The purpose of this assessment is to determine your understanding of quantitative reasoning in the context of the carbon cycle. For open response items provide a brief written answer. For the rating scale questions select 1 for strongly disagree, 3 for no opinion, and 5 for strongly agree.

1. The following is a reading from the National Oceanic and Atmosphere Administration (NOAA) Earth System Research Laboratory website. Read the passage to identify ways humans contribute to the carbon cycle.

Projecting climate into the future and forecasting regional impacts depends on our understanding of the exchange of carbon dioxide between the atmosphere, oceans and land ecosystems. NOAA is charged to provide the atmospheric measurements and analyses required to track the fate of carbon dioxide emissions caused by the burning of fossil fuels and biomass, and to reduce uncertainties in how the exchange of carbon responds to the variations and trends of climate and land use.

Carbon is exchanged, or "cycled" among Earth's oceans, atmosphere, ecosystem, and geosphere. All living organisms are built of carbon compounds. It is the fundamental building block of life and an important component of many chemical processes. It is present in the atmosphere primarily as carbon dioxide (CO2), but also as other less abundant but climatically significant gases, such as methane (CH4). Because life processes are fueled by carbon compounds which are oxidized to CO2, the latter is exhaled by all animals and plants. Conversely, CO2 is assimilated by plants during photosynthesis to build new carbon compounds.

CO2 is produced by the burning of fossil fuels, which derive from the preserved products of ancient photosynthesis. The atmosphere exchanges CO2 continuously with the oceans. Regions or processes that predominately produce CO2 are called sources of atmospheric CO2, while those that absorb CO2 are called sinks. Owing primarily to the burning of fossil fuels and secondarily to changes in land-use, the amount of CO2 in the atmosphere has been increasing globally since the onset of the industrial revolution.

We must understand regional variations in the sources and sinks of CO2 because they help identify possible sequestration or emission management options. Ideally, these regional evaluations would be done on a global basis. Continued emission of carbon dioxide to the atmosphere will affect climate and ocean chemistry, subsequently influencing both marine and terrestrial ecosystems. The warming effects of increasing CO2 and other greenhouse gases impinge on agriculture, natural systems, and a host of environmental variables. Increasing CO2 in the atmosphere also directly translates to increasing acidity of the oceans.

1. Select all of the following which are human causes that contribute to the carbon cycle by placing an X in the box following the term.

|  |  |  |  |
| --- | --- | --- | --- |
| 1. Burning fossil fuels |  | 6. Wildlife and plants emissions |  |
| 2. Oxidization of carbon compounds |  | 7. Ocean-atmosphere exchange |  |
| 3. Climate change |  | 8. Greenhouse gasses |  |
| 4. Clearing forests |  | 9. Sequestration |  |
| 5. Atmospheric CO2 |  | 10. Emission management |  |

1. Provide a sentence or two that explains the characteristics of how driving a car influences the carbon dioxide level in the atmosphere.

|  |
| --- |
|  |

1. How is the variable of carbon dioxide level measured?
2. The amount of carbon dioxide (CO2) a person is responsible for releasing into the atmosphere is referred to as that person's carbon footprint. The table below shows average amounts of carbon dioxide (CO2) emission of certain appliances per year that might contribute to one’s carbon footprint. The graph shows amount of CO2 produced per uses of a microwave oven.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| |  |  |  |  | | --- | --- | --- | --- | | Average carbon dioxide output (CO2) of appliances per year | | | | | Appliance | Usage | Per Use | kg CO2 per year | | Microwave Oven | 96 times per year | 0.945 kWh per use | 39 | | Washing Machine | 187 washes per year | 0.63 kWh per use | 51 | | Electric Dryer | 148 uses per year | 2.50 kWh per cycle | 159 | | Gas Oven | 135.1 uses per year | 1.52 kWh per use | 38 | | Electric Oven | 135.1 uses per year | 1.56 kWh per use | 91 | | Dishwasher | 135 uses per year | 1.44 kWh per use | 84 | | Fridge-Freezer | 24 hours a day | 270 kWh per year | 116 | | TV CRT (Cathode Ray Tube) 34-37 in. | On 6.5 hours a day | 198.5 W | 203 | | TV LCD (Liquid Crystal) 34-37 inch | On 6.5 hours a day | 211.1 W | 215 | |  |

1. Rate the statements below from very strongly disagree (1) to very strongly agree (5) on how well they match your interpretation of the trend depicted in the graph and table.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 1. | Trends cannot be determined from this graph. | **Very strongly disagree** | **1 2 3 4 5** | **Very strongly agree** |
| 2. | The per use column in the table implies that increase in CO2 emissions is linear. | **Very strongly disagree** | **1 2 3 4 5** | **Very strongly agree** |
| 3. | The amount of CO2 used by an appliance is increasing. | **Very strongly disagree** | **1 2 3 4 5** | **Very strongly agree** |
| 4. | Trends cannot be determined from this table. | **Very strongly disagree** | **1 2 3 4 5** | **Very strongly agree** |
| 5. | One can identify a point on the graph, such as (50, 20) as representing number of usages and amount of CO2 produced, but cannot use the graph to explain trend. | **Very strongly disagree** | **1 2 3 4 5** | **Very strongly agree** |
| 6. | The amount of CO2 is increasing at a constant or linear rate. | **Very strongly disagree** | **1 2 3 4 5** | **Very strongly agree** |
| 7. | The trend of CO2 emission for appliances is best represented by a linear function, not by a power or exponential function. | **Very strongly disagree** | **1 2 3 4 5** | **Very strongly agree** |
| 8. | The function y = 0.41x is a possible model for the microwave data, indicating that use of the microwave adds about 0.4 kg of CO2 per use to your carbon footprint. | **Very strongly disagree** | **1 2 3 4 5** | **Very strongly agree** |

Below are eight different possible representations of the data table on CO2 emissions for usage of an appliance. Use these representations and the table and graph above to answer questions B, C, and D.

|  |  |
| --- | --- |
| 1. Pie Chart | 2. Bar Graph |
| 3. Scatter Plot for microwave versus washer | 4. Linear graphs for microwave |
| 5. Linear equation representing data  y = 0.41x  where x represents microwave uses and y microwave CO2 emissions | 6. Quadratic equation representing data  y= 0.0006x2+0.41x-0.0001  where x represents microwave uses and y for microwave CO2 emissions |
| 7. Exponential equation representing data  y = 1043 ˖ 1.06x  where x represents microwave uses and y for microwave CO2 emissions | 8. Power equation representing data  y = 0.41 x0.9  where x represents microwave uses and y for microwave CO2 emissions |

1. Rate the statements below from very strongly disagree (1) to very strongly agree (5) on how well they match your understanding of the representations.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 1. | The linear model is a better fit then the power or exponential model since the data trend is linear. | **Very strongly disagree** | **1 2 3 4 5** | **Very strongly agree** |
| 2. | One would select the representation they prefer and use only it, because there may be differences in the values between the models. | **Very strongly disagree** | **1 2 3 4 5** | **Very strongly agree** |
| 3. | The power model gives a carbon emission of 24.9 for 96 microwave uses, this does not match the table value of 39 so likely they collected data on different microwaves. | **Very strongly disagree** | **1 2 3 4 5** | **Very strongly agree** |
| 4. | One cannot compare the different representations of the data. | **Very strongly disagree** | **1 2 3 4 5** | **Very strongly agree** |
| 5. | The linear model gives a carbon emission of 39.96 for 96 uses of the microwave. While this varies from the table value for the microwave it does not mean one should not use this model. | **Very strongly disagree** | **1 2 3 4 5** | **Very strongly agree** |
| 6. | There can only be one representation of kg of CO2 emitted, so the others are all wrong. | **Very strongly disagree** | **1 2 3 4 5** | **Very strongly agree** |
| 7. | One can compare the table with the bar graph since both represent kg of CO2 emitted and appliance. | **Very strongly disagree** | **1 2 3 4 5** | **Very strongly agree** |
| 8. | The other representations show CO2 emissions in a different state in the United States. | **Very strongly disagree** | **1 2 3 4 5** | **Very strongly agree** |

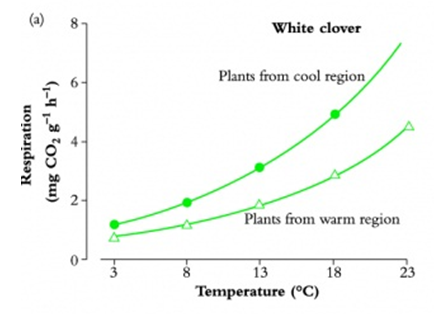
1. Rate the statements below from very strongly disagree (1) to very strongly agree (5) on how well they match your understanding of predicting future events.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 1. | The amount of kg of CO2 emitted for the washing machine is at 5 and increasing so there will be more kg of CO2. | **Very strongly disagree** | **1 2 3 4 5** | **Very strongly agree** |
| 2. | One could extend the linear trend of the data off the end of the graph, then estimate the uses and amount of CO2 emitted using the line. | **Very strongly disagree** | **1 2 3 4 5** | **Very strongly agree** |
| 3. | Since the graph only provides information for up to 50 uses of the microwave, one cannot make predictions of CO2 emissions beyond the given data. | **Very strongly disagree** | **1 2 3 4 5** | **Very strongly agree** |
| 4. | The uses increase so there will be more CO2. | **Very strongly disagree** | **1 2 3 4 5** | **Very strongly agree** |
| 5. | If the washing machine and dishwasher are both used 100 times, then the washing machine will emit more total CO2 than the dishwasher. | **Very strongly disagree** | **1 2 3 4 5** | **Very strongly agree** |
| 6. | To predict the amount of CO2 emitted after 100 uses substitute 100 for uses in the equation modeling the data, then solve for amount of kg of CO2 emitted. | **Very strongly disagree** | **1 2 3 4 5** | **Very strongly agree** |
| 7. | As uses increase the amount of CO2 is increasing, so there will be more CO2 emitted as you wash more loads. | **Very strongly disagree** | **1 2 3 4 5** | **Very strongly agree** |
| 8. | I am not sure how one can make predictions for future events from any of the representations. | **Very strongly disagree** | **1 2 3 4 5** | **Very strongly agree** |

1. Rate the statements below from very strongly disagree (1) to very strongly agree (5) on how well they match your understanding of how we can revise models. To revise a model means to change a model to better reflect the real world data.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 1. | One should revise the model so that it improves the ability to predict events. Perhaps this appliance has a non-linear rate of consumption. | **Very strongly disagree** | **1 2 3 4 5** | **Very strongly agree** |
| 2. | A model for kg of CO2 emitted is fixed and cannot be revised given new information. | **Very strongly disagree** | **1 2 3 4 5** | **Very strongly agree** |
| 3. | One should evaluate the graph and the equation model of the data to see how they inform each other. | **Very strongly disagree** | **1 2 3 4 5** | **Very strongly agree** |
| 4. | If the linear function does not fit the data, then one needs to recollect the data to fit the expected linear growth. | **Very strongly disagree** | **1 2 3 4 5** | **Very strongly agree** |
| 5. | One should consider revising the model by relating kilowatt hour use and carbon emissions. | **Very strongly disagree** | **1 2 3 4 5** | **Very strongly agree** |
| 6. | If the linear function does not fit the data, then there is error in the data we collected. | **Very strongly disagree** | **1 2 3 4 5** | **Very strongly agree** |
| 7. | We can test the graph or equation model for the kg of CO2 emission data to see if it is a good or bad fit. That is all the revision one can do. | **Very strongly disagree** | **1 2 3 4 5** | **Very strongly agree** |
| 8. | One should revise the model to better fit the evidence in the table not to make it fit an assumption. | **Very strongly disagree** | **1 2 3 4 5** | **Very strongly agree** |

1. Below are a graph representing respiration rate in White clover plants and a table of data on respiration.



|  |  |  |
| --- | --- | --- |
| Temperature  (Cº) | Respiration  (mg CO2 g-1h-1) | |
|  | Cool region | Warm region |
| 3 | 1.30 | 1.00 |
| 8 | 2.10 | 1.45 |
| 13 | 3.25 | 1.90 |
| 18 | 5.10 | 2.55 |
| 23 | 8.00 | 4.45 |

1. Rate the statements below from very strongly disagree (1) to very strongly agree (5) on how well they match your interpretation of the trend depicted in the graph and table.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 1. | The respiration of white clover is changing at an increasing rate as the temperature increases. | **Very strongly disagree** | **1 2 3 4 5** | **Very strongly agree** |
| 2. | The respiration of white clover in cool regions is increasing faster than the respiration of white clover in warm regions and neither rate is constant or linear. | **Very strongly disagree** | **1 2 3 4 5** | **Very strongly agree** |
| 3. | The respiration is increasing up to a temperature of 23, but one cannot determine the rate at which it is increasing. | **Very strongly disagree** | **1 2 3 4 5** | **Very strongly agree** |
| 4. | The function is a possible model for the warm region data. | **Very strongly disagree** | **1 2 3 4 5** | **Very strongly agree** |
| 5. | The single point (8, 2.10) represents temperature and respiration of white clover in cool regions, but one cannot explain trend using the graph. | **Very strongly disagree** | **1 2 3 4 5** | **Very strongly agree** |
| 6. | Trends cannot be determined from a table. | **Very strongly disagree** | **1 2 3 4 5** | **Very strongly agree** |
| 7. | Trends cannot be determined from a graph. | **Very strongly disagree** | **1 2 3 4 5** | **Very strongly agree** |
| 8. | The respiration trend is best represented by an exponential function, not a linear or power function. | **Very strongly disagree** | **1 2 3 4 5** | **Very strongly agree** |

Below are different possible representations of the data table on white clover respiration. Use these representations and the table and graph above to answer questions B, C, and D.

|  |  |
| --- | --- |
| 1. Pie chart | 2. Bar Graph |
| 3. Connected Scatter Plot | 4. Best fit curve |
| 5. Linear equation representing cool region data  y = 0.33x - 0.31  where x represents temperature and y respiration | 6. Quadratic equation representing cool region data  y = 0.01x2 - 0.04x + 1.35  where x represents temperature and y respiration |
| 7. Exponential equation representing cool region data  y = 1.00 ˖ 1.09x  where x represents temperature and y respiration | 8. Power equation representing cool region data  y = 0.44x0.85  where x represents temperature and y respiration |

1. Rate the statements below from very strongly disagree (1) to very strongly agree (5) on how well they match your understanding of the representations.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 1. | The graph and table of white clover respiration were collected in different places. | **Very strongly disagree** | **1 2 3 4 5** | **Very strongly agree** |
| 2. | One would select the representation they prefer and use only it, because there may be differences in the values between the models. | **Very strongly disagree** | **1 2 3 4 5** | **Very strongly agree** |
| 3. | One cannot compare the different representations of the data. | **Very strongly disagree** | **1 2 3 4 5** | **Very strongly agree** |
| 4. | There can only be one representation of white clover respiration, so the other representations are all wrong. | **Very strongly disagree** | **1 2 3 4 5** | **Very strongly agree** |
| 5. | The exponential model is a better fit than the quadratic model because of the increasing nature of the rate. | **Very strongly disagree** | **1 2 3 4 5** | **Very strongly agree** |
| 6. | One should not compare the pie chart to the graph since the pie chart provides percentage values and not amount of white clover respiration. | **Very strongly disagree** | **1 2 3 4 5** | **Very strongly agree** |
| 7. | One can compare the table with the scatter plot because both represent white clover respiration. | **Very strongly disagree** | **1 2 3 4 5** | **Very strongly agree** |
| 8. | The quadratic model gives a rate of white clover respiration of 1.37 for a temperature of 3 degrees. This varies from the table value for this temperature due to estimates in model. | **Very strongly disagree** | **1 2 3 4 5** | **Very strongly agree** |

1. Rate the statements below from very strongly disagree (1) to very strongly agree (5) on how well they match your understanding of predicting future events.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 1. | I am not sure how one can make predictions for future events from any of the representations. | **Very strongly disagree** | **1 2 3 4 5** | **Very strongly agree** |
| 2. | White clover respiration is increasing so temperature will rise. | **Very strongly disagree** | **1 2 3 4 5** | **Very strongly agree** |
| 3. | As temperature increases beyond 23 degrees the white clover respiration will increase for a period of time. | **Very strongly disagree** | **1 2 3 4 5** | **Very strongly agree** |
| 4. | To predict the white clover respiration at a temperature of 30 degrees, substitute the 30 into the equation model and solve for white clover respiration. | **Very strongly disagree** | **1 2 3 4 5** | **Very strongly agree** |
| 5. | To make a prediction extend the linear trend of the data off the end of the graph, then estimate the temperature and respiration using the line. | **Very strongly disagree** | **1 2 3 4 5** | **Very strongly agree** |
| 6. | As temperature increases respiration increases for warm climates, so at a temperature of 28 the respiration will be above 5. | **Very strongly disagree** | **1 2 3 4 5** | **Very strongly agree** |
| 7. | For a temperature of 25 degrees the white clover respiration will continue to rise. | **Very strongly disagree** | **1 2 3 4 5** | **Very strongly agree** |
| 8. | One cannot predict future events from a table, graph, or equation. | **Very strongly disagree** | **1 2 3 4 5** | **Very strongly agree** |

1. Rate the statements below from very strongly disagree (1) to very strongly agree (5) on how well they match your understanding of how we can revise models. To revise a model means to change a model to better reflect the real world data.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 1. | One could compare the rates of growth of respiration for the cool versus warm region. | **Very strongly disagree** | **1 2 3 4 5** | **Very strongly agree** |
| 2. | If a scientist says that the white clover respiration should not be impacted by temperature, then one needs to recollect the data. | **Very strongly disagree** | **1 2 3 4 5** | **Very strongly agree** |
| 3. | A model for white clover respiration is fixed and cannot be revised given new information. | **Very strongly disagree** | **1 2 3 4 5** | **Very strongly agree** |
| 4. | One should evaluate the graph and the equation model of the data to see how they inform each other. | **Very strongly disagree** | **1 2 3 4 5** | **Very strongly agree** |
| 5. | If the modeling function does not exactly fit the data, then the data was not collected correctly. | **Very strongly disagree** | **1 2 3 4 5** | **Very strongly agree** |
| 6. | One should revise the model so that it improves the ability to predict events, not revise the data to fit a model. | **Very strongly disagree** | **1 2 3 4 5** | **Very strongly agree** |
| 7. | One can test the graph or equation model for the white clover respiration data to see if it is a good or bad fit. That is all the revision one can do. | **Very strongly disagree** | **1 2 3 4 5** | **Very strongly agree** |
| 8. | One should revise the model to better fit the evidence in the table not to make it fit a scientist’s expectations. | **Very strongly disagree** | **1 2 3 4 5** | **Very strongly agree** |

1. The graph and table below show the concentration of carbon dioxide in the atmosphere in parts per million (ppm) for every year since 1958. The box model gives the exchange of CO2 during the years 2000-2005 in gigatons of CO2.

Carbon CycleBox Model



|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Year | 1960 | 1965 | 1970 | 1975 | 1980 | 1985 | 1990 | 1995 | 2000 | 2005 | 2010 |
| CO2 | 316.9 | 320.0 | 325.7 | 331.1 | 338.7 | 346.0 | 354.4 | 360.8 | 369.5 | 379.8 | 389.9 |

1. Rate the statements below from very strongly disagree (1) to very strongly agree (5) on how well they match your interpretation of the trend depicted in the model and table.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 1. | Trends cannot be determined from the box model. | **Very strongly disagree** | **1 2 3 4 5** | **Very strongly agree** |
| 2. | The change in CO2 concentration is not linear or curvilinear, it just randomly varies across time. | **Very strongly disagree** | **1 2 3 4 5** | **Very strongly agree** |
| 3. | The amount of CO2 concentration is increasing. | **Very strongly disagree** | **1 2 3 4 5** | **Very strongly agree** |
| 4. | Trends cannot be determined from a table. | **Very strongly disagree** | **1 2 3 4 5** | **Very strongly agree** |
| 5. | The single point in 1995 can provide the CO2 concentration, but cannot explain trends in CO2 concentration. | **Very strongly disagree** | **1 2 3 4 5** | **Very strongly agree** |
| 6. | The amount of CO2 concentration is increasing and the rate is not constant or linear. | **Very strongly disagree** | **1 2 3 4 5** | **Very strongly agree** |
| 7. | The CO2 concentration trend is best represented by a quadratic function, not a linear or exponential function. | **Very strongly disagree** | **1 2 3 4 5** | **Very strongly agree** |
| 8. | The function y = 0.012x2 + 0.83x + 314.33 is a possible model for this data, indicating that the increase of CO2 is more every year. | **Very strongly disagree** | **1 2 3 4 5** | **Very strongly agree** |

Below are different possible representations of the carbon cycle. Use these representations and the table and graph above to answer questions B, C, and D.

|  |  |
| --- | --- |
| 1. Box Model: Exchange of CO2 during the years 2000-2005 in gigatons | 2. Bar Graph |
| 3. Connected Scatterplot | 4. Best fit curve |
| 5. Linear equation representing data  y = 1.483x + 308.24  where x represents years and y represents CO2 concentration | 6. Quadratic equation representing data  y = 0.0119x2 + 0.8308x + 314.33  where x represents years and y represents CO2 concentration |
| 7. Exponential equation representing data  y = 309.99e0.0042x  where x represents years and y represents CO2 concentration | 8. Power equation representing data  y = 285.67x0.0651  where x represents years and y represents CO2 concentration |

1. Rate the statements below from very strongly disagree (1) to very strongly agree (5) on how well they match your understanding of the representations.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 1. | One would select the representation they prefer and use only it, because there may be differences in the values between the models. | **Very strongly disagree** | **1 2 3 4 5** | **Very strongly agree** |
| 2. | The other representations are of CO2 concentration in different parts of the world. | **Very strongly disagree** | **1 2 3 4 5** | **Very strongly agree** |
| 3. | One should not compare the pie chart to the graph because the pie chart presents percentages and not CO2 concentration. | **Very strongly disagree** | **1 2 3 4 5** | **Very strongly agree** |
| 4. | There can only be one representation of the CO2 concentration, so the other representations are all wrong. | **Very strongly disagree** | **1 2 3 4 5** | **Very strongly agree** |
| 5. | The Mauna Loa data indicates that CO2 increased 10ppm over 2000-2005 which is not compatible with the box model which indicates 4 gigatons of increase. | **Very strongly disagree** | **1 2 3 4 5** | **Very strongly agree** |
| 6. | The function y = 0.012x2 + 0.83x + 314.3 is the best fit for the data, indicating that CO2 intends to increase at higher rates. | **Very strongly disagree** | **1 2 3 4 5** | **Very strongly agree** |
| 7. | One can compare the graph with the box model for 2000-2005 because both represent CO2 concentration increase. | **Very strongly disagree** | **1 2 3 4 5** | **Very strongly agree** |
| 8. | One cannot compare the different representations of the data. | **Very strongly disagree** | **1 2 3 4 5** | **Very strongly agree** |

1. Rate the statements below from very strongly disagree (1) to very strongly agree (5) on how well they match your understanding of predicting future events.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 1. | The box model indicates that there is an increase of 4 gigatons of CO2 over 5 years and so we assume that will happen in the next 5 years as well. | **Very strongly disagree** | **1 2 3 4 5** | **Very strongly agree** |
| 2. | The box model shows that the CO2 concentration is increasing because more is being released into the atmosphere than taken out of it. | **Very strongly disagree** | **1 2 3 4 5** | **Very strongly agree** |
| 3. | I am not sure how one can make predictions for future events from any of the representations. | **Very strongly disagree** | **1 2 3 4 5** | **Very strongly agree** |
| 4. | As years pass beyond 2013 the CO2 concentration will not continue to increase. | **Very strongly disagree** | **1 2 3 4 5** | **Very strongly agree** |
| 5. | The box model shows an overall increase in the CO2 concentration. | **Very strongly disagree** | **1 2 3 4 5** | **Very strongly agree** |
| 6. | The box model shows that plants, animals, soils, and oceans are emitting less CO2 than they are taking in. | **Very strongly disagree** | **1 2 3 4 5** | **Very strongly agree** |
| 7. | One cannot predict future events from a table, graph, or equation. | **Very strongly disagree** | **1 2 3 4 5** | **Very strongly agree** |
| 8. | To predict the CO2 concentration in 2015, substitute the 2015 into the equation model and solve for CO2 concentration. | **Very strongly disagree** | **1 2 3 4 5** | **Very strongly agree** |

1. Rate the statements below from very strongly disagree (1) to very strongly agree (5) on how well they match your understanding of how we can revise models. To revise a model means to change a model to better reflect the real world data.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 1. | If a scientist says that the CO2 concentration should not increase, then one needs to recollect the data. | **Very strongly disagree** | **1 2 3 4 5** | **Very strongly agree** |
| 2. | If the modeling function does not exactly fit the data, then the data was not collected correctly. | **Very strongly disagree** | **1 2 3 4 5** | **Very strongly agree** |
| 3. | One should consider revising the box model if the time period chosen is a different one so that one can compare the rates over different periods of time. | **Very strongly disagree** | **1 2 3 4 5** | **Very strongly agree** |
| 4. | One should revise the box model so that it improves the ability to predict events, not revise the data to fit a model. | **Very strongly disagree** | **1 2 3 4 5** | **Very strongly agree** |
| 5. | One should evaluate the box model and the equation model of the data in the table to see how they inform each other. | **Very strongly disagree** | **1 2 3 4 5** | **Very strongly agree** |
| 6. | One can test the box model against the graph to see if it is a good or bad fit. That is all the revision one can do. | **Very strongly disagree** | **1 2 3 4 5** | **Very strongly agree** |
| 7. | One should revise the box model to better fit the evidence in the table not to make it fit a scientist’s expectations. | **Very strongly disagree** | **1 2 3 4 5** | **Very strongly agree** |
| 8. | A model for CO2 concentration is fixed and cannot be revised given new information. | **Very strongly disagree** | **1 2 3 4 5** | **Very strongly agree** |