**P4.4** RHI OBSERVATION OF PRECIPITATION WITH BOUNDARY LAYER WIND PROFILER

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**1. INTRODUCTION**

A boundary layer wind profiling radar (BLR) has been recently developed to measure a vertical wind profile in the lower atmosphere. The BLR is a kind of wind profiler and is operated at UHF. Usually, the size of the BLR is smaller than that of VHF wind profilers and enables to transport for field experiments.

One of problems of operational wind profilers is the reliability depreciation of horizontal wind measurement in convective precipitation. The operational wind profiler radar employs the Doppler Beam Swinging (DBS) method on the assumption that the atmosphere has horizontal uniformity. However this assumption is not satisfied in some conditions, particularly in severe storms.

The Spaced Antenna (SA) technique is one of the useful alternatives to the DBS wind profiling technique. Removing the need to cycle of beam pointing directions, Spaced Antenna Drift (SAD) or Full Correlation analysis method make it possible to estimate wind within one vertical beam, relaxing the assumption of horizontal uniformity. This technique has been used for the VHF radars and recently for the UHF boundary wind profiler at NCAR (Cohn et al., 1997). The Post Beam Steering (PBS) is also a kind of the SA technique. This technique enables radar to scan the atmosphere. Since a high powered wide-beam transmitting, a lot of receiving antennas and usually a multi-receiver system are necessary for the PBS, the system is huge and expensive. So this technique is applied only to the VHF radars (Helal et al., 2000). Therefore, another technique is needed for the transportable BLR to scan the atmosphere.

The Sequential Beam Steering (SBS) is easy for the BLR to actualize. We applied the SBS to the MRI-BLR for scanning the atmosphere. This angler scanning by narrow beam is identical to the Range Height Indicator (RHI) observation with the Doppler radar.

**2. PRINCIPLE OF THE RHI OBSERVATION**

The MRI boundary wind profiling radar equips with an active phased array antenna. The system has one receiver but has 24 small transmitters that are connected to each antenna element, which enable the system to steer the beam. Radar characteristics for the BLR are summarized in Table 1.

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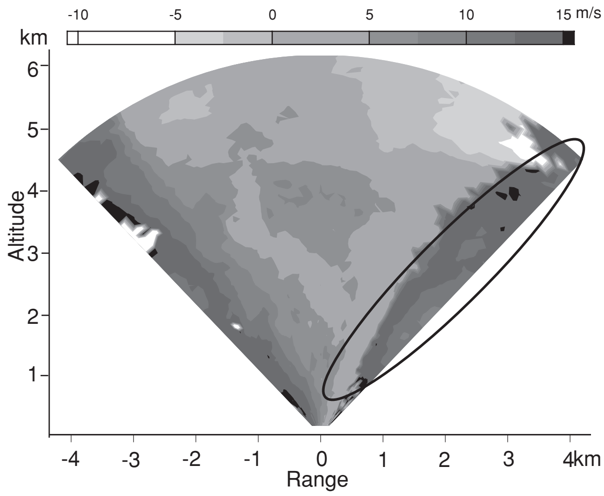


Figure1: An RHI of radial velocity on 6 Sept 2000 0836Z. An ellipse indicates the area of contamination by a grating lobe.

**3. OVERVIEW OF THE CASE STUDY**

In the afternoon on 6 September 2000, a low on a front has moved towards north part of Japan and passed over the Kanto plain where the BLR located. Convective precipitation with lighting was observed from 0810 UTC at the BLR site. The surface rain gauge at the site recorded 11.5 mm / 10 min just after 0839 UTC. We made the SBS observation from 0812 UTC.

Figure 1 shows the vertical cross-section of the radial velocity in the event obtained by the RHI scan mode at 0836 UTC. This figure shows the distribution of radial velocity has a consistency in the elevations higher than 60 degrees. Note the distinct discontinuous data exist in the ellipse in this figure. This data is arose from a grating lobe, which is one of disadvantage points of phased array antenna system and is evident especially in low elevation observation. In our system, the threshold elevation angle is about 60 degrees and the elevation under this threshold depreciates data reliability. We developed a new technique to retrieve the radial velocity in the low elevations.

## 4. ANALYSISY PROCEDURES

The phased array antenna forms a main beam by synthesizing multiple beams from antenna elements. On the case that the main beam elevation angle is low, a grating lobe, which is a pseudo synthesized beam, is formed on the opposite side of the main beam across the zenith. For instance, a grating lobe is formed toward 135° elevation when the main beam is toward 45° elevation on our system. The power of the grating lobe is weaker than that of the main beam. The returned power parallel to the grating lobe is, however, comparable or sometimes greater than that of main beam if heavy precipitation exists in the direction of the grating lobe. In that case, the return signal from the grating lobe contaminates the signal from main beam. In fact, the data in the ellipse of figure 1 is the copy from the left side. Therefore, a new algorithm to retrieve correct data from spectrum is needed.

The idea of the algorithm is as follows.
Although the echo power is not always continuous, the Doppler velocity changes continuously in the atmosphere. Since the directions of the main beam and the grating lobe are disparate, radial velocities from both beams are quite different. Therefore, each spectral peak from both beams can be identified in the Doppler velocity spectrum. So, if one of peaks is quite different from the peaks in high elevation, where no grating lobe is generated, this peak is judged to be the peak from a grating lobe.

The consistency check algorithm based on the idea is,
(1) Estimate the radial velocity by moment method.
(2) Check the consistency of the radial velocity in tangential direction by setting a velocity difference threshold that is proportion to cosign of elevation angle.
(3) If the estimated radial velocity dose not satisfy the consistency condition, the spectral data on the peak above the noise level are set the noise level. After this process, momentum calculation is done again (Fig. 2).

Figure 3 shows the RHI observation of retrieved radial velocity after the consistency check algorithm. This figure also indicates the fact that the distribution of the radial velocities in this event is far from symmetric which is essential for the reliable DBS observation.

**Table 1. MRI-BLR characteristics**

| | |
|---|---|
| Transmitter frequency | 1357.5 MHz |
| Peak Power | 2000 W |
| Pulse width selectable; | 0.67 μs to 2.0 μs (0.67 μs typ.) |
| Duty max | 21.3 % |
| Antenna type | low cost coaxial dipole. |
| Aperture | 16 $m^2$ |
| Direction | ± 90 degree from zenith in four orthogonal directions. |
| Gain | 33 dBi |
| Beam width | < 4° |

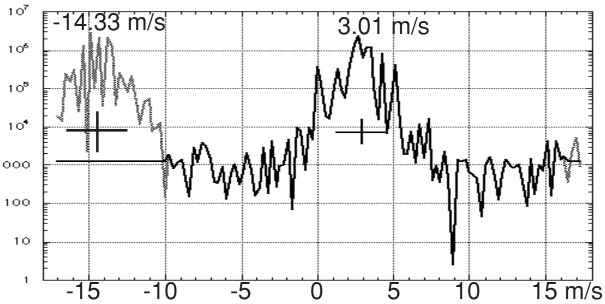


Figure2: A sample of the Doppler velocity spectrum at low elevation (45 degrees). The quality check judges that the left peak is that from a grating lobe. All the signals from the left peak to noise level (gray line) are set to be noise level, and then moment calculation is done again. The numbers over peaks are estimated radial velocities.

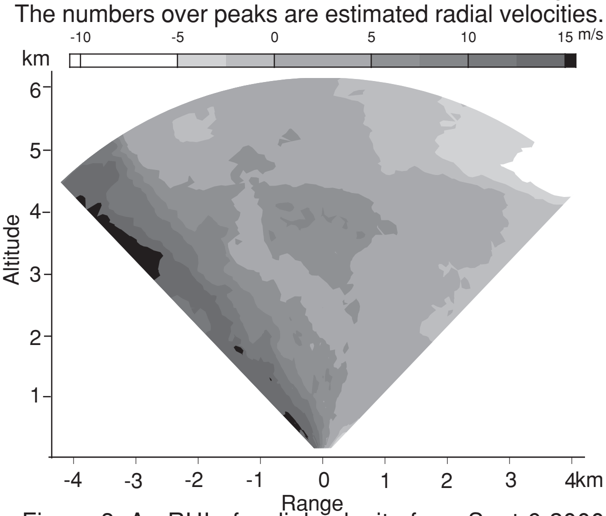


Figure 3: An RHI of radial velocity from Sept 6 2000 0836Z after the quality check. Note that the data at low elevation is retrieved.

## 5. CONCLUSION

The SBS applied to the MRI-BLR provides the RHI of a precipitation field. The SBS is proved to be useful even in an inhomogeneous atmosphere, which disable the DBS wind profilers to reliable observation. Moreover, it appears that the consistency check algorithm of the Doppler velocity may be able to separate the return signal of the main beam from that of the grating lobe and consequently extend reliable elevation angle range.

## 6. REFERENCES


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