New VHF radar beams through Davis atmosphere

For years, the shores of Heidemann Valley, about a kilometre behind Davis, have watched a parade of penguins and people pass by but have been largely left in peace. And after a summer of activity, that peace has returned, albeit with a difference; a VHF radar now sits there quietly probing the atmosphere above. This is a result of the efforts of the staff of the AAD's Space and Atmospheric Sciences group and the engineering tradespeople at Davis.

The reasons for all this effort relate to atmospheric radars and their ability to probe the mysteries of the atmosphere. They are widely used and can measure rainfall (for example as a storm approaches the cricket) and wind (using the balloon tethered targets, such as those that used to be released from meteorological observing stations). But in their more common form, their operation is limited by a requirement for a 'hard target'; an object off which to reflect their radio waves. The 55 MHz VHF radar that has been constructed at Davis is able to detect signals from extremely weak reflectors in the atmosphere itself, and so is less affected by these limitations. It can operate continuously, automatically, and largely unattended.

DAMIAN MURPHY

VHF radar antennas after installation at Davis

Raising a radar

The VHF radar consists of 144 Yagi antennas (similar to TV antennas), sited in a 50m by 50m square and all pointing upward. Each antenna needed to be vertical, precisely positioned and able to withstand the high winds that can buffet our Antarctic stations. A building, with power and data connections to the main station infrastructure, was required to house the radar's electronic equipment. And we wanted to do all this with the minimum environmental footprint so that the site could be easily remediated at the end of the life of the radar in a decade or so.

With the help of the AAD engineering section, a design was developed that was simple, easy to build and modular. The usual (but high impact) technique of levelling the radar site was replaced with the pouring of 144 small concrete pads. These provided a regular surface on which to position the pre-cast concrete blocks that hold the base of the antenna support posts. A guy system holds the top of the support post in place and bears the strain of the wind loading.

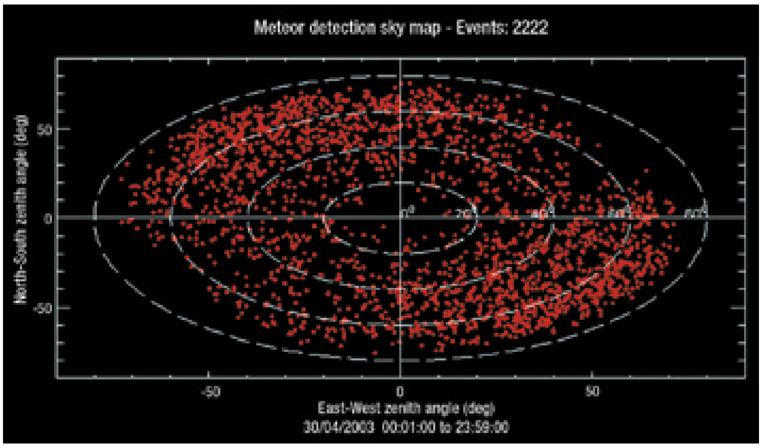
The design of the base blocks and the guy system was based on calculations made by Gandy and Roberts, a Hobart engineering firm. They modelled the radar with a computer and, with the wind data for Davis, calculated the weight of the base blocks, the breaking strain required for the rope guys and the anchors needed to prevent the radar from blowing away. The equipment module was built by Doric Engineering to AAD design standards. Local expertise was also used in completing signal cable entry points and ventilation fittings so that the building could be commissioned at Davis with a minimum of work on-site.

During planning, it became apparent that we would need more of the summer of 2002-03 to build the radar than was available to us after the heavy resupply in December. With the help of the AAD operations branch, construction materials were pre-positioned at Davis during the previous summer in readiness for the arrival of the Kapitan Khlebnikov and the summer expeditioners.

When the radar team started work at the VHF radar site (or the 'ant farm' as it became known) they surveyed the site so that the antenna positions sat exactly in a north-south aligned square. They dug a hole for the footing, poured a small unreinforced slab of concrete, placed a concrete base block on the slab and nudged it into its correct position. Insulating surrounds designed to limit heat flow into the soil were put in place. They cut a pole to the right length for each block position (so that the antennas were horizontal rather than following the lie of the ground) and bolted a base plate to the base block. With the guy system in place and some attachment points affixed to the pole, they set it to vertical and clamped it to the guy system. Three antenna elements were fixed to the pole at the correct height and spacing, and the cables that connect them to the electronics were put in place and protected by a system of poly pipe and cable tray. Finally, the electrical characteristics of the antennas were tuned to match the requirements of the radar electronics. And each of these tasks was carried out 144 times!

Needless to say, it was a big effort, and the dedication and skill of the scientific, technical and trade staff cannot be understated. In exchange for informal lessons on VHF radars, we experienced the skill and finesse of our plant operators, studied the art of concrete mixing with the carpenters and saw our mains electrical cable come to life.

The cooperative spirit that is so much a part of ANARE was also apparent in the generous support of the station community. The chef drove the concrete truck during the concrete pours, a geophysicist awaiting deployment in the field helped lay the cable support tray and almost everyone hauled and carried the power and communications cables when they were laid. The raising of the VHF radar touched the whole station in one way or another.



Skymap of meteor detections. Note that the detections are weaker when end-on to the antennas.

Reflections and detections

The remote sensing capabilities of a VHF radar make it a useful tool for probing the atmosphere at any location, but the southern polar regions offer even greater opportunities. Other than for a few months on a subantarctic island, there have not been any observations using VHF radars of this kind anywhere in the Antarctic. As a result, Australia is poised to make a significant scientific contribution using the first 'permanent' VHF radar in the region.

This is of particular interest because of a phenomenon called a Polar Mesosphere Summer Echo (PMSE). Unexpectedly strong echoes are returned from near 85 km (the upper mesosphere) at VHF frequencies during the summer in the northern hemisphere. But the southern hemisphere's response has remained a puzzle. Knowledge of the characteristics of PMSE over Antarctica will help to unravel the mysteries of what drives that part of the atmosphere into the frigid conditions that are present during summer.

Observations of the troposphere and lower stratosphere are also possible with a VHF radar, and the Davis system has been making observations of the wind speed from a few hundred metres up to around 10 km every few minutes since it was commissioned. In this region, reflections come from inhomogeneities in the clear air. These reflections are extremely weak and the ability of the VHF radar to use them demonstrates the advanced design of the system.

A last minute add-on allows us to use meteors to further our scientific goals. Thanks to the help of our collaborators at the University of Adelaide, we were able to include a meteor detection system in the first phase of the radar project. We now detect reflections from the trails of a few thousand meteors per day above Davis. Most of these are not visible to the naked eye, but they are intense enough to be observed with a VHF radar and to measure the wind speed in the mesosphere all year round. This enables us to verify some aspects of the 2MHz radar system that we also operate at Davis, and will allow us to measure temperature variations.

The summer of 2003/2004 will be a particularly bright one for the radar. The final major upgrade of the radar, which will see the power of the transmitter increase by a factor of about six, is due for completion early in the summer period. This will make an intensive season of observations of PMSE in the Antarctic possible for the first time ever.

JOHN CADDEN

Davis expeditioners help roll out the power cable for the VHF radar installation.

Acknowledgments

As we have said, many people have contributed to the VHF radar project. The assistance of the station community was acknowledged one sunny afternoon at the radar site as the Davis population enjoyed drinks, snacks and wandered among the antennas searching for the one that had been dedicated to them. But there are a few who should be singled out for particular thanks and they include Paul Saxby, the carpenter who worked with us for the summer and electrician Christopher Heath who gave us power. Thanks also to plant operator 'Squizzy' Taylor, and to Janine Lea, the trades supervisor, who was ever enthusiastic and supportive. Thanks also to the SAS team at Davis including Lloyd Symons, Danny Ratcliffe and Rich Groncki. Back in Kingston, thanks go to Jan Adolph, Brett Gogol and Peter Magill, and the staff at Macquarie 4 Cargo Facility and on Voyage 2, who tolerated the ever-changing schedule and ensured the safe delivery of our equipment. The expertise and assistance of the staff of Atmospheric Radar Systems (ATRAD), the radar supplier, is acknowledged. Finally, thanks to Michael Carr, Jeremy Smith and the winter-summer-winterers of 2002–03.

DAMIAN MURPHY AND RAY MORRIS, SPACE AND ATMOSPHERIC SCIENCES PROGRAM, AAD