Model of photoelectron impact ionization within the high latitude ionosphere at Mars: Comparison of calculated and measured electron density

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Abstract

The production rate, ion density and electron density are calculated between longitudes 0° and 360° E due to incident radiation of wavelength range 1–102.57 nm in the dayside atmosphere of Mars. These calculations are made by using global analytical yield spectrum (AYS) model at solar zenith angle 80° between latitudes 50° and 70° N for spring equinox and medium solar activity condition. These conditions are appropriate for Mars Global Surveyor (MGS) Phase 2 aerobraking period during which both the accelerometer and the radio occultation data are used. The calculated results are compared with MGS radio occultation measurements carried out at different latitudes (64.7°–67.3° N) and longitudes (0°–360° E) in December 1998 between solar zenith angle 78° and 81°. This measurement shows primary and secondary ionization peaks, which are varying with longitudes. Our calculation suggests that first peak is produced by photoionization and photoelectron impact ionization processes due to absorption of solar EUV radiation (9–102.57 nm). The second peak is produced by photoelectron impact ionization of soft X-ray photon (1–9 nm). There is a good agreement between our calculation and measurement as far as the maximum and the minimum values of primary peak altitude/peak density of electrons are concerned. However, the calculated values of secondary peak density and peak altitude are higher than the measured values by a factor of 1.5–2.0 and 1.1, respectively. The secondary peak is brought into agreement with the measurement using low X-ray flux by a factor of 2 to 3 below 9 nm. The longitudinal distribution of calculated and measured peak density and peak altitude are fitted by least-square method with 0.95 confidence limits.

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1. Introduction

The Mars Global Surveyor (MGS) spacecraft was launched from Cape Canaveral Air Station in Florida on 7 November 1996. Upon reaching Mars, MGS has observed thermospheric density during Phase 1 and 2 aerobraking periods from accelerometer experiment at different latitudes and longitudes under solar minimum to medium conditions (Keating et al., 1998).

The preliminary analysis of these measurements suggests that the martian thermosphere is controlled by strong tidal waves at low altitude region (Bougher et al., 2001; Wilson, 2002; Withers et al., 2003). These measurements provide global sampling of martian thermosphere; no data were obtained over north polar region or during solar maximum condition. Prior to arrival of MGS at Mars, its thermosphere was not well sampled spatially or temporally. The Viking 1 and 2 and Mars pathfinder have provided only two vertical profiles under solar minimum condition (Nier and McElroy, 1977; Seiff and Kirk, 1977; Magalhaes et al., 1999).

Apart from accelerometer measurements, MGS has also performed a series of radio occultation experiments in the martian ionosphere at high latitude. The four datasets EDS1, EDS2, EDS3 and EDS4 are now available from radio occultation...