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Mountain-valley circulation in central Chile: consequences for Black Carbon deposition over glaciers in wintertime and summertime

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The configuration of the Santiago basin, Chile (33.5°S 70.65°W) is quite unique in that it combines very strong emissions of urban anthropogenic pollutants with the steep topography of the coastal and Andes cordilleras surrounding the Metropolitan area. Interactions between atmospheric pollution and mountain meteorology are therefore exacerbated, and the potential for black carbon (BC) deposition on glaciers is strong. Based on chemistry-transport modeling with WRF-CHIMERE, we investigate (i) the pathways leading to deposition of BC from Santiago up to Andean glaciers in wintertime and (ii) the differences in magnitude and time dynamics of such deposition between wintertime and summertime.

Ice and snow in the central Andes contain significant amounts of BC often attributed to emissions from Santiago. However, given the usually stable conditions in wintertime and the height of the obstacle to overcome for urban air masses (Santiago is 500 m a.s.l., summits are above 4000 m a.s.l.) the pathways for such deposition are not straightforward. We find that, for a typical winter month, up to 40% of BC dry deposition on snow- or ice-covered areas in the central Andes directly downwind from the Metropolitan area can indeed be attributed to emissions from Santiago. The adjacent network of canyons plays a key role in this export: for the case of the Maipo canyon, polluted urban air masses follow gentle slopes upward in the afternoon, consistently with mountain-valley circulation, before being vertically exported when reaching the tip of the main canyon. Statistical analysis shows that zonal wind speed in the urban area and vertical diffusion deep into the canyon account for most of the variance in BC deposition.

In summertime, more intense convection takes place, and mountain-valley circulation is seldom perturbed by cloud cover, resulting in a greater export potential. Accordingly, summertime dry deposition of BC on glaciers occurs on a regular basis with equivalent amounts each day, contrarily to a more chaotic time series in wintertime. The contribution of wet deposition in winter (nonexistent in summer) exacerbates this irregularity. However, as a consequence of weaker emissions, average monthly dry deposition of BC over the central Andes glaciers (29°S to 38°S) is found to be less than half in summertime (135 μg/m^2) compared to wintertime (320 μg/m^2). Given the lesser role played by wood burning for residential heating in summertime, emissions from Santiago through traffic and industry dominate the signal leading to 55% of dry deposition, while it

accounts for only 14% in wintertime, at the regional scale, due to more scattered sources.