9B.4 EXPERIMENTAL STUDIES OF THE CORRECTIONS APPLIED TO THE OBSERVED SPECTRAL WIDTH FOR TURBULENCE STUDIES

G.D. Nastrom[1*], T.E. VanZandt[2], W.L. Clark[2], T. Tsuda[3], and J.-I. Furumoto[3]
[1]St. Cloud State University, St. Cloud, Minnesota
[2]Aeronomy Laboratory, NOAA, Boulder, Colorado
[3]RASC, Kyoto University, Kyoto, Japan

1. INTRODUCTION

Clear-air wind profiler Doppler radars offer the capability to estimate the intensity of small-scale turbulent kinetic energy per unit mass (TKE) over a broad range of altitudes in the troposphere and lower stratosphere from the width of the observed Doppler spectrum. The TKE is related to the eddy dissipation rate and the eddy diffusivity. However, the observed spectral widths contain contributions related to the interaction of the radar beam with the large-scale wind which must be removed. These corrections are usually significant, sometimes being larger than the turbulence contribution to the observed spectral width. Much of the theory used to estimate the corrections was developed decades ago. An experiment to test the corrections applied to the spectral width was conducted at the highly versatile MU radar in Japan. Essentially simultaneous observations were made using two different beamwidths and two different zenith angles with oblique beams directed at the four cardinal compass points during a two-day period of relatively strong winds (peak winds over 50 ms^{-1}). Theoretical predictions of changes in spectral width with respect to wind speed, azimuth, and altitude are compared with the observations.

2. ANALYSIS

For example, the theory predicts anisotropy between the spectral widths observed on the zonal (U) and meridional (V) beams. The observed spectral widths (σ_U^2 and σ_V^2) are the sums of the atmospheric turbulence and the effects of beam-, shear-, and wave-broadening. As discussed by VanZandt et al. (2002), σ_U^2 and σ_V^2 are given by Eqs. (1) and (2), respectively, where θ is the beamwidth, α is the zenith angle, u_z=dU/dz, v_z=dV/dz, and R is the range of the sample volume. The difference, σ_U^2 - σ_V^2, is given by Eq. (3).

Because U >V and |u_z|~|v_z| for conditions typically found at MU in the upper troposphere and lower stratosphere, Eq. (3) predicts σ_V^2 > σ_U^2 (the final term on the right side is usually negligible). Nastrom and Tsuda (2001) found that σ_V^2 > σ_U^2 at MU and at White Sands, New Mexico, and that the magnitude of the anisotropy was proportional to the magnitude of U for fixed V. Quantitative comparisons of these predictions with observations will be given and comparison with the recent results of Chu (2002) will be discussed

*Corresponding author address: G.D. Nastrom, St. Cloud State University, St. Cloud, MN 56301-4498; email: gdnastrom@stcloudstate.edu.

3. References

Chu, Y.-H., 2002: Beam broadening effect on oblique MST radar Doppler spectrum. J. Atmos. Oceanic Technol., 19, 1955-1967.

Nastrom, G.D., and T. Tsuda, 2001: Anisotropy of Doppler spectral parameters in the VHF radar observations at MU and White Sands, Ann. Geophys., 19, 883-888.

VanZandt , T.E., G.D. Nastrom, J. Furumoto, T. Tsuda, and W.L.Clark, 2002: A Dual-Beamwidth Method for observing atmospheric turbulence intensity with radar, Geophys. Res. Lettr., 29(12), 10.1029/2001GL014283.

$$\sigma_U^2 = \sigma_{turb}^2 + \frac{\theta^2}{3}\left[U^2\cos^2\alpha + V^2 - 2U\cos\alpha\sin^2\alpha u_z R + \sin^4\alpha\left(u_z R\right)^2\right] + \sigma_{wave}^2 \quad (1)$$

$$\sigma_V^2 = \sigma_{turb}^2 + \frac{\theta^2}{3}\left[V^2\cos^2\alpha + U^2 - 2V\cos\alpha\sin^2\alpha v_z R + \sin^4\alpha\left(v_z R\right)^2\right] + \sigma_{wave}^2 \quad (2)$$

$$\sigma_V^2 - \sigma_U^2 = \frac{\theta^2\sin^2\alpha}{3}\left[U^2 - V^2 + 2R\cos\alpha\left(Uu_z - Vv_z\right) - \sin^2\alpha R^2\left(u_z^2 - v_z^2\right)\right] \quad (3)$$