No portion of the work referred to in this thesis has been submitted in support of an application for another degree or qualification of this or any other University, or any other institution of learning

Abstract

Novel measurements of aspects of surface atmosphere exchange of aerosol are presented. These were gathered using a custom designed and built eddy covariance system based around a modified commercially available particle counter.

Aerosol flux measurements have been made above a managed grass canopy of variable height. The analysis shows that accumulation mode (0.1 μm < D_p < 0.2 μm) aerosol deposition velocities are 1.13 mm s^{-1} and 0.87 mm s^{-1} to long and short grass canopies respectively. The corresponding fine mode deposition velocities are 0.275 mm s^{-1} and 0.066 mm s^{-1}, where the long canopy height is 0.65 m – 1.0 m with a roughness length of 0.063 m and the short canopy height 0.07 m – 0.14 m with a roughness length of 0.022 m. These fine mode fluxes are shown to be representative of aerosol in the diameter range 11nm < D_p < 100 nm.

Fertilisation of the short grassland with 100 kg N ha^{-1} is shown to cause aerosol growth, the postulated cause being simultaneous condensation of ammonia and nitric acid onto the surface of existing particles. Diameter growth rates at 11 nm were calculated, ranging between zero and around 3490 nm hr^{-1}. This large systematic growth is shown to persist for around five days following fertilisation of the canopy.

Measurements have been made above the City of Edinburgh (UK). Aerosol concentration, number flux and emission velocity (11 nm < Dp < 3 μm; D_3) are presented, and the results shown to be representative of the sub-100 nm size interval. Aerosol (D_3) concentrations are found typically to range between 3,000 cm^{-3} and 20,000 cm^{-3}. The mean D_3 aerosol flux is found to be 42,500 cm^{-2} s^{-1}, with the mode being 30,000 cm^{-2} s^{-1} and a typical range of 9,000 cm^{-2} s^{-1} to 90,000 cm^{-2} s^{-1}. The mean and mode emission velocities are 45 mm s^{-1} and 35 mm s^{-1} respectively, typically ranging from 20 mm s^{-1} to 75 mm s^{-1}. It is shown that urban aerosol concentration can be adequately modelled by the following, where ζ is the stability parameter, A = 13,000, b = 1.6, $\overline{U}$ = wind speed and χ = concentration (cm^{-3}):

$$\chi = \frac{A \cdot e^{bT}}{\overline{U}^{-0.3}} \cdot 11 \cdot e^{(-\zeta)^{-0.3}} - 3 \qquad \zeta < 0$$

$$\chi = \frac{A \cdot e^{bT}}{\overline{U}^{-0.3}} \cdot \left(80 - 45 \cdot (\zeta)^{0.36}\right) \qquad \zeta \geq 0$$

The energy balance for an urban area is examined. It is demonstrated that the non-radiative heating is equivalent to the addition of 44 W m^{-2} to the system. Of this additional energy, which is assumed to be anthropogenic in origin, it is estimated that around 30% is derived from fossil fuel combustion within the city.

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