**Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Date: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

**Predict Earth’s Future:**

***Building Your Own Climate Model***

Earth is getting warmer. Temperatures have been rising worldwide since 1880. All 10 of the hottest years on record have all occurred since 2000. Sea levels rose 17 cm in the last century. Extreme weather events are far more common than they used to be. These may seem like gloomy prospects, but the good news is that we still have many options available to slow down this warming trend. In order to decide which solutions will do the best job, we need to be able to predict what effect different climate mitigation strategies will have. This is where you come in!

***Today, you are a climate scientist working for the Intergovernmental Panel on Climate Change and your job is to prepare a brief report for the United Nations showing the long-term effect of certain carbon emissions policies. You will start by developing a model to predict the average global temperature in the year 2050 and then you will use your model to estimate how much things will change if certain policies are enacted. At the end, you will turn in two things: this worksheet with questions and tables filled in and a copy of all the graphs you make using Google Sheets.***

As you build your climate model, you will have to make several decisions about what data to include in it. To do this to do this, you will make a series of graphs that show the relationship between different climate variables and global temperature and decide which ones make sense to include in your model. Below are descriptions of the data you are using, some going back to 1750 (some data are more limited because we only started collecting the data more recently):

**You can access the data here:** [**http://tinyurl.com/BuildClimateModel-1**](http://tinyurl.com/BuildClimateModel-1)

**Global Temp**: The average land surface temperature of the Earth based on interpolations from weather stations all over the Earth (data source: Berkley Earth)

**Catastrophic Volcanos**: Number of catastrophic volcanic eruptions around the world during that year (a “catastrophic” volcanic eruption is a volcanic eruption rated at a 3 or higher on the Volcanic Eruption Index) (data source: National Centers for Environmental Information)

**Aerosol Optical Depth:** A general measure of the concentration of aerosols (small particles found in dust, smoke, and ash) in the atmosphere that can shade out sunlight (source: National Centers for Environmental Information)

**Sunspot Number**: The average number of sunspots on the sun in a given year (data source: National Centers for Environmental Information)

**CO2 Concentration**: The average global atmospheric CO2 concentration during in a given year (data source: Institute for Atmospheric and Climate Science)

**Cattle in USA**: The total number of cows in the USA during in a given year (data source: National Agricultural Statistics Service)

Remember, you are doing something very difficult—predicting the future!—so you may get different answers from other people. That’s okay! A big part of the scientific process is comparing your findings to those of other researchers so that you can learn from each other.

**Step 1: Variability Over Time**

**Since we want our model to predict what will happen in the future, first we need to see how these climate variables have changed over time in the past and whether they follow any regular pattern. For each variable, use Google Sheets make a graph showing how it changes over time (you will make six graphs for this part). Be sure to label your axes and give each graph a title. A line graph would be a good way to represent these data. Once you make your graphs, paste each of them into a Google Doc.**

After making your six graphs, fill in the table below, briefly describing the trend in the data (is it increasing, decreasing, or staying the same over time), variability (is the trend fairly constant over time or does it vary widely from year-to-year), and general notes on the pattern that you see.

|  |  |  |  |
| --- | --- | --- | --- |
| Variable | General Trend | Variability | Notes |
| Global Temperature |  |  |  |
| Volcanic Eruptions |  |  |  |
| Sunspot Number |  |  |  |
| CO2 Concentration |  |  |  |
| Cattle in USA |  |  |  |
| Global Temperature |  |  |  |

**Step 2: Relationship with Temperature**

**While it may be interesting to see how these different variables change over time, what we’re really interested in is how they affect global temperature. Now use Google Sheets make series of graphs that show the relationship between each variable (x-axis) and the global temperature (y-axis) then fill in the table below. Be sure to label your axes and give each graph a title. Once you make your graphs, paste each of them into the Google Doc from before.**

Note: Since you aren’t looking at change over time, it’s not appropriate to use a line graph here. You will have to visualize your data with a scatterplot.

Fill in the table below to indicate the relationship between that variable and global temperature (are they positively related, negatively related, or unrelated) and the strength of any relationship (is it a strong relationship or just a weak one with a lot of variation).

|  |  |  |  |
| --- | --- | --- | --- |
| Variable | Direction of Relationship | Strength of Relationship | Notes |
| CO2 Concentration |  |  |  |
| Sunspot Number |  |  |  |
| Cattle in USA |  |  |  |
| Aerosol Optical Depth |  |  |  |
| Volcanic Eruptions |  |  |  |

**Step 3: Building Your Model**

**Now we need to decide which variables to include in your model. Based on the relationship between global temperature and each variable, decide whether or not you think it would be important to include that variable in your model (Circle Yes or No) and briefly justify your decision.**

**CO2 Concentration ( Y N )**

**Sunspot Number ( Y N )**

**Cattle in USA ( Y N )**

**Aerosol Optical Depth ( Y N )**

**Volcanic Eruptions ( Y N )**

**Okay, so you know two things about each variable: how it changes over time and how it is related to average global air temperature. Now it’s time to put your model together. For each of the variables you chose to include in your model, look back at your graphs from Step 1 and extrapolate the trend forward to the year 2050 to see what that value is. (Remember, you only need to include the variables you decided to include in your model from above)**

Variable: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Value in 2050: \_\_\_\_\_\_\_\_\_\_\_

Variable: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Value in 2050: \_\_\_\_\_\_\_\_\_\_\_

Variable: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Value in 2050: \_\_\_\_\_\_\_\_\_\_\_

Variable: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Value in 2050: \_\_\_\_\_\_\_\_\_\_\_

Variable: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Value in 2050: \_\_\_\_\_\_\_\_\_\_\_

**Now look at your graphs from Step 2 and make a prediction for what the temperature is likely to be in 2050 based on 2050 values you determined above.**

Variable: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Predicted Temp in 2050: \_\_\_\_\_\_\_\_\_\_\_

Variable: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Predicted Temp in 2050: \_\_\_\_\_\_\_\_\_\_\_

Variable: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Predicted Temp in 2050: \_\_\_\_\_\_\_\_\_\_\_

Variable: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Predicted Temp in 2050: \_\_\_\_\_\_\_\_\_\_\_

Variable: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Predicted Temp in 2050: \_\_\_\_\_\_\_\_\_\_\_

**Lastly, calculate an average of the predicted temperatures from each of the variables above to determine your final prediction.**

Your prediction for average global air temperature in 2050: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Step 4: Modeling Different Policies**

It’s nice to have a prediction for how things will turn out in the future, but what would be really nice is to know how we can change it! Now, test how changing a few of the inputs into your model would affect your temperature predictions.

**What would happen to your predicted temperature for 2050 if nations adopted stricter CO2 emissions standards and the rate of increase of atmospheric CO2 increase was cut in half? Explain how you determined your new estimate.**

**With rising levels of income in parts of the world like China and India, people are consuming more meat which increases meat production worldwide. Although you only have data on cattle being raised in the United States instead of worldwide, suppose the meat production began to increase at the same rate it did from 1900 to the 1970s. What would happen to your prediction temperature prediction for 2050?**

**Propose one more change that could affect global temperatures and use your model to see how it would change your temperature prediction for 2050. Explain how you determined your estimate.**

**Synthesis & Wrap Up**

**In what ways do you think your model is accurate? In other words, how does your model accurately represent the real world?**

**Give two limitations of your model. In other words, how is your model not like the real world?**

**What other variables do you think would help your model? What other things could influence global temperatures that could be included?**

**Using your knowledge from class and your findings from your model, propose two policy changes that the United States could make that would likely slowly the warming trend worldwide.**