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Charged Haze Layers in Venus' Lower Atmosphere

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Summary

- **Discharge sensors on the Venera landers recorded difficult to explain data**
- **Spectrophotometric readings from these landers showed large extinctions in the lower atmosphere – possibly caused by haze layers**
- **Data from these two sensors are compared to investigate the possibility of haze layers causing the current**

1. Introduction

As part of their instrumentation the Venera 13 & 14 Landers carried corona discharge sensors which operated during the final stages of the lander descents [1]. These sensors detected electrical discharges from the lander to the atmosphere, and were included to ensure that the LF emissions that other sensors were detecting were not being caused by some electrical effects from the landers themselves. For both landers, the discharge currents recorded increased linearly as the lander descended until around 25km, where the current became approximately constant with height. This behaviour cannot be explained by simple models of the Venusian environment. One proposed explanation was the presence of charged haze layers in the lower Venusian atmosphere [1]. The existence of haze layers in Venus' lower atmosphere has already been considered by Grieger et al. [2] who noted that the spectrophotometric data recorded by Venera 13 & 14 pointed to large amounts of extinction near the surface.

2. Method

Electrical Model

An electrical model of Venus' atmosphere was constructed: VAIL (Venus Aerosol-Ion modeL). VAIL analytically solved ion-aerosol balance equations to find the concentration of positive and negative ions in the atmosphere. Further, these ion concentrations were used to calculate the conductivity of the atmosphere, and by assuming a constant global vertical atmospheric current (as for Earth), the electric field in the atmosphere was found. The derived ion concentrations and atmospheric conductivities found from VAIL were compared with the results from Borucki et al.'s numerical model and were found to be in good agreement (the two models typically agreed within a factor of 2) [3]. As input parameters to VAIL, profiles of the number density and size of aerosols was required. Typically, it used aerosol profiles covering the cloud layer, however, it was also possible to include hypothetical haze layers allowing investigation into the impacts of these.

Assumed Haze Layer Properties

Following the same process as Grieger et al. [2], the spectrophotometric data recorded by Venera 13 & 14 allowed the extinction in the atmosphere to be calculated for several wavelength bands. From these, it was possible to calculate the concentration of particles that would be required to cause this extinction, if a size distribution was assumed. This concentration profile was then used along with the size profile as inputs into the electrical model, in order to evaluate their effect.

For the in situ recorded discharge currents to be explained by the presence of a haze layer, we would expect that the Electric field profile should have a similar shape to the discharge current profile. Since it was unknown what the "correct" aerosol size distribution was, instead we investigated whether it would be possible to hypothesise an aerosol distribution which produced a similar profile. The process of this investigation is described in figure 1.

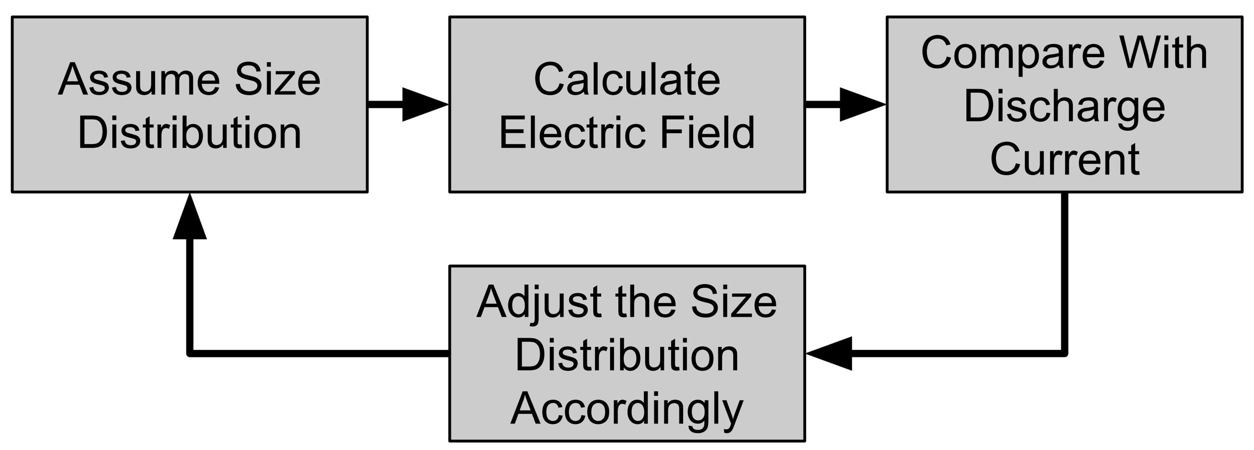

Figure 1: Diagram describing the process through which a possible size distribution was investigated

3. Results

The results shown here are only considering the Venera 13 data.

Initially, a monomodal particle distribution of 0.3µm radius particles was tested. A comparison between the discharge current recorded by the lander, and the electric field found by the model is shown in figure 2.

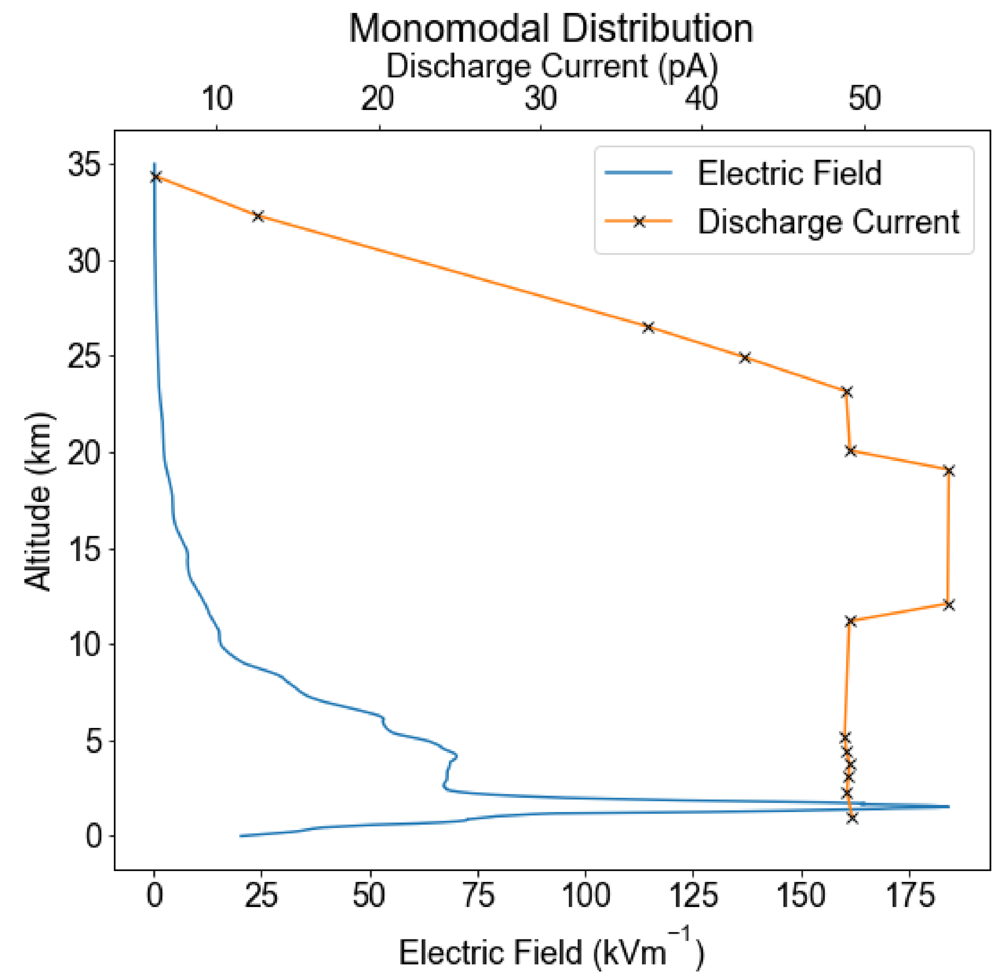

Figure 2: Comparison between recorded discharge current and the electric field found for a monomodal aerosol size distribution

From figure 2 it is clear that the electric field and discharge current profiles have very different shapes. This points to the discharge currents measured not arising from this monomodal distribution of particles.

Following this, several more complex multimodal distributions were tested. Since it is expected that larger particles would settle towards the surface, while smaller particles remained at higher altitudes, only distributions which monotonically decreased in size with altitude were used. Following many iterations, it was discovered that a particle size distribution which varied from 4 to 0.03 µm was able to produce an electric field profile with similar shape to the discharge current profile. The electric field found is compared with the discharge current in figure 3, and the associated size distribution is shown in figure 4.

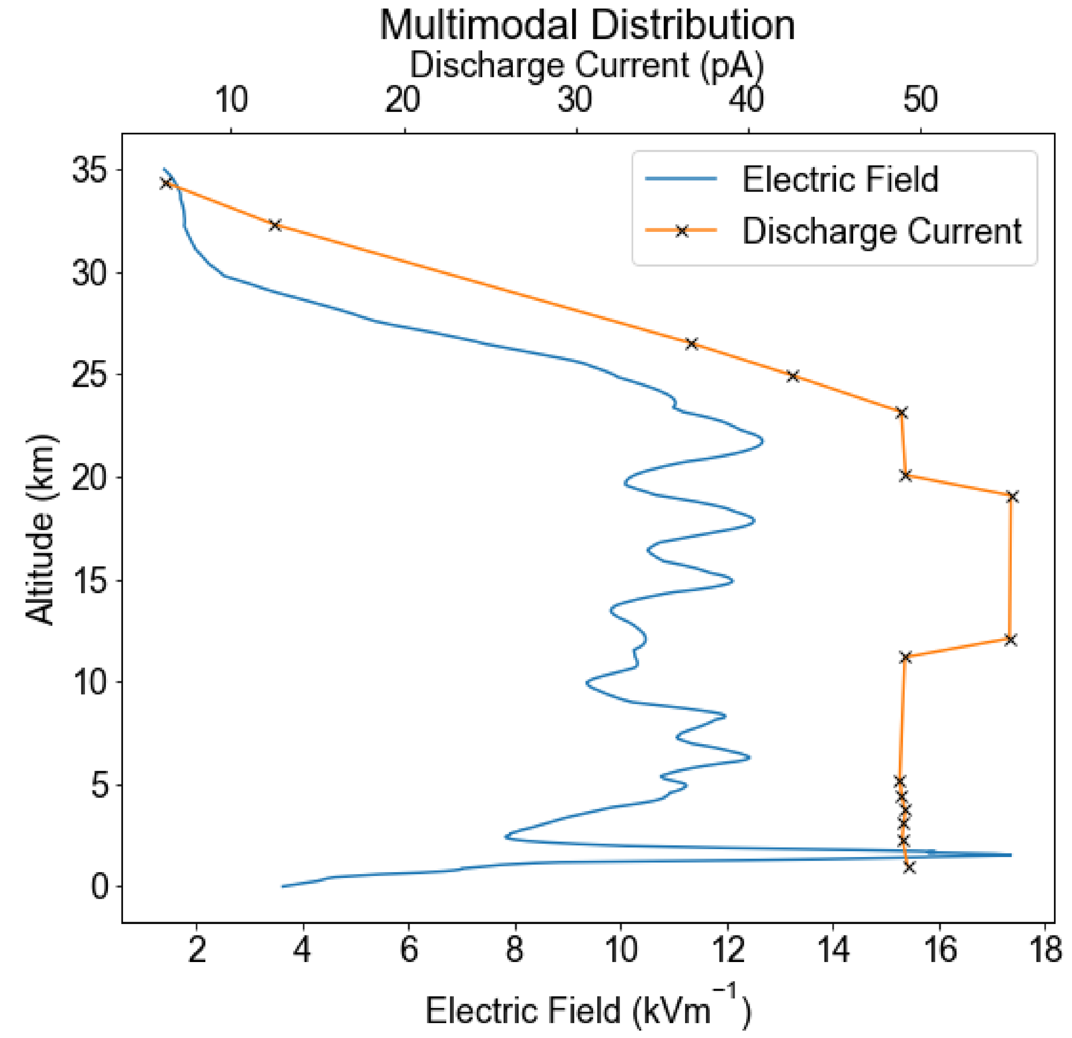

Figure 3: Comparison between recorded discharge current and the electric field, found for a multimodal aerosol size distribution

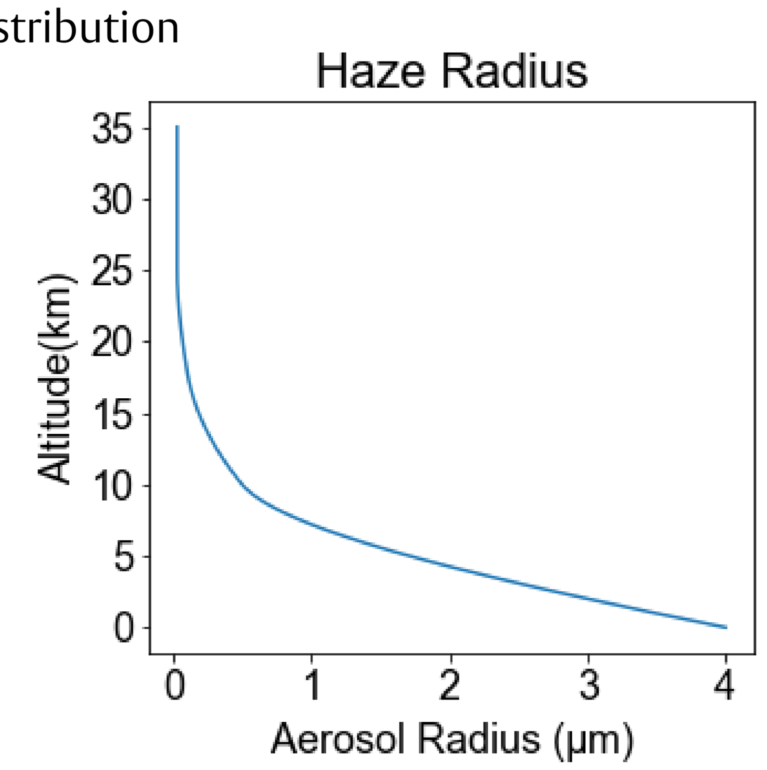

Figure 4: Multimodal size distribution used for the haze layer

4. Discussion

- The aerosol size profile used has no theoretical backing, instead it was selected to provide a good fit to the data.
- Further, the calculation of the electric field relies on a large number of assumptions – including the presence of a global electric circuit.
- However, this investigation has shown that it would be possible for a haze layer to cause the discharge current profiles.

References

1. R. D. Lorenz. (2018) Discharge current measurements on venera 13 & 14 – evidence for charged aerosols in the venus lower atmosphere? Icarus, 307, pp. 146–149
2. B. Grieger et al. (2004) Indication of a near surface cloud layer on venus from reanalysis of venera 13/14 spectrophotometer data. Planetary Probe Atmospheric Entry and Descent Trajectory Analysis and Science, 544, pp. 63-70
3. W.J. Borucki et al. (1982) Predicted electrical conductivity between 0 and 80 km in the Venusian atmosphere, Icarus, 51, pp. 302-321