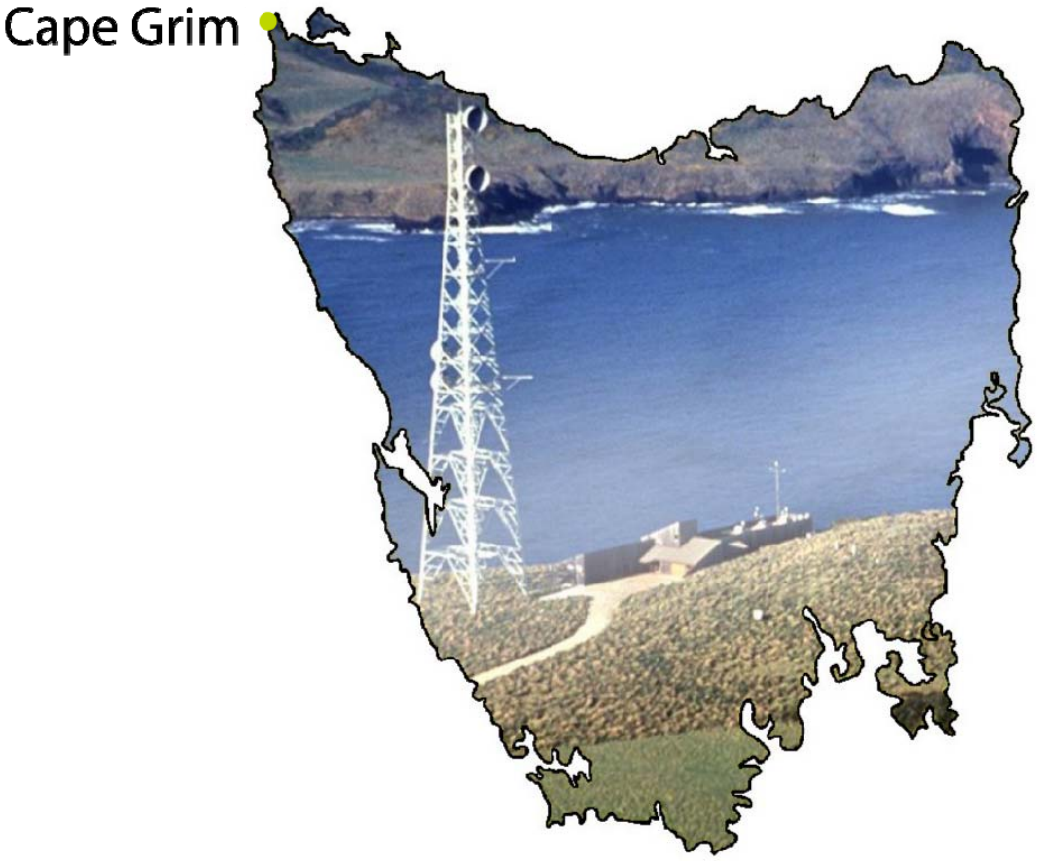
Cape Grim Annual Science Meeting

2010

Abstracts

9 – 10 December 2010



EDITED BY

Paul Krummel & Nada Derek

Centre for Australian Weather and Climate Research,
CSIRO Marine and Atmospheric Research
Aspendale, Victoria

Cape Grim Annual Science Meeting 2010

Centre for Australian Weather and Climate Research
CSIRO Marine and Atmospheric Research
Aspendale, Victoria

9 – 10 December 2010

Thursday, 9th December		
Chair	***Paul Krummel/John Gras***	
09:00	**Convenors**	**General information on arrangements etc.**
09:05	**John Gras**	**Welcome and opening of meeting**
09:15	Melita Keywood	Persistent organic pollutants at Cape Grim
09:40	Stephen Wilson	Photoreactivity measured by solar radiation
10:05	Wlodek Zahorowski	Rapid estimation of daily fine aerosol loadings in the boundary layer using ground based radon-222 observations
10:30	**Morning break**	**Provided**
11:00	Zoran Ristovski	Observation of ultrafine sea spray particles
11:25	Alan Griffiths	The spatial and temporal variation of radon flux from the Australian land surface
11:50	Paul Fraser *et al.*	Cape Grim Greenhouse Gas Program: Review
12:50	**Lunch**	**Provided**
Chair	***Sam Cleland***	
13:40	Gordon Brailsford	Atmospheric CO_2 and CH_4 in the Western Pacific
14:05	Nicholas Jones	CO_2 measurements from the ground
14:30	Edison Kurniawan	The study of eddy covariance in carbon dioxide mixing ratio related to vertical wind velocity
14:55	Andrew Smith	Developments in ^{14}C- gas capability at ANSTO
15:20	**Afternoon break**	**Provided**
15:40	James Butler	How will greenhouse gas observations meet changing requirements, laws, and demands?
16:05	Marcel van der Schoot	Atmospheric greenhouse gas (GHG) observation networks for the southeast Asian - Australian tropical region
16:30	Peter Rayner	Integrating Australian research on atmospheric composition: costs and benefits
16:55	**Paul Fraser/All**	**Strategic plan session**
17:50	Close of Papers	
18:30	**Meeting Dinner**	**Level 1: Hobson Room – Mordialloc Sporting Club, Mordialloc**

Cape Grim Annual Science Meeting 2010

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CSIRO Marine and Atmospheric Research
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Friday, 10th December		
Chair	***Paul Fraser***	
09:00	**Convenors / Hosts**	
09:05	Rachel Law	Methane simulations at Cape Grim
09:30	David Griffith	The Total Carbon Column Observing Network (TCCON) in the southern hemisphere: update of CO_2 and CH_4 columns, modelling and GOSAT comparisons at Darwin, Wollongong and Lauder
09:55	Ronald Macatangay	Train-borne measurements of greenhouse gases across central Australia
10:20	**Morning break**	**Provided**
10:45	Sarah Lawson	First measurements of VOCs at the Gunn Point Tropical Atmospheric Research Station
11:10	Laurie Goldsworthy	Ship engine exhaust emissions and their impacts: A review covering the southern hemisphere and Australia
11:35	Wayne Kirstine	Ethanol in the environment - a natural product, biofuel and potential environmental pollutant
12:00	Ian Galbally	A 29 year record of ozone in the Southern Ocean marine boundary layer from Cape Grim,Tasmania 41°S
12:25	**Lunch**	**Provided**
Chair	***Ian Galbally***	
13:25	Luke Hande	Boundary layer clouds and wind shear over the Southern Ocean
13:50	Vivian Huang	A CloudSat view of cloud phase climatology over the Southern Ocean
14:15	Ruhi Humphries	Atmospheric tomography: Determining the flux rate and location of point source fugitive emissions
14:40	Emma Young	Open-path FTIR measurements at hazard reduction burns in New South Wales
15:05	**Afternoon break**	**Provided**
15:30	David Etheridge	A new atmospheric monitoring station- Arcturus, Queensland
15:55	Paul Fraser	Global and Australian HFC, PFC and SF_6 emissions: atmospheric verification
16:20	Diane Ivy	Global emission estimates for C_4F_{10} - C_8F_{18}
16:45	Michael Leist	An unorthordox approach to extending the air archive
17:10		**Close of meeting**

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PERSISTENT ORGANIC POLLUTANTS AT CAPE GRIM

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Abstract

As a Party to the Stockholm Convention on Persistent Organic Pollutants, Australia, along with 172 other countries, has committed to eliminating or restricting the production and use of chemicals known as persistent organic pollutants (POPs). The Stockholm Convention is a global treaty to protect human health and the environment from chemicals that remain intact in the environment for long periods, become widely distributed geographically, accumulate in the fatty tissue of humans and wildlife, and have adverse effects on human health or the environment.

Here we will present a review of previous POPs observations carried out at Cape Grim, including those carried out under the National Dioxins Program [Gras *et al*., 2004] and the Global Atmospheric Passive Sampling (GAPS) Study [Pozo *et al*., 2006]. This work is part of a new initiative funded by the Department of Sustainability, Environment, Water, Population and Communities to establish long-term monitoring of selected POPs in air around Australia. The project involves a review of information on levels of Chemicals of interest (CoI) in ambient air in Australia that will inform will the development of a chemical transport model of CoI and a pilot measurement program on monitoring of CoI in ambient air in Australia.The initial sampling program will involve sampling at three locations around Australia, including Cape Grim, using both active and passive samplers.

The regional and global significance of measuring POPs at Cape Grim will be discussed.

Reference

Gras, J. G., J. Mueller, B. Graham, R. Symons, J. Carras, and G. D. Cook, (). Dioxins in ambient air. *National Dioxins Program Technical Report No. 4*, Australian Government Department of Environment and Heritage, Canberra, 2004.

Pozo, K., T. Harner, F. Wania, D. C. G. Muir, K. C. Jones, and L. A. Barrie, Toward a global network for persistent organic pollutants in air: Results from the GAPS study, *Environ. Sci. & Technol., 40*(16), 4867-4873, 2006.

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PHOTOREACTIVITY MEASURED BY SOLAR RADIATION

S. R.Wilson* and J. Demol

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Abstract

Direct-sun Differential Optical Absorption Spectrometry (DS-DOAS) involves the measurement and interpretation of direct beam solar spectra. This is in principle a straightforward extension of the sunphotometer measurements currently made at Cape Grim. By measuring solar spectra at differing elevations it is possible to derive a differential slant column amount of a trace gas in the atmosphere, and then under certain conditions derive the total vertical column amount.

DS-DOAS has been trialled with a system deployed at Wollongong. It consists of a sun-tracker, fore-optics to limit the field of view of an optical fibre which is connected, via a shutter, to a small (Ocean Optics) spectrometer. The spectrometer was maintained at a constant temperature. The spectrometer data collection was coordinated via in-house developed software which permitted the refinement of the data collection protocol. Once collected, spectra were analysed using QDOAS software developed by BIRA-IASB and A&T BV.

Initial analyses of ozone show good agreement with satellite measurements, given the uncertainties in such a comparison (see figure). Nitrogen dioxide retrievals were correlated with ground based measurements, and showed similar diurnal behaviour, although they are measuring different quantities (ground level concentrations versus total column). Formaldehyde retrievals have been made for a few days, and show promising agreement with FTIR measurements (provided by N. Jones) also made at Wollongong. As these measurements extend into summer there will be a chance to complete this comparison. Intriguingly, BrO is also observed at surprisingly high column amounts.

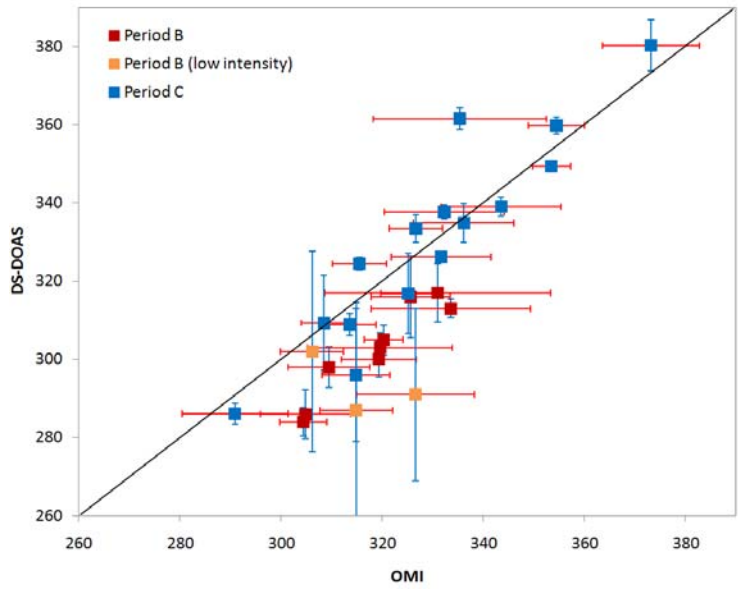


Figure 1. Ozone column amounts retrieved at Wollongong using DS-DOAS compared to satellite measurements. Both quantities are reported in DU. The 2σ error bars are derived from the spatial variation reported over the region around Wollongong for the satellite retrieval, and the scatter in the data over the 20 minute period around the satellite ozone overpass (DS-DOAS)

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RAPID ESTIMATION OF DAILY FINE AEROSOL LOADINGS IN THE BOUNDARY LAYER USING GROUND BASED RADON-222 OBSERVATIONS

J. Crawford*, W. Zahorowski, D. D. Cohen, S. Chambers, E. Stelcer and S. Werczynski

Australian Nuclear Science and Technology Organisation, Kirrawee DC, NSW

Abstract

For more than a decade radon-222 has been successfully used for calibrating regional terrestrial emissions of climatically sensitive gases. Here we explore a similar method which assumes that there is a quantifiable relationship between observed radon concentrations and elemental concentrations determined from fine ($PM_{2.5}$) aerosol samples collected over 24 hour periods. We propose and test the performance of a simple linear regression model to characterise this relationship.

Collocated radon measurements and fine aerosol sampling were conducted at four sites in the greater Sydney region. The study domain and locations of the four observation sites were chosen to test the method under a range of conditions typical of large population centres while, at the same time, offering a considerable range of maritime influence on mixing conditions. We first evaluated how the method performed when used to estimate the measured daily average radon concentrations as well as the measured radon concentrations at a set time of day. Then we explored correlations between measured and estimated daily average loadings of the total aerosol mass as well as selected elements including silicon, potassium, iron, zinc and black carbon. The graphs below illustrate the degree of correlation between measured and estimated black carbon concentrations.

A possible application of this method is the rapid estimation of daily loadings of selected pollution types present in fine aerosol samples.

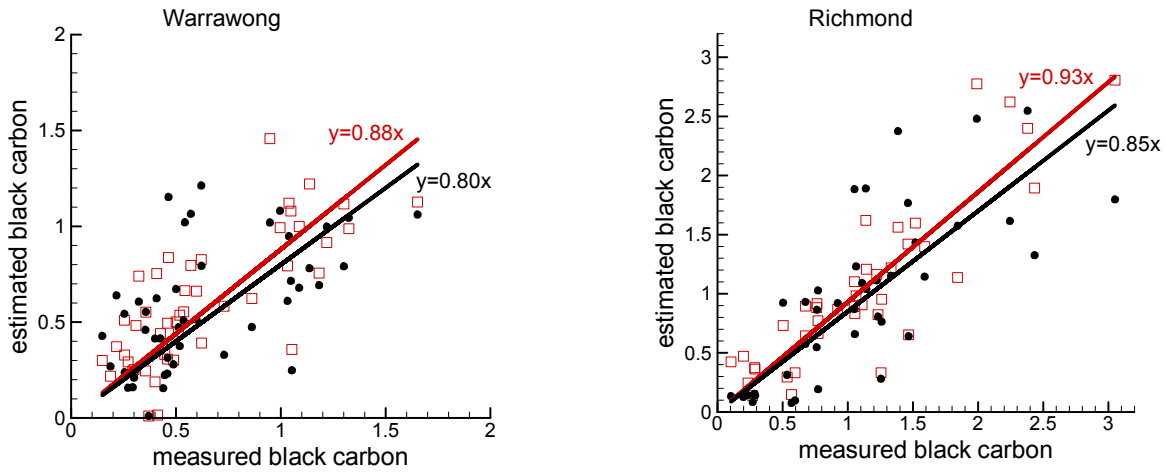


Figure 1. Estimated black carbon mass (μg/m³) for SH winter against measured black carbon mass for two sites: Warrawong (a coastal site) and Richmond (an inland site).

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OBSERVATION OF ULTRAFINE SEA SPRAY PARTICLES

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Abstract

Sea spray aerosol (SSA) particles produced primarily by bubble bursting processes on the ocean surface play an important role in both the direct and indirect effects of aerosols on climate. Recent laboratory bubble chamber studies have consistently detected a dominant mode in the SSA number distribution centred at 100 nm dry diameter [e.g. Modini *et al.* 2010 and references therein]. Particles in this mode can be found in significant quantities right down to 10 nm. However, despite these lab results observations of ultrafine sea spray particles (D<100 nm) in the Marine Boundary Layer (MBL) are relatively scarce. For example ultrafine particles with very high Hygroscopic Growth Factors (HGF>1.85, as is expected for fresh SSA) have not been observed as often as might be expected in remote marine environments [Swietlicki *et al.*, 2008]. Based on their thermal stability and response to changing humidity Clarke *et al.* (2006) identified sea spray particles as small as 10 nm in the MBL but this was only 20-30m from the surf-zone in Hawaii.

Here we report the observation of significant concentrations of ultrafine sea spray particles down to 15 nm diameter in clean, marine air at Cape Grim Baseline Air Pollution station in Tasmania, Australia, during one episode on the 8 December 2007. They were identified as sea spray particles based on measurement of their volatile (V) and hygroscopic (H) properties in a combined tandem-differential-mobility-analyser (VH-TDMA). Humidified size distributions of initially monodisperse particles with mobility diameter in the range 15-97 nm clearly showed two externally mixed particle modes with HGFs at 90% RH of around 1.5 and 2.

SSA particles are currently the only MBL particles that are known to have $HGF_{90\%}$ as high as 2. This suggests that particles observed in the very hygroscopic mode were sea spray particles. To further verify this, the particles were heated to over 250°C prior to humidification at 90% RH. Particles in the moderately hygroscopic mode (HGF≈1.5) evaporated, however particles in the very hygroscopic mode (HGF~2) were completely unaffected by the increase in temperature. Therefore, based on their very high hygroscopicity and thermal stability we conclude that the particles in this mode were in fact sea spray particles.

The observation of ultrafine sea spray particles on the 8/12/07 was very rare as significant concentrations of particles with HGF~2 were not observed at any other time during this month-long campaign or any other campaign at Cape Grim. In addition this is the first time that the production of primary marine nanoparticles (~15nm), through the sea spray mechanism very far from the surf zone, were observed. An open question remains why aren't ultrafine sea spray nanoparticles observed on other high wind speed days when bubble chamber studies suggest they should be common. This issue will be explored along with further analysis of the aerosol and meteorological data in the presentation.

Reference

Modini, R., B. Harris, and Z. D. Ristovski, The organic fraction of bubble-generated, accumulation mode Sea Spray Aerosol (SSA), *Atmos. Chem. Phys.*, 10(6), 2867-2877, 2010.

Swietlicki, E., H. C. Hansson, et al., Hygroscopic properties of submicrometer atmospheric aerosol particles measured with H-TDMA instruments in various environments - a review, *Tellus*, 60(3), 432-469, 2008.

Clarke, A. D., S. R. Owens, and J. Zhou, An ultrafine sea-salt flux from breaking waves: Implications for cloud condensation nuclei in the remote marine atmosphere, *J. Geophys. Res.*, 111., 2006.

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THE SPATIAL AND TEMPORAL VARIATION OF RADON FLUX FROM THE AUSTRALIAN LAND SURFACE

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Abstract

On numerous occasions radon–222 (radon) has found applications in atmospheric research, mainly as a tracer of mixing and transport processes. Generally, the exhalation of radon by soil has been treated as constant or modelled using simple algorithms. As models improve, this can be a problem because the limited realism of the radon source function is no longer masked by model deficiencies.

As a better alternative to such approximations, we have constructed a month-by-month radon flux map covering Australia at 0.05 degree resolution [Griffiths *et. al.*, 2010]. A simple diffusion model is used to generate the maps, with modelled soil moisture, aerial gamma survey data, and soil maps used as inputs. The model is calibrated using field measurements of radon flux, with especially good results over areas with constant soil types, as shown in Figure 1.

Reference

Griffiths, A. D., W. Zahorowski, A. Element, and S. Werczynski, A map of radon flux at the Australian land surface, *Atmos. Chem. Phys.*, 10, 8969-8982, doi:10.5194/acp-10-8969-2010, 2010.

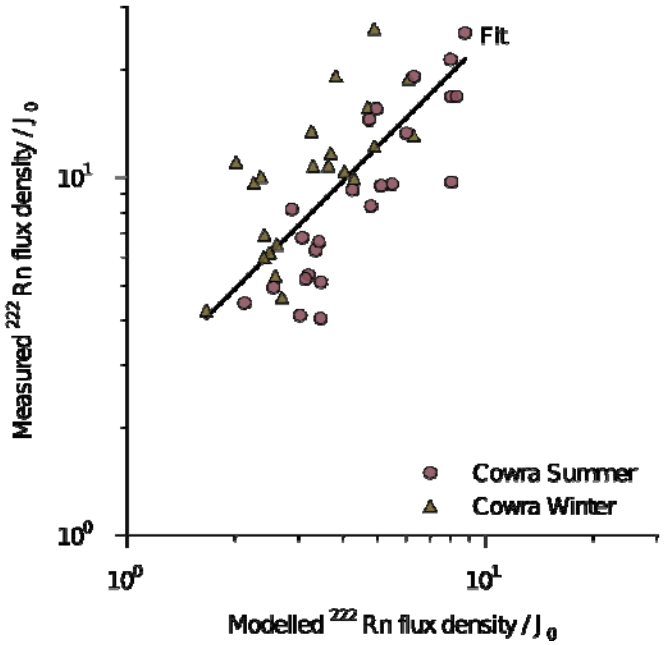


Figure 1. Flux map calibration, with data from an area southwest of Cowra, NSW. The data are normalised by a reference value, J_0 = 22 mBq m^{-2} s^{-1}, which is roughly equal to the Australian mean radon flux.

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CAPE GRIM GREENHOUSE GAS PROGRAM: REVIEW

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Abstract

This report is a review of the activities and achievements (2000-2010) of the Cape Grim Greenhouse Gases (GHG) Program, which is comprised of three Sub-Programs:

- Carbon Dioxide (CO_2) and CO_2 Isotopes ($^{13}CO_2$, $C^{18}OO$)
- Non-CO_2 Greenhouse and Ozone-Depleting Gases (methane – CH_4, nitrous oxide – N_2O, halocarbons, long-lived sulphur gases, as well as carbon monoxide – CO, and hydrogen – H_2); this sub-program is part of the international Advanced Global Atmospheric Gases Experiment (AGAGE) program, and
- the Cape Grim Air Archive.

In addition, the review covers several Co-operative Sub-Programs involving collaborations with the following international institutions:

- U. Heidelberg (UH, Germany): $^{14}CO_2$, sulphur hexafluoride (SF_6)
- Scripps Institution for Oceanography (SIO, USA)
  - O_2/N_2
  - halocarbons, SF_6 (ceased 2003)
- NOAA-Earth System Research Laboratory (NOAA-ESRL, USA)
  - CO_2, $^{13}CO_2$, $C^{18}OO$, CH_4, N_2O, CO, H_2, SF_6
  - halocarbons, N_2O, SF_6, COS, others
- U. East Anglia (UEA, UK): halocarbons (ceased 2008)
- National Institute for Environmental Sciences (NIES, Japan): halocarbons
- Swiss Federal Materials Science and Technology Institution (Empa, Switzerland): HFCs (ceased 2008)
- U. Princeton (UP, USA): O_2/N_2 (ceased 2010)
- Laboratoire des Sciences du Climat et de l'Environnement (LSCE, France): CO_2, $^{13}CO_2$, $C^{18}OO$, CH_4, N_2O, CO, H_2
- Tohoku Univ. (TU, Japan): CO_2, $^{13}CO_2$, $C^{18}OO$, CO, CH_4 (ceased 2003).

The Non-CO_2 Greenhouse and Ozone-Depleting Gases Sub-Program was last reviewed in 1999, and the Carbon Dioxide and CO_2 Isotopes Sub-Programs (separate sub-programs at that time) were last reviewed in 2000.

The GHG Program at Cape Grim is an integral part of research portfolio of the Climate and Atmosphere Theme of CSIRO Marine and Atmospheric Research (CMAR) and was reviewed favorably as part of the 5-year reviews of CMAR (2005, 2010) and in the review of CSIRO Atmospheric Research (CAR: 2003), before amalgamation with CSIRO Marine Research to form CMAR (2005).

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ATMOSPHERIC CO_2 AND CH_4 IN THE WESTERN PACIFIC

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Abstract

In October/November 2009 continuous measurements of CH_4 and CO_2 concentrations were made using a Picarro CRDS analyser during a voyage of MV Transfuture 5 between Nelson, New Zealand and Osaka, Japan. In addition to this large volume whole air samples were collected for later $^{13}CH_4/^{12}CH_4$ analyses. Large variations in concentrations were observed through the tropical regions and at the most northern section of the voyage. Variations in stable isotopic composition provide strong evidence for air mass changes. These variations are examined in terms of atmospheric transport from source regions using meteorological and climatological data.

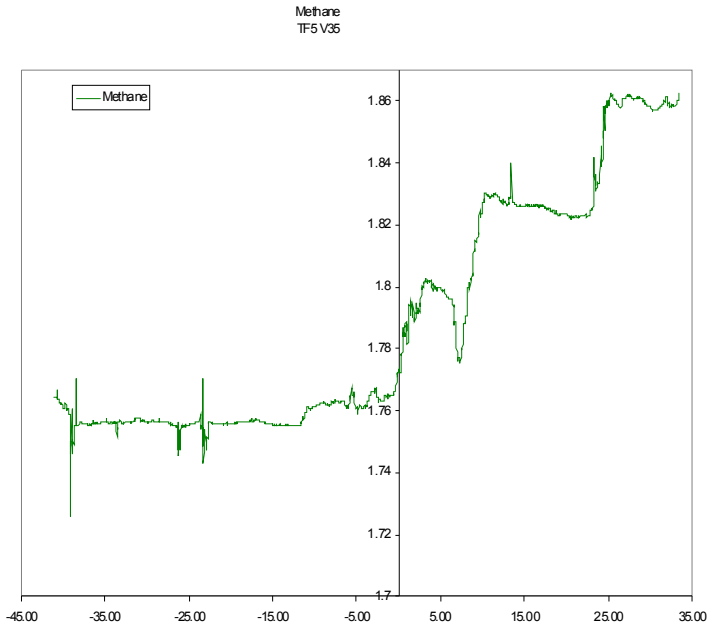


Figure 1. Methane concentration measured by Picarro CRDS as five minute averages between Nelson New Zealand and Osaka Japan .

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MEASURING CO_2 FROM THE GROUND; PROGRESS TOWARDS A NEW LOW COST HIGH PRECISION NETWORK

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Abstract

Sources and sinks of greenhouse gases, carbon dioxide (CO_2) in particular, must be measured for a number of reasons, including political (governance of any global carbon trading scheme), prudential (early warming system if the environmental diverges from its predicted path), and scientific (our knowledge of the sources and sinks and the mechanisms that control them is rudimentary). A network of remote sensing systems to accurately measure CO_2 from the ground, air and space is required with sufficient accuracy and density to adequately address these issues at a national level. At present, such a network does not exist. The 19 station Total Column Carbon Observing Network (TCCON) for example, with a station operating at the University of Wollongong, has the required precision but due to cost does not have the necessary global coverage

Progress towards a new network of high accuracy, and high density CO_2 measuring instrumentation is the subject of active research in several research centres around the world. The University of Wollongong, along with a number of domestic and overseas Institutions, has been testing new technology with the potential to measure the column CO_2 amount to precisions of around 0.2-0.3% with the target of reducing the instrument cost down by a factor of 5 to 10. Progress on these instrument trials and some early results will be discussed in comparison with the existing CO_2 column data from the University of Wollongong's TCCON instrument.

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THE STUDY OF EDDY COVARIANCE IN CARBON DIOXIDE MIXING RATIO RELATED TO VERTICAL WIND VELOCITY

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[2]*Department of Physics, Riau University, Pakanbaru*

Abstract

The variability of carbon dioxide (CO_2) influenced by atmosphere stability. This research aim to to explain about Eddy Covariance technique analysis and also its relation to surface temperature variation, vertical wind speed and mixing ratio of CO_2. This Theory will try to interpret various conditions of atmosphere when natural air move in lifting process, CO_2 will tend to decrease. On the contrary when natural air moment in process of subsidence, concentration of CO_2 which enter to inlet tube will tend to increase. The instruments which is used in this research such as Automatic Weather Station (AWS) for measuring surface temperature, Piccaro for measuring mixing ratio of CO_2, and Boundary Layer Radar (BLR) for measuring vertical wind velocity. The Result of calculation of vertical flux method of EC progressively clarify that increase or decrease mixing ratio of CO_2 is influenced by atmospheric stability. The existence of this pattern indicate that the balance process will be able to be realized by the role of vegetation which is very important. So that the measurement method of EC cycle practically can depict as standard approach to express the exchange of flux transfer between biosfer-atmosfer related to CO_2 variability.

Reference

Baldocchi, D., E. Falge, L. H. Gu, *et al*., FLUXNET: A new tool to study the temporal and spatial variability of ecosystem-scale carbon dioxide, water vapor, and energy flux densities, *Bull. Am. Meteor. Soc*., 82(11), pp 2415–2434, 2001.

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Burba, G.G., and D.J. Anderson, Introduction to the Eddy Covariance Method: General Guidelines and Conventional Workflow.,LI-COR Biosciences, http://www.licor.com, 141, 2007.

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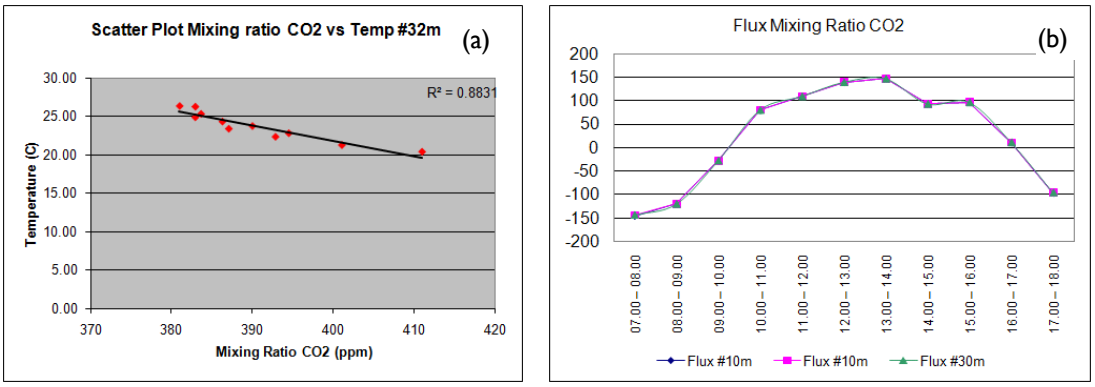


Figure 1. (a) Scatter Plot CO_2 vs Surface Temperature at the height of 32 m (b) Vertical Scalar Flux of CO_2

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DEVELOPMENTS IN ^{14}C-GAS CAPABILITY AT ANSTO

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Abstract

We report on developments in the ^{14}C of gas program ANSTO since the 2007 Cape Grim Baseline Air Pollution Station Annual Science Meeting. Over this period we have refined the apparatus used to cryogenically separate CO_2 from a gas stream. Principal changes are the incorporation an automated system to maintain a fixed pressure in the CO_2 trap and the use of a variable-speed diaphragm pump to pull the gas through the line, permitting control of the flow rate. A turbomolecular pumping system is used to ensure good base vacuum prior to commencing extractions and during transfer of the trapped CO_2. This apparatus was used for round 2 of the First Atmospheric Radiocarbon Intercomparison (FARI), organised by INSTAAR and NOAA/CMDL [Miller, 2009]. Samples were received for FARI round 3 in October 2010.

More recently, a dedicated quadrupole mass spectrometer (QMS) has been added to the line, enabling on-line analysis of the exhaust gas to check on the completeness of H_2O and CO_2 trapping. The entire processing line has been relocated to a new laboratory and has been improved with the rebuilding. Furthermore, a CH_4 combustion oven, using CuO in a quartz tube, plus additional H2O and CO2 traps, has been added after the CO_2 line. This has been driven by demand for ^{14}C of CH_4 samples from wastewater and landfill studies. An overview of these projects and preliminary experience with the CH_4 line will be given.

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HOW WILL GREENHOUSE GAS OBSERVATIONS MEET CHANGING REQUIREMENTS, LAWS, AND DEMANDS?

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Abstract

Recent efforts to develop a global greenhouse gas information system (GHGIS) have been driven by an anticipated need to support future national emission reduction policies or international treaties with observations. Such an effort would be similar to that done in support of the Montreal Protocol on Substances that Deplete Ozone, but more complex. Greenhouse gas emissions, however, are much more difficult to manage and will likely require regional scale information to assess progress. The Kyoto Protocol has been fraught with political and practical difficulties, not the least of which is the absence of an independent observation and analysis requirement. Nevertheless, no unifying agreement was reached at the much heralded 2009 Conference of Parties (COP-15) in Copenhagen. Thus, it is quite possible (likely?) that greenhouse gas emissions may be reduced owing to other, uncoordinated policies that have their own merits, e.g., energy efficiency, alternative energy development, air quality improvement, forest development, agricultural practices, etc. If this is the future, then what observations and observation system design are needed and to what end? This presentation will discuss those needs in light of critical observations, analytical approaches, and evolving, disparate policies.

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ATMOSPHERIC GREENHOUSE GAS (GHG) OBSERVATION NETWORKS FOR THE SOUTHEAST ASIAN - AUSTRALIAN TROPICAL REGION

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Abstract

A high precision atmospheric observation network for GHG and related trace gas species is being expanded in the Southeast Asia-Australian region. The primary objectives of the network are to:

1. Improve our global understanding of the forcing of climate change by providing observations of climatically active atmospheric constituents in the critically under-sampled tropical latitudes, and
2. Dramatically reduce the uncertainties in estimates of GHG emissions from Australia.

The Australian regional network has the Cape Grim Baseline Air Pollution Station as the central reference observation site. A new atmospheric observation site has recently been established at Gunn Pt. (near Darwin in the Northern Territory) in the Australian tropics region. This site incorporates high precision *in-situ* measurement and flask air sample collection programs for a range of GHG and related trace gas species. It is anticipated high precision atmospheric observations from this region should significantly improve the understanding of the tropical sources and sinks of the major anthropogenic GHG (CO_2, CH_4, N_2O). High precision 'LoFLo' (NDIR) and 'Picarro' (Cavity Ring Down Spectroscopy) instruments are being used for the continuous measurement of CO_2, CH_4 and $^{13}CO_2/^{12}CO_2$. The research program and preliminary data from this new site and collaborative programs at sites in the Asian tropical region at Cape Rama, India (NIO) and Danum Valley GAW station, Malaysia (MMD) will be discussed.

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INTEGRATING AUSTRALIAN RESEARCH ON ATMOSPHERIC COMPOSITION: COSTS AND BENEFITS

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Abstract

The formation of CAWCR and the recent funding of the Centre of Excellence for Climate Systems Science have gathered much of the Australian research on the physical climate into two large organizations. Research on the chemical composition of the atmosphere, however, remains distributed, with groups as small as one working within university departments and research organizations. Clearly this situation is not perfect but that does not automatically mean we can change it. Integration, too, has its costs, especially to those doing the integrating. In this talk I will briefly sketch my experiences with two European projects. One, the IMECC project (http://www.imecc.org) sought to integrate measurements of the European carbon cycle while the GEOMON project (http://www.geomon.eu) sought to integrate aspects of atmospheric composition measurement and modelling.

Drawing on the successes and failures of these two projects I will try to deduce some lessons on whether and how to integrate atmospheric composition research in Australia. Some tentative conclusions are:

- Integration is not an end in itself, it must be based around a question or a tool.
- Increased funding is a strong motivation but only until the project is funded
- Transaction costs are high and often increase with the level of funding
- 'Free' participants are usually worth what you pay for them
- Community building is surprisingly slow.

Finally, I will discuss a couple of vehicles available to fund such an activity and discuss some of their strenghts and weaknesses for the task.

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EVOLUTION OF RADON PROFILES IN THE ATMOSPHERIC BOUNDARY LAYER

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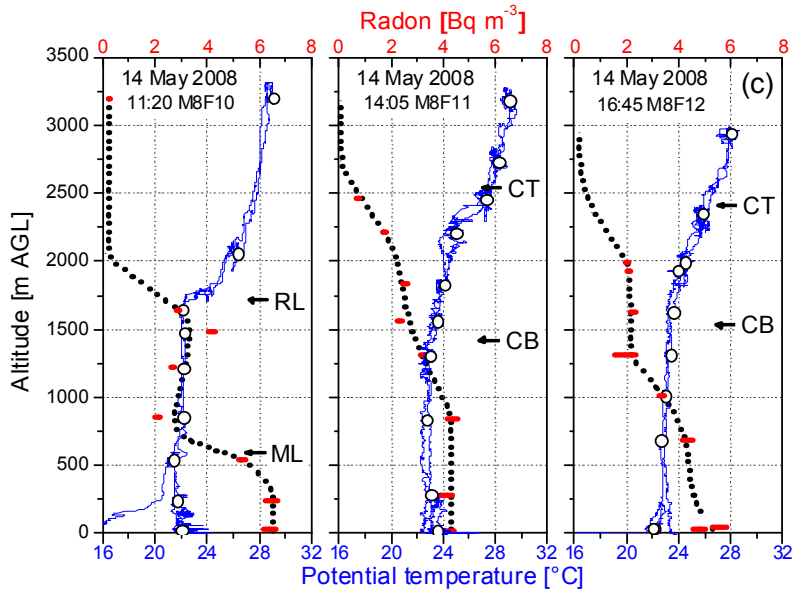
Australian Nuclear Science and Technology Organisation, Kirrawee DC, NSW

Abstract

Vertical profiles of atmospheric radon concentrations frequently exhibit a complex layered structure, as a result of mixing and exchange processes of varying strengths and extent working in clear and cloudy conditions within the context of the synoptic meteorology. Close to the surface, radon profiles can vary markedly over the course of a single day, reflecting many important aspects of the diurnal evolution of the atmospheric boundary layer (ABL). We discuss features of a unique dataset of high resolution vertical radon profiles up to 3500 m above ground level, obtained in clear and cloudy daytime terrestrial boundary layers over rural New South Wales using an instrumented motorised research glider [Williams *et al.*, 2010]. To demonstrate the relationship between diurnal / synoptic forcing and the evolution of vertical radon distributions in the ABL, we present two sequences of aircraft profiles collected under markedly different meteorological conditions: (1) a surface-heating driven convective boundary layer; and (2) a wind-shear driven neutral boundary layer. The striking contrast between the radon profiles in these two case studies demonstrates the utility of radon profiling as a tool for quantitative analysis of boundary layer mixing processes. With sufficient vertical resolution, radon measurements are capable of diagnosing features of boundary layer structure that cannot be unambiguously identified using more conventional variables. Conversely, there is a need to consider the structure of the ABL, its connected cloud layers, and its stage of development within the diurnal cycle, when postulating likely vertical distributions of radon for the purposes of regional emission integrations and other studies that rely on estimates of total column radon computed using surface-based radon measurements and supporting meteorological information.

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Three consecutive radon profiles, gathered on 14 May 2008 over inland NSW, reveal aspects of the diurnal evolution of a cumulus-topped CBL in light winds. Radon concentrations are shown as red bars (length indicates uncertainty) with dotted black lines drawn to guide the eye. Potential temperature profiles are shown as blue lines. Black circles are averages of the (1 Hz) potential temperature data over the radon sampling periods. Also marked are the tops of the mixed layer (ML) and residual layer (RL), as well as cloud base (CB) and cloud top (CT) heights. Flight identifiers are defined in Williams *et al.* [2010].

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METHANE SIMULATIONS AT CAPE GRIM

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Abstract

The transport model comparison project, TransCom, is currently undertaking an intercomparison of methane simulations. The protocol required the simulation of six methane tracers using varying surface fluxes, along with simulations of SF_6, Rn-222 and methyl chloroform (MCF). The chemical sink of methane and MCF is calculated using prescribed, seasonally-varying OH fields, which were provided as part of the experiment. Stratospheric loss rates for methane and MCF and surface deposition rates for MCF were also provided. Model output comprised monthly mean tracer fields on pressure levels, hourly timeseries at site locations and daily output centred on 1300 local time for comparison with satellite data. The model simulations were run from 1988 to 2008, with analysis beginning in 1990. We have performed the experiment with two models, the Australian Community Climate and Earth System Simulator (ACCESS) at 3.75° longitude by 2.5° latitude resolution and the CSIRO Conformal-cubic Atmospheric Model (CCAM) at ~220 km resolution. ACCESS is forced with observed sea surface temperatures but has no other constraint on the meteorology it generates. By contrast, the horizontal wind components (u, v) in CCAM are nudged to NCEP analyses. This allows the CCAM timeseries output at sites to be directly compared to observations. Preliminary analysis shows that both models produce plausible methane simulations. The modelled methane growth rate is largely dependent on the prescribed methane surface fluxes, as is the northern hemisphere seasonal cycle. The southern hemisphere seasonal cycle is dominated by the chemical sink and may be slightly better represented by CCAM than ACCESS. Both models tend to overestimate the interhemispheric difference (IHD) in methane concentration with ACCESS being closer to the observed IHD. Non-baseline events at Cape Grim seem to be reasonably well captured by CCAM, especially in winter. The peak concentration of the event is dependent on the fluxes used (Figure 1) so further analysis of non-baseline events should yield insights into South Eastern Australian methane fluxes.

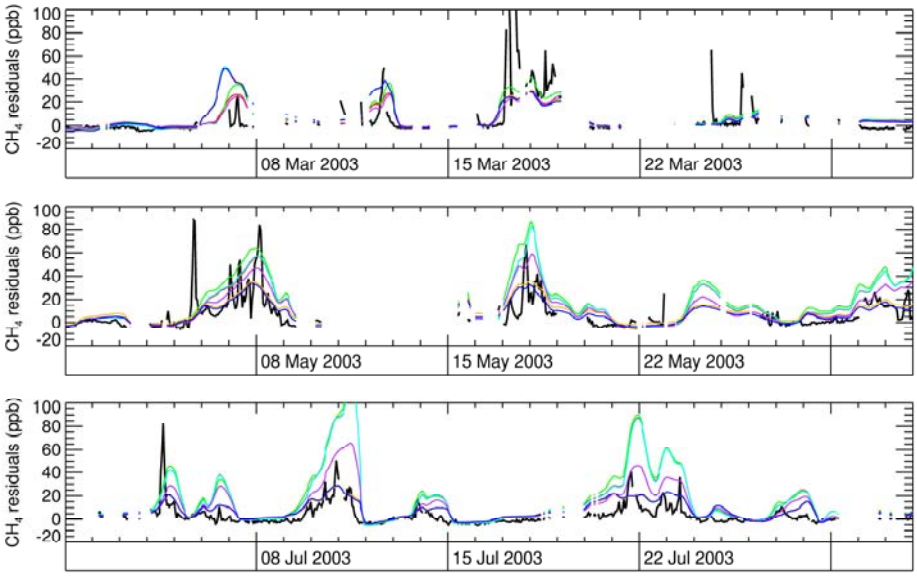


Figure 1. Methane excursions from the Cape Grim baseline record for three (non consecutive) months during 2003. Data have been filtered to remove Tasmanian signal (70° <θ <190°). Observations are shown in black, The six methane tracers are: CTL, CTL_E4, BB, WL_BB, INV, EXTRA.

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THE TOTAL CARBON COLUMN OBSERVING NETWORK (TCCON) IN THE SOUTHERN HEMISPHERE: UPDATE OF CO_2 AND CH_4 COLUMNS, MODELLING AND GOSAT COMPARISONS AT DARWIN, WOLLONGONG AND LAUDER

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Abstract

The Total Carbon Column Observing Network (TCCON, see Figure 1) currently consists of 15 operational ground based remote sensing stations measuring total column CO_2, CH_4 and other gases by solar Fourier Transform spectrometry in the near infrared. TCCON aims to provide column averaged dry air mole fractions (X_{CO2}, X_{CH4}) of sufficient accuracy and precision to resolve small spatial and temporal gradients for inverse modelling studies, and is the basis for validation of satellite measurements of greenhouse gases such as those from the Greenhouse gases Observing SATellite (GOSAT) and Orbiting Carbon Observatory (OCO-2). TCCON currently achieves better than 0.25% accuracy and precision for daily mean X_{CO2}. TCCON column averaged dry air mole fractions are linked to the relevant World Meteorological Organisation (WMO) in situ calibration scales via coincident vertical profile measurements of trace gas concentrations acquired by calibrated aircraft-borne *in situ* instruments, such as those in the HIPPO programme.

In this paper we will present a TCCON network update: calibration of the network, five years of southern hemisphere TCCON measurements of CO_2 and CH_4 at Darwin, Wollongong and Lauder, complementary in situ measurements, and model-measurement comparisons. We will also present the most recent comparisons between TCCON and GOSAT retrievals of X_{CO2} and X_{CH4}.

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Figure 1. Current and future TCCON observatory sites (2010)

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TRAIN-BORNE MEASUREMENTS OF GREENHOUSE GASES ACROSS CENTRAL AUSTRALIA

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Abstract

An *in situ* Fourier transform infrared (FTIR) gas analyser was deployed on-board the Ghan train travelling on a north-south route across central Australia. Concentrations of carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and carbon monoxide (CO) were retrieved from the measured spectra. Since this region is characterised by scarce greenhouse gas measurements, these data would potentially provide new constraints to improve local source and sink certainty.

To date, six train measurement campaigns have been conducted in 2008-2010. The Ghan runs from Adelaide (34.9°S, 138.6°E) to Darwin (12.5°S, 130.9°E) and return. In this study, the following will be presented:

1. an overview of the measurements showing the latitudinal variations of CO_2, CH_4, and N_2O;
2. a quantification of ephemeral methane wetland fluxes using a meteorological and air pollution model – The Air Pollution Model (TAPM);
3. an investigation of a significant CH_4 enhancement in northern Australia using a global chemical transport model – GEOS-Chem; and
4. an examination of the surface CO_2 latitudinal variations across central Australia using a series of tagged tracer model simulations.

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Figure 1. The route of the Ghan train. It starts from Adelaide, then through Alice Springs and ends in Darwin. Image taken from http://www.railaustralia.com.au/theGhan.php.

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FIRST MEASUREMENTS OF VOLATILE ORGANIC COMPOUNDS (VOCS) FROM THE GUNN POINT TROPICAL ATMOSPHERIC RESEARCH STATION

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Abstract

The Gunn Point Tropical Atmospheric Research Station was commissioned in 2010 in the Northern Territory of Australia. An important motivation for the Station is to characterize the atmosphere of the Australian tropics in terms of reactive gases, including volatile organic compounds (VOCs). The reactive chemistry in the Australian tropics is influenced by significant input of reactive gases and aerosol to the atmosphere through biomass burning, biogenic emissions, the high oxidative capacity of the atmosphere due to high temperature and solar radiation, and long range transport of air in the mixed layer and the free troposphere in the stable tropical troposphere. VOCs affect climate by driving formation of tropospheric ozone and climatically active secondary organic aerosol (SOA). The degree of radiative forcing from aerosol and tropospheric ozone is highly uncertain [IPCC, 2007]. It is therefore crucial to understand the sources and atmospheric processes which regulate VOCs, particularly in the Australian tropics where there have been few long term observations.

We report VOC observations from the first VOC and aerosol measurement campaign at the Gunn Point Tropical Atmospheric Research Station, carried out for 2 weeks in June 2010. The Station is located at the Bureau of Meteorology Radar site, -12.25°S, 131.05°E, and approximately 30 km north east of Darwin and 1 km inland from the coast. Measurements of VOCs and oxygenated VOCs (OVOCs) were made by actively sampling air on to adsorbent tubes and DNPH cartridges. Samples were analysed at CSIRO Marine and Atmospheric Research by ATD GC-FID/MS and HPLC. Aerosol property measurements were made alongside the VOC measurements, including Cloud Condensation Nuclei (CCN) concentration, Condensation Nuclei (CN) concentration and size resolved particle distributions as well as aerosol chemical composition.

Concentrations of VOCs at Gunn Point are presented, both during relatively clean background conditions and during an event where biomass burning emissions impacted the station. VOC concentrations and concentration ratios are compared to other tropical sites in Australia, (including Charles Point) and elsewhere in the world. The sources of VOCs at Gunn Point are discussed, including biogenic, biomass burning and marine sources.

VOC data from the Gunn Point Research Station will be used to ensure the accurate representation of reactive chemistry and aerosols in the atmospheric chemistry component of the Australian Community Climate Earth System Simulator (ACCESS), as well as to ground-truth data retrieved by remote sensing technology. Plans for long term monitoring of VOCs at Gunn Point are presented.

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SHIP ENGINE EXHAUST EMISSIONS AND THEIR IMPACTS: A REVIEW COVERING THE SOUTHERN HEMISPHERE AND AUSTRALIA

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Abstract

Shipping is the most fuel efficient means of moving freight, and carries more than 70% of the global freight task. However, ship engine exhaust emissions have been identified as a major source of environmental concern. These emissions from shipping constitute significant fractions of the anthropogenic emissions of CO_2, CO, CH_4, VOCs, SO_2, particles (direct), NO_x and N_2O. Furthermore emissions from shipping are growing while land based anthropogenic emissions are being constrained.

These shipping emissions are particularly significant in the oceanic regions of the Southern Hemisphere where they enter a pristine atmosphere compared with the more regionally polluted regions of the North Atlantic and North Pacific Oceans. The emissions produce particles that affect marine cloud properties and thereby potentially the climate. Shipping emissions of NO_x in the background atmosphere have several impacts, they lead to increasing levels of tropospheric ozone (a greenhouse gas) and a shortened lifetime for CH_4 (a greenhouse gas) and also, through deposition, fertilize the remote ocean surface layer with fixed nitrogen. Similarly, when the emissions are near land or in port, emissions of SO_2, NO_x, VOCs, and particles cause deterioration in air quality.

We review the causes of these ship exhaust emissions and the methodologies used to estimate them in state, national and international emissions inventory databases. Analyses of ship emissions for the southern hemisphere and for the Australian region are presented.

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ETHANOL IN THE ENVIRONMENT - A NATURAL PRODUCT, BIOFUEL AND POTENTIAL ENVIRONMENTAL POLLUTANT

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Abstract

Ethanol has long been known as a natural product and an important industrial chemical. More recently, ethanol has emerged as a useful biofuel and urban air pollutant. In spite of this, and the significant knowledge about aspects of ethanol in the environment, an overview of the environmental cycle of ethanol has not previously been formulated. We present an overview of the global environmental cycle of ethanol in plants, wetlands, the ocean and the atmosphere.

While most people are familiar with ethanol as a component of alcoholic drinks and industrial chemical, it appears that the cycling of ethanol in nature exceeds the anthropogenic component at this time. Ethanol is a key product of higher plants that experience flooding and other stresses, and is used as an energy source by these plants after the flooding/stress has ceased. Ethanol is also a substrate in the biological production of methane, an atmospheric greenhouse gas. However, because of its high solubility in water, the major cycling of ethanol is within plants and wetlands. Little naturally produced ethanol reaches the atmosphere.

The recently developed production of ethanol as a fuel has led to the situation where more than ten times the amount of ethanol is in fuel storage than is present in the global atmosphere. Within cities, where ethanol is used in vehicle fuels, there are elevated concentrations of both ethanol and the air toxic, acetaldehyde, which is an oxidation product of ethanol. With increasing usage of ethanol within fuel, higher atmospheric concentrations of both these compounds will occur. The possible consequences of this will be examined.

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A 29 YEAR RECORD OF OZONE IN THE SOUTHERN OCEAN MARINE BOUNDARY LAYER FROM CAPE GRIM, TASMANIA 41°S

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with contributions from Simon Bentley[1†] and Mick Meyer[1] and Cape Grim Staff[2]

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Abstract

Ozone in the troposphere is an important 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. Increases in background ozone, as have been observed to the present, have impacts also on the occurrence of urban and regional photochemical smog, related health effects and crop damage [Royal Society, 2008].Thus there is a need for information on changes in tropospheric ozone in the Southern Hemisphere.

Ozone has been measured in the surface air at Cape Grim Tasmania, 41°S. Selection of data by wind direction and speed, particle concentration and consistency of record, allows the determination of baseline ozone concentrations at Cape Grim, those concentrations that are representative of ozone in the Southern Ocean marine boundary layer. These ozone measurements have been made with ultraviolet adsorption methods since December 1981. Dual instruments and a separate calibrator have been maintained over most of the period. The task of producing a homogeneous record via long term instrument inter-comparisons and external calibration checks traceable to international primary standards in 1986, 2002 and 2010 will be described, along with the exploration of trends and their causes.

Increases in surface ozone are observed at Cape Grim, Cape Point South Africa, over the southern Atlantic Ocean and over Antarctica [Oltmans *et al*., 2006; Galbally, 2009]. It appears that tropospheric ozone has been increasing since the pre-industrial period, and will continue to increase during the 21st century. The likely causes of the observed southern hemisphere surface ozone increases will be discussed, including the effects of changed sources and changed sinks, as well as the impact of ongoing tropospheric ozone changes.

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BOUNDARY LAYER CLOUDS AND WIND SHEAR OVER THE SOUTHERN OCEAN

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Abstract

The Southern Ocean is a remote area, with the overlying atmosphere being unique and largely ignored by the meteorology community. There is a growing body of evidence that suggests that the clouds over the Southern Ocean are poorly understood, and poorly represented in climate models [Trenberth *et al*., 2010]. The focus of this study is on the structure and dynamics of the marine boundary layer.

Sounding data from Macquarie Island were analysed to determine the basic thermodynamic structure and the overall statistics for cloud amount, cloud vertical structure and changes in wind at cloud base and top. It was found that the majority of cloud is located in the lowest levels of the atmosphere. Changes in wind at cloud top and base were quantified, and it was found that the greatest changes in wind occur over cloud base, rather than cloud top, as one would expect.

Veritcal profiles from ECMWF ERA-Interim re-analysis data were analysed in the same way as Macquarie Island soundings. The re-analysis data reproduces a low-level cloud structure similar to that of the Macquarie Island soundings. The changes in wind at cloud top and base were quantified and it was found that a similar trend occurs where the greatest changes in wind are at cloud base, however the magnitude of the wind shift was less than Macquarie Island soundings suggest. These results indicate that the thermodynamic structure of boundary layer clouds over the Southern Ocean is unlike the typical thermodynamic structure of boundary layer clouds.

Reference

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A CLOUDSAT VIEW OF CLOUD PHASE CLIMATOLOGY OVER THE SOUTHERN OCEAN

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Abstract

The first three years of the CloudSat level 2 product "2B-CWC-RO" data have been analyzed to produce a climatology of the cloud phase distribution over the Southern Ocean. The cloud phase of the low-altitude clouds has a strong effect upon the radiative budget over the Southern Ocean (Mace et al. 2010), which has been found to be poorly represented in both reanalysis and couple climate models (Trenberth and Fasullo 2010).

The CloudSat climatology of the LWC concentrations of the low-altitude clouds is remarkable in that it displays neither a strong seasonal cycle nor a strong dependence on the latitude. Rather the climatology reveals a near uniform layer of liquid water clouds with tops typically below 2 km present year round over the studied region (40°S -65°S, 100°E -160°E). Peak liquid water content (LWC) concentrations of around 0.1g/m^3 occur at roughly 1 km above sea level and decrease marginally during summer.

In direct contrast, the ice water climatology displays both a pronounced dependence on the latitude and a seasonal cycle consistent with the movement in the Southern Ocean storm track. Higher average ice water content (IWC) concentrations with maximum 0.05g/m^3 are found over winter while the S-N inclination is more pronounced over summer.

The low-level cloud structure is compared against that suggested by the thermodynamic structure defined in the sounding data gathered at Hobart (42.52°S, 147.19°E) and Macquarie Island (54.30°S, 158.56°E). The relative frequency (RF) of cloud occurrence was computed for the two corresponding latitude bands from the CloudSat observations. The RF climatology from the soundings does not produce this rigid cloud field as produced by CloudSat; moreover it does display a stronger seasonal cycle.

The CloudSat observations offer an unprecedented view of the clouds over the Southern Ocean, but require direct observations to further reduce uncertainty.

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ATMOSPHERIC TOMOGRAPHY: DETERMINING THE FLUX RATE AND LOCATION OF POINT SOURCE FUGITIVE EMISSIONS

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Abstract

A method coined "atmospheric tomography" which enables simultaneous quantitative determination of location and emission rate of a point source fugitive emission is described in this paper. The method was tested experimentally on a flat, homogeneous field by the point source emission of two trace gas species, N_2O and CO_2, with continuous sampling of atmospheric trace gas concentrations at locations surrounding the release (~20 m radius), and measurement of atmospheric turbulence and dispersive conditions. Release species were chosen to enable evaluation of the method with different magnitudes of background variability: N_2O (~1%); CO_2 (~10%). Localisation using both release species occurred within 0.5 m (2% error) of the known location. Determination of emission rate was possible to within 7% for CO_2 (750 measurements) and 5% for N_2O (1300 measurements). Localisation required far fewer measurements for the required resolution compared to emission rate determination. With successful scaling-up, the method becomes a useful tool in applications requiring knowledge of location and rate of a fugitive emission.

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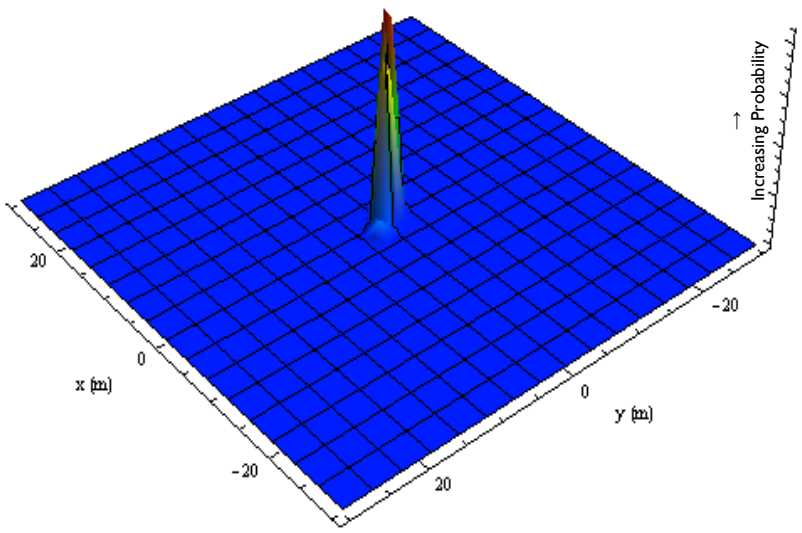


Figure 1. Probability distribution describing the location of a point source emission of CO_2 at 59 g min^{-1} calculated using 750 realisations. The probability is highest at the true location at the origin.

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OPEN-PATH FTIR MEASUREMENTS AT HAZARD REDUCTION BURNS IN NEW SOUTH WALES

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Abstract

Biomass burning is the largest contributor to variability in tropospheric composition. In order to model the chemistry and composition of the atmosphere it is important to characterise the emissions from biomass burning. Australian vegetation fires are responsible for approximately 8% of global biomass burning but measurements of emissions from Australian forest fires are relatively sparse given their global significance.

Here we present measurements of a number of trace gases using open-path FTIR through smoke plumes from hazard reduction burns in New South Wales (see figure 1). Concentration time-series and emission ratios are derived for a number of gases including carbon dioxide, carbon monoxide, formaldehyde, ammonia and ethylene. These results are considered in terms of their significance as a source of tropospheric pollutants and in terms of the health implications for the firemen and firewomen exposed to these hazardous gases.



Figure 1. Open path Fourier transform measurements of trace gases in smoke plumes from a hazard reduction burn at North Turramurra, NSW in September 2010.

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A NEW ATMOSPHERIC MONITORING STATION- ARCTURUS, QUEENSLAND

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Abstract

A new atmospheric monitoring station was established in central Queensland in mid 2010. The location is Arcturus (23 deg 51 min 31.4 sec south, 148 deg 28 min 28.6 sec east), a mostly rural area about 50 km southeast of Emerald. Measurements include continuous monitoring of CO_2, CH_4 and $\delta^{13}CO_2$, flask sampling for the CSIRO GASLAB suite and halocarbons, and meteorological data. Fluxes of CO_2 and CH_4 will be measured using eddy correlation techniques from early 2011. Potential monitoring applications of the station include contributing to the atmospheric network for inferring the continental carbon budget, improving estimates of regional ecosystem fluxes and providing a baseline for the geological storage of CO_2. Preliminary dispersion modelling suggests that coal mining activities in the district could also have a significant influence on methane concentrations and that measurements at Arcturus might enable top down estimates of the emissions.

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GLOBAL EMISSION ESTIMATES FOR C_4F_{10} - C_8F_{18}

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Abstract

Global emission estimates have been derived for C_4F_{10}, C_5F_{12}, C_6F_{14}, C_7F_{16} and C_8F_{18} using a global chemical transport model and an inverse method. Atmospheric histories were measured from a set of archive samples, which were filled between 1973 - 2009, from the Scripps Institution of Oceanography. The derived global emission estimates are significantly higher than EDGAR emission estimates for C_4F_{10} and C_5F_{12}; EDGAR emission estimates for C_6F_{14} and C_7F_{16} are comparable to the top-down estimates; and the UNFCCC reported emissions are 5-10 times lower than the top-down estimates. Furthermore, based on the current set of observations there appears to be a significant growth in emissions in the 1990s; most likely due to the heavier perfluorocarbons (PFCs) being used as replacements for Ozone Depleting Substances. However the observation set is fairly sparse, particularly in the 1990s, leading to high uncertainty in the temporal profile of emissions. Therefore, the Cape Grim Air Archive will be measured to decrease the uncertainty in the heavy PFC top-down emission estimates.

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GLOBAL AND AUSTRALIAN HFC, PFC AND SF_6 EMISSIONS: ATMOSPHERIC VERIFICATION

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Abstract

The synthetic greenhouse gases (GHGs: hydrofluorocarbons - HFCs, perfluorocarbons – PFCs, and sulfur hexafluoride - SF_6), emitted largely by the refrigeration, aluminium and electricity distribution industries respectively, are currently responsible for less than 2% of Australian and global net long-lived GHG emissions [DCCEE, 2010].

Nevertheless, they have attracted the attention of policymakers because (i) if their growth in concentrations and emissions continues unabated, particularly HFCs (currently 10% per year), then they could be responsible globally for more than 10% of the radiative forcing due to long-lived GHGs by 2050 [Velders *et al*., 2009], and (ii) they provide the opportunity for a very cost-effective GHG mitigation strategy, because emissions can be reduced significantly through better engineering to minimize emissions, through a ban on dispersive uses (as solvents for example) and through the use of low GWP (Global Warming Potential) alternatives (for example hydrofluoroolefins – HFOs).

CSIRO has been making high precision *in situ* measurements (12 per day) of HFCs, PFCs and SF_6 at Cape Grim, Tasmania, since 2004, and at Aspendale, Victoria, since 2006, using a gas chromatograph-mass spectrometer detector (GC-MSD) fitted with a custom-built cryo-focussing unit (Medusa: Miller *et al*., 2008). The resultant data, the associated data from the AGAGE global network, and the derived global and regional emissions by inverse modelling and interspecies correlation, have been published recently in international journals [HFCs: O'Doherty *et al*., 2009; Stohl *et al*., 2009; Miller *et al*., 2010; PFCs: Mühle *et al*., 2010; SF_6: Rigby *et al*., 2010].

The overall agreement between so-called 'bottom-up' estimates of global emissions, as reported to the UNFCCC (United Nations Framework Convention on Climate Change), and 'top-down' estimates from atmospheric observations is not good, with the atmospheric data suggesting that reported emissions are low, typically by factor of 2 or more. This is not unexpected, as major emitting nations such as China and India are not, at present, reporting their emissions to the UNFCCC process.

Such is not the case for Australia, where UNFCCC reported emissions [DCCEE, 2010] generally agree to within of 10% of emissions calculated from Cape Grim data, scaled on a population basis, with some notable exceptions, which will be discussed.

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AN UNORTHODOX APPROACH TO EXTENDING THE AIR ARCHIVE

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Abstract

Since 1978, CSIRO and the Bureau of Meteorology have been collecting and maintaining an air archive collected at Cape Grim, Tasmania [Langenfelds *et al*., 1996; Krummel *et al*., 2007]. Typically 2-4 air samples of baseline or clean background air samples air collected each year.

The archive air samples have been analysed at CSIRO [Francey *et al*., 2003] for all the important greenhouse and ozone depleting gases - carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulphur hexafluoride, chlorofluorocarbons (CFCs), hydrochlorfluorocarbons (HCFCs) and halons, halogenated alkanes and alkenes, as well as hydrogen, carbon monoxide and numerous other volatile organic compounds (VOCs – benzene and ethane for example) (Derek and Fraser, 2007; unpublished data). These data have proved invaluable in reconstructing the past chemical composition of the atmosphere as a driver of long-term climate change and ozone depletion [Clerbaux and Cunnold, 2007; Forster and Ramaswamy, 2007].

The only source of Southern Hemisphere baseline air prior to 1978 has been from Antarctic ice and firn. In conjunction with colleagues from the Antarctic Division and from the University of Tasmania, CSIRO have collected and analysed ice and firn air samples from Antarctica for CO_2, CH_4 and N_2O going back two thousand years [McFarling-Meure *et al*., 2006].

There is now an overlap in dates between the oldest archive air samples and the youngest firn air samples. Nevertheless, accurately dated, discrete background air samples older than 1978 are invaluable in reducing the date-concentration uncertainties associated with air samples extracted from firn or ice.

Through local community involvement, CSIRO has been alerted to old Scuba tanks as a source of air in pressurised containers that can precede the air archive. As Scuba tanks are typically filled using oil-free compressors, similar to compressors used to collect archive air samples, these additional samples have the ability to serve as an unorthordox addition to the air archive, thus assisting in illustrating long-term growth trends for species that exhibit long term stability in pressurized containers. Regulations governing the use of Scuba tanks dictate that these types of tanks must be hydrostatically tested yearly when in use, thereby providing an air age uncertainty less than 12 months. The results from the analysis of the Scuba tank air collected throughout Australia ranging in age from the late 1960s through to the 1990s have been analysed for a range of Greenhouse Gases (GHGs), the results of which will be presented.

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