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Observations of meteoric material and implications for aerosol nucleation in the winter Arctic lower stratosphere derived from in situ particle measurements

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Abstract. Number concentrations of total and non-volatile aerosol particles with size diameters >0.01 µm as well as particle size distributions (0.4–23 µm diameter) were measured in situ in the Arctic lower stratosphere (10–20.5 km altitude). The measurements were obtained during the campaigns European Polar Stratospheric Cloud and Lee Wave Experiment (EUPLEX) and Envisat-Arctic-Validation (EAV). The campaigns were based in Kiruna, Sweden, and took place from January to March 2003. Measurements were conducted onboard the Russian high-altitude research aircraft Geophysica using the low-pressure Condensation Nucleus Counter COPAS (COndensation PArticle Counter System) and a modified FSSP 300 (Forward Scattering Spectrometer Probe). Around 18–20 km altitude typical total particle number concentrations n_t range at 10–20 cm^{-3} (ambient conditions). Correlations with the trace gases nitrous oxide (N_2O) and trichlorofluoromethane (CFC-11) are discussed. Inside the polar vortex the total number of particles >0.01 µm increases with potential temperature while N_2O is decreasing which indicates a source of particles in the above polar stratosphere or mesosphere. A separate channel of the COPAS instrument measures the fraction of aerosol particles non-volatile at 250° C. Inside the polar vortex a much higher fraction of particles contained non-volatile residues than outside the vortex (~67% inside vortex, ~24% outside vortex). This is most likely due to a strongly increased fraction of meteoric material in the particles which is transported downward from the mesosphere inside the polar vortex. The high fraction of non-volatile residual particles gives therefore experimental evidence for downward transport of mesospheric air inside the polar vortex. It is also shown that the fraction of non-volatile residual particles serves directly as a suitable experimental vortex tracer. Nanometer-sized meteoric smoke particles may also serve as nuclei for the condensation of gaseous sulfuric acid and water in the polar vortex and these additional particles may be responsible

for the increase in the observed particle concentration at low N_2O. The number concentrations of particles >0.4 µm measured with the FSSP decrease markedly inside the polar vortex with increasing potential temperature, also a consequence of subsidence of air from higher altitudes inside the vortex. Another focus of the analysis was put on the particle measurements in the lowermost stratosphere. For the total particle density relatively high number concentrations of several hundred particles per cm^3 at altitudes below ~14 km were observed in several flights. To investigate the origin of these high number concentrations we conducted air mass trajectory calculations and compared the particle measurements with other trace gas observations. The high number concentrations of total particles in the lowermost stratosphere are probably caused by transport of originally tropospheric air from lower latitudes and are potentially influenced by recent particle nucleation.

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