- What is Climate? What is Weather?
- What is Change?

climate /ˈklʌɪmət/ *n. & v.*

LME. [(O)Fr. *climat* or late L *clima*, *-mat-* f. Gk *klima*, *-mat-* slope of ground, zone, region, f. *klinein* to lean, slope.]

A *n.* †1 **A belt of the earth's surface contained between two parallels of latitude.** LME–L18.

b **Any region of the earth.** L15–L18.

2 **A region considered with reference to its atmospheric conditions or its weather.** E17.

3 **The prevailing atmospheric phenomena and conditions of temperature, humidity, wind, etc., (of a country or region).** E17.

b *fig.* **The mental, moral, etc., environment prevailing in a body of people in respect of opinion, some aspect of life, etc.** M17.

3 *continental climate*: **see** CONTINENTAL *a.* ***MEDITERRANEAN climate.***

B *v.* †1 ***v.i.*** **Sojourn in a particular climate.** *rare* **(Shakes.).** Only in E17.

2 ***v.t.*** = ACCLIMATIZE. ***US.*** M19.

climatal *a.* = CLIMATIC M19.

climatize *v.t.* = ACCLIMATIZE E19.

†climature *n.* **(a)** *rare* **a region; (b) meteorological condition resulting from latitude:** E17–E19.

Climate?

- Definition

  Average course or conditions of weather at a place, usually over a period of years, as exhibited by

  - Temperature
  - Wind velocity
  - Precipitation
  - Humidity
  - Etc.

weather /ˈwɛðə/ *n.*

[OE *weder* = OFris., OS *wedar*, OHG *wetar* (Du. *weer*, G *Wetter*), ON *veðr*, f. Gmc, prob. f. base of **WIND** *n.*1]

1

The condition of the atmosphere at a given place and time with res pect to heat, cold, sunshine, rain, cloud, wind, etc. OE.**b**
(A spell of) a particular kind of weather. Now *rare*
exc. in *in all weathers*. OE. **c**
Bad weather; destructive rain, frost, wind, etc.; *spec.* **(now** *dial. & Naut.*) **violent wind accompanied by heavy rain or rough sea.** OE. **d**
Weather suitable for some purpose; *spec.* **fine weather. Long** *obs.*
exc. *Sc.* LME.

†e **Rain, snow, etc., falling from the clouds.** LME–E19.

†f **Air, sky.** LME–E17.

2 *Naut.*
The direction in or side towards which the wind is blowing; windwar d. Freq. ***attrib.*** LME.

3

More fully *angle of weather*. **The angle made by a windmill's sails w ith the perpendicular to the axis.** M18.

Defining “Climate Change”

IPCC usage:

- Any change in climate over time, whether due to natural variability or from human activity.

Alternate:

- Change of climate, attributed directly or indirectly <u>to human activity,</u> that
  - Alters composition of global atmosphere and
  - Is in addition to natural climate variability observed over comparable time periods

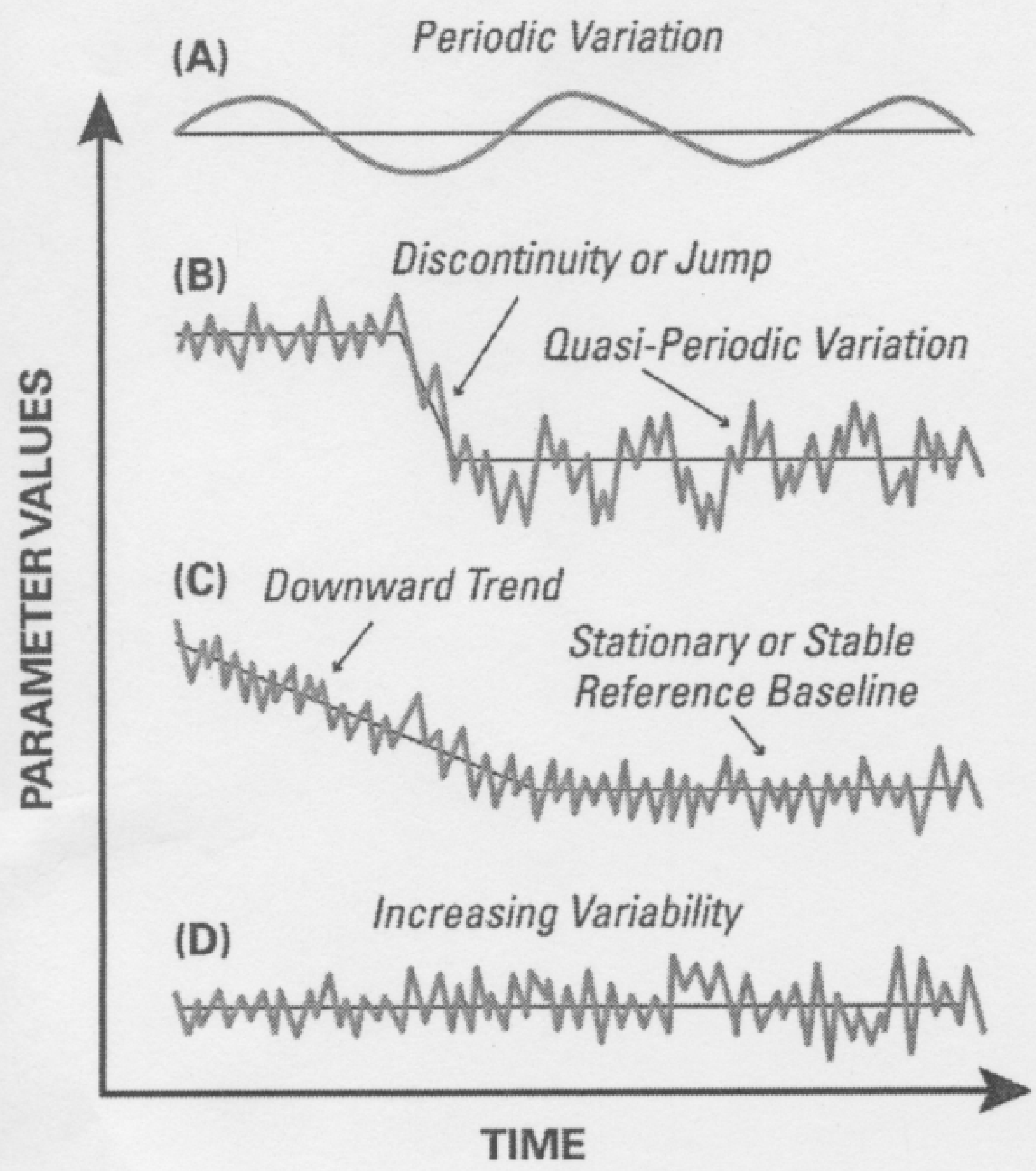


Figure 2.5. Types of climate variations.

(Or climate changes)

What Changes?

What changes?

More than just temperature

- – Precipitation (amount and patterns)
- – Atmospheric pressure
- – Humidity
- – Circulation changes (atmosphere & oceans)
- – Number of storms, droughts, freezes, etc.
- – And more….

What can change?

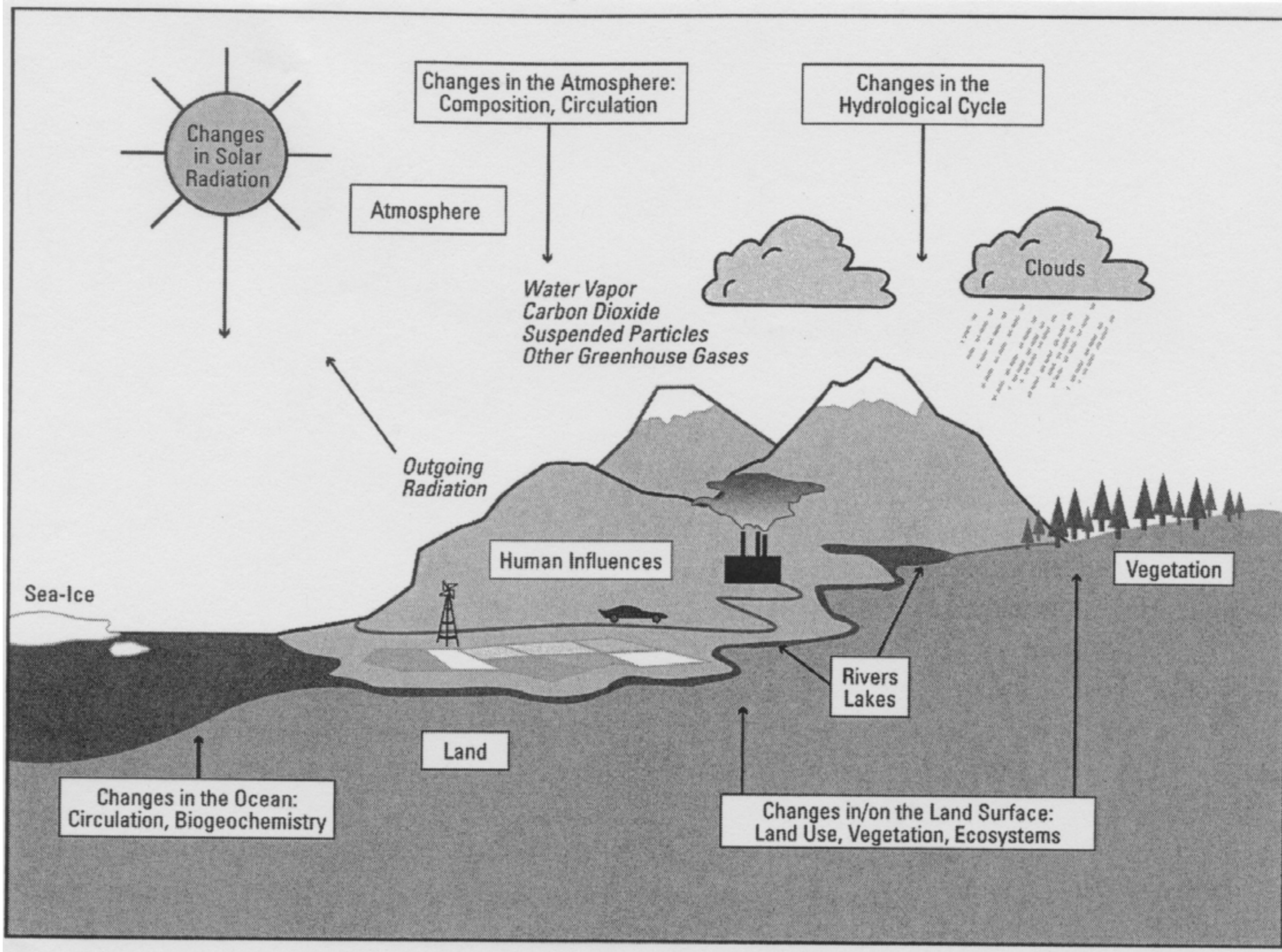
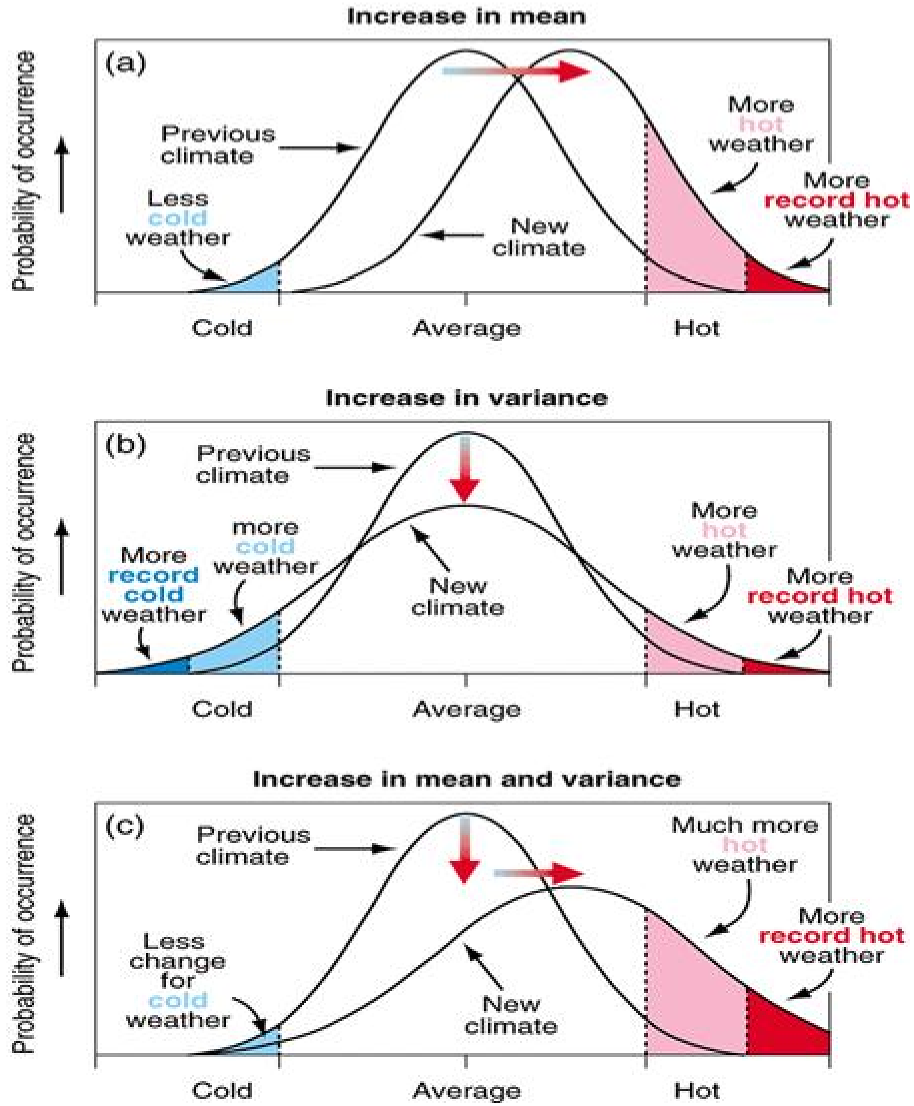


Figure 2.1. The components of the climate system are schematically illustrated along with some of their main interactions and origins of change. *Source:* Adapted from Trenberth, Houghton, and Filho 1996.

- What about mean values versus variance?



Increase in mean
(a)
Probability of occurrence
Previous climate
New climate
Less cold weather
More hot weather
More record hot weather
Cold
Average
Hot
Increase in variance
(b)
Probability of occurrence
Previous climate
New climate
More record cold weather
more cold weather
More hot weather
More record hot weather
Cold
Average
Hot
Increase in mean and variance
(c)
Probability of occurrence
Previous climate
New climate
Less change for cold weather
Much more hot weather
More record hot weather
Cold
Average
Hot

Evidence that climate is changing?

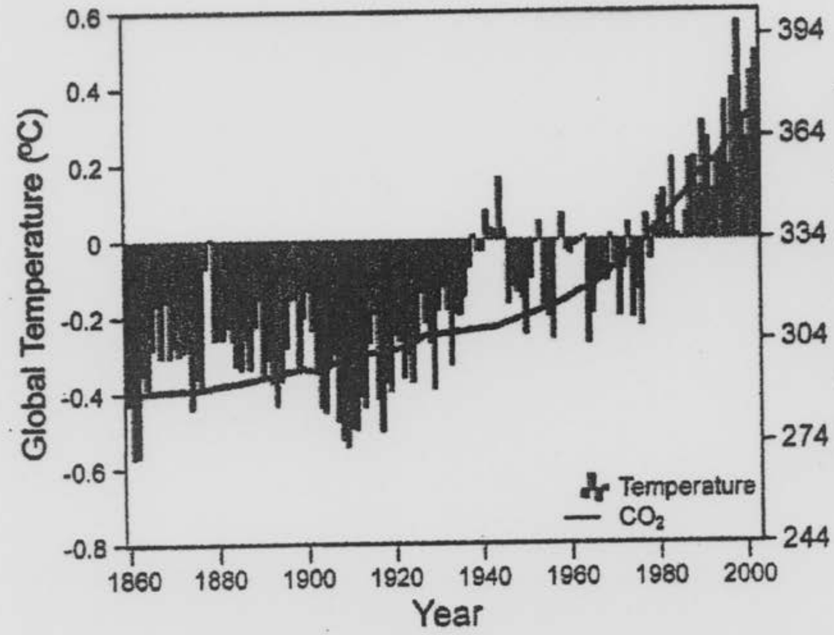


Fig. 1. Time series of departures from the 1961 to 1990 base period for an annual mean global temperature of 14.0°C (bars) and for a carbon dioxide mean of 334 ppmv (solid curve) during the base period, using data from ice cores and (after 1958) from Mauna Loa (*4*). The global average surface heating approximates that of carbon dioxide increases, because of the cancellation of aerosols and other greenhouse gas effects, but this does not apply regionally (*2*). Many other factors (such as the effects of volcanic eruptions and solar irradiance changes) are also important.

Mean temp. 1961-1990 = 14°C
for each year, plotted variation from 14°C

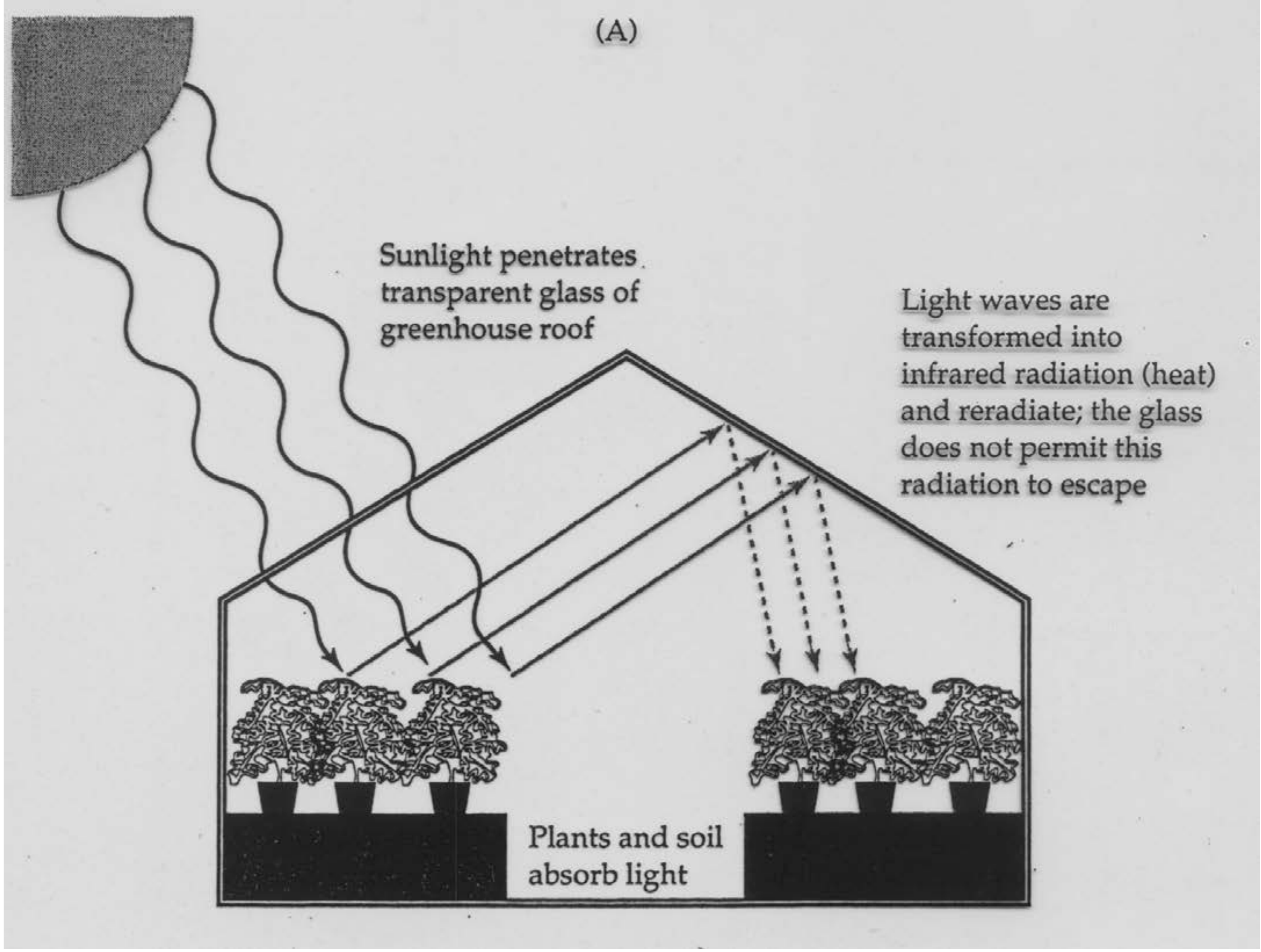
- Global warming…?
- Greenhouse effect….?

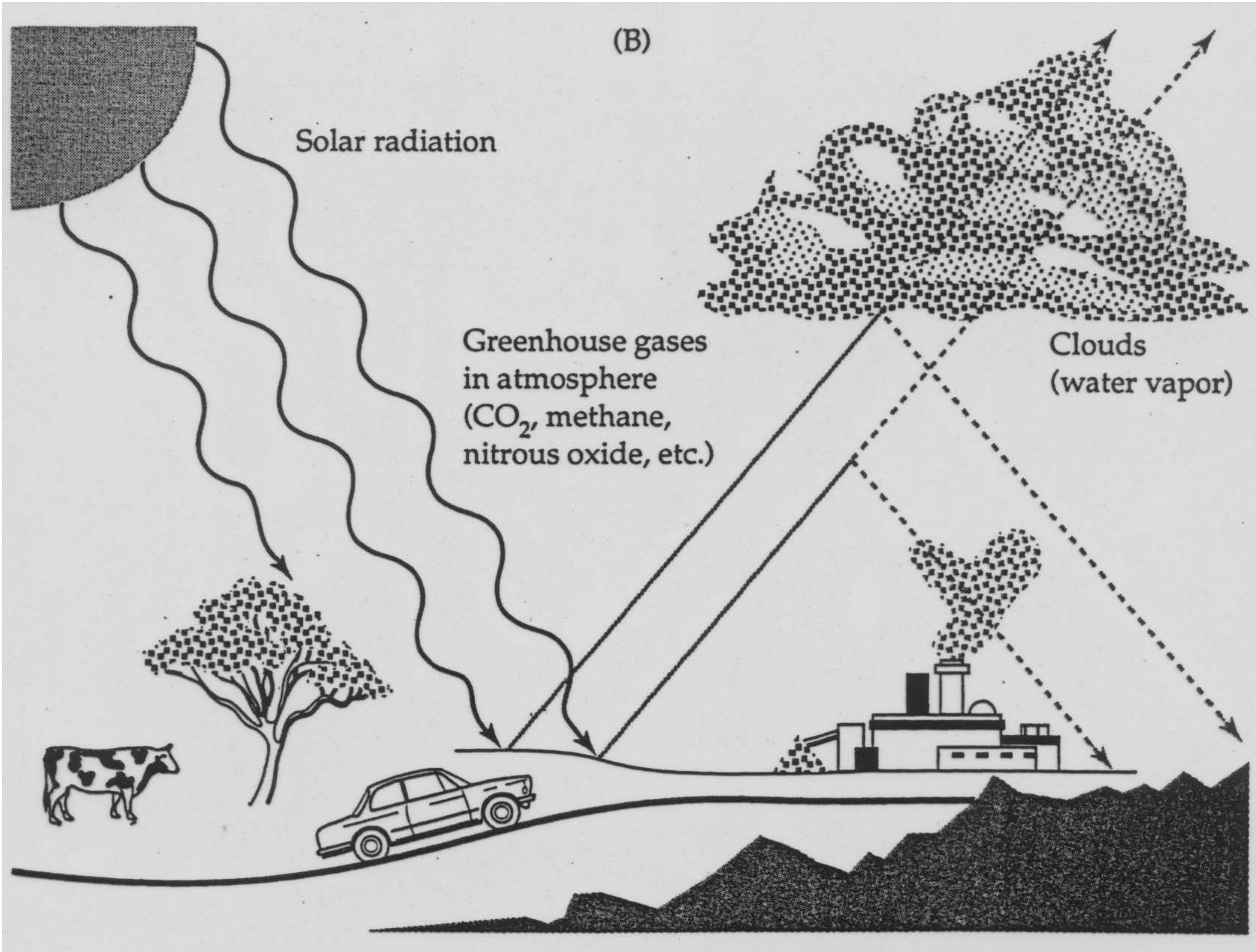
Who was Svante Arrhenius?

“On the influence of carbonic acid in the air upon the temperature of the ground” - 1896

Global warming?

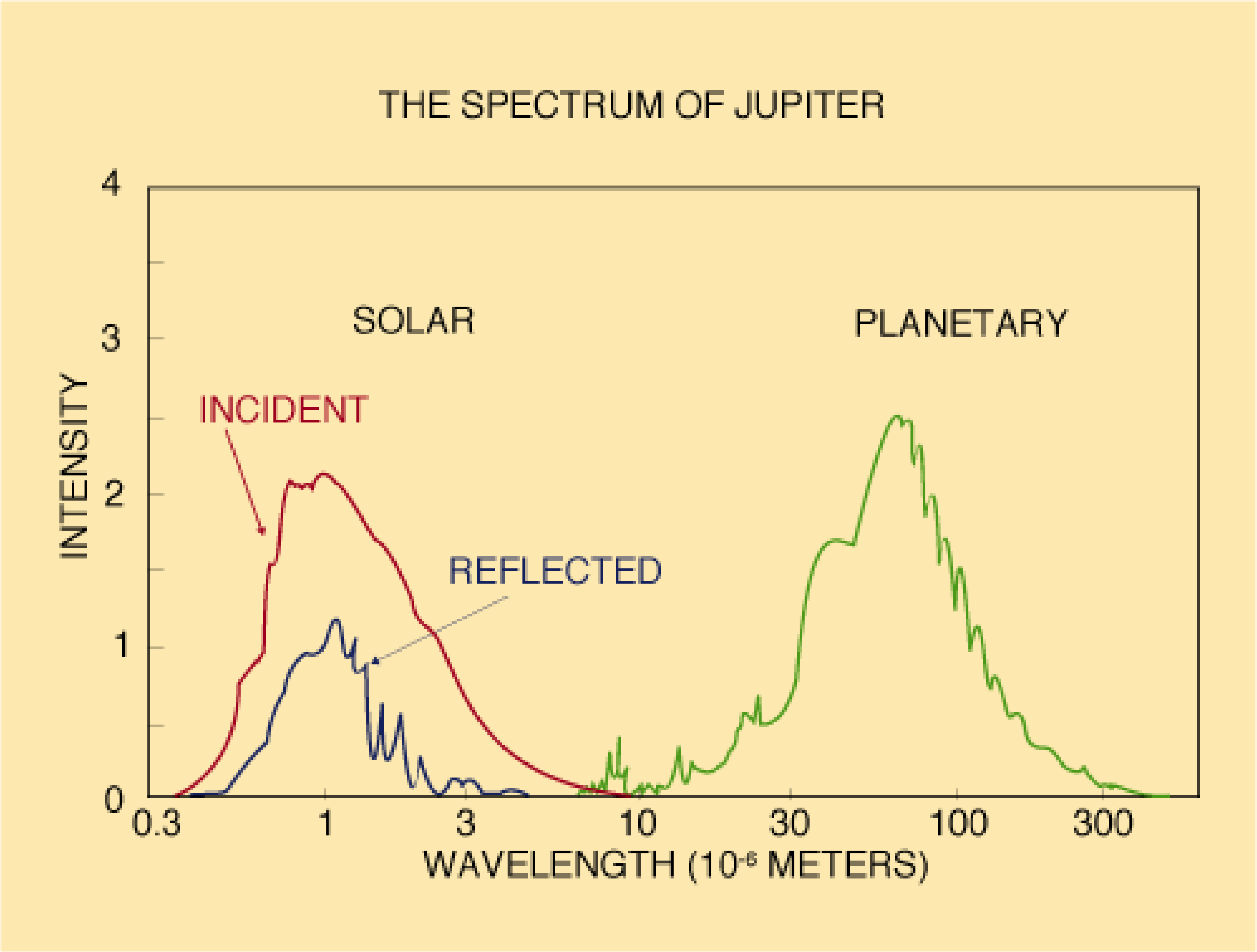
Greenhouse effect?



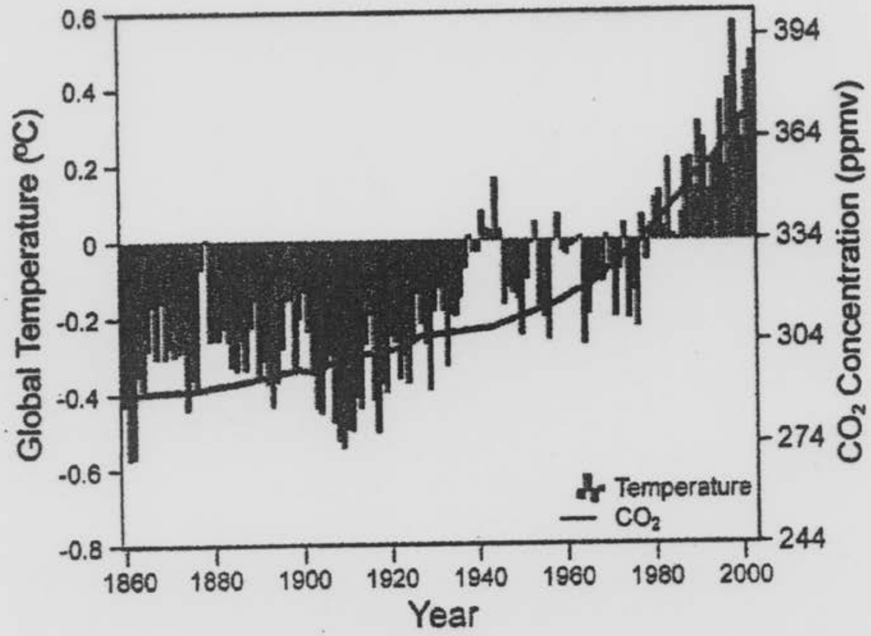

(B)
Solar radiation
Greenhouse gases
in atmosphere
(CO_2, methane,
nitrous oxide, etc.)
Clouds
(water vapor)

The Greenhouse…

- Earth as blackbody - ~+5 C
- Reflects ~ 30% of sunlight so temp ~-18 C
- ~33 C below actual surface temp of ~15 C
- Why?
- Water, carbon dioxide, methane, ozone, nitrous oxide, etc.
- Let’s talk about IR radiation…


THE SPECTRUM OF JUPITER
4
3
2
1
0
INTENSITY
SOLAR
PLANETARY
INCIDENT
REFLECTED
0.3
1
3
10
30
100
300
WAVELENGTH (10-6 METERS)

How are humans influencing the greenhouse effect?



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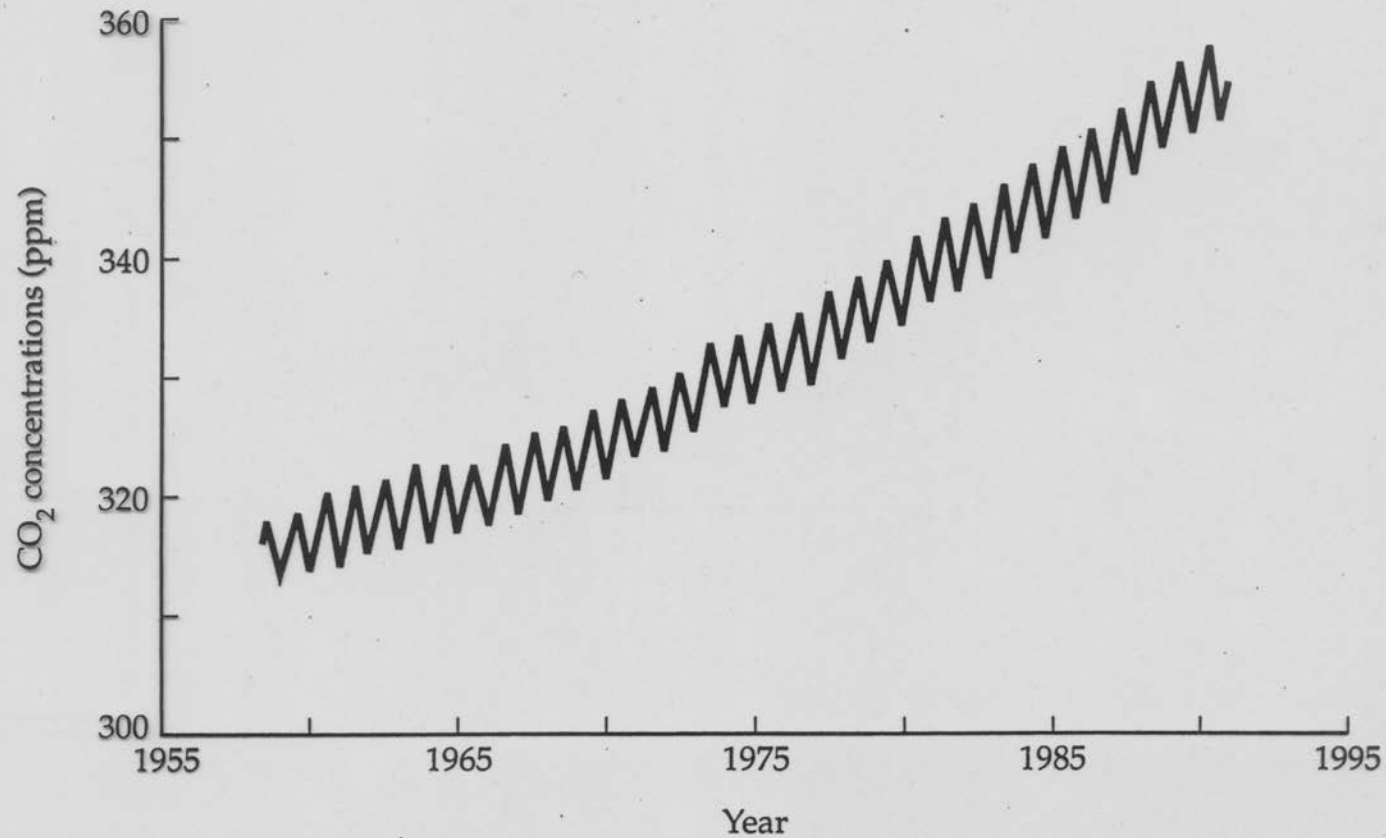


FIGURE 5 **The atmospheric carbon dioxide concentration measured at Mauna Loa, Hawaii from 1958 to 1991. (Courtesy of C. D. Keeling.)**

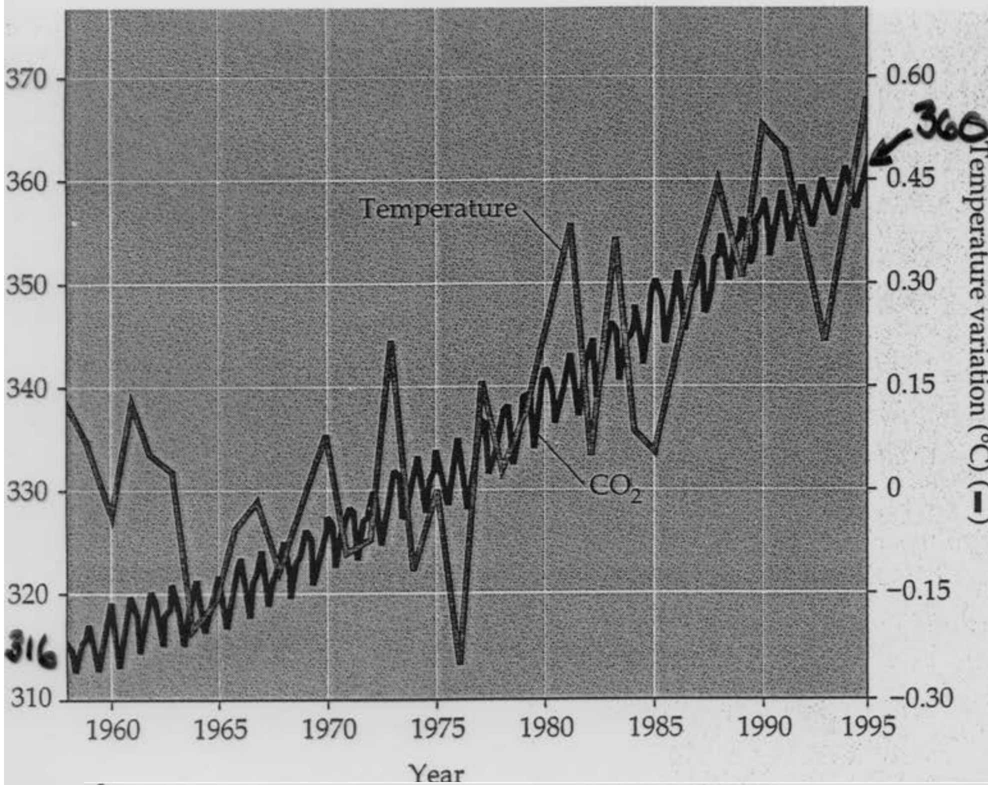


FIGURE 54.17 ▪ The increase in atmospheric carbon dioxide and average temperatures from 1958 to 1995. In addition to normal seasonal fluctuations in CO_2 levels (black), this graph shows a steady increase in the total amount of CO_2 in the atmosphere. These measurements are being taken at a relatively remote site in Hawaii, where the air is free from the variable short-term effects that occur near large urban areas. Though average temperatures over the same time period fluctuate a great deal (red), there is a warming trend. Climatologists predict that temperatures could rise about 2°C over the next 100 years if atmospheric CO_2 levels continue to rise at the current rate.

1958 - 2000 = 14 % increase

Currently ≈ 370 ppm

([CO_2] (ppm) —)

Before 1850 → 274 ppm

If current rate of increase continues, by ~ 2075 [CO_2] will be ~ 560 = 2x pre-industrial level

Now (July, 2016):

404.4 ppm

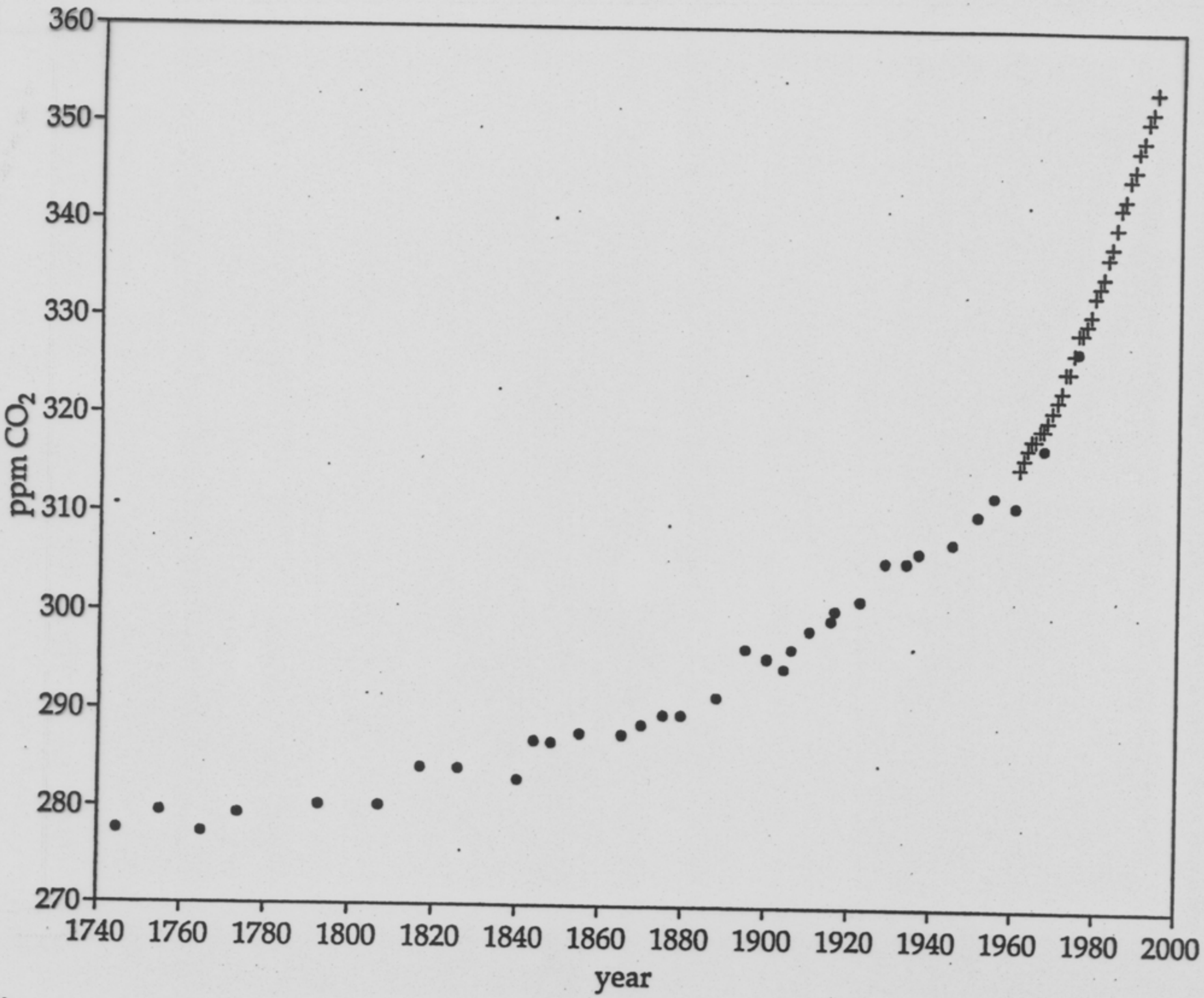
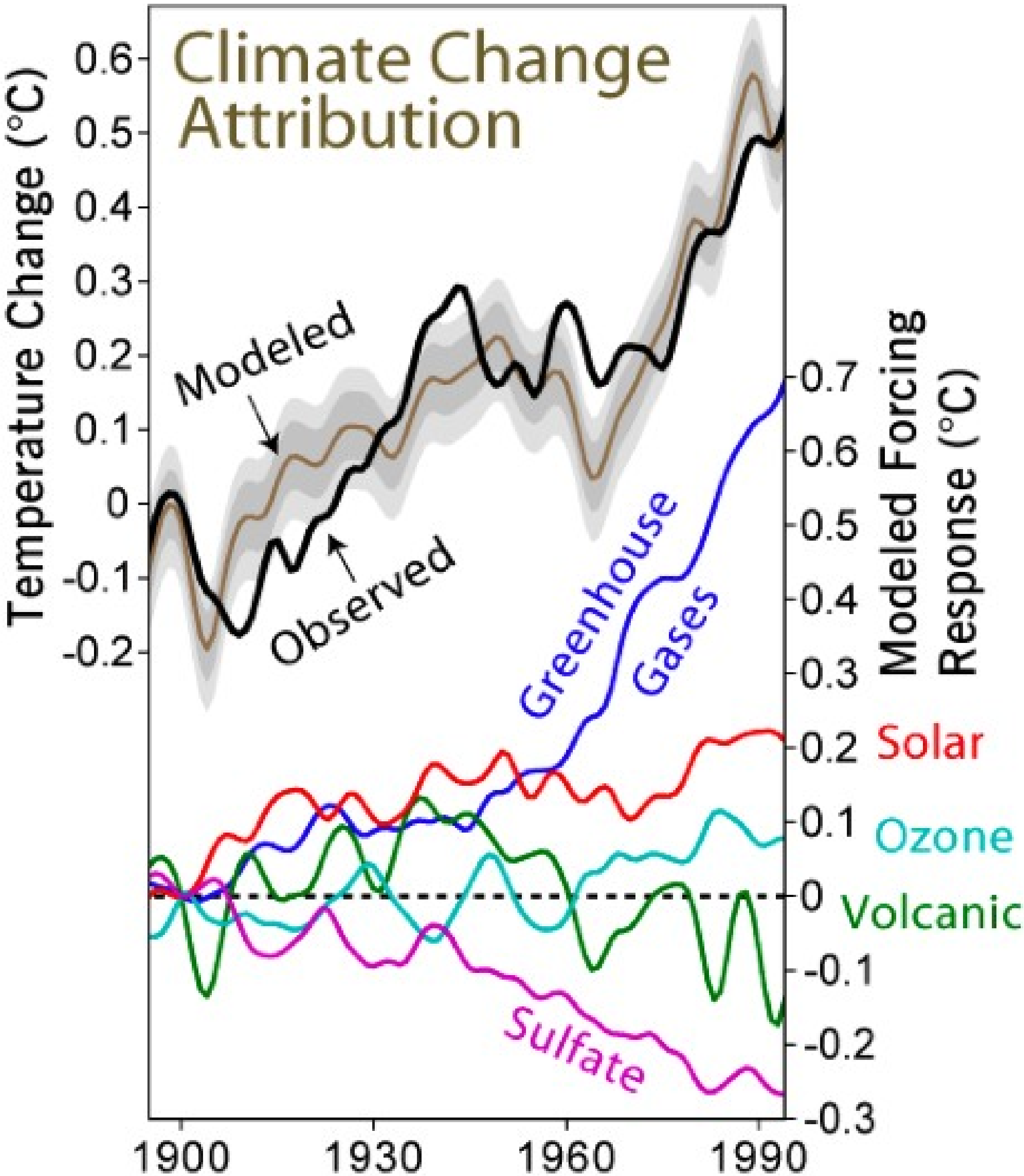


Figure 1.2 The increase in atmospheric CO_2 over the last 250 years. ●, measurements on air trapped in ice; +, direct measurements at Mauna Loa, Hawaii. (Data from UNEP 1991.)



Natural and anthropogenic contributions to global temperature change (Meehl et al., 2004). Observed values from Jones and Moberg 2001. Grey bands indicate 68% and 95% range derived from multiple simulations.

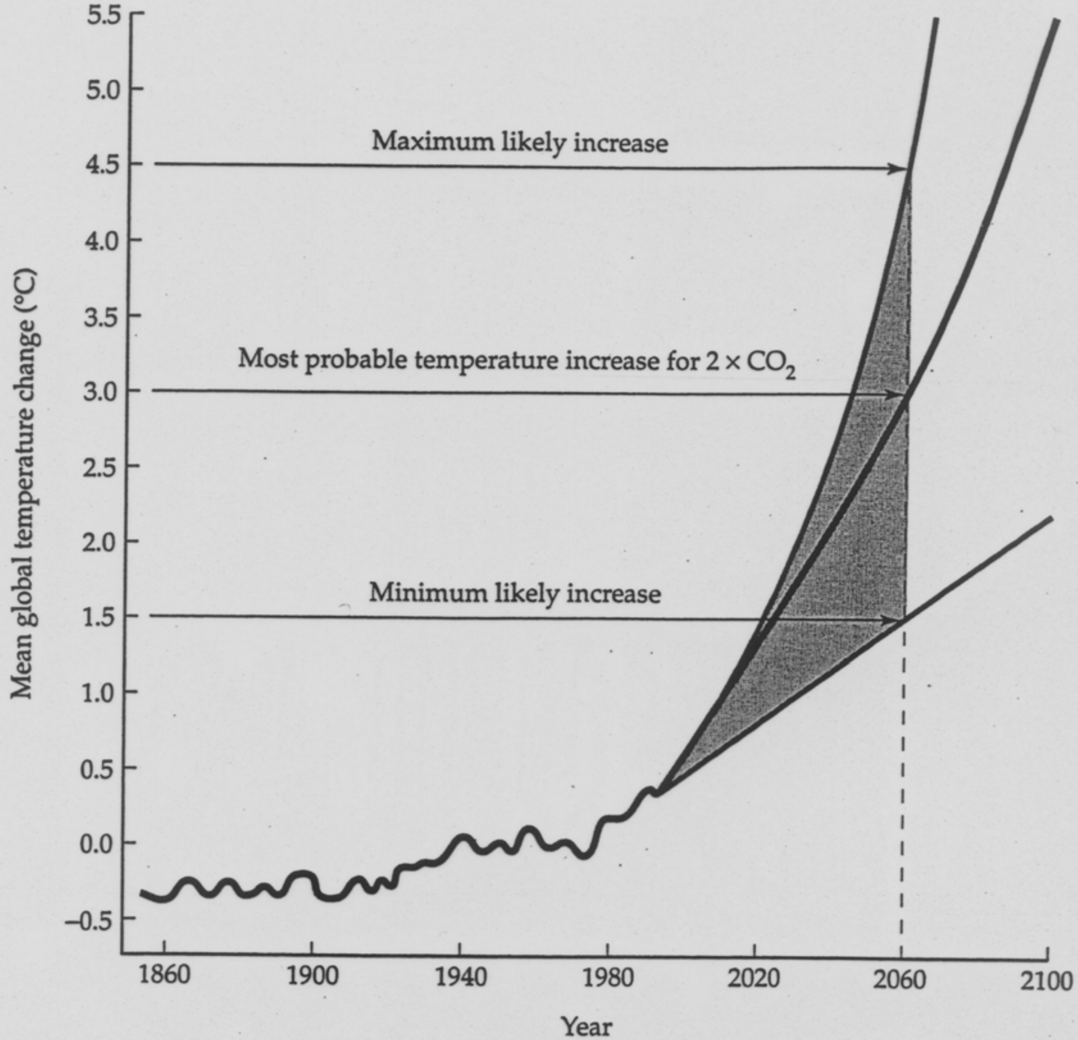


FIGURE 9 Mean global temperature change versus year showing past temperatures and projected most probable temperatures with increasing atmospheric carbon dioxide concentration. 2×CO_2 is assumed to occur around the year 2060. Because of uncertainties with modeling and in our knowledge of the carbon cycle, maximum and minimum temperature extrapolations are also shown.

Uncertainty

- Future emissions
- Water cycle & feedbacks
- Oceans as heat sinks
- Linear vs. non-linear responses
- Biotic feedbacks
- Regional effects
- Etc., etc.

Let’s talk about seeds…

- Why talk about seeds in the context of climate change…?

Global Warming and the Biology of Seeds

- Factors controlling dormancy?

Cold, moisture, fire, dispersers

Why is dormancy important?

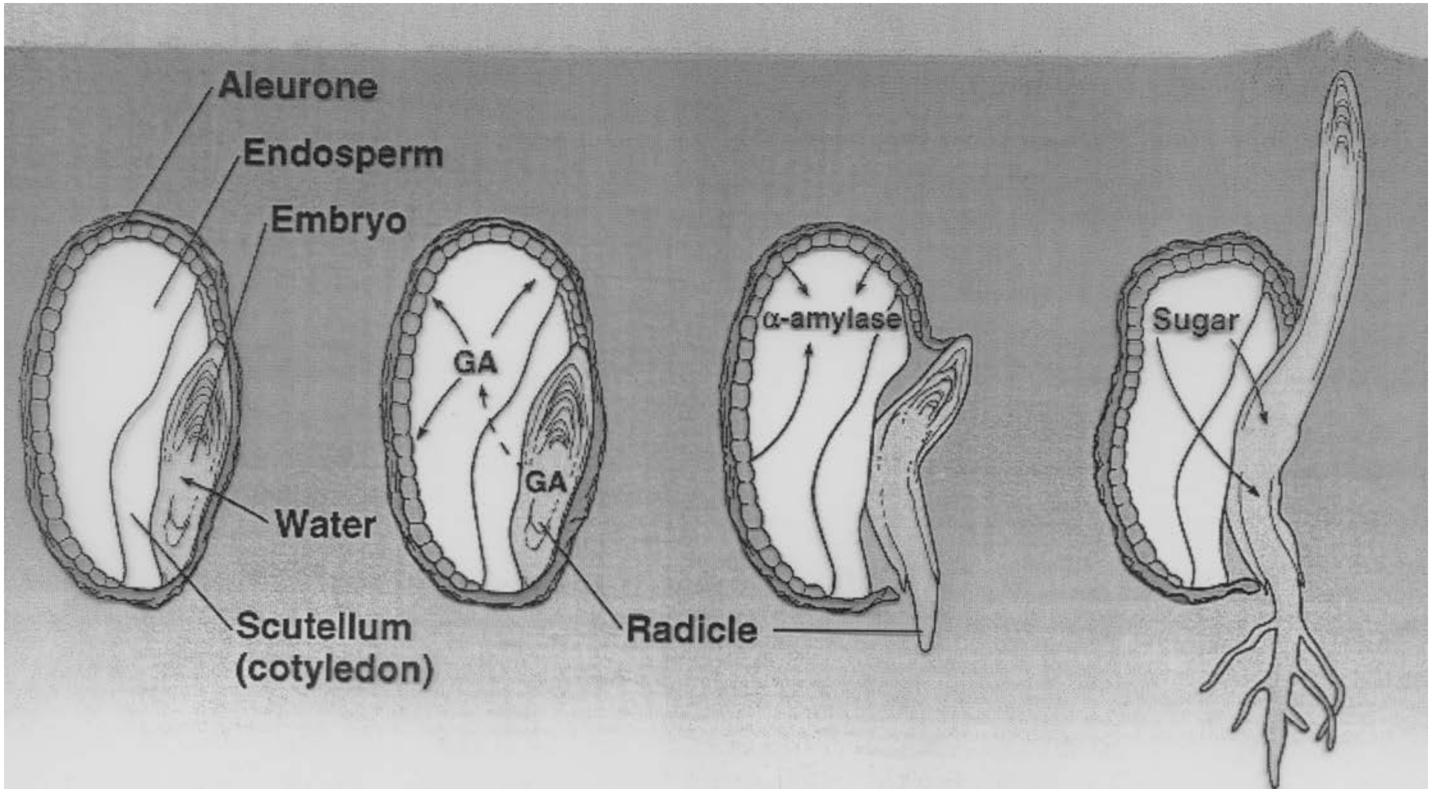
Adapting to appropriate conditions for germination
(under strong selection pressure?)

What conditions break dormancy?

- Warmer temps
- Moisture
- Fire
- Gut passage
- ABA (abscisic acid) levels and dormancy

Imbibition & Germination

- Seed absorbs water (imbibes)
- Activates hormones (GA) in embryo
- Enzyme (amylase in aleurone) activation via hormones (GA)
- Amylase break downs starch in endosperm (into sugar)
- Sugar fuels growth of radicle



How can global warming effect seeds?

- Optimal germination temp?
- Dormancy effects?
- Germination effects?
- Growth effects?
- Other climatic effects (variation in temp, moisture)

Can these be phrased as hypotheses?

Hypothesis: A testable statement about the natural world that can be used to build more complex inferences and explanations.

Theory: In science, a well-substantiated explanation of some aspect of the natural world that can incorporate facts, laws, inferences, and tested hypotheses.

- Now let’s go think about observations and testable hypotheses, and predictions and the associated design of an experiment…
- And about variables, controls, replicates and how we control for error… (something we’ll consider all semester…)
- And about model organisms…(e.g., the turnip – or why we love the Brassicaceae)

I was walking through the woods one day…

And what to my wandering eyes should appear…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