WR 417 Project
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Term Project

SNOTEL OBSERVATIONS

Summary:

Each winter a certain amount of snow falls that will later melt, become spring runoff, and resupply water sources. Analyzing the snowpack and having estimates of how much water can be expected throughout the melting season is beneficial to aid in the planning of water supply and demands. The snow water equivalent (SWE) measurement quantifies how much the current snowpack would be if in liquid form. SWE is affected by many physical conditions such as radiation, vegetation, and temperature but all of these attributes tie in to affect the snowpack density. In this module, you will learn how to collect SWE and snow density data to analyze and predict how snow density may affect total SWE.

Overall Learning Objectives:

At the end of this study, students will understand what SWE data represents and be able to analyze how certain snow densities affect total SWE. Students should also be able to use prior outside knowledge to give reasons for the relationship between the two variables. Students will show data collection skills by being able to retrieve snow data from the SNOTEL website and create graphs.

Measurement Details:

Guidelines: Students will use data a SNOTEL stations in Colorado. The station is Deadman Hill, CO SNOTEL station number 438.

Collected Data:

SWE: This measurement is the total amount of water contained in a fixed sample of snow. SWE is measured using snow pillows, which are large 3-meter x 3- meter bladders (steel and rubber) installed on the ground and filled with antifreeze. As snow accumulates on top of the pillow throughout the winter, instruments measure the increasing hydrostatic pressure upon the liquid. With that the mass of the overlaying snow is calculated , knowing the density allows us to then calculate the SWE.

Snow Density: Varies significantly from storm to storm. A snow depth measurement allows us to calculate snow density. Snow depth is measured by using a ruler or avalanche probe. It can also be more complicated at remote weather stations with automated measurements and logging of data. But specifically at SNOTEL sites snow depth is measured using an ultrasonic depth sensor mounted above the snow pillow measures the snow depth. The sensor sends a signal downward towards the ground and measures how long it takes the signal to bounce off the snow surface and return to the sensor. Knowing how fast the signal travels, a properly-calibrated sensor will give an accurate reading of snow depth. On the weather station page, there is a field for changes in depth over a 24-hour period (Sno24), in addition to the total depth of the snowpack (SnoHt). You then take the found SWE and divide it by the snow depth.

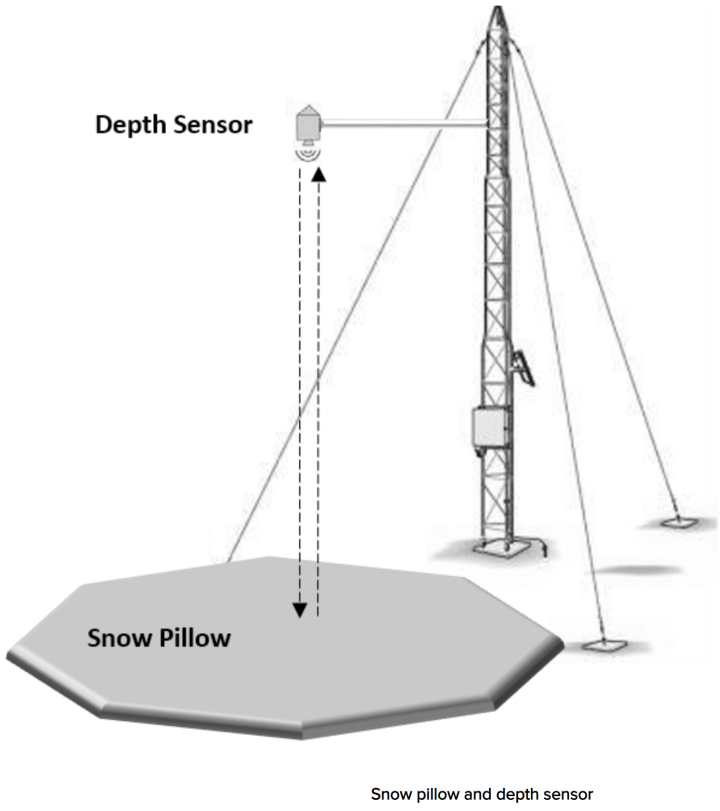

Image 1. Example of what a snow pillow and depth sensor equipment used to help find SWE and snow density.

Assessment:

Overview:

Retrieve data from SNOTEL site and create a niveograph to analyze SWE and a snow density graph to then compare how SWE and snow density are/ are not correlated. Conduct study on the Deadman Hill, CO SNOTEL station number 438 for ten years of record starting October 1, 2011 to September 30, 2021. Use the link to retrieve data.

-https://wcc.sc.egov.usda.gov/reportGenerator/

a. Create interactive graphs.
    i. The niveograph will have SWE on the y-axis and water years on the x-axis.
    ii. The density graph will have density on the y-axis and water years on the x-axis.
b. Graph Analysis
    i. State obvious trends in the SWE and density graphs and analyze any correlations.
    ii. What other factors may be affecting snowpack density?
    iii. How can SWE be used to help water management in urban areas?

Assessment: EXAMPLE

SNOTEL DATA

- Snow_termactivity.csv

Clean Data and R Code (R Markdown)

- Interactive graphs on R markdown to get data information on graphs

1. Graphs

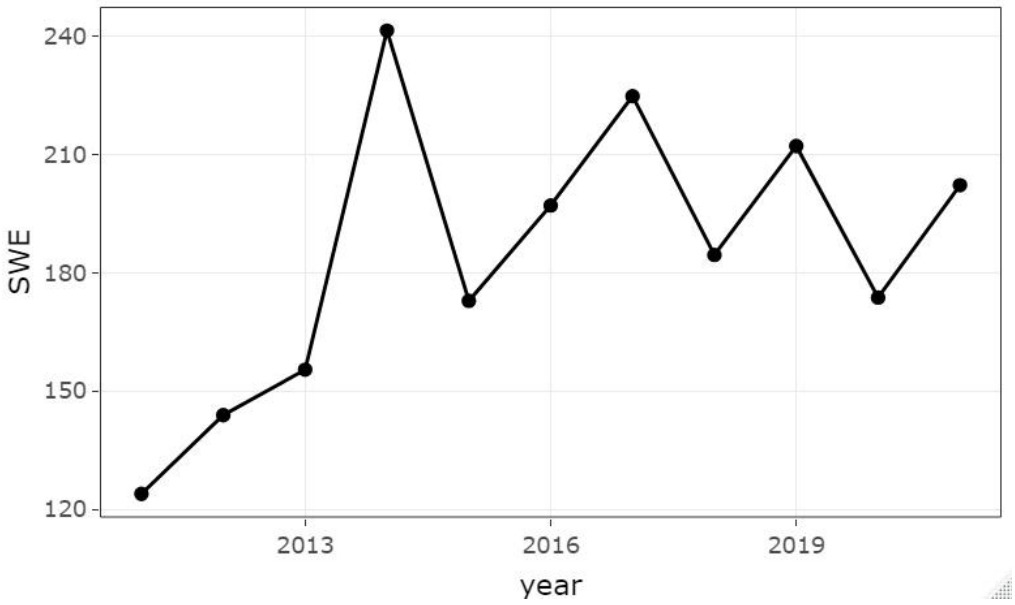

Figure 1. The snow water equivalent is graphed above for average annual totals for 2011 to 2021. SWE is measured in mm.

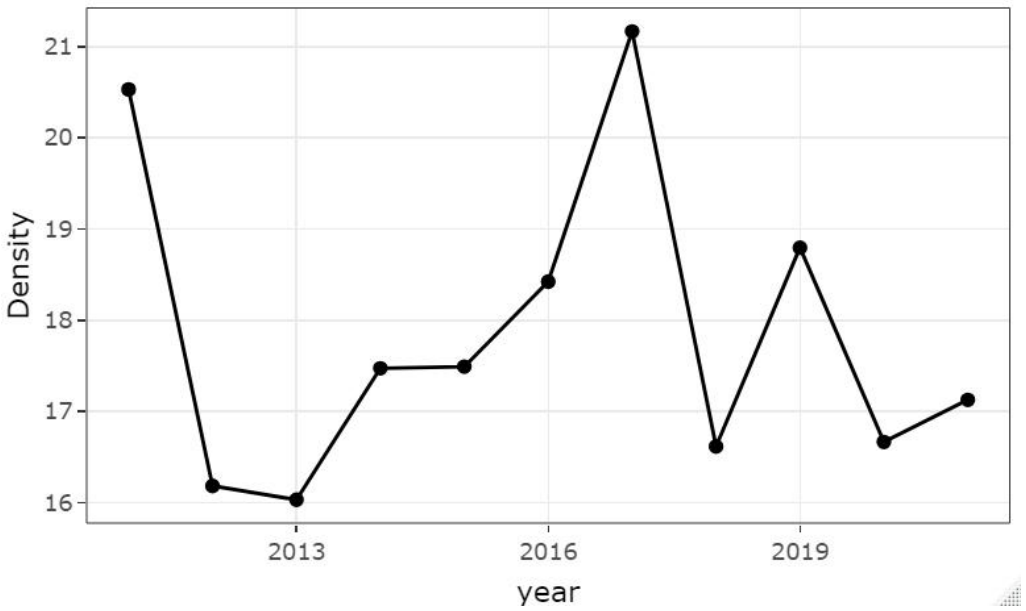

Figure 2. The snowpack density is shown above in units of a percent of the mass of snow per unit volume.

2. Analysis

A. State obvious trends in the SWE and density graphs and analyze any correlations.

From 2011 to 2014 SWE was significantly increasing. After this there was almost yearly trends of high SWE followed by a year with significantly lower SWE. Although there is the annual variations there is a general decreasing trend after 2014.

The density totals on Deadman Hill were decreasing until 2013 where a steady increase occurred until 2017 when there was a sudden drop in annual density amounts. There is no obvious general trends throughout the 10 year study period.

SWE and density do not show any significant correlations until 2017. After this year the two experience a similar decrease trend into 2018 then alternating increasing and decreasing values to 2021.

B. What other factors may be affecting snowpack density?

Other factors affecting snowpack density include solar radiation which lead to warming and faster melting. Surrounding vegetation also affects snowpack amounts

from things such as interception and shading incoming radiation. Particles covering the snow also affects how it reacts to radiation. Constituents such as ash from fires or sand may get blown onto snow which decreases the albedo of the snow and warms the surfaces.

C. How can SWE be used to help water management in urban areas?

SWE can help make predictions for a given watersheds discharge for the following year. Having a prediction for how much water could be in the system would allow for water managers to incorporate management plans such as drought contingency plans of how to decrease usage in low snow years and how to make better use of water sources when there is adequate supply.