Aerosol Charging by Ion and Electron Attachment in the Lower Atmosphere of Mars

M. Michael and S. N. Tripathi

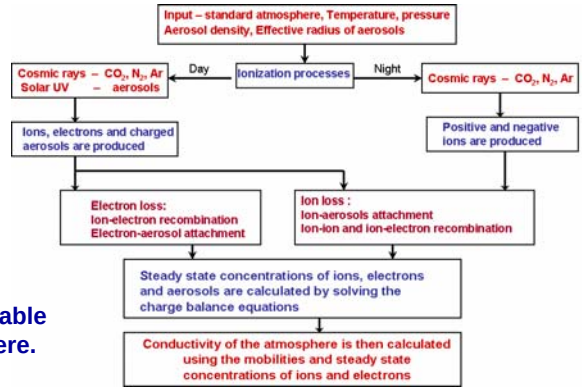
Civil Engineering, Indian Institute of Technology, Kanpur

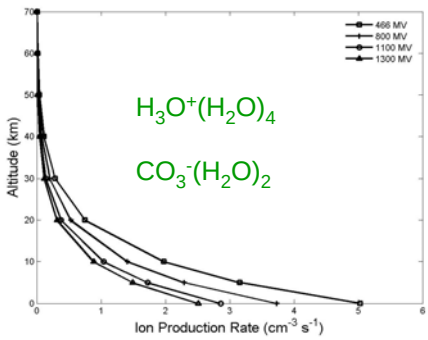
Aerosols are charged by the ion and electron attachment

Ion-aerosol interactions are important in understanding the electrical nature of the atmosphere; A direct effect is the removal of cluster ions, which reduces the conductivity

Electrical conductivity of an atmosphere is a necessary requirement in permitting an atmospheric electrical global circuit

Mars possesses a global electric circuit driven by dust storms; therefore the conductivity of the atmosphere discussed here will be valuable in the investigation of the global electrical circuit in the Martian atmosphere.





Charge Balance Equations (day-time)

$$\frac{dn^+}{dt} = q - \alpha n^+ n^- - \alpha_e n^+ n^e - \sum_i \left(\beta_i^{(i)} n^+ N^i\right)$$ Positive ion concentration

$$\frac{dn^-}{dt} = q - \alpha n^+ n^- - \sum_i \left(\beta_2^{(i)} n^- N^i\right) - Fn^-$$ Negative ion concentration

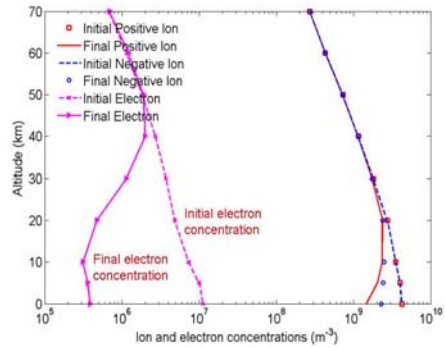
$$\frac{dn^e}{dt} = q_e - \alpha_e n^+ n^e - \sum_i \left(\beta_e^{(i)} n^e N^i\right) + Fn^-$$ Electron concentration

Aerosol concentration

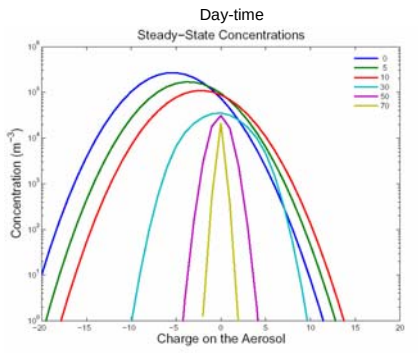
$$\frac{dN^i}{dt} = \beta_1^{(i-1)} n^+ N^{(i-1)} + \beta_2^{(i+1)} n^- N^{(i+1)} + \beta_e n^e N^{(i+1)} - \beta_1^{(i)} n^+ N^i - \beta_2^{(i)} n^- N^i - \beta_e n^e N^i$$

n – ion concentration
N – aerosol concentration
q – ion production rate
q_e – electron production rate

α– ion-ion recombination coefficient
α_e– ion-electron recombination coefficient
$\beta_{1,2}$ – ion aerosol attachment coefficient
β_e – electron aerosol attachment coefficient
F – electron detachment from negative ions

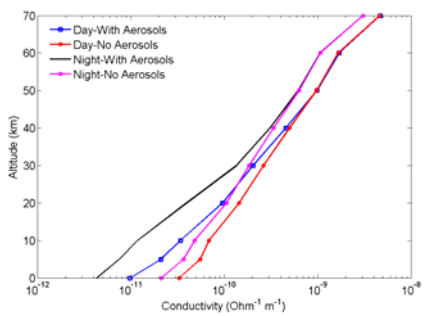


Electron and ion attachment to aerosols occur mostly in the lower altitudes (less than 40 km)



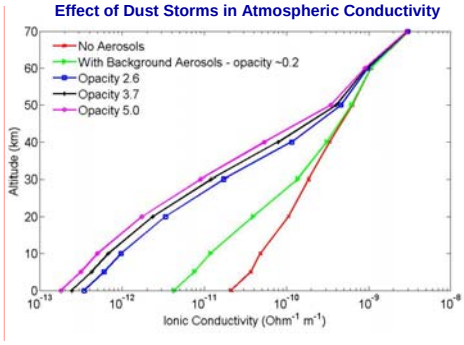
The aerosols with negative charges (between -1 and -10) have higher concentration than those of the neutral aerosols during the day time

Effect of Aerosols in Atmospheric Conductivity



Ion aerosol attachment reduces the conductivity of the atmosphere

Effect of Dust Storms in Atmospheric Conductivity



Higher the dust opacity, lower the atmospheric conductivity

Results:

More than 95% of the aerosols get charged during the day close to the surface while ~80% of the aerosols get charged during the night.

Negatively charged (-1 to -10) aerosols have higher concentration than the neutral aerosols after reaching the steady state during the day time. This happens as the highly mobile electrons get attached to the aerosols during the day time.

Conductivity increases by about a factor of 2 for the day time compared to the night time.

The variation in conductivity is less than 5% due to the differences in the seasonal and latitudinal temperature structure

The conductivity varies by about a factor of two in going from solar minimum to solar maximum conditions

During the dust storm (opacity ~5) of 2001 the conductivity decreased by about 2 orders of magnitude.

Questions: mary@iitk.ac.in