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Feasibility study of artificial rainfall system using ion seeding with high voltage source

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ABSTRACT

A non-linear computational modelling of ions from the ground station for electrifying the atmosphere to make feasibility study of artificial rainfall system is proposed and analyzed. The model considers generation of intermediate ions and ionized airflow velocity. The governing electro hydrodynamic (EHD) equations of the model shows that the space charge density, electric field intensity and velocity of the ionized airflow are function of high input voltage applied to generate the ions. The number of ions generated and their velocity is proportional to the applied ion generator voltage.

These artificial ions will be introduced in the atmosphere which will act in a similar manner as cosmic rays. These ions will ionize the aerosols and catalyze nucleation processes and thus electrify the atmosphere which will form cloud droplets to get artificial rain. The mathematical model to study the feasibility of artificial rainfall is also validated under favourable conditions.

Introduction

The necessity of having an effective analyzing tool is rapidly growing alongside the implementation of artificial rainfall techniques. Finding an appropriate multi-disciplinary model to study and implement the artificial rainfall system has become increasingly important in today's atmospheric science environment. However, the conventional cloud seeding techniques, which routinely requires huge investment, is not economic to manage the growing requests. Recently, a few new techniques that are used to assist the artificial rainfall have emerged. The modelling techniques and its simulation will reduce the time and money to make artificial rainfall, and improve operational performance. Given today's demand of the water requirement, it is important to understand this technology and its benefits. This paper gives a real-life example of how to make use of governing equations of ions to electrify the atmosphere for artificial rainfall. It is the first in the literature that reports the analysis of seeding technique of ions to electrify the atmosphere to study the feasibility of artificial rainfall based on modelling and simulation. Thus unlike cloud seeding, electrification of atmosphere approach.

- Does not emit chemicals into the air.
- Does not require aircraft and other expensive facilities.
- Is not dependent upon the presence of clouds to produce precipitation.

From the rain making process it is seen that the atmosphere can be ionized artificially to obtain rainfall. To ionize the atmosphere artificially, corona discharge the effect responsible for natural rainfall is preferred as it is a low energy discharge that produces ionization at the cost of a few mW of power.

Intermediate ions and velocity of the ionized airflow/wind is generated by the application of very high ion generator voltage to the Electrifier (a device used to generate ionized airflow/wind). To maximize the number of ions and its velocity, the electrical and physical variables are altered and tested to extrapolate optimal parameters.

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Application of the model to govern the equations of electrifier theory will confirm the electrostatic and fluid flow operation, regarding the optimization of parameters to maximize ionized wind velocity. In addition, the issue of Electrifier improvement techniques poses a challenge. Complex electric field interactions between the ion generator and shield electrodes lead to design difficulties and trial-error testing, instead of thorough analysis. Hence the optimization of the design parameters is carried out first using simulations. The experimental validation of these simulated results is also done to find the actual results. Mathematical model for feasibility study of artificial rainfall in the presence of water vapour by introducing continuous negative intermediate ions as aerosols, artificial rainfall is possible and is validated.

The proposed ion seeding technique is a low cost system compared to other systems. With one time investment and low maintainers cost it operates at very low range of high voltage. By considering above benefits it will be considered as a powerful tool.

Present state of art

The overall process of natural electrification of atmosphere responsible for coalescence and precipitation is shown in Fig. 1 and summarized [2,3,18–20,25–32,34–37]. It is demonstrated that air ions play an important role in the production of new particles under typical tropospheric conditions [Yu and Turco, 2000, 2001]. There are positive ions and free electrons present in the air as a result of background radiation by radioactive elements free photon excitation and cosmic radiation occupying the atmosphere. When electrons combine with the air molecules, negatively charged ions are formed, which immediately begin to attract groups of molecules of the atmospheric water vapour. The majority of the ionization is caused by cosmic radiation where the electric field is high. Radon gas released from the Earth's crust can cause radioactive ions to attach to airborne dust and other particles to form aerosols by nucleation. Attached aerosols coagulate to form condensation nuclei (CN) which further condense to give cloud condensation nuclei (CCN) to form cloud. The organics species and water molecules may play an important in growing the CN into the size of cloud condensation nuclei CCN.

Artificial electrification of atmosphere can be initiated and induced by generating abundant corona effect negative ions in the atmosphere. When high density uni-polar ions are added in the atmosphere, the recombination losses are negligible. As after recombination with available opposite polarity ions, high density ions acts as seeds for further reactions with dust particles. The net effect of ionization is to charge pre-existing aerosol or form new charged aerosol. Ions produced by direct current generators add to and enhance the catalyzing effects that cosmic ray ions are now known to produce in, among other things, lowering nucleation barriers, stimulating charged particle growth and stability and increasing the scavenging rate in clouds [20]. The injection of a large number of DC corona effect ions induces changes in cloud micro-physics and cloud cover and, consequently modifications in weather conditions. It is expected that DC generated ions are going to be a more aggressive catalyzers than cosmic rays as corona effect ions are hygroscopic and grow rapidly with increased humidity [18].

If these artificial ions are generated above the boundary layer (1–2 m above from the ground level) with humidity 60–70 percent (sufficient water vapour) available in the atmosphere, then these artificially generated ions of intermediate size (8–10 nm) may grow up to CCN (80–90 nm) particles and help for the formation of ion rain [25]. The particle flux changes directly affect the atmospheric concentration of ions, and indirectly affect the density of space charge in the troposphere. The changes in space charge and/or ion concentration are likely to affect properties of atmosphere to have artificial rainfall by electrifying the atmosphere.

When sufficient electric potential is supplied to the ion generator electrode it begins to display corona effect thus emitting electrons. The grounded shield electrode provides a stable outflow of the electrons emitted, thus maintaining the maximum possible level of emission from the ion generator electrode. The majority of the electrons emitted by the ion generator electrode and repelled by the negative background potential of the earth surface tend to rise upwards into the atmosphere forming a stable flow [29]. Since the direction of the ion flow is defined by the charge of the earth surface and the direction of the air stream is defined by the atmospheric pressure gradient, the overall direction of air stream will be substantially vertical under favourable conditions (e.g. in the absence of strong horizontal wind, this being typical for anticyclone areas) [36]. Thus, a stable upwards ionized air stream (or “current”) is formed in the atmosphere which is responsible for the rainfall.

The growing of the negative ion into a raindrop is stepwise process as shown in Fig. 2.

The presence of water molecules, H_2SO_4, HNO_3, $^{**}NH_3$ and other similar gases accelerate the flow of the ionized molecular complexes formed in the atmosphere. The charged molecular clusters, thus can preferentially achieve stable, observable sizes. The

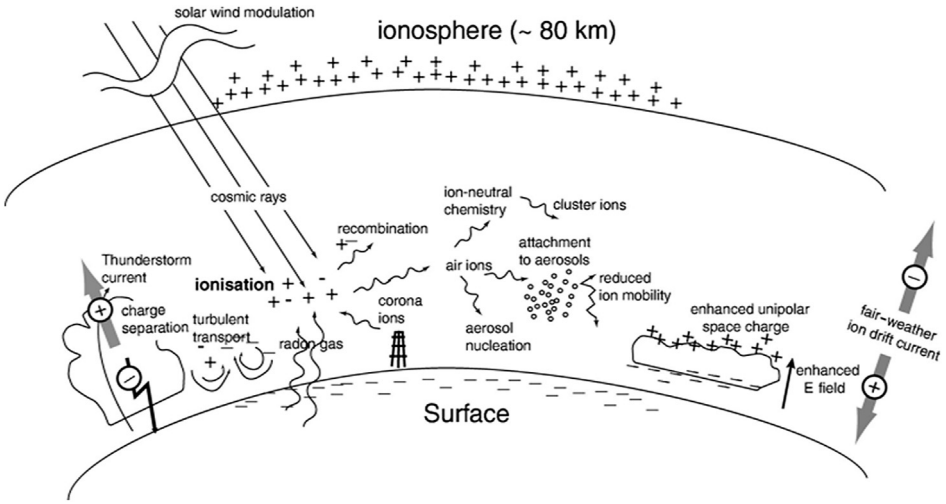

Fig. 1. Role of corona effect ions to form clouds [31].