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Aerosol measurements in the stratocumulus project

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Cloud Condensation Nuclei (CCN) and Condensation Nuclei (CN) were measured from the NCAR Electra throughout the marine stratocumulus project. The total particle concentration was measured with a TSI 3020 condensation nucleus counter. The CCN were measured with the DRI instantaneous CCN spectrometer (Hudson, 1986). This instrument simultaneously measures the concentration of aerosol active at up to 100 different critical supersaturations, Sc. This is accomplished by exposing the sample to a fixed supersaturation field and using the size of the droplets produced in this cloud chamber to deduce the Sc of the nuclei upon which they have grown. Droplet size is associated with Sc through a calibration which is accomplished by passing soluble aerosols of known size and composition through the cloud chamber. This procedure results in a calibration curve of Sc vs. droplet size. This then allows the channel number to be directly associated with Sc. Thus number concentration vs. Sc is obtained and this is a CCN spectrum. Since the instrument operates continuously the measurements at all Sc's are available simultaneously. Sample is drawn directly from the ambient air and data is displayed in nearly real time. Samples were integrated over times of about 10 seconds so that substantial spatial resolution is available. Calibrations performed once or twice a day and were found to be consistent.

Preliminary results are shown in the figures 1-4. Figure 1 shows the rather surprizing but consistent result that the particle concentration below cloud is lower than the concentrations above cloud. This was true for all measurements on the Electra. Therefore it appears that continental or polluted air was advected out over the ocean at these levels. Figures 2 and 3 exhibit differential CCN spectra above and below cloud. This differential display of the CCN spectrum is now possible because of the great number of Sc channels which are nov available with this new instrument. It is much more useful than the traditional cumulative CCN spectra because, for instance, it readily reveals the higher concentrations of small particles (CN and high Sc CCN) above cloud (fig. 3). This can be contrasted with the flatter spectrum seen below cloud (fig. 2). The steeper spectrum is indicative of more recent particle production

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whereas the flatter spectrum seen in figure 2 is characteristic of a more aged aerosol where the smaller particles have coagulated into larger particles. There is a preliminary indication that the feature exhibited in figure 1 and further explained in figures 2 and 3 is not as prominent at night. If so it would indicate photochemical particle production in the air above cloud.

At any rate the higher conctrations above cloud are very important when it is considered that the droplet spectrum in the upper layers of a cloud determines the cloud albedo. If the high CCN concentrations are indeed influencing the cloud microphysics and producing a cloud with more numerous small droplets then this could be an example of widespread anthropogenic influence on cloud albedo (i.e. Twomey et al., 1984) which could produce a climatic effect as large (but in the opposite direction) as the possible carbon dioxide effect.

Fig. 4 shows that ships are a source of CCN. Thus this hypotheses for the explanation of shiptrails first proposed by Conover (1966) is not contradicted. Although shiptrails themselves do not pose a threat to climate they are an indication of the sensitivity of maritime clouds to anthropogenic and continental influences on microphysics. These aerosol measurements indicate that the U.S. westcoast stratus may already exhibit the cloud microphysical effects which could have profound climatic implications. Shiptrails were not encountered by the Electra. However the high concentrations of CCN shown in figure 1 reveal that the clouds in this vicinity have already had microphysical alterations to the extent that the increase in concentration due to the ship exhaust may have only a minor effect on cloud microphysics. Therefore these widespread cloud decks may already be experiencing anthropogenic effects due to transport of air from the continent. This is consistent with the fact that shiptrails are rarely observed close to shore.

References

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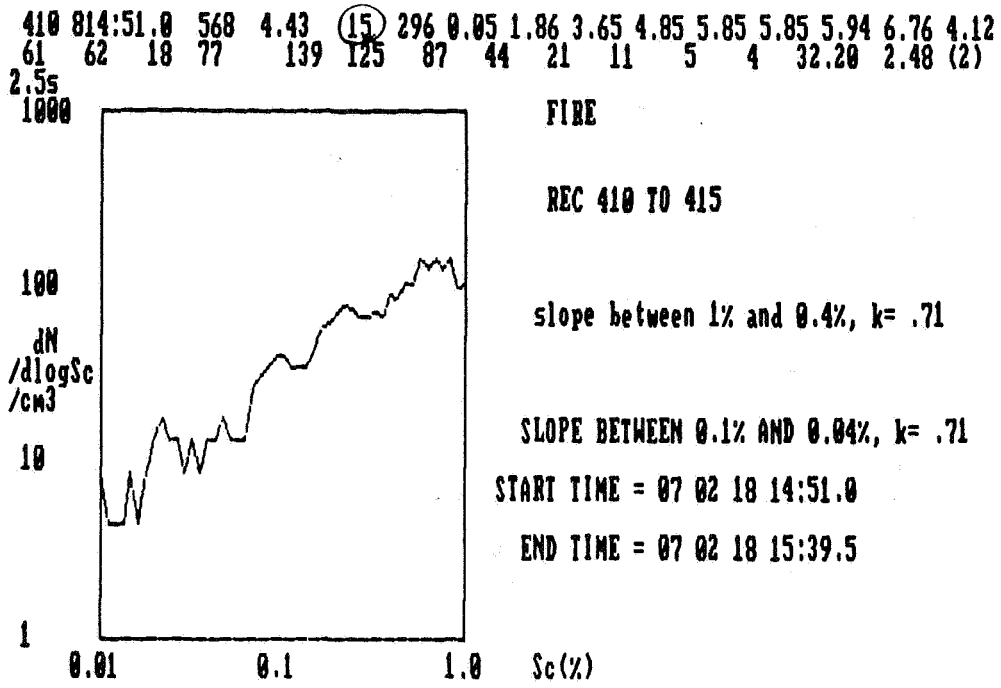

Fig. 2 Differential CCN spectrum in the air below cloud base. The cumulative CCN concentration is given in the second line from the top beginning with 25 and ending with 4. The CN or total aerosol concentration in this case was 78 per cubic centimeter.

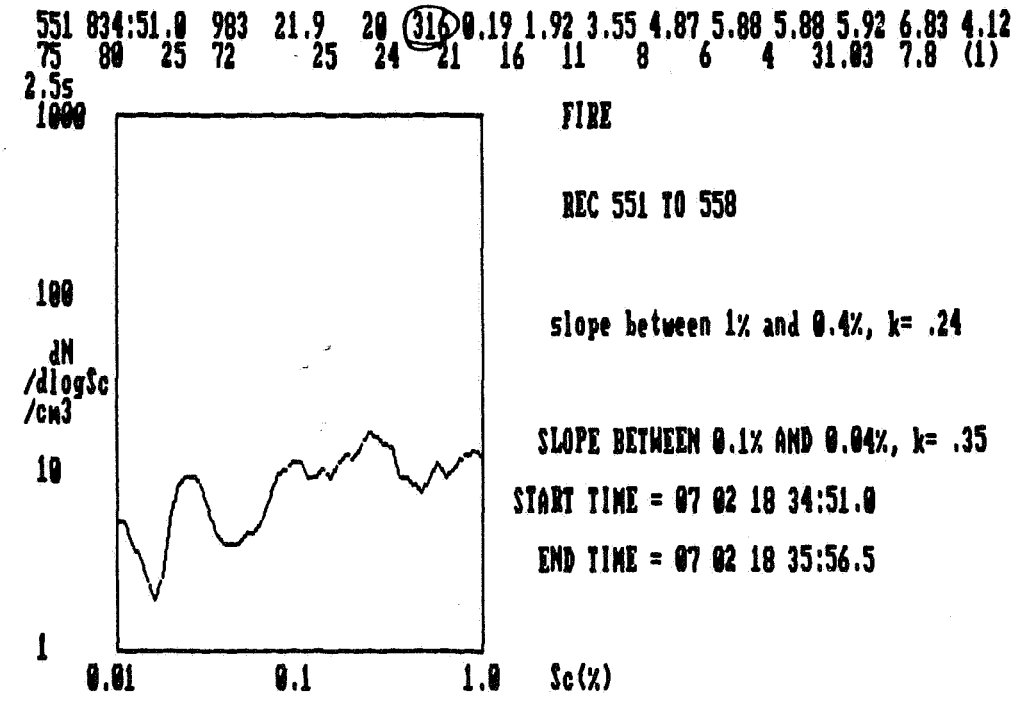

Fig. 3. As fig. 2 but above cloud where the total concentration was 248 and the total CCN concentration was 139.

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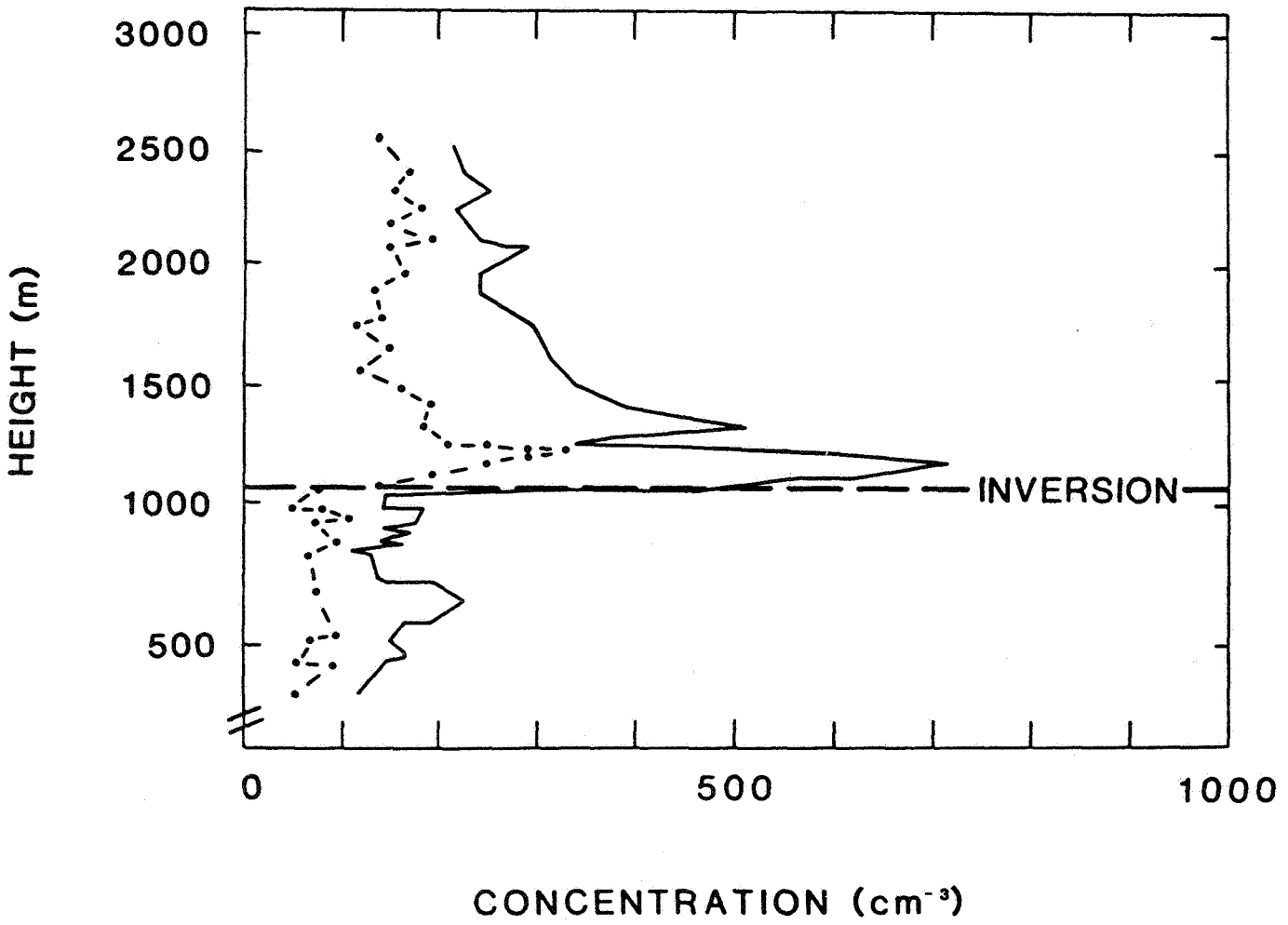

Fig. 1 Total particle (solid line) and CCN (dot-dash line) concentration measured as a function of height above sea level.