The understanding of the evolution of the particle number size distribution and aerosol dynamics effects has recently attracted considerable interest. In this paper, a new developed trajectory model for Aerosol Dynamics, gas phase CHEMistry and radiative transfer calculations (ADCHEM) has been applied to study the transformation of the particle number size distribution from the local-sub-grid scale to the regional scale. Multi aerosol dynamics was included in the vertical direction following the air mass trajectories. We implemented a detailed emission inventory including particle number size distributions with high spatial resolution (1km x 1km) for local traffic sources and lower resolution for other sources. The modelling results have been compared to the measured data at a rural site upwind of (LVBY), to an urban background site (HCOE), and to a regional background site (VVHL). The effects of different aerosol dynamic processes were evaluated. The model shows good agreement with measurements for the increase of the NOx levels from the rural site LVBY to the urban site HCOE for different case studies. This confirms the performance of the model in terms of atmospheric dispersion and the included emission inventory. The total particle number concentrations were fairly well predicted, and corresponding size distributions at the three stations are shown in Figure 1 for one of the cases. Deposition, coagulation and condensation processes have large effects on particles less than 100 nm in diameter. These processes can therefore not be neglected when dispersion models are used to predict particle number concentrations on regional scales.