## Idea 1, how is the carbon dioxide level in the atmosphere changing?



Here are the  $CO_2$  levels in parts per million measured at the Mauna Loa Observatory. The red line is the mean monthly value. The black line is the mean monthly value when seasonal variation is taken into account?

Why is there a periodic seasonal variation in the mean monthly  $CO_2$  level? (A picture of Earth is below.)

Do you see any evidence for the global shutdown due to COVID-19?

What is the overall trend in the data?





## Idea 2, what evidence do we have that the mean temperature of earth is increasing?

Below are plots of several climate trends from the 2013 IPCC Technical Summary.

- 1. What data are positively correlated?
- 2. What data are negatively correlated?



series presented are assessed in Chapters 2, 3 and 4. In each panel all data sets have been normalized to a common period of record. A full defailing of which source data sets go into which panel is given in Chapter 2 Supplementary Material Section 2.SM.5 and in the respective chapters. Further detail regarding the related Figure SPM.3 is given in the TS Figure TS.1 | Multiple complementary indicators of a changing global climate. Each line represents an independently derived estimate of change in the climate element. The times Supplementary Material. [FAQ 2.1, Figure 1; 2.4, 2.5, 3.2, 3.7, 4.5.2, 4.5.3]

## Idea 3, is variation in solar output the cause of the recent rise in global temperatures?

Some people argue against human activity as the cause of changes in surface air temperature by saying the cause of any temperature change is due to increased solar activity. Figure 2.13 shows the annual mean Surface Solar Radiation (SSR) observed at Stockholm, Sweden.

- 1. What trends do you notice in the SSR data?
  - a. increasing
  - b. decreasing
  - c. neither increasing nor decreasing



**Figure 2.13** | Annual mean Surface Solar Radiation (SSR) as observed at Stockholm, Sweden, from 1923 to 2010. Stockholm has the longest SSR record available worldwide. (Updated from Wild (2009) and Ohmura (2009).)

## Idea 4, does the atmosphere give clues about the effects of a rise in greenhouse gases?

Here is a diagram of the sun irradiating the earth with visible light. The earth's surface absorbs the visible light, which turns to thermal energy. The now warm surfaces emit infrared light. Some of the infrared light is then absorbed directly by atmospheric gases.

Consider the different regions of the atmosphere that we may have learned in our K-12 education. If increased **solar output** was the source of change in Earth's atmospheric temperature, how would the temperature of the troposphere and stratosphere change?

- (a) both increase
- (b) both decrease



(d) stratosphere decreases, troposphere increases





Here are the data for the changes in temperature of the troposphere and stratosphere over many decades.

- 1. What is the spatial relationship between the stratosphere and the troposphere?
- 2. What is the trend in temperature in the two regions?
- 3. As an aside, can you see the effects of the 1980 Mt. St. Helens and 1991 Mt. Pinatubo volcanic eruptions?
- 4. What hypothesis can you create to explain the relationship between the two temperature trends?
- 5. How does Figure 2.13 on the previous page fit into your hypothesis?



Figure 2.24 | Global annual average lower stratospheric (top) and lower tropospheric (bottom) temperature anomalies relative to a 1981–2010 climatology from different data sets. STAR does not produce a lower tropospheric temperature product. Note that the y-axis resolution differs between the two panels.