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Recent Advances in Dusty Space Plasma Modulation Using High-Power Radio Waves

Ingrid Mann [(1)]
(1) Dept. of Phys. &Techn., UiT, Arctic University of Norway, Tromsø, Norway, ingrid.b.mann@uit.no

Extended Abstract. Dusty plasma denotes an ionized gas where the charged dust component participates in the charge collective effects. Noctilucent clouds (NLC) are often mentioned as an example of dusty plasma in space. NLC are observed at mid to high latitudes during the summer months and at the transitions between Earth atmosphere and space in the lower ionosphere. This region of the Earth's atmosphere can be explored with radio waves because it displays weakly ionized plasma, and it includes poly-disperse charged dust particles. The neutral atmosphere changes there by orders of magnitude and yields collision dominated conditions. Ionospheric variability is observed in the modified electron content but also in the ions and charged dust. Dust particles form as a result of meteor ablation in the mesosphere and lower thermosphere, in short, the MLT region (60 to 130 km). A fraction of the dust particles carry a surface charge. Their mean equilibrium charge is typically determined by the ambient electron temperature. I addition, small particle effects play a role. Because of photoelectron emission and photo detachment, the charging is also influenced by solar photon flux, ionospheric processes and geo-corona. During summer at high and mid latitudes, temperatures can be below water freezing point so that clouds of ice particles, Polar Mesospheric Clouds (PMC) form at heights 80 to 85 km. Some of the PMCs are visible to the eye after sunset when the atmosphere below is not illuminated by the Sun, those are the NLC. The charged dust and ice particles also contribute to the formation of polar mesospheric summer echoes (PMSE), polar mesospheric winter echoes (PMWE), and rare low summer echoes (RLSE). The influence of charged nanoparticles on incoherent scatter is another example for observed dusty plasma, but has been observed in few cases, so far. Simultaneous temperature and PMSE confirm the importance of ice particles for PMSE formation, but also the dependence on turbulence. The PMSE vary with solar Lyman alpha flux and geomagnetic activity. Important information is also derived from rocket in-situ measurements within PMSE. Low frequency heating experiments where the electron temperature is locally and temporarily enhanced, show that the heating modulates PMSE strength. The modulation presumably varies with the electron density and other factors. Electron density influences the dust charging rates, but also the electron diffusivity. This, in turn is an important factor in the coupling of dust spatial structures and electron density gradients, which are thought to cause the formation of the coherent radar echoes. Radar studies from the EISCAT site near Tromsø (69.58°N, 19.2272°E) are made at 7.9MHz, 56MHz, 224MHz, and 930MHz. The future EISCAT_3D will operate its core-site nearby. The presentation addresses recent results, open questions and future observations.