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Mineral dust: observations of emission events and modeling of transport to the upper troposphere

T. Peter (1), A. Wiacek (2), and M. Taddeo (1)

(1) ETH Zürich, Atmosphere and Climate, Zürich, Switzerland (thomas.peter@env.ethz.ch, +41-(0)1-6331058), (2) Department of Physics and Atmospheric Science, Dalhousie University, Halifax, NS, B3H 3J5, Canada (aldona.wiacek@dal.ca)

The present study explores differences between mineral dust emission events in West African and Asian (Taklimakan) deserts, focusing on the availability of bare mineral dust ice nuclei for interactions with cirrus clouds without previous processing or washout by liquid water clouds. One-week trajectory calculations with high-resolution ECMWF fields are used to track transported (Lagrangian) relative humidities with respect to liquid water and ice, allowing to estimate the formation of liquid, mixed-phase and ice clouds. Transport trajectories can reasonably be assumed to carry dust with them throughout the year, except for the months of December-February, which are quiescent with respect to dust emission in both regions. Practically none of the simulated air parcels reach regions where homogeneous nucleation can take place ($T < -35°C$) along trajectories that have not experienced water saturation first, i.e. it is very unlikely that mineral dust particles could be a serious competitor for homogeneous nucleation during the formation of high, cold cirrus clouds. For the temperature region between $-35°C < T < 0°C$, i.e. in air parcels exhibiting necessary conditions for warmer ice clouds at lower altitudes, a small but significant number of air parcels are found to follow trajectories where $RHw < 100\%$ and $RHi > 100\%$ are simultaneously maintained. However, the potential for such low ice clouds originating from the Taklimakan desert is greater than that of the Sahara by a factor of 4-6. The implication is that although the Sahara is by far the biggest source of dust in the world, the much smaller Taklimakan desert in China's Tarim Basin may be of greater importance as a source of ice nuclei affecting cirrus cloud formation. This is likely the result of several meteorological factors, including the complex regional topography combined with the higher altitude of Taklimakan dust emissions and, on the synoptic scale, the higher altitude of potential temperature levels in the free troposphere at mid-latitudes than in the tropics. Finally, the very active Bodélé source region in Africa and the Gobi Desert in Asia will also be addressed.