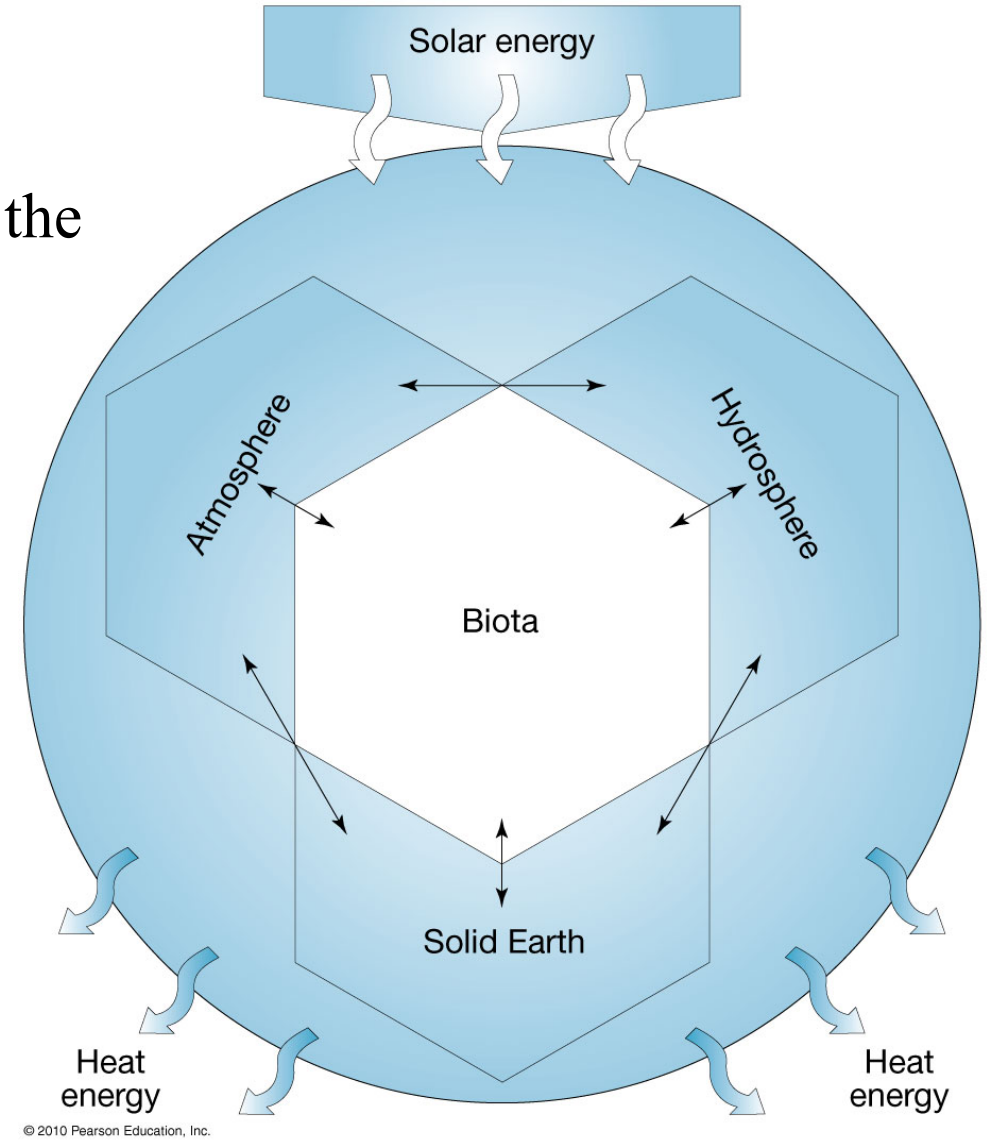
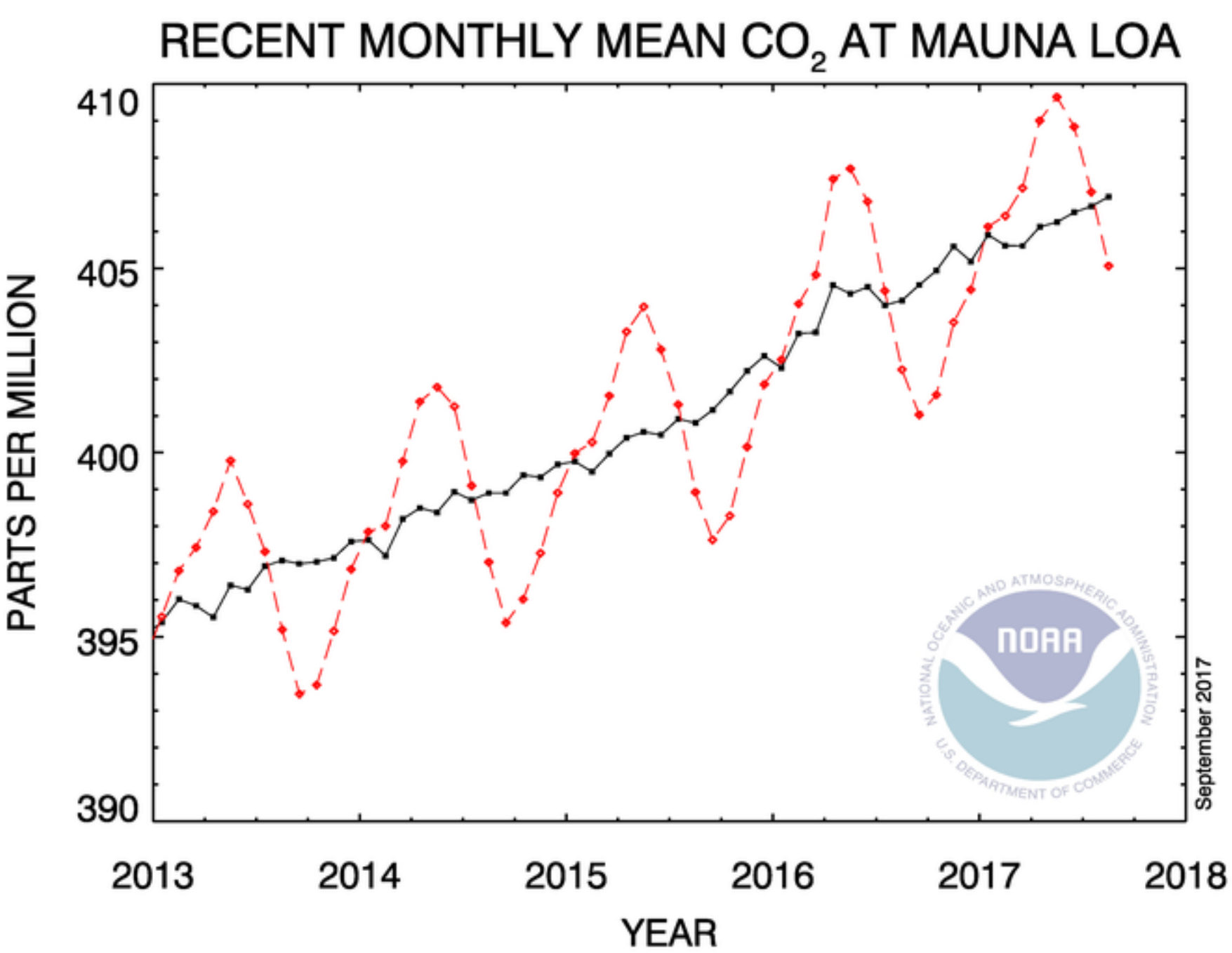
Three Themes

- Global environmental change today
- Global change in Earth's past
- Systems: we are - as a planet's population - learning how the Earth - as a system - reacts to changes in conditions, both natural and man-made

Fig. 1-1

System: Components that interact. Mostly the subject of Chapter 2.




RECENT MONTHLY MEAN CO2 AT MAUNA LOA
PARTS PER MILLION
410
405
400
395
390
2013
2014
2015
2016
2017
2018
YEAR
NOAA
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
U.S. DEPARTMENT OF COMMERCE
September 2017

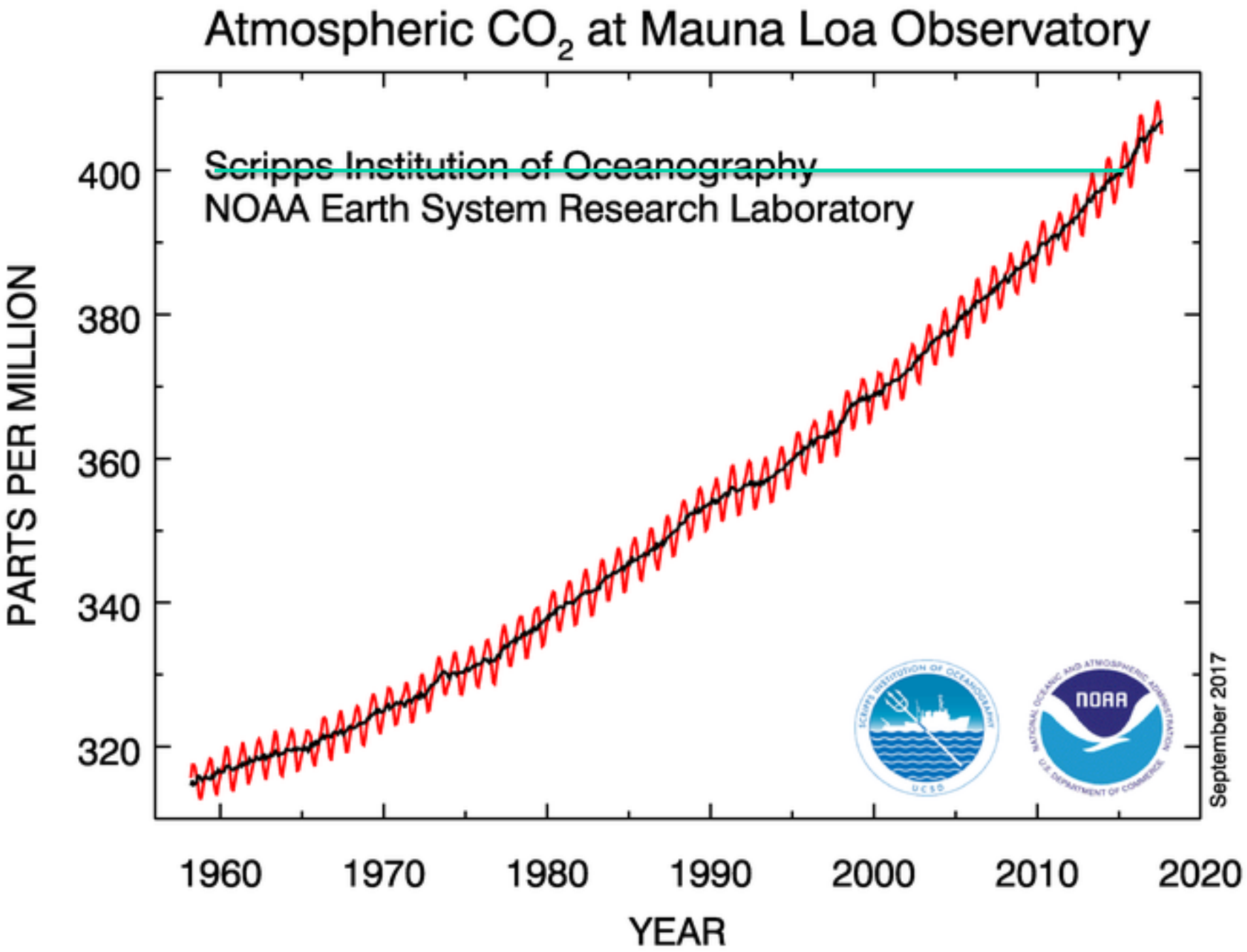

Atmospheric CO_2 at Mauna Loa Observatory
Scripps Institution of Oceanography
NOAA Earth System Research Laboratory
PARTS PER MILLION
400
380
360
340
320
1960
1970
1980
1990
2000
2010
2020
YEAR
September 2017

Fig. 1-3a

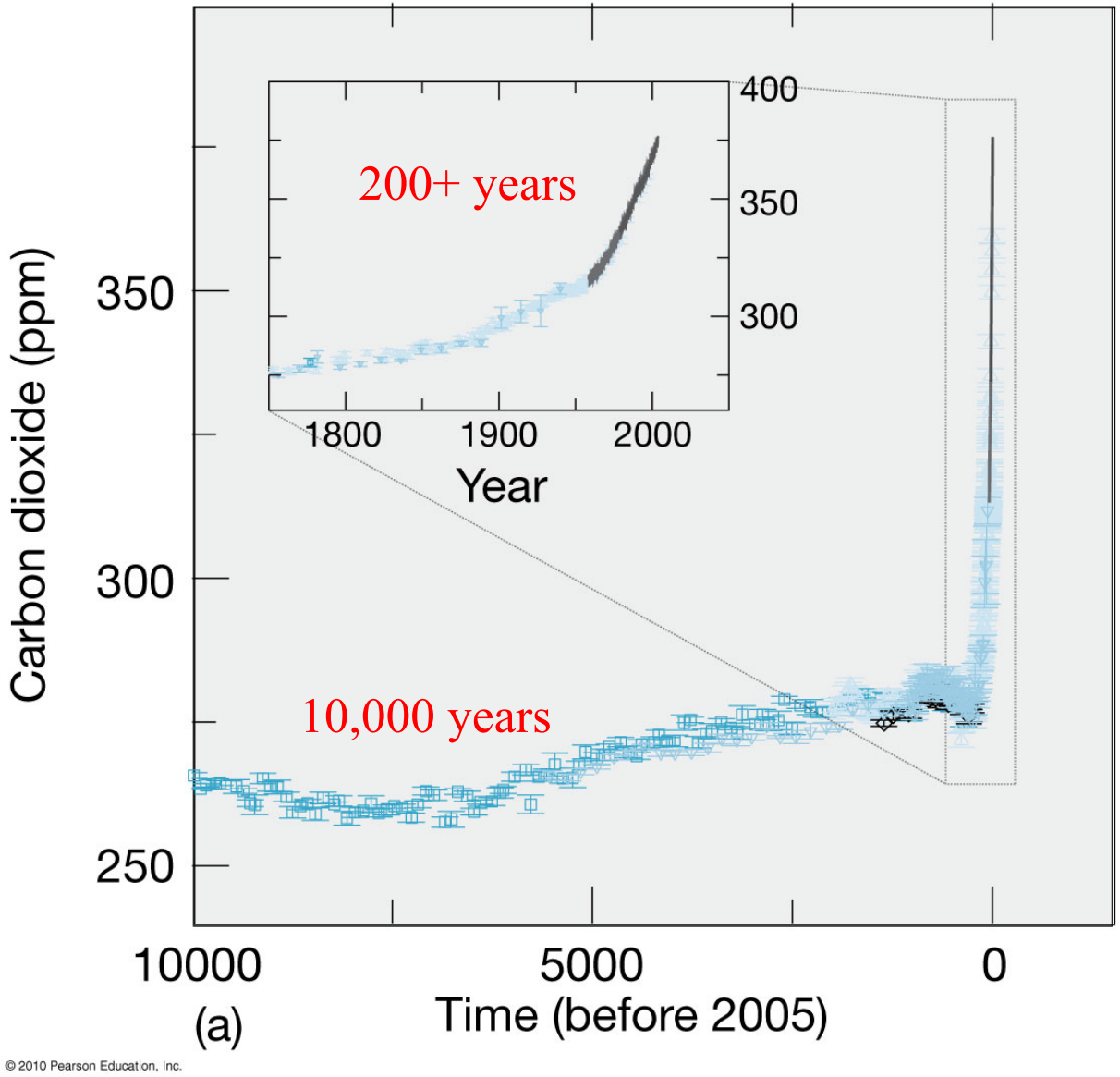

200+ years
10,000 years
Carbon dioxide (ppm)
350
300
250
400
350
300
1800
1900
2000
Year
10000
5000
0
Time (before 2005)
(a)
© 2010 Pearson Education, Inc.

Fig. 1-3b

Not just CO_2…

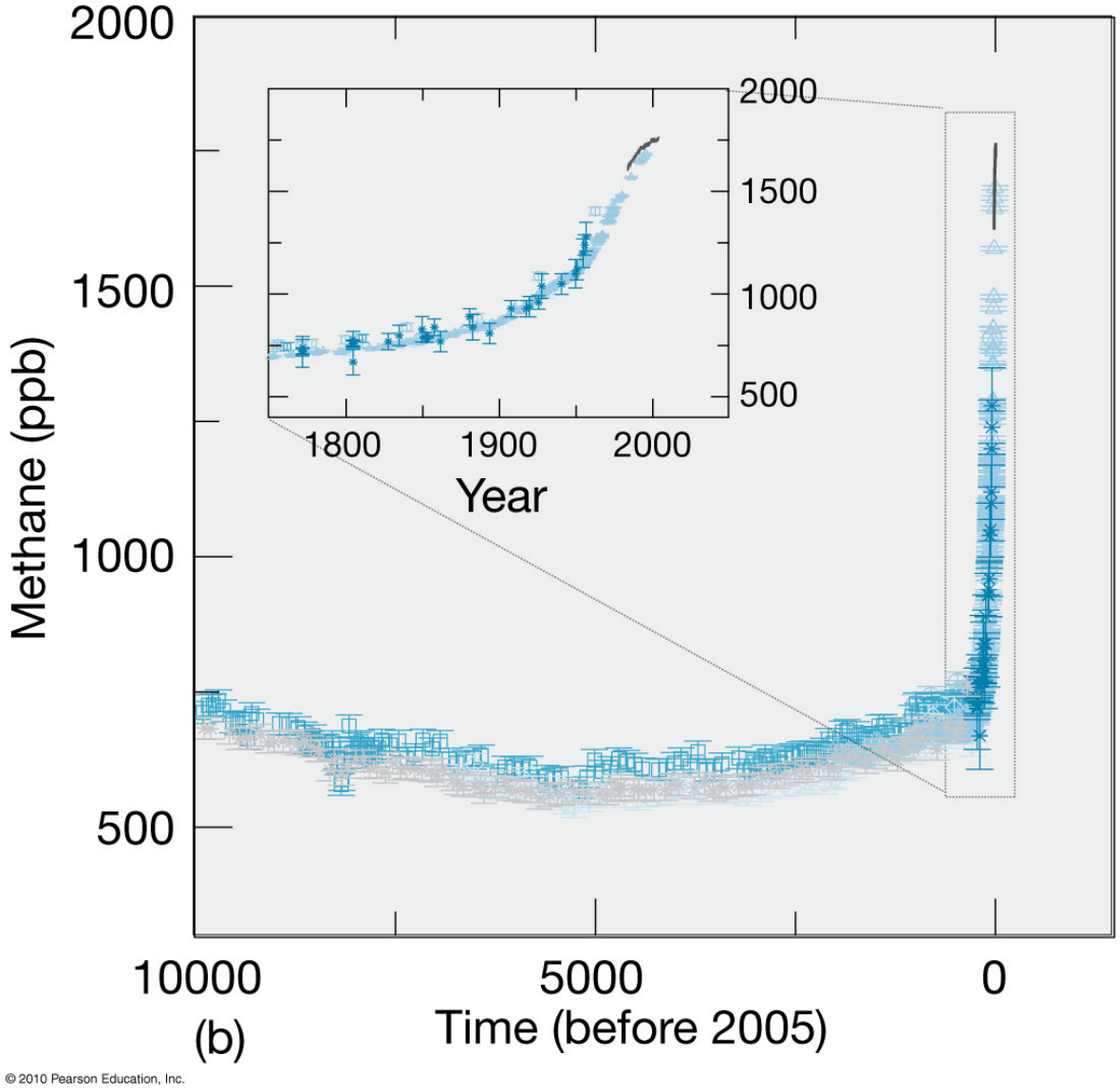


Fig. 1-3c

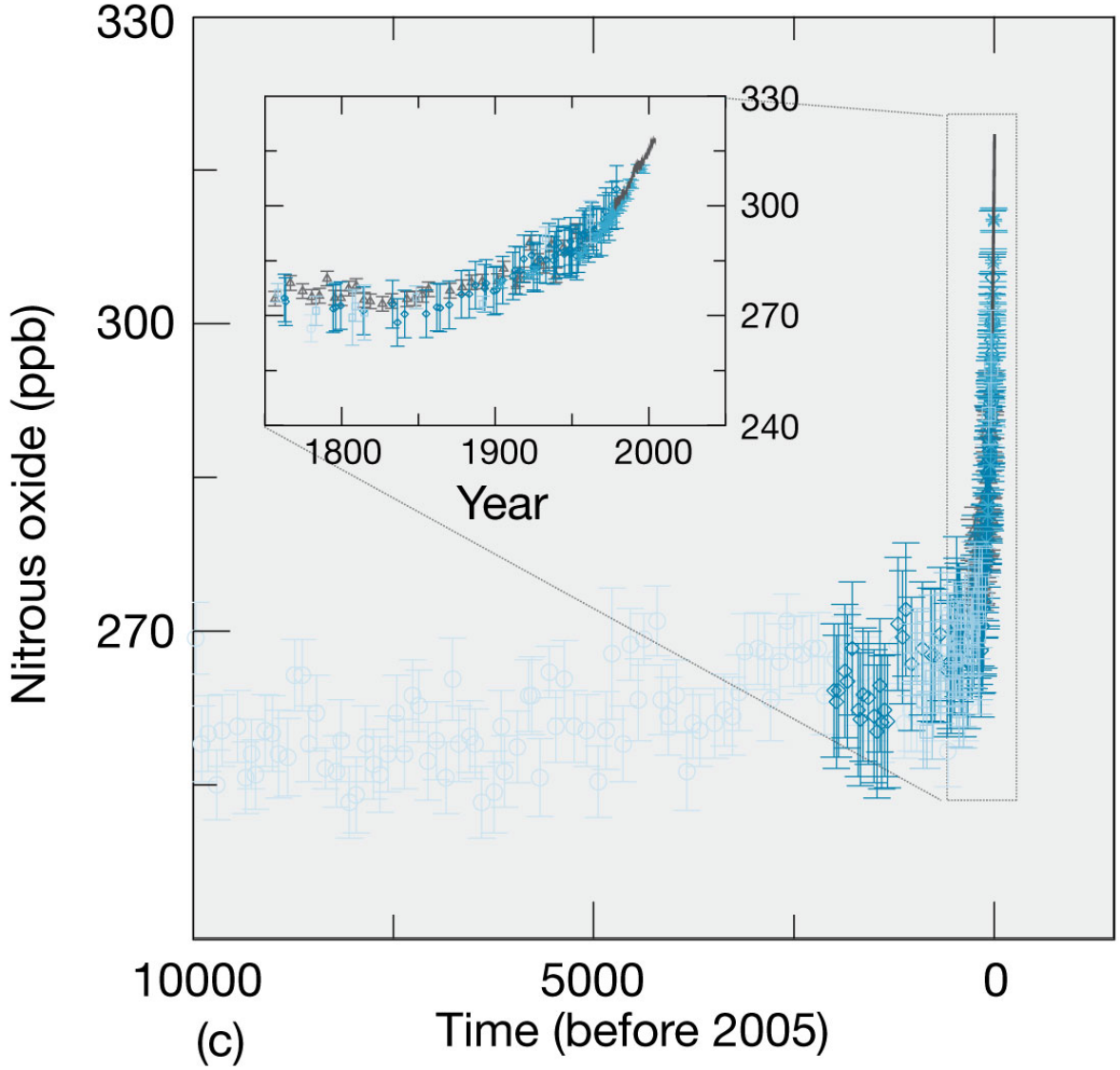
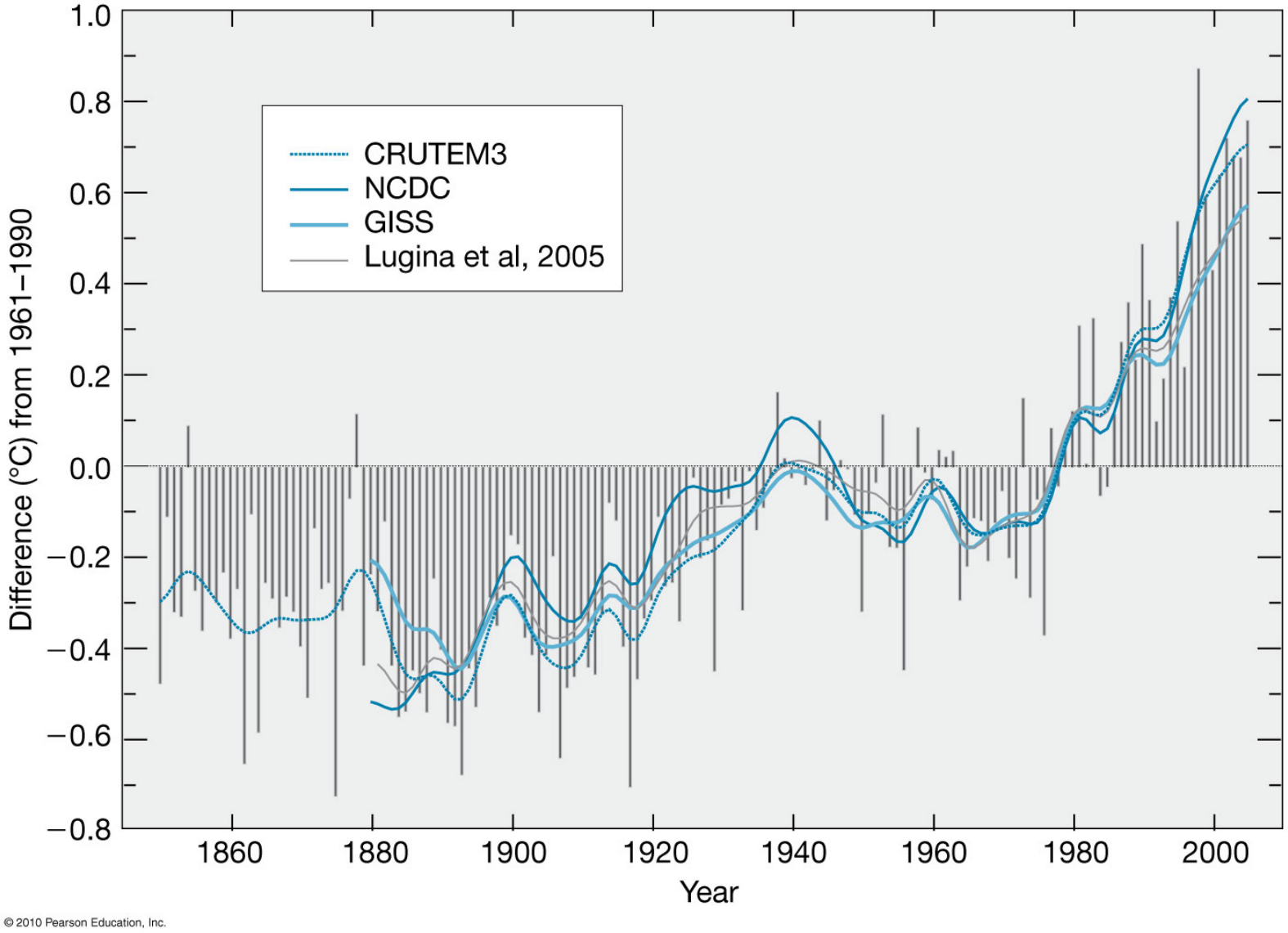


Fig. 1-4



CO_2 is not the only story - there are many factors, some cooling, some warming

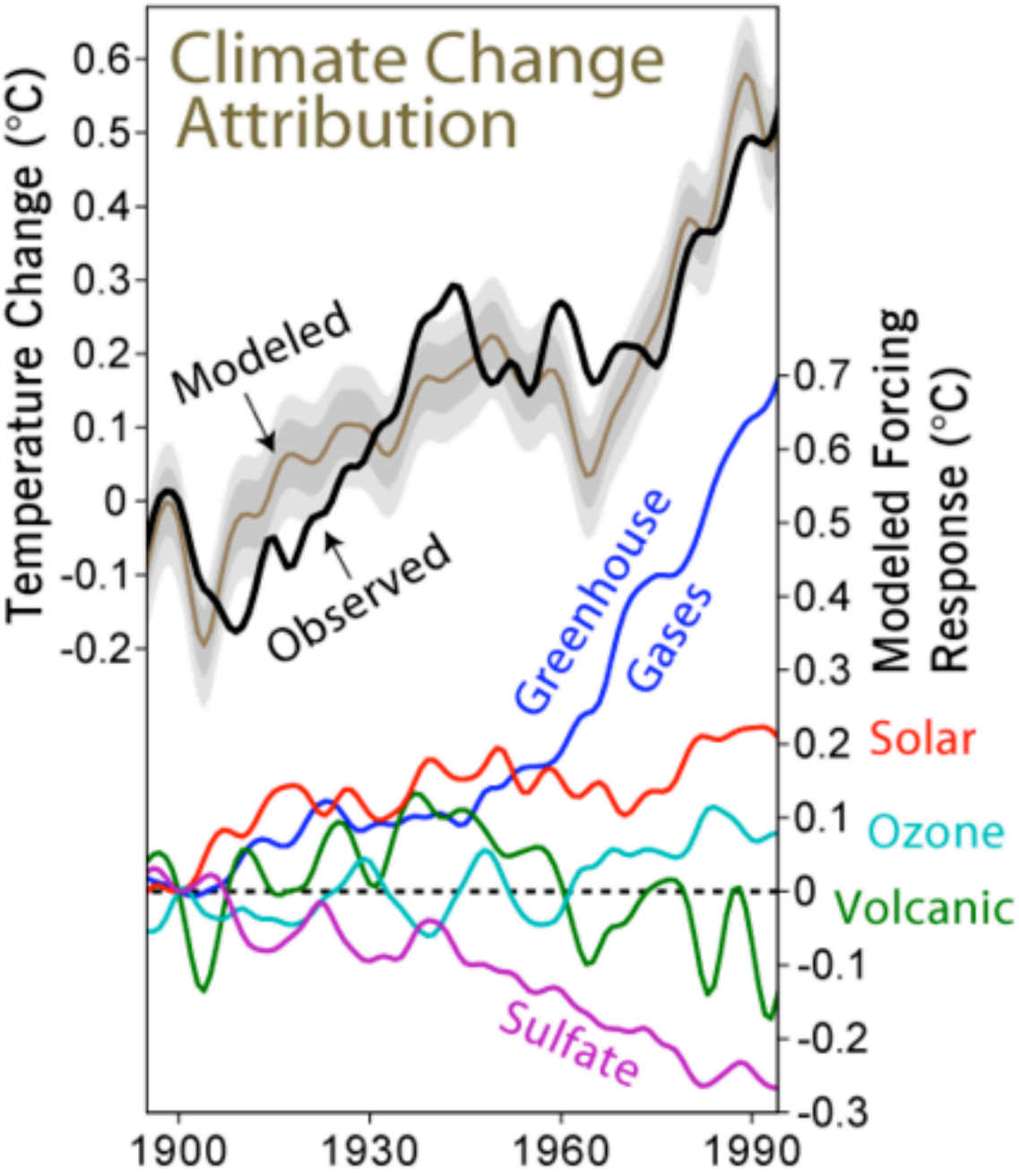
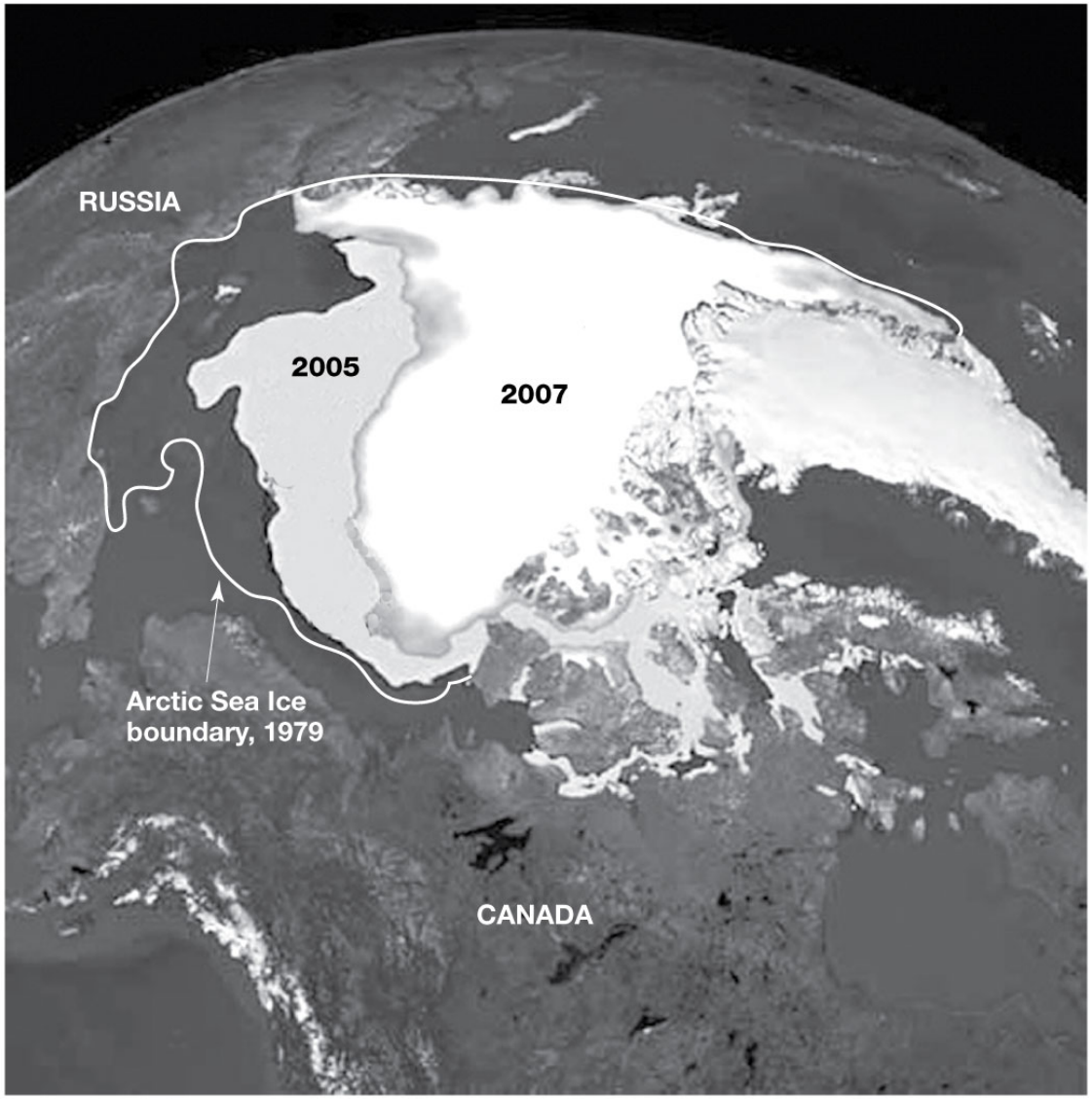
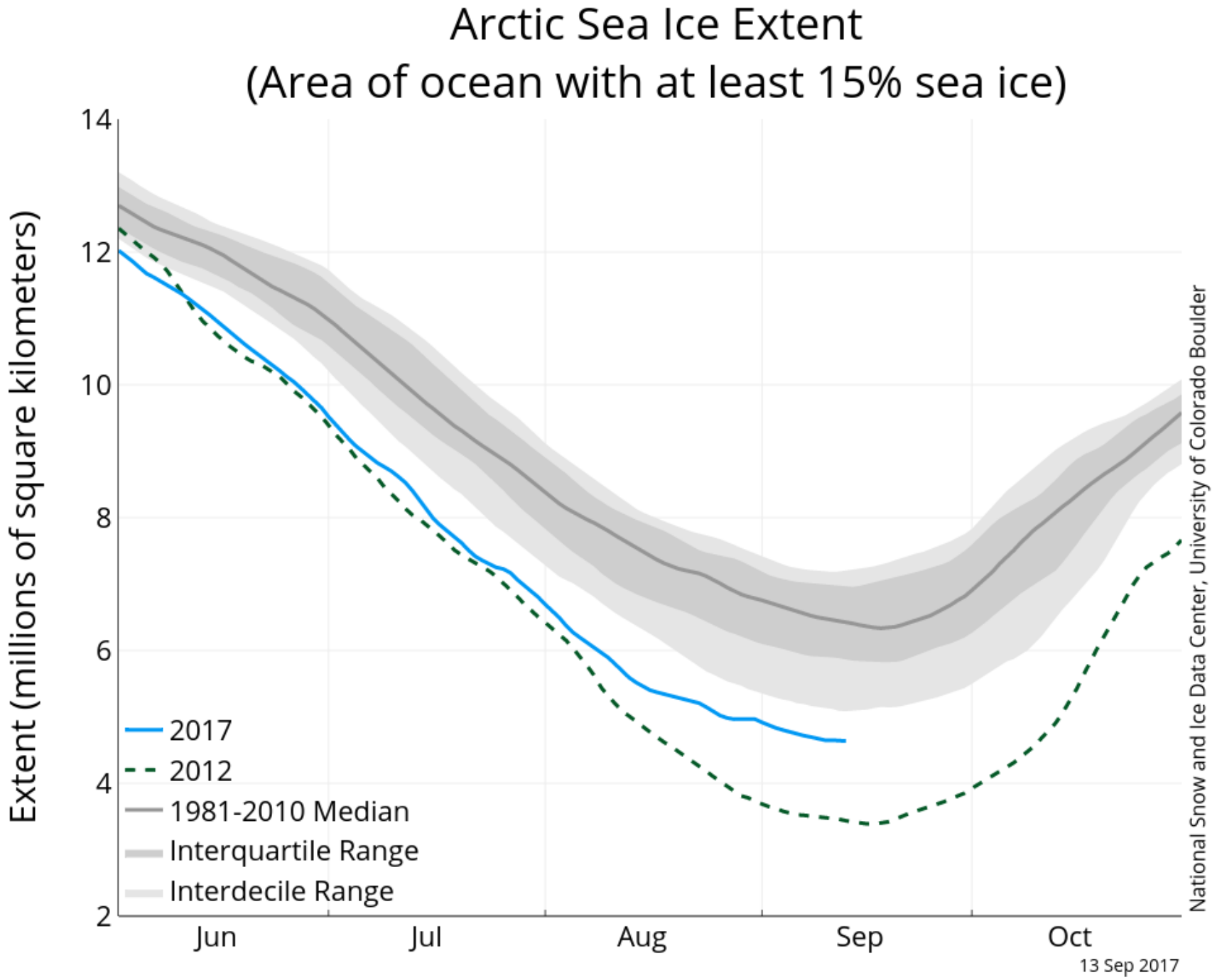
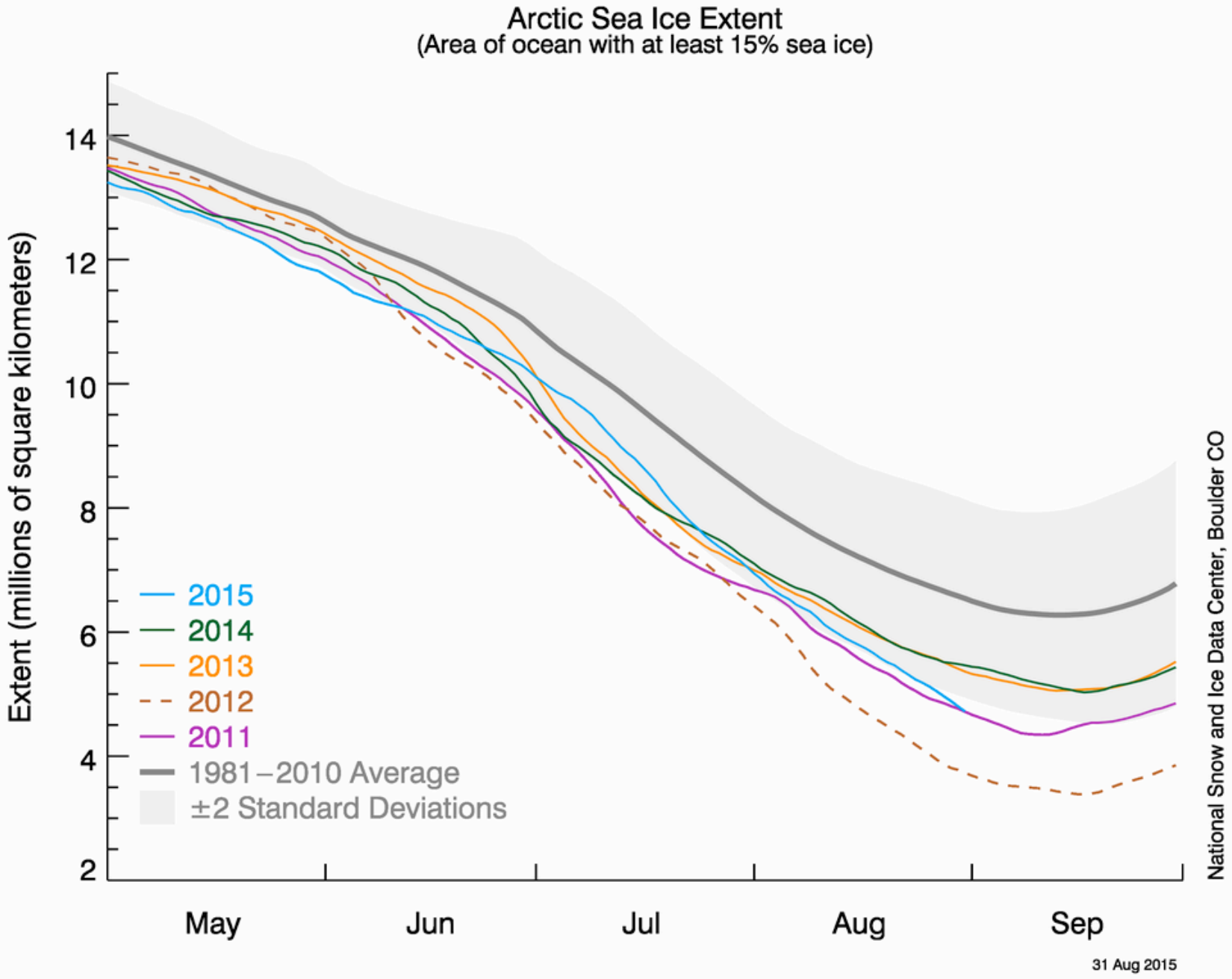

Climate Change
Attribution
Temperature Change (°C)
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
Modeled
Observed
Greenhouse
Gases
Solar
Ozone
Volcanic
Sulfate
Modeled Forcing
Response (°C)
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
1900
1930
1960
1990

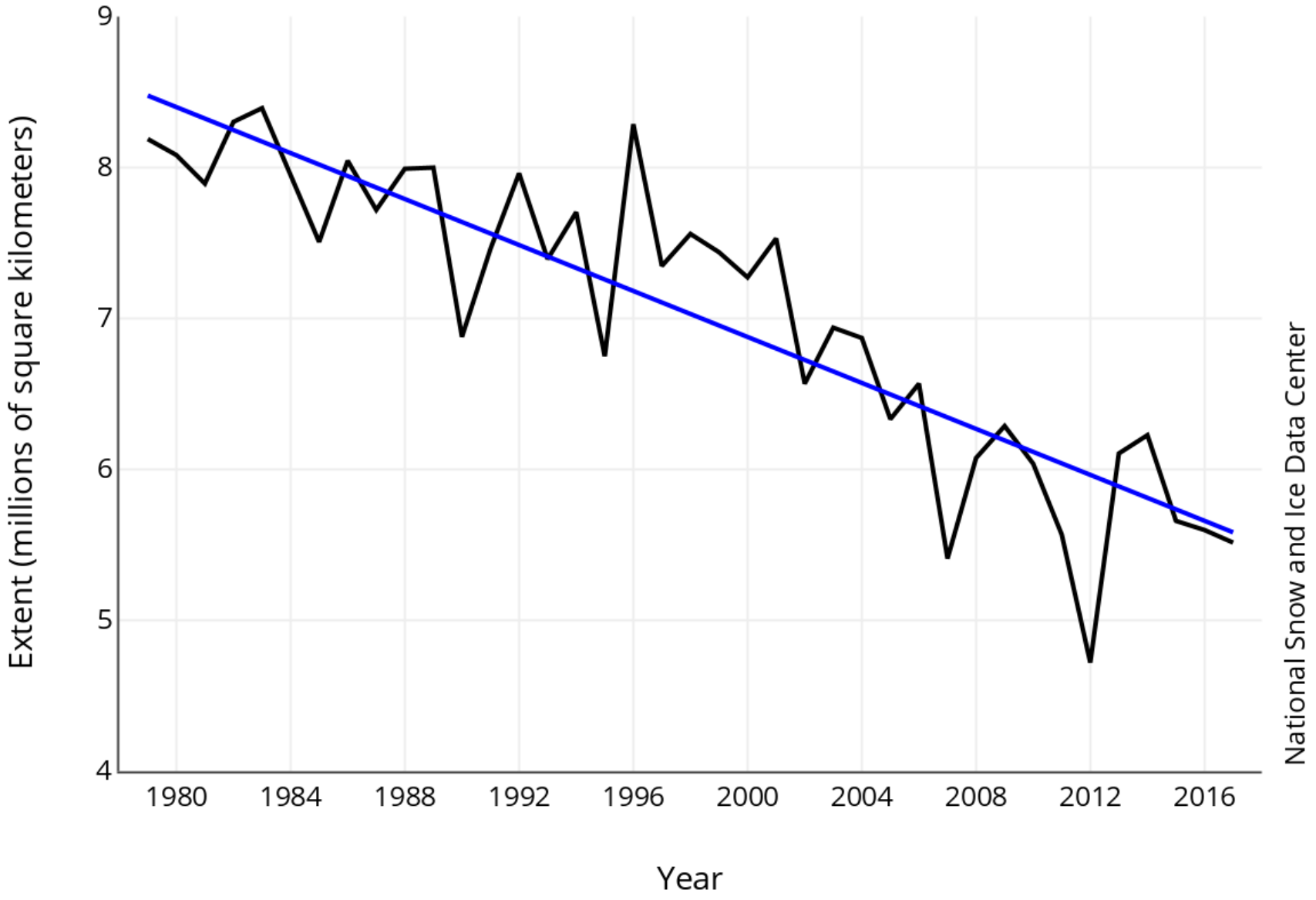
Fig. 1-5

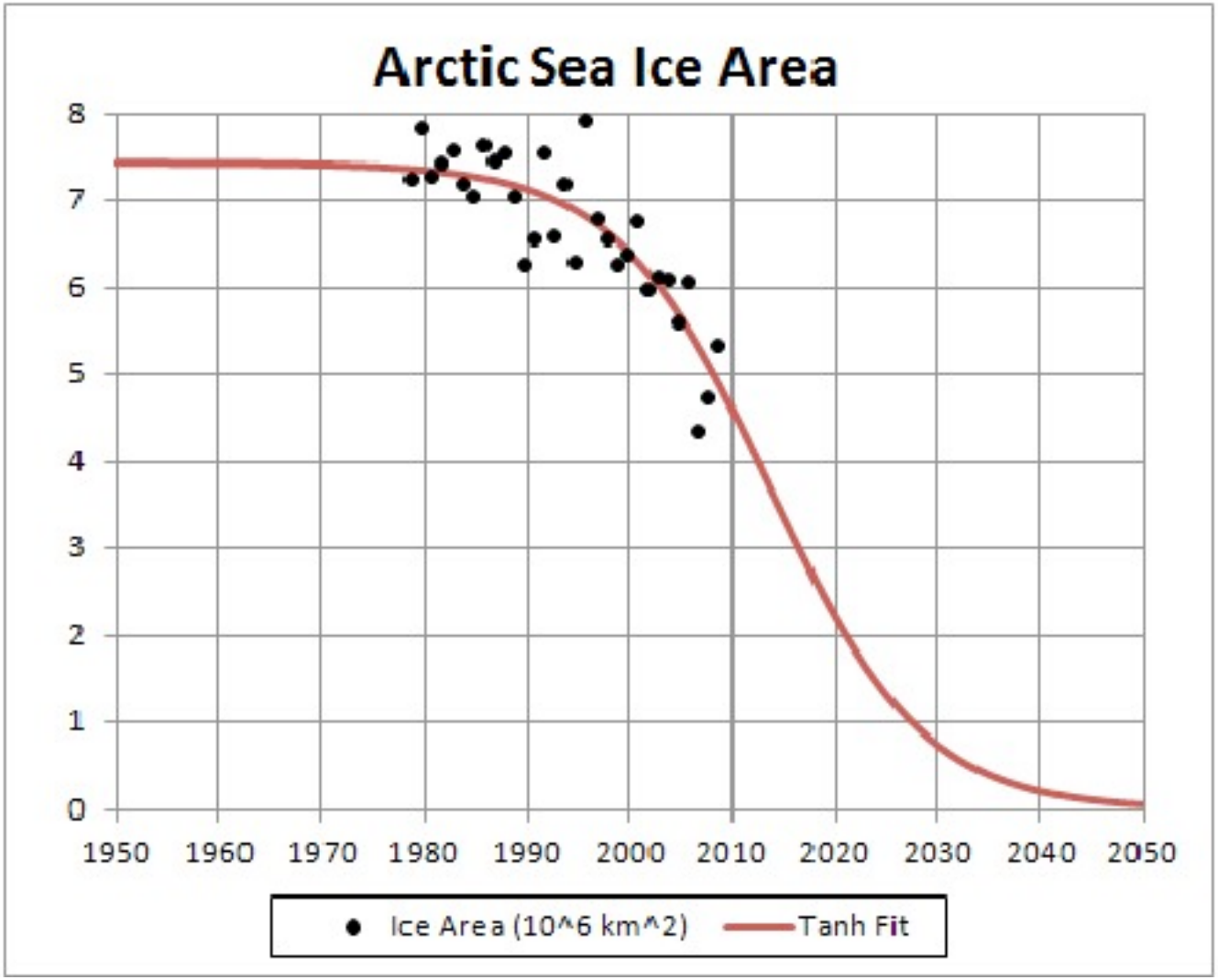
Disappearing sea ice in the arctic…

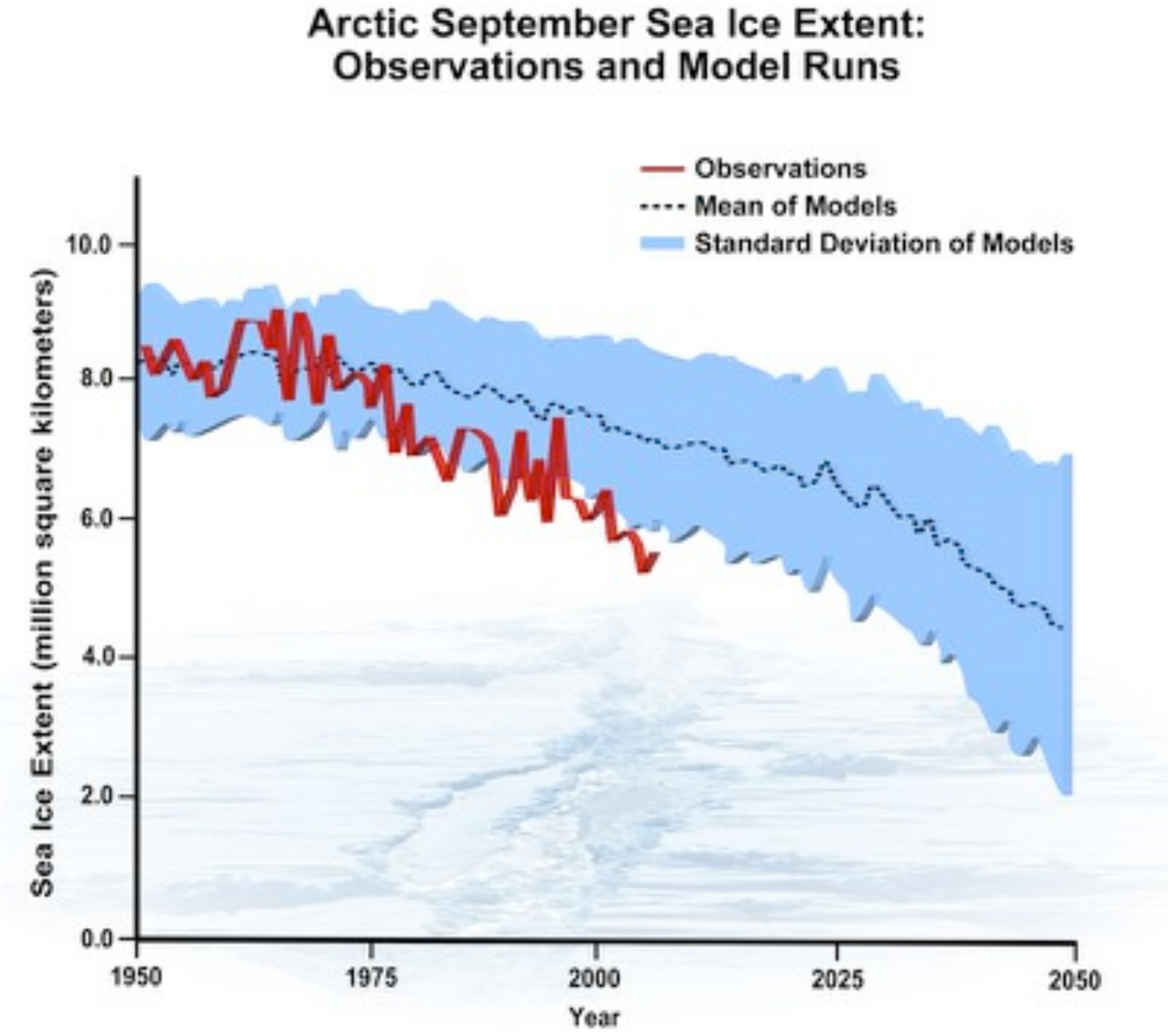



Arctic Sea Ice Extent
(Area of ocean with at least 15% sea ice)
Extent (millions of square kilometers)
14
12
10
8
6
4
2
Jun
Jul
Aug
Sep
Oct
2017
2012
1981-2010 Median
Interquartile Range
Interdecile Range
National Snow and Ice Data Center, University of Colorado Boulder
13 Sep 2017


Arctic Sea Ice Extent
(Area of ocean with at least 15% sea ice)
Extent (millions of square kilometers)
14
12
10
8
6
4
2
2015
2014
2013
2012
2011
1981–2010 Average
±2 Standard Deviations
May
Jun
Jul
Aug
Sep
National Snow and Ice Data Center, Boulder CO
31 Aug 2015


Average Monthly Arctic Sea Ice Extent
August 1979 - 2017
Extent (millions of square kilometers)
9
8
7
6
5
4
1980
1984
1988
1992
1996
2000
2004
2008
2012
2016
Year
National Snow and Ice Data Center

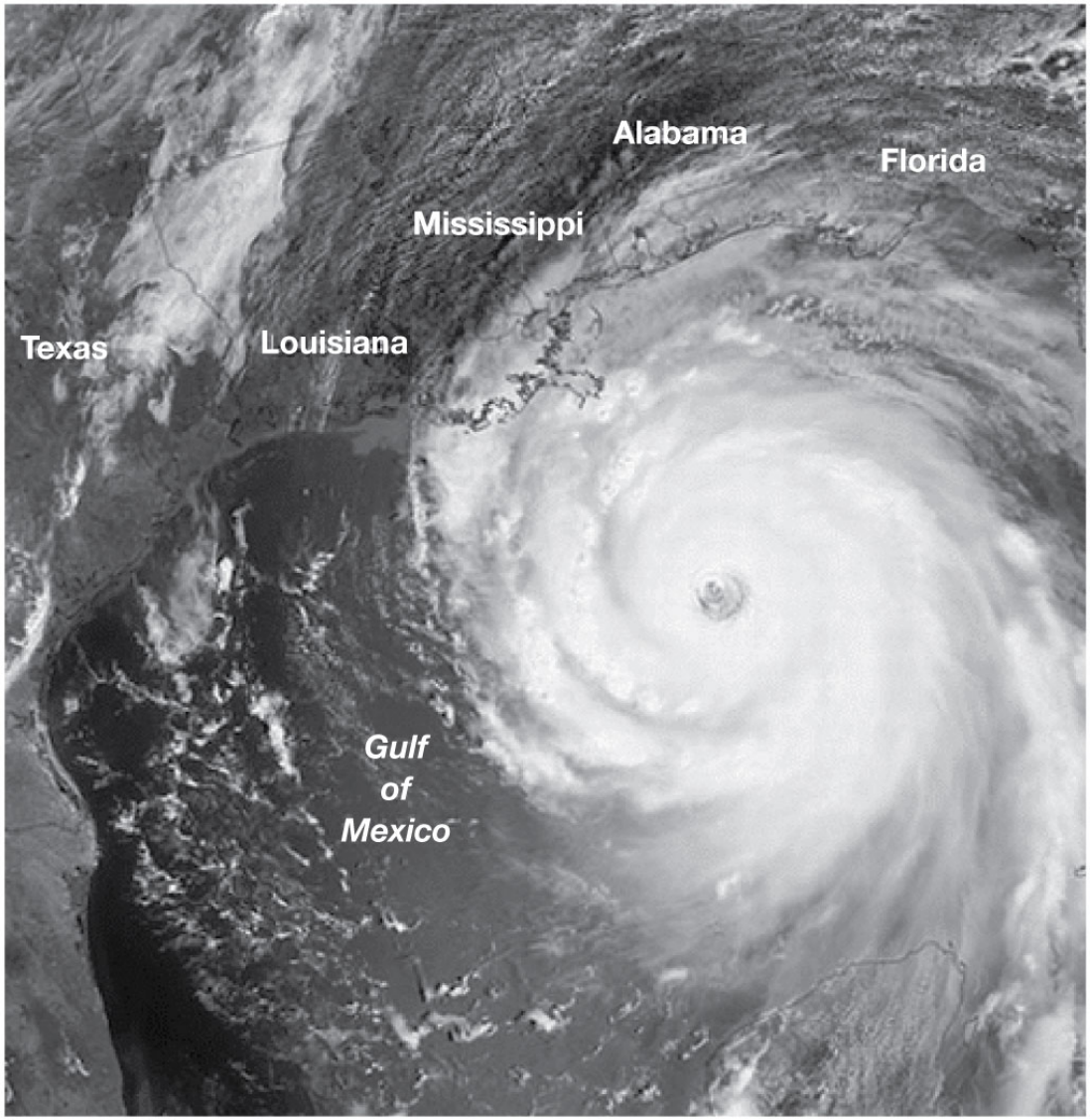

Arctic Sea Ice Area
8
7
6
5
4
3
2
1
0
1950
1960
1970
1980
1990
2000
2010
2020
2030
2040
2050
Ice Area (10^6 km^2)
Tanh Fit



http://ossfoundation.us/projects/environment/global-warming/models-v.-observations

Box Fig. 1-1

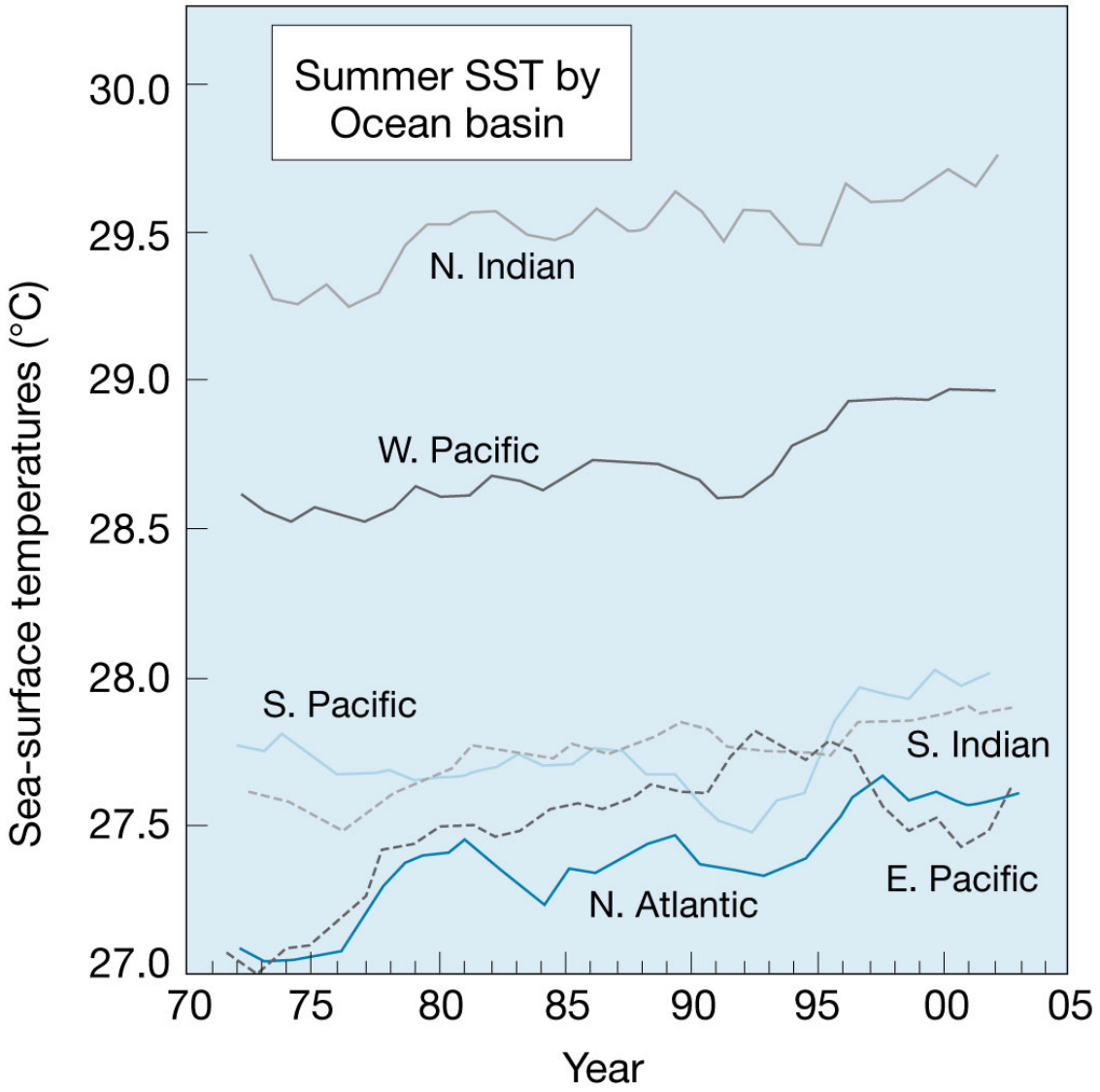
Hurricane Katrina



Box Fig. 1-2a

But hurricanes are not new- is there really any trend in hurricane frequency or strength lately?

Hurricanes feed off of the heat energy in warm ocean surface water. Sea Surface Temperature (SST) should have an effect on hurricanes.



Box Fig. 1-2b

We need more data - but data so far indicate a slight decrease in cat. 1 hurricanes, and a slight increase in more intense cat. 4 and 5 storms. No statistically significant change in cat. 2 and 3 storms.

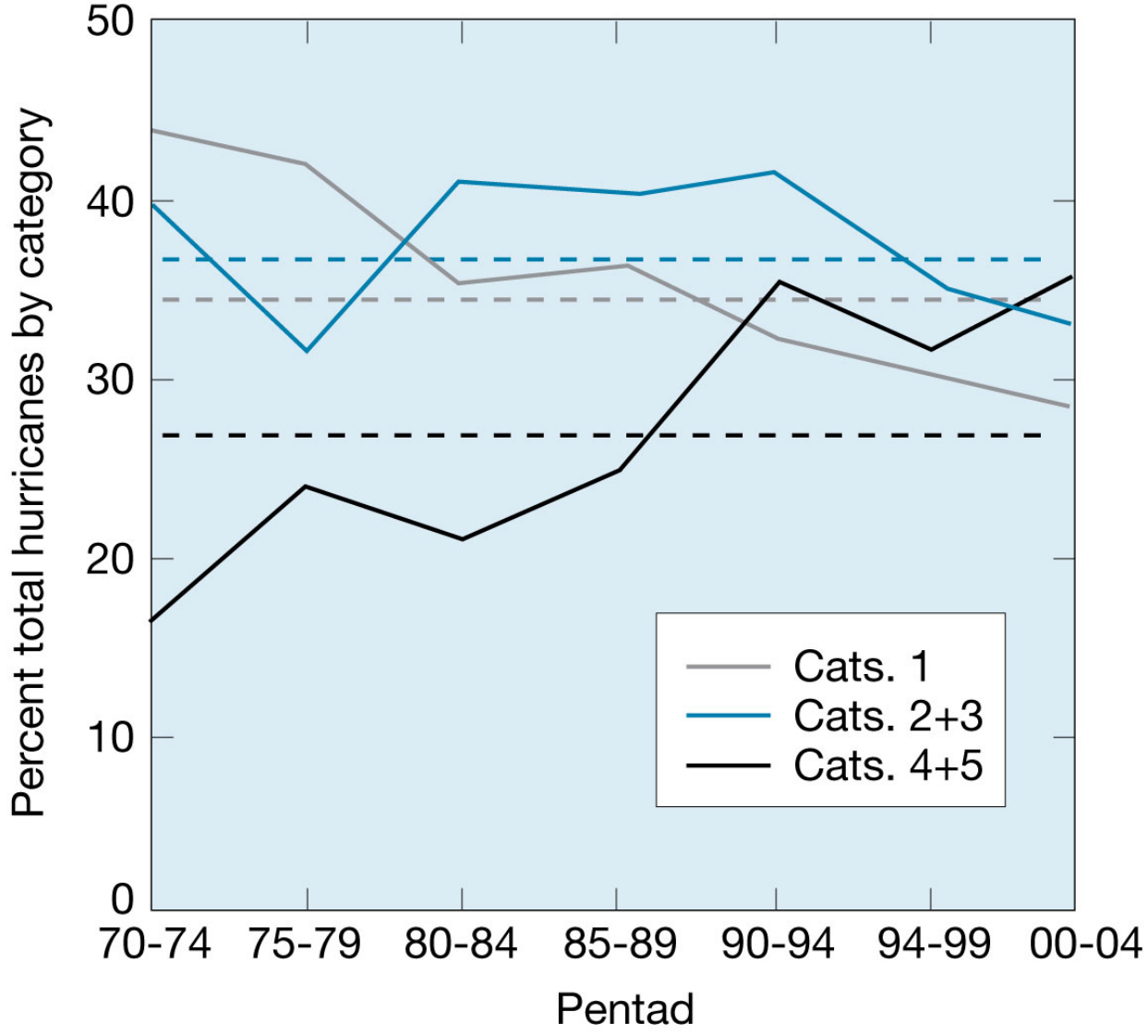


Fig. 1-6a

How else do we affect our atmosphere?

(a)

Fig. 1-6b

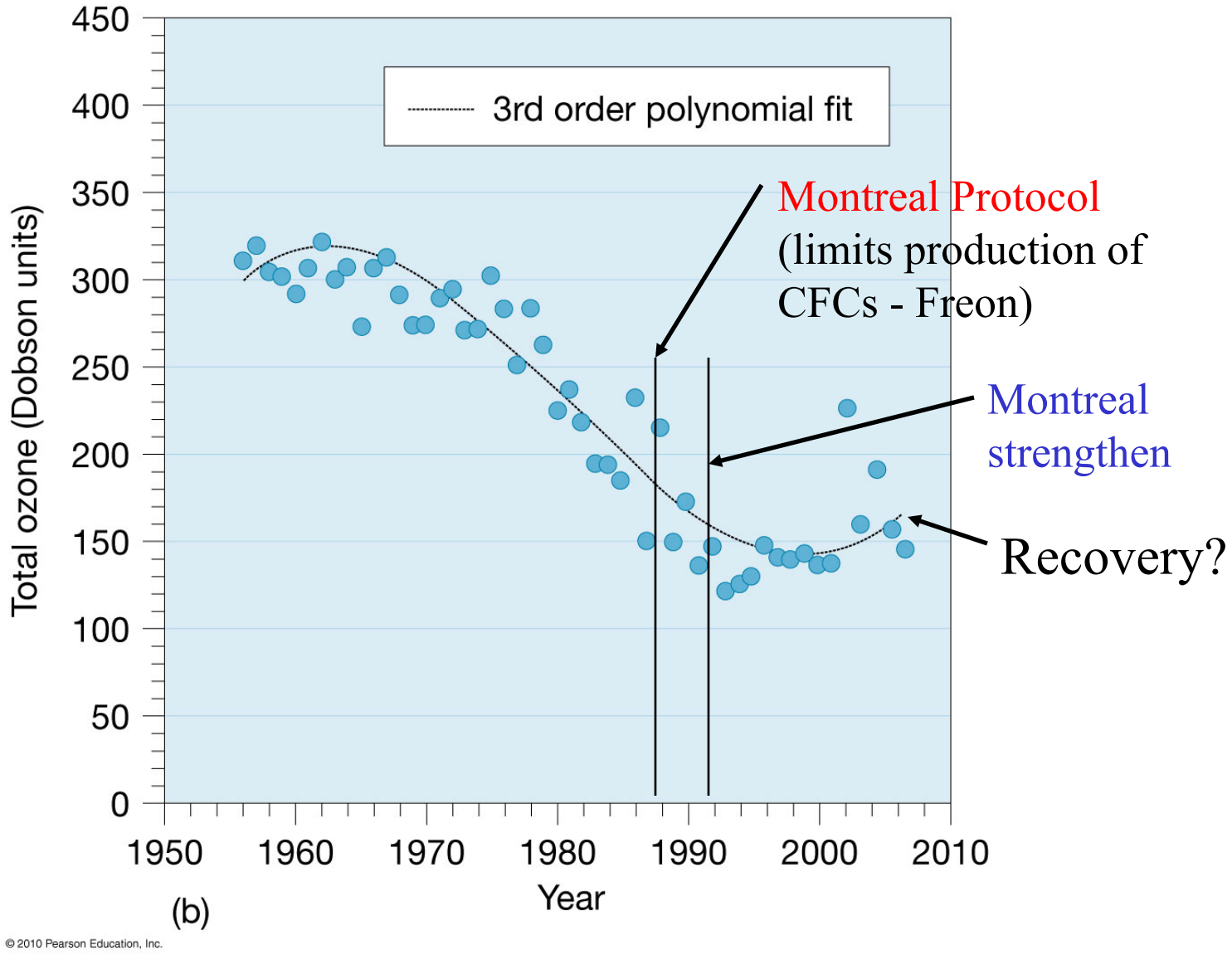

3rd order polynomial fit
Montreal Protocol
(limits production of
CFCs - Freon)
Montreal
strengthen
Recovery?
Total ozone (Dobson units)
450
400
350
300
250
200
150
100
50
0
1950
1960
1970
1980
1990
2000
2010
Year
(b)
© 2010 Pearson Education, Inc.

Fig. 1-7a

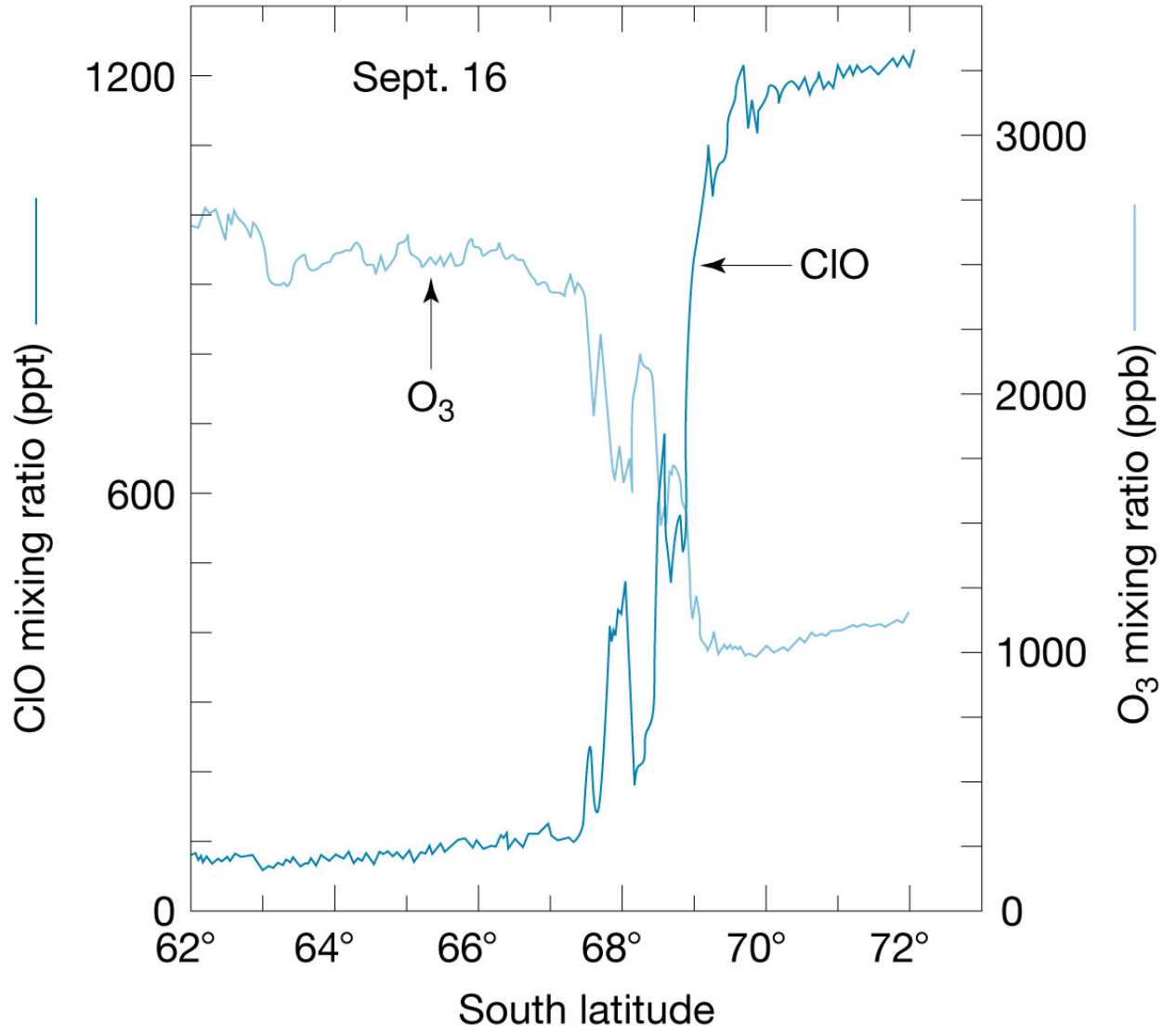


Fig. 1-7b

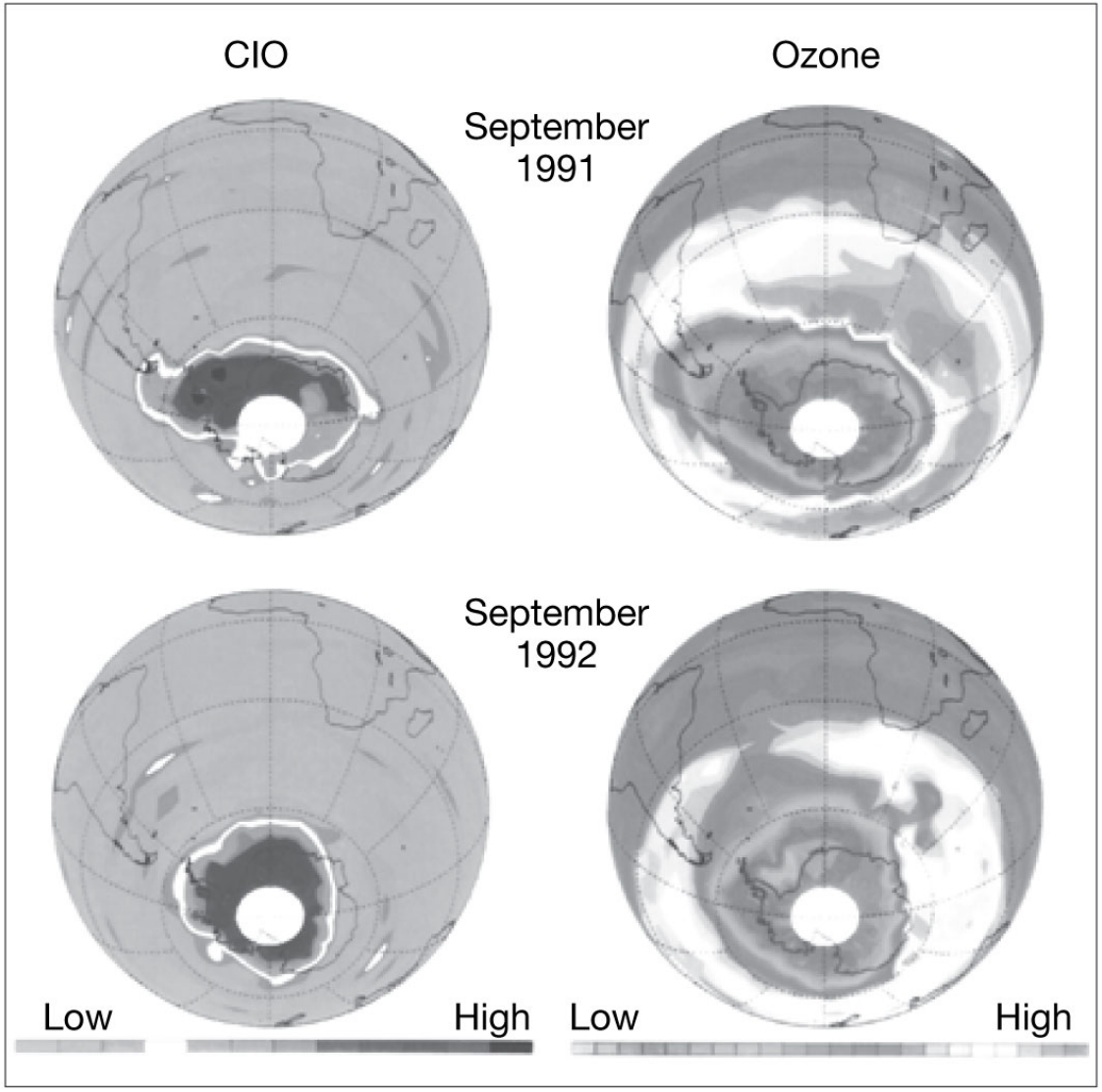


Fig. 1-8a Deforestation…

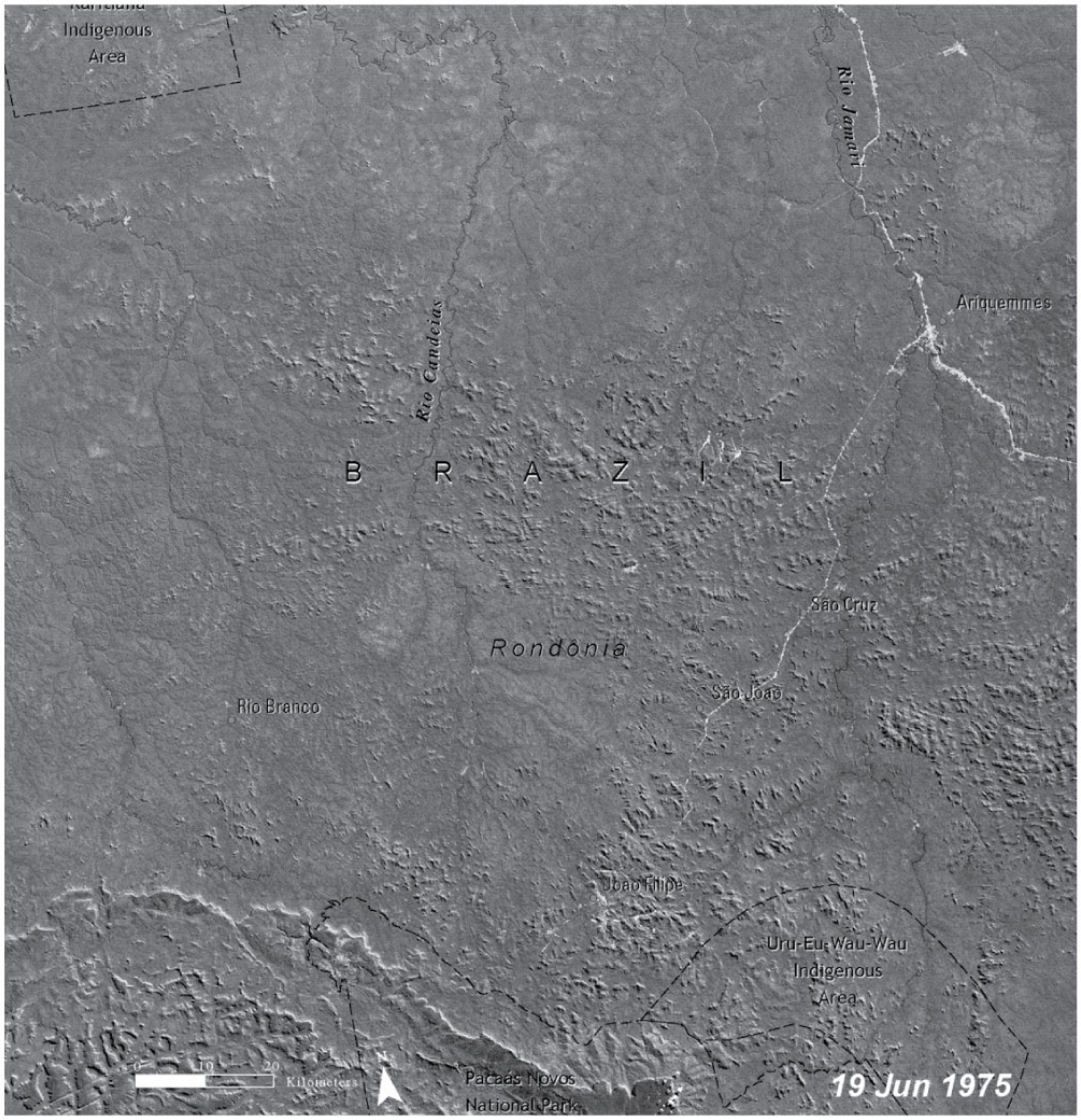
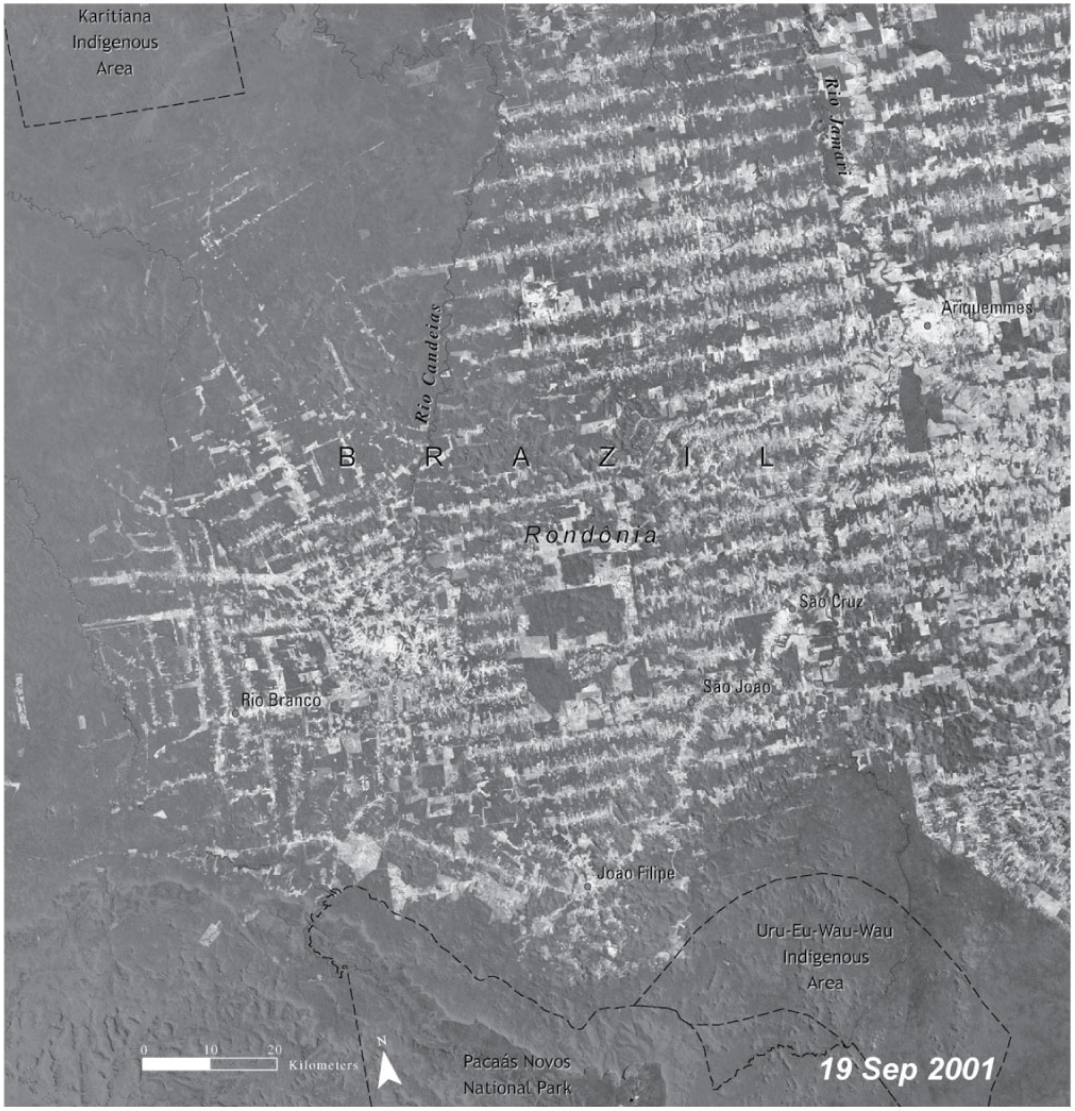


Fig. 1-8b




UNEP
Image Landsat
Google
Imagery Date: 4/10/2013 10°03'20.80" S 63°30'35.00" W elev 191 m eye alt 20


UNEP
EVERY HUMAN HAS RIGHTS
WWF
Image Landsat
ARK
Google earth


Image © 2013 DigitalGlobe
Image Landsat
Google earth
Imagery Date: 4/10/2013 0°26'36.64" S 76°16'58.30" W elev 223 m eye alt 21.45 km


N
Image © 2013 DigitalGlobe
Image Landsat
Google earth

Fig. 1-9

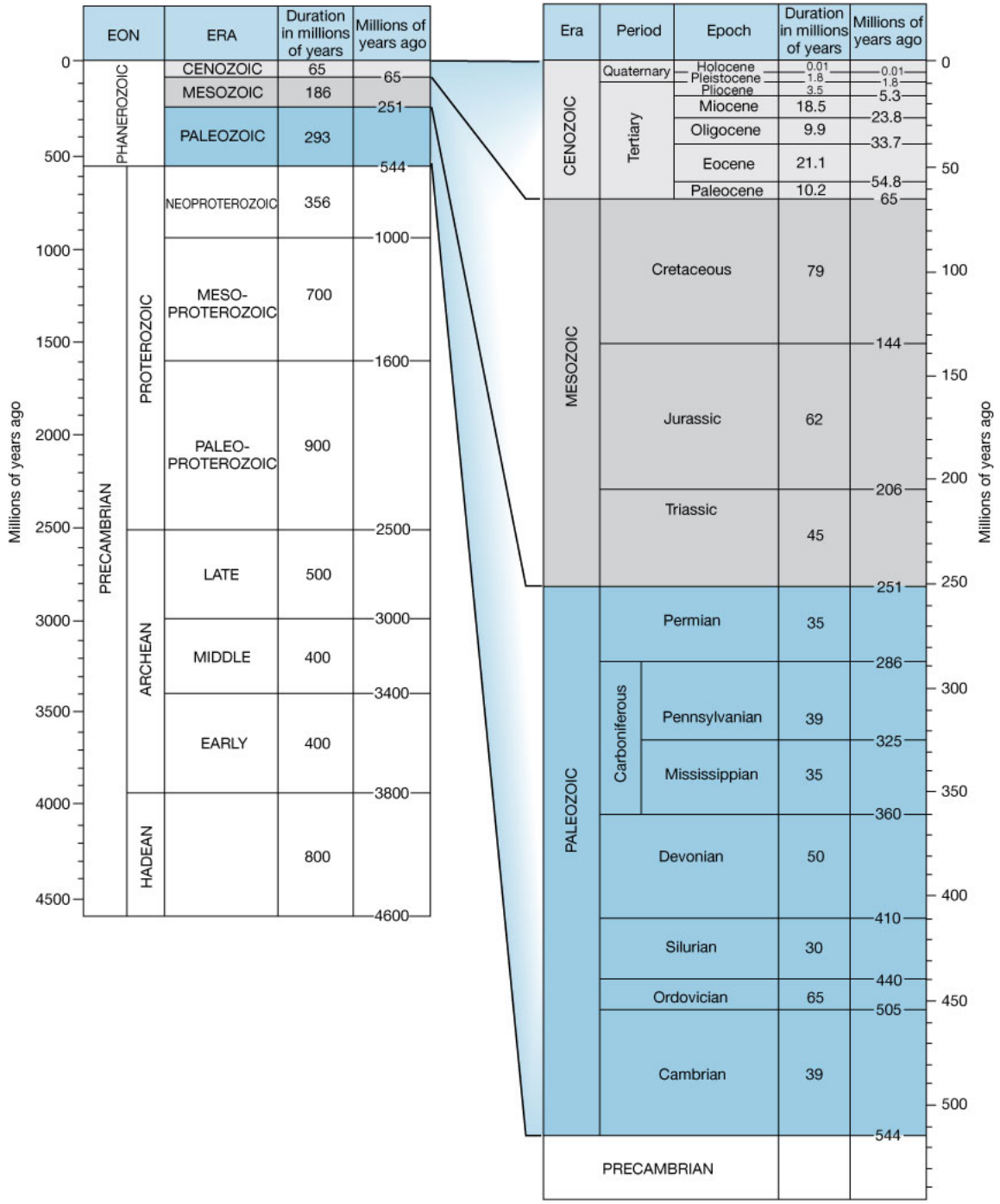


Fig. 1-10

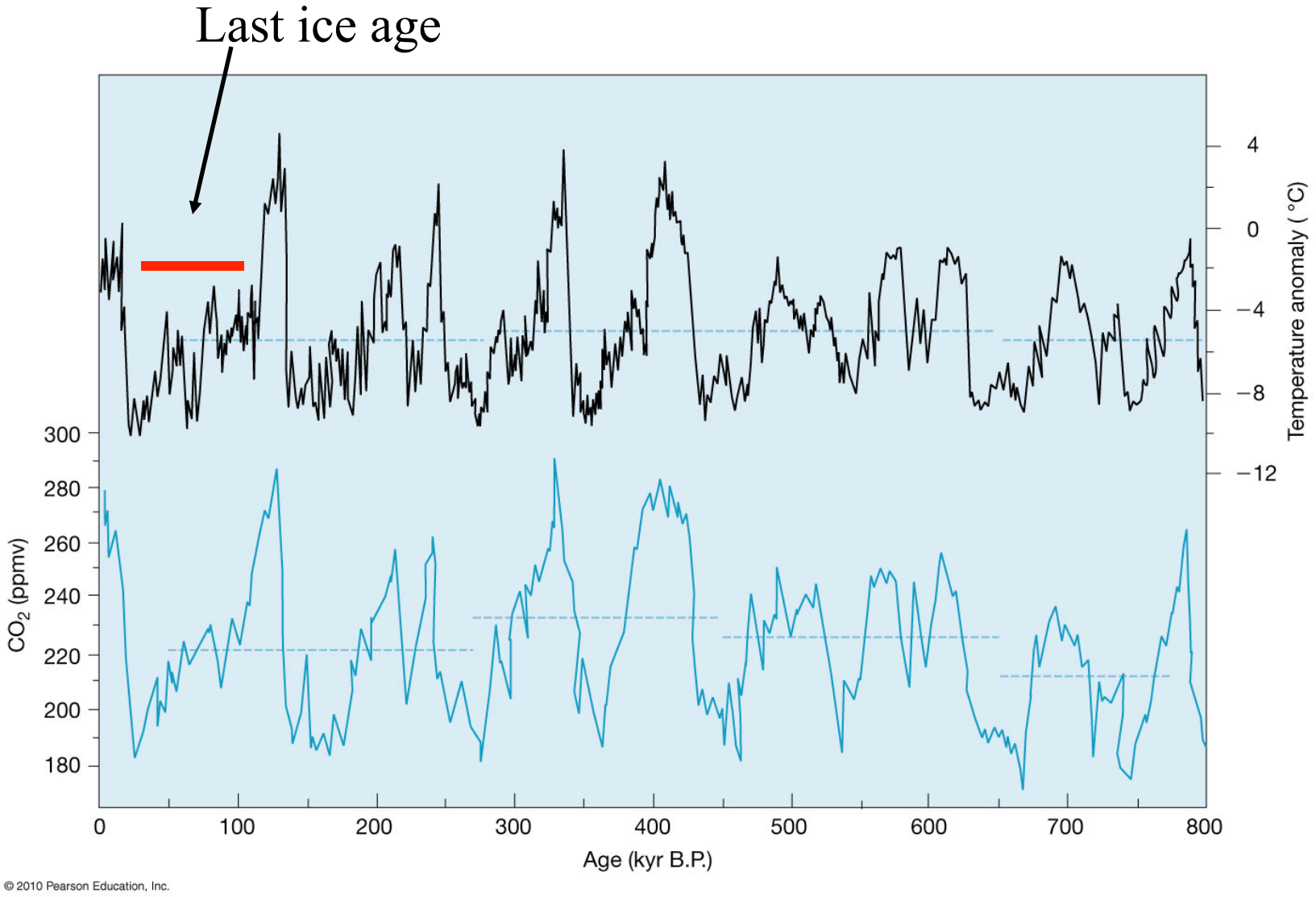


Fig. 1-11

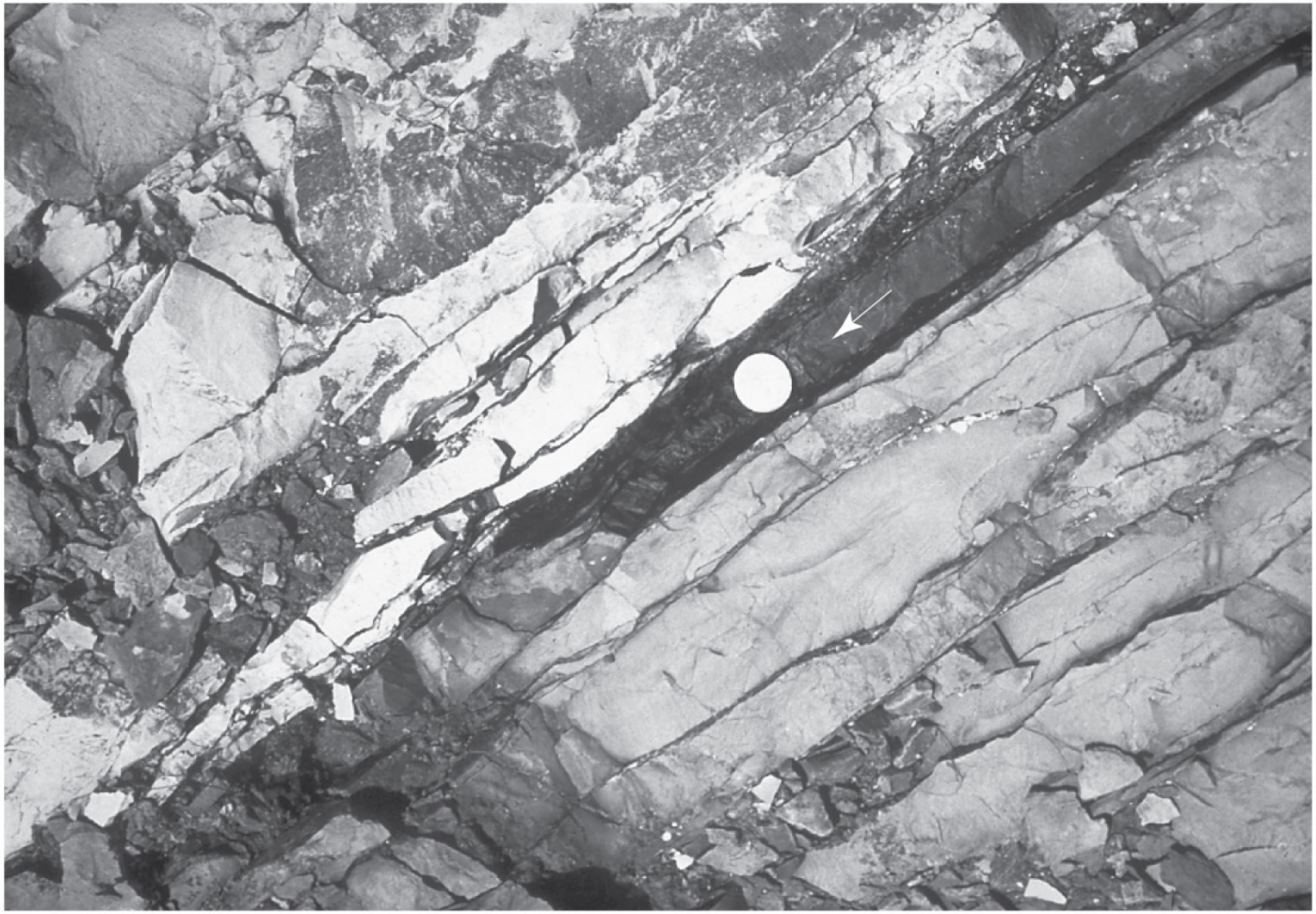


Fig. 1-12

Major change on a short time scale: Asteroid/comet impact on Earth

Ir is relatively rare at Earth's surface. Ir is more concentrated in meteorites, and probably is more abundant in Earth's core. Ir layer is consistent with impact.

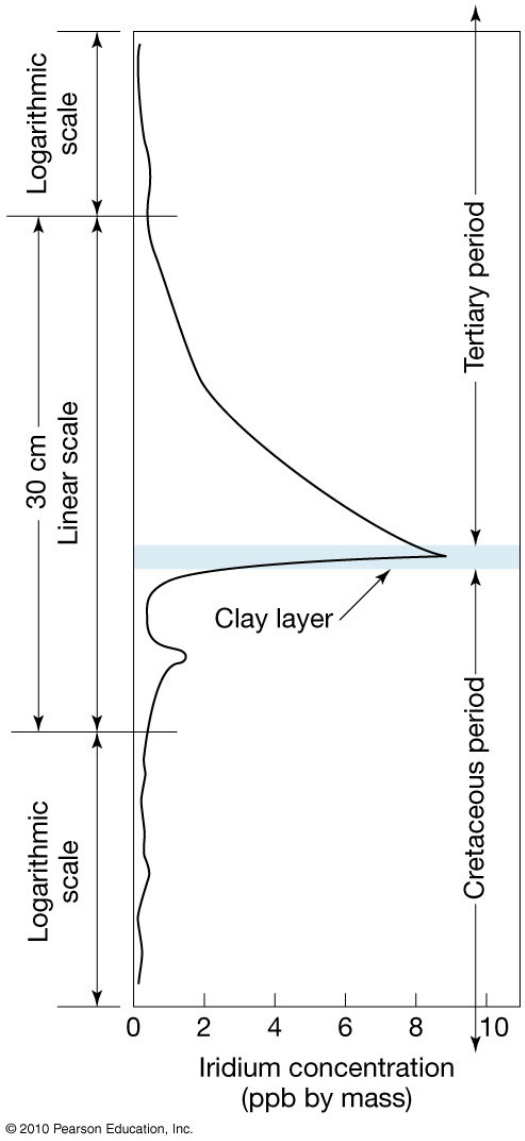


Fig. 1-13

Very long term change (forcing): Increase in solar energy output over Earth's history: