Pergamon

J. Aerosol Sci. Vol. 29, Suppl. 1, pp. S1097–S1098, 1998

Printed in Great Britain
0021-8502/98 $19.00 + 0.00

THE EFFECT OF DRIZZLE ON THE REDISTRIBUTION OF AEROSOL IN THE BOUNDARY LAYER: ESTIMATION OF THE SCALE OF THE EFFECT DURING ACE-2 USING AIRCRAFT DATA.

R. WOOD, D. W. JOHNSON and S.OSBORNE.

Meteorological Research Flight, Building Y46, DERA, Farnborough, Hants GU14 6TD, UK
Tel: ++44 1252 395416, fax: ++44 1252 376588, email: robwood@meto.gov.uk

KEYWORDS

ACE-2; Aerosol; Coalescence; Drizzle; Stratocumulus; Aircraft Measurements

The aerosol characteristics in a maritime boundary layer can have important effects upon cloud nucleation and coalescence processes (Beard and Ochs, 1993) and radiative effects (Twomey, 1977). It is therefore of primary interest to understand the processes by which the aerosol population can be modified by the cloud itself. One potentially important process is the removal and redistribution of aerosol by drizzle in stratocumulus-topped boundary layers (STBL) which may affect cloud lifetime.

Data taken using the Meteorological Research Flight C-130 aircraft during the EU funded Aerosol Characterisation Experiment (ACE-2) around the Canary islands are presented. Estimation of the precipiation rate close to cloud base is made using measured cloud droplet spectra for droplet radii (1-400 μm). Humidity profiles from close to the surface up to cloud-base are then used to model the evolution of the drizzle spectrum as the drops fall and evaporate below cloud-base. The precipiation rate at the surface can then be calculated. An example of the droplet evaporation upon falling out of cloud is given in figure 1 which shows the radius as a function of height for two drops with initial sizes of 150 μm and 300 μm at cloud-base (750 m). The smaller drop evaporates completely before it reaches the surface and thus would leave its aerosol content in the boundary layer where it could potentially be recycled into the cloud. In contrast, the larger drop does not evaporate completely and reaches the surface. The aerosol within this drop would be removed from the boundary layer.

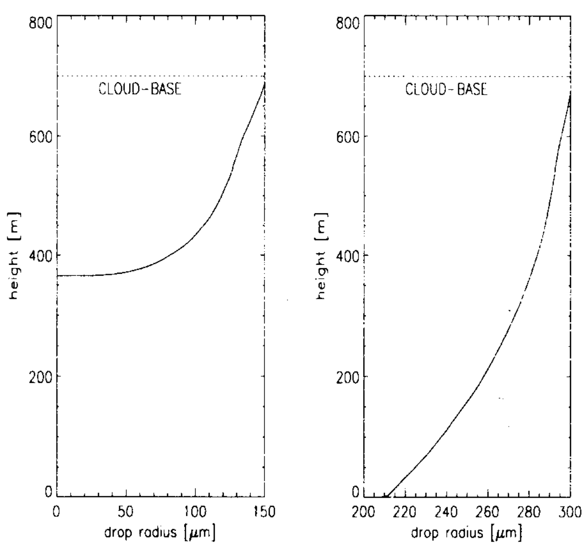

Figure 1: Examples of the behaviour of drops upon falling below cloud-base. The drop radius is plotted against the height for initial drop radii of 150 μm (left) and 300 μm (right).

Parameters of interest to atmospheric chemists and meteorologists are the rate of change of the aerosol concentration and total aerosol mass through droplet coalescence. These two parameters are affected in different ways by coalescence and drizzle fallout. Aerosol mass is lost only in drizzle drops that reach the surface whereas the number concentration of aerosols is reduced by all coalescence events regardless of whether drizzle-sized drops are formed. Given that the production of drizzle is a sign of enhanced coalescence within the cloud then one would expect a greater reduction in aerosol number when drizzle drops are formed, but it is coalescence itself that is mainly responsible for the fall in aerosol number concentration.

Quantitative estimates of the rate of reduction of aerosol mass and number are difficult to make because of the considerable doubt still remaining about the influence of aerosols on the growth of cloud droplets (Hudson and Yum, 1997). In this analysis it is assumed that the number of dissolved aerosol particles, all of which are identical, in a drizzle drop of radius r_d formed from the coalescence of cloud droplets of radius r_c is equal to $(r_d/r_c)^3$. A major source of uncertainty in the analysis is the choice of r_c and r_d, which have been chosen to be equal to the mean volume radii r_v of the measured droplet spectrum for radii less than 25 μm and greater than 25 μm respectively. The mass of a single aerosol particle is estimated using the observed cloud droplet concentration and 0.01-10 μm radius aerosol size spectrum below cloud-base. The rate of loss of total aerosol mass to the surface is then calculated using the number and size spectrum of the drops that reach the surface. The rate of loss of aerosol number is dependent not on the rate at which drops reach the surface but upon the rate at which liquid water is removed from the base of the cloud, as this is determined by the rate of coalescence.

Initial results suggest that the rate of loss of aerosol mass during ACE-2 is small during the daytime as the cloud-base is sufficiently high, and the relative humidty below cloud-base sufficiently low, to cause evaporation of most of the drizzle mass leaving the cloud-base. During the night however, when on several days thick drizzling stratocumulus formed with cloud-bases less than 300 m high, the aerosol mass removal rate is greater although the rate of loss per hour of aerosol mass is usually less than 1% of the total aerosol mass.

ACKNOWLEDGEMENTS

This work received financial support from EU contract no. ENV4-CT95-0032 and DETR.

REFERENCES

Beard, K. V. and H. T Ochs III, 1993: Warm-rain initiation: An overview of microphysical mechanisms. *J. Atmos. Sci.* **32**, 608-625

Hudson, J. G. and S. S. Yum, 1997: Droplet spectral broadening in marine stratus. *J. Atmos. Sci.*, **54**, 2642-2654.

Twomey, S., 1977: The influence of pollution on the shortwave albedo of clouds. *J. Atmos. Sci.*, **34**, 1149-1152.