Ten years of the meteor radar observations in Lapland

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In the Sodankyla Geophysical Observatory (SGO, 67° 22' N, 26° 38' E, Finland) the all-sky interferometric meteor radar (SKiYMET) is continuously operating since December 2008. The radar is designed for detecting ionized meteor trails at heights 80 -100 km. For the detected trails, their position, Doppler velocity of the scatter from these trails, and the decay time of the scatter from the trails are determined. Then, the Doppler velocity is used to estimate the atmospheric winds at these heights, while the height distribution of decay time is used to estimate the mesospheric temperature. Although the SKiYMET radar was primarily designed for atmospheric (mesospheric) research, a number of interesting phenomena related to meteor streams (showers) and specific properties of meteoroids were revealed in the meteor radar data.

First, meteoroids of some showers produce ionization trails at altitudes noticeably exceeding those of sporadic meteors. Namely, the main northern hemisphere meteor showers (such as the Quadrantids, Lyrids, Eta Aquariids, Arietids, Perseids, Orionids, Leonids, and Geminids) are identified in the height distributions of meteor trails. This may be due to higher speed and probably lighter or less dense meteoroids belonging to the showers. Alternatively, it may be due to the fragmentation of large meteoroids, which occurs at higher altitudes and results in non-specular long-lasting radar echoes.

Second, the mesospheric temperature derived from meteor decay times appears systematically underestimated by 20 – 50 K during the Geminids meteor shower which has peak on 13 December. These observations are for a specific height - decay time distribution of the Geminids meteor trails, which indicate a larger percentage of overdense trails compared to that for sporadic meteors and, hence unusual properties (mass or chemical composition) of the Geminids meteoroids. Similar properties were found also for Quadrantids, but not for other meteor showers.

Additionally, our investigations have revealed a number of unexpected phenomena and effects which may affect meteor radar output data due to imperfect algorithms of the identification of meteor trails. Such effects are: signatures of fast temporal/spatial variations of auroral precipitation, detection of ionospheric irregularities associated with enhanced electric field, effects of dust and aerosols, and the perturbations caused by a rocket explosion in the ionosphere. These effects are to be taken into account to diminish their influence on the meteor count, neutral wind, and temperature data, which is of particular importance at high (auroral) latitudes. On the other hand, this experience shows capability of the meteor radar for monitoring ionospheric irregularities, aerosol (dust) particles, and related phenomena like polar mesosphere summer echo (PMSE) and rocket launches.