A review of photochemical reactions and electrical discharge in the atmosphere of Venus with special focus on lightning in the cloud region

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Introduction

Investigations are carried out on the lightning regions in Venus based on previous works with the help of photochemical model published by Krasnopolsky 2011[1]. It is also found that optical and radio refractivity increases at low altitudes[2]. Several evidences of electromagnetic bursts were measured by various landers and orbiters studying Venus atmosphere (Venera landers, Venus Express and the Pioneer Venus Orbiter). The electromagnetic bursts that are taking place in the cloud region in the form of lightning or fluorescence might be a result of momentum transfer, solar convection and charge dispersion in the clouds of Venus. Polydisperse and monodisperse charging of ions will help understand the possibility of photochemical reactions taking place in the clouds regions.

Lightning characteristics

Lightning is a discharge of energy resulting from separation of charges(positive and negative) on particles in storm clouds over a large distance. This creates a potential that causes formation of an electric field. If an atmosphere of a planet is not very conductive, the field potential can grow very large and the possibility of an electric discharge in the form of lightning increases[3]

Electrical activity in the cloud region

Lightning occurs due to a sudden breakdown in the cloud medium. It is often due to large concentrations of positive and negative charge. Cloud lightning is also associated with the convective activity of the atmosphere. Cloud formation is associated with condensation of molecules on monodisperse or polydisperse aerosols which act as the nuclei. Solar radiation, cosmic rays, atmospheric circulation and heat transport from the solid planet act as some of the factors of ionization of aerosols and charge transport.

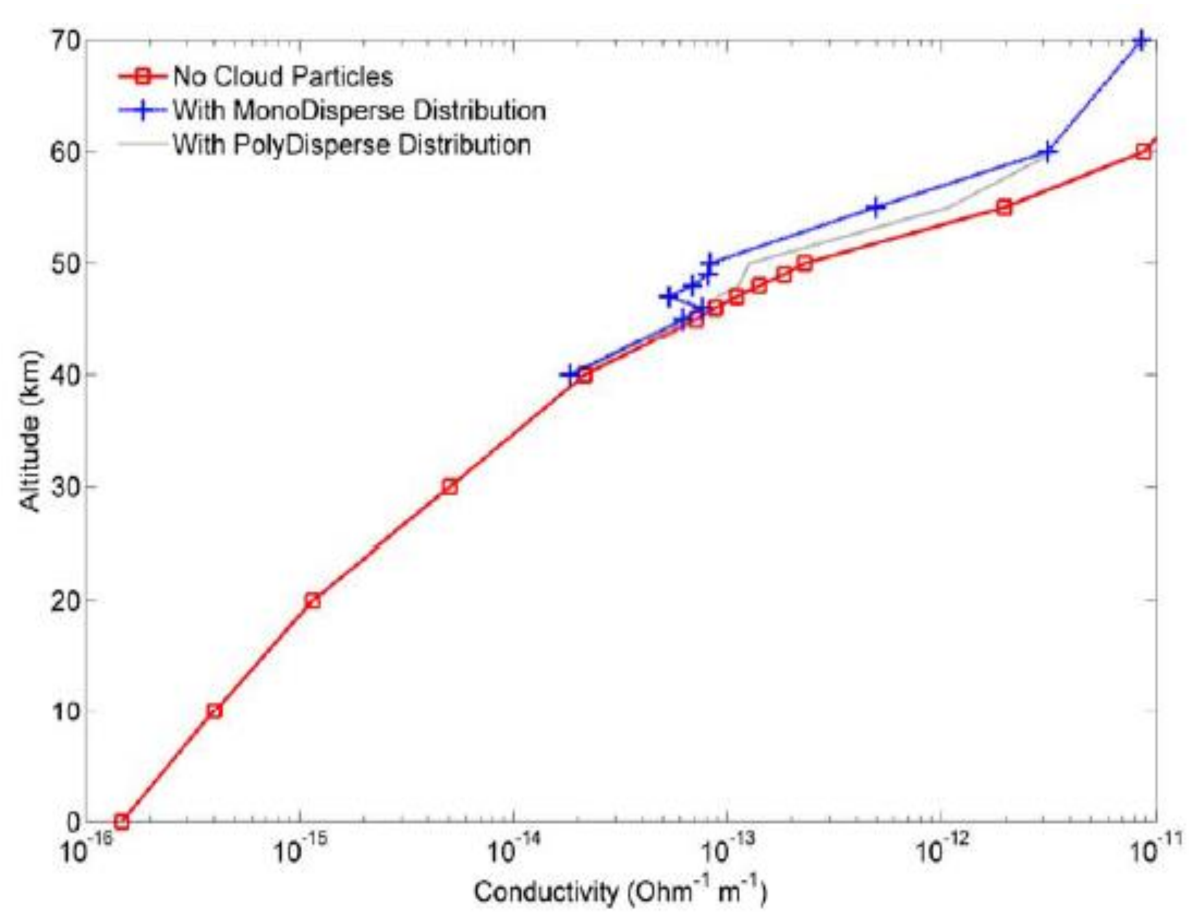

Fig 1 : Altitude profile of conductivity for various conditions in the atmosphere of Venus. (*extracted from Michael et al 2009*)

As the cloud conductivity is less in the bottom cloud region, there is a possibility lightning can be developed in these regions, it is possibly taking place in form of electromagnetic emissions in the ELF and VLF regions as measured by the Venera 11 and 12 landers.

Photochemical reactions

The photochemical model put forward by *Krasnopolsky 2011* [1] helps us understand the emissions in optical regions in the upper cloud regions. It is seen that most of the photochemical reactions occurs in the upper altitudes and specifically in the upper cloud regions which is one good way of classifying the emissions in the upper cloud deck.

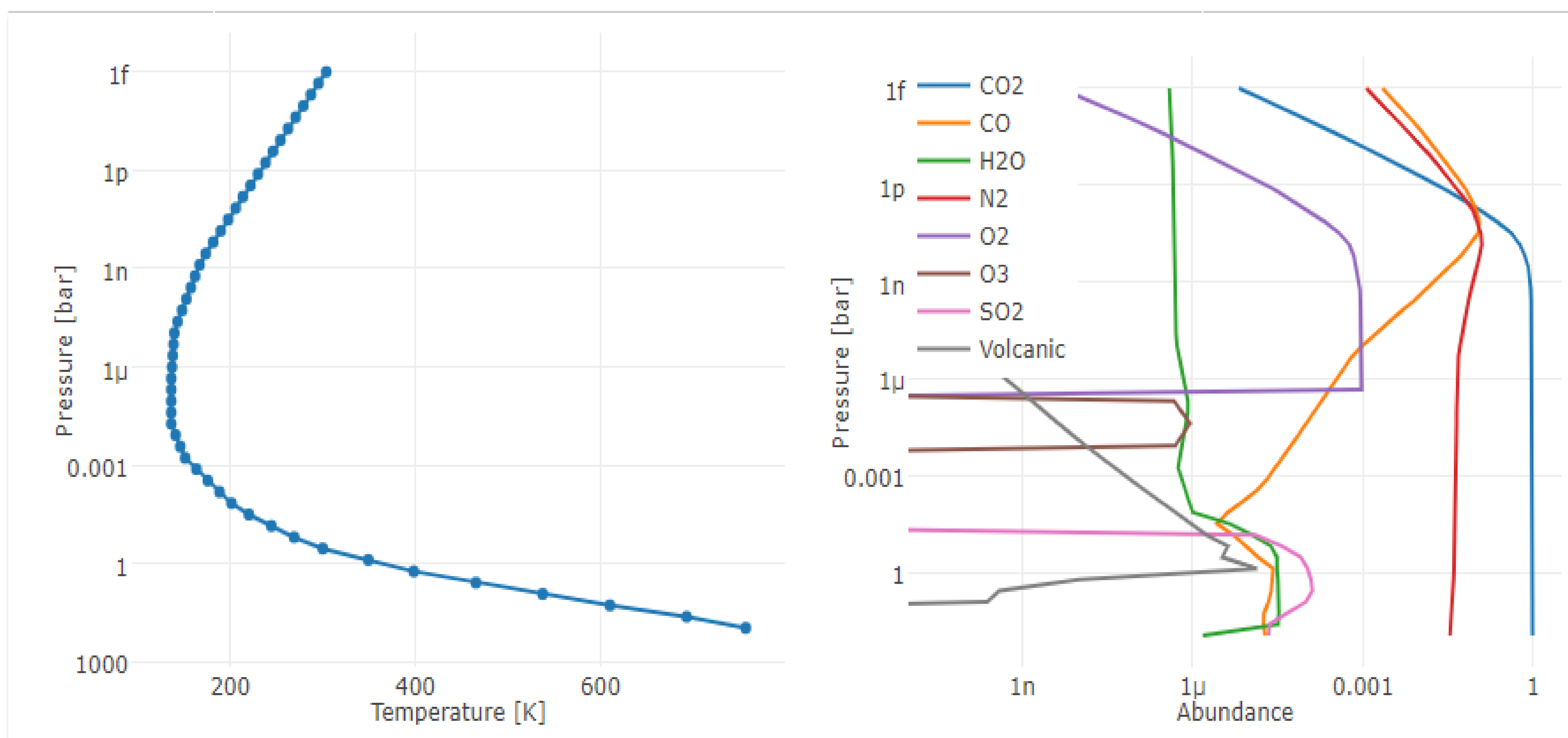

Fig 2 : Abundance of various compounds in the Venusian atmosphere (created using Planetary Spectrum Generator Tool NASA-Goddard)[4]

The above figure helps us understand the abundance of SO2 in the upper cloud regions, SO2 absorbs at 190-230 nm and fluoresces at 340-410 nm [5]. The formation of SO_2 in upper clouds is coincident with the UV absorption in the clouds.

Turbulence in the clouds

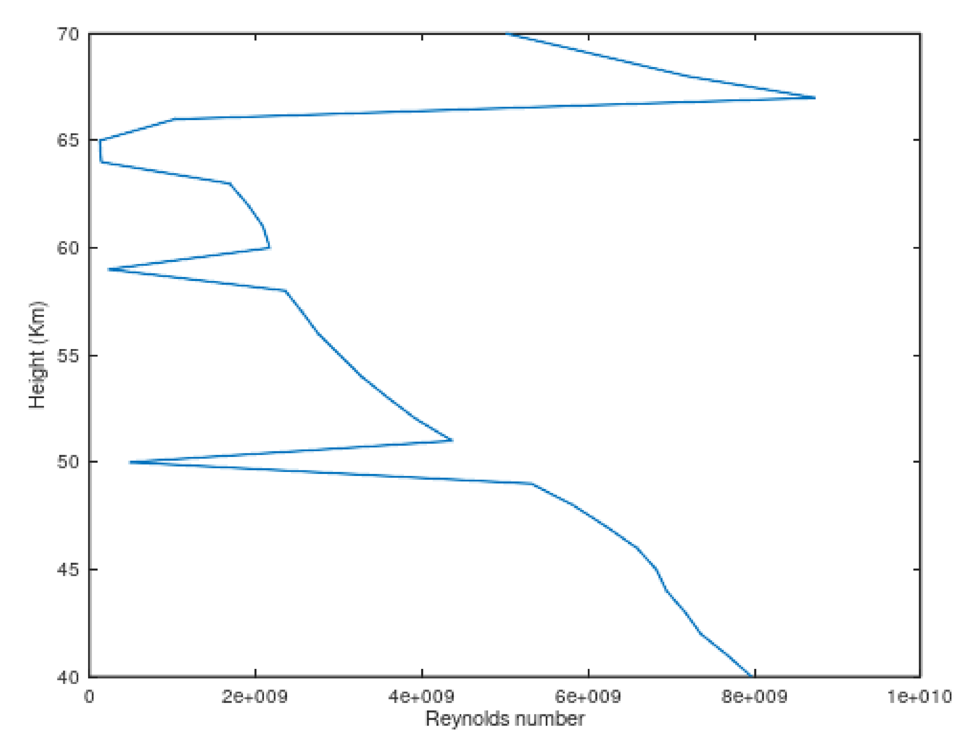

Fig 3 : Variation of Reynolds number vs altitude

It can be seen from the above figure that there is a high degree of turbulence in the cloud regions. The electrical discharges in the lower cloud regions is possibly due to the formation of ions caused by the rubbing of particles and the discharge occurs as it meets the ambient conditions.

Conclusion

Lightning or fluorescence in the cloud regions can be categorized into two types, in the upper altitudes it is because of the photochemical reactions and in the lower altitudes it is possibly due to the electric discharges caused by the turbulent behavior of clouds.

Reference

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[4] https:// psg.gsfc.nasa.gov/atmosphere.php#input

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