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Occurrence and altitude of the non-specular long-lived meteor trails during meteor showers at high latitudes

Alexander Kozlovsky¹, Renata Lukianova², and Mark Lester³

¹University of Oulu, Sodankylä Geophysical Observatory, Sodankylä, Finland (alexander.kozlovsky@oulu.fi)

²Space Research Institute, Moscow, Russia

³Department of Physics and Astronomy, University of Leicester, Leicester, UK

Meteoroids entering the Earth's atmosphere produce ionized trails, which are detectable by radio sounding. Majority of such radar detections are the echoes from cylindrical ionized trails, which occur if the radar beam is perpendicular to the trail, i.e., the reflection is specular. Typically such echoes detected by VHF radars last less than one second. However, sometimes meteor radars (MR) observe unusually long-lived meteor echoes and these echoes are non-specular (LLNS echoes). The LLNS echoes last up to several tens of seconds and show highly variable amplitude of the radar return. The LLNS echoes are received from the non-field-aligned irregularities of ionization generated along trails of bright meteors and it is believed that key role in their generation belongs to the aerosol particles arising due to fragmentation and burning of large meteoroids. The occurrence and height distributions of LLNS are studied using MR observations at Sodankylä Geophysical Observatory (SGO, 67° 22' N, 26° 38' E, Finland) during 2008-2019. Two parameters are analyzed: the percentage and height distribution of LLNS echoes. These LLNS echoes constitute about 2% of all MR detections. However during certain meteor showers (Geminids, Perseids, Quadrantids, Arietids or/and Daytime ζ -Perseids, and Lyrids) the percentage of LLNS echoes is noticeably higher (about 6, 5, 4, 4, and 3%, respectively). Typically, the LLNSs occur ~2 km higher than other echoes (in June-July the height difference is reduced to ~1 km). Due to this elevation, a larger percentage of LLNSs is manifested as an upward shift of the height distribution of meteor trails during meteor showers. Moreover, during Lyrids, η -Aquariids, Perseids, Orionids, and Leonids the LLNS echoes occur noticeably, up to 3-6 km, higher than the echoes from other types of trails. Thus, enhanced heights of meteor detections during major meteor showers (Quadrantids, Lyrids, η -Aquariids, Arietids or/and Daytime ζ -Perseids, Perseids, Orionids, Leonids, and Geminids) are predominantly due to long-lived non-specular echoes from the non-field-aligned irregularities associated with large meteoroids.