Evidence for Past Climate Data Processing Activity

Background

You are an astronaut on the Earth-like planet ESWA, in the year 2050. Your mission group is creating a permanent settlement at a site called Landing. This planet has Earth-like vegetation and climate. In addition to making observations of the current climate, you have collected cores from trees and from lake sediment near Landing, pollen samples from various ecosystems on ESWA, near Landing, and ice cores from the frozen polar region.

ESWA is so Earth-like that information you learned about climate variation on Earth will apply in this new situation. You are glad that you studied Earth and Environmental Science in high school!

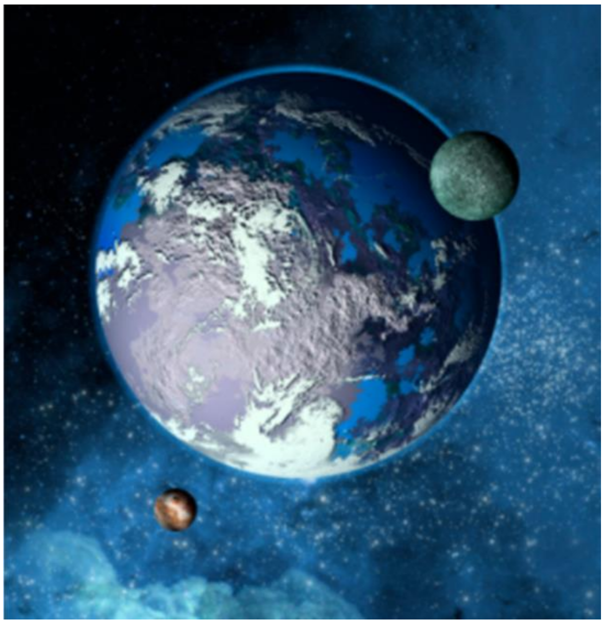

Figure 1: Planet ESWA and its two moons

Aim

To determine the past climate of ESWA and predict conditions at Landing for the next 100 years by analysing data sets from tree rings, pollen, and ice cores.

Data Set 1: Tree rings

When counting tree rings, you don't count the central pith or outer bark. Each ring has a wide area that represents growth and a dark line that represents the dormant season (very little growth).

You have taken core samples from three trees near Landing. Core 1 is from a living tree, so the bark later represents the present time (2050). Cores 2 and 3 are from dead trees. The cores are in Appendix 1.

Method

1. Count the number of tree rings in each core to determine the age of the tree (years). Record your results in Table 1.
2. Core 1 was taken from a living tree. Count backward along the rings to determine the year that this tree started growing. Record this in the *Year growth began* column of the data table.
3. Cut out Cores 2 and 3. Place them next to Core 1, matching ring patterns. Tape these in the Results section on the next page.
4. Using the known dates for Core 1, determine when growth began for Cores 2 and 3 and what year each tree died. Record your results in Table 1.

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Results

Table 1: Tree ring data

Core sample	Age of tree (y)	Year tree died or core taken	Year growth began
1		2050	
2			
3			

Tape aligned cores here

Analysis

1. Poor tree growth (narrow rings) is usually caused by drought. Identify THREE drought years at Landing. ____

2. Do the tree rings indicate a pattern of drought and rain? Explain your answer.______________

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3. Based on the tree ring patterns, what is your rainfall forecast for the next 5 years?__________

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Data Set 2: Pollen

You collected a sediment core from the lake near Landing. There were clear layers in the core with different pollens in them (Figure 2). The results of your data collection are shown in Table 2.

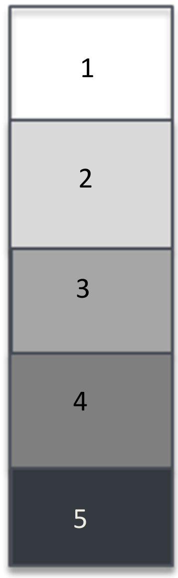

Figure 2: Sediment core and layers

Table 2: Pollen in the lake near Landing

Layer	Time (years before present)	Percent abundance of species
1	0 – 5 000	15% Pretty tree 10% Tough tree 20% Leafy tree 20% Leafy shrub 10% Straw flowers 25% Lush grass
2	5 000 – 10 000	25% Leafy tree 45% Jungle tree 20% Vines 10% Fluffy moss
3	10 000 – 17 000	5% Tough tree 15% Tough shrub 10% Straw flowers 20% Lush grass 50% Hardy grass
4	17 000 – 21 000	5% Stunted tree 10% Tough shrub 15% Tiny flowers 70% Hardy grass
5	21 000 – 25 000	25% Tough shrub 10% Straw flowers 65% Hardy grass

You also looked at pollen from a variety of plant communities around the planet. Appendix 2 shows the pollens (Reference Table 1) and the species that occur in different ecosystems (Reference Table 2) on ESWA.

Your Earth colleagues have asked for a sample of pollen from each layer. An enthusiastic colleague got the project started by scooping up pollen from one of the layers and putting it in a shipping container. Unfortunately, they forgot to label the layer of this pollen. The pollen is shown in Figure 3.

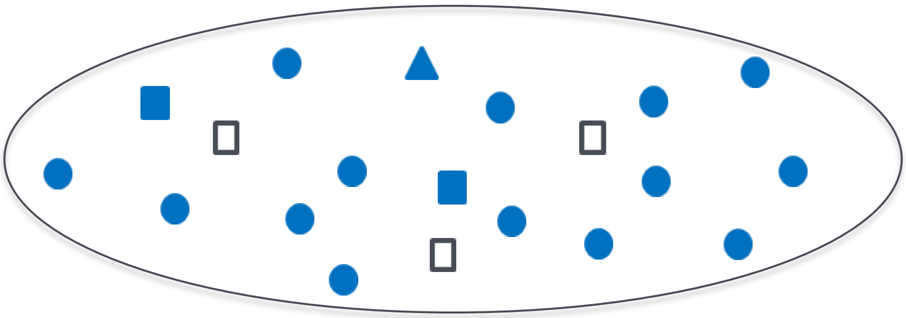

Figure 3: Pollen sample ready to ship to Earth

Method

1. Identify each species of plant using Reference Table 1 in Appendix 2.
2. Create a results table in the space below. Include the species, number, and percentage of each pollen type.

Results

Analysis

1. Based on the data in Table 2, which layer is ready for shipment and what time period does it represent? ____

2. Using the modern ecosystems shown in Reference Table 2 of Appendix 2, identify the most likely temperature and rainfall during the time of this pollen layer. Justify your answer. __________

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Data Set 3: Ice cores

Ice cores provide data about past atmospheric gas levels. Gases are collected from tiny bubbles trapped in snow as it falls. Over time, the snow is compacted into ice. The trapped gas provides a sample of air at the time the snow fell.

Temperature is measured using the ratio of ^{18}O to ^{16}O. Lower levels of ^{18}O in ice cores are associated with colder temperatures; higher ^{18}O in ice cores means warmer temperatures.

You will use these data to determine the climate history of ESWA. To simplify analysis, the present average temperature was used as a baseline to calculate temperature anomaly. The current ^{18}O ratio of snow is therefore 'normal' or zero anomaly. This represents an average yearly temperature of 14˚C (same as Earth in the year 2000). Your colleague who took the mass spectrometer readings of oxygen isotopes calculated the year and temperature anomaly represented by each sample of ^{18}O. The data are presented in Table 3.

Method

1. Graph the data in Table 3 on the grid provided. Label the axes and include a curve of best fit.

Table 3: Ice core data

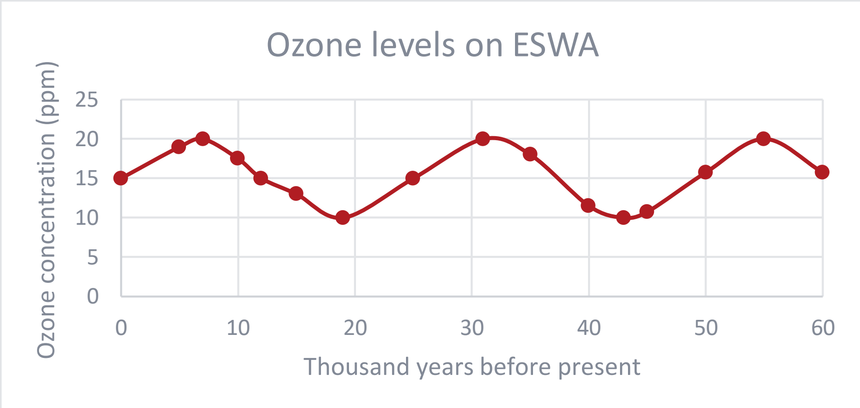
Thousand years before present (kybp)	Temperature anomaly (°C)	Thousand years before present (kybp)	Temperature anomaly (°C)
0	0.0	25	0.0
5	2.0	31	3.0
7	3.0	43	-3.0
10	1.7	55	3.0
15	-1.7	60	0.5
19	-3.0		

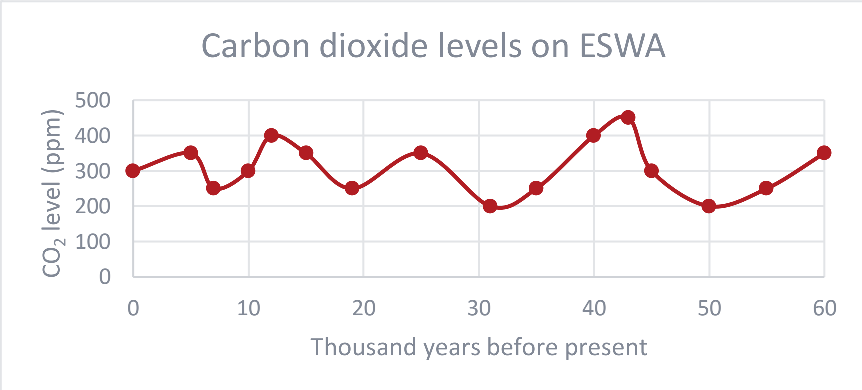
Analysis

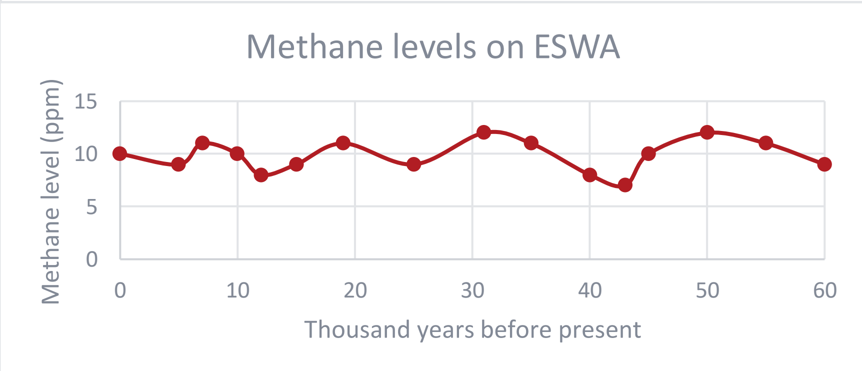
1. Using your graph and the background information, calculate the long term high and low average temperatures that have occurred on ESWA. ________________________________

2. On what timescale does the climate of ESWA change? ________________________

Your colleague also analysed greenhouse gases trapped in the ice. The graphs are below.







3. Compare temperature and gas graphs to explain the effect of greenhouse gases on temperature for ESWA. Which greenhouse gas seems to be driving the temperature fluctuations? Use data from the graphs in your response. ____

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Discussion

Your mission leader wants both short- and long-term forecasts for climate and rainfall at Landing. To provide this information, you must integrate information from all three data sets.

1. Using data from your investigations, predict the temperature and rainfall at Landing over the next 20 years.____

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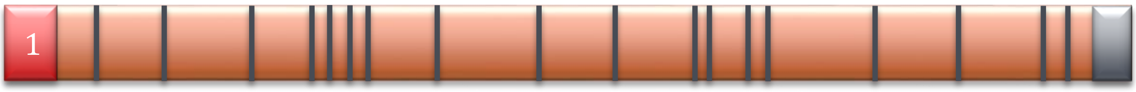
2. Use pollen and ice core data sets to describe variations in climate for the past 20 000 years. _

3. Predict the climate for the next 5 000 years. ___

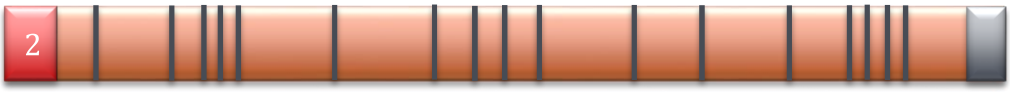
4. Based on your knowledge of the ESWA climate, what actions should ESWA settlers AVOID so that the climate will remain stable and predictable? Suggest alternative actions if needed. ___

Appendix 1: Tree rings

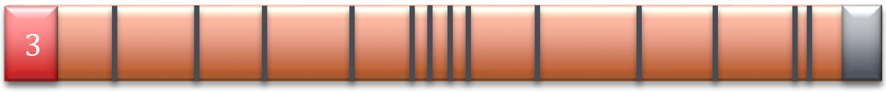
Core 1



Core 2



Core 3



Appendix 2: Pollens and ecosystems

Reference Table 1: Pollens

Pollen Picture	Species
	Stunted tree
	Pretty tree
	Tough tree
	Leafy tree
	Jungle tree
	Tough shrub
	Leafy shrub
	Vines
	Tiny flowers
	Straw flowers
	Hardy grass
	Lush grass
	Fluffy moss

Reference Table 2: Plant species in ecosystems around ESWA

Ecosystem	Temperature	Rainfall	Percent abundance of species
Frozen steppes	Cold	Low	3% Stunted tree 10% Tough shrub 12% Tiny flowers 75% Hardy grass
Dry gully	Warm	Low	27% Tough shrub 10% Straw flowers 63% Hardy grass
Sunny meadow	Warm	Moderate	12% Pretty tree 12% Tough tree 9% Leafy shrub 22% Straw flowers 35% Lush grass 10% Hardy grass
Forest by Landing	Warm	High	20% Pretty tree 5% Tough tree 32% Leafy tree 28% Leafy shrub 15% Lush grass
Jungle	Hot	High	22% Leafy tree 46% Jungle tree 20% Vines 12% Fluffy moss
Tropical savannah	Hot	Moderate	2% Tough tree 10% Leafy tree 21% Leafy shrub 67% Lush grass