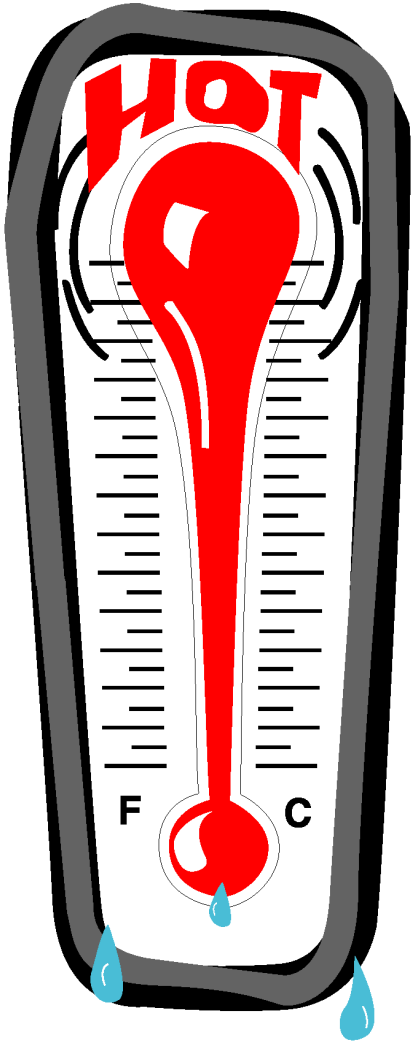
# IS THE CLIMATE REALLY CHANGING?

## SCIENTIFIC EVIDENCE REGARDING GLOBAL WARMING

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The Gatesworth
University City, Mo.

May 23, 2003

http://www.ecd.bnl.gov/steve/schwartz.html

# OUTLINE

Temperature change over the industrial era.

Other indicia of climate change over the industrial era.

Theoretical basis for climate change.

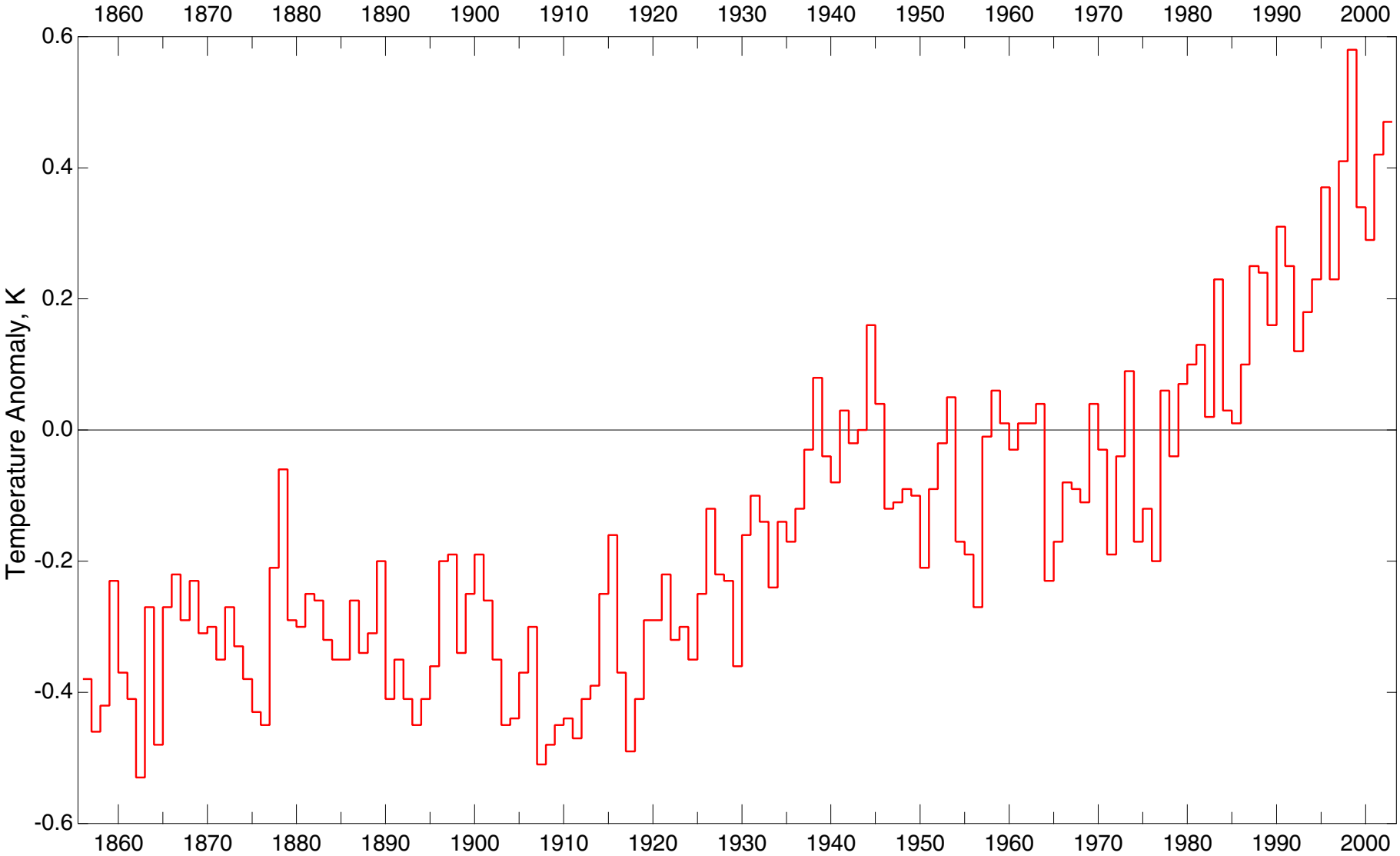
Causes of climate change.

Some key unanswered questions.

# GLOBAL AVERAGE TEMPERATURE TREND

## 1856-2002

### Temperature Anomaly Relative to Base Period 1961-1990




*Climate Research Unit, East Anglia UK*

# INDICATIONS OF SYSTEMATIC WARMING IN RECENT YEARS

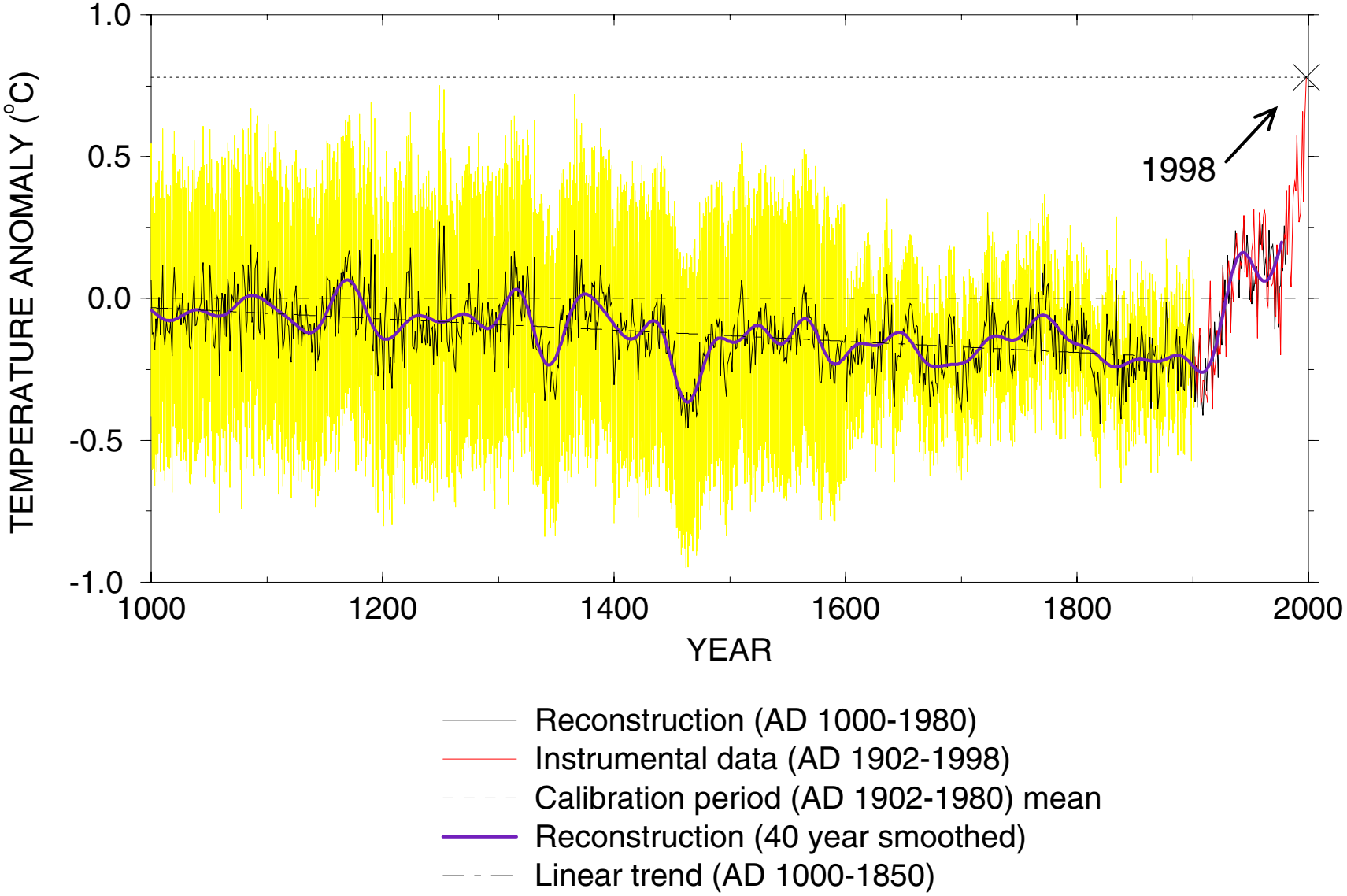
The 1990s were the ***warmest decade*** in the instrumental record.

The ***warmest two years*** of the entire instrumental record have been 1998 and 2002.

The ***nine warmest years*** globally have now occurred in the 1990s and 2000s.

# NORTHERN HEMISPHERE TEMPERATURE TREND (1000-1998)

## From tree-ring, coral, and ice-core proxy records
## As calibrated by instrumental measurements



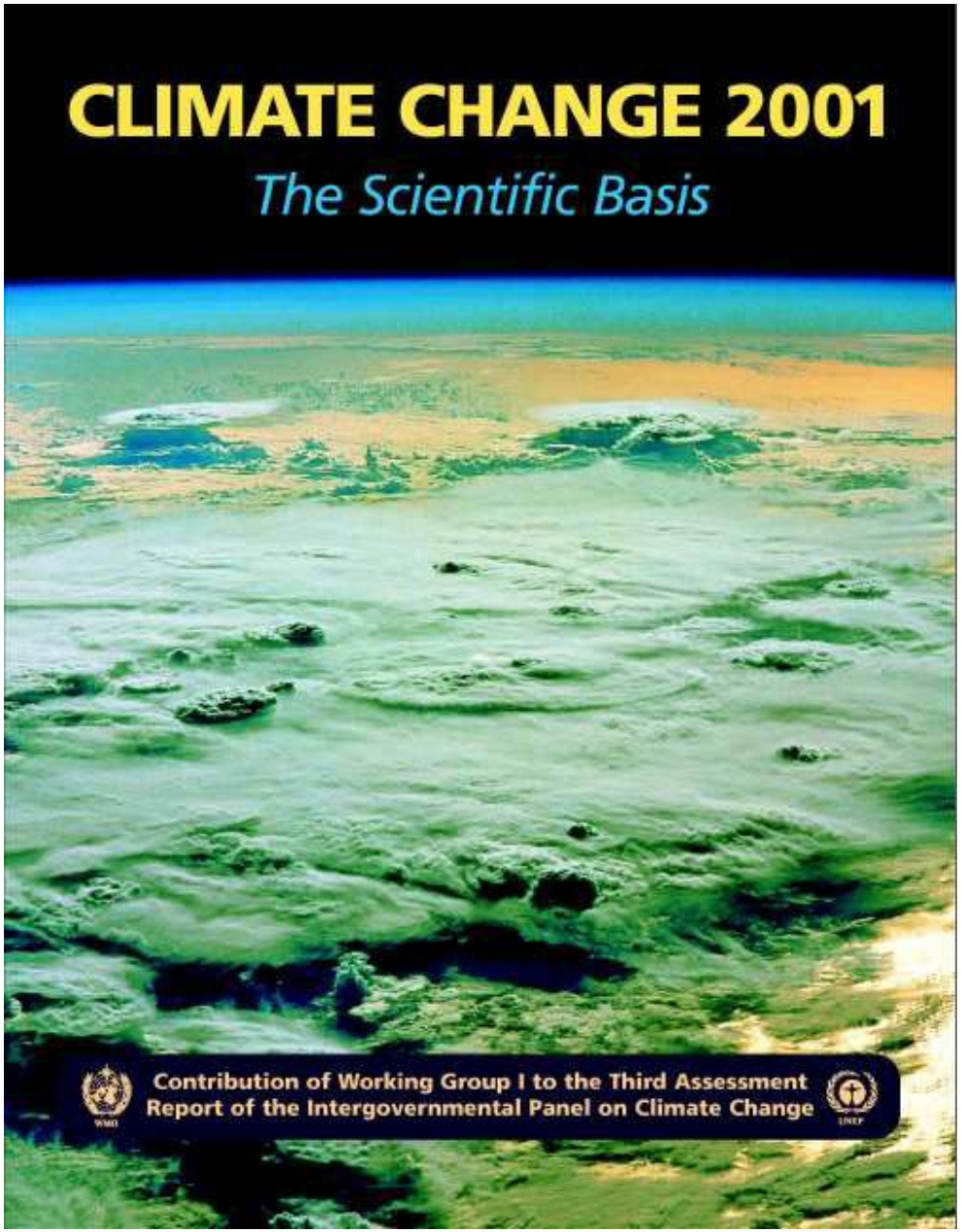

*Mann et al., GRL, 1999*

# FURTHER INDICATIONS OF SYSTEMATIC WARMING IN RECENT YEARS

Analyses of over 400 proxy climate series (from trees, corals, ice cores and historical records) show that the ***1990s was the warmest decade of the millennium and the 20th century was the warmest century***.

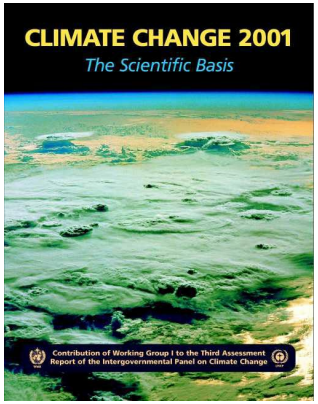
***The warmest year of the millennium was 1998.***

# THE “BIBLE” OF CLIMATE CHANGE RESEARCH




Cambridge University Press, 2001

# EVIDENCE OF GLOBAL WARMING OTHER THAN SURFACE TEMPERATURE ANOMALY




***The global ocean has warmed*** significantly since the late 1940s: more than half of the increase in heat content has occurred in the upper 300 m, ***mainly since the late 1950s***.

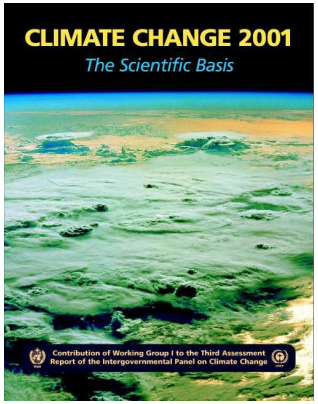
***Night minimum temperatures are continuing to increase,*** lengthening the freeze-free season in many mid- and high latitude regions.

There has been a ***reduction in the frequency of extreme low temperatures***, without an equivalent increase in the frequency of extreme high temperatures.

Over the last twenty-five years, it is likely that ***atmospheric water vapour has increased*** over the Northern Hemisphere in many regions.

***Widespread increases*** are likely to have occurred in the proportion of total ***precipitation derived from heavy and extreme precipitation events*** over land in the mid- and high latitudes of the Northern Hemisphere.

# ***MORE*** EVIDENCE OF GLOBAL WARMING OTHER THAN SURFACE TEMPERATURE ANOMALY




***Arctic sea-ice extent in spring and summer has decreased*** 10 to 15% since the 1950s.

The average ***thickness of summer Arctic sea ice has decreased*** nearly 40% over approximately the last thirty years.

***Alpine and continental glaciers have extensively retreated***.

***The duration of Northern Hemisphere lake-ice and river-ice cover*** over the past century, or more, ***shows widespread decreases*** averaging to about two fewer weeks of ice cover.

***Northern Hemisphere spring snow cover extent has decreased*** by about 10% since 1966.

# *Breaking Up Is Far Too Easy*

Science

30 August 2002, pp. 1494-1496

Rising temperatures on the Antarctic Peninsula are eroding ice shelves that have been in place for millennia.

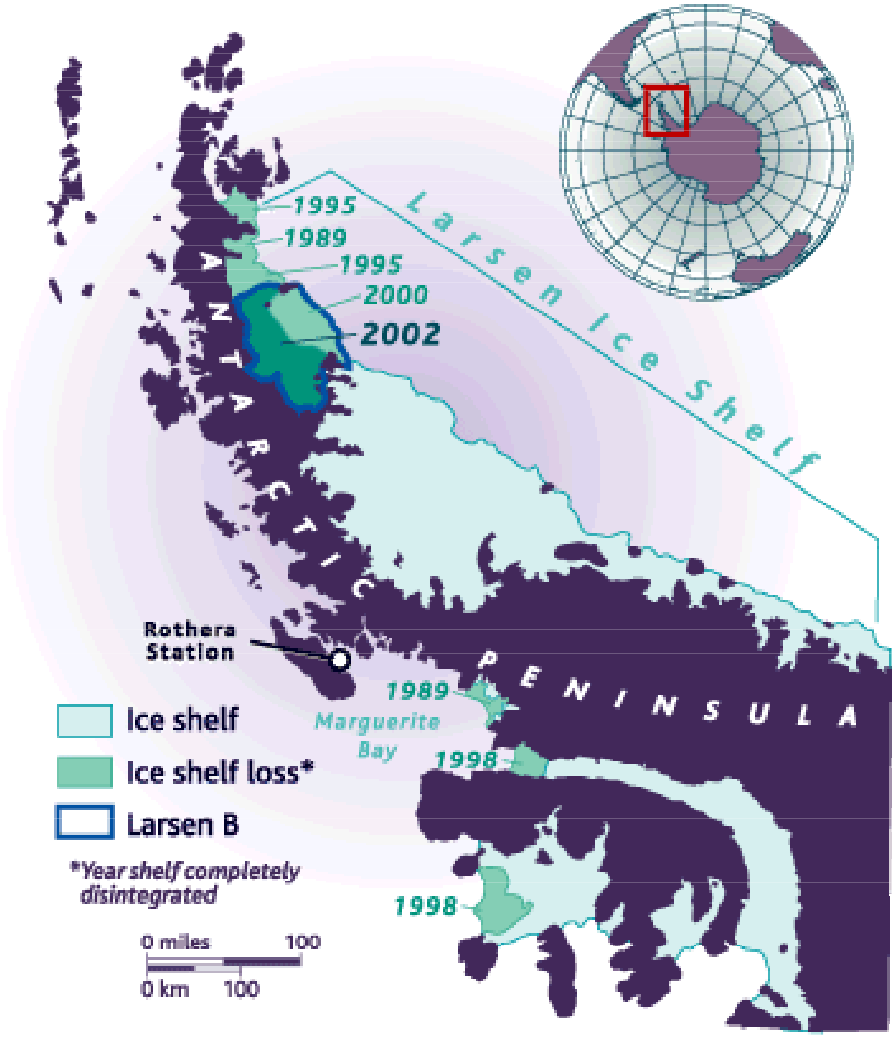
The past dozen austral summers have witnessed titanic breakups of the peninsula's ice shelves, the massive, floating plates that gird the peninsula's flanks.

In February, 2002, a slab of ice the size of Rhode Island started fissioning into fleets of icebergs.

# BREAK UP OF THE LARSEN B ICE SHELF, 2002

The Antarctic Peninsula has lost large chunks of its ice shelves to climate warming in recent years.

# BREAK UP OF THE LARSEN B ICE SHELF, 2002




The disintegration of much of the Larsen B ice shelf in a mere 5 weeks was ***"the largest event of its kind"*** since satellites began to record the ice shelves breaking up 30 years ago.

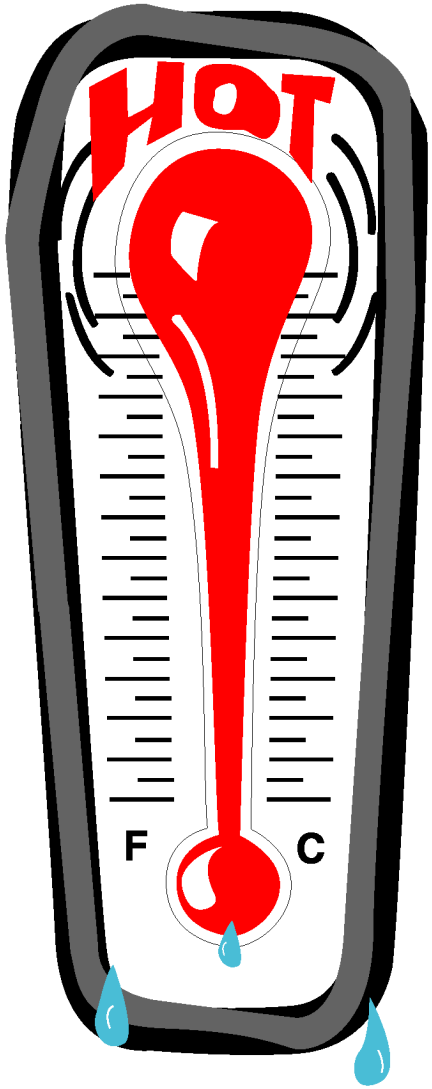
# BREAK UP OF THE LARSEN B ICE SHELF, 2002

Since 1950, 13,500 square kilometers of ice shelves--more than enough to cover Jamaica --have disintegrated.

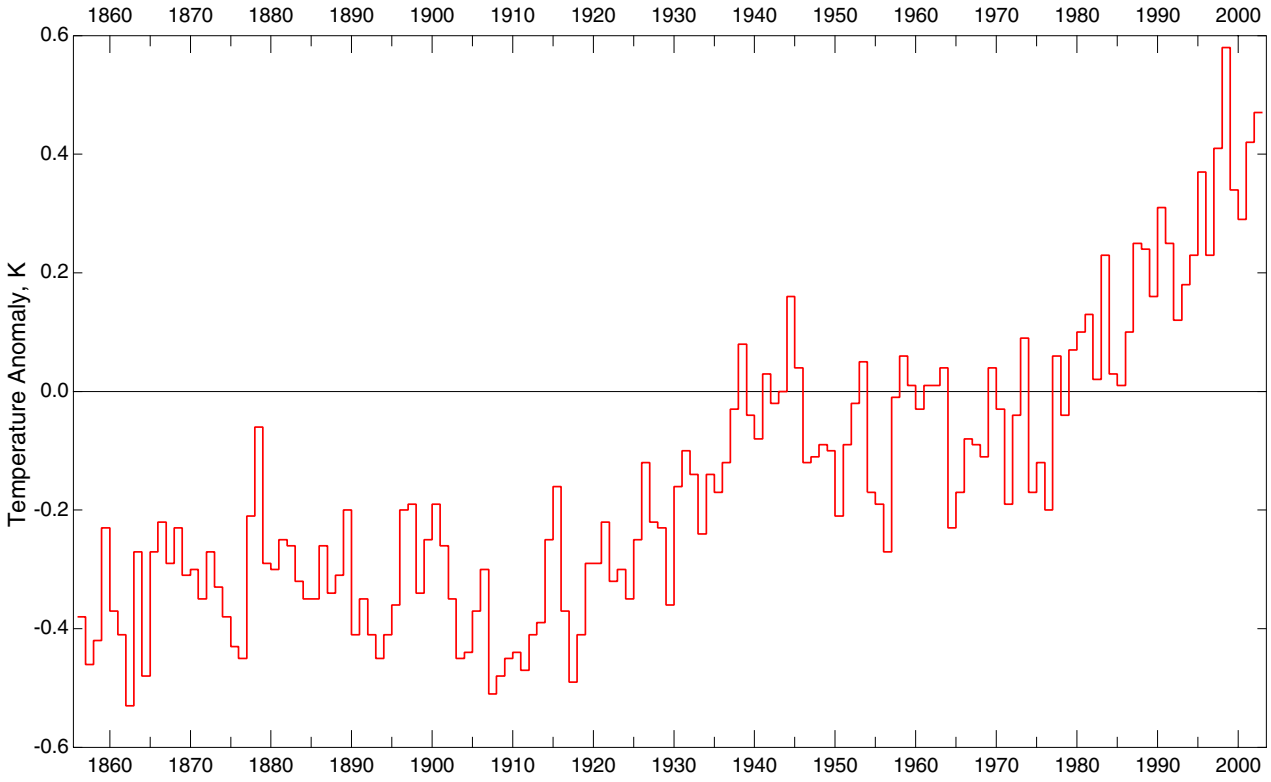
In the peninsula region the ***temperature has increased five times faster than the global average*** over the past half-century.

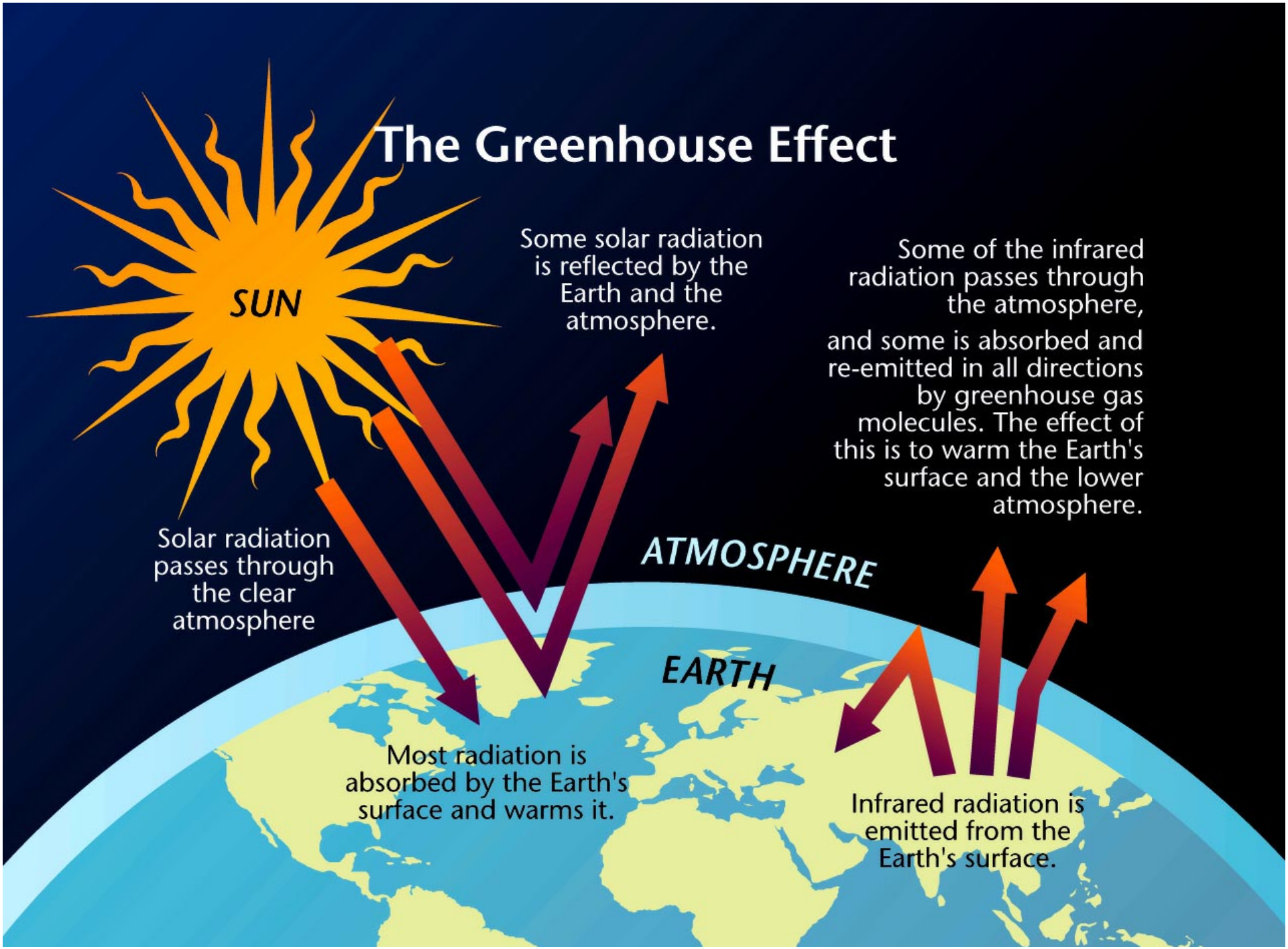
***Larsen B was at least 11,000 years old***, implying that the breakup is now extending farther south than ever before in the Holocene, suggesting that current warming far exceeds any of the previous Holocene hot spells.

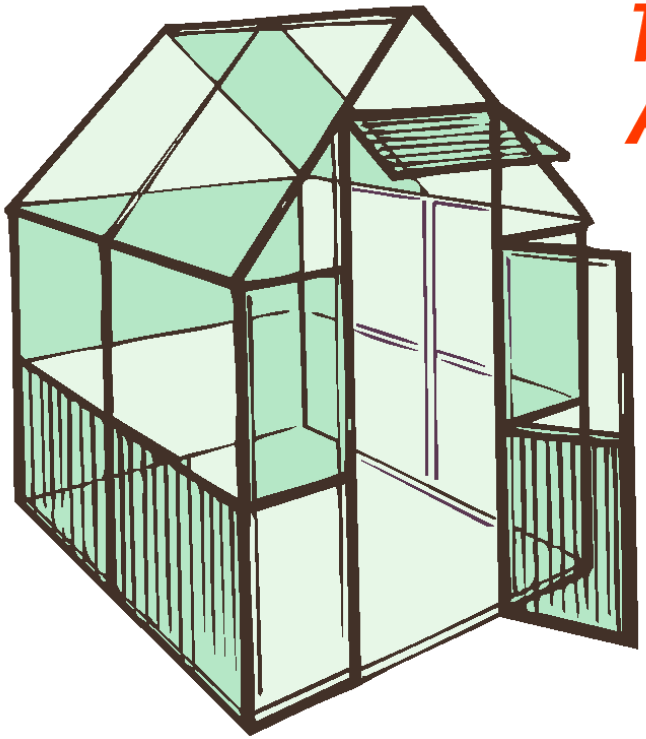
Satellite observations show that glaciers behind Larsen A are moving up to three times faster now that the ice shelf is gone




# WHY IS EARTH'S TEMPERATURE INCREASING?




The Greenhouse Effect
SUN
Some solar radiation is reflected by the Earth and the atmosphere.
Some of the infrared radiation passes through the atmosphere,
and some is absorbed and re-emitted in all directions by greenhouse gas molecules. The effect of this is to warm the Earth's surface and the lower atmosphere.
Solar radiation passes through the clear atmosphere
ATMOSPHERE
EARTH
Most radiation is absorbed by the Earth's surface and warms it.
Infrared radiation is emitted from the Earth's surface.

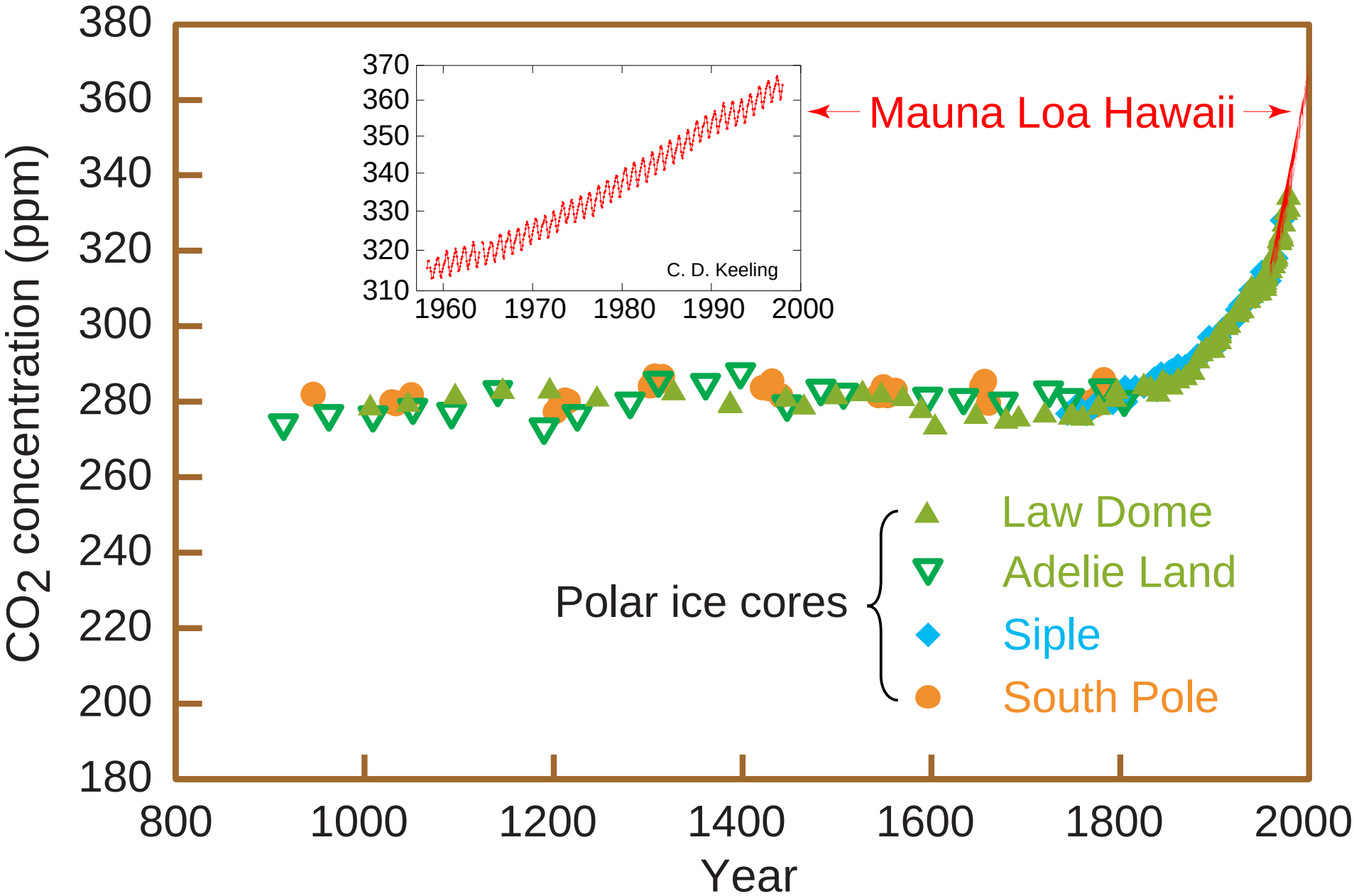


# THE EARTH'S ENERGY BUDGET: A DELICATE BALANCE

- Sunlight heats the Earth.
- The warm Earth radiates energy (in the form of infrared radiation, or heat) back out to space.
- Some of this infrared radiation is trapped in the atmosphere, giving Earth its temperate climate.

**This is the greenhouse effect. Without it, the Earth's climate would be like the moon's, harsh and severe.**

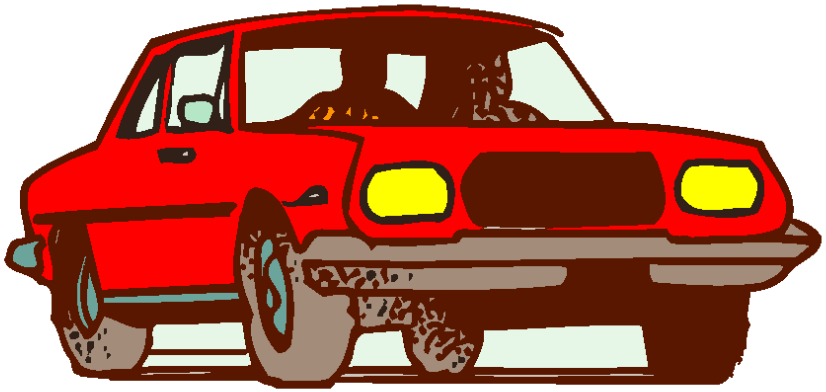
# ATMOSPHERIC CARBON DIOXIDE IS INCREASING




Global carbon dioxide concentration over the last thousand years

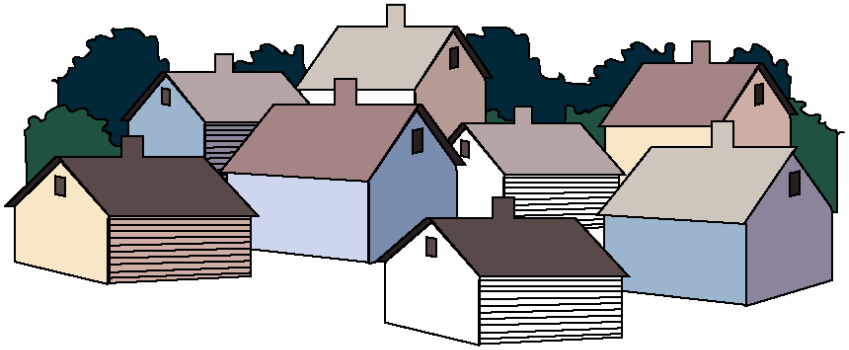
# *WHERE IS THIS CARBON DIOXIDE COMING FROM?*

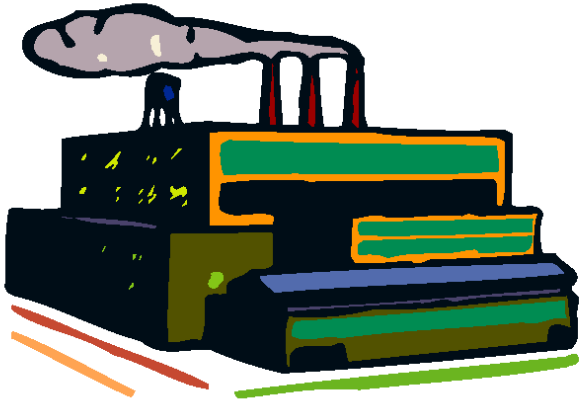
# *WE ARE ALL RESPONSIBLE.*



Burning a gallon of gasoline in your car puts 5 pounds of carbon in the atmosphere as carbon dioxide ($CO_2$), and it will stay there for decades — maybe a century!

Other sources are home heating and electric power production.





# Global Atmosphere, Global Warming

## QUESTIONS ABOUT GLOBAL WARMING

- IS IT REAL?
- IS IT IMPORTANT?
- WHAT IS IT DUE TO?
- HOW MUCH MORE CAN WE EXPECT?
- ARE WE SEEING JUST THE TIP OF THE ICEBERG?

***RESEARCH AT BROOKHAVEN NATIONAL LABORATORY IS HELPING TO ANSWER THESE QUESTIONS.***