Particle Number Concentrations over Europe in 2030: The Role of Emissions and New particle Formation

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The aerosol particle number concentration is a key parameter when estimating impacts of aerosol particles on climate and human health. Aerosol particles may be emitted directly (primary particles) or form in the atmosphere by homogeneous nucleation (secondary particles).

We use a three-dimensional chemical transport model with detailed microphysics, PMCAMx-UF, to simulate particle number concentrations over Europe in the year 2030, by applying emission scenarios (Amann et al., 2012) for trace gases and primary aerosols focusing on a photochemically active period. The emission scenarios include anthropogenic sulphur dioxide, ammonia, nitrogen oxides, and primary aerosol particles with a diameter less than 2.5 µm ($PM_{2.5}$) (Table 1). We test three different emission scenarios: a Baseline scenario assuming full implementation of existing air pollution control legislation in the European Union; a Maximum Technically Feasible Reduction (MTFR) scenario exploring to what extent emissions could be further reduced through full application of available technical measures; and a Maximum Control Efforts (MCE) scenario exploring the ultimate emission reductions that could be achieved through rapid decarbonisation, application of all available air pollution control technologies, and a change of diets to include less meat.

Table 1. Percentage change in emissions over Europe 2005-2030 (Amann et al., 2012).

	SO_2	NH_3	$PM_{2.5}$	NO_x
Baseline	-73	0	-38	-66
MTFR	-82	-30	-69	-75
MCE	-85	-40	-74	-90

Figure 1a shows the predicted percentage change in total particle number concentration (N_{tot}) over Europe from applying the baseline emission scenario in PMCAMx-UF. In general, a reduction of 40-70% in N_{tot} is predicted over continental Europe, resulting from the reduced emissons (Table 1). However, in some local areas, Figure 1a indicates enhanced total particle number concentrations. Since $PM_{2.5}$ emissions have been reduced, these locally enhanced concentrations must be associated with increasing new particle formation due to a reduced condensation sink following from the reduction in concentrations of primary particles. For particles larger than 100 nm (N_{100}) (Figure 1b), concentrations are predicted to decrease all over Europe; reductions of 60-80% are predicted over southeastern Europe, while reductions of 30-60% are predicted over most other parts of Europe.

The predicted decrease in N_{tot} is mainly a result of reduced new particle formation due to the expected reduction in SO_2 emissions, and the predicted decrease in N_{100} is a result of both decreasing condensational growth and reduced primary aerosol emissions. Sensitivity tests reveal that a reduction in SO_2 emissions is far more efficient than any other emission reduction investigated in reducing N_{tot}. For N_{100}, emission reductions of both SO_2 and $PM_{2.5}$ contribute significantly to the reduced concentration. The predicted reductions in both N_{tot} and N_{100} in this study will likely reduce both the aerosol direct and indirect effects, and limit the damaging effects of aerosol particles on human health in Europe.

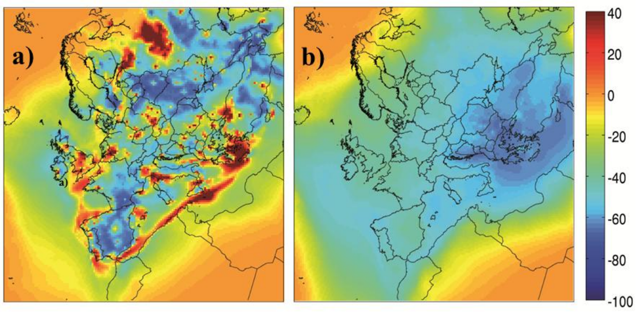

Figure 1. Mean percentage change in particle number concentration between 2008 and 2030 according to the baseline scenario for N_{tot} (a) and N_{100} (b).

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