1. Context of the activity

Climate change is leading to higher global temperatures and rising sea-levels. It is also leading to increased precipitation (rainfall) as higher temperatures lead to increased rates of evaporation.

Evaporation is taking place all the time. Water vapour, which is itself a potent greenhouse gas, eventually condenses, precipitates, and so ends up back in rivers lakes and seas, thus completing what you already know is the water cycle.

The mathematical model used to calculate increased precipitation is the Clapeyron equation. It has been derived from a scientific model, the latent heat of evaporation of liquids. The combination of such mathematical and scientific models is known as thermodynamics. The derivation of the equation is difficult but uses no more than the law of conservation of energy, the first law of thermodynamics. This means that the energy to evaporate the oceans is eventually released during condensation and so a steady state is reached where we can normally expect the same amount of rainfall every year. Unfortunately the mean global temperature is rising due to climate change and so rainfall is increasing year on year.

Climate modellers claim that rainfall will increase by 7% for every degree rise in temperature. You will use the Clapeyron equation to verify this and compare it with reality. Reality is very different in different geographical locations. Because of the distribution of land masses and forests and deserts some areas will experience catastrophic flooding while others will experience drought. Rain, essential as it is for access to fresh water, will result in disproportionate effects all over the globe.

2. Learning Outcomes

- Able to enter a complicated function into the graph page.
- Able to use the function notation in calculations.
- Know the difference between exponential and non-exponential change.
- Know that global warming will lead to increased rainfall.
- Understand how mathematical models support scientific models.

3. Experiment notes and instructions:

Open the tns file rainfall model.tns and work through the windows and questions.

On completion of the tns file you can carry out a simple experiment to verify the mathematical model.

1. First, what is the temperature rise that will double the evaporation rate?

2. Half fill two small beakers with water having a difference in temperature which will double evaporation. The colder water should be above room temperature, say 40 °C -50 °C to ensure that an appreciable amount of condensation will be observed.

   Since the evaporation rate will be doubled, we expect the condensation rate to be doubled also so if we give the cold water four times the length of time as the warm water we should observe similar amounts of condensation on the glass plates.

3. Place a plate above the colder water and start timing. After 15 seconds place a plate above the warm water and time for a further 5 seconds. This ensures that condensation has taken four times longer for the cold plate than the warm plate.

4. Quickly remove the plates hold them up and compare the amount of condensation.

   They should look similar. Satisfy yourself that different timings and/or temperature differences will not work.

4. Instructions for analysis of results

When entering the equation into the graph page take care to ensure there are enough brackets. Use the catalogue in TI-Nspire CX to enter the exponential function.

5. Questions

Complete the calculation pages as requested in the tns file.

The model suggests that rainfall should be higher than it actually is. Can you suggest a reason as to why the model predicts greater rainfall than reality?