Three cloud processes cause bimodal CCN spectra by increasing the mass of dissolved material within cloud droplets.

1) Coalescence among droplets;
2) Gas-to-particle chemical reactions, sulfate and nitrate;
3) Brownian capture of interstitial material.

Since these cloud processes do not affect unactivated particles a gap in the dry particle size distribution occurs when droplets evaporate. Sizes at minima between the unprocessed and cloud processed modes are referred to as Hoppel minima (Hoppel et al., 1985).

Surface aerosol modality measurements with an Scanning Mobility Particle Sizer SMPS at SGP during A-IOP of May 2003 were compared with remotely-sensed cloud fractions (CF) and cloud base altitudes (CBA). When these correlations were time adjusted to account for aerosol movement from clouds to surface, clouds were consistently implicated as the source of aerosol bimodality.

Figures 5 and 6 push the CF and CBA extremes further than Figs. 4. Fig. 5 displays progressively higher (black data) and progressively lower (red data) CF to show that the difference between normalized zero hour and at maxima (black data) and minima (red data) lags after zero hour are progressively greater for plots such as Fig. 4 for cumulatively higher CF (black) and cumulatively lower CF (red). For example, as higher CF than 0.8 are considered in figs. such as Fig. 4 minimal values of normalized are progressively lower. This means that the aerosol becomes progressively more bimodal for progressively greater CF (black data). On the other side of Fig. 5 as progressively lower CF are considered (red data) maximal normalized shows progressively greater differences from normalized at zero hour. This means that at progressively lower CF there are progressively greater shifts toward unimodal aerosol. For instance, in Fig. 4 normalized black goes from 0.2137 at zero hour (green line) to a minimum of -0.0125 at 8 hours after 0.8 CF is observed. This -0.2262 delta normalized is displayed in Fig. 5 and 6 for progressively greater CF (black) and progressively lower CF (red data). Shifts toward bimodality for progressively lower CBA (black) are similar to Fig. 5 black for higher CF. Shifts toward unimodality for progressively higher CBA (red) are similar to Fig. 5 red for lower CF.

Figures 7 shows analogously similar CBA trends for progressively lower CBA (black data) and progressively higher CBA (red data). Shifts toward bimodality for progressively lower CBA (black) are similar to Fig. 5 black for higher CF. Shifts toward unimodality for progressively higher CBA (red) are similar to Fig. 5 red for lower CF.

Table 1. First 3 rows characterize Fig. 7. N is number of hours, R is maximum correlation coefficient. Lag is the hour at maximum R. P2 is the two-tailed probability of the regression at maximum R. Destructive interference due to variations of the time lags for the various days during the project reduced R. Thus, plots of data within each day showed higher R values. Thus means of the daily averaged Rs are a factor of two higher than corresponding Rs from the entire 21-day project. 5-hour running means of the cloud data also make higher Rs. Rs are progressively higher for the instruments that have greater sky coverage.
Similar responses of both modal diameters and Hoppel minima diameters to cloudiness. Lower CBA or higher CF reduce the mean modal sizes in Fig. 8A and B whereas higher CBA or lower CF make greater mean modal particle sizes in Fig. 8C. Since cloud processing would move the larger of the Aitken particles to the accumulation mode this would reduce the mean size of the remaining yet unprocessed Aitken mode. Promotion of these marginal CCN particles would occur to smaller sizes of the accumulation mode. This then reduces the mean size of the accumulation mode. Apparently any tendency of the preexisting accumulation mode particles to grow larger by further cloud processing is less than the effect of newly promoted Aitken particles added to the low end of the accumulation mode.

The coordination of the two mode mean sizes in Figs. 3 and 8 and the opposite responses of the concentrations within the two modes to clouds in Fig. 2 verifies a single mechanism simultaneously affecting both modal sizes, i.e., cloud processing.

Conclusion:

At SGP in May 2003 cloud processing made most accumulation mode particles while it simultaneously altered the Aitken mode.

It is possible that in many environments much of the accumulation mode is caused by cloud processing (Kerminen and Wexler, 1995).

Particle size distribution measurements and cloud measurements at SGP and other ARM sites could test this hypothesis.