Recent Advances in Exploring Ionospheric Dusty Plasmas Using Ground-based High Power High Frequency (HF) Radiowave Heating

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It has long been recognized that the earth's middle atmosphere contains a dusty plasma, particularly in the mesospause region (near 85 km altitude), which ultimately results from meteor ablation. The physics of this region is quite different from a conventional laboratory dusty plasma due to the high neutral density and processes associated with the intimate collisional coupling of the neutral gas, which is often turbulent, with the dusty plasma. For instance, understanding the more complicated diffusion process in such a plasma, has been central to interpreting one of the most important phenomenological signatures of this dusty plasma, Polar Mesospheric Winter Echoes and Polar Mesospheric Summer Echoes (PMSE and PMWE) in the several MHz to near 1 GHz range. Due to the smallness of the dust particle size in the source region of these radar echoes (nm or possibly smaller), the dust particles only acquire a few charges, positive or negative, and the fundamental charging process is still not well understood. Recent advances in active space experiments have enabled some potentially powerful diagnostics for exploring dusty plasmas in the middle atmosphere. The emphasis in this presentation will be on active experiments that utilize high power high frequency (HF) ground-based radiowave heating of the radar echo source region. Modulation of the electron temperature during these experiments have enabled diagnostics due to the manipulation of the diffusion and charging processes in the dusty plasma region associated with PMWE and PMSE. Particularly, the relative timescales of the charging and diffusion may be manipulated which results in temporal behavior variations in the radar echoes that contain diagnostic information related to dust particle size, density, and charge state. This presentation will discuss recent experimental observations and comparisons with theoretical and computational models in order to further develop this experimental approach as a diagnostic technique for middle atmospheric dusty plasmas.