Land use change suppresses precipitation

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Outline

Background

Experimental setup

Results

Summary

RAINFALL

Fig. 4 Time series of Southwest Western Australia rainfall (mm). Solid trace depicts early winter (May to July) totals and dotted trace late winter (August to October) totals. Means for the periods 1900-1975 to 2004 are represented by horizontal lines.

RUNOFF

Fig. 5 Annual (May to April) inflow series (GL) for the Integrated Water Supply System. Source: [http://www.watercorporation.com.au](http://www.watercorporation.com.au)

DROUGHT IN WESTERN AUSTRALIAN WHEAT BELT
Precipitation change distribution

-clouds over natural vegetation

IOCI, 2002
The BUFEX experiment

airborne investigations
in a natural laboratory
comparing meteorology
and aerosols
2 seasons
Background

Experimental setup

Results

Summary
<table>
<thead>
<tr>
<th>Instrument</th>
<th>Measurement Range</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>GRIMM SMPS</td>
<td>5.5 – 350 nm</td>
<td>2 min</td>
</tr>
<tr>
<td>GRIMM 1.108</td>
<td>300 nm – 15 um</td>
<td>6 sec</td>
</tr>
<tr>
<td>TSI 3010</td>
<td>&gt; 10 nm</td>
<td>2 sec</td>
</tr>
<tr>
<td>FSSP 100</td>
<td>0.5 – 47 um</td>
<td>1 sec</td>
</tr>
</tbody>
</table>

Meteorology (temp, dewpoint) and radiation parameters (radiation balance, albedo)
Background

Experimental setup

Results

Summary
NO nm-SIZE PARTICLES OVER THE FOREST !!!

VERTICAL MIXED UP TO PBL

~ 15000

PBL

WEST

PBL

EAST

600 - 1000
PARTICLES > 10 nm (red)

NO nm SIZE PARTICLES OVER THE FOREST!!!

SIZE DISTRIBUTIONS

WEST
ultrafines

EAST
- INDEPENDENT FROM SEASON
- NO DEPENDENCE ON VEGETATION ON AGRICULTURE
SOURCE REGIONS FOR NUCLEATION-PARTICLES
New particle production

aged new particles

CCN

FORSCHUNGZENTRUM KARLSRUHE, IMK-IFU
NUCLEATION AEROSOL EFFECT ON PRECIPITATION -> HIGHER DROPLET NUMBER AND REDUCTION OF DROPLET SIZES DUE TO ENHANCED CCN (FLETCHER, 1962, Lohmann and Feichter, 2005....)

CCN as particles > 50 nm
CLOUDS OVER BOTH AREAS, 21.8.2007

Experimental proof
<table>
<thead>
<tr>
<th>Parameter</th>
<th>West (agriculture)</th>
<th>East (natural vegetation)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ground cloud base</td>
<td>ground cloud base</td>
</tr>
<tr>
<td>Temperature (air) [°C]</td>
<td>16</td>
<td>10</td>
</tr>
<tr>
<td>Pressure [hPa]</td>
<td>975</td>
<td>900</td>
</tr>
<tr>
<td>Dewpoint [°C]</td>
<td>11</td>
<td>9</td>
</tr>
<tr>
<td>Water [g/m³]</td>
<td>9.9</td>
<td>8.8</td>
</tr>
<tr>
<td>CCN</td>
<td>~ 280</td>
<td>~ 400</td>
</tr>
<tr>
<td>Cloud droplets [/cm³]</td>
<td>247</td>
<td>198</td>
</tr>
<tr>
<td>Average diameter [µm]</td>
<td>8.3</td>
<td>9.5</td>
</tr>
<tr>
<td>Liquid water content [g/m³]</td>
<td>0.10</td>
<td>0.15</td>
</tr>
</tbody>
</table>

Note the difference of water vapor converted into LWC
Background

Experimental setup

Results > Landuse change

Summary
SOURCE REGIONS FOR NUCLEATION-PARTICLES
DIFFERENCES BETWEEN THE LAKES?

MOIST

High GROUNDWATER TABLE low

~ 2 m

DRY

> 20 m
DIFFERENCES BETWEEN THE LAKES?

MOIST

High GROUNDWATER TABLE

~ 2 m

DEFORESTATION

DRY

low

> 20 m
SUMMARY

Enhanced ultrafine particle numbers over agriculture
Nucleation source not related to vegetation
Salt lake chemistry / emissions, most probably halogen (iodine?) chemistry
Enhanced CCN numbers affect cloud microphysics
Modification of cloud microphysics can explain the observed precipitation patterns

Link to land use change –>
Long term experiment, natural laboratory

Deforestation 1829-1960

-> rising ground water table (GWT)
-> GWT close to surface ~ 1970
-> wet chemistry in salt lakes
-> increased number of CCN
-> reduction of precipitation
Acknowledgement

Admiral James Stirling

Settlers who helped clearing the forest

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One of the aircraft was donated by the late Ms. Joyce Schultz
Thank you for your attention
HIGH WIND CONDITIONS AUGUST 2007, NW WIND 20-30 kts

MAIN SOURCE AREAS: CHAINS OF SMALL SALT LAKES

PARTICLES > 10 nm

LAKE KING

LAKE GRACE

SIZE DISTRIBUTIONS

0 10000

0 2500

0 10000

0 2500

Number Size Distribution (dN/dln(a)/cm^3)

Number Size Distribution (dN/dln(a)/cm^3)

Channel (nm)

Channel (nm)