Anthropogenic Global Warming

Slides from lectures preceding Climate Change exercise

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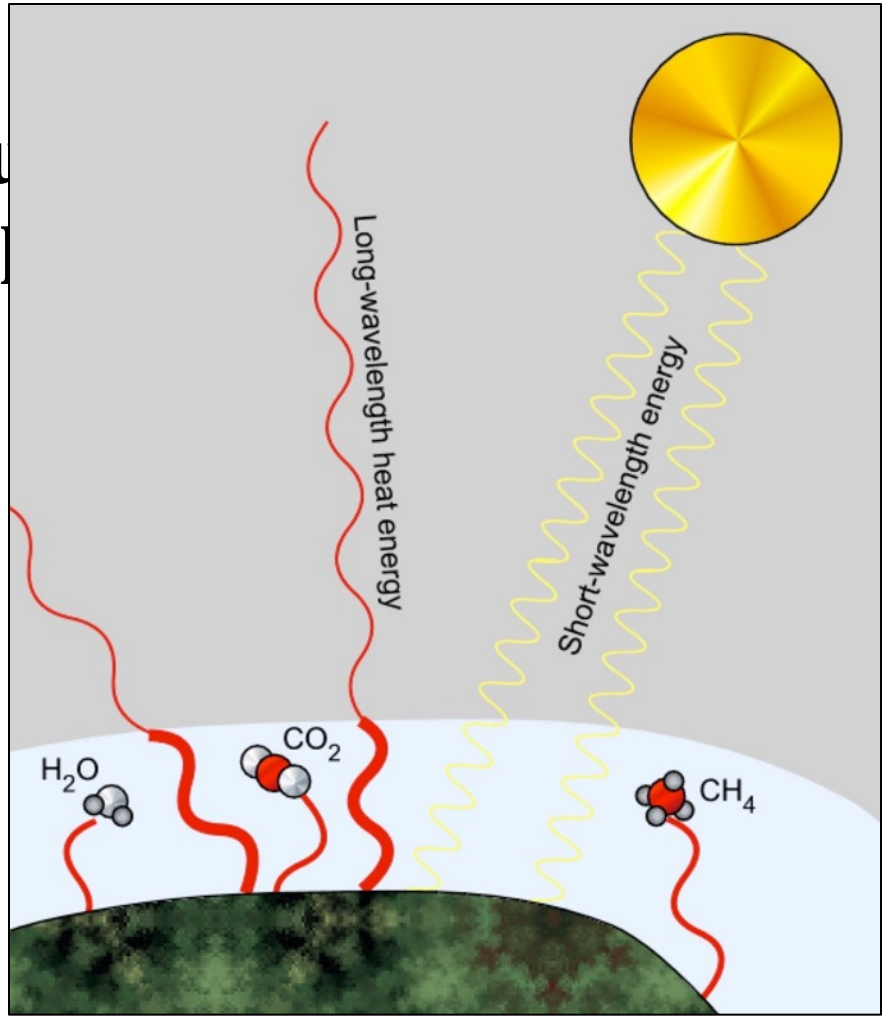
Incoming Solar Radiation

- **Insolation:**
  - **Is radiation from the Su (short wavelength visibl light & ultraviolet radiation)**
    - **Passes through the atmosphere**
    - **Heats Earth's surface**



The Greenhouse Effect (GHE)

- **Earth radiates heat outward (long wavelength, infrared radiation)**
  - **Absorbed by gases in the atmosphere:**

carbon dioxide (CO_2)

methane (CH_4)

nitrous oxide (N_2O)

All have increased in past 100 yrs

water vapor (H_2O)

Human Contributions to GHE

- **Burning forests and fossil fuels emits CO_2 (most important greenhouse gas (GHG) to date)**

accounts for ~1/2 of observed warming

Smokestacks for a coal-burning power plant.

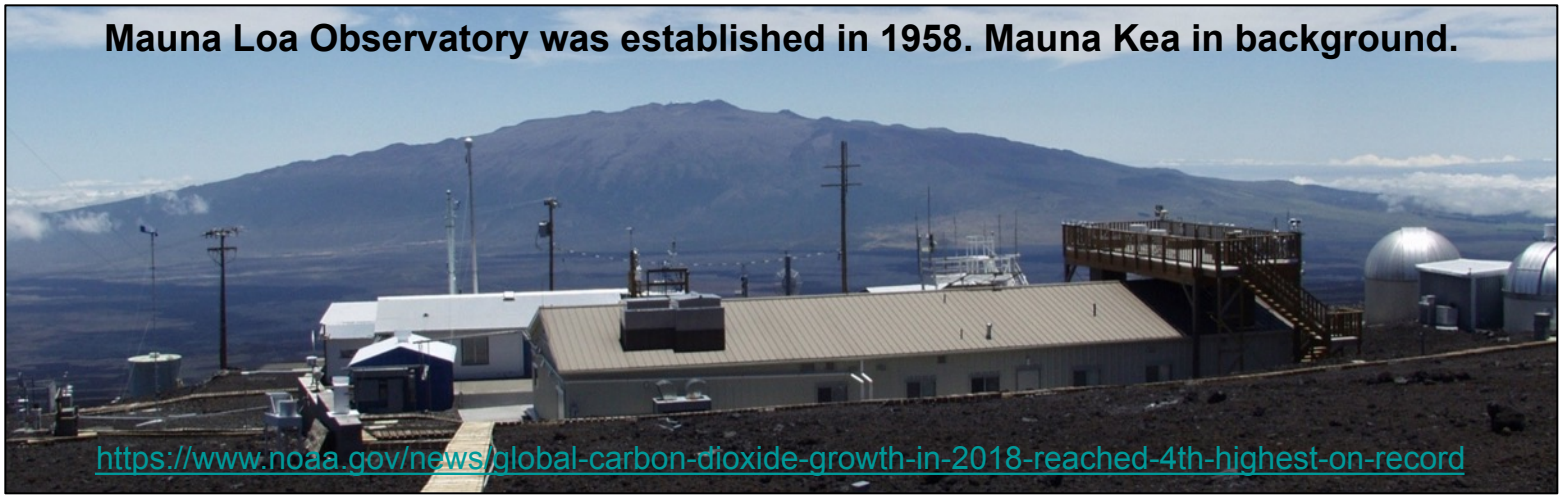
https://commons.wikimedia.org/wiki/File:Smokestacks_3958.jpg

Clearing rainforest to create farmland.

https://commons.wikimedia.org/wiki/File:NASAburningbrazil.jpg

Results of Human Actions

- People are changing natural balance of GHGs
- How do we know?
  - Direct measurements at Mauna Loa, Hawaii
  - Older data from air bubbles trapped in ice cores (Greenland & Antarctica)

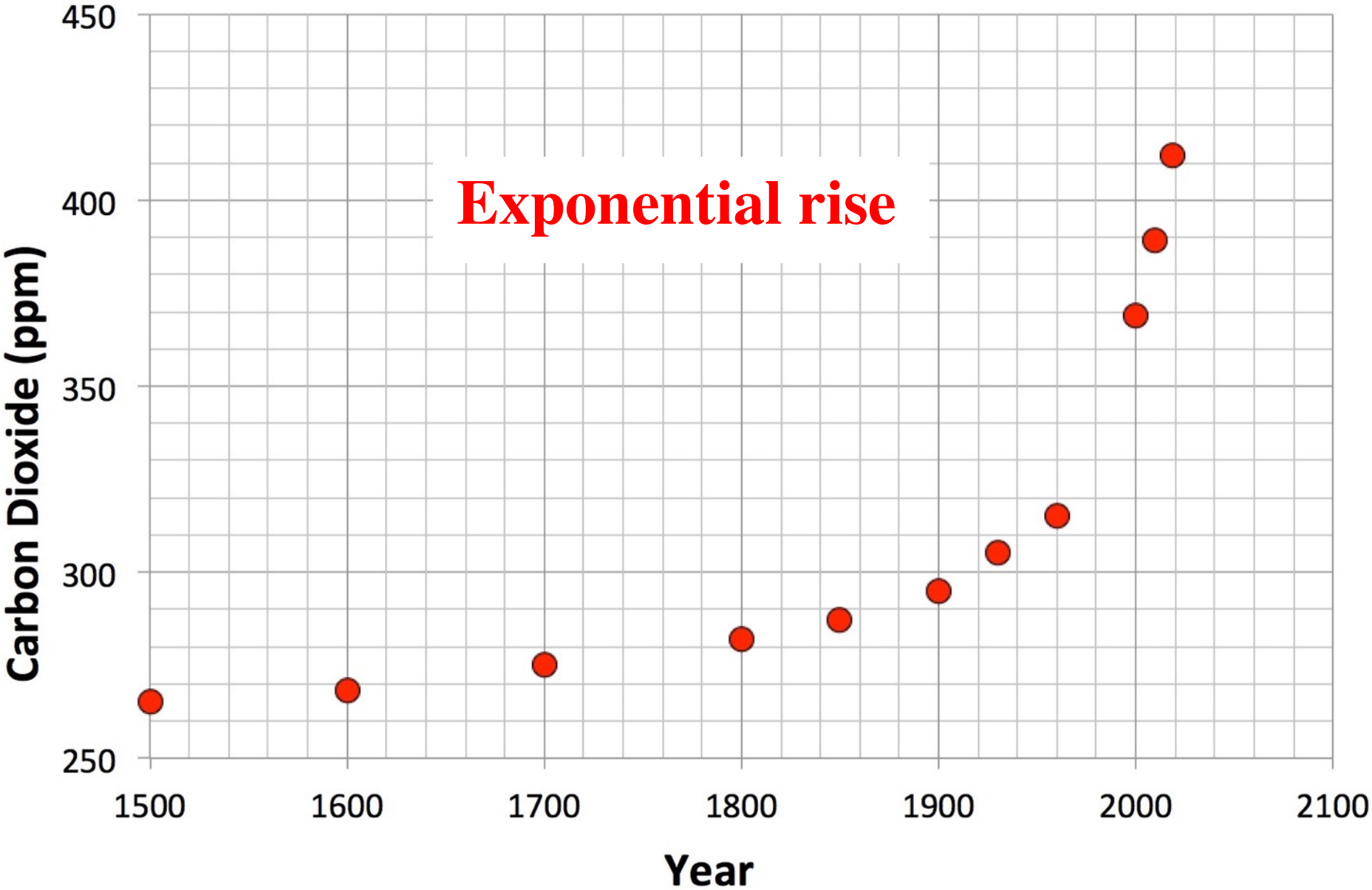


Atmospheric CO_2

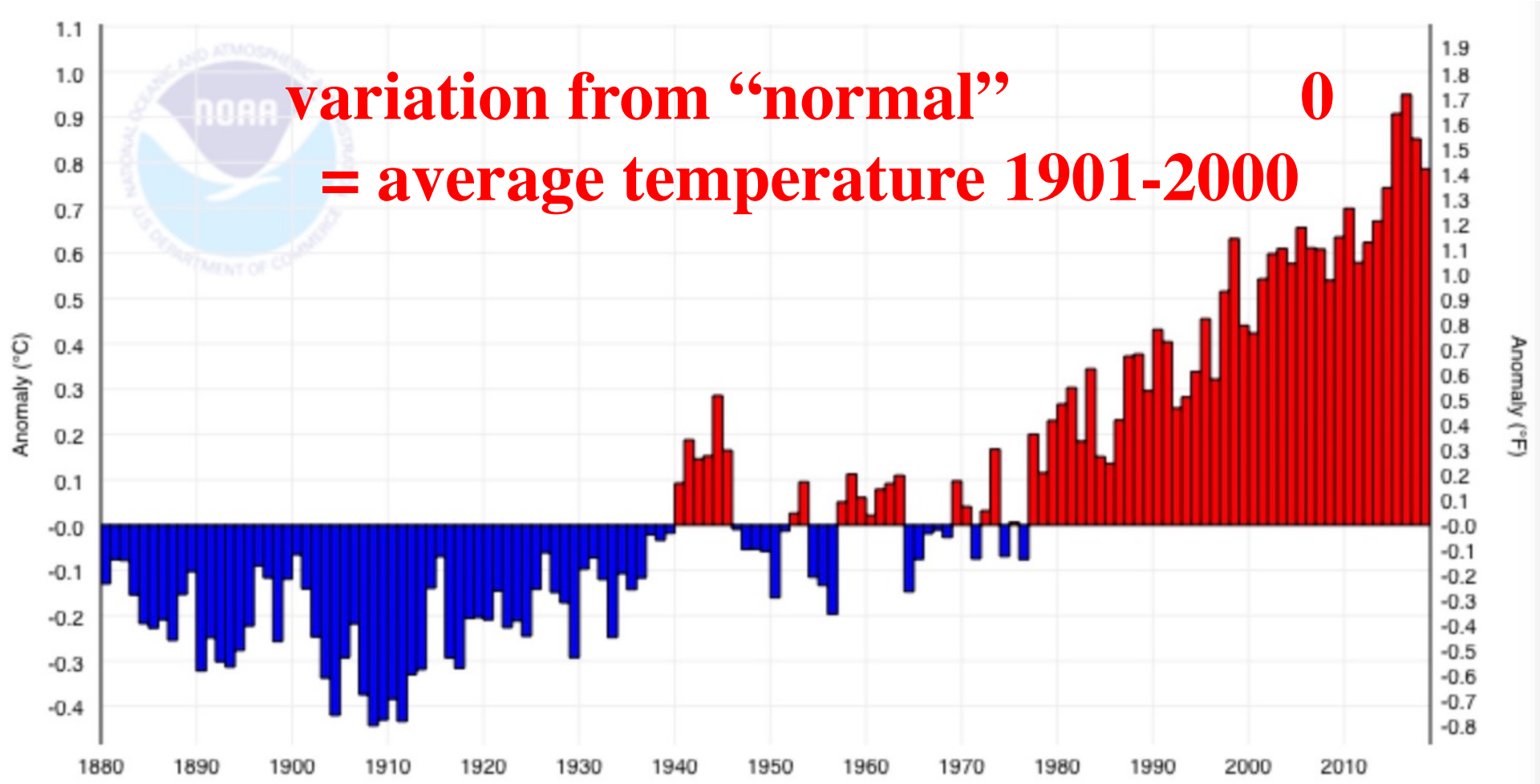
Year	CO_2	Year	CO_2
1500	265 ppm	1930	305
1600	268	1960	315
1700	275	2000	369
1800	282	2010	389
1850	287	Mar. 2019	412
1900	295		

https://www.esrl.noaa.gov/gmd/ccgg/trends/

CO_2 Graph


Exponential rise
Carbon Dioxide (ppm)
450
400
350
300
250
1500
1600
1700
1800
1900
2000
2100
Year

Annual Temperature Anomalies



Increase since 1900 = ~0.73°C (1.8°F)

NOAA National Centers for Environmental information, Climate at a Glance: Global Time Series, published April 2019, retrieved on April 29, 2019 from https://www.ncdc.noaa.gov/cag/

Humans and Climate

- **Humanity & civilization developed during a time of unusually stable climate**

Warmer temperatures in the Northern Hemisphere allowed the Vikings to colonize Greenland.

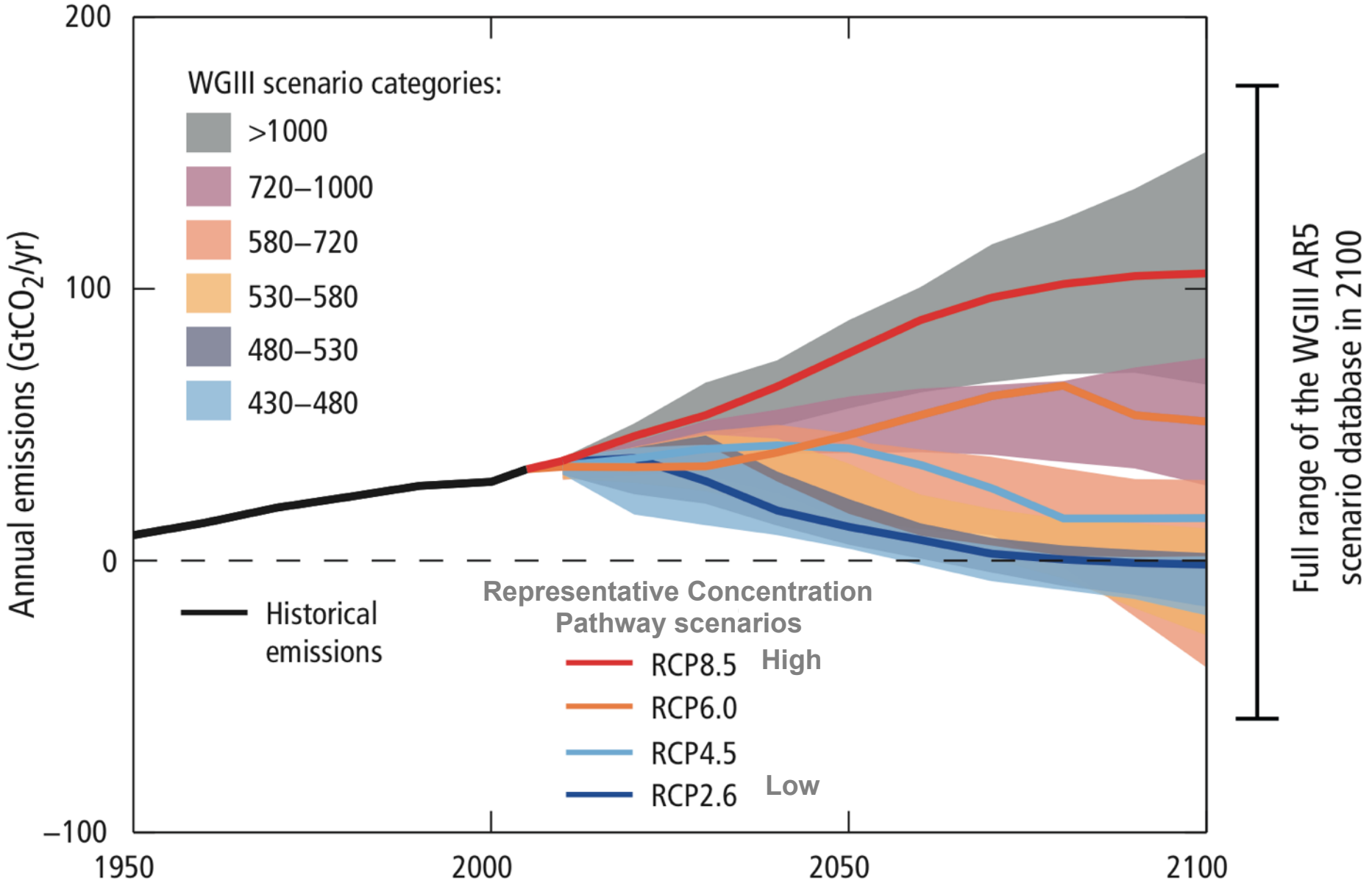
Medieval Climate Anomaly (~ 950-1250)

Colder global temperatures allowed the Thames to freeze in London, which it no longer does.

Little Ice Age (~1500-1800)

- **These events bracket human experience**

The Latest Word from the IPCC



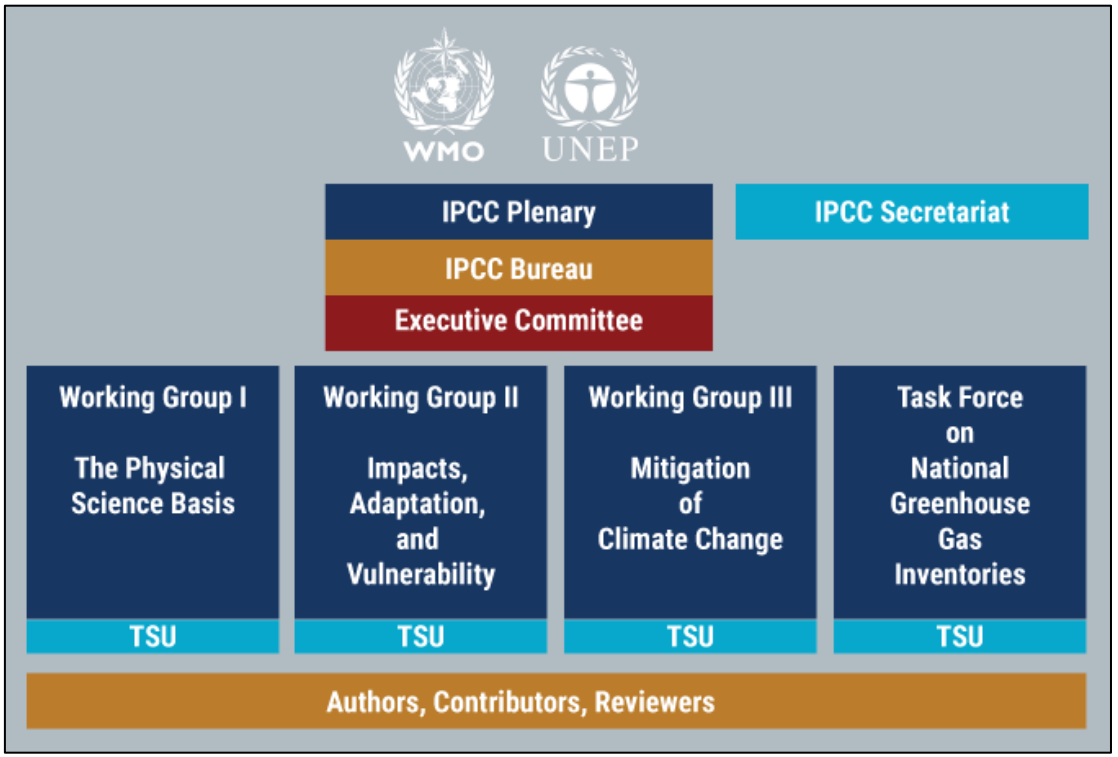
https://www.ipcc.ch/site/assets/uploads/2018/02/SPM.05-01-1.png

What Is the IPCC?

- **Intergovernmental Panel on Climate Change**
- **Established in 1988 by the UN**
- **Purpose:**

"... to assess … the risk of human-induced climate change, its ... impacts, and options for adaptation and mitigation."

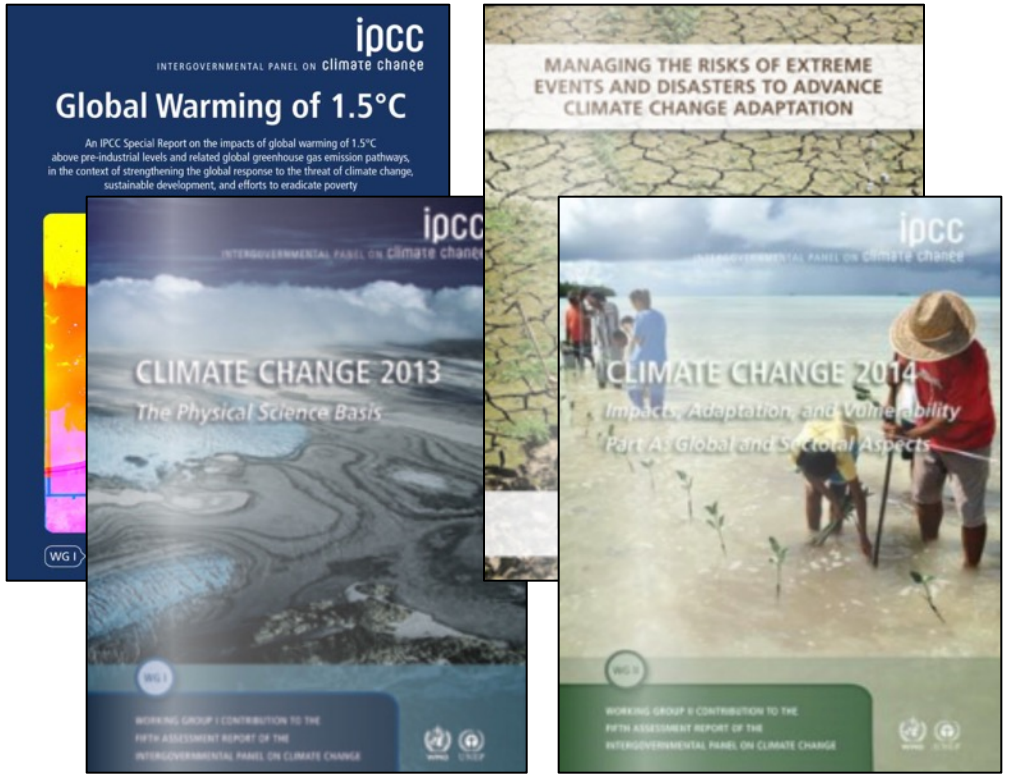
Organization of the IPCC



https://www.ipcc.ch/about/structure/

IPCC Reports

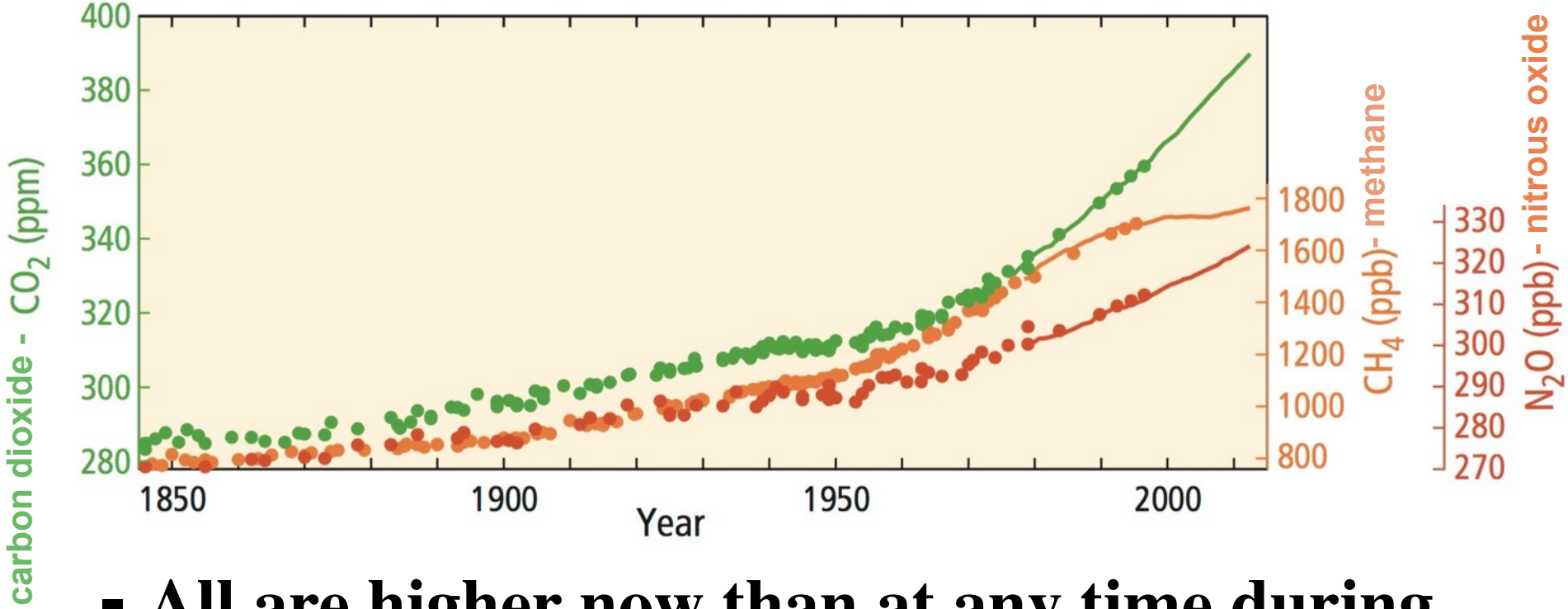
- **Assessments are based on work by 100s of scientists.**
  - **Each report represents a consensus view.**
    - **1990, 1995, 2001, 2007, 2014**
    - **6th: 2022**
- **Supplemental reports as needed**



https://www.ipcc.ch

Working Group I: Physical Basis

- **Three major GHGs**



  - **All are higher now than at any time during the past 800,000 years.**

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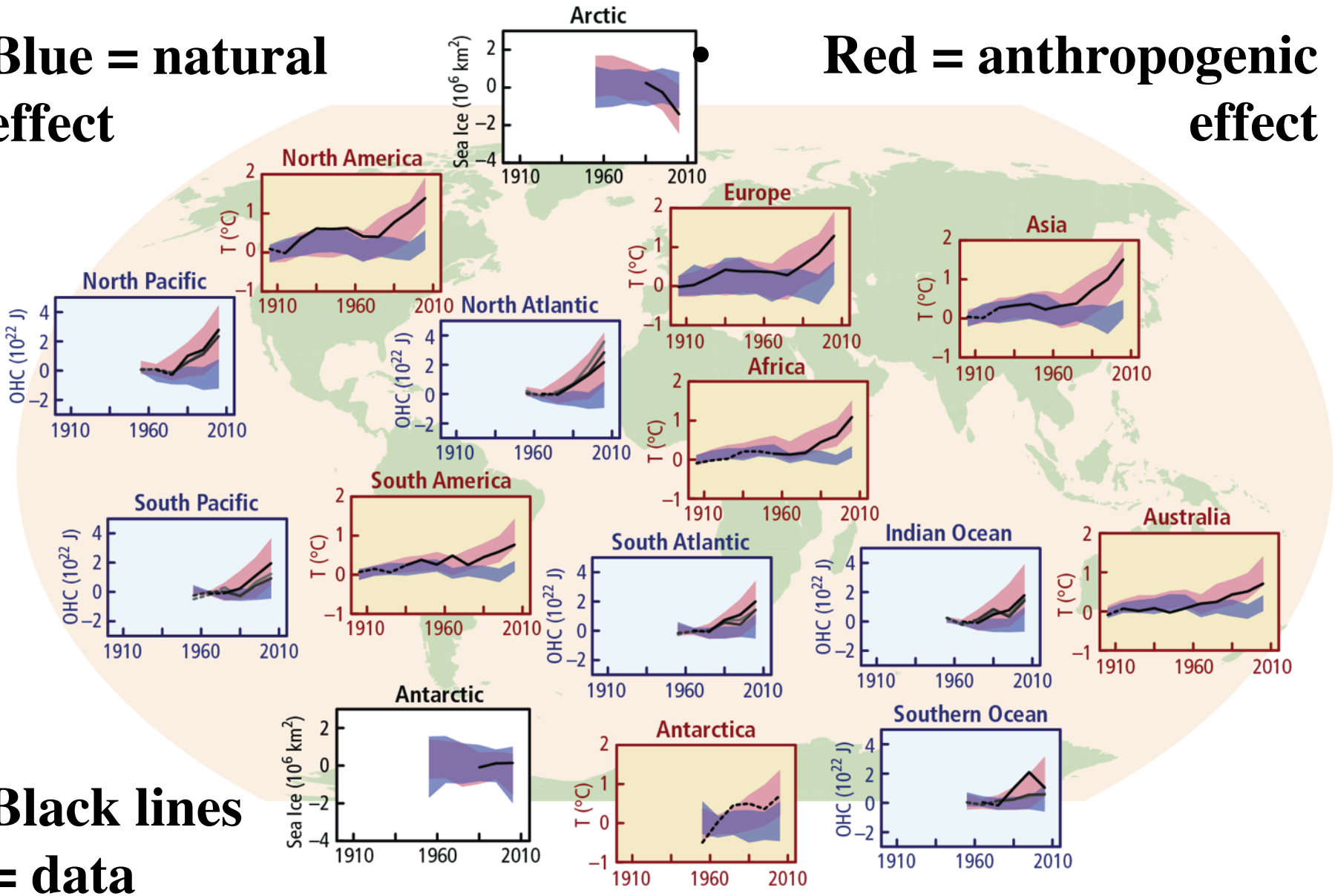
Observations vs. Models

- Blue = natural effect
- Red = anthropogenic effect
- Black lines = data



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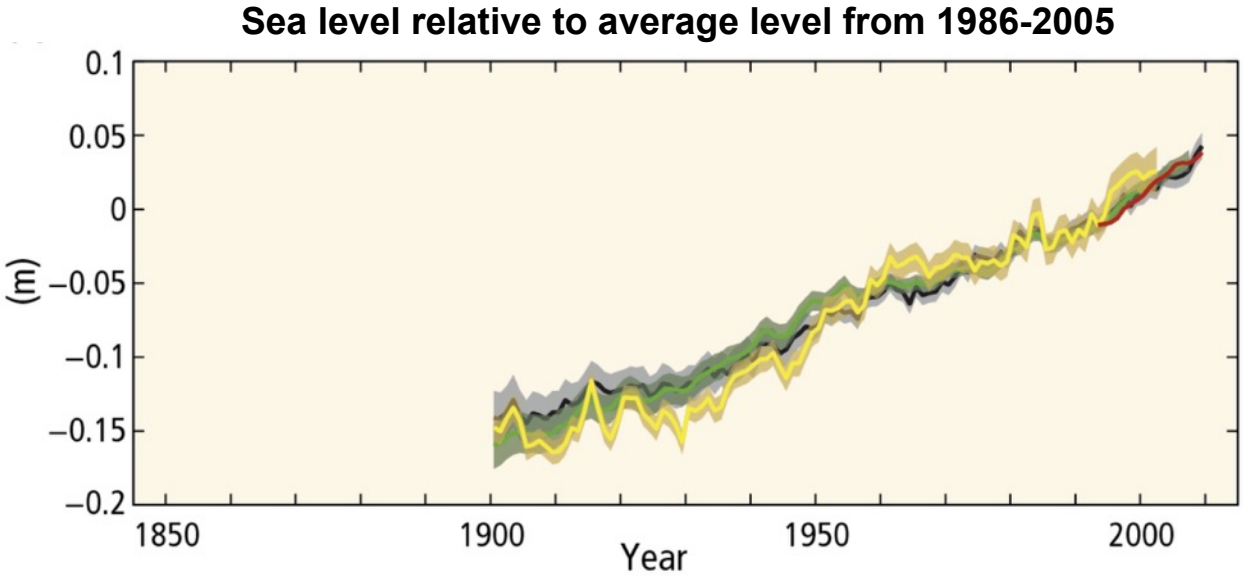
Working Group II: Effects

- **Reductions in snowfall & ice cover**
- **Earlier spring blooming, migration, planting**
- **More droughts**
- **More floods**
- **Rising sea levels**



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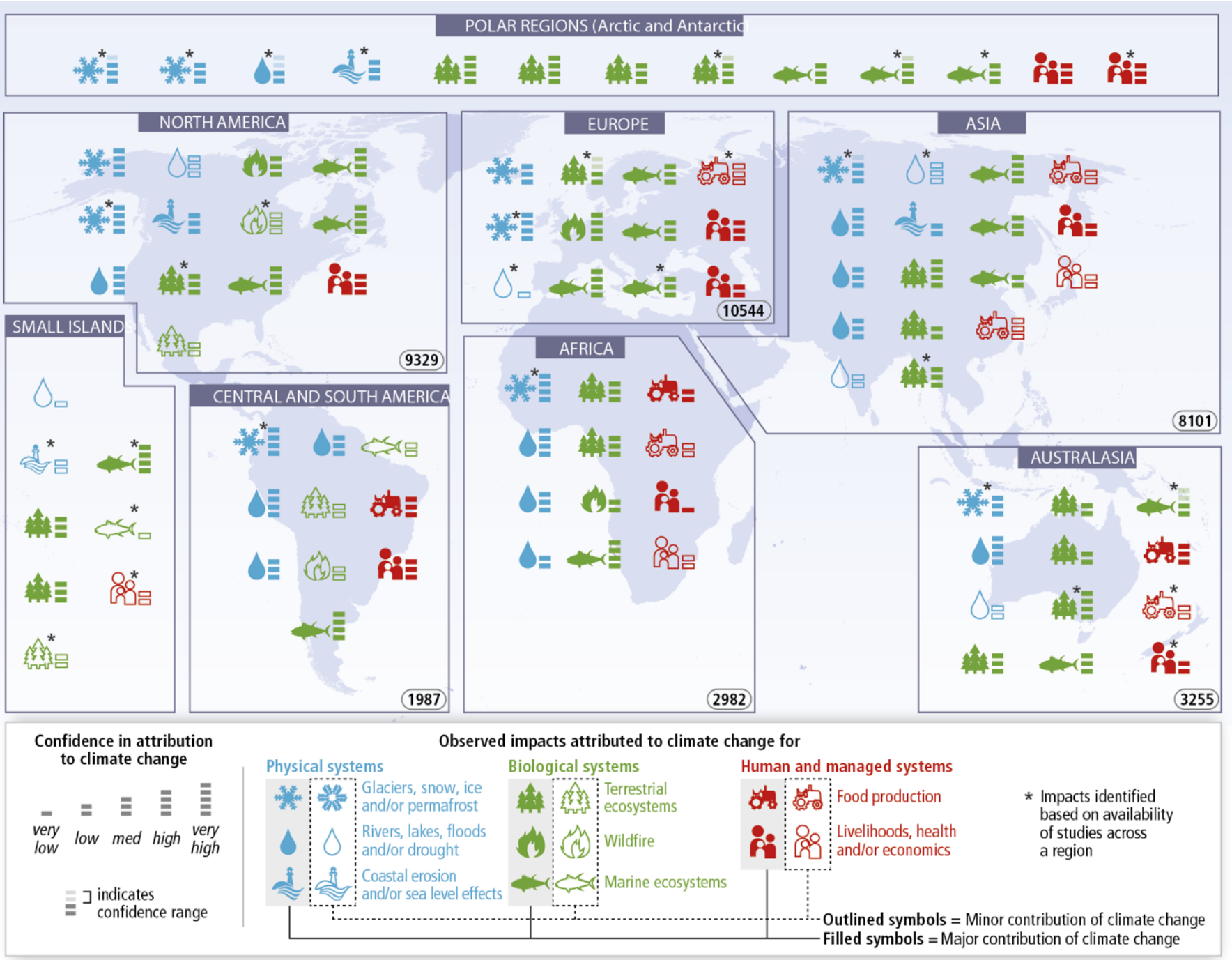
Observations



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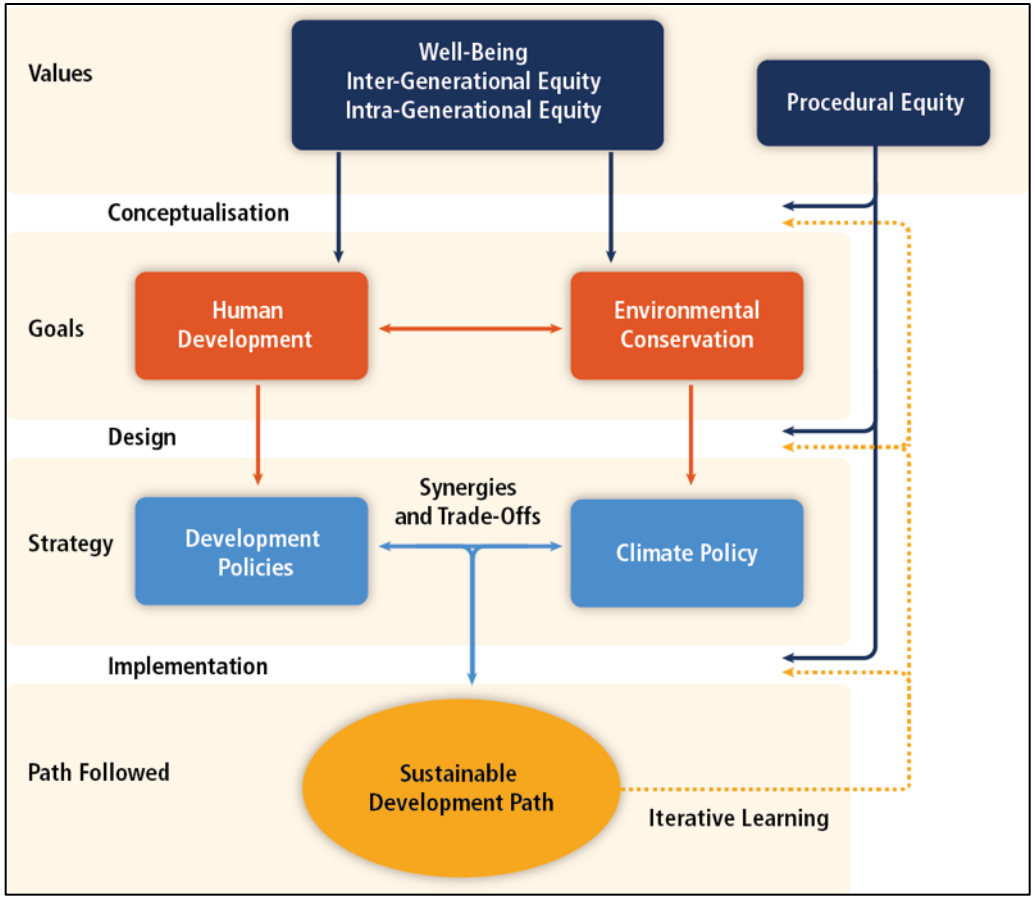
Working Group III: Mitigation

- It may be possible to slow the increase of GHGs
  - Even reduce levels
  - Without high costs
  - Or with gains

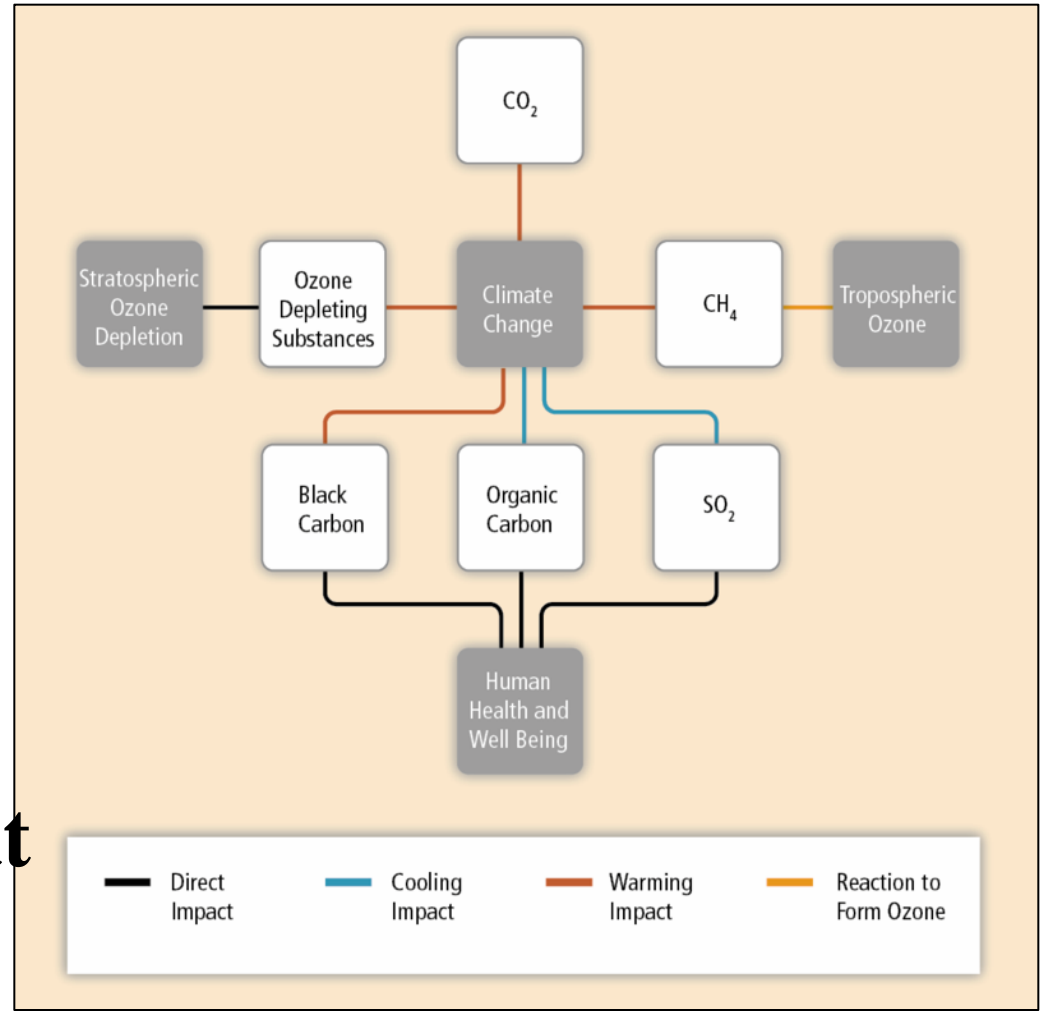


https://www.ipcc.ch/site/assets/uploads/2018/02/03_Figure_4.3.png

Connections

- **Between:**
  - **Climate change**
  - **Social & environmental objectives**
- **Lead to policies that affect various emissions**

Links between and impacts of GHGs in the atmosphere.



https://www.ipcc.ch/site/assets/uploads/2018/02/21_figure_5.21.png

After Each Assessment Report, Effects Have Occurred:

- **Sooner than predicted**
- **Faster than predicted**
- **With smaller increases in temperature than predicted**

Wildfires in California and Mexico in 2014.

https://earthobservatory.nasa.gov/images/83675/wildfires-in-california

What Can We Do?

- **US is a major contributor of GHG and a major obstacle to any solution**
- **Questions are now political, not scientific**
- **Each of us must get involved, and we must work together.**
    - **Individual actions are not enough…**

Teaching Notes and Tips

This exercise is divided into three complementary sections. The exercise may be completed in one extended laboratory period, or individual sections may be assigned as separate, shorter activities or as homework.

Note that the Excel workbook file includes two worksheets for that contain the key. The workbook given to students should have the following worksheets only: Temperature, Sunspots, Ice Cores, Recent, and Data.

The data used for this activity should be updated every year based on the sources listed in the workbook. Note that updating the data might require revising some of the questions or their answers.

Because computer software changes so rapidly, the instructions for accomplishing certain tasks with Excel might differ from those given in the student instructions. Thus, the instructor should be aware of possible difficulties using Excel.