Assignment – 02

Module 02 – Climate Science

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Q1)

Data provided to us:

- Greenland ice loss: 280 Gt/year
- Antarctica ice loss: 150 Gt/year
- Each gigaton of ice contributes 0.0028 mm to sea level rise.
- Uncertainty in measurements: ±5%

a)

Greenland's sea-level rise contribution:

$$Greenlands\ Sea\ Level\ Rise\ =\ 280\ x\ 0.0028\ =\ 0.784\ mm/year$$

Antarctica's sea-level rise contribution:

$$Antarctica\ \ Sea\ Level\ Rise\ =\ 150\ x\ 0.0028\ =\ 0.42\ mm/year$$

b)

$$Total\ \ Sea\ Level\ Rise\ =\ Greenlands\ Sea\ Level\ Rise\ +\ Antarctica\ \ Sea\ Level\ Rise$$
$$Total\ \ Sea\ Level\ Rise\ =\ 0.784\ +\ 0.42\ =\ 1.204\ mm/year$$

c)

$$Uncertainty\ in\ Greenland\ =\ 0.784\ x\ 0.05\ =\ 0.0392\ mm/year$$
$$Uncertainty\ in\ Antarctica\ =\ 0.42\ x\ 0.05\ =\ 0.021\ mm/year$$
$$Total\ Uncertainty\ =\ 0.0392\ +\ 0.021\ =\ 0.0602\ mm/year$$

Uncertainty range in sea level rise due to ice sheet loss:

$$Total\ Uncertainty\ =\ 1.204 \pm 0.0602\ mm/year$$

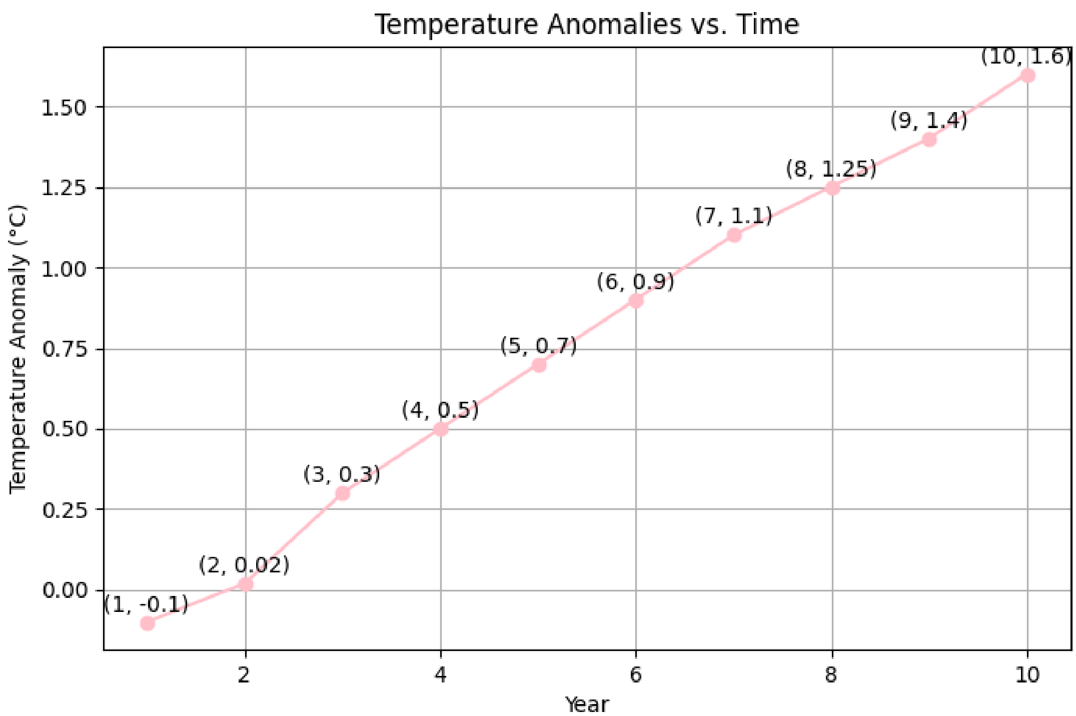
The upper and lower bounds of the total sea level rise with uncertainty are given below:

$$Upper\ Bound\ =\ 1.204\ +\ 0.0602\ =\ 1.2642\ mm/year$$
$$Lower\ Bound\ =\ 1.204\ -\ 0.0602\ =\ 1.1438\ mm/year$$

So, the total sea level rise is between **1.1438 mm/year** and **1.2642 mm/year**.

d)
Natural climate variability, satellite imperfections, and ice dynamics model assumptions all contribute to the ±0.0602 mm/year uncertainty in sea level rise caused by ice sheet loss. These uncertainties are caused by shifting climate trends, limitations in satellite precision, and variations in regional ice melt impacts. Furthermore, differences in data resolution and sampling frequency can impair measurement accuracy. The uncertainty range of ±5% means that the actual sea level increase may be somewhat greater or lower, which can alter long-term estimates. Addressing these uncertainties through improved technology and data calibration is critical for more credible climate models and informed policy decisions about sea level rise mitigation and coastal planning.

Q2)
a)



b)
Since this is linear trend it's equation is y = mx + c where,

- **y** is the temperature anomaly (the dependent variable).
- **x** is the year (the independent variable).
- **m** is the slope, which represents the rate of change of the temperature anomaly over time.
- **c** is the intercept, which represents the value of the temperature anomaly when the year is 0.

From the plotted linear regression we get **m (slope)** = 0.1922 and **c (intercept)** = -0.29. So hence the equation becomes,

$$y = 0.1922x - 0.29$$

c)

Because the slope is constant (0.1922), the temperature anomaly grows linearly and at a consistent rate. This indicates that the rate of warming is not accelerating.

If warming were accelerating, we would expect the slope to grow over time, indicating that the temperature rise is becoming faster by the year. However, the slope remains constant, implying that warming is continuing at a consistent rate and without acceleration.

Q3)

Data provided to us:

5 million annual deaths linked to temperature extremes where

- 4 million deaths are due to cold.
- 1 million deaths are due to heat.

Every **1°C** warming leads to:

- Heat deaths increase by 10%.
- Cold deaths decrease by 5%.

a)

Due to +2°C rise,

Heat-related deaths increase by 10% for each degree

$$New\ heat\ deaths = Old\ heat\ deaths\ x\ (1 + percentage\ increase\ per\ °C \times T)$$
$$New\ heat\ deaths = 1\ million\ x\ (1 + 0.10 \times 2) = 1.2\ million$$

Cold-related deaths decrease by 5% for each degree

$$New\ cold\ deaths = Old\ cold\ deaths\ x\ (1 - percentage\ increase\ per\ °C \times T)$$
$$New\ cold\ deaths = 4\ million\ x\ (1 - 0.05 \times 2) = 3.6\ million$$

b)

$$Net\ change = New\ heat\ deaths + New\ cold\ deaths - Old\ heat\ deaths - Old\ cold\ deaths$$
$$Net\ change = 1.2 + 3.6 - 1 - 4 = -0.2\ million$$

c)
Heat-related mortality reached from 1 million to 1.2 million when temperatures increased by 2 degrees Celsius, but cold-related deaths declined from 4 million to 3.6 million. This suggests that heat is becoming a higher problem, particularly for vulnerable groups such as the elderly, who are more susceptible to excessive heat and may fail to adjust to rising temperatures. Although people in colder places have already evolved to extreme cold, they are less affected by small temperature rises. However, older persons in both cold and hot settings continue to be at higher health risk due to their reduced ability to regulate body temperatures. This demonstrates that heat-related dangers are increasing, posing a growing concern for public health, particularly among the elderly.

Q4)
a)
To calculate the **Root Mean Square Error (RMSE)** between the observed and predicted temperature anomalies, we can use the following formula:

$$RMSE = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(Oi - Pi)^{2}}$$

where

- Oi is the observed temperature anomaly for year i,
- Pi is the predicted temperature anomaly for year i,
- n is the total number of years (in this case, 11 years, from 2000 to 2010).

Year	Difference (Observed - Predicted)	Squared Difference
2000	-0.03	0.0009
2001	-0.03	0.0009
2002	-0.03	0.0009
2003	-0.03	0.0009
2004	-0.02	0.0004
2005	-0.04	0.0016
2006	-0.04	0.0016
2007	-0.03	0.0009
2008	-0.03	0.0009
2009	-0.03	0.0009
2010	-0.03	0.0009

After adding up all squared differences then dividing it by n=11 we'll get 0.00098. The calculated **Root Mean Square Error (RMSE)** between the predicted and observed temperature anomalies is approximately **0.0313°C**.

b)

The RMSE value of 0.0313°C indicates that the model's predictions closely match the actual temperature anomalies, with an average error of only 0.0313°C. This is a minor inaccuracy, implying that the model makes fairly accurate predictions of global temperature anomalies.

Given that temperature anomalies are often measured with a precision of up to 0.01°C, an RMSE of 0.0313°C indicates a high level of accuracy, as the difference between predicted and observed values is quite small. While there may be minor inconsistencies, the model nevertheless provides a reliable prediction, with the error modest enough not to jeopardise its utility in forecasting global temperature trends. Thus, this model appears to be reliable for detecting global temperature anomalies.

Q5)

One highly discussed climate-related topic is the impact of climate change on the frequency and severity of extreme weather events. One side of the discussion, supported by studies such as Newman and Noy's (2023), contends that human-caused climate change is considerably contributing to the increased frequency and intensity of extreme weather events such as hurricanes, heatwaves, and floods. This viewpoint is supported by evidence from Extreme Event Attribution (EEA) investigations, which reveal a clear causal link between climate change and increased risk of such catastrophes. The research suggests that anthropogenic factors, such as increased greenhouse gas emissions, are increasing the risk of these catastrophic events, compounding societal costs such as human mortality and economic damages (Newman & Noy, 2023).

On the other hand, some scientists contend that, while climate change is influencing weather patterns, the rise in extreme weather occurrences may not be as important or directly linked to human activity. Some research, such as those conducted by the PNAS (2022) team, highlight the inherent variability of weather and argue that not all documented changes in extreme events ca n be definitely related to climate change. They propose that localised elements, such as local weather systems and natural oscillations in climate patterns, may have a greater impact than previously thought. This viewpoint emphasises the difficulty in determining the precise contribution of human-caused climate change to extreme weather, particularly when considering historical variability of climate events.

Based on the evidence, I agree that human-caused climate change contributes significantly to the increased frequency and intensity of extreme weather occurrences. The evidence from Scientific Reports shows a clear correlation between anthropogenic greenhouse gas emissions and an increase in extreme weather events. According to Newman and Noy (2020), "the global costs of extreme weather attributable to climate change" are significant, with human mortality accounting for the majority of the total. This rising collection of attribution studies provides compelling evidence for prioritising human-caused climate change as the principal cause of intensifying extreme weather occurrences.

References

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