Black Carbon on Mount Rainier

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Black Carbon on Mount Rainier: Effects and Implications

Background

The effects of climate change on the Puget Sound are in already effect. Increased wildfire frequency/severity, ocean acidification, and rising sea levels are commonly known products. An additional effect is water scarcity. At higher elevations, warmer winters lead to more variable precipitation and early season snow melt resulting in less melt water available during the summer months. Water scarcity means reduced viability of agriculture, hydroelectric power, and recreation throughout Washington. Mount Rainier, Washington's highest peak, is the origin of nine Puget Sound draining watersheds, each likely facing a future of water scarcity. Water scarcity is additionally compounded by heightened levels of black carbon (BC) in Rainier's snowpack. BC (Figure 1) is the product of the incomplete combustion of anthropogenic source (fossil fuels and biomass) or wildfires.

Research Objectives

The surge in climate change driven wildfires throughout the Pacific Northwest have raised notable concerns about PM2.5 (black carbon) and its implication on snow quality. Research objectives included:

- Estimating the BC loading on Mount Rainier through continuous sampling and monitoring.
- Tracking and integrating wildfire/snowfall activity using diverse softwares.
- Analyzing snow contaminants using the Light Absorption Heating Method (LAHM, Figure 2) and Scanning Electron Microscope (SEM).

Methods

Field Work:

1) On site (Figure 3) metadata was recorded: coordinates, altitude, time, temperature, aspect, direction-facing, and snow information.
2) Using a trowel, shovel, and avalanche probe, the snow is extracted as a column in intervals every 5 to 10 cm (Figure 4).
3) The samples were then placed into labeled two-layer bags and transported back to campus in a cooler for analysis. The bags remained frozen until processing.

Lab Work:

1) The snow was melted and then pushed through a 60 mL filter-mounted syringe.
2) The filtered water was measured in a graduated cylinder.
3) The filters were dried for 24 hours before analyzing.

Analysis:

1) The filters were placed in the LAHM and the Arduino ran to obtain a data list. The data list was analyzed using Python (Figure 5) for filter load, BC equivalent (BCE) concentrations, and the limit of the temperature curve (t0).
2) Sections of each filter were cut for investigation by SEM.
3) Metadata was used to track snow and wildfire events to observe patterns in BC concentration using the Hybrid Single Particle Integrated Trajectory Model (HYSPLIT) and BlueSkies.

Results

Figure 7 demonstrates the increase in BC concentrations on Mount Rainier between 2020 and 2021 at correlating locations and depths.

Conclusion/What Now?

1) Mount Rainier's snow is directly impacted by BC.
2) Elevated BC is correlated with wildfire activity.

To establish causation:
- Must narrow down timing for BC deposition and positive correlation.
- Better chemical analysis of BC.

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References

4. HYSPLIT and BlueSkies integration (Figure 6) allowed BC measured and the smoke dispersion from wildfires to be correlated. On four occasions, higher than expected BC was linked to wildfire smoke passing above Mount Rainier.

Figure 8. SEM images of particulates from above Paradise.