Atmospheric Composition & Chemistry Observations & Modelling Conference

incorporating the

Cape Grim Annual Science Meeting 2013

Abstracts

27-29 November 2013

hosted by

CSIRO Marine and Atmospheric Research

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Aspendale, Victoria



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Day 1

Wednesday 27 November 2013

09:00	**Convenors** **Graeme Pearman**	**Welcome & general information on arrangements etc** **Opening of meeting**
Chair	**Paul Krummel**	**Oral Session 1**
09:10	Alastair Williams	**The Radon Measurement Program At Cape Grim - Review**
09:50	Scott Chambers	Recent expansion of the Southern Ocean radon detector network
10:10	Alex Vermeulen	The InGOS Project on non-CO_2 Greenhouse Gases: Setup and First Results
10:30	Stephen Wilson	Sunphotometry – Cleaning Up Our Act
10:50	**Morning Tea**	**provided - Aspendale canteen**
Chair	**Ian Galbally**	**Oral Session 2**
11:20	Patrick Sheridan	The NOAA/ESRL Federated Aerosol Monitoring Network: Operations and Measurements
11:40	Martin Cope	The Use of GLOMAP for High Resolution, Two-Moment Particle Modelling in Australia- Early Outcomes
12:00	Sarah Lawson	The contribution of Secondary Organics to Aerosols in the Marine Boundary Layer: A Review
12:20	Melita Keywood	Organic Aerosol in Cape Grim PM10 Archive
12:40	John Ivey	Atmospheric Carbondisulfide and Dimethylsulfide Measurements at Cape Grim Australia, Marine, Terrestrial and Anthropogenic Contributions (Landscaping the Mine Site)
13:00	**Lunch Break**	**provided - Aspendale canteen**
Chair	**Melita Keywood**	**Oral Session 3**
14:00	Grant Edwards	A Potpourri of Australian Atmospheric Mercury Measurements
14:20	Dean Howard	Atmospheric Mercury in the Southern Hemisphere and Cape Grim Tekran 2537 Inter-Comparison Study
14:40	Paul Krummel	The 2013 Antarctic Ozone Hole
15:00	Cathy Trudinger	Reconstructing the Atmospheric Concentration and Emissions of PFC-14, PFC-116 and PFC-218 Prior to Direct Atmospheric Measurements, Using Air from Polar Firn and Ice
15:20	**Afternoon Tea**	**provided - Aspendale canteen**
Chair	**Clare Paton-Walsh**	**Oral Session 4**
16:00	Suzie Molloy	Identification Of A Suitable Baseline Definition Of Tropospheric Ozone At Cape Grim, Tasmania
16:20	Ian Galbally	The Distribution and Trends in Southern Hemisphere Tropospheric Ozone
16:40	Kathryn Emmerson	MEGAN: Modelling Emissions of Gases and Aerosols from Nature
17:00	Jenny Fisher	Distant Influences on Australasian Atmospheric Composition
17:20	Matthew Woodhouse	The ACCESS-UKCA Chemistry-Climate Model: Update and Results
18:30	**Dinner**	**Nachos Cantina - Aspendale**

Day 2

Thursday 28 November 2013

Chair	**David Griffith**	**Oral Session 5**
09:10	Clare Paton-Walsh	Overview of the MUMBA Campaign: Measurements of Urban, Marine and Biogenic Air
09:30	Xue Shi	Footprint analysis of Upstream Source Influences on *in situ* CO_2 and CH_4 Observations in Wollongong, NSW
09:50	Elise-Andrée Guérette	VOC Measurements by PTR-MS during the MUMBA Campaign: A First Look at Potential Source Influences
10:10	Sarah Lawson	Development of VOC Monitoring Programs at Cape Grim and Gunn Point
10:30	Robyn Schofield	Understanding Mercury and Ozone Depletion Events over East Antarctic Sea-Ice
10:50	**Morning Tea**	**provided - Aspendale canteen**
Chair	**Stephen Wilson**	**Oral Session 6**
11:20	Dagmar Kubistin	Greenhouse Gas Emissions and Ozone from Australia to the Marine Boundary Layer: Measurements from a Circumnavigation of Australia on the RV Southern Surveyor
11:40	David Griffith	Smoke Composition from the October 2013 NSW Bushfires Measured at Wollongong: A Quick First Look
12:00	Steven Utembe	Modeling Column Integrated CO_2 and CH_4 Observed during the Greenhouse Gas Monitor Experiment in Tara in August 2013
12:20	Voltaire Velazco	Investigating GOSAT-TCCON Greenhouse Gas Column Variability in the Southern Hemisphere: Wollongong and Darwin
12:40	Jocelyn Turnbull	Atmospheric Verification of Point Source Fossil Fuel CO_2 Emissions
13:00	**Lunch Break**	**provided - Aspendale canteen**
14:00		**Poster Session – includes afternoon tea**
Poster Presenters		**All poster presenters to give a 2 - 3 minute poster introduction**
Maximilien Desservettaz		Accounting for the Discrepancy between Modelled and Measured OH in Forested Environments
David Etheridge		A Data Filtering Technique for Monitoring Fugitive Emissions using Atmospheric Measurements at One Location
David Griffith		The Total Carbon Column Observing Network (TCCON)
Elizabeth Keller		Modelling CO_2 Point Sources with WindTrax
Sara Mikaloff Fletcher		What can Observations of O_2/N_2 and CO_2 at Maquarie Island tell us about the Future of the Ocean Carbon Sink?
Paul Selleck		Long Term Record of Aerosol Chemical Composition at Cape Grim Baseline Station
Andrew Smith		Continuation of the ANSTO/NIWA ^{14}C of Atmospheric Methane Program
Ian Galbally		Long-Term Observations of Tropospheric Ozone: GAW Measurement Guidelines
Holly Winton		Seasonality of Soluble Aerosol Iron in the Southern Ocean
Bin Yang		Second Generation Laser Heated Microfurnace for Graphitisation of Microgram Samples
Norazura Zakaria		The Global Atmosphere Watch (GAW) activities programme in Malaysia
15:30	**All welcome**	**Cape Grim Strategic Planning Session**

Day 3

Friday 29 November 2013

Chair	Zoë Loh	Oral Session 8
09:10	Paul Fraser	Australian Synthetic Greenhouse Gas (SGG) Emissions
09:30	Paul Fraser	Recent and Future Trends in Synthetic Greenhouse Gas Radiative Forcing
09:50	Colin Allison	The CMAR Carbon Dioxide Isotope Scale: Finished at last?
10:10	Tilo Ziehn	Greenhouse Gas Network Design: Results from a Case Study for Australia
10:30	Iliana Genkova	Carbon Dioxide Modelling in ACCESS NWP Model
10:50	**Morning Tea**	**provided – Aspendale canteen**
Chair	**Paul Fraser**	**Oral Session 9**
11:20	Gordon Brailsford	Carbon Dioxide Observations at Baring Head, New Zealand
11:40	Rachel Law	Using Macquarie Island Atmospheric CO_2 Measurements to Constrain the Seasonality of Southern Ocean Carbon Exchange
12:00	Ray Langenfelds	Recent Research Highlights from the Cape Grim Air Archive
12:20	Zoë Loh	The Cape Grim CO_2/CH_4 Picarro Record
12:40	Paul Steele	Strategies for the Future of Atmospheric Trace Species Measurements
13:00	Marcel van der Schoot	Development Progress of the Gunn Point pilot Australian Tropical Atmospheric Station (ATARS)
13:20		Closing remarks

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The Radon Measurement Program at Cape Grim

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Abstract

^{222}Rn (radon) is a naturally occurring radioactive noble gas of predominantly terrestrial origin, commonly used for atmospheric tracer studies. Radon has been measured at the Cape Grim Baseline Air Pollution Station since 1980, with a continuous data record collected since 1983. Over the years, these measurements have been used for a wide variety of applications, including:

- selection of least (terrestrially) perturbed marine air masses for baseline studies;
- tracing of terrestrial air mass movements;
- calibration / constraint of regionally-integrated emission estimates for important distributed trace gases; and
- evaluation of the performance of transport and mixing schemes in weather, climate and chemical transport models.

Aims, history and achievements of the radon program at Cape Grim will be reviewed in this presentation. The evolution and current state of the measurement systems and calibration techniques will be summarised, followed by a series of brief research 'snapshots' illustrating the breadth of applications for the Cape Grim radon data. The focus will then broaden to give an overview of other Cape Grim related radon research conducted within the group. The talk will conclude with a summary of future research aims.



Figure 1. Current 5000L main radon detector HURD3 (foreground) and 1500L backup radon detector BHURD (left background) at Cape Grim. In the pump enclosure (right), the common airstream from the top of the 70-m tower (behind and to the right of the camera) is split and 'pushed' towards the two radon detectors at ~300L/min and ~100L/min, respectively. This insures that the detector tanks, and the near-ground portions of their inlet lines, always operate at a slight overpressure in order to reduce the risk of ^{220}Rn (thoron) contamination.

Recent Expansion of the Southern Ocean Radon Detector Network

S. D. Chambers[1*], S. B. Hong[2], T. S. Rhee[2], S.-J. Park[2], J. Crawford & A. G. Williams[1]

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[2]*Korea Polar Research Institute, Incheon, Korea*

*corresponding author: Scott Chambers [scott.chambers@ansto.gov.au]

Abstract

In February 2013 a 1500 L dual flow loop, two-filter radon detector was installed at King Sejong Station (South Shetland Islands, Antarctic Peninsula; 62.23°S, 58.78°W), in collaboration with the Korea Polar Research Institute (KOPRI). The primary aim of the King Sejong Station (KSG) radon observations is to elucidate the air mass fetch history of anthropogenic gaseous and $PM_{2.5}$ aerosol species transported to the Antarctic Peninsula. However, KSG radon observations also supplement existing hourly radon observations at Cape Grim (Tasmania), Cape Point (South Africa), and Macquarie Island, and are expected to significantly improve our understanding of how global circulation patterns influence the characteristics of Southern Ocean air masses.

The specific aims of this presentation are: (i) to provide an overview of the recently established radon monitoring program at King Sejong Station, (ii) to characterise the observed temporal variability in KSG radon observations over the first 8 months of operation compared with existing Antarctic and sub-Antarctic radon observations, and (iii) to characterise the fetch regions and transport mechanisms of the most terrestrially influenced air masses arriving at the station.



Figure 1. View to the west of the first Korean Polar base, King Sejong Station, at the southern end of King George Island, near the tip of the Antarctic Peninsula. Further information about monitoring programs at this GAW site can be found at http://gaw.empa.ch/gawsis/reports.asp?StationID=2076202714

The InGOS Project on non-CO_2 Greenhouse Gases: Setup and First Results

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[2]*Institut für Umweltphysik, University of Heidelberg, Germany*
[3]*Institute for Environment and Sustainability, European Commission DG JRC, Ispra, Italy*
[4]*Max Planck Institute for Biogeochemistry, Jena, Germany*
[5]*University of Helsinki, Finland*

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Abstract

InGOS is a European Union funded IA (Integrating Activity) project targeted at improving and extending the European observation capacity for non-CO_2 greenhouse gases. The project will run from October 2011 to September 2015. InGOS is coordinated by ECN and involves 34 partners from 15 countries.

New (optical) measurements techniques have become available for non-CO_2 flux observations. During intensive field campaigns in June 2012 at Cabauw (NL) and June 2013 near Edinburgh (UK) we tested a number of different sensors for CH_4 resp. N_2O and found that all sensors allowed to measure the mean accumulated flux over the test period within about 10%. In the second phase of the CH_4 campaign the instruments measured within the footprint of Cabauw tall tower and the variability of the measured fluxes within this footprint proved to be a factor of three, despite the homogeneity of the landscape over all three measurement sites.

In the project we also work on improving the historic and future datasets of non-CO_2 mixing ratio observations in the European network, which have been based up to now on GC techniques. We target at providing with every measurement also estimates of precision and accuracy using a uniform method, despite the differences in measurement approaches. First results will be shown for the historic measurements (period 2000-2012) of mixing ratios at 14 stations for CH_4 and N_2O.

These mixing ratio measurements series results will be used for regional inversions in the integrating modelling section of the project using at least five independent model systems. Model validation will be performed using ^{222}Rn observations and a new prior high resolution flux field of time-varying ^{222}Rn emissions (Figure 1).

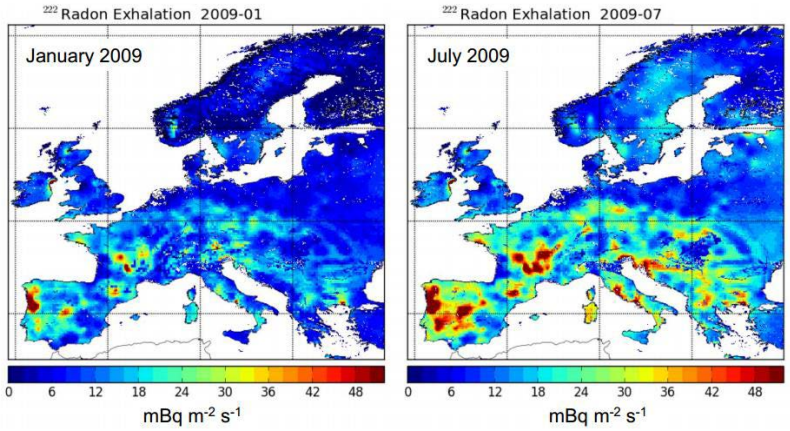


Figure 1. Left panel: ^{222}Rn emission rates for January 2009 from the high resolution emission model Right panel: ^{222}Rn emission rates for June 2009 from the high resolution emission model

Sunphotometry – Cleaning up Our Act

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Abstract

At the 2012 Annual Science meeting, results were presented which showed that the observed aerosol optical depth was higher on Saturday through Monday, presumably because the front window of the sunphotometer was not cleaned over the weekend (Figure 1). The entire dataset has now been recalibrated using only the Tuesday – Friday data, and the long term trend and annual cycle (1986 – 2013, Figure 2) has been determined. Work has progressed on methods to avoid the problem of window fouling, and results of initial tests will be presented.

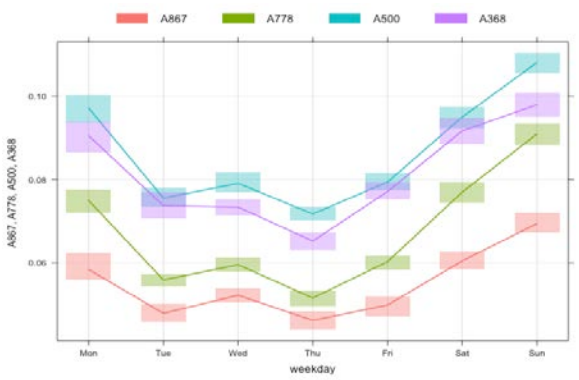


Figure 1. Observed mean weekly cycle of aerosol optical depth for 1986 – 2013. The bars are 95% confidence intervals for the mean, determined by bootstrap methods.

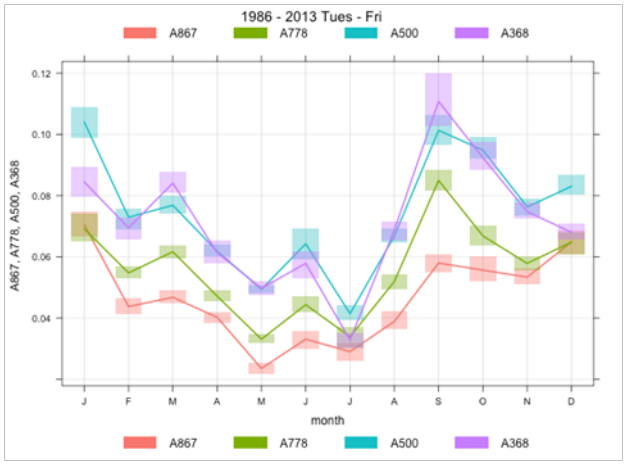


Figure 2. Observed mean annual cycle of aerosol optical depth for 1986 – 2013. The bars are 95% confidence intervals for the mean, determined by bootstrap methods.

The NOAA/ESRL Federated Aerosol Monitoring Network: Operations and Measurements

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Abstract

In order to estimate global aerosol radiative forcing and the effects of anthropogenic aerosols on the global climate, measurements of the aerosols are currently being made by the NOAA Earth System Research Laboratory (ESRL) at monitoring locations around the world. These stations are of two major types: Baseline Observatories, for monitoring changes in the global background values of many aerosol properties, and Regional Aerosol Monitoring Stations, which are at times strongly influenced by anthropogenic aerosols, for measuring aerosol optical properties and direct aerosol radiative forcing to assess climatic impacts and predict climate response.

NOAA has as major partners in these global and regional aerosol measurements the World Meteorological Organization (WMO) Global Atmosphere Watch (GAW) Program, several US science agencies, US and foreign universities, and foreign science organizations. Most of the network stations are also affiliated with the GAW network, and so these NOAA federated stations may be considered a subset of the larger GAW aerosol monitoring network. In these collaborations, each partner contributes different pieces to the overall effort to the benefit of both parties. NOAA contributes a standard set of system hardware, sampling methodology, the data acquisition system, automated and consistent data processing, and technical expertise, while the collaborator contributes major instruments, continuing station operating costs, and technician support. The result is a long-term, global effort of making atmospheric aerosol measurements that are directly comparable between network stations and with shared data access.

Long-term aerosol measurements from network stations show that the daily-average median values of aerosol extinction vary by nearly three orders of magnitude over all network stations, from a low of < 0.4 Mm^{-1} at the South Pole to nearly 400 Mm^{-1} at a station in China. Systematic variability in aerosol properties is observed at many stations, with larger extinction values associated with higher single-scattering albedos and lower hemispheric backscatter fractions [Delene & Ogren, 2002]. A climatology of aerosol hygroscopic growth measurements from network stations shows a wide range of observed hygroscopic growth factors, and the frequency distributions of this parameter are influenced by the variety of aerosol types, the aerosol size and composition, and the number of data points. Median daily values of the TOA direct aerosol radiative forcing efficiency (ΔF per unit AOD) vary within a limited range (-20 to -30 W m^{-2} AOD^{-1}), except for those from a few locations.

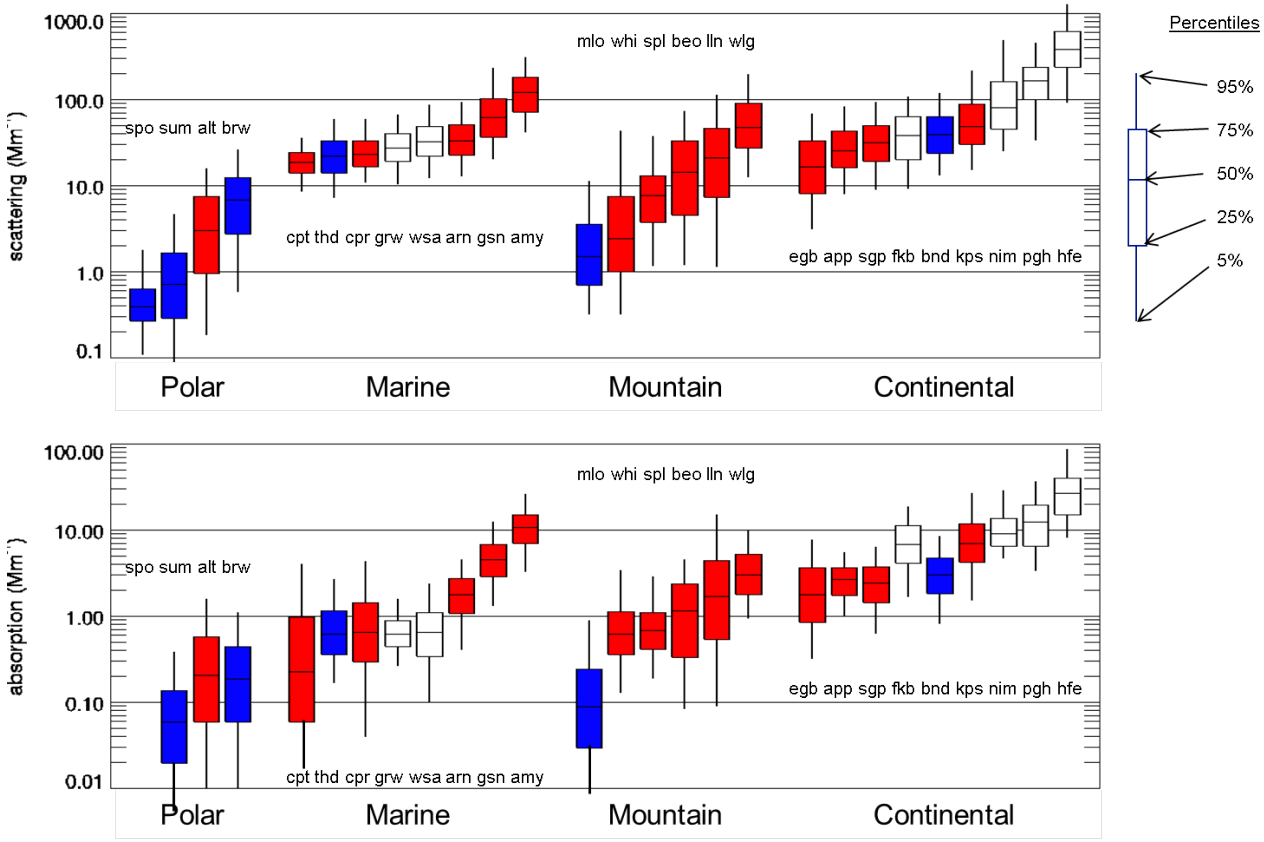


Figure 1. Daily-average distributions for each station, grouped by station category, of aerosol light scattering and absorption at 550 nm.

References

Delene, D. J. & J. A. Ogren, Variability of aerosol optical properties at four North American surface monitoring sites, *J. Atmos. Sci.*, 59, 1135-1150, doi:10.1175/1520-0469(2002)059<1135:VOAOPA> 2.0.CO;2, 2002.

The Use of GLOMAP for High Resolution, Two-Moment Particle Modelling in Australia- Early Outcomes

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Abstract

The Global Model of Aerosol Processes (GLOMAP) has been developed at Leed's University in the UK (Mann et al. 2010), is a component of the new UK community atmospheric chemistry-aerosol global model (UKCA) and will form an important component of the Australian Community Climate and Earth System Simulator (ACCESS) being developed by the Bureau of Meteorology, CSIRO and university partners. In the first instance the primary focus of the UKCA will be for earth systems modelling and climate change. The atmospheric chemistry and aerosol dynamics embodied in the UKCA forms an important science component for investigating the contribution of trace gases and aerosol characteristics to the direct and indirect radiative effects at global and regional scales. However GLOMAP (and the other science modules of ACCESS) also have great potential for investigating high resolution processes, including the effects of natural and anthropogenic aerosol composition and size distribution on sub-regional radiation balances, atmospheric visibility, and the impact of fine particles (nano- to super-micron) on amenity and human health at and below urban scales. The role of fine particles as an air pollutant has been well know for decades, however has received further attention recently following the International Agency for Research on Cancer announcement that both outdoor air pollution and PM (evaluated separately) have been classed as carcinogenic to humans.

In this paper, we will present work in which GLOMAP has been coupled to the CSIRO urban-regional chemical transport model (CTM) thereby enabling GLOMAP to immediately be used for investigating high resolution particle processes . Over the past decade, the CTM has been widely applied in Australia for short term air quality forecasting, for strategic emission reduction modelling, for modelling climate influence on urban scale air pollution, and for investigating particle processes. However, while the CTM includes state-of-the-art treatments of particle and particle precursor emissions, transport and chemical transformation, the CTM considered only particle mass (thus is a single moment model), and only a limited set of size ranges (typically PM2.5 and larger). The coupling of GLOMAP with the CTM provides the additional important capabilities of treating both particle mass and size (2 moments), and processes such as nucleation, coagulation and size-resolved condensation. Examples will be given of the coupled modelling system's capability and our plans for using this system to investigate high resolution particle processes- relevant both for health- and climate-related applications.

References

Mann, G. W., K. S. Carslaw, D. V. Spracklen, D. A. Ridley, P. T. Manktelow, M. P. Chipperfield, S. J. Pickering & C. E. Johnson, Description and evaluation of GLOMAP-mode: a modal global aerosol microphysics model for the UKCA composition-climate model, *Geosci. Model Dev.*, 3(2), 519-551, doi:10.5194/gmd-3-519-2010, 2010.

The Contribution of Secondary Organics to Aerosols in the Marine Boundary Layer: A Review

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Abstract

The proposal of the CLAW hypothesis by Charlson *et al*. in 1987 has triggered 25 years of investigation into links between emissions of gas and aerosol from the ocean, formation of cloud condensation nuclei (CCN) and climate feedbacks. CLAW postulated that the CCN in the remote marine boundary layer was largely controlled by dimethyl sulphide (DMS) emissions from phytoplankton, however research since then has revealed a much more complex picture. It is now recognised that marine CCN arises from a multitude of sources, including entrainment of ocean-derived primary aerosols during bubble bursting, and formation of secondary aerosols (both organic and inorganic) from reactions of a variety of ocean-derived precursor gases [Quinn & Bates, 2011]. Biological processes in the surface ocean may contribute significantly to the composition of primary and secondary aerosol in the overlying atmosphere, though direct emission of bacteria, viruses and algal debris and also through emission of highly reactive aerosol precursor gases (VOCs), for example isoprene and monoterpenes emitted from phytoplankton. Recent studies of aerosol chemical composition over the remote oceans have reported an enhanced proportion of organic matter in aerosols collected over biologically active regions of the ocean compared to less biologically active regions, although whether the organics are of primary or secondary origin, and the detailed chemical composition of the organics is highly uncertain.

The recent literature on organics in marine aerosol is reviewed with a focus on the contribution of secondary organic aerosol (SOA). The mechanism of SOA formation over the remote oceans is discussed, including gas phase and aqueous phase formation. Typical concentrations, sources and sinks of ocean-derived VOCs which are potential SOA precursors are summarised including monoterpenes and isoprene, DMS, oxygenated VOCs (OVOCs) including formaldehyde, acetaldehyde, acetone and methanol as well as dicarbonyls, carboxylic acids and dicarboxylic acids, amines and organic iodine compounds.

Findings from field studies which have shown evidence of an SOA contribution to marine aerosol are summarised, including studies at Mace Head [Facchini *et al*., 2008; Rinaldi *et al*., 2010; Ovadnevaite *et al*., 2011] , Cape Verde [Müller *et al*., 2009; Müller *et al*., 2010], Amsterdam Island [Claeys *et al*., 2010], Cape Grim [Fletcher *et al*., 2007], over the Arctic Ocean [Fu *et al*., 2013], and on a research vessel during a northern hemisphere cruise [Fu *et al*., 2011]. The findings from global modelling studies which estimate SOA mass produced from marine isoprene and monoterpenes are also summarised [Arnold *et al*., 2009; Gantt *et al*., 2009, 2010; Luo & Yu *et al*., 2010].

Knowledge gaps and future directions are highlighted, including an increasing recognition of the interrelatedness between secondary and primary organic aerosol, and the currently unknown source of small, water-soluble OVOCs over the remote ocean. Finally, future plans to further characterise the organic fraction of aerosols at Cape Grim are presented.

References

Arnold, S. R., D. V. Spracklen, J. Williams, N. Yassaa, J. Sciare, B. Bonsang, V. Gros, I. Peeken, A. C. Lewis, S. Alvain & C. Moulin, Evaluation of the global oceanic isoprene source and its impacts on marine organic carbon aerosol, *Atmos. Chem. Phys*., 9(4), 1253-1262, doi:10.5194/acp-9-1253-2009, 2009.

Charlson, R., J. Lovelock, M. Andreae & S. Warren, Oceanic phytoplankton, atmospheric sulphur, cloud albedo and climate, *Nature*, 326(655), doi:10.1038/326655a0 , 1987.

Claeys, M., W. Wang, R. Vermeylen, I. Kourtchev, X. G. Chi, Y. Farhat, J. D. Surratt, Y. Gomez-Gonzalez, J. Sciare & W. Maenhaut, Chemical characterisation of marine aerosol at Amsterdam Island during the austral summer of 2006-2007, *J. Aero. Sci*., 41(1), 13-22, doi:10.1016/j.jaerosci.2009.08.003, 2010.

Facchini, M. C., S. Decesari, M. Rinaldi, C. Carbone, E. Finessi, M. Mircea, S. Fuzzi, F. Moretti, E. Tagliavini, D. Ceburnis & C. D. O'Dowd, Important source of marine secondary organic aerosol from biogenic amines, *Environ. Sci. & Technol*., 42(24), 9116-9121, doi: 10.1021/es8018385, 2008.

Fletcher, C. A., G. R. Johnson, Z. D. Ristovski & M. Harvey, Hygroscopic and volatile properties of marine aerosol observed at Cape Grim during the P2P campaign, *Environ. Chem*., 4(3), 162-171, doi:10.1071/EN07011, 2007.

Fu, P. Q., K. Kawamura, J. Chen, B. Charriere & R. Sempere, Organic molecular composition of marine aerosols over the Arctic Ocean in summer: contributions of primary emission and secondary aerosol formation, *Biogeosciences*, 10(2), 653-667, doi:10.5194/bg-10-653-2013, 2013.

Fu, P. Q., K. Kawamura & K. Miura, Molecular characterization of marine organic aerosols collected during a round-the-world cruise, *J. Geophys. Res*., 116, D13302, doi:10.1029/2011JD015604, 2011.

Gantt, B., N. Meskhidze & A. G. Carlton, The contribution of marine organics to the air quality of the western United States, *Atmos. Chem. Phys*., 10(15), 7415-7423, doi:10.5194/acp-10-7415-2010, 2010.

Gantt, B., N. Meskhidze & D. Kamykowski, A new physically-based quantification of marine isoprene and primary organic aerosol emissions, *Atmos. Chem. Phys*., 9(14), 4915-4927, doi:10.5194/acp-9-4915-2009, 2009.

Luo, G. & F. Yu, A numerical evaluation of global oceanic emissions of alpha-pinene and isoprene, *Atmos. Chem. Phys*., 10(4), 2007-2015, doi:10.5194/acp-10-2007-2010, 2010.

Müller, C., Y. Iinuma, J. Karstensen, D. van Pinxteren, S. Lehmann, T. Gnauk & H. Herrmann, Seasonal variation of aliphatic amines in marine sub-micrometer particles at the Cape Verde islands, *Atmos. Chem. Phys*., 9(24), 9587-9597, doi:10.5194/acp-9-9587-2009, 2009.

Müller, K., S. Lehmann, D. van Pinxteren, T. Gnauk, N. Niedermeier, A. Wiedensohler & H. Herrmann, Particle characterization at the Cape Verde atmospheric observatory during the 2007 RHaMBLe intensive, *Atmos. Chem. Phys*., 10(6), 2709-2721, doi:10.5194/acp-10-2709-2010, 2010.

Ovadnevaite, J., C. O'Dowd, M. Dall'Osto, D. Ceburnis, D. R. Worsnop & H. Berresheim, Detecting high contributions of primary organic matter to marine aerosol: A case study, *Geophys. Res. Lett*., 38, L02807, doi:10.1029/2010GL046083 , 2011.

Quinn, P. K. & T. S. Bates, The case against climate regulation via oceanic phytoplankton sulphur emissions, *Nature* 480(7375), 51-56, doi:10.1038/nature10580, 2011.

Rinaldi, M., S. Decesari, E. Finessi, L. Giulianelli, C. Carbone, S. Fuzzi, C. O'Dowd, D. Ceburnis & M. C. Facchini, Primary and Secondary Organic Marine Aerosol and Oceanic Biological Activity: Recent Results and New Perspectives for Future Studies, *Advances in Meteorology*, 2010, ID 310682, doi:10.1155/2010/310682, 2010).

Organic Aerosol in Cape Grim PM10 Archive

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Abstract

The Multiphase Atmospheric Chemistry (MAC) program at Cape Grim has involved the collection of weekly baseline PM10 samples since 1988. The resulting long term record of soluble ion composition and mass (since 2002) reside in the WMO GAW World Data Centre for Aerosols and portions of the samples have been archived for future studies. One such study is the University of North Carolina/ Massachusetts Institute of Technology (UNC/ MIT) Organic Nitrogen in Atmospheric Aerosols study that will investigate the concentrations, chemical composition, and properties of organic nitrogen compounds in aerosols from a variety of aerosol samples, including the Cape Grim PM10 archive.

Organic nitrogen makes up 30% of total nitrogen deposited to the oceans. Organic nitrogen species by definition have polar functional groups (e.g., amine, amide, or nitrooxy functionalities), and so tend to be sufficiently low-volatility and/or water-soluble that they are found in the particle phase. The mechanisms for how organic nitrogen is incorporated into aerosols are poorly understood but may include via primary emissions (e.g. biomass burning), gas to particle conversion of reduced nitrogen species such as amines, acid-base chemistry and oxidative chemistry involving inorganic nitrogen species such as NO_X and NH_3. The oxidation state of Nitrogen found in atmospheric aerosol (oxidized vs. reduced organic nitrogen) is not well-understood at present.

The MIT/ UNC Organic Nitrogen in Atmospheric Aerosols study will address these gaps in understanding by identifying the organic nitrogen species in aerosols. This will be a challenging task for the Cape Grim PM10 samples. As would be expected PM10 mass at Cape Grim is dominated by soluble ions (these comprise over 80% of the mass) and Na^+ and Cl^- dominate these ions. Organic carbon comprises less than 5% of the PM10 mass. Thus novel analytical techniques are being developed at UNC and MIT. This presentation will provide the Cape Grim community with an introduction to this study and an update on its progress.

Atmospheric Carbondisulfide and Dimethylsulfide Measurements at Cape Grim Australia, Marine, Terrestrial and Anthropogenic Contributions (Landscaping the Mine Site)

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Abstract

This work completes our review of the measurement of the atmospheric concentrations of carbondisulfide (CS_2) and dimethylsulfide (DMS) gathered between 1994 and 1996 at Cape Grim, NW Tasmania that are focused on air mass source. The DMS data was originally gathered due to an interest in the marine DMS flux and its contribution via oxidation products to tropospheric sulfur particle production. CS_2 was concurrently measured at Cape Grim and was not previously assessed and reported. We have now examined that data, and contrasted the findings with those of DMS establishing a marine seasonal association.

The data has been source-segmented to address annual and seasonal contributions as well as episodic 'pollution' episodes.

The data shows that CS_2 and DMS concentration (converted to mixing ratios) are strongly influenced by mixed marine/terrestrial air streams, with CS_2 concentrations being significantly enhanced through contact with coastal margins, terrestrial and population centres. A source emission strength of approximately 30-40 tonnes of CS_2 per year is calculated using the CS_2 vs. carbon monoxide ratio from the Melbourne air shed. The annual ocean tropospheric sulfur mixing ratios of CS_2 to DMS, are calculated as 5.66 % varying between 4.30% in the summer to 12.3% in the winter for this latitude. To proportion source strength to the annual CS_2 mixing ratios as intercepted at Cape Grim we have crudely considered the marine sector, 190° – 280°, and the Tasmanian terrestrial sector, 90° – 140° as representative of oceanic and terrestrial CS_2 origin. We acknowledge that the seasonality of wind direction has not been considered in making this estimate. This not withstanding, the annual mixing ratio proportionality is calculated as 37.2% oceanographic and 62.8% terrestrial, varying from 46.5 to 53.3% (summer) and 32.3 to 67.7% (winter) respectively.

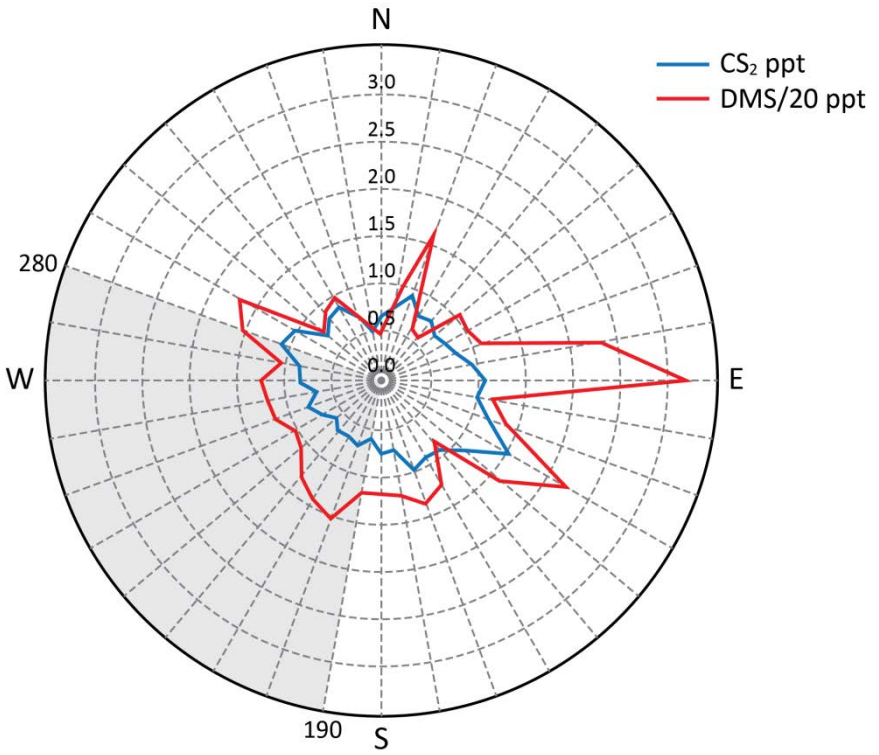


Figure 1. Annual distribution rose of carbondisulfide (CS_2) and dimethylsulfide (DMS) at Cape Grim.

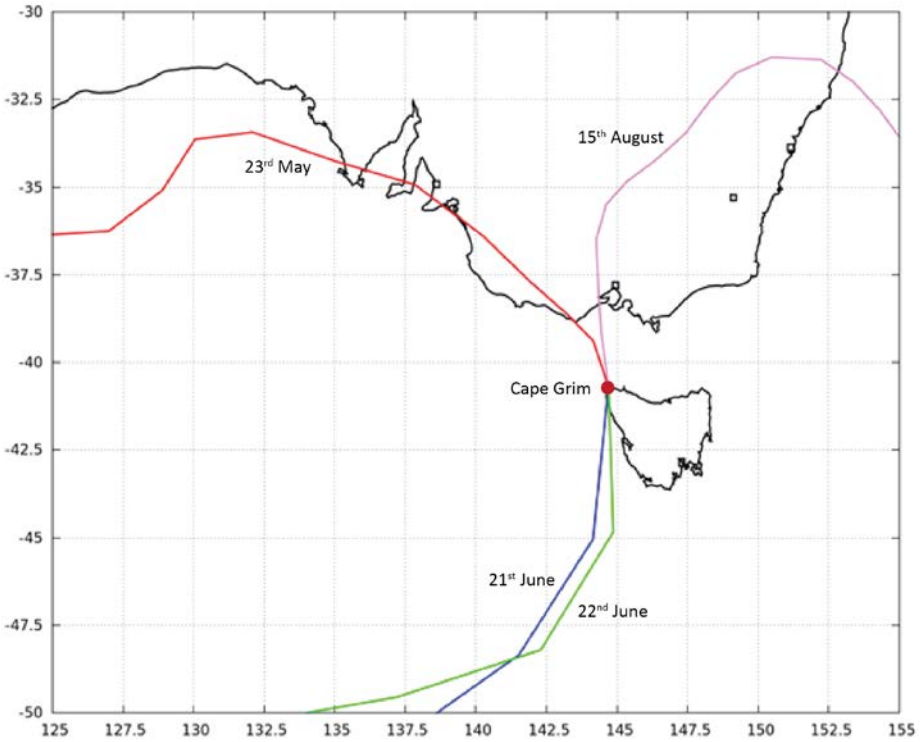


Figure 2. Air trajectories as considered in this presentation.

A Potpourri of Australian Atmospheric Mercury Measurements

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Abstract

The natural cycling of mercury in the environment is, at present, inadequately understood. In particular, the Southern Hemisphere (SH) is underrepresented by studies of the natural sources and sinks of atmospheric mercury and no previous attempts to examine these sources and sinks have been undertaken in Australia. In this study, both micrometeorological and chamber methods were used in the field to characterise emission and deposition of gaseous elemental mercury (GEM) fluxes over terrestrial surfaces in Australia. Naturally enriched and background sites were studied. In addition, an extensive suite of environmental correlates were concurrently measured with a view to elucidating the environmental biogeochemical processes controlling GEM fluxes.

Studies were carried out during Australian autumn, winter and summer seasons. The enriched sites results showed net emission to the atmosphere and a strong correlation between flux and substrate Hg concentration. Measurements at background sites showed both emission and deposition. The extensive suite of environmental correlates measured provided new insights into controlling parameters on the biogeochemical cycling of atmospheric mercury.

Atmospheric Mercury in the Southern Hemisphere and Cape Grim Tekran 2537 Inter-comparison Study

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Abstract

The Southern Hemisphere is under represented in terms of atmospheric background measurements of Gaseous Elemental Mercury (GEM). Until recently, Cape Point, South Africa was the only long term background atmospheric mercury measurement station in the SH. Under the Global Mercury Observation System (GMOS), Australia (CSIRO Marine and Atmospheric Research) has established a second SH long term atmospheric GEM background measurement site at Cape Grim.

A Tekran 2537 series GEM analyser was commissioned at the Cape Grim station to monitor ambient atmospheric GEM concentrations. Various difficulties have been encountered in establishing reliable GEM measurements under GMOS prescribed standard operating protocols. From 16 September to 14 October 2013 an inter-comparison study was undertaken between two Tekran 2537 series analysers with a view to identifying and remedying problems. Results of this study are presented and preliminary data from the Cape Grim measurement program are discussed in the context of atmospheric GEM measurements at Cape Point, South Africa and background data from campaign based measurements in the SH.

The 2013 Antarctic Ozone Hole

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Abstract

The 2013 ozone hole was relatively small, with about 15-17 ozone holes out of the last 20 (1994-2013) having been bigger/deeper (depending on the metric used), and only 2-4 having been smaller (2002, 2004, 2010, 2012). The development and recovery of the 2013 ozone hole will be shown via a set of metrics based on the Ozone Monitoring Instrument (OMI) on board the Earth Observing Satellite (EOS) Aura. Other observational results will be shown to complement these satellite data. The 2013 ozone hole metrics will be compared to the historical metrics, and these will be linearly regressed against Equivalent Effective Stratospheric Chlorine (EESC) data that are based entirely on Cape Grim Air Archive, Antarctic firn and AGAGE global measurements of ozone depleting substances (ODS). The year-to-year variability of the ozone hole does not reflect variations in the level of ODSs in the Antarctic stratosphere, which, based on surface observations, have fallen approximately 18% since their peak around 2000 in the Antarctic stratosphere. The decadal variations in the ozone hole do reflect the long-term changes of ODSs in the Antarctic stratosphere and the results shown here suggest that ozone hole recovery has commenced.

A brief comparison of the OMI satellite data to the new OMPS (Ozone Mapping and Profiler Suite) instrument on the Suomi National Polar-orbiting Partnership satellite (Suomi NPP) will also be shown. OMPS data will contribute to observing the recovery of the ozone layer in coming years.

Reconstructing the Atmospheric Concentration and Emissions of PFC-14, PFC-116 and PFC-218 Prior to Direct Atmospheric Measurements, using Air from Polar Firn and Ice

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Abstract

Perfluorocarbons are very potent and long-lived greenhouse gases in the atmosphere, released predominantly during aluminium production, electronic chip manufacture and refrigeration. Mühle *et al*. (2010) presented records of the concentration of (and inferred emissions of) PFC-14 (CF_4), PFC-116 (C_2F_6) and PFC-218 (C_3F_8) from the 1970s up to the present, using measurements from the Cape Grim and Northern Hemisphere air archives, and the AGAGE *in situ* network. Here we extend these concentration records back in time to preindustrial levels using air from polar firn at four sites (DSSW20K, EDML, NEEM and South Pole) and from bubbles trapped in ice at two sites (DE08 and DE08-2). Firn and ice core measurements were performed on the Medusa system at Aspendale or Cape Grim and/or on a high precision GCMS system at UEA. We relate the calibration scales for the different laboratories using measurements of common samples made at each laboratory. We estimate global emissions consistent with the concentrations, along with their uncertainties. The uncertainty analysis takes into account uncertainties in the firn model by the use of two different (independently-calibrated) firn models.

References

Mühle, J., A.L. Ganesan, B.R. Miller, P.K. Salameh, C.M. Harth, B.R. Greally, M. Rigby, L.W. Porter, L. P. Steele, C.M. Trudinger, P.B. Krummel, S. O'Doherty, P.J. Fraser, P.G. Simmonds, R.G. Prinn, and R.F. Weiss, Perfluorocarbons in the global atmosphere: tetrafluoromethane, hexafluoroethane, and octafluoropropane, *Atmos. Chem. Phys.,* 10, 5145–5164, doi:10.5194/acp–10–5145–2010, 2010.

Identification of a Suitable Baseline Definition of Tropospheric Ozone at Cape Grim, Tasmania

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Abstract

Tropospheric ozone concentrations, like numerous other atmospheric constituents, are a result of a complex mix of local, regional and global sources and sinks. Identifying the contribution of each potential component is a difficult task but essential to understanding the processes which affect the given atmospheric species. An understanding of the contribution of different sources and sinks enables a more accurate incorporation of the species into a range of models, which in turn can be used for a variety of purposes including forecasting.

A fundamental component of the concentration of a given atmospheric species is the baseline or background concentration. This can be considered an underlying, non-static concentration affected by many factors. For ozone, a knowledge and understanding of this baseline or background concentration provides essential input for three related objectives:

- To provide advice concerning the contribution of background ozone concentrations to ozone pollution events that may exceed environmental standards (Fiore *et al*. 2002);
- To investigate the variations and trends in tropospheric ozone and the physical/chemical processes regulating tropospheric ozone;
- To provide appropriate data for model-observation comparisons.

To separate baseline tropospheric ozone from non-baseline data, a variety of variables can be used, dependent on the particular circumstances under which the concentrations are measured and the data that is available. In this study, we build on previous work by Zahorowski *et al*. (1996) and trial a set of baseline definitions for use with ozone concentrations measured in the marine boundary layer at the Cape Grim Baseline Air Pollution Station (CGBAPS). These baseline definitions are based on wind speed and direction, radon concentrations and condensation nuclei counts and applied to a 10 year ozone data set from 1992 to 2001. The resulting baseline data sets are analysed for long term trends and the differences between the trends are examined.

References

Zahorowski, W., I. E. Galbally, S. Whittlestone & C. P. Meyer, Ozone and radon at Cape Grim: A study of their interdependence in *Baseline Atmospheric Program (Australia) 1993*, R.J. Francey, A. L. Dick & N. Derek (eds.), Department of the Environment, Sport and Territories, Bureau of Meteorology in cooperation with CSIRO Division of Atmospheric Research, Melbourne, 30-37, 1996.

Fiore, A. M., D. J. Jacob, I. Bey, R. M. Yantosca, B. D. Field & A. C. Fusco, Background ozone over the United States in summer: Origin, trend, and contribution to pollution episodes, *J. Geophys. Res.*, 107(D15), ACH 11-1–ACH 11-25, doi: 10.1029/2001JD000982, 2002.

The Distribution and Trends in Southern Hemisphere Tropospheric Ozone

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Abstract

Tropospheric ozone is a greenhouse gas, ranked third in anthropogenic radiative forcing after CO_2 and CH_4; ozone in the troposphere makes up an important fraction of the atmospheric shield against ultraviolet radiation particularly when ozone depletion events occur, and tropospheric ozone drives tropospheric chemistry being the major precursor of the OH radical which is the sink for gases such as methane. In the boundary layer increases in background ozone have other impacts through urban and regional photochemical smog on human health and through plant damage on crop productivity and the sequestration of carbon into the biosphere.

A short update will be given of the progress towards ensuring inter-decadal consistency of the long term measurements at Cape Grim. Then the presentation will move to a hemispheric perspective with particular focus on the extra-tropical atmosphere.

There is very limited long-term monitoring and few process studies of tropospheric ozone in the Southern Hemisphere. Analyses are presented of two decades of observations from 6 background surface ozone stations spanning 34°S to 90°S and 12 long-term ozonesonde stations spanning 1°S to 69°S. Special consideration is taken to consider only those parts of the ozone record that are free of local influences of ozone production and destruction.

Previous studies have shown a strong longitudinal asymmetry in tropical tropospheric ozone with the South Atlantic maxima and the Western Pacific minimum, both influenced by the Walker circulation. Biomass burning has a key role in the low to mid-troposphere in the tropics. Previous analyses indicate that there has been strong growth in ozone abundance in the lower troposphere over the South Atlantic, and negligible growth in the Western Pacific In the extra-tropics,

The extra tropical measurements analysed here reflect a NO_x depleted environment where there is net ozone loss at most oceanic and free troposphere locations. The seasonal signature of stratospheric-tropospheric exchange is evident in the ozone record in upper troposphere in mid-latitudes but not polar regions. There is little destruction of ozone at the water and snow surfaces. Halogen chemistry and local ozone production are evident in lower tropospheric air at some at Antarctic stations.

There has been a growth in ozone abundance in the extra-tropical lower troposphere over the last two decades, this growth is stronger over Antarctica compared with mid-latitudes, and regional differences are evident..As well, there are inter-annual variabilities at the stations that appear to be correlated over long distances. Possible drivers of both the growth and interannual variability will be discussed.

MEGAN: Modelling Emissions of Gases and Aerosols from Nature

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Abstract

The MEGAN model has been developed by Prof Alex Guenther's team at NCAR to predict emissions of volatile organic compounds (VOCs) from plants and trees [Guenther *et al*., 2006, 2012]. It is generally regarded as the best biogenic VOC model available. In collaboration with the NCAR team, I have been setting up the MEGAN code to work with Australian data. In this talk I will demonstrate a little of how MEGAN works, and what advances it represents for our capability.

While this talk is more of a concept study rather than showing many results, it is an opportunity to let others know what work is going on in the air quality team. In future I would like to improve the outputs of MEGAN Australia with collaborations with teams from CABLE and TERN, and use measurement data obtained from QUT and our soon-to-be new aerosol mass spectrometer for validation studies.

References

Guenther, A., T. Karl, P. Harley, C. Wiedinmyer, P. I. Palmer, & C. Geron, Estimates of global terrestrial isoprene emissions using MEGAN (Model of Emissions of Gases and Aerosols from Nature), *Atmos. Chem. Phys*., 6, 3181-3210, doi:10.5194/acp-6-3181-2006, 2006.

Guenther, A. B., X. Jiang, C. L. Heald, T. Sakulyanontvittaya, T. Duhl, L. K. Emmons, & X. Wang, The Model of Emissions of Gases and Aerosols from Nature version 2.1 (MEGAN2.1): an extended and updated framework for modeling biogenic emissions, *Geosci. Model Dev*., 5, 1471-1492, doi:10.5194/gmd-5-1471-2012, 2012.

Distant Influences on Australasian Atmospheric Composition

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Abstract

The sources of trace gases to the Australasian troposphere differ from their counterparts in the northern mid-latitudes. Australasia is characterised by low anthropogenic emissions, high biogenic emissions, and episodically large influence from biomass burning emissions. In addition to these local sources, transported emissions from across the Southern Hemisphere are known to exert a large influence, while emissions from Asia are thought to play a limited role due to the transport barrier formed by the Intertropical Convergence Zone. Much of the focus in understanding tropospheric composition in Australasia has centred on the influence of transported biomass burning plumes, which in austral spring provide the dominant source of many species. Efforts to characterize the overall impacts of different emission sources on regional composition have been limited, especially outside of austral spring. In this work, we use the GEOS-Chem global chemical transport model to quantify the relative influence of emissions from diverse sources on Australasian tropospheric composition, with initial focus on carbon monoxide (CO). The model is constrained by multi-year, ground-based column measurements from Darwin, Wollongong, and Lauder, spanning a latitudinal gradient from 12-45°S and allowing us to evaluate a range of different environments. Outside of austral spring, we find diverse contributions to Australian background CO, including Asian anthropogenic influence in the upper troposphere and transported biogenic influence throughout the column. Using a case study from February 2009, we show that transport from Asia can occur, with influence on composition extending from the tropics to the southern mid-latitudes. Follow-up work will use combined model-satellite analyses to identify the pathways by which this interhemispheric transport occurs and its relative importance in driving atmospheric chemistry in the region.

The ACCESS-UKCA Chemistry-Climate Model: Update and Results

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Abstract

ACCESS is the Australian Community Climate Earth-System Simulator [Bi *et al*., 2013], and forms the basis for current and future Australian contributions to CMIP and IPCC activities. ACCESS includes a detailed interactive chemistry and aerosol scheme [UKCA, O'Connor *et al*., 2013]. Other components of ACCESS include the CABLE land surface model [Wang *et al*., 2011], and an ocean model.

ACCESS-UKCA is used here to simulate global tropospheric chemistry over the period 1980-2000. The simulations are nudged to ECMWF ERA-interim reanalysis meteorology, conducted at 1.875 degrees x 1.25 degrees resolution, with 38 vertical levels extending to 42 km in height, with prescribed sea-surface temperatures. Anthropogenic emissions are time-varying, derived from the ACCMIP dataset.

In this work, we focus our attention on the performance of ACCESS-UKCA against observations in the Southern Hemisphere, and particularly Cape Grim. Evaluated species include O_3, CH_4, CO, NO_x

The aim of the evaluation is to benchmark this first iteration of the ACCESS-UKCA chemistry-climate model. An updated version of ACCESS will extend simulations up to 85 km in height, use of an explicit isoprene chemistry mechanism, and inclusion of a microphysical aerosol scheme. Future work will see UKCA used within the fully-coupled atmosphere-ocean configurations for chemistry-climate process studies and long-term climate simulations.

References

Bi, D., M. Dix, S. J. Marsland, S. O'Farrell, H. Rashid, P. Uotila, A. C. Hirst, E. Kowalczyk, M. Golebiewski, A. Sullivan, H. Yan, N. Hannah, C. Franklin, Z. Sun, P. Vohralik, I. G. Watterson, X. Zhou, R. Fiedler, M. Collier, Y. Ma, J. Noonan, L. Stevens, P. Uhe, H. Zhu, S. M. Griffies, R. Hill, C. Harris, & K. Puri, The ACCESS Coupled Model: Description, Control Climate and Evaluation, *Aust. Met. Oceanog. J.*, 63, 41-64, 2013

O'Connor, F. M., C. E. Johnson, O. Morgenstern, N. L. Abraham, P. Braesicke, M. Dalvi, G. Folberth, M. G. Sanderson, P. J. Telford, P. J. Young, G. Zeng, W. J. Collins, & J. A. Pyle,. Evaluation of the new UKCA climate-composition model – Part 2: The Troposphere, *Geosci. Model Dev. Disc*., 6, 1743-1857, 2013

Wang, Y.-P., E. Kowalczyk, R. Leuning, G. Abramowitz, M. R. Raupach, B. Pak, E. van Gorsel, and A. Luhar, Diagnosing errors in a land surface model (CABLE) in the time and frequency domains, *J. Geophys. Res*., 116, G01034, doi:10.1029/2010JG001385, 2011.

Overview of the MUMBA Campaign: Measurements of Urban, Marine and Biogenic Air

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Abstract

The Measurements of Urban, Marine and Biogenic Air campaign (MUMBA) took place in Wollongong, NSW (a city approximately 80 km south of Sydney, Australia) from 21 December 2012 to 15 February 2013. Instruments were deployed during MUMBA to measure the gaseous and aerosol composition of the atmosphere with the aim of providing a detailed characterisation of the complex environment of the ocean/forest/urban interface that could be used to test the skill of atmospheric models. Gases measured included ozone, oxides of nitrogen, carbon monoxide, carbon dioxide, methane and many of the most abundant volatile organic compounds. Aerosol characterisation included total particle counts above 3 nm, total cloud condensation nuclei counting; mass concentration, number concentration size distribution, aerosol chemical analyses and elemental analysis. There was a weather station and a LIDAR for vertical profiles of aerosols and boundary height measurement, and a MAX-DOAS for profiles of aerosols and trace gases (eg O_3 and NO_2). Total column amounts of trace gases are also available from a ground-based solar remote sensing Fourier transform spectrometer the nearby University of Wollongong. In this paper a preliminary overview of the campaign and its findings are given, highlighting the differences in the source regions sampled – i.e. marine, urban and biogenic.

Footprint analysis of upstream source influences on *in situ* CO_2 and CH_4 observations in Wollongong, NSW

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Abstract

Carbon Dioxide (CO_2) and Methane (CH_4) are the most two important greenhouse gases (GHG), playing the significant role in climate system. Attributing observed GHG variations to human or natural cause is critical to deducing and tracking emissions from observations. Attention has focused on assessment of global and regional sources. At the regional scale, STILT, the **S**tochastic **T**ime-Inverted Lagrangian Transport model [e.g. Lin *et al*., 2003], which transports Lagrangian air parcels backward in time from the receptors to provide linkages to the upstream source regions based on a 'footprint' concept has been widely used to assess the surface influence on trace species in observations.

In our study, we have used STILT with *in situ* CO_2 and CH_4 recorded at two sites during the MUMBA ground campaign of 21 December, 2012 to 15 February 2013, in Wollongong, NSW, to derive the upstream influence region, address and compare the relative importance of potential emission hotspot of observed CO_2 and CH_4 based on STILT footprints.

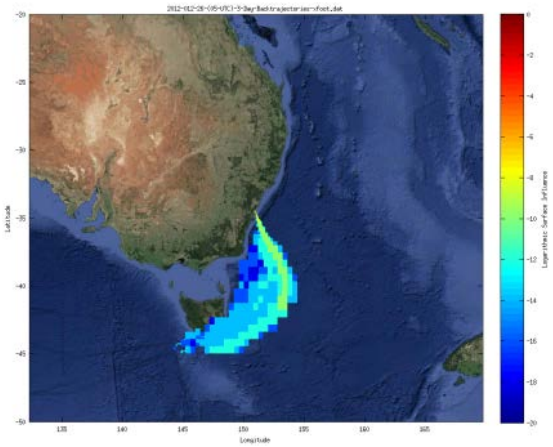


Figure 1. Footprint on 26 December 2012 at MUMBA site.

References

Lin J. C., C. Gerbig, S. C. Wofsy, A. E. Andrews, B. C. Daube, K. J. Davis & C. A. Grainger, A near-field tool for simulating the upstream influence of atmospheric observations: The Stochastic Time-Inverted Lagrangian Transport (STILT) model, *J. Geophys. Res.*, 108, 4493, doi: 10.1029/2002JD003161 , D16, 2003.

VOC Measurements by PTR-MS during the MUMBA Campaign: A First Look at Potential Source Influences

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Abstract

The Measurements of Urban, Marine and Biogenic Air (MUMBA) campaign took place in Wollongong, NSW from 21 December 2012 to 15 February 2013. The main purpose of the campaign was to measure the gaseous and aerosol composition of the atmosphere at the ocean/forest/urban interface in order to provide a detailed characterisation of this complex environment that could be used to test the skill of atmospheric models.

As part of the campaign, ambient mixing ratios of volatile organic compounds (VOCs) were measured by proton transfer reaction mass spectrometry (PTR-MS). We present preliminary pollution roses and explore correlations between selected species.

Development of VOC Monitoring Programs at Cape Grim and Gunn Point

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Abstract

VOCs influence climate by driving tropospheric ozone production and secondary organic aerosol formation and by influencing the oxidative capacity of the atmosphere. The World Meteorological Organisation (WMO) Global Atmosphere Watch (GAW) Program specifies 15 target VOCs (including hydrocarbons, oxygen, nitrogen and sulphur containing species) which should be measured in the background atmosphere. These target VOCs have been selected as tracers for sources of greenhouse gases such as methane, to indicate the extent of atmospheric processing by OH radicals and other oxidants, as precursors of organic and sulphate aerosols, and to provide air mass characterisation [WMO/GAW, 2013]. While the NOAA ESRL Co-operative Air sampling flask program allows a single weekly or fortnightly measurement of nine hydrocarbon species at 41 sampling sites worldwide (including from Cape Grim) [Helmig *et al*., 2009], only five sites worldwide make *in situ* higher time resolution hydrocarbon measurements which are reported to the World Data Centre for Greenhouse Gases (WDCGG), while only one site (Cape Verde) reports *in situ* oxygenated VOC measurements.

We report on development of two VOC monitoring systems, consisting of dual channel online gas chromatographs (GC) with flame ionisation detectors (FID). Once deployed, these systems will provide continuous *in situ* measurements of C2-C7 hydrocarbon and C2-C5 oxygenated VOC measurements at Gunn Point Tropical Atmospheric Observatory and Cape Grim Baseline Station. Details of the initial configuration of these systems, which is being based on the system currently deployed at Cape Verde Observatory [Hopkins *et al*., 2003], will be discussed. A list of VOCs which can be quantitated with this online GC-FID system will be compared with the GAW list of targeted VOCs.

Challenges associated with making trace level VOCs measurements at these two very different sites will be reviewed. Some challenges include the automatic and selective removal of water from sample air, successfully trapping and separating VOCs with a wide range of volatilities from C2 (ethane and acetylene) to C15 (sesquiterpenes) and potential difficulties using a non-selective detector (FID) to quantitate VOCs in complex sample matrices including biomass burning plumes at Gunn Point. In light of these anticipated challenges, possible future configuration changes and optimisation will be discussed.

VOC data obtained from these monitoring programs will be submitted to the WDCGG. VOC data will be integrated with other *in situ* reactive gas measurements including ozone, nitrogen oxides and carbon monoxide, and with measurements of aerosol chemical composition and microphysical properties, to allow an estimation of the SOA contribution to aerosol both in the temperate remote marine boundary layer (MBL) at Cape Grim, and in a tropical airshed impacted by biomass burning at Gunn Point. VOC data will also be used to validate chemistry schemes in chemical transport models, including emission factors for biomass burning events, changes in biomass burning plume composition with aging, and aerosol formation and growth events in the MBL at Cape Grim.

References

Helmig, D., J. Bottenheim,, I. E. Galbally,, A. Lewis,, M. J. Milton,, S. Penkett,, C. Plass-Duelmer,, S. Reimann,, P. Tans,, & S. Thiel, Volatile Organic Compounds in the Global Atmosphere, *Eos Trans. AGU*, 90(52), 513-520, doi: 10.1029/2009EO520001, 2009.

Hopkins, J. R., A. C. Lewis, & K. A. Read, A two-column method for long-term monitoring of non-methane hydrocarbons (NMHCs) and oxygenated volatile organic compounds (o-VOCs), *J. Environ. Monit.*, 5(1), 8-13, 2003.

WMO/GAW, WMO WDCGG *Data Summary No. 37, Greenhouse Gases and other Atmospheric Gases,* 2013.

Understanding Mercury and Ozone Depletion Events over East Antarctic Sea-Ice

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Abstract

Atmospheric chemistry measurements of the polar boundary layer conducted in the spring of 2012 during the Sea-Ice Physics and Ecosystems experiment II are presented. Here we show analyses of bromine radical, mercury, ozone and halocarbon measurements made during the 60 day RV Aurora Australis marine science voyage in the East Antarctic sea-ice zone. The oxidizing capacity of the polar boundary layer during spring is dramatically different from the remote marine boundary layer; driving mercury and ozone depletion events. These processes are driven by bromine released from the first year sea-ice and cause deposition of elemental mercury to the surface where it is available to be converted via microbes to bio-accumulative methyl-mercury. We present preliminary results of total and methyl-mercury from the snow, sea-ice and ocean. This provides the most complete suite of observations to date to improve our understanding of the implications of BrO explosion events in the Antarctic.

Greenhouse Gas Emissions and Ozone from Australia to the Marine Boundary Layer: Measurements from a Circumnavigation of Australia on the RV Southern Surveyor

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Abstract

Despite being one of the most pressing global environmental issues of our time, the impact of the Australasian region on climate change is sparsely investigated. Comprehensive measurements in the marine boundary layer can provide insights of the contribution of the Australian continent on southern hemispheric background conditions.

Here we present in situ observations of the key greenhouse gases CH_4, CO_2, N_2O, O_3 as well as CO and $\delta^{13}C(CO_2)$ in the marine boundary layer measured during a circumnavigation around Australia in 2013 aboard the Australian research vessel 'Southern Surveyor'. Predominantly air downwind of Australia was sampled throughout the cruises, showing signatures of emissions and photochemistry from large metropolitan areas, desert and rain forest, as well as biomass burning.

Backward trajectory analyses were performed to identify the origin of the air masses and to determine correlations between the different trace gases. Strong enhancements around the Top End were predominant when back trajectories indicate that the air mass has travelled over biomass burning regions. This unique dataset will be used in future comparison with global and regional models to characterise the different source attributions and to improve the emission inventories of the Australasian region.

Smoke Composition from the October 2013 NSW Bushfires Measured at Wollongong: A Quick First Look

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Abstract

In the recent October 2013 NSW bushfires west of Sydney, new smoke passed directly over Wollongong, and aged smoke collected in the stable boundary layer overnight and early mornings. We were able to make measurements of the smoke composition during smoke episodes by both solar FTIR spectroscopy through the daytime plumes, and *in situ* measurements on the UoW campus. We present a preliminary overview of the measurements.

Modeling Column Integrated CO_2 and CH_4 Observed during the Greenhouse Gas Monitor Experiment in Tara in August 2013

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Abstract

The Greenhouse Gas Monitor (GGM) Program, which is funded by VIPAC and the Australian Space Research Program (ASRP) has developed a novel, terrestrial instrument to autonomously measure carbon dioxide and other greenhouse gases in the atmosphere. The Program also is using advanced regional models to model the evolution of the measured greenhouse gases and attribute their sources and sinks in an inversion framework.

Here we present results of a GGM measurement campaign that was held in Tara, Queensland in August 2013, where column integrated concentrations of CO_2 and CH_4 from nearby power plants and coal seam gas fields (respectively) were measured. With CO_2 and CH_4 as passive tracers, we model their evolution in the atmosphere by using the Weather Research and Forecasting Chemistry (WRF-CHEM) model. The goal of this research is to use the measurements and simulations in an atmospheric inverse framework to estimate CO_2 fluxes from known sources.

Investigating GOSAT-TCCON Greenhouse Gas Column Variability in the Southern Hemisphere: Wollongong and Darwin

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Abstract

TCCON (Total carbon column Observing Network) is a network dedicated to the accurate and precise measurements of two main anthropogenic greenhouse gases: Carbon dioxide (CO_2) and Methane (CH_4). Other important atmospheric constituents including N_2O, HF, CO, H_2O, and HDO are also measured with high precision. TCCON data is also used to validate current atmospheric remote sensing satellites, e.g. GOSAT (Greenhouse Gases Observing Satellite). TCCON will also be used to validate future satellites (e.g. OCO-2, CarbonSat, GOSAT-2). However, despite the excellent level of agreement that can be achieved between GOSAT and TCCON comparisons, there are still interesting differences in column amounts of CO_2 and CH_4 that occur from time to time, especially in Wollongong. Here, we investigate the possible causes of these differences by examining the distribution of local sources of CO_2 and CH_4. A discussion on potential sites for the planned TCCON expansion in the Southern Hemisphere and beyond will also be shown.

Atmospheric verification of point source fossil fuel CO_2 emissions

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Abstract

Large point sources (electricity generation and large-scale industry) make up roughly one third of global fossil fuel CO_2 emissions. Currently, these emissions are determined from self-reported inventory data, and sometimes from smokestack emissions monitoring, and the uncertainty in emissions from individual power plants is about 20%. There is a need for independent, objective measurements of these emissions both to improve the accuracy of the reported emissions, and for verification as we move towards a regulatory environment.

We use the Kapuni Gas Treatment Plant to examine methodologies for atmospheric monitoring of point source fossil fuel CO_2 emissions. The Kapuni plant, located in rural New Zealand, removes CO_2 from locally extracted natural gas and vents that CO_2 to the atmosphere, at a rate of ~0.1 Tg carbon per year. The plant is located in a rural dairy farming area, with no other significant fossil fuel CO_2 sources nearby, but large, diurnally varying, biospheric CO_2 fluxes from the surrounding highly productive agricultural grassland.

We use measurements of $^{14}CO_2$ to determine the fossil fuel CO_2 component in atmospheric samples from near the Kapuni plant, using two different sampling methods. First, we use flask samples of air collected from a Helikite downwind of the plant. Second, we use samples of grass from the surrounding farmland, in which the ^{14}C content of assimilated CO_2 is faithfully recorded, providing an estimate of the average fossil fuel CO_2 content over the grass growth period of ~ one week.

We use a plume dispersion model to compare the atmospheric observations with the emissions reported by the Kapuni plant, and to determine how well atmospheric measurements can constrain the emissions. We find that the model has difficulty accurately capturing the fluctuations and short-term variability seen in the flask measurements, but good agreement between the modeled and observed fossil fuel CO_2 estimates for the grass samples, suggesting that this passive integrated-sampling method has the potential to monitor long-term emissions. Results from this pilot study indicate that emissions can be verified to within 30%.

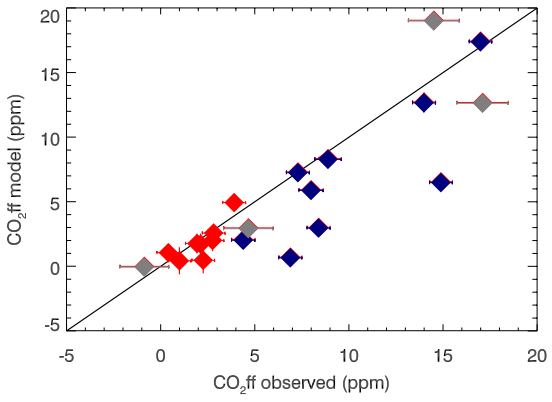


Figure 1. CO_2ff observed and modelled in surface flasks (grey) and grass samples collected in August 2012 (red) and October 2012 (blue).

Accounting for the Discrepancy between Modelled and Measured OH in Forested Environments

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Abstract

The hydroxyl radical, most oxidising species in our atmosphere, has been readily studied and measured in a large number of different environments and conditions. Although its chemistry is fairly well understood and predictable in polluted atmosphere, where chemistry is mainly powered by NO_x, this is not the case in clean and remote forested environments, charactered by high VOCs concentrations. Throughout the past two decades, models have underestimated measured OH and HO_2 concentrations in such environments. In this study, both possibilities for the discrepancies were examined, i.e. missing OH/HO_2 recycling chemistry in models and interferences in the Leeds FAGE cell used to measure OH, HO_2 and RO_2 species. Inspired by thermodynamics calculations, investigation was done on an isoprene derived RO_2 species expected to recycle OH when exposed to near infra-red light; experiments did not support such a mechanism. Internal OH interference from ozonolysis, as well as HO_2 interference from RO_2 species were quantified, allowing correction of data. The OH interference was found to be negligible on the Leeds instrument, and HO_2 interference to be significant from unsaturated VOCs RO_2 species.

A Data Filtering Technique for Monitoring Fugitive Emissions using Atmospheric Measurements at One Location

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Abstract

We developed a method to detect emissions to the atmosphere from sources such as potential leakage from geological CO_2 storage using atmospheric observations and modelling of the CO2CRC Otway Project. The method uses continuous measurements of CO_2 and CH_4 concentrations, CO_2 fluxes and meteorology from one location and selects optimum conditions to remove periods of high and variable concentrations caused by ecosystem emissions and atmospheric conditions. Hour-hour differences of the filtered data, expressed as probability distributions, establish the background variability of CO_2 and CH_4 concentrations above which a leakage signal would need to be detected. Probability distributions of concentration differences when wind trajectories alternate between the Otway storage site and adjacent 'pseudo-upwind' sectors reveal no statistically significant difference compared to the background variability. The sensitivity of the technique is tested by simulating a hypothetical source of CO_2 and CH_4 in the leakage sector which is dispersed using simple plume modelling. Emissions of less than 10 tonnes per day of CO_2 and 0.14 tonnes per day of CH_4 would be revealed by this method in measurements about 700 m from the source. This detection sensitivity compares well with the actual detection and quantification by atmospheric monitoring of emissions from occasional controlled releases of gas at the Otway site and is consistent with the recommended maximum leakage rate for operational-scale geological carbon storage sites to achieve long term climate mitigation. The high sensitivity of the method for detecting CH_4 would be suitable for monitoring emissions from geological seeps and coal seam gas activities.

The Total Carbon Column Observing Network (TCCON)

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Abstract

The Total Carbon Column Observing Network (TCCON; Figure 1) is a network of ground-based Fourier Transform Spectrometers that record direct solar absorption spectra of the atmosphere in the near-infrared. From these spectra, accurate and precise column-averaged abundances of atmospheric constituents including CO_2, CH_4, N_2O, HF, CO, H_2O, and HDO, are retrieved. TCCON measurements are linked to WMO calibration scales by comparisons with co-incident in situ profiles measured from aircraft. For CO_2 TCCON achieves 1σ precision of typically 0.2 μmol mol^{-1} for single measurements, and a network wide comparability of better than 0.1% (0.4 μmol mol^{-1} for CO_2). TCCON data provide the primary validation for satellite-based measurements of these gases, for example from GOSAT, and are increasingly used to constrain models of the global carbon cycle. TCCON was incorporated into GAW in 2009.

In this poster we present the current status of the network, typical data series, and describe ongoing efforts to improve network coverage, precision and accuracy.



Figure 1. TCCON site locations. Currently operational sites are indicated with red circles, and the planned future sites are indicated with blue squares.

References

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

Modelling CO_2 Point Sources with WindTrax

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Abstract

We use WindTrax (Thunder Beach Scientific, Nanaimo, Canada), a Lagrangian stochastic plume dispersion model, to model the emissions of a single CO_2 point source over short distances (~1km) and explore its potential as a tool to monitor CO_2 fossil fuel (CO_2ff) emissions. WindTrax has been successfully used in backward Lagrangian stochastic (bLS) simulations to estimate unknown trace gas (e.g. ammonia, methane) emission rates from large area sources such as livestock feedlots. In a new application, we run forward model simulations of CO_2 emissions, starting from known emission rates of a point source, the Kapuni Gas Treatment Plant in rural Taranaki, New Zealand, and evaluate the accuracy of the model by comparing results with CO_2 and ^{14}C measurements in the area surrounding the source.

We examine strengths and limitations of the model for this application, testing its performance over short (~1-5 minutes) and longer (~1 week) time-averaging intervals and varying model parameters such as atmospheric stability and stack height. We find that integrated averaging over longer times produces better correlation between measurements and modeled results, likely because rapid fluctuations in wind speed and direction can occur over short time intervals (on the order of a few minutes or less), and small errors in simulated wind direction result in large errors in the precise location of the modelled plume. Agreement between the model and observations at specific sampling locations and times is very sensitive to the model's ability to locate the plume correctly; however, these errors tend to average out over the longer term, and the model reproduces our observed concentrations to within 30% over time periods of ~15 minutes and one week. Varying the atmospheric stability parameter reveals that in general, the model is insufficiently dispersive in the horizontal and is better at replicating broad patterns of observations rather than those on a finer scale. Only basic meteorological information (wind speed and direction, temperature and pressure) was available to run our simulations, forcing the model to estimate important surface layer parameters; model accuracy could be improved with more detailed observations of actual turbulence and atmospheric stability, such as those obtained with a sonic anemometer.

Despite some limitations, we demonstrate that WindTrax has the ability to model point source emissions on a local scale over longer time periods. Further work is required to quantify uncertainty associated with the model and to apply it to different emissions sources and landscapes.

What can Observations of O_2/N_2 and CO_2 at Maquarie Island tell us about the Future of the Ocean Carbon Sink?

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Abstract

There are substantial gaps in our understanding of how the Southern Ocean carbon sink will respond to future climate change, because many processes that are critical to understanding this carbon sink are poorly represented in the current generation of ocean models [Böning *et al*., 2008; Rodgers *et al*., 2013].

Observations of atmospheric O_2/N_2 ratios and CO_2 in the atmosphere may provide a window onto the complex interactions between atmospheric wind stress, ocean dynamics, and biology in the Southern Ocean and improve our ability to predict the fate of the Southern Ocean carbon sink. Since photosynthesis and fossil fuel burning absorb and release CO_2 and O_2 with known stoichiometric ratios, these species can be combined to form a tracer that is free from terrestrial influences, known as atmospheric potential oxygen (APO)[Stephens *et al*., 1998].

Here, we force an atmospheric transport model with air-sea fluxes from a suite of different ocean models in order to explore where observing sites could be best placed in order to evaluate and better understand differences between ocean models. Our results suggest that Macquarie Island may be an excellent location for a continuous O_2/N_2 observing station in order to evaluate ocean models and understand processes that have a major impact on carbon uptake by the ocean. In addition, we demonstrate that processes that lead to differences in seasonal, intra-seasonal, and interannual variability in APO can also have a major impact on decadal trends in carbon uptake, highlighting the critical role of contemporary observations on understanding our future.

References

Böning, C. W.; A. Dispert, M. Visbeck, S. R. Rintoul; F. U. Schwarzkopf, The response of the Antarctic Circumpolar Current to recent climate change, *Nature Geoscience*, 1(12), 864-869, doi: 10.1038/ngeo362 ,2008.

Rodgers, K. B., O. Aumont, S. E. Mikaloff Fletcher, Y. Plancherel, L. Bopp, C. de Boyer Montégut, D. Iudicone, R. F. Keeling, G. Madec & R. Wanninkhof, Strong sensitivity of Southern Ocean carbon uptake and nutrient export to surface wind stirring, *Biogeosciences Disc.*, doi:10.5194/bgd-10-15033-2013, 2013.

Stephens, B. B., R.F. Keeling, M. Heimann, K.D. Six, R. Murnane & K. Caldeira, Testing global ocean carbon cycle models using measurements of atmospheric O_2 and CO_2 concentration, *Global Biogeochem. Cycles*, 12(2), 213– 230, doi:10.1029/97GB03500, 1998.

Long Term Record of Aerosol Chemical Composition at Cape Grim Baseline Station

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Abstract

Aerosols can have direct effects on the climate by scattering and absorbing light or indirectly by modifying cloud properties. A major goal of the Global Atmosphere Watch(GAW) Programme is to ensure long-term measurements of atmospheric constituents in order to detect and explain trends. The Scientific Advisory Group for aerosols recommends that GAW stations measure the mass concentration of major chemical components in PM10(coarse) and PM2.5(fine) aerosols.

PM10 samples have been collected at Cape Grim since 1976 and the mass is dominated by alkaline sea salt particles that can cause positive and negative chemical artefacts. Ammonium is almost completely lost on the PM10 samples through the conversion to ammonia. PM2.5 samples have been collected since 2002 and the sea salt mass is reduced by more than two thirds compared to the PM10 samples so that any positive or negative artefacts are greatly reduced. Hence PM2.5 samples are more suitable for investigating the detailed chemical composition of the aerosol.

The PM2.5 samples show a clear seasonal cycle with a summer maximum and winter minimum for methane sulfonate, non sea salt sulfate, ammonium, nitrate and oxalate (Figure 1). Sodium and chloride do not show a seasonal cycle, however a seasonal cycle is observed in the chloride/sodium ratio, with a maximum in winter of 1.13 close to the seawater ratio of 1.17 and a minimum in summer of 1.04. This indicates a loss of chloride which could have been displaced by sulphuric and nitric acid. The measured water soluble aerosol chemistry accounts for 90% of the mass in the summer month of December and 77% of the mass in the winter month of June. Higher concentrations of methane sulfonate, non sea salt sulfate, ammonium, nitrate and oxalate in summer is likely due to the photo-oxidation of precursor species. The 10% of mass unaccounted for in summer and 23% unaccounted for in winter may be due to components with a low water solubility, such as freshly emitted primary organic aerosol.

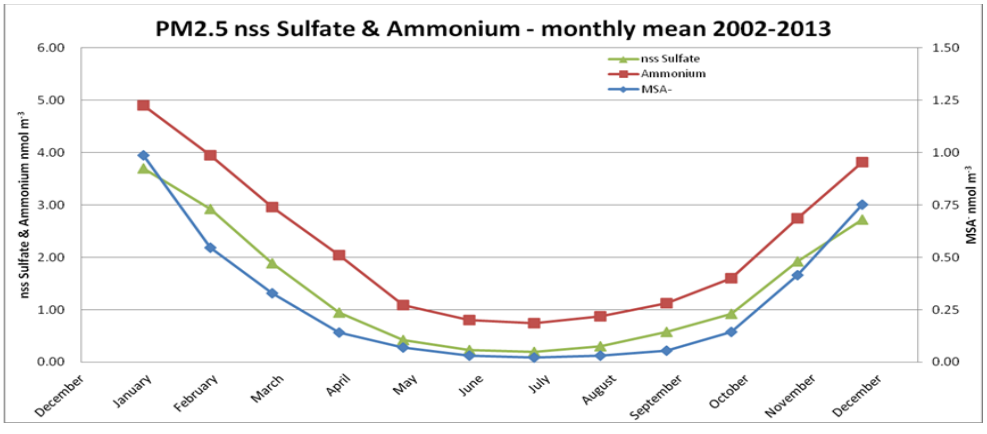


Figure 1. Monthly averaged concentrations of secondary aerosol components.

Continuation of the ANSTO/NIWA ^{14}C of Atmospheric Methane Program

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Abstract

At last year's meeting we reported on ^{14}C of CH_4 measurements undertaken at ANSTO [Smith 2012]. These samples were derived from the NIWA atmospheric methane program, frozen back into glass breakseals following measurement for CH_4 concentration and $\delta^{13}C$ of CH_4 at NIWA, NZ. All of these samples were converted to graphite using the laser heated microfurnace [Yang, 2011; Smith, 2010 a, b], developed at ANSTO and designed for the efficient graphitisation of micro-samples, containing as little as a few micrograms of carbon.

At that time there were three sample sets: 62 from Baring Head, NZ (BHD), collected each ~20 days between March 2009 and May 2012, 18 from Arrival Heights, Antarctica (SCT), collected each ~37 days between February 2008 and November 2009, plus 66 samples taken along Pacific Ocean voyages from Nelson (NZ) – Osaka (Japan) in 2008, 2009 and 2011 (FTW). Additional samples were prepared to establish the procedural background correction for the overall extraction and measurement process.

Since then we have added to the FTW and BHD data sets. We present results from the June 2012 (25 samples) and March 2013 (22 samples) Pacific Ocean voyages, along with a further 21 samples from Baring Head (mostly from 2012 and 2013). Again, all samples were prepared using the microfurnace and were measured on the ANTARES accelerator at ANSTO. The mean sample size for these new samples was also ~ 17 µg of carbon as CO_2.

CH_4 concentrations (Figure 1a) show a clear anthropogenic increase over the 5-year period (2008-2013). A North-South (NS) gradient is obvious due to the larger sources in the northern hemisphere. This is also reflected by the larger spread in the Japan end of the cruise track. The air near New Zealand originates mainly from the Southern Ocean and Antarctica and has thus very low methane concentration and the year-to-year and seasonal variability is low, as shown in the Baring Head measurements. The values in the southern latitudes (20°S to EQ) in 2013 suggest possible larger weather influence than in 2008-2012.

$\delta^{13}C$ shows [Figure 1b) much less spread in the NZ end of the cruise track, similarly to CH_4. The N-S gradient is present during all years, although it is weaker during the 2012 cruise, as for CH_4. We speculate that this is due seasonal effects, as this cruise took place in NH summer, while all other cruises took place in NH autumn/winter. The radiomethane concentrations (Figure 2) indicate a very slight N-S gradient as well, which is opposite to that of $\delta^{13}C$ with lower values in the SH. However, the fluctuations are large. The difference between 2012 and the other years is not distinctive, suggesting a reduced seasonal variability in the sources or sinks. The February/March 2013 samples are being measured for ^{14}C in November and the results will be available at the meeting

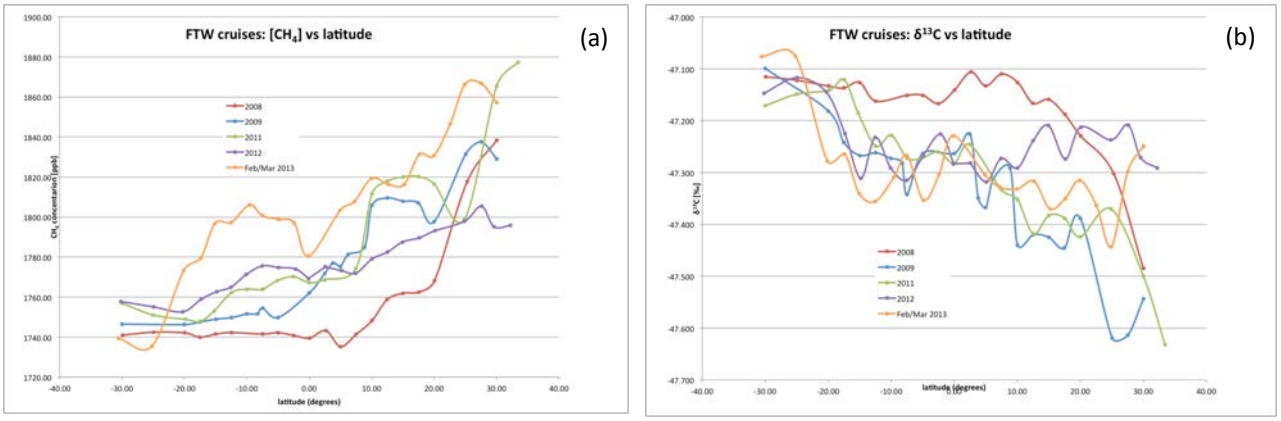


Figure 1. a) $^{14}CH_4$ concentrations and b) $\delta^{13}C$ (permil) measured in the breakseal samples

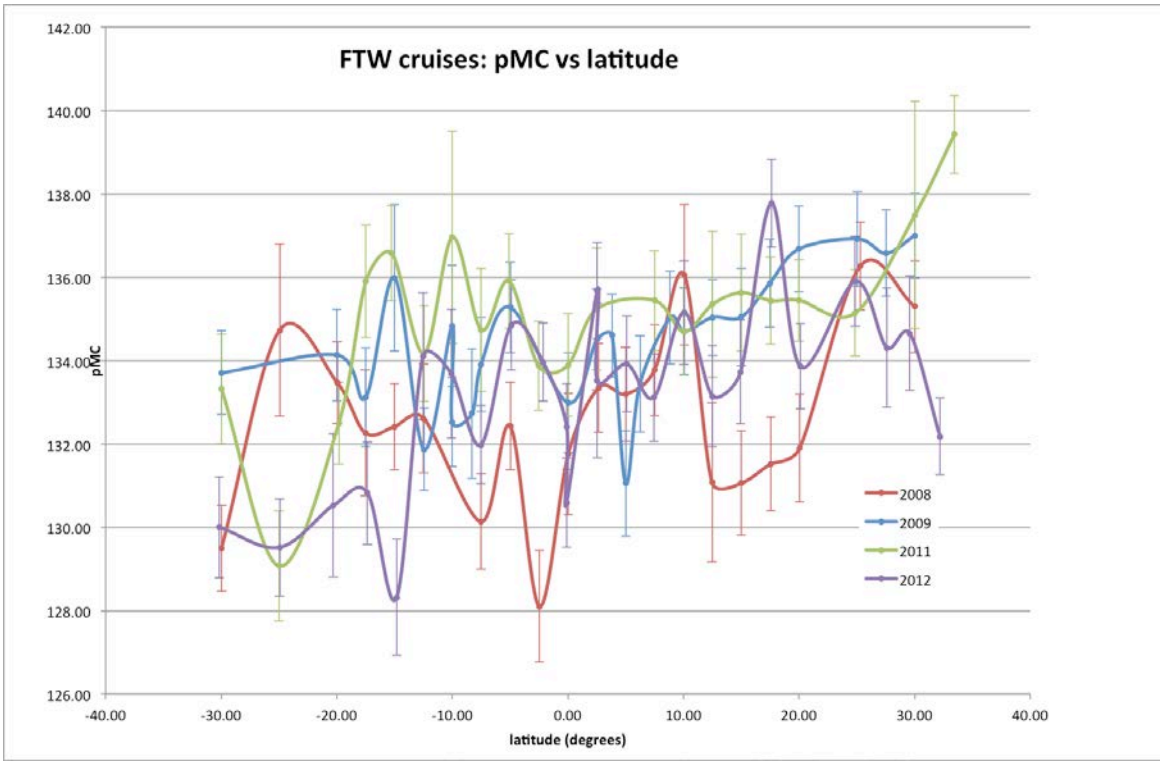


Figure 2. The measured $^{14}CH_4$ (percent Modern Carbon, pMC) for four cruises.

To investigate whether the origin of air explains these observations we performed trajectory simulations going 10 days backwards from each point of measurement. The simulations were performed using the FLEXPART particle dispersion model. As an example, the calculated trajectories during 2008 (Figure 3) show a distribution of source areas of air: near NZ the air mainly originates from the Southern ocean and Antarctica. Further along the ship track, air is sampled from Australia and tropical west Pacific. In the tropics (both southern and northern) the air originates from the west Pacific. In the NH the source is in the Pacific. Only the northernmost samples close to Japan collect air from the Asian continent: China and Siberia. The origin varies in altitude, ranging from the surface till the upper troposphere but not the stratosphere.

We present the measurement and model data we have to date and our early interpretations. A further FTW data set from the May 2013 cruise will be processed and measured early in 2014.

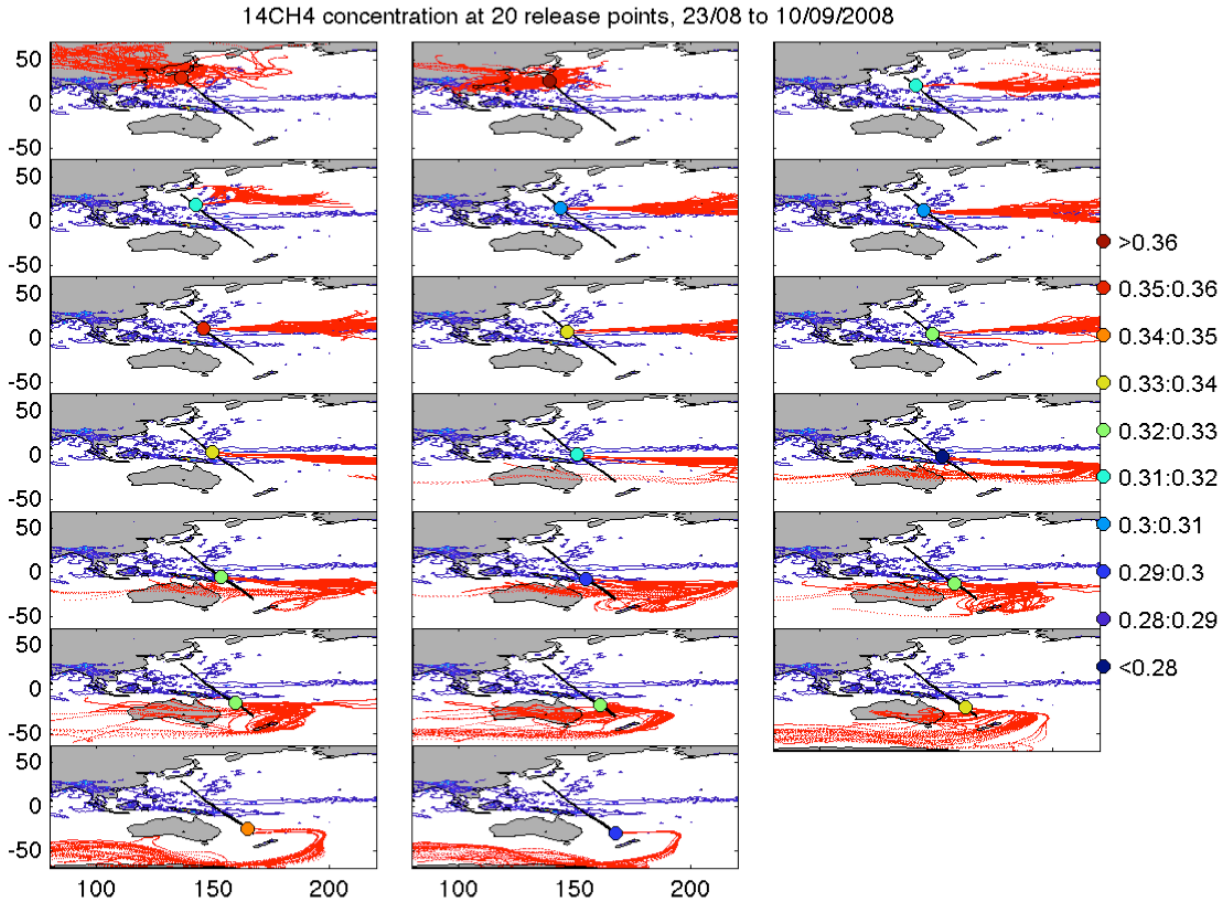


Figure 3. FLEXPART simulated 10-day back-trajectories from each point of measurement in 2008 (NH autumn/winter - SH spring/summer).

References

Smith, A. M., B. Yang, T. Bromley, R. Martin, G. Brailsford & U. Heikkilä, Early results from the ANSTO/NIWA ^{14}C of atmospheric methane program, in *ACOMC-CGASM2012* [abstracts], 28-30 November 2012, South Durras, NSW, University of Wollongong, CSIRO and Bureau of Meteorology, 17, 2012.

Yang, B., A.M. Smith, & Q. Hua, A cold finger cooling system for the efficient graphitisation of microgram-sized carbon samples, accepted for publication in *Proceedings of 12th International Conference on Accelerator Mass Spectrometry*, 20-25 March 2011, Wellington, New Zealand, GNS Science, 214, 2011.

Smith, A. M., B. Yang, Q. Hua, & M. Mann, Laser-heated microfurnace – gas analysis & graphite morphology, *Radiocarbon*, 52(2-3), 769-782, 2010a.

Smith, A. M., Q. Hua, A. Williams, V. Levchenko, & B. Yang, Improvements in micro-sample ^{14}C AMS at the ANTARES AMS facility, *Nucl. Instr. Meth. Phys. Res.*, B 268, 919–923, 2010b.

Long-term Observations of Tropospheric Ozone: GAW Measurement Guidelines

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Abstract

The Global Atmosphere Watch (GAW) Programme of the World Meteorological Organization (WMO) coordinates long-term observations of the chemical composition and physical properties of the atmosphere which are relevant for understanding of atmospheric chemistry and climate change. Atmospheric observations of reactive gases (tropospheric ozone, carbon monoxide, volatile organic compounds and nitrogen oxides) coordinated by the GAW Programme complement local and regional scale air quality monitoring efforts.

As part of the quality assurance (QA) system developed within the GAW Programme detailed measurement guidelines for atmospheric trace species are developed by international expert teams at irregular intervals. The most recent report focuses on continuous in-situ measurements of ozone in the troposphere, performed in particular at continental or island sites with altitudes ranging from sea level to mountain tops. Data Quality Objectives (DQOs) are defined for different applications of the data (e.g. trend analysis and verification of global model forecasts), and they include a thorough discussion about the tolerable level of measurement uncertainty and data completeness. The guidelines present the best practices and practical arrangements adopted by the GAW Programme in order to enable the GAW station network to approach or achieve the defined tropospheric ozone DQOs. This includes information on the selection of station and measurement locations, required skills and training of staff, recommendations on the measurement technique and the necessary equipment to perform highest quality measurements, rules for conducting the measurements, preparing the data and archiving them, and more. Much emphasis is given to discussions about how to ensure the quality of the data through tracing calibrations back to primary standards, proper calibration and data analysis, etc. In the GAW Programme the QA system is implemented through Central Facilities (Central Calibration Laboratory, World and Regional Calibration Center and World Data Center), who support primary standards, organize comparison campaigns and station audits, collect, archive and disseminate the observational data and data products, provide documentation and support training of station personnel.

References

Guidelines for Continuous Measurement of Ozone in the Troposphere, GAW Report No 209, Publication WMO-No. 1110, ISBN 978-92-63-11110-4, World Meteorological Organisation, Geneva Switzerland, 76pp., 2013 http://www.wmo.int/pages/prog/arep/gaw/gaw-reports.html

Seasonality of Soluble Aerosol Iron in the Southern Ocean

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Abstract

Past changes in the atmospheric deposition of soluble iron (Fe_s) to high nutrient low chlorophyll (HNLC) and tropical waters may have stimulated primary production, drawing down atmospheric CO_2 and thus initiating changes in global climate. An understanding of the sources (mineral dust, biomass emissions, fuel combustion, extra-terrestrial dust) and geochemistry of Fe_s in atmospheric aerosols is critical for determining the impact of Fe deposition on ocean fertility in the past and the future. Here we present a seasonally resolved record of Fe_s concentrations derived from aerosols transported from the Southern Ocean and collected at Cape Grim Baseline Air Pollution Station, northwest Tasmania. Seasonal variability in Fe_s concentrations is attributed to changes in source.

Second Generation Laser Heated Microfurnace for Graphitisation of Microgram Samples

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Abstract

At ANSTO we have recently commissioned and tested a second generation laser heated microfurnace (MF Mark-II). Like the prototype unit, this has been designed to produce targets for the measurement of ^{14}C by accelerator mass spectrometry which contain as little as a few micrograms of carbon. Based on our systematic studies aimed at optimising the performance of the prototype, (Yang 2013; Smith 2010a,b), we constructed the MF Mark-II to have the following features: 1) a small reactor volume of 0.25 cc allowing us to graphitise very small carbon dioxide samples containing 2µg of carbon with near 100% reaction efficiency and low background, 2) it can operate over a large pressure range (0 to 2 bar) and has the capacity to graphitise CO_2 samples containing up to 80 µg of C; 3) it is compact, with three valves integrated into the microfurnace body, 4) these valves can be controlled electronically, enabling automation of the process through the LabVIEW interface, 5) it is compatible with the new version of the conventional small-sample graphitisation furnace and shares a common vacuum system. We use a 'budget' fibre packaged array for the diode laser with custom-built focusing optics. The use of a new IR thermometer with a short focal length has allowed us to decrease the height of the unit. This has resulted in a cheaper and more compact device. As with the MF Mark-I, feedback control of the catalyst temperature and logging of the reaction parameters is handled by a LabVIEW interface.

References

Yang, B., A.M. Smith & Q. Hua, A cold finger cooling system for the efficient graphitisation of microgram-sized carbon samples, *Nucl. Instr. & Meth. Phys. Res.*, B294 (2013) 262-265, 2011.

Smith, A.M., B. Yang, Q. Hua & M. Mann, Laser-heated microfurnace – gas analysis & graphite morphology, Radiocarbon, 52(2-3), 769-782, 2010a.

Smith, A.M., Q. Hua, A. Williams, V. Levchenko, & B. Yang, Improvements in micro-sample ^{14}C AMS at the ANTARES AMS facility, *Nucl. Instr. & Meth. Phys. Res.*, B268, 919-923, 2010b.

The Global Atmosphere Watch (GAW) Activities Programme in Malaysia

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Abstract

Malaysia has participated in WMO-GAW programme since 2003 with the establishment of its GAW global station in Danum Valley, Sabah. Presently, Malaysia through the Malaysian Meteorological Department (METMalaysia) is operating three GAW monitoring stations, namely GAW global (baseline) station in Danum Valley (DV) and two GAW regional stations which are located in Cameron Highlands (CH) and Petaling Jaya (PJ). The DV Global GAW station is situated in the pristine tropical forest representing background atmosphere of the equatorial rain forest. Among the monitoring programmes established at the station are the aerosols physical & optical properties and mass concentration (aerosol absorption coefficient, aerosol scattering coefficient and aerosol optical depth), greenhouse gases (surface ozone and carbon dioxide), precipitation chemistry and persistent organic pollutants (POPs).

The CH and PJ GAW regional stations are representing the developing rural and urban site respectively. The CH station is surrounded by tea plantations and other agricultural practices and its air quality is very much influenced by these activities. Among the pollutants monitored at this station are particulate matter (PM10), total suspended particulate (TSP), acid depositions, reactive gases (NO, NO_2, NO_x, SO_2, CO) and surface ozone. Whilst, PJ station which is situated in the Klang Valley, in which most of the atmospheric pollutants in this urban site contributed mainly from the fuel combustion of motor vehicles and industrial processes. Among the parameter monitored at this station are particulate matter (PM10), total suspended particulate (TSP), acid depositions, total column ozone and UV radiation.

These three GAW monitoring stations especially the Danum Valley Global GAW Station are actively engaged in several collaboration projects with national and international institutes of higher learning and research agencies in the areas of environmental research and atmospheric monitoring. Some of the research findings based on the data analyses are discussed and explained in this poster.

References

Mohamad, M., S. Urban, S. Shangari & Y. Y. Toh, The Status of Acid Deposition in Malaysia Based on Malaysian Meteorological Department (MMD) Data Analysis from 1994 - 2008, *Malaysian Meteorol Dept., No.2*, 2010.

Abdullah, N. A., S. H. Shuhaimi, Y. Y. Toh, A. H. Shapee and M. Mohamad, The Study of Seasonal Variation of PM10 Concentration in Peninsular, Sabah and Sarawak, *Malaysian Meteorol Dept., No.9*, 2011.

Zakaria, N., M. F. Jahaya, Y. Y. Toh, M. R. Abdul Rahman and M. Mohamad, The Analysis of Dry Deposition of Acidifying Substance Between Urban and Developing Rural Station of Malaysian Meteorological Department from 2007-2010, *Malaysian Meteorol Dept., No.1*, 2013.

van der Schoot, M., Y. K. Tiwari, I. C. Shin, S. Y. Park and M. Mohamad, Asia GAW Greenhouse Gases Newsletter 2012, *KMA, No.3*, 2012.

Report on Monitoring and Research Activities at the Global Atmosphere Watch (GAW) Station, Bukit Atur, Danum Valley 2012

Earth System Research Laboratory (NOAA) Global Monitoring Division, http://www.esrl.noaa.gov/gmd/ccgg/trends

World Meteorological Organization, http://www.wmo.int/pages/prog/arep/gaw/gaw_home_en.html

Australian Synthetic Greenhouse Gas (SGG) Emissions

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Abstract

Global emissions of synthetic greenhouse gases (SGGs), comprising emissions of hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6), regulated under the Kyoto Protocol, and emissions of chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs) etc., regulated via production and consumption controls under the Montreal Protocol, are a fast-growing greenhouse gas (GHG) emission sector [Forster, P. & V. Ramaswamy *et al*., 2007; Daniel, J. & G. Velders *et al*., 2011; Montzka, S. & S. Reimann *et al*., 2011]. Over the past 50 years, the climate change impact of the collective emissions of SGGs exceeded that of methane (CH_4), becoming the second most import GHG emission sector climatically over this period after carbon dioxide (CO_2).

All of the important SGGs in the Australian and Southern Hemispheric polar atmospheric environments have been measured continuously since the late-1990s by CSIRO and the Bureau of Meteorology at Cape Grim, Tasmania, since 1978 in the Cape Grim air archive and since the 1940s in Antarctic firn air. From these data, and other SGG data collected globally, CSIRO and colleagues at MIT, SIO and NOAA have been able to estimate global and regional, including Australian, emissions of SGGs [Prinn *et al*., 2000; O'Doherty *et al*., 2004; Dunse *et al*., 2005; Miller *et al*., 2010; Mühle *et al*., 2010; Rigby *et al*., 2010].

CSIRO estimates of Australian SGG emissions (Kyoto and Montreal) are reported annually to the Australian government. The Australian government independently estimates Australian emissions of the Kyoto SGGs from industry data, using Intergovernmental Panel on Climate Change (IPCC) recommended methodologies, for the National Greenhouse Accounts (NGA). These Kyoto SGG emission estimates, as well as those from CSIRO, are reported annually to the United Nations Framework Convention on Climate Change (UNFCCC), fulfilling Australia's GHG emissions reporting obligations under the Kyoto Protocol [DIICCSRTE, 2013].

In this paper, the CSIRO/UKMO estimates of Australian SGG emissions will be reported, and their contribution to Australian GHG emissions evaluated. The CSIRO/UKMO emission estimates for individual and combined SGGs will be compared to those in the NGA. Significant differences, where they exist, will be discussed. Details of future work to improve the accuracy and precision of CSIRO/UKMO SGG emission estimates will be discussed.

References

Forster, P. & V. Ramaswamy *et al*., Changes in Atmospheric Constituents and in Radiative Forcing, Chapter 2 in *Climate Change 2007: The Physical Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, S. Solomon *et al*. (eds.), Cambridge University Press, Cambridge, UK & New York, NY, USA, 129-234, 2007.

Daniel, J. & G. Velders *et al*., A Focus on Information and Options for Policymakers, Chapter 5 in *Scientific Assessment of Ozone Depletion: 2010, WMO Global Ozone Research and Monitoring Project – Report No. 52*, 5.1-5.56, 2011.

Montzka, S. & S. Reimann *et al*., Ozone-Depleting Substances (ODSs) and Related Chemicals, Chapter 1 in *Scientific Assessment of Ozone Depletion: 2010, WMO Global Ozone Research and Monitoring Project – Report No. 52*, 1.1-1.108, 2011.

Prinn, R., R. Weiss, P. Fraser, P. Simmonds, D. Cunnold, F. Alyea, S. O'Doherty, P. Salameh, B. Miller, J. Huang, R. Wang, D. Hartley, C. Harth, P. Steele, G. Sturrock, P. Midgley & A. McCulloch, A history of chemically and radiatively important gases in air deduced from ALE/GAGE/AGAGE, *J. Geophys. Res*., 105 (D14), 17751-17792, doi: 10.1029/2000JD900141 , 2000.

O'Doherty, S., D. Cunnold, A. Manning, B. Miller, R. Wang, P. Krummel, P. Fraser, P. Simmonds, A. McCulloch, R. Weiss, P. Salameh, L. Porter, R. Prinn, J. Huang, G. Sturrock, D. Ryall, R. Derwent & S. Montzka, Rapid growth of hydrofluorocarbon-134a and hydrochlorofluorocarbons-141b, -142b, and -22 from Advanced Global Atmospheric Gases Experiment (AGAGE) observations at Cape Grim, Tasmania, and Mace Head, Ireland, *J. Geophys. Res*., 109, doi:10.1029/2003JD004277, 2004.

Dunse, B., P. Steele, S. Wilson, P. Fraser & P. Krummel, Trace gas emissions from Melbourne Australia, based on AGAGE observations at Cape Grim, Tasmania, 1995-2000, *Atmos. Environ*., 39, 6334-6344, doi:10.1016/j.atmosenv.2005.07.014, 2005.

Miller, B., M. Rigby, L. Kuijpers, P. Krummel, P. Steele, M. Leist, P. Fraser, A. McCulloch, C. Harth, P. Salameh, J. Mühle, R. Weiss, R. Prinn, R. Wang, S. O'Doherty, B. Greally & P. Simmonds, CHF_3 (HFC-23) emission trend response to $CHClF_2$ (HCFC-22) production and recent CHF_3 emissions abatement measures, *Atmos. Chem. Phys*., 10, 7875-7890, doi:10.5194/acp-10-7875-2010, 2010.

Mühle, J., A. Ganesan, B. Miller, P. Salameh C. Harth, B. Greally, M. Rigby, L. Porter, P. Steele, C. Trudinger, P. Krummel, S. O'Doherty, P. Fraser, P. Simmonds, R. Prinn & R. Weiss, Perfluorocarbons in the global atmosphere: tetrafluoromethane, hexafluoroethane and octofluoropropane, *Atmos. Chem. Phys*., 10, 5145-5164, doi:10.5194/acp-10-5145-2010 , 2010.

Rigby, M., J. Mühle, B. Miller, R. Prinn, P. Krummel, P. Steele, P. Fraser, P. Salameh, C. Harth, R. Weiss, B. Greally, S. O'Doherty, P. Simmonds, M. Vollmer, S. Reimann, J. Kim, K. Kim, R. Wang, J. Olivier, E. Dlugokencky, G. Dutton, B. Hall & J. Elkins, History of atmospheric SF_6 from 1973 to 2008, *Atmos. Chem. Phys*., 10, 10305-10320, doi:10.5194/acp-10-10305-2010, 2010.

DIICCSRTE 2013, Australian National Greenhouse Accounts, National Inventory Report 2011, Volume 1, Department of Industry, Innovation, Climate Change, Science, Research and Tertiary Education, April 2013, 299 pp.

Recent and Future Trends in Synthetic Greenhouse Gas Radiative Forcing

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Abstract

For more than 30 years, measurements from the Advanced Global Atmospheric Gases Experiment (AGAGE) have tracked the atmospheric concentrations of long-lived 'synthetic' greenhouse gases (LLSGHG; substances with no significant natural sources and atmospheric lifetimes of more than one year). The radiative forcing due to these gases, which is currently dominated by the chlorofluorocarbons (CFCs), has shown only modest growth since the 1990s, compared to earlier decades, primarily due to the global CFC phase-out under the Montreal Protocol. AGAGE observations show that the growth in radiative forcing due to LLSGHG is now being driven by CFC replacements and other compounds, some of which are also due to be phased out under the Montreal Protocol in the near future (hydrochlorofluorocarbons; HCFCs), and some of which are currently un-regulated at the global scale (hydrofluorocarbons; HFCs, and perfluorinated compounds; PFCs). Projections of the use of HFCs and PFCs in the coming decades indicate that they could make a substantial contribution to anthropogenic radiative forcing. In light of this, we examine the potential impact of a recently proposed HFC phase-down schedule, and find that it could be sufficient to reduce the overall radiative forcing due to LLSGHGs for the first time since they emerged in the atmosphere. However, action must be taken to develop more complete reporting of global HFC and PFC emissions, of which less than 50% are currently accounted for, according to AGAGE-derived estimates.

The CMAR Carbon Dioxide Isotope Scale: Finished at Last?

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Abstract

For over 30 years, CSIRO Marine & Atmospheric Research's GASLAB has been measuring the stable isotopic composition of carbon dioxide (CO_2) at Cape Grim using two programs: the Cape Grim *in situ* program (CIA: CO_2 cryogenically extracted at Cape Grim) and the Cape Grim flask program (CGO: part of the global air sampling program). Samples from both programs are analysed in GASLAB using an isotope ratio mass spectrometer (IRMS). Over the 30 years, the agreement between the two programs has varied considerably, from excellent (no difference) to unacceptable, as various iterations of the calibration procedures were developed. A third, and independent, check on the calibration procedures has been provided by the flask air sharing program CMAR operates with the NOAA-ESRL/INSTAAR group.

Aided by the agreement (or disagreement) between these 3 Cape Grim records, we have revised the mechanism by which the CMAR calibration scale is tied to the international VPDB-CO_2 scale several times as more information has been assessed [e.g. Allison & Francey, 2007]. The most recent revision has just been completed and ties the CMAR calibration scale to that generated by the WMO central calibration laboratory (CCL) for stable isotopes of CO_2 in Jena, Germany.

We will describe the improvements made to the CMAR calibration scale and attempt to answer the question: Is this the final scale?

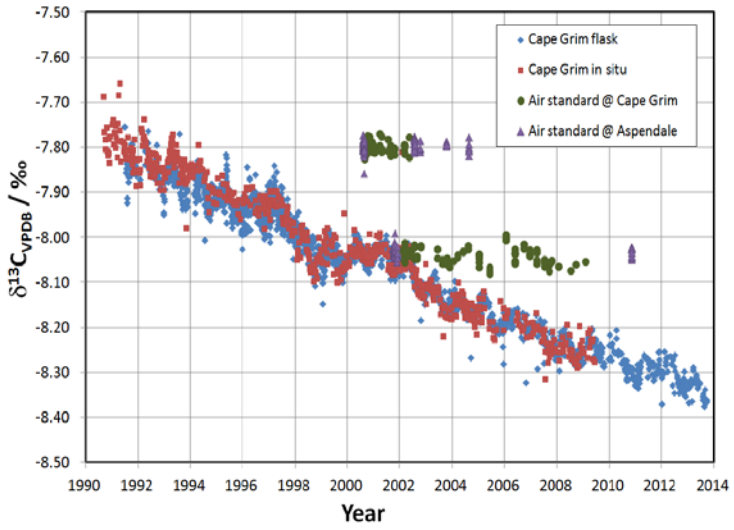


Figure 1. The $\delta^{13}C_{VPDB}$ of atmospheric CO_2 at Cape Grim from the two programs: 1990 through 2013. Also shown are results from the analysis of tanks of air at Cape Grim and Aspendale that have been used to assess the performance of the two programs.

References

Allison, C. E. & R. J. Francey, Verifying southern hemisphere trends in atmospheric carbon dioxide stable isotopes, *J. Geophys. Res.*, 112(D21304), doi:10.1029/2006JD007345, 2007.

Greenhouse Gas Network Design: Results from a Case Study for Australia

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Abstract

Monitoring major greenhouse gases (GHGs) such as carbon dioxide (CO_2) is important, not only for the continuous observation of atmospheric concentrations in order to detect global trends, but also for deriving GHG fluxes and their uncertainties on a regional scale. Here, we aim to assess how the current network of GHG ground based measurement stations in Australia can be extended to reduce the uncertainties on Australian GHG flux estimates. This is done by optimising the location of proposed stations for CO_2 while also considering logistic constraints such as availability of supporting infrastructure and accessibility and maintenance of the site.

The Lagrangian Particle Dispersion Model (LPDM) is used for the inversion of atmospheric transport and a genetic algorithm is applied for the optimisation of the network. Driving fields are provided using the high resolution (12km) operational version of the Australian Community Climate and Earth System Simulator for the Australian region (ACCESS-R). Prior estimates of CO_2 fluxes for the Australian biosphere are obtained from high resolution model simulations.

We present results from various optimisation scenarios using the location of existing ground based measurement stations as a base network. Existing stations are able to reduce the uncertainties on CO_2 flux estimates for Australia by more than 30%. Potential new measurement locations that are considered in the optimisation framework comprise the stations in the Australian Bureau of Meteorology weather watch radar network. Although the results differ for each season reflecting the change in the dominant wind direction, the optimal new measurement stations are mostly placed in the northern and eastern part of the Australian continent. A further 20% reduction in uncertainty on CO_2 flux estimates can be achieved by adding 4 new stations to the existing network.

Carbon Dioxide Modelling in ACCESS NWP Model

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Abstract

An accurate knowledge of the carbon dioxide concentration is important for modeling of the radiative processes in the atmosphere, the land-atmosphere flux exchange and the chemical composition of the atmosphere in the ACCESS NWP model. Recent developments in the data assimilation of satellite radiances using radiative transfer model as an observational operator is an additional motivation for understanding and assessing the effects of CO_2 on NWP models.

We present an evaluation of the global variability of CO_2 and compare it to observations over Australia. This is used to design a sensitivity study of the ACCESS model data assimilation system to CO_2 levels. We simulate IASI radiances for channels, which are responsive to carbon dioxide, and compare the results with satellite-measured radiances. Simulations show that using a realistic three-dimensional variable CO_2 arrives closer to the measured radiances compared to simulations with constant global CO_2. Until recently ACCESS was using lesser CO_2 concentration, however a newer model version would allow for variable CO_2 to be included.

Carbon Dioxide Observations at Baring Head, New Zealand

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Abstract

The *in situ* observation of atmospheric carbon dioxide has been undertaken at Baring Head (41.4°S, 174.4°E) New Zealand for over 40 years [Brailsford *et al*., 2012] with the key goals of understanding the processes that drive variability and change in the carbon cycle. Measurements at the site have always been linked directly to the central calibration labs (SIO and NOAA) to assist in ensuring that the data collected are compatible with observations made at other sites making similar measurements as part of a global network. Analysis of the 40 year record demonstrates long term growth rate and the key drivers in the seasonal cycle of CO_2 at the site [Stephens *et al*., 2013].

As the station is located in the mid-latitudes of the southern hemisphere it is influenced heavily by ocean processes, and while changes in the southern ocean carbon cycle potentially have a significant effect on the hemispheric and global carbon cycle the observed changes at individual stations are small. For this reason NIWA has joined with CSIRO and LSCE in constraining the CO_2 observations at southern hemisphere network stations through regular comparisons [Stavert *et al*., 2013]. A CSIRO LoFlo instrument operates at Baring Head in parallel with the NIWA systems providing a co-located instrument comparison. Baseline air data from both the NIWA Siemens NDIR and the LoFlo instrument is compared and presented.

References

Brailsford, G. W., B. B. Stephens, A. J. Gomez, K. Riedel, S. E. Mikaloff Fletcher, S. E. Nichol, & M. R. Manning, Long-term continuous atmospheric CO_2 measurements at Baring Head, New Zealand, *Atmos. Meas. Tech*., 5, 3109-3117, doi:10.5194/amt-5-3109-2012, 2012.

Stavert, A., M. van der Schoot, P. Steele, D. Spencer, C. Allison, S. Coram, G. Brailsford, M. Ramonet & B. Wastine, Southern Ocean CO_2 network: Intercomparison results from multiple measurement platforms, *17th WMO/IAEA Meeting on Carbon Dioxide, Other Greenhouse Gases, and Related Tracer Measurement Techniques (GGMT-2013)*, 10-14 June 2013, Beijing, China, 2013.

Stephens, B. B., G. W. Brailsford, A. J. Gomez, K. Riedel, S. E. Mikaloff Fletcher, S. Nichol, and M. Manning, Analysis of a 39-yr continuous atmospheric CO_2 record from Baring Head, New Zealand, *Biogeosci. Discuss*., 9, 15237–15277, doi:10.5194/bgd-9-15237-2012, 2012.

Using Macquarie Island Atmospheric CO_2 Measurements to Constrain the Seasonality of Southern Ocean Carbon Exchange

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Abstract

High precision, continuous measurements of atmospheric CO_2 were established on Macquarie Island (54°38'S, 158°52'E) in 2005. The record has been 'baseline' selected to exclude local island influences or transport of continental signals from Australia and New Zealand. Comparisons with atmospheric CO_2 at Cape Grim (40°41'S, 144°41'E), also baseline selected, show a coherent seasonal cycle with a peak to peak amplitude of around 0.6-0.8 ppm. Atmospheric CO_2 at Macquarie Island is on average lower than Cape Grim from December-March and higher than Cape Grim for the remainder of the year. This is likely related to a northward shift in the region of maximum ocean carbon uptake from summer to winter. Hourly Macquarie Island-Cape Grim (MQA-CGO) CO_2 differences show considerable variability on synoptic timescales (standard deviation within months of 0.13-0.32 ppm). Similar variability is also seen in atmospheric model simulations using estimated sea-air CO_2 fluxes. This suggests that the synoptic variability is dominated by variations in the air mass sampled at each site on synoptic timescales. There are differences between the model simulated seasonality of MQA-CGO CO_2 difference and that observed, particularly for the April-June period. A comparison of model simulations using different sea-air fluxes all show discrepancies with the atmospheric observations in this season including those modeled using sea-air fluxes derived from ocean CO_2 partial pressure (pCO_2) measurements. Since there are limited pCO_2 observations outside of summer in this region of the Southern Ocean, the atmospheric CO_2 measurements provide a valuable complementary dataset for resolving Southern Ocean carbon flux seasonality.

Recent Research Highlights from the Cape Grim Air Archive

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Abstract

The Cape Grim Air Archive holds a record of baseline air samples dating back to 1978. It has played a pivotal role in establishing multi-decadal histories of a wide range of atmospheric trace gas species, and continues to do so as either new species of interest or improved measurement technologies emerge. This talk will describe recent research activities using air from this archive.

The Cape Grim CO_2/CH_4 Picarro Record

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Abstract

A Picarro cavity ringdown spectrometer for continuous measurement of atmospheric CO_2, CH_4 (and water vapour) was installed at Cape Grim in February 2012. Since that time, it has been sampling from the 70m intake, providing an overlap experiment with both the LoFlo CO_2 analyser and the AGAGE (Advanced Global Atmospheric Gases Experiment) CH_4 record.

In this presentation, we take a first look at how the new Picarro record compares to the existing CO_2 and CH_4 records at Cape Grim, noting that the new record provides more truly continuous time coverage than the LoFlo (which normally measures ambient air for 45 minutes in every hour) and the AGAGE record which consists of a discrete air sample measurement every 40 minutes. Other differences include the fact that the Picarro measurements are made on wet air with a water vapour correction applied to yield a dry air mole fraction, whereas the LoFlo and AGAGE measurements are made on pre-dried air, and differences in which isotopologues each measurement technique is sensitive to.

Strategies for the Future of Atmospheric Trace Species Measurements

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Abstract

A survey of recent developments in instrumentation and related technologies will be presented, with some thoughts and speculations about their roles into the future of research in atmospheric composition.

Development Progress of the Gunn Point pilot Australian Tropical Atmospheric Station (ATARS)

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Abstract

The Cape Grim Baseline Air Pollution Station (CGBAPS) is the central reference site for the expanding Australian Greenhouse Gas Observation Network (AGGON). A key addition to this network is a new (2010) pilot Australian Tropical Atmospheric Research Station (ATARS) established at Gunn Point in Australia's Northern Territory (12.249°S, 131.045°E, elevation 25 metres). This site incorporates high precision in-situ measurement and flask air sample collection programs for a range of climatically active atmospheric constituents. The Gunn Point site is an existing Australian Bureau of Meteorology research radar station (since 1997) and part of the US Atmospheric Radiation Measurement network program. The site has been involved in numerous tropical meteorology field campaigns and experiments including: 'Mctex', 'TRMM', 'Dawex', and 'TWP-ICE'. This combination of research capabilities with both chemical composition and physical, dynamical aspects of the tropical atmosphere provides an opportunity to develop a unique tropical atmosphere research capability in Australia. This combined research capability would enable atmospheric budget studies yet to be undertaken on a continuous, ongoing basis anywhere else in the tropics and would increase scientific understanding in three key areas:

1. address key uncertainties in aerosol-climate interactions and their implication for the hydrological cycle in the Australian tropics;
2. significantly reduce the uncertainty in estimates of total greenhouse gas (GHG) emissions from Australia, and
3. provide key data on climatically active atmospheric constituents and their sources and sinks in the tropics in order to improve our understanding of climate change forcing.

This presentation will summarise the recent developments at the site. The research capability at the station has been significantly improved with the installation of a second laboratory on-site, installation of an automatic weather station (AWS) on-site and the ongoing development of new research programs and campaigns.