Australia's National Science Agency

How will a changing climate (and emissions reduction measures) impact sources of air pollution and secondary pollutant formation?

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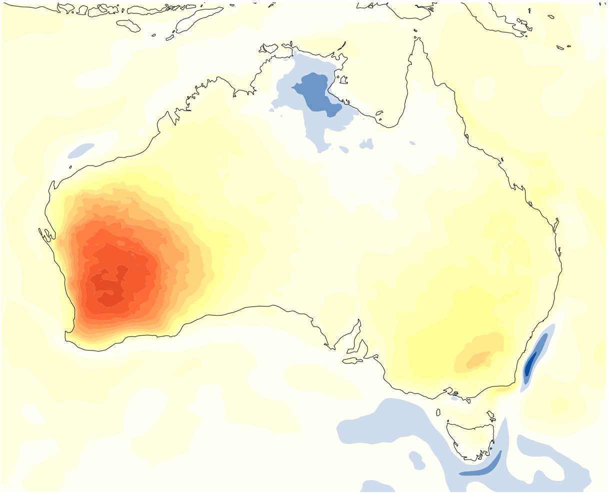


@EmmersonKathryn

Project brief

Australia is committed to emission reduction measures that will help combat future climate change.

These measures will impact the sources, types and strengths of anthropogenic emissions to the air and thus change the levels of air pollution and secondary pollutant formation in our cities.

Whilst we expect reducing anthropogenic emissions to lead to less air pollution, the impact of increasing temperatures and drought on natural emissions and their chemical processing could increase air pollution.

What changes could occur if we do nothing?

This is a modelling study.

The results will provide a lens on what a new baseline could look like, and which measures will have the greatest impact on air quality in 2050, giving us time to adapt and/or find solutions.

Climate variables and air quality?

Changes in:

- Temperature affect the rates at which chemical reactions take place;
- Changes in humidity affects the production and destruction of chemical species and, specifically, the loss rate of tropospheric ozone;
- Atmospheric cloudiness modify the penetration of solar radiation and, hence, the photochemical activity in the atmosphere;
- The frequency and intensity of precipitation resulting from climate change affect the rate at which soluble species are scavenged and therefore removed from the atmosphere;
- Surface temperature affects the emission of chemical compounds from vegetation and soil;
- The frequency and intensity of prolonged stagnant air conditions affect the dispersion of pollutants and enhance the intensity of pollution events;
- The general circulation of the atmosphere affect the long-range transport of pollutants from continent to continent;
- Surface wind intensity modify the mobilization of dust particles in arid regions, and sea salt aerosol over the ocean and, therefore, the aerosol burden in the troposphere;

Guy Brasseur, WMO Bulletin, 58, 2009

CSIRO

2050 experiment

Global Climate Models

Model	Outcomes for Australia
ACCESS-CM2	A much hotter future, and drier in most regions except the southeast
ACCESS-ESM1.5	A hotter and much drier future
NCAR CESM2	A hotter future, wetter in parts of the east and north
CMCC-ESM2	A much warmer future with little change in mean rainfall (with regional exceptions)
CNRM-ESM2-1	A much hotter future, much drier especially in the east, but wetter in the northwest
EC-Earth3 (or EC-Earth3-Veg)	A hotter and much wetter future for much of Australia (except SWWA)
NorESM2-MM	Lower warming, mid-range changes in rainfall
UKESM1-0-LL	Low probability, high impact case (high climate sensitivity, high Australian warming)

Grose et al, Climate Services, 2023

CSIRO

Shared Socio-economic Pathways

	SSP1-1.9 "SUSTAINABILITY"	SSP1-2.6 "SUSTAINABILITY"	SSP2-4.5 "MIDDLE OF THE ROAD"	SSP3-7.0 "REGIONAL RIVALRY"	SSP5-8.5 "FOSSIL-FUELLED DEVELOPMENT"
RCP equivalent	No equivalent RCP	RCP2.6	RCP4.5	No equivalent RCP	RCP8.5
THE WAY THE WORLD MIGHT CHANGE IN THE FUTURE					
Emissions reduction	Very high and immediate	High and immediate	Moderate from 2040s	None (minor slowing)	None (accelerating)
Energy sources	Renewables	Renewables and biofuels	Renewables and fossil fuels	Fossil fuels	Increased fossil fuels
Carbon dioxide removal	CO_2 New technology	CO_2 New technology	None	None	None
Global socio-economic trends	Gradual move towards sustainability and environmental respect; increasing action towards Sustainable Development Goals (SDGs)	Gradual move towards sustainability and environmental respect; increasing action towards SDGs	Similar to the past; unevenly distributed; slow progress towards SDGs	Slow and increasingly unequal	Rapid growth at the expense of the environment; resource intensive lifestyles and industries; high investment in health and education; dependence on technological solutions
WHAT THE FUTURE CLIMATE MAY LOOK LIKE UNDER EACH SSP					
Global warming by 2100	1.0-1.8°C	1.3-2.4°C	2.1-3.5°C	2.8-4.6°C	3.3-5.7°C
Resulting global warming levels*	Due to past emissions all SSPs reach 1.5°C in the 2030s and then diverge				
	Overshoots 1.5C slightly around 2050 then returns and stabilises near 1.5C by 2100	Reaches 2°C around 2050s and stabilises	Reach 2°C around 2050s 2.7°C by 2100	Reach 2°C around 2050s 3°C around 2070s 4°C possible by 2100	Reach 2°C around 2050s 3°C around 2060s 4°C by around 2080s

* As a general guide or "rule of thumb"

The Climate Systems Hub is funded by the Australian Government under the National Environmental Science Program.

Passing the pub test…..

….. with John Clarke from the Climate Systems Hub

#1

Run 2050 for each model and compare to a 2015 ERA5 driven run

Only 1 year. Is 2050 representative? Climate timescales are 20+ years

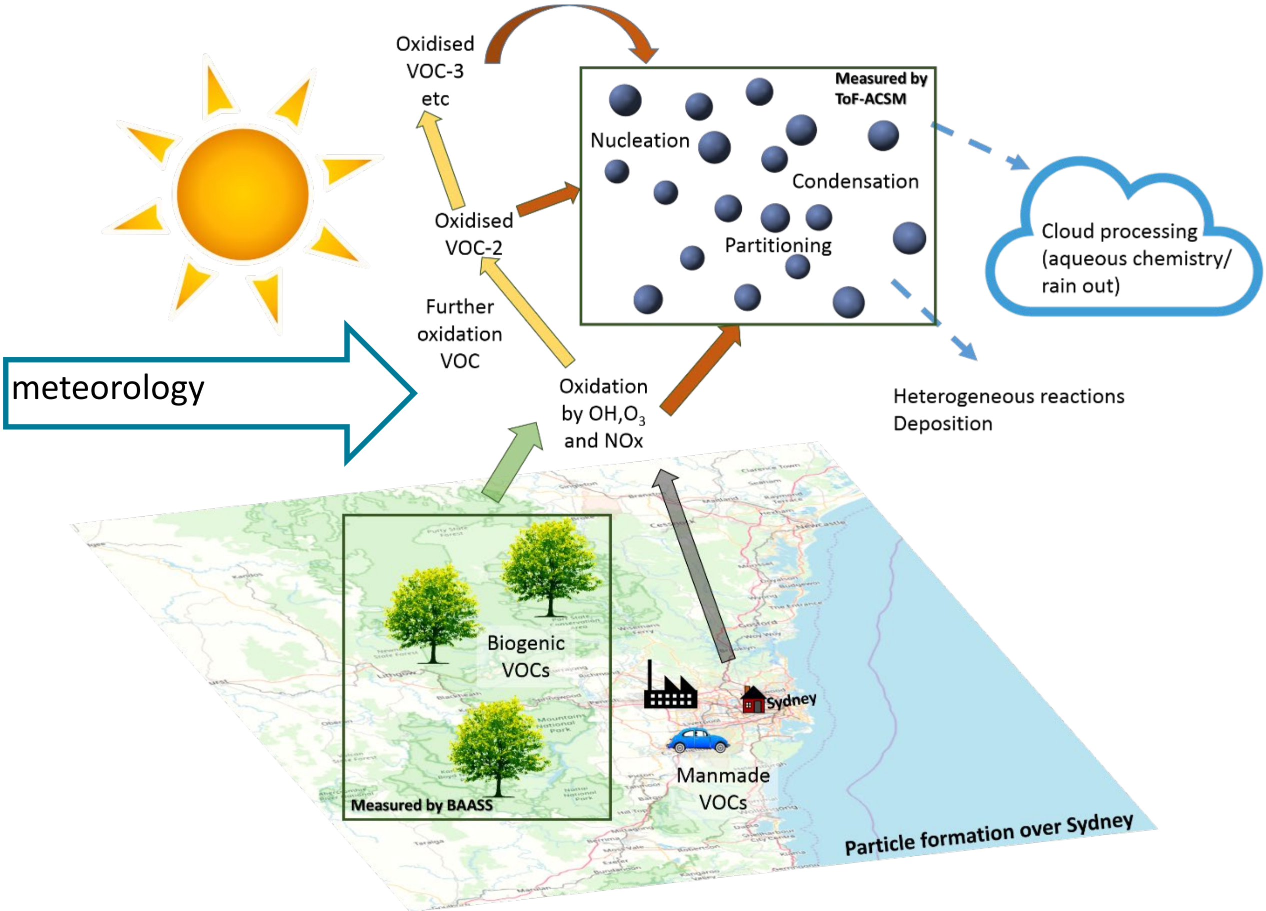
Each GCM has its own biases. Results can't be directly compared to each other or to an ERA5 driven model

#2

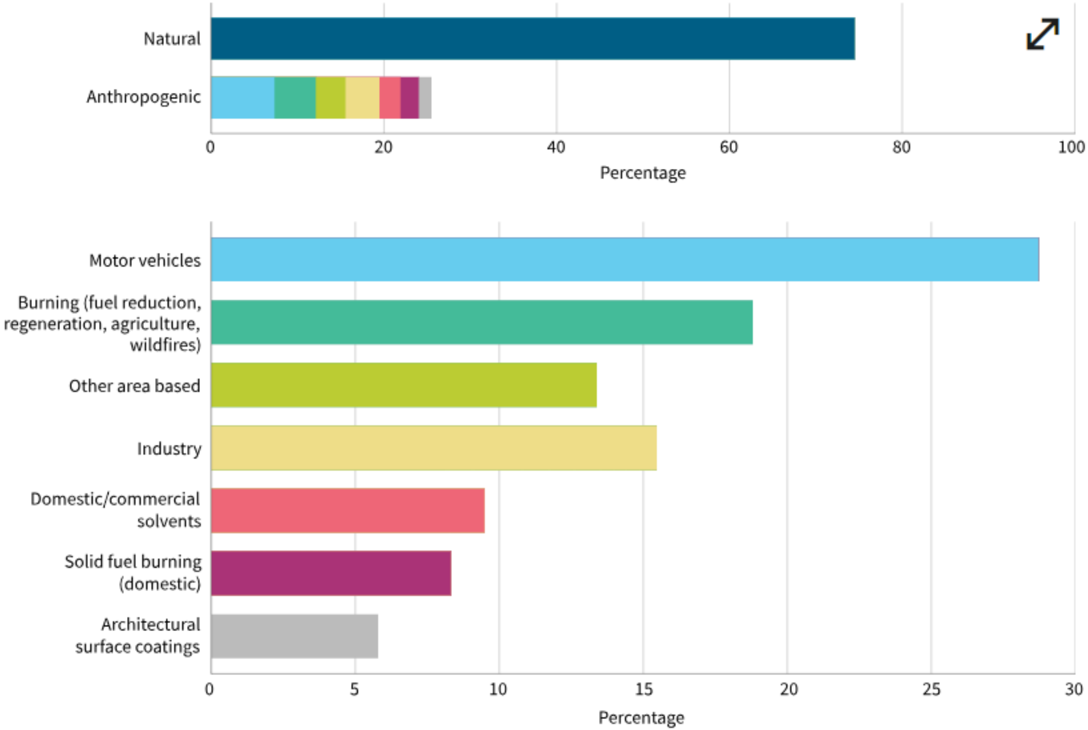
Run 2048-2052 for each model and compare to a 2013-2017 historical run from each GCM

It's not 20 years, but OK

VOCs in the atmosphere



Importance of biogenic VOCs

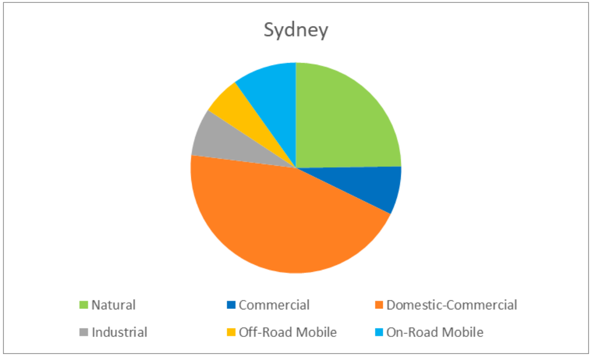


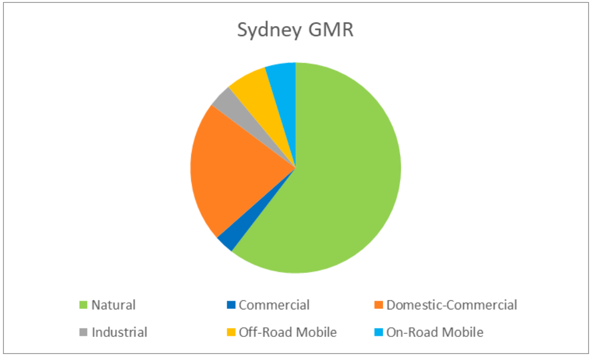
VOC = volatile organic compound

Source: National Pollutant Inventory

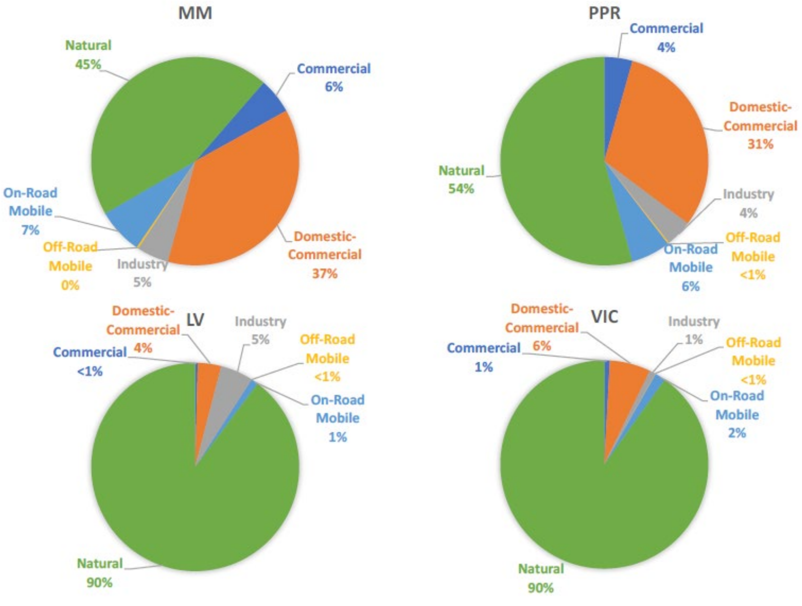
State of the Environment: Air Quality, 2021

Importance of biogenic VOCs





NSW

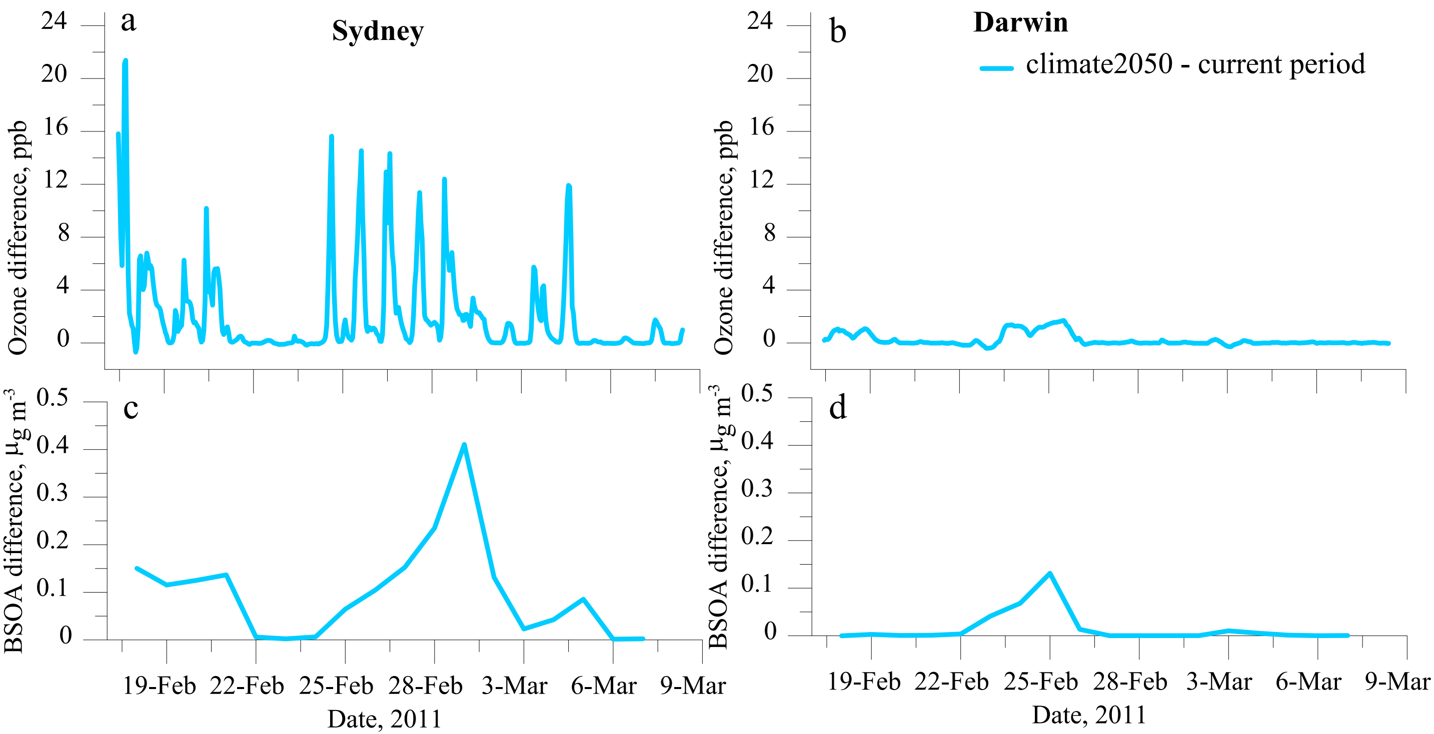


Victoria

NSW (2013) and Victorian (2016) inventories

CSIRO

2 ppb isoprene creates 10-20 ppb peak ozone



Up to 1/5th of hourly ozone limit!*

* At the time of this paper!

Emmerson et al, 2020, Atmos. Chem. Phys.

Conclusions

We need to do the 'climate only' experiment to attribute how much of the resulting air pollution in 2050 is due to a particular emission intervention versus meteorological changes.

Using SSPs 1-26 and 3-70 gives a 2050 with increases in temperature up to 2 K, that impact atmospheric chemistry.

Other changes in meteorology could occur from wind speeds, cloud cover and rainfall that impact chemical and physical processes in different ways.

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Thank you

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