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Lab Exercise 4: Orographic Analysis of Precipitation in Colorado

GEOG 3511

TA – Sidney Bush

Methods

The focus of our lab this week is centered on finding an estimation of annual precipitation across the state of Colorado. However, there are some problems in finding this estimation which are mainly due to the diverse topography of Colorado. Using measurements from multiple data collection centers throughout the state, we can establish a relationship between **elevation** and **precipitation**. Utilizing Microsoft Excel, we can combine multitudes of numbers and create scatter plots to show a visual representation of this relationship. Once these scatter plots are put together, a linear regression line can help further define the ratio between elevation and precipitation. Once this relationship is established, we can make conclusions about the rest of Colorado, and eventually calculate a general annual precipitation value. Once this precipitation value is found, we can also calculate other hydrological figures, such as the runoff ratio/coefficient.

Results and Figures

Most of the results we found were in regards to precipitation. The sum of the weighted precipitation, or the precipitation values which take into account variation of elevation, was about 17 inches (44 centimeters). Additionally, the calculated area was 269,892 Km^2. The given/actual area of the state of Colorado was 239,837 Km^2, which was 30,055 Km^2 lower than our calculations. The calculated runoff was 1.3e10 m^3, and the runoff ratio was 8.99 (dimensionless).

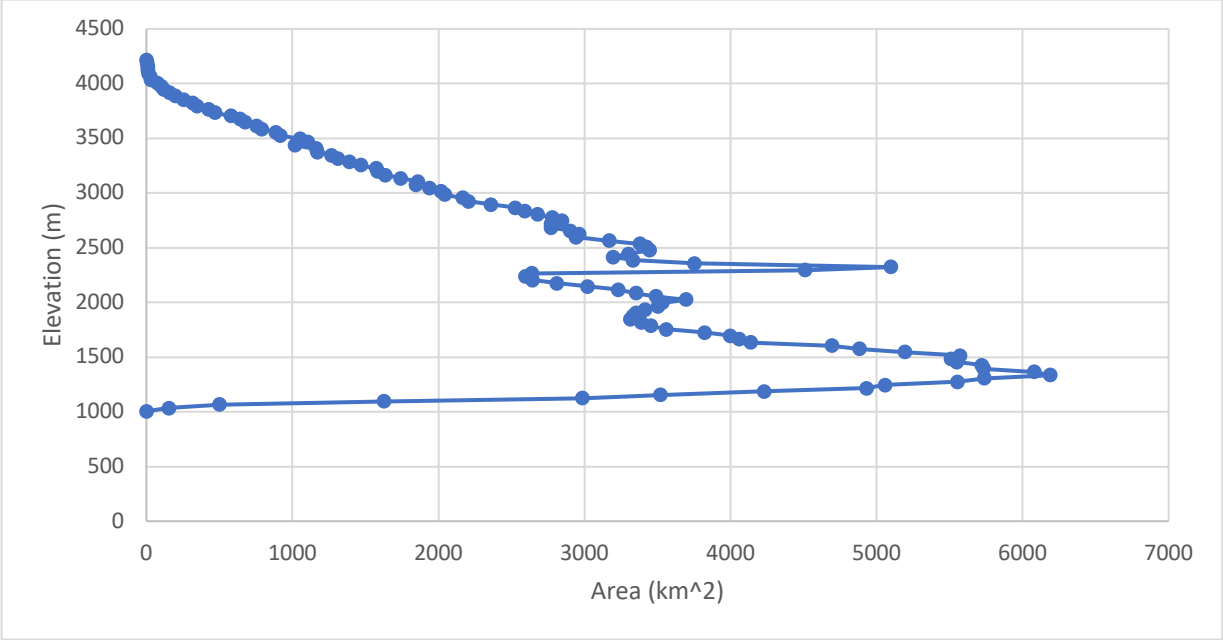

Figure 1.1: Pictured above is a hypsometry graph of Colorado, relating average elevation of a given section of land and the area of that land.

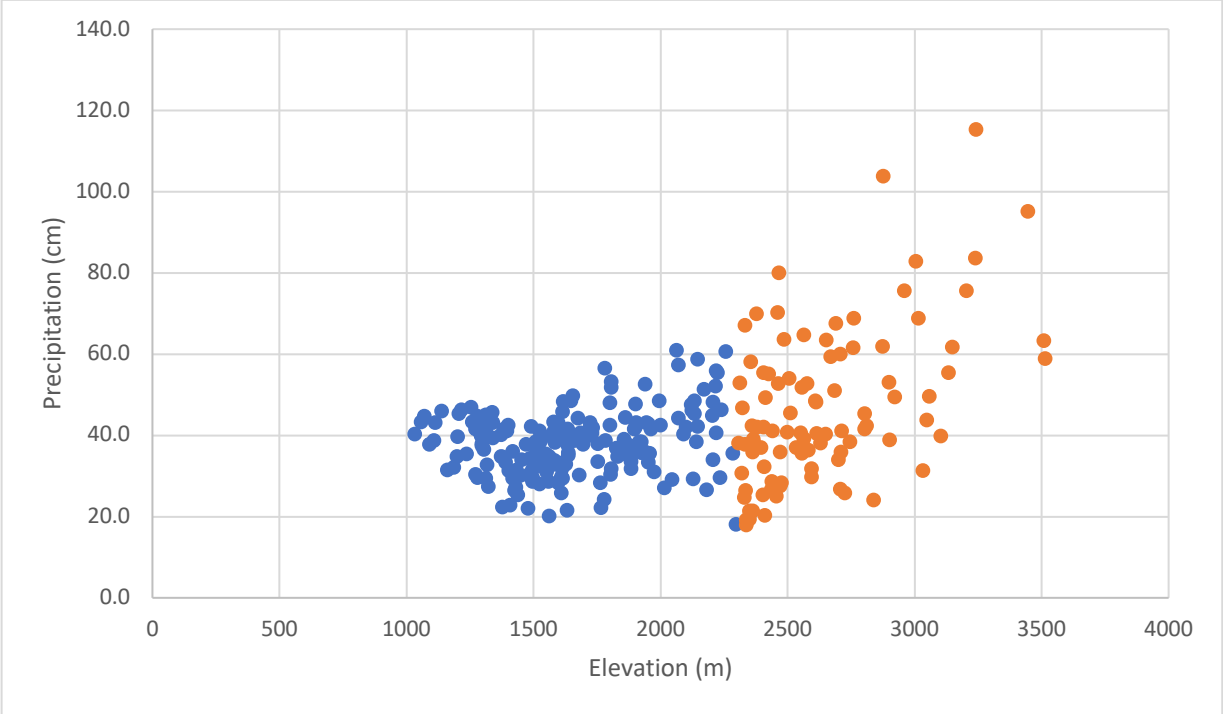

Figure 1.2: Pictured above is the scatter plot relating elevation and precipitation, separated into elevations below (blue) and above 2300m (orange). Also included is the linear regression line for both sets of data.
Below 2300m: **y = .0062x +27.855**
After 2300m: **y = 0.0337x – 42.022**

Table 1.1: Summation of weighted/unweighted precipitation values, displayed in cm and in. Also included is the calculated runoff ratio.

Sum of weighted P (cm):	43.98
Sum of weighted P (in):	17.32
Sum of calc. P (cm):	6050.16
Runoff Ratio:	8.99

Table 1.2: Pictured below is the calculation used for area of Colorado, as well as the actual area and the difference.

Total calculated (km^2):	269892
Total actual (km^2):	239837
Difference (km^2):	30055

Table 1.13: Pictured below is the calculations/conversions utilized in the runoff ratio calculation.

Calculating Runoff Ratio	
Runoff (cubic meters):	1.3E+10
Precip. (in):	1.7E+01
Precip. (m):	4.4E-01
Precip. (km):	4.4E-04
Precip. (km^3):	1.2E+02
Runoff (cubic meters):	1.3E+10
Runoff (km^3):	1.3E+01
Discharge (cubic meters):	1.32E+10

Discussion

From our data, it can be seen that at around 2300 meters, there is a distinct shift in the data. Before 2300 meters, it can be seen that generally the precipitation values are relatively closely grouped together. After 2300 meters, however, the values start to increase at a much faster rate. The linear regression lines we found, which essentially represent the relationship between precipitation and elevation, show this directly. The slope of the lines, which is the numerical relationship between the two variables, is much higher after 2300 meters. This calculation/relationship is most likely due to the colder temperatures at higher elevations. Cloud formation relies on **saturation**, which corelates with a **lower temperature** and therefore a **higher elevation**. These findings can have broader implications in the aspect of habitability of higher elevations. If a certain elevation line exhibits a much greater precipitation rate than that of a lower elevation, people can decide whether or not living at that elevation would have a

significant negative impact. Additionally, if precipitation is highest at a certain elevation which is accessible to humans, we can harvest some of that precipitation for our use.

In regard to the calculated runoff ratio, the results are slightly surprising. The final calculated runoff coefficient was around 9, which is significantly higher than the expected range of 0-1. This number may be a result of **inaccurate calculations** for the total area per bin measurements. An incorrect measurement in area would result in wrong precipitation values, mainly due to the fact that precipitation is recorded in depth and then converted to volume using the **area** of measurement. If a precipitation value were to be highly skewed, so would the runoff ratio, which is a relationship between discharge and precipitation. The precipitation value which was calculated, however, was very accurate when compared to that of the reported value by the Colorado Climate Center (≈ 17 inches).

This runoff ratio is also significantly **higher** than that of our previous calculations made a couple weeks ago (≈ 0.36). This ratio, being between 0-1, is much more acceptable and is to be expected when computing a ratio in regard to hydrology. There is a caveat, however, in the fact that our computation from a couple weeks ago was simply **one** watershed in Colorado. The runoff ratio found in this weeks' lab was in regard to the **entire state**, which has much broader implications. The significantly higher ratio may be a direct result between elevation and precipitation. As can be seen in the data analysis, higher elevation also results in higher precipitation. At this high elevation, however, there is much less biomass to hold water, which results in higher runoff. Additionally, a larger gradient of slope allows precipitation to runoff quicker. In summation, the significant runoff ratio of about 9 may not be as ridiculous as it seems. The runoff ratio computed a couple weeks ago doesn't take into account the very diverse

topography of Colorado. The runoff ratio computed in this lab, however, analyzes many different areas of the state.

These findings can have very significant implications for the future. If water runs off at a higher rate in more mountainous regions, should more people consider relocating to some of these places? On the contrary, if water is running off at a very significant rate in these mountainous regions, should we do something to prevent drought? There are many unforeseeable outcomes in this study, and most of them are very difficult to analyze considering the inaccessibility of the regions in question.