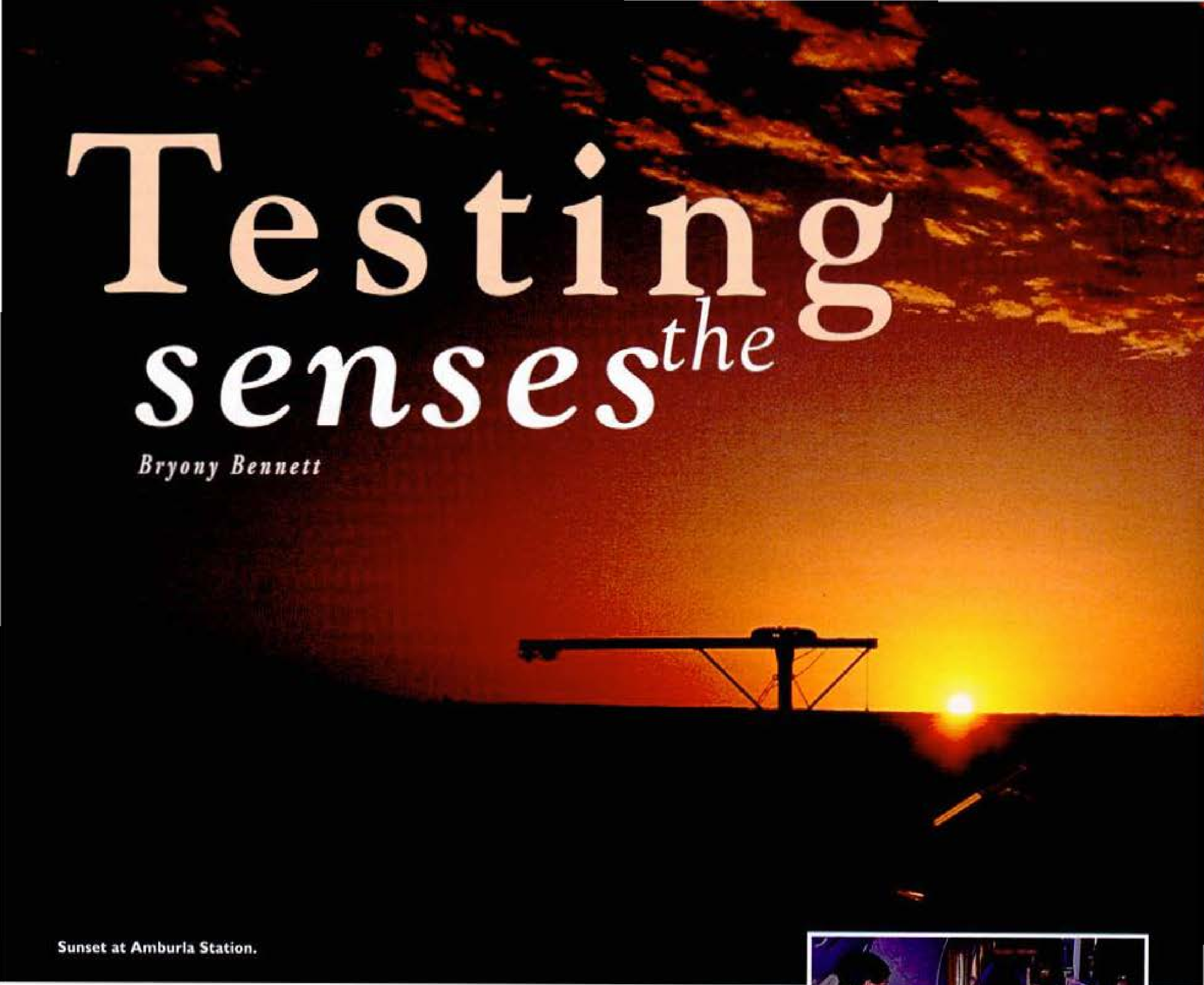
Testing the senses

Bryony Bennett



Sunset at Amburla Station.

When it comes to remote sensing, summer in central Australia has it all. Vast blue skies and terra cotta plains; hot, clear desert air; and for a lucky few, the tantalising sizzle of an outback barbecue as the MacDonnell Ranges glow in the sunset.

Soaking up such sensual delights early this year was a group of Japanese and Australian visitors to Amburla Station, a cattle and camel-grazing property that starts about 100 kilometres north-north-west of Alice Springs, and ends at the edge of the Tanami Desert.

The visitors were celebrating the end of an important week's work at Amburla, during which they had 'sensed' the outback environment intensely. Using an array of instruments – deployed on the ground, on an F-27 aircraft, and on four-wheel-drive vehicles – they had gathered a swag of information about the atmosphere and land surface along a 20 km stretch of Amburla's 'Mt Hay' paddock.

Their activities were all part of a million dollar experiment involving 22 scientists: six from CSIRO and 16 from Japan's National Institute for Resources and Environment, and the Central Research Institute of the Electric Power Industry. The experiment was designed to fine-tune and ensure the long-term accuracy of an instrument that measures greenhouse gases from space. This instrument, called an interferometer, will be carried on a Japanese Advanced Earth Observing System (ADEOS) satellite to be launched in August from the island of Tanegashima.

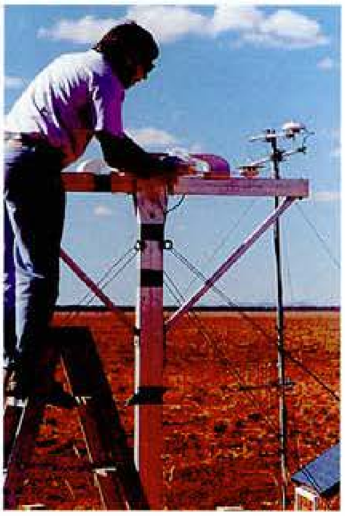
A web of truth

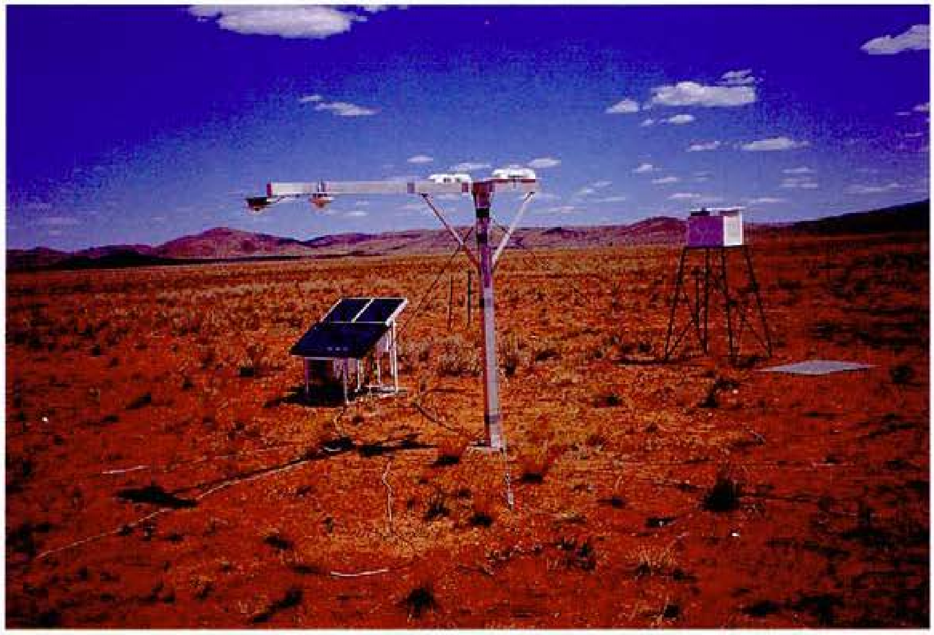
Now you may be pondering the link between a long flat paddock near Alice Springs and a Japanese Earth-observing mission. Well it seems that this part of Australia – in addition to being a Mecca for camels and tourists – is a great place from which to 'ground truth' the performance of satellite sensors.

And this is not the only site in Australia with the right credentials. Amburla is the second field station in a growing network that eventually will encompass about six long flat paddocks representing different natural surfaces and atmospheric regimes across the continent.

Inside CSIRO's F-27 with the airborne Interferometer for Measuring Greenhouse gases. Japanese scientist Dr Kobayashi and CSIRO's Dr Prata discuss plans for testing the instrument's performance.

The Australian Continental Integrated Ground-truth Site Network is being set up by CSIRO to obtain long-term measurements of surface temperature, radiative fluxes (downward and upward) and albedo (surface reflectivity). The data will be used to calibrate satellite instruments and to validate their





Measurements taken from an aircraft, a four-wheel-drive thermal mapping vehicle, and from static instrument arrays were compared with data from a Japanese remote-sensing device during the ground-truthing exercise at Amburla.

measurements. (Calibration involves defining how an instrument responds to known signal inputs. This knowledge enables the instrument's consistency to be checked over time.) Data from the network will also be used to validate climate models, and to improve the modelling of surface processes – such as the apportionment of heat and energy – which have an important influence on climate.

Dr Fred Prata from CSIRO's Division of Atmospheric Research says that calibration and validation increase the reliability and usefulness of remotely-sensed data. As a result, they are receiving increasing attention from space agencies. 'By operating and maintaining calibration field sites, Australia is contributing to the efficiency of international Earth-observation satellite systems,' Prata says. 'In return, we have access to data which can be used in resource management and to improve our knowledge of the environment.'

Prata was a principal investigator on the Amburla experiment which was known officially as the Campaign for the Evaluation of IMG Data Retrieval. (IMG stands for Interferometric Monitor for Greenhouse-gases.) He says the Japanese interferometer will enable the global mapping of greenhouse gases such as water vapour, carbon dioxide, methane and nitrous oxide. The purpose of the field work at Amburla was to help ensure the accuracy of those maps by validating and calibrating the sensor's measurements.

Amburla's high summer temperatures (50-60°C on the ground), cloudless skies and uniform surface features provided near-perfect conditions for the ground-truthing exercise. High temperatures were essential, because the sensor's designers wanted to test its performance above the coldest and hottest land surfaces available. The reason for this relates to the way that information about atmospheric temperature and greenhouse gases is derived.

Like many satellite instruments, the interferometer does not make direct measurements of its ultimate 'target'. It

Grasping Earth's climate control

DATA FROM Australia's ground-truth network will be used by scientists to improve the way that radiation fluxes at the surface of the Earth are represented in climate models. Studies at the Division of Atmospheric Research have revealed that estimates of net radiation at the land surface are generally too high, apparently due to overestimates of incoming solar radiation at the ground and underestimates of outgoing thermal radiation from the ground.

Understanding the components of the surface radiation budget is important, because it controls all aspects of climate. Long and shortwave fluxes at the Earth's surface control the amount and nature of the energy entering and leaving the atmosphere at its lower boundary. When radiation at the top of the atmosphere is considered, the total energy budget of the earth-atmosphere system can be evaluated.

'We would like to do this from satellite, because it is the only way to get representative time and space scales (many years and global coverage),' Prata says. 'But because we don't yet have good algorithms or perfect instruments with which to determine the surface radiation budget from space, we must augment our remote sensing measurements with ground-based data.

'This allows us to develop algorithms (by comparing fluxes measured on the ground with those determined from a satellite-based algorithm), and to check the calibration of the satellite instrument (this process is called vicarious calibration). Our sites are set-up to do both validation and vicarious calibration.'

actually records variations in the intensity of radiation (or heat) in the infrared region of the electromagnetic spectrum (see story on page 25). From this data, information about the atmosphere and Earth's surface can be inferred.

The IMG 'sees' the infrared region between about four and 16 micrometers, but only a fraction of this picture is used to measure gases. Determining gas concentrations involves zeroing in on data relating to 'molecular absorption bands' within this range. These represent the point of the spectrum at which particular gases absorb and emit the most radiation. For example, the molecular absorption band for carbon dioxide is 15 µm, and for water vapour it is 6.3 µm. 'Different gases absorb and emit infrared radiation in different bands,' Prata says. 'By looking at these bands we unambiguously know which gas is present and how much of it is there.'

Before yielding this result, however, another set of extraneous information must be weeded out. Included in the interferometer's initial measurement is radiation emitted from the Earth's surface, as well as radiation absorbed and re-emitted by atmospheric gases. Disentangling the earth radiation from the gas radiation is an important function of the interferometer's data-retrieval system. Complicating this process is the fact that Earth radiation varies according to land cover. Giving the interferometer a thorough workout therefore meant testing its performance over land surfaces with different emissive properties.

Having already tested the interferometer over snow-covered land in northern Japan, the cold extreme had been taken care of. CSIRO's Amburla field site in summer offered the perfect opportunity for a run in the heat.

While the interferometer was flown above Mt Hay paddock in CSIRO's F-27, Prata and his team scurried about on the ground, measuring variables such as longwave and shortwave radiation, trace gases and surface temperature, both from a static instrument array, and from a four-wheel drive vehicle. This exercise was carried out four times: twice at night and twice in daylight. The ground-based measurements were then compared with the interferometer readings, enabling its calibration.

After its launch in August, the ADEOS satellite will fly over the Amburla field site every few days. This means that data from the interferometer can be checked against independent, ground-based measurements on an ongoing basis. It also offers a great opportunity for Prata and his colleagues to 'sense the outback environment' some more.

The first Australian Continental Integrated Ground-truth Site Network field site at Hay, NSW.

Network born on plain terrain

THE FIRST field site in the Australian Continental Integrated Ground-truth Site Network was set up three years ago at the Uardry sheep station on the Hay plain in southern New South Wales. Like Amburla, the site features flat, natural terrain, an atmosphere with few aerosols and low water vapour, and predominantly clear skies. A useful reference point for remotely-sensed images is provided by the Murrumbidgee River which flows a few kilometres to the south.

A solar-powered measurement system, known as CSIDAT (CSIRO Data Acquisition and Telemetry Network), records temperature every 200 seconds, regularly transmitting data back to the Division of Atmospheric Research by satellite. The system includes radiometers and temperature sensors fitted to a 15-metre-high central tower, and further instruments spread across one-square kilometre, a range comparable with the coverage of many of the currently used satellite sensors.

The Uardry site is providing regular ground-based reflectances to compare with shortwave measurements from the Advanced Very High Resolution Radiometer, a sensor carried on the United States National Oceanic and Atmospheric Administration satellites. (Ground-based measurements are necessary for correcting observed drift in sensitivity of the instrument's shortwave channels.)