Investigation of plasma irregularity sources associated with charged dust in the earth's mesosphere

W. A. Scales[1] G. Ganguli[2]

[1] *Bradley Department of Electrical and Computer Engineering, Virginia Polytechnic Institute and State University, U.S.A., wscales@vt.edu*

[2] *Plasma Physics Division, Naval Research Laboratory, U.S.A.*

Noctilucent clouds NLCs and polar mesospheric summer echoes PMSEs are two phenomenon at the forefront of near earth space science. NLCs are high altitude clouds in the earth's mesosphere that are formed from dust/aerosol particles. The increase in the occurence of NLCs over time is believed to have profound implications for global climate change. PMSEs are believed to be related to NLCs and are strong radar echoes from mesospheric turbulence in the 50 MHz to 1.3 GHz range. Since PMSEs most likely provide a powerful remote sensing tool for the structure and dynamics of NLCs and therefore the earth's middle atmosphere, the understanding of PMSEs and their relationship to NLCs have become a vigorous area of research investigation. Currently, there is no universally accepted explanation for PMSEs. Recent simultaneous sounding rocket, radar, and lidar observations of NLCs and PMSEs [1,2] have provided the most detailed description of the electrodynamics and plasma configuration inside NLCs and the relationship to PMSEs to date. Particularly important is the simultaneous observation of charged dust, electron depletions, and small-scale electric field irregularities in the PMSE generation region.

This work considers the consequences of the recent experimental observations on ultimately understanding the source region and generation mechanism for PMSEs and the relationship to NLCs. It will be shown that the recent observations strongly support the hypothesis that the boundary layer of the NLC is a prime candidate for the source region for PMSEs. Therefore, the NLC boundary layer is investigated for sources of plasma irregularities that may result in PMSEs. Theoretical and numerical models for the electrodynamic equilibrium structure of NLC boundary layers are used for this investigation. The models consider a three species magnetized collisional plasma which includes electrons, ions and negatively charged dust. The ambient plasma is taken to be made up of electrons and ions and to be separated from the NLC region, which contains charged dust as well, by a thin boundary region. Inside the NLC boundary layer, there is a reduction in eletron density commonly refered to as an electron 'bite-out'. The results indicate that D.C. electric fields are expected to exist in the equilibrium boundary layer which may be consistent with several past experimental observations. The magnitude of this electric field is investigated for various parameters including the depth and steepness of the electron 'bite-out'. The resulting plasma flows in the boundary layer are then considered. The role of these flows in producing electron turbulence and irregularities in the NLC boundary layer that may ultimately result in PMSEs will be described. Finally, preliminary results of plasma instability analysis will be presented which show production of irregularities resulting from these plasma flows. Characteristics of these irregularities are compared to those of recent experimental observations.

References

[1] Goldberg, R.A. et al., DROPPS: A study of the polar summer mesosphere with rocket, radar and lidar, *Geophys. Res. Lett.*, **28**, 1407–1410 (2001).

[2] Havnes, O., A. Brattli, T. Aslaksen, W. Singer, R. Latteck, T. Blix, E. Thrane, and J. Troim, First common volume observations of layered plasma structures and polar mesospheric summer echoes by rocket and radar, *Geophys. Res. Lett.*, **28**, 1419–1422 (2001).