Ultrafine particles and rainfall modification: experimental evidence from airborne studies?

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Modification of cloud microphysics by anthropogenic aerosols is well known since several decades. Whether the underlying processes leads to changes in precipitation is by far less confirmed. Several different factors affect the production of rain in a way that causality between increasing aerosol load in the atmosphere and a change of annual rainfall is very difficult to confirm. What would be expected as an effect of additional cloud condensation nuclei is a shift in the spatial and temporal rainfall distribution towards a lower number of days with low rain intensity and more frequent or more vigorous single events. In fact such a shift has been observed in several locations worldwide and has been suggested to be caused by increasing aerosol load, however, without further specification of the nature and number of the aerosols involved. Measurements of aerosols which might be important for cloud properties are extremely sparse and no long term monitoring data sets are available up to now.

The problem of missing long term aerosol data sets, that could be compared to available long term meteorological data can possibly be resolved in certain areas where well characterized aerosol sources were introduced in otherwise pristine areas. Of special interest are ultrafine particles that are not interacting with short wave radiation. Their climatic impact is restricted to cloud processes, brightening and droplet size changes leading to rainfall modification. We investigated aerosol sources and current ultrafine aerosol number, size and spatial distributions with airborne measurements in the planetary boundary layer over two regions in Australia that are reported to suffer from extensive drought. Within these regions water vapor (dewpoint) in the atmosphere is reported to increase slowly and constantly. Such an increase of the total water in the planetary boundary layer could imply also an increase in annual precipitation as observed in many other locations elsewhere. The observed decline of rainfall in these areas thus might be explained by a local to regional scale physical process modifying cloud properties in a way that rain spatial, temporal and intensity distributions are modified. We observed enhanced numbers of anthropogenic ultrafine particles as precursors of cloud condensation nuclei from well documented sources. We are thus able to reconstruct also their historical development without having a continuous data record. The derived aerosol trends are well in agreement with the observed negative trends in precipitation based on the assumption that additional CCN in a first step delay the production of raindrops allowing more efficient horizontal transport to redistribute rainfall, in these cases leading to a regional loss of total rainfall.