Bivariate data

Mathematics Year 10–12

Exploring trends in sea level

1. About the lesson plan

Grade Level	Year 10–12
Discipline	Mathematics
Contents Strand & Sub-strand	Statistics and probability Data representation and interpretation
Topic(s) in Discipline	Bivariate data
Australian Curriculum code	**Year 10** Use scatter plots to investigate and comment on relationships between two numerical variables (ACMSP251). Investigate and describe bivariate numerical data where the independent variable is time (ACMSP252). **Year 10A** Use information technologies to investigate bivariate numerical data sets. Where appropriate use a straight line to describe the relationship allowing for variation (ACMSP279). **Years 11 and 12** Identify the response variable and the explanatory variable (ACMGM055). Use a scatterplot to identify the nature of the relationship between variables (ACMGM056). Model a linear relationship by fitting a least-squares line to the data (ACMGM057). Interpret the intercept and slope of the fitted line (ACMGM059).

	Use the equation of a fitted line to make predictions (ACMGM061). distinguish between interpolation and extrapolation when using the fitted line to make predictions, recognising the potential dangers of extrapolation (ACMGM062).
Climate Topic	Sea level rise
Cross Curriculum Priority	Aboriginal and Torres Strait Islander Histories and Cultures
Lesson Length	55 min

2. Brief Introduction to the Lesson Plan

One of the impacts of climate change is sea level rise. It poses a potential threat to hundreds of millions of people living in coastal communities around the world by causing flooding, loss of habitats, destructive erosion, and soil contamination with salt. In this lesson, students will use **sea level data** from a water level measuring station located in northern Australia to investigate how sea level has been changing. This lesson fits within the topic of **Statistics** and focuses on **bivariate data**. Students will be provided with clear step-by-step instructions that describe how to import the data into Microsoft Excel, create a **scatter plot**, and interpret the plot.

3. Learning Outcomes

The tools in this lesson plan will enable students to:

- Use technology to construct a scatter plot using bivariate data and draw the line of best fit.
- Explain the meaning and significance (qualitatively) of the data by referencing the line of best fit.
- Use the equation line of best fit to make predictions and distinguish between interpolation and extrapolation.

4. Introduced Climate Science Concepts

The tools in this lesson plan will help students understand:

- Sea level rise

5. Presumed Knowledge

Students should already have addressed the following curriculum points:

- Identify everyday questions and issues involving at least one numerical and at least one categorical variable, and collect data directly and from secondary sources (ACMSP228).
- Substitute values into formulas to determine an unknown (ACMNA234).
- Solve problems involving linear equations, including those derived from formulas (ACMNA235).

In addition, students should already be familiar with the following:

- Definition of bivariate data; Introduction to scatter plots; How to describe a relationship between independent and dependent variables.
- How to draw a scatter plot by hand/eye.
- How to interpret a line of best fit; Determining the equation of the line of best fit; Using the line of best fit for interpolation and extrapolation.

Resources R1.1, R1.2 and R1.3 in the table below are YouTube videos that can help with teaching these concepts.

6. Teaching Resources

Tool ID	Type of Tool	Tool	Brief Description	Credits
R1	YouTube Videos	(R1.1) Introduction to bivariate data [13min] (R1.2) How to draw a scatter plot by hand/eye [18min] (R1.3) How to interpret a line of best fit [17min]	Short videos created as teaching tools for grades 7-10 Mathematics (ACARA) and Queensland syllabuses for senior students.	McClatchey Maths
R2	YouTube Video	Rising Tides: Understanding Sea Level Rise [2min]	Short video describing how climate change is causing sea level rise, the rate of change of sea level rise and its impacts on the coastal communities.	NASA Climate Change
R3	Data	Mean Sea Level Trends for Global Network Stations	Annual mean sea level data available from a set of stations around the world.	US National Oceanic and Atmospheric Administration (NOAA)
R4	Printable document	Tutorial	Clear step-by-step instructions describing how to: • Import sea level data available from R3 into MS Excel. • Clean up and prepare the data. • Create a scatter plot using sea level data and plot the line of best fit.	Climate Classrooms
R5	YouTube Video	Climate Change in the Torres Strait [5min]	Short video showing the impacts of sea level rise on the Torres Straits Islands in Australia. Aboriginal and Torres Strait Islander viewers are advised that the video contains images and voices of people who have passed away.	Dr. Donna Green, UNSW Sydney

7. Step-by-Step Lesson Plan Activities

Students need desktop computers or laptops to access the resources and to carry out the suggested learning activities.

Teacher activities and student tasks	Tool ID	Timing
Class discussion The teacher asks the students: *Why might we be concerned about sea level rise?* (causing flooding, loss of habitats, destructive erosion, and soil contamination with salt). Then, the teacher plays a video (R2) that describes why climate change causes sea level rise, how sea level has been changing at the global scale, and how it is expected to affect coastal communities worldwide in the future. It also sheds light on space missions that study sea level rise using satellites. Next, the teacher prompts students with questions on other kinds of data that could be used to investigate sea level rise (e.g. direct sea level measurements).	R2	10 min
Independent practice The teacher distributes print outs of tutorial R4. Students will follow the instructions provided in the tutorial to: • Import sea level data (R3) from the *Weipa station* located in northern Australia into Excel. They are encouraged to search for the location of the station on Google Maps. • Cleanup and prepare the data. • Create a scatter plot using sea level data and plot the line of best fit of best fit.	R3, R4	15 min

Pair work	R4	15 min

Students will refer to their plots to answer the following questions

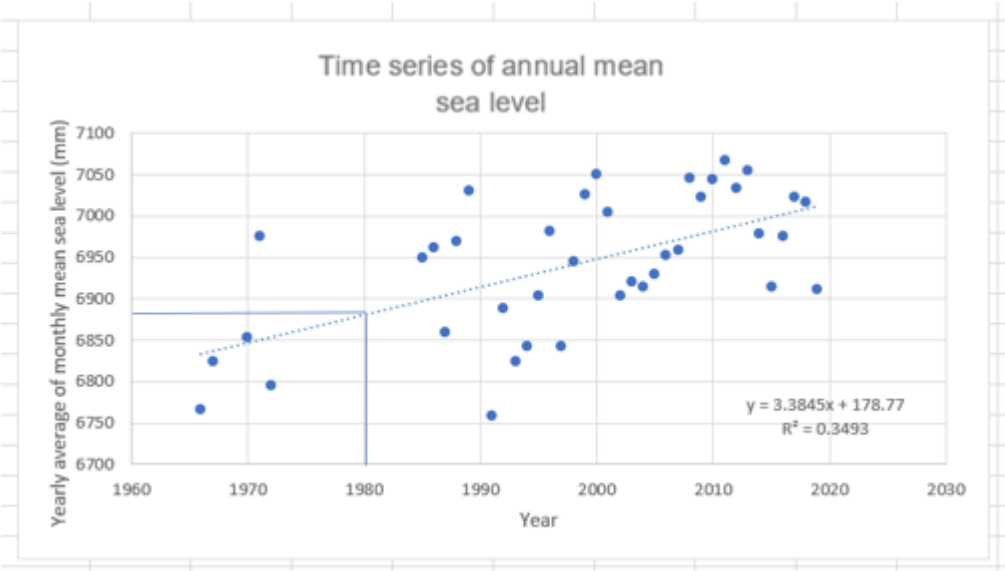
a) What is the independent (or explanatory) variable?
b) What is the dependent (or response) variable?
c) What is the gradient (slope) of the line of best fitline of best fit? Explain what it means.
d) What is the value of the coefficient of determination? What does it tell us about the strength of the relationship between the annual mean sea level and the year?
e) Use the equation of the line of best fitline of best fit to calculate the annual mean sea level in 1980? Annotate it on the graph. Did you use interpolation or extrapolation?
f) In which year(s) was the annual mean sea level 7000 mm? Did you use interpolation or extrapolation? Explain your answer.
g) Use the graph to predict the annual mean sea level in 2030. Did you use interpolation or extrapolation? Explain your answer.
(Extension) What assumptions have you made in making your prediction?

Solution

a) Year
b) Annual mean sea level.
c) The gradient is 3.3845. Because the gradient is positive, the correlation is also positive. This means that the annual mean sea level increases with time, and the rate of increase is 3.3543 mm per year.
d) R^2 = 0.3493.
Since R^2 is between 0.3 and 0.5, the relation is weak.

e) Algebraically, substitute x=1980 in the equation of the line of best fit: y= 3.3845 x + 178.77
y= 6880.08. The annual mean sea level was approximately 6880.08 mm in 1980
*To annotate the graph: go to the **Shapes** tool in the **Insert** tab. Then select the **Line** shape* 

. Draw a vertical line starting from x=1980 and ending on the line of best fit, then use the same tool to draw a horizonal line from the line of best fit to the y-axis. The horizontal line cuts the y-axis at around 6880 mm.
Interpolation, since 1980 is within the time period covered by the data.



f) *Algebraically, substitute y = 7000 in the equation of the line of best fit, x = 2015.432.*
Between 2015 and 2016, the annual mean sea level was 7000 mm.
Interpolation, since 7000 mm is within the time period covered by the data.

g) *Algebraically, substitute x=2030 in the equation of the line of best fit, y=7049.305. In 2030 the predicted annual mean sea level is about 7049 mm*
Extrapolation, since 2030 is outside the time period covered by the data (1966 – 2019).
(Extension) The prediction assumes a linear relationship between sea level and time and that this relationship will continue beyond 2019 to 2030.
Implicit in this is the assumption that sea level rise will not accelerate or decelerate before 2030.

Class discussion The teacher displays the final plot using a smart board or a data projector and invites the students to read their answers to questions a → g. The teacher identifies students' misconceptions and addresses them.		10 min

Class discussion The teacher concludes the lesson by playing a short video (R5) that shows how sea level rise has already impacted the Torres Straits Islander communities. Aboriginal and Torres Strait Islander viewers are advised that the video contains images and voices of people who have passed away.	R5	5 min
Assignment: Students can repeat the analysis using available data from another sea level station in Australia or the world.	R3, R4	40 min (at home)

Acknowledgment

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