

# The Greenhouse Effect

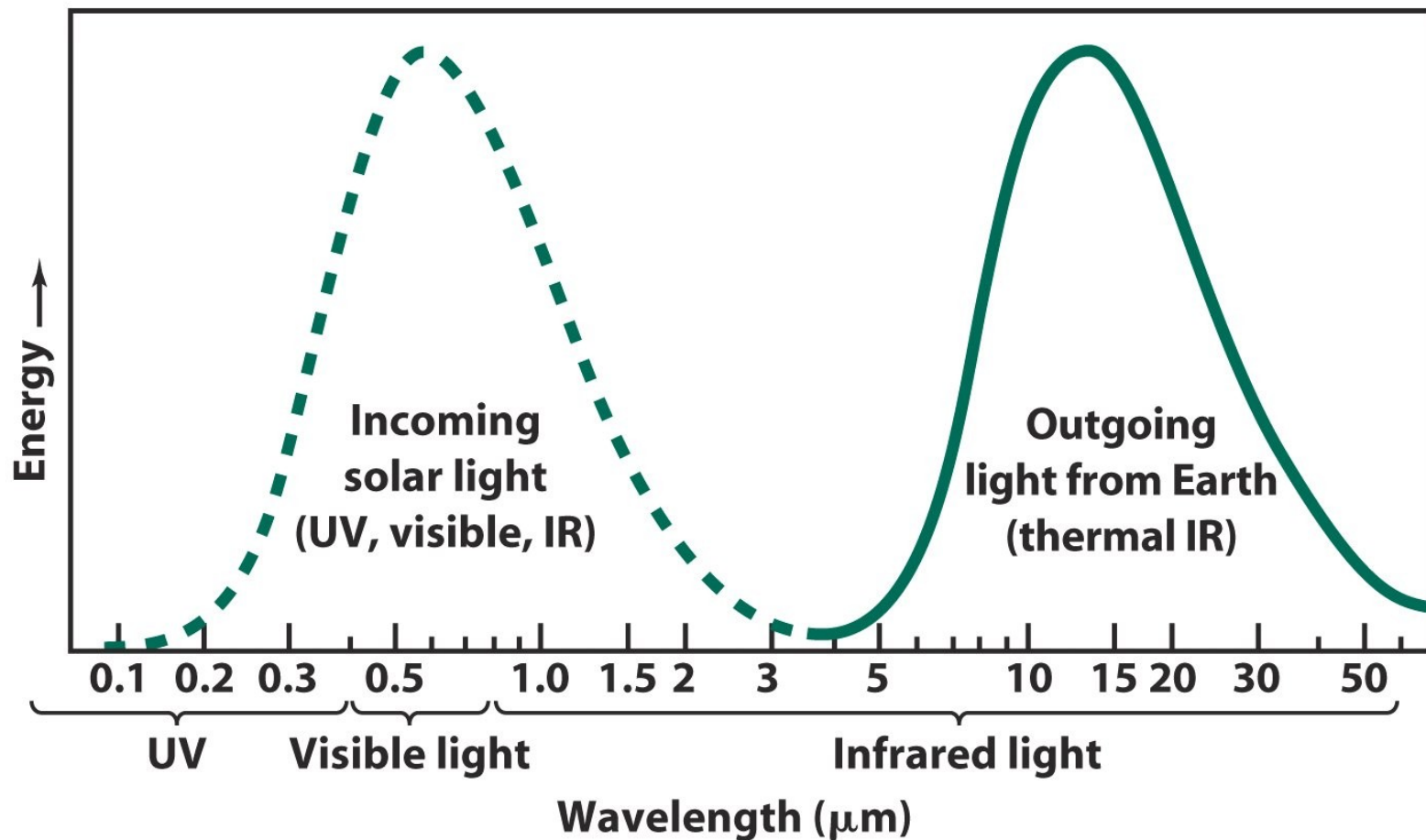
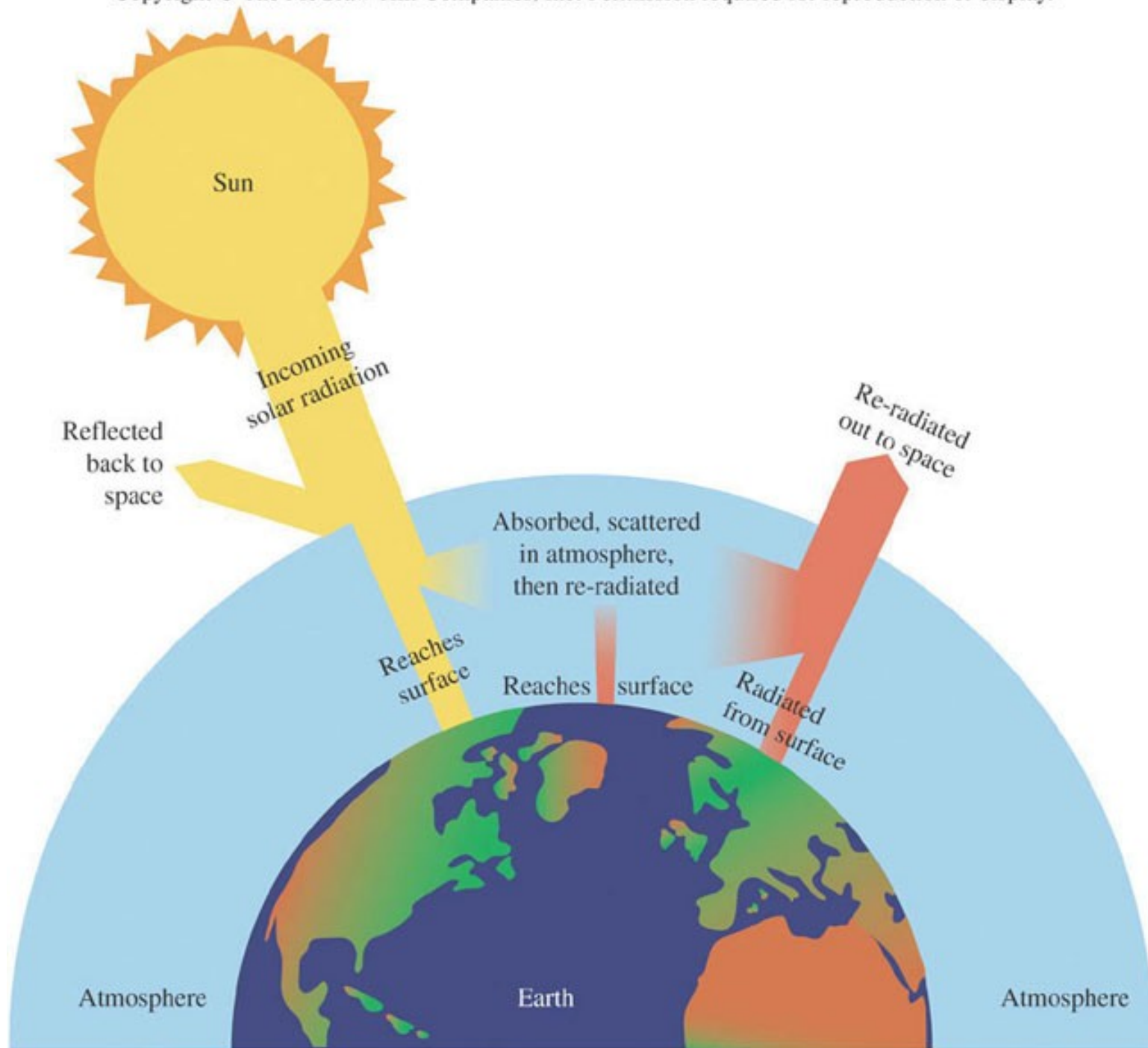


Figure 4-1  
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**Blackbodies emit a broad spectrum centered around  $\lambda_{\max} = 2897/T$**

$$\lambda_{\max}(\text{sun}) = \lambda_{\max}(5800\text{K}) = 0.50 \mu\text{m}$$

$$\lambda_{\max}(\text{earth}) = \lambda_{\max}(300\text{K}) = 10 \mu\text{m}$$



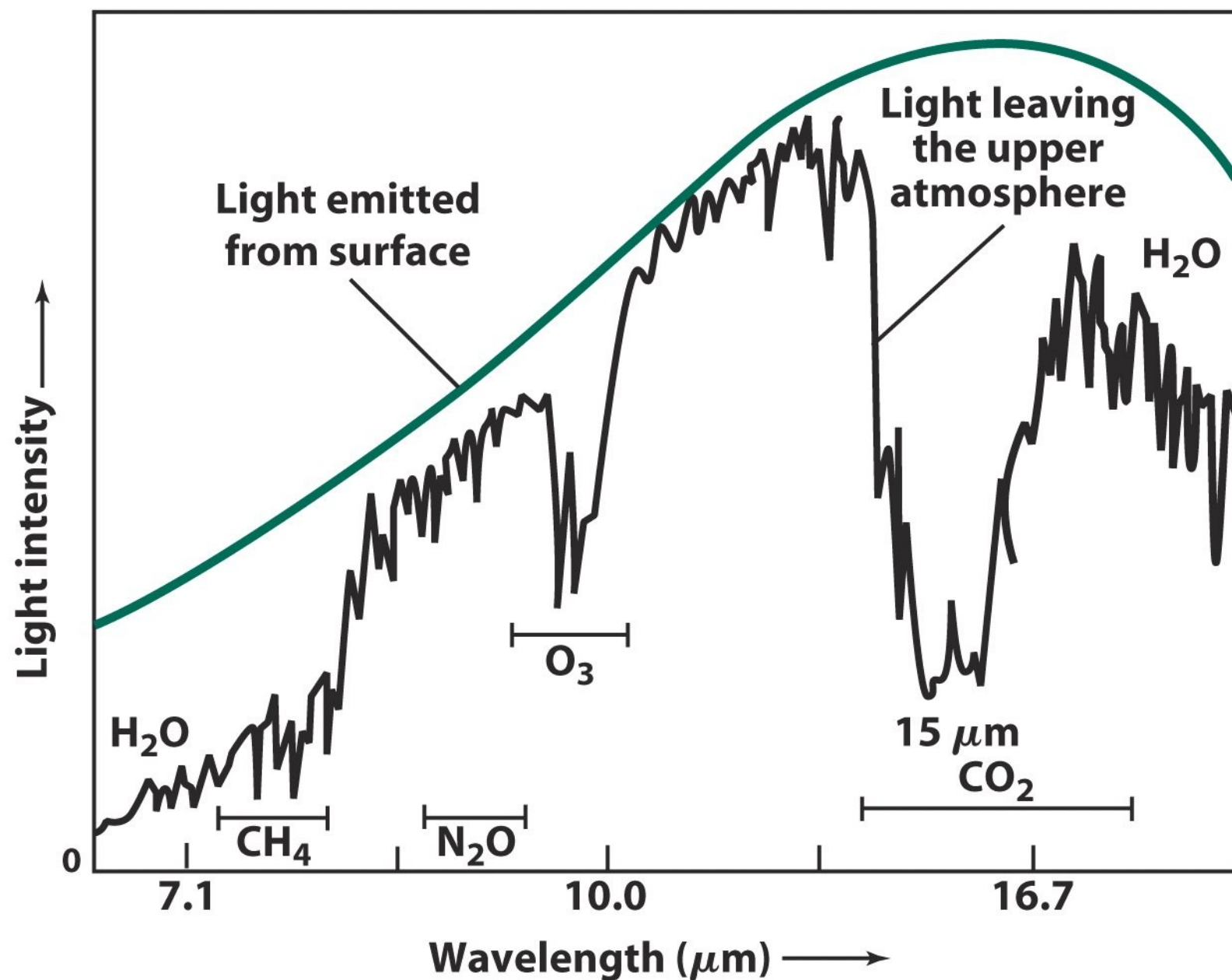
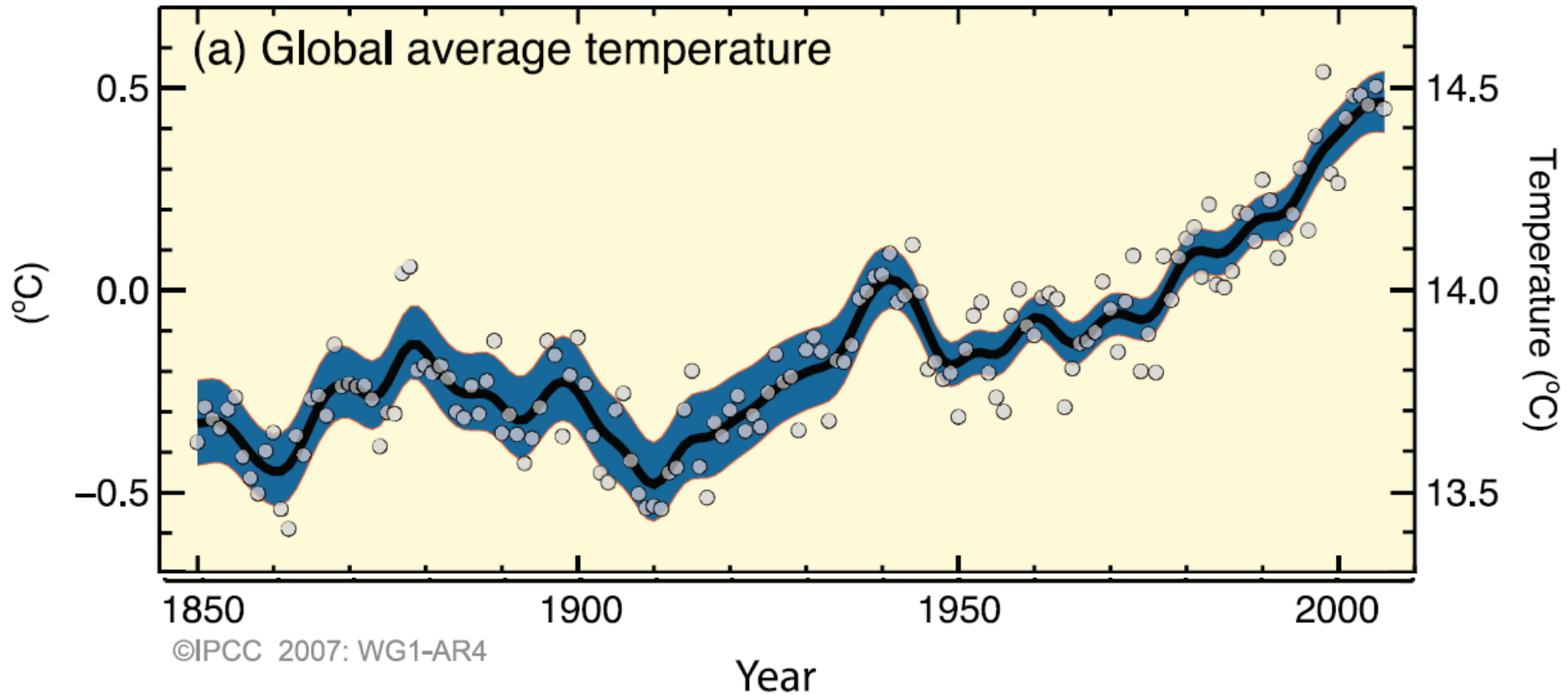


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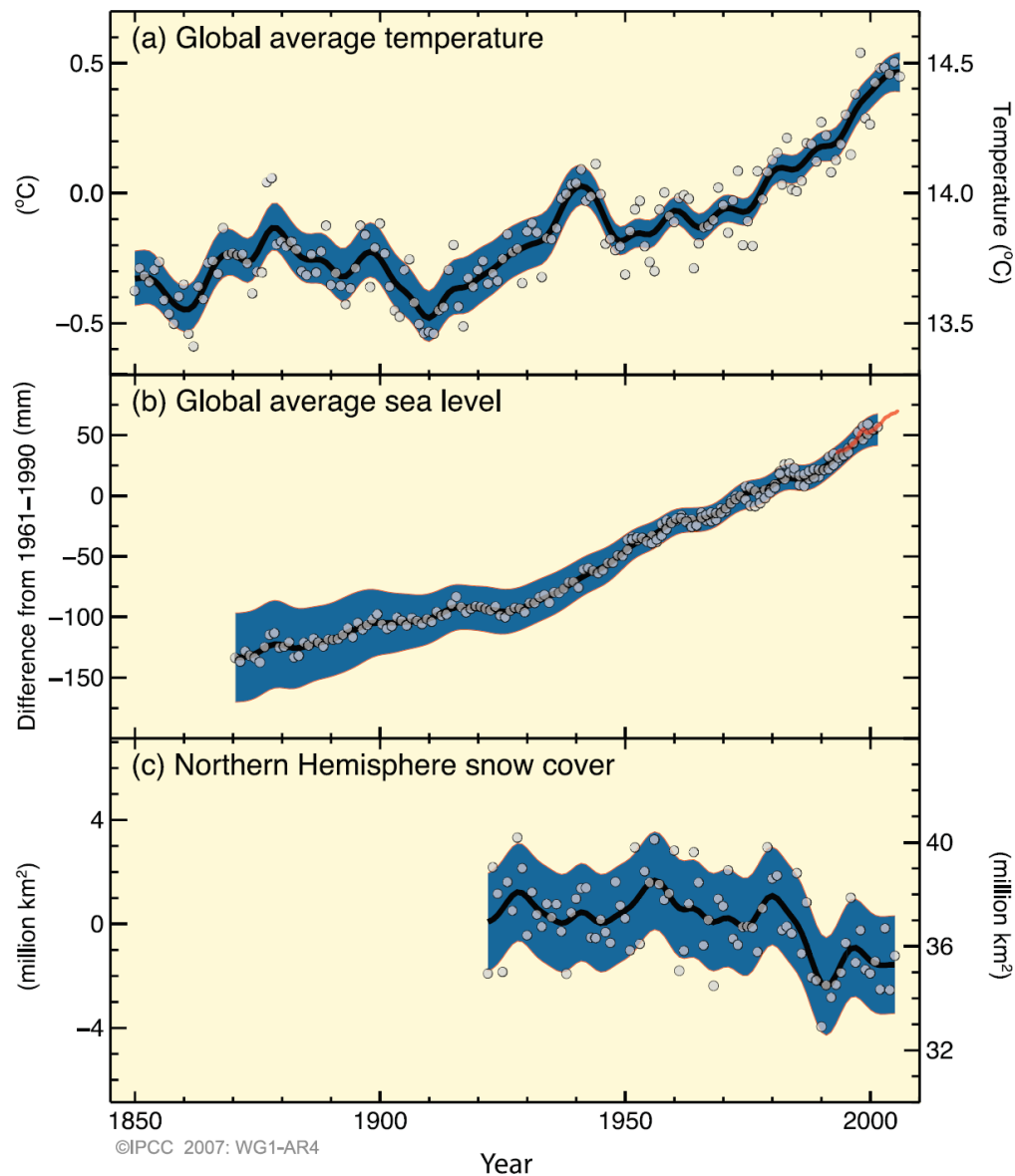
**Ok, so that's the Greenhouse Effect.**

**What's global warming?**

## CHANGES IN TEMPERATURE, SEA LEVEL AND NORTHERN HEMISPHERE SNOW COVER



**This is global warming**

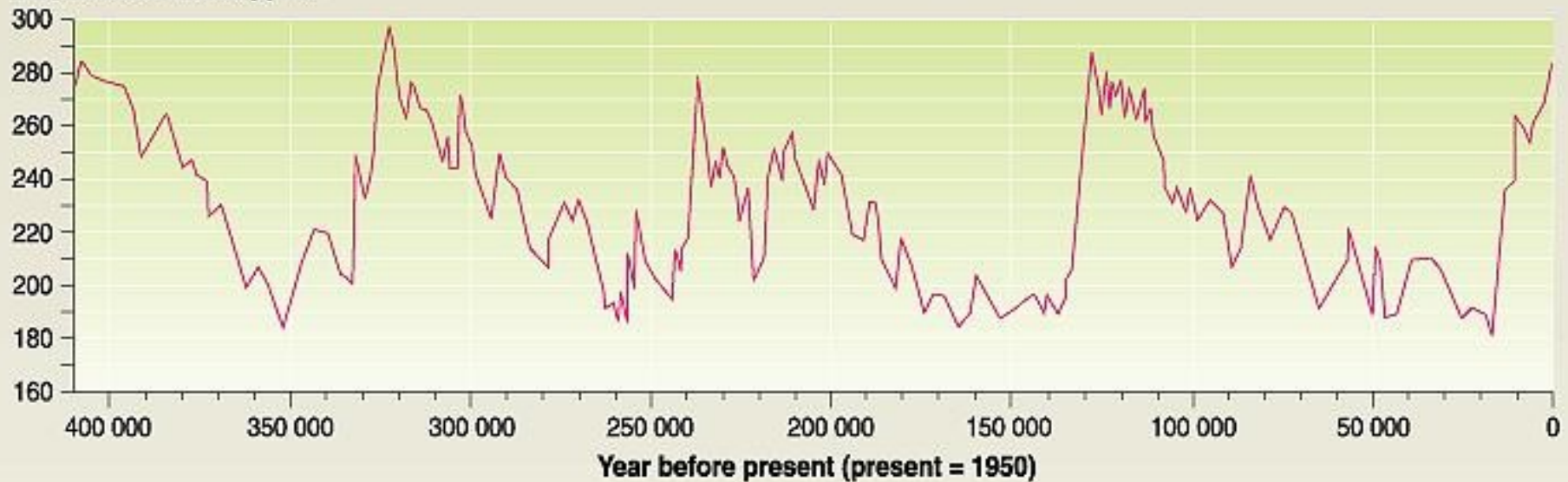


**Figure SPM.3.** Observed changes in (a) global average surface temperature, (b) global average sea level from tide gauge (blue) and satellite (red) data and (c) Northern Hemisphere snow cover for March-April. All changes are relative to corresponding averages for the period 1961–1990. Smoothed curves represent decadal average values while circles show yearly values. The shaded areas are the uncertainty intervals estimated from a comprehensive analysis of known uncertainties (a and b) and from the time series (c). {FAQ 3.1, Figure 1, Figure 4.2, Figure 5.13}

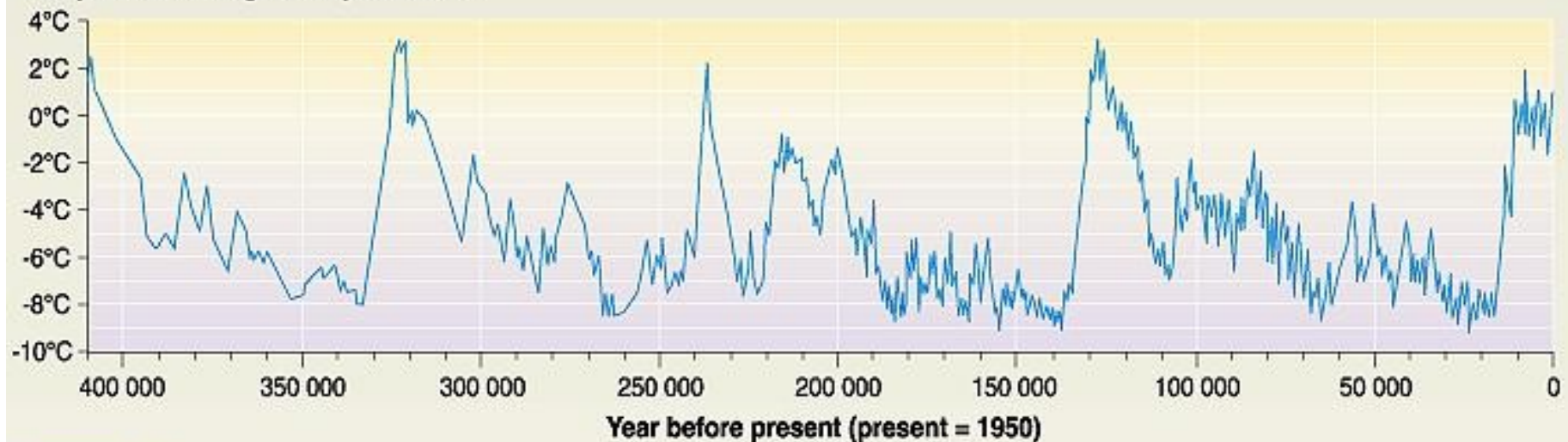


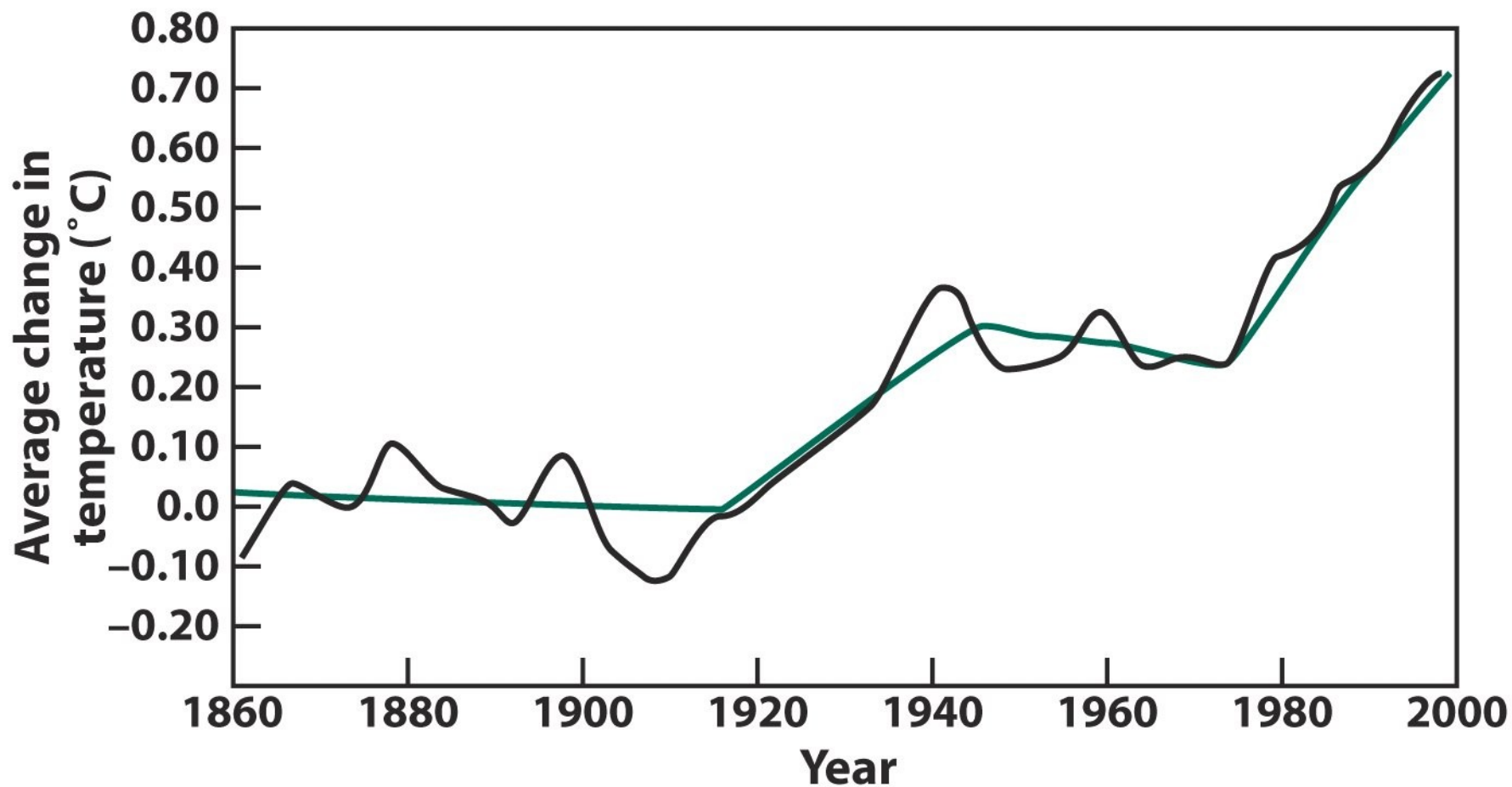
# Temperature and CO<sub>2</sub> concentration in the atmosphere over the past 400 000 years (from the Vostok ice core)

CO<sub>2</sub> concentration, ppmv



Temperature change from present, °C





**Figure 4-2b**  
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## Greenhouse Gases: CO<sub>2</sub>

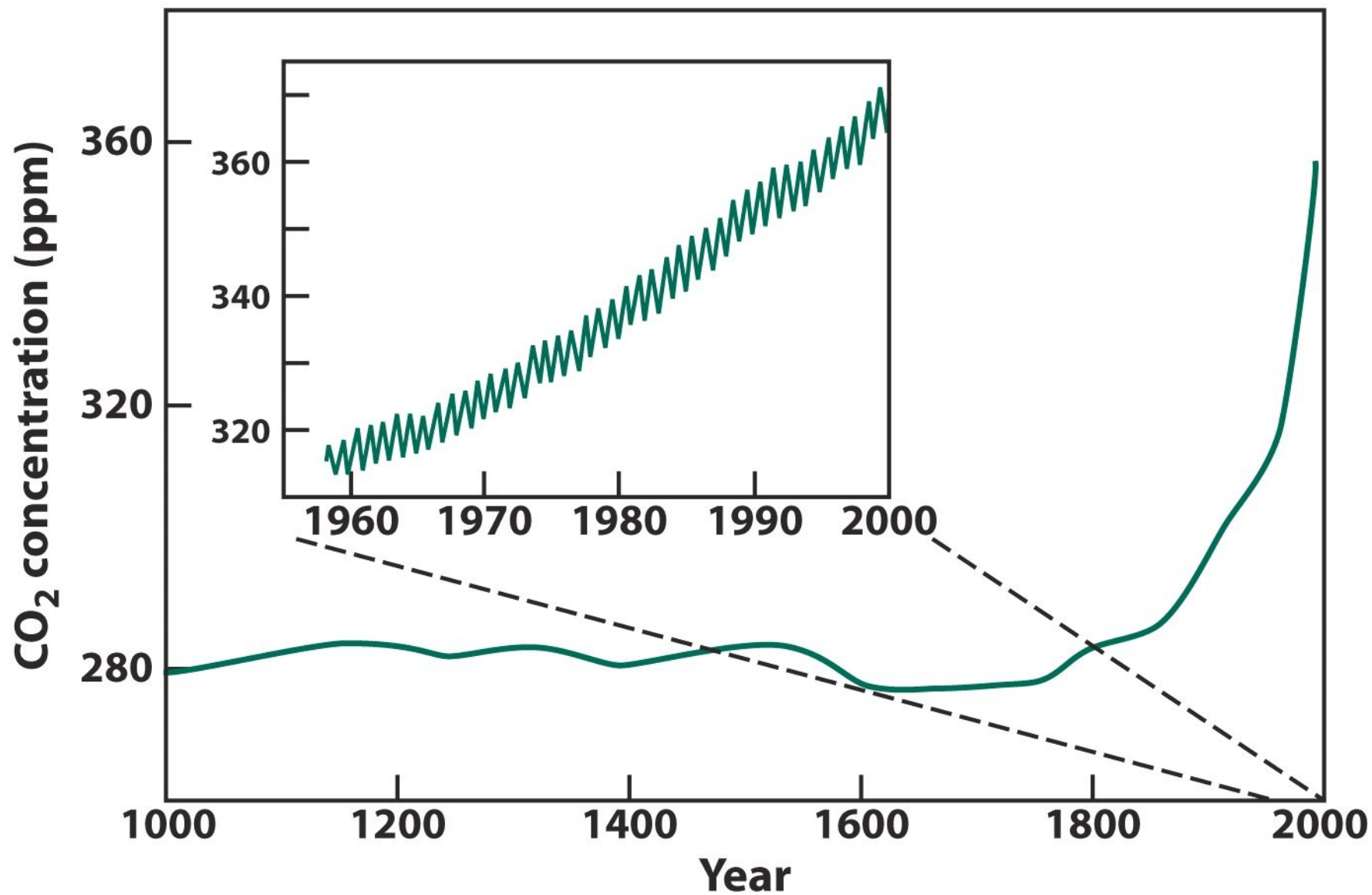
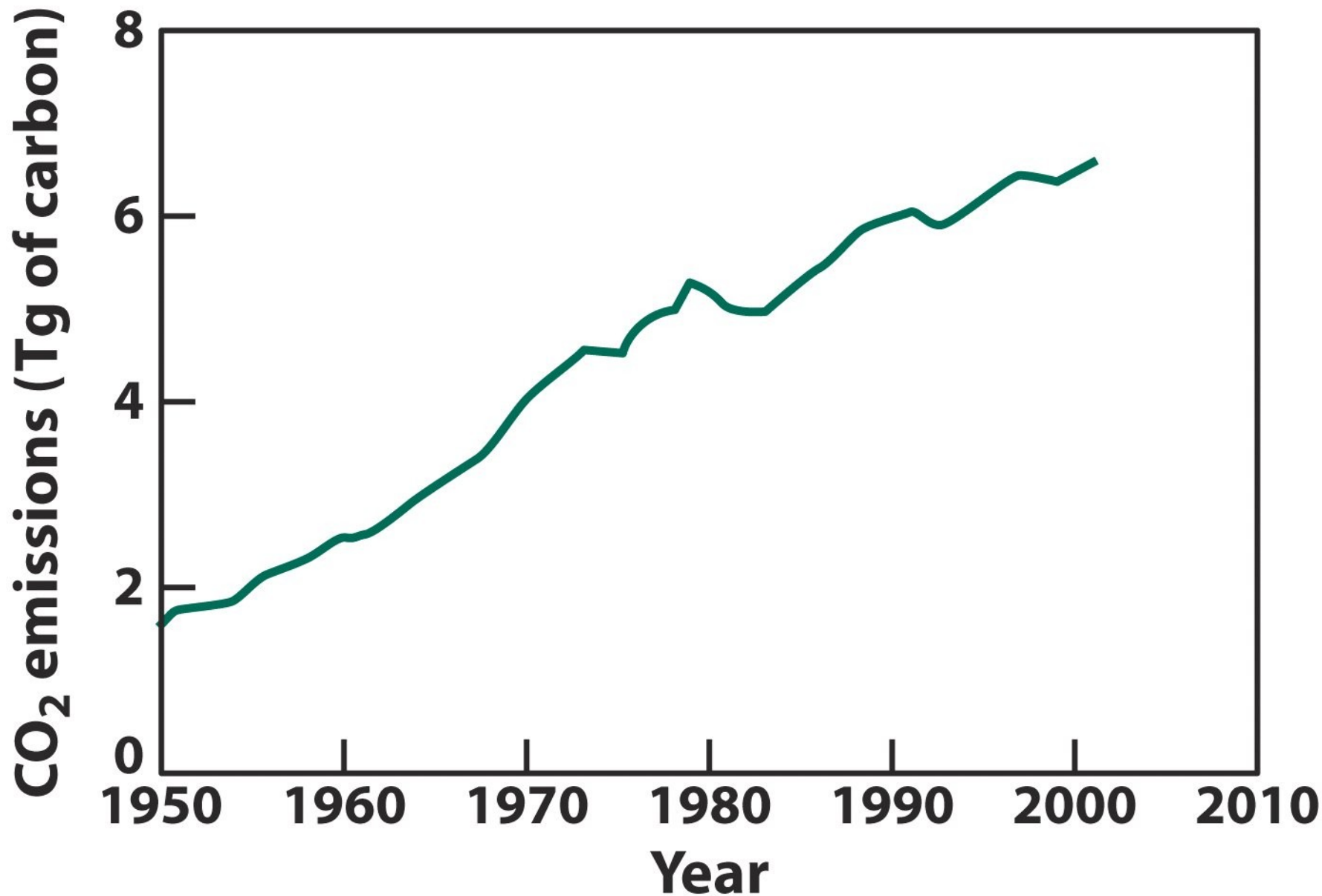


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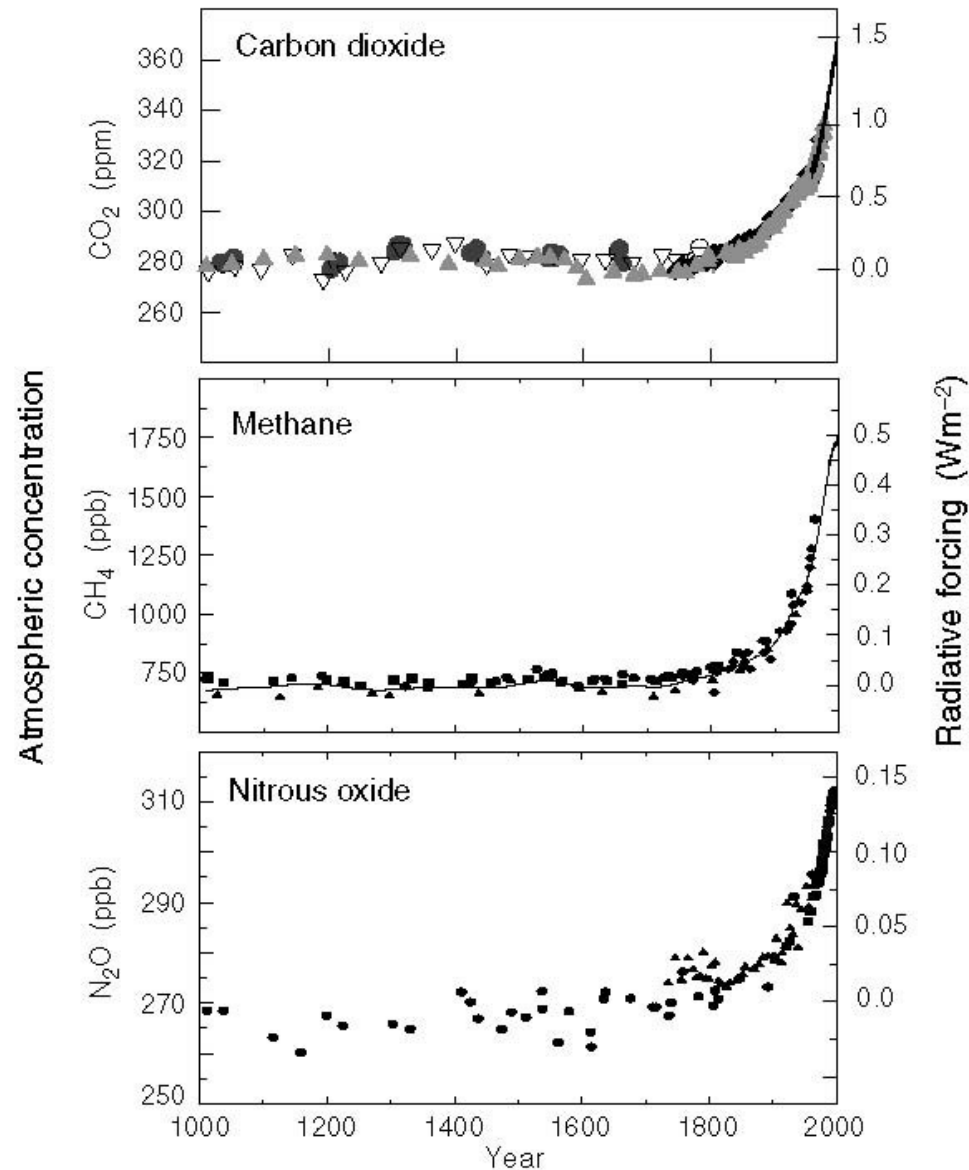


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**CO<sub>2</sub> emissions from fossil fuel combustion**

# Indicators of the human influence on the atmosphere during the Industrial Era

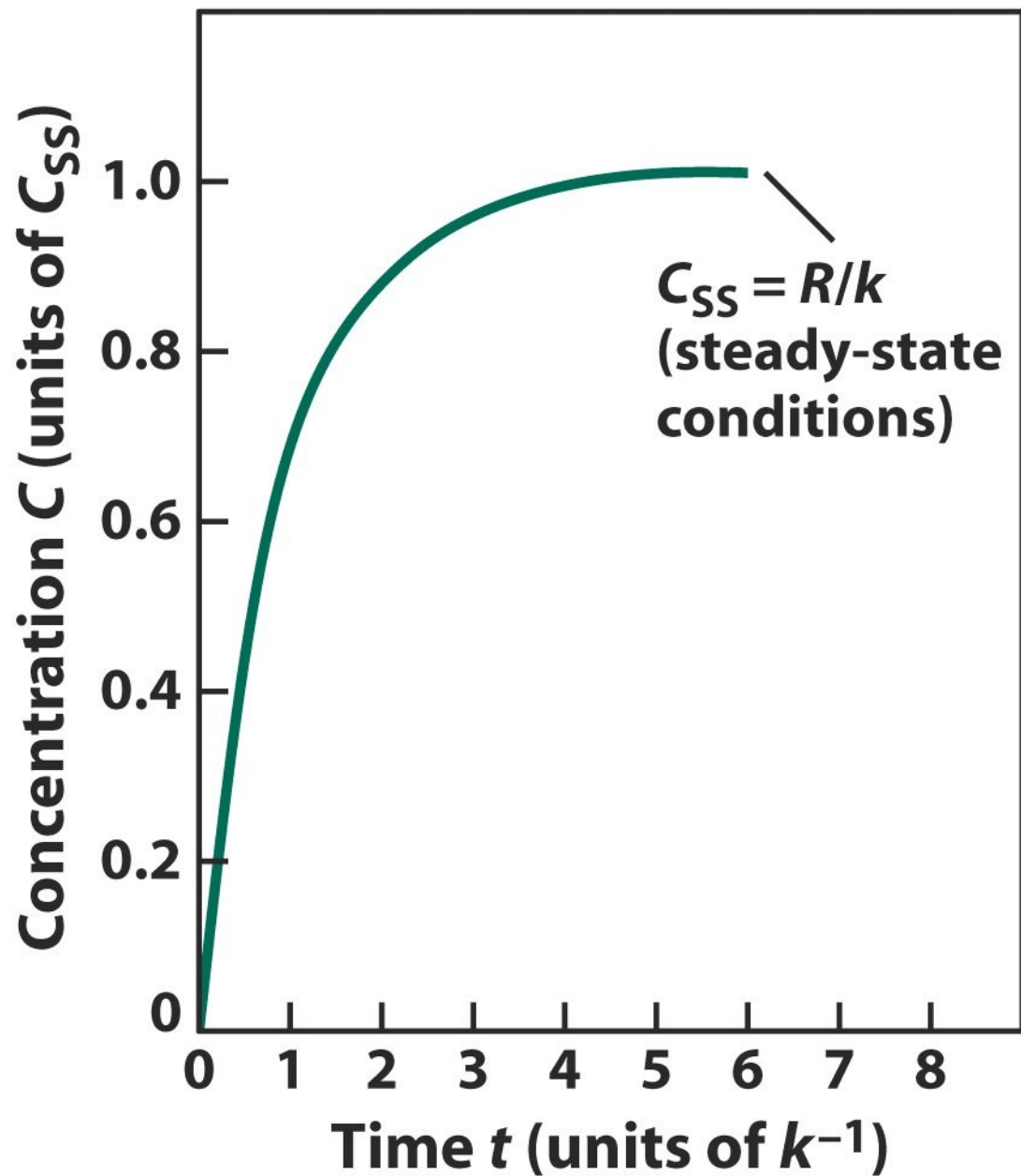
(a) Global atmospheric concentrations of three well mixed greenhouse gases



**TABLE 4-1****Summary of Information About Some Greenhouse Gases**

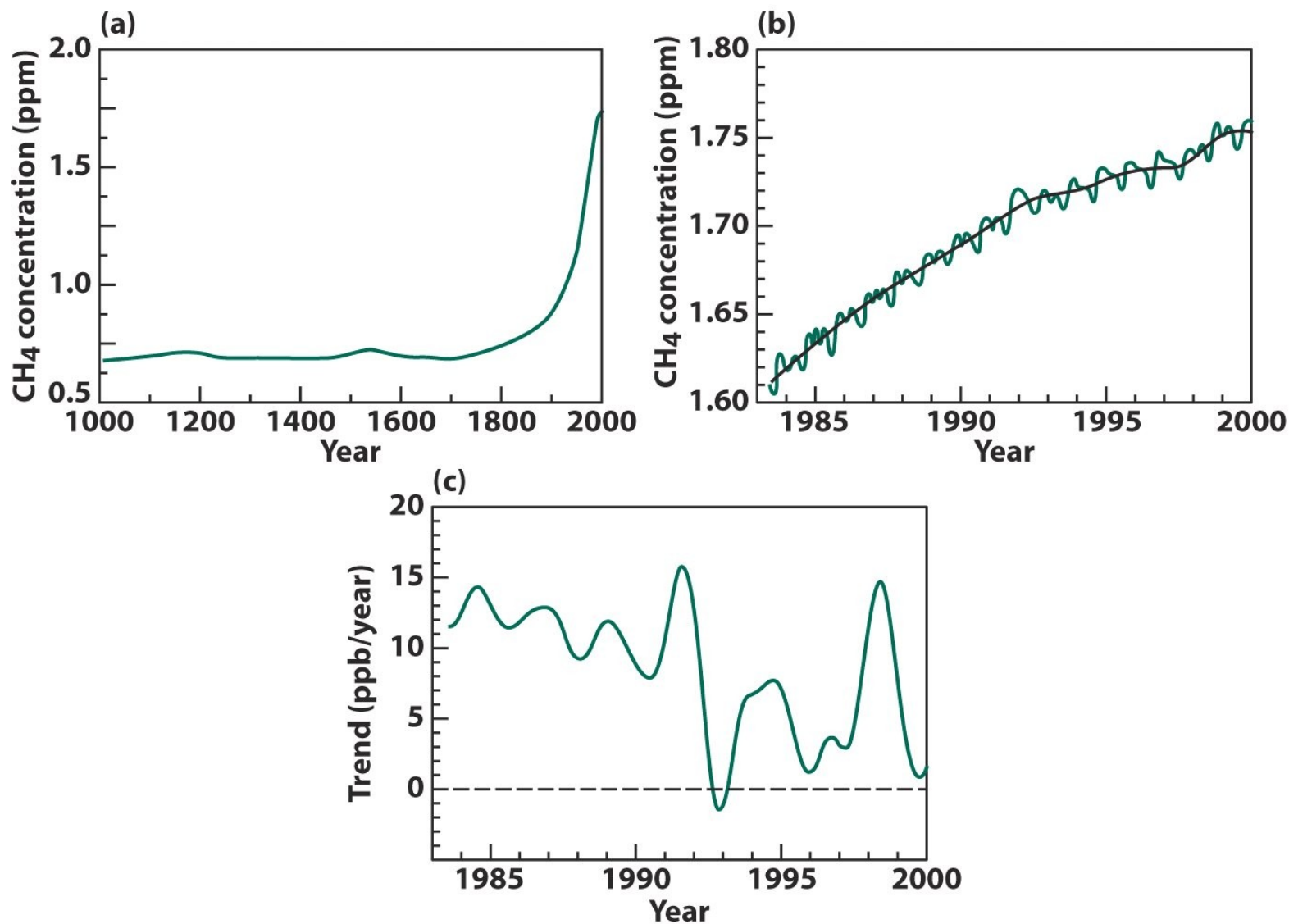
| Gas              | Current concentration | Residence time, in years | Relative global warming efficiency, 100-year horizon |
|------------------|-----------------------|--------------------------|------------------------------------------------------|
| CO <sub>2</sub>  | 373 ppm               | 50–200                   | 1                                                    |
| CH <sub>4</sub>  | 1.77 ppm              | 12                       | 23                                                   |
| N <sub>2</sub> O | 316 ppb               | 120                      | 296                                                  |
| CFC-11           | 0.26 ppb              | 45                       | 4600                                                 |
| HCFC-22          | 0.15 ppb              | 12                       | 1700                                                 |
| HFC-134a         | 0.01 ppb              | 14                       | 1300                                                 |
| Halon-1301       | 0.003 ppb             | 65                       | 6900                                                 |

**Table 4-1**  
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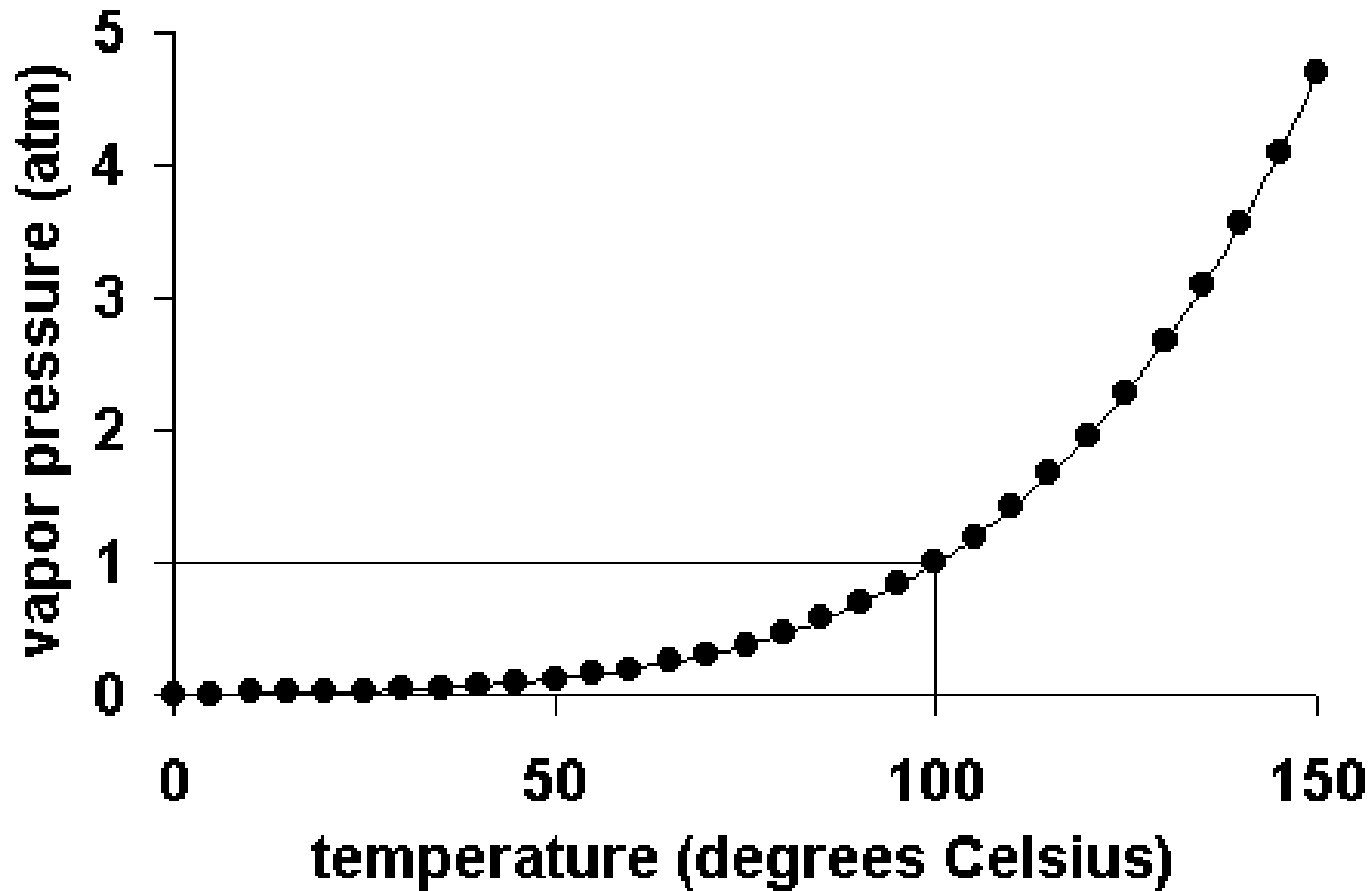
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# Greenhouse Gases: Methane



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## Greenhouse Gases: Water Vapor



Positive feedback



## RADIATIVE FORCING COMPONENTS

