Available online at www.sciencedirect.com

ScienceDirect

Advances in Space Research 53 (2014) 1255–1264

ADVANCES IN SPACE RESEARCH (a COSPAR publication)

www.elsevier.com/locate/asr

Effect of severe geomagnetic storm conditions on atomic oxygen greenline dayglow emission in mesosphere

T. Bag, M.V. Sunil Krishna *, Shilpa Gahlot, Vir Singh

Department of Physics, Indian Institute of Technology Roorkee, Uttarakhand, Roorkee 247667, India

Received 12 September 2013; received in revised form 17 January 2014; accepted 29 January 2014
Available online 6 February 2014

Abstract

Severe geomagnetic storms and their effects on the 557.7 nm dayglow emission are studied in mesosphere. This study is primarily based on photochemical model with the necessary input obtained from a combination of experimental observations and empirical models. The model results are presented for a low latitude station Tirunelveli (8.7°N, 77.8°E). The volume emission rates are calculated using MSISE-90 and NRLMSISE-00 neutral atmospheric models. A comparison is made between the results obtained from these two models. A positive correlation amongst volume emission rate (VER), O, O_2 number densities and Dst index has been found. The present results indicate that the variation in emission rate is more for MSISE-90 than in NRLMSISE-00 model. The maximum depletion in the VER of greenline dayglow emission is found to be about 30% at 96 km during the main phase of the one of the geomagnetic storms investigated in the case of MSISE-90 (which is strongest with Dst index −216 nT). The O_2 density decreases about 22% at 96 km during the main phase of the same geomagnetic storm.The NRLSMSISE-00 model does not show any appreciable change in the number density of O during any of the two events. The present study also shows that the altitude of peak emission rate is unaffected by the geomagnetic storms. The effect of geomagnetic storm on the greenline nightglow emission has also been studied. It is found that almost no correlation can be established between the Dst index and variations in the volume emission rates using the NRLMSISE-00 neutral model atmosphere. However, a positive correlation is found in the case of MSISE-90 and the maximum depletion in the case of nightglow is about 40% for one of the storms. The present study shows that there are significant differences between the results obtained using MSISE-90 and NRLMSISE-00.

Keywords: Airglow and aurora; Mesosphere – composition and chemistry; Solar radiation; Geomagnetic storms; Ring current

1. Introduction

The geomagnetic storm has adverse effect on the ground as well the space based technological systems, which are becoming integral parts of human life. The origin of geomagnetic storm is firmly known these days (Gonzalez et al., 1994). The response of atmospheric constituents to the storm mainly, depends on the intensity of storm, time of occurrence, duration of storm, season and longitude (Prolss, 1982; Yao et al., 2013). The Dst index defines the effectiveness of geomagnetic storm. The negative value of Dst index indicates the commencement of the storm. The intensity of storm depends on the value of Dst index. As the Dst index becomes more and more negative the storm also becomes stronger and stronger. The effect of ring current is very less during the quiet time. However ring current shows large disturbances in Dst index at the time of storm, it produces large disturbances up to 500 nT (Emmanuel et al., 2013). The variation in current is responsible for

* Corresponding author. Tel.: +91 9719150217; fax: +91 1332 273560.
E-mail addresses: tiku1dph@iitr.ac.in (T. Bag), sunilfph@iitr.ac.in (M.V. Sunil Krishna), gahlot.shilpa@gmail.com (S. Gahlot), virphfph@iitr.ac.in (V. Singh).

http://dx.doi.org/10.1016/j.asr.2014.01.031

the decrease of horizontal component of earth's magnetic field B_z (Daglis, 2001). The geomagnetic storm can be either positive or negative depending on the increase or decrease in electron density. The state of geomagnetic storm is determined by the local time at which a storm starts. It is very well established that storm commencing in the day time results in the positive phase and that in night results the negative phase. The equatorward neutral wind alone or together with PPEF (prompt penetration of Electric field) can produce positive storm (Balan et al., 2009; Lu et al., 2012). The storms can induce a wide range of ionospheric disturbances. It has also been found that alteration of neutral composition, thermospheric circulation and oscillation of f_oF_2 during storm determines the ionospheric disturbances (Pirog et al., 2006).

During magnetic disturbed conditions, the prompt penetration of magnetospheric electric fields (PPEF) mainly occurs during initial phase with IMF B_z reversal from northward to southward and during recovery phase with IMF B_z reversal from southward to northward. There are two principal sources for the variation in the low- and mid-latitude ionospheric electric field during geomagnetic

Table 1
Rate of reaction coefficients.

Reaction	Rate constants	Value	Reference
$O(^3P) + O(^3P) + M \rightarrow O_2^* + M$	k_2	$4.7\times10^{-33}(300/T_N)^2$	(Gobbi et al., 1992)
$O_2^* + O(^3P) \rightarrow O_2 + O(^1S)$	k_3	Calculated	(McDade et al., 1986)
$O(^1S) + O_2 \rightarrow O(^3P) + O_2$	k_4	$4.0\times10^{-12}exp(-865/T_N)$	(Melo et al., 1996)
$O(^1S) + O \rightarrow O(^3P) + O$	k_5	2.0×10^{-14}	(Gobbi et al., 1992)
$O(^1S) \rightarrow O(^1D) + 557.7$ nm	A_6	1.18	(Nicolaides et al., 1971)
$O(^1S) \rightarrow O(^3P) + h\nu(total)$	A_7	1.35	(Nicolaides et al., 1971)

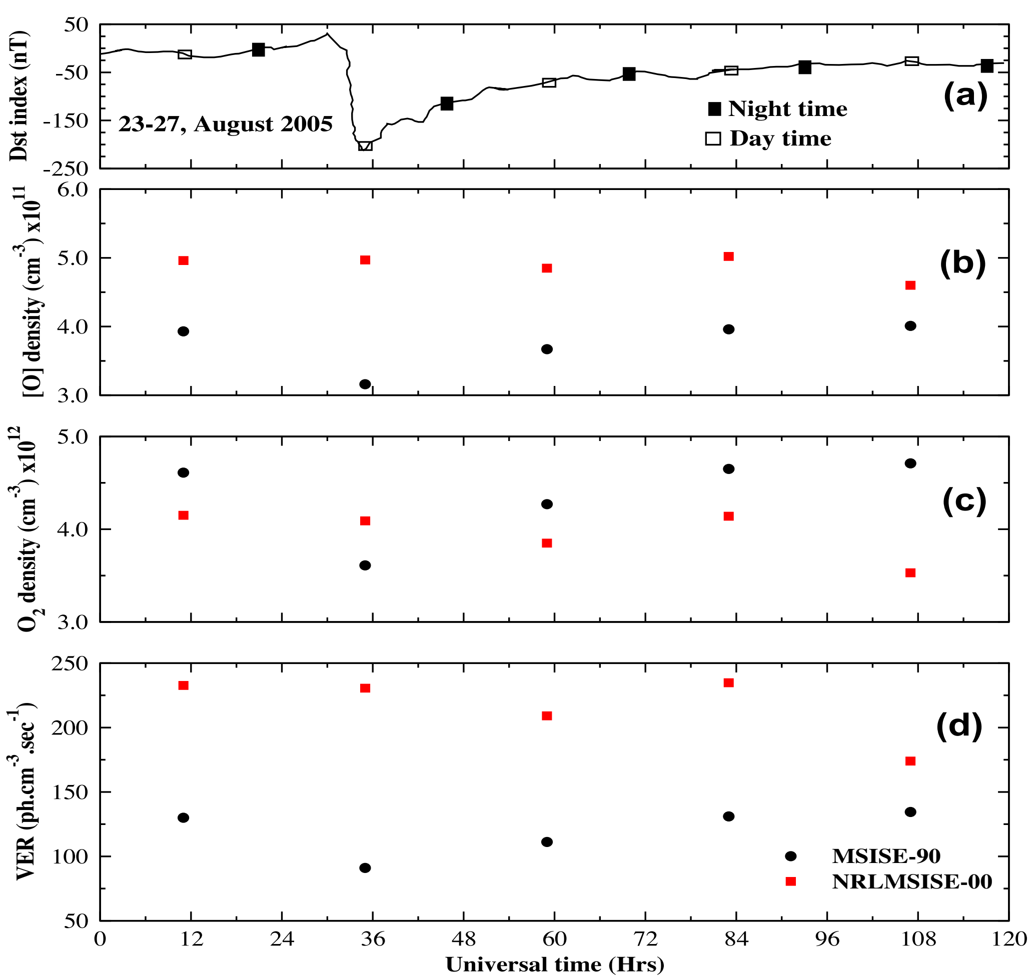

Fig. 1. Variation of Dst Index (panel a), O number density (panel (b)), O_2 number density (panel c) and volume emission rate (panel d) for storm1 with universal time at 96 km.