G-P10

MESOSPHERIC DUST/AEROSOL DENSITY FROM A DETAILED HETEROGENEOUS ION-CHEMISTRY MODEL

N. Srinivas and K. Narasimhamurthy

Department of Physics and Electronics
Maharani's Science College for Women, JLB Road, Mysore-570 005, India.

1. Introduction

Several mesospheric model studies have reported in the past about a problem: the established conventional gas-phase ion-chemistry schemes (e.g., DAIRCHEM code) of the mesosphere may not give ion densities in agreement with those observed in the experiments when experimentally observed electron densities are input to the scheme (for example, Heaps et al, 1978; Cole and Heaps, 1980; Swider and Narsici, 1983; Heaps and Heimerl, 1984). In the present study it is observed that, when experimentally observed electron densities are input to established conventional gas-phase ion-chemistry schemes of the mesosphere, the resulting ion densities are generally not consistent with the charge balance criterion of the region under steady state. Several studies have suggested that this problem may be due non-inclusion of the possible role of dust as source and/or sink for electrons and ions in the ion-chemistry schemes of the mesosphere (for example, Cole and Heaps, 1980, Srinivas et al, 1997). It is also known that dust of meteoric origin exists at all heights and latitudes of the mesosphere during all seasons (Reid, 1990). Thus, instead of considering mesosphere as a region having pure ionic plasma, it is more meaningful to consider it as a region containing a dusty plasma or complex plasma (Srinivas et al, 2007). This necessitates a study to explore the presence of dust and the possibilities role of dust grains in the ion-chemistry of the region. However, sufficient experimental information regarding various physical and chemical properties of mesospheric dust, such as size distribution, dust content and surface properties and surface contamination, etc. are not presently available.

In this background, and with the presently available information about the properties of mesospheric dust, a heterogeneous ion-chemistry model has been developed. The model quantifies the steady-state background dust densities, corresponding to various assumed effective sizes in the range of 1--50 nm, prevailing in the 60--90 km region of the equatorial mesosphere under steady state.

2. The Model

The heterogeneous ion-dust model of the present study is shown in Fig. 1. The study attempts include dust, as source and/or sink for both ions and electrons, in to the conventional ion-chemistry scheme of mesosphere. The model incorporates the various possible interactions between dust and ions and electrons including photo ionization of dust. Various possible interactions between the dust grains are neglected since the mobility of dust grains is very small compared to those of ions and electrons in the region.

The dust density profiles for the low latitude mesosphere are derived by seeking a numerical solution to the problem described in the previous section. The model computes, with experimentally observed electron density as one of the inputs, the densities of singly positively and singly negatively charged ion-attached dust ions, singly charged photoionized dust ions and multiply charged electron-attached dust ions under steady state, with an assumed effective size (radius) of dust in the range of 1-50 nm.

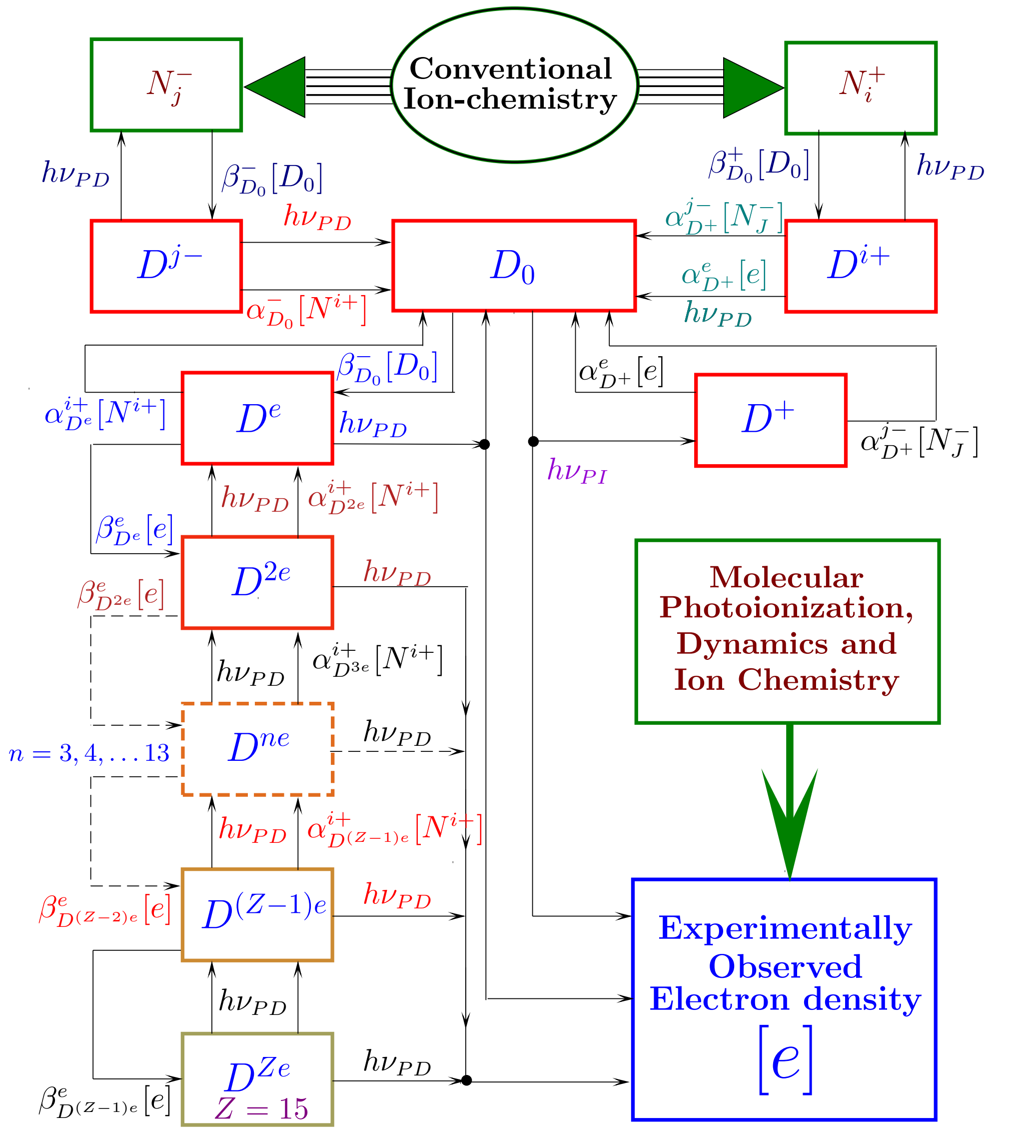

Fig. 2: The heterogeneous ion-dust model of the present study.

3. Results

All the dust density profiles show interesting height structures in the mesosphere. However, the ion-attached dust densities are seen to be very small compared to photo ionized and electron-attached dust densities. Thus it appears that the dust grains primarily act as source and/or sink for free electrons in the entire 60--90 km region of the mesosphere. Below about 80 km the source effect of dust is seen to be dominant over its sink effect for electrons, whereas, the opposite is seen to be the case above this altitude of 80 km.

In the source region (below 80 km) The total positive molecular ion density is indirectly related to the effective sie of the dust, whereas, opposite of this is seen to be the case above this altitude (sink region). Thus it is evident that, from a set of simultaneously observed total positive ion and electron density profiles, the model can be used to find the effective grain size in the region.

The results of this study indicate a need for experimental measurements of mesospheric dust concentration, size distribution, etc. for a better understanding of the region.

4. Acknowledgments

One of the authors (NS) is grateful to the University Grants Commission (UGC), New Delhi, India for providing financial support vide Letter No. MRP(S)-486/2006(X Plan)/ KAMY004/UGC-SWRO dated 29-Dec-05 for initiating this model study.

References

1. Cole, H.P. and Heaps, M.G.(1981). Properties of dust as an electron and ion attachment site for use in D-region ion-chemistry. Scientific report No ASH-TAR-0098, Atmospheric Sciences Laboratory, White Sands Missile Range, NM 880022, USA.
2. Heaps, M.G., Heimerl, J.M. The quiet midlatitude D-region: a comparison between modeling efforts and experimental measurements. J. Atmos. Terr. Phys. 42, 1980.
3. Heaps, M.G., Niles, F.E., Sears, R.D. (1978). Modeling the ion chemistry of the d-region: a case study based upon the 1966 total solar eclipse. Scienti.c Report ASL-TR-0015, Atmospheric Sciences Laboratory, White Sands Missile Range, NM 880022. USA.
4. Reid, G.C.(1990). Ice particles and electron \bite-outs" at the summer polar mesopause. J. Geophys. Res., 95:13891-13896.
5. Sears, R.D, Heaps, M. G. and Niles, F.E.(1981). Modeling the ion chemistry of the d-region: A case study based upon the 1966 total solar eclipse. J. Geophys. Res., 86:10073-10086.
6. Srinivas, N., Prasad, B.S.N., Lastovicka, J.(1997). A heterogeneous ion-chemical model for the upper mesosphere. Indian J. Radio Space Phys. 26, 264–273, 1997.
7. N. Srinivas, B.S.N. Prasad, Jayati Datta, S.C. Chakravarty Advances in Space Research 39 (2007) 1256–1266
8. Swider, W. and Narcisi, R.S.(1983). Steady state model of d-region during the February 1979 eclipse. J. Atmos. Terr. Phys., 45:493-498.
9. Swider, W. and Narcisi, R.S.(1983). Steady state model of d-region during the february 1979 eclipse. J. Atmos. Terr. Phys. 45, 493–498.