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Aerosol-aware, convection-resolving climate modelling

Regional and global modelling approaches with WRF and MPAS

Anthropogenic aerosol emissions and rainfall decline in South-West Australia

D. Heinzeller, W. Junkermann, H. Kunstmann, 2016: Journal of Climate, http://dx.doi.org/10.1175/JCLI-D-16-0082.1

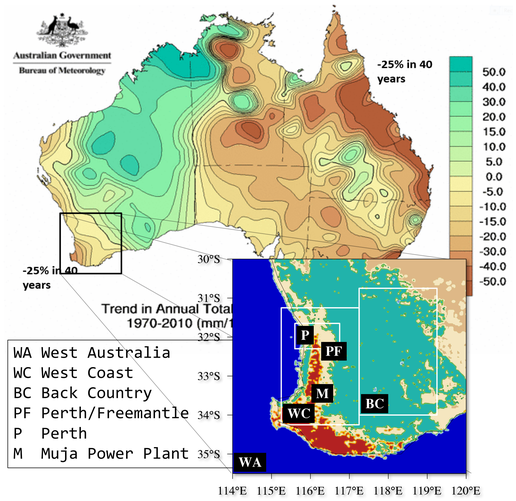
Significant decline in precipitation in SW Australia in the 20th century

- Continuous decline by about 15% for entire region (WA)
- Sudden drop by further 15% for Perth/Freemantle (PF) in the 70s

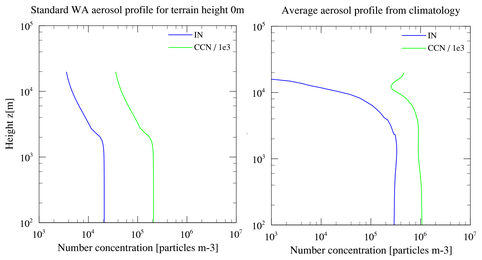
Possible reasons are:

- Continuous changes due to large scale circulation (slow)
- Deforestation, irrigation (fast)
- Anthropogenic aerosols from power plants/smelters (fast)

Anthropogenic aerosol emissions and rainfall decline – coincidence or causality?

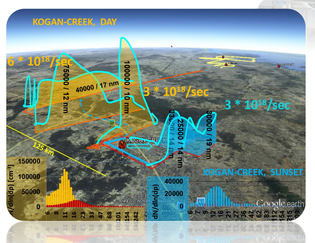


A high-resolution (3.3km) regional climate modelling study using WRFV3.6.1 with a new aerosol-aware microphysics scheme (Thompson and Eidhammer, 2014) for 1970-1974.



Pre-industrial CCN/IN emissions from 1970s observations and current (2000-07) climatology

Muja Power Station, commissioned 1966, 974MW, ≈10^{19}CCN/s



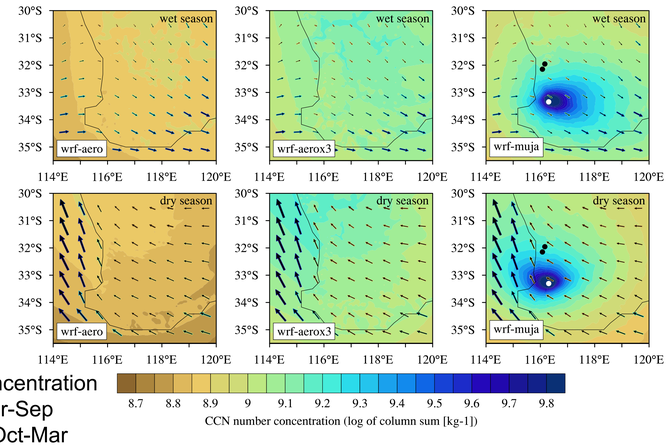
Airborne measurements of CCN emission rates of coal power plants in East Australia w/ similar size (Junkermann and Hacker, 2015).

Three different aerosol model runs

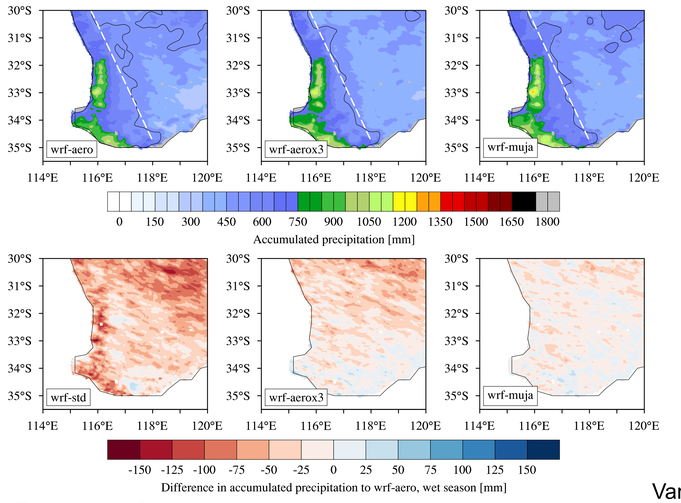
- Pre-industrial CCN/IN levels, std. aerosol profile (wrf-aero)
- Post-1970s CCN/IN levels, 3x std. aerosol profile (wrf-aerox3)
- Pre-industrial CCN/IN levels + Muja Power Station (wrf-muja)

Muja Power Station emissions:

- 4.6x10^8 particles/kg/s, added to surface emissions at Muja Power Station within 1500m above ground



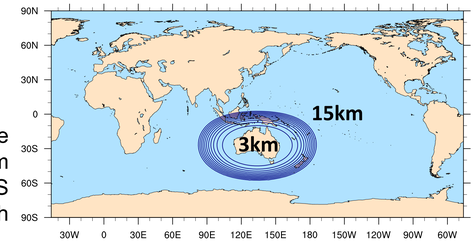
1970-1974 means of CCN number concentration and surface wind (right) and rainfall Apr-Sep (bottom); wet / dry season: Apr-Sep / Oct-Mar



Decline in rainfall for increasing aerosol concentrations, strongest effect on the back country. CCN are advected by near-sfc wind, seasonal variation for wrf-muja.

	wrf-muja >3xCCN	wrf-muja dry/wet	wrf-aerox3 3xCCN/IN
WA	-2.0%	3.1	-5.3%
WC	-1.7%	3.3	-3.1%
BC	-2.8%	2.9	-6.5%
PF	-1.7%	11.0	-4.0%

Variable 15-3km MPAS mesh



Future work

- Separating the effects of anthropogenic aerosols, land clearing and global climate change in AU
- Airborne measurement campaign to quantify aerosol emissions of modern power plants
- Global and regional modelling studies for the East Coast and West Coast with WRF and MPAS

RELATED WORK

Preparing for Exascale: Convection-permitting, global atmospheric simulations with MPAS
Poster X5.504, AS4.10/CL5.12, Wednesday

The Model for Prediction Across Scales (MPAS): the future of weather modelling?
Poster X5.150, CL5.11/AS1.32, Thursday