Mon Sept 29 Outline

Course mechanics

Who am I and what are my qualifications to teach this course?

Earth-System Introduction

Level of difficulty of this course

Surveys: Personal and Global Warming

Course Mechanics

Look over syllabus

Visit the class web page!

Bring questions to class this week

Course structure in a nutshell:

Week 1:	**Introduction to Earth-System and Science**
Week 2:	**Stratospheric Ozone Depletion ('ozone hole')**
Weeks 3-11:	**Global climate change**

Who am I?

Primarily, a research scientist

- Aerosol particles, climate forcing, atmospheric chemistry
- An experimentalist with interest/concern for "integration"

As a teacher

- Taught this course in 1997, 2003
- Love the subject (all its facets)
- Deep interest in conveying the nature of science to non-scientists
- Very aware of the challenge of learning new concepts (new ways of thinking)

joke #1

Why did the lady go outside with her purse open?

She was expecting 'change' in the weather.

What can you hope to gain from a better understanding of global climate change?

Earth as a "coupled system"

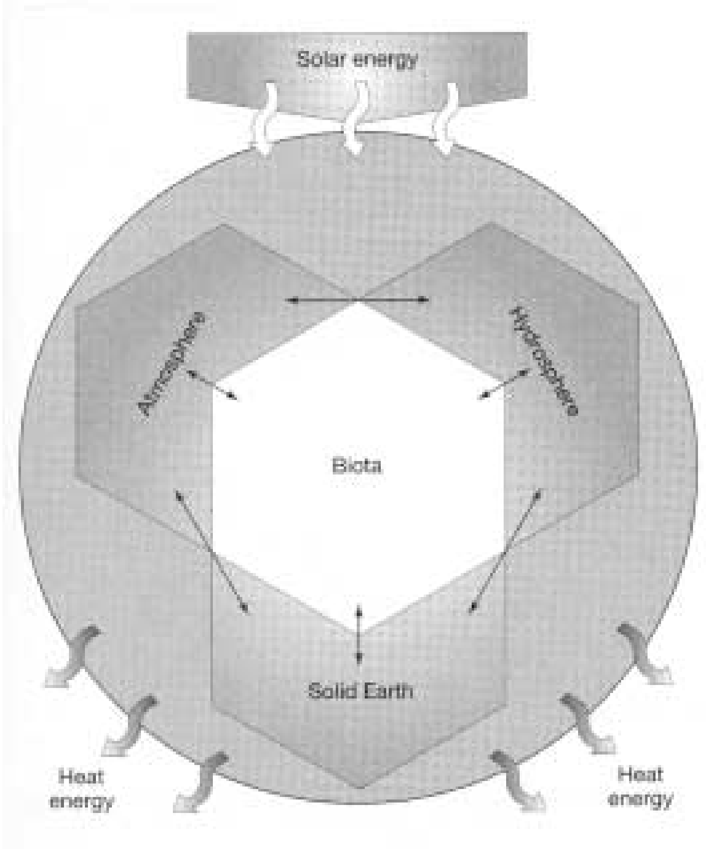


FIGURE 1-1

Schematic diagram of the Earth system, showing interactions among its four components. (From R.W. Christopherson, *Geosystems: An Introduction to Physical Geography*, 3/e, 1997. Reprinted by permission of Prentice Hall, Upper Saddle River, N.J.)

What is this figure trying to show?
In what ways is it misleading?
How else could the same information be presented?

Earth as a “coupled system”: Natural example

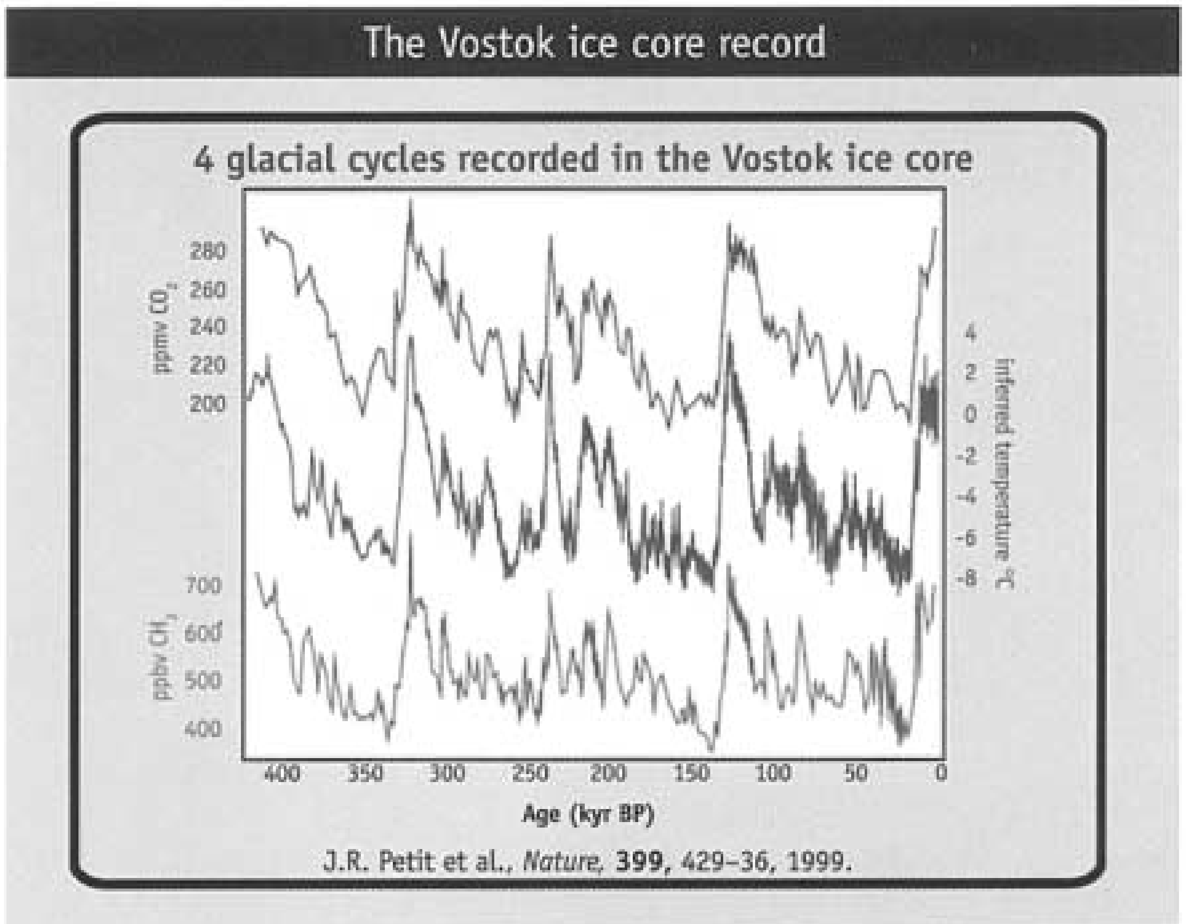


Figure 1 The 420,000 year Vostok ice core record, showing

Earth as a "coupled system": human perturbation

Do humans have the ability to affect the global environment?

text p.1: "Earth is changing faster today than it has throughout most of its 4.6 billion year history." Why?

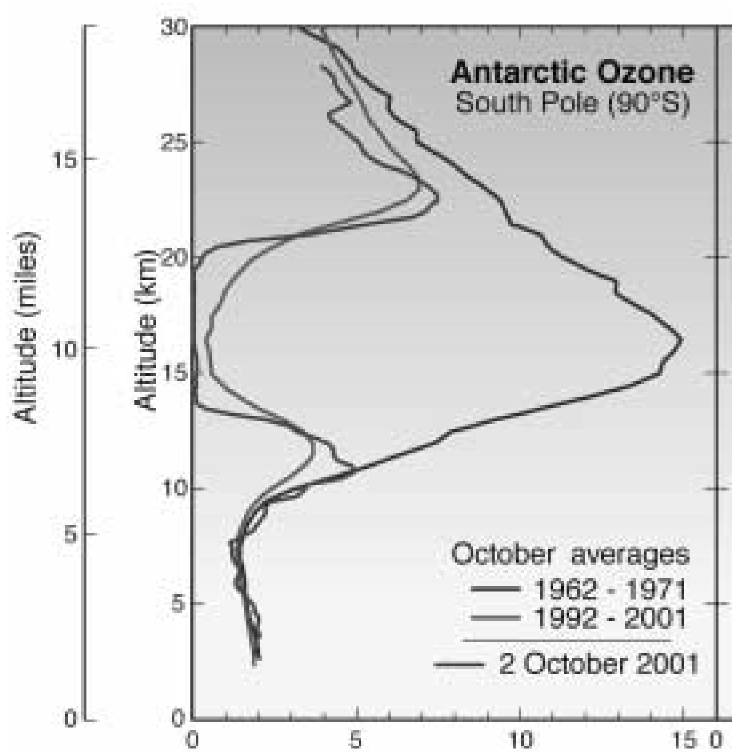
Do we have the ability to prevent undesirable consequences?

"Anthropogenic" (formerly, "man-made"): caused by humans

high-tech examples:

low-tech examples:

The 'Ozone Hole' over Antarctica



Ozone Concentration (hPa)

Figure source: http://www.al.noaa.gov/WWWHD/pubdocs/Assessment02/Q&As.html

MATH / CHEM QUIZ

Tues Sept 30 Outline

Announcements/mechanics

discuss global warming survey

introduce key themes of course
- define climate
- earth as a "coupled system"
- energy balance theory of climate change
- nature and role of science (tomorrow)

handouts: Popper article, HW#1

Sept 30 Announcements:

WASHPIRG speaker

Web-address change

http://www.atmos.washington.edu/2003Q4/211/

Other questions on syllabus?

discuss global warming survey (new experiment)

Key themes

Weather vs Climate (overheads)

climate: "The characteristic pattern of weather over a region and over a period of time."

weather elements: temperature, rainfall, humidity, sunshine, wind, etc

climate: what you expect *weather:* what you get

Key themes

what factors control climate?

latitude (sunshine)
land/ocean contrasts
altitude, topography
atmospheric and ocean currents

- climates through time

- climates around the world

Key themes

- Earth as a "coupled system"

Forcing

(p.3-4): "One of our goals is to show how the different components of the Earth system interact in response to various internal and external influences, or *forcings*."

Distinguish "Forcing-response" from "cause-effect"

"Forcing": an imposed change on one or more components of the Earth system. Examples?

Earth as a coupled-system

> stability: "dynamic equilibrium"

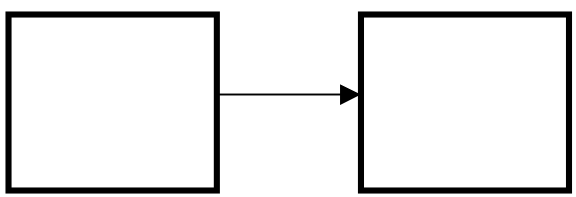
> change: "forcing/response" (not simple "cause/effect")

> response involves "feedbacks"; can be "non-linear" and unanticipated

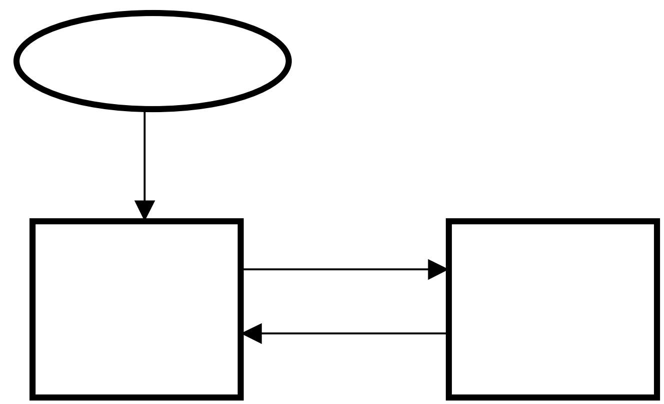
> timescales (e.g. of response to a perturbation)

> complexity ("no law says nature has to be simple")

> Note: ozone-hole (week 2) will illustrate all of this



Cause >>> Effect



perturbation of a coupled system

Energy Balance Theory of Climate Change

$$\Delta T = \lambda \, \Delta F$$

Note:

Δ: common symbol to refer to change in some quantity

ΔF: forcing (change in energy balance)

ΔT: response (change in surface temperature)

λ: feedbacks (climate sensitivity)

This equation will run throughout the climate-change portion of the class as a unifying theme.

Equations are fun! Concise statements of knowledge. "Do not be intimidated by these wonderful little artifacts of science" ! [Richard Turco]

Wed Oct 1

Announcements:
- Textbook: we will use the older, 1999 edition, ozone Ch 14
- HW #1 and homework policy (due at beginning of class)
- Articles: handouts vs pdf files
- Need a volunteer notetaker

Outline:
- energy balance theory of climate change
- nature of scientific knowledge (Popper article)
- role of science in public policy (e.g. "skeptics" vs science)
- compare three global-scale problems

Tomorrow: begin ozone
Friday: math/chem refresher (session 1)

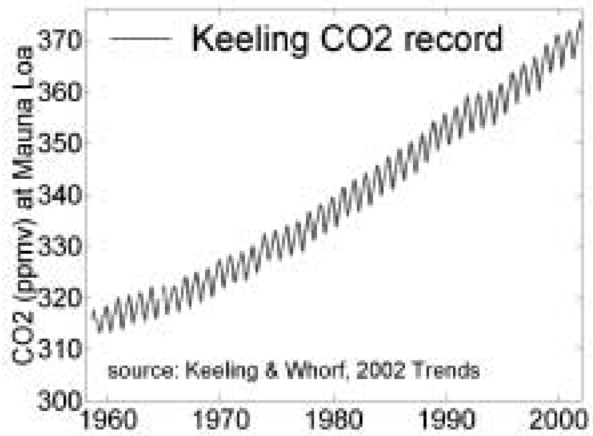
What makes everyone sick except those who swallow it?

flattery

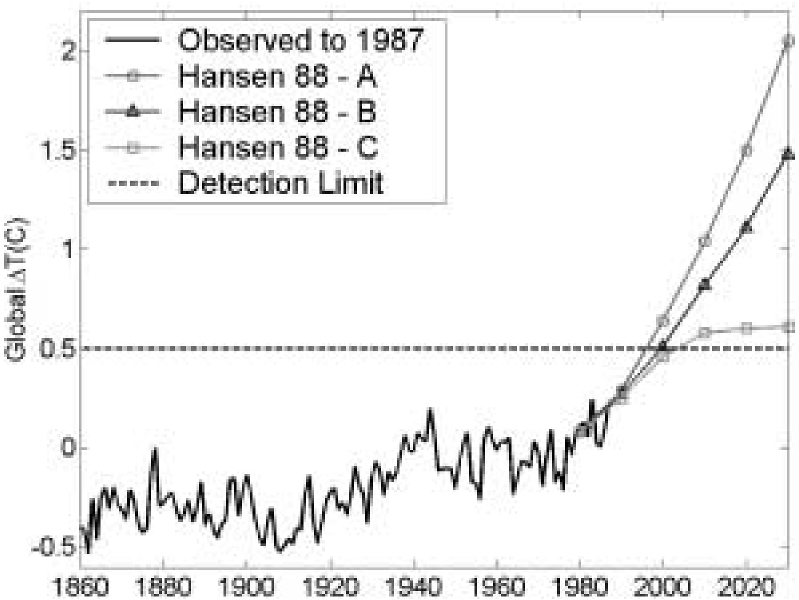
Where will you find the center of gravity?

Current global-warming paradigm

1. Climate forcing from CO2 and other "greenhouse gases"



2. Predicted response, based on climate models



Current global-warming paradigm

3. warming has been <u>detected</u>

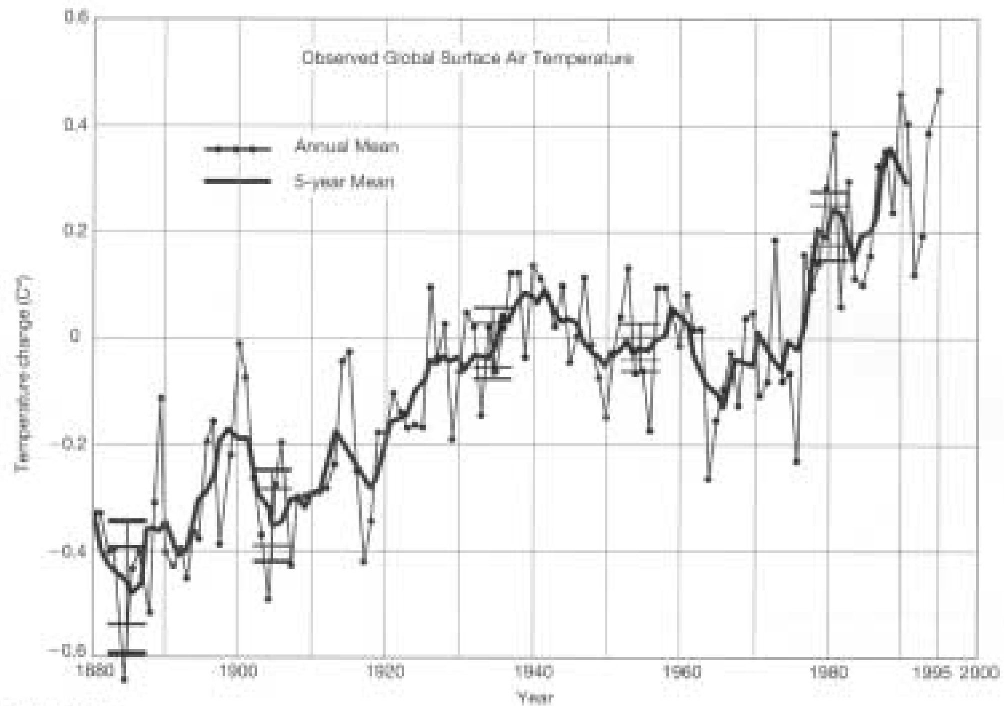


FIGURE 2-4

The globally averaged temperature history from 1950 to 1996, showing the 0.5°C (1°F) cooling associated with the eruption of Mt. Pinatubo in 1991. Anomalies are defined as deviations from the 1951–1980 mean. (From R.W. Christopherson, *Geosystems: An Introduction to Physical Geography*, 3/e, 1997. Reprinted by permission of Prentice Hall, Upper Saddle River, N.J.)

Measured change in global-annual average surface temperature (GAAST)

Energy Balance Theory of Climate Change

1. climate forcing from increased greenhouse gases is a change in energy balance, ΔF
2. predicted response, ΔT_{pred}, requires knowledge of climate sensitivity, λ
3. measured response, ΔT_{meas}, requires global monitoring and allows testing of the prediction

The fundamental theory behind global-warming research is the "energy balance theory of climate change":

$$\Delta T = \lambda \, \Delta F$$

$\Delta T = \lambda \, \Delta F$ questions... (see Ch 1 and HW#1)

1. How do we know that CO_2 is increasing and that this increase is due to humans?
2. How accurately can we quantify the resulting change in planetary energy balance, ΔF?
3. How do scientists estimate climate sensitivity, λ? What elements and couplings of the climate system are involved?
4. Exactly what is ΔT? How is it measured? How well is it known?

definition: GAAST

Global-Annual Average Surface Temperature

ΔT: change in GAAST

Nature of scientific knowledge

Theme: scientific knowledge is falsifiable

Popper article (overheads)

Science and Policy: The Ideal

Science and Policy: The Ideal

Goal of science --> understand the Earth

Goal of society --> maintain habitability of Earth

} Symbiotic relationship

Healthy and Unhealthy Public Debates

healthy:

i. public debate based on options and risks laid out by science

> Selecting among options, weighing risks and benefits, involves **values**. This is beyond domain of science.

unhealthy:

ii. public debate based on bad or distorted science

iii. public debate about the science itself

(are you okay with that?)

(ii) and (iii) occur when individuals or organizations:

- claim to speak for science, but in fact are on the margins
- command attention due to impressive credentials
- address their arguments directly to the public
- receive "equal coverage" in media

This problem is becoming extremely common!

typical arguments of the "skeptics"

typical arguments of the "skeptics"

1) Natural variations are much more important than human impacts.
   > historical record shows more extreme conditions than today
   > effects of sun and volcanoes dwarf effects of humans

2) Changes observed to date are insignificant; the larger changes predicted for the future are based on flawed theoretical models.

3) Observed changes are not due to humans (see 1).

4) Even if humans are changing the environment, the consequences are not serious and may even be good.

5) On the other hand, regulations designed to reduce human impacts will cause severe economic damage.

NOTE:
This overall perspective is valuable - both to science and society.

Distorting the science and subverting the scientific process, however, undermines our ability as a society to make rational decisions. (compare to Popper)

Thurs Oct 2

Announcements:

- HW #1: change Chap 17 to Chap 14; skip 9a
- web changes: e.g. "auxiliary" button (math helps)
- class list, yellow sheets
- lecture slides to web each Friday
- weather roundup: 12:30 Tues, 310 ATG (extra credit)

Outline:

- science and policy
- three global-scale problems
- ozone introduction

Friday: math/chem refresher (session 1)

next week: ozone

Science and Policy

The ideal:

Goal of science --> understand the Earth

Goal of society --> maintain habitability of Earth

} Symbiotic relationship

"Skeptics" <u>and "alarmists"</u>:

- Misrepresent current knowledge
- Circumvent the scientific process; make scientific assertions in public but not through peer-review

Effect of "skeptics" and "alarmists":

- neutral or <u>good</u> for science
  - > for the most part, ignored
  - > occasionally, do raise issues being overlooked
- bad for rational decision-making by society

Science and Policy

<u>Other issues:</u>

• How make decisions in the face of large uncertainty?

• What criteria should determine when we intervene? Rely on scientific predictions? The "precautionary principle"? Wait for effects to be manifest?

• How do we define "dangerous interference" with the climate system (UN Treaty)?

• Intervention options: prevention, adaptation, mitigation
  associated costs: hard to estimate
  values: not science

Three major global-scale issues (see Chap 1 and HW#1)

ozone hole
loss of **biodiversity**
global warming

Exercise 1: define each problem in 1-2 sentences

Exercise 2: give a timescale for each problem

Exercise 3: rank these in order of importance

Week 2

Chap 14: stratospheric ozone

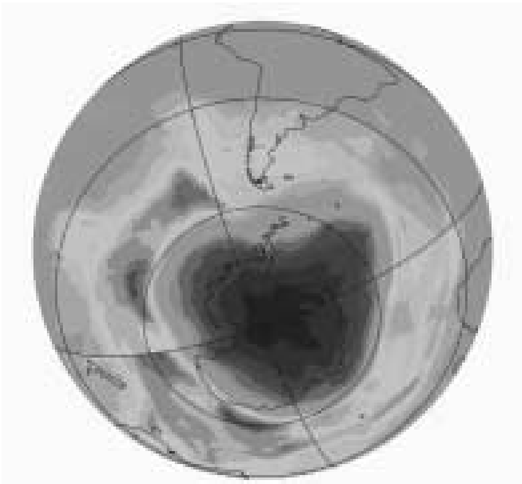
Mon: ozone basics
- photochemistry
- UV radiation
- atmospheric structure
- terrestrial life

Tues: CFC's and ozone
- catalytic reactions
- atmospheric cycles

Wed: Antarctic ozone hole
- unexpected couplings

Thurs: global ozone depletion
ozone protection treaties
ozone "skeptics"
lessons from ozone

Fri: *tutorial: math and chem*



Goal / Motivation

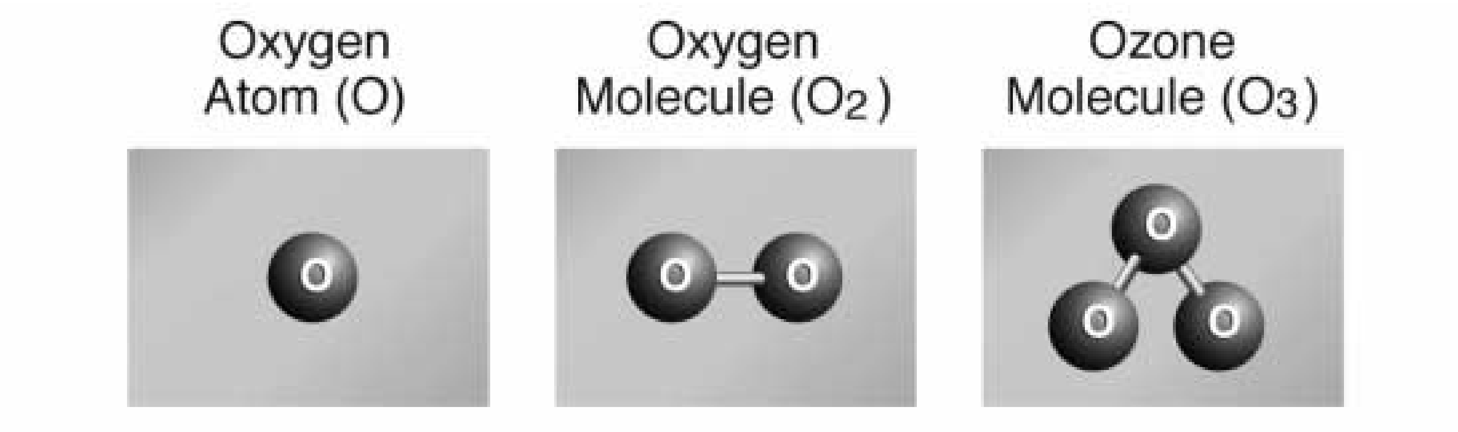
• tidy example illustrating nature of the Earth-System (including humans)

• coupled system...
unbounded complexity
unexpected consequences

• global environmental problem
discovery
explanation
solution

Molecular forms of oxygen

molecular forms of
oxygen



All three occur throughout the atmosphere.
Which is most common?

Atmospheric ozone: vertical structure

ozone in vertical

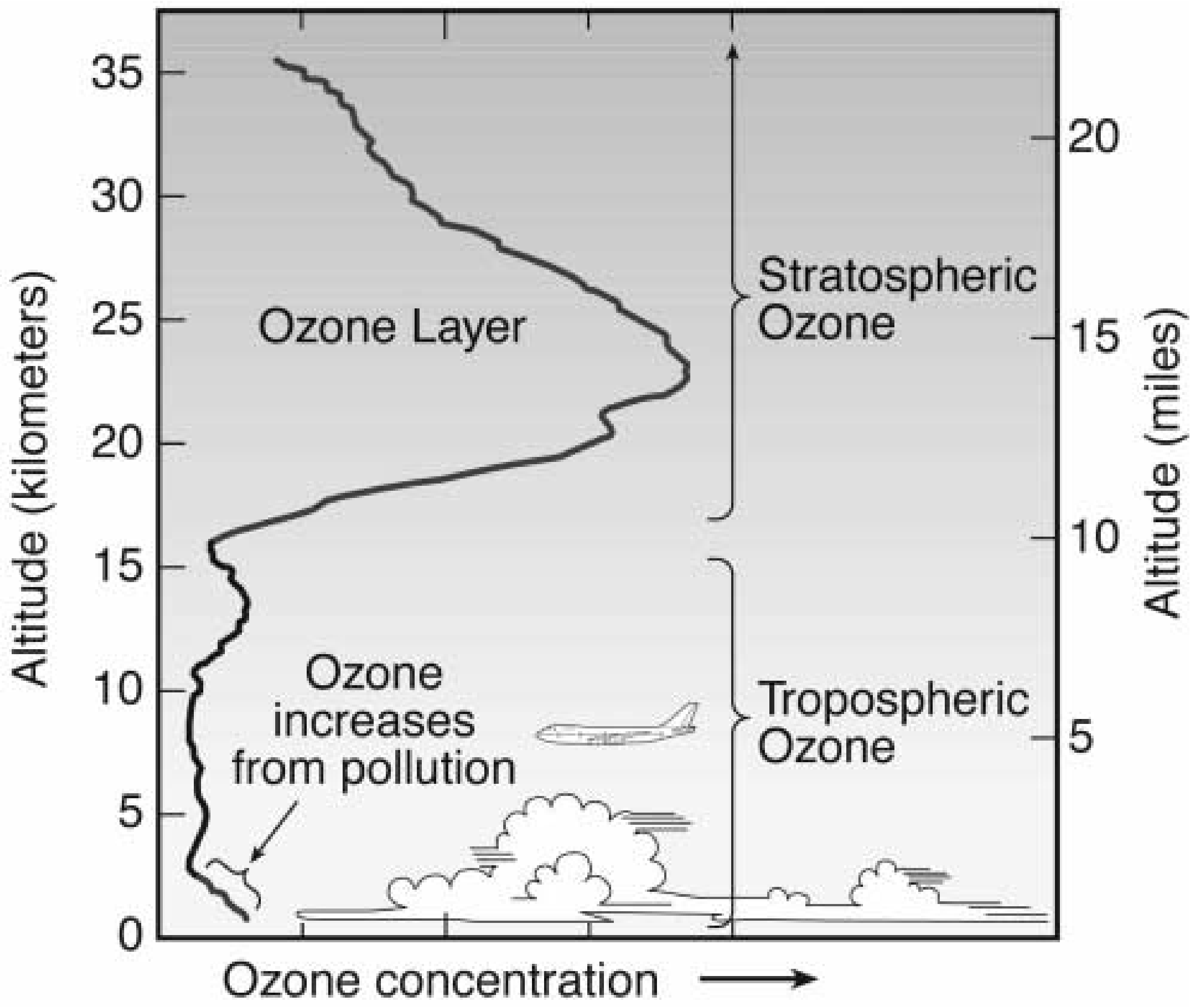


Figure source: http://www.al.noaa.gov/WWWHD/pubdocs/Assessment02/Q&As.html