Australian Government
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Atmospheric Composition & Chemistry Observations & Modelling Conference

incorporating the

Cape Grim Annual Science Meeting 2020

and

16th Australia and New Zealand Aerosol Assembly

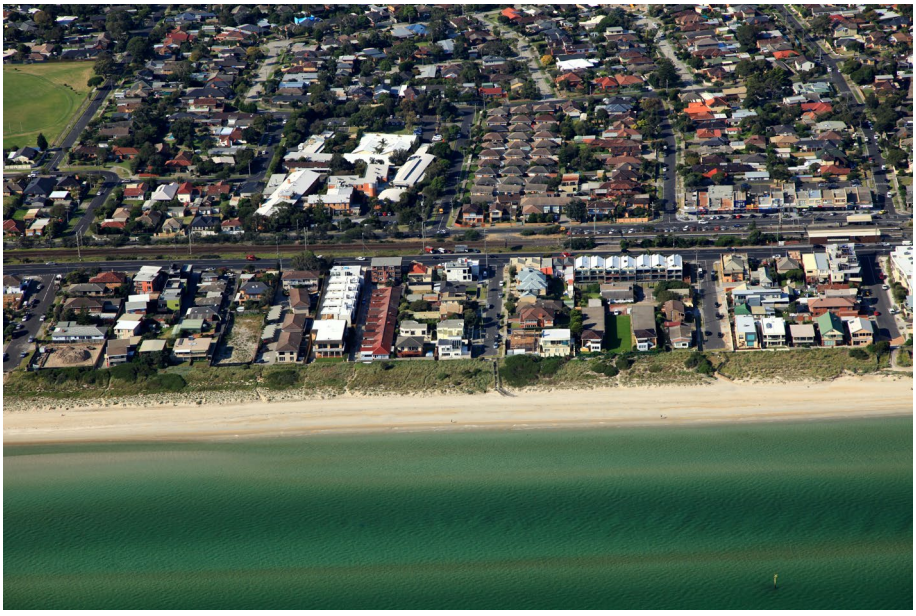
Abstracts

30 November – 4 December 2020

hosted by

CSIRO Oceans and Atmosphere, Climate Science Centre

Virtual Meeting
Aspendale, Victoria, Australia



Edited by: N. Derek and P. B. Krummel

Citation

Author, A. B., A. B. Author and A. B. Author (2020). Abstract Title. In 'ACCOMC incorporating the CGASM2020 and 16th ANZAA [abstract]' (30 Nov-4 Dec 2020, online) (eds. N. Derek and P. B. Krummel) viii, p. 64 (BoM and CSIRO: Melbourne, Australia), page#, 2020.

Posters – available during the meeting at

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Please take the time to view the posters and if you have any questions, contact the author directly.	
Scott Chambers	First results from a portable two-filter dual-flow-loop radon detector
Alan Griffiths	Enhanced head developments for a compact high-sensitivity radon detector: status update
Neil Page	Sea ice cover drives a seasonal decrease in tropospheric bromine in coastal Antarctica
Jack Simmons	Characterising the persistent smoke plume over SE Australian population centres during the 2019-2020 'Black Summer'
Hazel Titley	Station intercomparison between NT BAPS and RV *Investigator*
Bin Yang	Cryogenic trapping of CO_2 in the presence of other gases

Day 1: Monday, 30 November 2020; 11:00-13:00

11:00	**Convenors**	**Welcome & general information on arrangements etc**
Chair	**Cathy Trudinger**	**Session 1 – Oral Presentations**
10	Sally Taylor	Acknowledgement of Traditional Owners
10	Michael Bertolacci	WOMBAT: A fully Bayesian global flux-inversion framework
10	Sara Mikaloff Fletcher	From the soil to the stars: New developments in greenhouse gas measurements and modelling in Aotearoa New Zealand
10	Beata Bukosa	CarbonWatchNZ: Regional to national scale inverse modelling of New Zealand's carbon balance
10	Dimitri Lafleur	The impact of background concentrations on the quantification of regional methane emissions in Australia
5	Ruth Reef	Understanding and quantifying coastal wetland methane emissions
10	Zoë Loh	Global and national assessments of greenhouse gases
10	Ian Enting	Comparing greenhouse gas emission metrics
10	David Griffith	Long term records of greenhouse gases at Wollongong and Darwin, 2011-2020
10	Nicholas Deutscher	An update on the Total Carbon Column Observing Network

Day 2: Tuesday, 1 December 2020; 11:00-13:00

11:00	**Convenors**	**Daily welcome includes acknowledgement of traditional owners**
Chair	**Zoë Loh**	**Session 2 – Oral Presentations**
10	Shyno Susan John	Can anomalies in total column carbon monoxide provide a proxy for smoke-related surface exposure?
10	Ray Langenfelds	The 2019/20 Australian bushfires
10	Fabienne Reisen	Forecasting the air quality impacts of the Cobden peat fires
2	Jyoti Campbell	New refrigerants ultimately produce the global warming agents they were meant to replace
10	Christopher Hansen	A new source of HFC-23 in the atmosphere: profound implications for new refrigerants
10	Blagoj Mitrevski	A potential future of atmospheric measurements of synthetic greenhouse gases (GHG) and ozone depleting substances (ODS) at CSIRO
10	Paul Fraser	The rise and fall of recent CFC-11 emissions from eastern China
10	Paul Krummel	The 2020 Antarctic ozone hole
5	Matt Tully	Antarctic ozone loss observed at Davis in 2020
5	Fraser Dennison	Chemistry-Climate Modelling with ACCESS-CM2-Chem

Day 3: Wednesday, 2 December 2020; 11:00-13:00

11:00	Convenors	Daily welcome includes acknowledgement of traditional owners
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10	Zhenyi Chen	Cape Grim Boundary Layer Characterization Study
10	Kathryn Emmerson	Dust modelling within the Drought Resilience Mission
10	Jeremy Silver	Lessons arising from modelling grass pollen over Victoria
10	Xavier Barthélémy	Choosing the soup recipe: changing the lumping ingredients to each one's taste
10	Francis Abulude	Assessment of air quality using the Plume Air Quality Index Indicator (PAQI): Reference to five towns in Nigeria
7	Nasimeh Shahrokhi	Regenerating urban scale carbon monoxide inventory using 4D-Var Data Assimilation: Preliminary results for Tehran
10	Akinyinka Akinnusotu	Organochlorine pesticides (OCPs) assessment of sediment, soil, and fish samples from River Owan in Edo State, Nigeria
5	Jenny Fisher	An updated budget for atmospheric mercury in Australia

Day 4: Thursday, 3 December 2020; 11:00-13:00

11:00	Convenors	Daily welcome includes acknowledgement of traditional owners
Chair	**Elise Guerette**	**Session 4 – Oral Presentations**
5	Clare Paton-Walsh (Murphy)	The COALA-2020 Campaign: Charaterising Organics and Aerosol Loading in Australia
5	Jhonathan Ramirez	VOCs seasonality during the COALA-JOEYS campaign
10	Erin Dunne	VOC fluxes measurements from ship-born Air-Sea Tank experiments over the Western Pacific Ocean (New Zealand)
10	Maija Peltola	Using air-sea interaction tanks to study new particle formation from emissions by marine micro-organisms
10	Lorrie Jacob	Understanding the photooxidation of acetone in the troposphere through FTIR experiments and MCM modelling
10	Blair Welsh	Atmospheric photothermal oxidation: Shining a new light on formaldehyde photochemistry
5	Maria Paula Perez-Peña	Building a global simulation of H2 on GEOS-Chem to use in the assessment of new photochemical sources
10	Ian Galbally	Recent work in the Cape Grim Reactive Gases Program
5	David Dicker	Sponsor: Vaisala
5	Jason Potts	Sponsor: Benchmark Monitoring

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10	Michael Harvey	Examining pollution sources in size segregated aerosols collected at Baring Head with sulfur and nitrogen isotopic analyses
10	Robyn Schofield	AIRBOX 2020 - from the Tropics to Bushfires to 'Staying at Home'
10	Samantha Orum	Aerosol optical depth over the Southern Ocean
10	Joel Alroe	Winter-time sea spray aerosol over the Southern and South Pacific Oceans
10	Melita Keywood	First look at near real time aerosol chemical composition at Cape Grim
10	Daniel Harrison	Atmospheric interventions considered in the Reef Restoration and Adaptation Program
10	Zoran Ristovski	Real time reactive oxygen species measurements in Chinese cities
5	Sonya Fiddes	Towards reducing the Southern Ocean radiation bias in ACCESS

Posters

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First results from a portable two-filter dual-flow-loop radon detector

S. D. Chambers[1*], A. G. Williams[1], A.D. Griffiths[1], O. Sisoutham[1], S. Werczynski[1] and A. Röttger[2#]

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Abstract

There is a growing need, with considerable overlap between the climate science, air quality and radiological protection communities, for a portable, robust and direct atmospheric radon monitor with a low detection limit and high measurement precision. In order to reliably characterise outdoor afternoon radon concentrations, or resolve daytime vertical radon gradients in the surface layer (requirements for evaluating the performance of urban climate or chemical transport models), detection limits below 0.2 Bq m-3 for hourly counts are required. Contemporary portable commercial radon detectors are designed mainly for indoor use, and the best of these has a detection limit between 2 - 3 Bq m^{-3} for hourly counts, with an uncertainty of around 60% at ambient outdoor radon concentrations. Our poster presentation introduces a new, portable (200 L) two-filter dual-flow-loop radon detector, designed and built by ANSTO in collaboration with the EMPIR 19ENV01 *traceRadon* project. Although not as compact as commercial monitors (standing 1.5 m tall, and 0.48 m wide when assembled), its longest individual piece is 1.1 m, so it can be transported in a standard vehicle (and can fit inside a 19" instrument rack). Constructed of marine grade stainless steel, it is weather resistant, robust, and suitable for long-term, continuous, autonomous deployment; in fact it is fully remotely controllable if a networked computer is available. The estimated lower limit of detection is 0.13 Bq m^{-3} for hourly observations, and the counting uncertainty at typical ambient outdoor radon concentrations is around 7%. Uncertainty associated with current calibration techniques varies from 2-6% (since calibration gas is injected on top of ambient sampled air) and direct traceability to the SI will be established within *traceRadon*. One further objective of the *traceRadon* project is to develop an improved closed-loop calibration technique, using a new, low activity Radium-226 source. If successful, the absolute accuracy of the 200 L radon detector at typical ambient outdoor concentrations could be kept well below 15% for hourly observations. Furthermore, improvements in detector head design presently being explored by Griffiths et al. [this volume], may bring the detection limit of the 200 L detector below 0.04 Bq m^{-3}, making measurements in the marine boundary layer, characterised by radon < 0.1 Bq m^{-3}, feasible.

[§] *This project has received funding from the EMPIR programme co-financed by the Participating States and from the European Union's Horizon 2020 research and innovation programme. 19ENV01* traceRadon *denotes the EMPIR project reference.*

Enhanced head developments for a compact high-sensitivity radon detector: status update

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Abstract

The central component of ANSTO's radon detectors is a combined filtration and alpha detection unit, called the detector head. The current head is robust and stable but, possibly due to the constraints of late 90s technology, the head has a low efficiency, counting only about one in five alpha decays. The overall detector sensitivity scales with the product of detector volume and head efficiency, meaning that any gains in head efficiency can be used to shrink the detector volume while maintaining a high sensitivity. As reported at last year's meeting, we have developed a concept for a detector head which retains the favourable elements of the existing design, but with a theoretical efficiency close to 100%. Filtration is inspired by 1950s era 'diffusion batteries' whereas detection of the scintillation light relies on wavelength shifting fibre optics, which have found applications in nuclear physics more recently. The initial concept has now progressed to a benchtop experiment intended to test the assumptions made during the preliminary design, most importantly the diffusivity of the radon decay products which are trapped in the head. This poster will detail these first laboratory tests.

Sea ice cover drives a seasonal decrease in tropospheric bromine in coastal Antarctica

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Abstract

Seasonal sea ice plays an important role in the production and distribution of tropospheric bromine. In early spring the rapid release of bromine from sea ice surfaces to the atmosphere can initiate a series of chemical reactions, known as a bromine explosion, which depletes ozone and oxidises gaseous elemental mercury. This affects the chemistry and oxidising capacity of the polar troposphere, resulting in the subsequent deposition of toxic water-soluble mercury into the polar environment. The process of sea ice formation helps to concentrate sea salts, resulting in freshly formed first-year sea ice (and the snow on this first-year sea ice) having a higher surface salinity and therefore being particularly important for bromine production. The combined effects of increasing anthropogenic mercury in the polar troposphere and changes to sea ice coverage under climate change may be negatively impacting polar ecosystems. Given the remoteness and limited accessibility of the Antarctic sea ice region, the distribution and variability of bromine, along with environmental mechanisms that control bromine cycling, are still poorly characterised.

MAX-DOAS (Multi-AXis-Differential Optical Absorption Spectroscopy) retrievals of atmospheric bromine monoxide (BrO) were made onboard the Australian icebreaker RSV Aurora Australis during the Chemical and Mesoscale Mechanisms of polar Cell Aerosol Nucleation (CAMMPCAN) campaign between October and March over a two-year period. The campaign involved 6 research voyages spanning three seasons each year that traversed the Southern Ocean from Australia to Antarctica.

Results indicate that seasonal tropospheric BrO concentrations decreased between spring and summer, likely resulting from a reduction in sea ice cover. Observations show a positive relationship between sea ice cover and BrO concentration in the surface layer during periods of both low wind speeds (<7 m/s) and high wind speeds (>7 m/s). Jones et al. (2009) proposed two regimes for enhanced BrO: one regime at low wind speeds and another regime at high wind speeds. Low wind speeds combined with strong atmospheric stability above the snowpack can allow photolabile bromine species to accumulate, which then reacts with O_3 to from BrO (Peterson et al., 2015). However, high wind speeds (>7 m/s) can result in blowing snow conditions, when the snow sublimates it produces sea salt aerosols which provide a surface for heterogenous chemistry, this results in the release of Br_2 that subsequently reacts with O_3 to form BrO (Jones et al., 2009). Additional factors that drive the distribution of BrO over coastal Antarctica include low sea level pressure, cold surface air temperature and ozone mixing ratio.

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Characterising the persistent smoke plume over SE Australian population centres during the 2019-2020 'Black Summer'

J. B. Simmons[1*], C. Paton-Walsh[1], T. A. Naylor[1], R. S. Humphries[2], M. D. Keywood[2], G. Gunashanhar[3], J. Ramirez-Gamboa[1], A. D. Griffiths[4] et al.

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Abstract

Smoke, sourced from prescribed burns and wildfires, is a major contributor to instances of poor air quality experienced in heavily populated areas of southeastern Australia such as Sydney, Melbourne and Wollongong. Bushfire smoke is also a major source of variability in tropospheric composition in this region, which can have a climatic impact. The 2019-2020 Australian bushfire season was among the most significant in recent history. Smoke caused exceedances of air quality monitoring criteria pollutants on an unprecedented scale at sites across Australia's east coast, with plumes impacting air quality on the week-to-month timescale. Considering the importance of this pollutant source to air quality and tropospheric composition in eastern Australia, the observed health impacts of bushfire smoke and the duration and extent of the 2019-2020 event, it is critical to understand the chemical composition of persistent bushfire plumes over SE Australia during the 'Black Summer'. This work presents measurements and analysis of greenhouse gas and aerosol variables from the COALA-2020 field campaign which ran from January to March 2020 at Cataract Scout Park, near Wollongong, N.S.W. A particular focus is determining the composition of the 'smoky background' is discussed.

Station intercomparison between NT BAPS and RV *Investigator*

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* corresponding author: Hazel Titley [titleyhazel@gmail.com]

Abstract

The Northern Territory Baseline Air Pollution Station (NT BAPS) at Gunn Point and the Research Vessel *Investigator* (RVI) are both part of the World Meteorological Organisation Global Atmospheric Watch (WMO GAW). The WMO GAW is an international network of baseline air pollution stations that provides valuable long-term observations to the global atmospheric research community. As the RV *Investigator* is the world's first mobile GAW station, it has opened the possibility of direct inter-comparison between itself and coastal GAW stations, such as Gunn Point (NT BAPS) and Cape Grim (CG BAPS). From 19 October to 17 December 2019 the RV *Investigator* undertook a Maritime Continent Voyage (IN2019_v06) between the Northwest Shelf and Warruwi (NT). During this voyage, the vessel passed NT BAPS, allowing for a direct station-to-station intercomparison. To allow for direct comparison between measurements both stations must be measuring the same air mass. Data from periods where this occurred was identified using HYSPLIT (Hybrid Single-Particle Lagrangian Integrated Trajectory model) and selected for comparison. The data was filtered for local effects (such as the CO_2 diurnal cycle at NT BAPS, or exhaust contamination on the RVI) to produce data sets which could be reasonably compared and checked for correlation (shown in Fig. 1.). The challenges and subsequent insights from this comparison will be useful in planning a dedicated intercomparison voyage to Cape Grim. Such a voyage could benchmark RVI measurements against the Cape Grim gold standard and validate the long-held assumption that 'baseline' air masses reaching Cape Grim are indeed representative of the broader Southern Ocean marine atmosphere.

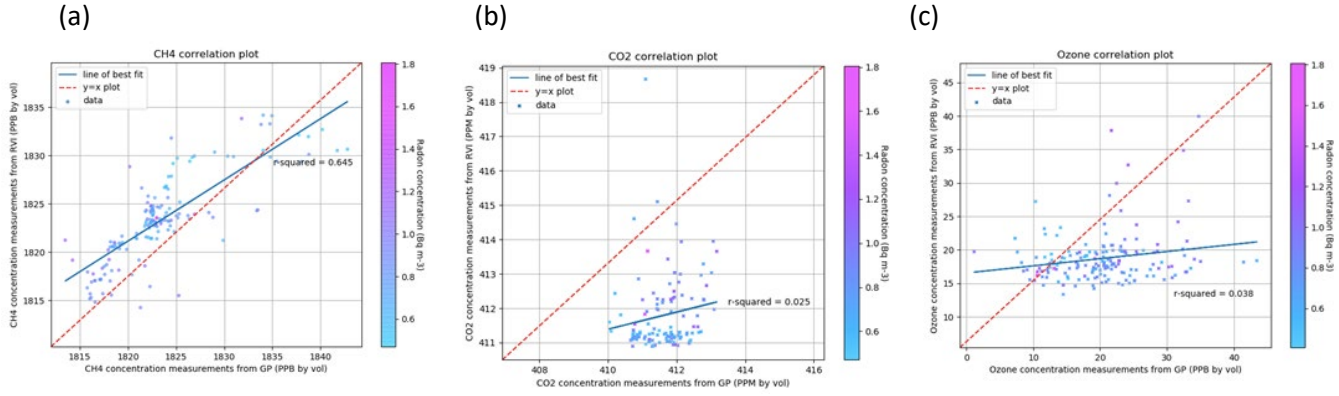


Fig. 1. correlation plots between NT BAPS and RVI measurements for a) CH_4, b) CO_2, and c) ozone. The dashed red line represents the ideal line of best fit for the data, with the blue line being the true one. The plots show the strongest correlation between the CH_4 measurements, followed by ozone, and then CO_2. However, it should be noted that the correlation between CO_2 and ozone is low.

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Cryogenic trapping of CO_2 in the presence of other gases

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Abstract

Cryogenic separation of CO_2 from gas mixtures is a common step in the preparation of targets for accelerator mass spectrometry (AMS) measurement of radiocarbon activity. We investigated cryogenic trapping of CO_2 from static gas mixtures and from flowing gas mixtures to better understand the process. The static experiment aimed to determine how the trapping time is affected by the gas composition. We mixed CO_2 separately with H_2, He, CH_4, N_2 and O_2 at different concentrations. We then trapped the CO_2 by freezing it into a cold finger at -150°C, recording the change of pressure with time. The results indicated that the trapping time is inversely related to the diffusion coefficient of the binary gases mixture – the time is proportional to the gas pressure, the square root of the molecular reduced mass and molecular collision cross-section of the mixed gas. This result confirms that helium is the best choice of carrier gas to transfer CO_2. To study isotopic fractionation during sample preparation, we compared the measured ^{14}C activity of samples that were prepared by partially trapping pure CO_2 and others for which CO_2 was separated from a gas mixture. This experiment revealed that, in each case, the degree of fractionation was proportional to the fraction of CO_2 being trapped. Hence, when preparing radiocarbon samples, it is important to ensure sufficiently long trapping times to allow for complete CO_2 collection from a gas mixture. The gas flow experiment studied the dependency of CO_2 trapping efficiency from gas mixtures (including air) at a constant flow speed on cold finger temperature. A CO_2 analyser was used to evaluate the trapping efficiency. The results indicated that the best trapping temperature is -165°C giving an efficiency up to 99%. We also studied how the flow speed and concentration of CO_2 affects the trapping efficiency in order to optimise the design of the trapping line.

WOMBAT: A fully Bayesian global flux-inversion framework

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Abstract

WOMBAT, the WOllongong Methodology for Bayesian Assimilation of Trace-gases, is a framework developed for flux inversion of trace gases from remote sensing data. It is built around a fully Bayesian hierarchical statistical model that accounts for instrument bias, correlated measurements, and transport-model errors. Fluxes are modelled using a classical basis-function decomposition, and the framework uses source-receptor relationships that are obtained empirically through forward simulation of an atmospheric transport model. WOMBAT uses an efficient and fully Bayesian Markov chain Monte Carlo scheme to obtain posterior estimates and uncertainties (including joint uncertainties) for all quantities of interest.

Using GEOS-Chem to model atmospheric transport of CO_2 and XCO_2 values derived from the OCO-2 Version 7 retrospective (V7r) dataset, we show the utility of WOMBAT in inferring non-fossil-fuel CO_2 fluxes by comparing our results to those in the OCO-2 Model Intercomparison Project (MIP) reported in Crowell et al. (2019). We find substantial spatial correlation structure spanning thousands of kilometres in the posterior model errors and, by accounting for this, we obtain posterior means and uncertainties on the CO_2 fluxes that are comparable to the MIP ensemble means and spreads, respectively.

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From the soil to the stars: New developments in greenhouse gas measurements and modelling in Aotearoa New Zealand

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Abstract

New Zealand's atmospheric greenhouse gas measurements and modelling programme is growing rapidly. New in situ, flask, and eddy covariance observations have been added to our long running timeseries through the CarbonWatchNZ Research Programme. In addition, New Zealand has funded a new Research Programme to use data from MethaneSAT, a methane sensing satellite that will launch in 2022, to infer agricultural CH_4 emissions in New Zealand and around the world. Here, we present an overview of these two programmes.

CarbonWatch-NZ is a five year programme will expand New Zealand's national observing network to eleven permanent and four field deployable stations, introduce urban and regional forest scale studies, leverage measurements of isotopes and carbonyl sulphide to understand source and sink processes, and integrate flux tower observations to understand the role of pastures. State of the art land modelling, focused field studies, sub-national inverse modelling and partnerships with indigenous groups will allow a deeper understanding of forest carbon uptake and the impact of planting strategies and land management practices on our forest carbon sink. Data from over more than 30 site years of eddy covariance measurements will be combined with land modelling and atmospheric observations to study carbon cycling in New Zealand's grasslands. National scale CH_4 inverse modelling will inform NZ's emissions reporting and agricultural CH_4 mitigation strategy. An urban inverse model for New Zealand's largest city, Auckland, will shed new light on both emissions and the urban biosphere in this green subtropical city.

MethaneSAT is a state-of-the-art satellite that has been designed to detect CH_4 with unprecedented accuracy. It is the first greenhouse gas sensing satellite to be funded by private philanthropy, through Environmental Defense Fund (EDF), and it's primary mission is to reduce oil and gas CH_4 emissions by 45% by 2025. Scientists at Harvard University and Smithsonian Astrophysical Observatory are leading the research needed to accomplish this core mission. Yet, while the satellite has been designed to detect fossil emissions, it is also theoretically capable of detecting agricultural emissions. New Zealand has recently funded a new science project to work with the overseas team to develop this capability and identify key agricultural targets in New Zealand and around the world. We are currently in the process of developing the project plan for the MethaneSAT Science Project. In this presentation, we will share our vision for the project and open the door for potential collaborations across the Tasman.

CarbonWatchNZ: Regional to national scale inverse modelling of New Zealand's carbon balance

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Abstract

Atmospheric observations of CO_2 and other greenhouse gases have been widely used to constrain estimates of terrestrial and oceanic CO_2 fluxes through atmospheric inverse modelling. Yet, applying these methods at national scale to verify and improve the National Inventory Report (NIR) and support the Paris agreement remains at the frontier of CO_2 science.

We use inverse modelling to estimate New Zealand's carbon uptake and emissions using atmospheric measurements and model. This effort is part of a five-year CarbonWatch-NZ research programme, which aims to develop a complete top-down picture of New Zealand's carbon balance using national inverse modelling and targeted studies of New Zealand's forest, grassland and urban environments. In addition to quantifying New Zealand's carbon emissions on a national scale, we also focus on identifying the prevailing processes driving CO_2 changes in New Zealand to support climate mitigation.

In an initial study based on the inversion system used in CarbonWatch-NZ, a significantly stronger (30-60 %) sink was found relative to the NIR [Steinkamp et al. 2017], suggesting a strong CO_2 uptake in Fiordland, a region covered by indigenous temperate rainforest in New Zealand's South Island. Here, we present new results of CarbonWatch-NZ by expanding the studied time period from 2011-2013 to 2020, expanding our atmospheric observing network from two (Baring Head, 41.41°S, 174.87°E and Lauder, 38.33°S, 176.38°E) to a total of eleven in situ greenhouse gas measurement sites and improving our atmospheric model resolution by roughly a factor of ten (NAME model, 1.5 km).

Our new results suggest that the strong sink observed in 2011-2013 did not diminish, but for recent years we have found an even stronger sink than for before. Implementing observations from an additional site in the North Island (Maunga Kakaramea, 45.034°S, 169.68°E) has increased the strength of the sink, pointing to additional strong sink region at the top of the North Island. Measurements of a range of tracers (mixing ratios, carbonyl sulphide, as well as stable and radio isotopes of CO_2) in the Fiordland region also suggest strong CO_2 uptake, supporting our inversion results and suggesting that Fiordland might be a more efficient carbon sink than thought before. Both the measurements and inversion results show that the CO_2 uptake does not seem to shut down completely during wintertime, suggesting that there might be something about this ecosystem that we do not yet understand. This winter uptake signal is also present in independent data collected in and around New Zealand as part of the ATom campaigns (Atmospheric Tomography Mission).

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The impact of background concentrations on the quantification of regional methane emissions in Australia

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Abstract

In Queensland's Surat basin, anthropogenic methane emissions originate from various sectors of the economy, in particular the oil and gas sector, mining and agriculture. The region has seen a large increase in gas extraction in the last decade with the associated methane emissions not well understood.

The magnitude and geographical distribution of regional greenhouse emissions can be quantified using modelling techniques in combination with observational measurements. Using inverse modelling techniques one can back-calculate where emissions should have come from, based on observational concentration data with the use of an atmospheric transport model. This top-down approach can then be used as complementary input to bottom-up approaches, such as emission factors, point source emission measurements and activity data, for a regional or national emission inventory.

Here we show the progress of research that aims to quantify regional emissions in the Surat Basin using a WRF-CMAQ model setup in combination with a regional emission inventory as the prior. The observational concentration data comes from two stations along the prevailing wind direction and on either side of the main gas extraction region. The choice of background concentration, or the boundary condition, is an important parameter in the model, and impacts how well the model concentrations can match the observed concentrations at the stations.

Understanding and quantifying coastal wetland methane emissions

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Abstract

Wetlands emit approximately 30% of global methane (CH_4) emissions and though salinity can reduce soil methane generation, it is increasingly recognised that emissions from coastal wetlands in particular are larger than expected, albeit still poorly quantified. We quantified methane emissions from a temperate coastal saltmarsh using direct eddy covariance (EC) measurements. Our flux tower is located on the south-west tip of French Island, Victoria in a coastal saltmarsh community (38.3879S, 145.2783E, 1.21 m above MSL). The vegetation height is <1.2 m and ground cover is ca. 90%. The vegetation is composed of *Sarcocornia quinqueflora* (dominant), *Sporobolus virginicus*, *Juncus kraussii* and *Tecticornia pergranulata*. Annual precipitation at the site is 540 mm and the predominant wind direction is south/south-westerly from October through March and from NNW during the cooler months. Footprint modelling across the entire collection period (February 2019 onwards) indicates that the fetch area measured by the tower includes only the saltmarsh ecosystem described above. The methane emission from this marsh was on average 0.177 μmol CH_4 m^{-2} s^{-1} (0.24 g CH_4 m^{-2} day^{-1}). Emissions were lower during the day time than during the night time (-0.07 vs 0.18 μmol CH_4 m^{-2} s^{-1} respectively). We did not find a significant correlation between fCH_4 and air temperature or plant productivity (i.e. CO_2 assimilation). Other environmental forcings, like phenology, tidal inundation and soil temperature are being investigated. The extent of subtropical and temperate coastal saltmarsh vegetation in Australia is not comprehensively mapped but is estimated to be ca. 370,000 ha, thus accounting for an estimated emission of 890 Mg of methane per day from this ecosystem (22,200 CO_2eMg day^{-1} or a working estimate of 8.1 CO_2eMt y^{-1}). At this site we also report net mean CO_2 assimilation of 3.9 μmol CO_2 m^{-2} s^{-1} and water vapour fluxes of 2.3 mmol H_2O m^{-2} s^{-1}. By using EC to quantify GHG fluxes in coastal wetlands, this ongoing investigation is filling a gap in our understanding of global GHG emissions.

Global and national assessments of greenhouse gases

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Abstract

In recent weeks, two high-level assessments which draw on Cape Grim observations have been released. The World Meteorological Organisation Global Atmosphere Watch (WMO GAW) Program has released its annual Greenhouse Gas Bulletin [WMO 2020]. CSIRO and the Bureau of Meteorology have also jointly released State of the Climate [2020].

In this presentation, I will give an overview of each of these assessments, highlighting the key messages stemming from Cape Grim (and other GAW network stations) data.

Background atmospheric CO_2 levels continue to rise, despite the impact of COVID-19 on anthropogenic CO_2 emissions. Globally, the annual mean background CO_2 concentration reached 410.5 ppm in 2019, and 407 ppm at Cape Grim.

In Cape Grim's 45-year measurement record, background CO_2 has increased at an accelerating rate. Measurements of air trapped in Antarctic ice cores, dating back 800,000 years show that the most rapid rates of natural CO_2 increase, during de-glaciations, were around 10 ppm per century. A rise of 10 ppm CO_2 currently takes fewer than 5 years.

Atmospheric methane also continues to rise rapidly, increasing by 8 ppb between 2018-2019 in the global atmosphere. The IPCC Fifth Assessment Report included a series of representative concentration pathways resulting in a range of climate outcomes. Although the ultimate climate outcome will be driven by the total greenhouse gas forcing in the atmosphere, the growth of atmospheric methane (the second most important driver of radiative forcing increase) is tracking between the two strongest warming scenarios.

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Comparing greenhouse gas emission metrics

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Abstract

Comparing and trading greenhouse gas emissions requires a metric for relating the different gases.

The Global Warming Potential (GWP) with 100-year time horizon has become the standard under the Kyoto Protocol and subsequent agreements. The 100-year GWP is known to give a very poor representation of equal radiative forcing for scenarios targeting stabilisation. This is because

- Stabilising CH_4 emissions will stabilise concentrations. BUT
- Stabilising CO_2 emissions will have concentrations grow indefinitely.

We can capture this distinction (short-lived vs long-lived gases) by:

- An ongoing CH_4 emission should be treated as equivalent to a one-off CO_2 emission.
- More generally, the CO_2 equivalent should be proportional to rate of change of CH_4 emission.

This distinction can be refined by more detailed consideration of different timescales.

We look at newer metrics that capture differences between long-lived and short-lived gases by considering rates of change. We analyse the specific case of CH_4 referenced to CO_2.

Myles Allen and his colleagues at Oxford have undertaken extensive analyses of a range of metrics of this type (see references in our ACP discussions paper).

We give examples of how metrics behave, comparing the radiative forcing from CH_4 over time to the radiative forcing of the notionally equivalent CO_2 emissions. These are illustrated in Fig. 1, with 'RM' a specific proposed metric which arises naturally from a Laplace transform analysis.

The improved behaviour of these newer metrics can be understood using a generic analysis in terms of growth rates and frequencies. In terms of frequencies, a metric is like an equalizer in an audio system, transforming the frequency response of CH_4 emissions into a CO_2 response, ideally with similar frequency dependence. The mathematical analysis is based on the FEI (Forcing Equivalent Index) concept of Wigley [1998].

Finally, we note that, for the Paris agreements, New Zealand has adopted targets that reflect the difference between methane and other greenhouse gases.

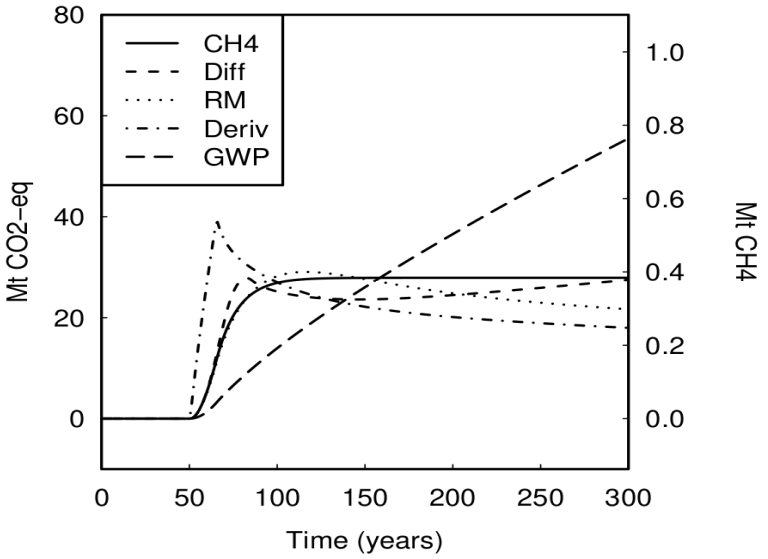


Fig. 1. The solid line shows the radiative forcing for an example emissions profile of ongoing CH_4 emissions which commence in 50 years. Equivalent CO_2 emissions from different metrics are shown as dashed lines, with 'GWP' being the result of application of GWP with a 100-year time horizon, and the so-called reduced model 'RM' as the specific proposed metric inspired by a Laplace transform analysis.

This talk is based on our paper 'Technical note on comparing greenhouse gas emission metrics', currently under review in *Atmos. Chem. Phys. Discuss*., ACP-2020-996. See: https://doi.org/10.5194/acp-2020-996

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Long term records of greenhouse gases at Wollongong and Darwin, 2011-2020

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Abstract

Long term measurements of greenhouse gas mole fractions meeting Global Atmosphere Watch requirements for accuracy and comparability exist at only a few sites across Australia, notably Cape Grim in Tasmania and Gunn Point, NT. Broader and denser geographical coverage is highly desirable for attribution and quantification of sources and sinks of GHGs, particularly through regional and continental scale model inversions of the measurements.

Since the late 2000s, we have made pseudo-continuous in situ measurements of CO_2, CH_4, CO, N_2O and $\delta^{13}C$-in-CO_2 using University of Wollongong – developed FTIR trace gas analysers located at our Total Carbon Column Observing Network (TCCON) sites at Wollongong, NSW and Darwin, NT. In this presentation we present an overview and initial assessment of the *in situ* datasets since 2011, with comparisons to the co-located TCCON total column data records and CSIRO *in situ* data collected at Cape Grim and Gunn Pt. over the same periods.

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An update on the Total Carbon Column Observing Network

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Abstract

The Total Carbon Column Observing Network (TCCON) measures column-averaged dry-air mole fractions of greenhouse gases at approximately 25 sites around the world. 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 using a non-linear least squares fitting program, GGG. Periodically, GGG is updated to take into account advances in spectroscopy, improvements in modelling instrument behaviour, and other factors that can impact the spectrum fitting process.

Since 2014, the GGG2014 software version has been used by all TCCON sites, and the data available on the TCCON Data Archive are processed using this version. This year, a new software version, GGG2020, has been released, resulting in a major re-processing of all spectra for all sites for the full time series, dating back to 2004. GGG2020 features improved spectroscopy, improved *a priori* representation of the atmosphere via more frequent pressure, temperature and humidity data, as well as including potential vorticity and other changes.

In this talk, we provide an update on the TCCON, particularly on the improvements made by the GGG2020 version relative to GGG2014. The GGG2020 data will be available to the public in the coming months.

Can anomalies in total column carbon monoxide provide a proxy for smoke-related surface exposure?

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Abstract

In Australia, bushfires are natural part of the country's landscape and essential for the regeneration of the plant species, but the 2019-20 bushfires were unprecedented in their extent and intensity. Biomass burning can emit many chemical species that have an impact on human health. One of the most abundant, and widely measured is carbon monoxide (CO), whose long-term exposure can lead to potential human health risk. This study is particularly focussed on the 2019-20 Australian bushfires and resulting surface and column atmospheric carbon monoxide anomalies and exposures around Wollongong.

Satellite measurements are effective at providing spatial coverage of atmospheric composition but are less precise and have reduced temporal coverage compared continuous ground measurements. Hence, this study focusses on comparing in situ and column measurements of CO to better understand whether column measurements can be used as an estimate of the surface concentrations. If so, satellite column measurements of CO could be used to estimate the exposure of humans to CO and other fire-related pollutants.

Column CO data from the ground-based Total Carbon Column Observing Network (TCCON) and Network for the Detection of Atmospheric Composition Change (NDACC) site in Wollongong are used together with surface measurements. It is found that the enhancements in the column measurements are not always significantly evident in the corresponding surface measurements. However, there exists a significant correlation with the surface CO observed over the air quality station (Campbelltown West, elevation- 112 meters) situated well above the site. This suggests the complex topographical features near Wollongong lead to the formation of a double planetary boundary layer, with a well-mixed layer above the escarpment and comparatively cleaner air over the site due to the proximity of the sea. This suggests the primary role of topography and local meteorological effects in representing the ambient surface air in the site. Hence, satellite measurements are not always reliable in representing the ambient surface exposures.

The 2019/20 Australian bushfires

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Abstract

Australia experienced a severe bushfire season in 2019/20. Large areas of forest and farmland were burned across five states, taking in the length of the eastern seaboard and the south-east corner of the continent.

Emissions of combustion products were observed throughout CSIRO's Southern Hemisphere atmospheric measurement network. Fresh smoke plumes were encountered at sites close to fire-affected regions. Hemispheric-scale perturbations in background air were evident for some trace gases, e.g. CO and H_2.

This talk will discuss the nature of these fires, and what can be inferred from atmospheric data, including a preliminary top-down evaluation of the magnitude of emissions.

Forecasting the air quality impacts of the Cobden peat fires

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Abstract

Peatlands are important carbon stocks. For example, Victoria's wetlands have a total estimated carbon stock of 68 million tons of organic carbon [Carnell et al. 2018]. However, many peatlands have been degraded through increased groundwater use and rapid land use change, transforming them from carbon storage systems to sources of atmospheric carbon emissions. Furthermore, drying of peatlands as a result of climate change is likely to make them more vulnerable to fires and cause deeper burn depths [Minasny et al. 2019; Cowley and Fryirs 2020]. Consequently, harmful smoke pollution events such as those experienced in south-west Victoria in March/April 2018, in Port Macquarie, NSW in July 2019 and in Gippsland in February 2020 are likely to become more frequent.

This talk will discuss the air quality impacts from a series of peat fires in south-west Victoria in 2018, and the performance of the smoke forecasting system AQFx for managing the smoke risk.

The peat fires were ignited by a grass fire on 17 March 2018 and smouldered for 40 days. The surrounding communities were exposed to significant concentrations of fine particles (PM2.5), resulting in the need for active interventions (such as the relocation of schools) in order to protect vulnerable communities.

We reconfigured AQFx to account for the different combustion process of a subsurface peat fire and the finer spatial scales of smoke transport (10-20 km). Time series plots of hourly observed and modelled PM2.5 for the nearest model cell to the monitoring site showed that the high PM events were generally captured well. However, calm conditions, meso-scale meteorological transition events, and the close proximity of monitoring sites to the peat fires were the main challenges in regard to accurate forecasting.

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New refrigerants ultimately produce the global warming agents they were meant to replace

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Abstract

Refrigerants have a history of creating climate problems, with the CFCs resulting in the ozone hole followed by the HFCs contributing significantly to global warming. CFCs have been banned and phased out in accordance with the Montreal Protocol (1987) and HFCs were added to that document in a 2016 amendment. The latest refrigerants are HFOs, which incorporate a double bond to increase their reactivity and shorten their lifetimes to greatly reduce their global warming potentials. Many of the new HFOs produce trifluoroacetaldehyde in the atmosphere which, in studies since the 1950s, has been shown to produce the environmentally benign radicals HCO and CF_3. However, a channel producing CO and CHF_3 (the worst known HFC) has occasionally been observed and its analogue is an established channel in CH_3CHO photochemistry at similar wavelengths. We have completed laboratory experiments confirming this pathway following 308nm photolysis identifying CO and its cofragment CHF_3 as primary photoproducts with a quantum yield of several percent.

A new source of HFC-23 in the atmosphere: profound implications for new refrigerants

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Abstract

The Montreal Protocol (1987) governed the global phasedown of chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs), solving the ozone crisis and setting the upper atmosphere off on its slow path to recovery. Hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs), which have zero ozone depletion potential (ODP), were named in the Montreal Protocol as the successors to and replacements for a suite of industrially important refrigerants, fire retardants, foam-blowing agents and other useful chemicals. However, these molecules exhibit global warming potentials (GWPs) that are hundreds to tens-of-thousands of times worse than that of CO_2 and concerns about offsetting the hard-won environmental gains brought about by the CFC and HCFC phasedown led to their blacklisting in a 2016 amendment to the very document that championed them 30 years earlier. The leading replacements are a new class of molecule called hydrofluoroolefins (HFOs), which have already been emitted and detected in significant quantities. These compounds are derived from the HFCs but incorporate a carbon-carbon double bond that increases their reactivity leading to faster atmospheric degradation. The resulting GWPs are determined to be near-zero and their atmospheric lifetimes reduced to weeks, as opposed to decades/centuries for the HFCs.

One of the most important HFOs is HFO-1234ze (CHF=CH-CF_3), for which atmospheric decomposition yields trifluoroacetaldehyde (CF_3CHO) in *100% molar yield*. CF_3CHO is removed from the atmosphere at a rate four times faster than that of its progenitor *via* photolysis. Studies dating back to the 1950s suggest that photolysis exclusively (or near exclusively) leads to trifluoromethyl (CF_3) and formyl (HCO) radicals that lead to environmentally less hazardous CO_2 and HF. However, recent work at UNSW has shown that $CF_3CHO \xrightarrow{h\nu} CO + CHF_3$ is unambiguously a primary pathway in the decomposition of CF_3CHO that may account for the fate of ~10% of atmospheric CF_3CHO. CHF_3 (HFC-23 *i.e.* fluoroform) is the most environmentally hazardous of all the HFCs with a GWP 12 700 times worse than CO_2 (by mass) leading to an effective GWP for HFO-1234ze that is indeed ~1 270 times worse than CO_2. Furthermore, atmospheric monitoring has revealed an unknown source of CHF_3 (HFC-23) over the past 2 years. After falling for several years, the measured concentration of CHF_3 in 2018 was higher than measured any year in history. The authors of these studies explicitly suggest that China might not have met abatement targets, but this work suggests that increasing global production of legal HFOs, rather than illegal production or insufficient abatement might account for the observed increase.

This seminar will present and discuss the results of velocity map imaging (VMI, collision free) and laser-photolysis Fourier-transform infrared spectroscopy (FT-IR, collisional/bulk) experiments, as well as some computational chemistry calculations and atmospheric modelling to extend the results to atmospheric conditions.

A potential future of atmospheric measurements of synthetic greenhouse gases (GHG) and ozone depleting substances (ODS) at CSIRO

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Abstract

Synthetic greenhouse gases (GHG) and ozone depleting substances (ODS) in the ambient air are currently measured at CSIRO by using a custom-made Medusa-GCMS system. The system is based on preconcentration of selected analytes from 2 L of air, thermal desorption (TD) and gas chromatographic separation of the condensate, and mass spectrometric (MS) detection of selected ions (SIM). The system is very robust, sensitive and precise but it lacks detection of species not specified on the SIM list.

The Time-of-Flight mass spectrometer (TOFMS) is known for its ability to detect all the species in a sample, at a speed exceeding that of the current Medusa-GCMS system. Instrument manufacturers are offering systems with a range of mass resolution, giving another dimension in unambiguous species identification. However, little is known about their performance in this field. In order to explore the future of GHG and ODS measurements at CSIRO, the in-situ laboratory at Aspendale had a LECO BT Time-of-Flight Mass Spectrometer (TOFMS) on trial in 2018. In general, TOFMS showed similar precision and greater sensitivity for the lowest abundant species in the atmosphere when compared to the current Medusa-GCMS system. Advantages and disadvantages of the TOFMS versus the Medusa-GCMS system will be further discussed in the talk.

The rise and fall of recent CFC-11 emissions from eastern China

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Abstract

At the Cape Grim Annual Science Meeting held at Smithton, Tasmania, in November 2016, Steve Montzka (NOAA) revealed [Montzka et al. 2016], based on CFC-11 atmospheric trends derived from the NOAA global flask air sampling network (including Cape Grim), that the observed decline in global CFC-11 (CCl_3F) emissions since 1987, resulting from the production and consumption controls imposed by the Montreal Protocol, ceased in 2011. By 2013 CFC-11 emissions had started to increase again, three years after its global production phase-out mandated by the Montreal Protocol. Further analysis of these global emission changes showed that global CFC-11 emissions had increased at 13±5 Gg/year since 2012, and that the likely cause was new production of CFC-11. This enhanced level of CFC-11 emissions, if continued for decades into the future, had the potential to delay the anticipated recovery of the depleted stratospheric ozone layer. The CFC-11 data from Mauna Loa showed that some portion of this global increase in emissions was from eastern Asia. (Montzka *et al.* 2018). The impact of these growing CFC-11 emissions has been observed in the Cape Grim data, with the growth rate signal at Cape Grim delayed by about 1 year compared to the signal observed at Mauna Loa (Fraser *et al*., 2020).

Analysis of high-frequency CFC-11 data from the AGAGE station at Gosan, South Korea, and from the NEIS station at Hateruma, Japan, to the end of 2017, showed that these east Asian emissions were substantially from eastern mainland China and were 6±1 Gg per year in 2008-2012 growing to 13±2 Gg per year in 2014-2017. These eastern China CFC-11 emissions were again likely resulting from new, unreported production of CFC-11 and accounted for 40%-65% of the observed rise in global CFC-11 emissions from the AGAGE and NOAA global networks [Rigby et al. 2019].

The 2018 and 2019 *Nature* papers resulted in renewed interest in global and regional CFC-11 emissions, in particular by the Parties to the Montreal Protocol [Harris et al. 2019], encouraging a rapid reanalysis of NOAA and AGAGE CFC-11 data to the end of 2019. The preliminary findings of this recent analysis of global and east Asia CFC-11 observations will be discussed in this presentation, as will emissions of related ozone-depleting substances, carbon tetrachloride (CCl_4) and CFC-12 (CCl_2F_2), which are typically the precursor to, and co-product of, CFC-11 production. These new findings will also be presented at the AGU Fall Meeting, December 2020 [Western et al. 2020].

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The 2020 Antarctic ozone hole

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Abstract

The 2020 ozone hole developed in earnest in mid- to late-August and by early September had reached about 25 million km2 in area. Since then, the 2020 ozone hole has remained relatively large and persistent. This has been due to very cold conditions in the mid- to low-stratosphere and record low levels of heat transport towards the pole (especially in late October and early November). This has resulted in a very stable polar vortex and ideal conditions for stratospheric ozone depletion chemistry. Some of the ozone hole metrics in 2020 are in the top 5 largest/deepest holes ever.

This presentation will give an update on 2020 Antarctic ozone hole season and how the 2020 ozone hole metrics compare to the historical metrics from the last 40 years of satellite measurement.

Antarctic ozone loss observed at Davis in 2020

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Abstract

Observations of the 2020 Antarctic Ozone Hole by ozonesonde flights at Davis showed a number of unusual features compared to the 2003-2019 record. Depletion in the 12-15 km altitude range was quite modest. The key 15-18 km partial ozone column (at the core of the depleted altitude range) saw more significant depletion but did not reach the very low values in early October observed in previous years with large Antarctic ozone loss, such as 2006, 2009, 2015 and 2018. Very unusually, however, the value of the full 14-22 km partial column continued to decrease well past the end of October and was considerably below the previous range seen at Davis for most of November. Stratospheric temperatures in early November were up to 25 K lower than the previous record for this time of year as measured during an ozonesonde flight.

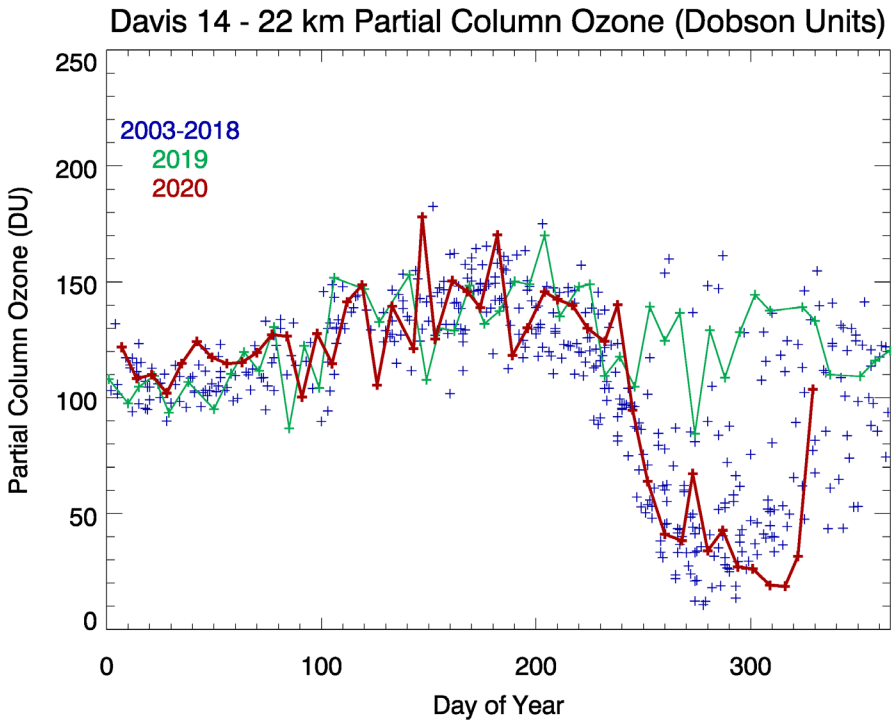


Fig. 1. Davis 14-22 km partial column ozone in 2020, compared to 2019 and the 2003-2018 record.

Chemistry-Climate Modelling with ACCESS-CM2-Chem

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Abstract

ACCESS-CM2-Chem is the chemistry-climate version of the Australian Community Climate and Earth-System Simulator (ACCESS). ACCESS-CM2-Chem builds upon ACCESS-CM2 [Bi et al. 2020] by adding the full stratosphere-troposphere configuration of the United Kingdom Chemistry and Aerosol (UKCA) module which includes the oxidation of organic compounds e.g. methane, ethane, propane, and isoprene and inorganic O_x, NO_x, HO_x, ClO_x, and BrO_x chemistry [Archibald et al. 2020]. Importantly for Australia, this allows us to project the influence of Antarctic ozone hole recovery on Southern Hemisphere climate in a way that includes feedbacks between the atmospheric chemistry and dynamics.

In this presentation we will show an evaluation of ACCESS-CM2-Chem simulation of Southern Hemisphere ozone depletion, noting improvements over the previous generation of models. Also, we will outline planned contributions to the Chemistry-Climate Model Initiative phase 2 (CCMI-2) activity which is aimed at supporting the 2022 WMO/UNEP Ozone Assessment.

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The critical importance of climate data to electricity networks

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Abstract

Australia's electricity networks are undergoing a transformation from delivering generated electricity from large centralised generators, typically coal-fired, to more distributed generation on rooftops, which is typical renewable solar generation.

While this shift to decentralised generation comes with many challenges for ensuring the power system remains stable and reliability delivers electricity, it presents many opportunities.

Clearly renewable generation is highly dependent on weather and climate and good data is needed on operational to planning time scales to support energy forecasting. Conventional generation is also very temperature sensitive as the Victorian outages of Australia Day 2019 demonstrate, when extremely hot temperatures limited the output of key plant in the La Trobe Valley.

Natural hazards present one of the most significant threats to the electricity networks, particularly at the distribution level, where over 97 % of power outages are the result of damage to the poles and wires:

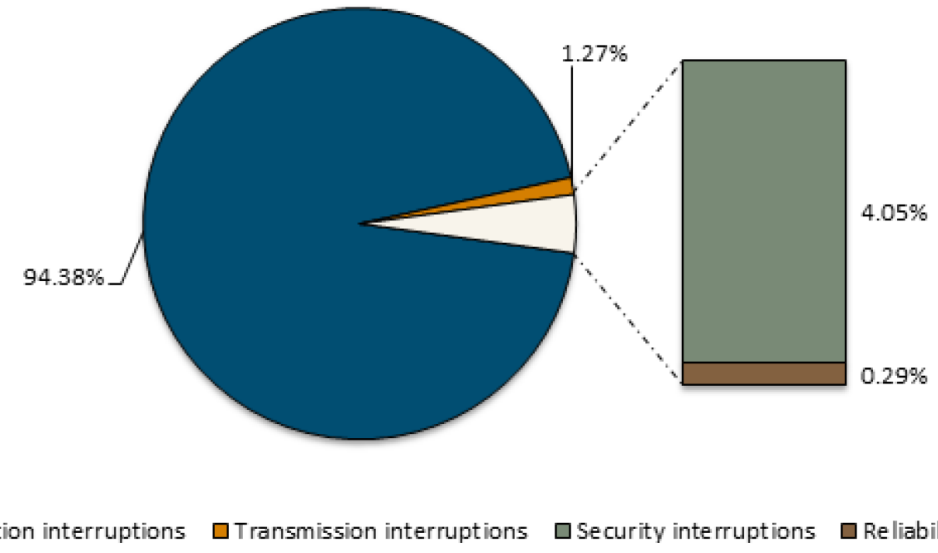


Fig. 1. Sources of supply interruptions in the National Electricity Market from 2007/08 to 2017/18 [Reliability Panel 2019].

In the bushfires of 2019-2020 over 280,000 customers were without power for 1 to 10 days [REF] resulting in major impacts that fell disproportionally on rural communities.

There are opportunities to deliver electricity to customers in ways that remove the vulnerability of long rural powerlines and the need to spend significant amounts of money on managing vegetation near to powerlines to minimise the risk of damage and the risk of starting a fire [Cainey 2019].

Energy Networks Australia explored how Stand-Alone Power Systems (SAPS or microgrids) could deliver resilient electricity to customers, but one of the barriers to deploying SAPS was a lack of current projections and probabilities to support a positive investment case.

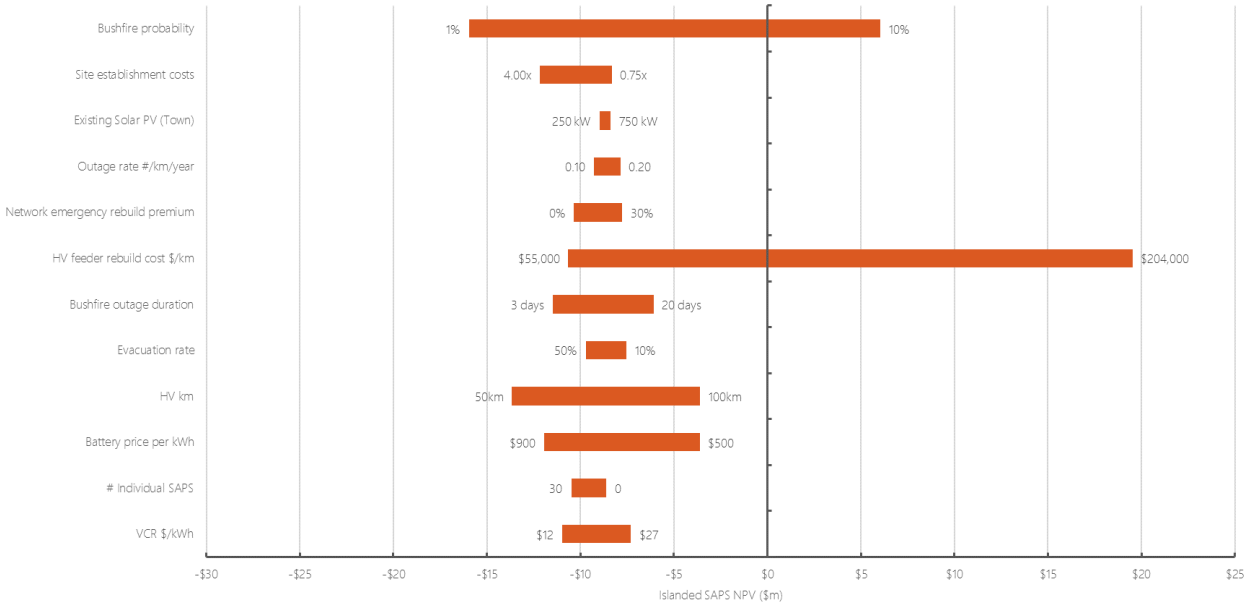


Fig. 2. Sensitivity analysis of isolating a remote town (pop. 500) on a SAPS [Energy Networks Australia 2020]

Australia's electricity networks are regulated to ensure that any investment and costs meet the long-term interests of consumers, since consumers contribute to these costs through electricity bills. Typically, powerlines have a lifetime of 50-60 years, which means assets built today, could still be standing in 2080, if designed to withstand the climate of 2080. If powerlines are not appropriate for the future climate, then different approaches must be explored.

It is critically important that electricity networks, the Regulator and customers have access to fit-for-purpose climate projections and a risk assessment framework that will support investment decisions today, to ensure that customers receive a cost-effective reliable and resilient electricity service in the future.

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Cape Grim Boundary Layer Characterization Study

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Abstract

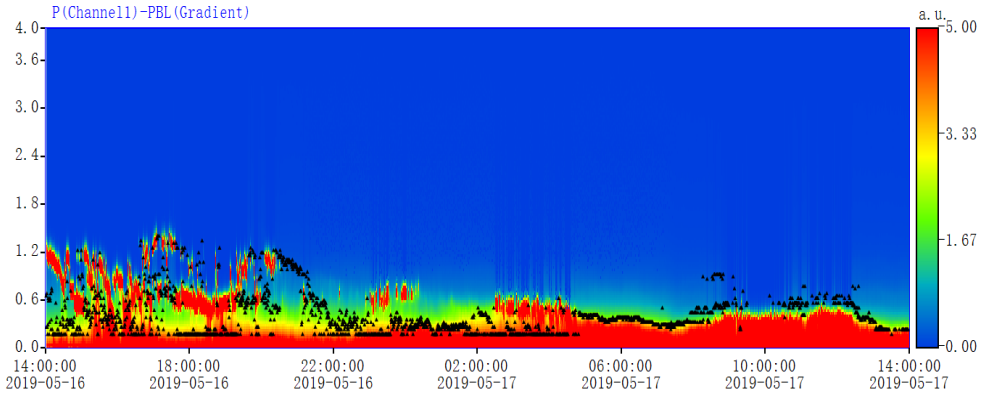
The boundary layer (BL) is directly influenced by the Earth's surface and responds to surface forcing by frictional drag, evaporation and transpiration, and sensible heat transfer with a timescale of one hour or less. Regarding air quality, the Boundary Layer height (BLH) determines the volume of air available for pollutant dispersion and resulting concentrations and is therefore one of the fundamental parameters computed in many dispersion models. Continuous observation of the BLH with high vertical and temporal resolution is thus desirable to support weather and air-quality prediction. Active remote sensing of meteorological parameters, trace gases, and aerosols by means of lidar, ceilometer, sodar, and wind profiler are among the most appropriate tools for a continuous BLH measurement. The objective of this paper is to evaluate various algorithms for the characterization of the BLH from three instruments – MiniMPL, Celiometer and SODAR.

The MiniMPL and Ceilometer permits the detection of the BLH with a high vertical and temporal resolution.The known methods to assess BLH from backscatter profiles are generally based on the assumption that the BL has a somewhat constant aerosol concentration that is distinctly higher than that of the air above. A variety of lidar techniques have been developed to identify the BLH such as the gradient detection algorithm, the curve fitting and the wavelet covariance technique [Flamant et al. 1997; Steyn et al. 1999; Emeis et al. 2008; Baars et al. 2008; Pichelli. et al. 2014]. Here the Image Edge Detection Algorithm (IEDA), an extension of the gradient detection algorithm, is utilized to determine the BLH [Xiang et al. 2019].

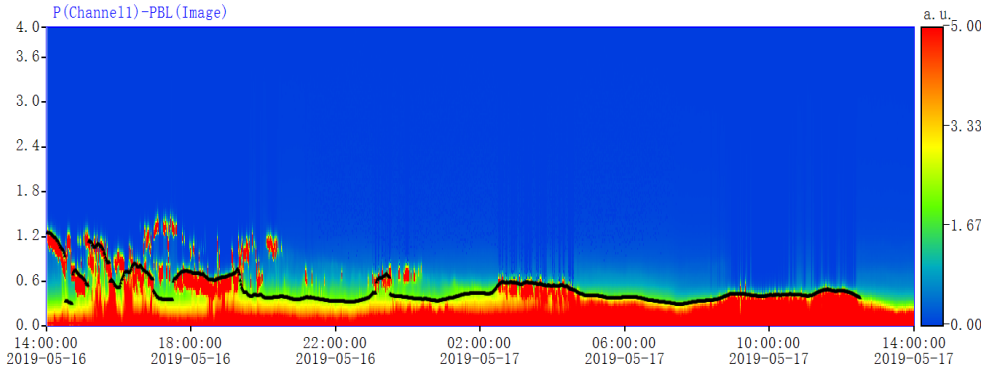
SODAR (Sodars) are systems which are used for remote measurement of the vertical turbulence and wind profile by means of acoustic waves.The BLH from the SODAR-RASS system was estimated using acoustic backscatter signal profiles. For the SODAR-RASS, direct determination of the BLH is possible only if the BLH is well with the range the Sodar (here is about 50 m to 0.4 km). Typically, it is more suitable under low to moderate winds or when local flows are developed with weak stability. Sodar also reveals the wind conditions and the thermal structure, which are more important to study the BL evolution or structure.

The analysis suggests that each approach could provide reliable estimations of the BLH only under certain meteorological conditions. Both, lidar and Sodar data are able to depict different aspects of the inversion layers above the surface. The lidar/Ceilometer detects the vertical aerosol backscatter profiles, which arise from the wind and temperature structure. The Sodar reveals the wind conditions and, from a combination of backscatter and vertical velocity data, the thermal structure. Thus, information from both instruments is complementary and the combination of the results from the analysis of the optical backscatter and acoustic intensities gives quite a complete picture of the vertical layering.

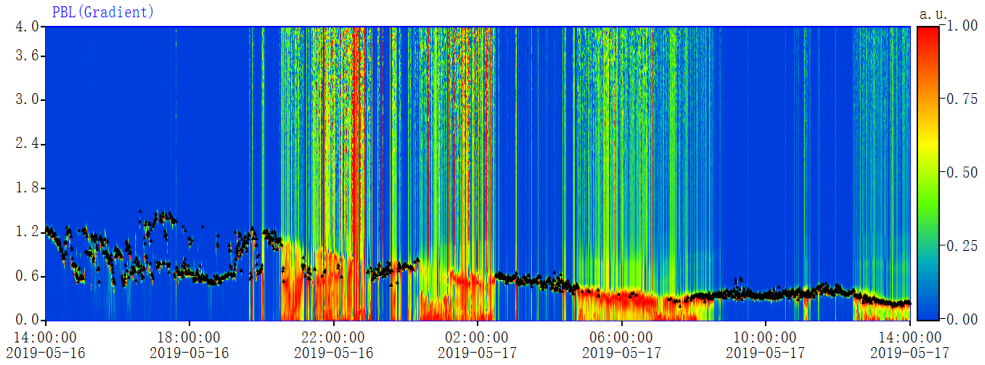
(a) Gradient- algorithm-retrieved BLH by miniMPL



(b) IEDA-retrieved BLH by miniMPL



(c) Gradient-algorithm-retrieved BLH by ceilometer



(d) IEDA-retrieved BLH by ceilometer

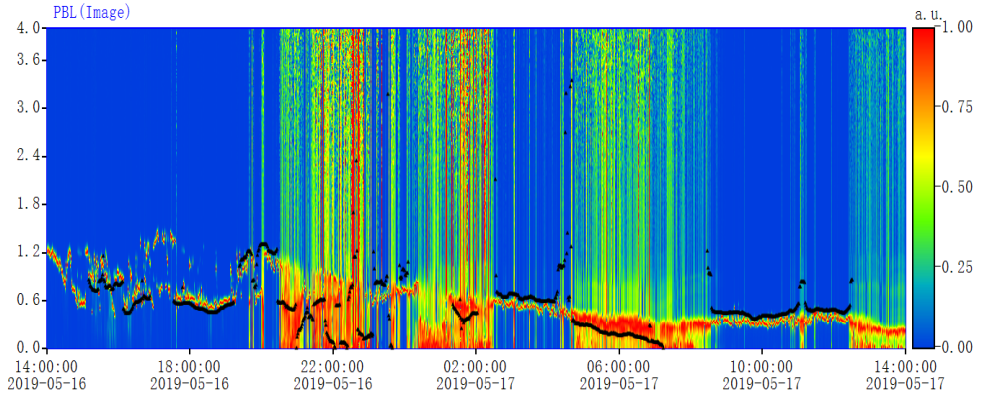
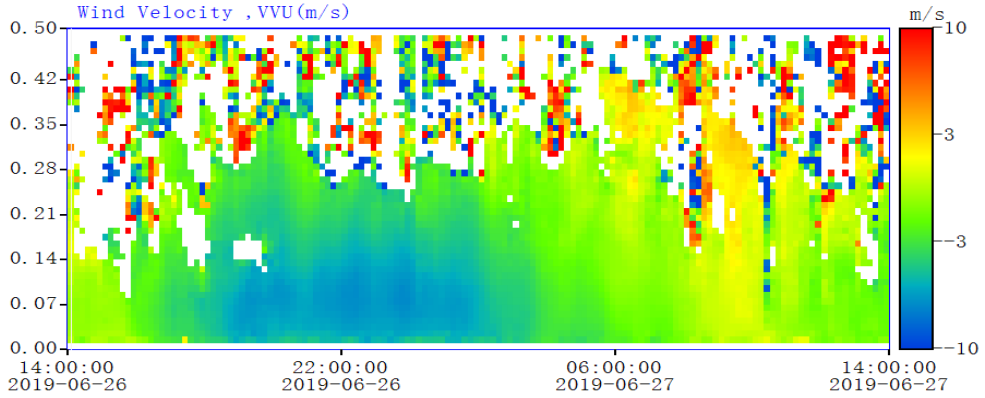
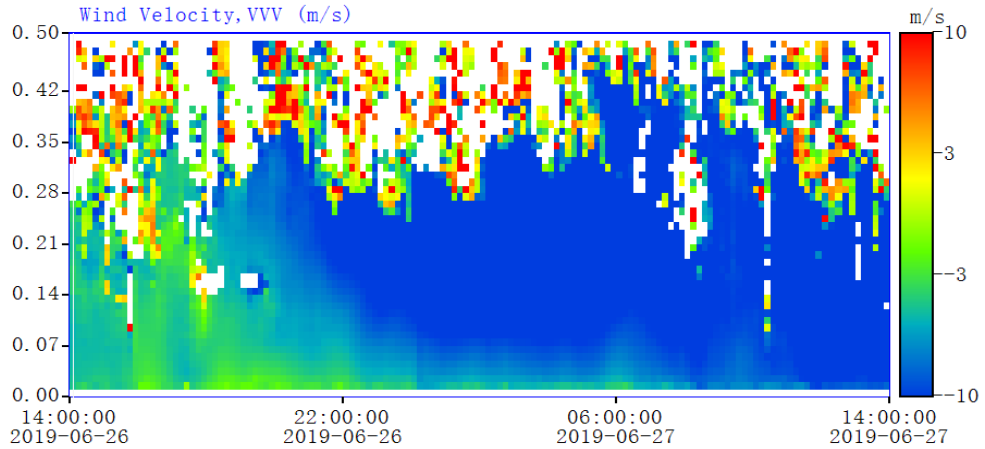


Fig. 1. Gradient-method-retrieved and IEDA-retrieved BLH by miniMPL and ceilometer on 17 May, 2019 (UTC)

(a) U component of horizontal wind (easterly being positive)



(b) v component of horizontal wind (northerly being positive)



(c) temperature

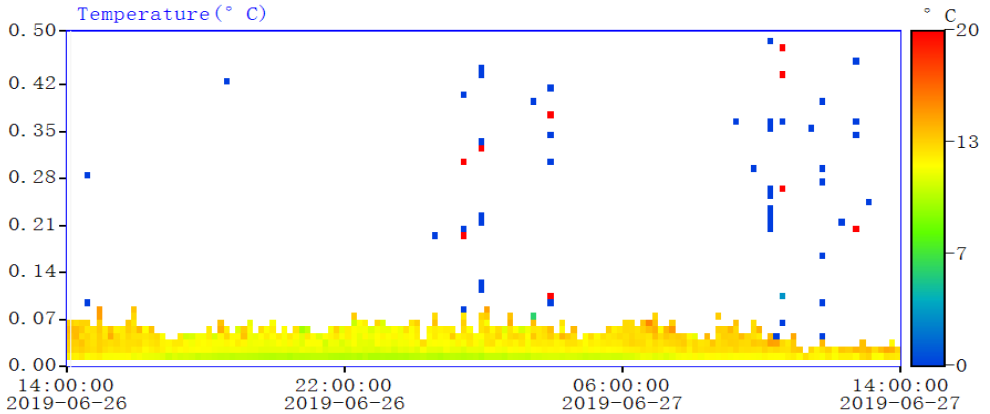


Fig. 2. Time-height plot of wind u and v components and temperature measured by SODAR-RASS on 27 June, 2020

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Dust modelling within the Drought Resilience Mission

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Abstract

Lessons arising from modelling grass pollen over Victoria

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Abstract

Grass pollen forecasts have been utilised in the period October-December since 2017 as inputs for thunderstorm asthma risk predictions in Victoria, produced collaboratively between the University of Melbourne, the Bureau of Meteorology and the Victorian Department of Health and Human Services. This world-first thunderstorm asthma forecasting service has continued into 2020, with heightened relevance given the overlap between allergic asthma and COVID symptoms, and in an attempt to mitigate the potential for thunderstorm asthma overloading a health-care system that is experiencing new pressures. Over 2017-2019, a statistical model was used to estimate daily average grass pollen concentrations in the outdoor air across the state. This model incorporates past and present surface weather conditions, satellite-derived vegetation index data and land-use maps. A number of changes to the system were made in preparation for the 2020 grass pollen season, including updating the weather inputs (from the Bureau's APS2 to APS3 ACCESS configuration) and processing not only MODIS but also VIIRS vegetation index data.

It was noted that while the model performance was acceptable from 2017-2019, in 2020, however, the model consistently under-predicted grass pollen during the first month of the Victorian grass pollen season. This presentation focuses on the possible causes of this under-prediction. Considerable investigations were made into both the weather and remote-sensing inputs, as well as the model code. Furthermore, this was the first time this model had been used under La Nina conditions. We will discuss lessons arising in terms of model development and deployment.

Choosing the soup recipe: changing the lumping ingredients to each one's taste

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Abstract

Accurate atmospheric chemistry predictions are a long-standing problem of significant theoretical and applied interest, standing at a junction between many disciplines. One of the key aspects of these numerical simulations is the simplification of all atmospheric chemical reactions into a representative sets of model equations, referred to as a lumping mechanism. In a lumped mechanism, organic compounds of similar chemical formula are grouped or 'lumped' together and treated as a single representative species (AMS definition).

Emission inventories and emission models are a core component when addressing any environmental pollution problem. These emissions inventories contain a vast array of primary species defined in space-and-time, on a grid or as individual sources.

To simplify the computation of emission models, these emissions are reduced to a smaller set of representative species. Matching these primary emissions to a custom set of lumped species is the purpose of the new flexible toolkit that DPIE has developed. The toolkit provides specific chemical mechanisms of primary and lumped species for air quality models to simulate aerosol and gaseous pollutants formation and dispersion. This software lumps the primary species from different activities based on a range of lumping mechanisms, and outputs both standard NetCDF files and spatial plots (Fig. 1), projected onto a chosen geographic system of coordinates.

The primary species inputs can come from an emission inventory or a modelled activity. The choice of a lumping system is flexible and implements a customised or standard (derived from the USEPA SPECIATE tool) chemical mechanism, including different versions of CB4-5-6, CRI, RACM and SAPCR.

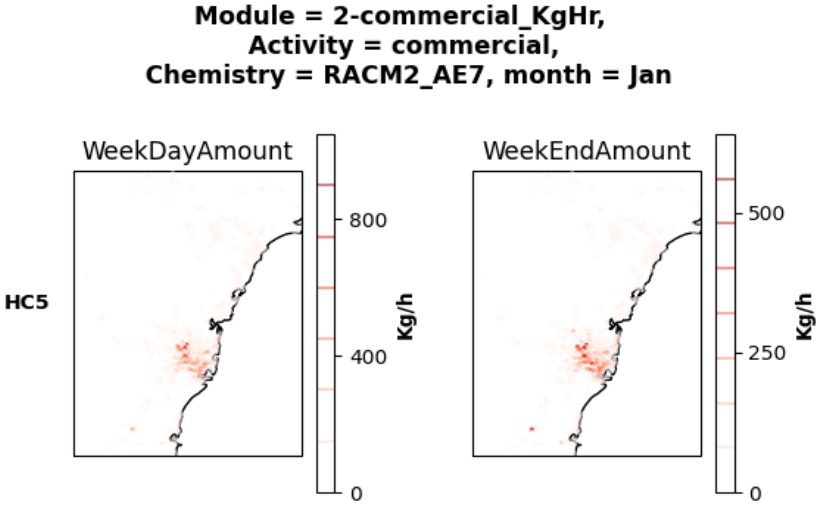


Fig. 1. Example of a lumped species spatial plot

Assessment of air quality using the Plume Air Quality Index Indicator (PAQI): Reference to five towns in Nigeria

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Abstract

Air quality is an important issue world-wide due to the health implications on man and livestock. For this reason, different countries constructed air quality index (AQI) which depicts pollution levels and the impact on health. PAQI is an example of air quality index built by Plumes Labs, Paris, France. It has seven levels (Low, Moderate, High, Very High, Excessive, Extreme, and Airpocalypse) of pollution which are linked to the World Health Organization (WHO) limits. The aim of this study was to assess the AQI of five different towns in Nigeria using the satellite model data released by the Plumes Labs. Daily data of the towns were recorded between 9am and 12 noon for 60 days and statistically analysed. The air quality index was determined by whatever pollutant was measuring the highest. It was observed that PM2.5 and 03 (>30 and >40 respectively) had the highest concentration levels most times. The results were compared with the PAQI indicator. The air quality of the towns has reached high levels of pollution above the maximum limit for 24 hours established by WHO.

Keywords: Air Quality, Pollutants, Outdoor, Health Implication, Plumes Labs, Nigeria.

Regenerating urban scale carbon monoxide inventory using 4D-Var Data Assimilation: Preliminary results for Tehran

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Abstract

Improved air quality estimation depends on uncertainty reduction in the atmospheric modelling system and, particularly, emission inventories (EIs). In this study, a priori urban scale EIs are prepared by using global-scale datasets. After running a forward model and assessing the capability of a priori EIs in estimating pollutant concentrations, an inverse framework is applied to use the satellite retrievals to modify a posteriori carbon monoxide (CO) inventory.

Emissions Database for Global Atmospheric Research (EDGAR), Gridded Population of the World, and Fossil Fuel Data Assimilation System are used to downscale the spatiotemporal resolution of global EIs to the finer scale. The resultant high-resolution inventory is applied to run the forward WRF-CMAQ Modeling System and simulate the concentrations of air pollutants.

The Tropospheric Monitoring Instrument (TROPOMI) spectrometer is a part of the Copernicus Sentinel 5 Precursor (S5P) mission. The modelled concentration of CO is compared with the retrieved CO from TROPOMI data product and surface measurements. After comparison, an inverse framework is applied to refine knowledge of the CO-EIs in the target urban area. In this four-dimensional variational data assimilation (4D-Var) process, an adjoint model is applied to generate gradients for gradient-based 4D-Var optimization. Independent in-situ measurements are utilized to evaluate the inverse estimates.

Organochlorine pesticides (OCPs) assessment of sediment, soil, and fish samples from River Owan in Edo State, Nigeria

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Abstract

In this study, the concentrations of sixteen (16) organochlorine pesticides (OCPs) (α-BHC lindane), β-BHC, chlorothalonil, δ-BHC, heptachlor, aldrin, heptachlor epoxide, o, p – DDE, endosulfan I, p,p' – DDE, dieldrin, endrin, endosulfan II, p,p- DDT and L- cyhalothrin in sediment, soil and fish (*Clarias anguillaris*) samples of Owan River in Edo State, Southern Nigeria were investigated using standard analytical methods. The results obtained revealed the presence of the 16 determined OCPs in the soil, sediment and fish (*Clarias anguillaris*) samples in varying concentrations. ∑OCP in the sediment samples ranged between 0.00332-0.0319 (ng/g) with total value of 0.150592 (ng/g) for the first sediment sample (SE1); 0.002092-0.05866(ng/g) with total value of 0.0291265(ng/g) for the second sediment sample (SE2). The concentrations of the OCPs in the soil samples ranged between 0.006859-0.06262 (ng/g) with total concentrations of 0.398595(ng/g) for soil sample 1 (SO1) and 0.002604-0.06296 (ng/g) with total concentration of 0.367746 (ng/g) for soil sample 2 (SO2). The concentration of the OCP components in the fish sample ranged between 0.004597-0.17066 (ng/g) with total concentration of 0.149042 (ng/g). Soil samples showed higher concentration values than the sediments. OCPs values recorded in the fish sample were higher than that in the sediments. Hazard quotient showed that the hazard is moderate (1.49) when compared with the guidelines.

Key words: Organochlorine Pesticides, Ecology, Soil, Sediment, Fish, Owan river.

Introduction

Organochlorine pesticides (OCPs) are synthetic pesticides widely used all over the world. OCP is one of the persistent organic pollutants (POPs) which has become a global environmental problem (Trukhina and Boyarovab 2020; Olisah et al. 2019; Ogbonnaya et al. 2017). These compounds are known for their persistency in the environment, high toxicity, slow degradation and bioaccumulation (Laigi et al. 2020; Olisah et al. 2019; Azmi and Naqvi 2010).

Studies have suggested that OCPs may affect the normal function of the endocrine system of humans and wildlife including growing evidence on cancer, neurological da-mage, endocrine disruption and birth defects (Williams et al. 2013; Colborn and Smolen 1996).

The need for this research arises because there has been no report on the levels of organochlorine pesticide (OCP) residues in soil around Owan which is the major source of the pesticides in sediment and fish samples from river Owan in Edo State. Hence, the objectives of this preliminary study are to determine the concentrations of organochlorine pesticides (OCPs) in soil, fish and sediment samples from river Owan, Edo State, Nigeria.

Materials and methods

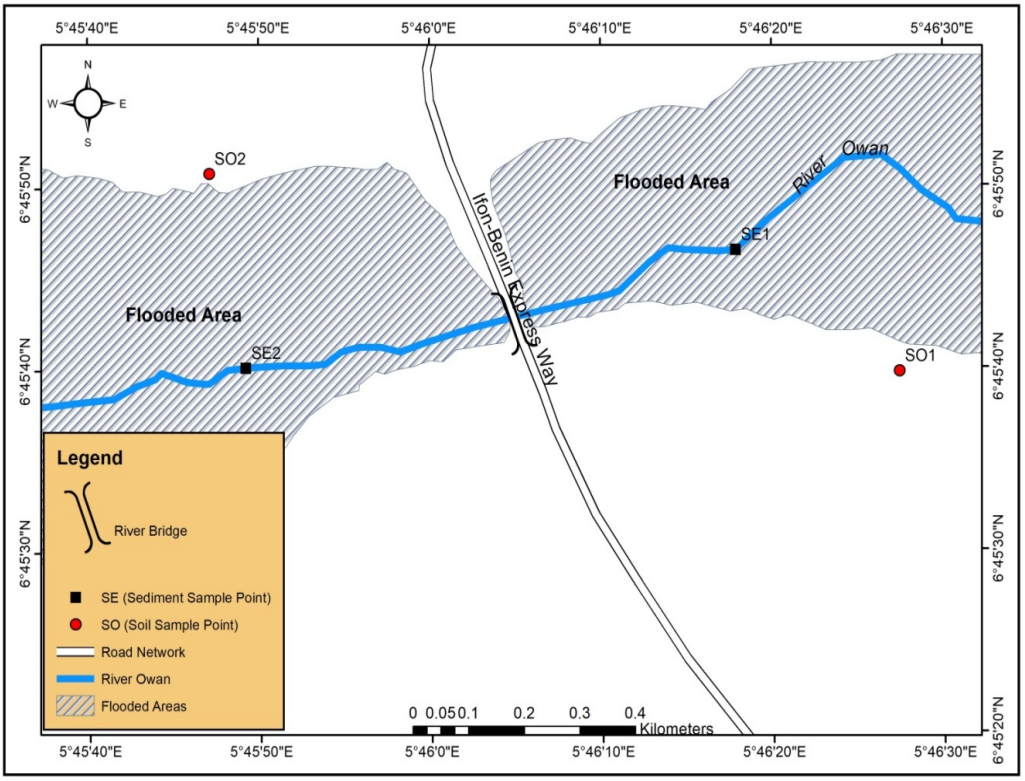


Fig. 1. Map of the study area and sampling points

Samples, sampling and determination of organochlorine pesticides (OCPs)

Sediment, soil and fish (*Clarias anguillaris*) were the samples involved in this study. Sampling locations were geo-referenced (Fig. 1). Concentration of OCPs in the different samples was done using Agilent 7890A gas chromatography, column Varian VF-5 Pesticide capillary column, 30m x 0.25um x 0.25mmID equipped with electron capture detector (GC/ECD) using standard analytical methods (US EPA, 2007; US EPA, 2002).

Hazard Quotient

A hazard quotient (HQ) is the ratio of the potential exposure to a substance and the level at which no adverse effects are expected. HQ is thus calculated with this model by (EPA 2019):

$$HQ = \frac{Dose\ Rate}{Reference\ Dose}$$

The guidelines for the interpretation of HQ calculations given by Feng et al. (2011) are:

HQ < 0.1 – no hazard exists, HQ = 0.1 – 1.0 – hazard is low, HQ = 1.1 – 10, hazard is moderate and
HQ > 10 - hazard is high.

Results

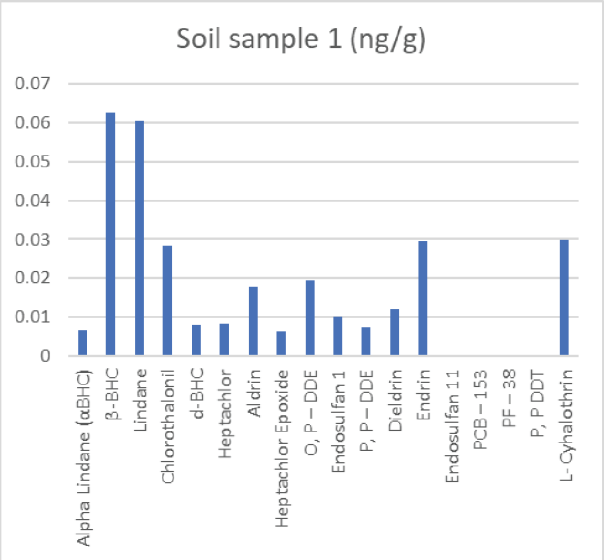


Fig. 2. Concentration of OCP in soil sample 1.

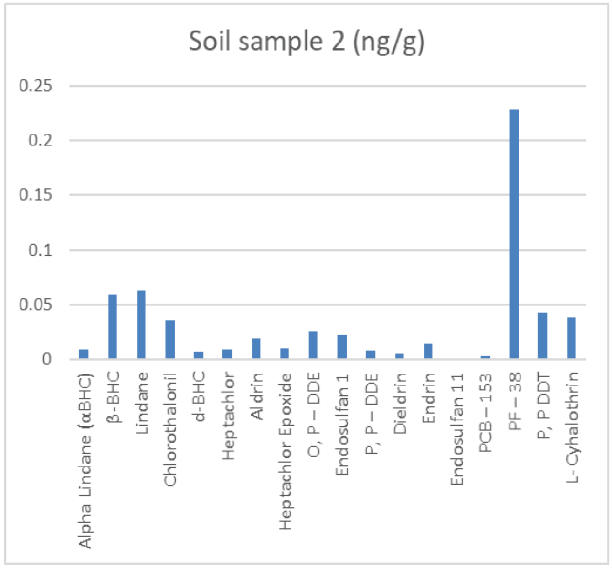


Fig. 3. Concentration of OCP in soil sample 2.

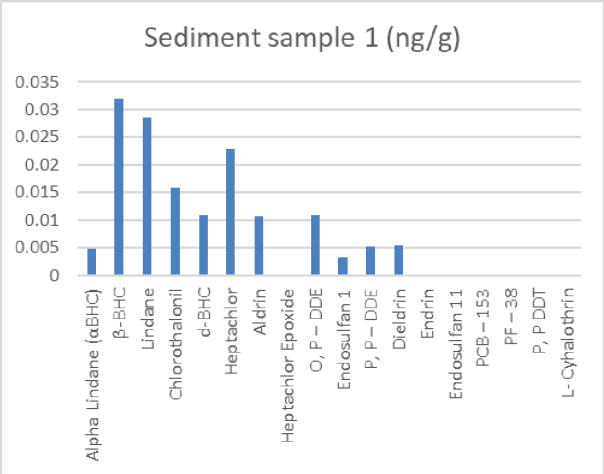


Fig. 4. Concentration of OCPs in sediment sample 1.

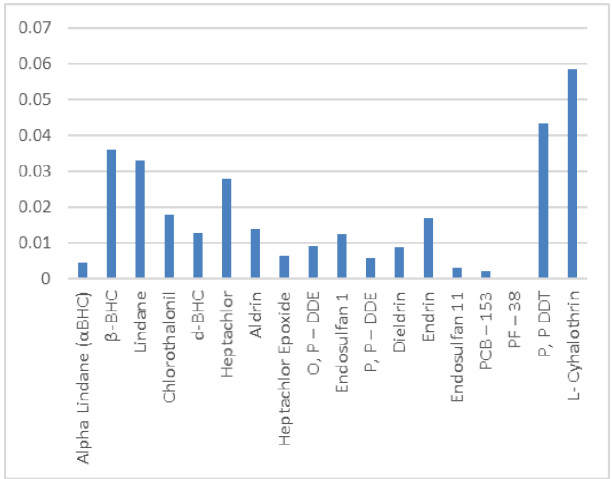


Fig. 5. Concentration of OCPs (ng/g) in sediment sample 2.

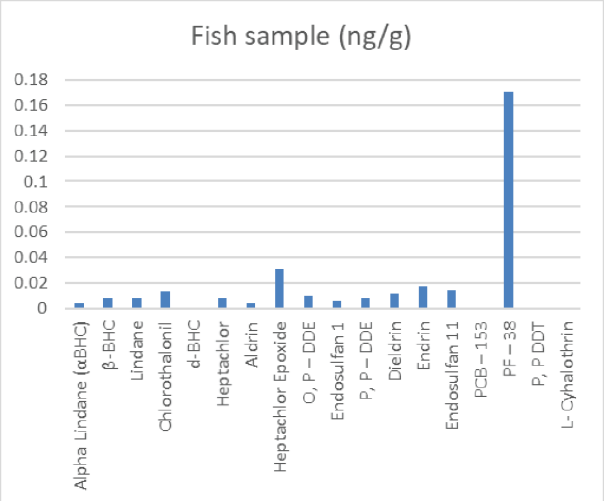


Fig. 6. Concentration of OCPs in fish sample.

Table 1. Hazard quotient for the fish sample.

	∑OCPs concentrations (ng/g)	**HQ**
Toxicity	0.149	1.49
Reference level	0.1	

Conclusion

The study has revealed the presence of the 16 determined OCPs in the soil, sediment and fish (*Clariasanguillaris*) samples in varying concentrations. The concentrations of these pesticides were higher in the soil samples from the farm locations around the river and bio-accumulate in the tissues of the fish. Concentrations of the OCP residues detected in the fish samples were higher than that in the sediments. The hazard quotient assessment result revealed that the hazard is moderate.

Acknowledgement

The authors wish to acknowledge Tertiary Education Trust Fund (TETFund) through Rufus Giwa Polytechnic, Owo, Nigeria for the research grant received (TETFUND/DRSS/POLY/OWO/2016/RP/VOL 1) to execute this research project.

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An updated budget for atmospheric mercury in Australia

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Abstract

Mercury is a toxic bio-accumulative pollutant, with the atmosphere the primary pathway for global distribution. While atmospheric mercury cycling has been extensively monitored and modelled across the Northern Hemisphere, there has long been a dearth of mercury data for the Southern Hemisphere. Recent efforts in Australia are helping to fill this gap, with new observational records that span environments ranging from cool temperate to warm tropical climates and near-source to background conditions. Here, drawing on a new review of recent research on atmospheric mercury in Australia, we provide our best estimate of the current Australian atmospheric mercury budget. While significant uncertainties remain, our analysis suggests that emissions from terrestrial sources (both newly released and legacy) significantly exceed those from anthropogenic sources. However, recent bidirectional air-surface flux observations suggest this source is likely balanced by deposition and surface uptake at local scales. Lingering uncertainties point to critical future research needs for understanding Australian atmospheric mercury and its role in Southern Hemisphere mercury cycling.

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The COALA-2020 Campaign: Charaterising Organics and Aerosol Loading in Australia

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Abstract

COALA (Characterizing Organics and Aerosol Loading over Australia) is a project designed to study the emissions and atmospheric chemistry of Australian biogenic species in pristine conditions and as they interact with anthropogenic pollution. The COALA-2020 campaign, was an intensive phase of the project that ran during the Austral summer at Cataract Scout Park near Sydney, with campaign dates of 16 January - 16 March 2020. This presentation will give a very brief overview of the three aspects of the campaign: the ambient atmospheric composition measurements; the biogenic VOC emissions measurements and the soil emissions measurements.

VOCs seasonality during the COALA-JOEYS campaign

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Abstract

Volatile organic compounds (VOCs) play a key role in the formation of ozone and secondary organic aerosol, the two most important air pollutants in Sydney, Australia. Despite their importance, there are few available VOC measurements in the area. Continuous GC-MS measurements of 10 selected VOCs were taken between February and June of 2019 in a semi-rural area close to Sydney. Combined, these 10 compounds provide a reasonable representation of variability in the total biogenic VOC (BVOC) and anthropogenic VOC (AVOC) loading in the area. Seasonal changes in environmental conditions were reflected in observed BVOC concentrations with summer peaks and low concentrations in winter. Isoprene, and its immediate oxidation products methacrolein and methyl-vinyl-ketone dominate BVOC concentrations during summer and early autumn while monoterpenes comprise the larger fraction during winter. Temperature and solar radiation drive most of the seasonal variation observed in BVOCs. The available isoprene, MACR and MVK in the atmosphere are closely related with temperature and solar radiation variation but chemistry and meteorology may play a more important role. AVOCs maintain an average concentration ~0.4 ppb with a slight decrease during autumn-winter. The low AVOC concentrations observed indicate a relatively low anthropogenic influence on site. Most of the time northerly winds influence the AVOC concentration, transporting Sydney emissions to the measurement site. We conclude that the variation in atmospheric composition observed during the seasons is an important variable to consider when formulating air pollution control policies over Sydney given the influence of biogenic sources during summer, autumn and winter.

VOC fluxes measurements from ship-born Air-Sea Tank experiments over the Western Pacific Ocean (New Zealand)

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Abstract

VOCs are key species in the atmosphere: they are precursors of Secondary Organic Aerosol (SOA) and play a role in ozone formation and the oxidative capacity of the atmosphere [Seinfeld and Pandis 2016]. The most studied VOC emitted over the ocean is dimethylsulfide (DMS) [Keller et al. 1989; Liss et al. 1997]. Oxidation of this compound produces sulfuric and methane sulfonic acids which play crucial roles in the formation of new particles, SOA and climate [Liss and Lovelock 2008]. However, a large set of other VOCs are also emitted from the ocean via complex biological, chemical and physical processes, many of which are not yet well characterized [Engel et al. 2015, Misztal et al. 2015).

VOC fluxes were measured over the Pacific Ocean on board of the R/V *Tangaroa* from 17 to 27 March 2020 by Proton Transfer Reaction and Mass Spectrometry (PTR-MS), using an original experimental set-up of Air Sea Interface Tanks (ASITs) in the frame of the Sea2Cloud project. The goal of the experimental set-up was to directly link the seawater biogeochemical properties to net VOC fluxes under natural environmental conditions. Two ASITs were used, one of which ~10 ppb of ozone was added to the ASIT's headspace.

The voyage was separated in three experiments (i.e. investigating three different types of seawaters along the ship transect) each lasting 72 hours. Methanol, acetaldehyde, acetonitrile, isoprene, Methyl Ethyl Ketone (MEK), Methacrolein + Methyl Vinyl Ketone (MACR+MVK), monoterpenes, methyl iodide and DMS concentrations and fluxes were continuously measured by PTR-MS from the 2 ASITs. On average, significant positive net fluxes of methanol, isoprene and DMS were recorded: 3.04 ± 1.26 ng m^{-2} s^{-1}, 0.64 ± 0.32 ng m^{-2} s^{-1} and 0.85 ± 0.83 ng m^{-2} s^{-1}. As shown in Fig. 1 for methanol, concentrations and fluxes varied between experiments, and in relation to ozone and sunlight, indicating the effect on VOC fluxes of varying biogeochemical properties of the seawater, as well as biological physical and chemical processes occurring at the air-sea interface. Combined with data from comprehensive biogeochemical analysis of the sea water, and simultaneous measurements of aerosol nucleation, these experiments will shed new light on drivers of VOC emissions of over the ocean and how these compounds play a role in marine aerosol formation (companion presentation by Maija Peltola, *Meteorological Society*, New Zealand).

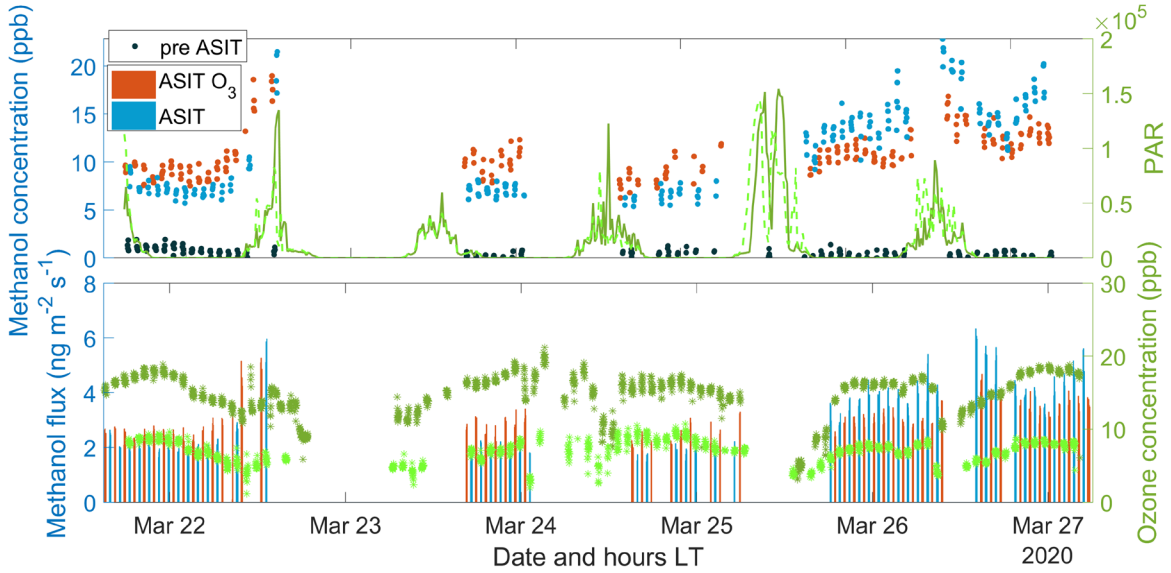


Fig. 1. Concentration and fluxes of methanol in ASITs (red ASIT with ozone, blue = control). PAR and ozone concentrations are represented. Dark green for ASIT with ozone and light green for control.

Acknowlegements

This research received funding from the European Research Council (ERC) under the Horizon 2020 research and innovation programme (Grant agreement number - 771369).

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Using air-sea interaction tanks to study new particle formation from emissions by marine micro-organisms

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Abstract

Marine micro-organisms such as phytoplankton can play an important role in regulating climate by releasing different chemical species into air. In the air these chemical species can get oxidized and participate in the formation of new aerosol particles. If grown to large enough sizes, aerosol particles can act as cloud condensation nuclei thus influencing the formation and properties of clouds and further on climate. While a connection of marine biology and climate through aerosol formation was first proposed already in 1987 by Charlson et al., the processes related to this connection are still uncertain.

In order to shed more light on aerosol formation from precursors emitted by marine micro-organisms, we built Air-Sea Interaction Tanks that enclose seawater and the air above the water. We made two tanks that each contain 1000 l of water and 1000 l of air. The seawater was collected from different locations and kept in the tanks over several days. The airspace was continuously flushed with filtered ambient air (residence time ~40 min) and sampled for aerosol number size distribution and gas phase species (VOCs, chemical composition of molecular clusters, SO_2, O_3). To characterize the seawater, we took daily water samples of different biological and chemical variables.

The tanks were deployed aboard RV Tangaroa during the Sea2Cloud research voyage in March 2020 in the South Pacific Ocean east of New Zealand. This way we could collect open ocean seawater from various locations with varying biological activity. To further expand our knowledge from the voyage, we performed additional experiments with coastal New Zealand seawater during winter 2020.

Particles in the smallest observable size range of 1-3 nm were observed in the ASITS headspace, with concentrations varying depending on the seawater sampling location (Fig. 1), indicating secondary aerosol formation from marine precursors. In this presentation I will give a more detailed overview of the preliminary results of the experiments.

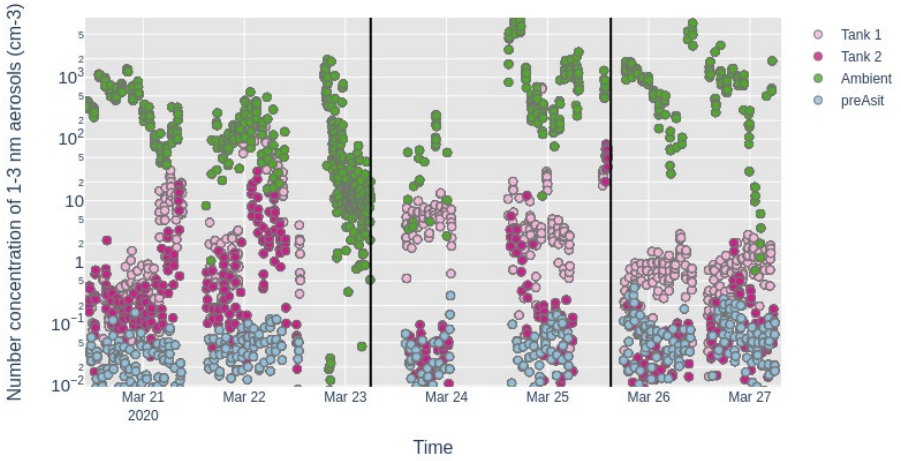


Fig. 1. Time evolution of the number concentration on aerosol particles in 1-3 nm size range during the experiment on the Sea2Cloud voyage in March 2020. Pink points are from the two tanks, blue points are background air and green points are from ambient air. Black vertical lines mark different experiment with seawater taken from different locations.

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Understanding the photooxidation of acetone in the troposphere through FTIR experiments and MCM modelling

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Abstract

Annually, around 73 million tonnes of acetone is formed or emitted into the atmosphere [Khan et al. 2015]. The major sinks of acetone are photolysis and reaction with hydroxyl radicals, and in the high-altitude regions of the troposphere where the concentration of hydroxyl radicals is low, photolysis is the dominant sink [Khan et al. 2015; Gierczak et al. 1998]. Due to the prominence of acetone in the atmosphere, the discovery of new decomposition pathways might impact atmospheric models and our understanding of its fate. In this study, we performed experiments and ran atmospheric box models to improve our understanding of acetone photooxidation.

Experiments were conducted in a variety of experimental conditions, including low-pressure, neat acetone, and a variety of pressures of O_2 and N_2, including synthetic air at atmospheric pressures. Following photolysis with monochromatic wavelengths between 280-325 nm, Fourier transform infrared (FTIR) spectroscopy was used to probe the photolysis and photooxidation products. The acetone photolysis experiment at 300 nm in synthetic air was studied in detail and compared with the Master Chemical Mechanism (MCM) implemented through the AtChem v1.2 box model [Sommariva et al. 2020]. The production of some chemical species, namely formaldehyde, methanol and methyl hydroperoxide, were in agreement with the model, however, there were significant differences for CO and acetic acid (see Fig. 1). In addition, ketene, CO_2 and formic acid were observed, and these products are not found in the current model.

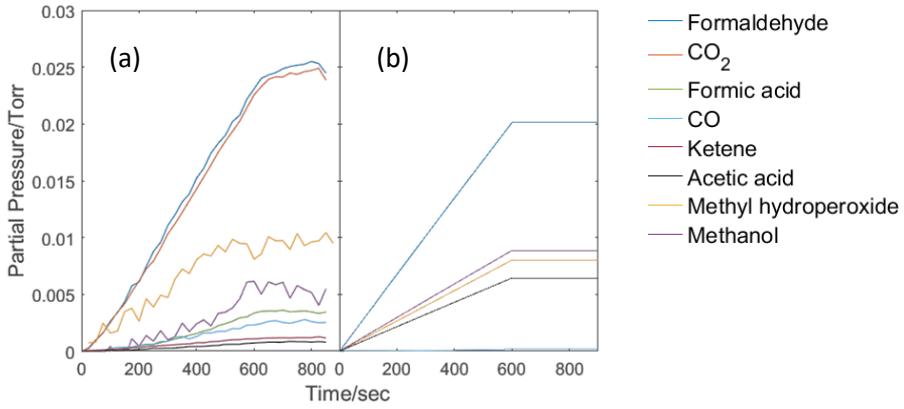


Fig. 1. The products of 300 nm photolysis of acetone in 760 Torr of synthetic air, a) measured experimentally and b) modelled with MCM. The laser was blocked after 600 seconds to monitor the stability of the products.

The MCM does not include CO_2 as it is an end product of VOC oxidation [Sommariva et al. 2020]. Formic acid and acetic acid have been observed in other experimental studies and can be explained through the reaction of hydroperoxyl radicals with formaldehyde, and RO_2 reactions, respectively [Chattopadhyay et al. 2015; Gardner et al. 1984]. Although CO production has been explained through the photolysis of formaldehyde, our experiments suggest CO is also a primary photolysis product arising on the ground electronic state [Chattopadhyay et al. 2015; Emrich and Warneck 2000]. Ketene has previously been identified as a ground state photolysis product, and our experiments identify a ketene quantum yield of 0.5-1.1% in the troposphere [Toulson et al. 2018].

Our experiments show that the MCM can be improved through the inclusion of formic acid and ketene pathways. Further investigation of the CO pathway is underway to determine the photolysis mechanism.

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Atmospheric photothermal oxidation: Shining a new light on formaldehyde photochemistry

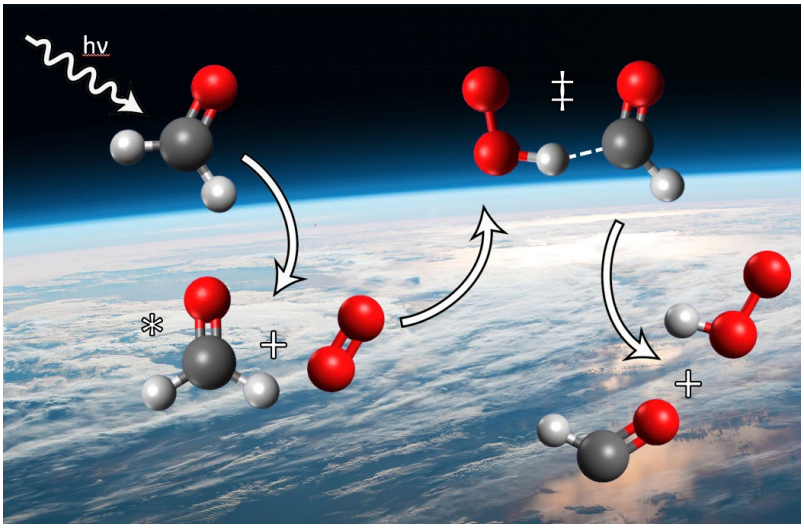
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Abstract

Formaldehyde was the first volatile organic compound (VOC) to be identified in our atmosphere, and it remains one of the most important due to it being a natural decomposition product of nearly all larger VOCs [Finlayson-Pitts and Pitts 1986]. Its photochemistry is of great interest since it is one of the final steps for complete oxidation to CO_2, it is the only known photolytic source of atmospheric H_2, and it recycles the crucial OH radical. Despite the vast amount of research performed on this molecule, there remain several unexplained curiosities in its behaviour. Primary among them is why the photolytic quantum yield for radical products is non-zero below the well-established energetic threshold for said products. Historically it has been attributed to hot band excitation [Troe 2007], but we hypothesise that another process is responsible, one that we have named Atmospheric Photothermal Oxidation (APTO). In the short time between a formaldehyde molecule absorbing a photon and breaking apart to its photolysis products, it is possible for an O_2 molecule to abstract one of the labile H atoms from the excited formaldehyde, forming HO_2 +HCO. High-resolution cavity ring-down spectroscopy was used to both discount the possibility of the postulated hot band excitation and establish the spectral signature of the APTO mechanism. Fourier-transform infrared spectroscopy was performed to determine the dependence of APTO on the pressure and mixing ratio of an N_2/O_2 buffer gas. DFT calculations performed using an M06-2X functional support the viability of this new mechanism. This new APTO mechanism reverses the pressure dependence of the low energy radical quantum yields of formaldehyde and settles our understanding of the underlying chemistry. Beyond formaldehyde, APTO is an exciting possibility for any atmospheric molecule with a significant excited state lifetime. This includes a variety of plant-based VOCs like the myriad daughter molecules of isoprene oxidation [Reguero et al. 1994], as well as some other major atmospheric players like nitrogen dioxide [Roehl et al. 1994].



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Building a global simulation of H_2 on GEOS-Chem to use in the assessment of new photochemical sources

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Abstract

Current atmospheric chemical models account for the chemical production of H_2 from the photodissociation of formaldehyde, and to a lesser extent from glyoxal. However, H_2 is also produced from the photochemical degradation of larger VOCs [Harrison et al. 2019], reactions that are not included in the present models. To evaluate the impact of unexplored atmospheric photochemical sources of H_2, we developed a baseline simulation using the 3D chemical transport model GEOS-Chem (modified from v12.5.0). The baseline simulation of H_2 builds upon previous work to account for emissions from anthropogenic combustion sources. We used a mass scaling factor on global emission inventories of CO, as H_2 and CO are co-emitted. The GFED4 inventory for biomass burning emissions, and the Price et al. [2007] ocean emission values were used. Given that the most important atmospheric sink of H_2 is soil uptake, here we used one of the most spatially refined dry deposition velocities to account for this process. The deposition velocities were those estimated by Yashiro et al. [2011] that used a two-layer soil model. Our simulation was initialized with a value of 530 ppbv in the troposphere based on the average mixing ratio of H_2 from global historic ground measurements [Dlugokencky et al.]. GEOS-Chem was run from January to December 2015 with a six-month spin-up time. Our model yielded a global burden of H_2 of 155 Tg with a lifetime of 1.9 y. The tropospheric burden, lifetime and budget values of H_2 obtained in our work were well within values reported by previous studies [Price et al. 2007; Yashiro et al. 2011; Novelli et al. 1999; Rhee et al. 2006; Ehhalt and Rohrer 2009; Yver et al. 2010; Derwent et al. 2020]. The model was able to reproduce most of the observed seasonal cycle of H_2. However, sites located in the lower northern hemisphere (15°N-45°N) were consistently low-biased. The baseline presented here will serve also to test potential anthropogenic sources and understudied sinks, as well as other emission scenarios.

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Recent work in the Cape Grim Reactive Gases Program

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Abstract

A summary is presented of recent work in the Cape Grim, Reactive Gases Program. This year, following the completion of the 36 year ozone record from Cape Grim on the BiPM/WMO scale and its archiving in the World Data Centre for Reactive Gases, part of the group output has been on publications utilizing this data, see References. The program has three current measurement activities; ozone, nitrogen oxides and volatile organic compounds. A brief update will be given on each.

For ozone, monthly average data for 2020 will be compared with that from earlier years to look for anomalies that may be the result of COVID restrictions. Also, the recent analysis of the long-term trend 1982-2017 will be presented.

For Nitrogen oxides the major achievement is the documentation of the system in a technical manual (see References). Examples of the NO_{xy} measurements at Cape Grim will be presented including the January 2016 bushfire plumes.

For volatile organic compounds, the instrument re-vamp in September 2019 will be described and the instrument testing and achievements in limit of detection and precision for 10 compounds will be compared against expected levels at Cape Grim.

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Seeing the sun - the Spectral Radiation Sub-Program 2012 – 2020

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Abstract

This presentation will cover highlights for the Spectral radiation sub-program of CGBAPS since it was last reviewed in 2012. These will be presented for three areas – Aerosol Optical Depth, UV-B and MAX-DOAS measurements.

The measurement of Aerosol Optical Depth continues to be supported by the Bureau of Meteorology (M. Milner, P. Freeman, F. Jobin, B. Forgan). Changes in the configuration that have occurred across the Bureau's solar radiation network have been implemented, including the shift to a single tracker for all measurements and data recording at 1 s intervals rather than minute statistics on 6 s measurements. Work has also progressed on keeping the front window of the sunphotometers free from contamination.

Measurements of UV-B and $J(O\ ^1D)$ have been previously reported for 2000 – 2005 [Wilson 2015]. However, the hardware had failed and attempts to repair were not fruitful. UV-B measurements were reinstated at Cape Grim in 2017 with the installation of a new tracker/ optics and control hardware in a housing that includes temperature control. Initial issues with tracker reliability appear to have been overcome, and the new software developed for this system is now reliable. Initial characterisation of the performance of this system will be presented.

A MAX-DOAS system was installed at Cape Grim in 2014, initially using a standard Bureau of Meteorology radiation tracker. Following some initial problems with reliability, the system now seems robust. Some initial data will be presented.

None of this could have been achieved without the ongoing support of many!

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Examining pollution sources in size segregated aerosols collected at Baring Head with sulfur and nitrogen isotopic analyses

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Abstract

AIRBOX 2020 from the Tropics to Bushfires to 'Staying at Home'

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Abstract

Aerosol optical depth over the Southern Ocean

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Abstract

A series of atmospheric instruments were deployed aboard the RV *Investigator* in 2018 to quantify aerosol optical depth and properties associated with aerosol formation in the Southern Ocean marine boundary layer between Australia and Antarctica. The optical depth measurements collected via Microtops sun photometers were compared to measurements collected from previous studies in the Antarctic region and the Baseline Station at Cape Grim.

Two case studies, a high aerosol optical depth period (mean of 0.198) and a low period (mean of 0.061), were identified for analyses from the data collected by the Microtops II sun photometer. The periods were compared statistically and via meteorological backward trajectory models to which physical mechanisms that were consistent with sea spray aerosol production for the high period. The low period which was the closest period to Antarctica indicated continental and high-altitude influence, reducing the likelihood of aerosol formation.

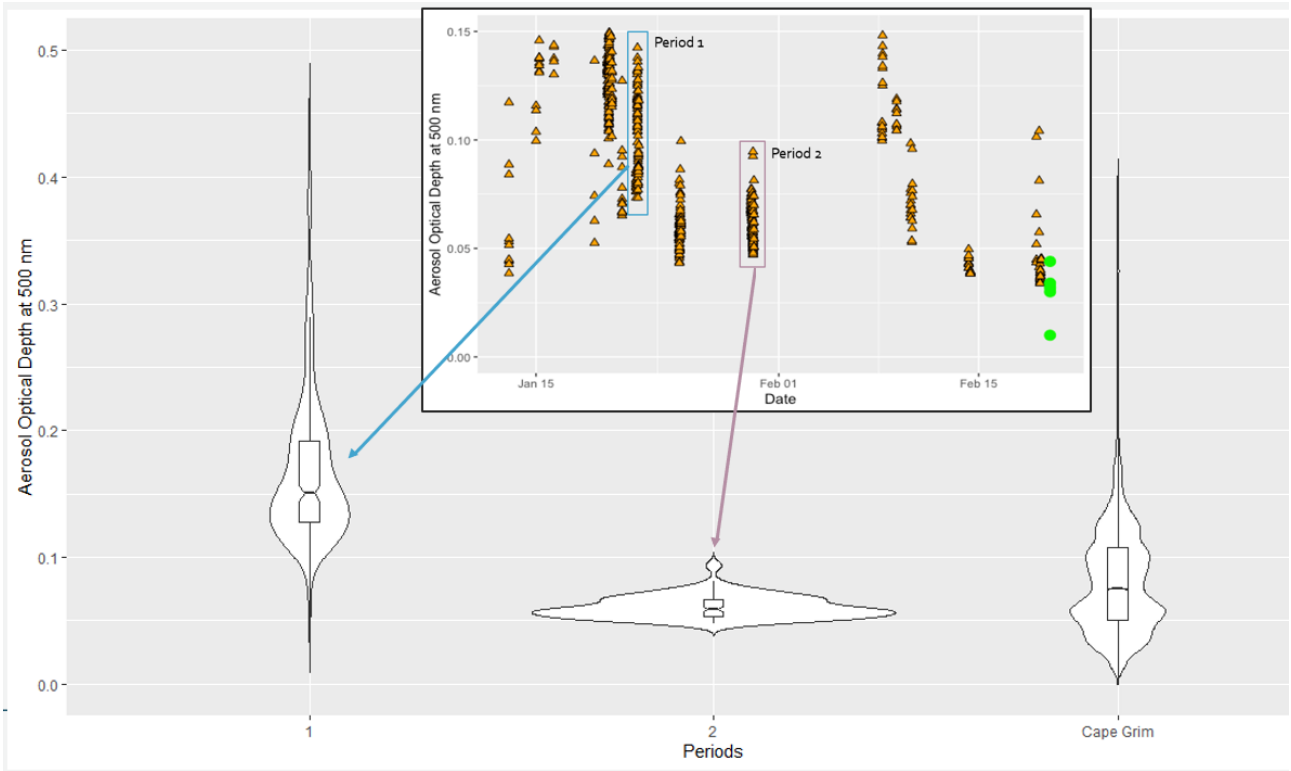


Fig. 1. Violin plot of the aerosol optical depth at 500 nm collected over the Southern Ocean the key high period (Period 1), low period (Period 2) of the CAPRICORN II campaign. This is compared to the long-term data collected at the Baseline Station at Cape Grim. Inset graph displays the placement of these periods within the complete dataset.

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Winter-time sea spray aerosol over the Southern and South Pacific Oceans

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Abstract

Sea spray aerosols (SSA) have been shown to contribute a substantial fraction of cloud condensation nuclei (CCN) over the Southern Ocean [Quinn et al. 2017]. This is in distinct contrast to other regions of the world, where other aerosol sources far outweigh any contributions from SSA. Considering the existing deficiencies in modelling low- and mid-level cloud albedo over the Southern Ocean, it may be important to accurately constrain the SSA number concentrations.

Direct measurement of SSA is challenging, particularly due to the confounding presence of secondary marine aerosols and in most studies, the concentrations have been derived from aerosol number size distributions under the assumption that the SSA can be well represented by a single broad mode [Fossum et al. 2018]. The 2016 Ice-edge to Equator voyage of the RV Investigator provided a unique dataset of winter-time aerosol observations, collected during a full north-south transect of the southern hemisphere. Biological activity was comparatively low during this period, leading to a much greater relative contribution of SSA to the overall aerosol population compared to those observed during summer voyages.

This presentation will outline the resulting changes in the observed marine aerosol size distributions and how these changed as the ship moved from the polar waters to the Equator. Within the Southern Ocean, they show evidence of a multi-peak SSA distribution, which is largely overwhelmed by secondary marine aerosol in the southern Pacific Ocean. While the total SSA concentrations approximately agree with estimates derived from several sea spray source functions, none of them reliably reproduced the observed temporal trends. These findings may offer a valuable opportunity to establish a size distribution which more accurately represents SSA production within the Southern Ocean.

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First look at near real time aerosol chemical composition at Cape Grim

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Abstract

Atmospheric interventions considered in the Reef Restoration and Adaptation Program

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Abstract

Australia has embarked on a bold project: to catalogue, assess, refine, and ultimately roll-out an innovative suite of potential interventions at the scale needed to help preserve and restore the Great Barrier Reef. To proceed all the way to implementation, technologies must be targeted, effective, affordable, socially and ethically acceptable, and pass comprehensive risk assessment. The underlying goal is to both assist the reef to adapt to a changed climate and to 'buy' time while global action on emissions reductions is given greater political weight.

One class of interventions under exploration are reef-scale atmospheric engineering technologies designed to mitigate further damage by relieving the physical bleaching stressors of temperature and irradiance. Two of these interventions would leverage sea salt aerosol to regionally alter the amount of solar radiation reaching the sea surface by targeting the aerosol direct or indirect effects. Cloud or sky brightening would target large areas (tens of thousands km^2) over prolonged periods (months) primarily to lower sea surface temperatures. Conversely 'misting' would target small areas (tens of km^2) over short periods (days) during maximum bleaching stress to primarily reduce light stress on corals.

The initial feasibility analysis and some early fieldwork has focused on assessing technical feasibility and the cost-benefit case projected over forward climate scenarios. These aspects along with environmental risk, societal and legal implications, stakeholder / public acceptability, and development pathways are the subject of the research program over the next four years.

Work completed thus far has demonstrated that the potential benefits are significant, however each of the methods have significant unknowns, technology development requirements and risk to be still assessed.

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Real time reactive oxygen species measurements in Chinese cities

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Abstract

The oxidative stress hypothesis is aimed at explaining the link between particulate matter (PM) and adverse health effects. PM generated through combustion processes introduce a group of free radicals known as reactive oxygen species (ROS) to cells when inhaled. These ROS impede cell function creating oxidative stress, which can lead to inflammation and cell death.

To investigate this hypothesis, instrumentation to accurately measure the ROS content (oxidative load) of PM is essential. For this reason, a new ROS probe, BPEAnit profluorescent nitroxide [Stevanovic et al. 2012], was combined with a purpose-built particle collector and miniature flow-through fluorimeter to create the particle into nitroxide quencher (PINQ) [Brown et al. 2019]. This instrument has a faster response time and lower limit of detection than any other instrument presented in the literature.

The PINQ collects PM for oxidative load measurements with > 97% efficiency and a cut-off size of >20 nm, regardless of chemical composition. This is achieved through a custom-made steam collection device known as the insoluble aerosol collector (IAC). Aerosol is continuously sampled, grown into water droplets, and collected into a solution of DMSO and the BPEAnit probe inside a vortex collector. The liquid sample is then debubbled and passed through the fluorimeter for quantification of ROS.

The system is fully automated, with a time resolution as low as one minute and software providing real time data analysis. In this configuration the instrument has operated for a total of over several months over 3 separate campaigns in the Chinese cities of Hong Kong [Stevanovic et al. 2019], Heshan [Brown et al. 2020], and Beijing.

Data will be presented on high time resolution diurnal profiles of PM oxidative potential in the aforementioned cities. Observations of pollution events and correlations with other PM and gas pollutants will also be discussed.

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Towards reducing the Southern Ocean radiation bias in ACCESS

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Abstract

The new generation of ACCESS (Australian Community Climate and Earth System Simulator) global climate models continue to display radiation biases over the Southern Ocean (Figure 1), as do other models submitted to the Coupled Model Intercomparison Project (CMIP) 5 and 6. This bias has significant impacts on global climate and has been in part attributed to poorly simulated cloud properties, specifically the representation of ubiquitous super cooled liquid water clouds.

As a part of the Australian Antarctic Partnership Program, Theme 1: Atmosphere, we aim to make updates to the ACCESS model that will improve cloud and aerosol representation and reduce this radiative bias. Importantly, observations collected during field campaigns from the last five years can now provide us crucial data to make changes relevant to the Southern Ocean. Of particular interest to this project is how biological activity contributes to cloud condensation nuclei and ice nucleating particles, which subsequently play a role in determining cloud phase.

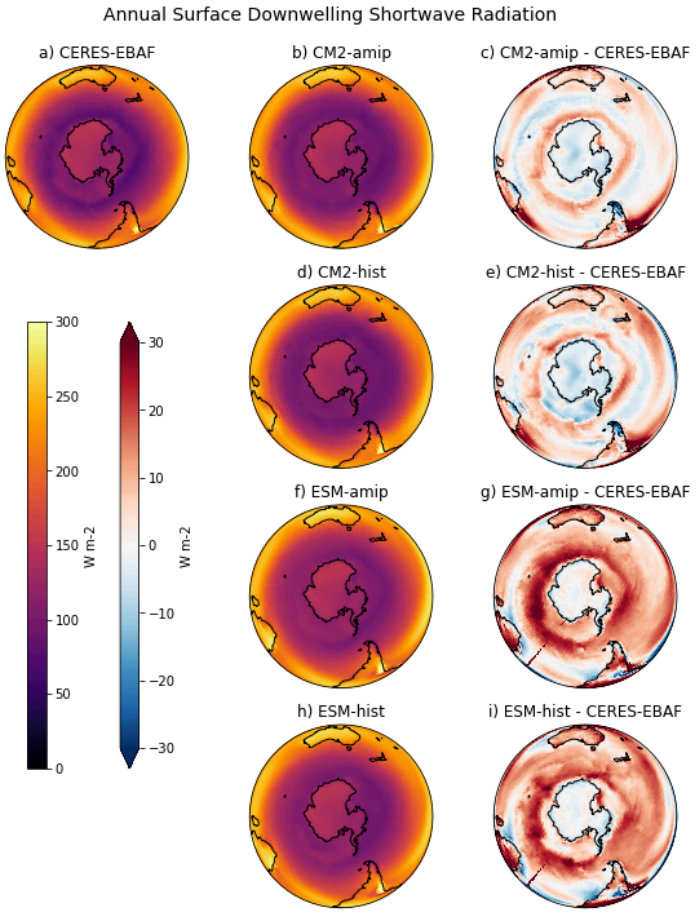


Fig. 1: The annual mean surface downwelling shortwave radiation (W m^{-2}) from a) satellite observations; b,d,f and h) ACCESS CMIP6 simulations (Earth System Model or Coupled Model 2, atmosphere only or historical runs), and c,e,g and i) the difference between the satellite observations and the simulations.