Going automatic… Australia's ASP observatories

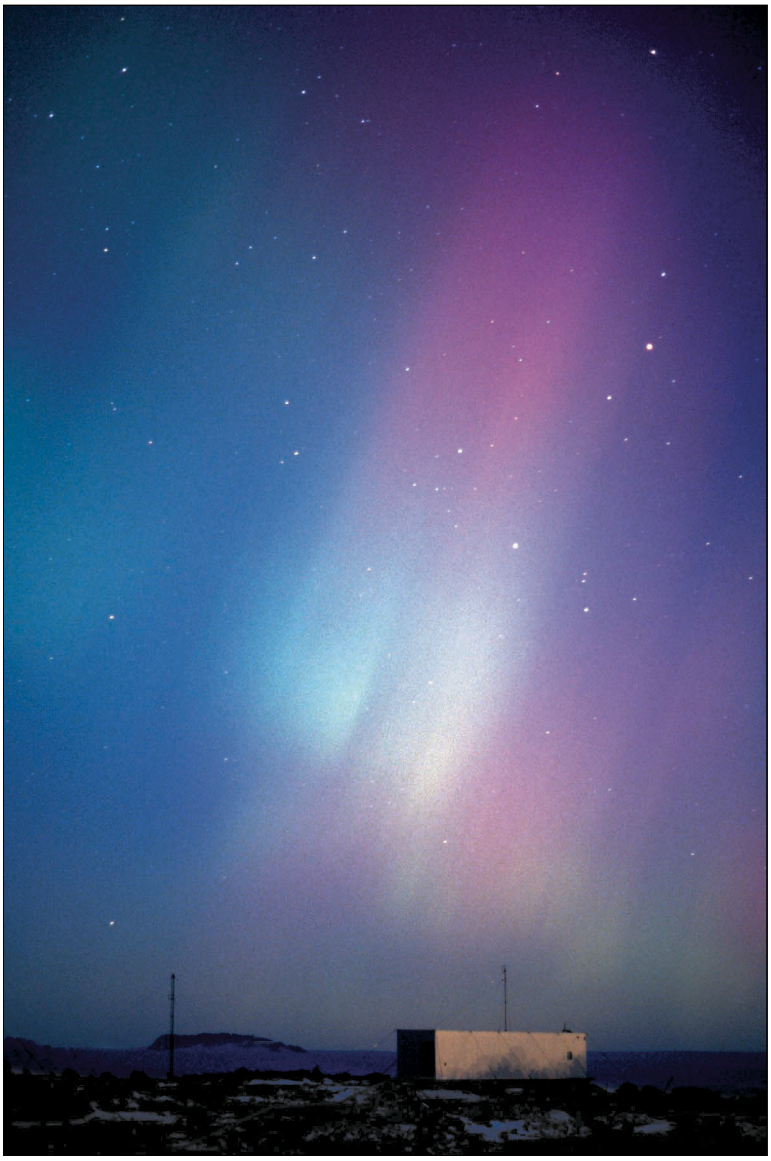
The year 2001 marks a turning point for the Atmospheric and Space Physics (ASP) program. For the first time for many years (since 1957 for Mawson, early 1980s for Macquarie Island) there are no people wintering at Mawson or Macquarie Island whose primary role is to support atmospheric and cosmic ray physics research.

Despite this, the ASP program is alive and well at both stations, as well as Casey, which will go automatic from 2002. Autonomous equipment will enable continued logging of essential data under the control of ASP personnel at Australian Antarctic Division headquarters in Kingston, Tasmania. Standard riometer and magnetic pulsation observations will continue at all three stations, as well as fluxgate magnetometer observations at Casey, all-sky imaging at Casey and Macquarie Island, and cosmic ray observations at Mawson.

The automation program, which implements a recommendation of *Australia's Antarctic Program Beyond 2000* (1997), puts ASP at the leading edge of instrument automation. The program was aimed at continuing collection of essential data from each station while reducing operational costs to allow resources to be diverted to major programs at Davis, including the Lidar project.

Three new systems have been developed to control and collect data from these experiments.

An analogue data acquisition system (ADAS), designed to collect time-stamped, time series data from any analogue signal is currently used to log data from the riometer, magnetic pulsations and fluxgate magnetometers. Data collection is synchronised to a GPS (global positioning system) chronometer allowing data to be sampled with a time resolution of one millisecond, allowing accurate propagation delays to be estimated from data recorded at multiple sites.



Kym Newbery

An aurora illuminates the Cosmic Ray Laboratory at Mawson station

The all-sky imaging system (ASIS), a specialised data acquisition and control system designed to record the night time activity in the skies over each station, uses a monochrome video camera fitted with a fish eye lens to take a circular horizon to horizon image of the sky every 30 seconds. These images are annotated with the time and date and then stored in digital format on hard disk for later transmission back over the satellite link.

Logging of data from the Mawson Cosmic ray observatory is now fully automatic, thanks to enhancement of an earlier automatic system that required weekly visits for essential manual intervention. The current system collects data from the neutron monitor and three surface muon telescopes and from the four underground muon telescopes (using the rock to filter out weaker cosmic radiation) on a one minute sampling basis. Also collected are outside and inside air pressure, laboratory and vault temperatures, and wind speed.

The new ADAS system was installed at Casey, Macquarie Island and Mawson in 2000-2001, while ASIS systems were deployed at Casey and Macquarie Island and the updated COSLOG system was commissioned at Mawson.

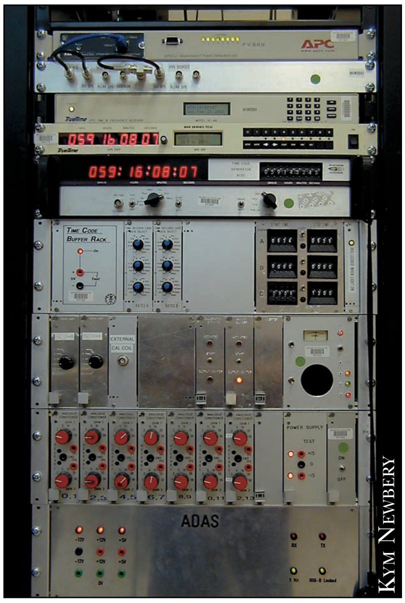
Data distribution

A major ASP observatory task is ensuring that data gets to the researchers needing it. These experiments provide valuable background data for advanced research elsewhere in the world. To reduce the data collection and archiving workload, arrangements have been made with IPS Radio and Space Services in Sydney, which has recently become a World Data Centre and also performs ionospheric forecasting. Every five minutes data is sent from each station to IPS in Sydney and then fed into forecasting models, and 24-hour files are sent to IPS for long term archiving. The Australian Geological Survey Organisation (AGSO) receives daily copies of the magnetic data from Casey.

Cosmic ray data are transmitted back to Kingston each day and even the large all-sky imaging files can be squeezed back over the satellite link during off peak times.

The permanent satellite data links between Kingston and the stations provide limited bandwidth. New software allows scheduling of large data transfers at off peak times to make efficient use of the link. While some data files are required at up to three different destinations, care is taken to avoid multiple transfers of the same data over the ANARESAT link. Copies of transferred files are made at Kingston and sent to interested agencies.

So who fixes the equipment when it breaks down? And how do we monitor data quality remotely?



Electronic equipment for the automation of the Mawson ASP laboratory

Remote power switches at each station are a first line of defence, providing mains power to ASP experiments and allowing individual items of equipment to be switched on and off under commands transmitted via satellite. Kingston staff can thus reset any recalcitrant equipment and switch off sensitive optical equipment over summer to save on power and protect the equipment.

Of course, unattended observatories raise the risk of reduced data quality with no specialist skills on site to monitor data as it is being collected and repair problems as they occur. The ASP program still relies on people at each station making regular equipment inspections. The all-sky imager dome still needs to be cleaned and station lights monitored. Physical equipment failures can still only be resolved with the human touch, although as older equipment is gradually upgraded even this requirement will be minimal.

All new automatic systems use email to keep in touch with Kingston headquarters. Any error conditions are stored in log files which are sent to Kingston to enable problems to be detected and rectified as soon as possible.

Future developments

The ANARE physics community has been encouraged to automate future experiments before deployment at stations, and to locate experiments at Davis where this is consistent with scientific objectives.

The DPS-4 Ionosonde will be moved from Casey to Davis in 2001-2002 so that it can be supported by wintering expeditioners. The GPS chronometers at Casey, Mawson and Davis will be upgraded to ensure accurate and dependable timing. An all-sky imager system will be reinstalled at Mawson after some renovation work, and ADAS and ASIS systems will be deployed at Davis, enabling expeditioners to concentrate on major research work.

Monitoring of ASP instruments and their environment will be done using webcams (such as checking build-up of grime inside the all-sky imager domes) and the Australian Antarctic Division's building monitoring and control system.

Mechanical switches and knobs on future ASP equipment will be replaced with digital controls that can be activated and adjusted remotely. New systems will be designed specifically for autonomous operation.

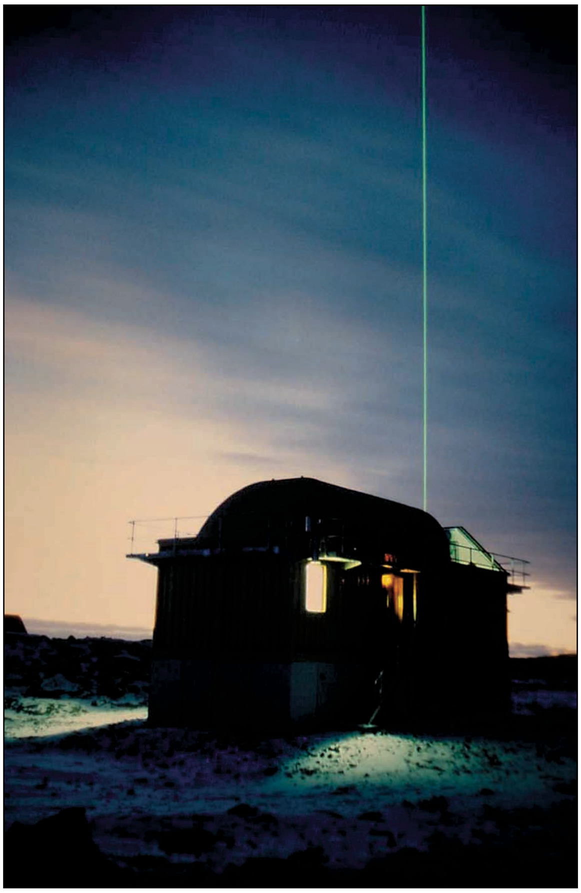
Lloyd Symons, Science Technical Support, AAD & Ray Morris and Marc Duldig, Atmospheric and Space Physics Program, AAD

Network technology aids in operating the LIDAR

The Davis Lidar has been collecting new data on the upper atmosphere since February 2001 (*Australian Antarctic Magazine* #1, p 29). Operation of this complex instrument has been aided by novel applications of computer technology developed by the ASP and Science Technical Support groups.

Consideration of issues related to laser safety and weather necessitate that the Lidar is not a fully autonomous system. However, a large amount of the control of the instrument is automatic, and the capability exists to operate and modify the observing program from any remote site with access to the Internet.

The Lidar has three levels of instrument control. The bottom level is provided by dedicated microcontrollers. Each of these 'modules' performs a specific hardware task, such as firing the laser, moving a filter into the optical path, or running high speed rotating shutters. The most complex of the modules controls and monitors the operation of a Fabry-Perot spectrometer, which forms the heart of the detector system.



Malcolm Lambert

The green LIDAR beam and the LIDAR Observatory

At the middle level of the control system are four networked PCs. The PCs do specific jobs; one is the main controller and communicates with the majority of the modules, a second controls the temperature inside the spectrometer, a third collects general monitoring data such as temperatures and voltages from around the system, and a fourth logs data from the spectrometer.

At the top level is a computer workstation that schedules the operation of the whole system through 'jobs', passing commands to the PCs via the network. The workstation collates the data files produced, and does some real-time analysis for the operator to view. The data are then transmitted to Kingston for detailed analysis.

The majority of the electronic systems have been developed in-house using a design philosophy developed by Peter Yates and David Rasch. David and Lloyd Symons have developed the majority of the control software in PIC micro code and LabVIEW, while David Watts, Damian Murphy and Andrew Klekociuk have developed the analysis and job control system in IDL (Interactive Data Language).

The flexibility of the system means that the observing program can be rapidly altered when phenomena of specific interest are detected. An example of this ability involved detection of tenuous clouds in the stratosphere during July 2001 by Malcolm Lambert, the Lidar physicist at Davis. These so-called Polar Stratospheric Clouds form at high latitudes in winter typically between altitudes of 15km and 25km. The clouds occur in regions where the temperature is below about -80°C, and are formed from crystals of sulphuric acid, nitric acid and water ice. The surfaces of the cloud particles provide a catalyst for the destruction of ozone, and so the observation of the clouds is of specific interest in understanding the nature of the Antarctic and Arctic 'ozone holes'.

When the clouds were first detected above Davis, the Lidar observing program was altered from Kingston to undertake high vertical resolution measurements. With 18 metre resolution, these are amongst the most detailed Antarctic observations that have been made using Lidar, and show complex structure that is indicative of the passage of small temperature perturbations associated with propagating atmospheric waves. The clouds themselves were subvisual due to the lack of direct solar illumination in the polar mid-winter night and would have gone completely unnoticed if not for the Lidar observations.

Further observing programs related to the clouds are planned with the aim of coordinating with other Antarctic ground-based and satellite measurements.

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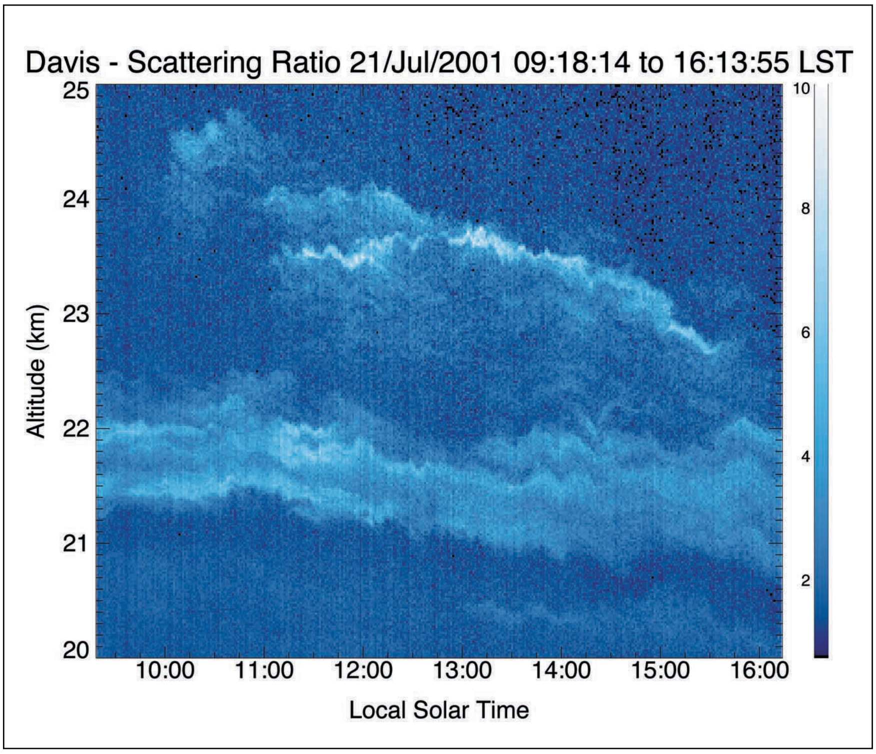

Andrew Klekociuk

Polar stratospheric clouds at altitudes between 20km and 25km above Davis