ACTIVITY

What Do the Data Tell Us about Climate Change?

LEARNING GOAL

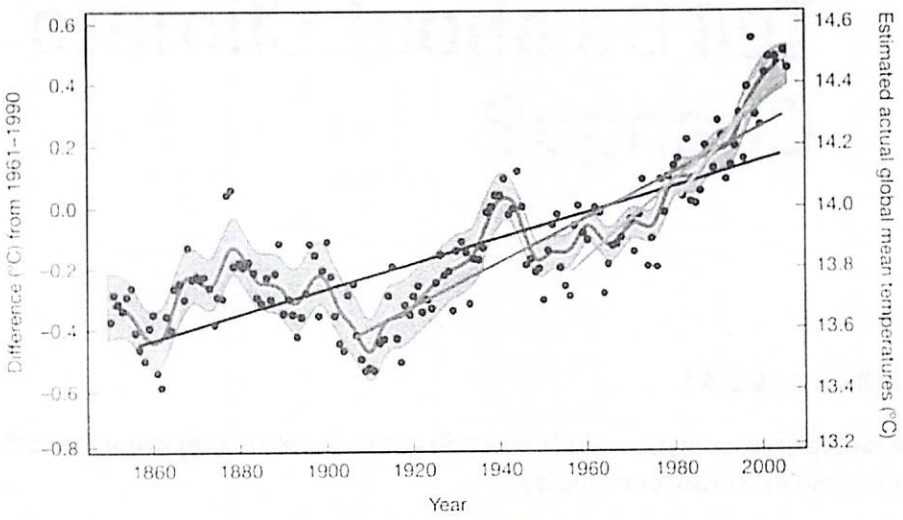
- **To develop your analytical skills in reading and summarizing graphical data, trends, and scientific confidence**

INTRODUCTION

The United Nations brought together the Intergovernmental Panel on Climate Change (IPCC) to study climate change and to inform the global community about the potential consequences of climate change. The IPCC comprises hundreds of the most respected climate experts in the world. They study historical and current climate data and create models to predict future consequences. The following worksheet refers to data and figures taken from the IPCC report *Climate Change 2007: The Scientific Basis.* Completing this worksheet will help you to better understand how scientific data and uncertainty are represented in graphical forms.

PROBLEMS

1. Examine the graph given here and read the associated caption.



Annual global mean temperatures (black dots) with linear fits to the data. The left-hand axis shows temperature anomalies relative to the 1961–1990 average, and the right-hand axis shows estimated actual temperatures, both in degrees Celsius. 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. The total temperature increase from the period 1850–1899 to the period 2001–2005 is 0.76°C ± 0.19°C.

A color version of this figure can be found at www.ipcc.ch/publications_and_data/ar4/wg1/en/tssts-3-1-1.html

a) Is the IPCC reporting that the temperature has increased over the last 150 years? If so, by how much?

0.76 ± 0.19 °C is the value stated in the caption

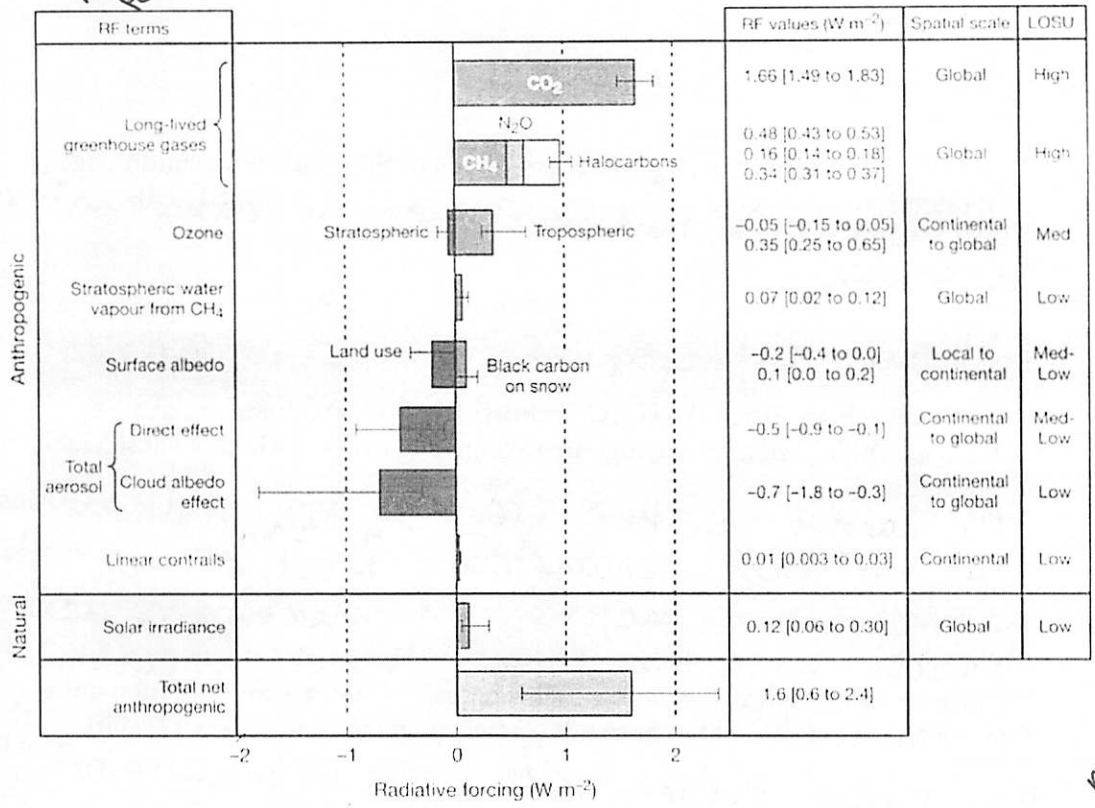
b) Describe how the rate of temperature increase has changed over this time period?

seems faster since 1960s. As reflected by steeper curve for shorter time periods (to present time) examined

Radiative forcing

level of scientific understanding

2. Examine the figure here and carefully read its caption.



Global mean radiative forcings (RF) and their 90% confidence intervals in 2005 for various agents and mechanisms. Columns on the right-hand side specify best estimates and confidence intervals (RF values); typical geographical extent of the forcing (Spatial scale); and level of scientific understanding (LOSU) indicating the scientific confidence level. Errors for CH_4, N_2O and halocarbons have been combined. The net anthropogenic radiative forcing and its range are also shown. Best estimates and uncertainty ranges can not be obtained by direct addition of individual terms because of the asymmetric uncertainty ranges for some factors; the values given here were obtained from a Monte Carlo technique. Additional forcing factors not included here are considered to have a very low LOSU. Volcanic aerosols contribute an additional form of natural forcing but are not included because of their episodic nature. The range for linear contrails does not include other possible effects of aviation on cloudiness.

A color version of this figure can be found at www.ipcc.ch/publications_and_data/ar4/wg1/en/spmsspm-human-and.html

monte Carlo - computational algorithms repeated random sampling used to generate probability distributions

a) Radiative forcing has units of watts per square meter. What does it mean for something to have a positive radiative forcing? A negative radiative forcing?

positive radiative forcing - increases amount of ~~energy~~ solar power (J/s) incident on the earths surface. This will result in warming.

negative - less solar power reaches the earth surface - cooling

b) Which of the factors shown in the preceding graph have a warming influence on climate? Which of these factors are anthropogenic (human caused) in origin?

warming: CO_2, other greenhouse gasses (CH_4, NO_2, hydrocarbons), O_3, Black carbon on snow, linear contrails, solar irradiance

Anthropogenic origin - all but solar irradiance

c) Which single factor has the most influence on global warming?

CO_2

d) Which factors have a cooling influence? Which of these factors are anthropogenic in origin?

Stratospheric O_3, land use change in albedo, atmospheric aerosols.

All are anthropogenic

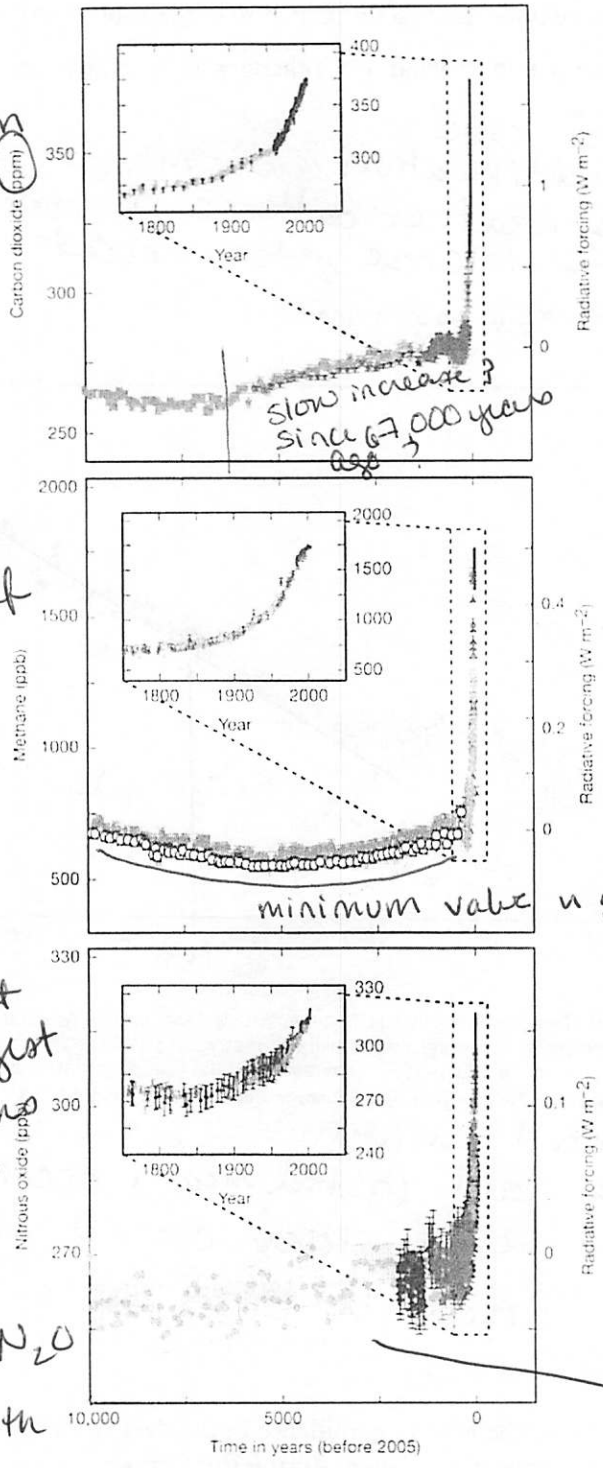
e) Summarize how certain the IPCC scientists are about the different radiative forcings. Which radiative forcings are well understood? Which have considerable uncertainty?

The largest factors (CO_2, CH_4, NO_2, hydrocarbons) are the best understood. Most other natural & anthropogenic factors are much less well-understood Aerosols have the largest Absolute uncertainty. Ozone has the largest relative unc.

3. Summarize each graph shown on the following page. Consider concentration units, time scale, past trends, and recent trends (shown as an inset in the larger graph).

The figure demonstrates the concentrations of CO_2, CH_4, & N_2O for the last 10,000 & 250 years. The data all show a relatively stable concentration until ~~1800~~ 200 years ago and an exponential increase since that time. ~~Increase~~. CO_2 has the highest concentration (~370 ppm) and the largest Radiative forcing (~1.65 ~~per~~ W/m^2) making it the most influential factor. ~~But~~ However, CH_4 has about half the Radiative forcing & N_2O has about 1/10th the radiative forcing with Much lower concentrations.

largest concentration in atmosphere & largest RF.



less CH_4 than CO_2 but still about half the RF. indicating the influence of CH_4 is high.

N_2O has the lowest concentration & largest error bars / fluctuations on short time scale.

~~But still~~ with 1/100th of the CO_2 concentration, N_2O still has about 1/10th the RF

Atmospheric concentrations of carbon dioxide, methane, and nitrous oxide over the preceding 10,000 years (large panels) and since 1750 (inset panels). Measurements are shown from ice cores (symbols with different colors for different studies) and atmospheric samples (solid red lines). The corresponding radiative forcings are shown on the right-hand axes of the large panels.

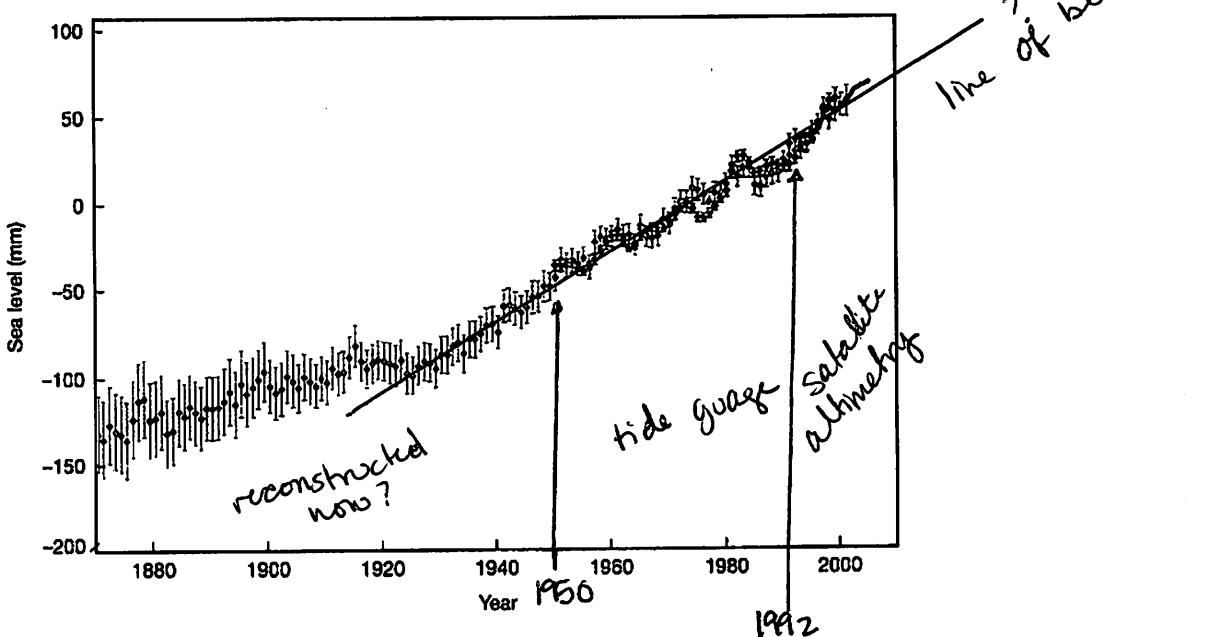
A color version of this figure can be found at www.ipcc.ch/publications_and_data/ar4/wg1/en/spmsspm-human-and.html

4. Temperature is one important factor related to climate, but there are many others.

a) Aside from temperature, what other changes in the climate system do you anticipate?

Sea level rise
ocean acidification & warming
shifting weather patterns - increasing desertification,
more intense storm events.

b) Describe the trends in the following figure.



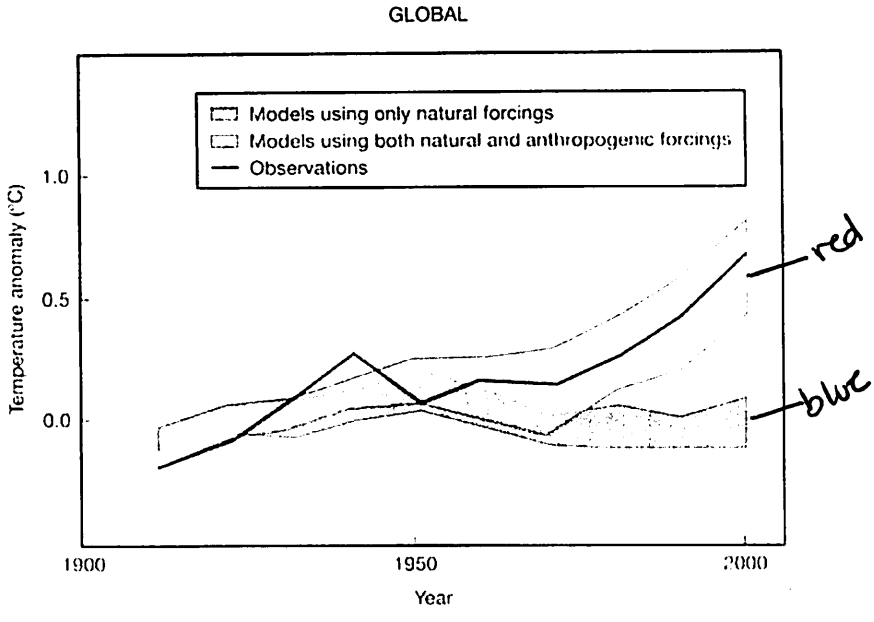
Annual averages of the global mean sea level based on reconstructed sea level fields since 1870 (light gray), tide gauge measurements since 1950 (dark gray), and satellite altimetry since 1992 (solid black line). Units are in millimeters relative to the average for 1961–1990. Error bars are 90% confidence intervals.
A color version of this figure can be found at www.ipcc.ch/publications_and_data/ar4/wg1/en/tssts-3-3-3.html

Moving toward modern time, the error bar associated with sea level (global mean) decreases. And there seems to be a clear overall trend of increasing sea level since ~ 1920 ish.

c) What happens to the level of confidence in the data from 1870 to 2000? Why do you think the uncertainty changes during this period?

the uncertainty decreases substantially as we rely on real (and increasingly accurate) measurements. Presumably the 1870 - 1950 data were reconstructed using a model? which would likely be less reliable the farther back it is extrapolated.

5. Examine the graph here and read its caption carefully. According to the climate models used by the IPCC, can natural influences alone explain the temperature changes we have seen in the past 100 years?



Comparison of observed global-scale changes in surface temperature with results simulated by climate models using natural and anthropogenic forcings. Decadal averages of observations are shown for the period 1906–2005 (black line) plotted against the center of the decade and relative to the corresponding average for 1901–1950. Darker blue-shaded bands show the 5%–95% range for 19 simulations from five climate models using only the natural forcings due to solar activity and volcanoes. Lighter red-shaded bands show the 5%–95% range for 58 simulations from 14 climate models using both natural and anthropogenic forcings.

A color version of this figure can be found at www.ipcc.ch/publications_and_data/ar4/wg1/en/spmsspm-understanding-and.html

90% CI

No, the IPCC models cannot reconstruct the temperatures observed since ~1950.

Adapted from the ChemConnections module "What Should We Do about Global Warming?" by Sharon Anthony, Tricia A. Ferrett, and Jade Bender.