EPSC Abstracts,
Vol. 4, EPSC2009-206-1, 2009
European Planetary Science Congress,

Dust and Schumann resonances on Earth and Titan

Yu.N. Besedina, S.I. Popel, I.N. Sharykin

Institute for Dynamics of Geospheres, Moscow, Russia (besedina_yn@mail.ru / Fax: +7-499-1376511)

Abstract

The influence of dust particles on the global electromagnetic (Schumann) cavity has been studied in the context of two possible mechanisms. First, the presence of charged microscale particles in the ionospheric plasma modifies the dispersion properties of the upper boundary of the Schumann cavity (SC) and, thus, affects its eigenfrequencies and quality factor. Second, there is a relation between the dust concentration in the atmosphere and lightning discharges, which excite Schumann resonances (SRs). Therefore, dust grains can enhance the energy pumping of the cavity, thereby increasing the amplitude of electromagnetic oscillations in it. Comparison between Schumann resonances on Earth and Titan is carried out.

Dust Particles and Schumann Resonances on Earth

Charged nano and microscale particles can substantially modify the dispersion properties of the plasma [1]. A change in the dielectric permittivity of the ionospheric plasma can alter the properties of the SC. In a dusty ionosphere, dissipation is determined by the frequency, which characterizes momentum transfer between electrons and dust grains. Thus, in order to estimate the effect of dust, it is necessary to compare this frequency with the electron–neutral collision frequency. These frequencies become comparable at a dust density and the dust grain size on the order of 10^3 cm^{-3} and 10 μm simultaneously. The presence of dust with such parameters in the lower ionosphere leads to a decrease in the SC quality and in the resonant frequencies. In the model of a homogeneous ionosphere, the resonant frequencies reduction can reach several percent [2]. In spite of the fact that the number density of microscale particles in the ionosphere is usually lower than the above critical value, situations can occur (e.g., after volcanic eruption).

On the other hand dust particles participate in convective processes in the cloud and intensify charge separation, thereby increasing the number of thunderstorms. Since thunderstorm activity is the main source of SRs, this leads to an increase in the energy density in the cavity and, therefore, in the SR amplitude. The energy emitted by lightnings in the volcanic cloud is added to the energy generated by the world thunderstorm activity. It can be estimated that the ejection of ash with a total mass of about 10^4 tons can result in a twofold increase in the SR amplitude [2].

There exist other effects of dust presence in SC. The presence of greenhouse gases makes the atmosphere less transparent to longwavelength radiation, thereby increasing this temperature. On the other hand, the presence of dust, as well as sulfate aerosols, in the atmosphere changes the optical properties of clouds. As a result, the Earth's surface is less heated since the reflecting power of the atmosphere increases.

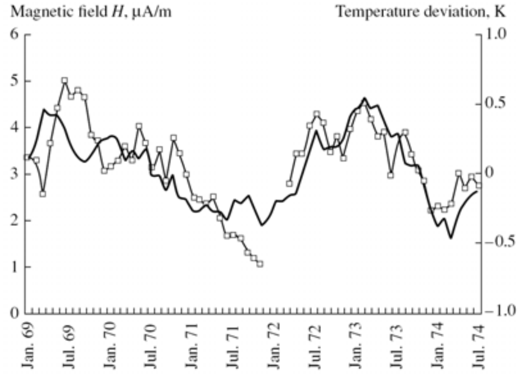

Figure 1. Fluctuations of the monthly average temperature and the magnetic field of the fundamental mode [9].

Violent volcanic eruptions can lead to a decrease in the average temperature by several tenths of a degree over subsequent years. Such a decrease in the average temperature was observed, e.g., after the Mount Tambora (1815), Krakatoa (1883), and

EPSC Abstracts,
Vol. 4, EPSC2009-206-1, 2009
European Planetary Science Congress,

Agung (1963) eruptions. Since there is correlation between the monthly average temperature and the fundamental mode of the SC magnetic field (see Fig. 2) [3], the amplitude of the first harmonic should decrease significantly after volcanic eruptions (as the temperature decreases by 1°C, the amplitude decreases twofold).
Summarizing the aforesaid, we present a scheme illustrating possible mechanisms for the influence of dust particles on SRs (see Fig. 2).

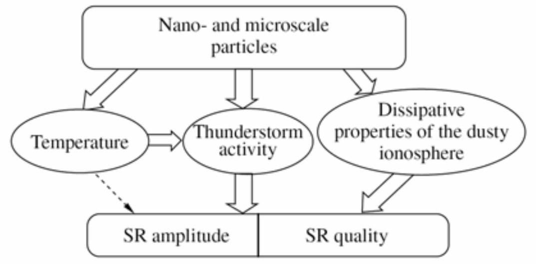

Figure 2. Possible mechanisms for the influence of dust particles in the atmosphere on SRs. The dashed arrow indicates correlation between the temperature and the SR amplitude.

Dust and Schumann Resonances on Titan

According to the data achieved from the Cassini/Huygens mission [4] Titan has an ionosphere with a structure similar to terrestrial one and a conductive surface. These facts make possible an existence of Schumann resonances on Titan. Cassini established a presence of electrical activity in a range of heights of 80-120 km. The source of SRs can be lightning, for Saturn's moon is covered with a dense cloudiness with the primary maintenance of liquid methane with nitrogen, and also water vapour [5]. Lightning can also be trigged by activity of cryovolcanoes which results in eruption of water of ammonia and methane.
Investigations of SRs on Titan are of a great interest because the atmospheres of the Earth and the Titan are very similar on the chemical compound (prevailing the nitrogen maintenance, presence of cloudiness and downfalls), so understanding of physics of SRs on the Titan will help to understand similar processes on the Earth. Besides considering that on the Earth the basic sources of dust are technogenic processes and meteoric substance, and on the Titan formation of dust particles is promoted by global photochemical reactions in all its atmosphere (so its concentration should be higher) it is reasonable to assume that on the Titan influence of a dust on the electromagnetic phenomena is much more essential than on the Earth. According to nowadays observations and laboratory experiments [5] the main component of dust are tholins, which form dense orange smog, evaporated meteor matter, and ice dust from cryovolcanoes. Spectral analysis shows that the dust particles are aggregates of some hundreds of very small particles, about 50 nanometers across. Now it is shown [6] that the dust layer reaches down to the surface. Analogously to the situation oh the Earth, the dust influence on SRs on Titan is reduced to the decrease in quality factor of the SC, owing to amplification of dissipative processes, and an increase in storm activity as the dust promotes charge separation.

Acknowledgements

This study was supported by the Division of Earth Sciences, Russian Academy of Sciences (the basic research program “Nanoscale particles in nature and technogenic products: conditions of existence, physical and chemical properties, and mechanisms of formation”) and by the Division of Physical Sciences, Russian Academy of Sciences (the basic research program “Plasma physics in the Solar system”). One of the authors (S.I.P.) acknowledges the financial support of the Dynasty Foundation.

References

[1] Klumov, B.A., Morfill, G.E., and Popel, S.I. (2005) *JETP*. 100, N 1, 152-164.

[2] Besedina, Yu.N., Popel, S.I. (2007) *Plasma Physics Reports*, 33, N 2, 138–145.

[3] Williams, E.R. (1992) *Science* 256, 1184-1187.

[4] Navarro, E.A., Soriano, A., Morente, J.A. Portí, J.A. (2007) *Radio science*. 42, RS2S04, doi:10.1029/2006RS003490.

[5] Owen, T., Atreya, S.K., Niman, H. (2005) *Usp. Fiz. Nauk.* 175. 664-668.

[6] English, M.A., Mcbridge, N. (1995) *Earth, Moon, and planets* 71, 265-271.