

LAND USE CHANGE SUPPRESSES PRECIPITATION

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Aerosols of natural and anthropogenic origin have important climate effects through interaction with clouds, which are among the main uncertainties in climate models due to the large variability of aerosol sizes, types and 3D-distributions [1]. Experimental investigations are typically restricted to high concentrations in industrial and urban aerosol plumes although in more remote areas already slight changes in the aerosol concentrations can have a large impact. This study reports on investigations of aerosols over a remote natural laboratory, along the ~1500 km long Vermin Proof Fence, also called “State Barrier Fence”, in Western Australia. This Fence, built in the first decade of the 20th century, separates an area of >100.000 square km of homogeneous terrain, converted to arable land (west), from the natural vegetation of inner Australia, conserved as a nature preserve (east). The Fence protects the agriculture from an invasion of animals but also protects the nature preserve from farming pressure and serves as a clear cut between the two types of landscape. Recent satellite images indicate that the Fence also works as a separation line between different meteorological regions. Clouds, for example, develop more often over regions with natural vegetation [2]. Early surveys of aerosols over Australia [3] found generally clean conditions with less than 1000 ultrafine (~ 20 nm) particles / cm³ throughout most of Australia. Local enhancements were occasionally observed in coastal areas, but, for the analysis of particle distributions they were considered to be unimportant. However, higher numbers of ultrafine particles were now also found downwind of tropical eucalyptus forests on the Australian east coast.

The rationale for this project was to investigate the processes behind the regional change of the precipitation patterns in Western Australia [4]. The western tip of the continent has experienced a reduction of precipitation by about 30% (from an average of 325 mm/a) since the 1970’s. This reduction of precipitation pattern is most probably due to a combination of regional processes. Modifications of albedo and surface roughness by land use affect regional meteorology and cloudiness. A regional change of aerosol populations would be another important factor controlling the conversion of water vapour and cloud condensation nuclei to raindrops. A response of clouds to additional aerosols depends on convection and temperature levels, but in general, precipitation would be reduced. A recent critical review of the current state of research indicated the difficulties to relate rainfall depletion to increased anthropogenic aerosol numbers [5] as precipitation is an effect of both, cloud dynamics and aerosol driven cloud microphysics and these processes cannot be separated. Here we report on a new biogenic, though human-induced, source of ultrafine particle production observed over continental Australia, which was previously overlooked. This source is intense enough to double the number of CCN on a regional scale. Their identification was possible only with the deployment of novel instrumentation for particle size distributions.

In contrast to previous results from European boreal forests with new particle production over forests in Western Australia ultrafine particle numbers were up to an order of magnitude higher over agricultural areas while over forests continental background concentrations were found. These particles show the typical behaviour of nucleation mode aerosols which grow within a couple of hours into CCN. As a source for nucleation precursors the scattered salt lakes in then agriculture could be identified, salt lakes in the natural vegetation never emitted particles. The contribution of nucleation mode particles doubled the available CCN over the deforested area.

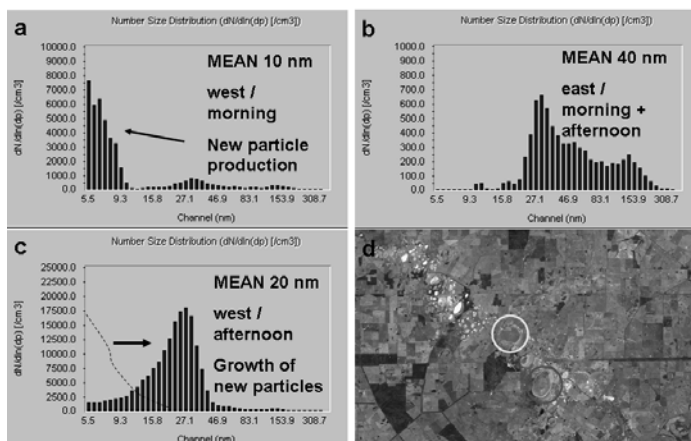


Fig 1: Aerosol size distributions under calm conditions (wind speed below 2.5 m/s). Nucleation mode particles were found only over selected salt lakes. The white spots are smaller salt lakes (d). Size distributions over Lake

Stubbs (circle) in the west in the morning (a) and three hours later after aging of the particles (c). Size distribution over natural vegetation (b) without change between morning and afternoon. Note also the different scales in the total numbers.

A closer look into cloud microphysics of a single layer of cumulus clouds confirmed the expected dependence of cloud droplets on additional aerosols. The higher number of cloud condensation nuclei (CCN) over the agriculture lead to an increase in droplet number, and a reduction of droplet size and the number of droplets above 15 μm . Though more water vapour was available over the agriculture the liquid water content was higher within the clouds over the natural vegetation.

The production mechanism for the observed enhanced CCN precursor aerosols finally could be traced back to changes in the ground water table following large scale deforestation.

References

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