Atmospheric Composition & Chemistry Observations & Modelling Conference

incorporating the

Kennaook/Cape Grim Annual Science Meeting 2023

and in conjunction with the

Australian and New Zealand Aerosol Assembly

[Abstracts]

20 – 23 November 2023

hosted by

University of Wollongong

Murramarang Beachfront Nature Resort
South Durras, NSW, Australia



Edited by: N. Derek, P. B. Krummel and C. Paton-Walsh (Murphy)

Citation

Author, A. B., A. B. Author and A. B. Author (2023). Abstract Title. In ‘Atmospheric Composition & Chemistry Observations & Modelling Conference incorporating the Kennaook/Cape Grim Annual Science Meeting 2023 and in conjunction with the Australian and New Zealand Aerosol Assembly’ [abstract], 20–23 November 2023, Murramarang, NSW, Australia. (eds. N. Derek, P. B. Krummel and C. Paton-Walsh (Murphy), pp. xx. (BoM and CSIRO: Melbourne, Australia)

Arrival: Monday, 20 November 2023

18:00	**Dinner**	**Beach Bistro**

Day 1: Tuesday, 21 November 2023

08:00	**Breakfast**	**Beach Bistro**
09:00	**Convenors**	**Welcome & general information on arrangements etc**
Chair	**Elise Guerette**	**Session 1 – Oral Presentations**
09:15	Emily Franklin	Non-traditional anthropogenic contributions to particulate pollution in the modern megacity
09:30	Rosemary Fedele	Characterising sources and composition of $PM_{2.5}$ in inner west Melbourne
09:45	Steven Utembe	Apportioning the contribution of domestic wood fire heater emissions on air pollution
10:00	David Cohen	Victorian power station impacts global baseline station at Kennaook/Cape Grim
10:15	Clare Paton-Walsh (Murphy)	The revised World Health Organisation's Air Quality Guidelines – a perspective from the International Global Atmospheric Chemistry project
10:30	**Morning Tea**	**Poolside**
Chair	**Cathy Trudinger**	**Session 2 – Oral Presentations**
11:15	Paul Krummel/Zoe Loh/ Ray Langenfelds	Review of the Greenhouse Gases and Ozone Depleting Substances Program at Kennaook/Cape Grim
11:45	Elise-Andree Guerette	An overview of the new GASLAB database
12:00	Paolo Sebastianelli	Warming Refrigerants?
12:15	Kathryn Emmerson	Is the globally accepted mechanism for rupturing pollen about to be shattered?
12:30	Erin Dunne	PTR-MS measurements of gas and particle phase organics at Kennaook/Cape Grim: a pilot study
12:45	**Lunch**	**Poolside**
Chair	**Zijun Li**	**Session 3 – Oral Presentations**
14:15	Ruhi Humphries	The Cloud And Precipitation Experiment at Kennaook (CAPE-K)
14:30	Branka Miljevic	Capricorn-2 Southern Ocean voyage: Aerosol precursor vapours and aerosol chemical composition
14:45	Marc Mallett	Biogenic enhancement of cloud droplet concentrations observed off East Antarctica
15:00	Robert Ryan	Aerosol optical depth measurements at the Great Barrier Reef using MAX-DOAS, sun photometer and Lidar
15:15	All	CAPE-K and Southern Ocean discussion – introduction to discussion session on Day 3
15:30	**Afternoon Tea**	**Poolside**
Chair	**Emily Franklin**	**Session 4 – Oral Presentations**
16:15	Bakhat Rawat	Long-term monitoring of atmospheric mercury and its source contributions in Kennaook/Cape Grim, Australia
16:30	Dominique Kpokro	Mercury from artisanal gold mining in rural sub-Saharan Africa
16:45	Stephen Rigney	Flux and flow: Variation and physicochemical drivers of GHG fluxes across the intertidal wetland gradient
17:00	Stephen Wilson	Baseline AOD
17:15	**End of Day 1**	
18:30	**Dinner**	**Beach Bistro**

Day 2: Wednesday, 22 November 2023

08:00	**Breakfast**	**Beach Bistro**
09:25	**Convenors**	**General house keeping**
Chair	**David Griffith**	**Session 5 – Oral Presentations**
09:30	Sougol Aghdasi	High-resolution methane emission uncertainties in Gippsland: An *in situ* data assimilation study
09:45	Nasimeh Shahroki	Refining prior methane gridded emissions for Melbourne by national data integration and inverse modelling
10:00	Hasan Nawaz	Remote sensing of methane and its major sources in Australia
10:15	Sara Mikaloff-Fletcher	Quantifying agricultural emissions from ground-based and satellite data
10:30	**Morning Tea**	**Poolside**
Chair	**Hasan Nawaz**	**Session 6 – Oral Presentations**
11:15	Leigh Fleming	CarbonWatch-NZ: *In situ* and flask sampling network in Auckland for quantifying urban emissions
11:30	Peter Rayner	Monitoring Australia's methane emissions: An update on the OpenMethane Project
11:45	Ray Langenfelds	Progress towards extending the Australian Greenhouse Gas Observing Network (AGGON)
12:00	Nicholas Deutscher	What we do in the sunshine – an update on the Total Carbon Column Observing Network
12:30	**Lunch**	**Poolside; Aerospan discussion**
13:30		**Session 7 – Posters and Discussion Groups**
	Andrew Balch	PlumeMapper: An innovation in ambient odour assessment
	Robyn Schofield	A year of observations at University of Melbourne's AirLab
	Brittany Walker	Novel techniques of measuring carbon dioxide for Wollongong
14:00	Discussion Group 1	Methane/AGGON
14:00	Discussion Group 2	PICCASSO – Cape-K and Southern Ocean Studies
15:30	**Afternoon tea**	**Poolside**
Chair	**Nicholas Deutscher**	**Session 8 – Oral Presentations**
16:15	Paul Krummel	The 2023 Antarctic ozone hole
16:30	Justin Takacs	Comparison of stratospheric ozone trends from NDACC FTIR, Microwave Limb Spectrometer and Ozonesonde observations and model predictions in the Southern Hemisphere
16:45	David Griffith	Portable instrument developments for solar remote sensing of atmospheric composition
17:00	Leigh Crilley	Cooking and cleaning emissions in a commercial kitchen and its impact on outdoor and indoor air quality
17:15		**End Day 2**
18:30	**Dinner**	**Beach Bistro**

Day 3: Thursday, 23 November 2023 – Oral Presentations

08:00	**Breakfast**	**Beach Bistro**
09:10	**Convenors**	**Welcome & general information on arrangements etc**
Chair	**Clare Murphy**	**Session 9 – Oral Presentations**
09:15	Melita Keywood	Aerosol composition measured at Kennaook/Cape Grim using the tofACSM: October 2020-June 2023
09:30	Adhitya Sutresna	PMF representation of biomass burning organic aerosols from sea salt-interfered measurements using capture vapouriser-ToF-ACSM
09:45	Madhura Manohar	Characterizing the long-term contribution of the dust burden transported into the Sydney Basin, Australia
10:00	Christopher Roulston	Emission factors of greenhouse gases and particles from smouldering combustion of coarse woody debris, southeastern Australia
10:15	Stephen MacFarlane	Impacts of aromatic chemistry on the global atmosphere
10:30	**Morning Tea**	**Poolside**
Chair	**Robyn Schofield**	**Session 10 – Oral Presentations**
11:15	Matt Tully	Variability in ozone in the Upper Troposphere/Lower Stratosphere from Broadmeadows and Macquarie Island ozonesondes
11:30	Cathy Trudinger	Radiative Forcing, CO_2-equivalent and Equivalent Effective Stratospheric Chlorine calculated using measurements of greenhouse gases and ozone depleting substances in Antarctic firn and at Kennaook/Cape Grim
11:45	David Etheridge	Trends in atmospheric chemical species over the Anthropocene from firn, ice and baseline station measurements
12:00	**Lunch**	**Poolside – End of meeting, safe travels, we hope you enjoyed Murramarang**

This page was left blank intentionally.

Contents

Day 1 – Tuesday, 21 November 2023

Non-traditional anthropogenic contributions to particulate pollution in the modern megacity 1
E. B. Barnes Franklin, R. Rossell, K. L. Rediger, L. Yee, M. P. Vermeuel, T. Maddaleno, C. Osburn, A. De Groodt, R. E. O'Brien, A. H. Goldstein, D. B. Millet and D. K. Farmer

Characterising sources and composition of $PM_{2.5}$ in inner west Melbourne 2
R. Fedele, P. Davy, M. D. Keywood, M. Mclennan-Gillings, J. C. Powell, J. Shen, S. Taylor and P. Torre

Apportioning the contribution of domestic wood fire heater emissions on air pollution 4
S. R. Utembe, J. Choi, P. Torre, J. A. Noonan and M. E. Cope

Victorian Power Station Impacts Global Baseline Station at Kennaook/Cape Grim 5
D. D Cohen, A. Atanacio, M. Manohar and F. Wilkins

The revised World Health Organisation's Air Quality Guidelines – a perspective from the International Global Atmospheric Chemistry project 6
C. Paton-Walsh (Murphy), R. Subramanian, J. H. Crawford, L. Dawidowski, H. Langley Dewitt, L. Emberson, L. Emmons, R. Garland, Y. Kanaya, A. Mbandi, K. Pratt, N. Y. Rojas, A. Salam, K. Sindelarova, V. Sinha, N. E. Touré, L. E. Yu and M. Zheng

Review of the Greenhouse Gases and Ozone Depleting Substances Program at Kennaook/Cape Grim 7
P. B. Krummel, Z. M. Loh, R. L. Langenfelds, P. J. Fraser and L. P. Steele

An overview of the new GASLAB database 8
E-A. Guerette, G. Sergeant, R. L. Langenfelds and Z. M. Loh

Warming Refrigerants? 9
P. Sebastianelli, C. Griffith, M. C. P. Taylor, S. H. Kable, C. S. Hansen and M. J. T. Jordan

Is the globally accepted mechanism for rupturing pollen about to be shattered? 10
K. M. Emmerson, E. A. Stone, C. Mampage, E. Newbigin and E. Lampagnani

PTR-MS measurements of gas and particle phase organics at Kennaook/Cape Grim: a pilot study 11
C. Mynard[2], E. Dunne and R. S. Humphries

The Cloud And Precipitation Experiment at Kennaook (CAPE-K) 12
G. G. Mace, R. Marchand, M. D. Keywood, R. S. Humphries, S. J. Cleland, A. Protat, S. Fiddes, C. S. McCluskey, S. T. Siems, P. T. May and Y. Huang

Capricorn-2 Southern Ocean voyage: Aerosol precursor vapours and aerosol chemical composition 13
B. Miljevic, M. D. Mallet, C. G. Osuagwu, Z. D. Ristovski, R. S. Humphries, S. Taylor, P. W. Selleck and M. D. Keywood

Biogenic enhancement of cloud droplet concentrations observed off East Antarctica 15
M. D. Mallet, B. Miljevic, R. S. Humphries, G. G. Mace, S. P. Alexander, A. Protat, J. P. Ward, L. T. Cravigan, C. Mynard, K. Moore, P. J. DeMott, S. Fiddes, M. D. Keywood, C. G. Osuagwu, Z. D. Ristovski, S. Taylor and P. W. Selleck

Aerosol optical depth measurements at the Great Barrier Reef using MAX-DOAS, sun photometer and Lidar 16
R. Ryan, L. Toms-Hardman and R. Schofield

Long-term monitoring of atmospheric mercury and its source contributions in Kennaook/Cape Grim, Australia 17
B. Rawat, J. A. Fisher, N. M. Deutscher and J. C. Powell

Mercury from artisanal gold mining in rural sub-Saharan Africa 18
D. B. Kpokro

Flux and flow: Variation and physicochemical drivers of GHG fluxes Across the intertidal wetland gradient 19
S. D. Rigney, J. Kelleway, N. M. Deutscher, M. Hughes and T. A. Naylor

Baseline AOD 20
S. R. Wilson

Day 2 – Wednesday, 22 November 2023

High-resolution methane emission uncertainties in Gippsland: An *in situ* data assimilation study 21
S. Aghdasi, P. J. Rayner, N. M. Deutscher and J. D. Silver

Refining prior methane gridded emissions for Melbourne by national data integration and inverse modelling 22
N. Shahrokhi, C. M. Trudinger, P. J. Rayner, Z. M. Loh, J. Ramirez Gamboa, A. R. Stavert, D. M. Etheridge, C. G. R. Caldow, P. J. Fraser, B. L. Dunse, A. K. Luhar and P. B. Krummel

Remote sensing of methane and its major sources in Australia 23
H. Nawaz*, C. Paton-Walsh (Murphy) and N. T. Deutscher 23

Quantifying agricultural emissions from ground-based and satellite data 24
S. Mikaloff-Fletcher, B. Bukosa, A. Geddes, G. W. Brailsford, J. S. Benmergui, D. I. Campbell, J. Franklin, S. Hamburg, R. Law, J. Laubach, D. Noone, D. Pollard, J. Turnbull, H. Schaefer, L. A. Schipper and S. C. Wofsy

CarbonWatch-NZ: *In situ* and flask sampling network in Auckland for quantifying urban emissions 25
L. S. Fleming, J. Turnbull, L. Domingues, H. A. Young, T. W. Hilton, V. Monteiro, J. Parry-Thompson, G. W. Brailsford, S. Gray and S. Nichol

Monitoring Australia's methane emissions: An update on the OpenMethane Project 26
P. J. Rayner and G. Mason 26

Progress towards extending the Australian Greenhouse Gas Observing Network (AGGON) 27
R. L. Langenfelds, C. G. R. Caldow, Z. M. Loh, A. R. Stavert, C. M. Trudinger, P. B. Krummel, D. M. Etheridge, N. Shahrokhi, J. Ramirez Gamboa, E-A. Guerette, P. J. Fraser, B. L. Dunse, T. Ziehn, R. M. Law, A. Luhar, L. P. Steele, B. Mitrevski, D. A. Spencer, C. T. Roulston, C. E. Allison, Y. Villalobos Cortes, P. Canadell, M. B. Tully, N. M. Deutscher, C. Paton-Walsh (Murphy), D. W. T. Griffith, B. F. J. Kelly, A. G. Williams, S. D. Chambers and P. J. Rayner

What we do in the sunshine – an update on the Total Carbon Column Observing Network 28
N. M. Deutscher, D. W.T. Griffith, C. Paton-Walsh (Murphy)[1], N. B. Jones, B. T. Walker, H. Nawaz and TCCON Partners

The 2023 Antarctic ozone hole 29
P. B. Krummel, A. R. Klekociuk, M. B. Tully, P. J. Fraser and N. Derek

Comparison of stratospheric ozone trends from NDACC FTIR, Microwave Limb Spectrometer and Ozonesonde Observations and Model Predictions in the Southern Hemisphere 30
J. Takacs, N. T. Jones, C. Paton-Walsh (Murphy), D. Smale, C. Vigouroux and M. B. Tully

Portable instrument developments for solar remote sensing of atmospheric composition 31
D. W. T. Griffith, N. B. Jones, N. M. Deutscher and C. Paton-Walsh (Murphy)

Cooking and cleaning emissions in a commercial kitchen and its impact on outdoor and indoor air quality 32
L. R. Crilley, J. C. Ditto, M. Lao, L. Salehpoor, A. Chan, J. P. D. Abbatt and T. C. VandenBoer

Day 3 – Thursday, 23 November 2023

Aerosol composition measured at Kennaook/Cape Grim using the tofACSM: October 2020–June 2023 33
M. D. Keywood, C. Mynard, E. Dunne, R. S. Humphries and J. N. Harnwell

PMF representation of biomass burning organic aerosols from sea salt-interfered measurements using capture vapouriser-ToF-ACSM 34
A. R. Sutresna, M. D. Keywood, C. Paton-Walsh (Murphy), J. B. Simmons, Q. Dang, C. Mynard, R. S. Humphries, E. Dunne, J. P. Ward, F. Reisen, K. M. Emmerson, D. Worsnop, R. Schofield and P. J. Rayner

Characterizing the long-term contribution of the dust burden transported into the Sydney Basin, Australia 36
M. Manohar, D. D. Cohen, J. Crawford, A. Atanacio and F. Wilkins

Emission factors of greenhouse gases and particles from smouldering combustion of coarse woody debris, southeastern Australia 37
C. T. Roulston, J. C. Powell, S. Taylor, S. B. Molloy, D. Lynton and F. Reisen

Impacts of aromatic chemistry on the global atmosphere 38
S. M. MacFarlane, J. A. Fisher, L. Xu, K. Ball, J. Crouse, P. O. Wennberg and H. Pye

Variability in ozone in the Upper Troposphere/Lower Stratosphere from Broadmeadows and Macquarie Island ozonesondes 39
M. B. Tully

Radiative Forcing, CO_2-equivalent and Equivalent Effective Stratospheric Chlorine calculated using measurements of greenhouse gases and ozone depleting substances in Antarctic firn and at Kennaook/Cape Grim 40
C. M. Trudinger, P. B. Krummel, P. J. Fraser, N. Derek, Z. M. Loh, R. L. Langenfelds, D. M. Etheridge, B. Mitrevski and L. P. Steele

Trends in atmospheric chemical species over the Anthropocene from firn, ice and baseline station measurements 43
D. M. Etheridge, V. V. Petrenko, X. Fain, C. M. Trudinger, R. L. Langenfelds, A. M. Smith, P. B. Krummel, M. Rubino, A. Menking, Z. M. Loh, D. A. Spencer, E.-A. Guerette, C. G. R. Caldow, P. D. Neff, C. Buizert, M. T. Woodhouse, L. Murray, P. Martinerie and M. A. J. Curran

Posters

PlumeMapper: An innovation in ambient odour assessment 44
A. Balch and S. S. John

A year of observations at University of Melbourne's AirLab 45
R. Schofield, D. Hocking, R. Ryan, I. Wadlow, L. Toms-Hardman, A. Sutresna, Z. M. Loh, J. Ramirez Gamboa, C. He, R. Jayaratne, Z. D. Ristovski, L. Morawska and J. Choi

Novel techniques of measuring carbon dioxide for Wollongong 46
B. T. Walker, N. M. Deutscher, C. Paton-Walsh (Murphy), D. W. T. Griffith, N. B. Jones, H. Nawaz and TCCON Partners

This page was left blank intentionally.

Non-traditional anthropogenic contributions to particulate pollution in the modern megacity

E. B. Barnes Franklin[1,2*], R. Rossell[1], K. L. Rediger[1], L. Yee[3], M. P. Vermeuel[4], T. Maddaleno[4], C. Osburn[1], A. De Groodt[5], R. E. O'Brien[6], A. H. Goldstein[3], D. B. Millet[4] and D. K. Farmer[1]

[1] Department of Chemistry, Colorado State University, Fort Collins, CO, USA
[2] CSIRO Environment, Climate, Atmosphere and Ocean Interactions, Aspendale, VIC, Australia
[3] Department of Environmental Science, Policy, and Management, University of California, Berkeley, CA, USA
[4] Department of Soil, Water and Climate, University of Minnesota, St Paul, MN, USA
[5] Department of Chemistry, Hendrix College, Conway, AR, USA
[6] Department of Chemistry, William & Mary, Williamsburg, VA, USA

[*] corresponding author: Emily Barnes Franklin [emily.franklin@csiro.au]

Abstract

Secondary organic aerosol (SOA), particulate matter formed in the atmosphere from the oxidation of gas phase emissions, plays an important role in both radiative forcing and public health. As regulations and emissions control technologies have evolved, the relative importance of traffic and industrial emissions has declined compared to other, more complex emissions classes. Recent studies have indicated that volatile chemical products (VCPs), which include paints, pesticides, cleaners, and consumer products, may now play a dominant role in urban volatile organic compound (VOC) reactivity and SOA formation potential in densely populated urban areas. Semivolatile organic compounds (SVOCs), species that partition between gas and condensed phases under normal ranges of atmospheric temperatures, are a potentially important part of this process. SVOCs' emissions are highly temperature dependent, and they have high secondary aerosol yields relative to more volatile species. In this work, composition of SVOCs and organic aerosol in the New York City region is investigated through a range of both bulk and speciated techniques to assess the contributions of VCPs and other nontraditional anthropogenic to urban air pollution in the modern North American megacity. This work is primarily based upon measurements from FROG-NY (Fluxes of Reactive Organic Gases in New York), an observational campaign conducted in July and August 2023 and based at a suburban location on Long Island periodically downwind of New York City. SVOCs are characterized by gas chromatography mass spectrometry (GC-MS), while aerosol composition is characterized by aerosol chemical speciation monitor (ACSM) and two-dimensional gas chromatography mass spectrometry (GCxGC-MS). Properties of unidentifiable compounds resolved by GCxGC-MS are predicted using Ch3MS-RF, a machine learning-based model that has been newly updated to better represent the properties of urban aerosol. Preliminary results indicate that infrastructure and consumer products significantly contribute to organic aerosol, particularly under high temperature conditions when mixing is suppressed. Comparisons between the chemical signatures of specific products and gas and aerosol observed under ambient urban conditions provides a unique opportunity to identify likely tracers of VCP oxidation chemistry, a key step in characterizing how consumer products contribute to aerosol formation potential in the modern megacity.

Characterising sources and composition of $PM_{2.5}$ in inner west Melbourne

R. Fedele[1*], P. Davy[2], M. D. Keywood[3], M. Mclennan-Gillings[1], J. C. Powell[3], J. Shen[1], S. Taylor[3] and P. Torre[1]

[1] Environment Protection Authority Victoria, Macleod, VIC, Australia
[2] GNS Science, Lower Hutt, New Zealand
[3] CSIRO Environment, Climate, Atmosphere and Ocean Interactions, Aspendale, VIC, Australia

[*] corresponding author: Rosemary Fedele [rosemary.fedele@epa.vic.gov.au]

Abstract

Exposure to airborne particles smaller than 2.5 μm in aerodynamic diameter ($PM_{2.5}$) results in adverse health outcomes. There are multiple sources of these particles in inner west Melbourne, such as vehicle emissions, wood heater emissions, industry, shipping and natural sources like sea salt. EPA monitored air pollution in inner west Melbourne between February 2021 and June 2022 to identify the major sources of these particles to inform programs aimed at reducing air pollution in the area.

Specifically, this study collected $PM_{2.5}$ samples to addresses the following research questions:

- What are the sources contributing to $PM_{2.5}$ in inner west Melbourne?
- What are the key chemical species in $PM_{2.5}$ in inner west Melbourne?
- What are the major anthropogenic activities contributing to $PM_{2.5}$ that we should focus our interventions on?

$PM_{2.5}$ samples were collected at eleven sites in inner west Melbourne from 28 February 2021 to 25 June 2022. Two of the eleven sites were designated as generally representative of ambient air (Site 1: Yarraville and Site 2: Spotswood) where samples were collected predominantly every third day. At the remaining nine sites $PM_{2.5}$ samples were collected near specific sources such as shipping docks, roads with heavy vehicle traffic or general traffic, for different time periods for the express purpose of characterising the chemical composition of the targeted pollution source.

$PM_{2.5}$ samples were analysed to determine the presence and concentration of 62 chemical species. The chemical composition of $PM_{2.5}$ samples were input into a chemical element mass balance (receptor) model (EPA PMF 5.0.14) to determine sources of particles at the two ambient air quality sites.

The receptor model was run using various input data, including sub-groupings by location, using the following sets of data:

- Single ambient sites on their own (Yarraville or Spotswood) – 124 or 140 samples respectively
- Both ambient sites together (Yarraville and Spotswood) – a total of 264 samples
- A single ambient site (Yarraville or Spotswood) with source specific samples – 174 or 190 samples respectively
- All sites – a total of 314 samples

Source specific samples weren't used on their own in the receptor model due to the small number of samples collected (50 samples).

Analysis was carried out assuming 7 or more factors would be present, as it is common to see this many factors in $PM_{2.5}$ at urban locations. We selected 8 factors for Spotswood when this site was run on its own and 11 factors for Yarraville when this site was run with source specific samples.

Eleven sources were found to contribute to particle mass at the two ambient sites by the receptor model. Of these, eight sources were common to both sites: aged biomass burning, fresh biomass burning, diesel vehicles, petrol vehicles, crustal matter (road dust), ammonium sulphate, sea salt and nitrates (aged sea salt). Three additional sources were identified at Yarraville, which related to shipping and two local industry sources. The receptor model could not separate the shipping contribution from industrial sources at Yarraville without the

source specific samples. With the addition of the source specific samples, a shipping factor was identified by receptor modelling for the first time in Australia.

The key chemical species identified at the two ambient air quality sites were black carbon (BC) and organic carbon (OC), comprising ~ 60% of the average $PM_{2.5}$ concentrations at the ambient air quality sites. The sources identified reflect this chemical composition with major sources containing BC and OC as dominant chemical species.

Most of the sources identified by the study are anthropogenic, the most predominant sources were diesel vehicle emissions and biomass burning (smoke from wood heaters in winter and hazard reduction burns in autumn). Targeting our interventions to human activities linked to major $PM_{2.5}$ sources such as diesel vehicle emissions and wood heater smoke will have the greatest impact on reducing $PM_{2.5}$ pollution and improving human health in inner west Melbourne.

Apportioning the contribution of domestic wood fire heater emissions on air pollution

S. R. Utembe[1*], J. Choi[1], P. Torre[1], J. A. Noonan[2] and M. E. Cope[2]

[1] Environment Protection Authority, Centre for Applied Sciences, Macleod, VIC, Australia
[2] CSIRO Environment, Climate, Atmosphere and Ocean Interactions, Aspendale, VIC, Australia

[*] corresponding author: Steven Utembe [steven.utembe@epa.vic.gov.au]

Abstract

This study investigates the contribution of wood heater emissions on predicted $PM_{2.5}$ concentrations in Victoria, Australia. Using CSIRO's Conformal Cubic Atmospheric Model and Chemical Transport Model (CCAM-CTM) coupled to an offline meteorological model, concentrations of $PM_{2.5}$ have been predicted for two runs, one with all emissions, including wood heater emissions, and another without wood heater emissions. For the run with wood heater emissions, predicted concentrations are compared with measurement data from Environment Protection Authority (EPA) monitoring sites with the model showing reasonable skill at predicting both meteorological variables as well as atmospheric composition variables (r coefficient values ranging from 0.5 to 0.8). The model run with wood heater emissions result with higher predicted $PM_{2.5}$ concentrations (mean of about 5 $\mu g/m^3$ and maximum of about 43 $\mu g/m^3$) especially to the northeast area of Metropolitan Melbourne, compared to the run without wood heater emissions. The study found the levels of $PM_{2.5}$ were significantly increased due to wood heater emissions across large areas (405 km^2) in the Metropolitan Melbourne area.

Victorian Power Station Impacts Global Baseline Station at Kennaook/Cape Grim

D. D Cohen*, A. Atanacio, M. Manohar and F. Wilkins

Centre for Accelerator Science, Australian Nuclear Science and Technology Organisation, Menai, NSW, Australia

* corresponding author: David Cohen [dcz@ansto.gov.au]

Abstract

The Aerosol Sample Program (ASP) at ANSTO has been characterising $PM_{2.5}$ fine particles at Kennaook/Cape Grim since June 1992. Samples are collected on 25 mm stretched Teflon filters and analysed for over 20 different elemental and chemical species using accelerator-based ion beam analysis (IBA) techniques. These IBA methods coupled with Positive Matric Factorisation (PMF) source apportionment methods allowed us to generate five unique source fingerprints covering the whole sampling period. These fingerprints included *Secondary Sulfate, Sea Salt, Soil* and industrial components.

In Table 1 we identify 13 possible point sources in Victoria and Tasmania that could impact the Kennaook/Cape Grim site under favourable wind conditions. The locations of these point sources are shown as squares in Fig. 1.

This presentation will discuss the PMF source fingerprints obtained and show how by using HYSPLIT wind back trajectory methods we can demonstrate that emissions from the Hazelwood coal fired power station (square 13) in Victoria could be detected at Kennaook/Cape Grim. This occurred not only occasionally on a daily basis, but during the whole sampling period up to 2017 when it closed down. Hazelwood power station was responsible for over 17% of the sampling days when the *Secondary Sulfate* fingerprint was above 2 µg/m^3 at Cape Grim.

Table 1. Possible industrial sources affecting Kennaook/Cape Grim and the percentage of daily back trajectory intersections when *Secondary Sulfate* was greater than 2 µg/m^3

Industrial Source	Back Trajectory Intersections (%)
13 Hazelwood Power	17.6
14 Melbourne city	14.1
12 Alcoa Pt Henry	13.5
6 Wynyard Si	9.1
1 Waratah Si	7.0
11 Portland Al	6.6
9 Bell Bay Al	4.7
8 Beaconsfield Au	4.5
4 Queenstown CuAu	4.4
7 Railton Cement	4.3
3 Renison Sn	4.3
2 Zeehan Ni	4.2
5 Rosebery CuZnPb	3.9
10 Fingal Coal	1.8

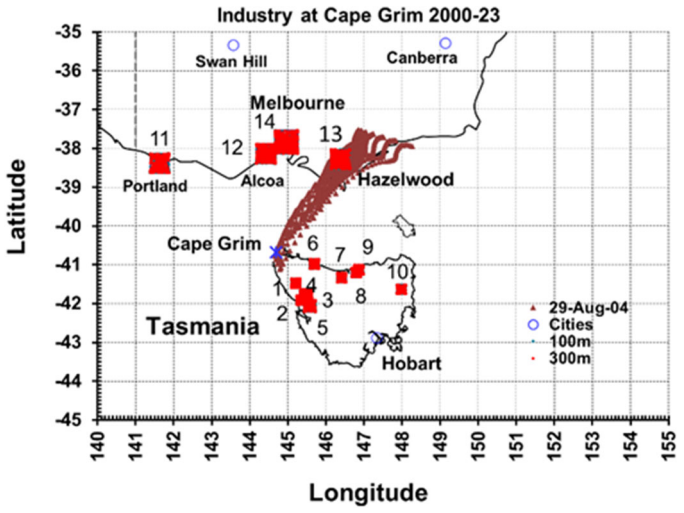


Fig. 1. Map of Tasmania and Southern Victoria showing 14 industry sources (boxes) and hourly HYSPLIT back trajectories for 29 August 2004.

The revised World Health Organisation's Air Quality Guidelines – a perspective from the International Global Atmospheric Chemistry project

C. Paton-Walsh (Murphy)[1*], R. Subramanian[2*], J. H. Crawford[3], L. Dawidowski[4], H. Langley Dewitt[5], L. Emberson[6], L. Emmons[7], R. Garland[8], Y. Kanaya[9], A. Mbandi[10], K. Pratt[11], N. Y. Rojas[12], A. Salam[13], K. Sindelarova[14], V. Sinha[15], N. E. Touré[16], L. E. Yu[17] and M. Zheng[18]

[1] School of Earth Atmospheric and Life Sciences, University of Wollongong, Wollongong, NSW, Australia
[2] Center for Study of Science, Technology, and Policy, Bengaluru, India
[3] NASA Langley Research Center, Hampton, VI, USA
[4] Comisión Nacional de Energía Atómica, Buenos Aires, Argentina
[5] CIRES, University of Colorado, Boulder, CO, USA
[6] Environment & Geography Dept., University of York, York, North Yorkshire, UK
[7] National Center for Atmospheric Research, Boulder, CO, USA
[8] University of Pretoria, Pretoria, Gauteng, South Africa
[9] Japan Agency for Marine-Earth Science and Technology, Yokohama, Kanagawa, Japan
[10] School of Engineering and Technology, Department of Mechanical Engineering, South Eastern Kenya University, Kitui, Kenya
[11] Departments of Chemistry and Earth & Environmental Sciences, University of Michigan, Ann Arbor, MI, USA
[12] Universidad Nacional de Colombia, Bogota, Columbia
[13] Department of Chemistry, Faculty of Science, University of Dhaka, Dhaka 1000, Bangladesh
[14] Deptartment of Atmospheric Physics, Faculty of Mathematics and Physics, Charles University, Prague, Czechia
[15] Indian Institute of Science Education and Research, Mohali, Punjab, India
[16] d LASMES, Université Félix Houphouët-Boigny, Cocody, Abidjan, Côte d'Ivoire
[17] Department of Civil & Environmental Engineering, National University of Singapore, Singapore
[18] College of Environmental Science and Engineering, Peking University, Beijing, China

[*] corresponding authors: Clare Paton-Walsh (Murphy) [clarem@uow.edu.au]; R Subramanian [subu@cmu.edu]

Abstract

Despite being based on the best available health assessments, from an atmospheric chemistry point of view the World Health Organisation's air quality targets are problematic for several reasons. Firstly, the annual averaged target set for $PM_{2.5}$ of 5 μg/m^3 is below natural occurring exposure levels for more than 70% of the earth's population. It is unclear what purpose is served by setting a target that is so far from what can be realistically achieved, especially considering emerging evidence that chemical composition and particle number may be more important for health impacts than particle mass density (as measured in $PM_{2.5}$). We are concerned that by focussing on the lowest possible levels of pollution for everyone, the most vulnerable citizens in the most polluted cities are being overlooked. It is in these areas that the greatest health gains can be made by reducing atmospheric pollution levels.

Secondly, the combination of targets for the different pollutants fail to provide a clear pathway to a cleaner atmosphere. Much of the $PM_{2.5}$ and all the ozone is chemically formed in the atmosphere from so-called 'precursor' pollutants including sulfur dioxide, nitrogen oxides and volatile organic compounds. However, the targets set for sulfur dioxide and for carbon monoxide are representative of an atmosphere with relatively high levels of pollution from fossil fuel combustion, so these targets are incompatible with the ambitious targets for $PM_{2.5}$. Similarly, the combination of the new peak-season target for ozone and the reduced target for nitrogen dioxide are hard to reconcile in the absence of any measure or control on volatile organic compounds. Fundamentally, it is not possible to successfully reduce ozone and $PM_{2.5}$ without more stringent controls on the precursor pollutants.

The Scientific Steering Committee of International Global Atmospheric Chemistry (IGAC) project has recently penned a letter about the revised WHO Air Quality Guidelines, explaining these issues and commenting on how realistic targets can be set and achieved in each region to reduce air pollution and the accompanying health burden. This presentation will discuss the contents of this letter and outline the main points put forward by IGAC.

Review of the Greenhouse Gases and Ozone Depleting Substances Program at Kennaook/Cape Grim

P. B. Krummel*, Z. M. Loh, R. L. Langenfelds, P. J. Fraser and L. P. Steele

CSIRO Environment, Climate, Atmosphere and Ocean Interactions, Aspendale, VIC, Australia

* corresponding author: Paul Krummel [paul.krummel@csiro.au]

Abstract

The Kennaook/Cape Grim Baseline Air Pollution Station has been producing long-term, high-quality data and research outputs on the composition and chemistry of the southern mid-latitudes for nearly 50 years. Each program within the broader Science Program is reviewed regularly, to ensure that a culture of science excellence is maintained and that the objectives of each program remain fit for purpose. The Greenhouse Gases and Ozone Depleting Substances (GG-ODS) program was last reviewed in 2018.

The objectives of the GG-ODS program are:

- To continue the long-term, highest-quality observations of all the important, long-lived gases that drive climate change and ozone depletion, using both in situ measurements and flask samples;
- The maintenance of accurate, stable and internationally-accepted calibration standards and procedures;
- The collection, analysis and storage of Kennaook/Cape Grim air archive samples;
- To ensure regular submission of the Kennaook/Cape Grim GG-ODS data to the relevant national and international data archives;
- To enhance the measurement science at Kennaook/Cape Grim through the introduction of state-of-the-art measurement capability;
- To sustain collaboration with international laboratories and programs;
- To use the Kennaook/Cape Grim data, through national and international partnerships, to derive, by inverse and other modelling techniques, global and regional sources (emissions) and sinks for these important trace gas species;
- To inform ‘bottom-up’ national and global emissions inventories with ‘top-down’ estimates based on Kennaook/Cape Grim and other global observational data;
- To participate fully in all the national and international assessments of climate change and ozone depletion so that Kennaook/Cape Grim data receive the widest possible global recognition and application; and
- To ensure that Kennaook/Cape Grim retains its status as a premier Baseline Station in the Global Atmosphere Watch hierarchy.

Here we present an overview of the GG-ODS program covering the achievements of 2018 through to 2023 and the future directions of the program.

An overview of the new GASLAB database

E-A. Guerette[1*], G. Sergeant[2], R. L. Langenfelds[1] and Z. M. Loh[1]

[1] CSIRO Environment, Climate, Atmosphere and Ocean Interactions, Aspendale, VIC, Australia
[2] CSIRO National Collections & Marine Infrastructure, Hobart, TAS, Australia

[*] corresponding author: Elise-Andree Guerette [elise-andree.guerette@csiro.au]

Abstract

Long-term measurement programs need to be supported by fit-for-purpose, maintained, data and metadata management tools. Over the years, GASLAB has used a succession of database solutions to record sample collection details, manage flask movements, and process analytical data from the GASLAB gas chromatographs. This presentation will describe the latest incarnation of the GASLAB database, which has been operational since June 2023. This new database builds on its predecessor, keeping all existing features and adding new ones, such as the ability to ingest sulphur hexafluoride data from the new gas chromatograph with electron capture detector (GC-ECD) and the ability to track cylinder movements. The new database also has a test environment and version control. Porting the data processing code uncovered opportunities to optimize the reprocessing of the entire database, reducing reprocessing times by an order of magnitude.

Warming Refrigerants?

P. Sebastianelli[1*], C. Griffith[2], M. C. P. Taylor[3], S. H. Kable[3], C. S. Hansen[3] and M. J. T. Jordan[2]

[1] School of Earth, Atmospheric and Life Science, University of Wollongong, Wollongong, NSW, Australia
[2] School of Chemistry, University of Sydney, Sydney, NSW, Australia
[3] School of Chemistry, University of New South Wales, Sydney, NSW, Australia

[*] corresponding author: Paolo Sebastianelli [paolos@uow.edu.au]

Abstract

Hydrofluoroolefins (HFOs) are used as fourth-generation refrigerants. They have been thought to be promising chemical replacements for previous refrigerants due to their zero ozone-depleting potential (ODP) and assumed low global warming potential (GWP) [Arora et al. 2018]. However, there has been recent evidence that HFOs could decompose under atmospheric conditions into hydrofluorocarbons (HFCs) [Campbell et al. 2021]. In this work, we explored theoretically the possible tropospheric photolysis pathways of one of the most important HFO breakdown products: fluorinated acetaldehydes. Three HFOs were considered: HFO-1234ze, HFO-1243ze, and HFO-1252ze, producing CF_3CHO, CHF_2CHO, and CH_2FCHO, respectively [Javadi et al. 2008]. Here, we show how their major tropospheric photolysis channels have been characterised by an accurate simulation protocol. A comparative analysis of the results reveals that HFO-1234ze has the highest likelihood of HFC production.

CH_2FCHO, CHF_2CHO, and CHF_3CHO are the fluorinated acetaldehydes that could be produced [Javadi et al. 2008] during the HFOs breakdown processes. Their major tropospheric photolysis' channels have been characterised by an accurate simulation protocol. A comparative analysis of the results revealed that the probability that HFO-1234ze would produce HFC is the highest.

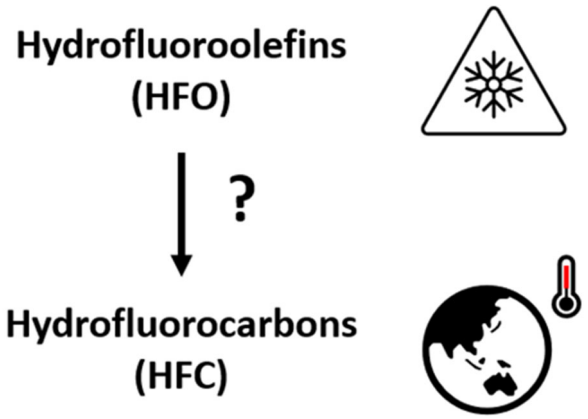


Fig. 1. Are HFOs source of HFCs?

References

Arora, P., G. Seshadri and A. K. Tyagi (2018). Fourth-generation refrigerant: HFO-1234yf. *Curr. Sci*. 115, 1497–1503. https://www.jstor.org/stable/26978441

Campbell, J. S., K. Nauta, S. H. Kable and C. S. Hansen (2021). Photodissociation dynamics of CF_3CHO: C-C bond cleavage. *J. Chem. Phys.* 155:20, 204303. https://doi.org/10.1063/5.0073974

Javadi, M. S., R. Søndergaard, O. J. Nielsen, M. D. Hurley and T. J. Wallington (2008). Atmospheric chemistry of trans-CF_3CH=CHF: Products and mechanisms of hydroxyl radical and chlorine atom initiated oxidation. *Atmos. Chem. Phys.* 8, 3141–3147. https://doi.org/10.5194/acp-8-3141-2008

Is the globally accepted mechanism for rupturing pollen about to be shattered?

K. M. Emmerson[1*], E. A. Stone[2], C. Mampage[2], E. Newbigin[3] and E. Lampagnani[3]

[1] CSIRO Environment, Climate, Atmosphere and Ocean Interactions, Aspendale, VIC, Australia
[2] Department of Chemistry, University of Iowa, Iowa City, IA, USA
[3] Biosciences, University of Melbourne, Melbourne, VIC, Australia

[*] corresponding author: Kathryn Emmerson [kathryn.emmerson@csiro.au]

Abstract

The world's most severe thunderstorm asthma event occurred in Melbourne, Australia on 21 November 2016, coinciding with the peak of the grass pollen season. The role of thunderstorms in these events is thought to cause pollen to rupture in high humidity conditions, releasing large numbers of sub-pollen particles (SPPs) with sizes very easily inhaled deep into the lungs [Taylor and Jonsson 2004]. Modelling of the event suggests the relative humidity was too low to support this hypothesis [Emmerson et al. 2021], but we do not have measurements of SPPs to corroborate this.

Until now.

References

Emmerson, K. M., J. D. Silver, M. Thatcher, A. Wain, P. J. Jones, A. Dowdy, E. Newbigin, B. W. Picking, J. Choi, E. Ebert and T. Bannister (2021). Atmospheric modelling of grass pollen rupturing mechanisms for thunderstorm asthma prediction. *PloS ONE* 16(4): e0249488. https://doi.org/10.1371/journal.pone.0249488

Taylor P. E. and H. Jonsson (2004) Thunderstorm asthma. *Curr. Allergy Asthma Rep.* 4:5, 409–413. https://doi.org/10.1007/s11882-004-0092-3

PTR-MS measurements of gas and particle phase organics at Kennaook/Cape Grim: a pilot study

C. Mynard[1,2], E. Dunne[2*] and R. S. Humphries[2]

[1] Monash University, Clayton, VIC, Australia
[2] CSIRO Environment, Climate, Atmosphere and Ocean Interactions, Aspendale, VIC, Australia

[*] corresponding author: Erin Dunne [erin.dunne@csiro.au]

Abstract

A pilot study measuring gas and sub-micron particle phase organics using a new Proton Transfer Reaction-Time of Flight-Mass Spectrometer (PTR-ToF-MS) equipped with an aerosol sampling system (CHARON) (Ionicon Analytik GmbH, Austria) was initiated at Kennaook/Cape Grim (KCG) in August 2023. This new generation PTR-ToF instrument offers high sensitivity (< 10 pptv), and higher time (10 s) and mass resolution (>4 m/dm) than PTR-Quadrupole-MS instruments previously deployed at KCG allowing a wider range of VOCs to be accurately identified and quantified (Fig 1).

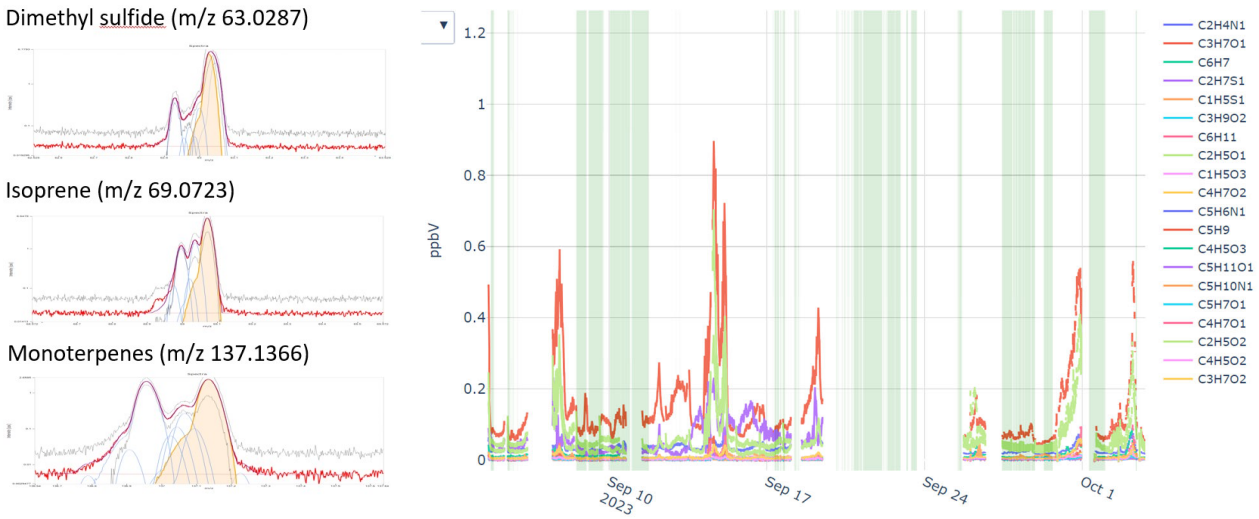


Fig. 1. (Left) Improved peak identification of key biogenic VOCs with PTR-ToF-MS. (Right) Time series of top 20 VOCs identified and quantified using Ionicon Data Analyser software (Ionicon GmbH) in data collected at KCG August – October 2023. Green bars represent periods when clean marine air masses were sampled (Baseline 3).

The CHARON aerosol sampling system expands the volatility range detectable by PTR-MS to include the semi- to low- volatility organics as well as particulate nitrate and ammonium [Mueller et al. 2017]. For example, at KCG this instrument offers the potential to measure marine biogenic VOCs such as DMS alongside its less volatile oxidation product MSA in sub-micron aerosol in near-real-time with a single measurement system. Here we will present preliminary data of gas and aerosol phase organics from the initial deployment of CHARON PTR-ToF-MS at KCG and provide an early assessment of its potential to provide new insights on the relationships between VOCs and SOA from the Southern Ocean.

References

Mueller M., P. Eichler, B. D'Anna, W. Tan and A. Wisthaler (2017). Direct Sampling and Analysis of Atmospheric Particulate Organic Matter by Proton-Transfer-Reaction Mass Spectrometry. *Anal. Chem.* 89, 20, 10889–10897. https://doi.org/10.1021/acs.analchem.7b02582

The Cloud And Precipitation Experiment at Kennaook (CAPE-K)

G. G. Mace[1], R. Marchand[2], M. D. Keywood[3,4], R. S. Humphries[3,4*], S. J. Cleland[5^], A. Protat[5], S. Fiddes[4], C. S. McCluskey[6], S. T. Siems[7], P. T. May[7] and Y. Huang[8]

[1] Department of Atmospheric Sciences, University of Utah, Salt Lake City, UT, USA
[2] College of the Environment, University of Washington, Seattle, WA, USA
[3] CSIRO Environment, Climate, Atmosphere and Ocean Interactions, Aspendale, VIC, Australia
[4] Australian Antarctic Program Partnership, University of Tasmania, Hobart, TAS, Australia
[5] Bureau of Meteorology, Melbourne, VIC, Australia
[6] National Center for Atmospheric Research, Boulder, CO, USA
[7] School of Earth Atmosphere and Environment, Monash University, Melbourne, VIC, Australia
[8] Geography, Earth and Atmospheric Sciences, University of Melbourne, Melbourne, VIC, Australia
[^] retired October 2022

[*] corresponding author: Ruhi Humphries [ruhi.humphries@csiro.au]

Abstract

The Baseline Air Pollution Station at Kennaook / Cape Grim (KCG) has produced the longest and most consequential record of Southern Hemisphere aerosol and gas-phase chemistry. However, cloud and precipitation measurements have not been collected there over an extended period and have been limited to campaigns at the site or aboard research vessels that typically traversed higher latitudes. These limited observations have resulted in large model uncertainty in the surface radiation budget due to clouds and precipitation in the region – a region where strong latitudinal gradients in cloud feedbacks are found. This uncertainty exists in a region where there are strong and well-documented seasonal variations in marine aerosol properties. Satellite data suggest that cloud properties covary with the seasonal cycle in aerosol in the SO, yet detailed vertically resolved measurements of cloud and precipitation in the marine boundary layer are lacking.

The Cloud And Precipitation Experiment at Kennaook (CAPE-K) is a 17 month deployment of the US Atmospheric Radiation Measurement's (ARM) Mobile Facility which consists of extensive cloud and precipitation observations to complement the extensive observational program already at KCG. CAPE-k will provide detailed cloud and precipitation observations from April 2024 to September 2025 – long enough to capture a full annual cycle as well as two winter seasons. It has also been designed to align with the COAST-K voyage aboard the RV Investigator currently scheduled for May 2025.

This presentation will provide an overview of the scientific objectives, as well as some of the more practical considerations of the project including opportunities for the scientific community to engage in the science being produced from the project, or to attend as part of the numerous intensive operating periods occurring throughout the deployment.

Capricorn-2 Southern Ocean voyage: Aerosol precursor vapours and aerosol chemical composition

B. Miljevic[1*], M. D. Mallet[2], C. G. Osuagwu[1], Z. D. Ristovski[1], R. S. Humphries[3], S. Taylor[3], P. W. Selleck[3] and M. D. Keywood[3]

[1] School of Earth and Atmospheric Sciences, Queensland University of Technology, Brisbane, QLD Australia
[2] Australian Antarctic Program Partnership, Institute for Marine and Antarctic Studies (IMAS), University of Tasmania, Hobart, TAS Australia
[3] CSIRO Environment, Climate, Atmosphere and Ocean Interactions, Aspendale, VIC, Australia

[*] corresponding author: Branka Miljevic [b.miljevic@qut.edu.au]

Abstract

The Southern Ocean (SO) is a region of the world where most climate models have a persistent positive bias in the amount of sunlight reaching the Earth's surface. This bias is caused, in part, because models consistently underpredict aerosol and cloud cover in this region, which, in turn, stems from an insufficient understanding of aerosol-cloud interactions and aerosol production mechanisms in this pristine environment. This has motivated a number of recent and upcoming field campaigns in the SO. Here we present findings from the summertime CAPRICORN-2 SO voyage (2018) with a focus on low volatility vapours relevant for marine new particle formation (sulfuric acid, methanesulfonic acid (MSA) and iodic acid) and aerosol chemical composition.

CAPRICORN-2 (Clouds, Aerosols, Precipitation, Radiation, and atmospheric Composition Over the southeRn oceaN) campaign aboard the RV Investigator during January–February of 2018 took place in the western Pacific sector of the Southern Ocean. Sulfuric acid, MSA and iodic acid were measured using a nitrate Chemical Ionisation Mass Spectrometer (NO_3-CIMS). Aerosol chemical composition was measured with an Aerosol Chemical Speciation Monitor (ACSM) as well as using Ion Chromatography for sub-micron filters analysis. The aerosol size distribution was measured using two Scanning Mobility Particle Sizers (SMPS; Grimm and TSI)) covering together a size range from 4 nm to 660 nm. Standard meteorological variables (temperature, pressure, relative humidity, wind speed /direction) were measured as a part of the ongoing underway systems.

The main feature of the 2018 CAPRICORN-2 SO voyage was a week-long period of unusually high gaseous MSA levels after crossing the Polar Front heading south (Fig. 1). This was correlated with increased levels of gaseous H_2SO_4 and HIO_3, however, their counts were substantially lower than for MSA. During this period aerosols exhibit prominent and persistent accumulation mode with increased concentrations of SO_4^{2-} and MSA. SMPS data indicate that there were no nucleation events during the "high MSA" period and HYSPLIT back-trajectories analysis shows that "high MSA" airmasses came from Antarctica and higher altitudes suggesting new particle formation had occurred in the free troposphere.

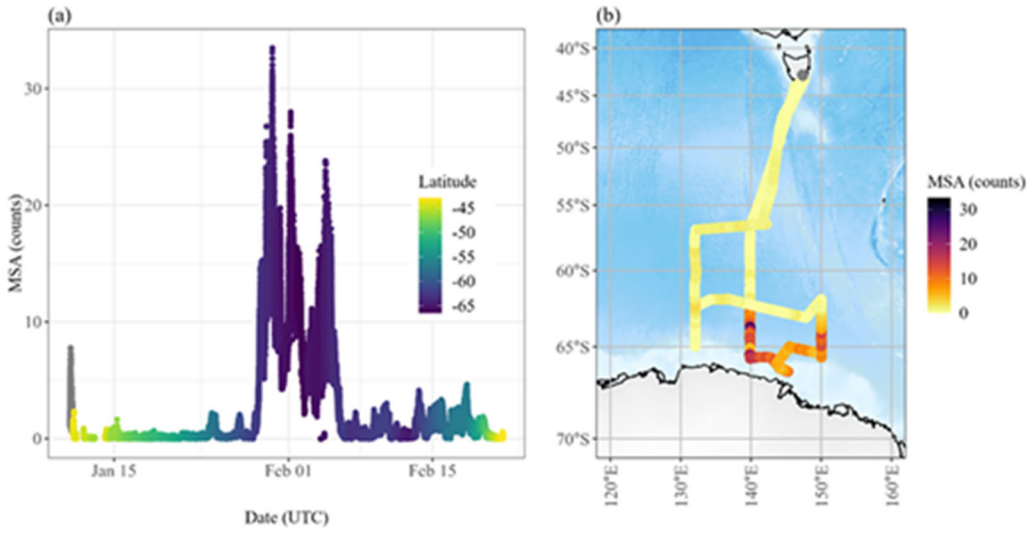


Fig. 1. (a) Time series of MSA during CAPRICORN-2 SO voyage colour-coded by latitude and (b) voyage track of CAPRICORN-2 colour-coded by the MSA counts. Note high MSA counts south of the polar front.

Biogenic enhancement of cloud droplet concentrations observed off East Antarctica

M. D. Mallet[1], B. Miljevic[2*], R. S. Humphries[3,1], G. G. Mace[4], S. P. Alexander[5,1], A. Protat[6,1], J. P. Ward[3], L. T. Cravigan[2], C. Mynard[7], K. Moore[8], P. J. DeMott[8], S. Fiddes[1], M. D. Keywood[3,1], C. G. Osuagwu[2], Z. D. Ristovski[2], S. Taylor[3] and P. W. Selleck[3]

[1] Australian Antarctic Program Partnership, Institute for Marine and Antarctic Studies (IMAS), University of Tasmania, Hobart, TAS Australia
[2] School of Earth and Atmospheric Sciences, Queensland University of Technology, Brisbane, QLD Australia
[3] CSIRO Environment, Climate, Atmosphere and Ocean Interactions, Aspendale, VIC, Australia
[4] Department of Atmospheric Sciences, University of Utah, Salt Lake City, UT, USA
[5] Australian Antarctic Division, Hobart, TAS, Australia
[6] Bureau of Meteorology, Melbourne, VIC, Australia
[7] Monash University, Clayton, VIC, Australia
[8] Department of Atmospheric Science, Colorado State University, Boulder, CO, USA

[*] corresponding author: Marc Mallet [marc.mallet@utas.edu.au]

Abstract

The biologically-productive high-latitudes of the Southern Ocean emit precursor gases and aerosol from marine and sea-ice environments. However, the role that biogenic emissions have on aerosol-cloud interactions is poorly quantified, with large regional climate model biases at high latitudes of the Southern Ocean. Here we use satellite and ship observations from the CAPRICORN-2018 voyage during the austral summer to study these interactions. We show observational evidence that biogenic precursors and aerosols lead to an increase in cloud droplet number concentrations off the coast of East Antarctica (Fig. 1). In contrast to the precipitating air masses from the open Southern Ocean, air masses with recent influence from the Antarctic continent had higher concentrations of biogenic cloud condensation nuclei in an aged and cloud-processed accumulation mode, fewer ice nucleating particles, and a higher occurrence of supercooled-liquid water containing clouds with enhanced liquid water paths. Given future uncertainties in the sea-ice and biogeochemistry of the Antarctic region, understanding present-day aerosol-cloud interactions at high Southern Ocean latitudes is crucial.

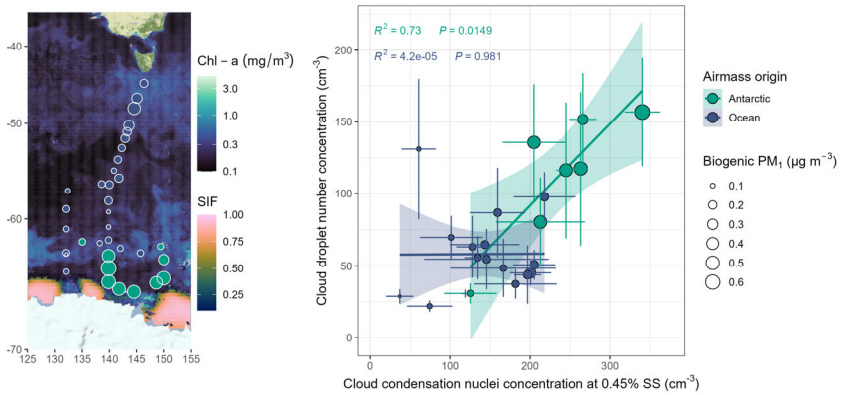


Fig. 1. a), Daily location of the RV Investigator in January and February 2018. The points are coloured by the predominant air mass backward trajectory origin at the RV Investigator, and the size of the points corresponds to the daily average concentration of PM1 methanesulfonic acid and sulfate. b), Cloud droplet number concentrations of low-level non-precipitating clouds derived from MODIS overpasses of the RV Investigator within ± 2.5° as a function of daily averaged surface cloud condensation nuclei concentrations at 0.45% supersaturation. Error bars represent the standard deviation of the cloud droplet retrieval and the standard deviation of the cloud condensation nuclei measurements over each daily average.

Aerosol optical depth measurements at the Great Barrier Reef using MAX-DOAS, sun photometer and Lidar

R. Ryan[1*], L. Toms-Hardman[2] and R. Schofield[1]

[1] School of Geography, Earth and Atmospheric Sciences, University of Melbourne, VIC, Australia
[2] Defence Science and Technology Group, HMAS Stirling, WA, Australia

[*] corresponding author: Robert Ryan [rryan1@unimelb.edu.au]

Abstract

Aerosol vertical distribution and total column information over the Great Barrier Reef (GBR) region remains sparse. This is despite the fundamental role of atmospheric aerosols in influencing the climate system over environment severely threatened by climate change. In particular, a lack of vertical information is a limiting factor for incorporating aerosol information in atmospheric models. Here we present vertical aerosol extinction profiles from a two-month field campaign at One Tree Island (OTI) in the Capricorn Bunker Group of the Southern GBR. These measurements were taken during fieldwork under the auspices of the Reef Restoration and Adaptation Program's Cooling and Shading subprogram, which proposes marine cloud brightening using sprayed sea-salt to mitigate coral bleaching.

Aerosol extinction profiles, and their integrated counterpart aerosol optical depth (AOD), are presented from two different techniques: Mini Micro Pulse LiDAR (MiniMPL) and Multi-Axis Differential Optical Absorption Spectrometer (MAX-DOAS). These instruments measure aerosol extinction using active and passive optical methods respectively, and sample different regions of the sky. We also report on AOD measurements using a hand-held Microtops sun photometer, a reference method for NASA's global Marine Aerosol Network.

We find broad consistency in the vertical distribution of aerosol extinction measured by the MAX-DOAS and MPL, with frequent elevated aerosol layers observed around 1-2 km altitude. The depolarization ratio measured by the MPL shows elevated values (>0.02) above the highest extinction layers, supporting the presence of dried sea-salt aerosol above the marine boundary layer. The AOD measured by the Microtops at OTI (mean AOD ≈ 0.08) aligns with previous AOD reports from the Australian region in the Marine Aerosol Network database. The comparison of AOD between Microtops, MPL and MAX-DOAS is challenging due to the different wavelength, vertical sensitivity and vertical and temporal resolution of each retrieval method. Despite correcting for these factors, we find only limited temporal consistency in AOD values between techniques. This result suggests challenges in appropriately accounting for cloud in this environment and may also point to horizontal inhomogeneity in the background aerosols at OTI.

Long-term monitoring of atmospheric mercury and its source contributions in Kennaook/Cape Grim, Australia

B. Rawat[1], J. A. Fisher[1*], N. M. Deutscher[1] and J. C. Powell[2]

[1] Centre for Atmospheric Chemistry, University of Wollongong, Wollongong, NSW, Australia
[2] CSIRO Environment, Climate, Atmosphere and Ocean Interactions, Aspendale, VIC, Australia

[*] corresponding author: Jenny Fisher [jennyf.@uow.edu.au]

Abstract

The atmosphere is a key component of the biogeochemical cycle of mercury from source to receptor. The long-term monitoring of atmospheric elemental mercury (Hg^0) is critical for the effective evaluation of the Minamata Convention. To date, atmospheric Hg has been sparsely measured in the Southern Hemisphere (SH), with shorter records available relative to the Northern Hemisphere (NH). Therefore, long-term continuous monitoring of atmospheric Hg initiated in 2013 at the pristine environment of Kennaook/Cape Grim (Tasmania) is particularly valuable. Here, we present an analysis of atmospheric elemental mercury (Hg^0) measurements conducted at Kennaook/Cape Grim. Hg^0 has been measured continuously with 5-min resolution using a Tekran-2537B instrument since 2011, and since June 2017, an additional instrument 2537X. The mean Hg^0 concentration from the Tekran-B was 0.92±0.10 ng m^{-3} with a range of 0.29-1.53 ng m^{-3} from 2011 to 2022. The mean Hg^0 concentration from the Tekran-X was 1.05±0.05 ng m^{-3} from 2017-2022. The lower Hg^0 concentration of Tekran-B was influenced by the passivation effect. The mean measured by both instruments is lower than the NH background value (1.5-1.7 ng m^{-3}) but in the range of previous estimates of the SH background (1.0-1.3 ng m^{-3}) [Sprovieri et al. 2010]. There is no clear seasonality in Hg^0 concentrations observed at Kennaook/Cape Grim; however, values are somewhat higher in winter (Jun-Aug) compared to other seasons, reflecting that the Southern Ocean contributes to the atmospheric Hg^0 in Winter. There is evidence of high Hg^0 in the winter and spring as the wind speed increases from the south to west directions, indicating increased influence from the Southern Ocean and minimal influence from terrestrial sources.

References

Sprovieri, F., N. Pirrone, R. Ebinghaus, H. Kock and A. Dommergue (2010). A review of worldwide atmospheric mercury measurements. *Atmos. Chem. Phys*. 10:17, 8245–8265. https://doi.org/10.5194/acp-10-8245-2010

Mercury from artisanal gold mining in rural sub-Saharan Africa

D. B. Kpokro[1*]

[1] University of Wollongong, Wollongong, NSW, Australia

[*] corresponding author: Dominique Bally Kpokro [bkdfk511@uowmail.edu.au]

Abstract

Well known for its multiple applications, mercury (Hg from its Latin name Hydrargyrum "liquid silver") is the only liquid metal used in the mining industry to extract precious metals since nearly 2700 years before our era [Eisler 2003]. From this mercury use in Artisanal and Small-Scale Gold Mining (ASGM), the sector has become the largest anthropogenic source of mercury releases worldwide [UNEP 2018]. Sub-Saharan Africa, with more than twenty-five countries involved in ASGM is undoubtedly contributing to this environmental pollution by mercury. By considering mercury emissions and the associated transboundary contamination with ASM activities, my research seeks to map the circulation and pathways of mercury supplies in ASGM, the different actors engaged in its distribution, and the ancillary economic activities it gives rise to; pinpointing contamination "hotspots", and to modelling pollution pathways to later define intervention scenarios from existing regulations and/or policies at regional and global level constitute the major activities to cover in that research. Therefore, my contribution will be to provide a comprehensive analysis of transboundary networks responsible for ASGM mercury distribution and supplies in West Africa, as well as associated hotspots and exposure pathways taking the case of Côte d'Ivoire. Thereby, Air, soils, sediments and mines tailings have been sampled in ASGM sites and their surroundings for analysis. The obtained results will contribute to providing further guidance of sustainable interventions to address mercury pollution from ASM sector.

References

Eisler, R. (2003). Health risks of gold miners: A synoptic review. *Environ. Geochem. Health* 25, 325–345. https://doi.org/10.1023/A:1024573701073

United Nations Environment Programme (UNEP, 2019). Global Mercury Assessment 2018. Chemicals and Health Branch Geneva, Switzerland, accessed 13th Oct 2022 at https://wedocs.unep.org/handle/20.500.11822/27579, p. 32: 1 – 62

Flux and flow: Variation and physicochemical drivers of GHG fluxes Across the intertidal wetland gradient

S. D. Rigney[1*], J. Kelleway[1], N. M. Deutscher[1], M. Hughes[2] and T. A. Naylor[1]

[1] Centre for Atmospheric Chemistry, University of Wollongong, Wollongong, NSW, Australia
[2] NSW Office of Environment & Heritage, Parramatta, NSW, Australia

[*] corresponding author: Stephen D. Rigney [sdr827@uowmail.edu.au]

Abstract

Intertidal wetlands are some of the most productive and threatened ecosystems in the world, offering several important ecosystem services. They are also long-term carbon sinks capable of sequestering carbon for millennia. However, for intertidal wetlands to have a net cooling effect on the atmosphere, their carbon storage (blue carbon) must exceed their greenhouse gas (GHG) emissions. Meanwhile, the conditions that facilitate carbon sequestration favour the production of several potent greenhouse gases (GHGs), including methane (CH_4) and nitrous oxide (N_2O). The direction and magnitude of these fluxes may be modulated by multiple environmental drivers, including inundation dynamics and salinity. While there is increasing understanding of coastal wetland CO_2 fluxes, little research has been conducted on the drivers of CH_4 and N_2O, particularly within the Australian context. In summer 2022 and winter 2023, soil-atmosphere fluxes were analysed via FTIR spectroscopy using 12 chambers installed over an elevation gradient spanning mangrove, lower saltmarsh, upper saltmarsh and swamp oak forest ecosystems at Towra Point Nature Reserve, New South Wales, Australia. These data were compared with water-level loggers installed adjacent to each vegetation community, recording temperature, salinity, and water level to understand the physicochemical drivers of GHG sediment flux variation. Site-wide mean sediment CO_2 fluxes (2.96×10^{-05} µg m^{-2} s^{-1}) were several orders of magnitude larger than both CH_4 (-1.56×10^{-08} µg m^{-2} s^{-1}) and N_2O (-2.12×10^{-09} µg m^{-2} s^{-1}), even when adjusted for global warming potential (GWP). Vegetation communities acted as CH_4 and N_2O sources and sinks in different seasons. Generally, GHG fluxes were higher in summer than winter, likely due to enhanced microbial activity in warmer sediment. As expected, the low elevation mangrove community was a moderate CH_4 source due to the anoxic conditions that facilitate anaerobic respiration. In contrast, the lower and upper saltmarsh acted as mean CH_4 sinks (-6.31×10^{-08} and -5.01×10^{-08} µg m^{-2} s^{-1} respectively). Sediment N_2O fluxes were complex and, in some cases, switched from sources and sinks between seasons. Significant upper saltmarsh summer sediment N_2O efflux was observed (2.24×10^{-08} µg m^{-2} s^{-1}). Variation in the sediment flux of oxygen-containing molecules (i.e., CO_2 and N_2O) was partly explained by changes in temperature and salinity. In contrast, variation in CH_4 sediment flux was driven primarily by inundation dynamics. These findings provide insight into the magnitude of intertidal wetland soil GHG fluxes and the drivers of flux variation. With sea levels predicted to rise by 0.43-0.84m by 2100, and intertidal wetlands already undergoing significant structural change, it is critical that we understand how intertidal GHG emissions will respond to a warming climate.

Baseline AOD

S. R. Wilson*

Centre of Atmospheric Chemistry, University of Wollongong, Wollongong, NSW, Australia

* corresponding author: Stephen Wilson [swilson@uow.edu.au]

Abstract

Aerosol Optical Depth (AOD) has been measured using automated sunphotometers at Kennaook/ Cape Grim since 1986, and is a component recommended for measurement at a Global Atmospheric Watch site. An analysis of the data record for the period 1986 – 1999 concluded that the eruption of Mt Pinatubo had a large impact on the observations, that the annual average AOD at 500 nm was 0.037, and that the AOD observed was lower when the wind was coming from the baseline sector, although not a significant difference was observed [Wilson and Forgan 2002].

With a further 20 years of observations with no significant volcanic eruptions, these conclusions are revisited. The observed median of all AOD hourly observations at 500 nm is higher (0.07) and the annual cycle derived from the data collected outside the period affected by Mount Pinatubo shows that the AOD is higher when "baseline" periods are present, particularly in Winter.

References

Wilson, S. R. and B. W. Forgan (2002). Aerosol optical depth at Cape Grim, Tasmania, 1986–1999. *J. Geophys. Res.* 107, 4068. https://doi.org/10.1029/2001JD000398

High-resolution methane emission uncertainties in Gippsland: An *in situ* data assimilation study

S. Aghdasi[1*], P. J. Rayner[2], N. M. Deutscher[3] and J. D. Silver[4].

[1] School of Geography, Earth and Atmospheric Sciences, University of Melbourne, Melbourne, VIC, Australia
[2] Superpower Institute, Melbourne, VIC, Australia
[3] Centre for Atmospheric Chemistry, University of Wollongong, Wollongong, NSW, Australia
[4] School of Mathematics and Statistics, University of Melbourne, Melbourne, VIC, Australia

[*] corresponding author: Sougol Aghdasi [saghdasi@student.unimelb.edu.au]

Abstract

Our research aims to enhance methane (CH_4) emission estimates in Gippsland, Victoria, by incorporating *in situ* data into an assimilation system. Utilising the Community Multiscale Air Quality (CMAQ) model, we examined CH_4 emissions for May 2019. We intend to expand this analysis to include February, August, and November 2019, offering a comprehensive assessment at a 2 km grid resolution. Furthermore, to understand the implications of the Black Summer period, our study will also encompass simulations for December 2019 and January 2020. Initially, our emission data were sourced from the Emission Database for Global Atmospheric Research (EDGAR) as a benchmark prior. To achieve this, we compare the posterior data with the *in situ* CH_4 data obtained during the Gipnet project (Hoffman et al. 2017) using three instruments: two Picarros and one Spectronus. This comparison exposes significant problems with the EDGAR database for these scales. We are transitioning to the "openmethane" prior, which shows promise in these comparisons. Preliminary results indicate a significant decrease in emission uncertainties. As always, with regional inversions, our results are somewhat sensitive to lateral boundary conditions. By incorporating these boundary conditions, we aim to mitigate these biases effectively.

References

Hoffman, N., N. Hardman-Mountford, C. Jenkins, P. J. Rayner, G. Gibson and M. Sandiford (2017). GipNet–Baseline environmental data gathering and measurement technology validation for nearshore marine Carbon Storage. *Energy Procedia* 114, 3729-3753. https://www.sciencedirect.com/science/article/pii/S1876610217316971

Refining prior methane gridded emissions for Melbourne by national data integration and inverse modelling

N. Shahrokhi[1*], C. M. Trudinger[1], P. J. Rayner[2,3], Z. M. Loh[1], J. Ramirez Gamboa[1], A. R. Stavert[1], D. M. Etheridge[1], C. G. R. Caldow[1], P. J. Fraser[1], B. L. Dunse[1], A. Luhar[1] and P. B. Krummel[1]

[1] CSIRO Environment, Climate, Atmosphere and Ocean Interactions, Aspendale, VIC, Australia
[2] The Superpower Institute, Melbourne, VIC, Australia
[3] The Inversion Lab, Hamburg, Germany

[*] corresponding author: Nasimeh Shahrokhi [Nasimeh.shahrokhi@csiro.au]

Abstract

Methane is the second most significant contributor to anthropogenic radiative forcing from greenhouse gases after carbon dioxide. Therefore, it is essential to gain a better understanding of methane emissions across various sectors in Australia. This understanding is vital for prioritizing mitigation efforts and tracking progress in emissions reduction. Despite the importance of accurate methane emission estimates, there is a notable uncertainty, particularly at fine resolutions necessary for effective mitigation strategies. Additionally, discrepancies between emission estimates and atmospheric observations have been highlighted in previous studies.

The absence of local methane gridded inventories has led to the utilisation of globally-accessible datasets to estimate emissions for Melbourne, including (1) anthropogenic emissions from the Emissions Database for Global Atmospheric Research (EDGAR), (2) fire emissions from the Global Fire Assimilation System (GFAS) dataset, and (3) biogenic emissions from the Model of Emissions of Gases and Aerosols from Nature (MEGAN). Nevertheless, previous findings have indicated that the EDGAR dataset does not accurately capture the spatial distribution of major anthropogenic sources in the Melbourne area, particularly enteric fermentation and landfills [Shahrokhi et al. 2023]. Here, we explore the potential of improving the spatial distribution of prior emissions by incorporating local and national datasets, such as national livestock maps [Navarro and Marcos Martinez 2021], landfills, and wastewater treatment plants. Our findings demonstrate that using the national livestock map and relevant emission factors [ANGA 2022] yields a more precise representation of emission patterns compared to the EDGAR dataset.

To create more comprehensive and accurate emission inventories for Melbourne, additional observational data on methane mole fractions in the region are essential. This study has initiated the expansion of the methane monitoring network in Melbourne, increasing the number of in-situ observation sites from one station (Aspendale) to four stations (Bangholme, Clayton and Parkville) since late 2022. We are employing the existing *in situ* observations and a four-dimensional variational data assimilation system to assess the enhancements achievable through an inverse modelling system.

References

Australian National Greenhouse Accounts (ANGA, 2022). The Australian Government Submission to the United Nations Framework Convention on Climate Change, National Inventory Report 2020, national-inventory-report-2020-volume-1.pdf (dcceew.gov.au)

Navarro, J. and R. Marcos Martinez (2021). Estimating long-term profits, fertiliser and pesticide use baselines in Australian agricultural regions. User Guide. (CSIRO: Australia)

Shahrokhi, N., C. M. Trudinger, P. J. Rayner, Z. M. Loh, A. R. Stavert, P. B. Krummel, P. J. Fraser, D. M. Etheridge, B. L. Dunse, A. Luhar and S. Thomas (2023). Supporting Methane Mitigation Efforts by Improving Urban-scale Methane Emission Estimates in Melbourne, Australia. Part 1: Modelling, EGU General Assembly 2023, Vienna, Austria, 24–28 Apr 2023, EGU23-4716. https://doi.org/10.5194/egusphere-egu23-4716

Remote sensing of methane and its major sources in Australia

H. Nawaz*, C. Paton-Walsh (Murphy) and N. T. Deutscher

[1] Centre for Atmospheric Chemistry, University of Wollongong, Wollongong, NSW, Australia

* corresponding author: Hasan Nawaz [hn487@uowmail.edu.au]

Abstract

Methane (CH_4) contributes to 20% of global warming caused by greenhouse gases. Therefore, the mitigation of CH_4 emission is important to tackle short-term global warming. This study presents spatiotemporal variations of total column average dry air mole fraction of CH_4 from TROPOspheric Monitoring Instrument (TROPOMI) over Australia during February 2019 – April 2023. In the present study, high CH_4 (~1841-1850 ppb) is observed in the Northern Australia and low CH_4 (~1800-1816 ppb) is found in the South and Southeastern Australia during. High CH_4 in the Northern Australia is associated with biomass burning and wetland emissions. Seasonally, the concentration CH_4 is found to be high over Australia during spring (September-November) followed by winter (June-August), summer (December-February), and autumn (March-May).

Quantifying agricultural emissions from ground-based and satellite data

S. Mikaloff-Fletcher[1*], B. Bukosa[1], A. Geddes[1], G. W. Brailsford[1], J. S. Benmergui[2], D. I. Campbell[3], J. Franklin[2], S. Hamburg[4], R. Law[5], J. Laubach[2], D. Noone[6], D. Pollard[1], J. Turnbull[7], H. Schaefer[1], L. A. Schipper[5] and S. C. Wofsy[2]

[1] NIWA, Wellington, Aotearoa-New Zealand
[2] School of Engineering and Applied Sciences, Harvard University, Cambridge, Massachusetts, USA
[3] School of Science and Environmental Research Institute, University of Waikato, Hamilton, Aotearoa-New Zealand
[4] MethaneSAT LLC/Environmental Defense Fund, Austin, Texas, USA
[5] Manaaki Whenua Landcare Research, Palmerston North, Aotearoa-New Zealand
[6] Department of Physics, University of Auckland, Auckland, Aotearoa-New Zealand
[7] GNS Science, Lower Hutt, Aotearoa-New Zealand

[*] corresponding author: Sara Mikaloff-Fletcher [sara.mikaloff-fletcher@niwa.co.nz]

Abstract

Atmospheric greenhouse gas observations from ground-based stations, satellites, and other platforms can be combined with atmospheric transport models to estimate regional to national greenhouse gas emissions or uptake. This approach can provide valuable independent verification of the inventory at regional to national scales. Data from existing and planned satellite missions has the potential to provide information with much higher spatial resolution.

The MethaneSAT satellite is a joint American and Aotearoa-New Zealand (Aotearoa-NZ) initiative, involving a partnership between Environmental Defense Fund's (EDF) subsidiary MethaneSAT LLC, and the New Zealand government. The satellite's core mission is to catalyse CH_4 emission reductions around the world by measuring atmospheric CH_4 with unprecedented precision and mapping flux rates. While MethaneSAT was designed to detect emissions from oil and gas infrastructure, we demonstrate that it can also be used to measure more diffuse and thus harder to resolve agricultural methane emissions using model simulations and aircraft data.

In addition, we present results from New Zealand's first national methane inverse modelling system, which uses observations from ground-based stations. Then, we will outline our plans to advance this system to allow for more rapid delivery of emissions estimates and incorporate observations from new ground-based stations and satellites to support climate policy.

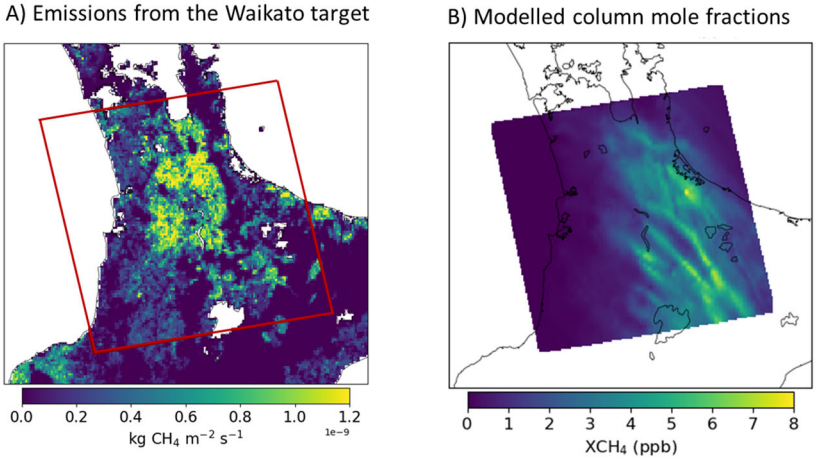


Fig. 1. Although the MethaneSAT satellite is not scheduled to launch until 2024, model simulations demonstrate what could be observed for diffuse agricultural emissions targets. A) Bottom up estimates of CH_4 emissions for the Waikato target area (red box). B) High resolution model simulations of total column mole fractions of CH_4 across the Waikato target area for an example day.

CarbonWatch-NZ: *In situ* and flask sampling network in Auckland for quantifying urban emissions

L. S. Fleming[1*], J. Turnbull[1], L. Domingues[1], H. A. Young[1], T. W. Hilton[1], V. Monteiro[1], J. Parry-Thompson[1], G. W. Brailsford[2], S. Gray[2] and S. Nichol[2]

[1] GNS Science, Wellington, New Zealand
[2] NIWA, Wellington, New Zealand

[*] corresponding author: Leigh Fleming [l.fleming@gns.cri.nz]

Abstract

Auckland is responsible for approximately 26% of Aotearoa New Zealand's (NZ) industry and household CO_2 emissions. Therefore, quantifying Auckland's emissions is a necessary step in supporting measures for greenhouse gas (GHG) emissions reduction in NZ. A GHG measurement network was established in Auckland in 2021 as part of the CarbonWatch-NZ programme. This network consists of three *in situ* sites (Fig. 1) equipped with a Picarro G2401 CRDS analyser, continuously measuring CO_2, CO and CH_4. Hourly integrated flask samples are also collected weekly at each site and measured for CO_2, CO, CH_4, and $\Delta^{14}C\text{-}CO_2$.

I will present the measurement site details and time-series data, then discuss our measurement performance and reasons for instrument down-time. Then I will show the seasonal and diurnal trends observed at each site. We see a strong diurnal and seasonal cycle at the urban sites, with little variability and lower mole fractions observed at the background site. We intend to use the $\Delta^{14}C\text{-}CO_2$ and CO flask data along with the Picarro CO data to obtain continuous fossil fuel CO_2 values.

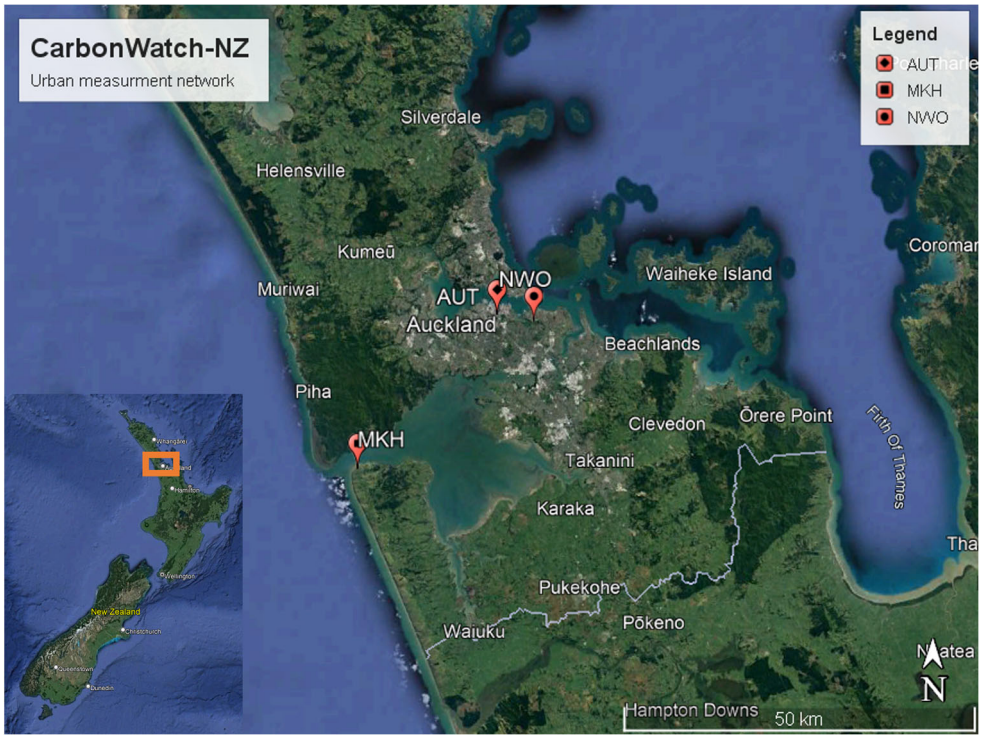


Fig. 1. Location of the three *in situ* measurement sites in Auckland used for CarbonWatch-NZ

Monitoring Australia's methane emissions: An update on the OpenMethane Project

P. J. Rayner and G. Mason

[1] The Superpower Institute, Melbourne, VIC, Australia

[*] corresponding author: Peter Rayner [peter.rayner@superpowerinstitute.com.au]

Abstract

OpenMethane aims to establish transparent, actionable and auditable data on Australia's methane emissions. OpenMethane combines a classical variational inversion framework (py4dvar) with the Community Multiscale Air Quality Model (CMAQ). The first version uses data from the TROPOMI instrument aboard the sentinel 5 Precursor satellite. The two major outputs from OpenMethane are improved emissions estimates each month, including sectoral attribution and a daily log of potentially anomalous methane concentrations. Each step of the variational assimilation can be interrogated or downloaded.

The talk will discuss the design of the system and some of the improvements it required, notably an improved emissions prior estimate. We will present first results from the period July-September 2022. Finally we will show how these results will be presented on openmethane.org

Progress towards extending the Australian Greenhouse Gas Observing Network (AGGON)

R. L. Langenfelds[1*], C. G. R. Caldow[1], Z. M. Loh[1], A. R. Stavert[1], C. M. Trudinger[1], P. B. Krummel[1], D. M. Etheridge[1], N. Shahrokhi[1], J. Ramirez Gamboa[1], E-A. Guerette[1], P. J. Fraser[1], B. L. Dunse[1], T. Ziehn[1], R. M. Law[1], A. Luhar[1], L. P. Steele[1], B. Mitrevski[1], D. A. Spencer[1], C. T. Roulston[1], C. E. Allison[1], Y. Villalobos Cortes[2], P. Canadell[2], M. B. Tully[3], N. M. Deutscher[4], C. Paton-Walsh (Murphy)[4], D. W. T. Griffith[4], B. F. J. Kelly[5], A. G. Williams[6], S. D. Chambers[6] and P. J. Rayner[7]

[1] CSIRO Environment, Climate, Atmosphere and Ocean Interactions, VIC, Australia
[2] CSIRO Environment, Climate Intelligence, Black Mountain, ACT, Australia
[3] Kennaook / Cape Grim Baseline Air Pollution Station, Bureau of Meteorology, Smithton, TAS, Australia
[4] University of Wollongong, Wollongong, NSW, Australia
[5] School of Biological, Earth and Environmental Sciences, University of New South Wales (UNSW), Sydney, NSW, Australia
[6] Australian Nuclear Science & Technology Organisation (ANSTO), Lucas Heights, NSW, Australia
[7] The Superpower Institute, Melbourne, VIC, Australia

[*] corresponding author: Ray Langenfelds [ray.langenfelds@csiro.au]

Abstract

Recent national and international developments have prompted renewed efforts to establish an effective national top-down greenhouse gas (GHG) observing system. Following discussions among the Australian Composition & Chemistry Observations & Modelling (ACCOM) community last year, the need for such a system has been raised with various government entities involved in regulating and accounting for Australia's GHG emissions (and carbon uptake, e.g. in relation to carbon credit schemes).

Collaborating science groups within ACCOM are developing a coordinated proposal to establish a fit-for-purpose top-down observing system that would harness a range of capabilities from across our community. An expanded AGGON would provide long-term, broad coverage of GHG measurements across Australia, suitable for constraining national/regional scale emissions and supporting complementary methods that target emissions at smaller, e.g. facility scales.

This presentation will provide an update on important developments and efforts that have occurred since many of us met at the ACCOM Conference held at Aspendale last year. It will set the context for discussions to follow including future strategies and pathways that we can work towards as a community to operationalise AGGON at the required scale.

What we do in the sunshine – an update on the Total Carbon Column Observing Network

N. M. Deutscher[1*], D. W.T. Griffith[1], C. Paton-Walsh (Murphy) [1], N. B. Jones[1], B. T. Walker[1], H. Nawaz[1] and TCCON Partners[2]

[1] School of Earth Atmospheric and Life Sciences, University of Wollongong, Wollongong, NSW, Australia
[2] TCCON Partners

[*] corresponding author: Nicholas Deutscher [ndeutsch@uow.edu.au]

Abstract

The Total Carbon Column Observing Network (TCCON) (Wunch et al. 2011) measures column-averaged dry-air mole fractions of greenhouse gases at nearly 30 sites around the world, including two in Australia at Wollongong and Darwin. The measurement stations operate high spectral resolution solar Fourier Transform Infrared (FTIR) spectrometers, which record infrared spectra of the Earth's atmosphere. From these spectra, column abundances of atmospheric absorbers can be quantified, and are used for carbon cycle science, model validation and as the gold standard for validating greenhouse gas satellites. TCCON is constantly developing to measure in new locations, improve existing products and add new measurement capabilities.

In this talk an update on the status of TCCON will be provided, with a focus on the Australian sites.

References

Wunch, D., G. C. Toon, J-F. L. Blavier,R. A. Washenfelder, J. Notholt, B. J. Connor, D. W. T. Griffith, V. Sherlock and P. O. Wennberg. (2011). The Total Carbon Column Observing Network (TCCON). *Phil. Trans. Roy. Soc*. A 369:1943, 2087–2112. https://doi.org/10.1098/rsta.2010.0240

The 2023 Antarctic ozone hole

P. B. Krummel[1*], A. R. Klekociuk[2], M. B. Tully[3], P. J. Fraser[1] and N. Derek[1]

[1] CSIRO Environment, Climate, Atmosphere and Ocean Interactions, Aspendale, VIC, Australia
[2] Australian Antarctic Division, Hobart, TAS, Australia
[3] Australian Bureau of Meteorology, Melbourne, VIC, Australia

[*] corresponding author: Paul Krummel [paul.krummel@csiro.au]

Abstract

The 2023 ozone hole developed in earnest in early August and reached a peak of just under 26 million km^2 on 21 September (Fig. 1). The development of the ozone hole during the first 3 weeks of August saw the ozone hole area reach record and/or near record levels for this time of year. Following this to the peak in the area on 21 September, the ozone hole returned to levels similar to or above the ozone holes from the past 3 years. However, soon after the peak in the ozone hole area on 21 September until late October, the Antarctic stratosphere went through a series of warming events due to wave activity which considerably reduced the size and depth of the 2023 ozone hole compared to the most recent 3 ozone holes.

This presentation will give an update on 2023 Antarctic ozone hole season and how the 2023 ozone hole metrics compare to the historical metrics from the last 44 years of satellite measurement.

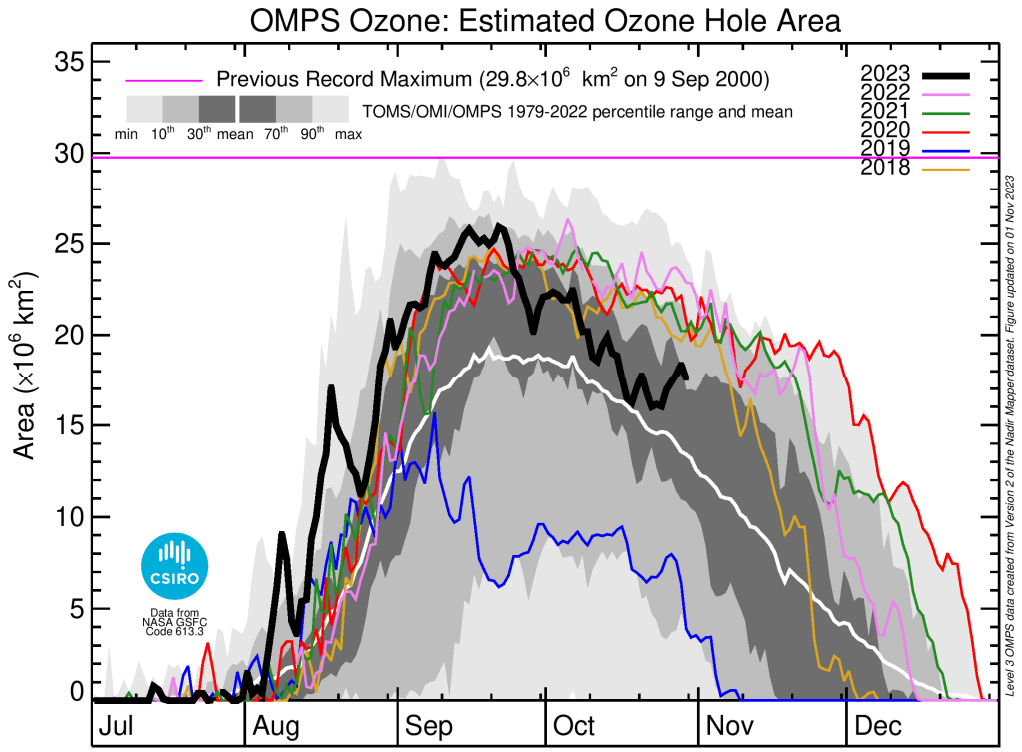


Fig. 1. Daily Antarctic ozone hole area based on OMPS data as of 29 October 2023, along with the daily ozone hole area from the past 5-years.

Comparison of stratospheric ozone trends from NDACC FTIR, Microwave Limb Spectrometer and Ozonesonde Observations and Model Predictions in the Southern Hemisphere

J. Takacs[1*], N. T. Jones[1], C. Paton-Walsh (Murphy)[1], D. Smale[2], C. Vigouroux[3] and M. B. Tully[4]

[1] Centre for Atmospheric Chemistry, University of Wollongong, Wollongong, NSW, Australia
[2] National Institute of Water and Atmospheric Research, Lauder, New Zealand
[3] Royal Belgian Institute for Space Aeronomy (BIRA-IASB), Uccle, Belgium
[4] Bureau of Meteorology, Melbourne, VIC, Australia

[*] corresponding author: Justin Takacs [jt378@uowmail.edu.au]

Abstract

Timeseries were created of stratospheric ozone partial columns from a range of ozone profile retrievals, direct observations and predictions across several Southern Hemisphere sites. These included Network for the Detection of Atmospheric Composition Change (NDACC) Fourier Transform Infrared (FTIR) retrievals, ozonesonde profiles, Microwave Limb Spectrometer retrievals from within a given radius of each station, and model predictions from the Global Modelling Initiative (GMI). Each of the higher-resolution profiles were smoothed to match the sensitivity the other spatially and temporally co-located retrievals and a region of the low- to mid-stratosphere was selected to produce several timeseries of ozone partial columns at each site. A multiple linear regression model was created containing terms to account for seasonal cycles, long-term linear trends and the influence of several dynamical processes and other external factors known to significantly affect ozone concentrations over the medium term. The regression model was separately fitted to each partial column timeseries to produce an estimate of the contribution of each factor, including the shape of the seasonal cycles and an overall decadal trend. A process of bootstrap resampling provided confidence intervals for each fitted parameter.

Portable instrument developments for solar remote sensing of atmospheric composition

D. W. T. Griffith*, N. B. Jones, N. M. Deutscher and C. Paton-Walsh (Murphy)

School of Earth Atmospheric and Life Sciences, University of Wollongong, Wollongong, NSW, Australia

* corresponding author: David Griffith [griffith@uow.edu.au]

Abstract

Total column amounts of atmospheric trace gases measured from the ground and from satellites complement in situ measurements in several ways, such as spatially integrated measurement footprint, lower sensitivity to local variability of concentrations, and near global coverage (from satellites). The Total Carbon Column Observing Network [TCCON, Wunch et al. 2011] provides the ground-based reference measurements by solar Fourier Transform Spectroscopy (FTS) which link satellite measurements to WMO mole fraction scales. However, TCCON provides only limited geographical coverage with around 30 fixed stations globally. Cheaper and more portable instruments with lower spectral resolution, like the Bruker EM27/SUN provide a third approach which complements TCCON and form the basis of the more recent Cooperative Carbon Column Observing Network [COCCON, Frey et al. 2019].

The EM27/SUN FTS as refined in COCCON has a solar tracker fixed to the spectrometer and the tracker + FTS must operate outdoors in direct sun, thus requiring either daily setup or an automated cover for weather protection. This has proved a significant impediment to continuous, automated measurements and restricts the potential coverage and utility of this approach. At the University of Wollongong (UoW) we are investigating a variant of low-resolution total column measurements in which a simple, weatherproof solar tracker similar to those used in Aeronet or solar radiation studies is coupled by a fibre optic cable to the FT spectrometer kept indoors in a controlled laboratory environment safe from weather. This allows fully automated measurements from sunrise to sunset without hands-on intervention.

In this talk we present the new instrumentation and side-by-side simultaneous measurements in Wollongong with TCCON and the conventional EM27/SUN spectrometers as used in COCCON. We compare results from the three instrument types and their respective pros and cons.

References

Frey, M., M. K. Sha, F. Hase, M. Kiel, T. Blumenstock, R. Harig, G. Surawicz, N. M. Deutscher, K. Shiomi, J. E. Franklin, H. Bösch, J. Chen, M. Grutter, H. Ohyama, Y. Sun, A. Butz, G. M. Tsidu, D. Ene, D. Wunch, Z. Cao, O. Garcia, M. Ramonet, F. Felix and J. Orphal (2019). Building the Collaborative Carbon Column Observing Network (COCCON): long-term stability and ensemble performance of the EM27/SUN Fourier transform spectrometer. *Atmos. Meas. Tech*. 12:3, 1513–1530. https://doi.org/10.5194/amt-12-1513-2019

Wunch, D., G. C. Toon, J-F. L. Blavier,R. A. Washenfelder, J. Notholt, B. J. Connor, D. W. T. Griffith, V. Sherlock and P. O. Wennberg. (2011). The Total Carbon Column Observing Network (TCCON). *Phil. Trans. Roy. Soc*. A 369:1943, 2087–2112. https://doi.org/10.1098/rsta.2010.0240

Cooking and cleaning emissions in a commercial kitchen and its impact on outdoor and indoor air quality

L. R. Crilley[1,2*], J. C. Ditto[3,4^], M. Lao[1], L. Salehpoor[1], A. Chan[3,4], J. P. D. Abbatt[3] and T. C. VandenBoer[1]

[1] Department of Chemistry, York University, Toronto, ON, Canada
[2] WSP Australia, Brisbane, QLD, Australia
[3] Department of Chemistry, University of Toronto, Toronto, ON, Canada
[4] Department of Chemical Engineering and Applied Chemistry, University of Toronto, Toronto, ON, Canada
[^] now at: Department of Energy, Environmental and Chemical Engineering, Washington University in St Louis, St Louis, MO, USA

[*] corresponding author: Leigh Crilley [leigh.crilley@wsp.com]

Abstract

Within the indoor environment, cooking and cleaning are key primary sources that lead to poor air quality. Commercial kitchens are significant sources/areas of indoor and outdoor air pollutants and yet are understudied. Regular high volumes of cooking and cleaning are typical in commercial kitchens making these excellent study locations for emissions from these two sources and their interactions. Here we present work from the Kitchen Organic Carbon, Emissions, Nitrogen and Aerosol (KOCENA) study, performed in a well-ventilated commercial kitchen on a university campus from 1–17 September 2021. Instruments included aerosol and gas-phase instrumentation (VOCUS PTR-MS and custom-built reactive nitrogen instrument) to measure concentrations of particles, volatile organic compounds (VOC), N-containing species.

Overall, a complex and diverse range of gas-phase compounds were identified during cooking and cleaning dominated periods. Oxygenated compounds, including amides, were dominant class of the observed gas-phase VOC, likely from the thermal degradation of cooking oils and as may represent possible tracers for cooking. While combustion tracers such as NO peaked during the main mid-morning cooking period, the enhancement of many volatile gas-phase species during the cooking period was modest relative to night-time when there was no kitchen activity. This was despite the very high air exchange rates (AER) during the day (ca. 28 hr^{-1}) and points to large persistent surface reservoir as a key source of many compounds, in addition to cooking and cleaning.

During the day, basic Nr species were key component of the reactive nitrogen budget, and in addition to NH_3, supporting measurements point to contributions from amines. A significant portion of reactive nitrogen budget (18%) was not accounted for by NO_x, HONO or basic Nr during the day and night, with neutral species like acetonitrile accounting for reminder. Many of the top N-containing ions measured by the VOCUS were chlorinated. Monochloramine was the most abundant of these detected ions, with levels peaking in the afternoon during cleaning. Coarse particle mass concentrations were also elevated during afternoon cleaning periods, possibly due to mechanical processes even with high ventilation rate.

The very high AER was key to reducing worker exposure to cooking and missions, it also means kitchen were a significant source affecting outdoor air quality. These include emissions of chlorinated species, which are increasingly being recognised as important for urban air quality.

Aerosol composition measured at Kennaook/Cape Grim using the tofACSM: October 2020–June 2023

M. D. Keywood*, C. Mynard, E. Dunne, R. S. Humphries and J. N. Harnwell

CSIRO Environment, Climate, Atmosphere and Ocean Interactions, Aspendale, VIC, Australia

* corresponding author: Melita Keywood [melita.keywood@csiro.au]

Abstract

PMF representation of biomass burning organic aerosols from sea salt-interfered measurements using capture vapouriser-ToF-ACSM

A. R. Sutresna[1,2*], M. D. Keywood[2], C. Paton-Walsh (Murphy)[3], J. B. Simmons[3], Q. Dang[3], C. Mynard[2], R. S. Humphries[2], E. Dunne[2], J. P. Ward[2], F. Reisen[2], K. M. Emmerson[2], D. Worsnop[4], R. Schofield[1] and P. J. Rayner[1,5]

[1] School of Geography, Earth and Atmospheric Sciences, University of Melbourne, Parkville, VIC, Australia
[2] CSIRO Environment, Climate, Atmosphere and Ocean Interactions, Aspendale, VIC, Australia
[3] Centre for Atmospheric Chemistry, University of Wollongong, Wollongong, NSW, Australia
[4] Aerodyne Research Incorporated, Billerica, MA, USA
[5] The Superpower Institute, Melbourne, VIC, Australia

[*] corresponding author: Adhitya Sutresna [asutresna@student.unimelb.edu.au]

Abstract

Sea salt has been shown to interfere in measurements of biomass burning organic aerosols (BBOA) using the Capture Vapouriser Time-of-Flight Aerosol Chemical Speciation Monitor (CV-ToF-ACSM) when the instrument is deployed in environments where particles from the two sources coexist, such as in coastal Australia (Sutresna 2023, Fig. 1). Interference is caused by the molecular fragment weighing 60 amu (m/z 60) being a key marker ion of particles from both sea salt and biomass burning, which cannot be distinguished using the instrument's unit mass resolution. This phenomenon has not been reported on in studies using a CV-ACSM or CV-Aerosol Mass Spectrometer focusing on BBOA as nearly all of them have been conducted in locations more than 100 km inland (e.g., Lei et al. 2021 [Beijing, China]; Lalchandani et al., 2021 [Delhi, India]; Joo et al., 2021 [Atlanta, GA, USA]).

Further analysis also shows that when CV-ToF-ACSM data from coastal locations are used as inputs for factor analysis model Positive Matrix Factorisation (PMF), the detection of sea salt also leads to an underprediction of BBOA in PMF factors. The underprediction of BBOA is likely due to the fragmentation of levoglucosan and similar compounds producing less m/z 60 in instruments that use the CV. This study aims to identify a method to resolve BBOA in coastal Australia more representatively using PMF by removing data points in which sea salt measurements dominate BBOA, which can be classed as its own species in ACSM fragmentation calculations.

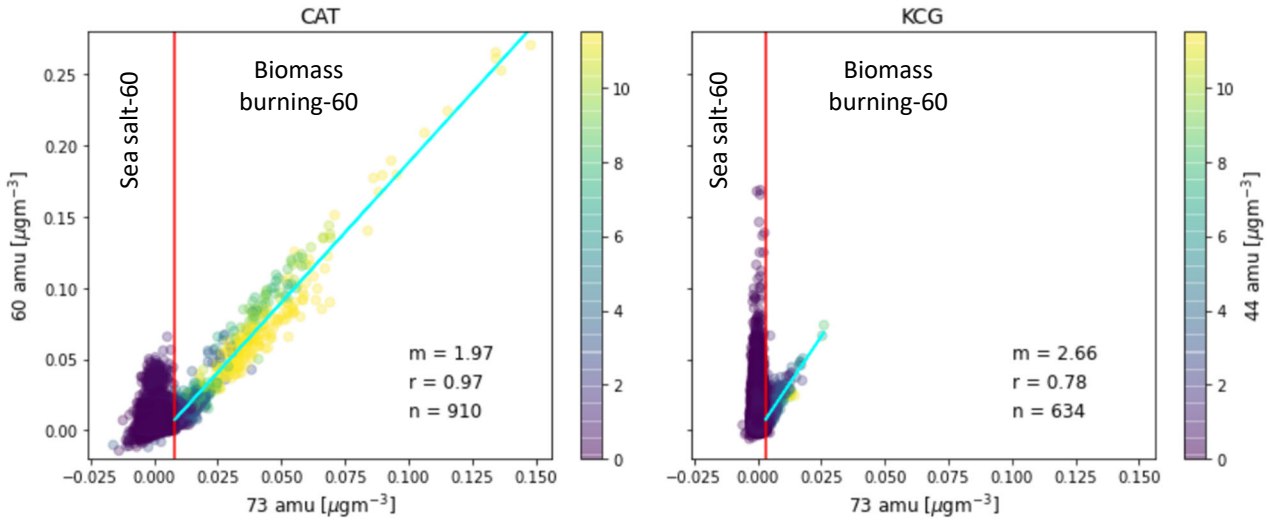


Fig. 1. Correlation plots of the molecular ions at m/z 60 and m/z 73 concentrations at Cataract, NSW (left) and Kennaook-Cape Grim (right). The portion where the two ions are strongly positively correlated illustrate points where m/z 60 originated from biomass burning particles, while the uncorrelated portion represents m/z 60 from sea salt.

Data for this study were collected from three locations in coastal Australia: baseline site Kennaook/Cape Grim, Tasmania; Cataract, NSW, directly adjacent to the Black Summer bushfires during the COALA-2020 campaign; and Aspendale, Victoria, a bayside Melbourne suburb. Sea salt points were removed by applying a threshold concentration of m/z 44 from the CV-ToF-ACSM as that marker ion represents oxidised organic aerosols that are not typically formed from sea salt. There were also attempts to remove sea salt points using radon concentrations, but this was not feasible at Kennaook-Cape Grim due to the location being on the coast of an island, meaning that even periods with relatively high radon concentration were accompanied by non-negligible levels of sea salt. This study compares PMF solutions with and without removal of sea salt points and finds that solutions made after sea salt removal improves the approximation of m/z 60 to total organic mass ratios (Fig. 2).

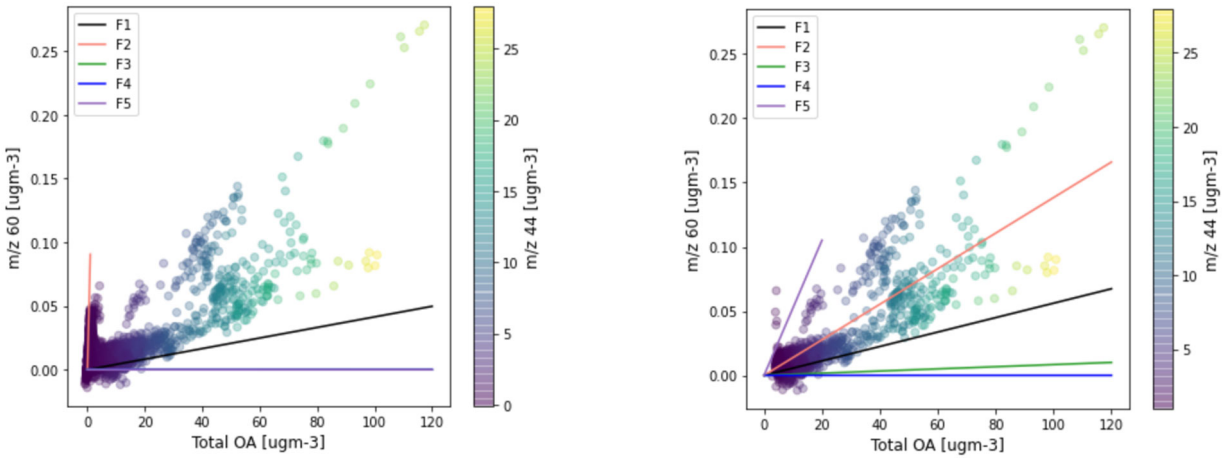


Fig. 2. Scatterplots of the molecular ion at m/z 60 and total OA concentrations superimposed with the m/z 60 to total OA ratio in factors of a 5-factor PMF solution.

References

Sutresna, A. R., M. Keywood, C. Paton-Walsh, J. B. Simmons, Q. Dang, M. Mochida, S. Ohata, S. Afsana, B. Kunwar, K. Kawamura, C. Mynard, R. S. Humphries, K. Emmerson, A. Griffiths, R. Schofield and P. J. Rayner (2023). Biomass burning organic aerosol CV-ToF-ACSM measurements from the Australian 2020 bushfires. *ICNAA conference presentation*. https://az659834.vo.msecnd.net/eventsairaueprod/production-nectarcc-public/026590652bbf421392b824d80899959c

Joo, T., Y. Chen, W. Xu, P. Croteau, M. R. Canagaratna, D. Gao, H. Guo, G. Saavedra, S. S. Kim, Y. Sun, R. Weber, J. Jayne, and N. L. Ng (2021). Evaluation of a new aerosol chemical speciation monitor (ACSM) system at an urban site in Atlanta, GA: The use of capture vaporizer and $PM_{2.5}$ inlet. *ACS Earth Space Chem*. 5:10, 2565–2576. https://doi.org/10.1021/acsearthspacechem.1c00173

Lalchandani, V., D. Srivastava, J. Dave, S. Mishra, N. Tripathi, A. K. Shukla, R. Sahu, N. M. Thamban, S. Gaddamidi, K. Dixit, D. Ganguly, S. Tiwari, A. K. Srivastava, L. Sahu, N. Rastogi, P. Gargava and S. N. Tripathi (2021). Effect of biomass burning on $PM_{2.5}$ composition and secondary aerosol formation during post-Monsoon and Winter haze episodes in Delhi. *J. Geophys. Res.* 127:1. https://doi.org/10.1029/2021jd035232

Lei, L., Y. Sun, B. Ouyang, Y. Qiu, C. Xie, G. Tang, W. Zhou, Y. He, Q Wang, X. Cheng, P. Fu, and Z. Wang (2021). Vertical distributions of primary and secondary aerosols in urban boundary layer: Insights into sources, chemistry, and interaction with meteorology. *Environ. Sci. Technol*. 55:8, 4542–4552. https://doi.org/10.1021/acs.est.1c00479

Characterizing the long-term contribution of the dust burden transported into the Sydney Basin, Australia

M. Manohar*, D. D. Cohen, J. Crawford, A. Atanacio and F. Wilkins

[1] Centre for Accelerator Science, Australian Nuclear Science and Technology Organisation, Menai, NSW, Australia

* corresponding author: Madhura Manohar [madhuram@ansto.gov.au]

Abstract

The Sydney Basin is frequently polluted by dust storm events as well as general fine dust that is carried by the high velocity winds from the dry desert conditions of the central Australian deserts. This fine particle dust can impact the environment, health and even the economy. Dust storms from agricultural locations for instance can cause topsoil erosion which can induce land degradation and desertification. Dust deposition on leaves from dust storms can impact crop yield as photosynthesis is inhibited or reduced. Furthermore, the iron and phosphorus rich Australian soil when transported to the ocean, can cause algal blooms, alter ocean biota and change the albedo of the oceans.

Using accelerator-based ion beam analysis (IBA) we have generated a long-term elemental concentration database for a key location within the Sydney basin (Liverpool, NSW, Australia). The elemental concentrations are statistically modelled using a technique known as positive matrix factorisation (PMF) to identify seven to eight key fingerprints. The soil fingerprint was then further investigated to identify the likely source using a technique known as point source wind back trajectory analysis, where the path of the wind parcels was investigated with the soil fingerprint associated with a source region. The soil fingerprint was divided into high, medium and low soil concentration days. These were then modelled with the wind speed and direction to identify the likely source of the high, medium and low soil concentration days. This presentation will discuss the results of the statistical modelling carried out on this long-term database and demonstrate a unique way of identifying likely origins of dust pollution.

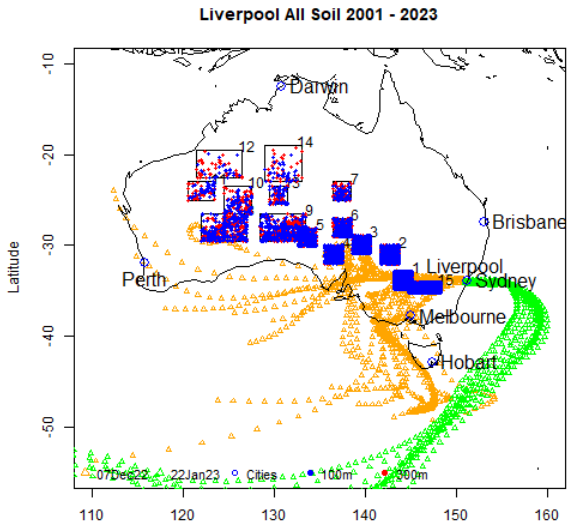


Fig. 1. Point Source Wind Back Trajectory Intersection Analysis carried out during this study. Each square represents a possible dust source. The green and orange lines are possible 24-hourly back trajectories on selected days.

References

Crawford, J., D. D. Cohen, A. Atanacio, M. Manohar and R. Siegele (2021). Fingerprinting Australian soils based on their source location. *Atmos. Poll. Res*. 12:3, 173–183. https://doi.org/10.1016/j.apr.2021.01.007

Emission factors of greenhouse gases and particles from smouldering combustion of coarse woody debris, southeastern Australia

C. T. Roulston*, J. C. Powell, S. Taylor, S. B. Molloy, D. Lynton and F. Reisen

CSIRO Environment, Climate, Atmosphere and Ocean Interactions, Aspendale, VIC, Australia

* corresponding author: Christopher T. Roulston [chris.roulston@csiro.au]

Abstract

Smoke from bushfires and planned burns can have damaging impacts on air quality, population health and agricultural yields. Records of emission factors have primarily focused on the lofted emissions from flaming combustion. Using these emission factors can substantially underestimate emissions for burn areas dominated by coarse woody debris. Emissions from smouldering coarse fuel are not lofted by strong fire-induced convection and continue to be released after flaming combustion has subsided. The smoke typically remains at or close to ground level. This can significantly impact local and downwind air quality for prolonged periods.

In this data set we report emission factors of greenhouse gases, particle mass ($PM_{2.5}$ and TSP) and chemical composition of particles from the residual smouldering combustion of coarse woody debris. The emission factors are grouped as a function of dominant combustion process, as well as fuel characteristics to provide an initial assessment of the variability in emissions. The data set, provided through the CSIRO data access portal [Roulston et al. 2023], fills an important data gap in the current literature. The code used to process this data is also available through the CSIRO data access portal [Roulston et al. 2023] and provides raw instrument data and the processed dataset.

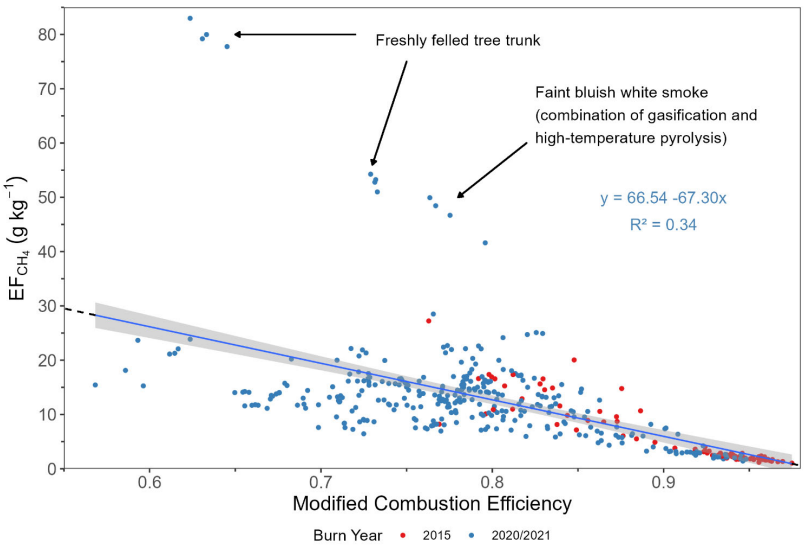


Fig. 1. Emission factor of Methane (CH_4) as a function of Modified Combustion Efficiency (MCE)

References

Roulston, C. T., J. C. Powell, S. Taylor, S. B. Molloy, D. Lynton and F. Reisen (2023). CSIRO Smouldering Emissions 2022 – Data. v1. CSIRO. Data Collection. https://doi.org/10.25919/0qv1-xq67

Roulston, C. T., J. C. Powell, S. Taylor, S. B. Molloy, D. Lynton and F. Reisen (2023). CSIRO Smouldering Emissions 2022 – Software. v4. CSIRO. Software Collection. https://doi.org/10.25919/pajm-gn63

Impacts of aromatic chemistry on the global atmosphere

S. M. MacFarlane[1*], J. A. Fisher[1], L. Xu[2], K. Ball[3], J. Crouse[3], P. O. Wennberg[3] and H. Pye[4]

[1] School of Earth, Atmospheric and Life Sciences, University of Wollongong, Wollongong, NSW, Australia
[2] National Oceanic and Atmospheric Administration, Boulder, CO, USA
[3] California Institute of Technology, Pasadena, CA, USA
[4] US Environmental Protection Agency, Research Triangle Park, NC, USA

[*] corresponding author: Stephen MacFarlane [smm997@uowmail.edu.au]

Abstract

Aromatics are an important subset of volatile organic compounds (VOCs), emitted mostly by anthropogenic sources such as vehicle exhaust, industry, and solvent usage [Cabrera-Perez et al. 2016]. These sources make them particularly important in urban environments, accounting for up to 60% of total VOCs in urban and semi-urban areas [Cabrera-Perez et al. 2016]. Aromatic species can undergo atmospheric oxidation resulting in significant contributions to both ozone and secondary organic aerosol (SOA) production [Seinfeld and Pandis 2016]. Aromatic oxidation also forms different species depending on the oxidant, either OH or NO_x, with different impacts on air quality, such as higher SOA formation potential or higher toxicity. It is therefore important for air quality to understand aromatic chemistry. The impacts of aromatic chemistry can be examined using Chemical Transport Models (CTMs) that simulate atmospheric processes. However, CTMs are only useful if they can be trusted to provide an accurate description of the real atmosphere.

Here, we evaluate a new aromatic chemistry mechanism recently implemented in GEOS-Chem, a global CTM. The new aromatic mechanism includes new reactions, species, and products. However, it has not yet been evaluated using atmospheric observations. To evaluate the new aromatic mechanism, we compare GEOS-Chem model simulations to measurements from the Korea-United States Air Quality (KORUS-AQ) aircraft campaign, during which a variety of aromatic species and their oxidation products were measured around the Korean Peninsula from May to June 2016. Based on these comparisons and a variety of sensitivity simulations, changes are made to the chemical mechanism and emissions to improve model performance. In this presentation, we will discuss the changes to the model and how they improve model performance, with comparisons between the baseline model, updated model, and observations. We will also provide analysis of the atmospheric budget of two aromatic species, phenol and cresol, using the updated model.

References

Cabrera-Perez, D., Taraborrelli, D., Sander, R. and A. Pozzer (2016). Global atmospheric budget of simple monocyclic aromatic compounds. *Atmos. Chem. Phys.*, vol. 16, no. 11, pp. 6931-47. https://doi.org/10.5194/acp-16-6931-2016

Seinfeld, J. H. and S. N. Pandis (2016). Atmospheric Chemistry and Physics : From Air Pollution to Climate Change (3rd edition), 1152 pp. (John Wiley & Sons Inc.: New York, USA). ISBN: 978-1-119-22117-3

Variability in ozone in the Upper Troposphere/Lower Stratosphere from Broadmeadows and Macquarie Island ozonesondes

M. B. Tully*

Bureau of Meteorology, Melbourne, VIC, Australia

* corresponding author: Matt Tully [matt.tully@bom.gov.au]

Abstract

The 2022 WMO/UNEP Scientific Assessment of Ozone Depletion [WMO 2022] identified a discrepancy between models and observations in the ozone trend since the year 2000 in southern mid-latitudes in the stratosphere below approximately 40 hPa. The Bureau of Meteorology operates two long-running ozonesonde programs in the southern mid-latitudes, at Broadmeadows (37.7° S 144.9° E) and Macquarie Island (54.5° S 158.9° E), providing weekly high resolution vertical profiles of ozone and temperature. In this presentation, variability and trends in the Upper Troposphere/Lower Stratosphere (UTLS) region will be studied based on ozonesonde data at both sites over the period 1999 to the present, during which equipment changes have been minimal. Variations in UTLS ozone will be expressed in the context of the trends in total column ozone over the same period.

References

World Meteorological Organization (WMO, 2022). Executive Summary. Scientific Assessment of Ozone Depletion: 2022, GAW Report No. 278, 56 pp. [WMO: Geneva, Switzerland]

Radiative Forcing, CO_2-equivalent and Equivalent Effective Stratospheric Chlorine calculated using measurements of greenhouse gases and ozone depleting substances in Antarctic firn and at Kennaook/Cape Grim

C. M. Trudinger*, P. B. Krummel, P. J. Fraser, N. Derek, Z. M. Loh, R. L. Langenfelds, D. M. Etheridge, B. Mitrevski and L. P. Steele

CSIRO Environment, Climate, Atmosphere and Ocean Interactions, Aspendale, VIC, Australia

* corresponding author: Cathy Trudinger [cathy.trudinger@csiro.au]

Abstract

Radiative forcing is a useful metric to compare the relative impacts of different greenhouse gases on Earth's energy balance and therefore climate. CO_2-equivalent (CO_2-e) can be calculated from radiative forcing, and gives the CO_2 level that corresponds to radiative forcing from all greenhouse gases together. Equivalent Effective Stratospheric Chlorine (EESC) is a parameter developed to relate the Cl and/or Br content and atmospheric lifetimes of ozone depleting substances to their contribution to stratospheric ozone depletion. Here we present radiative forcing, CO_2-e and EESC calculated using the latest formulations and parameters with observations of greenhouse gases and ozone depleting substances from Kennaook/Cape Grim and Antarctic firn. The firn, air archive and in situ measurements were carried out with effectively the same instruments and calibrations, giving consistent and continuous records from before 1900 to now.

Using the formulations and radiative efficiencies from the latest IPCC report [AR6, Smith et al. 2021], CO_2-e at Kennaook/Cape Grim has recently passed 520 ppm (in June 2023). This is a bit earlier than expected from previous estimates, due mainly to a revision of the estimated radiative efficiency of CFC-11 and CFC-12. Fig. 1 shows the latest radiative forcing estimates and Fig. 2 compares the corresponding CO_2-e with the CO_2-e calculated using the formulations and parameters from the previous IPCC report [AR5, Myhre et al. 2013], and the CO_2-e presented at ACCOMC 2018 [Krummel et al. 2018]. (The difference between the estimates based on AR5 and those presented at ACCOMC 2018 is due to an update to the radiative forcing of methane from inclusion of shortwave absorption [Krummel et al. 2018]). We will also show CO_2-e calculated with global records of greenhouse gases.

We will present EESC calculated with the latest observations of ozone depleting substances from Kennaook/Cape Grim and Antarctic firn, using the approach presented in the latest Ozone Assessment [WMO 2022] based on Engel et al. [2018]. This new approach involves the use of 'release time distributions', in which age spectrums for inert tracers are weighted with the release function for inorganic hydrogen from the source gases. We will compare EESC calculated with this new approach with that from previous approaches, including the results described in Fraser et al. [2014].

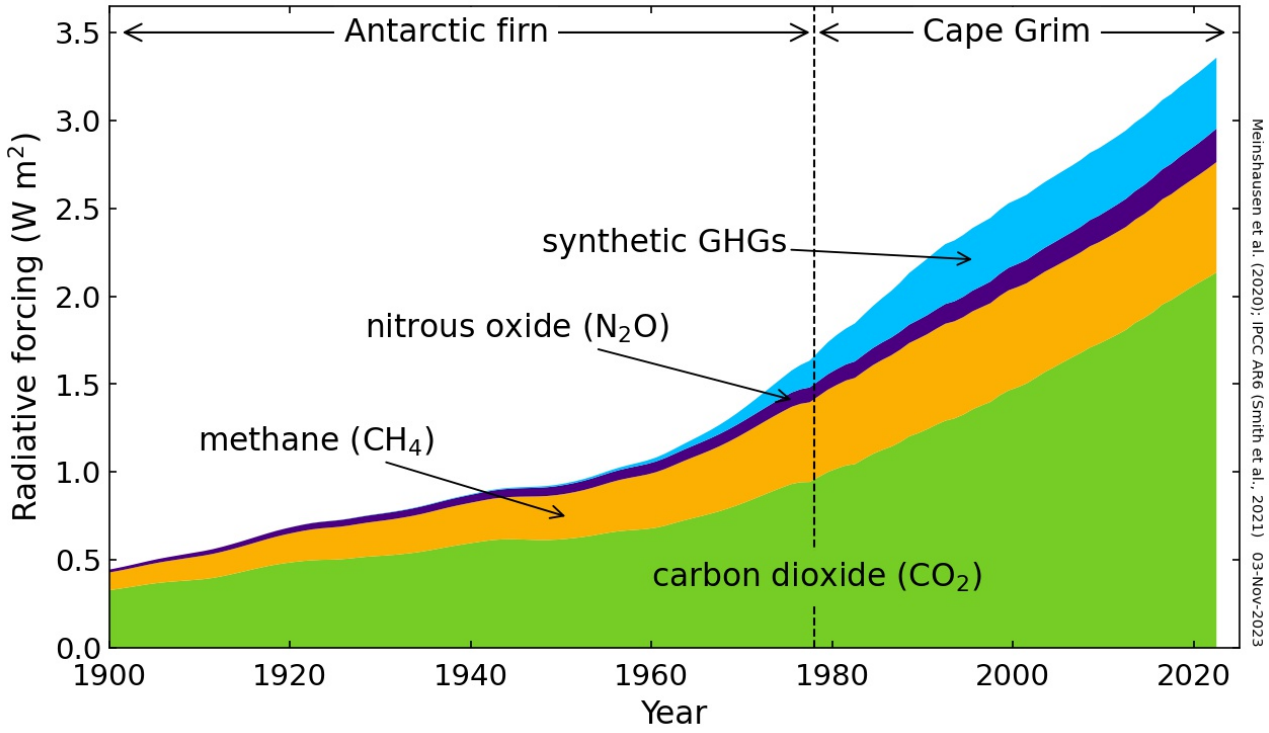


Fig. 1. Radiative forcing calculated from southern hemisphere greenhouse gas records based on measurements from Antarctic firn and Kennaook/Cape Grim with the latest formulations and radiative efficiencies used in the AR6 IPCC report [Smith et al. 2021].

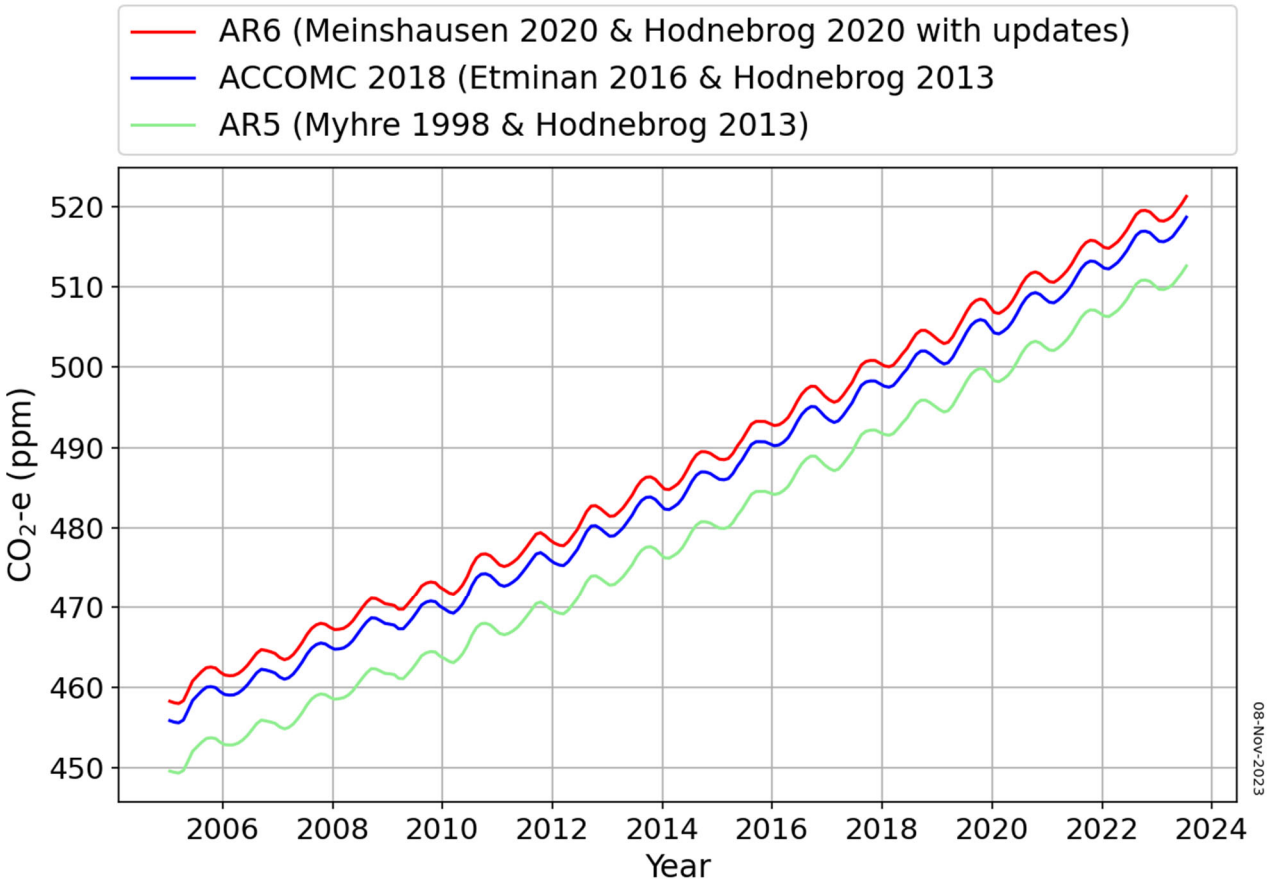


Fig. 2. CO_2-e in the southern hemisphere calculated from radiative forcing based on different formulations and radiative efficiencies, and observations from Kennaook/Cape Grim and Antarctic firn.

References

Engel, A., H. Bonisch, J. Ostermoller, M. P. Chipperfield, S. Dhomse and P. Jöckel (2017). A refined method for calculating equivalent effective stratospheric chlorine. *Atmos. Chem. Phys*. 18:2, 601–619. https://doi.org/10.5194/acp-18-601-2018

Etminan, M., G. Myhre, E. Highwood and K. Shine (2016). Radiative forcing of carbon dioxide, methane, and nitrous oxide: A significant revision of the methane radiative forcing. *Geophys. Res. Lett*. 43, 12614–12623. https://doi.org/10.1002/2016GL071930

Fraser, P. J., P. B. Krummel, L. P. Steele, C. M. Trudinger, D. M. Etheridge, S. J. O'Doherty, P. G. Simmonds, B. R. Miller, J. Mühle, R. F. Weiss, D. E. Oram, R. G. Prinn and R. Wang (2014). Equivalent effective stratospheric chlorine from Cape Grim Air Archive, Antarctic firn and AGAGE global measurements of ozone depleting substances. In 'Baseline Atmospheric Program (Australia) 2009-2010'. (eds. N. Derek, P. B. Krummel and S. J. Cleland) pp. 17–23. (BoM and CSIRO: Melbourne, Australia). https://doi.org/10.25919/5f2075c5e2ec5

Hodnebrog, Ø., M. Etminan, J. S. Fuglestvedt, G. Marston, G. Myhre, C. J. Nielsen, K. P. Shine and T. J. Wallington (2013). Global warming potentials and radiative efficiencies of halocarbons and related compounds: A comprehensive review. *Rev. Geophys*. 51, 300–378. https://doi.org/10.1002/rog.20013

Hodnebrog, Ø., B. Aamaas, J. S. Fuglestvedt, G. Marston, G. Myhre, C. J. Nielsen, M. Sandstad, K. P. Shine and T. J. Wallington (2020). Updated global warming potentials and radiative efficiencies of halocarbons and other weak atmospheric absorbers. *Rev. Geophys*. 58, e2019RG000691. https://doi.org/10.1029/2019RG000691

Krummel, P. B., Z. M. Loh, P. J. Fraser, R. L. Langenfelds, L. P. Steele, N. Derek, B. Mitrevski, D. M. Etheridge and S. J. Cleland (2018). Cape Grim CO_2-e exceeds 500 ppm … or has it? In 'Atmospheric Composition & Chemistry Observations and Modelling Conference incorporating he Cape Grim Annual Science Meeting 2018' [abstract], 4–6 December 2018, Aspendale, Victoria. (eds. N. Derek and P. B Krummel) 74 pp. (BoM and CSIRO: Melbourne, Australia)

Meinshausen, M., Z. R. J. Nicholls, J. Lewis, et al. (2020) The shared socio-economic pathway (SSP) greenhouse gas concentrations and their extensions to 2500. *Geosci. Model Dev*. 13, 3571–3605. https://doi.org/10.5194/gmd-13-3571-2020.

Myhre, G., D. Shindell, F.-M. Bréon, W. Collins, J. Fuglestvedt, J. Huang, D. Koch, J.-F. Lamarque, D. Lee, B. Mendoza, T. Nakajima, A. Robock, G. Stephens, T. Takemura and H. Zhang (2013). Anthropogenic and Natural Radiative Forcing (Supplementary Material). Chapter 8 in 'Climate Change 2013: The Physical Science Basis'. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (eds. Stocker, T. F., D. Qin, G.-K. Plattner, M. Tignor, S. K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P. M. Midgley). (Cambridge University Press: Cambridge, UK & New York, NY, USA).

Smith, C., Z. R. J. Nicholls, K. Armour, W. Collins, P. Forster, M. Meinshausen, M. D. Palmer and M. Watanabe (2021). The Earth's Energy Budget, Climate Feedbacks, and Climate Sensitivity (Supplementary Material). Chapter 7 in 'Climate Change 2021: The Physical Science Basis'. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. (eds. Masson-Delmotte, V., P. Zhai, A. Pirani, S. L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M. I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J. B. R. Matthews, T. K. Maycock, T. Waterfield, O. Yelekçi, R. Yu, and B. Zhou). (Cambridge University Press: Cambridge, UK & New York, NY, USA).

World Meteorological Organization (WMO, 2022). Scientific Assessment of Ozone Depletion: 2022. GAW Report No. 278, 509 pp. (WMO: Geneva, Switzerland)

Trends in atmospheric chemical species over the Anthropocene from firn, ice and baseline station measurements

D. M. Etheridge[1,2*], V. V. Petrenko[3], X. Fain[4], C. M. Trudinger[1,2], R. L. Langenfelds[1], A. M. Smith[5], P. B. Krummel[1], M. Rubino[6], A. Menking[1,2], Z. M. Loh[1], D. A. Spencer[1], E.-A. Guerette[1], C. G. R. Caldow[1,2], P. D. Neff[3,7], C. Buizert[8], M. T. Woodhouse[1,2], L. Murray[3], P. Martinerie[4] and M. A. J. Curran[2,9]

[1] CSIRO Environment, Climate, Atmosphere and Occean Interactions, Aspendale, VIC, Australia
[2] Australian Antarctic Program Partnership, Institute for Marine and Antarctic Studies, University of Tasmania, Hobart, TAS, Australia
[3] Department of Earth and Environmental Sciences, University of Rochester, Rochester, NY USA
[4] University Grenoble Alpes, CNRS, INRAE, IRD, Grenoble INP, IGE, Grenoble, France
[5] Australian Nuclear Science and Technology Organisation, Kirrawee DC, NSW, Australia
[6] Dipartimento di Matematica e Fisica, University of Campania, 81100 Caserta CE, Italy
[7] Department of Soil, Water, and Climate, University of Minnesota Twin Cities, Saint Paul, MN, USA
[8] College of Earth, Ocean, and Atmospheric Sciences, Oregon State University, Corvallis, OR, USA
[9] Australian Antarctic Division, Kingston, TAS, Australia

[*] corresponding author: David Etheridge [david.etheridge@csiro.au]

Abstract

We report on progress in quantifying the long-term trends in background concentrations of the chemically active trace gases carbon monoxide (CO), hydroxyl (OH), hydrogen (H_2) and methane (CH_4). Recent measurements have addressed many of the difficulties of some of these gases being reactive, unstable or diffusive in archived air or polar ice and firn, allowing the extension of their observational records to the beginning of the Anthropogenic perturbation.

CO concentrations have recently been measured in firn air, ice cores and flask air samples from Antarctica, complementing a previous northern hemisphere counterpart from Greenland. OH has been inferred from measurements in Antarctic ice and firn of radiocarbon in CO ($_{14}CO$), which acts as an integrating tracer, and plans are underway for similar measurements in Greenland. H_2 concentrations have been reported previously from Greenland and Antarctic firn air and atmospheric measurements. CH_4 concentrations have been available from both ice and firn from both polar regions and new measurements from Law Dome (Antarctica) provide highly resolved variations over the past century.

These gases have significant and tightly coupled roles in the atmosphere and all are affected at least partly by emissions related to the energy sector. Their records provide observational constraints for atmospheric chemistry-climate models to infer the causes of changes over past centuries and help simulate the atmospheric impacts of future changes in emissions resulting from a global energy transition.

PlumeMapper: An innovation in ambient odour assessment

A. Balch* and S. S. John

Air Environment Consulting Pty Ltd, Brisbane, QLD, Australia

* corresponding author: Andrew Balch [andrew@airenvironment.com.au]

Abstract

Impacts on communities from odorous air pollution have gained increasing attention in recent years to become an important environmental issue. Traditional approaches to odour nuisance assessment used in Australia based on source emission sampling, dynamic olfactometry testing and atmospheric dispersion modelling for predictive assessment against odour impact criteria in odour units are being challenged by some state environmental regulators that prefer a more direct and empirical method for evaluating odour impact. Field ambient odour assessment surveys, based on 'sniffing patrols', are a robust method for collecting actual odour plume and exposure information. The method incorporates the collection of meteorological and ambient odour characteristics (e.g. odour intensity and/or concentration, hedonic tone, duration, character, likely source) from each measurement location in a survey. This survey technique is largely based on European standard methods and has become more widely used in Australia and New Zealand over the past 20 years for assessing facilities with established odour issues. It is now the preferred assessment method of some Australian state regulatory authorities. Observations and measurements collected in the field during plume surveys have traditionally been collected on paper forms. Surveys and data analyses are complex and timing consuming, while the standards provide a lack of clear guidance for assessing odour nuisance, which is often evaluated differently in different jurisdictions. Survey results are often assessed in isolation, with little or no consideration of the long-term impact through temporal and spatial analyses. In this poster, the authors present a comprehensive and concise approach to data collection and multi-survey analyses over different seasons that identifies and assesses the odour footprint of different sources from one industrial site. The presentation also illustrates the development of a purpose-built, commercially available, mobile and web-based software platform called *PlumeMapper*, specifically designed by the authors to efficiently and cost-effectively collect, store, analyse, and report on field survey data.

A year of observations at University of Melbourne's AirLab

R. Schofield[1*], D. Hocking[1], R. Ryan[1], I. Wadlow[1], L. Toms-Hardman[1,2], A. Sutresna[1], Z. M. Loh[3], J. Ramirez Gamboa[3], C. He[4], R. Jayaratne[4], Z. D. Ristovski[4], L. Morawska[4] and J. Choi[5]

[1] School of Geography, Earth and Atmospheric Sciences, University of Melbourne, Parkville, VIC, Australia
[2] Defence, Science, Technology Group, Rockingham, WA, Australia
[3] CSIRO Environment, Climate, Atmosphere and Ocean Interactions, Aspendale, VIC, Australia
[4] Queensland University of Technology, Brisbane, QLD, Australia
[5] Environmental Protection Authority, Melbourne, VIC, Australia

[*] corresponding author: Robyn Schofield [robyn.schofield@unimelb.edu.au]

Abstract

AirLab was established in 2022 on the roof of the Redmond Barry building (-37.7967°S, 144.9626°E) on the urban Parkville campus of the University of Melbourne just 1-2 km to the north of Melbourne's Central Business District. At an elevation of 43 m this site represents a fairly well-mixed urban boundary layer background observing site.

With a Nephelometer and a filter system for particulate matter we have been participating in the grassroots Surface Particulate Matter Network (SPARTAN) [Snider 2015] since June 2022. The SPARTAN observations are used to validate satellite remote sensing estimates of $PM_{2.5}$ mass, chemical composition and radiative properties with the aim to better characterize health implications of air pollution of cities globally. Ultrafine particle size and number density observations with a Scanning Mobility Particulate Sizer have been made since June 2023 and an EPA Beta Attenuation Monitor (BAMs) that automatically measures mass concentrations of $PM_{2.5}$ particles has recently been installed. A Picarro Greenhouse Gas instrument has been monitoring CO_2, CH_4 and CO concentrations since February 2023, and more recently MAXDOAS observations have been conducted.

Meteorological data and miniMPL aerosol optical depth data provide insights into the boundary layer and source regions of the co-located urban observations.



Fig. 1. Spartan instruments on the rooftop platform above the AirLab laboratory.

References

Snider, G., C. L. Weagle, R. V. Martin, A. van Donkelaar, K. Conrad, D. Cunningham, C. Gordon, M. Zwicker, C. Akoshile, P. Artaxo, N. X. Anh, J. Brook, J. Dong, R. M. Garland, R. Greenwald, D. Griffith, K. He, B. N. Holben, R. Kahn, I. Koren, N. Lagrosas, P. Lestari, Z. Ma, J. Vanderlei Martins, E. J. Quel, Y. Rudich, A. Salam, S. N. Tripathi, C. Yu, Q. Zhang, Y. Zhang, M. Brauer, A. Cohen, M. D. Gibson and Y. Liu (2015). SPARTAN: a global network to evaluate and enhance satellite-based estimates of ground-level particulate matter for global health applications. *Atmos. Meas. Tech*. 8, 505–521. https://doi.org/10.5194/amt-8-505-2015

Novel techniques of measuring carbon dioxide for Wollongong

B. T. Walker[1*], N. M. Deutscher[1], C. Paton-Walsh (Murphy)[1], D. W. T. Griffith[1], N. B. Jones[1], H. Nawaz[1] and TCCON Partners[2]

[1] School of Earth Atmospheric and Life Sciences, University of Wollongong, Wollongong, NSW, Australia
[2] TCCON Partners

[*] corresponding author: Brittany Walker [btw292@uowmail.edu.au]

Abstract

The Total Carbon Column Observing Network (TCCON) is a global network of ground-based Fourier Transform Spectrometers that record direct solar in the near-infrared spectral region which produce accurate and precise column-averaged abundance of CO_2, CH_4, N_2O, HF, CO, H_2O, and HDO [Wunch et al. 2011]. TCCON can serve as a validation resource for both satellites and portable ground-based remote sensing instruments. The established CO_2 product has relatively uniform sensitivity throughout the vertical profile of the atmosphere. New TCCON data [Laughner et al 2023] now report multiple CO_2 products with differing vertical sensitivities. The stronger CO_2 channel is more sensitive to changes in mole fraction at lower altitudes, while the weaker CO_2 channel is more sensitive to changes in mole fraction at higher altitudes in the atmosphere. Here we present an initial look at the new TCCON CO_2 products relative to the existing product, based on measurements at Wollongong. The strong channel has the largest positive difference with the standard product during the months of summer, indicating more of the CO_2 in the atmosphere is higher in the atmosphere during this time. The difference between the weak channel and standard product has less seasonal variation than the difference between strong channel and standard product – during late winter to spring there is a negative difference in the weak band (high altitude) product relative to the standard product, which increases to a positive difference marginally until April and May.

References

Wunch. D., G. C. Toon, J.-F. L. Blavier, R. A. Washenfelder, J. Notholt, B. J. Connor, D. W. T. Griffith, V. Sherlock and P. O. Wennberg (2011). The Total Carbon Column Observing Network. *Phil. Trans. Roy. Soc. A*. 369, 2087–2112. https://doi.org/10.1098/rsta.2010.0240

Laughner, J. L., G. C. Toon, J. Mendonca, C. Petri, S. Roche, D. Wunch, J.-F. Blavier, D. W. T. Griffith, P. Heikkinen, R. F. Keeling, M. Kiel, R. Kivi, C. M. Roehl, B. B. Stephens, B. C. Baier, H. Chen, Y. Choi, N. M. Deutscher, J. P. DiGangi, J. Gross, B. Herkommer, P. Jeseck, T. Laemmel, X. Lan, E. McGee, K. McKain, J. Miller, I. Morino, J. Notholt, H. Ohyama, D. F. Pollard, M. Rettinger, H. Riris, C. Rousogenous, M. K. Sha, K. Shiomi, K. Strong, R. Sussmann, Y. Té, V. A. Velazco, S. C. Wofsy, M. Zhou and P. O. Wennberg (2023). The Total Carbon Column Observing Network's GGG2020 Data Version. Earth Syst. Sci. Data Discuss. [preprint]. https://doi.org/10.5194/essd-2023-331 (in review)