Effects of size distributions from two distinct polluted environments on dry deposition of atmospheric aerosols

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Resumo

Um modelo matemático simples foi utilizado para estudar o efeito da distribuição de tamanho das partículas sobre a eficiência de remoção por deposição seca. Para esta finalidade foram utilizadas duas distribuições de tamanho de aerossóis, típicas de ambientes poluídos: uma distribuição de ambiente de queimada (Amazônia) e outra de ambiente urbano (São Paulo). Os resultados mostraram que partículas originárias de ambiente urbano são mais eficientemente removidas por deposição seca do que partículas de queimada. Este comportamento está associado ao fato de que a natureza de remoção das partículas por deposição seca é pouco eficiente para diâmetros entre 0,1 e 1,0 mm, domínio em que se concentra a maior parte das partículas de queimada. Esse mecanismo diferencial de deposição é o que explica o maior efeito deletério das partículas ultra-finas no sistema respiratório humano.

1. Introduction

A number of aerosol-related processes determine the dynamic of the size distribution and contribute to the direction of the total aerosol flux. Emission, nucleation, coagulation, wet removal, sedimentation and dry deposition are the most important processes in the aerosol system. The contribution of individual aerosol processes to the total mass variation in the surface-atmosphere interface is very dependent on atmospheric condition and intrinsic nature of the size distribution. In order to pursue this conjecture, the authors of this work have carried out a comparative numerical evaluation of two distinct regions under polluted atmospheric conditions.

2. Methodology

Using a simple mathematical formulation that includes dry deposition and sedimentation, a numerical evaluation of the impact of size distribution on removal of particles was performed. The parameterisation described by Seinfeld and Pandis (1998) was employed. Two size distributions measured in the polluted locations of São Paulo (September 3, 2003) and Rondônia (September 21, 2002) were used as initial conditions. The selected samples represent a concentration of about 18000 cm^{-3} and are shown in Figure 1.

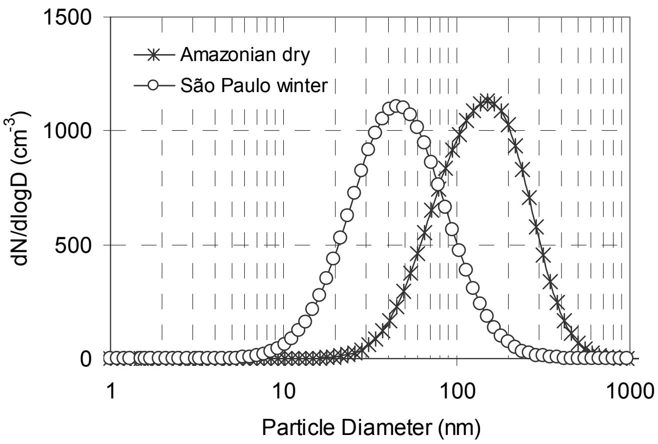

Figure 1. Aerosol size distributions under distinct pollution regimes: biomass burning (Amazônia) and urban (São Paulo).

3. Results and discussion

The two selected aerosol size distributions described before were submitted to the effect of dry deposition for 12 hours of simulation. Neutral stability condition was also assumed. The effect of dry deposition in removing particles was more efficient for distributions associated with urban environment. Biomass burning aerosols suffered less significant impact. Assuming a level of 100 m above the ground as reference, during the 12 hours of simulation, the aerosol concentration was reduced in 76% and 39% for urban and biomass burning environments, respectively. At the level of 1000 m above surface, these values were 18% and 5%. Figure 2 shows the comparisons between the initial and final aerosols size distributions for the polluted environments at 100 m level.

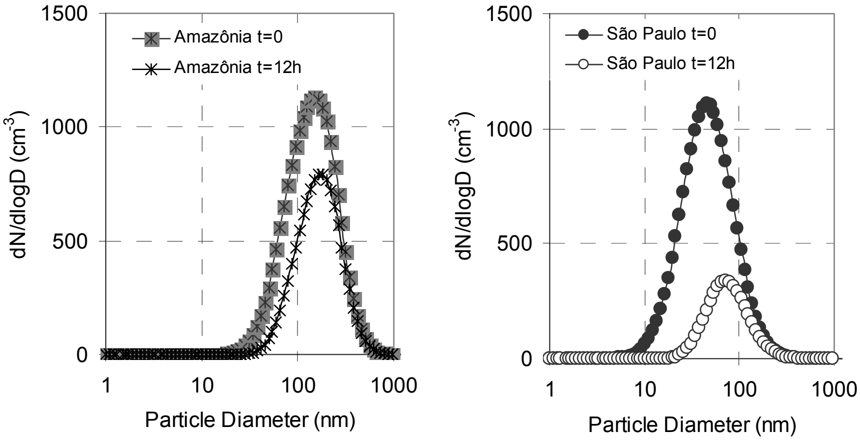

Figure 2. Evolution of the aerosol size distributions under effect of dry deposition after 12 h of simulation at 100 m above ground.

Deposition velocity is very dependent on particle diameter. The predominant decreasing in urban aerosols is caused by Brownian diffusion process that is more efficient to small particles, normally with diameter less than about 100 nm. The particle size distribution from biomass burning (Amazônia) has a large geometric-mean diameter, and Brownian diffusion is not so efficient in removing the particles in this size bin. Gravitational sedimentation becomes efficient for particles with diameter larger than 1 mm. This is not the case of biomass burning aerosols. So, the nature of the dry deposition process reveals that there is a size range of very low deposition velocities for particles, from 0.1 to 1.0 m. Thus, our numerical results show that biomass burning aerosols, which predominate in this size range, will be less efficiently removed from the atmosphere.

4. Conclusions

Using mathematical formulation of parameterisations typically employed in atmospheric models we could see that there is a minimum in deposition velocity of particles within 0.1 to 1.0 mm diameter range. Biomass burning aerosols from the Amazonian region during dry season has a geometric-mean diameter centred in this range. Differently, urban aerosols from São Paulo have a geometric-mean diameter smaller than

0.1 mm, being much more efficiently removed. Therefore, one could conclude that aerosols from biomass burning, which predominates in the size range from 0.1 to 1 mm, will reside in the atmosphere for a long time period, being more transported over long distances than particles from urban atmosphere.

5. References

Seinfeld, John H.; Pandis, Spyros N., 1998: Atmospheric Chemistry and Physics - From Air Pollution to Climate Change. John Wiley and Sons, Inc.