

## GLOBAL TEMPERATURE CHANGE

### RELEVANT JMP PLATFORMS AND STATISTICAL TECHNIQUES

Graph Builder : Line Graph, Heat Map

Bubble Plot : Dynamic Scatterplot

Formula Editor : Creating new variables

### PROBLEM STATEMENT

Since the Industrial Era began in the late 18th century, global temperatures have been on the rise. The burning of fossil fuels, deforestation, and industrial activities have released greenhouse gases such as carbon dioxide into the atmosphere, leading to the enhanced greenhouse effect and trapping more heat. This phenomenon has resulted in a significant increase in global temperatures.

Throughout the past century, there have been noticeable fluctuations and regional variations in temperature, but the overall trend has been one of warming. This warming trend has accelerated in recent decades, with each successive decade since the 1970s being warmer than the last.

The consequences of this global temperature rise include melting ice caps and glaciers, rising sea levels, more frequent and severe weather events, and disruptions to ecosystems and biodiversity.



Copernicus, the European Union's climate monitoring service, aggregates temperature measurements from a wide array of sources. This vast volume of data is processed and summarized into overall daily average global temperature values. These condensed data can be used to more easily examine and describe changes in global temperature over time.

## DATA SET

Global\_Temperature\_Change.jmp

Date (Day)	Day (YYYY-MM-DD) from Jan 1, 1940 to Dec 31, 2023
Daily Temp	Daily mean global near-surface absolute temperature (Celsius)

## EXERCISES

The exercises consist of creating a variety of visualizations to summarize changes in global temperature across time. As you'll see, each one emphasizes and communicates the features in the data in different ways with some doing so better than others. This provides you with many options to pick from to effectively tell the "story in the data".

As the dataset has only two variables 'Date(Day)' and 'Daily Temp', you'll need to create a new set of date temperature variables.

1. Create the following new date variables:

a) Variable that contains only the year.

*Instructions: Right-click on the 'Date (Day)' variable and choose New Formula Column > Date Time > Year. A new column will be added to the data table titled 'Year'. You'll notice a small "+" symbol next to the variable name in the Columns pane on the left indicating that this column is derived via a formula. Right-click on the column and choose Formula to open up the Formula Editor to see the formula that was created. The default Modeling Type for this variable is Continuous. Double-click on the column and change the Modeling Type to Ordinal. This can also be done by right-clicking on the blue triangle symbol next to the column name in the columns pane and selecting Ordinal.*

b) Variable that contains only the month.

*Instructions: Right-click on the 'Date (Day)' variable and choose New Formula Column > Date Time > Month Abbr.*

c) Variable that contains both the month and year.

*Instructions: Right-click on the 'Date (Day)' variable and choose New Formula Column > Date Time > Month Year.*

2. Create the following new temperature variables:

- a) Variable that has the yearly average temperature for every row of each year.

**Instructions:** Choose Cols > New Columns. Type 'Yearly Avg Temp' for the Column Name. Click on Column Properties > Formula. In the functions listed on the left in the Formula Editor, select Statistical > Col Mean. Insert the variable 'Daily Temp' in the field inside the parentheses, click on the insert symbol in the controls at the top, then insert the variable 'Year' into the second field.

The final formula should look like: **Col Mean (Daily Temp , Year<sub>^</sub>)**

- b) Variable that has the monthly average temperature for every row of each month and year.

**Instructions:** Choose Cols > New Columns. Type 'Monthly Avg Temp' for the Column Name. Click on Column Properties > Formula. In the functions listed on the left, select Statistical > Col Mean. Insert the variable 'Daily Temp' in the field inside the parentheses, click on the insert symbol in the controls at the top, then insert 'Month Year' into the second field.

The final formula should look like: **Col Mean (Daily Temp , Month Year<sub>^</sub>)**

Click OK.

- c) Variable that is the difference the average temperature is for each 'Year-Month' from the average temp of each given month across all years.


**Instructions:** Choose Cols > New Columns. Type 'Diff in Monthly Temp from Overall Monthly Avg' for the Column Name. Click on Column Properties > Formula. Click on the variable 'Monthly Avg Temp' to start the formula. Then select the '-' from the controls at the top. From the functions listed on the left, select Statistical > Col Mean. Insert the variable 'Daily Temp' in the field inside the parentheses, click on the insert symbol in the controls at the top, then insert 'Month' into the second field.


The final formula should look like: **Monthly Avg Temp - Col Mean (Daily Temp , Month<sub>^</sub>)**

Click OK.


3. Create the following visualizations.

- a) A line graph of the 'Yearly Avg Temp' from 1940 to 2023 with an overlay line for each month.

*Instructions:* Use Graph > Graph Builder. Place 'Year' on the X axis. Place 'Yearly Avg Temp' on the Y. Remove the smoother by deselecting the smoother icon from the graph palette. 


Add connected line to the graph by choosing the line graph icon  while holding down the shift key to preserve the dots on the graph as well.

- b) A line graph of the 'Monthly Avg Temp' from Jan 1940 to Dec 2023 with an overlay line for each month.


*Instructions:* Use Graph > Graph Builder. Place 'Month Year' on the X axis. Place 'Monthly Avg Temp' on the Y. Place 'Month' in the Overlay role. Select the line graph icon from the graph palette. 

Add a data filter for 'Month' by selecting Local Data Filter under the top left red triangle. Choose the variable 'Month'. Now specific months can be selected if desired and only those will be shown on the graph.


- c) A line graph of the 'Monthly Avg Temp' from Jan 1940 to Dec 2023 with a panel for each month.

*Instructions:* Use Graph > Graph Builder. Place 'Year-Month' on the X axis. Place 'Monthly Avg Temp' on the Y. Place 'Month' in the Group X role. Select the line graph icon from the graph palette. 

- d) A bar graph displaying 'Diff in Monthly Temp from Overall Monthly Temp' by 'Year-Month'.

*Instructions:* Use Graph > Graph Builder. Place 'Year' on the X axis. Place 'Month' on the X axis above 'Year'. Place 'Monthly Temp Diff from Avg Temp for Month' on the Y Axis. Choose the Bar Chart icon from the graph palette. 

e) A line graph of the 'Monthly Avg Temp' from Jan-Dec with an overlay line for each year.

**Instructions:** Use Graph > Graph Builder. Place 'Month' on the X axis. Place 'Monthly Avg Temp' on the Y. Place 'Year' in the Overlay role. Select the line graph icon from the graph palette. 

With there being 84 years, JMP's default is to create a grouping of the years. To have a line for each year, right-click on the 'Year' legend on the right, choose Number of Levels and type in 84.

Add a data filter for year by selecting Local Data Filter under the top left red triangle. Choose the variable 'Year'. Now specific years can be selected and only those will be shown on the graph. Using the Local Data Filter approach results in only seeing years that are chosen.

An alternative approach is to create another display of the years and select desired years from that display. This approach highlights the chosen years in the graph and fades back the ones not selected. This will make it easier to see the changes in temperature as the years progress. Do this by creating a Frequency Table of the Years. choose Analyze > Distribution. Select 'Year' as the Y Column. Click OK.

Select the year 1940 in the resulting Frequency Table . You'll see that year highlighted in the line graph with the remaining years faded back. Now hold the down arrow on the keyboard so that the selected year goes forward in time. Examining the line graph while doing so will make it easier to see the change in 'Monthly Avg Temp' over time.

f) Create a Bubble Plot of the 'Monthly Avg Temp' by 'Month' indexed by Year.



**Instructions:** Use Graph > Bubble Plot. Choose 'Monthly Avg Temp' as the Y and 'Month' as the X axis. Use 'Month' as the ID, 'Year' as the Time, and 'Diff in Monthly Temp from Overall Monthly Temp' for the Coloring. Click OK.

From the graph, choose Trail Bubbles > All and Label > All from the red triangle menu. Click the play button at the bottom left. Note: You may want to adjust the speed the bubbles move.

g) Recreate the Bubble Plot using 'Diff in Monthly Temp from Overall Monthly Temp' as the Y variable. Note: This will position the location of the bubbles to locations that are relative to each month and will make it easier to see and compare the temperature changes for each month.

**Instructions:** Relaunch Graph > Bubble Plot. Click Recall, then change the variable used for Y.

- h) A heat map displaying the temperature with a cell for each of the  $12 \times 48 = 624$  months and years.

*Instructions:* Use Graph > Graph Builder. Place 'Year' on the X axis and 'Month' on the Y Axis. Place 'Monthly Avg Temp' in the Color role. Select the heat map icon from the graph palette.  The default creates cells for groups of years. Change it to having a cell for each year by double-clicking on the X axis. Choose Increments of 5 so that the axis will display a value for each 5 years. Choose # Minor Ticks of 4. Choose a single color theme by double-clicking on the legend. Select Color Theme and choose 

- i) Augment the heat map above so that the variable 'Diff in Monthly Temp from Overall Monthly Avg' can be used as the color variable as well.

*Instructions:* From the Heat Map created above, select Redo > Column Switcher under the red triangle. Choose to 'Monthly Avg Temp' for the Initial Column to Switch, and choose that same variable and 'Diff in Monthly Temp from Overall Monthly Avg' for the Replacement Columns.

4. Select only one of the visualizations that you feel best communicates the change in global temperature. Write a few brief bullet points summarizing key features the graph communicates.
5. What other data would be helpful to have available for analysis in order to develop a more thorough understanding of changes in global temperature?
6. What other data would be needed in order to identify possible causes of changes in global temperature?

## SUPPLEMENTAL MATERIALS

Website of Copernicus – the European Union's climate monitoring service and source of the data.  
<https://www.eea.europa.eu/en/about/key-partners/copernicus>

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