

ARTIFICIAL ATMOSPHERIC IONIZATION: A Potential Window for Weather Modification

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Abstract:

Galactic cosmic rays have been positively correlated to the Earth's low cloud cover. It is now evident that cosmic ray ionization is linked to lowering nucleation barriers and promoting early charged particle growth into the Aitken range. There is a substantially high probability that some of the charged particles grow to the 100 nm range and beyond to become CCN. There is also evidence that electrically charged aerosol are more efficiently scavenged by cloud droplets, some of which evaporate producing evaporation aerosol, which are very effective ice formation nuclei.

The assumption is made that artificially generated, corona effect ionization should act in much the same way as cosmic ray ionization, with some differences that might make unipolar corona effect ionization a more powerful catalyzer of cloud microphysical processes and, consequently, climate. There is much further work required to understand the cause and effect relationship between artificial ionization and weather, including electrical, chemical and physical measurements at the nanoparticle level and beyond, as well as mathematical modeling to describe the observed, measured or hypothesized atmospheric phenomena at different levels of artificial ionization, and, hopefully equal levels of cosmic ray ionization.

Introduction: Cosmic Rays and Cloud Processes

In 1997 Svensmark and Friis-Christensen reported a correlation between cosmic rays and cloud cover (1). They found that the observed variation of 3 – 4% of the global cloud cover during the recent solar cycle is strongly correlated with cosmic ray flux. This was hailed by some as the key to the mystery of how the sun affected climate and produced climactic changes. It was also a confirmation of the long standing suspicion that cosmic rays were linked to global cloudiness.

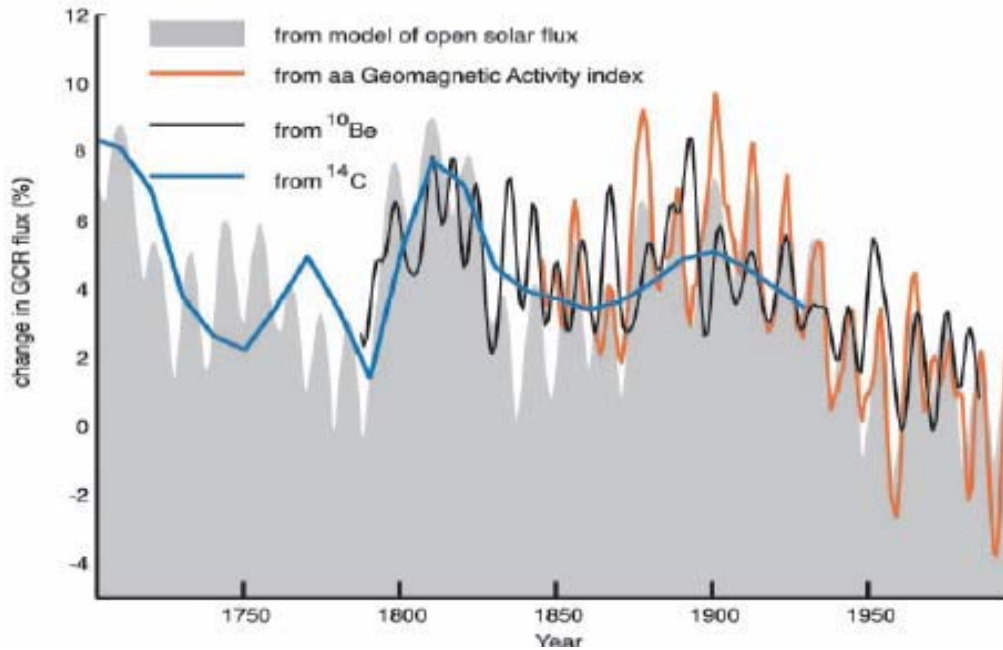
Numerous articles followed studying the catalytic effects of ions from cosmic rays on micro-physical cloud processes and cloud cover. Of particular interest is the observation from recent satellite data, that cosmic ray-cloud correlation is much more intense in low level clouds than in high level ones. More cosmic rays correlate to more low level clouds (altitudes of less than 3 km) and lower temperatures (1). Low clouds exert a large net cooling effect on the climate. Therefore, greater cosmic ray intensity translates to more cloud cover and cooler temperatures.

The link between global low cloud amounts and cosmic ray intensity has been published in the U.S. by Marsden and Lingenfelter who say: "The observed correlation between global low cloud amount and the flux of high energy cosmic rays supports the idea that ionization plays a crucial role in tropospheric cloud formation". (3)

Cosmic ray flux variability is not limited to a solar cycle. Although the energy input from cosmic rays is tiny, as the dominant source of ionizing particle radiation, they have a profound effect on many atmospheric processes. Through interaction with air nuclei they generate isotopes such as ^{10}Be and ^{14}C , which is the basis for Carbon dating and reconstructing past changes of cosmic ray activity. The model of open solar flux has been analyzed, together with data from archives recording ^{10}Be concentration in ice cores and ^{14}C rings on trees and a strong correlation has been observed (2).

From those observations, it has been established that cosmic ray intensity declined about 15% during the 20th century, roughly about the same variation as the last solar cycle, as can be seen in figure 2.

Figure 2- Fluctuations in Cosmic Ray Flux



As can be observed, in the above graph, decadal, centennial and perhaps even millennial changes in GCR flux translates into long term weather changes. The correlation is not well established here and is, clearly, an open issue that warrants further modeling.

Ions produced by galactic cosmic rays are lost by one of three processes (4):

1. Ions are quickly lost due to a mechanism called ion-ion recombination.
2. Many of the remaining ions after ion-ion recombination will attach to aerosol, charging the aerosol.
3. When ion attachment occurs in a cloud, ions attach directly to water droplets, charging the droplet.

Ice Nucleation

Charged aerosol are attached easily to cloud droplets (scavenging). The resulting charged droplet, when at the cloud – clear air boundary, will often evaporate. When it does, all its charge and traces of the organic and inorganic aerosol it attached in the past remain with the evaporation nucleus.

This nucleus is now an effective ice formation nucleus. A supercooled droplet scavenges this

evaporation nucleus and freezing can occur as a consequence of contact ice nucleation. This process is called electroscavenging (6).

Charged Versus Uncharged Clusters

Recent modeling work suggests that a charged atmosphere will have a lower nucleation barrier and will also help stabilize embryonic particles. This allows nucleation to occur at lower vapor concentrations. Other work by Yu and Turco [2000] demonstrates that charged molecular clusters, condensing around natural air ions can grow significantly faster than corresponding neutral clusters, and can preferentially achieve stable, observable sizes” (7)

The models also indicate that the nucleation rate of fresh aerosol particles in clean regions is limited by the ion production rate from cosmic rays (2).

Stable charged molecular clusters resulting from water vapor condensation and coagulation growth can survive long after nucleation. “Simulations reveal that a 25% increase in ionizing rate leads to a 7-9% increase in concentrations of 3 and 10 nm particles 8 hours after nucleation.” (6)

Nucleation

Aerosol particles of terrestrial origin are formed by three major mechanisms:

- (1) gas-to-particle conversion (GPC),
- (2) drop-to-particle conversion (DPC), and
- (3) bulk-to-particle conversion (BPC).

The first one precisely promotes the formation of new aerosol particles from nanoparticles and gives an important role to the present ions.

In the atmosphere where normal supersaturations do not exceed 2%, GPC without a pre-existing aerosol particle has, essentially, four nucleation sub-mechanisms:

Binary Nucleation:
($\text{H}_2\text{SO}_4 - \text{H}_2\text{O}$)

Ternary Nucleation:
($\text{H}_2\text{SO}_4 - \text{H}_2\text{O} - \text{NH}_3$)

Ion Induced Nucleation:
($\text{H}_2\text{SO}_4 - \text{H}_2\text{O} - \text{Ion}$)

Ion Mediated Nucleation:
($(\text{H}_2\text{SO}_4)_n - (\text{H}_2\text{O})_m - \text{Ion}$)

The difference between IIN and IMN is that in IIN the ion is the one attaching to new molecules and in IMN it is the molecules within the cluster that are attaching to new molecules.

It has been observed that when the concentration of H_2SO_4 (or nitric acid) vapor is low, the observed nucleation rate is less than the predicted rate for binary nucleation. If there is a third species (such as, for example, ammonium or even an organic species) the observed ternary nucleation rate is much closer to the predicted rate.

The two proposed nucleation mechanisms that have been used to explain the observed nucleation events occurring in Earth's atmosphere are ternary nucleation and, preferentially, ion mediated nucleation (8)

Ionization and Cloud Properties

Recent observations, simulations, models and research establish a relationship between cosmic ray ionization and cloud microphysics "... A mechanism linking cosmic ray ionization and

cloud properties cannot be excluded and there are established electrical effects on aerosol and cloud microphysics." (6).

Building on the relationship between low cloud cover and cosmic ray ionization the observations are extended to the realm of cloud microphysics by exploring this idea quantitatively with a simple model linking the concentration of cloud condensation nuclei to the varying ionization rates due to cosmic rays.

Cosmic rays produce positive ions and free electrons. Many of these ions will be quickly lost to ion-ion recombination. Some of the ions escape recombination because the ionization produced by cosmic rays often is skewed because the positive and negative ions that are generated are not exactly equal in number. Some of the ions escape recombination because their opposite charge would be combining ion attached to an aerosol instead. The surviving ions will either attach themselves to an aerosol, thus charging the aerosol, or else grow by condensation and coagulation into charged particles called ion clusters.

So far, we have ions that have attached to aerosol, ions that have grown to ion clusters and ions that have been lost by recombination to form neutral particles. Some of the ion clusters (subcritical embryos $< 3\text{nm}$) will quickly attach to aerosol, thus charging the aerosol, or else continue to grow through condensation and coagulation to become critical embryos, then through the Aitken particle size range of 3 to 80 nm and from there, some will become cloud condensation nuclei (CCN $> 100\text{nm}$). (2)

Aerosol particles of all sizes are capable of becoming condensation nuclei, provided the supersaturation is great enough. Direct condensation by water vapor onto ions cannot occur in the open atmosphere because the level of supersaturation (S) is far too high to occur in the atmosphere, it must be achieved in a laboratory, in a Wilson cloud chamber, for example (the level is approximately 400%; $S=4$).

If the condensation nucleus is large enough to cause condensation at atmospheric levels of supersaturation, usually no more than a percent or two and typically around 0.06% then the condensation nucleus is considered to be a Cloud Condensation Nucleus and is of primary interest in atmospheric physics.

Particle Growth Processes

Once ions have attached to aerosol, recombined with another ion or grown into aerosol, there are several aerosol particle processes that regulate

the concentration (number of particles cm^{-1}) of particles as well as the growth of these particles in the troposphere.

- a. **Condensation:** This is a process where water molecules condense on an aerosol, changing phase from gaseous to liquid and releasing latent heat. The aerosol grows as it acquires water molecules, adding to its diameter and mass. Charged aerosol are more effective in inducing condensation than uncharged ones because polar molecules have an enhanced condensation rate. Calculations show that this growth rate is greater by a factor of at least 2, and, since a 5 nm particle's coagulation loss rate is $1/20^{\text{th}}$ that of a 1 nm particle, it is an important factor in determining the early survival rate of aerosol (2).
- b. **Coagulation:** This is a process where molecules (ligands) attach themselves onto aerosol through agglomeration
- c. **Scavenging:** The process whereby a cloud droplet collects an aerosol. If the aerosol is charged, the charge transfers to the droplet. The charged droplet will be further attracted to charged aerosol
- d. **Electroscavenging:** When a cloud droplet reaches the clear air – cloud boundary it often evaporates, leaving behind all its charge to the nucleus as well as coatings of sulfate and organic compounds that the droplet absorbed while in the cloud. Charged evaporation nuclei enhance collection by droplets because of their coatings and because they create an image charge on the droplet. Even if the droplet is charged with the same polarity as the nucleus, the image charge will greatly enhance the possibility of attachment. In supercooled clouds, droplet freezing can create contact ice nucleation (5).
- e. **Collision – Coalescence:** It is widely accepted that growth of droplets to raindrops by condensation of water vapor takes several hours (7). This means that the only probable mechanism for droplets to grow into raindrops is by collision. Larger drops fall faster than smaller drops, so they sometimes collide. However, the air

pressure of the larger, faster falling drop will, even if it is in a collision course with a smaller drop, may make the smaller drop go around the larger one and prevent collision. This is the same aerodynamic principle that causes most insects to avoid collision with an oncoming car, because the elevated air pressure surrounding the car will propel the insect away from the car. The collision efficiency of charged aerosol-droplet is increased by thirty-fold for aerosol carrying large (>50) elementary charges (9). It is possible that charged droplets collide with larger falling droplets by inducing the same type of image charge over and over again until a raindrop is formed, given a sufficiently large elementary charge. The following diagram shows how neutral aerosol escape collision because of streamline pressures, whereas charged aerosol cross streamlines, resulting in collision (9).

Partial Summary

Most ions generated by galactic cosmic rays will be lost because of ion-ion recombination. The remaining ions will catalyze the nucleation of ultrafine, stable particles ($<1\text{-}2$ nm) by condensation. Once this happens:

- Most of them will feed larger existing particles (aerosol) thus increasing particle size and catalyzing the process of CCN formation,
- Some will be scavenged by cloud droplets, contributing to the cleansing effect of depositing small particles (pollutants) on the ground, and,
- A fraction of the ultrafine condensation nuclei will again condense and coagulate to form critical embryos (2-5 nm) and a fraction of the former will again coagulate and condense to form cloud condensation nuclei ($\sim 100\text{nm}$).
- Some CCN will grow through condensation and coagulation to form cloud droplets (activation).
- Charged aerosol can grow to become ice formation nuclei through electroscavenging.

Hypothesis: General Statement and Conceptual Model

Ions produced by direct current generators by corona effect will 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.

The injection of a large number of DC corona effect ions will induce changes in cloud microphysics and cloud cover and, consequently modifications in weather conditions. For reasons explained below, it is expected that DC generated ions are going to be a more aggressive catalyzer than cosmic rays.

Hygroscopicity

It is clear that corona generated particles are hygroscopic and grow rapidly with increased humidity, while laser created particles are only weakly influenced by humidity (10) thus reinforcing the possibility that corona effect ionization will complement or even potentiate cosmic ray ionization's effect on cloud physics.

Ion Losses

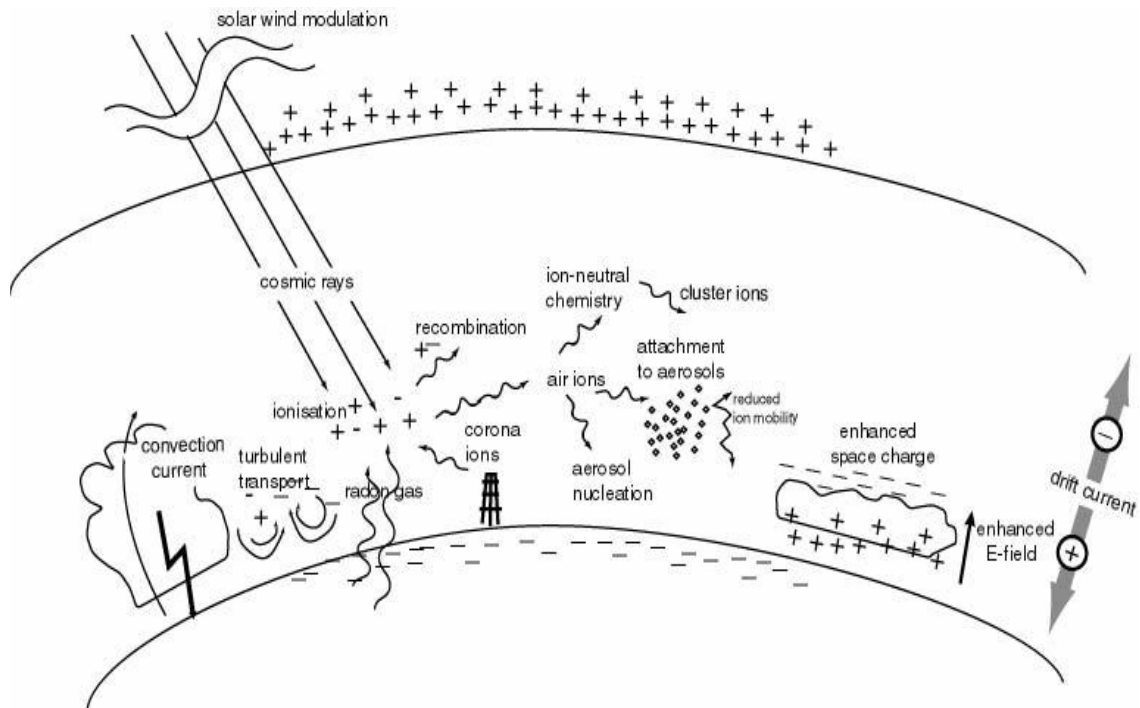
Since all DC generated ions will have the same polarity, very few ions will be lost due to ion-ion recombination. That means that almost all these small ions are lost only by ion-aerosol and ion-droplet attachment in clouds. What this means is

that almost all the ions produced by direct current sources are available to feed aerosol or droplets.

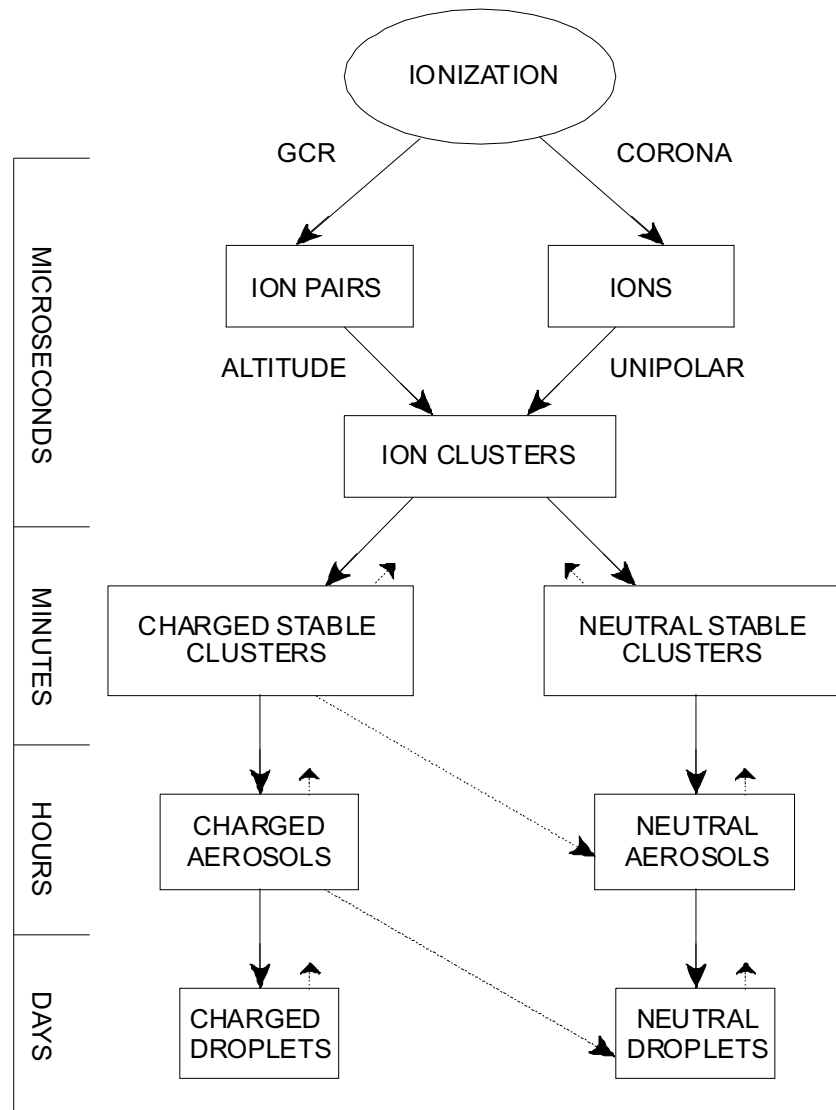
Other Considerations

1. Particle growth processes will essentially be the same as for particles ionized by cosmic rays.
2. Just like particles ionized by cosmic rays, particles ionized by corona effect ions will quickly stabilize and grow to the critical embryo (1-2 nm) and beyond, to the Aitken particle phase.
3. Certainly Aitken particles and perhaps some growing critical embryo particles have the stability that is required to survive long enough to reach and surpass the PBL through convection, turbulence and thermals.
4. Ionization may improve conductivity in the lower atmosphere by cleaning pollutants which are barriers to the Earth's natural current flow. If the atmosphere is cleansed of pollutants, increased precipitation will be achieved.

Corona effect ions may have a role in catalyzing atmospheric phenomena as suggested by R.G. Harrison and K.S. Carslaw in 2003



Conceptual Model



The conceptual model diagrams the operation of natural (galactic cosmic ray produced) and anthropogenic direct current corona effect ionization operating in parallel. Galactic cosmic ray ionization is greater in the upper levels of the atmosphere and only a small fraction of ions reach the lower levels of the troposphere. Cosmic ray ionization has the advantage that it occurs at the tropospheric level that is of interest (0.5 – 3 km), whereas corona effect ionization occurs at ground level and so it can only reach the altitude required by creating stable particles that gain altitude by the atmosphere's convective current, turbulence or thermals.

In both cases, cosmic ray or corona ions, will quickly ($< s$) form ion clusters that have the stability and lifetime to allow them to either attach or grow by condensation and coagulation into stable charged clusters. This will happen in a time-span of a few minutes. In either case the net effect of ionization will be to charge pre-existing aerosol or form new charged aerosol. Aerosol have lifetimes measured in hours and sometimes days, depending on a wide array of variables.

Aerosol may grow to become CCN and, CCN, in turn, may activate to become water droplets.

Water droplets may collide and coalesce to become raindrops.

At any stage of evolution, particles may lose their charge and become neutral. When this happens, the particle loses its preferential growth capabilities, thus decreasing its probability of becoming a CCN. Also, at any point in the process, the reverse path may apply. Thus charged aerosol may grow by condensation and coagulation into CCN, but a portion of the CCN might also lose their CCN size by evaporation and become, once again, charged aerosol (or even uncharged aerosol if they lose their charge as well). In general, however, the model proceeds according to the above diagram.

Epilogue: a Brief Philosophical Consideration

Cloud seeding has been the predominant tool used during the short history of the **Advertent**

Weather Modification discipline. It pretends to induce instability in cloud processes by using chemical agents. Experimental and operational works have suggested that glaciogenic seeding might produce increases in snow and rain of about 10 % over an area, whereas hygroscopic seeding is still under scrutiny. However these increases do not seem to be enough to solve the increasing demands of water in many regions on Earth and the discipline of Weather Modification urges to broaden its horizon. On the other hand, **Inadvertent Weather Modification** has pointed out that the anthropogenic byproducts can produce irreversible alterations in local weather. In particular, gas-to-particle conversion appears to be the mechanism through which great non-intentional alterations might be acting on specific local and regional areas. The hypothesis here presented suggests that atmospheric ionization might be used intentionally to improve degraded weather.

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Appendix 1: ELAT

The history of the Ionogenics' technology began in the mid '70's when Dr. Pokhmelnikh, a Russian scientist, started researching the effects of electricity in the atmosphere. In the 1980's, while working at the USSR Meteorological Protection Laboratory in Moscow, Dr. Pokhmelnikh continued his work in weather modification and developed the first patented atmospheric ionization technology and later founded ELAT, a Moscow-based weather modification company.

Pokhmelnikh's research on the atmospheric electro-magnetic field led him to believe that cosmic ray ionization had profound effects on cloud physics. His idea was that corona effect ionization could be used to boost the effects of cosmic rays on cloud properties.

In the 1990's, collaborative efforts between Mexican and Russian space programs eventually led to a meeting between Dr. Bisiacchi, the Director of the Mexican Space Program, and Dr. Pokhmelnikh. Dr Bisiacchi became interested in ELAT's technology and this, ultimately, led to their collaboration in an atmospheric electrification weather modification endeavor in Mexico, with the help of Mr. Heberto Castillo.

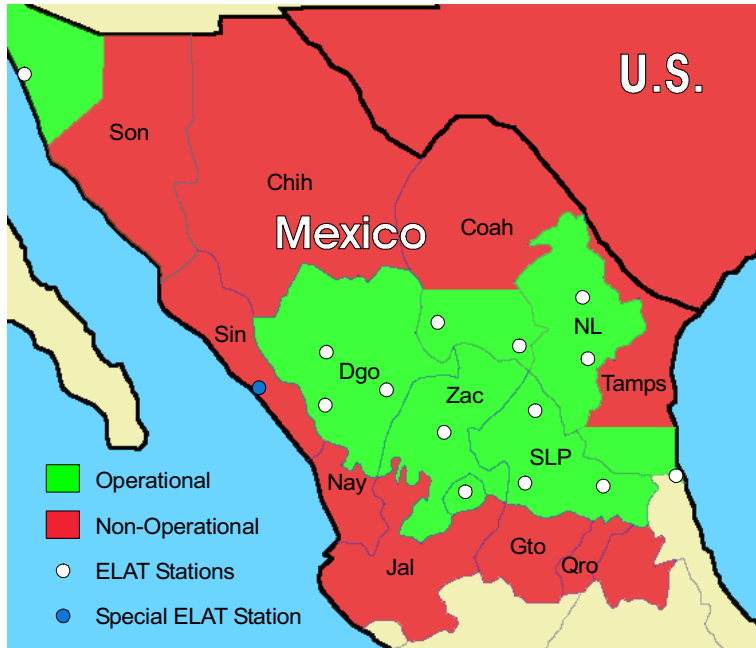
Mr. Castillo, Mexico's President of the Senate Committee on Science and Technology, and a long time associate of Dr. Bisiacchi, was introduced to the ELAT technology. Quickly recognizing the significance of the technology and its potential to help Mexico address its

ongoing drought, Mr. Castillo obtained funding to transfer the ELAT technology and company from Russia to Mexico where ELAT S.A. was formed. Shortly thereafter ELAT secured a contract to provide its atmospheric ionization weather modification services to the state of Sonora, an arid state with much of its land categorized as desert.

Mexican Operations

ELAT technology has been put to work in Mexico since 1996 and the results have been such that the state governments in Mexico have expanded the original network of 3 stations (in 1999) to 21 in 2004. The federal government held a meeting last January to discuss this technology with participation by 7 federal agencies and representatives from 9 states in Central and Northern Mexico that had been, or were planning on becoming, users of ELAT technology. The result of that meeting is that the federal government, specifically the Mexican Council on Science and Technology, will fund the continued expansion of the operational network up to 36 stations by 2006. Additionally this federal agency will also fund a research program where ionization stations will be set up with the sole objective of performing further research on ELAT ionization technology and not for operational results.

The following map describes the areas where ELAT technology operated in Mexico from 1996 through 2002:



The white dots represent ELAT stations operating in precipitation enhancement mode and the blue dot represents an ELAT station that in 2002 was operating in precipitation inhibiting mode.

The green areas are where ELAT stations were operational, red is where they were not operational. In some cases (Tamps, Coah and Son) the ionization stations located in the green areas covered only part of the state. The names of the different states are as follows:

Son = Sonora
Chih = Chihuahua

Coah = Coahuila
NL = Nuevo Leon
Tamps = Tamaulipas
Sin = Sinaloa
Dgo = Durango
Zac = Zacatecas
SLP = San Luis Potosi
Nay = Nayarit
Ags = Aguascalientes
Jal = Jalisco
Gto = Guanajuato
Qro = Queretaro
Hdgo = Hidalgo

Operations Data – Indicators

Data gathered from Mexican operations from 1996 through 2003 provide strong indicators that the technology has produced measurable and, in some cases, dramatic results.

One of the projects covers the operational areas is Central and South Durango (CS). It started operations in 1999 and continues operating today.

Conditional Probability (VD in CS / VD in N) = 73%
 Conditional Probability (D in CS / VD in N) = 20%
 Conditional Probability (N in CS / VD in N) = 7%

In order to evaluate results a categorization of years was established based on precipitation: The lowest precipitation quintile (0-20%) is categorized as Very Dry. The following quintiles are labeled Dry, Normal, Wet and Very Wet. The years during the period 1999-2003 were very dry in the control area, Northern Durango (ND) and for the period 1931-1998, in the operational area (CS):

What this means is that when conditions were very dry in Northern Durango, in the last 72 years of data:

1. There were only 5 years when conditions were "Normal" in Central-Southern Durango

2. There were 14 years with "Dry" conditions in Central-Southern Durango
3. There were 53 years with "Very Dry" conditions in Central-Southern Durango

The equation used for predicting precipitation in Central-Southern Durango with precipitation in Northern Durango was given is:

$$\text{PrecCS} = 0.33 \text{ PrecN} + 156.6\text{mm}$$

**Precipitation – Durango
 Central South vs. North
 (mm)**

	1999	2000	2001	2002	2003
Predictor Values (Prec N)	156	185	148	212	210
Predicted Values (Prec CS)	192	211	186	230	226
Actual Values	246	300	244	365	324
Probability	13.16%	0.0076%	12.54%	0.030%	0.060%
Difference Actual to Pred'd	54	89	58	135	98
Standard Errors	1.58	2.60	1.70	3.96	2.87

Note: Standard Error is 34.1 mm

The joint probability of these five independent events (each year being considered as an event) is 2.258×10^{-12} . The odds that these five events occurred naturally are less than 1 in 400 billion.

Another example of dramatic data produced by Mexican operations involves the comparison between precipitation in Durango and its neighbor to the West, Sinaloa. The operation during 2002 (and ONLY during 2002) was unique in that Durango had its three stations operating in a precipitation enhancement mode, while Sinaloa

had a single station operating in a precipitation inhibition mode.

The historical (1931 to 2001) precipitation factor, that is, the precipitation in Central-Southern Durango divided by the precipitation in Southern Sinaloa has mean value of 0.650 and a standard deviation of 0.123. The historical data is normally distributed.

The precipitation factor obtained in 2002 was 2.182. This factor is over 12 standard deviations above the mean of 0.650:

$$2.182 = 0.65 + Z \times 0.123;$$
$$Z = (2.182 - 0.65) / 0.123$$

$$Z = 12.455$$

It is impossible to calculate the probability of the occurrence of an event that is over 12 standard deviations away from the mean because the probability is so low. In fact, any event more than 6.5 standard deviations away from the mean is considered to have zero probability of occurrence.

where **Z** is the number of standard deviations

Summary – Mexican Data

The two examples cited above are strong enough to warrant further scrutiny. Had this data originated in the United States, where data is better controlled, the technology would be the subject of extensive research, evaluation and operational use.

Appendix 2: HEALTH AND ENVIRONMENTAL CONSIDERATIONS

This ionization technology injects ions into the atmosphere. Nothing is being introduced into the environment but ions. No magnetic field is associated with direct current precisely because it is direct current.

Some studies have been published associating cancer with populations that live *directly* under high voltage power transmission lines. As an example, one such paper concludes: "The total (indoor + outdoor) 218 Po and 214 Po dose to the basal layer of facial skin is increased by between 1.2 and 2.0 for 10% of time spent outdoors under high voltage power lines" (11). There are some problems with this conclusion, not the least of which is that 10% of time spent outdoors means an average of 2.4 hours (2 hours and 24 minutes) spent outside, *directly* under high voltage power lines and living indoors, again *directly* under high voltage power lines seems somewhat excessive.

None of these publications have been able to establish a link between the intensity of the electric field and any harmful effect on the environment. The reason is that the only component of the high voltage lines that has been linked with harmful side effects has been the magnetic field generated by those lines.

There is, however, widespread disagreement even on the hazards of magnetic fields associated with high voltage power lines:

- In 1999 the National Academy of Sciences, National Research Council (NRC) published a review of the evidence from the EMF-RAPID program and concluded: "An earlier Research Council assessment of the available body of information on biological effects of power frequency magnetic fields (NRC 1997) led to the conclusion 'that the current body of evidence does not show that exposure to these fields presents a human health hazard. . . .'"
- "There are no known health risks that have been conclusively demonstrated in

relation to living near high-voltage power lines. But science is unable to conclusively prove that anything, including low-level EMFs, is completely risk-free. Most scientists believe that exposure to the low-level EMFs near power lines is safe, but some scientists continue research to look for possible health risks associated with these fields. If there are any risks such as cancer associated with living near power lines, then it is clear that those risks are small.")

Atmospheric ionization technology does produce a strong electric field, but it introduces no magnetic field whatsoever. Consequently, there is no disruption to communications or risk (however small) of cancer induced by powerful magnetic fields.

Some of the operational sites in Mexico have farm animals living directly under the ionization stations for as long as five plus years and there haven't been any reports of any side effects.

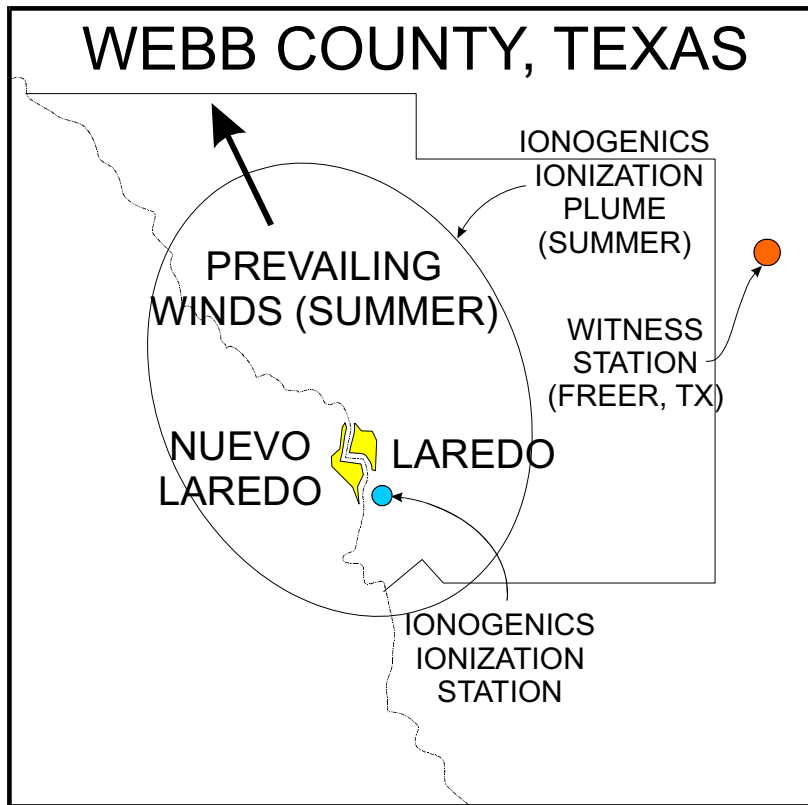
Many stories have been published linking negative ions with 'overall benefits for humans' and positive ions producing negative side effects on humans. While the ionization station operates almost all the time producing negative ions, no claims are made about providing any kind of health benefit to humans. No reports of any kind of environmental effect whatsoever have been received from either the operators of ionization stations in Mexico, the authorities in those areas or the population at large. The only reports even remotely linking the technology to impact on the environment were from testimonials from many of the Agricultural Commissioners that attended a Federal Government meeting on ionization technology in Mexico City last January. They indicated that climactic conditions in their state (or portions thereof) had changed because they were "...getting more precipitation, less forest fire damage, bigger crops and more robust livestock." (Roberto Von Bertrab, Agricultural Commissioner, Aguascalientes)

Appendix 3: Proposed Experiment in Webb County, Texas

To further explore the validity of ionization technology and to address the drought conditions in Laredo and surroundings, Ionogenics is proposing the installation of a single ionization station in the southeast suburban area of Laredo, Texas. Once the station is operational, a number of measurements will be taken in order to gather information that would allow approval or rejection of our hypothesis that DC generated ions produced by corona effect are inducing changes in the weather patterns of Webb County.

The following map of Webb County shows the location of the ionization station (blue), the location of the witness area, Freer, Texas (red) and the ellipse depicting the ionization plume that should result based on the direction of 3 km winds during the summer months. During the winter months the prevailing 3 km wind direction is from the southwest.

As can be observed, the ionization plume covers most of Webb County and some of part of the country of Mexico. It must be noted that current operations in Mexico have ionization stations where the situation is reversed: Mexican stations cover a portion of U.S. territory (Arizona).



Objective

The purpose of the Webb County experiment is to obtain data that will confirm or deny the credibility of the claims that Mexican users make regarding the weather modifications they have experienced, which are attributed to this technology.

Concurrently, it is certainly an objective to improve the drought conditions in Webb County by increasing the amount of rainfall. It is our objective to expand the operational side of the program during the second year and beyond and to continue to record data that will help us to better understand the atmospheric processes and, long range, to build a mathematical model that will link ionization activity to predictable atmospheric results.

Measurements and Data Analysis

Data will be obtained and analyzed in three different scenarios:

a. Historical Precipitation Analysis

There will be a record of monthly precipitation values for the available NOAA recorded values for Laredo from 1947 to 2003. Statistical analysis will be performed to compare precipitation levels obtained during the operational period to historical data. Historical precipitation data has been examined to assure that the distribution is normal, using the Kolmogorov-Smirnov test. The result of that test is that the 1947-2003 Laredo precipitation data does, in fact, have a normal distribution. Operational precipitation data will be compared to historical data on a monthly, quarterly and yearly basis,

b. Operational-Witness Analysis

This will compare the precipitation values in Laredo with a witness area that is to be Freer, Texas. The Freer historical precipitation data has been analyzed to assure that its distribution is normal, which it is. The precipitation data for Laredo and Freer have a good correlation (Correlation Coefficient ~ 0.72). It would have been ideal to find a location close enough to Laredo to have the same synoptic climatology and, at the same time, a higher precipitation correlation coefficient. If such a location existed, it would have

lowered the differential requirements for operational precipitation data to become convincing. However, such a location does not exist in the U.S. and this means that precipitation enhancement has to be strong enough to produce statistically significant results.

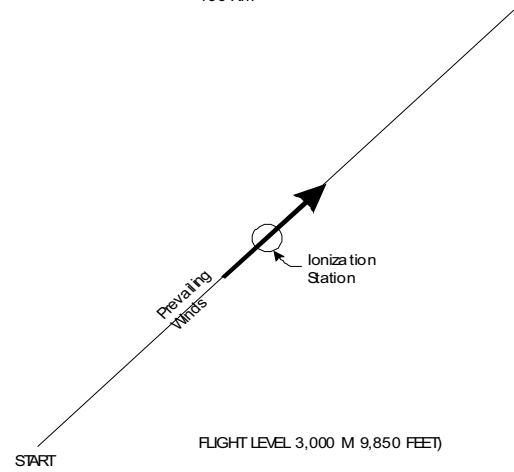
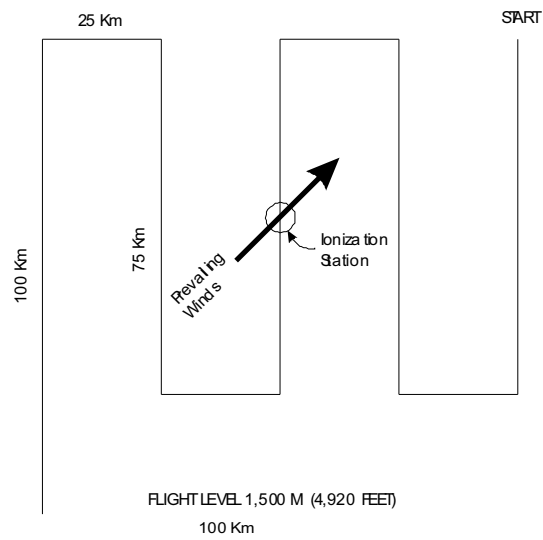
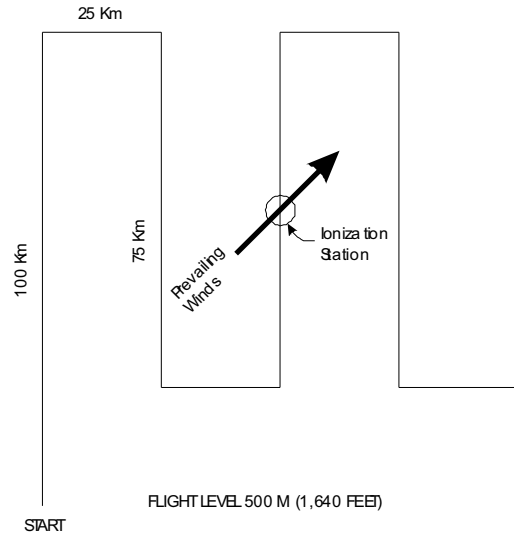
c. Real Time Analysis

In an attempt to understand the impacts that ionization stations are producing in the atmospheric boundary layer (ABL), an observational experiment was designed which would study how the ions released by the source diffuse in the ABL, how they affect the electrical atmospheric field in fair weather, and how they are correlated to the CCN particles. This first experiment would take place over the area around the ionization station. Every attempt will be made to secure the funding required to acquire the services of an aircraft laboratory, equipped with humidity and temperature sensors, an ion counter, a CCN counter, and an electrical atmospheric field sensor. Quasi-synchronic land observations would complement the airborne observations.

The goals are to measure at least the following variables:

- i. CCN's (greater than 100nm)
- ii. Ions (and their polarity)
- iii. Small CN's
- iv. Atmospheric charge
- v. Humidity

Flight Grids



In brief:

- i) Airborne and land data would be obtained for a single ionization station;
- ii) The basic grid is to be 100 km by 100 km, with the ionization station at the center;
- iii) Three level flights: 500 m (1640 feet), 1500 m (4920 feet), and 3000 m (9850 feet);
- iv) Two flights would be done before the station is turned on;
- v) Two flights to occur during the first week after the station is turned on;
- vi) One flight to occur about two weeks after the station is turned on.

This design will provide for an understanding of the actual rate of emission of the sources, the actual ion concentration and the plume dimensions.

Although the data acquisition method outlined above calls for an aircraft laboratory, equipped with the right type of instrumentation, alternative methods of data acquisition are currently review. The outcome of this review has not yet been finalized.

d. Temperature Analysis

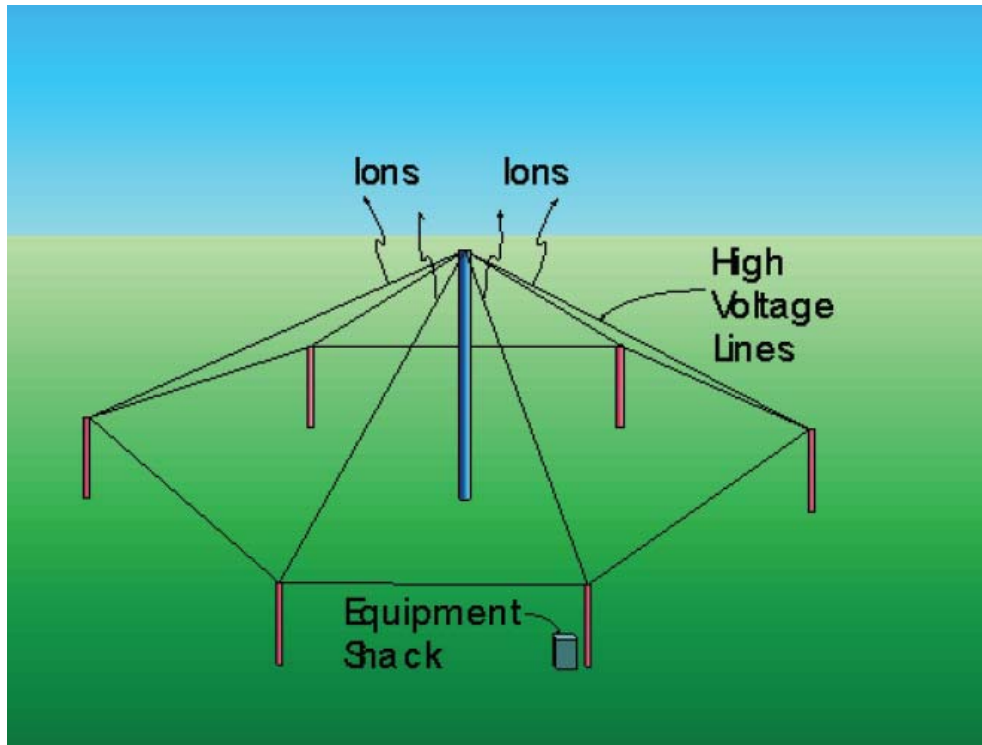
Historic and Witness/Operational area temperature data will be recorded and analyzed. The processes are exactly the same as those described for precipitation,

Required Resources

a. Ionization Station Equipment

Ionization weather modification technology utilizes an electrical antenna that is suspended on a central tower about 100 feet high and peripheral posts about 25 to 30 feet high. The central tower and peripheral posts are erected on a plot of land approximately 900 by 900 feet. Fed by a direct current power supply, the thin steel wire antenna releases positive or negative ions to modify the number of water condensation nuclei in the atmosphere. The modification of the energy balance resulting from this process induces small temperature changes over the area of influence which is about a 30 mile radius from the antenna.

These processes directly induce changes in weather phenomena with minimal electrical energy consumption. The following schematic diagram illustrates the layout of the antenna:



The power supply will be a 100 – 200 KV direct current supply with continuous duty cycle to allow operation 24 x 7 with the capability for remote control, diagnostics and self-testing and with reverse polarity circuitry that will allow operation to go from full

negative to full positive and back to full negative in a relatively short period of time.

Both the power supply and the computer interface that controls it will be housed in an equipment shack.

b. Weather Data

Weather data for this project will be provided by the WeatherTAP website as well as by weather stations in the operational area in Webb County.

The radar that WeatherTAP uses is the NEXRAD radar installed at Laughlin AFB, TX which is approximately 40 miles north-northwest of Webb County. The radar's range of 230km is ample to cover all of Webb County. Additional radar images would be available, if needed from Brownsville, also NEXRAD, which covers almost all of Webb County and San Antonio, again, also NEXRAD, which also covers most of Webb County.

Satellite imagery is a crucial tool for ionization station operational decisions. Both visible as well as infrared images are utilized. WeatherTAP's GOES-12 (Geostationary Operational Environmental Satellite) satellite provides the coverage required. Another tool that is very useful and is provided by the WeatherTAP satellite images is water vapor. Unfortunately, it may be necessary to access two regional satellite images to get the full picture for Webb County since it seems that the Eastern GOES-12 regional image and the Western GOES-10 regional image border almost exactly on Webb County, but this, hopefully, will only be a minor inconvenience.

Weather stations in Webb County will provide the standard meteorological data required for operation, such as precipitation, RH, temperature, pressure, wind speed, wind direction, etc. The use of MesoNet weather stations in the area is still being explored.