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Modelling the surface deposition of meteoric smoke particles

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The flux of meteoric smoke particles (MSPs) in Greenland and Antarctica has been measured using Ir and Pt observations in ice cores, by Gabrielli et al. [1,2]. They obtained MSP deposition fluxes of $1.5 \pm 0.45 \times 10^{-4}$ g m^{-2} yr^{-1} (209 ± 63 t d^{-1}) in Greenland and $3.9 \pm 1.4 \times 10^{-5}$ g m^{-2} yr^{-1} (55 ± 19 t d^{-1}) in Antarctica, where the values in parentheses are total atmospheric inputs, assuming a uniform global deposition rate. These results show reasonable agreement with those of Lanci et al. [3], who used ice core magnetisation measurements, resulting in MSP fluxes of $1.7 \pm 0.23 \times 10^{-4}$ g m^{-2} yr^{-1} (236 ± 50 t d^{-1}) (Greenland) and $2.0 \pm 0.52 \times 10^{-5}$ g m^{-2} yr^{-1} (29 ± 5.0 t d^{-1}) (Antarctica).

Atmospheric modelling studies have been performed to assess the transport and deposition of MSPs, using WACCM (Whole Atmosphere Community Climate Model), and the CARMA (Community Aerosol and Radiation Model) aerosol microphysics package. An MSP input function totalling 44 t d^{-1} was added between about 80 and 105 km. Several model runs have been performed in which the aerosol scavenging by precipitation was varied. Wet deposition is expected (and calculated here) to be the main deposition process; however, rain and snow aerosol scavenging coefficients have uncertainties spanning up to two and three orders of magnitude, respectively [4]. The model experiments that we have carried out include simple adjustments of the scavenging coefficients, full inclusion of a parametrisation reported by Wang et al. [4], and a scheme based on aerosol removal where relative humidity > 100 %. The MSP fluxes obtained vary between 1.4×10^{-5} and 2.6×10^{-5} g m^{-2} yr^{-1} for Greenland, and 5.1×10^{-6} and 1.7×10^{-5} g m^{-2} yr^{-1} for Antarctica. These values are about an order of magnitude lower than the Greenland observations, but show reasonable agreement for Antarctica.

The UM (Unified Model), UKCA (United Kingdom Chemistry and Aerosols Model), and GLOMAP (GLObal Model of Aerosol Processes) have also been used. The maximum height of this model is 85 km, and so MSP concentrations have been taken from WACCM and imposed above about 65 km. The important MSP-sulphate interaction has only very recently been implemented in GLOMAP. GLOMAP contains a modal treatment of aerosol microphysics, in contrast to the full sectional description in CARMA. The predicted evolution of the MSP size distribution and deposition fluxes from both models will be compared.

[1] P. Gabrielli et al., Nature 432, 1011 (2004)

[2] P. Gabrielli et al., Earth Planet. Sci. Lett. 250, 459 (2006)

[3] L. Lanci et al., Quaternary Sci. Rev. 33, 20 (2012)

[4] X. Wang et al., Geosci. Model Dev. 7, 799 (2014)