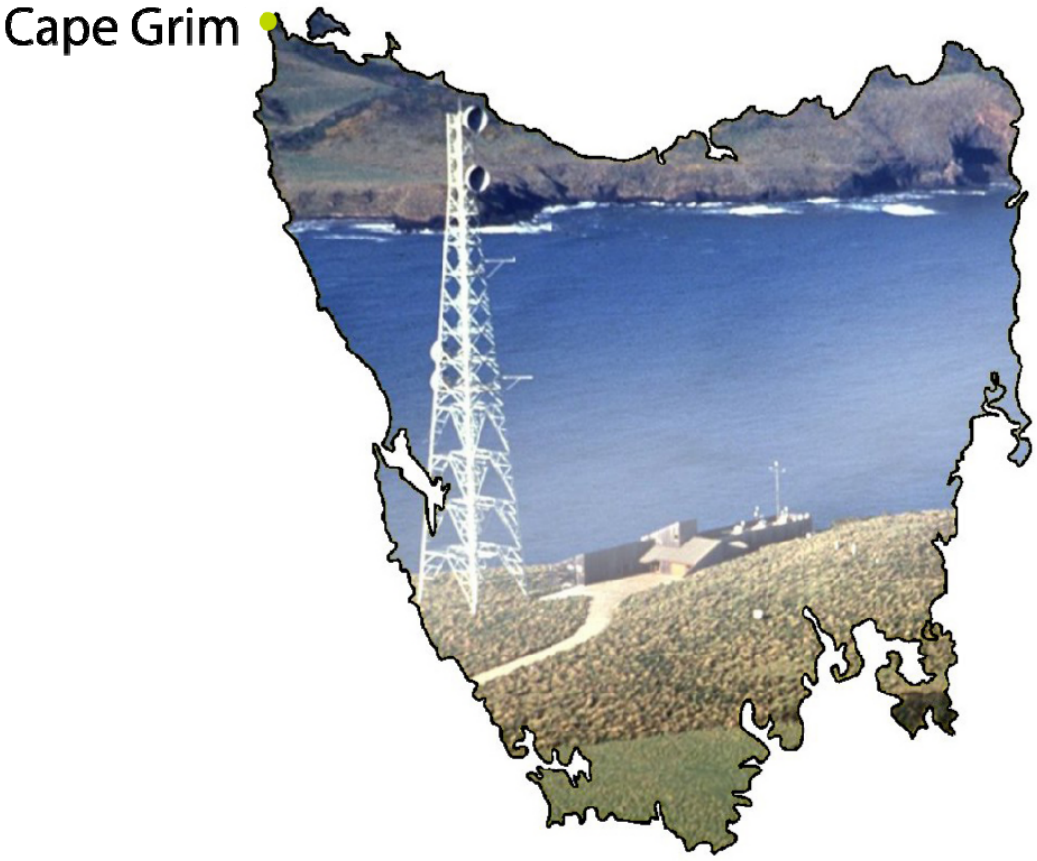
Cape Grim Annual Science Meeting

2009

Abstracts

3 – 4 December 2009



EDITED BY

Paul Krummel & Nada Derek

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

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Cape Grim Annual Science Meeting 2009

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

3 – 4 December 2009

Thursday, 3rd December		
Chair	***Paul Krummel***	
09:00	**Convenors**	**General information on arrangements etc.**
09:05	**Bruce Mapstone**	**Welcome and opening of meeting**
09:15	Ian Galbally	The Reactive Gases Program: past, present and future
09:40	Sarah Lawson	VOCs in marine air at Cape Grim
10:05	Clare Paton-Walsh	Characterising emissions from Australia's Black Saturday fires
10:30	**Morning Tea**	**Provided**
11:00	John Ogren	Seasonal climatology of vertical profiles of aerosol optical properties at two rural locations in the U.S.
11:25	John Gras	CCN at Cape Grim: Sources and processes
11:50	Melita Keywood	Cape Grim Multiphase Atmospheric Chemistry Program: Review
12:40	**Lunch**	**Own Arrangements**
Chair	***Stephen Wilson***	
13:40	Sara Mikaloff Fletcher	What can we learn about ocean biogeochemistry from atmospheric O_2/N_2 and CO_2?
14:05	Marcel van der Schoot	Australian regional high precision GHG observation network: Southern Ocean network (CO_2 sink) and new Australian tropical atmospheric research station
14:30	Ann Stavert	Southern Ocean CO_2: strategy, instrumentation and preliminary results
14:55	Rachel Law	Modelling synoptic variations of carbon dioxide and radon at Cape Grim: results from a TransCom experiment
15:20	**Afternoon Tea**	**Provided**
15:40	Roger Francey	The case for on-line global CO_2 growth from Cape Grim
16:05	David Etheridge	Atmospheric composition studies using Greenland firn air – first results from the NEEM project
16:30	Paul Fraser	A revised approach to estimating Melbourne/Port Phillip emissions of synthetic greenhouse gases by interspecies correlation
16:55	Colin Allison	Emissions of greenhouse gases from urban landfills
17:20	**All**	**Discussion about possible expanded future meetings**
17:50	Close of Papers	
19:00	**Meeting Dinner**	**Level 1: Hobson Room – Mordialloc Sporting Club, Mordialloc**

Cape Grim Annual Science Meeting 2009

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

3 – 4 December 2009

Friday, 4th December		
Chair	***Paul Fraser***	
09:00	**Convenors / Hosts**	
09:05	Wlodek Zahorowski	^{222}Rn flux density from the Southern Ocean – an estimate based on radon baseline observations in 2001-2008
09:30	Scott Chambers	^{222}Rn gradient measurements at Lucas Heights – some new results
09:55	Nicole Hyett	An investigation into the Zenith Blue corrections for the Australian Dobson network
10:20	David Griffith	An FTIR analyser for simultaneous high precision measurements of CO_2, CH_4, CO, N_2O and δ^{13}C-CO_2 in air: intercomparison measurements at Cape Grim
10:45	**Morning Tea**	**Provided**
11:05	Zoë Loh	A combined CH_4, $^{12}/^{13}CO_2$ record at Aspendale from a pair of Picarro WS-CRDS instruments
11:30	Paul Steele	Emerging analytical methods, and their potential role at Cape Grim
11:55	Russell Howden/ Ray Langenfleds	CSIRO GASLAB'S GC and flask management database
12:20	Paul Krummel	Overview of trace gas comparisons between flask and in situ measurements at Cape Grim
12:45	**Close of meeting**	

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THE REACTIVE GASES PROGRAM: PAST, PRESENT AND FUTURE

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Abstract

During the last 18 months there have been three international meetings concerned with monitoring ozone, nitrogen oxides and volatile organic compound in the background atmosphere. These meetings have addressed the issues of what is necessary, in terms of measurements and modelling of reactive gases, to provide useful information that can be integrated into global information systems. Issues addressed include: the rationale for these measurements and modelling, the locations for monitoring, instrumentation and platforms available and the integration of these measurements through chemical transport modelling.

A review will be presented of (a) the insights gained from these workshops and (b) the contributions to these issues of studies from Cape Grim. A number of options for future Reactive Gases work in Australia will be presented.

References

GAW-VOC/CCQM-GAWG Workshop EMPA, Dübendorf, Switzerland, 7-9 July 2008

NOxy – GAW Workshop at Hohenpeissenberg, Germany October 8-9, 2009

Tropospheric Ozone Changes: Observations, state of understanding, and modeling requirements. Workshop NOAA Earth System Research Laboratory, Boulder, Colorado October 14 - 16, 2009.

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VOCs IN MARINE AIR AT CAPE GRIM

S. Lawson*, I. Galbally, M. Keywood and J. Gras

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Abstract

We present high time resolution VOC observations made at Cape Grim during November-December 2007 and April 2008 using Proton Transfer Reaction-Mass Spectrometry. VOCs measured include dimethyl sulphide (DMS), isoprene, isoprene oxidation products Methyl Vinyl Ketone and methacrolein, methanol, acetone and acetonitrile. VOC concentrations at Cape Grim are compared to past Cape Grim measurements from the P2P campaign [Galbally *et al*., 2007] and measurements elsewhere in the world.

Diurnal cycles of VOCs are explored and show a clear diurnal cycle of DMS that agrees well with the observations from Cape Grim reported by Ayers & Gillett [2000], see Figure 1. A diurnal cycle of isoprene is also observed in November-December.

The possibility of new particle formation was explored by combining VOC data with continuous CN (10 nm) and UCN (3 nm) particle data. An increase in particle number of size range 3-10 nm occurred in Baseline conditions on the evening of the 13th April, that was accompanied by enhanced DMS concentrations, suggesting that DMS and its oxidation products may be contributing to new particle formation. This approach of making high time resolution VOC and particle measurements offers promise for understanding the formation of secondary organic aerosol and its role in climate.

Reference

Galbally, I. E., *et al*., Volatile organic compounds in marine air at Cape Grim, Australia, *Environ. Chem*., 4(3), 178-182, 2007.

Ayers, G. P. and R. W. Gillett, DMS and its oxidation products in the remote marine atmosphere: implications for climate and atmospheric chemistry, *J. Sea Res*., 43, 275-286, 2000.

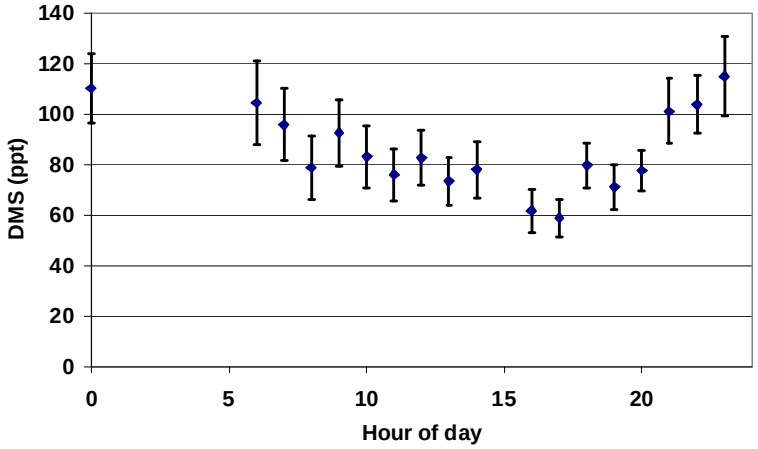


Figure 1. Concentrations of DMS presented as an average for each hour of the day combined for data from December 2007 and April 2008.

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CHARACTERISING EMISSIONS FROM AUSTRALIA'S BLACK SATURDAY FIRES

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Abstract

The 'Black Saturday' fires were a set of devastating bushfires that burned across the Australian state of Victoria on Saturday the 7th of February 2009 killing 173 people. The fires continued into March when rain and cooler conditions allowed the fires to be extinguished. Smoke plumes from the Black Saturday fires were transported south eastwards eluding local ground-based remote sensing FTIR spectrometers, but were captured by a number of satellite-based sensors. OMI UV-aerosol index data show that smoke from the first intense fires separated from subsequent plumes and was transported to the north of New Zealand where it stayed for over a week before moving west across northern Australia and dissipating over the Indian Ocean in early March.

Here we present an analysis of the emissions from the Black Saturday fires including total emissions estimates for a number of trace gases and a study of the aging of the smoke emitted from the first days of the fires.

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SEASONAL CLIMATOLOGY OF VERTICAL PROFILES OF AEROSOL OPTICAL PROPERTIES AT TWO RURAL LOCATIONS IN THE U.S.

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[2]*Cooperative Institute for Research in Environmental Sciences, University of Colorado, Boulder, Colorado*
[3]*Department of Earth Physics and Thermodynamics, University of Valencia, Valencia, Spain*

Abstract

Instrumented small airplanes measured more than 1100 vertical profiles of aerosol optical properties over rural sites in Oklahoma and Illinois between March 2000 and September 2009. Statistically, these *in-situ* profiling measurements suggest there are significant differences in aerosol profile properties as a function of season. Over Oklahoma, the highest amounts of aerosol throughout the column are observed during the summer, while the aerosol is most absorbing (i.e. lowest single scattering albedo) in the winter (Oklahoma) or fall/winter (Illinois). Spring and fall profiles of aerosol scattering and absorption tend to be quite similar to the annual aerosol profiles. The seasonal variability observed for aerosol absorption and scattering is consistent with other reported aerosol measurements in the region (e.g. surface *in situ* optical, mass concentrations and aerosol optical depth). This talk will compare the seasonal profiles of aerosol optical properties at the two sites, compare the profiles with aerosol optical properties observed at the associated surface sites, and examine the systematic dependence of aerosol single-scattering albedo with aerosol amount. Results from the in-situ measurements on the aircraft will be compared with values retrieved from co-located AERONET observations.

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CCN AT CAPE GRIM: SOURCES AND PROCESSES

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Abstract

For many years much of our understanding of the drivers for CCN over the Southern Ocean has relied on correlative studies with various sulfur species and a developing understanding of sulfur chemistry in the marine atmosphere. Recently global chemical transport models and observations in other regions have brought a new view of the potential source contributions. This work re-examines some of the associations between CCN and various tracers to investigate source contributions to CCN at Cape Grim and also looks for evidence of a potentially important mechanism that is not yet included in current models.

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CAPE GRIM MULTIPHASE ATMOSPHERIC CHEMISTRY PROGRAM: REVIEW

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A report is presented of the Cape Grim Multiphase Atmospheric Chemistry (MAC) Program. The components of the MAC program reviewed here include aerosol composition research since 2000, precipitation chemistry research since 1976 and relevant collaborative programs.

The report briefly covers: (a) the Program scientific objectives; (b) discussion of existing activities and outcomes; (c) work in progress; (d) future plans and (e) relevance to GAW and Cape Grim.

The achievements of the MAC Program include:

- A 21 year record of weekly baseline PM10 soluble ion composition, including sea-salt, non sea-salt sulfate and methanesulfonic acid (MSA)
- A 7 year record of weekly baseline PM2.5 soluble ion composition including sea-salt, non sea-salt sulfate and MSA.
- A 28 year record of weekly baseline rainfall composition including sea-salt, non sea-salt sulfate and MSA; however removing data with soil contamination based on criteria specified by Ayers (2001) results in removal of 30% of the record
- Precursor to Particle Campaign in February 2006
- Mass closure and organic speciation of baseline PM10 aerosol
- Evaluation of the effect of baseline event switches on PM10 chemical composition and mass
- Establishment of a long term modelling project with the aim of understanding the Southern Ocean coupled aerosol-chemistry system
- Measurement of Persistent Organic Pollutants at Cape Grim as part of the National Dioxin Measurement Program
- Successful collaboration with a range of Australian and international research partners

Throughout the review period there has been an active use of Cape Grim data and also advocacy of global atmospheric composition monitoring. Twenty one journal papers, six peer reviewed reports and 10 conference papers have resulted from activities within or associated with the Program.

Future plans for the MAC Program include the continued collection of samples for the long term PM10 aerosol and rainfall composition records as well as an enhancement of aerosol sampling activities to progress our understanding of the sources contributing to cloud condensation nuclei formation over the Southern Ocean. In particular this will involve the collection of size-resolved aerosol samples for chemical and mass closure analysis focused on the cloud processing mode of particles (300 nm) at a location where samples will not be contaminated with local soil from the cliff top. In addition, there is an ongoing need to address significant national research questions related to the baseline levels of airborne pollutants in and entering the Australian atmospheric environment, and the Cape Grim research Programs are a means by which this can be addressed. Specifically, atmospheric mercury and Persistent Organic Pollutants are of concern because of their growing atmospheric concentrations and their detrimental effects on a range of ecosystems. Here we suggest the addition of these pollutants into the long term measurement programs included in the MAC Program.

Finally, collaboration with Australian and international partners will continue to be a major emphasis of the MAC program with existing collaborations continuing and new ones developing.

Reference

Ayers, G. P., Influence of local soil dust on composition of aerosol samples at Cape Grim, in *Baseline Atmospheric Program Australia 1997-98*, edited by N. W. Tindale, N. Derek, and R. J. Francey, Bureau of Meteorology and CSIRO Atmospheric Research, Melbourne, Australia, 50-56, 2001.

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WHAT CAN WE LEARN ABOUT OCEAN BIOGEOCHEMISTRY FROM ATMOSPHERIC O_2/N_2 AND CO_2?

S. Mikaloff Fletcher[1*], B. Stephens[1,2] and G. Brailsford[2]

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[2]*National Center for Atmospheric Research (NCAR), Boulder, CO, U.S.A.*

Abstract

The greatest ocean uptake of anthropogenic carbon occurs in the Southern Ocean, which is responsible for nearly a quarter of the global ocean carbon sink *[Mikaloff Fletcher et al., 2006].* Recent studies using ocean models and atmospheric CO_2 observations have suggested that the Southern Ocean carbon sink is saturating in response to climate change *[Le Quéré et al., 2007],* which would have major implications for future climate change projections and regional carbon budgets. However, this result is highly sensitive to the direction and magnitude of the response of ocean biology to climate change in the ocean models, which is poorly understood.

Atmospheric measurements of O_2/N_2 ratios and CO_2 have the unique potential to elucidate the ocean biological sink and its response to climate change. The net air-sea fluxes of O_2 and CO_2 can be thought of as a combination of two 'pumps': a solubility pump resulting from the fact that gases are more soluble in colder waters and a biological pump resulting from photosynthesis, respiration, and remineralization. It is difficult to disentangle the biological and solubility pumps from atmospheric CO_2 data alone, because increasing temperatures tend to decrease CO_2 uptake from the solubility pump while increasing CO_2 uptake from the biological pump. However, in the case of O_2, increasing temperatures tend to decrease uptake from both pumps. By using observations and models of both of these species, it may be possible to reveal the response of these two processes to seasonality and climate variability and deepen our understanding of how they will respond to climate change *[Stephens et al, 1998].* We compare the observed seasonal cycle of O_2/N_2 and CO_2 at high latitude southern hemisphere stations with results from an atmospheric transport model forced with fluxes from ocean models and data-based estimates to asses the ability of the models to capture the seasonality of key tracers of ocean biogeochemistry.

Reference

Le Quéré, C., *et al.*, Saturation of the Southern Ocean CO_2 sink due to recent climate change, *Science*, 316, 1735-1738, 2007.

Mikaloff Fletcher, S., *et al*., Inverse estimates of anthropogenic CO_2 uptake, transport, and storage by the ocean, *Global Biogeochem. Cycles*, 20, doi: 10.1029/2005GB002530, 2006.

Stephens, B., R. F. Keeling, M. Heimann, K. D. Six, and R. Murnane, Testing global biological ocean models using measurements of atmospheric O_2 and CO_2 concentrations, *Global Biogeochem. Cycles*, 12, 213-230, 1998.

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AUSTRALIAN REGIONAL HIGH PRECISION GHG OBSERVATION NETWORK : SOUTHERN OCEAN NETWORK (CO_2 SINK) AND NEW AUSTRALIAN TROPICAL ATMOSPHERIC RESEARCH STATION

M. V. van der Schoot[1*], L. P. Steele[1], D. A. Spencer[1], P. B. Krummel[1], R. J. Francey[1], A. Stavert[1], P. Fraser[1], M. Schmidt[2], M. Ramonet[2] and B. Wastine[2]

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Abstract

A high precision atmospheric observation network for GHG and related trace gas species is being developed for the South East Asian-Australian region. The primary objectives of the network are to:

- provide key data on climatically active atmospheric constituents in the critically under-sampled tropics region, in order to improve our global understanding of the forcing of climate change;
- investigate the potential for a high-precision atmospheric CO_2 observation network to assist detection of any changes in the CO_2 fluxes in the globally important Southern Ocean region, and
- dramatically reduce the uncertainties in estimates of GHG emissions from Australia

This expanding regional network has the Cape Grim Baseline Air Pollution Station as the central observation site. A new atmospheric research station is being developed in the Australian tropics region, incorporating high precision and continuous measurements of GHG and related species. It is anticipated high precision atmospheric observations from this region should significantly improve the understanding of the biogeochemical cycles of the tropical sources and sinks of the climatically active constituents. High precision 'LoFLo' (NDIR) and 'Picarro' (Cavity Ring Down Spectroscopy) instruments are being used for the measurement of CO_2, CH_4 and $^{13}CO_2/^{12}CO_2$.

The Southern Ocean observation network (CSIRO, Australia and LSCE, France) has been in operation since 2005. High quality data from this network will support measurement and modelling research of the atmospheric and oceanic carbon cycles in the Southern Ocean region, in particular to investigate the role of the Southern Ocean as a current and future sink for atmospheric CO_2. High precision continuous CO_2 data records from three key Southern Ocean sites (Cape Grim, Macquarie Is. and Amsterdam Is.), which have high precision LoFlo CO_2 analyser systems operating at each, will also be presented. The inter-calibration strategy for maintaining a long term, high precision network will be discussed.

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SOUTHERN OCEAN CO_2: STRATEGY, INSTRUMENTATION AND PRELIMINARY RESULTS

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Abstract

The Southern Ocean (south of 44° S) is a major sink of atmospheric CO_2, however a recent paper [Le Quéré *et al*., 2007] has suggested that this sink may be shrinking, which would have serious implications for the global carbon cycle. Our ability to constrain the mean Southern Ocean carbon flux and its seasonality and interannual variability has been limited by the small number of southern ocean pCO_2 measurements, especially in winter. We are investigating whether the magnitude of and variations in the Southern Ocean carbon flux can be observed in the atmospheric CO_2 mixing ratio using a high precision network of continuous *in situ* CO_2 measurements based on a common calibration scale. The network will comprise existing LoFlo instruments based at Cape Grim (40.68° S, 144.69° E), Macquarie Island (54.5° S, 158.95° E) and Amsterdam Island (37.83° S, 77.50° E), augmented with new Cavity Ring-Down (CRD) instruments. Simultaneous O_2 measurements and a new mainland Antarctic site are also planned. Data from this network will be used in combination with modelling studies to investigate carbon cycling within the Southern Ocean area.

This talk will outline the development of the network, strategies used to ensure comparability within the network, the progress so far and future directions. It will also describe the calibration and initial comparison of three CO_2/CH_4 CRD instruments currently located within the Aspendale Greenhouse Gas Laboratory.

Reference

Le Quéré, C., C. Rödenbeck, E. T. Buitenhuis, T. J. Conway, R. Langenfelds, *et al*., Saturation of the Southern Ocean CO_2 sink due to recent climate change, *Science*, 316, 1735-1738, 2007.

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MODELLING SYNOPTIC VARIATIONS OF CARBON DIOXIDE AND RADON AT CAPE GRIM: RESULTS FROM A TRANSCOM EXPERIMENT

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[2]*Australian Nuclear Science and Technology Organisation, Menai, NSW*

Abstract

A model intercomparison project, 'TransCom-continuous', was designed to assess the ability of atmospheric models to simulate diurnal and synoptic variations in CO_2 at measuring sites. Model output was submitted for over 250 locations, with profile and meteorological data also submitted for around 100 of these sites, one of which was Cape Grim. Model output is available for 2002 and 2003. Most of the 25 participating models and model variants were run globally with typical horizontal resolution of 100-200 km. Nine atmospheric tracers were simulated, biospheric CO_2 (five variants from two biosphere models, CASA and SiB), ocean CO_2, fossil CO_2, SF_6 and radon. The experimental design and overview results are presented by Law *et al*., (2008) and Patra *et al*., (2008).

Atmospheric measurements of CO_2 at Cape Grim are typical of coastal sites with periods of baseline CO_2, when the sampled air is from the ocean, and non-baseline periods, when the air has had relatively recent contact with land. Our analysis focuses on how well the models capture the temporal evolution of these non-baseline events, having first excluded those models that failed to adequately separate baseline and non-baseline periods. We divide 2002-2003 into 90 events (e.g. Figure 1). Less than 20% of the events are well modelled for CO_2 (correlation > 0.6) compared to around 60% for radon. We use a number of case studies to explore typical situations where the models perform poorly. The resolution of input fluxes is found to be one limitation. We also highlight some good simulations, such as the unusually long, below-baseline deviation on 16 August (Figure 1) which is captured by the modelled CO_2 using CASA biosphere fluxes.

References

Law, R. M., *et al*., TransCom model simulations of hourly atmospheric CO_2: Experimental overview and diurnal cycle results for 2002, *Global Biogeochem. Cycles*, 22, GB3009, doi:10.1029/2007GB003050, 2008.

Patra, P. K., *et al*., TransCom model simulations of hourly atmospheric CO_2: Analysis of synoptic-scale variations for the period 2002-2003, *Global Biogeochem. Cycles*, 22, GB4013, doi:10.1029/2007GB003081, 2008.

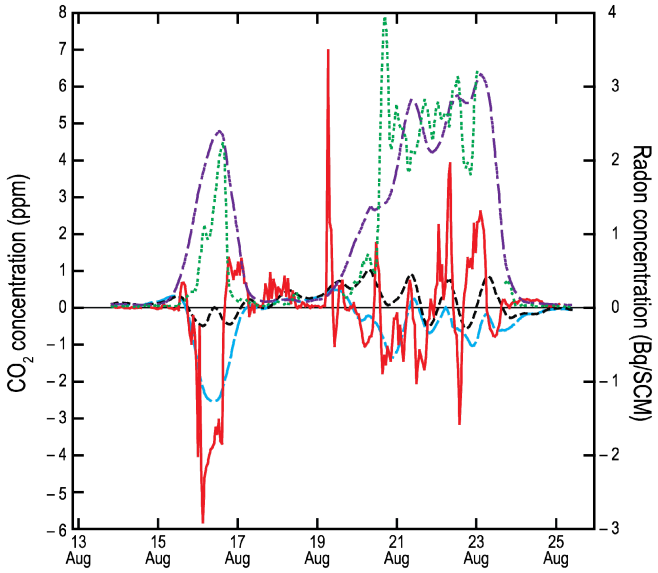


Figure 1. Observed (red) and modelled CO_2 residuals from baseline for 13-25 August 2003 in ppm (left axis). The modelled CO_2 is the ensemble model mean for fossil + ocean + biospheric CO_2 using the CASA (blue) or SiB (black) diurnally varying biosphere fluxes. Also shown is observed (green) and modelled (purple) radon in Bq/SCM (right axis).

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THE CASE FOR ON-LINE GLOBAL CO_2 GROWTH FROM CAPE GRIM

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Abstract

Top-down estimates of global trends in CO_2 fluxes, which largely determine changes in climate forcing and in factors like the airborne fraction, are reaching a limit determined by substantial uncertainties arising from statistical combinations of uncertainties in anthropogenic emissions, ocean exchange, land exchange (biospheric and land-use) and measured atmospheric trends.

These studies were developed to obtain regional fluxes, and continue to require reliable information from high-quality regionally distributed monitoring sites to do this. However, to address global trends, top-down inversions continue to incorporate atmospheric CO_2 data with demonstrable regional (systematic) bias which is incorrectly interpreted as a statistical uncertainty in global behaviour. The Bayesian inversions can thus accommodate significant atmospheric carbon changes and often obscure correct attribution of global causes.

Geography, meteorology and advanced technology at Cape Grim combine to provide large scale atmospheric growth trends that largely exclude regional influence and lead to large reductions in uncertainty in estimated global trends on multi-year time frames. The uncertainty reductions can provide improved constraints on the top-down inversions and more accurately define recent CO_2 global growth trends. These results challenge trends in recent source and sink estimates.

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ATMOSPHERIC COMPOSITION STUDIES USING GREENLAND FIRN AIR - FIRST RESULTS FROM THE NEEM PROJECT

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Abstract

The North Greenland Eemian (NEEM) ice drilling in Greenland is a major international project, lasting from 2007 to 2011. It aims to reach back through the last interglacial, the Eemian (115 to 125 thousand years ago), a period that was possibly slightly warmer than present. The NEEM site is at 2500 metres elevation in northwest Greenland where the temperature, snow accumulation rate and ice flow are expected to preserve an undisturbed and highly resolved record of climate, atmospheric composition and ice sheet extent. These conditions also create a firn layer (consolidated snow) that is suitable for reconstruction of atmospheric trace gases.

We will present an overview of the project and its progress over the 2009 field season, and report early results from the firn air sampling program, where CSIRO MAR in collaboration with the University of Copenhagen extracted air directly from the upper 80 metres of the ice sheet. The air is being used to track the evolution of ultra trace compounds and isotopes over the last century, and to constrain the air age resolution of the deeper core. The firn air samples provide a useful complement to the firn and ice core air measurements from Law Dome and South Pole, Antarctica.

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A REVISED APPROACH TO ESTIMATING MELBOURNE/PORT PHILLIP EMISSIONS OF SYNTHETIC GREENHOUSE GASES BY INTERSPECIES CORRELATION

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Abstract

The tracer-ratio method [Dunse *et al*., 2005], used to estimate emissions of a number of traces gases from the Melbourne/Port Phillip region, has been revised and updated.

The original method used two markers - CFC-12 (CCl_2F_2) and HFC-134a (CH_2FCF_3) - to identify pollution episodes attributable to Melbourne/Port Phillip emissions, and carbon monoxide (CO) was used as the ratio species, given the substantial knowledge of the magnitude and trends in CO emissions in the Melbourne/Port Phillip airshed.

The revised method uses HFC-134a as the pollution marker and meteorological back-trajectory information to provide confirmation that air parcels arriving at Cape Grim had passed over, or very close to Melbourne. The trajectories are used to exclude air masses that passed over the Latrobe Valley on route to Cape Grim because the Latrobe Valley has a disproportionately large CO source (compared to Melbourne/Port Phillip). For the study period (2005-2008) constant CO emissions are assumed as indicated in the National Pollutant (NPI, 2008). The interspecies correlation algorithm has been revised.

The methodology changes will be described, and the new emissions results will be compared to those from the original methodology.

References

Dunse, B. L., L. P. Steele, S. R. Wilson, P. J. Fraser, and P. B. Krummel, Trace Gas Emissions From Melbourne, Australia, Based on AGAGE Observations at Cape Grim, Tasmania, 1995-2000, *Atmos. Environ*., 39, 6334-6344, 2005.

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EMISSIONS OF GREENHOUSE GASES FROM URBAN LANDFILLS

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Abstract

The National Greenhouse Gas Inventory for 2007 [NGGI, 2009] estimates that methane emissions from solid waste disposal on land were 11.1 Mt CO_2-e in 2007, i.e. about 3% of Australia's national emissions. Interestingly, the 2007 emissions are about 25% lower than the 1990 emissions even though there has been a significant increase in the amount of waste generated over this period [WSGGE, 2008] and Australia's population has increased by 23% and CO_2-e emissions from energy production increased by more than 50%. The decrease in emissions from the solid waste disposal is due to two factors, (1) increased recycling, leading to reduced quantities of waste going into landfill, and (2) improved management of the landfill sites, including methane capture.

We have used flux chamber experiments performed at the Rye landfill site, 60 km south of Melbourne, to estimate the emissions of a large number of greenhouse gases from a range of activities at an active landfill site. The emissions are highly variable and, as expected, CH_4 dominates the non-CO_2 greenhouse gas emissions, but many other greenhouse gases are seen escaping from the landfill.

We will present results from flux chamber experiments and our estimates of greenhouse gas emissions from the Rye landfill site. We then use the Rye landfill site emissions to estimate national emissions of a number of greenhouse gases.

References

NGGI, National Greenhouse Gas Inventory accounting for the Kyoto target May 2009, Australian Government Department of Climate Change, Commonwealth of Australia, ISBN 978-1-921298-42-4, 2009.

WSGGE, Waste Sector Greenhouse Gas Emissions Projections 2007, Australian Government Department of Climate Change, Commonwealth of Australia, ISBN 978-1-921297-183-0, 2008.

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RADON-222 FLUX DENSITY FROM THE AUSTRALIAN LAND SURFACE

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Abstract

Radon-222 is a natural passive tracer of atmospheric transport and mixing, and so is used to evaluate these processes in models. Commonly, such studies assume uniform flux from ice-free land, thus neglecting spatial and temporal variability. We present an improvement: a map of the monthly-averaged time evolution of the surface flux of radon from the Australian mainland and Tasmania. This is based on a spatially-resolved diffusion model, which we calibrate empirically using point data from field measurements of radon flux. The flux map incorporates airborne gamma ray measurements, monthly soil moisture, and other soil parameters. Shown in Figure 1, we find significant departures from spatial uniformity and, in Figure 2, large regions where the seasonal cycle is as large as the continental mean.

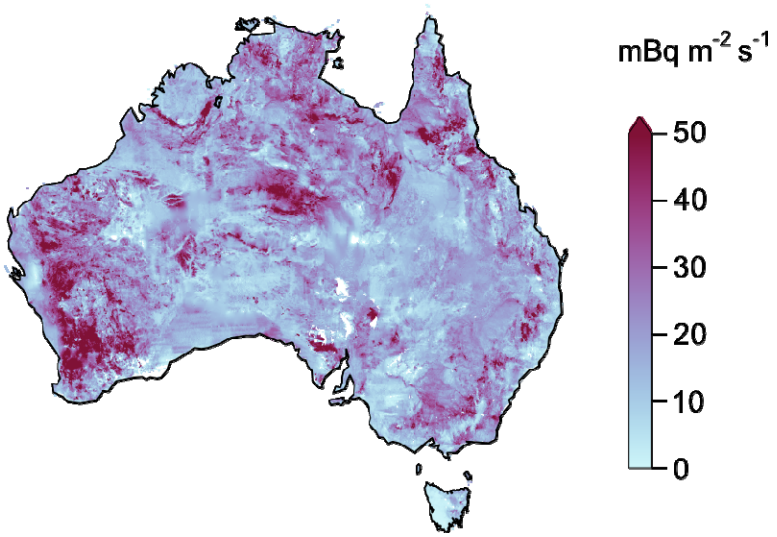


Figure 1. Radon flux density: multi-year mean from 1900-2008.

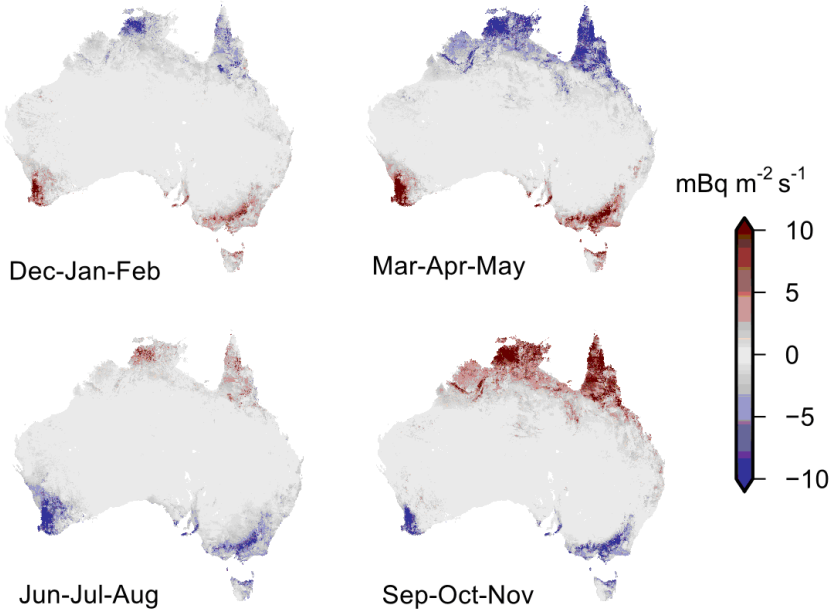


Figure 2. Radon flux density: seasonal departures from the multi-year mean.

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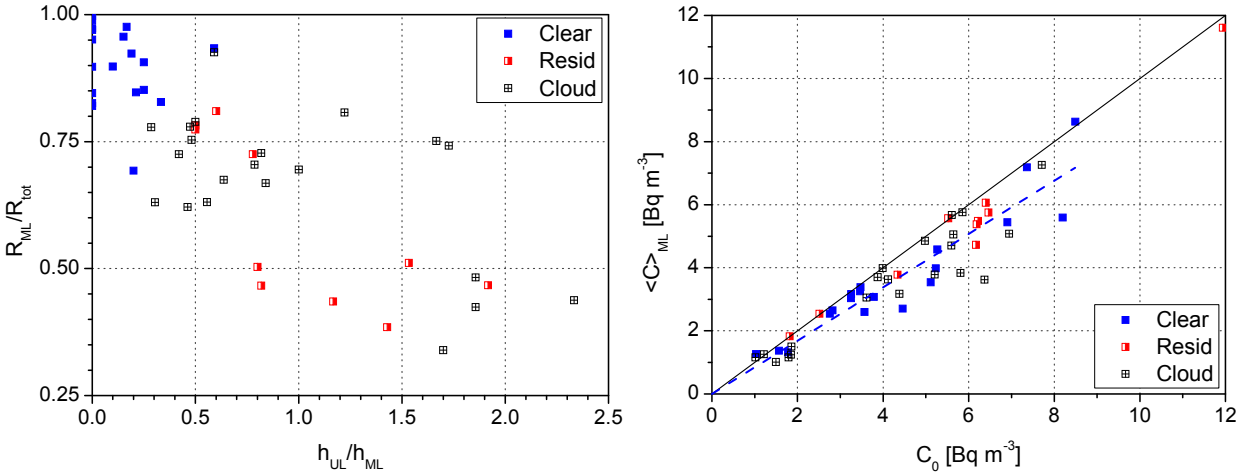
TOWARDS A MORE REALISTIC ESTIMATION OF TOTAL BOUNDARY LAYER RADON WHEN ONLY SURFACE-BASED MEASUREMENTS ARE AVAILABLE

A. G. Williams*, W. Zahorowski, S. Chambers, A. Element, S. Werczynski and A. Griffiths

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Abstract

Estimation of the total amount of the natural radioactive tracer radon-222 (radon) in a vertical column through the troposphere is a critical step in the process of calculating regionally integrated emissions of important greenhouse gases using radon-calibrated budget techniques. As continuous long-term radon time series used for such calculations are typically gathered at sites located at or near the surface, total column radon estimates require *a priori* knowledge of the vertical distribution of radon through the atmospheric boundary layer (ABL). The most frequent approach is to assume a uniform radon profile within the ABL and an arbitrary venting fraction (often set to zero) characterising the loss of radon into the free atmosphere above. This study aims at refining that simplistic assumption by presenting vertical integrations of high-resolution radon profiles gathered in and above daytime boundary layers over rural inland Australia under a range of stability and cloud conditions. Robust estimates are obtained for boundary layer venting due to entrainment processes and the action of coupled cloud layers.



Column-integrated radon statistics over rural inland Australia for daytime boundary layers with clear-skies (blue squares), residual layers (red half-squares) and substantial coupled cloud layers (squares with black crosses). Note that 'clear-sky' cases sometimes include a few thin clouds.

Left: Proportion of total column radon contained within the mixed (or sub-cloud) layer, as a function of the ratio of the upper (residual or cloud) layer to the mixed layer depth. In cloudy conditions, and when the mixed layer is topped by a residual layer, the fraction of total column radon in the mixed layer can be as low as 30%.

Right: Mixed-layer average radon concentration as a function of the surface concentration. Line of best fit (blue line), calculated for the clear cases only, has a slope of 0.84. It is clear that the assumption of a uniform radon profile will lead to an overestimation of the total mixed layer radon in the majority of situations.

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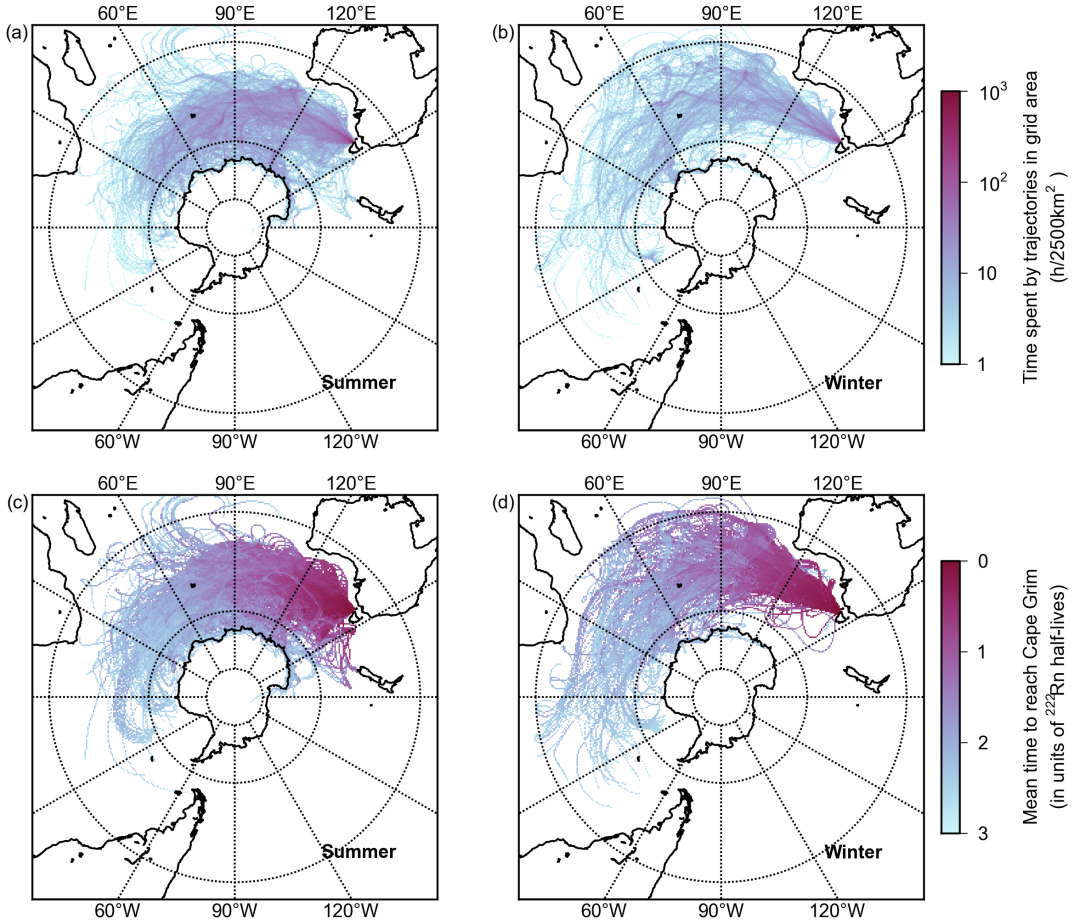
^{222}Rn flux density from the Southern Ocean – An estimate based on radon baseline observations in 2001-2008

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Abstract

We present a new evaluation of radon-222 flux density from the Southern Ocean based on selected hourly radon baseline observations at Cape Grim in 2001-2008. The selection process targeted only those radon observations corresponding to air parcels in equilibrium with the oceanic radon source. Together with various other selection conditions, this resulted in less than 10% of all baseline events being used for the evaluation. The composite winter and summer fetch for the selected set of observations is shown in the figure below, with the contrast signifying the coverage as well as the mean time required for the corresponding air parcels to arrive at Cape Grim. The necessary boundary layer heights were derived from a reanalysis of the ECMWF operational model on a 1.5º grid. The reanalysis was compared for 1998 with mini-lidar measurements gathered at Cape Grim – on average the lidar estimates were about 11% lower.



2001-2008 seasonal back trajectory density functions for the selected base events at Cape Grim. Composite density plots are shown for summer (a) and winter (b). Plots (c) and (d) indicate the mean time required for corresponding air parcels to reach Cape Grim. 10 day back trajectories were calculated using the HYSPLIT model.

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^{222}Rn Gradient Measurements at Lucas Heights – Some New Results

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Abstract

To evaluate, and ultimately improve, numerical schemes for mixing within the atmospheric boundary layer it is necessary to quantify vertical mixing and exchange within the lower atmosphere at a temporal resolution sufficient to resolve the diurnal cycle. One way to quantitatively characterise near-surface mixing processes on diurnal time scales is to make continuous, high temporal resolution, ^{222}Rn gradient measurements. The strength of the ^{222}Rn gradient is a useful proxy for diurnal concentration effects on many trace gas and aerosol species. ^{222}Rn gradient measurements have been made from a 50 m tower at Lucas Heights, NSW, using a pair of 1500 L dual flow loop, two filter radon detectors, with lower limits of detection of ~40 mBq m^{-3}. The diurnal radon signal at Lucas Heights, a topographically complex site near the coast, is suppressed in comparison to that of flat, inland sites (Figure 1). Recent results from these observations are used to show how the ^{222}Rn gradient is influenced by mechanical and convective turbulence. For 10 m agl wind speeds in excess of 2 ms^{-1}, mechanical turbulence greatly reduces the observed ^{222}Rn gradient (Figure 2; Figure 3). At night, only when the Bulk Richardson Number exceeds the critical value (R_c= 0.25) does the observed ^{222}Rn gradient significantly exceed 1 Bq m^{-3} (Figure 4).

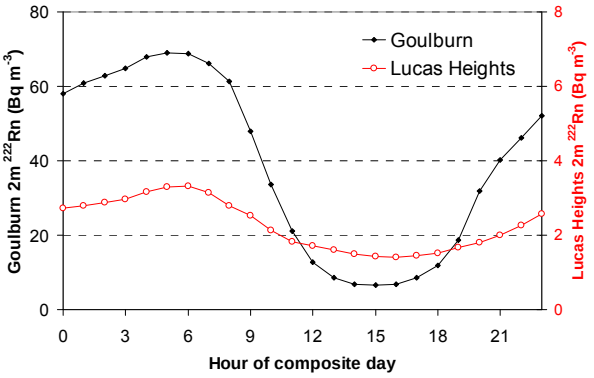


Figure 1. Composite diurnal 2m ^{222}Rn concentrations at a flat, inland site and a topographically complex site 20 km from the ocean.

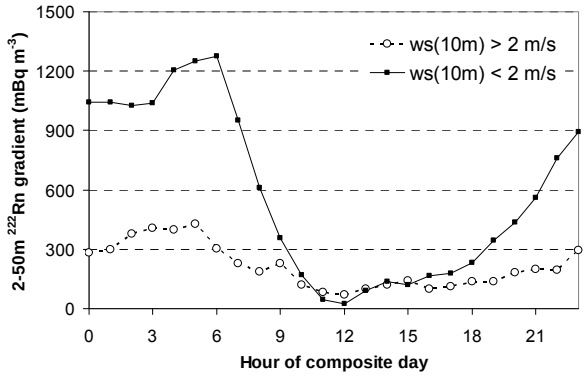


Figure 2. Example of the effect of wind speed on the ^{222}Rn gradient at Lucas Heights.

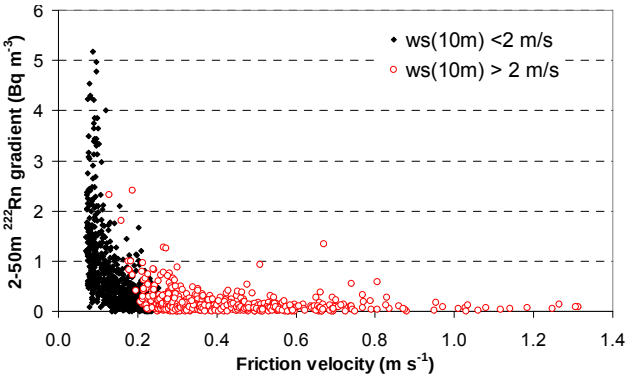


Figure 3. ^{222}Rn gradient at Lucas Heights as a function of the friction velocity at 10 m agl.

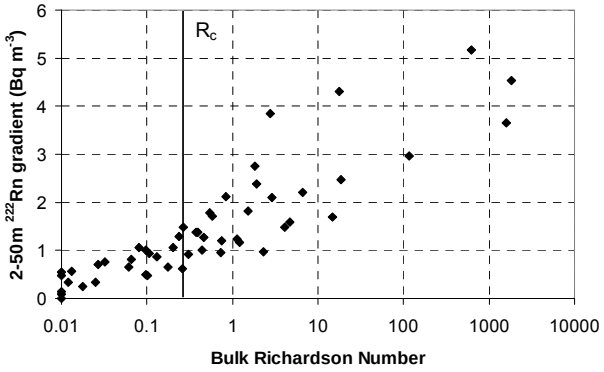


Figure 4. Maximum nocturnal ^{222}Rn gradient at Lucas Heights as a function of maximum nocturnal Bulk Richardson Number (note semi log scale).

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AN INVESTIGATION INTO THE ZENITH BLUE CORRECTIONS FOR THE AUSTRALIAN DOBSON NETWORK

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Abstract

The Bureau of Meteorology monitors total column ozone at various locations around Australia daily using a network of Dobson spectrophotometers. The most accurate Dobson measurement occurs when the instrument is operating in the Direct Sun (DS) mode. When the sun is obscured by cloud, the next best measurement is obtained by operating the Dobson in Zenith Blue (ZB) mode. However, when DS and ZB measurements are performed simultaneously and at the same location the total ozone derived from each measurement differs. This difference is known as the Zenith Blue correction, which traditionally has been empirically derived and then applied to ZB observations.

This study uses quasi-simultaneous DS-ZB pairs to evaluate various parameterisations of the Zenith Blue correction proposed in the literature or known to be in current use.

A simple model linear in μ (where μ is the ratio of the actual and vertical paths of solar radiation through the ozone layer, assuming the mean height of the ozone layer to be 22 km) was found to be the most suitable for general use due to its simplicity, its stability over time, its stability over μ (when μ is within normal observational range) and its stability over different instruments. A slight variation in the form of the linear relationship with variation in total ozone was also detected however.

The results of modelling the zenith blue correction using a radiative transfer calculation through the atmosphere are in excellent qualitative agreement with these findings.

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AN FTIR ANALYSER FOR SIMULTANEOUS HIGH PRECISION MEASUREMENTS OF CO_2, CH_4, CO, N_2O AND $\delta^{13}C$-CO_2 IN AIR: INTERCOMPARISON MEASUREMENTS AT CAPE GRIM

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Abstract

Over the past decade we have developed and refined a multi-species trace gas analyser based on Fourier Transform Infrared (FTIR) spectroscopy for atmospheric composition measurements. The analyser determines mixing ratios of CO_2, $\delta^{13}C$-in-CO_2, CH_4, CO and N_2O simultaneously in air with high precision and accuracy.

From October 2008 to February 2009 we operated a new analyser at Cape Grim, parallel to the CSIRO LoFlo CO_2 analyser and AGAGE automated GC system. The FTIR analyser operated autonomously, measuring 10-minute average mixing ratios continuously over the 110 day trial. In this paper we compare the FTIR measurements to coincident measurements from LoFlo and AGAGE instruments, and flask samples measured by IRMS for $\delta^{13}C$-in-CO_2. Figure 1 illustrates the results with a 12-day CH_4 record of FTIR and AGAGE measurements (absolute calibrations not finalised). The table collects the demonstrated 10-minute precisions from the FTIR (1-σ repeatabilities): these precisions are significantly higher than those of the AGAGE measurements but somewhat lower than LoFlo for CO_2.

The FTIR analyser provides a cost-effective, low maintenance solution for the simultaneous high precision measurement of the five target species. The only consumables are mains power, a small flow of purge N_2, magnesium perchlorate drying agent and calibration gas (one calibration per day). The analyser can be managed remotely if the controlling PC is connected to the internet. Several analysers have been deployed in applications including continuous measurements at fixed locations (such as Cape Grim and Lauder, NZ), on mobile platforms (trains, ships), and in field campaigns, for example for micrometeorological flux measurements.

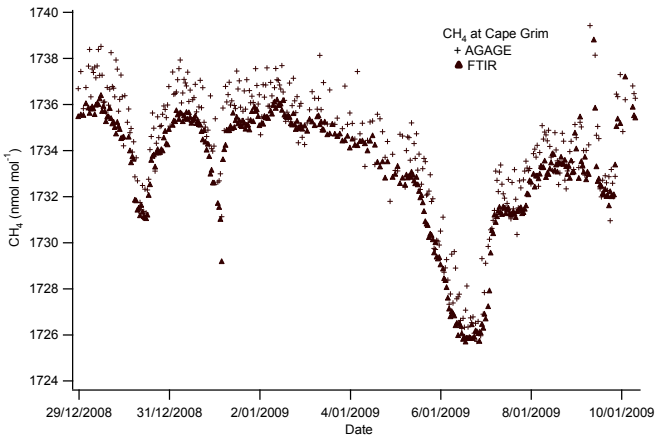


Figure 1. Example of FTIR and AGAGE GC measurements of CH_4 for a representative period of the comparison. FTIR precision is summarised in the table.

FTIR 1-σ precision	
CO_2	0.05 μmol mol^{-1}
$\delta^{13}C$-CO_2	0.08 ‰
CH_4	0.2 nmol mol^{-1}
CO	0.2 nmol mol^{-1}
N_2O	0.06 nmol mol^{-1}

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COMPARING THE $^{12}CO_2$ AND H_2O RECORDS AT ASPENDALE FROM A PAIR OF PICARRO WS-CRDS INSTRUMENTS

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Abstract

A pair of wavelength scanned cavity ringdown spectrometers (WS-CRDS) has been operating in the Aspendale Greenhouse Gas Laboratory for the past twelve months. One instrument measures $^{12}CH_4$, $^{12}CO_2$ and H_2O; the second measures $^{12}CO_2$, $^{13}CO_2$ and H_2O, giving a continuous record of both methane and the two major isotopologues of carbon dioxide.

In this talk, time-series from these two instruments will be examined to determine how consistent they are with respect to their common measurements: $^{12}CO_2$ and H_2O.

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EMERGING ANALYTICAL METHODS, AND THEIR POTENTIAL ROLE AT CAPE GRIM

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Abstract

For many years the basic analytical methodologies that have been used by most laboratories to measure the major atmospheric greenhouse gases have remained relatively unchanged.

As a range of technologies have emerged and matured in recent years, the long-established analytical methodologies are under some challenge. Some of the opportunities and challenges that are presented by these new approaches will be described.

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CSIRO GASLAB'S GC AND FLASK MANAGEMENT DATABASE

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Abstract

CSIRO GASLAB maintains long running atmospheric measurement programs for the key greenhouse gases CO_2, CH_4 and N_2O and biogeochemically related species H_2 and CO. Air samples obtained from a global flask sampling network, from polar ice cores and from other miscellaneous sources are routinely analysed for this suite of trace gases using three gas chromatograph instruments.

The need to effectively record sample collection details, manage flask movements, process analytical data and integrate all this information for end-users demands a powerful database. The database developed in GASLAB since the early 1990s has recently been upgraded to enhance its data processing capabilities and accessibility to users. This presentation will describe the construction and main features of the new database, and demonstrate some parts of its operation.

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OVERVIEW OF TRACE GAS COMPARISONS BETWEEN FLASK AND IN SITU MEASUREMENTS AT CAPE GRIM

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Abstract

Three dimensional model studies that estimate emissions often require more data than from only one individual network's group of stations, therefore it is important to be able to accurately merge atmospheric trace gas data sets from different laboratories and networks, which may use different calibration scales. To facilitate this, on-going comparisons of in situ data with independent flask and/or in situ data collected at common sites are useful as they are sensitive diagnostic tests of data quality for the laboratories involved, and they provide a basis for merging these data sets with confidence.

For the past 10+ years comparisons of more than 30 greenhouse gases and ozone depleting substances have been regularly carried out between flask results from CSIRO as well as cooperative flask programs, and in situ measurements at Cape Grim. The laboratories/institutions involved in the cooperative flask programs and comparison exercise at Cape Grim are: the Halocarbons and other Atmospheric Trace Species (HATS) and Carbon Cycle Greenhouse Gas (CCGG) groups at NOAA/ESRL/GMD, USA; National Institute for Environmental Studies (NIES), Japan; University of Heidelberg, Germany; Scripps Institution of Oceanography (SIO), USA; and University of East Anglia (UEA), UK.

In this presentation an overview of the comparisons undertaken will be given, along with the comparison methodology used and results from selected comparisons. An outline of an improved mechanism on how to summarise/disseminate the results will also be given.

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