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Airborne Measured New Particle Formation Event in the Atmospheric Boundary Layer

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A new particle formation (NPF) event measured by unmanned aerial systems is presented. The NPF occurred during the morning transition of the atmospheric boundary-layer near Melpitz, Germany, during springtime. Airborne measurements were able to capture the morning transition continuously from a shallow convective boundary layer below a strong capping inversion layer to a mixed boundary layer with high temporal and spatial resolution of thermodynamics, turbulence and nucleation mode particles number concentrations. Airborne measured vertical profiles from the surface up to 1000 m show the start of a NPF event with enhanced concentrations of nucleation mode particles within the thermal inversion.

We show that the inversion layer was responsible for creating favorable thermodynamic conditions for a NPF. Strong gradients of mean potential temperature and mixing ratio, as well as a 10 times higher temperature structure parameter CT2 and 5 times higher humidity structure parameter CQ2 than in the remaining parts of the vertical profile were observed in the inversion. Only high turbulent fluctuations of temperature and humidity plus relatively high dissipation rates create the conditions for supersaturation of precursor gases due to non-linear mixing.

Further an anti-correlation of temperature and humidity fluctuations is observed in the layer, where new particle formation is assumed.

Our observations support the hypothesis that NPF is likely to be initiated by the thermodynamics and turbulence of the inversion.

With the estimation of turbulent mixing and dissipation rates we could prove that the downward transport of particles by convective eddies is the cause of the sudden increase of nucleation mode particles in ground data. Thus, it is very likely that these particles observed at the ground were formed locally at higher altitudes and mixed downwards.

These observations have consequences for the interpretation of many earlier published ground-based observations of new NPF. In the morning, stable thermal stratification may trap enhanced concentrations of nucleation mode particles. Once daytime convection initiates,

turbulence mixes the boundary layer, and the vertical profile of nucleation mode particles becomes more homogeneous. Without the airborne in-situ measurements, the observations at ground level could lead to a misinterpretation of location and processes causing the increase in nucleation mode particles.