atmosphere

Issue 8
April 2000

Newsletter of CSIRO Atmospheric Research

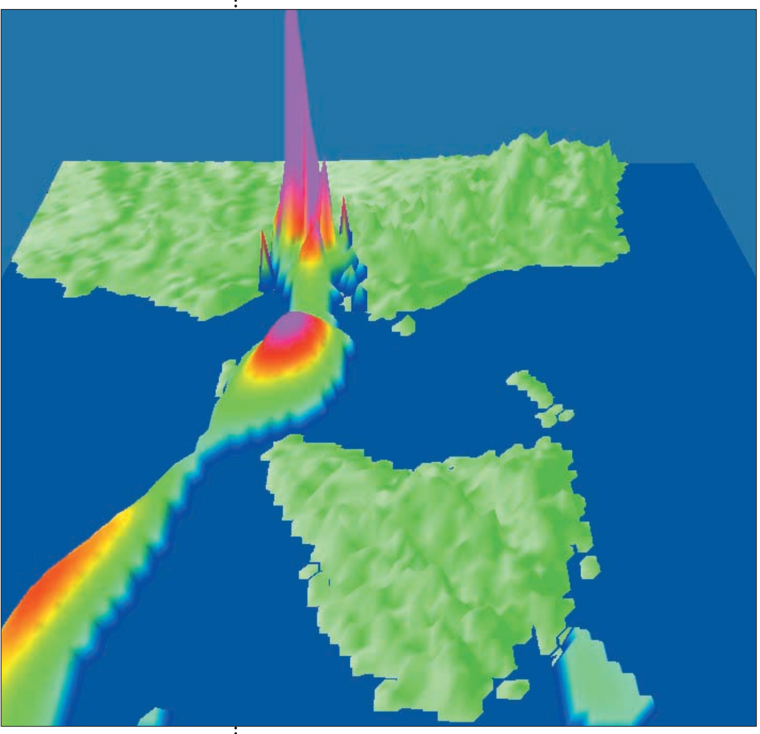
CSIRO

Air quality anywhere: CSIRO airs new management tool

CSIRO scientists have developed new software for assessing the spread and impact of air pollution. Appropriately named 'The Air Pollution Model' (TAPM), the model is designed to run on a personal computer, unlike comparable models in the past that have required powerful mainframes or even supercomputers.

With an advanced scientific basis for all components, TAPM predicts meteorological and pollution parameters (including simplified photochemistry) on local, urban or regional scales, for periods ranging from one hour to one year.

Dr Bill Physick (left) with Dr Peter Hurley, who developed TAPM.



Modelled surface carbon monoxide concentrations in an air pollution plume travelling south from Melbourne past Tasmania. The colours and heights show varying concentrations of carbon monoxide.

No additional data are needed, as the software package contains all the necessary meteorological, terrain and vegetation data sets. Model set-up, post-processing and display of results are all done with a user-friendly graphical interface.

'The advantage of TAPM is that it is easy to use and runs on a PC, yet at the same time contains the latest scientific understanding of atmospheric dispersion processes,' says Dr Bill Physick, leader of the air quality modelling team.

TAPM has already been used to assess ground-level concentrations from chimney emissions, to investigate photochemical smog in cities, and to study haze in a large urban area.

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Volcano warning system in the sky

A global warning system for volcanic eruptions will soon be in place, following the launch late last year of a NASA Terra satellite from California. Dr Fred Prata is a co-investigator on the NASA team that will use a sensor on the satellite to monitor the surface of the planet, looking for 'hot spots' that may signal an active volcano.

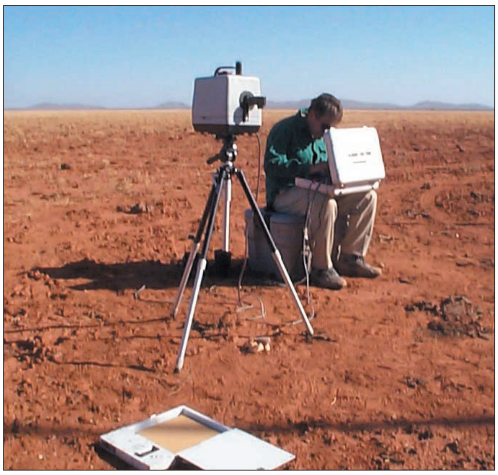
'We will be collecting information at dozens of different wavelengths,' says Dr Prata.

'Until now, we haven't had sufficient information to be able to spot a volcano that is about to erupt. Our objective is to provide timely alerts to local authorities when we spot high temperatures, known as 'thermal anomalies', produced by lava near the surface.'

'We will also be able to warn pilots to keep clear of the area.'

Researchers will also be using the sensor, known as a Moderate Resolution Imaging Spectroradiometer (MODIS), to study the effects of eruptions on the atmosphere and on climate. They will be able to investigate the composition of particles and gases ejected into the air.

'The sensor will provide temperature readings throughout the atmosphere, assessments of cloud patterns and will enable us to track smoke plumes from biomass burning,' says Dr Prata.



Dr Simon Hook, a NASA JPL scientist, makes radiometer measurements at Amburla in central Australia.

Courtesy NASA

Launch of the NASA Terra satellite on 18 December, 1999.

Australian scientists will have daily access to NASA satellite data, which will be received at ground stations in Hobart, Alice Springs and Perth.

Working with NASA, CSIRO is using measurements from a site near Alice Springs to calibrate another sensor on board the NASA Terra satellite — an advanced radiometer. The radiometer will provide high-resolution data on land use and land cover, track natural disasters, and probe climate variability and hydrology. The radiometer, a result of collaboration between the United States and Japan, will also aid in exploration for metal deposits, petroleum and ground water.

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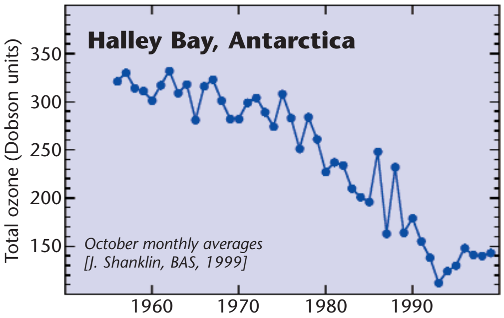
Ozone layer damage to continue until at least 2050

It's likely to be at least 20 years before we see clear signs of repair to the ozone layer and 50 to 100 years before full recovery, according to Dr Paul Fraser.



Decline in ozone levels over Antarctica

The annual springtime ozone hole over Antarctica peaked in early October 1999, covering 25 million square kilometres, more than three times the area of Australia. Measurements at Halley Bay in Antarctica reveal that October ozone concentrations are now less than half what they were during the 1960s.

Ozone damage has not been restricted to Antarctica. The ozone layer over sub-tropical parts of Australia has thinned, which means that levels of harmful ultraviolet radiation reaching the ground are far greater than in the past.

Anticipated global warming next century will cool the stratosphere, further increasing the rate of ozone destruction, according to Dr Fraser.

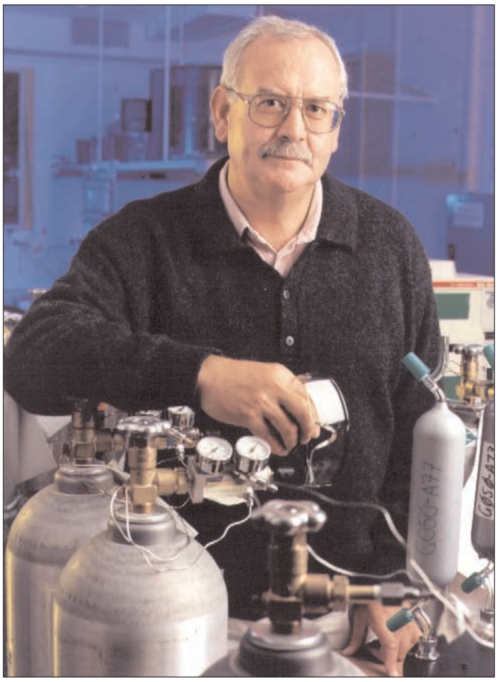
'Based on the maximum predicted emissions of ozone depleting chemicals allowed under the Montreal Protocol, it will be at least the year 2050 before the ozone layer recovers. Global warming may further delay recovery by 10–20 years,' says Dr Fraser.

'A positive step we could take to reduce emissions would be to expand CFC and halon recovery, recycling or destruction.'

In Australia, the not-for-profit companies Refrigerant Reclaim and the Halon Bank are responsible for CFC and halon recovery, recycling and destruction.

Australia and other developed countries have completely phased out production of CFCs and halons. However, under the Montreal Protocol, designed to protect the ozone layer, developing countries have until the year 2010 before they must completely phase out halon production.

Support for CSIRO's research into ozone depletion comes from the Co-operative Research Centre for Southern Hemisphere Meteorology at Monash University, and from Refrigerant Reclaim Australia.



Dr Paul Fraser

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South-East Asia is likely to experience warmer and slightly wetter conditions in future, according to participants in a five-week workshop on climate change run at the Division.

Warmer, wetter future for South-East Asia

The 15 participants used results from CSIRO's climate model simulations to estimate likely temperature and rainfall changes in Indonesia, Malaysia, Philippines, Singapore, Vietnam, Cambodia and Pacific islands.

By the year 2050, these countries are likely to experience temperatures 1°C greater than today with small increases in rainfall for most land areas.

Workshop participants also assessed how variable future rainfall will be and the impacts of El Niño and La Niña events on agricultural production.

'We established the workshop to help climate scientists in South-East Asia understand and apply results from high-resolution climate model simulations,' says workshop leader, Dr John McGregor.

'The visiting scientists are now carrying out further analyses in their home countries and we are looking forward to continuing scientific collaboration with them.'

During the workshop, the participants accessed CSIRO's computing facilities and applied a range of analysis and graphics tools to interpret likely climate changes.

'We need to know the regional impacts of climate change,' says Dr Mezak Ratag, a participant from the Indonesian National Institute of Aeronautics and Space.

'Most of the developing countries do not have the tools to examine impacts of climate change. Many of Indonesia's agricultural activities, such as rice growing, are in coastal regions such as Java,' says Dr Mezak.

Workshop participants, Ms Felicidad Villareal from the Philippines (far left) and Dr Mezak Ratag (far right), with Dr John McGregor and Dr Jack Katzfey from CSIRO Atmospheric Research.

During the workshop CSIRO provided lectures on topics such as rainfall and temperature extremes, tropical cyclones, monsoons, El Niño and La Niña, detection of climate change and coastal modelling.

Participants were from Cambodia, Fiji, India, Indonesia, Malaysia, Papua New Guinea, the Philippines, Samoa, Singapore, Thailand and Vietnam.

The Asia-Pacific Network for Global Change Research funded the workshop. The Network is an inter-governmental program established to promote global environmental change research.

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Sniffing out the distant polluters

Using instruments so sensitive that they will detect just a few kilograms per day of a gas released from a distant city, researchers have begun monitoring urban emissions of a variety of ozone depleting and greenhouse gases.

Releases from Melbourne are being detected some 12 hours later at Cape Grim in Tasmania, three hundred kilometres to the south.

Ms Michelle Cox and Ms Bronwyn Dunse, PhD students, have tracked releases of CFCs, HCFCs and HFCs from Melbourne.

HCFCs and HFCs are refrigerants, developed as short-term and long-term replacement chemicals, respectively, for ozone-depleting CFCs.

When the wind blows from Melbourne, the gas chromatographs at Cape Grim measure concentrations of a range of pollutants from the city. The students are using these measurements to calculate how much CFCs, HCFCs and HFCs are emanating from Melbourne.

'We have been able to provide industry with estimates of refrigerant releases from Melbourne,' says Ms Cox.

'Remote measurement of gaseous releases also offers potential for monitoring Australia's emissions of greenhouse gases.'

Ms Cox is a student of the Co-operative Research Centre for Southern Hemisphere Meteorology at Monash University; Ms Dunse is enrolled at the Chemistry Department of Wollongong University. Refrigerant Reclaim Australia is partially funding the students' research.

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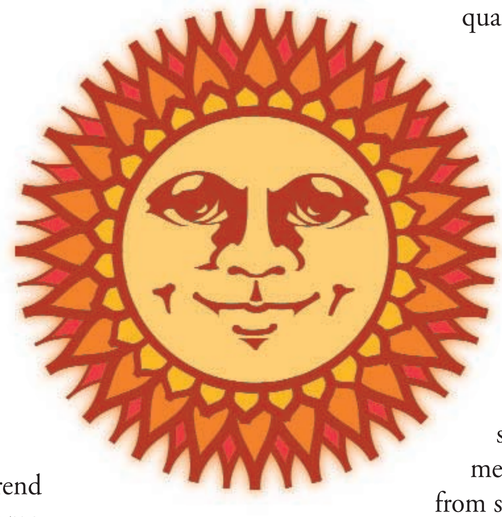
Ms Michelle Cox and Ms Bronwyn Dunse in GASLAB.

Temperature changes since the 19th century

The full text of the publication on which this article is based can be found at http://www.dar.csiro.au/publications/Holper_1999a.htm

Global mean surface air temperature has increased by between 0.3 and 0.6°C since the late 19th century. Recent years have been among the warmest on record. For example, 1998 had the highest global mean temperature in the instrumental record and was the 20th consecutive year with an above-average global mean temperature. Ten of the past twelve years have been the warmest on record.

Night-time temperatures over land have generally increased more than daytime temperatures. Consequently, in many places the diurnal temperature range over land has decreased. Increases in minimum temperature have been about twice those in maximum temperature.



However, the warming trend has not been uniform. Some regions, such as continents between 40°N and 70°N, have warmed more than others. Other parts of the world, such as the North Atlantic Ocean, have cooled slightly during the past century.

During the period with the most reliable data (the past 40 years), global average surface temperature has increased by between 0.2 and 0.3°C.

Australian temperature changes

Surface temperatures in Australia have also increased during the 20th century, particularly since the 1950s and particularly at night-time.

There has also been an increase in the frequency of warm days and nights and a decrease in cool days and nights in the latter half of the 20th century. Occurrences of minimum temperatures below 0°C have decreased significantly over inland eastern Australia during the past 100 years.

In 1998, Australia recorded the highest annual mean temperature since high-quality data records began in 1910. The 1990s was Australia's warmest decade in the ninety years for which high-quality records are available.

Measuring surface temperature

Researchers have assessed global and Australian temperature trends over land using millions of measurements made by thermometers in Stevenson screens. Sea-surface temperature measurements have come from ships and other platforms such as buoys.

Some land-based measurements have been affected by cities sprawling to occupy areas that were once countryside or farmland. Cities are usually warmer than the countryside, so this phenomenon often elevates temperatures. However, according to the Intergovernmental Panel on Climate Change (IPCC), 'Urbanisation in general and desertification could have contributed only a small part (a few hundredths of a degree) of the overall global warming, although urbanisation influences may have been important in some regions'.

Well-aware of urban heating, the Bureau of Meteorology has established a set of reference climate stations that have high-quality, long climate records and are located away from large urban centres. Many of these stations are included in a network of high-quality temperature stations used to investigate long-term temperature trends in Australia.

Satellite measurements of temperature

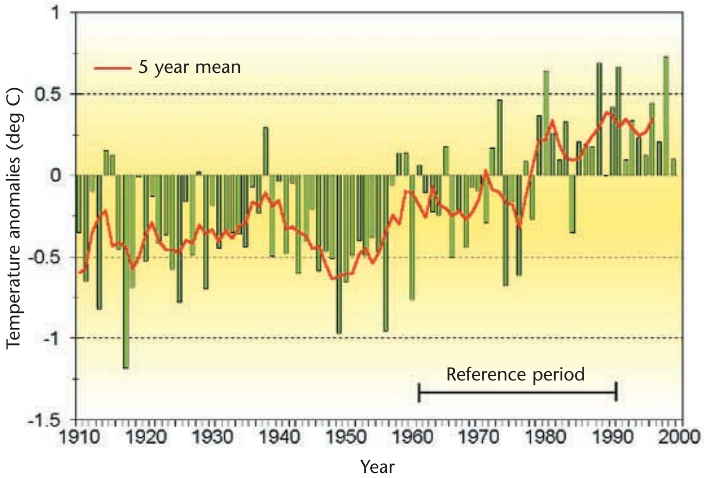
Scientists have used data from satellite instruments to deduce air temperatures since the 1970s. The instruments record the radiation emitted by air molecules, which changes according to temperature.

Infrared sensors and an instrument known as a microwave sounding unit are commonly used for measuring temperature from satellites. For climatic studies, the microwave sounding unit is a powerful tool. It provides records going back to the late 1970s and its measurements are not particularly affected by clouds.

Satellites measurements have the advantage of being made frequently at most places on Earth. However, the sensors do not measure temperature at the Earth's surface. The microwave sounding unit, for example, monitors the lowest six kilometres of the atmosphere. Thus, ground-based temperature measurements cannot be compared directly with those from this sounding unit. Interpretation of satellite measurements depends also on a number of assumptions about the composition of the atmosphere.

Satellite measurements since 1979 initially appeared to show a slight cooling of the world's atmosphere, by about 0.06°C per decade. This is despite the global warming trend shown by measurements of surface temperature.

However, the data have been reanalysed to account for atmospheric drag, which lowers the orbit of the satellites. Once corrected for this drag, the satellites reveal no significant



Annual mean temperature anomalies for Australia

Courtesy Bureau of Meteorology

atmospheric temperature change. CSIRO research confirms that surface temperature measurements are not invalidated by satellite observations. For example, if short-term events such as El Niño and volcanic eruptions are taken into account, satellite measurements of the lower atmosphere *do show* slight warming since 1979.

Interpreting the changes

Is 20th century warming due to natural climatic fluctuations or has it been caused by greenhouse gases released into the air by human activity?

Changes to solar radiation are likely to have contributed only a fraction of the climate-forcing changes to the heat trapping ability of the atmosphere produced since 1850 by increasing concentrations of greenhouse gases.

According to the IPCC, warming since the late 19th century 'is unlikely to be entirely natural in origin. The balance of evidence, from changes in global mean surface air temperature and from changes in geographical, seasonal and vertical patterns of atmospheric temperature, suggests a discernible human influence on global climate.'

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CSIRO scientists recently used the Division's multiwavelength scanning lidar to fire pulses of laser light at trees in a Victorian forest. The results of the study will be used to help design an airborne system that will map the structure of vegetation canopies over Australia. Forest managers and environmental researchers will use the data to determine the coverage, growth rate and biomass over the continent.

This is a collaborative project with CSIRO Earth Observation Centre, and CSIRO Forestry and Forest Products, and Exploration and Mining.

Annual Priestley Lecture

In 1995, the Division inaugurated an annual lecture in honour of Dr Bill Priestley, our founding Chief. Since then, we have hosted five eminent, invited scientists, who have delivered high-quality, thought-provoking addresses on atmospheric science topics.

The 1999 Priestley Lecturer was Prof. Richard Goody from Harvard University. Prof. Goody's research interests include atmospheric chemistry, stratospheric physics and atmospheric radiation. He has recently published a number of research papers on atmospheric entropy and the detection of climate forcing using emission spectra.

Prof. Goody described to a packed lecture theatre recent advances in using observational data to test and improve climate models.

CSIRO Atmospheric Research Priestley Lecturers

1995	Prof. Akiva Yaglom,	*MIT, USA*	Atmospheric turbulence
1996	Dr Syukuro Manabe	*Princeton University, USA*	Computer models of global warming
1997	Dr John Philip	*ex- CSIRO Centre for Environmental Mechanics*	Applications of maths and physics to environmental problems
1998	Dr Susan Solomon	*NOAA, USA*	Stratospheric ozone depletion
1999	Prof. Richard Goody	*Harvard University, USA*	New observing techniques and the evaluation of climate models

How wet? Check the Net

Risk-managers and weather enthusiasts can use a new Web site to view rainfall trends in Australia for most of the past century.

The web site has rainfall information from 1910 to 1995, averaged for each State and Territory.

'Most parts of the country have become wetter since 1910,' says Mr Kevin Hennessy, who initiated the Web project at CSIRO Atmospheric Research.

'Many areas are experiencing more rainy days and more heavy rainfall than in the past.'

For every Australian State and Territory, and for south-west Western Australia, there are graphs showing annual and seasonal total rainfall, rain days and heavy rainfall — 135 graphs containing more than 11,000 statistics.

All the rainfall data presented on the Web site come from the Bureau of Meteorology.

The Australian rainfall trends Web site is at *http://www.dar.csiro.au/res/cm/rainfall_trends.htm*

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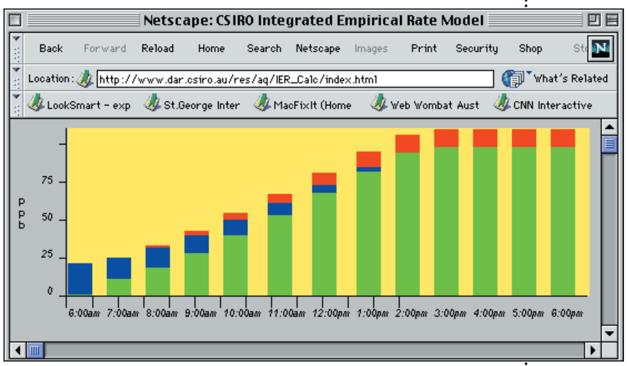
On-line air pollution programs

Researchers, students and anyone interested in how things work can explore several new interactive Javascript programs on the Division's Web site.

Visit *http://www.dar.csiro.au/res/aq/inter-act/* for an insight into the science that we apply to solving a range of environmental problems. You can see:

- how chimney plumes mix to the ground
- the relationship between peak and mean odour concentrations
- how to calculate the height of the convective mixed layer and surface heat flux
- how to determine smog levels throughout the day from basic measurements
- how to assess pollution levels from chimneys



- how sea breezes can cause high air pollution levels.

For the truly curious, we have displayed all the underlying code for these programs.

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.*

Ayers, G.P., **Keywood, M.D.** and **Gras, J.L.** (1999) TEOM vs. manual gravimetric methods for determination of PM2.5 aerosol mass concentrations. *Atmospheric Environment,* **33**(22), 3717–3721.

Beer, T. and Ricci, P.F. (1999) A quantitative risk assessment method based on population and exposure distributions using Australian air quality data. *Environment International,* **25**(6–7), 887–898.

Cai, W.J., **Baines, P.G.** and **Gordon, H.B.** (1999) Southern mid- to high-latitude variability, a zonal wavenumber-3 pattern, and the Antarctic Circumpolar Wave in the CSIRO Coupled Model. *Journal of Climate,* **12**(10), 3087–3104.

Francey, R.J., Manning, M.R., **Allison, C.E.**, **Coram, S.A.**, **Etheridge, D.M.**, **Langenfelds, R.L.**, Lowe, D.C. and **Steele, L.P.** (1999) A history of $\delta^{13}C$ in atmospheric CH_4 from the Cape Grim Air Archive and Antarctic firn air. *Journal of Geophysical Research,* **104**(D19), 23,631–23,634.

Fraser, P.J. and Prather, M.J. (1999) Uncertain road to ozone recovery. *Nature,* **398**(6729), 663–664.

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.

Hurley, P.J. (1999) *The Air Pollution Model (TAPM) Version 1: technical description and examples*, CSIRO Atmospheric Research, Aspendale, 41 p.

Katzfey, J.J. (1999) Storm tracks in regional climate simulations: verification and changes with doubled CO_2. *Tellus,* **51A**(5), 803–814.

Keywood, M.D., **Ayers, G.P.**, **Gras, J.L.**, **Gillett, R.W.** and Cohen, D.D. (1999) An evaluation of PM10 and PM2.5 size selective inlet performance using ambient aerosol. *Aerosol Science and Technology,* **30**(4), 401–407.

McInnes, K.L., **Walsh, K.J.E.** and **Pittock, A.B.** (1999) *Impact of Sea Level Rise and Storm Surges on Coastal Resorts: a Project for CSIRO Tourism Research: Second Annual Report.* Aspendale, Vic.: CSIRO Atmospheric Research, 29 p.

Meyer, C.P. (1999) *Australia's national greenhouse gas inventory, 1997: Workbook 5.1: agriculture — non-carbon dioxide gases from the biosphere: report to the National Greenhouse Gas Inventory Committee,* CSIRO Atmospheric Research, Aspendale, 67 p.

O'Brien, D.M. and **Dilley, A.C.** (2000) Infrared cooling of the atmosphere: accuracy of correlated κ-distributions. *Journal of Quantitative Spectroscopy and Radiative Transfer,* **64**(5), 483–497.

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Conclusions

Average surface temperatures globally and in Australia have risen during the past hundred years. These increases and their nature — with minimum temperatures rising more than maxima — are in keeping with scientists' descriptions of likely changes associated with rising concentrations of greenhouse gases.

As pointed out by the IPCC, there is a discernible human influence on global climate. Solar variation and climatic variability have also had, and will continue to have, an impact on climate.

Irrespective of past temperature changes, scientists' knowledge of the climate system leads them to expect that increasing atmospheric concentrations of greenhouse gases will produce global warming. In turn, this warming is likely to produce changes to the world's climate.

New flow hood calibration service

As a result of demand from the air conditioning industry, CSIRO Atmospheric Research has introduced a flow hood calibration service. The new service complements the NATA-registered wind tunnel facility for calibrating anemometers, which has operated since 1958.

'Industry said to us that they needed a 'one-stop-shop' for anemometer and flow hood calibrations,' says Ms Julie McLean, wind tunnel manager.

'We calibrate both devices in the one laboratory.'

For quality assurance, companies need to ensure that their flow hoods (also known as air capture hoods) are properly calibrated at least once a year.

CSIRO's wind tunnel facility draws on the expertise of the Division's air modellers, mathematicians and physicists to ensure that its operation is always exemplary.

The purpose-built flow tunnel has been designed in collaboration with RMIT and constructed by workshop staff to Australian Standards specifications. The tunnel is a non-return (supply mode), blow-through system. Controlled flows are available from 20 to 500 litres per second with an accuracy of ±4% or 2 litres per second, whichever is greater.

Flow hood calibration is NATA traceable, with CSIRO working towards full NATA accreditation for the service.

The new calibration service caters for all brands of commercial hoods including Shortridge, TSI and Alnor.

As well as the air conditioning industry, flow hoods are used by building services companies and occupational health and safety contractors.

CSIRO now has facilities to calibrate flow hoods used in the air conditioning industry.

CSIRO's long-established anemometer calibration service caters for meteorologists, EPAs, construction companies, power stations as well as for indoor applications such as assessments of fume hood operation and of air and filter processes.

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Profile — Melita Keywood

Identifying environmental problems and trying to solve them is what Dr Melita Keywood enjoys most about her work at CSIRO Atmospheric Research.

A research scientist in the Division's Aerosol Program, Melita has been measuring visibility levels and analysing the make-up of fine particles in the air in Kuala Lumpur. This is a collaborative project with the Malaysian Government designed to establish sources of haze and use meteorological and forest fire data to predict when aerosol levels are likely to be high.

Outdoor work and field research attracted Melita to atmospheric science. She obtained a PhD in environmental geochemistry at the Australian National University after completing a science degree at Auckland University majoring in geology.

As to why she chose to concentrate on science at school: 'I couldn't understand why you had to be on the right side of the teacher to get good marks in English. Science is more objective!'

Applying our research

Significant recent and ongoing projects

Air quality modelling for the Pilbara region	Department of Environmental Protection, Western Australia
Australian greenhouse science program	Australian Greenhouse Office
Climate change and coral bleaching on the Great Barrier Reef	Department of Natural Resources, Queensland
Climate change scenarios for southern Western Australia	Department of Environmental Protection, Western Australia
Gas sampling and analysis	Central Queensland University
Preparation of The Atmosphere chapter for the 2001 National State of the Environment report	Environment Australia

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

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