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Carrington Event not recorded in nitrate in polar ice cores

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There is a strong requirement to better quantify the recurrence frequency of solar flare events of different magnitudes. One way to do that is to extend the observation of phenomena associated with the flares into the past. The idea has surfaced several times in the last 20 years that short-lived spikes of nitrate concentration observed in ice cores may be the result of solar energetic particle (SEP) events, and that their occurrence can therefore be used to extend the statistics of solar events. Despite a number of objections from the glaciological and atmospheric community, this idea is still popular in some communities, with particular emphasis placed on a large peak observed in once core in 1859, apparently contemporaneous with the Carrington Event. Here we re-examine ice core records for the period surrounding 1859, compiling more than 10 records that have the resolution required to observe such a sharp but strong nitrate signal. We show that no signal is seen in any of the cores from Antarctica for the years surrounding 1859. In Greenland, most cores have no signal in the ice dated to 1859, but some of them do have a nitrate spike within a few years of 1859. However, where other chemistry has been measured, it is found that the relevant nitrate spike (in common with most of the other nitrate spikes in the cores) is associated with an ammonium spike, which previous work has shown is characteristic of deposition from a biomass burning plume. We therefore conclude that many of the nitrate spikes seen in records to date are actually from biomass burning plumes passing over Greenland. Taking together the chemical fingerprint of the Greenland signal and the lack of spikes seen in Antarctica, we conclude that it is unlikely that there is any significant ice core nitrate enhancement that can be identified associated with the Carrington Event. While SEPs should enhance nitrate production at different layers in the atmosphere, and therefore should lead to a small broad peak in deposition to ice, it seems unlikely that the statistics of such events are accessible from ice cores.