on radioactive decay
      - Tight correlation with radiometric dates
    - Relative dates based on
      - Sequences in the rock record
        - » Layering, Fossils, Cross-cutting
        - » Correlations

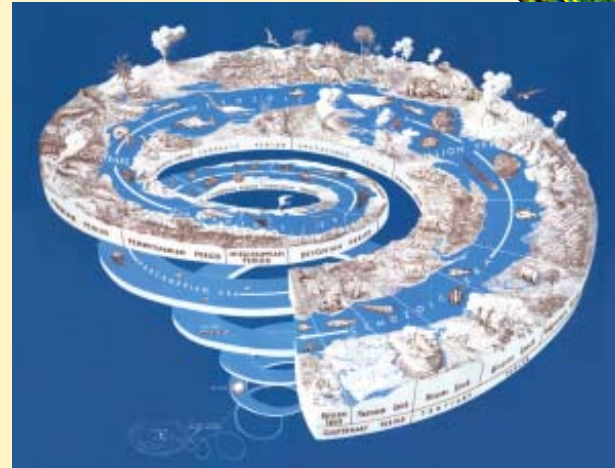


Image Courtesy of USGS  
<http://pubs.usgs.gov/gip/geotime/time.html>

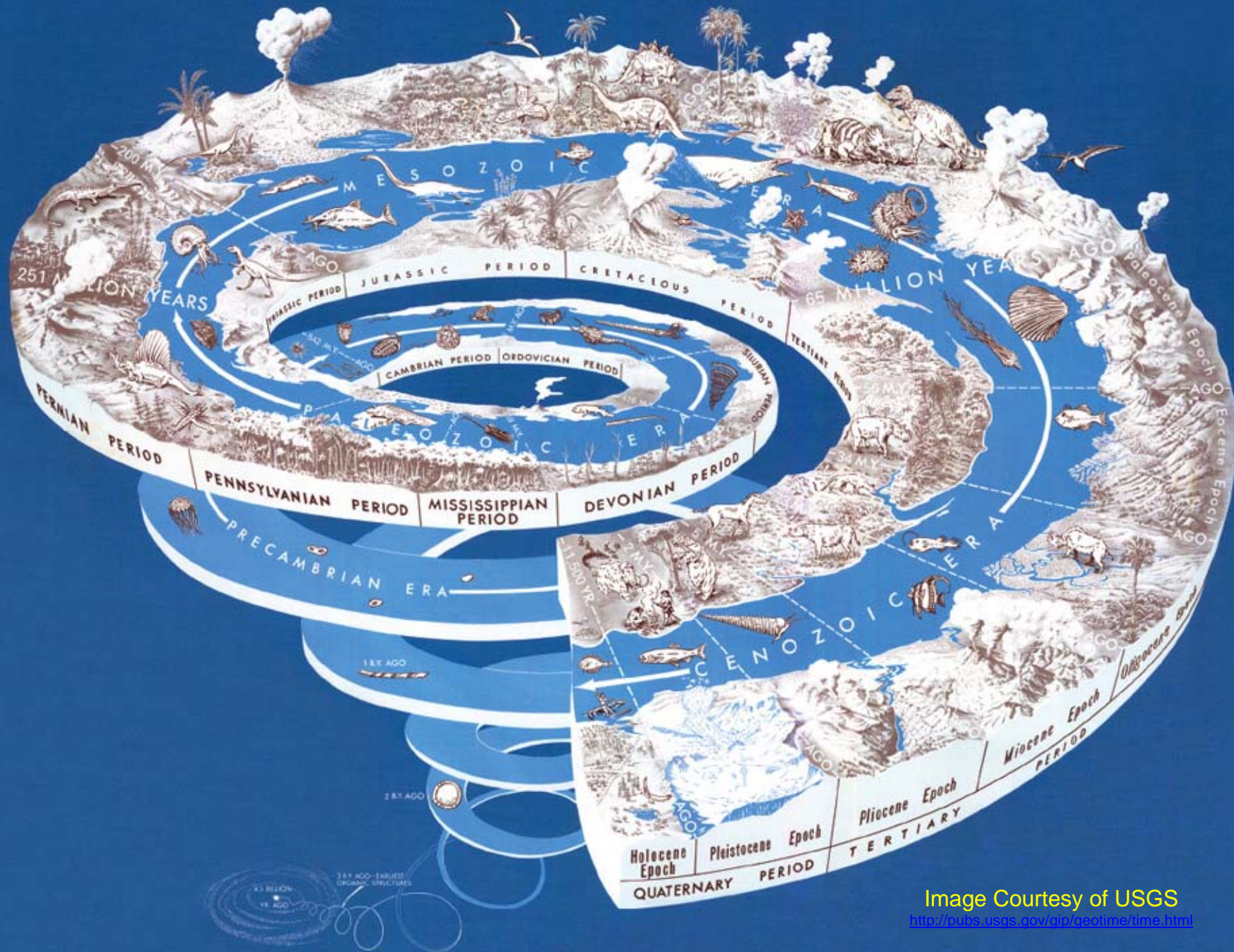


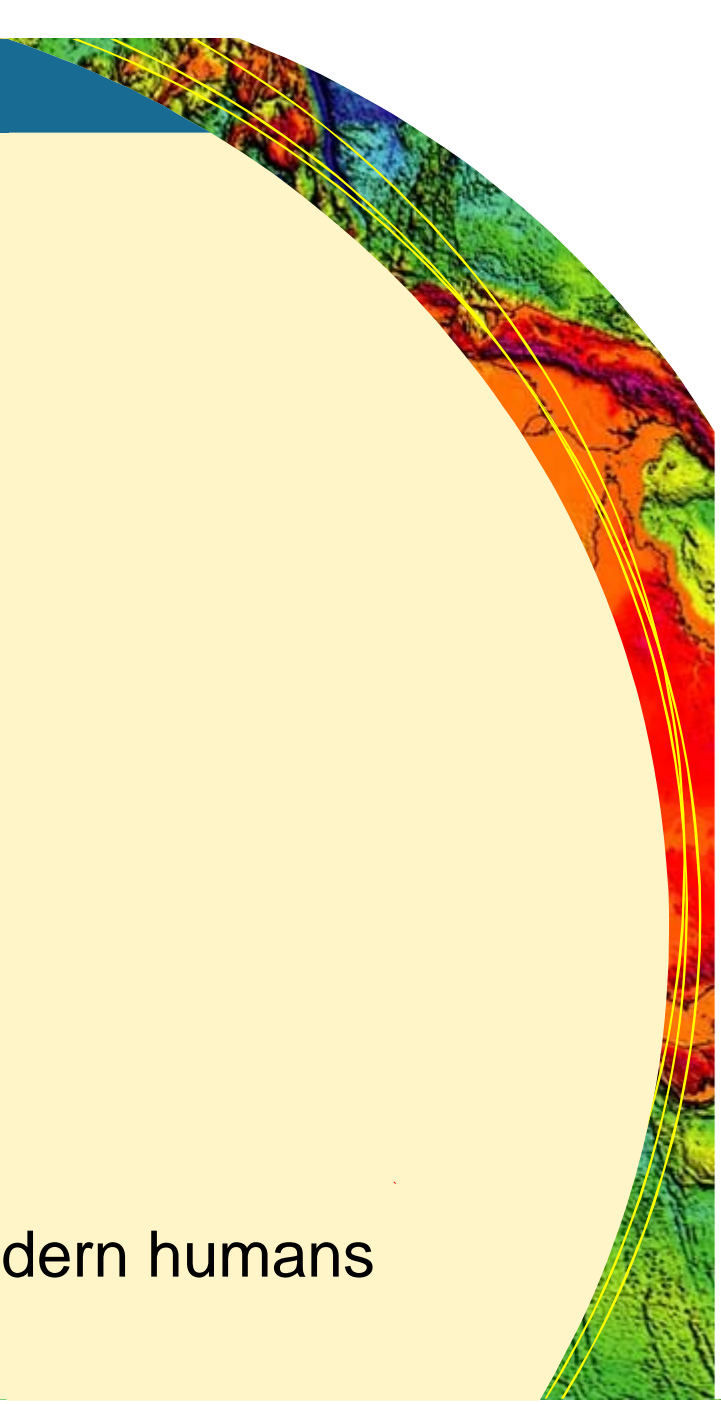
Image Courtesy of USGS

<http://pubs.usgs.gov/gip/geotime/time.html>

# Deep time

Crunch the numbers!

- 87% Precambrian
- 13% for all of the Phanerozoic
  - of this
    - ~46% Palaeozoic - pre Dinosaurs
    - ~41% Mesozoic - age of Dinosaurs
    - ~13% Cenozoic – age of Mammals
      - of this
        - » ~ last 6% hominid time
        - » ~0.15% modern human time
- ~0.002% of all time occupied by modern humans



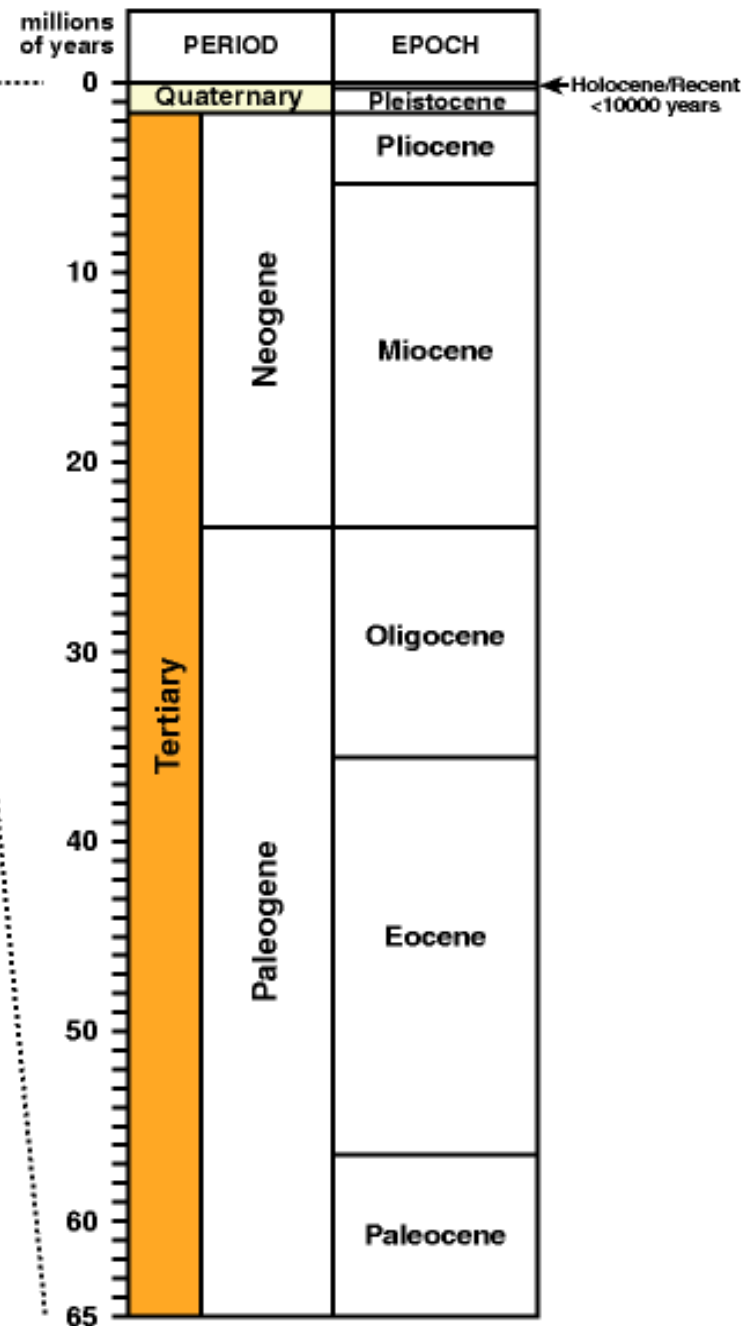
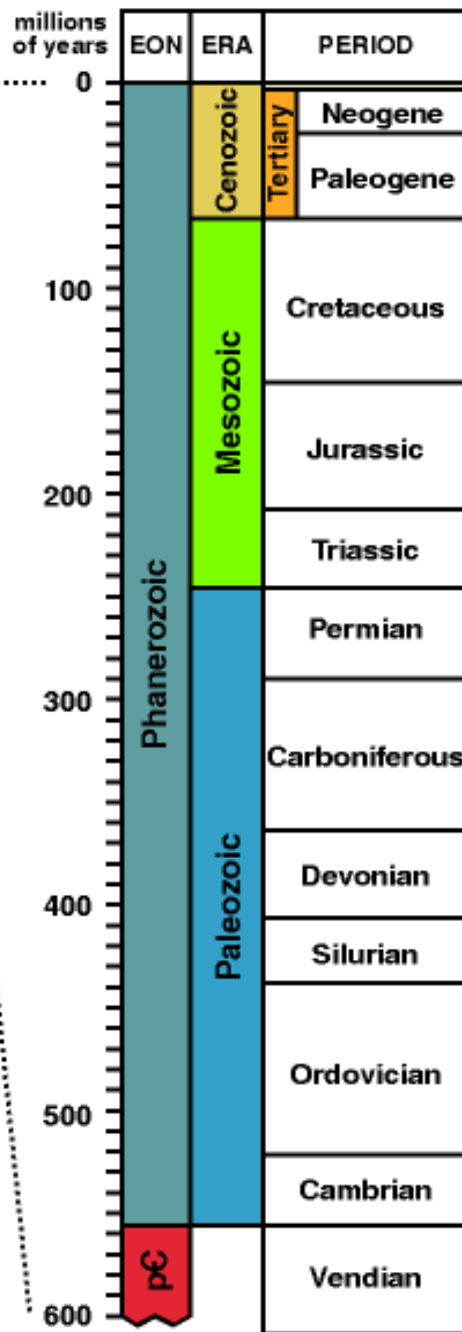
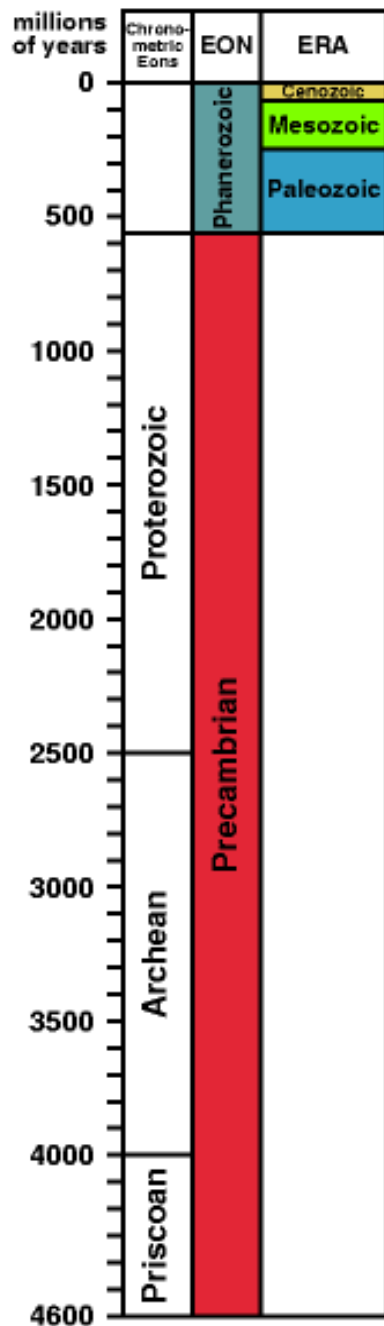


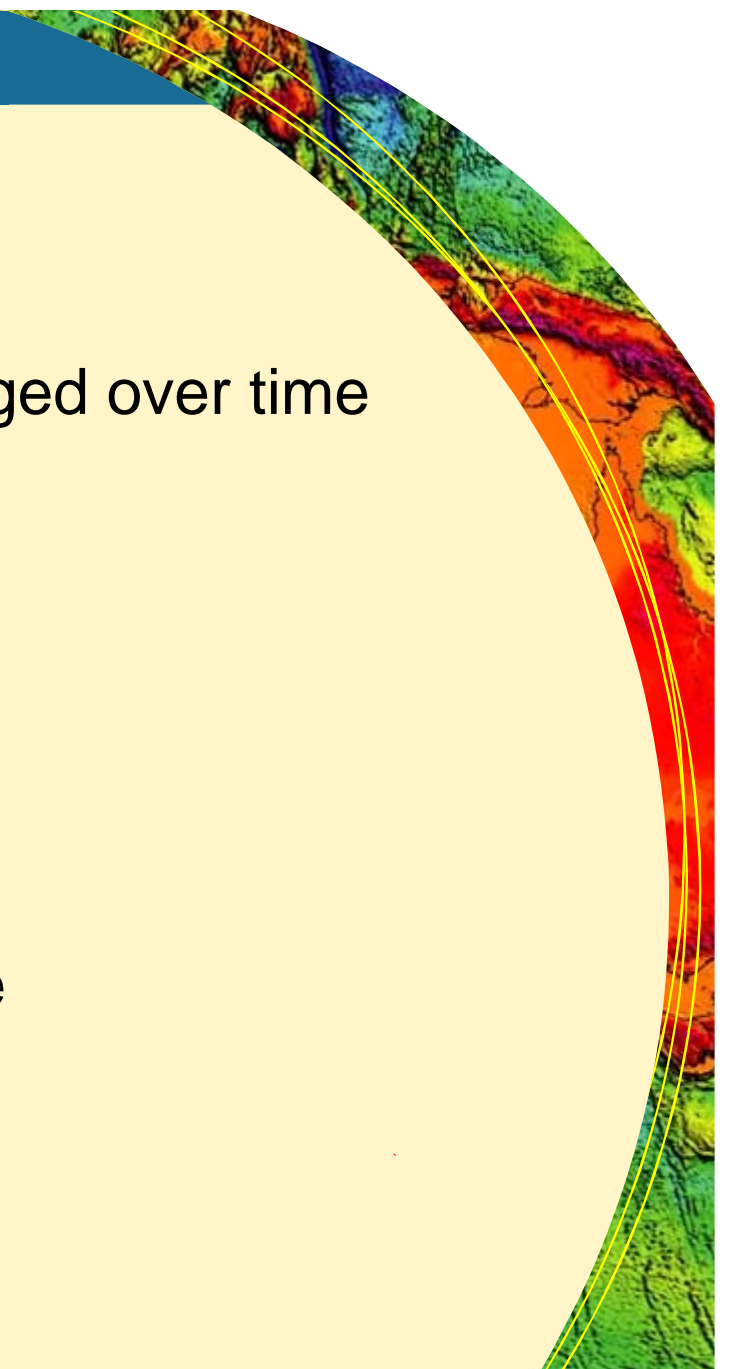
Image Courtesy University of Calgary

<http://pubs.usgs.gov/gip/geotime/time.html>

# Climate through time

Rocks tell us global climate has changed over time

- Sometimes colder
  - Ice ages
  - Snowball Earth
- Sometimes warmer
  - Polar dinosaurs
  - Ice free Earth
- Never constant over geological time
  - Stable long enough to allow evolution
  - Unstable enough to drive evolution



# Climate proxies

Ancient sources of temperature & climate information?

- Rocks themselves
  - Red beds
  - Tillites
  - Some minerals
- Fossils
  - Key families, genera, species
    - Distributions
- Isotope ratios
  - Oxygen 16-18
    - Minerals, fossil hard parts & ice



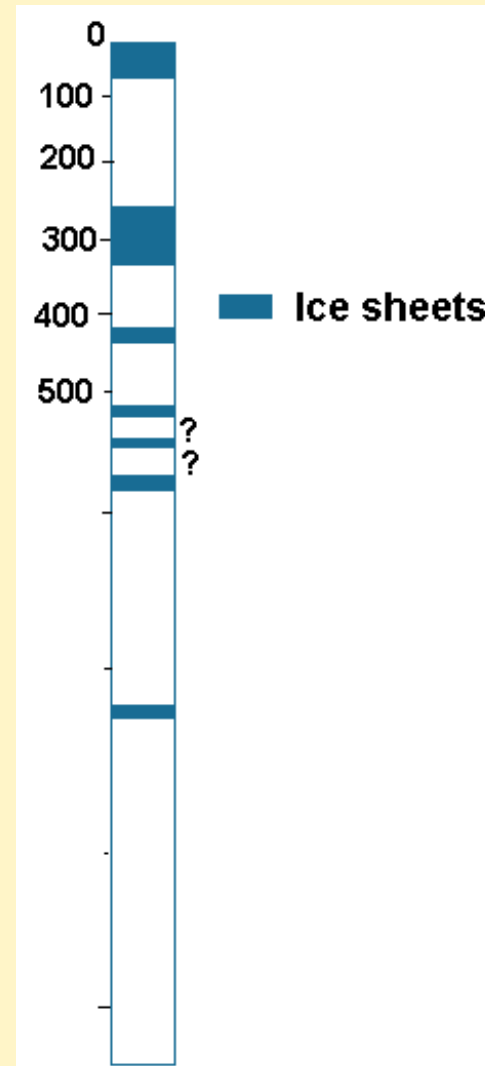
Image Courtesy Mila Zinova

[http://commons.wikimedia.org/wiki/Image:Concretion\\_and\\_crystals.jpg](http://commons.wikimedia.org/wiki/Image:Concretion_and_crystals.jpg)

# Climate in deep time

## Global climate variations

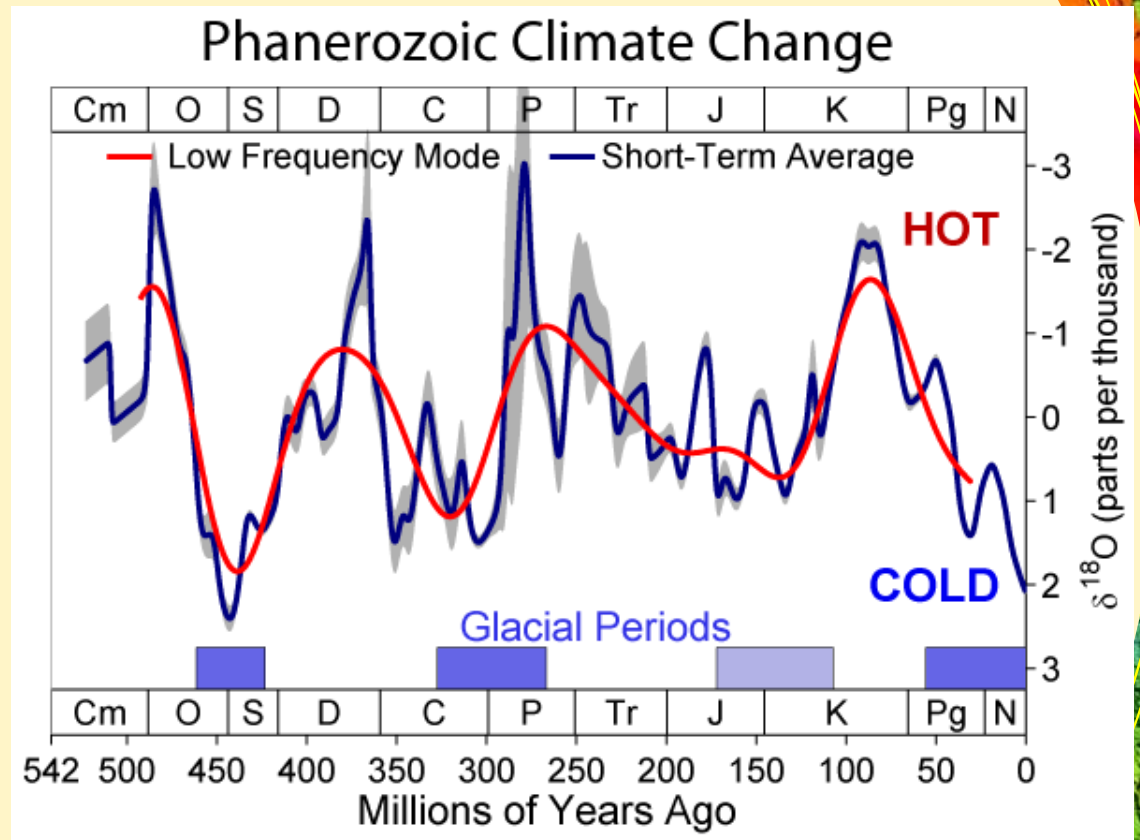
- Record beyond 500My
  - patchy
  - open to more interpretation



# 500My of climate change

## Global climate variations

- Glaciations
  - at least 4
  - ?extinctions
- Warm–Hot
  - at least 4
  - ?Ice free Earth





# 65My of climate change

Global climate variations since the dinosaurs

- Glaciations
  - lots of cycles
  - ?extinctions
- Warm–Hot
  - Eocene
  - ?Ice free Earth

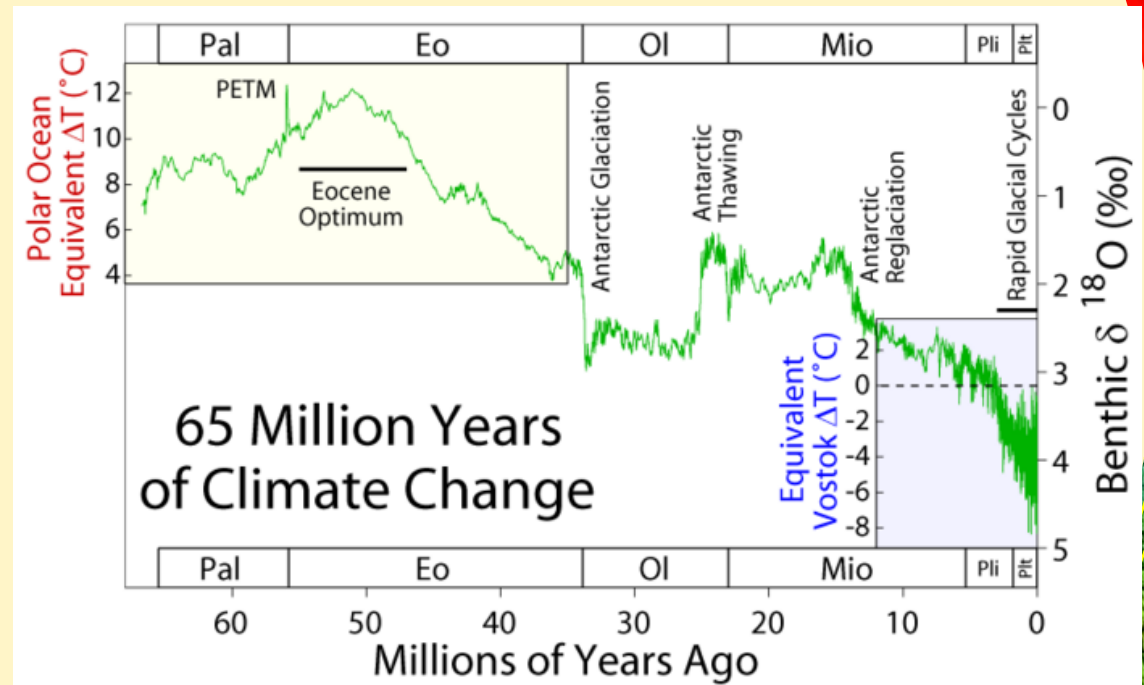
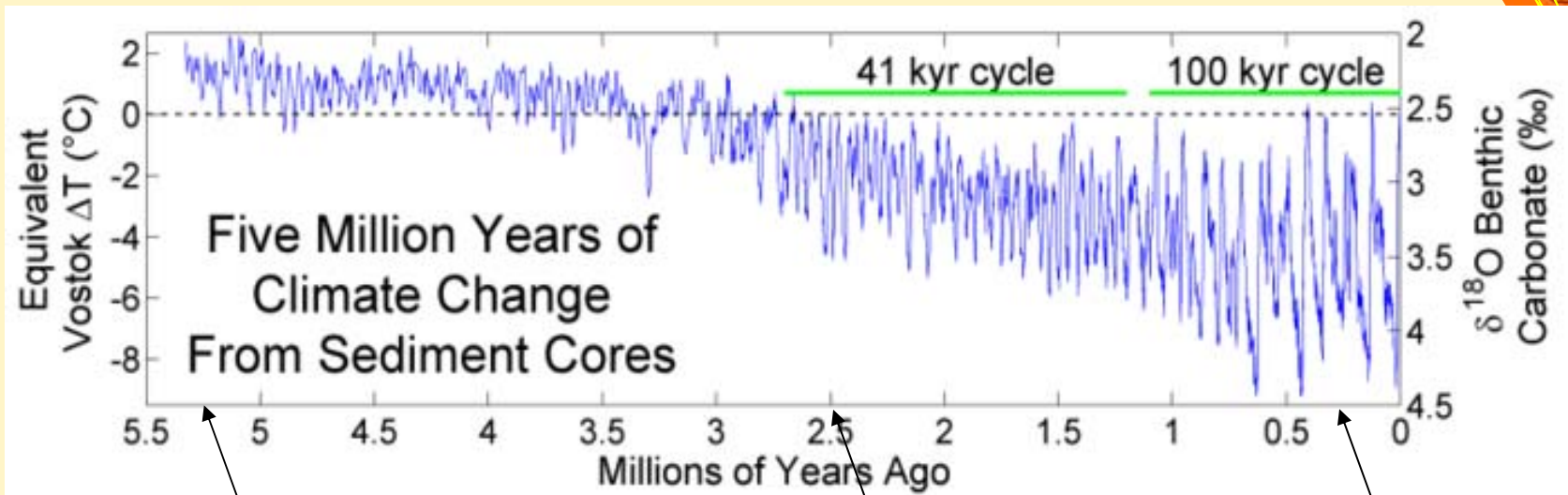


Image Courtesy of Global Warming Art

[http://www.globalwarmingart.com/wiki/Image:65\\_Myr\\_Climate\\_Change\\_Rev.png](http://www.globalwarmingart.com/wiki/Image:65_Myr_Climate_Change_Rev.png)

# Humans in climate change



Earliest  
australopithecines

Genus  
Homo

Homo  
sapiens

Image Courtesy of Global Warming Art

[http://www.globalwarmingart.com/wiki/Image:Five\\_Myr\\_Climate\\_Change\\_Rev\\_png](http://www.globalwarmingart.com/wiki/Image:Five_Myr_Climate_Change_Rev_png)

# Recent climate changes

## Big oscillations

- Glacial – interglacial cycles
  - Ice ages
  - ?extinctions
  - evolution
- Sources
  - O18-16 ratios
  - Ice core gas inclusions
  - Sediment core fossils

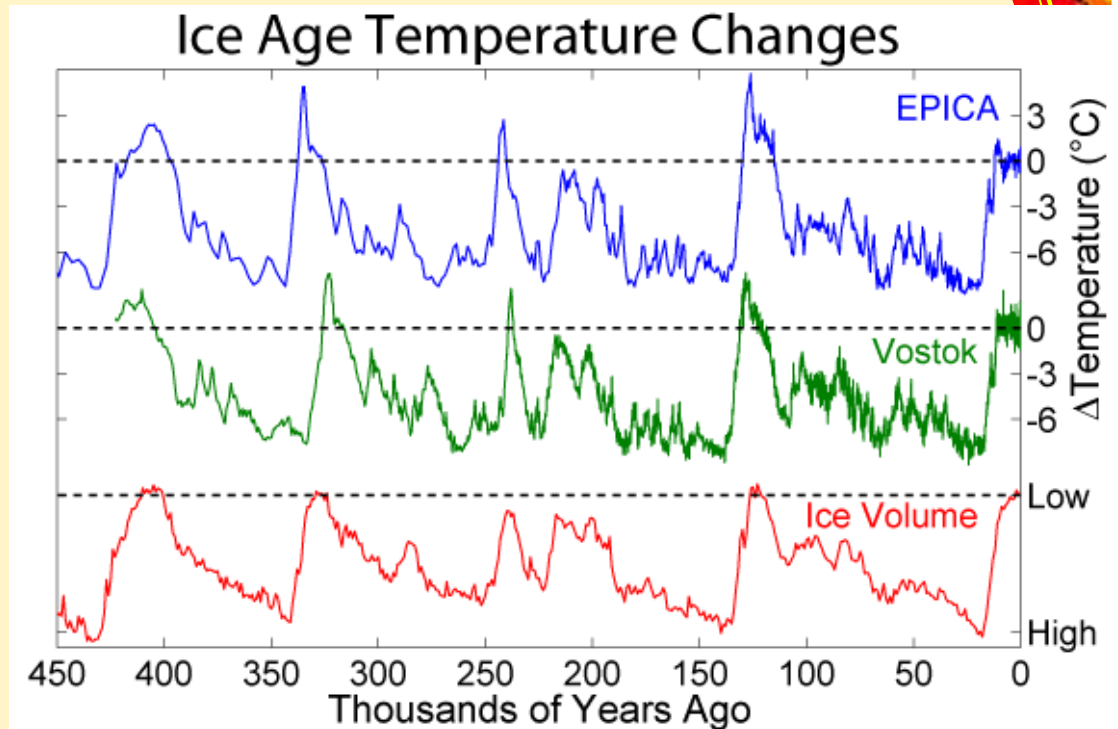


Image Courtesy of Global Warming Art

[http://www.globalwarmingart.com/wiki/Image:Ice\\_Age\\_Temperature\\_Rev.png](http://www.globalwarmingart.com/wiki/Image:Ice_Age_Temperature_Rev.png)

# Climate change drivers

## Beyond Earth

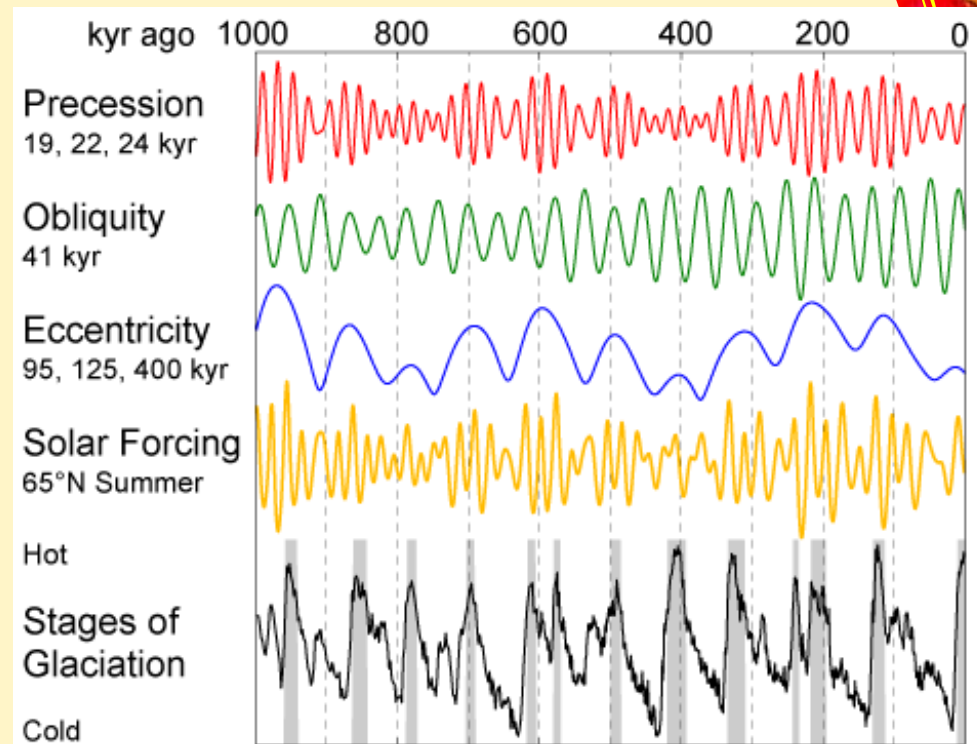
- Solar radiance
- Orbital variance – Milankovitch cycles
  - Eccentricity
  - Tilt
  - Precession
- Bolide impacts

## Earthly origins

- Plate Tectonics
- Volcanism
- Evolution - biosphere
- Feedback mechanisms

Image Courtesy of Global Warming Art

[http://www.globalwarmingart.com/wiki/Image:Milankovitch\\_Variations.png](http://www.globalwarmingart.com/wiki/Image:Milankovitch_Variations.png)



# Ancient Climates

## Ice Free Earth

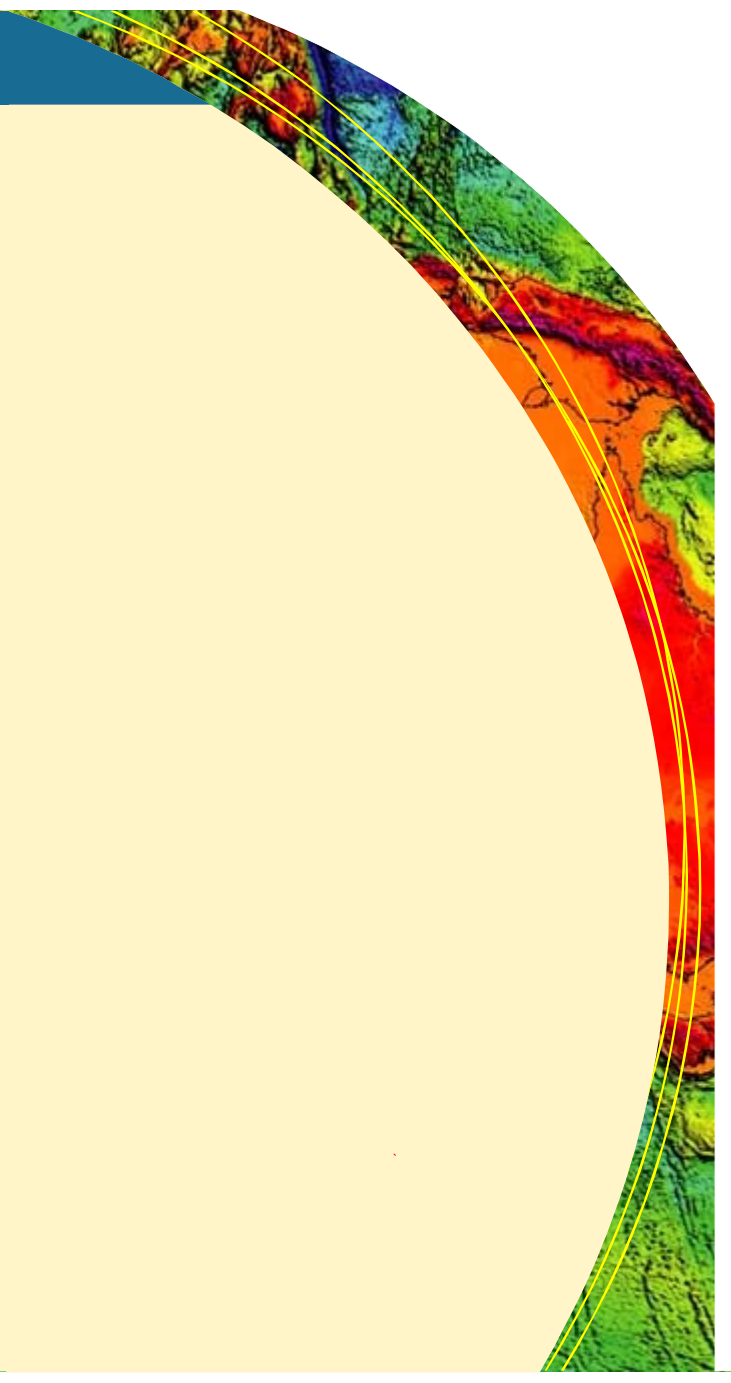
- Late Cretaceous
  - Happy dinosaurs and other things
  - High CO<sub>2</sub> levels
  - No significant polar ice
  - Very warm oceans
  - Very high sea levels
- Feedback
  - Anoxic ocean events
  - Extinctions
  - Cooling as C locked away



Image courtesy freeimages.com

# End of Part 1:

Questions?





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