Characteristics of scattering layers in the troposphere revealed by simultaneous observations with a Raman/Mie lidar and the MU radar

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INTRODUCTION

Atmospheric turbulence causes diffusion of substances which induce the climate change such as greenhouse effect. However, observations to reveal relationships between atmospheric turbulence and humidity or clouds are very limited. Both an MST (Mesosphere, Stratosphere, Troposphere) radar and a Raman/Mie lidar are remote sensing techniques for measuring atmospheric properties with high altitude and time resolutions. An MST radar observes atmospheric turbulence and wind velocity. A Raman/Mie lidar measures humidity, temperature and backscattering ratio. The MU radar has a capability of FII (Frequency domain Interferometric Imaging) observation that can investigate fine-scale turbulence structure with a height resolution smaller than 30[m]. A new data acquisition system was installed in the lidar system in Shigaraki MU observatory to improve the height resolution as small as 9[m]. We have carried out simultaneous observations with the Raman/Mie lidar and the MU radar to investigate relationships between atmospheric turbulence and humidity.

EXPERIMENTAL SETUP AND DATA PROCESSING

The MU radar was operated on 5 frequencies and the power distribution in each 150[m] range gate was estimated by applying the filter-bank Capon method. The antenna beam was pointed toward zenith and one or 4 oblique direction at 10 degrees. For lidar observation, analogue detection mode has been used to observe Mie-scattered signals even below 2.5[km] altitude.

RESULTS

Fine-structure of turbulence and humidity was examined by the lidar with a resolution of 50[m] and 30[sec] below 4.0[km] due to higher resolutions by enough signal-to-noise ratio. The thin layered structures observed by the MU radar were compared with the parameters derived from the lidar and we found that the peaks of height derivative of backscattering ratio (|dBS/dz|) or humidity (|dqdz|) corresponded well with the peak of radar signal intensity . The height differences between the maxima of radar echo power and the peaks of |dBS/dz| or |dq/dz| were within 30[m] (Fig 1), and the agreement lasted for more than 270 minutes (Fig 2). This correspondence was also observed even where isotropic turbulence echoes were dominant. Results in this study suggest that intense·radar echo layers are mainly produced by large gradients of refractive index in this height range. The remarkable relationship between radar echo power and |dBS/dz| indicates development into the new sensing technique.

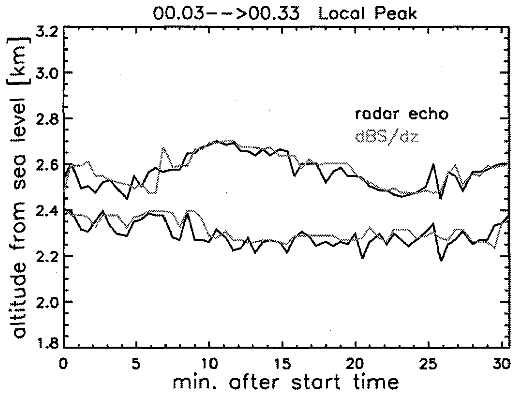

Figure 1. The relations between the positions of the maxima of radar echo power (black lines) and the peaks of |dBS/dz| (orange lines) between 0:03 to 0:33 on November 15, 2005.

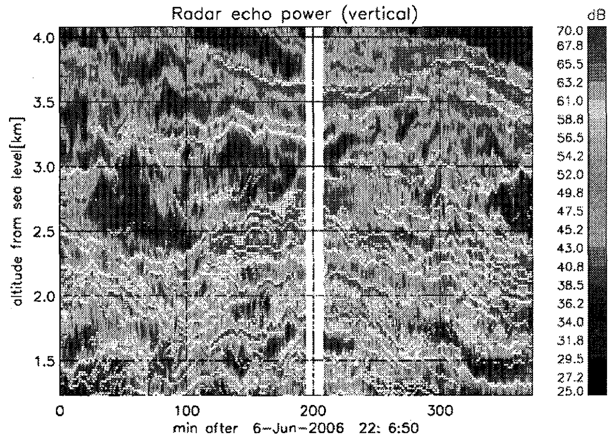

Figure 2. Time-height variations of the radar echo power between 22:06 on June 6 to 4:14 on June 7, 2006. The time resolution is 42 seconds. White dots indicate the positions of the peaks of |dBS/dz|.