Answer Sheet

LABORATORY 2: HEAT AND TEMPERATURE IN THE ATMOSPHERE

Student Name _____

Student Number _____

QUESTION 1

Using the following equations, determine the values of the following in one of the three temperature scales: **°Celsius**, **Kelvin,** and **°Fahrenheit**.

$$T(°C) = 5/9 \times (T(°F) - 32)$$

$$T(°C) = T(K) - 273$$

$$T(°F) = (9/5 \times T(°C)) + 32$$

$$T(K) = T(°C) + 273$$

1.1a) Calculate the freezing point of water in °C. _____°C

1.1b) Calculate the freezing point of water in °F. _____°F

1.1c) Calculate the freezing point of water in K (to one decimal point). _____K

1.2a) Calculate the boiling point of water in °C. _____°C

1.2b) Calculate the boiling point of water in °F. _____°F

1.2c) Calculate the boiling point of water in K (to one decimal point). _____K

1.3a) Sun's average surface temperature is 5778 K, covert this into °C. _____°C

1.3b) Sun's average surface temperature is 5778 K, covert this into °F. _____°F

1.4a) Earth's average surface temperature is 288 K, covert this into °C. _____°C

1.4b) Earth's average surface temperature is 288 K, covert this into °F. _____°F

1.5a) The average temperature of the human body is 99°F, covert this into °C. _____°C

1.5b) The average temperature of the human body is 99°F, covert this into K. _____K

1.6a) The average January mean (monthly) temperature of Edmonton, Alberta, Canada is -15°C, covert this into °F.

_____°F

1.6b) The average January mean (monthly) temperature of Edmonton, Alberta, Canada is -15°C, covert this into K.

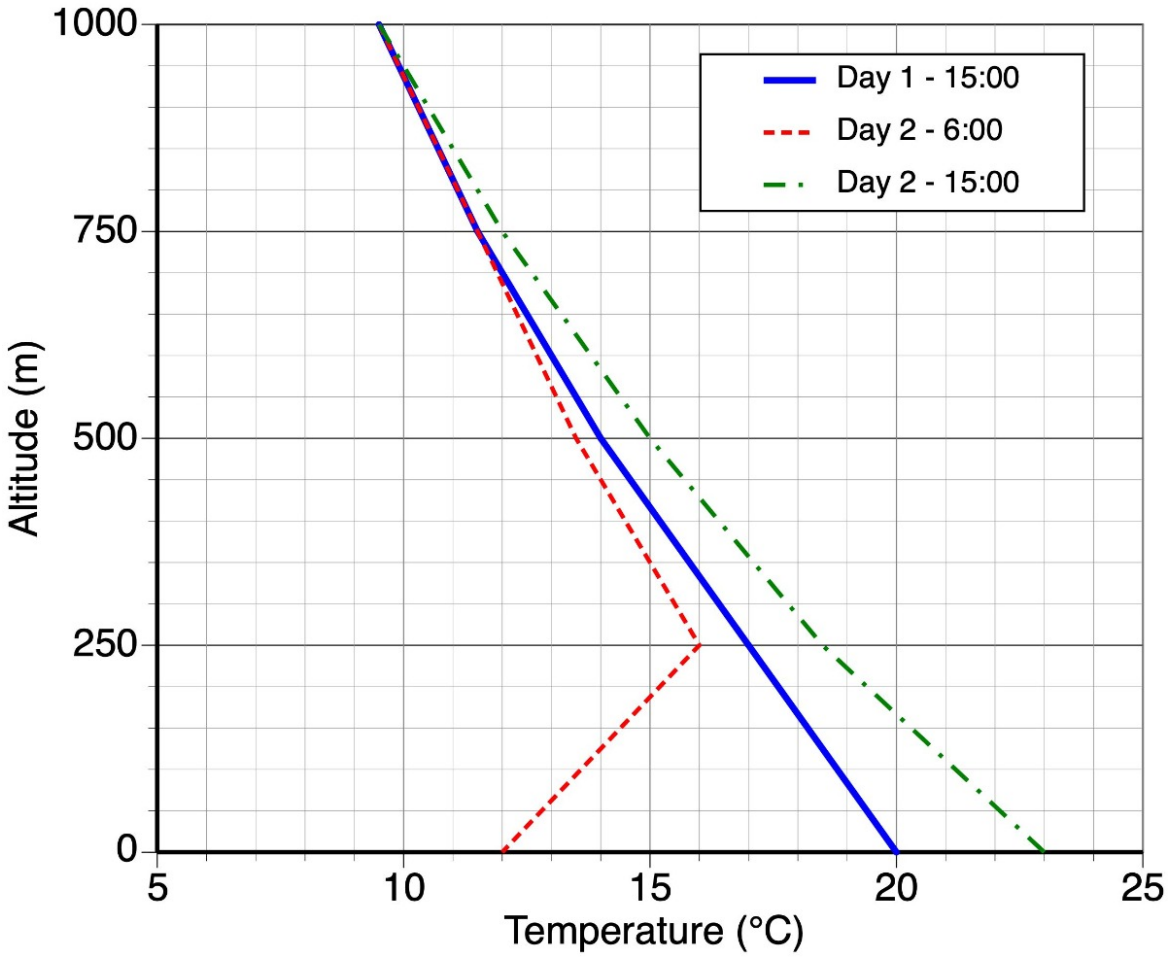
_____K

QUESTION 2

Tabulated below are vertical temperature data obtained from a **radiosonde** attached to a weather balloon.

Elevation (m)	0	250	500	750	1000
Day 1 – 15:00 hrs	20.0	17.0	14.0	11.5	9.5
Day 2 – 06:00 hrs	12.0	16.0	13.5	11.5	9.5
Day 2 – 06:00 hrs	23.0	18.5	15.0	12.0	9.5

On the graph that follows, temperature profiles have been drawn using the data from the table above.



A lapse rate is simply the mathematical expression of the temperature change with elevation. Complete the following table by calculating the missing lapse rates; express your answers in mathematically correct units of °C per 1000 m, to one decimal place.

Calculate lapse rates (°C / 1000m) for the following two vertical temperature profiles.

For Day 2 – 6:00

2.1a) On Day 2 at 6:00, the calculated lapse rate per 1000 meters for the interval 0-250 meters is

_____°C/1000 m

2.1b) On Day 2 at 6:00, the calculated lapse rate per 1000 meters for the interval 250-500 meters is

_____°C/1000 m

2.1c) On Day 2 at 6:00, the calculated lapse rate per 1000 meters for the interval 500-750 meters is

_____°C/1000 m

2.1d) On Day 2 at 6:00, the calculated lapse rate per 1000 meters for the interval 750-1000 meters is

_____°C/1000 m

Day 2 – 15:00

2.2a) On Day 2 at 15:00, the calculated lapse rate per 1000 meters for the interval 0-250 meters is

_____°C/1000 m

2.2b) On Day 2 at 15:00, the calculated lapse rate per 1000 meters for the interval 250-500 meters is

_____°C/1000 m

2.2c) On Day 2 at 15:00, the calculated lapse rate per 1000 meters for the interval 500-750 meters is

_____°C/1000 m

2.2d) On Day 2 at 15:00, the calculated lapse rate per 1000 meters for the interval 750-1000 meters is

_____°C/1000 m

2.3) Why is air temperature the highest right near the Earth's surface in both of the 15:00 hr profiles?

2.4) What processes caused the lower atmosphere to cool overnight on the Day 2 – 6:00 profile?

2.5) What processes caused the air in the lower atmosphere to warm up by 15:00 hr on Day 2?

2.6) The atmospheric condition displayed in the Day 2, 6:00 AM vertical temperature profile is called a

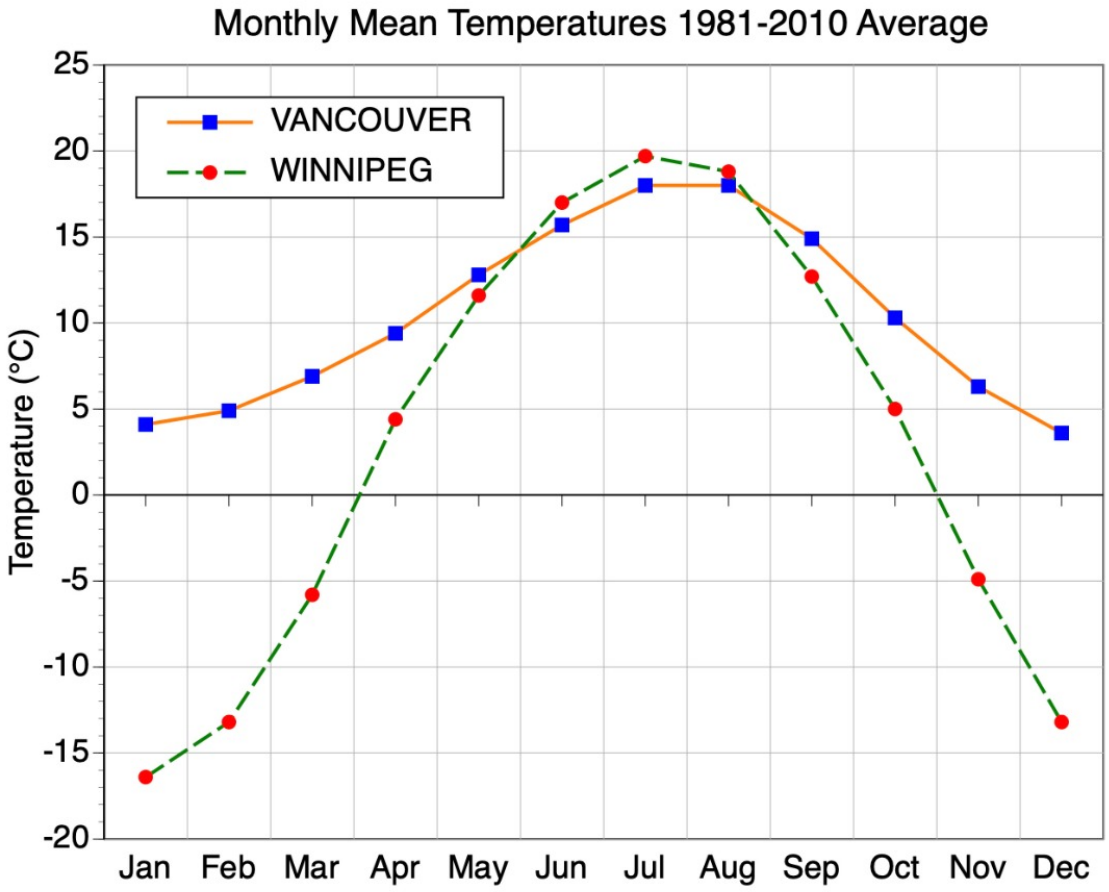
A Stratosphere.
B Temperature Inversion.
C Equilibrium kink.
D Temperature Diversion.

QUESTION 3

Below are the monthly mean surface air temperatures (°C) for two locations at approximately the same latitude: Vancouver, British Columbia, Canada (Latitude 49.25°, Longitude -123.10°) and Winnipeg, Manitoba, Canada (Latitude 49.89°, Longitude -97.15°) averaged for the period 1981-2010. *(Note: a climate "normal" monthly average is the average of daily surface air temperature maximums and minimums throughout the month, usually over a period of 30 years.)*

Month	Vancouver	Winnipeg
January	4.1	-16.4
February	4.9	-13.2
March	6.9	-5.8
April	9.4	4.4
May	12.8	11.6
June	15.7	17.0
July	18.0	19.7
August	18.0	18.8
September	14.9	12.7
October	10.3	5.0
November	6.3	-4.9
December	3.6	-13.2

On the graph below, are plots of monthly mean surface air temperature data for the two locations, and the data points are connected with lines.



From the data in the table, calculate the following values:

3.1) Average annual surface air temperature (°C) for Vancouver.

_____°C

3.2) Average annual surface air temperature (°C) for Winnipeg.

_____°C

3.3) The annual surface air temperature range (°C) for Vancouver. (Note: "annual temperature range" is the difference between maximum monthly temperature and minimum monthly temperature.)

_____°C

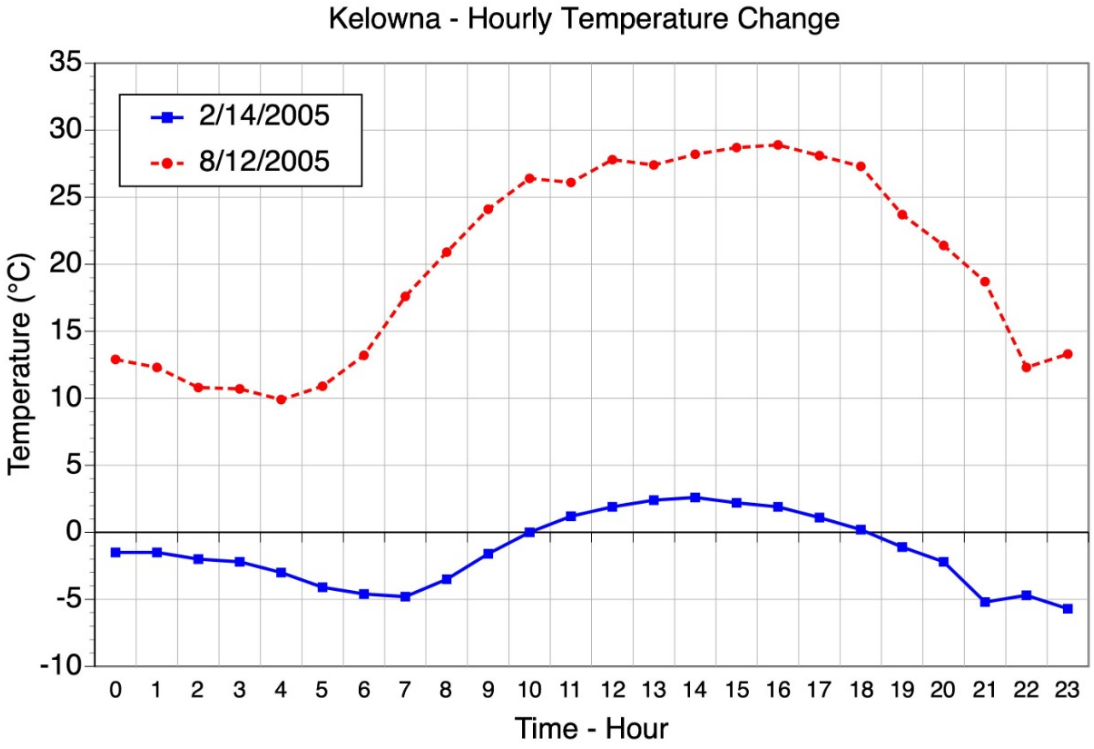
3.4) The annual surface air temperature range (°C) for Winnipeg. (Note: "annual temperature range" is the difference between maximum monthly temperature and minimum monthly temperature.)

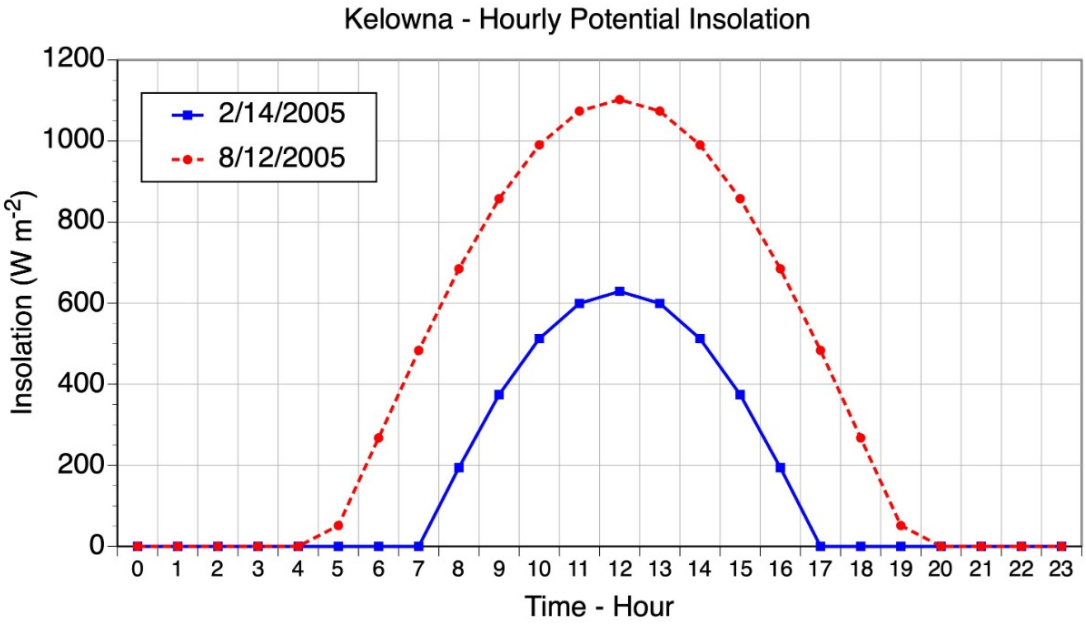
_____°C

3.5) Explain the difference in magnitude of the annual ranges of temperature for these two locations. Keep in mind that these two locations are at similar latitudes. Which city has a more "continental" climate?

QUESTION 4

The graphs below describe hourly fluctuations in surface air temperature and potential insolation for Kelowna, British Columbia, Canada (Latitude 49.89°, Longitude -119.50°). Data is shown for two specific days: February 14, 2005 and August 12, 2005. Explain the patterns in air temperature using the insolation data.





4.1a) At what time (hour) did minimum surface air temperature occur on February 14, 2005?

_____

4.1b) At what time (hour) did minimum surface air temperature occur on August 12, 2005?

_____

4.1c) Explain why the morning minimum surface air temperature on the two days occurs at different times.

4.2a) At what time (hour) did maximum surface air temperature occur on February 14, 2005?

_____

4.2b) At what time (hour) did maximum surface air temperature occur on August 12, 2005?

_____

4.2c) Explain the difference in the timing of maximum daily surface air temperature for both days.

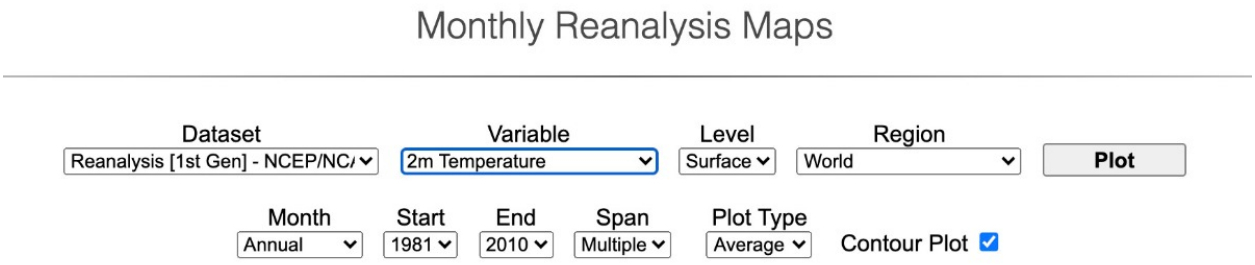
4.3) Why are the daily surface air temperatures on February 14, 2005 much cooler than those that occurred on August 12, 2005?

QUESTION 5

Use the following web link to go to **Climate Reanalyzer**, Monthly Reanalysis Maps.

https://climatereanalyzer.org/reanalysis/monthly_maps/

Create a global map showing **annual** average 2 meter temperature °C for the 30-year period 1981-2010 with the following inputs.



Answer the following questions.

5.1) In general, the warmest surface temperatures are found at

A the equator.
B 25° South Latitude.
C 25° North Latitude.
D 50° South Latitude.
E 50° North Latitude.

5.2) In general, the coldest surface temperatures are found at

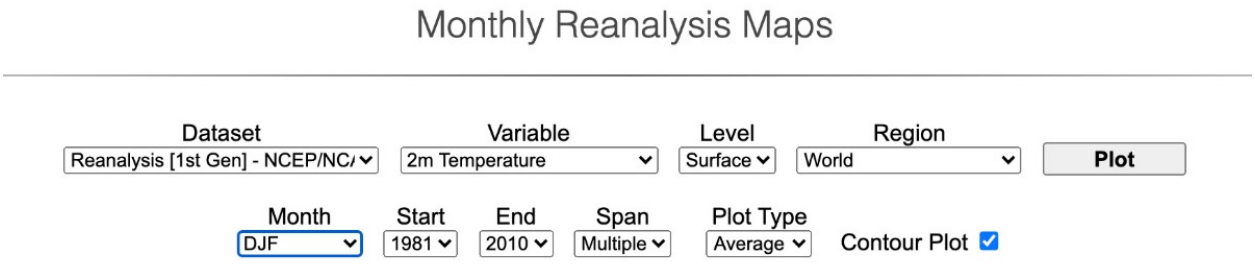
A Antarctica.
B the Arctic.
C the center of Greenland.
D Siberia.

5.3) At 50° North, the warmest surface temperatures are found on

A land surfaces.
B ocean surfaces.
C the center of Greenland.
D Siberia.

5.4) Explain your answer for question 5.3.

Create a SECOND global map showing **Winter Season (DJF - December/January/February)** average 2 meter temperature °C for the 30-year period 1981-2010 with the following inputs. Create this map in a separate window so you can make comparisons to the annual average.



Answer the following questions.

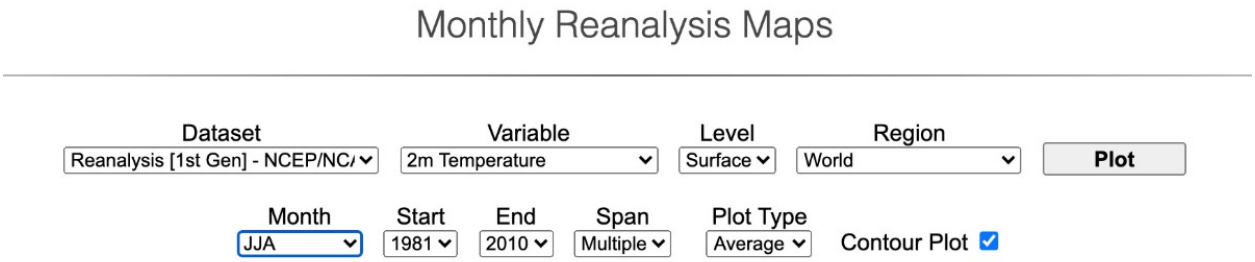
5.5) In general, the warmest surface temperatures are found

A at the equator.
B over Australia.
C over Mexico.
D over Northern Africa.
E over Canada.

5.6) In general, the coldest surface temperatures are found at

A Antarctica.
B the Arctic.
C the Southern Ocean around Antarctica.
D Atlantic Ocean in between Canada and Europe.

Create a THIRD global map showing **Summer Season (JJA - June/July/August)** average 2 meter temperature °C for the 30-year period 1981-2010 with the following inputs. Create this map in a separate window so you can make comparisons to the annual average.



Answer the following questions.

5.7) In general, the warmest surface temperatures are found

A at the equator.
B over Australia.
C over Mexico.
D over Northern Africa.
E over Canada.

5.8) In general, the coldest surface temperatures are found at

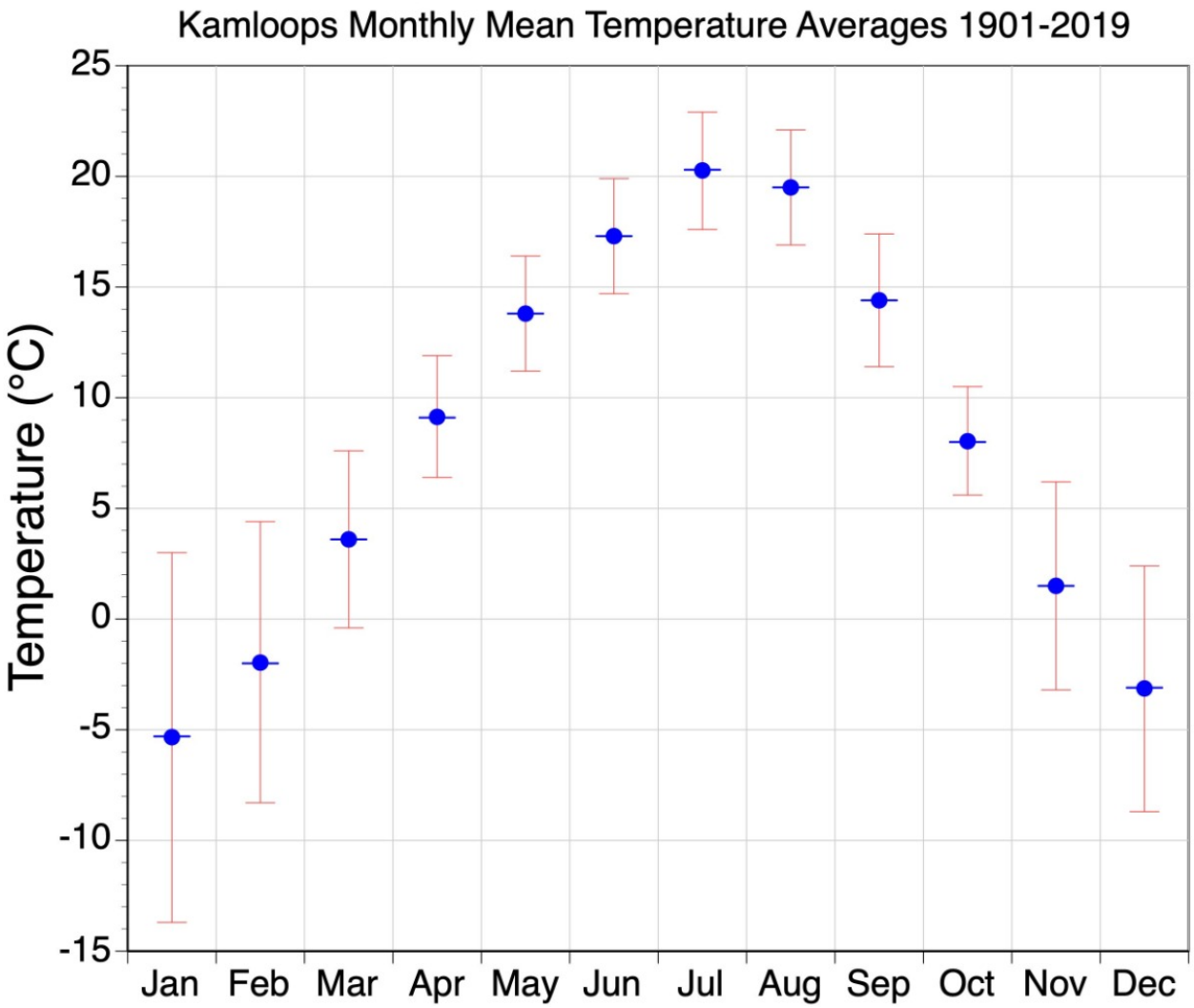
A Antarctica.
B the Arctic.
C the Southern Ocean around Antarctica.
D Atlantic Ocean in between Canada and Europe.

5.9) Explain why surface temperatures over Australia have cooled off when compared to Winter (DJF), 1981-2010?

QUESTION 6

The Microsoft Excel file *Lab_2_Kamloops_Temp_Data.xlsx* shows the monthly and annual mean surface air temperatures for Kamloops, British Columbia, Canada for the period 1901-2019. At the end of each data column means, **standard deviations** (**σ**), Mean + 2**σ**, and Mean - 2**σ** have been calculated for the entire time series. The **mean** has been calculated by adding together all the values in the data set and dividing by the number of values in the data set.

The following graph (*Image Copyright Michael Pidwirny*), plots the average monthly surface air temperature for Kamloops, connecting the data points with straight lines. Also, for each month plot "error bars" representing two standard deviations (± **2σ**) of dispersion around the mean value have been drawn.



For January and July, list the years in which the average surface air temperatures were higher or lower than 2 standard deviations (± **2σ**) than the averages in these months. January has been done for you as an example.

January Mean = -5.3, ± **2σ** = 3.0 to -13.7

Higher than +2s: No years have values greater than +2s.

Lower than -2s: 1950, 1916, 1930, 1969, 1907, 1937, and 1957.

Answer the following questions for July.

July Mean = 20.3, ± **2σ** = 22.9 to 17.6

6.1) For July, are there any years with a monthly mean temperature that is higher than +2σ? Please list them.

6.2) For July, are there any years with a monthly mean temperature that is lower than -2σ? Please list them.

6.3) For July, would you consider the years listed in questions 6.1 and 6.2 to be anomalies in the climate record of Kamloops? Explain relative to the normal distribution concept.

6.4) Generally, in which season does Kamloops have the GREATEST interannual variations in surface air temperature at shown by the calculation of standard deviation?

A Winter (December, January, and February)
B Spring (March, April, and May)
C Summer (June, July, and August)
D Fall (September, October, and November)

6.5) Generally, in which season does Kamloops have the LEAST interannual variations in surface air temperature at shown by the calculation of standard deviation?

A Winter (December, January, and February)
B Spring (March, April, and May)
C Summer (June, July, and August)
D Fall (September, October, and November)