The Influence of Pollution Aerosols on Local and Regional Scale Colorado Snowpack

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Abstract. Cloud droplet nucleating aerosols have been found to modify the amount and spatial distribution of snowfall in mountainous areas where riming growth of snow crystals contributes substantially to the total snow water equivalent precipitation. In the Park Range of Colorado, a 2km deep supercooled liquid water orographic cloud frequently enshrouds the mountaintop during snowfall events. This leads to a seeder-feeder growth regime in which snow falls through the orographic cloud and collects cloud water prior to surface deposition. The addition of higher concentrations of cloud condensation nuclei (CCN) modifies the cloud droplet spectrum toward smaller size droplets and suppresses riming growth. Without rime growth, the density of snow crystals remains low and horizontal trajectories carry them further downwind due to slower vertical fall speeds. This leads to a downwind shift in snowfall accumulation known as the Spillover Effect.

Cloud resolving model simulations were performed (at 600m horizontal grid spacing) for several snowfall events over the Park Range of Colorado. The chosen events were well simulated and occurred during a winter field campaign in 2007 based at Storm Peak Laboratory in Steamboat Springs, CO. For each event, sensitivity simulations were run with various initial aerosol concentration vertical profiles that represent clean to polluted environments. Further, 60-day simulations that cover most of the Colorado mountains at 3km grid spacing were performed for the January-February periods of 2005 and 2006; similarly, sensitivity simulations representing clean and polluted aerosol conditions were performed to determine a potential seasonal impact on snowfall.

Results from both the individual high resolution simulated events and coarser resolution seasonal simulations indicate that under moist conditions, where orographically enhanced supercooled liquid water clouds are present, pollution aerosols can induce a snowfall spillover effect that essentially redistributes upwards of 10% of accumulated snow water from windward slopes to leeward slopes. A river basin analysis of the accumulated seasonal effects reveals that this snowfall spillover is most noticable in the San Juan mountain range in southwest Colorado. In these simulations, lee-side river basins tend to benefit from these pollution effects, while upwind basins experience a reduction in water resources.