

# Interdisciplinary Climate Change Expedition:



## Black Carbon Measurements from the Dinwoody Glacier

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### Abstract

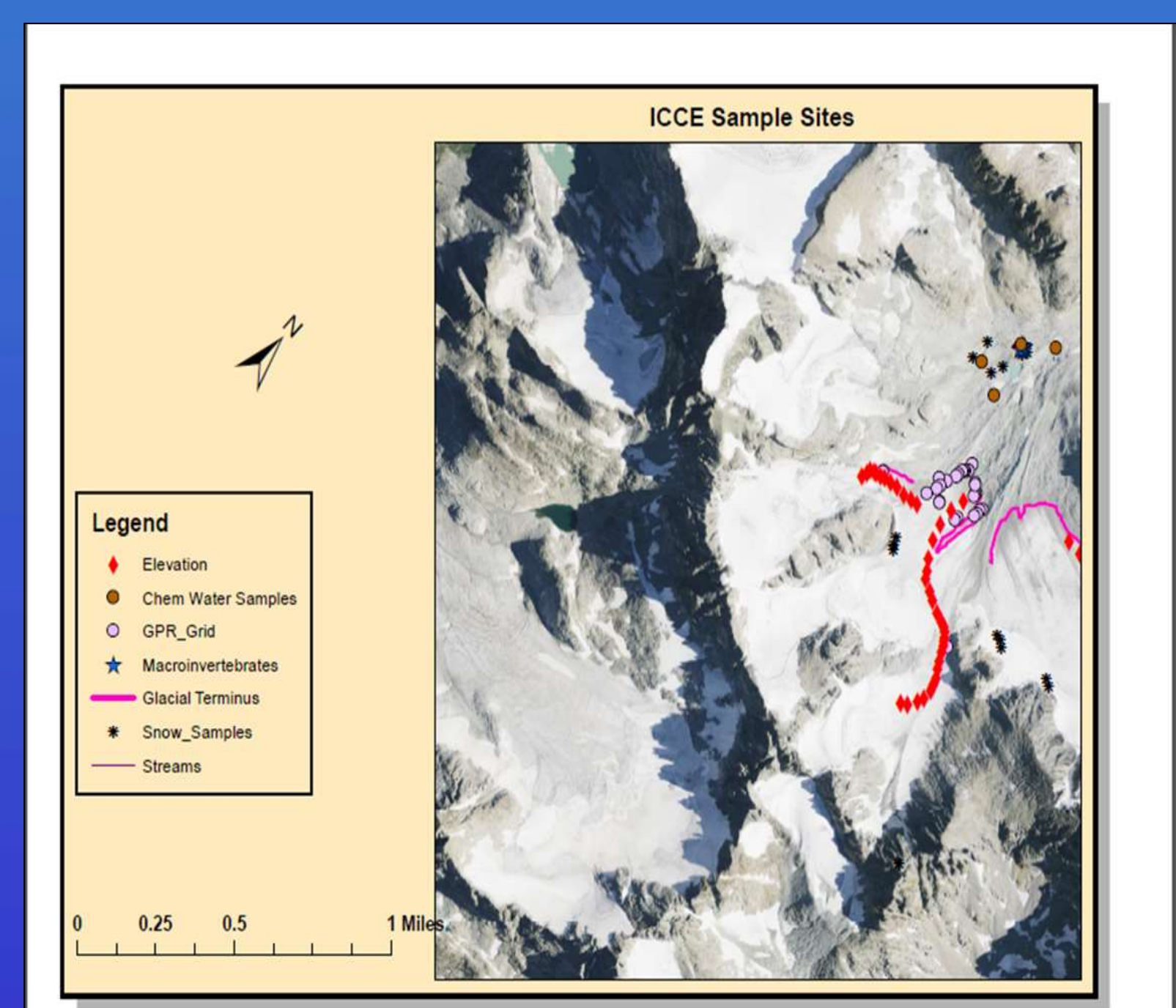
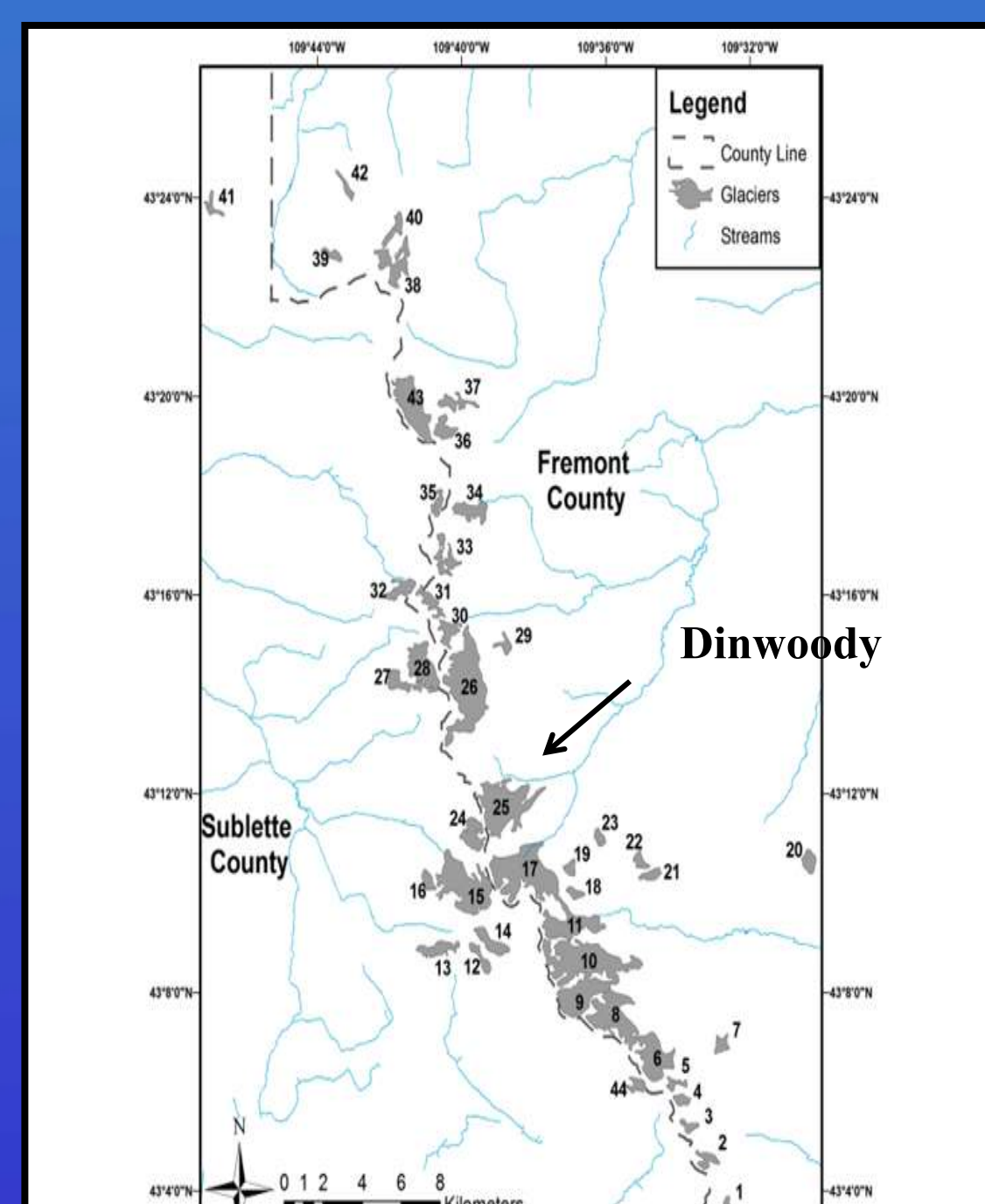
The impacts of climate change on glacial ice melt have become steadily more pressing over the past several decades. Increased average yearly temperatures have contributed to the recession of glaciers world-wide, and water resource managers are concerned about the implications for surface water availability. Black carbon particulate has been documented in South America as a contributing factor to accelerated melt - working in concert with rising temperatures to reduce the ice mass and volume of tropical glaciers. Black carbon is non-decomposed particulate that results from the burning of agricultural and forest lands, and from other chemical exhaust sources. These particles reduce albedo in the snowpack, increase energy absorption, and accelerate glacial ice melt. The data set for glaciers of the Wind River Range of Wyoming is incomplete at best. In August 2014, and in conjunction with Dr. Carl Schmitt and the American Climber Science Program, the Interdisciplinary Climate Change Expedition (ICCE) collected and analyzed 14 snow samples from the Dinwoody glacier in the Fitzpatrick Wilderness. Results indicated an average of 30ng/g – fairly typical North American snowpack values, but potentially high for such a remote location. Research will continue in 2015 with more subsurface sampling and replicates of 2014 samples.

### Introduction

Global climate change is leading to increased temperatures globally and impacting the rate of glacial melt in many regions. An additional anthropogenic impact on glaciers is increased levels of pollution in the atmosphere. Atmospheric pollutants such as black carbon particles can be deposited on glacier surfaces through precipitation processes or through 'dry deposition'. Black carbon on glacier surfaces increases the rate of melting due to absorption of light that would otherwise be reflected. (Painter et al., 2013). Recent studies in the tropics have demonstrated that the impacts of global climate change and warming temperatures on glacial recession is further exacerbated by the presence of black carbon in the snow pack (Schmitt pers. Comm. 2015). Black carbon results from incomplete combustion of organic matter and when deposited in the snow pack can accelerate melting considerably. At values of 30 ng of black carbon per gram of water (ng/g) - typical of North American snow samples, the albedo (degree of reflectivity off of the snow or ice) is decreased between 2.5-6.0% (Warren and Wiscombe, 1985). Minimal work in the Wind River Range of Wyoming has been completed to either measure, source, or assess the impacts of black carbon on the melt of glacial snow pack in WY (Schmitt pers.omm.2015). Sampling and analysis of snow samples from this region stand to contribute greatly to the scientific, local and regional communities.

### Study Area

This research was performed on the Dinwoody Glacier of the Wind River Range of Wyoming. This glacier is located approximately 21 miles south-southwest of the Trail Lakes Road head in the Fitzpatrick Wilderness Area. This area must be accessed by foot or horseback as there are no motorized vehicles permitted in Wilderness Areas.



### Methods

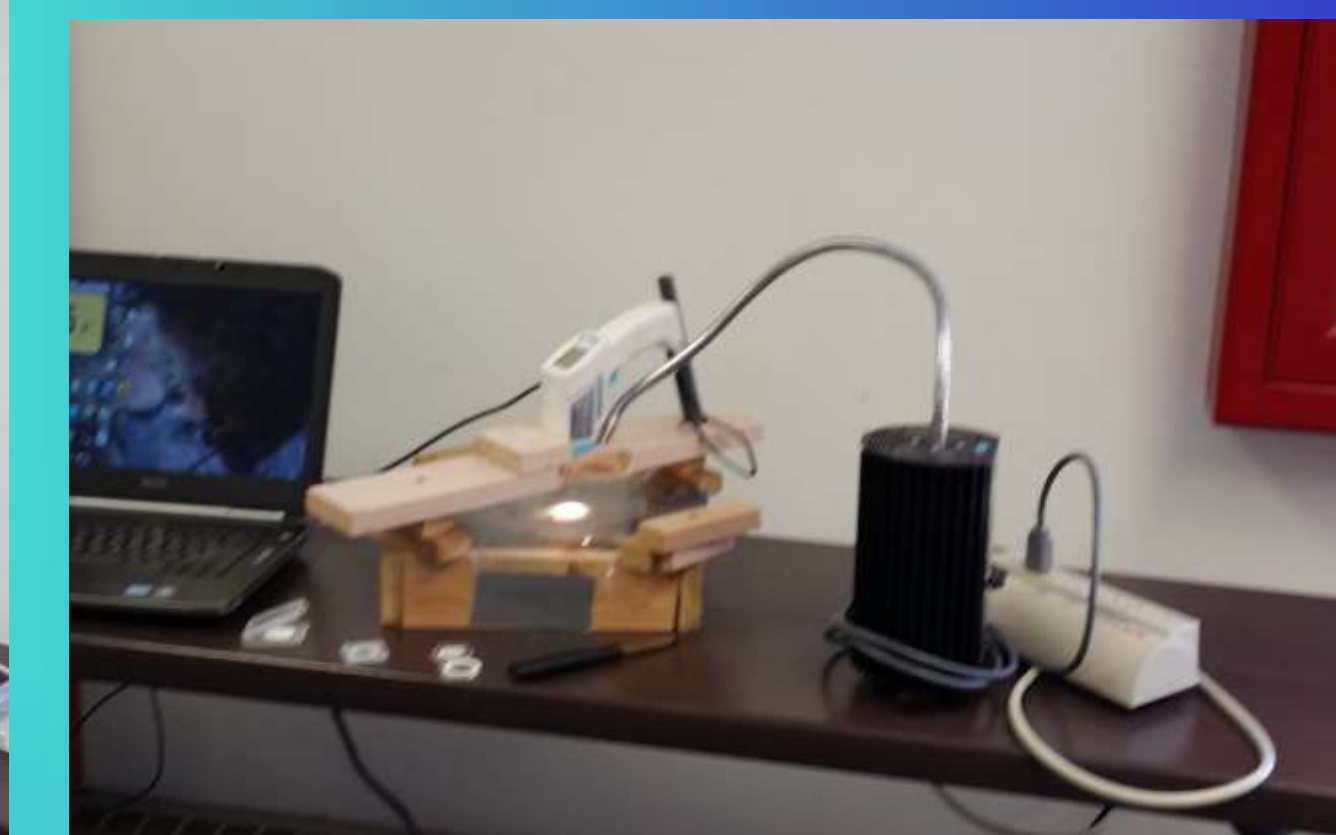
Seventeen snow samples of one quart in volume were collected by hand throughout the glacier and permanent snow fields on the moraine of the glacier. They were collected with a sterile digging tool and placed in clear plastic food grade bags. All sampling locations were mapped on a Trimble Juno SB GPS device. Samples were immediately melted and filtered on site adjacent to the glacier. Filters were dried and packed out for later analysis. Analysis was performed by Dr. Carl Schmitt from the National Center for Atmospheric Research, using a technique developed by Schmitt referred to as Light Absorption Heating Method (LAHM), a technique that measures the ability of particles on filters to absorb visible light (Schmitt pers. Comm. 2015). LAHM results have been calibrated using filters with known amounts of fullerene soot, a common industrial surrogate for black carbon (BC). As sample filters often contain dust in addition to BC, results are presented in terms of effective black carbon (eBC). The amount of black carbon in each sample was determined based upon the amount of heat absorbed by each sample. The greater the temperature increase, the greater the amount of black carbon (Schmitt pers. comm. 2015)



### Results/ Findings

Black carbon measurements varied dependent upon location. The lowest value sample seventeen 11.0771 ng/g, highest value sample sixteen 56.6226 ng/g. The general trend evidenced highest values in the snow obtained from the permanent snow fields, while the samples taken from the glacier were lower in effective black carbon.

filter #	eBC ng/g
1	17.4468
2	11.3771
3	20.9885
4	11.1365
5	12.066
6	14.0888
7	20.5907
8	14.9419
9	34.5017
10	28.7689
11	12.4592
12	20.3717
13	54.3745
14	30.8576
15	24.5071
16	56.6226
17	11.0771



### Discussion

Values obtained from this site are not significantly above or below typical North American values, but given the unique characteristics of the study area, still warrant consideration (Schmitt pers. comm. 2015). Most other measurements in North America were taken at lower altitudes and proximal to roads. These samples were obtained from a remote Wilderness site at high elevations (~11 000 feet). Of interest was the fact that snowfield samples exhibited higher values than samples from the glacier itself. It is possible that the snowfields could be experiencing more dust contamination. If this was the case, this dust contamination was not visible to the naked eye. It is important to recognize that dust requires 60 times more mass to absorb the same amount of light as black carbon. As a result, having dust on the filter doesn't mean that the dust is a substantial contributor to the absorption (Schmitt pers. comm. 2015).

### Conclusion

This study demonstrated measurable quantities of black carbon in the Dinwoody glacier snowpack and adjacent snow fields. While these values are similar to other snowpacks sampled in North America, the presence of black carbon on a remote Wilderness headwater glacier may prove more consequential than anticipated. Next steps include additional sampling within crevasses on the Dinwoody, and determining the source of the black carbon.

### References

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