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Evaluation of historical SO_2 emissions based on an inversion of ice core records using atmospheric transport modeling

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Sulfur dioxide (SO_2) is an air pollutant which can have harmful effects on both human health and the environment. Furthermore, SO_2 also contributes to climate change — SO_2 emissions form sulfate aerosols that act as cloud condensation nuclei, increasing cloud formation and decreasing solar radiation reaching the surface. An accurate knowledge of past SO_2 emissions is therefore essential to quantify and model the associated global climate forcing. Current bottom-up SO_2 emission inventories used for historical Earth System Modeling (ESM) are poorly constrained by observations prior to the late 20th century.

Here we revisit and evaluate the historical SO_2 emission inventories of the last 150 years used in the Coupled Model Intercomparison Project Phase 6 (CMIP6). Our emission reconstruction is based on an inversion technique employing an array of ice core records of deposited sulfur and atmospheric transport/deposition modeling. The inversion technique minimizes discrepancies between the spatial-temporal patterns of emission inventories and the observed deposition at the ice core sites.

We find substantial differences between reconstructed SO_2 emissions and existing bottom-up inventories which do not fully capture the spatial-temporal emission patterns. Our results imply that changes to existing historical emission inventories might be necessary in order to ensure an accurate modeling of the Earth's climate sensitivity within future ESM simulations.