atmosphere

Newsletter of CSIRO Atmospheric Research

Issue 7
Oct 1999

CSIRO

Australia from space as never before seen

Dr Peter Turner has created a unique view of Australia.

CSIRO scientists have produced a stunning new image of Australia using a sophisticated dual-view sensor on board the European Remote Sensing Satellite.

The sensor, known as the Along-Track Scanning Radiometer (ATSR), achieves great precision by probing each location on the earth's surface twice as the satellite passes overhead. The first view is ahead of the sensor and the second, directly underneath. This dual measurement process enables researchers to eliminate most of the distortions that the atmosphere produces with conventional satellite images.

'This image is a crystal-clear composite of 100 separate satellite images, each approximately 500 km square,' explains Dr Peter Turner.

'The ATSR measures sunlight reflected from the ground and gives us really detailed information about Australia's terrain and vegetation,' says Dr Turner.

The new satellite measurements will help scientists better monitor our environment, as well as agricultural capacity and production.

'Our understanding of climate and the likely impact of global warming also relies on accurate sea-surface temperature measurements supplied by the ATSR,' says Dr Turner.

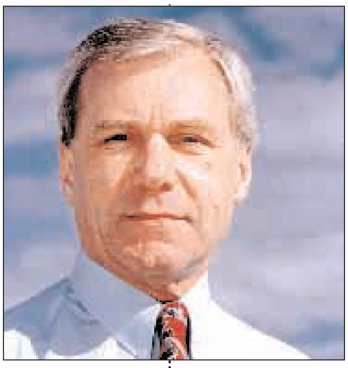
CSIRO and other Australian agencies have contributed to the design and manufacture of the ATSR in a consortium with the Rutherford Appleton Laboratory in the UK. The European Space Agency and Rutherford Appleton Laboratory receive and pre-process the data before delivery to Australian scientists.

For more information please contact:
Peter Turner, Ph: 03 9239 4674;
Fax: 03 9239 4553;
E-mail: peter.turner@dar.csiro.au

Atmospheric science at the millennium

Dr Graeme Pearman, Chief, CSIRO Atmospheric Research

As we stand at the beginning of the new millennium, atmospheric science is at a truly exciting and profound stage. Investment over the past few decades by CSIRO and other national and international institutions is about to deliver significant pay-offs for industry and the community. The investment has also generated new and fascinating challenges.



We have taken our knowledge of the chemical and physical processes in the atmosphere and built this into sophisticated models of the world's weather and climate. Our advances in knowledge, coupled with new computer capabilities, new environmental monitoring equipment, and improved connections between science and policy set the stage for significant outcomes.

New predictive capabilities for weather, climate and air quality are likely to underpin temperature control systems in buildings, the way energy is bought and sold, and production rates in many factories. Agriculture will profit from seasonal predictions that will dictate planting, fertilising and harvesting cycles. Climatic, weather and air quality information will be an essential component of financial and political decision-making.

When drought and floods strike, new management tools will use environmental forecasts to provide guidance and suggest remedial action to preserve ecosystems and help with pastures, crops and rangelands. Warning systems will reduce the harm done by natural disasters.

Environmental management will help bring about a more stable, sustainable use of natural resources in generation of well-being, wealth and security.

The devastating drought of 1982–83 took most of us unawares. Climate scientists soon established that the drought was caused by El Niño, an event that we can foresee today with some accuracy. In coming years, our computer-based models will give us reliable forecasts of El Niño and its counterpart, La Niña, many months ahead.

Advances in atmospheric science are helping Australia contribute to international agreements such as the United Nations Framework Convention on Climate Change. A decade ago, it was unimaginable that this type of global agreement could be in place, and that it could be affecting so many aspects of our lives.

Some of the forthcoming challenges for atmospheric science in general and CSIRO Atmospheric Research specifically include:

- how best to jointly manage the spectra of pure and applied, and reductive and integrative, research.
- better understanding of policy formation and tailoring of scientific outputs to render real outcomes for private and public good.
- assessment of scientific outputs and their true impact.
- incorporating information from advances in satellite technology and physical and chemical detectors. We are viewing the world as we have never before seen it.
- new connections between human health and outdoor and indoor air quality.

I am highly optimistic that our science can make a difference. Ask Australians what science's first priority should be and the most common answer is 'environmental research and conservation'. A recent survey found that 14–17 year olds listed climate change, ozone/greenhouse and environment as the most important types of research for CSIRO to undertake.

Governments are showing a commitment to maintaining funding levels for science. CSIRO has benefited recently from a Commonwealth Government undertaking to maintain funding for the next triennium.

At CSIRO Atmospheric Research, our scientific output — as measured by quality journal papers — continues to grow. Meanwhile, government, industry and the community apply the results of our research to a greater extent than ever before.

What an exciting time the next few decades will be for atmospheric science!

As levels of the greenhouse gas carbon dioxide rise, concentrations of oxygen in our air have fallen. Divisional scientists have measured the minuscule decline in oxygen that has occurred during the past 20 years, the longest period over which such an assessment has been made.

Oxygen measurements help determine the role of oceans and plants in greenhouse

'As fossil fuels burn, they generate carbon dioxide, using up oxygen in the process,' explains Mr Ray Langenfelds.

About half of the carbon dioxide from fossil fuels remains in the atmosphere. The other half is absorbed by the world's oceans and plants, although the relative proportions of carbon dioxide removed by these reservoirs has been uncertain. Scientists' recent ability to make high precision oxygen measurements provides a way of distinguishing between carbon dioxide uptake by oceans and plants.

The significance of measuring oxygen concentrations is that carbon dioxide is more soluble in the oceans than oxygen. Reduction in atmospheric oxygen is a 'signal' produced by burning of fuel. Simultaneous observations of changes in atmospheric concentrations of both gases allow scientists to describe with certainty for the first time the way in which carbon dioxide released into the air is shared between the three major reservoirs: the oceans, the biosphere and the atmosphere.

'The changes we are measuring represent just a tiny fraction of the total amount of oxygen in our air (20.95% by volume). The oxygen reduction is just 0.03% in the past 20 years and has no impact on our breathing.'

'While the oceans emerge as the slightly larger long-term sink, plants are clearly soaking up more carbon dioxide with time. If they weren't, levels of carbon dioxide would be far higher and oxygen would be declining more rapidly.'

Mr Ray Langenfelds, monitoring changes to atmospheric oxygen levels.

The oxygen measurements show that the collective mass of the world's plants has remained close to steady over the past 20 years. Although deforestation has released large amounts of carbon dioxide, remaining plants are taking up much of this gas.

Researchers speculate that plants today could be growing more rapidly due to warmer conditions, higher carbon dioxide concentrations or increased nitrogen fertilisation. Alternatively, previously cleared land may be returning to forest.

Mr Langenfelds has analysed air dating back to 1978 from the unique 'archive' of pristine air collected at the remote Cape Grim Baseline Air Pollution Station in north-west Tasmania. The Cape Grim program, to monitor and study global atmospheric composition, is a joint responsibility of the Bureau of Meteorology and CSIRO.

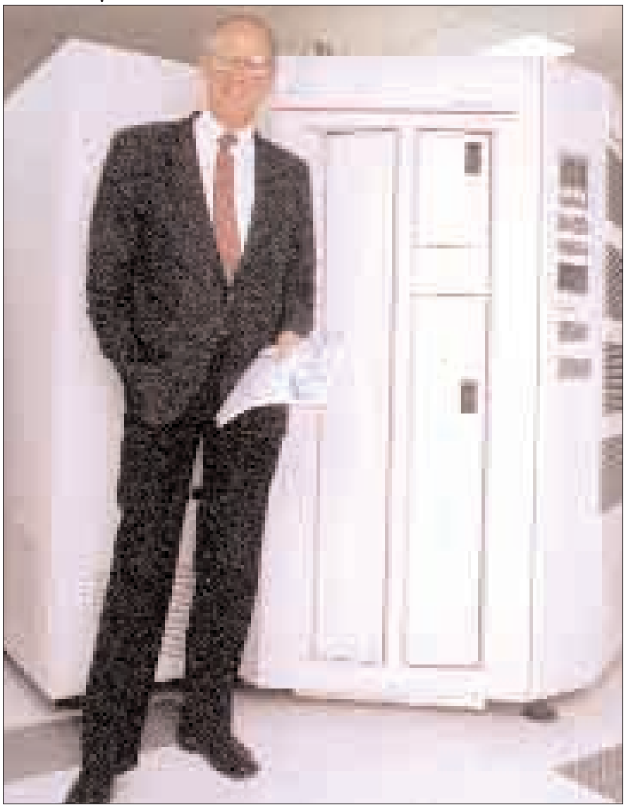
Measurements have been made using new mass spectrometric technology that provides the precision necessary for these studies.

Findings based on the decline in oxygen have been published in *Geophysical Research Letters.*

For more information please contact:
Ray Langenfelds, Ph: 03 9239 4598;
Fax: 03 9239 4553;
E-mail: ray.langenfelds@dar.csiro.au

A 30-year dry spell?

How variable is our climate? This is the question that Mr Barrie Hunt, Leader of the Division's Climate Modelling Program, set out to discover recently.



Mr Barrie Hunt in front of the Division's StorageTek automated data tape storage facility.

Reliable climatic records only go back a century or so, so Mr Hunt used output from a CSIRO climate model run that had generated 1000 years' worth of simulated data. For the exercise, concentrations of greenhouse gases were held constant to match today's levels.

The model showed that some regions could suddenly experience sustained lower or higher rainfall for as long as 30 years.

'Half the globe seems to have a 10-year drying or wetting sequence within a 1000-year period,' says Mr Hunt.

'Significant changes in regional climate can occur even without any global warming.'

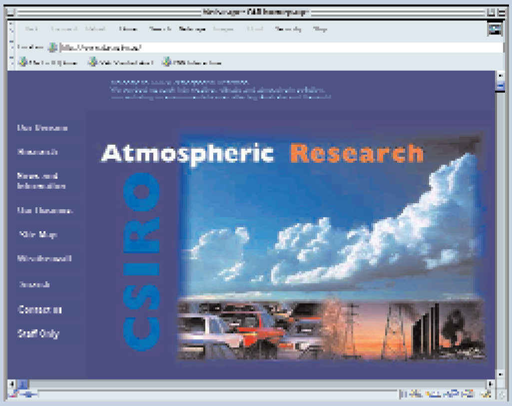
The findings have implications for places such as south-western Western Australia, which has experienced a drying trend that has persisted since about 1970. The model shows that the region is currently suffering a drought that comes once in a thousand years, if the trend is due to natural climatic fluctuations.

'However, the good news for the region is that, based on our model results, none of the simulated dry periods lasted more than 50 years.'

Many of the climate swings can be linked to phenomena such as El Niño, which influence ocean surface temperatures.

The research could help regional planners estimate how severe wet or dry spells will be and how long they will last.

For more information please contact:
Barrie Hunt, Ph: 03 9239 4680;
Fax: 03 9239 4553;
E-mail: barrie.hunt@dar.csiro.au



New Web site

CSIRO Atmospheric Research's new Web site is proving very popular, attracting almost 10,000 hits each day.

Visit our famous Weather Wall, check out the extensive information pages (air pollution, El Niño, the greenhouse effect, ozone depletion and remote sensing), learn about our research activities, view animations and then take our quick quiz. You can even read this newsletter on-line.

http://www.dar.csiro.au/

Australia becoming wetter

Parts of Australia have become wetter, with more rainy days and more heavy rainfall. This is the conclusion of a CSIRO study of daily rainfall at over 300 Australian sites from 1910 to 1995.

Annual total rainfall has risen by about 15% in New South Wales, South Australia, Victoria and the Northern Territory, with little change in the other states. South-west Western Australia has become 25% drier in winter, largely due to a decline between 1960 and 1972.

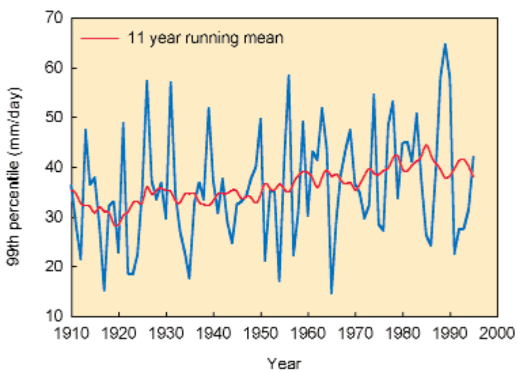
'There has also been a significant 10% rise in the Australian-average number of rainy days,' says Mr Kevin Hennessy.

The Northern Territory and New South Wales have experienced the greatest increase in rainy days, while Tasmania and south-west Western Australia now have fewer rainy days than in the past.

'One of the most interesting findings from our study was an increase in heavy rainfall.'

'Heavy rainfall was defined as the 99th percentile of daily rainfall — this is the largest amount each season, or the 4th largest amount each year. Increases of 10–45% were found in many regions but few were statistically significant.'

Significant increases in heavy rainfall of 20–30% have occurred in New South Wales in autumn (see Figure) and summer, in the Northern Territory in autumn, and in Western Australia in summer. South-west Western Australia experienced a 15% decrease in heavy rainfall in winter.



Autumn 99th percentile for New South Wales

Mr Kevin Hennessy, tracking rainfall changes.

Following the sequence of wet La Niña years during 1973–75, there were seven El Niños and only one La Niña up to 1995. El Niños are normally associated with relatively dry conditions in Australia, but since 1975 annual rainfall shows:

- no trend for the whole country, for NSW and for Victoria
- a slight decline followed by a recovery after 1990 in Western Australia, South Australia and the Northern Territory
- a steady decrease in Queensland and Tasmania
- no trend in south-west Western Australia but still well below pre-1960 levels.

Mr Hennessy says 'many climate models indicate that global warming may lead to more storms. Although the observations over Australia during the past century are consistent with the model results, there may be other factors causing the observed changes, such as land-use change, burning of vegetation, ozone depletion, sunspot activity and long-term natural variability'.

For more information please contact:
Kevin Hennessy, Ph: 03 9239 4536;
Fax: 03 9239 4553;
E-mail: kevin.hennessy@dar.csiro.au

Breathe easy, and make money

Dr Malcolm McIntosh – Chief Executive of CSIRO

Saving money and the environment at the same time might sound like fantasy, yet it is precisely what Australian companies are helping numerous industries to achieve in the area of air quality.

Industry has worked hard to reduce pollutant emissions, recognising that waste is product lost. That our air today is generally cleaner than at any time in the past 20 years is a tribute to a range of successful pollution reduction strategies.

However, lowering emissions can be expensive. The conventional method of using a tall smelter stack to lift a smoke plume over a local town can cost millions of dollars, and is often ineffective anyway. For a small company, pollution controls can bite heavily into profitability.

It is not suggested that industry abrogate its environmental responsibilities. Cleaner production methods can lead to dramatically reduced emissions, but some discharge to air may be unavoidable. However, there are approaches that can optimise gains from anti-pollution expenditure.

In the past, companies were sometimes forced to implement expensive emission reduction measures that were far stricter than necessary in order to conform with pollution standards. The reason was that regulators' environmental effects procedures were primitive by today's standards, so there was no choice but to set requirements based on the most conservative of assessments. At times, the recommended measures failed to achieve their objectives.

Knowledge of what happens to pollutants once they get into the air has advanced considerably. The chemistry of air pollution and the way in which pollutants spread through the atmosphere are better understood.

Australian companies have developed sophisticated computer-based modelling systems that show precisely how weather, sunshine and pollution interact to affect our

environment. 'Virtual' industrial plants can be built to assess their likely environmental effect. We can do this for mountainous regions or coastal areas, taking into account the often complex pattern of local winds.

Today's more realistic, reliable appraisals of potential emissions are saving industry and the community millions of dollars while at the same time effectively safeguarding the environment.

Monitoring the emissions that do occur need not always be expensive. CSIRO scientists have proved the effectiveness in Australia of a Swedish-designed air sampler. The sampler could not be cheaper or simpler. It comprises a small circle of impregnated filter paper protected by a plastic tube. These passive detectors, not much bigger than a dollar coin, give accurate measurements of gases such as oxides of nitrogen and sulfur, ozone, nicotine and formaldehyde. Benzene and other toxics can also be monitored. A hundred locations, indoors and out, can be monitored for what used to be the cost of monitoring at one location.

The ultimate application of these devices is to measure the total pollution we inhale. Australian scientists are collaborating with respiratory specialists on trial projects in which volunteers wear an air sampler day and night. The information obtained will help ensure that air quality standards are set at the right levels to safeguard our health.

On a global scale, rapidly rising concentrations of greenhouse gases are of concern. As just one example of an innovative solution, CSIRO is engaged in a multimillion-dollar project to develop a new way of generating electrical power. The hybrid solar/fossil fuel approach doubles the efficiency of today's coal-fired generators while reducing emissions of carbon dioxide.

Of course, industry is not the only source of greenhouse gases and air pollution. Many of the noxious gases we breathe come mainly from motor vehicles. Twelve million exhaust pipes represent a serious threat to air quality. If cities continue to sprawl haphazardly, pollution from cars will eventually overwhelm any air quality gains made now.

There are positive steps to be taken. Urban designers and planners can help to reduce our reliance on private transport, so that Australian cities evolve in a far cleaner manner. There is also potential to reduce pollution from cars. Next year will bring two locally made hybrid cars that will look and drive like conventional vehicles but will emit less than half the greenhouse gases and no more than one-fifth of the air pollutants. A vehicle with almost zero pollutant emissions could be developed.

Forward-looking industry sees a clean, sustainable environment as a shared objective with the community. Such an environment provides opportunities for new or differentiated products or technologies offering competitive advantage — of which there are many examples.

Australia is a world leader in developing ways of doing things better and more safely in terms of the environment. Cleaner production can help to maintain quality of life. It may also be the growth export earner in the new decade.

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For more information about how CSIRO can help tackle air quality problems, please contact
Dr Peter Manins, Ph: 03 9239 4630;
Fax: 03 9239 4553;
E-mail: peter.manins@dar.csiro.au

Passive air samplers

For more information, see http://www.dar.csiro.au/publications/samplers.htm, or contact:
Dr Greg Ayers,
CSIRO Atmospheric Research,
PB 1, Aspendale, Victoria 3195
Ph: (+61 3) 9239 4687;
Fax: (+61 3) 9239 4688;
E-mail: greg.ayers@dar.csiro.au

SO_2, NO_2, HNO_3, NH_3, O_3, HCHO

An inexpensive, accurate, versatile approach to measuring air pollution for R&D projects

Research applications: acid deposition, ambient exposure, personal exposure, plume dispersion mapping, urban air monitoring, verification of numerical models

Gases measured: sulfur dioxide, nitrogen dioxide, nitric acid, ammonia, ozone and formaldehyde

CSIRO's passive air samplers are ideal for low-cost sampling from days to several months. We offer data interpretation, evaluation and assessment for a wide range of air quality applications.

Recent clients include Alcoa, BHP, Comalco, CRA, MIM and Pacific Power.

Taking the air

Ray Langenfelds

For almost 30 years, CSIRO Atmospheric Research has undertaken regular aircraft sampling of the atmosphere above south-eastern Australia.

The measurements are being made to improve our understanding of the cycling of greenhouse gases. Where do they come from and what happens to them in the atmosphere? How are the gases distributed over the globe? How are their concentrations changing? It is these questions that we seek to answer.

Since 1991, the Division has chartered light aircraft flights about once a month over Bass Strait and the Cape Grim Baseline Air Pollution Station in north-western Tasmania. Air has been sampled at about 15 different heights during each flight from as low as 150 metres to more than 7000 metres.

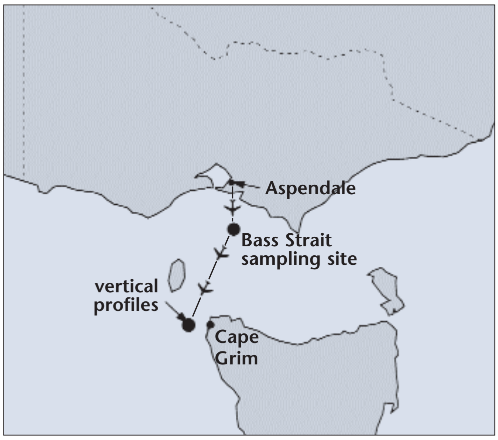
At the Division and at Cape Grim, scientists analyse the samples, measuring concentrations and isotopic compositions of gases such as carbon dioxide, methane and nitrous oxide.

This program is one of only a few ongoing aircraft sampling programs in the world.

The program complements the more extensive global network of approximately

Photo: Lisa Cooper

Air sampling gear inside a light aircraft.



100 ground-based sampling sites. Ground sites tell us only about what's happening in the lower atmosphere. To illustrate the importance of our aircraft measurements, we see larger changes in atmospheric composition between ground-level and an altitude of five kilometres than we do between Tasmania and the South Pole.

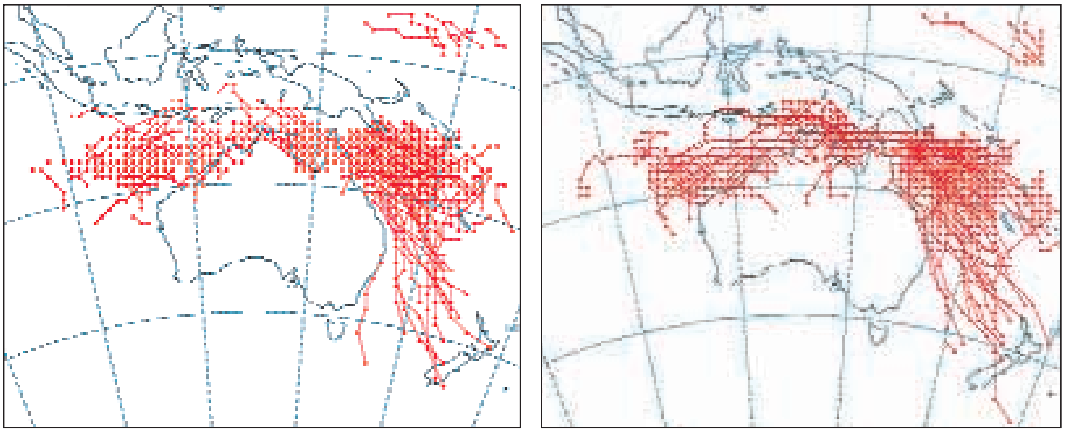
Mr Bernard Pak from the University of Melbourne has analysed data since 1992 as part of his PhD thesis. A feature of the measurements are episodes of elevated concentrations of carbon dioxide, methane and carbon monoxide during late winter and spring in the mid-troposphere (altitudes of 3–7 km).

These episodes have been traced to emissions from biomass burning in tropical Africa and South America during the dry season. Measurements should help to characterise this source of greenhouse gases.

Vertical profile measurements also reveal information about photochemical destruction of methane and carbon monoxide, the rate of mixing in the Southern Hemisphere troposphere and carbon dioxide uptake by the Southern Ocean.

For more information please contact:
Ray Langenfelds, Ph: 03 9239 4598;
Fax: 03 9239 4553;
E-mail: ray.langenfelds@dar.csiro.au

Future tropical cyclone behaviour

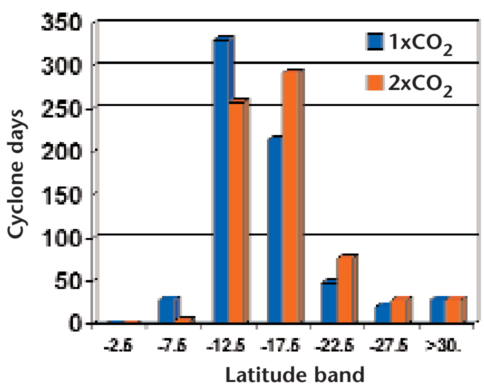


Simulated current tropical cyclone storm tracks (left) and those for 2050 (right) under conditions of effectively doubled carbon dioxide concentrations.

Divisional scientists are examining the impact of climate change on tropical cyclones.

'Our modelling and analysis are showing that tropical cyclones are likely to increase slightly in intensity and may possibly travel further polewards,' says Dr Kevin Walsh.

Using CSIRO's regional climate model, Dr Walsh performed a 20-year simulation of present-day cyclone tracks from January to March over the Australian region. The model has points spaced 125 kilometres apart with nine levels through the atmosphere at which climatic changes are tracked.



Simulated number of days of tropical cyclone occurrence, January to March, for 20 years of present conditions (1xCO_2) and 2050 conditions (2xCO_2).

The simulation shows reasonable agreement with observed cyclone tracks, although the model slightly underestimates the numbers of tropical cyclones.

'For storms off the east coast under an effective doubling of present carbon dioxide concentrations, representative of likely conditions around 2050, there are fewer cyclone days north of latitude 15°S in far north Queensland and more days of tropical cyclones to the south. However, at present we have low confidence in this finding, but this important topic will be examined further.'

'If the southward shift occurs, it may increase the damage caused by cyclones and associated coastal flooding,' warns Dr Walsh.

For more information please contact:
Kevin Walsh, Ph: 03 9239 4532;
Fax: 03 9239 4553;
E-mail: kevin.walsh@dar.csiro.au

Greenhouse training

Melbourne University Private, CSIRO and the private company Energetics formed a consortium to prepare and present training material on greenhouse gas mitigation at a recent training course. The course included modules on global warming potentials, greenhouse gas baselines, waste, fuels and sink enhancement.

Course participants were from Argentina, Brazil, Chile, China, Fiji, India, Indonesia, Malaysia, Mauritius, Papua-New Guinea, Philippines, Solomon Islands, South Africa, Thailand and Vietnam.

The Commonwealth Government's International Greenhouse Partnerships Office supported the course.

Selected publications

Here is a sample of the more than 100 papers published by staff of CSIRO Atmospheric Research during the past six months. For a full list of our publications, visit **http://www.dar.csiro.au/info/lib/pubsearch.html.**

Abbs, D. J. (1999). A numerical modeling study to investigate the assumptions used in the calculation of probable maximum precipitation. *Water Resources Research,* **35** (3): 785–796.

Allan, R. J., and D'Arrigo, R. D. (1999). 'Persistent' ENSO sequences: how unusual was the 1990–1995 El-Niño? *Holocene,* **9** (1): 101–118.

Baines, P. G. (1999). Downslope flows into a stratified environment: structure and detrainment. In: *Mixing and dispersion in stably stratified flows.* P. A. Davies (editor). (The Institute of Mathematics and Its Applications Conference Series; New Series; 68) Oxford: Clarendon Press. p. 1–21.

Cai, W., and **Gordon, H. B.** (1999). Southern high-latitude ocean climate drift in a coupled model. *Journal of Climate,* **12** (1): 132–146.

Frederiksen, J. S. (1999). Subgrid-scale parameterizations of eddy–topographic force, eddy viscosity, and stochastic backscatter for flow over topography. *Journal of the Atmospheric Sciences,* **56** (11): 1481-1494.

Gras, J. L., **Jensen, J. B.**, Okada, K., Ikegami, M., Zaizen, Y., and Makino, Y. (1999). Some optical properties of smoke aerosol in Indonesia and tropical Australia. *Geophysical Research Letters,* **26** (10): 1393-1396.

Hughes, R. L., and **O'Farrell, S. P.** (1999). Spatially growing Rossby lee waves: implications for a coupled ocean–atmosphere global circulation model. *Journal of Geophysical Research,* **104** (C5): 11009–11019.

Jones, R. N., **Abbs, D. J.**, and **Hennessy, K. J.** (1999). Climate change analysis relevant to Jabiluka. (Supervising Scientist Report; 141) Canberra, ACT: Supervising Scientist, Environment Australia. ix, 24 p.

Keywood, M. D., **Ayers, G. P.**, **Gras, J. L.**, **Gillett, R. W.**, and Cohen, D. D. (1999). Relationships between size segregated mass concentration data and ultrafine particle number concentrations in urban areas. *Atmospheric Environment,* **33** (18): 2907–2913.

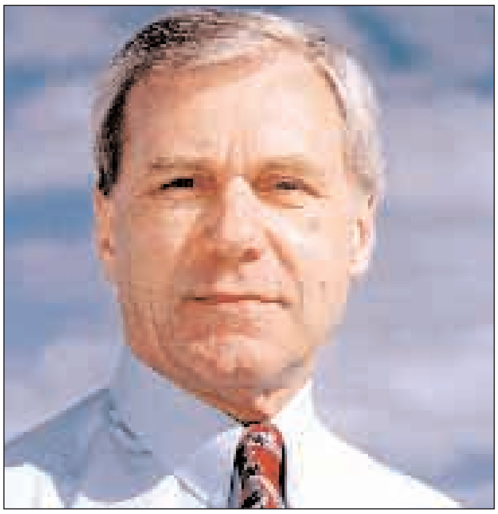
Langenfelds, R. L., **Francey, R. J.**, **Steele, L. P.**, Battle, M., Keeling, R. F., and Budd, W. F. (1999). Partitioning of the global fossil CO_2 sink using a 19-year trend in atmospheric O_2. *Geophysical Research Letters,* **26** (13): 1897–1900.

Rayner, P. J., Law, R. M., and Dargaville, R. (1999). The relationship between tropical CO_2 fluxes and the El-Niño-Southern Oscillation. *Geophysical Research Letters,* **26** (4): 493–496.

Rotstayn, L. D. (1999). Indirect forcing by anthropogenic aerosols: a global climate model calculation of the effective-radius and cloud-lifetime effects. *Journal of Geophysical Research,* **104** (D8): 9369–9380.

Trudinger, C. M., **Enting, I. G.**, **Francey, R. J.**, **Etheridge, D. M.**, and **Rayner, P. J.** (1999). Long-term variability in the global carbon cycle inferred from a high precision CO_2 and δ13C ice core record . *Tellus,* **51B** (2): 233–248.

Awards and honours



Dr Graeme Pearman

Chief of CSIRO Atmospheric Research, Dr Graeme Pearman, was made a Member of the Order of Australia in this year's Queen's Birthday Honours. Dr Pearman's award is for service to science, particularly in the field of atmospheric research, and to the community through promoting education on climate change issues.

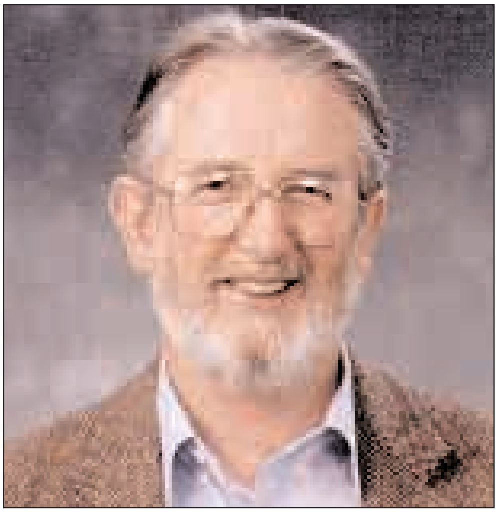
Dr Pearman is recognised nationally and internationally for research on increasing levels of carbon dioxide in the atmosphere. He was a key force behind the first measurements of carbon dioxide over Southern Hemispheric mid-latitudes and played a major role in the establishment of the Australian Baseline Station at Cape Grim. He also initiated measurements of pre-industrial air from Antarctic ice cores. In the 1980s, Dr Pearman pioneered studies of the global carbon cycle, particularly the use of global atmospheric transport modelling and stable carbon isotopes.

Dr Barrie Pittock

Dr Pittock's scientific contributions have been recognised with a Public Service Medal for 'outstanding public service through his leadership and visionary approach to identifying, researching and communicating a range of global climate science issues'.

Dr Pittock's first scientific activities involved assessments of stratospheric ozone and examination of the likely environmental effects of nuclear war. He then began to investigate the possibility that rising atmospheric levels of carbon dioxide might change global climate.

In the 1980s, Dr Pittock established the Division's climate impact group, which has performed detailed investigations of the likely impact of climate change on Australian states and territories, and on countries in South-East Asia and the Pacific.



AirWatch

AirWatch, a schools-based, air quality monitoring program has won this year's prestigious Allen Strom Eureka Prize for Environmental Education Programs. The prize was awarded to Ms Jennifer Anderton, of the WA Environment Department, who originated the project.

Program Leader of CSIRO Atmospheric Research's Atmospheric Pollution Program, Dr Peter Manins, has made major contributions to development of the scientific and technical component of AirWatch. National AirWatch Facilitator, Ms Margot Finn, who has also developed many of the experiments, is based at this Division.

For information on AirWatch, visit http://www.environment.gov.au/net/airwatch.html

Profile – Julie Noonan

A scientist in the Atmospheric Pollution Program, Dr Julie Noonan uses a variety of sophisticated computer models to establish patterns of meteorological variables, such as wind speed and direction. She does this for regions such as Hong Kong and the north-west Australian coastline, no mean feat as the landscape and nearby ocean produce complex patterns of winds. It is these winds that can concentrate and carry pollutants into populated areas.

Julie's modelling underpins a host of the Division's applied research projects.

Julie has a PhD in applied maths, and has been at CSIRO Atmospheric Research since 1989. Away from work, Julie contributes to community projects and is a keen gardener.

Applying our research

Significant recent and ongoing projects

Deployment of CSIRO Data Acquisition and Telemetry Network system	Jet Propulsion Laboratory, USA
Analysis of meteorological and air quality data	Department of Environmental Protection, Western Australia
Air quality forecasting for Australia's major cities	Commonwealth Department of Environment
Hong Kong greenhouse gas emissions inventory	ERM Hong Kong Ltd
Climate change impact assessments for the Hunter Valley	NSW State Government
ADEOS 2 satellite calibration and validation	National Space Development Agency, Japan
Gas sampling and analysis	Tenaga Nasional R&D, Malaysia
Indoor air sampling	Canberra Clinical School

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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