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Particle charging: its role in the ionospheric composition and the growth of aerosols

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Abstract

We present detailed calculations for the interaction of aerosols with the ionosphere. This investigation is performed with the use of a model that couples between the ionospheric photochemical evolution and the microphysical growth of aerosols. Our results show that aerosols formed in the thermosphere accumulate a significant fraction of the total electron abundance produced by the solar radiation. Subsequently, the negatively charge aerosols attract the positive ions. The mass added in this way to the surface of the particles increases their size.

1. Introduction

Observations of Titan's lower thermosphere and ionosphere by Cassini instruments demonstrate the presence of large mass negative ions, which are considered to be the first steps of aerosol production [1]. Recently, during a rare flyby of deep penetration in the atmosphere, a discrepancy in the observed positive ions and electron density was observed, with the electron density lower than the abundance required to satisfy charge balance [2]. The remaining electron density was found in the form of the large mass negative ions. Aerosols can be charged on interaction with electrons and ions, while this charge can affect the particle coagulation, thus, their subsequent growth [3]. Given the above observations we investigate here the potential role of aerosols in Titan's ionosphere and how this interaction affects the aerosol evolution.

2. Model description

In order to investigate the overall impact of aerosols in the ionosphere, we developed a simplified model of the ionosphere that includes, one type positive ions, one type negative ions and electrons. We assume a production profile for positive ions (of 30 amu) that is based on detailed energy deposition calculations [4] and attribute 99% of this production to electrons and 1% to negative ions (of 30 amu). The model is coupled to an aerosol microphysics model with a production profile centered at 1200 km. The charge distribution for different particle sizes is calculated by considering the interaction with each charged species and the loss of electrons from the particle surface due to the photoelectric effect. The system is then simulated towards a steady state of overall charge neutrality.

3. Summary and Conclusions

Our results show that particle charging has an important role in the ionosphere. Most of the produced particles in the ionosphere attain a negative charge. Thus they act as a sink for the free electrons with the remaining free electron densities consistent with the recent Cassini observations.

Being negatively charged, the particles repel each other reducing in this way the coagulation rates and the growth of the aerosols. On the other hand, the negatively charged particles attract the abundant positive ions, which results to enhanced collisions between them. The mass added to the particles by the ions leads to an increase in their size (compensating in this way the decrease of the coagulation rate) and an increase in the resulting mass flux of the aerosols.

As the particles become larger due to the above processes, their absorption cross section increases, resulting to a stronger electron photoemission (for day time conditions). Consequently as the particles grow, their charge distribution starts to move towards positive values. As a result, from being completely negatively charged in the ionosphere, the particles can be either negatively charged, neutral or positively charged at lower altitudes. This configuration enhances the particle coagulation leading to a further increase in their resulting size.

These characteristics provide a new, more detailed picture of the particle production and evolution and demonstrate the strong interaction of the aerosols with the background atmosphere at multiple locations of the atmosphere.

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References

[1] Coates, A., et al: Discovery of heavy negative ions in Titan's ionosphere, GRL, Vol. 34, L22103, 2007.

[2] Agren, K., Edberg, N.J.T., and Wahlund, J.-E.: Detection of negative ions in the deep ionosphere of Titan during the Cassini T70 flyby. GRL, 2012, in press.

[3] Lavvas, P., Yelle, R.V., Griffith, C.A.: Titan's vertical aerosol structure at the Huygens landing site: Constraints on particle size, density, charge, and refractive index, Icarus, vol. 210, pp. 832-842, 2010.

[4] Lavvas, P., et al.: Energy deposition and primary chemical products in Titan's upper atmosphere, Icarus, vol. 213, pp.233-251, 2011.