Climate Lab Student Materials

Lesson 5: Conclusion

Activity 1: Getting more signal from the noise

Look over the answers you gave to the last two questions in the first Where's Waldo activity, at the beginning of the week.

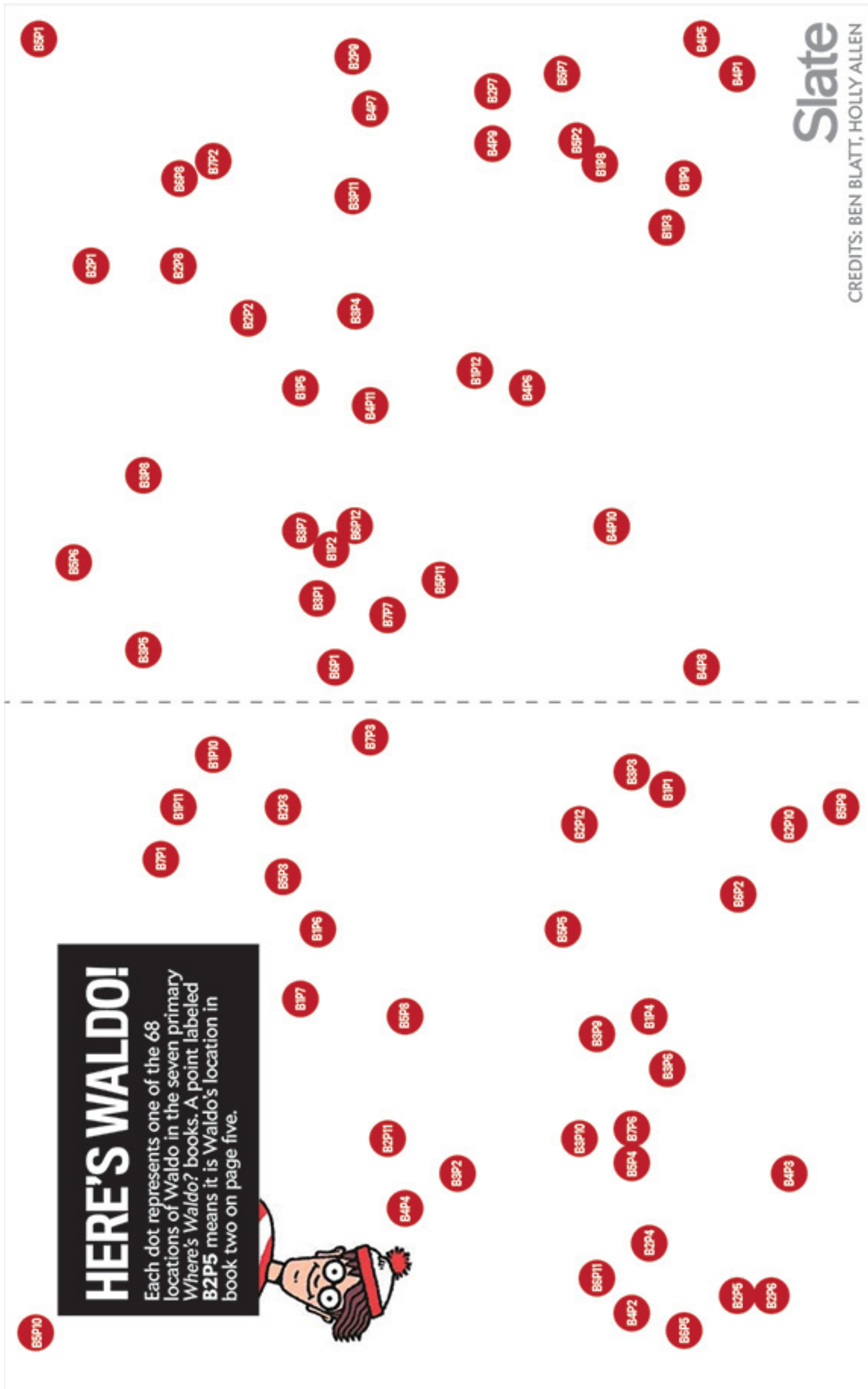
Based on the Where's Waldo puzzle you were looking at, would you be able to predict Waldo's location in other puzzles? What would you need to make that prediction?

With your small group, discuss the answers you gave at the beginning of the week. While discussing, focus on the following questions

Based on what you've learned this week, is there anything you would change about your answers?

If so, write down those changes, and why they are good changes to make.

Now look at Figure 1.


HERE'S WALDO!
Each dot represents one of the 68 locations of Waldo in the seven primary Where's Waldo? books. A point labeled B2P5 means it is Waldo's location in book two on page five.
Slate
CREDITS: BEN BLATT, HOLLY ALLEN

This figure was put together by a writer at Slate magazine. It shows the location of Waldo from 68 different puzzles with the same dimensions.

Looking at this plot, do you see any patterns that might help you predict future Waldo locations?

Now look at Figure 2 (shown or provided by the teacher).

These data clearly won't give us Waldo's location 100% of the time, but do we have a better idea of where Waldo is likely to be?

How would having this knowledge be useful if presented with future Where's Waldo puzzles?

In this case, a thorough analysis didn't give us results that can predict an outcome 100% of the time. What it DID do, however, is make it much easier to find the signal, both by showing us where it's likely to be in slightly over half the cases, *and* by allowing us to quickly eliminate the more likely locations in a systematic manner.

Even without 100% accuracy, using a large dataset to analyze what's going on can make a huge difference.

Activity 2: What's causing the change?

This activity has two parts. The first is to briefly review your reading assignment from the last night, covering the history of climate science. You can think of this as an open-book quiz that you're allowed to help each other on.

The second, which will have further instructions, is to work through the implications of the discoveries made by Fourier, Tyndall, and Arrhenius (along with others). As you go through this activity, it may be useful to have the reading assignment on hand to refer to.

Part 1: Reading review

Fourier discovered that the amount of solar energy that hits the earth isn't enough to keep the planet above freezing by itself.

a. What hypothesis did he form to explain Earth's temperature?

Who discovered the evidence to support Fourier's hypothesis, and what was that discovery?

Who calculated how much we would warm if CO_2 levels doubled, and how much was that?

What is Charles David Keeling known for?

Part 2: Finding the human fingerprint on global warming.

Saying that the warming we are seeing *could* be caused by human CO_2 emissions isn't enough. We also have to look for confirmation that the warming really is consistent with the greenhouse gas theory. For this section, you should read the material and questions as a group, and discuss each question with your group as you read them. Always keep in mind – "I don't know" is the best answer, when you don't know something, because it means that you can then go and try to find out.

We know from the reading that CO_2 acts as insulation, trapping heat like a jacket around the planet. There are a couple ways to check whether that is how we're being warmed, that rely on that similarity.

Imagine that you put on a jacket before going outside in the winter, but it's colder than you expected it to be, so your jacket isn't thick enough.

a. Would you get really cold right away?

Would you get cold faster or slower than if you had no jacket at all?

When you go inside, after getting really cold, do you warm up right away, or does it take time for you to get hot enough that you need to take off your jacket?

Does you jacket keep the heat indoors from reaching you as fast as it would if you didn't have a jacket on?

Moving to how Earth deals with temperatures, what time of day is usually the coldest, and why?

If Earth has a thicker "jacket" of CO_2, what change would we expect to see in night-time temperatures?

Take a look at Figure 3, showing the change in night time and daytime temperatures over time:

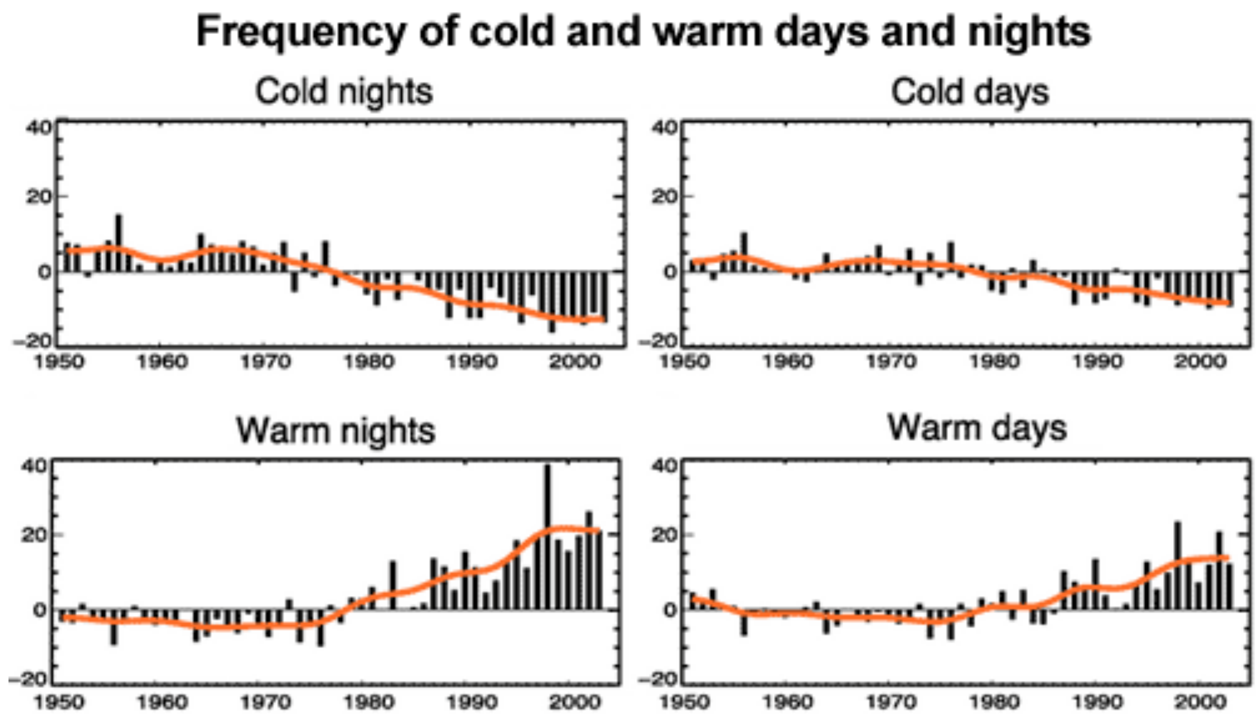


Figure 3

Which is warming faster – nights or days?

Does this support the CO_2 "jacket" hypothesis?

So, we know what's causing the warming, but do we know it's from humans? Where is the CO_2 coming from? Well, if it's coming from humans, then it's coming from carbon we burn, primarily from fossil fuels (though slash-and-burn forest clearing is also a big source). Burning this stuff combines carbon with oxygen to form CO_2

b. Where does that oxygen come from?

If the increase in CO2 levels is caused by burning fossil fuels, then what other changes would we expect to see in the chemistry of the atmosphere?

Figure 3 shows us what changes have been measured:

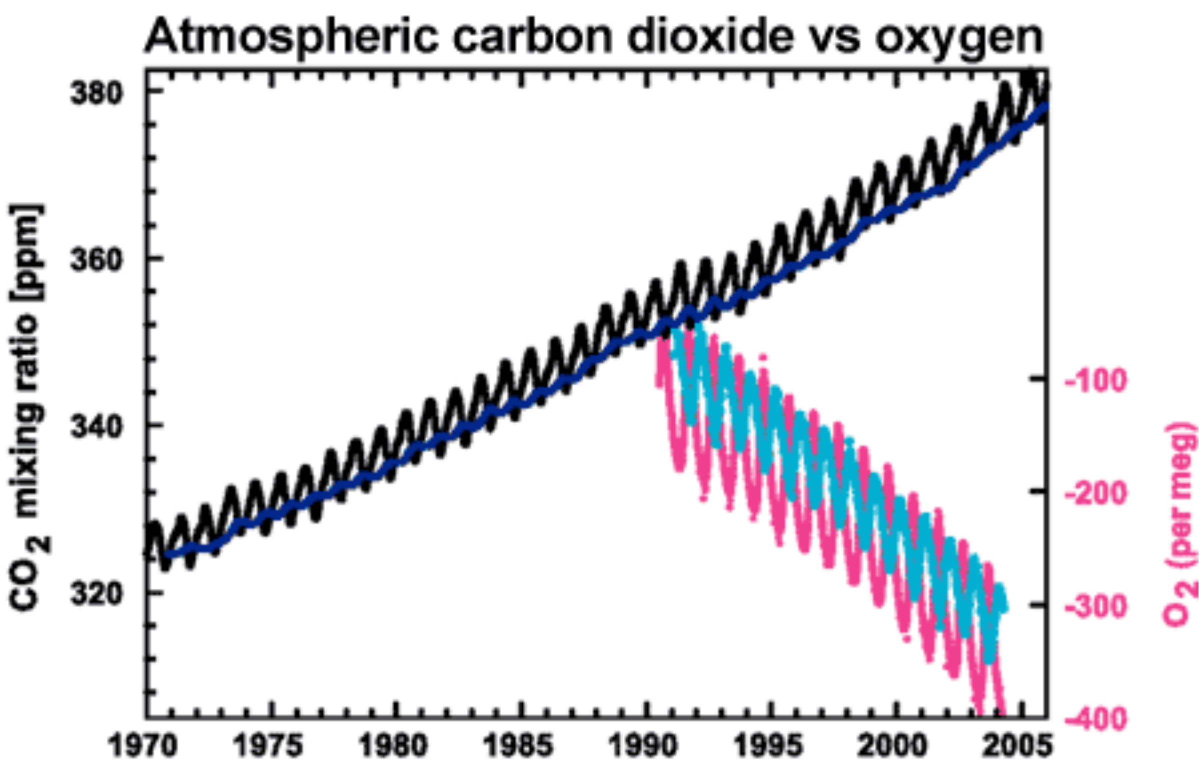


Figure 4: CO_2 concentrations from Mauna Loa, Hawaii (black) and and Baring Head, New Zealand (blue). In bottom right corner is atmospheric oxygen (O2) measurements from Alert, Canada (pink) and Cape Grim, Australia (cyan) (IPCC AR4 2.3.1 adapted from Manning 2006).

Does this graph support the hypothesis that human use of fossil fuels is causing CO_2 levels to rise?

Is the warming that we have seen so far being caused by the rise in CO_2 levels?

Now for the last check. The sun is Earth's major heat source, and so if there's a rise in temperature, it's natural to want to see if it's caused by the sun. Fortunately, there's an easy way to tell whether an increase in temperature is coming from an increase in insulation (the CO_2 jacket), or from an external source of heat like the sun.

Imagine you're wearing a jacket, and you're still feeling a bit cold, and someone lights a great big bonfire right next to you. Which part of your jacket would warm up first?

Burning this stuff combines carbon with oxygen to form CO2If CO2 was responsible for the warming, by acting like an extra layer to the "jacket" of Earth's atmosphere, what changes would we expect in the outermost layer of Earth's atmosphere?

Figure 5 shows the results of measurements taken between 1980 and 1995 at different elevations in Earth's outer atmosphere, from 50km (farthest out) on the upper left, to 22km (closer, but still upper atmosphere) at the lower right.

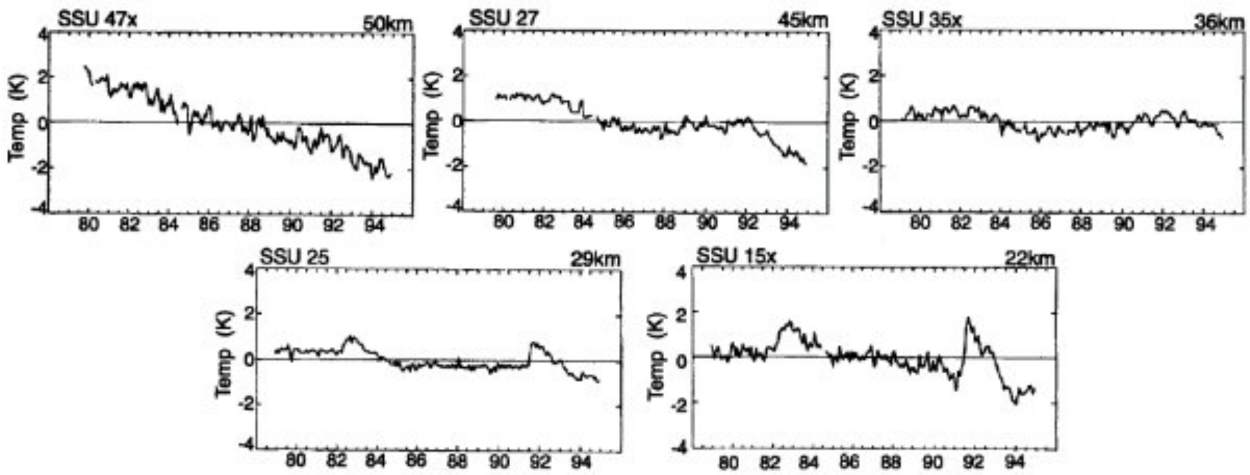
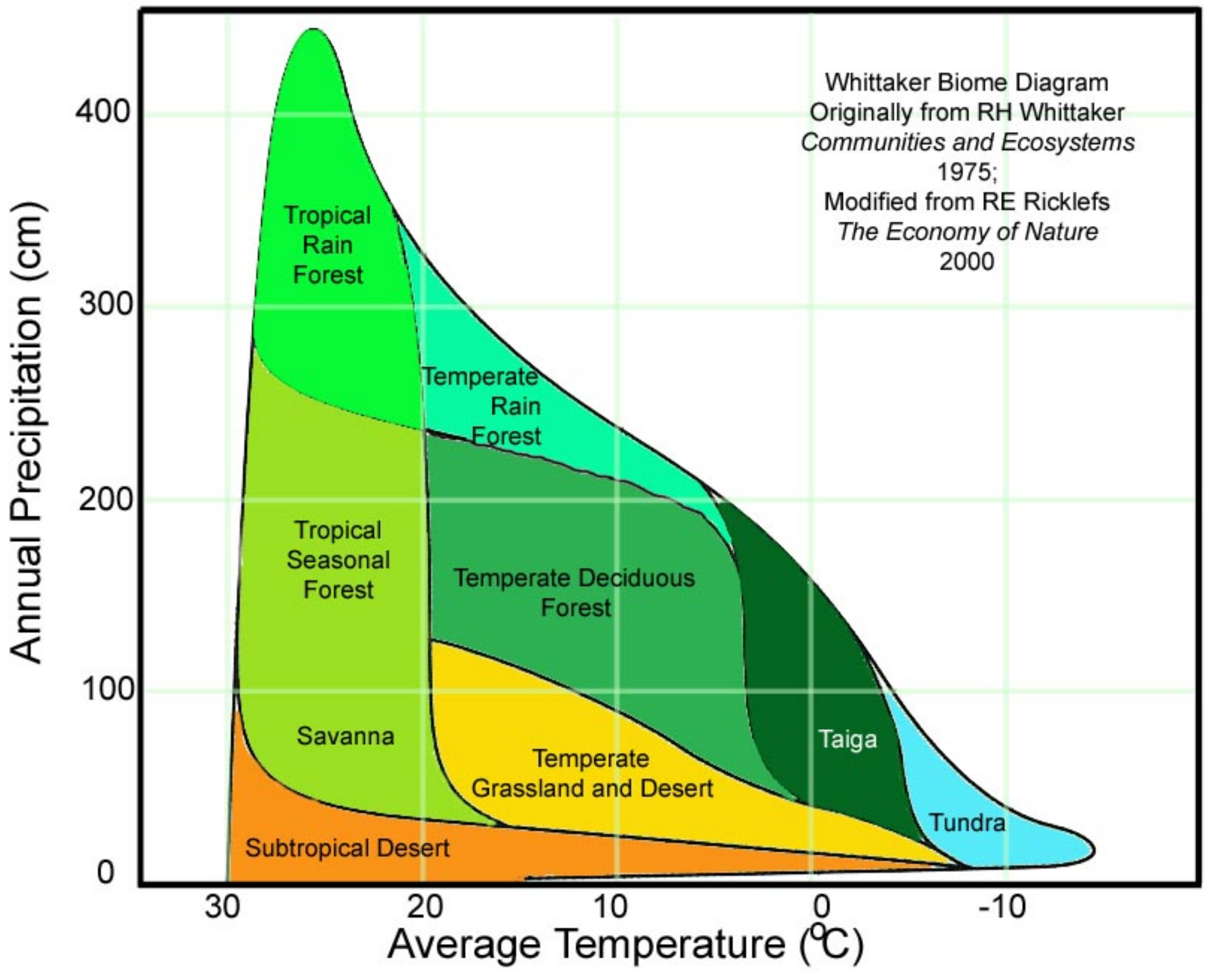


Figure 5– Stratospheric Temperatures over time at different elevations

Do the data represented here support the hypothesis that CO_2 is warming the Earth by insulating it, and trapping more heat?

Student name___________ Teacher name__________ Date______



Student Name_________ Teacher Name___________ Date_______

Instructions: Please go through this sheet and fill out the answers by discussing them with each other, and by using the Whittaker diagram and the Wikipedia page for your location. For questions 1, 3, 4, and 5, mark the answers on the diagram and label them with the appropriate question number. Use the Celsius and metric scales.

Location:
Current average annual high and low temperatures:
Current average annual precipitation (cm):

1) **Biome/place on the Whittaker diagram:**

2) **Location within that biome - what other biome(s) is the location nearest to?**

3) **100 years ago, global average temperature was about 1˚C lower than it is today.**
Assuming that the increase in temperature is the only change, where on the Whittaker diagram did your location fall 100 years ago?

4) **The mid-range estimate for warming by 2100 has the planet adding another 2.5˚C. Where does that put your location on the Whittaker diagram?**

5) **If you have a dry location, it's likely to get drier as the climate warms, and wet locations are likely to get wetter. Depending on which you have, where does an increase or decrease of 10cm precipitation per year move your location?**

6) **What are some characteristics of organisms that would make good indicator species**? *(Hint:* It depends a lot on what you're trying to measure.*)*

