The contribution of Saharan dust to the ice-nucleating particle concentrations at the High Altitude Station Jungfraujoch (3580 m a.s.l.), Switzerland

JournalArticle (Originalarbeit in einer wissenschaftlichen Zeitschrift)

ID 4636482
Author(s) Brunner, Cyril; Brem, Benjamin T.; Collaud Coen, Martine; Conen, Franz; Hervo, Maxime; Henne, Stephan; Steinbacher, Martin; Gysel-Beer, Martin; Kanji, Zamin A.
Author(s) at UniBasel Conen, Franz ;
Year 2021
Title The contribution of Saharan dust to the ice-nucleating particle concentrations at the High Altitude Station Jungfraujoch (3580 m a.s.l.), Switzerland
Journal Atmospheric chemistry and physics
Volume 21
Number 23
Pages / **Article-Number** 18029-18053
The ice phase in mixed-phase clouds has a pivotal role in global precipitation formation as well as for Earth's radiative budget. Above 235 K, sparse particles with the special ability to initiate ice formation, ice-nucleating particles (INPs), are responsible for primary ice formation within these clouds. Mineral dust has been found to be one of the most abundant INPs in the atmosphere at temperatures colder than 258 K. However, the extent of the abundance and distribution of INPs remains largely unknown. To better constrain and quantify the impact of mineral dust on ice nucleation, we investigate the frequency of Saharan dust events (SDEs) and their contribution to the INP number concentration at 243 K and at a saturation ratio with respect to liquid water (S-w) of 1.04 at the High Altitude Research Station Jungfraujoch (JFJ; 3580 m a.s.l.) from February to December 2020. Using the single-scattering albedo Angstrom exponent retrieved from a nephelometer and an Aethalometer, satellite-retrieved dust mass concentrations, simulated tropospheric residence times, and the attenuated backscatter signal from a ceilometer as proxies, we detected 26 SDEs, which in total contributed to 17 % of the time span analyzed. We found every SDE to show an increase in median INP concentrations compared to those of all non-SDE periods; however, they were not always statistically significant. Median INP concentrations of individual SDEs spread between 1.7 and 161 INP std L-1 and thus 2 orders of magnitude. In the en- tire period analyzed, 74.7 +/- 0.2 % of all INPs were measured during SDEs. Based on satellite-retrieved dust mass concentrations, we argue that mineral dust is also present at JFJ outside of SDEs but at much lower concentrations, thus still contributing to the INP population. We estimate that 97 % of all INPs active in the immersion mode at 243 K and S-w = 1.04 at JFJ are dust particles. Overall, we found INP number concentrations to follow a leptokurtic lognormal frequency distribution. We found the INP number concentrations during SDEs to correlate with the ceilometer backscatter signals from a ceilometer located 4.5 km north of JFJ and 1510 m lower in altitude, thus scanning the air masses at the same altitude as JFJ. Using the European ceilometer network allows us to study the atmospheric pathway of mineral dust plumes over a large domain, which we demonstrate in two case studies. These studies showed that mineral dust plumes form ice crystals at cirrus altitudes, which then sediment to lower altitudes. Upon sublimation in dryer air layers, the residual particles are left potentially pre-activated. Future improvements to the sampling lines of INP counters are required to study whether these particles are indeed pre-activated, leading to larger INP number concentrations than reported here.
ISSN/ISBN 1680-7316
URL https://doi.org/10.5194/acp-21-18029-2021