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On the competition among aerosol number, size and composition in predicting CCN variability: a multi-annual field study in an urbanized desert

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A two-year dataset of measured CCN concentrations at 0.2% supersaturation is combined with aerosol size distribution and aerosol chemistry data to probe the effects of aerosol number concentrations, size distribution and composition on CCN patterns. Data have been collected over a period of two years (2012-2014) in central Tucson, Arizona: a significant urban area surrounded by a sparsely populated desert. Average CCN concentrations are typically lowest in spring (233 cm-3), highest in winter (430 cm-3) and have a secondary peak during the North American Monsoon season (July to September; 372 cm-3). There is significant variability outside of seasonal patterns with extreme concentrations (1% and 99% levels) ranging from 56 cm-3 to 1945 cm-3 as measured during the winter, the season with highest variability.

Modeled CCN concentrations based on fixed chemical composition achieve better closure in winter, with size and number alone able to predict 82% of the variance in CCN concentration. Changes in aerosol chemistry are typically aligned with changes in size and aerosol number, such that composition can be parameterized even though it is still variable. In summer, models based on fixed chemical composition explain at best only 41% (pre-monsoon) and 36% (monsoon) of the variance. This is attributed to the effects of secondary organic aerosol (SOA) production, the competition between new particle formation and condensational growth, and the complex interaction of meteorology, regional and local emissions, and multi-phase chemistry during the North American Monsoon. Chemical composition is found to be an important factor for improving predictability in spring and on longer timescales in winter.

Regimes where parameterized models exhibit improved predictive skill are typically explained by strong relationships between CCN concentrations and the prevailing meteorology and dominant aerosol chemistry mechanisms suggesting that similar findings could be possible in other locations with comparable climates and geography.