COMPARISON OF SPACED ANTENNA AND DOPPLER INTERFEROMETER TECHNIQUES USING THE MT GAMBIER VHF ST PROFILER

D. A. Holdsworth*
Atmospheric radar systems
1/26 Stirling St, Thebarton, SA, 5031.

I. M. Reid
Department of Physics and Mathematical Physics, University of Adelaide,
SA, 5005, Australia

Abstract: A new VHF ST profiler was installed in Mount Gambier (38 S, 141 E), Southern Australia, in October 1997. The profiler employs six receiver channels, allowing operation in spaced antenna (SA) or hybrid Doppler interferometer (HDI) modes. In SA mode, the antenna array is divided into six 4 x 6 subarrays which are connected to each receiving channel, allowing the full correlation analysis (FCA) to be applied to two independent near-equilateral triangles. In HDI mode, the array is divided into six 12 x 2 subarrays, allowing the transmit beam to be steered off-zenith and post-set beam steering to be applied to form beams on reception for the application of a revised Doppler beam steering (DBS) technique. The interferometer arrangement allows the advantage over traditional Doppler radars that the effective beam direction resulting from the aspect sensitivity of the atmosphere can be estimated. The revised DBS technique will be discussed, and comparisons between the wind fields estimated using the SA-FCA and HDI-DBS analyses will be presented.

Introduction

The Mount Gambier ST profiler was designed and manufactured by Atmospheric Radar Systems of Australia. The technical details of the radar are described in the current proceedings by *Reid et al.*, [1998]. The radar can operate in either spaced antenna (SA) or hybrid Doppler interferometer (HDI) modes, and can alternate between these modes on subsequent acquisitions. In HDI mode the beam can be steered on a pulse-to-pulse basis along the $\pm 27^\circ$ azimuth (nominally North-South), and $\pm 117^\circ$ azimuth (nominally East-West). The available zenith angles are $\pm 7^\circ$, $\pm 14^\circ$ and $\pm 21^\circ$. It follows that a 5-beam cycle in the vertical and (nominally) cardinal directions can be completed in two subsequent acquisitions.

The analysis employed in HDI mode is based on the time-domain interferometry technique (TDI) of *Vandepeer and Reid* [1995], rather than the standard Doppler analysis [e.g. *Woodman and Guillen*, 1974]. The relatively wide transmission half-power half-width of the system (3°) results in the effective beam direction (EBD) being biased towards the zenith due to the aspect sensitivity of the atmosphere [e.g. *Röttger*, 1981]. Use of the transmit beam direction rather than the EBD can therefore lead to substantial velocity biases. TDI allows the EBD to be determined, allowing the compensation for the effects of aspect sensitivity.

The TDI technique is implemented as follows. After correction for complex gain differences the post-statistic steering (PSS) technique of *Kudeki and Woodman* [1990] is used to steer the receive beam. The returned power for each recieve beam direction is calculated, and a Gaussian fit is applied about the peak of the power variation to determine the direction of maximum power (DMP). If the power variation of the transmit beam as a function of zenith angle θ is assumed Gaussian

$$P(\theta) = \exp(-(\sin\theta - \sin\theta_t)^2 / \sin^2\theta_b), \tag{1}$$

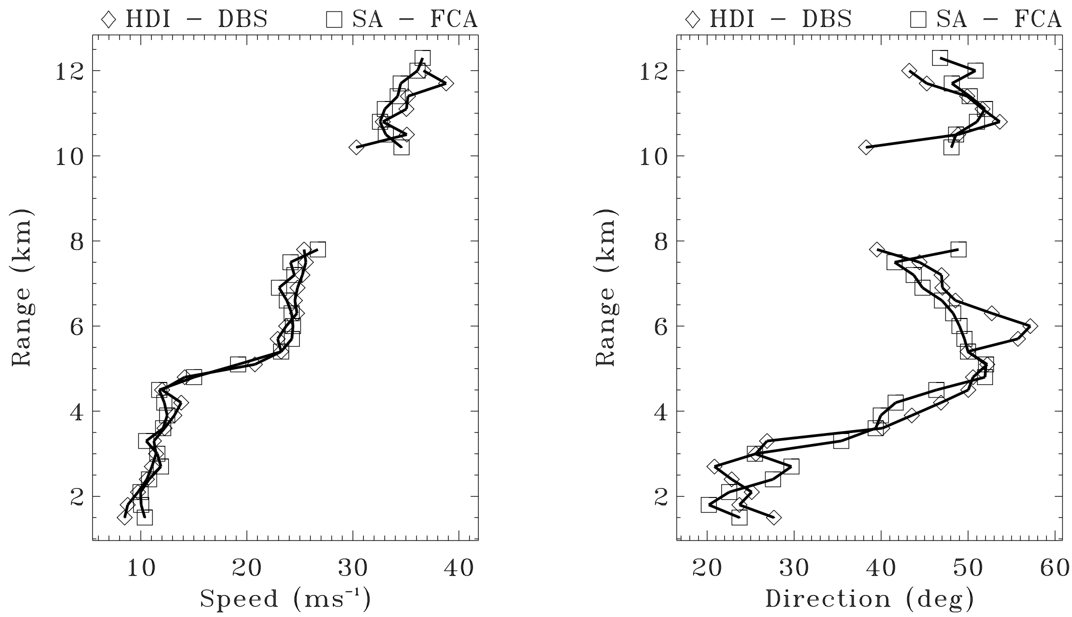

Figure 1: Half hourly velocity magnitudes (left) and directions (right) obtained for HDI-DBS (solid - diamonds) and SA-FCA (dashed squares) between 4:30 and 5:05 UT on May 5, 1998.

where θ_b is the e^{-1} beamwidth and θ_t is the transmit beam zenith, and the returned power due to aspect sensitivity is also assumed Gaussian

$$P(\theta) = \exp(-\sin^2\theta/\sin^2\theta_s), \tag{2}$$

where θ_s is the aspect sensitivity parameter [e.g. *Vandepeer and Reid*, 1995], it is easily shown that the EBD corresponds to the direction of maximum power. Furthermore, the EBD will also correspond to the mean angle of arrival (MAOA) [e.g. *Röttger and Ierkic*, 1985] determined using the phase differences between receiving antennas. The advantage of using PSS rather than MAOA determination to determine the EBD is that the combination of the six receiver time-series employed for PSS increases the SNR by 9 dB, thereby reducing the error statistics and increasing the range extent. The receive beam is then resteered into the EBD, and the radial velocity, spectral width, power and SNR are estimated. The aspect sensitivity parameter, θ_s, is then calculated using (1) and (2) [e.g. *Vandepeer and Reid*, 1995]

$$\theta_s = \arcsin(\sin^2\theta_b/(\sin\theta_t/\sin\theta_e - 1)), \tag{3}$$

where θ_e is the EBD. The TDI analysis can be configured to use either correlation or spectral analyses. The correlation analysis is recommended except in environments where ground clutter, sea scatter or interfering signals are a problem. In this case the spectral analysis is recommended, as the user can configure the experiment to minimise the effects of the non atmospheric returns.

In SA mode the full correlation analysis (FCA) [e.g. *Briggs*, 1984] is applied. The FCA can be applied to two independent, almost equilateral, triangles.

Results

The FCA and HDI analyses are currently implemented as real-time routine analyses. The acquisition sequence involves a 60-second vertical beam SA experiment, followed by a 30

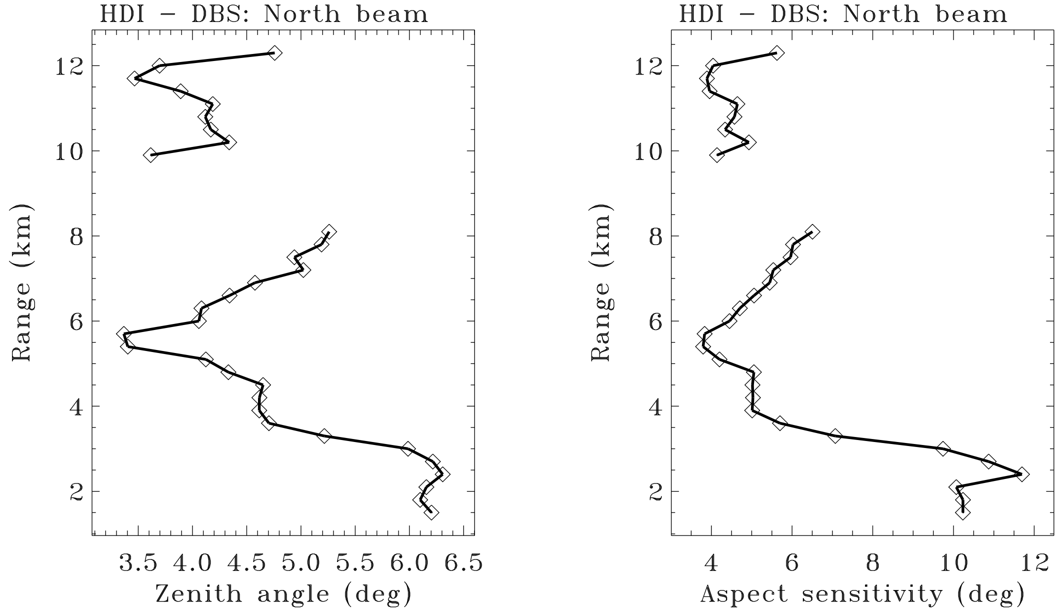

Figure 2: Half hourly HDI effective beam zenith (left) and aspect sensitivity (right) estimates obtained between 4:30 and 5:05 UT on May 5, 1998.

second pulse-to-pulse steered EW 7° HDI experiment, followed by 30 second pulse-to-pulse steered NS 7° HDI experiment. The SA data is also used for vertical beam HDI analysis. This sequence allows SA and HDI estimates to be determined every 2 minutes. A typical example of the SA and HDI velocity profiles obtained over a half hour period are shown in Figure 1. The agreement between the two techniques is very good. The velocity magnitudes and directions agree to within $3ms^{-1}$ and 10°, respectively, at all heights. The effective beam zeniths and aspect sensitivity parameters estimates for the 7° beams are shown in 2. The effective beam zenith is significantly smaller than the transmit beam zenith of 7°, thereby confirming the need to use the TDI analysis.

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