Large-scale dune aurora event investigation combining Citizen Scientists' photographs and spacecraft observations

Maxime Grandin¹, Minna Palmroth¹,², Graeme Whipps³, Milla Kalliokoski¹, Mark Ferrier³, Larry J. Paxton⁴, Martin G. Mlynczak⁵, Jukka Hilska⁶, Knut Holmseth⁷, Kjetil Vinorum⁷, and Barry Whenman³

¹University of Helsinki, Department of Physics, Helsingin Yliopisto, Finland (maxime.grandin@helsinki.fi)
²Space and Earth Observation Centre, Finnish Meteorological Institute, Helsinki, Finland
³Citizen Scientist, Scotland
⁴The Johns Hopkins University Applied Physics Laboratory, Laurel, MD, USA
⁵Atmospheric Sciences Division, NASA Langley Research Center, Hampton, VA, USA
⁶Citizen Scientist, Finland
⁷Citizen Scientist, Norway

Recently, citizen scientist photographs led to the discovery of a new auroral form called "the dune aurora" which exhibits parallel stripes of brighter emission in the green diffuse aurora at about 100 km altitude. This discovery raised several questions, such as (i) whether the dunes are associated with particle precipitation, (ii) whether their structure arises from spatial inhomogeneities in the precipitating fluxes or in the underlying neutral atmosphere, and (iii) whether they are the auroral manifestation of an atmospheric wave called a mesospheric bore. This study investigates a large-scale dune aurora event on 20 January 2016 above Northern Europe. The dunes were observed from Finland to Scotland, spanning over 1500 km for at least four hours. Spacecraft observations confirm that the dunes are associated with electron precipitation and reveal the presence of a temperature inversion layer below the mesopause during the event, creating suitable conditions for mesospheric bore formation. The analysis of a time lapse of pictures by a citizen scientist from Scotland leads to the estimate that, during this event, the dunes propagate toward the west-southwest direction at about 200 m/s, presumably indicating strong horizontal winds near the mesopause. These results show that citizen science and dune aurora studies can fill observational gaps and be powerful tools to investigate the least-known region of near-Earth space at altitudes near 100 km.