Frequency domain interferometric imaging to monitor detailed temperature profiles with the MU radar-RASS measurement

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INTRODUCTION

Atmospheric temperature, which is closely related with atmospheric buoyancy, is one of the most important parameters to characterize atmospheric behavior. Although the tropospheric temperature generally decreases with height, the detailed temperature variation plays an important role in the generation of various meteorological phenomena. Development of the temperature measurement technique with good height and temporal resolutions are very important for unveiling the thermodynamics of the meteorological phenomena. This study was devoted to improve height resolution of Radio Acoustic Sounding System (RASS), which is a radar remote-sensing technique to monitor temperature profiles by detecting the Bragg scattering from the acoustic wavefronts. In this study, a Frequency domain Interferometric Imaging (FII) technique, which is an adaptive technique for multiplied operational frequency array, was applied to RASS with Middle and Upper atmosphere (MU) radar (MU radar-RASS), aiming to improve the height resolution from 150 m to 50 m.

APPLICATION OF FII TECHNIQUE TO RASS ECHO

The FM-chirped acoustic pulse is employed to satisfy the Bragg condition in the wide height range for the RASS observation. The RASS echo is effectively scattered in the region of where the Bragg condition is satisfied. Since the effective scattering region of RASS echo propagates upward with time, we can improve the height resolution by extracting the FII results to an adequate period. Note, however, that the Doppler velocity of RASS echo is biased due to the effects of the radar range gate shape and the temperature profile. The effect was compensated using the model of the range gate function and temperature profiles with a constant lapse ratio. The simulation study to apply FII to RASS echo revealed that the inversion layer is successfully reproduced in the FII results. The discrepancy between the model and retrieved temperature is smaller than 0.2 K. For the MU radar-RASS imaging observation, the expected range resolution and the precision of range selectivity are estimated as about 50 m and less than 1 m, respectively.

THE MU RADAR-RASS OBSERVATION USING IMAGING TECHNIQUES

The MU radar-RASS imaging observation campaign was conducted on October 29-31, 2006. Continuous detailed time-height variations of temperature within the radar range gate were retrieved from the MU radar-RASS imaging data.

Left panel of Figure 1 shows the temperature profile between 0853 LT and 0919 LT on October 29, 2006. The horizontal dashed line shows the reference of the conventional height resolution of 150 m. The FII result shows the clear inversion structure with the minimum temperature at 1.85 km and the positive lapse ratio at 1.85-1.90 km. The structure agrees very well with the simultaneous radiosonde result (dot-dash line). The result at 18 LT on October 30, 2006 is shown in the right panel, showing the increase of temperature at 1.95-2.05 km and the decrease at 2.3-2.35 km. Temperature variation within the radar range gate agrees very well with the simultaneous radiosonde results.

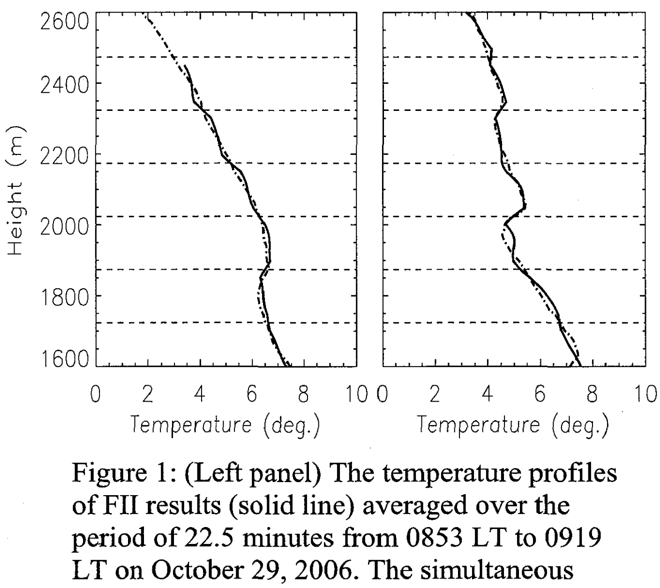

Figure 1: (Left panel) The temperature profiles of FII results (solid line) averaged over the period of 22.5 minutes from 0853 LT to 0919 LT on October 29, 2006. The simultaneous radiosonde result is also plotted in dot-dash line. The dash lines show the conventional range resolution of 150 m. Right panel is the same as left one except the results at 18 LT on October 30, 2006.