

**ATOC 1060-002**  
**OUR CHANGING ENVIRONMENT**

**Class 3: Global Change: (Chapter 1)**

Objectives of today's class:

Observations

Global change on short time scales

<http://atoc.colorado.edu/~whan/>  
ATOC1060

# Question 1

# Previous class

## The changing Earth: an overview

### Emphasis - human-induced changes:

- a) Global warming: Increased greenhouse gases
- b) Ozone depletion: freon
- c) Tropical deforestation

## Three major themes

- a) Global environmental issues
- b) Climate in the past
- c) The Earth system

# 1. Global change on short time scales: Observations

Three major global environmental changes occurring today:

- a) Global warming;
- b) Ozone depletion;
- c) Tropical deforestation.

## a) Evidence of global warming

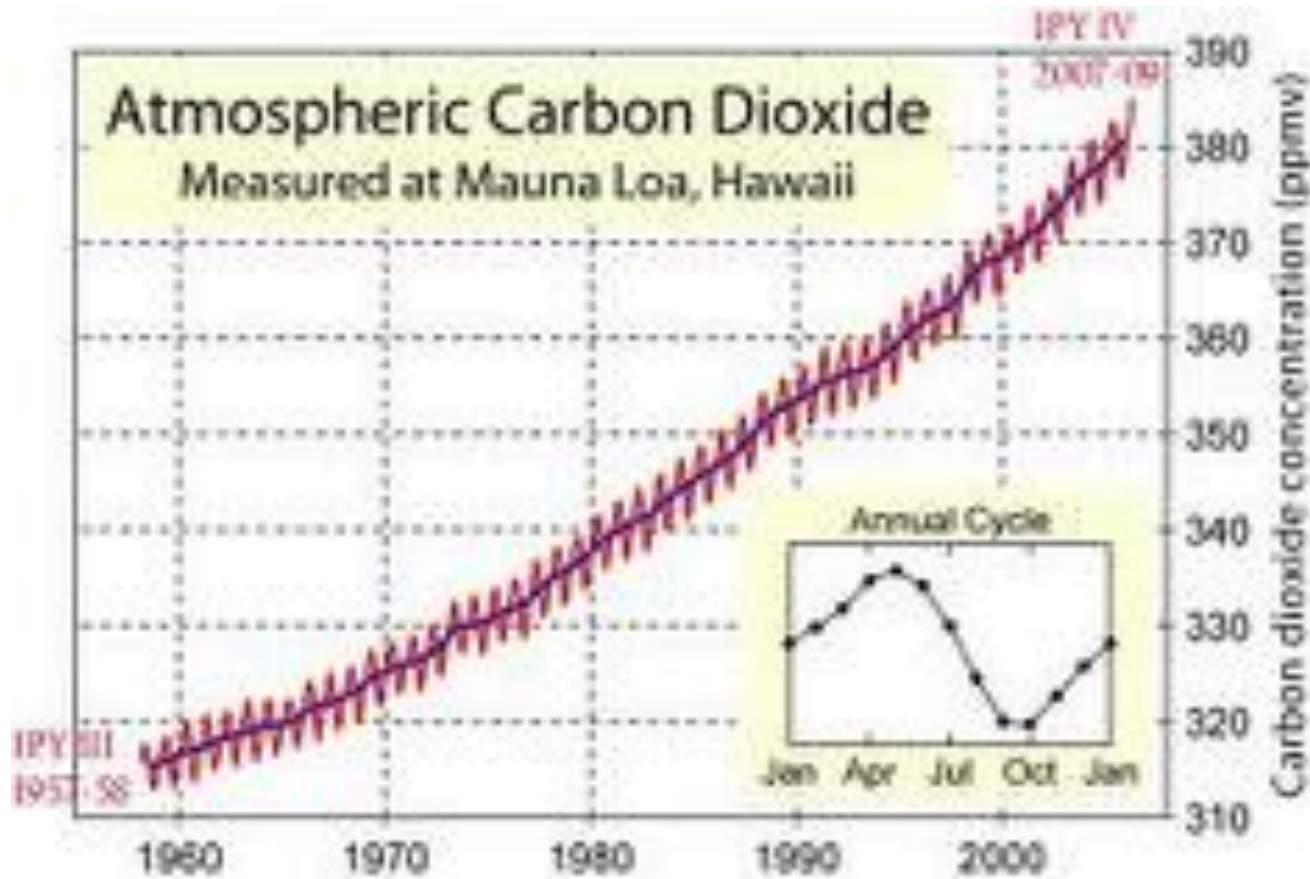
*Global warming*: an increase in Earth's surface temperature caused by a combination of industrial and agricultural activities (human-induced forcing).

*Greenhouse gases* → Enhance greenhouse effect



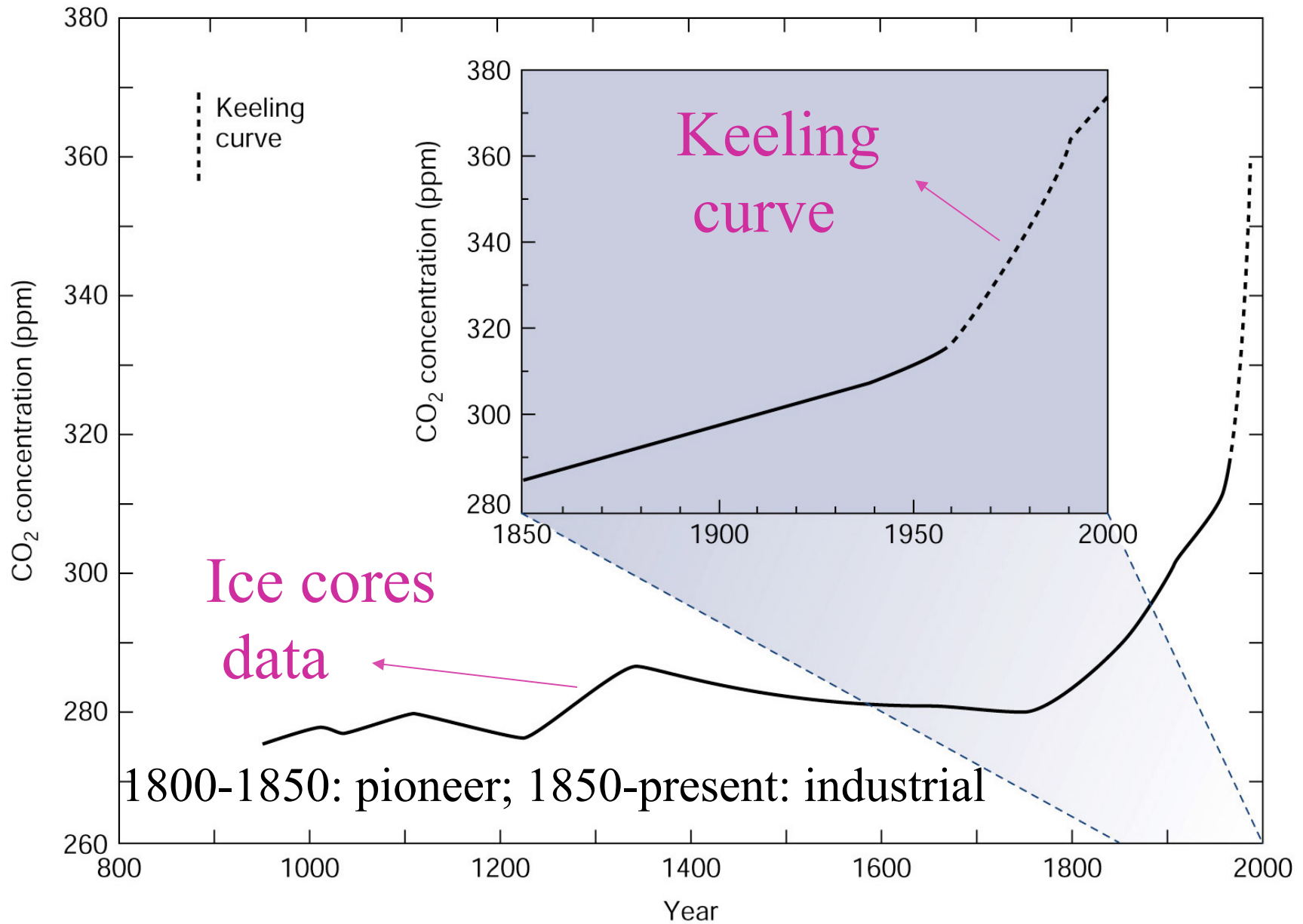
First step: measurement of greenhouse gases in the atmosphere

# The Keeling Curve: Measurement of atmospheric $CO_2$



Seasonal change  
5-6 ppm

Fig 1-2. Measurements of atmospheric carbon dioxide ( $CO_2$ ) at the top of Mauna Loa (volcano) in Hawaii.



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Fig 1-3 Atmospheric  $CO_2$  from ice cores on Antarctic & from direct atmospheric measurement for the past 1000 years

## Other Greenhouse Gases

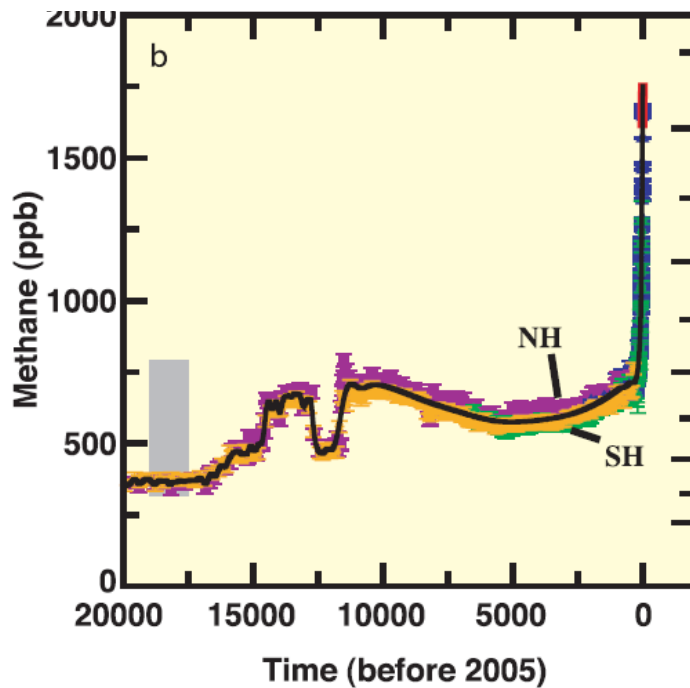
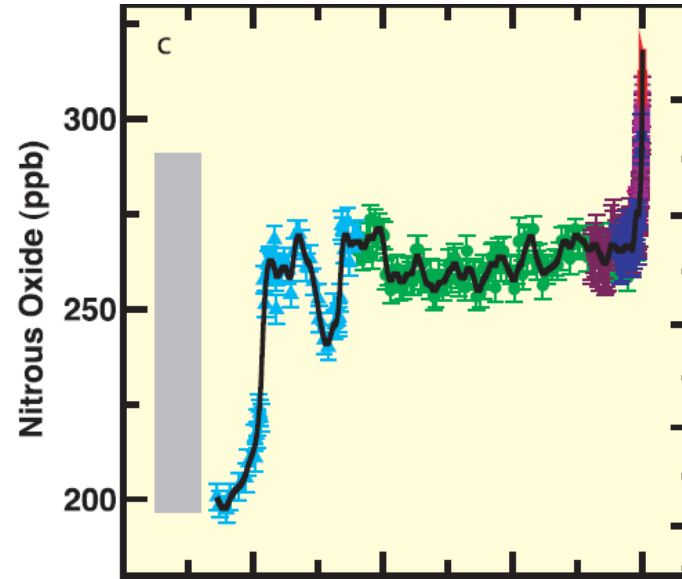
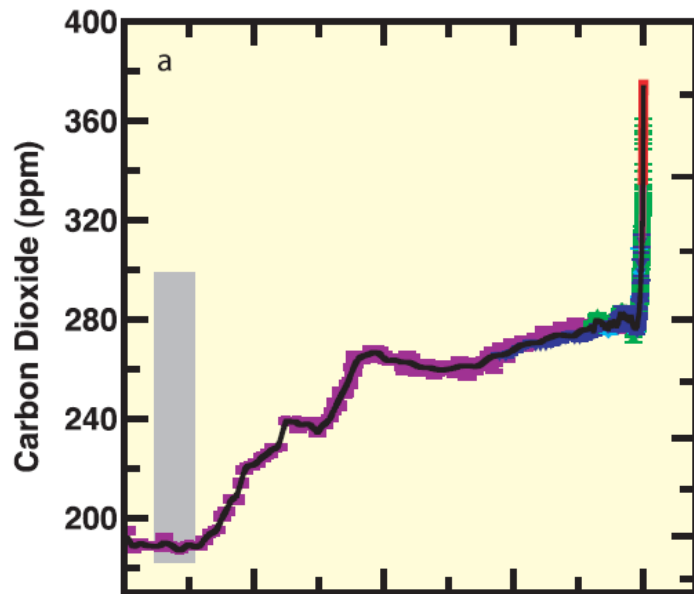
In addition to  $CO_2$ , other greenhouse gases such as methane ( $CH_4$ ), nitrous oxide ( $N_2O$ ), and certain chlorofluorocarbon compounds (CFCs; also called *freon*) have also been increasing as a result of human activities.

We are certain that anthropogenic greenhouse gases are increasing!

→ Are the increased greenhouse gases causing global warming?

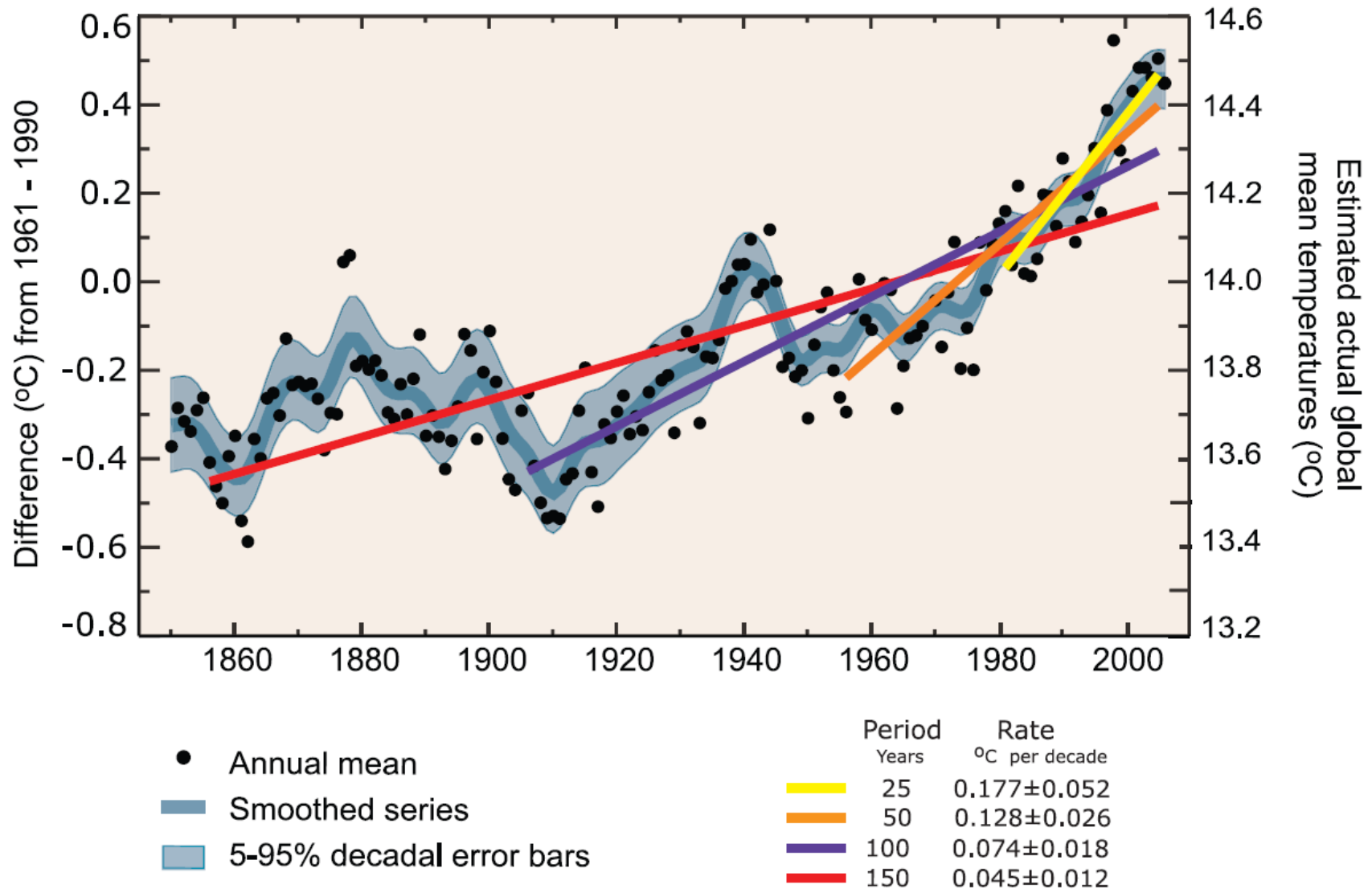


# CHANGES IN GREENHOUSE GASES FROM ICE CORE AND MODERN DATA



IPCC AR4 (Intergovernmental Panel on Climate Change, 4th Assessment Report). Atmospheric greenhouse gases concentrations over the past 20,000 years, as determined from ice cores and from direct atmospheric Measurements.

## 2. Global temperature



IPCC AR4. Annual global mean temperatures (black dots) with linear fits to the data. The left hand axis shows temperature anomalies relative to the 1961 to 1990 average and the right hand axis shows estimated actual temperatures, both in °C. Linear trends are shown for the last 25 (yellow), 50 (orange), 100 (purple) and 150 years (red). The smooth blue curve shows decadal variations, with the decadal 90% error range shown as a pale blue band about that line.

# Levitus et al., 2005: Global ocean heat content

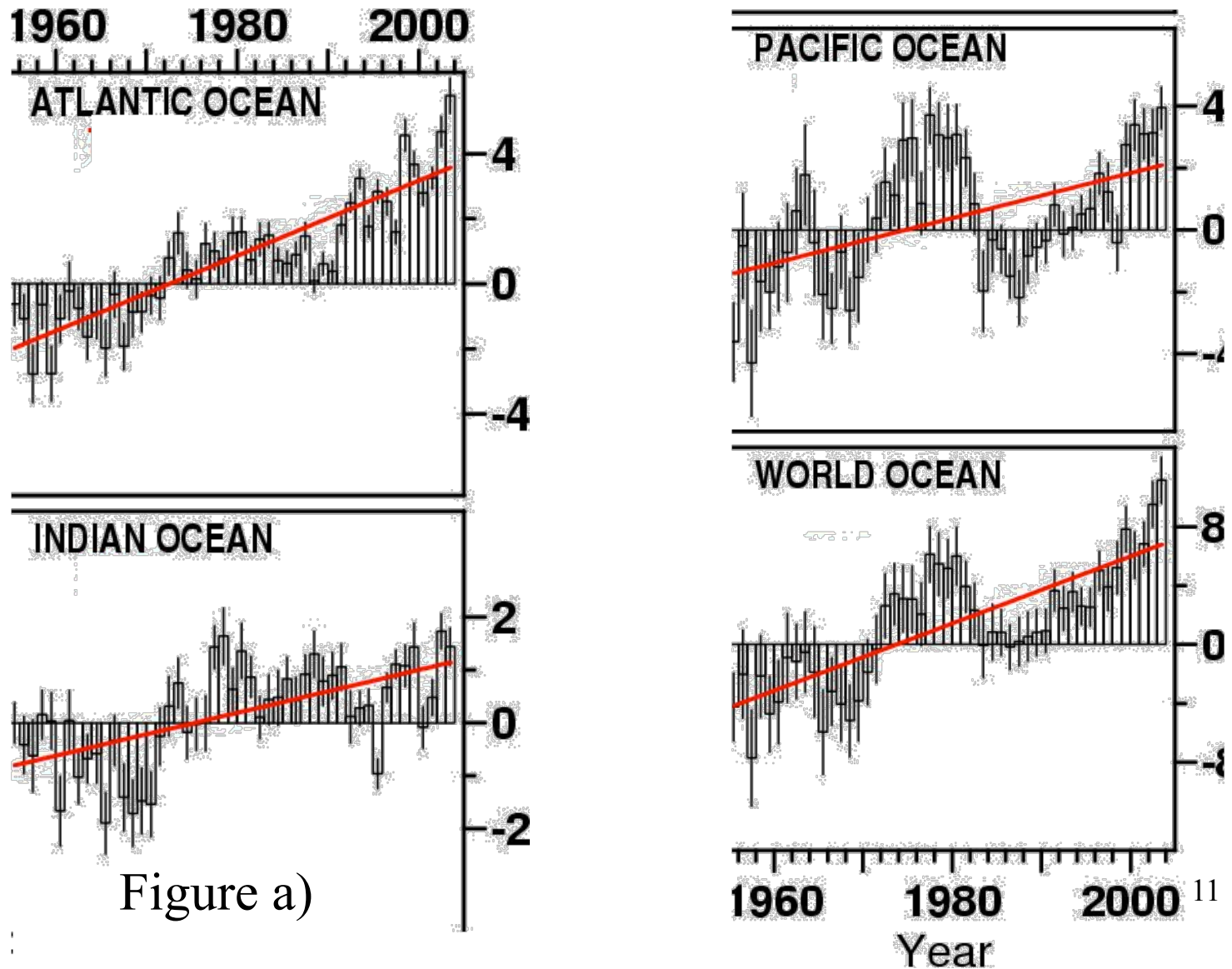
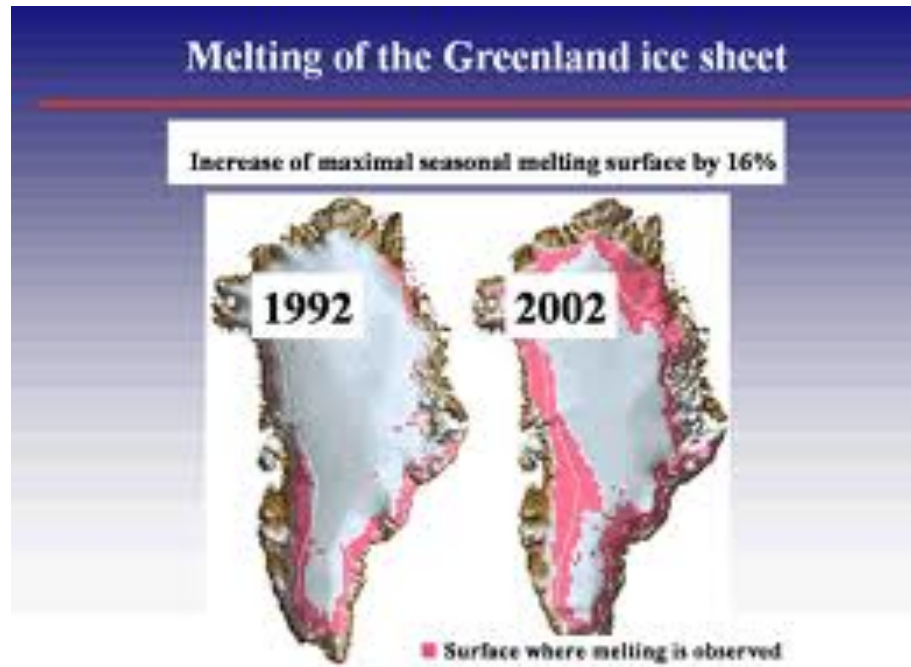


Figure a)

# Clicker question 2

# Changes in the Cryosphere



Melting of the Greenland ice sheet (Note: record is short)  
Pink area: melting is observed.

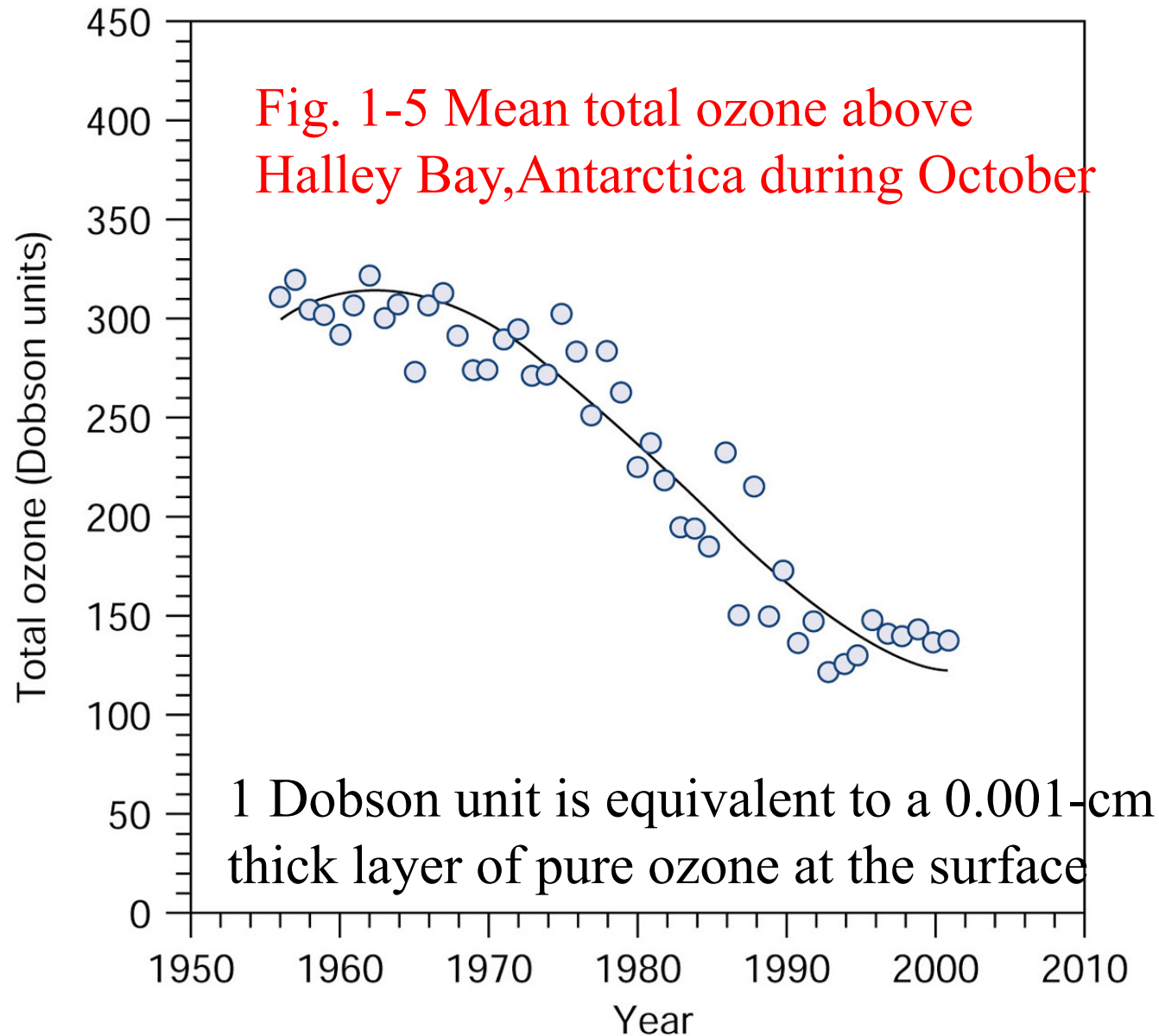
# Possible consequences of global warming

Has it been changing our climate? Concern?

Although debatable, global warming =>  
extreme weather events;  
say possibly increased hurricane intensity  
(Webster et al. 2005);

sea level rise (~10 cm in the past century).

## b) Observed Ozone Depletion



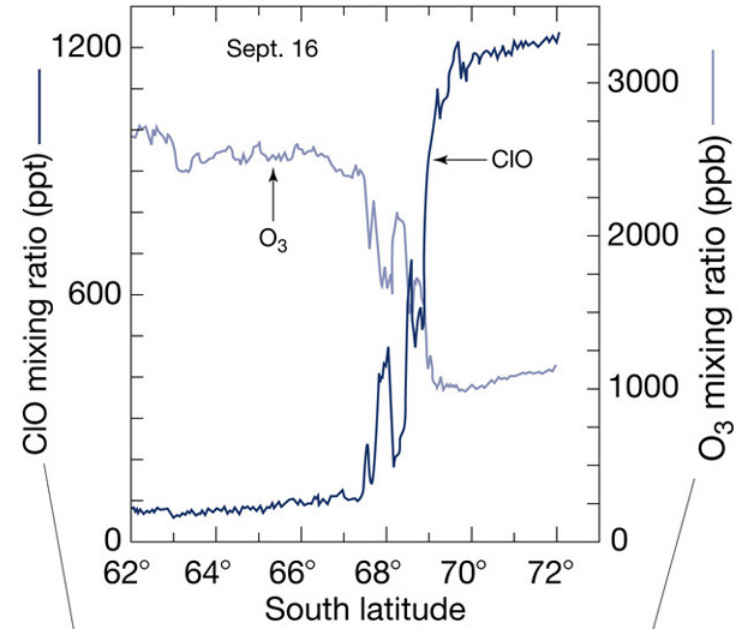
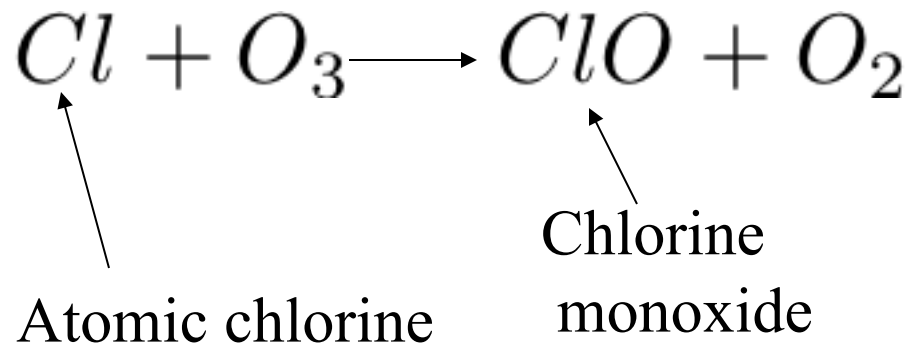
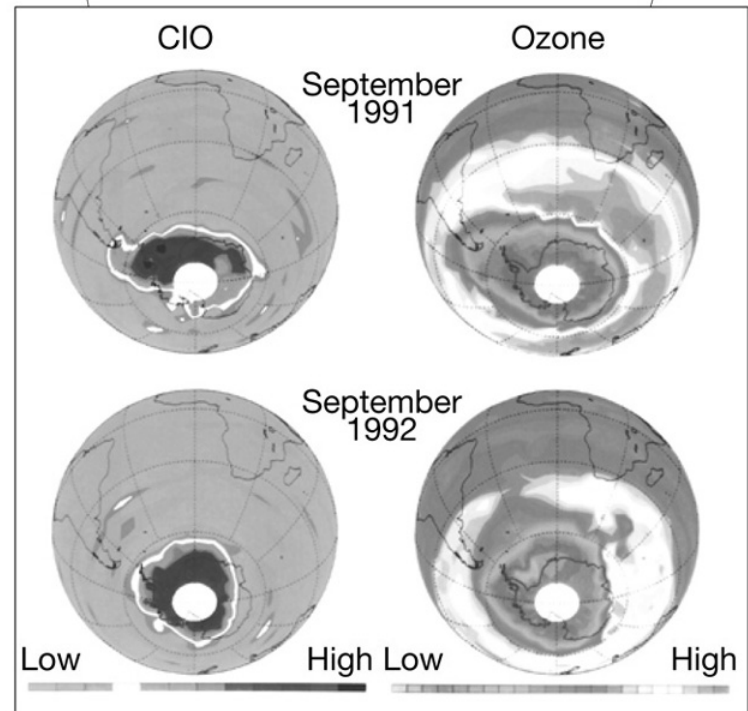


Fig 1-6 Observed Ozone (O<sub>3</sub>) and chlorine monoxide (ClO).  
 NASA aircraft September 1987.





# Ozone depletion: concern?

Far south: Chile and New Zealand concerned;  
Gradual decreasing of Ozone in mid-latitude  
of both hemispheres, maybe due to increased  
human-induced CFCs.

Now: Ground-level CFCs decreasing!

# Clicker question 3