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On the use of trace metals in non-polar ice to identify anthropogenic source processes in industrialized regions

Content

Human activities have emitted numerous trace metal species to the atmosphere in the past, sometimes well before the onset of industrialization (~1850 AD). Air and precipitation monitoring available since 1990 permit evaluation of the post 1990 decline of emissions of various metals. The records of trace metals in ice contain useful information on past emissions, and are especially useful for placing recent atmospheric observations into a longer-term context, thereby allowing assessment of the impact of human activities on the natural atmosphere.

Trace metals archived in ice also can serve as potential proxies of specific anthropogenic processes such as coal burning, oil combustion, mining, non-ferrous smeltering, pig iron and steel manufacturing, as well as alloy and aluminum manufacturing. The identification of such proxies underpins deciphering of the contribution of the different processes contributing other forms of pollution such as sulfur and nitrogen species.

It has to be recognized, however, that among metals that were previously investigated in non-polar ice, studies often failed to identify a unique anthropogenic process modulating a given observed trend in ice. In the best case, previous conclusions were drawn on qualitative examination of correlation over time between different species and no quantitative comparison between estimated past emission versus ice-core data was attempted. Here we examine the trend of several metals archived over the 20th century in the Col du Dome ice cores and compare them with available estimates of past anthropogenic emissions. We show that a multi-metal record does not necessary help to identify the anthropogenic sources since in many cases one metal may have several origins. Lead (Pb) is an excellent example with successive sources being smelters, coal burning, pig iron and leaded-gasoline. Furthermore, a good correlation observed in the temporal trend of two metals does not necessarily mean that they have a common source. For instance, molybdenum (Mo) and vanadium (V) both increased rapidly in Alpine ice after 1950 suggesting a common source, whereas in Europe the major V emissions came largely from petroleum combustion while those from Mo were predominately from the metallurgy, although both emission sources increased quickly after 1950. An additional difficulty of the multiparameter approach lies in the fact that for most metals, emission factors changed over time and not by the same magnitude.

We here review the case of Pb, zinc (Zn), cadmium (Cd), V, Mo, manganese (Mn), chromium (Cr), thallium (Tl), etc. In only in a few cases were we able to identify unambiguously a good proxy for a single anthropogenic process.

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