THE MOUNT GAMBIER STRATOSPHERIC TROPOSPHERIC RADAR: A NEW VHF RADAR FOR USE IN OPERATIONAL METEOROLOGY[1]

Abstract

A new VHF (44.75 MHz) radar is being used to prototype an operational profiler in a collaboration between the Atmospheric Physics Group at the University of Adelaide, the Australian Bureau of Meteorology, and Atmospheric Radar Systems Pty Ltd. The radar system is capable of operation as a Spaced Antenna Radar, as a Doppler Beam Swinging Radar, and as a hybrid Doppler -- Interferometer. The final operational configuration will be determined after an evaluation phase, in which inter-comparison of the different modes of operation, and comparison with rawindsonde and other observations will be conducted.

Introduction

The application of VHF radar techniques to investigate the atmosphere in a research mode is a mature field. The application to operational meteorology is less mature. The development of operational profilers in the lower VHF band (~50 MHz) is being pursued in France and in Australia. Elsewhere, most effort is being directed at the lower UHF (~400 MHz band). All current operational profilers utilise the Doppler Beam Swinging (DBS) Technique. The lower VHF frequency has advantages in its reduced susceptibility to bird, insect and precipitation echoes, although it does require physically larger antenna arrays. In many situations, the Spaced Antenna (SA) technique utilising the Full Correlation Analysis (FCA) offers advantages. These include the need for only relatively small antenna arrays, and no requirement for beam steering. Like all techniques, however, there are advantages and disadvantages, and it is one of the aims of the present project to determine the relative applicability of the SA and DBS techniques in an operational system.

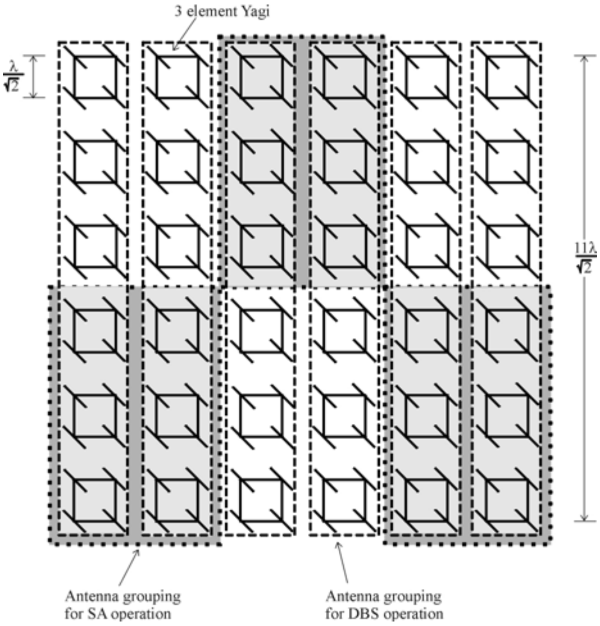

Figure 1a (left). A schematic of the antenna array of the Mt Gambier Profiler. Each diagonal line represents a three-element Yagi antenna. The antenna groupings for both Spaced Antenna and Doppler operation are indicated.

Figure 1b (right), a view through the array looking back at the Observing office.

[1] **Results are on-line at www.physics.adelaide.edu.au/atmospheric/home.html**

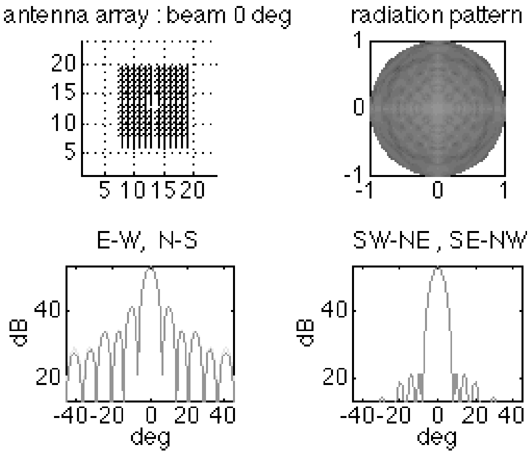

Figure 2 (left). The location of the profiler at Mount Gambier.

Figure 3 (right) The polar diagram of the antenna array for Doppler operation for a vertically directed beam.

Another consideration with radars operating in the VHF band is the effect of the atmospheric aspect sensitivity on the antenna polar diagrams. For the SA technique, this results in a narrowing of the vertically directed beam pattern, and this generally has no effect on the technique. For the DBS technique, with off-vertical beams, the effect is to bias the polar diagrams back towards the zenith. With relatively broad beams (or relatively small antenna arrays; say <4°) the effect can result in severe underestimation of the radial velocities. However, if the mean angle of arrival can be determined, the effect can be corrected for. This suggests a combined Doppler – Interferometer mode of operation, in which hardware beam-steering is applied on transmission to form a relatively narrow transmit beam, and the returned signal is received on multiple sections of the array, so that the receive beam can be formed in software.

This arrangement allows the effective beam direction to be determined, and permits a smaller antenna array to be utilised. This arrangement is used with the large Buckland Park MF Radar, the new ESRAD Radar at ESRANGE, the new Kühlungsborn VHF radar in Germany, and the Mt. Gambier prototype operational profiler described here.

The Radar

The radar is a six receive channel 36 kW solid state system that operates at a maximum 5% duty cycle. The antenna array consists of 144 Yagi antennas grouped in fours, so those 36 basic units are available in the array (Figure 1). The array polar diagram for Doppler operation is shown in Figure 3.

SA FCA Operation

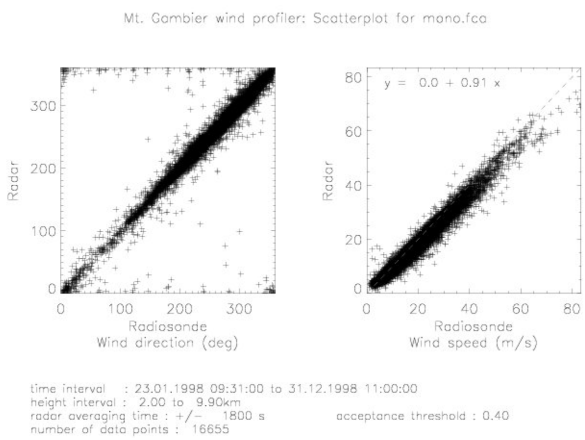

Figure 4 (left). Scatter plot of radiosonde winds compared to the FCA SA winds for approximately one year of observation.

For SA FCA operation, six groups of 24 Yagis (6x4) are available on both transmission and reception. Only three non-collinear groups are needed for SA

FCA operation. Multi-channel FCA or Spatial Correlation Analysis (SCA) operation is also possible, but generally these applications would not offer operational advantages in terms of convincing benefits for the cost of the additional channels involved. Such operation would, however, be cheaper than DBS operation. An operational SA FCA radar would only require three non-collinear subgroups.

DBS Operation

For DBS operation, six East-West rows (or six North-South columns) are used to form beams that can be steered off-zenith in the North-South (or East-West) directions on transmission. On reception, in DBS mode, the effective receive beam is formed in software. The radar is reconfigured under software for either DBS or SA operation under software control.

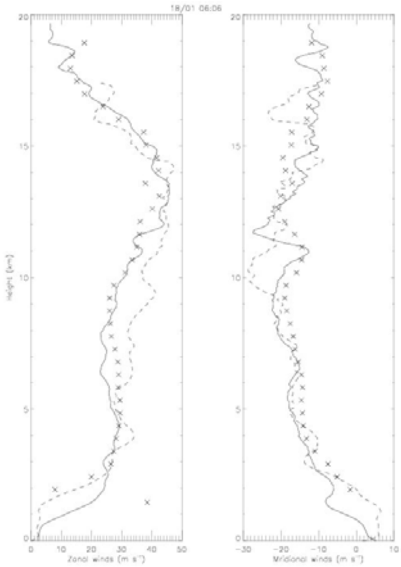

Figure 5 (right). A comparison between radiosonde derived winds and Doppler mode winds foe the radar. Two sonde flights (separated by 6 hours) are indicated

RASS Operation

The radar has a Radio Acoustic Sounding System (RASS) capability. The results of a preliminary trial are shown in

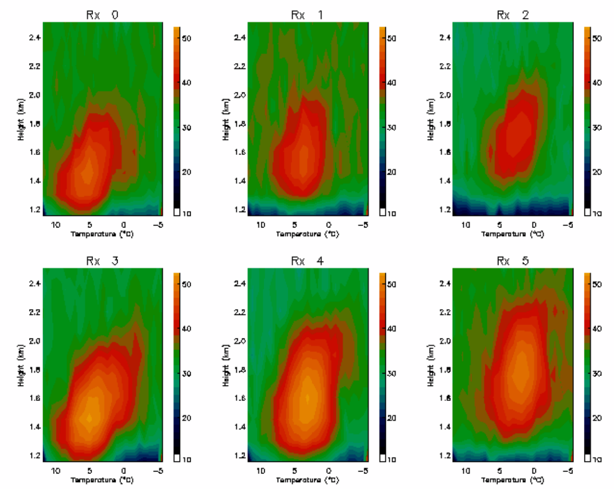

Figure 6. This plot shows the temperature derived for each of the six spaced-antenna sub-sections of the array for a range of heights. For this trial a single acoustic source was utilised. In the final system configuration, two acoustic sources will be added to the system to provide a RASS capability. The radar's ability to rapidly the transmit beam on transmission in hardware, and its ability to steer the beam in software on reception, together with ray-tracing calculations will enable the acoustic wave to be tracked effectively, providing temperatures through the lower troposphere.