Exercise 2:

Objective

Determine the effect of surface disturbance on annual and monthly temperature ranges as well as active-layer depth. Data is provided in Table 1 and Table 2.

Abstract and Data Set

10 cm ground temperatures were obtained for two sites within the Stewart River Valley in the central Yukon Territory from July 2008 to June 2009 (Table 1). Active-layer depth was measured in 2007, 2008, and 2009 (Table 2). Surface vegetation and organic material was removed from one site (Figure 1). This activity is intended to emphasize the linkage between vegetation cover, near-surface temperature fluctuations, and active-layer depth.

Figure 1. *Contrast between the undisturbed site (left) and the disturbed site (right). Photos taken by Dr. C.R. Burn, Carleton University, Ottawa, Ontario.*

Activities

i) For each month, calculate the range in temperature at the disturbed and undisturbed sites using the data provided in Table 1.

When compared to air temperatures, temperature in the ground exhibits less variation at diurnal (daily), monthly, and annual time scales. Compare the impact of surface vegetation on soil temperatures by following the steps below.

- Calculate the temperature range as the difference between maximum and minimum temperatures for each month and each site in Table 1.
- Plot these values as two lines on a line graph with temperature range (°C) on the y axis and Month on the x-axis.
- Compared to the other months, what factors might explain the reduced temperature range during February and March? Consider parameters which are subject to variation over the course of the year.
- Determine the annual temperature range by calculating the difference between the maximum and minimum annual temperatures in each data set. What is the impact of denudation on the annual temperature amplitude?

ii) Using the active-layer depths supplied in Table 2, run a paired t-test in Excel (or other statistics software) to test the null hypothesis that disturbance involving vegetation removal does not increase active layer depth and the alternate hypothesis that disturbance does increase active layer depth.

At sites experiencing the same air temperatures, active-layer development is principally controlled by the surface energy balance. The absence of surface organic matter and exposure of darker mineral soil tends to reduce reflectance and increase the amount of solar radiation absorbed by the surface. This energy heats the soil surface and drives evaporation. As a result, near-surface mineral soil may be slightly drier which then reduces the amount of energy required to raise the soil temperature. Finally, heat can flow by conduction from the warm surface down into the soil more readily in mineral soil vs. organic soil because of less air space and better contact between the mineral soil particles. Consequently, disturbed sites are able to thaw deeper each season.

Table 1. *10 cm ground temperatures at disturbed and undisturbed locations in the Stewart River Valley, Yukon from July 2008 to June 2009.*

Month	Disturbed Site			Undisturbed Site		
	Average Temp (°C)	Maximum Temp (°C)	Minimum Temp (°C)	Average Temp (°C)	Maximum Temp (°C)	Minimum Temp (°C)
2008						
July	10.0	11.2	8.5	5.3	5.7	4.4
August	8.6	9.6	6.1	5.7	6.3	4.9
September	4.3	5.7	0.5	3.5	4.6	1.3
October	-0.3	0.4	-0.6	0.6	1.3	0.3
November	-0.7	-0.6	-1.1	0.3	0.3	0.3
December	-1.5	-0.6	-2.4	-0.1	0.3	-0.6
2009						
January	-3.2	-1.6	-4.5	-1.1	-0.3	-1.7
February	-3.6	-3.4	-4.0	-1.7	-1.4	-2.0
March	-3.9	-3.6	-4.3	-2.4	-2.1	-2.5
April	-2.6	-1.1	-3.5	-1.4	-0.2	-2.2
May	0.6	4.2	-0.9	0.6	0.7	0.0
June	8.2	9.9	4.2	2.3	3.2	0.7

Table 2. *Active-layer depths at disturbed and undisturbed locations in the Stewart River Valley, Yukon. The depth of the active layer was determined by measuring the depth at which water was thawed in a 2 m long water-filled tube drilled into the permafrost at each site. This measurement is made at the end of August.*

Year	Disturbed Site Active-layer depth (cm)	Undisturbed Site Active-layer depth (cm)
2007	85	68
2008	89	76
2009	93	64