Experimental Evidence for Dusty Plasmas in the Polar Summer Mesosphere during DROPPS

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The Distribution and Role of Particles in the Polar Summer Mesosphere (DROPPS) was a highly coordinated international study conducted in July 1999. It involved two sequences of rockets launched from the Norwegian rocket range in Andøya, Norway [1, 2]. These studies were designed to investigate the properties of the polar summer mesosphere, particularly relating to polar mesospheric summer echoes (PMSE) and their possible relationship to dust particles (aerosol and dust layers) and to noctilucent clouds (NLC). Each of two rocket sequences included a DROPPS NASA-Black Brant payload, consisting of an array of instruments to measure the electrodynamic and optical structure of the mesosphere and lower thermosphere, i.e., the existence of dusty plasmas. The DROPPS payloads were each accompanied by several European payloads (MIDAS, Mini-MIDAS, and Mini-DUSTY) designed to study electrodynamic structure of the same region, and by meteorological rockets to provide wind and temperature data in the critical region of study. ALOMAR Lidar and the ALWIN MST Radar were used to continuously monitor the mesosphere for NLCs and PMSEs. EISCAT VHF radar provided information about PMSEs downstream from the launch site. Rocket sequence 1 was launched during the night of 5-6 July 1999 into a strong PMSE display with a weak NLC located at the base of the PMSE. Sequence 2 was launched on the early morning of 14 July into a strong NLC, but surprisingly with no PMSE evident. Of note during sequence 1 was the observed presence of negatively charged particles or aerosols within the PMSE region, which also contained an electron "biteout" that could be indicative of scavenging. Evidence for this dusty plasma was observed independently by several instruments aboard the DROPPS 1 payload. The PMSE layer during sequence 1 also contained electrodynamic turbulence or irregularities, which was less evident within the observed NLCs on either night. Spectral plots of the a.c. electric field during the first flight show higher frequencies generated within the NLC region than in the PMSE region, although the particle size within the NLC was significantly larger. Meteorological data from the MET payloads show a wind shear which could have generated neutral turbulence within the PMSE on the first night, but which was absent on the second. Finally, the electron density during sequence 2 was lower by a factor of 4 in the region of interest (80-90 km) than during sequence 1, which could help explain the absence of PMSE observations during the second sequence. A detailed description of the DROPPS Program can be found in [1, 2]. Implications regarding the role of dusty plasmas on the origin of PMSEs and their relationship to NLCs are discussed.

[1] R. Goldberg, R. Pfaff, R. Holzworth, F. Schmidlin, H. Voss, A. Tuzzolino, C. Croskey, J. Mitchell, M. Friedrich, D. Murtagh, G. Witt, J. Gumbel, U. von Zahn, W. Singer, and U. Hoppe, "DROPPS: A study of the Polar summer mesosphere with rocket, radar, and lidar," *Geophys. Res. Lett.*, vol. 28, pp. 1407-1410, April 15, 2001.
[2] R. Goldberg, R. Pfaff, R. Holzworth, F. Schmidlin, H. Voss, A. Tuzzolino, C. Croskey, J. Mitchell, M. Friedrich, D. Murtagh, G. Witt, J. Gumbel, U. von Zahn, W. Singer, and U. Hoppe, "The DROPPS program to study the Polar summer mesosphere," *Adv. Space Res.*, vol. 7, pp. 1037-1046, 2001.