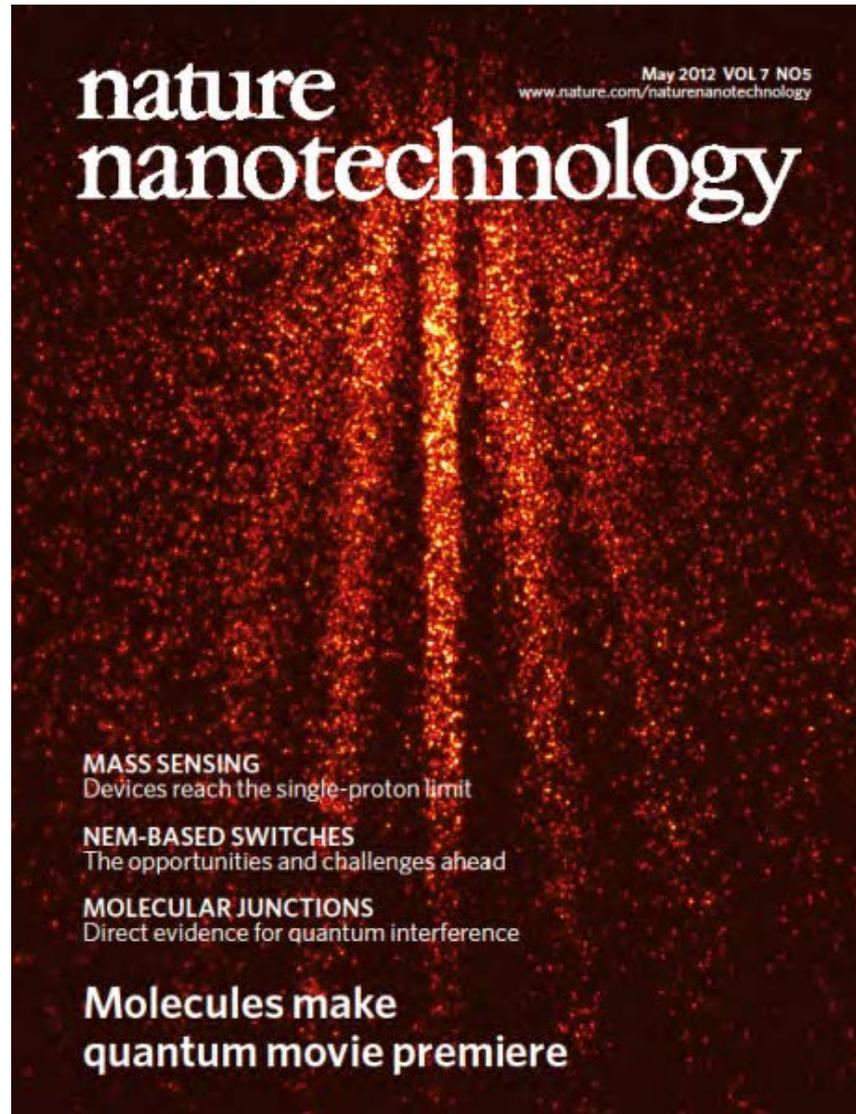


## Far-field diffraction of larger molecules [2,4]

- Phthalocyanine P<sub>c</sub>H<sub>2</sub> (red):  
Highly fluorescent dye, thermally stable
- Perfluoro-alkylated phthalocyanines (green):  
Higher masses, high volatility,  
optical properties similar to P<sub>c</sub>H<sub>2</sub>.

[http://www-lpl.univ-paris13.fr/icap2012/docs/Juffmann\\_poster.pdf](http://www-lpl.univ-paris13.fr/icap2012/docs/Juffmann_poster.pdf)

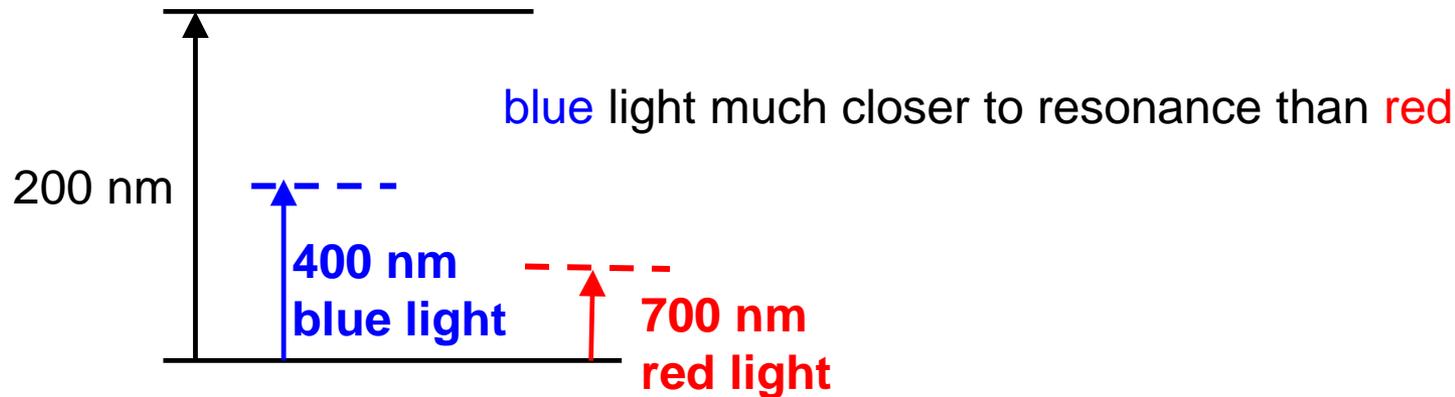
[http://www.youtube.com/watch?v=NUS6\\_S1KzC8](http://www.youtube.com/watch?v=NUS6_S1KzC8)



# Why is the sky **BLUE**, but sunsets are **RED**?

This question may be on the Final Exam (demo with pendulums)

**N<sub>2</sub>** and **O<sub>2</sub>** are small. Therefore quantum electron energy levels are spaced far apart: They absorb at 200 nm, far in UV



Rayleigh scattering efficiency increases as  $\lambda^{-4}$

$$(700/400)^4 = 9.4$$

so blue light scatters far more than red;

The scattered sunlight is **greatly enriched in blue**

Light emitted by all objects not at 0 Kelvin.

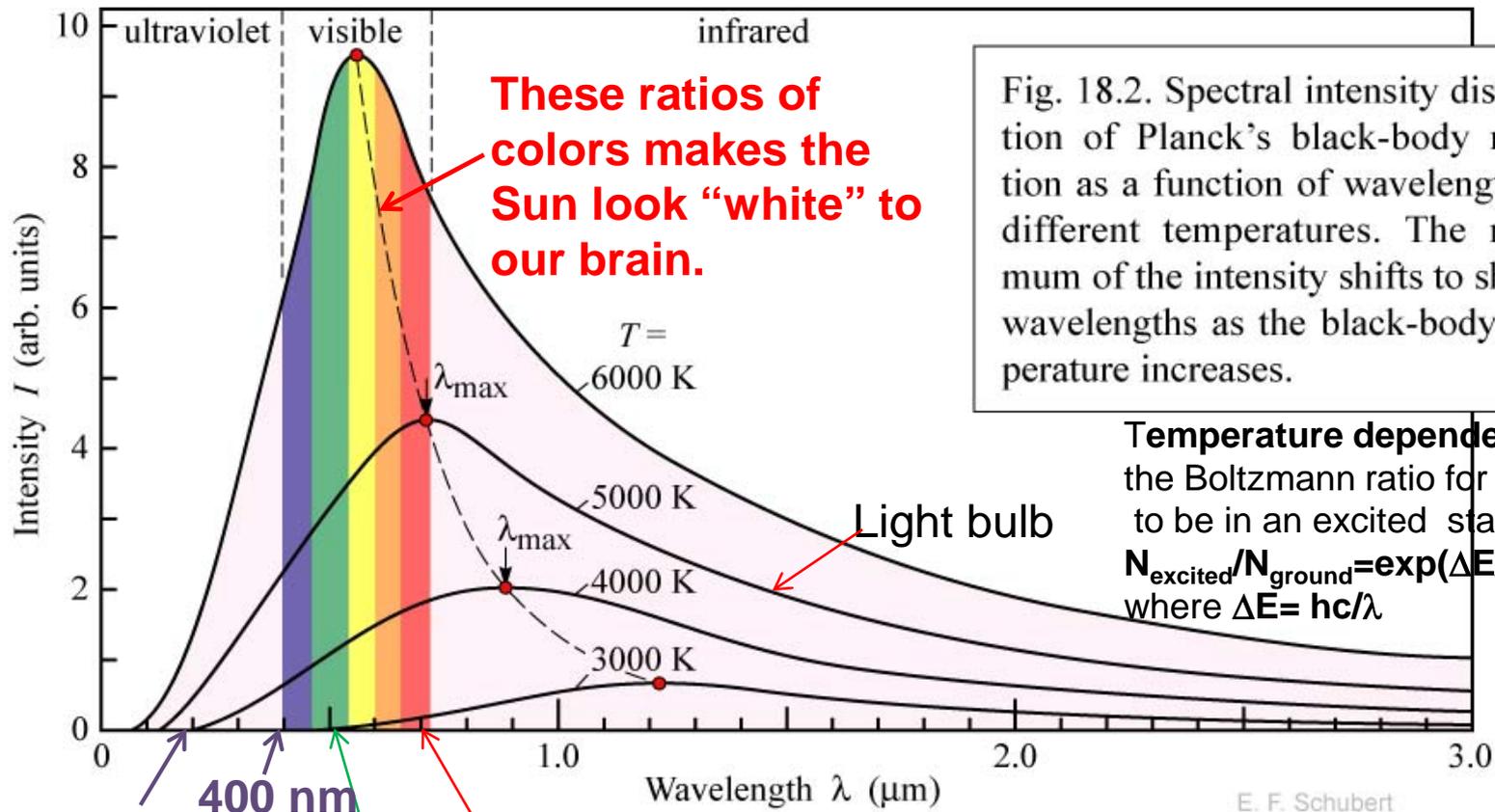


Fig. 18.2. Spectral intensity distribution of Planck's black-body radiation as a function of wavelength for different temperatures. The maximum of the intensity shifts to shorter wavelengths as the black-body temperature increases.

**These ratios of colors makes the Sun look "white" to our brain.**

**Temperature dependence** is from the Boltzmann ratio for probability to be in an excited state:  

$$N_{\text{excited}}/N_{\text{ground}} = \exp(\Delta E/k_B T)$$
 where  $\Delta E = hc/\lambda$

Light bulb

**200 nm**  
 Where N<sub>2</sub> and O<sub>2</sub> start to absorb

**400 nm**

**500 nm**

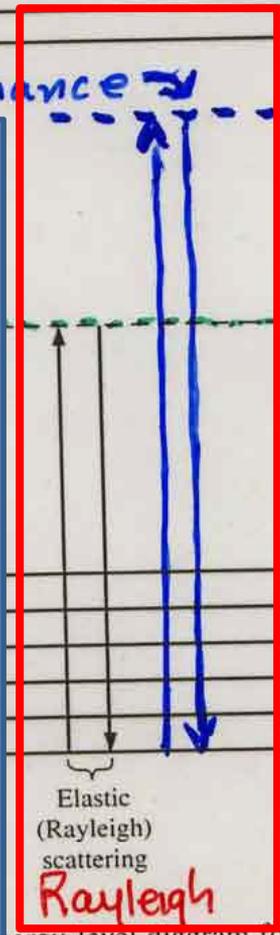
**700 nm**

E. F. Schubert  
 Light-Emitting Diodes (Cambridge Univ. Press)  
[www.LightEmittingDiodes.org](http://www.LightEmittingDiodes.org)

**FIG 10.27**

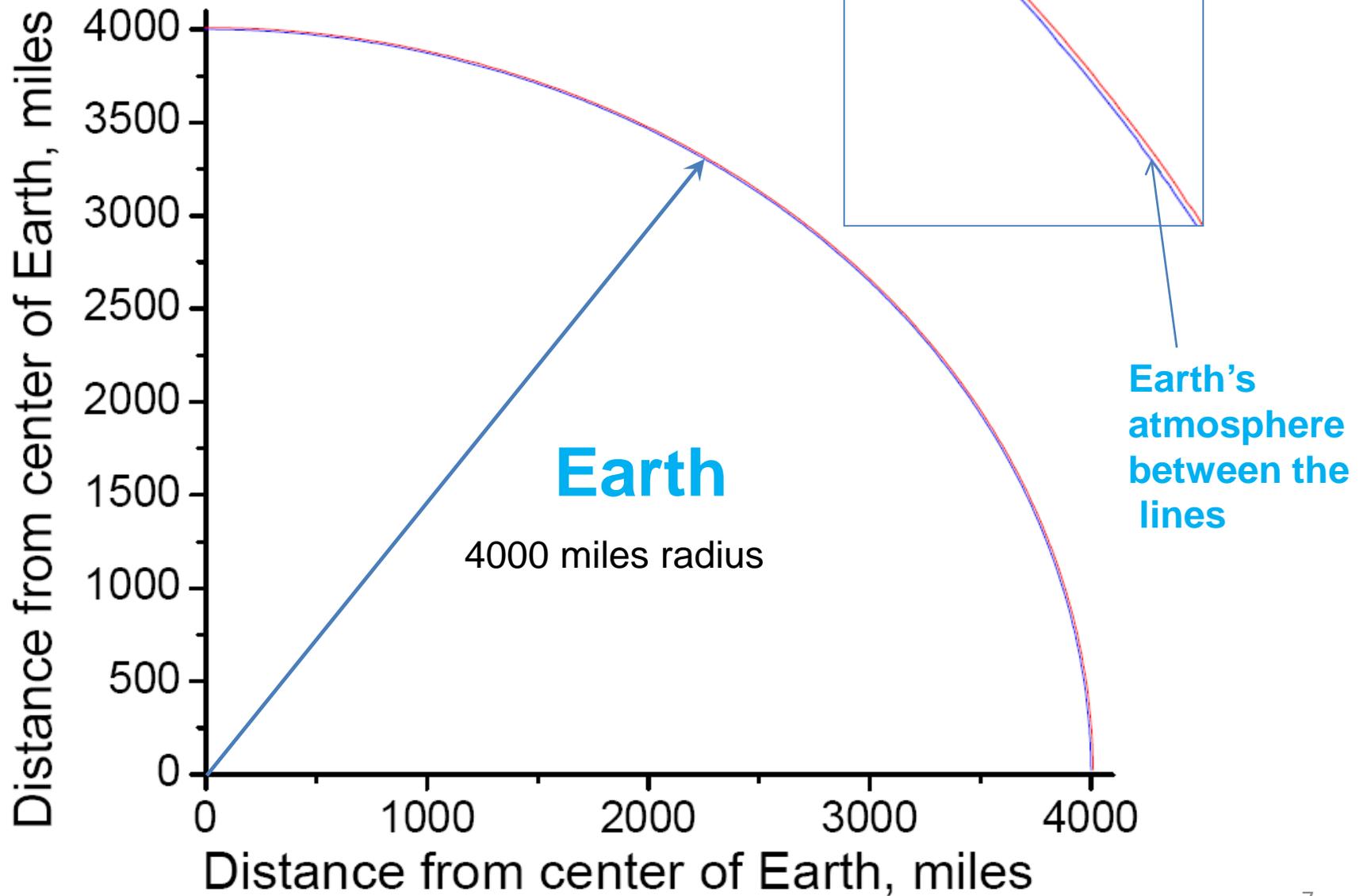
scattering

Closer to resonance



energy-level diagram for  
inelastic (Raman) scatter  
the ground electronic state  
transitions are allowed. For elastic scattering  
equal to the frequency of the scattered  
frequency of the scattered light is different  
initial state shown can have any energy; t  
of the spectrum.

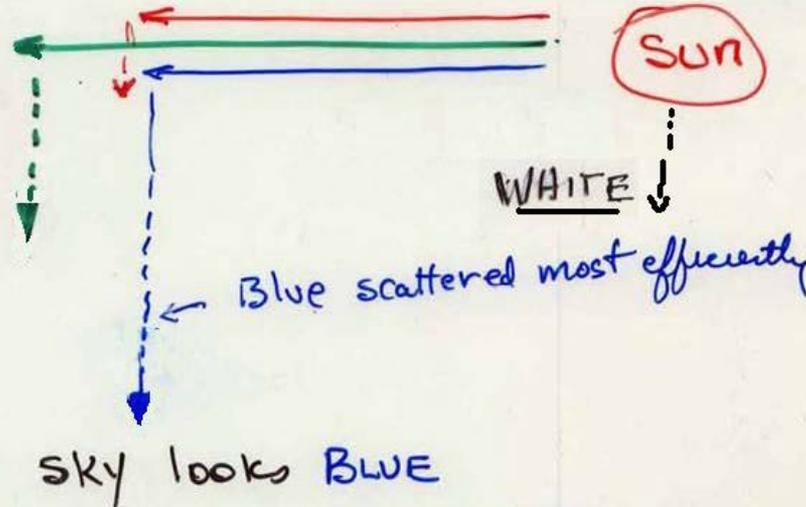
1. The *pertinent* atmosphere is very thin (from here to Belgrade)





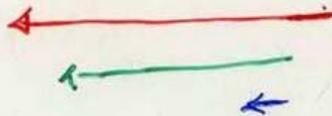
[Space Shuttle Endeavour](#) appearing to straddle the stratosphere and mesosphere. The orange layer is the [troposphere](#), which gives way to the whitish [stratosphere](#) and then the blue [mesosphere](#).<sup>[14]</sup> (Why is the troposphere reddish?)

“White” light is a mix of red, green, and blue



WHAT IS TRANSMITTED ?

If blue is scattered most, and red least, more red is transmitted



LOOKS REDDISH at SUNSET, but..

why does SUN look white at noon ?

Why is steam white, but smoke and viruses are often bluish?

# Selected Essentials of Climate Physical Chemistry

1. The **pertinent** atmosphere is very thin (from here to Belgrade)
2. The **pertinent** ocean is very thin (only the top layer appears to be important for the next 1000 years)
3. The CO<sub>2</sub> level is going to rise to much higher levels, **unless something very unexpected** is discovered. This **suggests** that temperatures will continue to rise, because CO<sub>2</sub> is a “greenhouse gas”.
4. The Earth cools itself by fluorescing infra-red radiation in the region of 10 μm ( 1000 cm<sup>-1</sup>)—just where water molecules do not absorb.
5. “Greenhouse” in this context means that CO<sub>2</sub> (also CH<sub>4</sub>) absorbs IR in this same “ frequency window of cooling”, thereby intercepting radiation that would have left the planet, and sending some of it back to earth.
6. The Arctic ice has been melting for 10,000 years. This was not caused by humans, but we may be hastening the process now. --Callis

# Selected slides on climate change, greenhouse effect, and global warming

## Links:

<http://www.aip.org/history/climate/index.htm#contents>

<http://www.aip.org/history/climate/summary.htm>

<http://www.aip.org/history/climate/co2.htm>

[http://en.wikipedia.org/wiki/Climate\\_change](http://en.wikipedia.org/wiki/Climate_change)

[http://en.wikipedia.org/wiki/global\\_warming](http://en.wikipedia.org/wiki/global_warming)

## [ericgrimsrud](http://ericgrimsrud.org/)

On the science and implications of climate  
change

<http://ericgrimsrud.org/>

<http://ericgrimsrud.org/scientific-basics/>

# Our Atmosphere and its Essential Functions

- (1) filters out UV light
- (2) regulates surface temperatures
- (3) cleans itself
- (4) others?

**Note: The atmosphere is NOT very deep!**

Air pressure halves every 3.4 mi

**1 bar at sea level**

**0.5 bar at 3.4 miles**

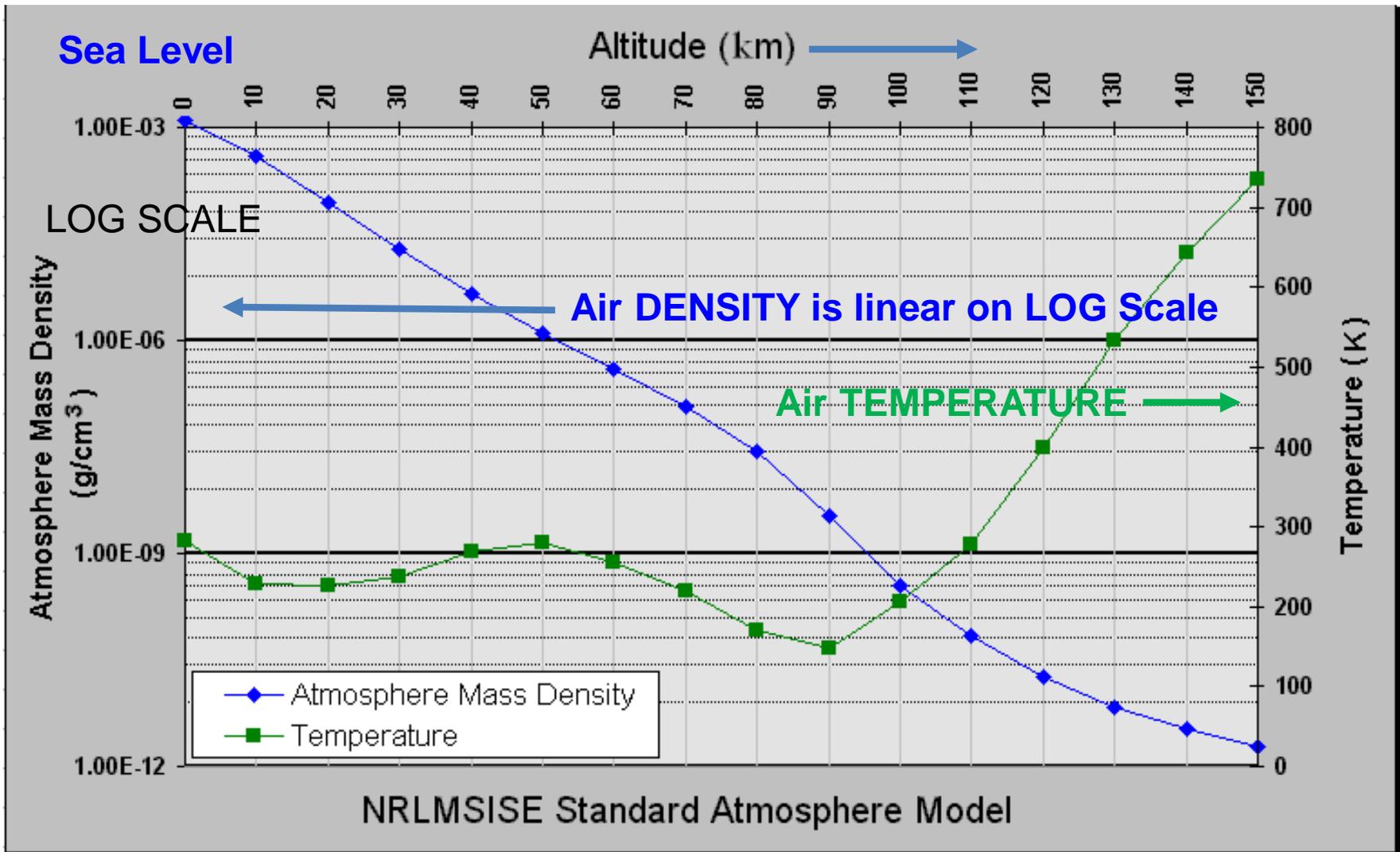
**0.25 bar at 6.8 miles**

**0.125 bar at 10.2 miles**

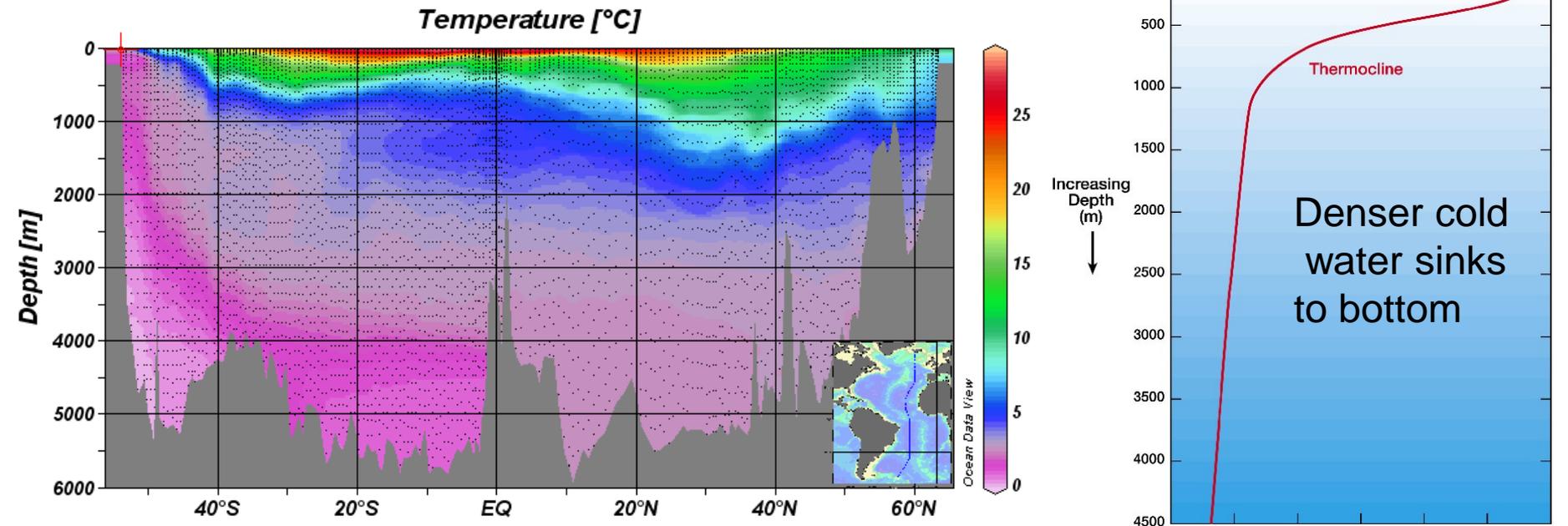
(About the distance to Belgrade)



# The Atmosphere is layered



# The Ocean is layered

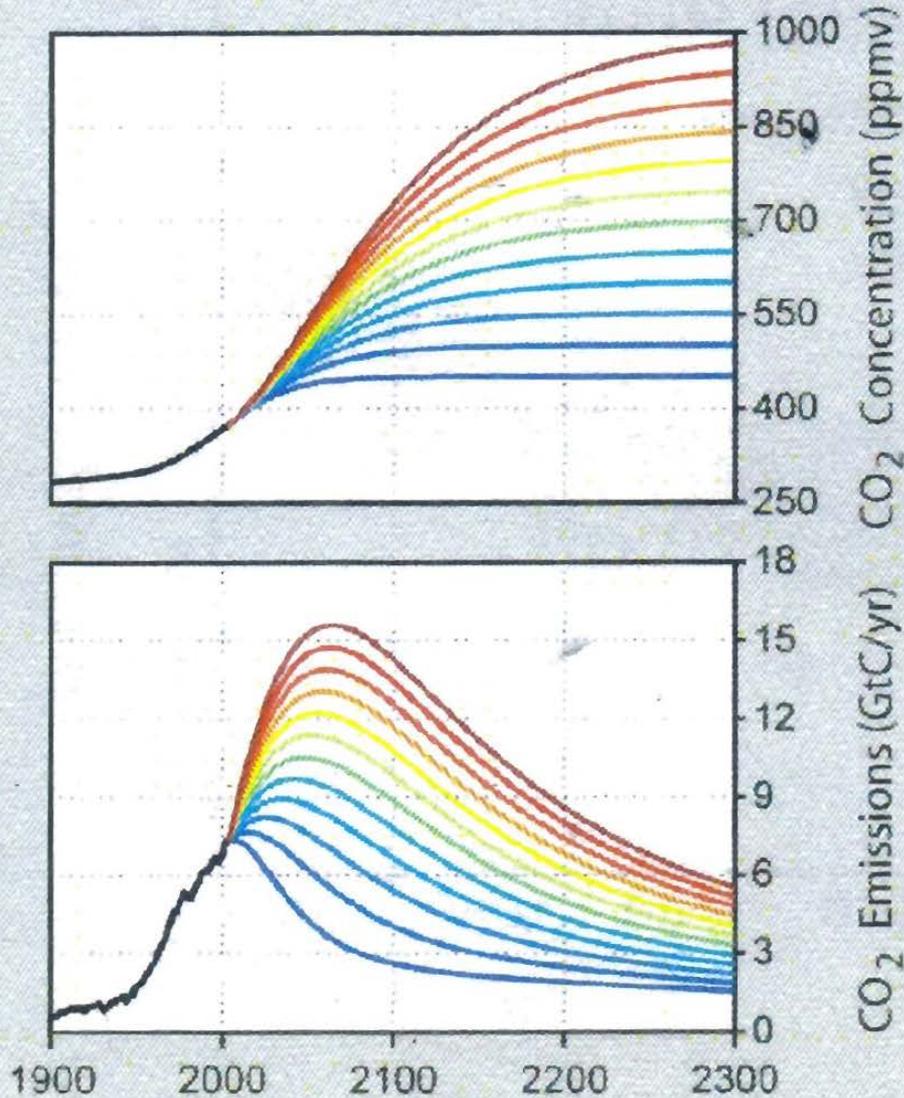


This is a simple temperature-depth ocean water profile. You can see temperature **decreases with increasing depth**.

Mixing of the thin top layer with the vast deeper bulk takes **~1000 years!**

*Windows to the Universe original image*

## Carbon Dioxide Stabilization

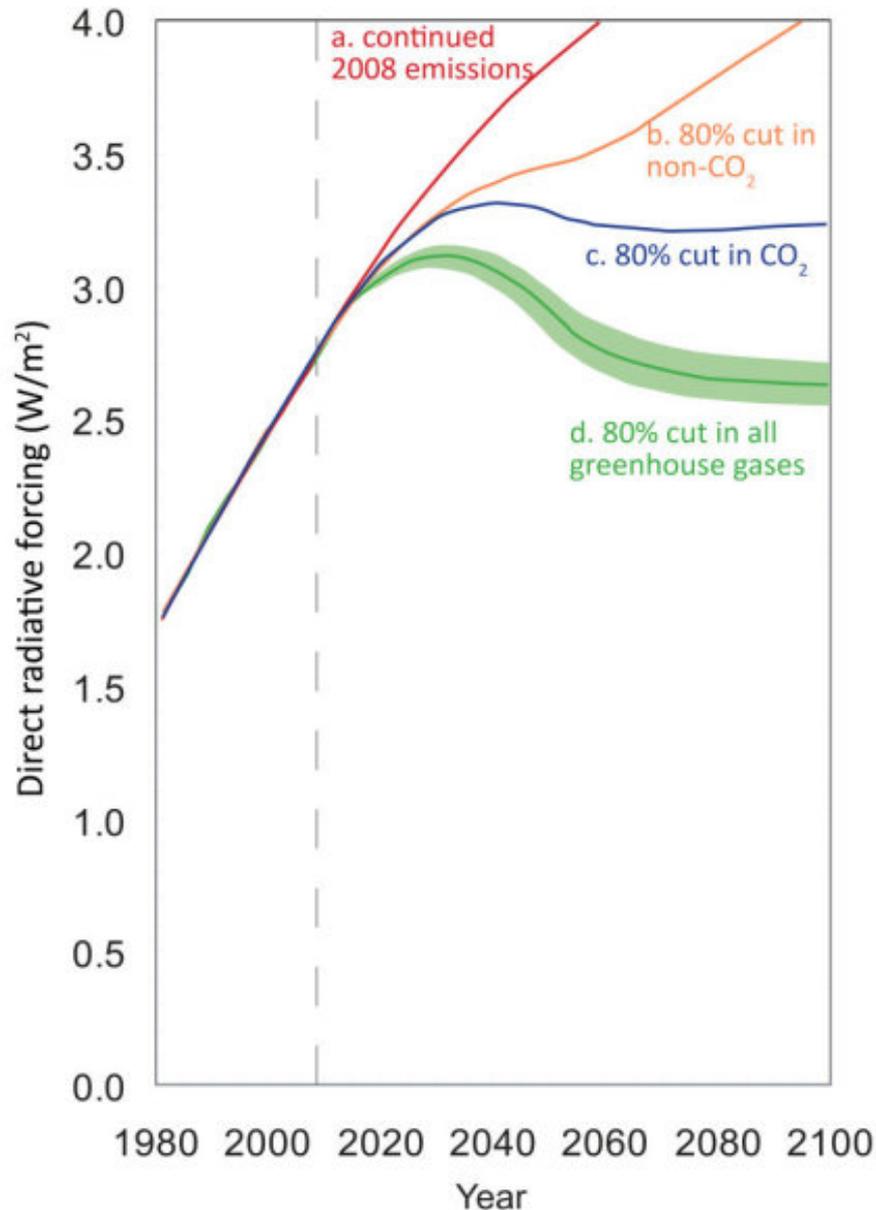


## NOTE:

The CO<sub>2</sub> “overload” due to the extra CO<sub>2</sub> put into the biological cycle by the combustion of fossil fuels has a very long lifetime, on the order of a millennium.

What we decide to do in the coming decades is likely to last for a millennium. That is essentially “forever” on the time scale of western civilization.

## Science News from research organizations



### Long-term Stabilization Of Carbon Dioxide In Atmosphere Will Require Major Cuts In Emissions

Date:

November 3, 2008

Source:

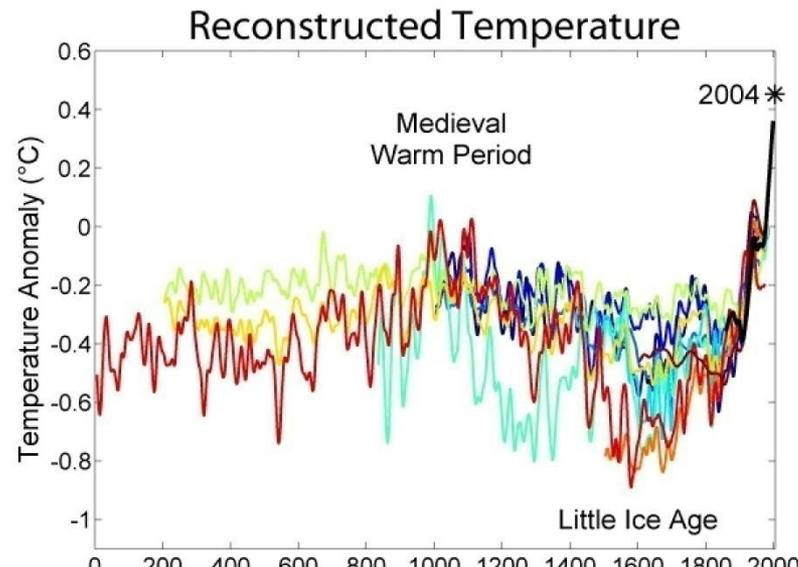
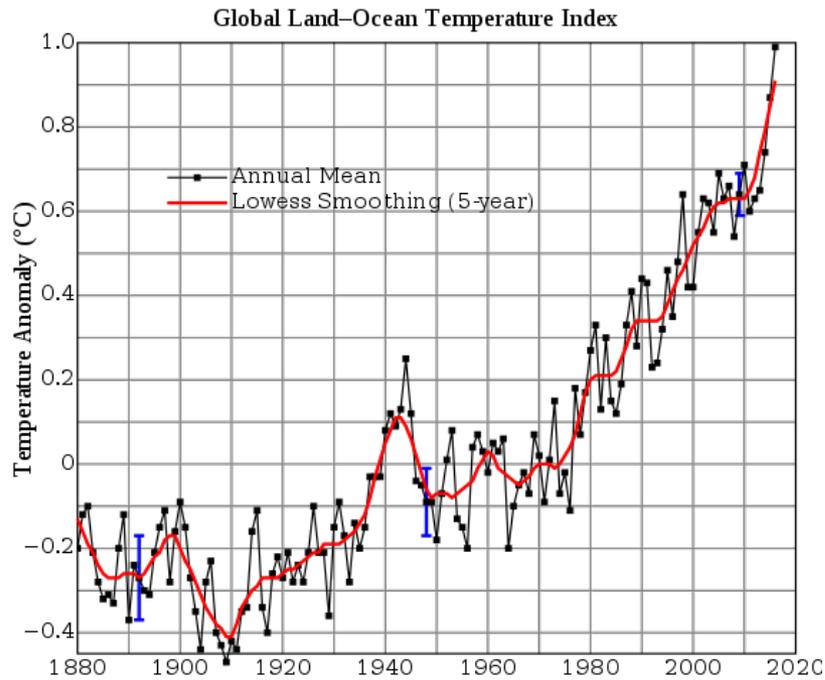
Natural Environment Research Council (NERC)

Summary:

Carbon dioxide, the greenhouse gas that has had the largest impact on our climate, will continue to rise even if current national and international targets for reducing emissions are met, scientists warn.

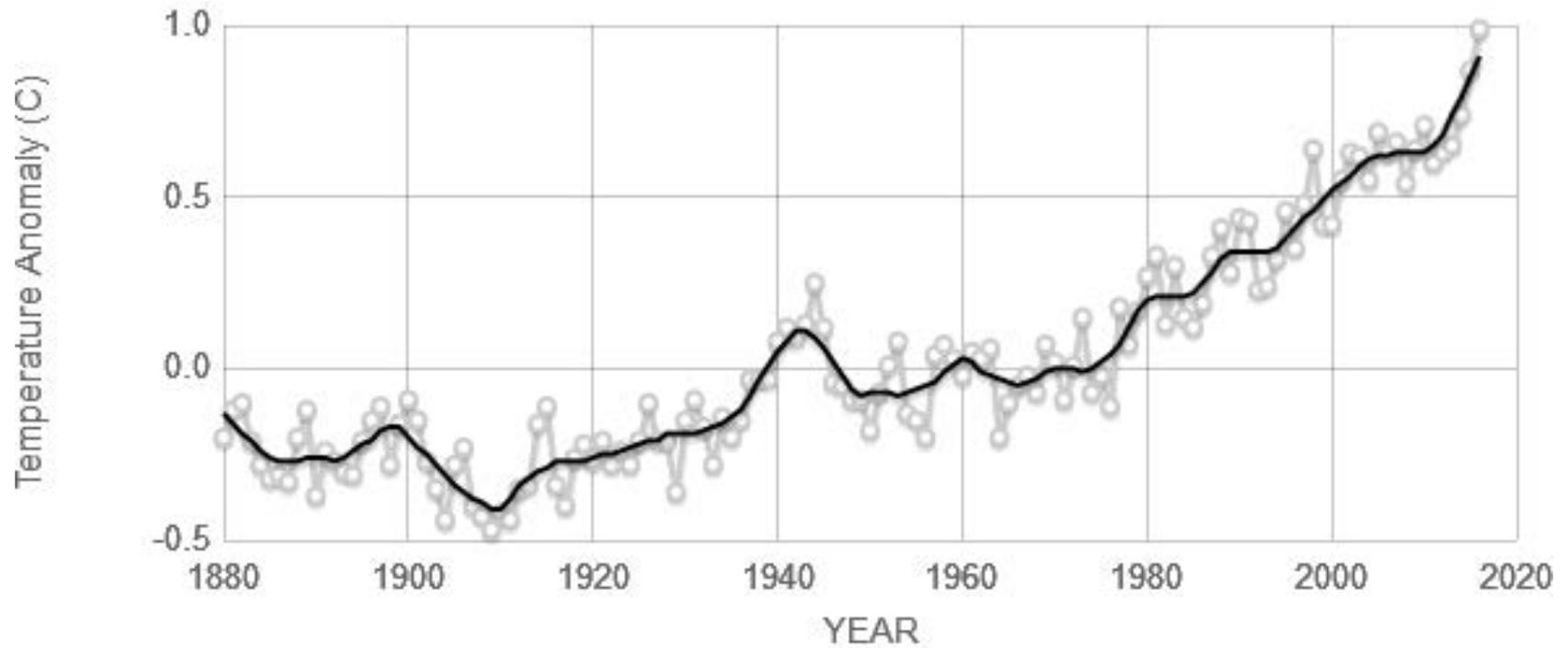
But, they say, strong action taken now – such as the 80% target recently announced by the UK government – will continue to have be

[https://en.wikipedia.org/wiki/Global\\_warming](https://en.wikipedia.org/wiki/Global_warming)

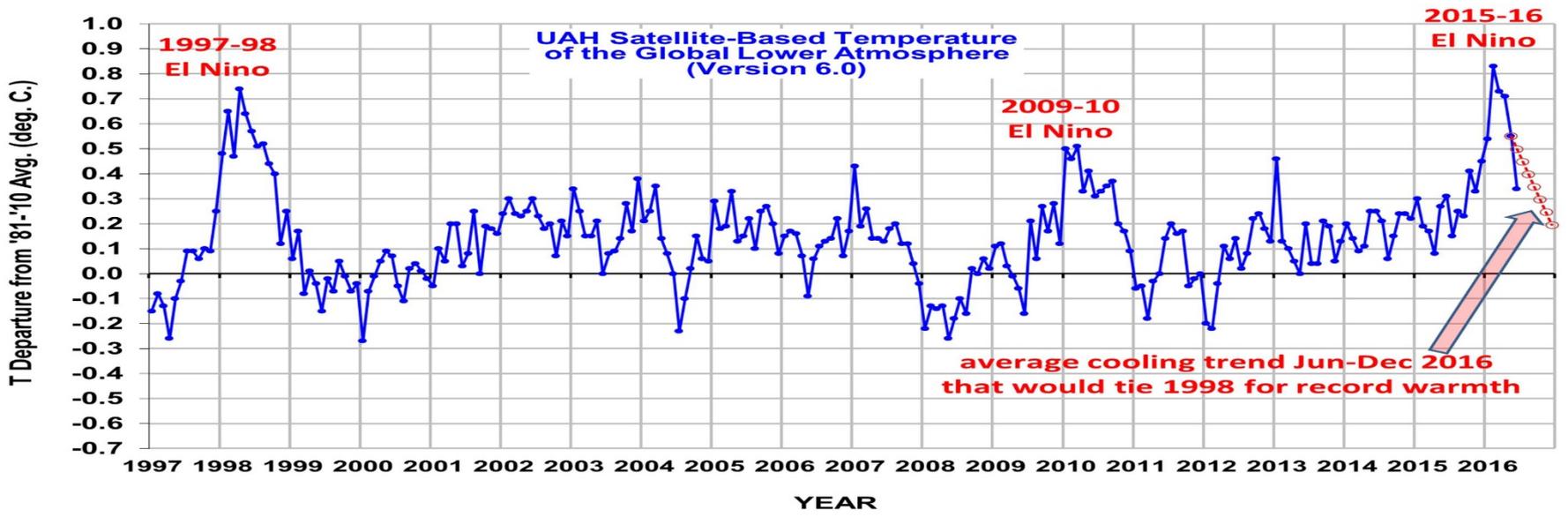
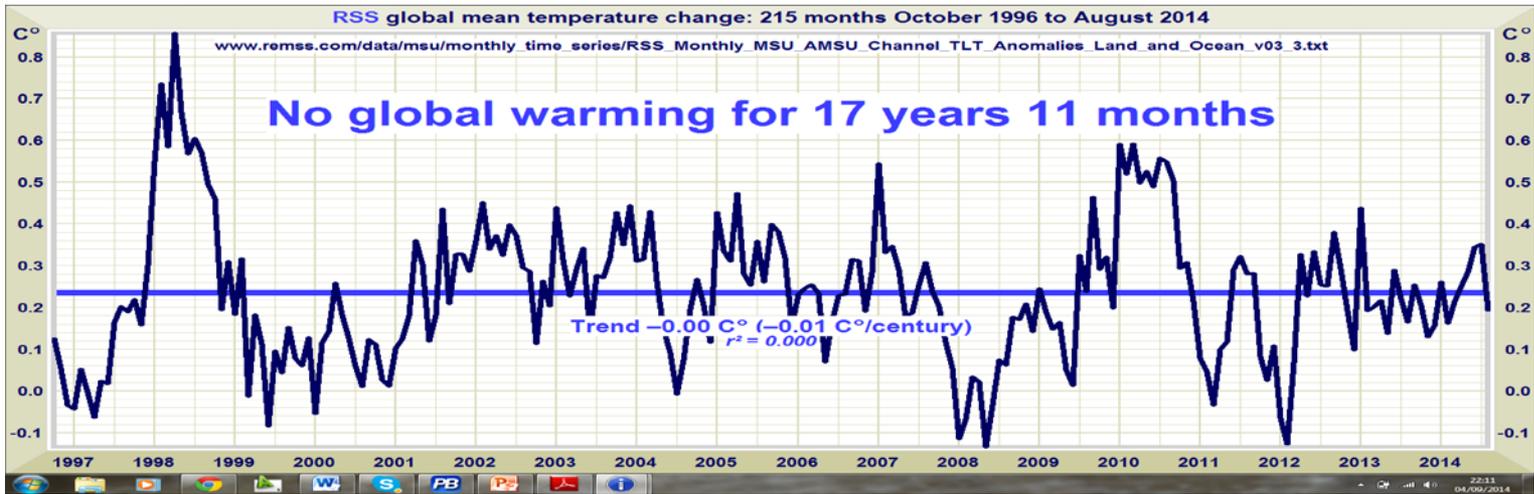


Wikipedia

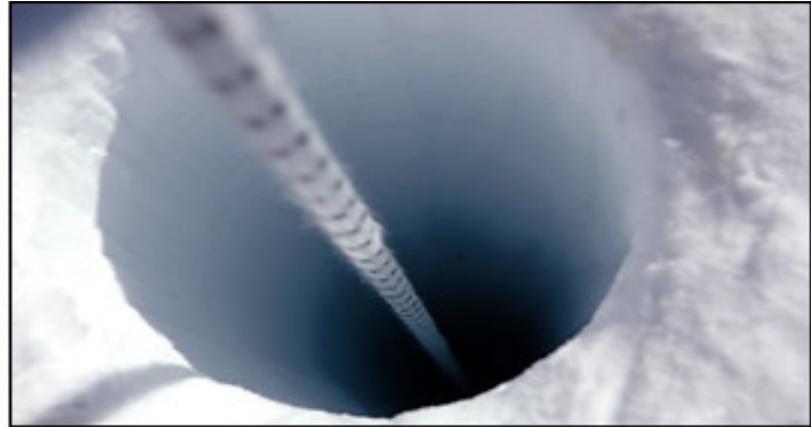
<https://climate.nasa.gov/vital-signs/global-temperature/>



Source: climate.nasa.gov

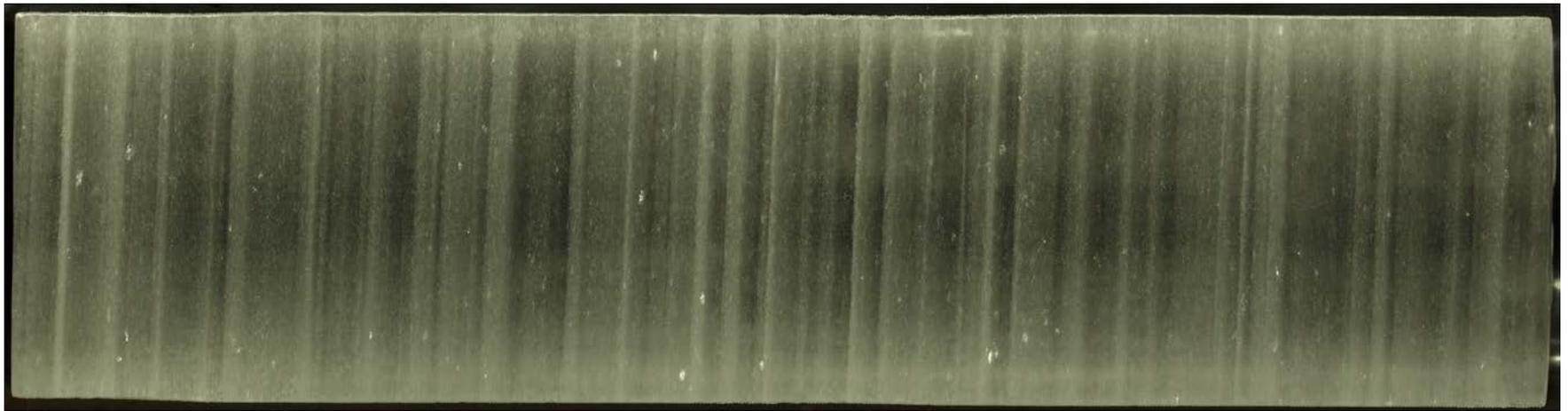


# The Ice Core Record of Antarctica and Greenland



# ice core samples provide a record of the previous 800,000 years

- Taken from both Greenland and Antarctica
- Gases trapped in bubbles include CO<sub>2</sub>, CH<sub>4</sub>, and N<sub>2</sub>O
- Deuterium content in water indicates Temperature  
(that is DHO content in H<sub>2</sub>O)



Cores are about 6 inches in diameter by several miles long.

Note the “fast” (1000 year) temperature rise and melting near the peaks

