Model calculation of production rates, ion and electron densities in the evening troposphere of Mars at latitudes 67°N and 62°S: Seasonal variability

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[1] We have developed a model to calculate the production rates and densities of positive and negative ions in the troposphere of Mars at evening. Using this model, the densities of 35 ions (Ar, O², CO₂, NO, NO₂, H₂O, H₂O²⁺, H₂O³⁺, H₂O⁺(H₂O)₂, H₂O⁺(H₂O)₃, H₂O⁺(H₂O)₄, H₂O²⁺HO, CO₂⁺CO₂, CO⁺, C⁺, N⁺, NO⁻CO₂, N⁺, O₂⁻(CO₂)₂, O₂⁻H₂O, O₂⁻(H₂O)₂, O₄⁻O⁻, CO⁻H₂O, CO⁻(H₂O)₂, CO⁻, CO₂⁻, NO₂⁻, NO₂⁻H₂O, NO₂⁻(H₂O)₂, NO₃⁻, NO₃⁻H₂O, NO₃⁻(H₂O)₂, O₂⁻, O₃⁻, O⁻) are estimated in summer and winter at latitudes 67°N and 62°S for solar zenith angles 80° and 85°, respectively. The impact ionization source is taken as galactic cosmic rays. The model atmospheres at these locations are constructed from air density measured by radio occultation experiment aboard Mars Global Surveyor. The maximum electron densities in southern winter and northern summer are obtained at altitudes ~25 km and ~30 km, respectively, due to high efficiency of electron attachment to O₃ molecules. Of the 35 ions considered in the model, the chemistry of 9 major ions (H₂O⁺(H₂O)ₙ for n = 1, 2, 3, 4 and CO₂⁻, CO⁻, NO₂⁻H₂O and CO⁻(H₂O)ₙ for n = 1, 2) are discussed in this paper. The ion densities are changed by factors of 5 to 10 between these two seasons.


1. Introduction

[2] The radio occultation experiment onboard Mars Global Surveyor (MGS) contributes detailed measurements to an improved understanding of the basic thermal structure, circulation, and dynamics of the troposphere of Mars. These results are based on analysis of the radio signal received from MGS as it enters and exits occultation by the planet. Occultation studies with MGS encompass a range of diverse phenomena that has been investigated based on high vertical resolution profiles of atmospheric density, pressure, and temperature [Tyler et al., 2001]. These measurements are made available by radio science team at NASA's Planetary Data System (http://pds-geophys.wustl.edu/pds/mgs/rs/).

[3] In this paper we have used temperature and air density profiles measured by radio occultation experiment at solar zenith angles 85° and 80° on 3 March and 30 December 1998 for Ls = 285° and 67° in southern and northern hemispheres, respectively, at nearly same latitude and longitude (62°S, 205°E; 67°N, 200°E). At the time of these measurements, Mars had winter in south and summer in north with moderate solar activity period (f10.7 = 132–181). Two model atmospheres of 12 gases (CO₂, N₂, A, O₂, H₂, CO, H₂O, O, O₃, NO, NO₂, and HNO₃) are obtained at these locations from measured air density by multiplying it by the mixing ratio of their gases [Rodrigo et al., 1990; Nair et al., 1994; Tyler et al., 2001]. We have examined the seasonal variability in the calculation of ion production rates and electron density. The model calculations are carried out between altitudes 1 to 40 km at observed points. The ion production rates are calculated because of the impact of galactic cosmic rays by using the energy loss method which is described in section 3. The production rate and temperature have been used later in the continuity equation for the calculation of ion and electron densities under photochemical steady state condition.

[4] The first theoretical study of the Martian lower ionosphere was carried out by Whitten et al. [1971]. They considered the ionization by cosmic rays and solar radiation in the dayside ionosphere of Mars. Later Molina-Cuberos et al. [2002] calculated electron density in the nighttime lower ionosphere of Mars. Recently Haider et al. [2007] have estimated mean electron density in the nighttime ionosphere of Mars due to absorption of solar wind electron and galactic cosmic rays between altitudes 0 and 220 km.