R005-P10
ポスター 3 ：11/25　PM1/PM2 （13:15-18:15）

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High resolution wind observations based on network MF radar meteor echo measurements

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We have recently redeveloped MF radar meteor wind measurements technique by Tsutsumi and Aso [2005], and have significantly improved its time/spatial resolutions by using the MF system at Syowa Station (69S, 39E), Antarctic. Because the duration of meteor echoes is proportional to the square of the radio wavelength, the duration for MF (2-3 MHz) meteor echoes is more than 100 times longer than that of usual VHF (~30 MHz) meteor echoes, indicating that the actual observation time of MF radar meteor measurement is significantly longer and that a more continuous and dense measurement is possible under a geomagnetically quiet condition where MF radio wave can travel without significant absorption or retardation. The redeveloped technique shows that horizontal wind velocities can be estimated with a highly improved time resolution of about 10 minutes in the height region of 80-115 km, and can even be resolved horizontally every 50 km or so within the 10 minutes at around 90 km, the centroid height of meteor echo distribution. Such resolutions are unprecedentedly high as meteor wind measurements [Tsutsumi et al., JPGU 2023].

This technique is being applied to MF radars at the northern hemisphere, Saura (69N, 16E) and Juliusruh (54N, 13E), routinely operated by Leibniz Institute of Atmospheric Physics. These radars are well equipped with an interferometer capability with 9 and 6 receiver channels, respectively. We have found that existing archived data of these radar systems can be applicable to the meteor echo analyses as those we have done with the Syowa system.

However, one radar measurement can provide only radial wind component, not the tangential component. This means that the vorticity is hard to estimate with one radar system, hindering further statistical analyses of the wind field.

To overcome this limitation we are now trying to conduct common volume meteor measurements using two MF radar systems in the northern high latitude, that is, the Saura system mentioned above and the Tromsoe system (70N, 19E) operated by Arctic University of Norway. Because the Tromsoe system has currently only limited number of receiving antennas and channels, we are planning to add a digital receiver and antenna system to enable all-sky interferometer capability. The Saura and Tromsoe systems are ideally separated to share a common illuminating volume, and are expected to resolve fine time and spatial structures of wind fields, even with much better resolutions than those of recent VHF meteor radar based network measurements.

References

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