S1 Methods

We present here additional details of experimental or modeling methodologies.

S1.1 Snow samples. Filters treatment

All samples from snow pits were taken with an aluminum shovel, previously "rinsed" with fresh snow, and preserved in plastic bags (PP or PET). In 2016 campaign we also used a snow/firn hand auger to sample a $2.5\,\mathrm{m}$ snow/firn core (site *Acc2-2016*). The core was sampled in eight different fractions according to the in-situ stratigraphy (see Fig. 2 in the manuscript), which were also collected in plastic bags.

All samples were transported to the base camp and stored below melting temperature until processing. Sealed plastic bags were heated in a warm water bath in the mountain hut until complete melting. A fraction of the melted sample was filtered through a Millipore vacuum filter holder (XX1104700), with a plastic hand vacuum pump (XKEM00107). We used polycarbonate filters of $0.4\,\mu\mathrm{m}$ (2016) or $0.8\,\mu\mathrm{m}$ (2017) pore size. The filter material and pore size is thought to be appropriate to collect most of carbonaceous particles without increasing significantly the filtering time (Doherty et al., 2010). Filtered volume was measured after filtering, with a plastic measuring cylinder. All filters were kept in individual plastic boxes. Before field campaigns, unused filters were conditioned in a desiccator for at least 48 hs prior to weighting (Sartorius ME5-F microbalance and Mettler universal anti-static kit). Total PM was determined by weighting (with the same protocol) the $0.4\,\mu\mathrm{m}$ or $0.8\,\mu\mathrm{m}$ filters and subtracting the mass of the unused filters.

S1.2 Albedo corrections

Albedo values were obtained applying Equation S1, which includes corrections related with the diffuse or reflected light blocked by the operator or the support and, for upwelling radiation, the effect of shadows of the sensor and the support in the snow surface (Wright et al., 2014; Carmagnola et al., 2013).

$$\alpha = \frac{C_{shadow\uparrow} I_{refl\uparrow}}{C_{shadow\downarrow} I_{diff\downarrow} + I_{dir\downarrow}} \tag{S1}$$

$I_{refl\uparrow}$ is the upwelling reflected radiation, $I_{diff\downarrow}$ is the downwelling diffuse radiation and $I_{dir\downarrow}$ is the downwelling direct radiation. $C_{shadow\uparrow,\downarrow}$ are the correction factors that account for the light obstruction and shadows, and are calculated as follows:

$$C_{shadow\uparrow,\downarrow} = \left(\int_{0}^{\phi} \int_{\theta}^{\pi/2} \sin\theta \cos\theta \, d\theta \, d\phi \right) (1/\pi) \tag{S2}$$

where the integration angles ϕ and θ are represented in Fig. 3 (b) of the manuscript. These equations assume that reflected and diffuse radiation are isotropic. Even though it is known that this assumption is incorrect for the radiation reflected from snow (Dumont et al., 2010), the corresponding error is lower than the uncertainty of the measured albedo (Carmagnola et al., 2013).

To calculate shadows position we needed to calculate the effective incidence angle over the glacier slopes. A simple geometrical relationship was used (Lai et al., 2010):

$$\cos\gamma_{inc} = \cos\theta_{sl}\cos\theta_{zen} + \sin\theta_{sl}\sin\theta_{zen}\cos(\phi_{asp} - \phi_{az}) \tag{S3}$$

where γ_{inc} is the effective angle between the sunbeam and the normal of the sloped surface, θ_{zen} and ϕ_{az} are the zenith and azimuth angles of the sun, θ_{sl} is the average slope of the surface and ϕ_{asp} is the aspect of the slope, measured clockwise from the north.

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