

EARTH SCIENCE REGENTS
Factors Controlling Climate

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Name _____

Date _____

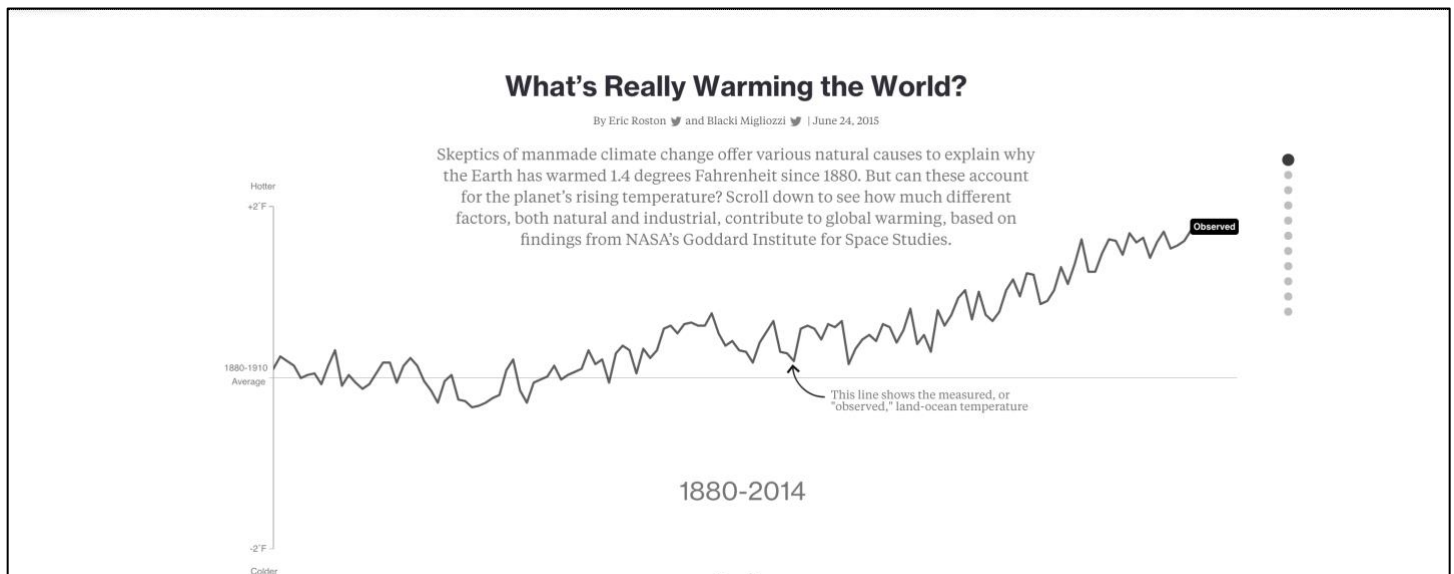
Period _____

Companion Website: <https://www.bloomberg.com/graphics/2015-whats-warming-the-world/>

Climate is the long-term average of weather, typically averaged over a period of 30 years¹. It is difficult for us to grasp a variation in climate due to this large timescale. We can grasp variations in weather – short-term changes in the atmosphere. For example, a humid day, a frigid week, or even a particularly warm or wet summer are all relatively small intervals of time that feel relevant and memorable. Therefore, climate, the average of decades worth of data, is best analyzed using large timescale graph. Specifically, climate factor graphs attempt isolate individual climate variables – you will study this scientific practice in this activity.

A “**climate forcing**” is a factor, or variable, that influences, or controls, climate. Climate forcings can include:

- orbital changes – the tilt of earth’s axis, or the shape its orbit.
- solar activity – the intensity of radiation being emitted by the sun.
- volcanic dust – small sediments, or bits of rocks, that enter the stratosphere.
- land use – changes in the quantity and quality of carbon sinks (deforestation).
- Ozone – a pollutant and also a greenhouse gas.
- Aerosols – tiny suspended particles that can include sulfates, black carbon, smog, and other material.
- greenhouse gases – carbon dioxide, methane, and others gases.

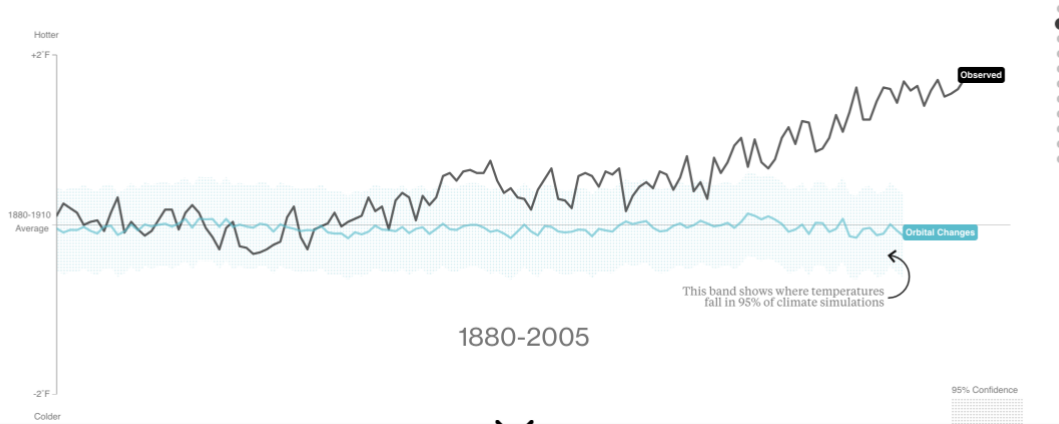


1) Are the short-term increases and decreases significant in the above graph? Why or why not?

2) Draw, with a colored pencil, a “best fit” or “trend line” of the above temperature dataset.

Is It the Earth's Orbit?

The Earth wobbles on its axis, and its tilt and orbit change over many thousands of years, pushing the climate into and out of ice ages. Yet the influence of orbital changes on the planet's temperature over 125 years has been negligible.



You can circle terms, or write the terms, for the blanks below.

3a) What is the climate forcing (cause that affects temperature) shown above? _____

3b) The climate forcing above is generally _____ (increasing, decreasing, or remaining the same) global temperature for the entire period of time shown on the graph.

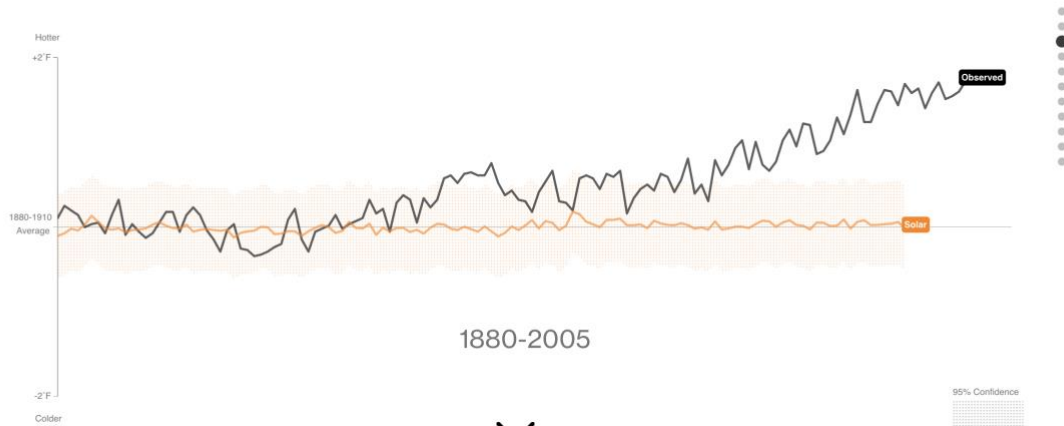
3c) The climate forcing above is _____ (human caused, or naturally occurring).

3d) A climate question you can come up with for the above climate forcing is:

Draw a model summarizing the climate forcing above:

Is It the Sun?

The sun's temperature varies over decades and centuries. These changes have had little effect on the Earth's overall climate.



4a) What is the climate forcing (cause that affects temperature) shown above? _____

4b) The climate forcing above is generally _____ (increasing, decreasing, or remaining the same) global temperature for the entire period of time shown on the graph.

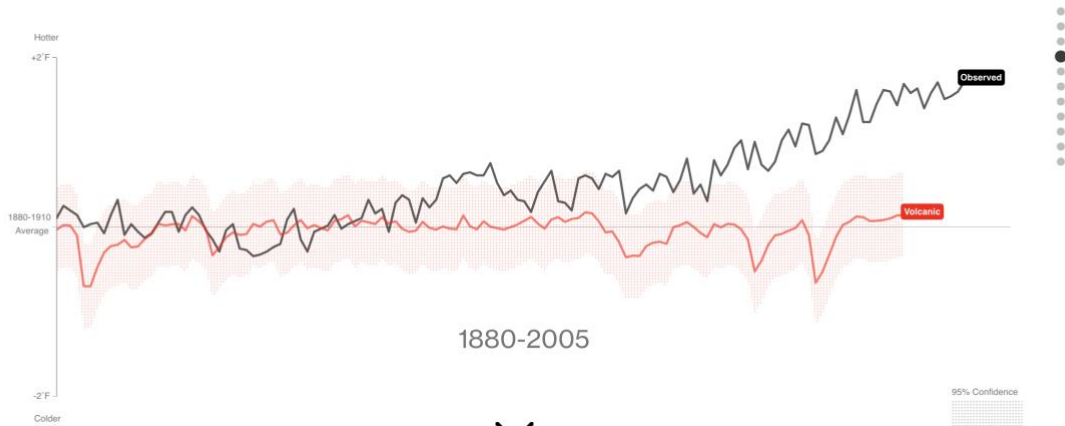
4c) The climate forcing above is _____ (human caused, or naturally occurring).

4d) A climate question you can come up with for the above climate forcing is:

Draw a model summarizing the climate forcing above:

Is It Volcanoes?

The data suggest no. Human industry emits about 100 times more CO₂ than volcanic activity, and eruptions release sulfate chemicals that can actually cool the atmosphere for a year or two.



5a) What is the climate forcing (cause that affects temperature) shown above? _____

5b) The climate forcing above is generally _____ (increasing, decreasing, or remaining the same) global temperature for the entire period of time shown on the graph.

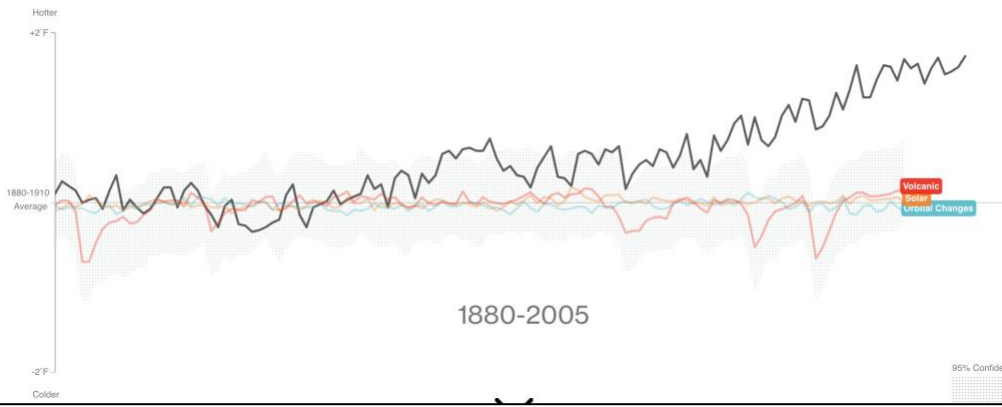
5c) The climate forcing above is _____ (human caused, or naturally occurring).

5d) A climate question you can come up with for the above climate forcing is:

Draw a model summarizing the climate forcing above:

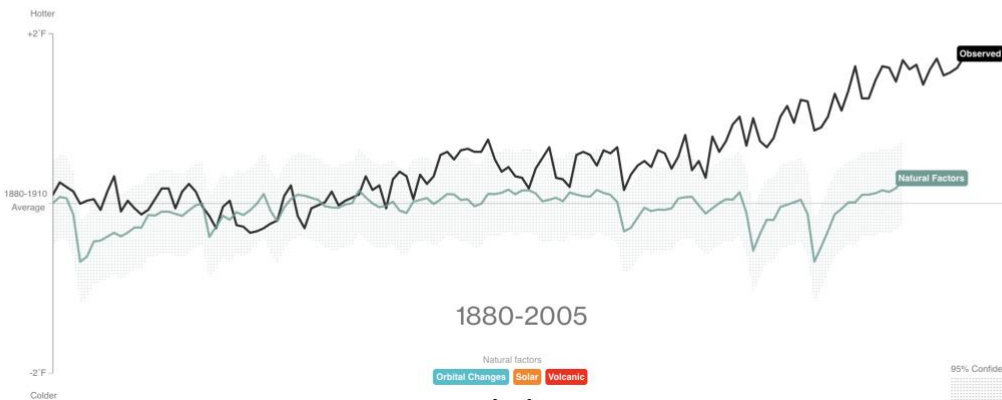
Is it All Three of These Things Combined?

If it were, then the response to natural factors should match the observed temperature. Adding the natural factors together just doesn't add up.



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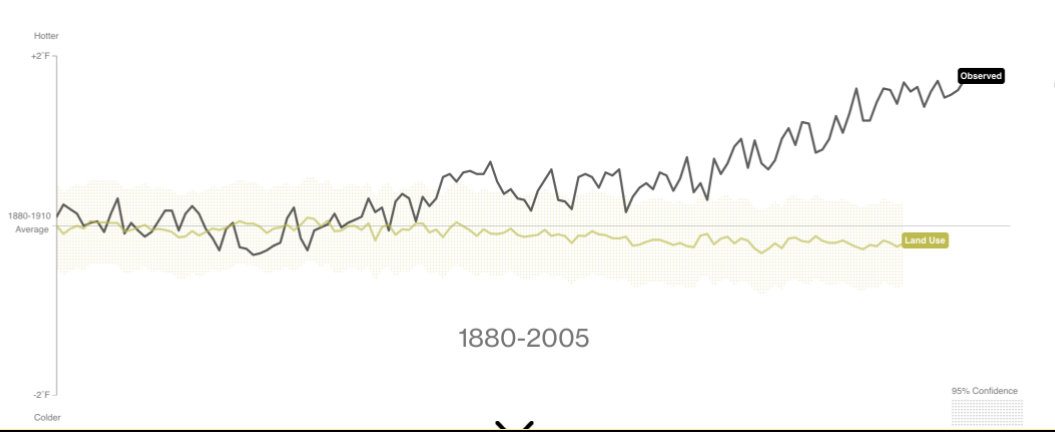


6a) What do all three forcings – orbital changes, solar variability, and volcanic eruptions all have in common?

6b) Why might the instrumental temperature record (the black line) not correspond, or matchup, with the “natural factors” (green line on lower graph above)?

So If It's Not Nature, Is It Deforestation?

Humans have cut, plowed, and paved more than half the Earth's land surface. Dark forests are yielding to lighter patches, which reflect more sunlight—and have a slight cooling effect.



7a) What is the climate forcing (cause that affects temperature) shown above? _____

7b) The climate forcing above is generally _____ (increasing, decreasing, or remaining the same) global temperature for the entire period of time shown on the graph.

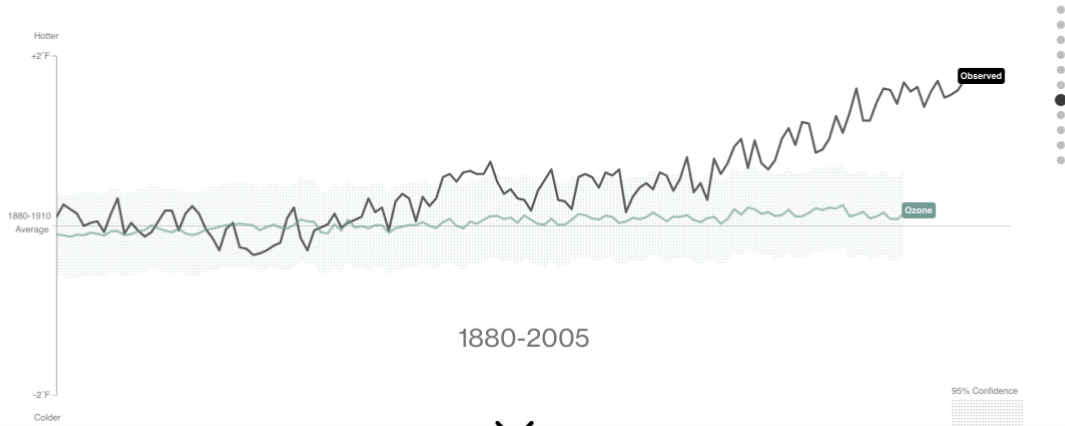
7c) The climate forcing above is _____ (human caused, or naturally occurring).

7d) A climate question you can come up with for the above climate forcing is:

Draw a model summarizing the climate forcing above:

Or Ozone Pollution?

Natural ozone high in the atmosphere blocks harmful sunlight and cools things slightly. Closer to Earth, ozone is created by pollution and traps heat, making the climate a little bit hotter. What's the overall effect? Not much.



9a) What is the climate forcing (cause that affects temperature) shown above? _____

9b) The climate forcing above is generally _____ (increasing, decreasing, or remaining the same) global temperature for the entire period of time shown on the graph.

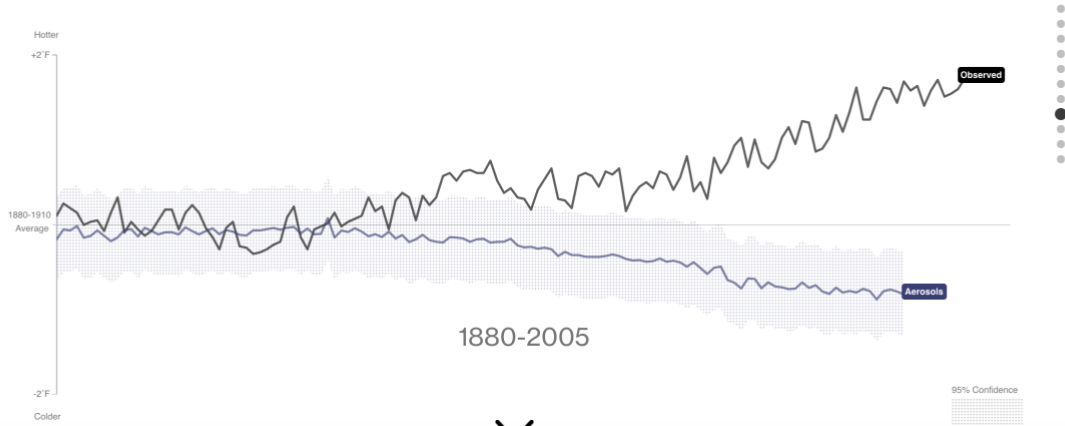
9c) The climate forcing above is _____ (human caused, or naturally occurring).

9d) A climate question you can come up with for the above climate forcing is:

Draw a model summarizing the climate forcing above:

Or Aerosol Pollution?

Some pollutants cool the atmosphere, like sulfate aerosols from coal-burning. These aerosols offset some of the warming. (Unfortunately, they also cause acid rain.)



10a) What is the climate forcing (cause that affects temperature) shown above? _____

10b) The climate forcing above is generally _____ (increasing, decreasing, or remaining the same) global temperature for the entire period of time shown on the graph.

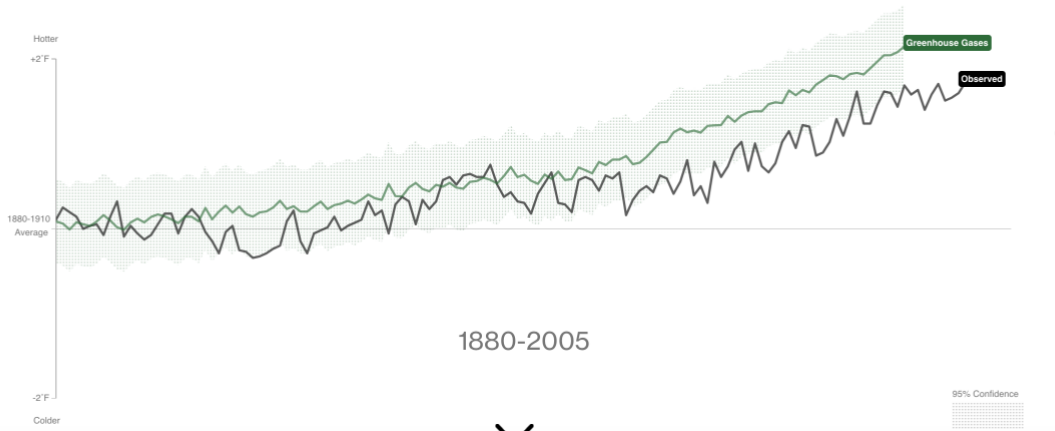
10c) The climate forcing above is _____ (human caused, or naturally occurring).

10d) A climate question you can come up with for the above climate forcing is:

Draw a model summarizing the climate forcing above:

No, It Really Is Greenhouse Gases.

Atmospheric CO₂ levels are 40 percent higher than they were in 1750. The green line shows the influence of greenhouse gas emissions. It's no contest.



11a) What is the climate forcing (cause that affects temperature) shown above? _____

11b) The climate forcing above is generally _____ (increasing, decreasing, or remaining the same) global temperature for the entire period of time shown on the graph.

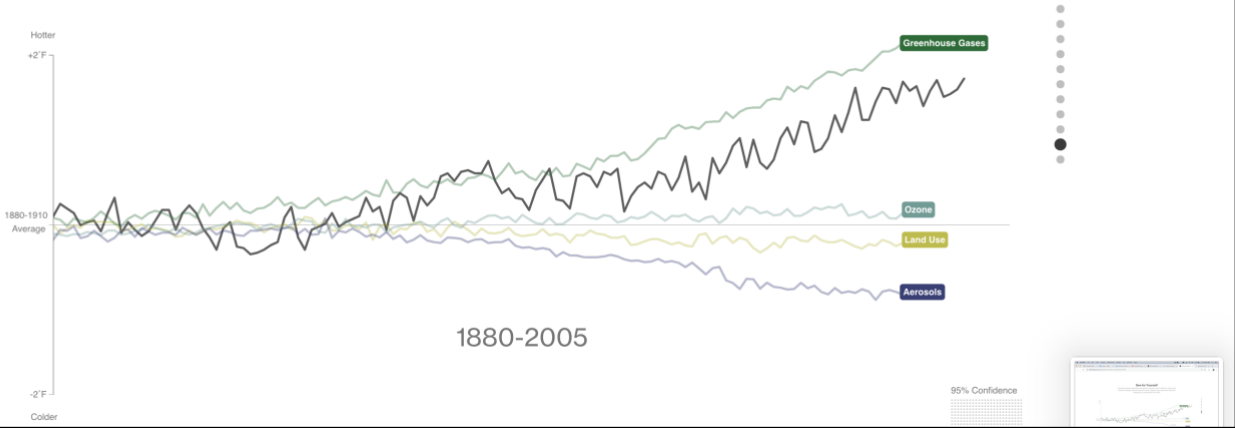
11c) The climate forcing above is _____ (human caused, or naturally occurring).

11d) A climate question you can come up with for the above climate forcing is:

Draw a model summarizing the climate forcing above:

See for Yourself

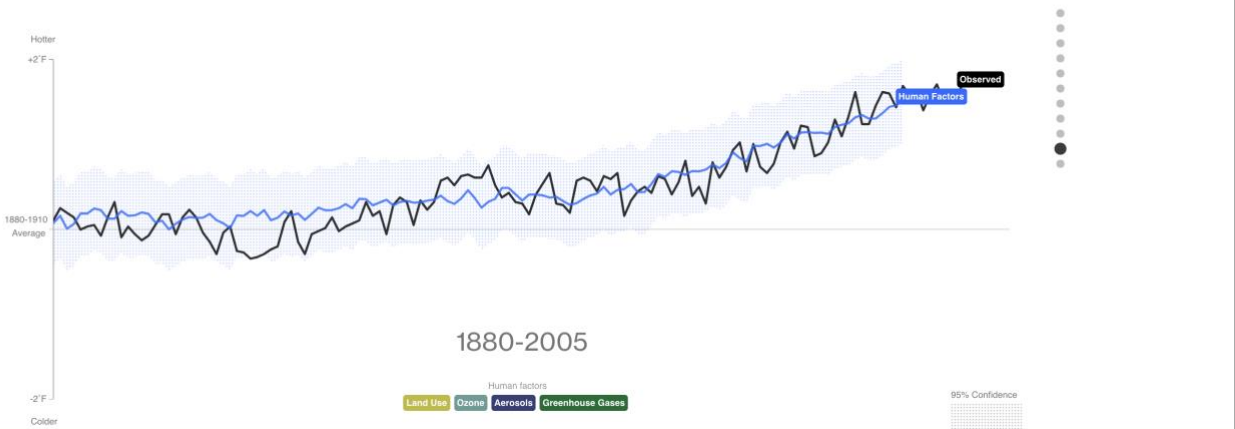
Greenhouse gases warm the atmosphere. Aerosols cool it a little bit. Ozone and land-use changes add and subtract a little. Together they match the observed temperature, particularly since 1950.



12) How do greenhouse gases compare to ozone, land use changes, and aerosols in terms of climate forcing?

See for Yourself

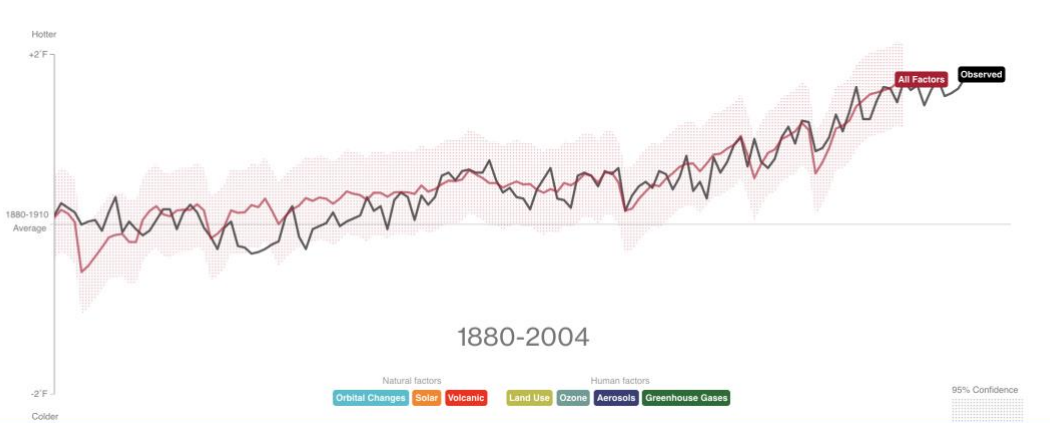
Greenhouse gases warm the atmosphere. Aerosols cool it a little bit. Ozone and land-use changes add and subtract a little. Together they match the observed temperature, particularly since 1950.



13) What does the blue line above represent?

Compare and Contrast

Putting the possible natural and human causes of climate change alongside one another makes the dominant role of greenhouse gases even more plainly visible. The only real question is: What are we going to do about it?



14) Overall, or "on the net", do the climate forcings, or climate factors, match the observed temperature record? Why or why not?

Conclusion

Write a brief summary as to what you gained from this activity:

References:

- (1) Planton, Serge (France; editor) (2013). "[Annex III. Glossary: IPCC – Intergovernmental Panel on Climate Change](#)" (PDF). [IPCC Fifth Assessment Report](#). p. 1450. Archived from [the original](#) (PDF) on 2016-05-24. Retrieved 25 July 2016.