

Comparative Studies of the Lower Ionospheres of Earth and Mars

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The Processes controlling various phenomena in the lower ionosphere of Earth have been understood fairly well as compared to the ionosphere of Mars. The lower ionosphere of Earth is divided into D and E region. The formation of D region is the result of the following ionization sources: (1) solar Lyman alpha (1216 \AA) ionizing the minor constituent NO, (2) solar X-ray ($\lambda < 8 \text{ \AA}$) ionizing N_2 and O_2 , (3) Cosmic ray ionizing all atmospheric constituents and (4) photo ionization of meta stable $\text{O}_2(1\Delta_g)$ by solar UV radiation ($\lambda < 1118 \text{ \AA}$). The E region is produced by X- rays ($10- 100 \text{ \AA}$) and by EUV ($800-1026 \text{ \AA}$) radiations. Both regions are mainly controlled by photochemical rather than by plasma transport processes. The knowledge of ion composition and understanding of the ion chemistry in the lower ionosphere of Mars are required to fully understand the atmospheric electricity and wave propagation problems which are really unknown due to lack of measurements. The objective of this paper is to compare the lower ionospheres of Earth and Mars and to see whether the physical processes in the ionosphere of the two planets are similar or different. In this paper we have calculated altitude profiles of ion and electron densities in the lower ionospheres of Earth and Mars at high latitude under photochemical equilibrium condition. In this calculation the solar radiation and cosmic rays are used as the primary sources of ionizations. The cosmic ray particles passing through the lower atmosphere of Earth and Mars decay, giving rise to various charge and neutral particles. The flux and degradation of dominant particles namely neutrinos and pions are computed and ionization contributions at altitudes are estimated. Our chemical model couples ion-neutral, electron-neutral, electron photo-detachment, ion-ion and ion electron recombination processes through over 100 chemical reactions. Results show that above 40 km, the densities of negative ions on Mars are found significantly low in comparison to that obtained on Earth while the main features of positive ions [O_2^+ , NO^+ , $\text{H}^+(\text{H}_2\text{O})$, $\text{H}^+(\text{H}_2\text{O})_2$, $\text{H}^+(\text{H}_2\text{O})_3$ and $\text{H}^+(\text{H}_2\text{O})_4$] and their total density are nearly same in the ionospheres of both planets. Below this altitude, the water cluster $\text{NO}_2^-(\text{H}_2\text{O})_n$ and $\text{CO}_3^-(\text{H}_2\text{O})_n$ for $n=1$ and 2 are found dominant ions on Mars. The maximum electron density on Mars occurs around 30-40 km due to high efficiency of the electron attachment to O_x molecules.

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