atmosphere

Issue 10

April 2001

Newsletter of CSIRO Atmospheric Research

CSIRO

Improving air safety: detecting volcanic ash

CSIRO is collaborating with an Australian company, Integrated Avionic Systems, to commercialise a world-first detector designed to warn pilots of volcanic ash clouds in their flight paths.

In the past 30 years, more than 90 jet aircraft have encountered ash clouds emitted from erupting volcanoes. Silicon compounds within these clouds can cause costly damage to aircraft, ranging from abrasion of windows and composite surfaces to engine destruction. Engine failure associated with ash cloud encounters is a major safety hazard.

CSIRO has constructed a prototype volcanic ash detector and has been awarded world-wide patents for the technologies developed. The instrument may also be suitable for detection of clear air turbulence and hazards such as low-level wind shear as well as for terrain avoidance.

'The detector will give pilots five to ten minutes to take evasive action if an ash cloud appears in their flight path,' says Dr Fred Prata, from CSIRO Atmospheric Research.

Dr Fred Prata from CSIRO and Mr Mitchell Lennard from Integrated Avionic Systems.

CSIRO estimates that the ash detector sales could be worth $50 million per year.

'The Australian aviation industry is especially concerned about flights over the numerous active volcanoes in Japan, South-East Asia and New Zealand,' says Mr Mitchell Lennard, Engineering Manager from Integrated Avionic Systems.

'There are also potential savings for airlines, as reliable detection of ash clouds will reduce the impact of flight diversions,' says Mr Lennard.

The ash detector can distinguish between volcanic clouds and normal water and ice clouds. Ash clouds, which may occur thousands of kilometres from an eruption, are virtually invisible to radar.

For more information please contact:
Fred Prata, Ph: +61(3) 9239 4681
Fax: +61(3) 9239 4553
E-mail: fred.prata@dar.csiro.au

Increases in atmospheric concentrations of carbon dioxide and other greenhouse gases are inevitable this century and it is inevitable that we will experience climate change.

'There is no question that greenhouse gas concentrations are rising,' says Dr Graeme Pearman, Chief of CSIRO Atmospheric Research.

Climate change 'inevitable'

'The levels we are now experiencing are certainly higher than for the past 400,000 years and quite possibly higher than at any time in the past 20 million years.'

'Each year 8 billion tonnes of carbon in the form of carbon dioxide is released into the air globally. To stabilise atmospheric greenhouse gas concentrations, we would need to immediately massively reduce emissions.'

'Given existing investment in fossil fuel energy generation, the need for enhanced energy for development in parts of the world, and population growth, during the next 100 years it is unlikely that we can avoid doubling the amount of carbon dioxide in the air.'

'Surface temperature has risen by about half a degree during the past century. This is not simply a reflection of cities getting warmer. This is a real trend, which we can even see in the oceans. The temperatures a kilometre below the ocean surface are also rising.'

According to Dr Pearman, the likelihood is that there will be global warming of between 1 and 6 degrees Celsius during the next 100 years. The most likely changes to climate will be an increase in the number of extreme weather events, such as storms and downpours.

CSIRO Atmospheric Research Chief, Dr Graeme Pearman, with CSIRO Chief Executive, Dr Geoff Garrett, during a recent visit to the Division.

Hydrocarbons in southern hemispheric air

Hydrocarbons such as ethane, propane and acetylene are present in minute concentrations in pristine air. Sources of these gases include biomass burning, vehicle exhausts and gas production. There are also natural sources, including emissions from plants, the ocean and from soils.

Ms Loretta Kivlighon

Ms Loretta Kivlighon, an MSc student at CSIRO, has measured levels of these hydrocarbons at the Cape Grim Baseline Air Pollution Station in Tasmania.

'There are lots of reasons for measuring these gases,' says Ms Kivlighon.

'It gives us information about the Earth's biogeochemical cycles and tells us whether the atmosphere's self-cleansing ability is changing.'

The main method by which the atmosphere rids itself of hydrocarbons is through oxidation by the hydroxyl radical.

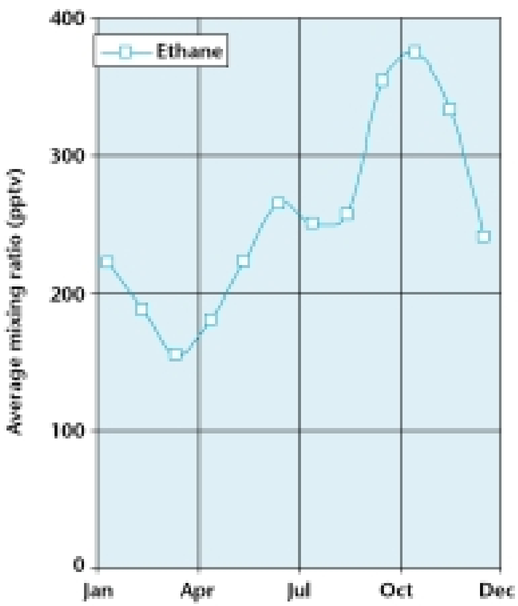
In background air of the southern hemisphere, ethane, propane and acetylene reach peak concentrations in spring, coinciding with biomass burning in Africa, South America and Australia. Some biomass burning occurs due to forest clearing for agriculture. Atmospheric photochemistry during summer produces a seasonal maximum of hydroxyl radicals that react with the hydrocarbons, accounting for the annual minimum concentrations of these hydrocarbons at this time.

As well as her measurements of air collected at ground level, Ms Kivlighon also analysed samples collected on aircraft flights over Cape Grim. This represents the first time in the southern hemisphere that upper air measurements of ethane, propane and acetylene have been linked with continuous surface measurements.

These measurements of trace hydrocarbon concentrations depend on painstaking sample collection techniques and new, high-precision analytical tools. Ms Kivlighon is measuring concentrations of gases that exist at just parts per trillion levels.

The Cape Grim program, to monitor and study global atmospheric composition, is a joint responsibility of the Bureau of Meteorology and CSIRO.

Mr Ian Galbally and Dr Ian Weeks at CSIRO Atmospheric Research and Dr Bruce James at La Trobe University supervise Ms Kivlighon's postgraduate studies.



Atmospheric concentrations of ethane measured at Cape Grim.

For more information please contact:
Loretta Kivlighon, Ph: +61(3) 9239 4530
Fax: +61(3) 9239 4553
E-mail: loretta.kivlighon@dar.csiro.au

Atmospheric pollution and global rainfall patterns

Tiny pollutant particles in the atmosphere may be changing global rainfall patterns, say climate researchers.

'Climate model simulations show that atmospheric particles produced by human activity may be inducing a southward shift in tropical rainfall patterns, particularly over the Pacific Ocean,' says Dr Leon Rotstayn.

'If this shift is confirmed, it will have an impact on the Australian and Asian monsoon. We may see some increase in rainfall over northern tropical Australia, with a decrease over most of the Indian sub-continent. There may also be a reduction in rainfall over China and South-East Asia.'

Atmospheric particles, known as aerosol, are produced by both natural and anthropogenic sources. The main anthropogenic sources are combustion of fossil fuels and burning of biomass.

Aerosol act as tiny nuclei on which cloud droplets can form. In regions where aerosol concentrations are high, such as polluted parts of the northern hemisphere, the additional cloud droplets make clouds brighter. As a result, more solar energy is reflected back into space, lowering the temperature in polluted areas. It is this cooling that may be altering global rainfall patterns.

Dr Leon Rotstayn

'Aerosol may even be affecting El Niño, a change that could have implications for rainfall in Australia. Aerosol emissions are rising in parts of the developing world, so there is potential for further change to rainfall patterns,' according to Dr Rotstayn.

The localised cooling effect of aerosol acts in a way that is opposite to likely warming caused by increased concentrations of greenhouse gases. The effect of greenhouse warming on Australian rainfall is the subject of ongoing CSIRO research.

CSIRO's research into aerosol and climate is in part supported by the Australian Greenhouse Office and involves collaboration with the University of Michigan. The findings on the potential impact of aerosol on rainfall patterns have been published in *Geophysical Research Letters*.

For more information please contact:
Leon Rotstayn, Ph: +61(3) 9239 4542
Fax: +61(3) 9239 4553
E-mail: leon.rotstayn@dar.csiro.au

Late last year, Divisional scientists detected a massive smoke plume stretching across much of north-western Australia. At the time, the plume represented the highest concentration of airborne particles on the globe. The plume came from fires dotted across the Kimberly district of Western Australia.

Massive smoke plume over northern Australia

'There was so much smoke in the air that this part of the country suffered air pollution levels greater than those often experienced in major cities,' says Dr Ross Mitchell.

Dr Mitchell and colleagues are studying levels of atmospheric particles from observatories at Lake Argyle in Western Australia and Jabiru in the Northern Territory.

'People often regard Australia's air as pristine, but at times we do have high pollution levels, even in remote regions,' says Dr Mitchell.

There was above average rainfall during the November to April wet season, which led to rapid vegetation growth. As a result, there was plenty of fuel for fires, such as those associated with seasonal burning of the annual grasses over the Kimberley and Pilbara regions of Western Australia.

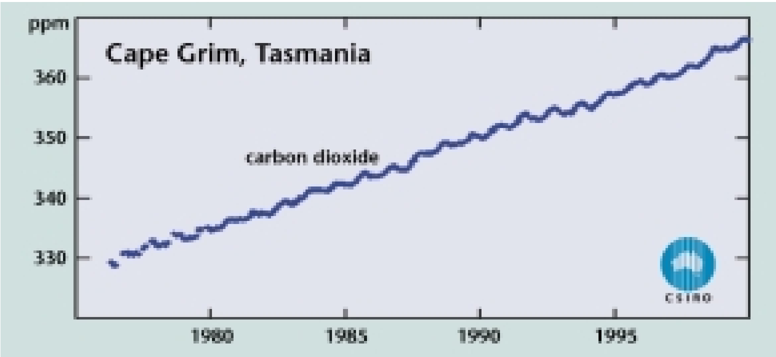
CSIRO Atmospheric Research is developing methods that will enable airborne particle concentration across Australia to be mapped using satellite data.

The Australian Greenhouse Office is providing support for CSIRO's ground-based measurements of atmospheric particles.

Dr Ross Mitchell: measuring airborne particles over northern Australia.

For more information please contact:
Ross Mitchell, Ph: +61(3) 9239 4663
Fax: +61(3) 9239 4553
E-mail: ross.mitchell@dar.csiro.au

Carbon dioxide and the carbon cycle



Atmospheric concentrations of carbon dioxide, measured at the Cape Grim Baseline Air Pollution Station in Tasmania.

Atmospheric carbon dioxide concentrations have increased by 30% during the past 200 years. The concentration today is almost 370 parts per million (0.037%). Human activities such as burning of fossil fuels and deforestation are responsible for the rapid increase.

Scientists are working to improve their knowledge of the circulation of carbon between the atmosphere, the oceans, the land and the biosphere in order to assess the impact of human activity on the carbon cycle and the likely changes to climate that will follow.

Currently, about 6.5 billion tonnes of carbon (as carbon dioxide) are emitted each year during the combustion of fossil fuels and 1–2 billion tonnes per year from land clearing.

About 3 billion tonnes of the carbon stays in the atmosphere. The ocean takes up just over 2 billion tonnes. Terrestrial sinks such as growing forests, which remove carbon from the air and store it, take up the remaining 2–3 billion tonnes.

The rise in atmospheric carbon dioxide

The global carbon cycle remained fairly much unchanged for the 800 years before the Industrial Revolution. The cycle has changed rapidly during the past 200 years.

Human activity is responsible for the rapid increase in atmospheric carbon dioxide concentrations. Scientists know this from a range of evidence.

Calculations of carbon dioxide emitted from fossil fuel combustion (well-known from economic data) match measured variations of atmospheric concentrations between the northern hemisphere and the southern hemisphere. The biggest global sources of carbon dioxide are regions of peak fossil fuel use.

Atmospheric oxygen concentrations are declining slightly as carbon in fossil fuels and plants combines with oxygen during combustion to form carbon dioxide.

Measurements of carbon isotopes, different forms of carbon, reveal extensive release of carbon from fossil fuels.

Carbon sinks

As plants grow, they photosynthesise, removing carbon dioxide from the atmosphere and converting it into organic compounds. Under ideal conditions, 1 million hectares of new forest could absorb about 25 million tonnes of carbon dioxide each year.

Because of so-called carbon dioxide fertilisation, carbon uptake by most terrestrial plants will increase with increasing atmospheric carbon dioxide concentration. However, this increase will be limited by environmental factors such as availability of water and nutrients.

Higher temperatures will lengthen the growing season and increase carbon uptake by plants in high latitudes, but will decrease carbon uptake by tropical plants. The response to a changing environment is difficult to quantify, particularly as the relative abundance of different types of plants will change as the environment does.

Carbon dioxide fertilisation

Most crops and trees are expected to have higher productivity at higher carbon dioxide concentrations, all other things being equal.

The extent to which those plants benefit from elevated carbon dioxide concentrations depends on factors such as air temperature, rainfall and soil nutrients. Studies in Australia and USA have shown that a forest can initially increase productivity by up to 24% with a doubling of atmospheric carbon dioxide. However, this productivity increase cannot be sustained and will drop significantly as soil nutrients become limiting. Most Australian soil is deficient in phosphorus, a deficiency that may counteract the beneficial effect of higher carbon dioxide.

Recent research has concluded that agriculture in Australia will benefit from higher temperatures and carbon dioxide concentrations only if crop management strategies adapt to the changed climate. Studies at the UK Hadley Centre suggest that the impact of climate change on tropical forests may counteract and eventually reverse the impact of carbon dioxide fertilisation.

Students sample Greenland air

Eight Victorian secondary school students have just returned from West Greenland's Disko Island, where they spent five weeks at the oldest and most prestigious scientific polar research station in the Arctic.

CSIRO Atmospheric Research was one of the expedition's supporters. The Division supplied flasks for collection of air samples. Results from analysis of the air enabled the students to compare background pollution levels in the northern and southern hemispheres.

The students also took an Airwatch kit with them and made local air quality measurements.

Mentor for the project, mountaineer explorer Peter Hillary described the expedition as a remarkable opportunity for young Australians to venture into the upper reaches of the northern hemisphere and experience firsthand the excitement of a research environment not previously accessible to secondary school students.

Victorian secondary school students visit CSIRO Atmospheric Research before departing to the Arctic Station in Greenland.

The students participated in a range of research activities as well as travelling by dog sledge and visiting Inuit settlements.

Native plants add to air pollution

Australia's native plants emit chemical compounds that can interact with other air pollutants to exacerbate smog formation over Australian cities.

The NSW Environmental Protection Authority commissioned CSIRO to investigate emissions of organic compounds from Australian eucalypt trees and grasses.

'It's not just cars and industry that cause air pollution,' says Mr Ian Galbally, from CSIRO Atmospheric Research.

'Plants release highly reactive hydrocarbons that can add significantly to photochemical smog problems.'

'The blue haze you often see over the Dandenongs in Victoria and in the Blue Mountains near Sydney is caused in part by the gases released by vegetation. We have also found that grasses, particularly when cut, are potent emitters of reactive hydrocarbons.'

Researchers measured a number of hydrocarbons, including isoprene and monoterpenes, released from three Australian eucalypt species.

'Emission rates are highest during the day and drop off towards evening. We can use this information to assist the EPA to more accurately estimate chemical emissions from Australian trees and grasses,' says Dr Peter Nelson from CSIRO Energy Technology.

Measuring hydrocarbon emissions from plants. Emissions are collected in a teflon film bag.

For more information please contact:
Ian Galbally, Ph: +61(3) 9239 4684
Fax: +61(3) 9239 4553
E-mail: ian.galbally@dar.csiro.au

Selected publications

Here is a sample of the numerous papers published by staff of CSIRO Atmospheric Research during the past six months.
For a full list of our publications, please visit http://www.dar.csiro.au/info/lib/pubsearch.html

Ayers, G. P., Leong, C. P., Lim, S. F., Cheah, W. K., **Gillett, R. W.**, and **Manins, P. C.** (2000). Atmospheric concentrations and deposition of oxidised sulfur and nitrogen species at Petaling Jaya, Malaysia, 1993–1998. *Tellus,* **52B** (1): 60–73.

Beer, T., Grant, T., **Brown, R. J.**, Edwards, J., Nelson, P., Watson, H., and Williams, D. (2000). *Life-cycle emissions analysis of alternative fuels for heavy vehicles: stage 1*C/0411/1/1.1/F2. Aspendale, Vic.: CSIRO Atmospheric Research. xxi, 125 p.

Cai, W. J., and **Whetton, P. H.** (2000). Evidence for a time-varying pattern of greenhouse warming in the Pacific Ocean. *Geophysical Research Letters,* **27** (16): 2577–2580.

Galbally, I. E., **Bentley, S. T.**, and **Meyer, C. P.** (2000). Mid-latitude marine boundary-layer ozone destruction at visible sunrise observed at Cape Grim, Tasmania, 41°S. *Geophysical Research Letters,* **27** (23): 3841–3844.

Gras, J. L., **Keywood, M. D.**, **Ayers, G. P.**, and Cohen, D. (2000). Aerosol microphysics in Launceston, Tasmania. *Clean Air,* **34** (2): 33–36.

Hirst, A. C., **O'Farrell, S. P.**, and **Gordon, H. B.** (2000). Comparison of a coupled ocean-atmosphere model with and without oceanic eddy-induced advection. Part I: Ocean spinup and control integrations. *Journal of Climate,* **13** (1): 139–163.

Katzfey, J. J., and **Ryan, B. F.** (2000). Midlatitude frontal clouds: GCM-scale modeling implications. *Journal of Climate,* **13** (15): 2729–2745.

Keywood, M. D., **Ayers, G. P.**, and **Gras, J. L.** (2000). Testing a low-cost aerosol sampler. *Clean Air,* **34** (4): 38–42.

Kowalczyk, E. A., and **McGregor, J. L.** (2000). Modeling trace gas concentrations at Cape Grim using the CSIRO Atmospheric Research Limited Area Model (DARLAM). *Journal of Geophysical Research,* **105** (D17): 22167–22183.

Manins, P. C. (2000). Air pollution in 20th Century Australia. *Clean Air,* **34** (3): 30–36.

McGregor, J. L., **Katzfey, J. J.**, and **Nguyen, K. C.** (2000). Analysis of climate change simulations for Southeast Asia: final report to: Asia-Pacific Network for Global Change Research: APN Workshop 10 January–10 February 2000 held at CSIRO Atmospheric Research, Melbourne, Australia. Aspendale: CSIRO Atmospheric Research. 12 p.

McInnes, K. L., **Walsh, K. J. E.**, and **Pittock, A. B.** (2000). *Impact of sea level rise and storm surges on coastal resorts: a report for CSIRO Tourism Research: final report.* Aspendale, Vic.: CSIRO Atmospheric Research. 13 p.

Rayner, P. J., and **O'Brien, D. M.** (2001). The utility of remotely sensed CO_2 concentration data in surface source inversions. *Geophysical Research Letters,* **28** (1): 175–178.

Smith, I. N., McIntosh, P., Ansell, T. J., Reason, C. J. C., and **McInnes, K. L.** (2000). Southwest Western Australian winter rainfall and its association with Indian Ocean climate variability. *International Journal of Climatology,* **20** (15): 1913–1930.

Whetton, P. H., **Hennessy, K. J.**, **Katzfey, J. J.**, **McGregor, J. L.**, **Jones, R. N.**, and **Nguyen, K. C.** (2000). *Climate averages and variability based on a transient CO_2 simulation: research undertaken for the Department of Natural Resources and Environment.* (Fine Resolution Assessment of Enhanced Greenhouse Climate Change in Victoria Annual Report; 1997–98) East Melbourne, Vic.: Dept. of Natural Resources and Environment. x, 38 p.

Wilson, S. G. (2000). How ocean vertical mixing and accumulation of warm surface water influence the "sharpness" of the equatorial thermocline. *Journal of Climate,* **13** (20): 3638–3656.

Gold medal team

Dr Peter Manins, Dr Peter Hurley and Prof. Tom Beer are members of a team that won the CSIRO Chairman's Gold Medal for 2000.

The medal is for the team's work on two low-emission car projects, designed to cut air pollution by up to 90 per cent. One of the cars is Holden's ECOmmodore; the other is a concept car known as the *aXcessaustralia* Low Emission Vehicle.

The Chairman's Gold Medal is awarded each year for the research project that is judged to be the best in CSIRO research, and of national or international importance.

Kirstie Frederiksen

Each day, thousands of people passing the Division are reminded about our Web site. For up-to-date information on our research, and on issues such as climate change, ozone depletion, air pollution and climate variability, pay us a (virtual) visit.

Profile — Michael Edwards

A chemist by training, Mr Michael Edwards has joined CSIRO Atmospheric Research as commercial development manager.

'My brief is to work with scientists to find additional applications for research and to help develop areas of science that will meet new market needs,' says Mike.

'I am excited about all the opportunities available to us and the business areas that are emerging.'

Before joining CSIRO, Mike worked with Orica (formerly ICI Australia) in their plastics and chemicals divisions. His roles included technical service provision, as well as sales and marketing.

His young family occupy most of his time away from work. 'It's great, and when the children are older, I'm looking forward to again playing cricket, soccer and a round or two of golf'.

Applying our research

Significant recent and ongoing projects

Compilation of the 1999 greenhouse gas inventory for the agriculture sector	Australian Greenhouse Office
Research program on climate change, impacts and adaptation strategies	Department of Natural Resources and Environment, Victoria
Characterisation of emissions from domestic solid fuel heaters	Environment Australia
Preparation of The Atmosphere chapter for the 2001 National State of the Environment report	Environment Australia
GLOBALHUBS initiative to measure atmospheric carbon dioxide	European Commission Research Directorates
Training and support in the use of regional climate models	LAPAN, Indonesia

Atmosphere is the six-monthly newsletter from CSIRO Atmospheric Research. You are welcome to reproduce material from this newsletter providing you acknowledge the source.

ISSN 1325–0299

Editor: Paul Holper

Design and layout: Melissa Gibson Design

CSIRO Atmospheric Research
PB 1, Aspendale,
Victoria 3195, Australia

Ph: +61 3 9239 4400
Fax: +61 3 9239 4553
E-mail: chief@dar.csiro.au

Web: www.dar.csiro.au

Printed using Waterless Printing "the most environmentally clean method of printing in the world today". Printed on 50% recycled paper.