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- Title and Author Search

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[Volumes and Issues](#) [Contents of Issue 3](#) [Special Issue](#)

Atmos. Chem. Phys., 10, 1105-1120, 2010

www.atmos-chem-phys.net/10/1105/2010/

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Particle formation in the Arctic free troposphere during the ASTAR 2004 campaign: a case study on the influence of vertical motion on the binary homogeneous nucleation of H₂SO₄/H₂O

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Abstract. During the ASTAR (Arctic Study of Tropospheric Aerosol and Radiation) campaign nucleation mode particles (4 to 13 nm) were quite frequently observed at altitudes below 4000 m. However, in the upper free troposphere, nucleation mode particles were only observed once, namely during the flight on 24 May 2004 (7000 m). To investigate if vertical motion were the reason for this difference that on one particular day nucleation mode particles were observed but not on the other days we employ a microphysical box model. The box model simulations were performed along air parcel trajectories calculated 6-d backwards based on European Center for Medium-Range Weather Forecasts (ECMWF) meteorological analyses using state parameters such as pressure and temperature in combination with additional parameters such as vertical stability. Box model simulations were performed for the 24 May where nucleation mode particles were observed (nucleation event) as well as for the days with measurements before and after (22 and 26 May) which are representative for no nucleation (non-nucleation event). A nucleation burst was simulated along all trajectories, however, in the majority of the simulations the nucleation rate was either too low or too high so that no nucleation mode particles were left at the time when the measurements were performed. Further, the simulation results could be divided into three cases. Thereby, we found that for case 1 the temperature was the only driving mechanism for the formation of new particles while for case 2 and 3 vertical motion have influenced the formation of new particles. The reason why nucleation mode particles were observed on 24 May, but not on the other days, can be explained by the conditions under which particle formation occurred. On 24 May the particle formation was caused by a slow updraft, while on the other two days the particle formation was caused by a fast updraft.

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Citation: Khosrawi, F., Ström, J., Minikin, A., and Krejci, R.: Particle formation in the Arctic free troposphere during the ASTAR 2004 campaign: a case study on the influence of vertical motion on the binary homogeneous nucleation of H₂SO₄/H₂O, Atmos. Chem. Phys., 10, 1105-1120, 2010. [Bibtex](#) [EndNote](#) [Reference Manager](#)

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