Black Carbon & Ultrafine Particles

Towards a National Monitoring Program

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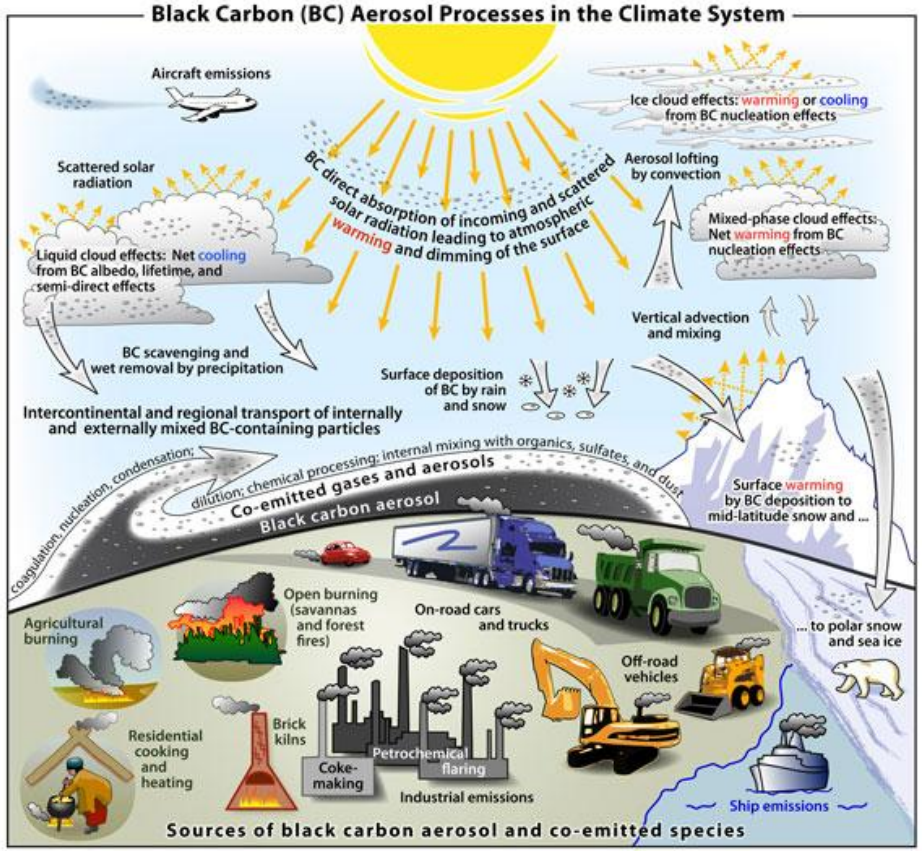
I would like to begin by acknowledging the Gimuy-Walubara Yidinji People as the Traditional Owners of the land/s that we're meeting on today, and pay my respect to their Elders past and present.

'Eternal Wisdom, Infinite Innovation'
artwork by Rachael Sarra, working with Gilimbaa.

What is Black Carbon?

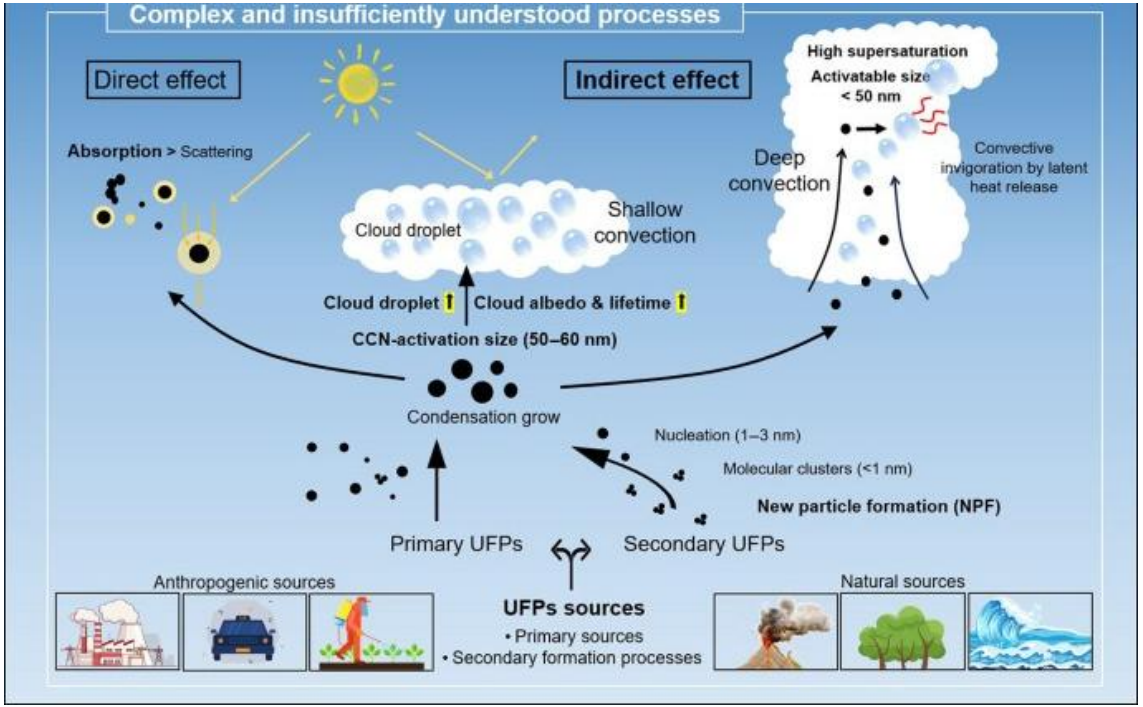


- A carbonaceous component of fine particulate matter
- Incomplete combustion
- Strongly tied to anthropogenic combustion sources
- Acts acts as a valuable tracer for emissions within scope of regulatory control
- Absorbs heat
- Lifetime of days

Bond, T. C., et al. (2013), Bounding the role of black carbon in the climate system: A scientific assessment, *J. Geophys. Res. Atmos.*, 118, 5380–5552, doi:10.1002/jgrd.50171.

What are Ultrafine Particles -UFP?

- smaller than 100 nm
- numerically dominant in the atmosphere
- growing evidence suggests they act as CCN
- Not captured by PM2.5



Jin, Y., Wang, J., Wu, S. *et al.* The climate effects of ultrafine particles: uncertainties and future perspectives. *ENG. Environ.* **20**, 77 (2026). https://doi.org/10.1007/s11783-026-2177-x

Why BC and UFP Matter Now

- Recognised internationally as important indicators of air pollution exposure and environmental health risk (WHO 2021)
- Policy-relevant air pollutants not yet routinely monitored across all Australian jurisdictions
- Australian monitoring capability is geographically limited
- Air quality management is evolving to address both public health and climate objectives

Public health

Cardiovascular, respiratory & cancer risk from combustion particles

Climate

Short-lived but potent atmospheric warming and albedo effects

Regulation

International frameworks moving beyond mass-based indicators

Health Evidence- Black Carbon

Cardiovascular disease

Consistent short- and long-term associations between BC exposure and CVD (Yang et al. 2022)

Respiratory disease

High-confidence evidence linking BC to respiratory morbidity (Redaelli et al. 2019)

Birth outcomes

Prenatal BC exposure linked to low birth weight and preterm birth (Goriainova et al. 2022)

Cancer risk

Diesel exhaust classified as carcinogenic, Group 1 (Benbrahim-Tallaa et al. 2012)

BC is increasingly regarded as a more health-relevant indicator of traffic-related air pollution than PM2.5 mass alone (Janssen et al. 2011).

References: Yang et al. 2022, PubMed 35504636 · Redaelli et al. 2019, Environ Epidemiol · Goriainova et al. 2022, Toxics · Benbrahim-Tallaa et al. 2012, Lancet Oncol · Janssen et al. 2011, EHP

Health Evidence: Ultrafine Particles

Cardiovascular disease

Systematic review links UFP exposure to disrupted CVD blood markers (Lachowicz & Gać 2025)

Respiratory disease

Short-term UFP exposure linked to respiratory hospital admissions (Bergmann et al. 2023)

Systemic & neurological

Small enough to translocate beyond the lungs into circulation (Peters et al. 2006)

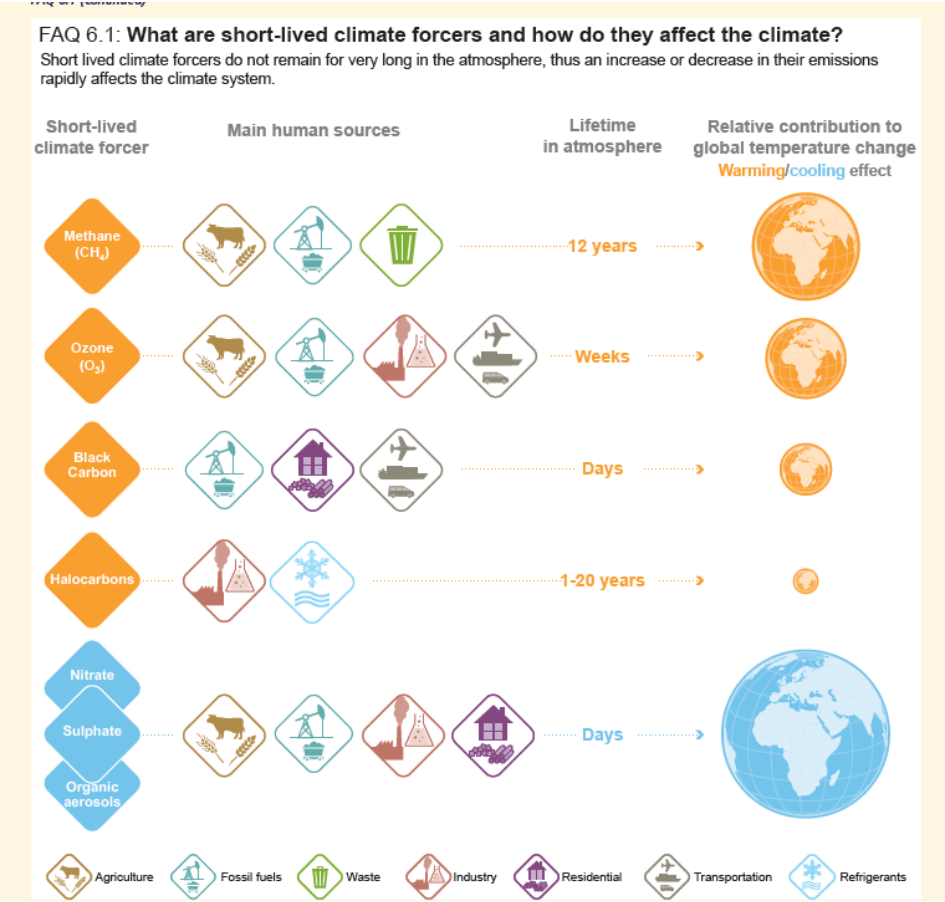
Long-term mortality

Long-term exposure linked to increased mortality (Qi et al. 2024)

WHO's 2021 guidelines found evidence still insufficient for quantitative UFP limits, but issued good-practice statements given UFP's ability to cross into circulation (WHO 2021).

References: Lachowicz & Gać 2025, J Clin Med · Bergmann et al. 2023, Environ Pollut · Peters et al. 2006, Part Fibre Toxicol · Qi et al. 2024, J Hazard Mater · WHO 2021

Black Carbon: A Climate Forcer



Atmospheric warming

Strong absorption of solar radiation while airborne

Clouds

Influences cloud formation and regional climate processes

Snow

Reduces surface reflectivity, accelerating melt

Climate Policy: The IPCC and international momentum

- BC is one of the short-lived climate forcers included
- The report is expected to improve consistency in how emissions are estimated and reported, helping support future climate policy decisions.
- Methodology could be used to report Australia's BC emissions to the UNFCCC

Transition from research to regulation

Official Journal
of the European Union

EN
L series

2024/2881

20.11.2024

DIRECTIVE (EU) 2024/2881 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL

of 23 October 2024

on ambient air quality and cleaner air for Europe

(recast)

(14) It is important that pollutants of emerging concern, such as ultrafine particles, black carbon and elemental carbon, as well as ammonia and the oxidative potential of particulate matter, be measured at monitoring supersites at both rural background locations and urban background locations in order to support scientific understanding of their effects on human health and the environment, as recommended by the WHO. For Member States whose territory is less than 10 000 km^2 measuring at monitoring supersites at urban background locations would be sufficient.

Current Capability in Australia:BC

11

NSW BC monitoring sites statewide

20

ANSTO Aerosol Sampling Program BC sites

3

Global Atmosphere Watch stations (incl. Kennaook/ Cape Grim)

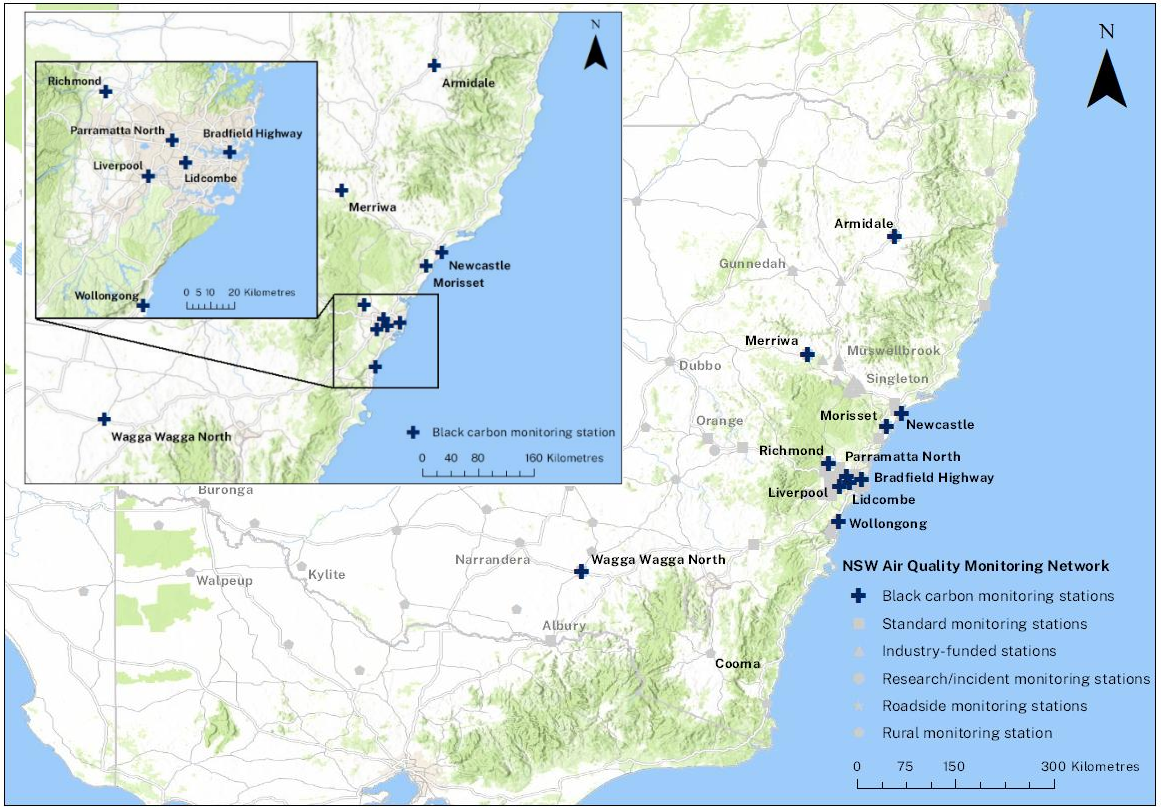
2

ACT Health

2

Port Headland (BHP)

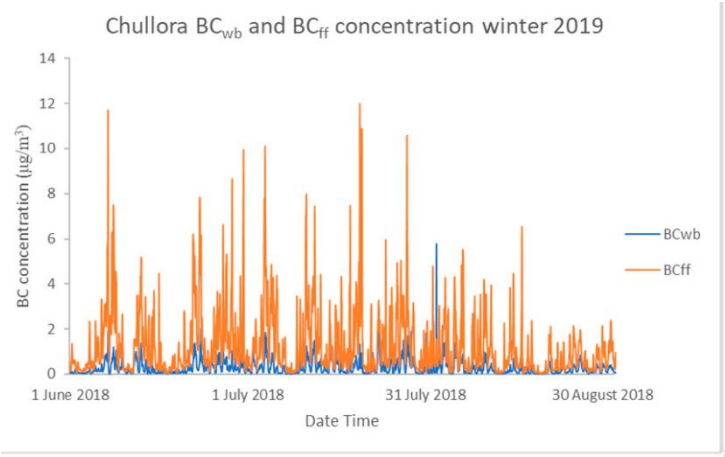
NSW DCCEEW BC monitoring sites- Aethelometer

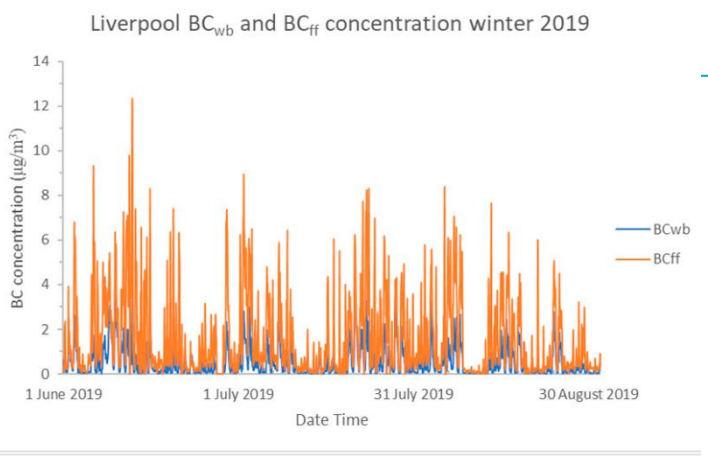


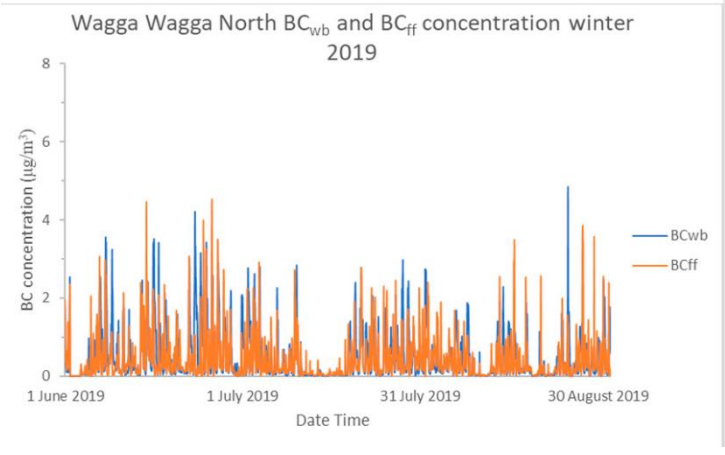
Monitoring Site	Latitude (South)	Longitude (East)	Elev. (m)	BC Installed
Armidale	30°30'30"	151°39'41"	979	12/04/2018
Bradfield Hwy	33°50'36"	151°12'41"	36	23/11/2020
Lidcombe	33°52'53"	151°02'48"	39	2/12/2020
Liverpool	33°55'58"	150°54'21"	25	9/05/2019
Merriwa	32°07'33"	150°27'33"	406	13/08/2020
Morisset	33°06'29"	151°33'09"	51	22/11/2020
Newcastle	32°55'57"	151°45'30"	19	9/12/2015
Parramatta North	33° 47' 58"	150° 59' 52"	16	01/03/2025
Richmond	33°37'06"	150°44'45"	23	30/04/2019
Wagga Wagga	35°06'16"	147°21'37"	181	3/04/2019
Wollongong	34°25'01"	150°53'14"	15	12/04/2018

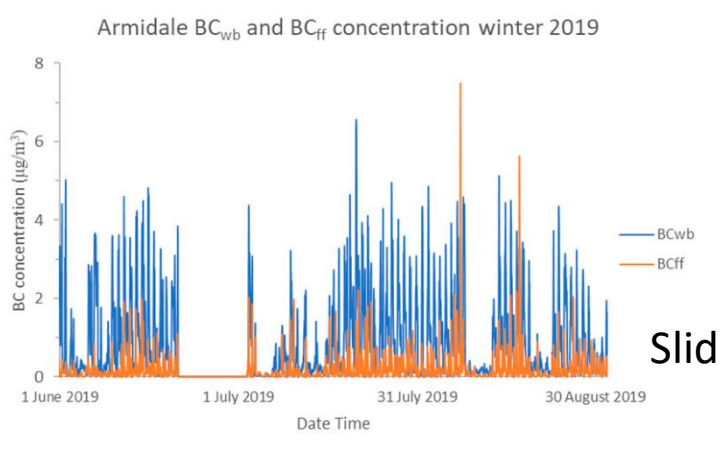
Slide from Matt Riley

What do aethalometer results tell us?





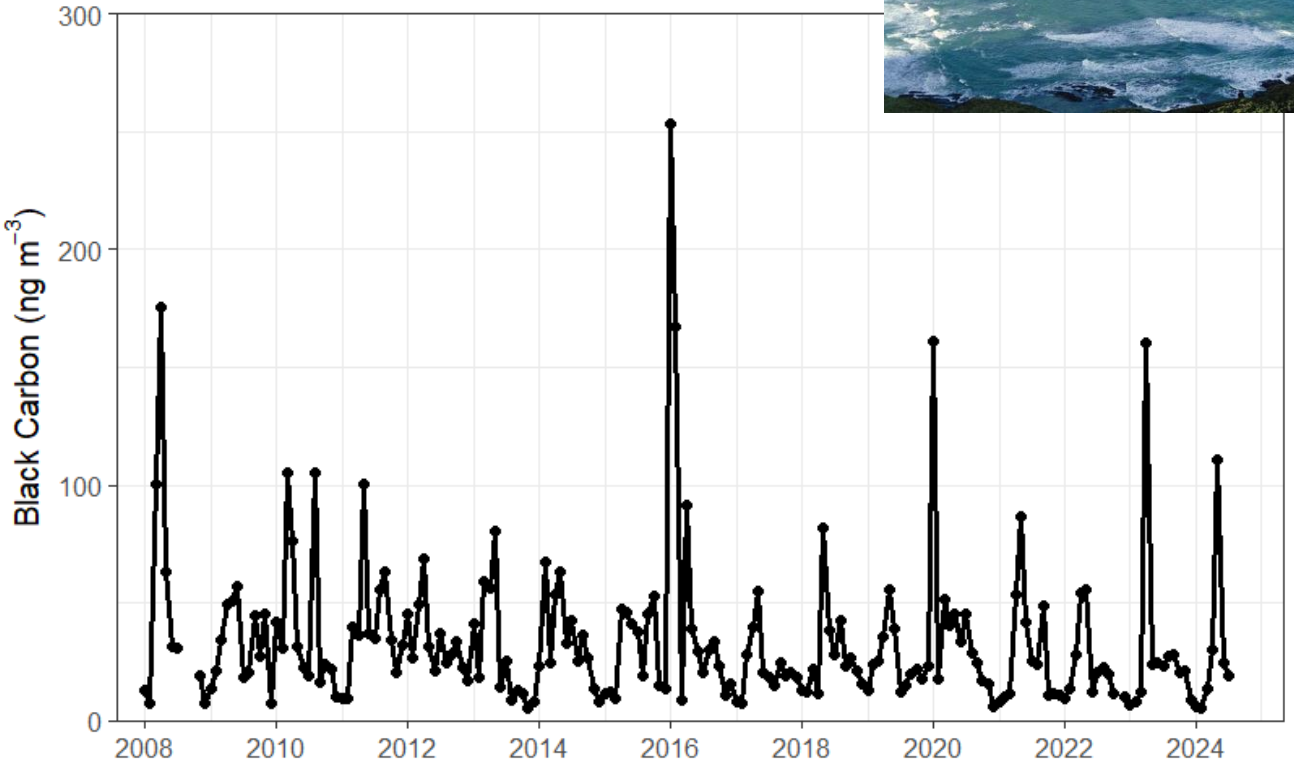


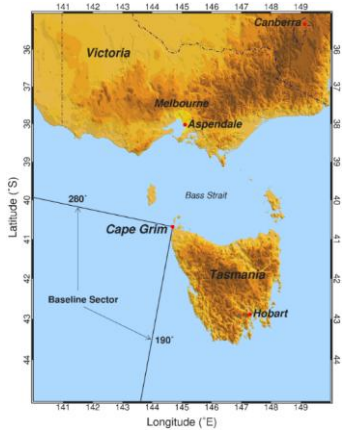


Duc et al, 2020. Spatial-Temporal Pattern of BC Emission from Biomass Burning and Anthropogenic Sources in NSW, Australia. https://doi.org/10.3390/atmos11060570

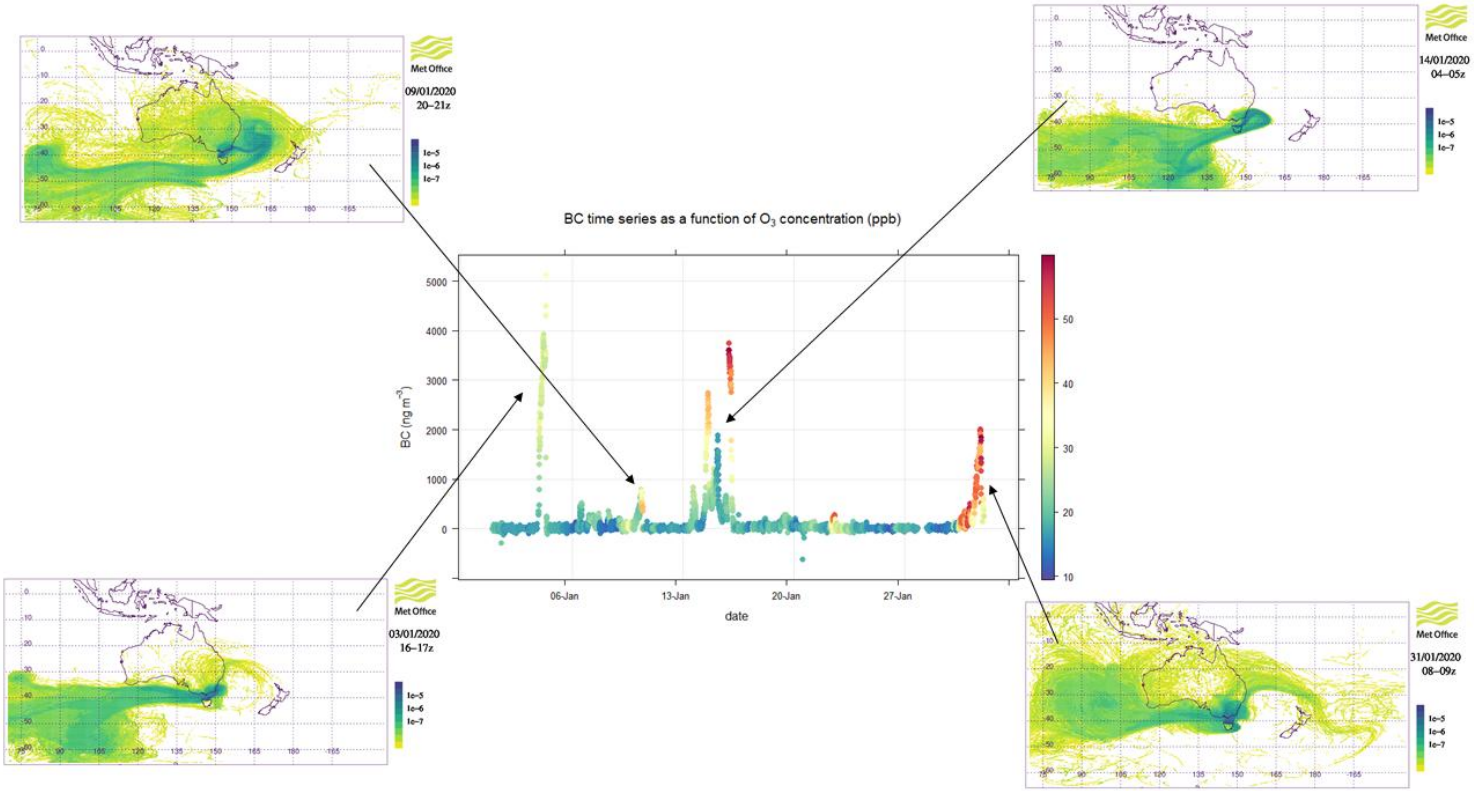
Slide from Matt Riley

Kennaook/Cape Grim

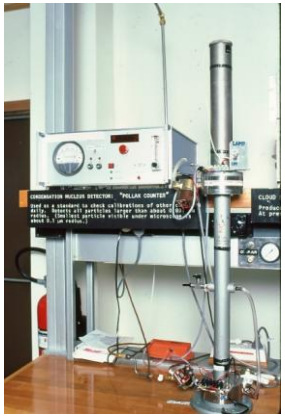


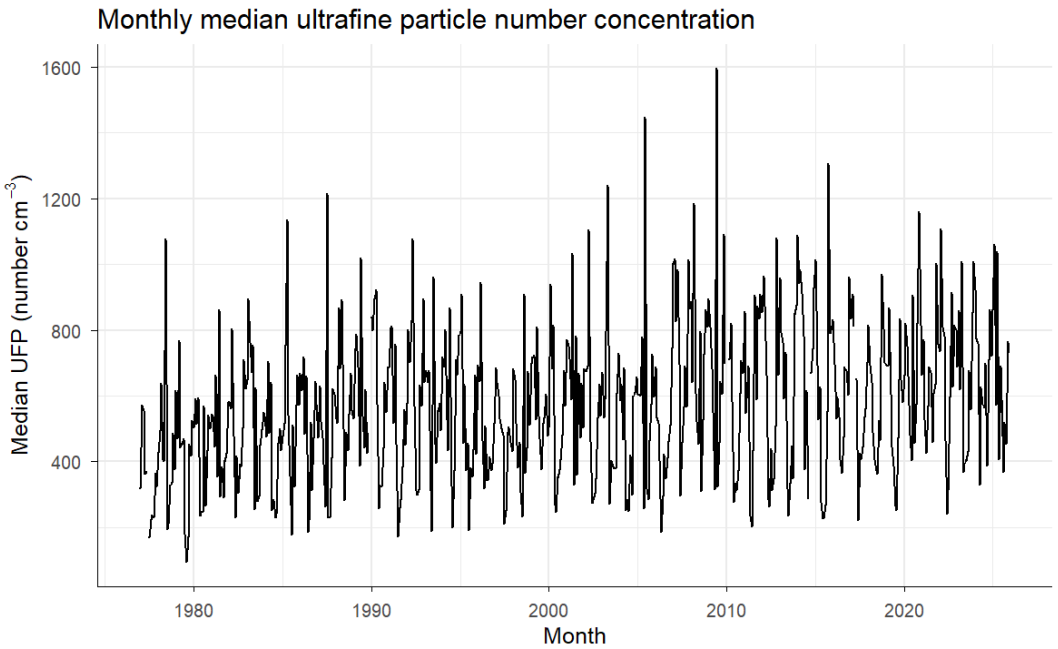


Black Summer Smoke at KCG



UFP at KCG




Monthly median ultrafine particle number concentration
Median UFP (number cm^{-3})
1600
1200
800
400
1980
1990
2000
2010
2020
Month

Why Now?

The recent NEPM review process (Amanda Wheelers presentation yesterday) highlighted increasing s interest in emerging pollutants, in this case, BC and UFP, as candidate metrics for future consideration.

Implementation challenges identified

Instrumentation cost

Specialised BC and UFP instruments carry significant capital cost

Training requirements

New measurement techniques demand dedicated technical skills

Resource constraints

Smaller jurisdictions face the greatest capacity pressure

What could a National Network look like?

- Nationally agreed measurement objectives and monitoring strategies.
- Standardised instrumentation specifications and performance criteria.
- Quality assurance and quality control frameworks.
- Common data formats, processing protocols and reporting standards.
- National training programs and technical support networks.
- Co-location studies and intercomparison exercises to ensure consistency between agencies.
- Integration of BC and UFP measurements into existing PM2.5 monitoring stations and supersites where appropriate.

A Coordinated Opportunity

- BC and UFP sit at the intersection of air quality management, public health protection and climate policy. International frameworks like WHO, IPCC, the EU are strengthening the case for their inclusion in monitoring programs.

- Australia has pockets of excellence in BC and UFP measurement but lacks the coordinated national capability needed to support future regulatory, health and climate objectives.

- Collaboration will maximise the value of existing expertise and infrastructure.