Report as of FY2010 for 2009NV150B: "Black Carbon in Sierra Nevada Snow: Impacts on Snowmelt and Water Supply"

Publications

- Other Publications:
    - Sterle, K.M., J.R. McConnell, J. Dozier, R. Edwards, and M. Flanner, Retention and radiative forcing of black carbon in eastern Sierra Nevada snow, Geophysical Research Letters, Submitted.
    - Sterle, K., and J. R. McConnell (2010) Black carbon science at DRI (Invited), Presented at the Impurities in Snow and Ice (ISI) Workshop, Silverton, USA.

Report Follows

Synopsis

The vast majority of Nevada's water supplies originate as mountain snow so quantitative understanding of processes that influence snow melt and spring runoff is critical to Nevada's economic growth and ecological sustainability. Black carbon (BC or soot) aerosols emitted during combustion and deposited on snow decrease reflectance, leading to enhanced snow pack warming, sublimation and melt, but sources of BC and impacts are poorly understood. Measurements of black carbon (BC) in a sequence of snow pits and surface snow samples in the eastern Sierra Nevada during the snow accumulation and melt seasons of 2009/10 showed that surface concentrations of BC were enhanced seven fold in surface snow (~25 ng/g) compared to bulk values in the snowpack (~3 ng/g). Unlike major ions which are preferentially released during initial melt, BC and continental dust were retained in the snow, enhancing concentrations late into spring, until a final flush well into the melt period. We estimate a combined BC and continental dust surface radiative forcing of 20 to 40 W/m^2 during April and May, with dust likely contributing a greater share of the forcing than BC.

Final Report

Problem and research objectives

Because >85% of Nevada's water supplies originate as mountain snow, quantitative understanding of processes that influence snow melt and spring runoff is critical to Nevada's economic growth and ecological sustainability. Although the sources and impacts are poorly understood, black carbon aerosols emitted during combustion and deposited on snow decrease reflectance, leading to enhanced snow pack warming, sublimation and melt. Because local emissions are significant, abatement efforts in Nevada and California could help preserve Sierra Nevada snow resources.

Primary objectives of this research were to (1) characterize concentrations of BC in fresh Sierra Nevada snow using samples from a series of snow pits excavated throughout the snow accumulation and snow melt seasons, (2) measure changes in concentration and movement of BC in snow during melt by comparing mean and layer snow pack concentrations during the snow accumulation and snow melt seasons , and (3) simulate surface radiative forcing from BC on snow throughout winter snow accumulation and spring melt periods using the Snow, Ice, and Aerosol Radiative (SNICAR) model. Field research primarily was conducted in 2009 and 2010 at two Sierra Nevada locations: the Cooperative Snow Study Site on Mammoth Mountain and the Sagehen Creek Field Station, both of which are administered by the U. of California.

Principal findings and significance

BC and continental dust concentrations measured in eastern Sierra Nevada snow in 2009 were significant enough to reduce snow albedo changes and alter water resources in the region. Temporal variability investigated at Mammoth suggests that BC accrued during the accumulation period because there was little melt or transport through the snowpack. During the melt season, BC was conserved in snowpack well after the initial elution of solutes, and remained stable well into the ablation season (with some relocation in the snowpack), until a final flush was observed at the end of the 2009 sampling period. BC concentrations at the surface continued to increase until the final flush near the end of May.

Comparisons of BC, continental dust, and major ions concentrations indicate that, unlike major ions which are preferentially released during initial melt, BC and continental dust are retained in the snowpack and then flushed well into the melt season. The retained BC and dust enhance radiative forcing in the eastern Sierra Nevada's spring snowpack, with dust contributing greater forcing than BC.

Although speculative, we hypothesize that melt scavenging ratios could provide better tracking of the ionic pulse and final release of BC and dust through the snowpack, particularly in the top 30 cm. Expanded sampling networks would improve quantification of BC in Sierra Nevada snow and future investigations of ice layers, source trajectories and duration of exposed surfaces would contribute to the understanding of high concentration layers that exist within the snowpack and vary inter-annually.

Papers:

This research formed the basis of K. Sterle's M.S. thesis "Black Carbon in Eastern Sierra Nevada Snow Pack" at the University of Nevada, Reno.

Sterle, K.M., J.R. McConnell, J. Dozier, R. Edwards, and M. Flanner, Retention and radiative forcing of black carbon in eastern Sierra Nevada snow, *Geophysical Research Letters, Submitted*.

Presentations:

Sterle, K., and J. R. McConnell (2010) Black carbon science at DRI (Invited), Presented at the *Impurities in Snow and Ice (ISI) Workshop*, Silverton, USA.