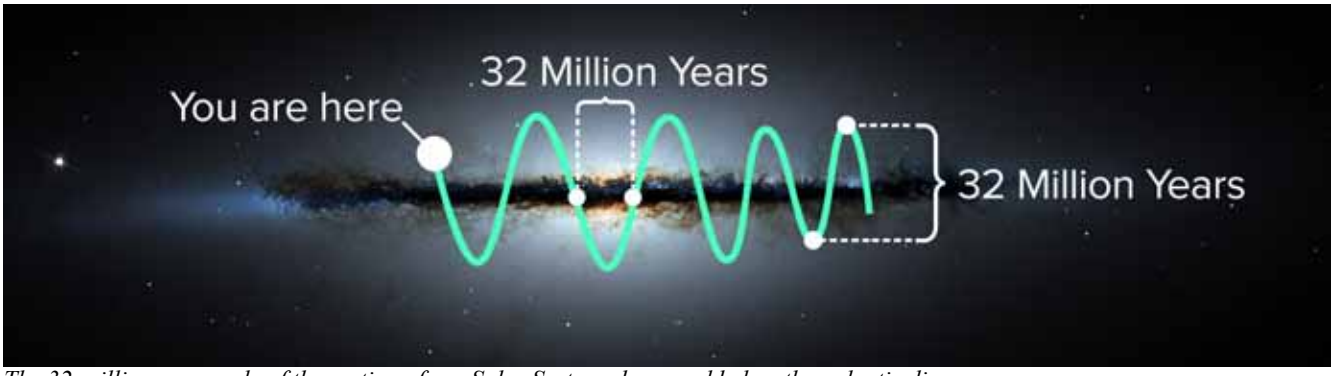
Atmospheric Moisture Control

Based on estimates of the global average, 413,000 cubic kilometers of freshwater is evaporated from the oceans each year. For comparison, the mighty Mississippi River discharges only 530 cubic kilometers into the Gulf of Mexico each year. The sum of all rivers added together only reaches 40,000 cubic kilometers per year—less than a tenth of the total ocean evaporation.

This atmospheric flow is an immense source of freshwater, generously provided by the work of the Sun—although 90% of it never reaches the land. Could mankind possibly tap into this unused portion of the freshwater being constantly produced by the Sun, a resource which is an order of magnitude larger than what is available in all the world's rivers combined?

This has been the subject of much speculation, investigation, and desire. "Rainmaking," "weather modification," and "cloud seeding" are terms that immediately come to mind. Could there be greater potentials for addressing the water crisis in this long-desired ability to influence and control the weather?

Here we will focus on one particular technology, the use of ionization systems to stimulate condensation and precipitation of atmospheric water vapor. A few differ-



The 32-million year cycle of the motion of our Solar System above and below the galactic disc.

ent variations of these ionization technologies have already been successfully used to increase rainfall in various nations, under various conditions, for decades. However, before discussing the successful demonstrations, the potential applications for the United States, and the interaction of this approach with others, we must start with a higher understanding of what this approach tells us about our water cycle.

The general method is to use these ground-based ionization systems to modulate the atmospheric conditions involved in determining when and where the atmospheric moisture condenses and precipitates. However, while these systems have shown clear success, we don't fully understand all the aspects of the atmospheric conditions involved in these processes—and the pursuit of a fuller understanding takes us in to a higher, galactic perspective on the nature of the Earth's water cycle.

A Galactic Perspective

As early as 1989, one of Russia's leading scientists in the field of solar-terrestrial physics, M.I. Pudovkin, put forward the hypothesis that galactic cosmic radiation was affecting the Earth's climate and weather.[2] Over the subsequent years, Pudovkin and his team became a leading group within a growing movement studying this Galaxy-Sun-Earth interaction.[3]

In the West, a similar thesis began being popularized in the late 1990s, when the Danish physicist Prof. Henrik Svensmark began to champion a new science of "cosmoclimatology." Svensmark and his associates showed correlations between changes in global cloud cover, and variations in galactic cosmic radiation, and proposed that the ionizing effects of cosmic radiation were playing a role in stimulating cloud formation, and thus affecting the climate by modulating the amount of solar radiation reaching the Earth's surface, by creating clouds. He posited that the ions created by galactic cosmic radiation become centers around which water vapor can condense, facilitating the development of clouds.

The role of galactic cosmic radiation in helping to stimulate the condensation of water vapor, carries additional implications for the energy balance of the atmospheric system. Because it takes a relatively large amount of energy to evaporate water, there is a vast store of potential energy in the water vapor of the atmosphere, and this energy gets released as heat when the water condenses back to a liquid state.[4] Just how much energy is involved here? Nearly a quarter of the Sun's energy reaching the Earth is captured in the process of evaporation, and released back into the atmosphere, as heat, when the vapor condenses. An energy equivalent to 7 million megatons of TNT is stored in the water vapor of the atmosphere at any one time, and the average flow of energy released by the condensation of water vapor in the atmosphere is about 30 million gigawatts (providing a major source of the warmth of the atmosphere)!

In comparison, the total energy of all the galactic cosmic rays intersecting the Earth is extremely small, quantitatively. However, the ionizing quality of that ga-

2. Correlations between solar activity and variations in climate have been long documented, but there is still much debate about how the interaction occurs. Because the Sun (through its magnetic field) modulates the galactic cosmic radiation reaching the Earth, Pudovkin proposed that it is actually the galactic cosmic radiation that is affecting the Earth's climate, and the correlation of climate changes with changes in solar activity is attributed to the Sun's role in modulating the flow of galactic cosmic radiation reaching the Earth.

3. O.M. Raspopov and S.V. Veretenenko,"Solar Activity and Cosmic Rays: Influences on Cloudiness and Processes in the Lower Atmosphere (in Memory and on the 75th Anniversary of M.I. Pudovkin)," *Geomagnetism and Aeronomy*, April 2009, Vol. 49, No. 2 (pp. 137-145).

4. The importance of this latent head release has been emphasized by Professor Sergey Pulinets. See, "Are Earthquakes Foreseeable? The Current State of Research," *EIR*, August 5, 2011.

Cosmic Rays and Katrina

To better understand the significance of galactic cosmic rays modulating the energetic conditions of the atmospheric system, consider a 2008 study that showed a remarkable relationship between solar activity, galactic cosmic rays, and the infamous hurricane Katrina which devastated New Orleans in 2005.[1]

As described in the study, one key component in the intensity of cyclones and hurricanes is the temperature difference between the relatively warm ocean, compared with the colder upper atmosphere. A greater temperature difference leads to a more intense convection process, in which the warmer ocean air rises up to meet the colder air high in the atmosphere above.

In the case of Katrina, while the storm was out over the Atlantic Ocean, the Earth's magnetic field entered a period of intense fluctuation, known as a geomagnetic storm.[2] Geomagnetic storms can, in turn, reduce the galactic cosmic rays entering the Earth's atmosphere, because the Earth's magnetic field acts to deflect charged particles like galactic cosmic rays. This lowering of cosmic-ray flux reaching the Earth due to a geomagnetic storm is a well-known phenomenon, called a Forebush decrease.

This geomagnetic effect is important, because the constant inflow of cosmic rays causes an ionization of the Earth's atmosphere, inducing condensation of water vapor and the release of latent heat.

Latent heat release plays a critical role in increasing the temperature of the cold upper atmosphere. A reduction in cosmic-ray flux (and its ionization effect) lowers the rate of condensation and latent heat release—leading to an even cooler upper atmosphere. As Katrina approached the Gulf of Mexico, the reduction of the cosmic-ray flux caused by the geomagnetic storm of August 24-25 led to a 9°C drop in the temperature of the upper atmosphere, *and a consequent increase in the intensity of the hurricane* (because the increased temperature difference between the warmer ocean and the now even colder upper atmosphere resulted in increased convection).

This shows how significant the seemingly weak force of galactic cosmic radiation can be in its interaction with the Sun-Earth system.

1 V.G. Bondur, S.A. Pulinets, and G.A. Kim, "The Role of Galactic Cosmic Rays in Tropical Cyclogenesis: Evidence of Hurricane Katrina," *Doklady Earth Sciences*, 2008, Vol. 422, No. 2, pp. 244-249.

2 Geomagnetic storms are generated by strong outbursts of solar activity which bombard and rattle the Earth's magnetic field, causing fluctuations in the intensity.

lactic input can act as a factor modulating these much more significant energy flows, by stimulating cloud formation and latent heat release. For an illustration of the type of effect, variations in galactic cosmic radiation can have on even the most powerful atmospheric systems, see the study by Professor Sergey Pulinets showing how a variation in the galactic cosmic radiation flux led to a significant strengthening of hurricane Katrina in 2005 (see box).

This provides a completely new perspective on the nature of the Earth's global water cycle. The atmospheric component of the water cycle, and the associated climate and weather experienced on Earth, expresses an effect from the galactic system as a whole—taking the water cycle beyond the Earth, or even the Solar System.

Other lines of evidence have already been pointing in this direction.

Studies of the very long-term records of the Earth's climate have indicated cycles of large-scale climate variations on the scale of tens of millions of years. On the order of about 140 million years, the Earth has cycled in and out of major periods of global glaciation, in a cycle which corresponds to the motion of our Solar System into and out of the spiral arms of our galaxy.[5] In a slightly shorter period, records indicate a 32 million year cycle of climate cooling and warming as well, a variation which corresponds to the oscillations of our Solar System above and below the plane of our galactic disc.[6]

The galactic cosmic radiation conditions vary in these different regions of the galaxy (above or below the disk, in the disk, in a spiral arm, etc.), and in both of

5. "The spiral structure of the Milky Way, cosmic rays, and ice age epochs on Earth," by Nir J. Shaviv, *New Astronomy*, Volume 8, Issue 1, January 2003, Pages 39–77.

6. "Is the Solar System's Galactic Motion Imprinted in the Phanerozoic Climate?" Nir J. Shaviv, Andreas Prokoph, and Ján Veizer, *Nature Scientific Reports*, August 2014, #6150.

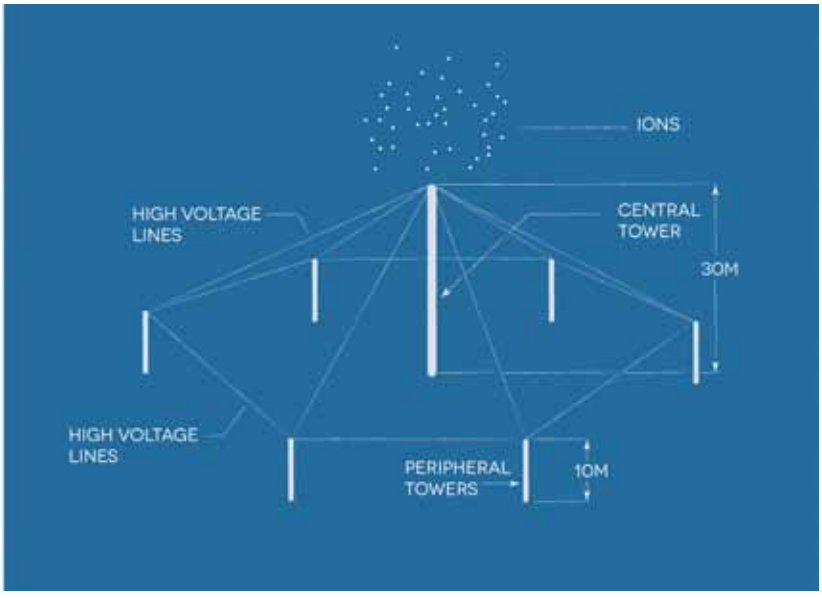


Illustration of the structure of an ELAT tower.

these long-term cycles, we see indications that the Earth's climate (and necessarily the global water cycle), changes in response to the experience of these different galactic environments.

This brings us back to the opening question: how to better understand and utilize the atmospheric conditions involved in determining when and where the atmospheric moisture condenses and precipitates. We see that this takes us to nothing less than the relationship between the Solar System and our Milky Way Galaxy.

The frontiers of water cycle management include tapping into and modulating the conditions related to and associated with this galactic factor in the water cycle (and climate)—that is, developing a galactic perspective on the water cycle, and utilizing that understanding to produce our own control over the system.

As mentioned above, tapping into this aspect of the global water cycle has certain unique advantages. First, it is a large resource. The water flow (from the oceans to the atmosphere) is an order of magnitude larger than the flow through all the world's rivers. Second, the Sun has already put in the bulk energy requirement for desalination. Third, tuned processes of ionization (using relatively low power levels) can trigger large effects, enabling a relatively small input to be able to access these vast stores of atmospheric water.

Here we will review some of the places where these types of effects have already been successfully utilized by ground-based ionization technologies to increase precipitation in desired locations.

According to the information available to this author, one variation of this technology was developed and utilized in Russia in the 1980s, then brought into use in Mexico in the 1990s, and successfully used in Israel more recently. Another variation of this technology was tested and demonstrated in Switzerland in 2005, brought online for use in the United Arab Emirates the following year, then used for a series of successful trial demonstrations in Australia from 2007 to 2010, and is now being used for a new series of trials in Oman which started in 2013 and are scheduled to run to 2018.

ELAT—From Russia to Mexico and Israel

In 1984 experimental work on weather modification using electrical ionization systems began at the Laboratory of Meteorological Protection of Moscow at Moscow City Hall. The first active station—referred to as using ELAT (Electrification of the Atmosphere) technology—was constructed in 1986, and used to experiment on improving the weather conditions in Moscow. In the 1990s a Russian scientist involved in this earlier work, Dr. Lev Pokhmelnykh, began to publicly offer his services for weather modification, based on his experience with technologies developed in Russia.[7] This created enough of a buzz for the *UK Independent* and *Wall Street Journal* to cover the story in 1992.[8]

Around this time, the then-director of the National University of Mexico's Space Research and Development Program, Dr. Gianfranco Bissiachi, began collaboration with Dr. Pokhmelnykh. In 1996, supported by Heberto Castillo, then-president of Mexico's Senate Committee on Science and Technology, Pokhmelnykh and Bissiachi oversaw the development of an initial net-

7. According to an article by Professor Pulinets, "Pokhmelnykh's former colleagues in Russia did not forget what he had taught them, and over a number of years the technology was applied in the Krasnodar region, resulting in increased harvests." See, "Weather control? Yes, it is really possible..." by Sergey Pulinets, in *Russia Beyond the Headlines*, March 25, 2009 - http://rbth.com/articles/2009/03/25/250309_weather.html

8. "Rain, Rain, Go Away, Go Soak Someone Less Willing to Pay: Moscow Firm Offers 'Weather Made to Order'; Our Man Requests Three Days," by Adi Ignatius, *Wall Street Journal,* October 2, 1992. "Out of Russia: For a Price, Even Weather is up for Sale,: by Andrew Higgins, *UK Independent,* October 9, 1992.

work of three ionization stations based upon Pokhmelnykh's designs. Reuters covered these developments in 1996.[9]

The ELAT stations (operating at only one to two kilowatts) looked somewhat like a wire frame of a large tent, with high voltage wires connecting a small array of poles. With the correct electrical current and voltage, these wires will ionize the surrounding air, creating streams of ions which help the processes of water vapor condensation and precipitation.

The success of the initial tests generated enough interest and support, that the system was expanded from three stations in 1999, to 21 by 2004. In 2003, *Mass High Tech* ran an article discussing the potential use of ionization systems in the United States, based upon the precedent set in Mexico. It describes the success of the first Mexican ELAT ionization station as follows:

> That country's first ELAT station, in the drought-stricken state of Sonora, increased average rainfall from 10.6 inches to 51 inches in the first year, according to Mexican department of agriculture statistics. When a lack of state funds shut down the station the following year, area rainfall measured 11 inches. In the third year, with the station operational again, the area recorded 47 inches of rainfall. [In 2003 the technology was operational] in eight states in the driest regions of Mexico, and some areas [reported] a doubling or tripling of annual rainfall.[10]

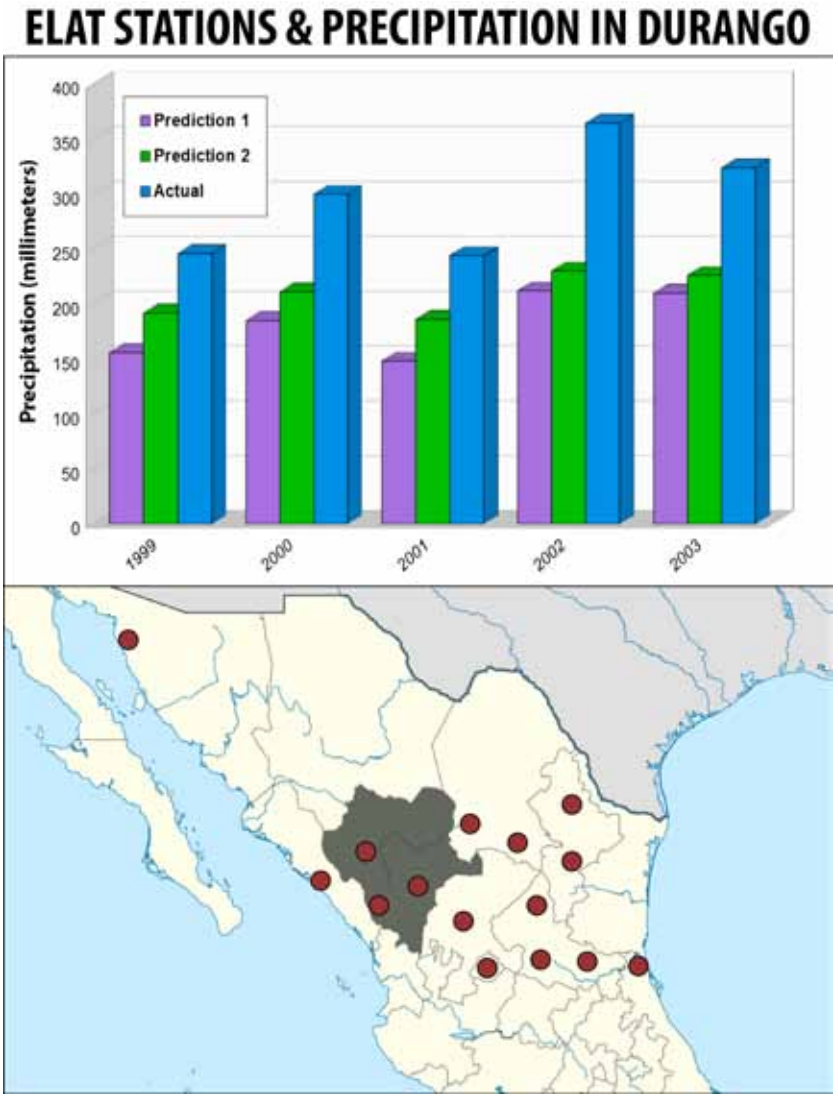


Chart (top) showing the actual rainfall (blue) with that predicted without ELAT, in the state of Durango (shaded, below).

In 2004, *IEEE Spectrum* also covered these Mexico operations, citing a doubling of the average historical precipitation in Mexico's central basin, resulting in a 61% increase in bean production in the affected areas.[11]

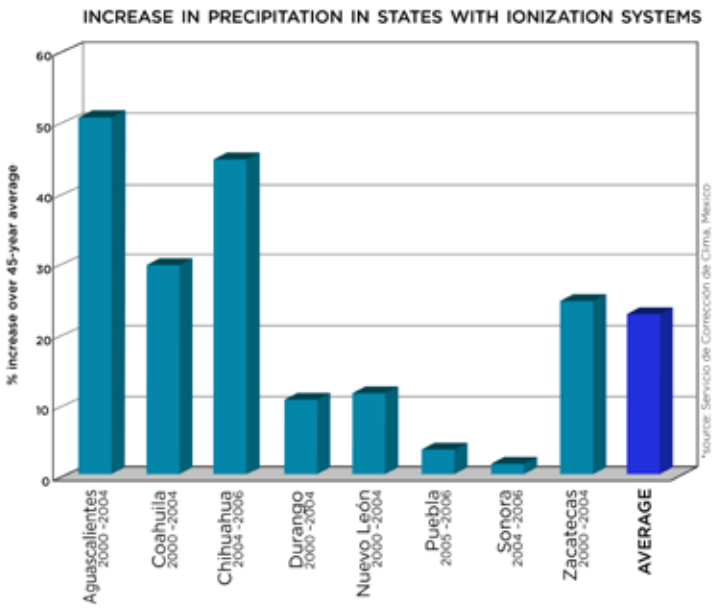
A 2008 paper on the potential use of these ionization systems in Texas analyzed the rainfall levels in the Mexican state of Durango, which benefited from these systems. Each year from 1999 to 2003 showed a significant increase in rainfall over the expected levels. The authors of the paper calculated that there was less than a 1 in 400 billion chance that this could have happened by coincidence.

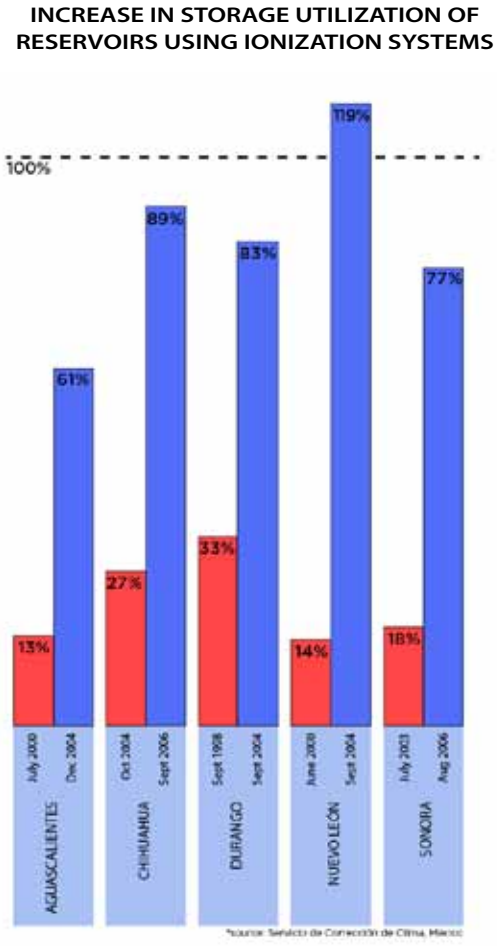
Following the successful demonstrations up to 2004, a meeting was held to discuss the technology with representatives of seven Federal agencies and of

9. "Russian Scientist—Mexico's New Rain God?" Reuters, June 24, 1996.

10. Jay Rizoli, "Looking for a Change in the Weather?" *Mass High Tech: The Journal of New England Technology*, March 10, 2003.

11. "Electric Rainmaking Technology Gets Mexico's Blessing, But for now, doubters prevail north of the border," by Samuel K Moore, *IEEE Spectrum*, April 1, 2004. http://spectrum.ieee.org/energy/environment/electric-rainmaking-technology-gets-mexicos-blessing





The effectiveness of ionization systems can be seen in these graphs of reservoir levels and rainfall measures.

the nine states in central and northern Mexico which were using or planning on using the technology. This resulted in further support, including from the Mexican Council on Science and Technology, to fund the continued expansion of the network to 36 stations by 2006. These systems were so effective that they were used to fill specific reservoirs and to even put out fires over large areas of the Yucatán Peninsula.

Before passing away in 2006, Dr. Bisiacchi expressed an optimistic vision for what mankind could do with such systems, "One of my dreams is some time to be able to go to Africa and stop the advance of the Sahara desert."

Unfortunately, after more than eight years of successful commercial operations (preceded by four years of successful tests), in 2008 the ELAT systems lost support in Mexico, with particular opposition from Mexico's National Water Commission (which, at the time, was operating under the direction of José Luis Luege Tamargo, a direct agent of the British Monarchy's leading anti-growth, population reduction outfit, the Worldwide Fund for Nature[12]).

Dr. Pokhmelnykh then brought the ELAT technology to the Middle East, where he led the installation of three stations in the Golan Heights area in 2011. Operating these stations during the winter periods of November 2011 to March 2012, and from November 2012 to January 2013, they were able to increase the rainfall in the catchment areas of seven reservoirs in the region.

By the conclusion of their work, all seven reservoirs were filled to their full capacity, something which had not occurred in the forty years since their initial construction.[13]

Meteo Systems—From Switzerland to the UAE

Another variation of the technology was developed by a group in Switzerland, Meteo Systems, which began carrying out initial trials in Switzerland in 2005, and then in the United Arab Emirates in 2006.

In early 2011, a barrage of media reports covered

12. For more on Tamargo, see "Luege Tamargo: WWF's Hitman Against Mexico," by Gretchen Small, *EIR*, May 30, 2008.

13. "Inducción Experimental De Lluvias Por Ionización Atmosférica En Las Alturas Del Golán, Israel, En El Período Invernal 2012-2013," by Mario Domínguez and Lev Pokhmelnykh, May 2013.

successful results of the systems in the UAE, starting when the *London Sunday Times* broke the story.[14] The initial coverage pointed to 52 unanticipated rain showers, and cited interest from numerous scientists. However, the level of publicity apparently generated opposition and backlash, with subsequent media coverage filled with "skeptical" reports insisting such systems could never work.[15]

National Geographic consulted Peter Wilderer of the Technical University of Munich, who provided some deeper background to the issue, saying, "ionization technology was first mentioned in 1890 by [Nikola] Tesla. In 1946 General Electric executed some field trials under the leadership of [Bernard] Vonnegut. Later the technology was used for military purposes in the former Soviet Union." Wilderer cited evidence he had seen from radar images, suggesting that ionization can generate some effects, but he couldn't personally attest to the work of Meteo Systems.[16]

After the publicity died down, in 2012 Meteo Systems redesigned and expanded its website, providing greater explanations of their work, locations of their trials, images of the systems, and assessments of what conditions are required for the systems to work.[17]

Atlant—From Australia to Oman

A spin-off of Meteo Systems, Australian Rain Technologies (ART), began operation in 2007, with an initial pilot trial supported by some funding from the Australian Government's National Water Commission. Using their Atlant technology (a variation of these ionization systems), they averaged 10% or more enhancement in rainfall in the affected areas, and the program expanded to new trials from 2008 to 2010.

In the same location as the pilot trial (Paradise Dam, Bundaberg), from January to May, 2008 ART's systems produced a 17.6% increase above anticipated rainfall in a 30° downwind arc from the system.

Later that same year, they started a series of three trials at a new location, Mt. Lofty Ranges, Adelaide. From August to November, 2008 they were able to produce an increased rainfall of 15.8% above the anticipated levels over a 120° arc downwind from the system. A year later, from August to December, 2009, they were able to expand this success, generating an increase of 9.4% over an area roughly twice the size of the previous trials. The following year, from August to December, 2010, they were able to again replicate their results, with a 11.5% increase in rainfall.

Extensive documentation on each of these trials is available on their website.[18]

Following their success in Australia, the company has more recently found partners in Oman, and in 2013 initiated a new five-year trial there. This trial program includes an independent evaluation of the results by the National Institute for Applied Statistics Research Australia (NIASRA) at the University of Wollongong, and started with two stations, with the plan of adding an additional two stations each year until the completion in 2018.

In the first year of the Oman trial, they ran their two stations for 170 days (May to October, 2013), and reported an 18% boost in rainfall for the area, resulting in greater runoff and reservoir fill-rates. For the second year, as planned, they added two more stations, and reported a 18.5% increase in rainfall from their expanded array of four stations (operating for 140 days, June to October, 2014).

Extensive reports on the success of the first two years of the trial are already available on Australian Rain Technologies' website, and they are in the process of proceeding with the addition of two more stations this year, in preparation for the third year of the trial.

The volume of rainfall increase attributed to these stations in 2013 and 2014 was estimated to be about 15 billion gallons each year.[19] This estimate allows us to make an interesting comparison. Because each station only takes about 500 watts to operate, we can determine that the amount of energy required to increase the freshwater input for Oman was about 250 to 500 joules per cubic meter of added water (or 50 to 100 million gallons per day, per kilowatt), measured over the time span of operation.

For comparison, a new, state of the art desalination

14. Rod Chayto and Jonathan Leake, "Looks Like Rain: Science Creates Downpours," *London Sunday Times,* Jan. 2, 2011.
15. For example, see Jonathan Gornall, "Rumors and Rainmaking in Al-Ain," *The National of UAE*, Feb. 3, 2011.
16. Brian Handwerk, "Scientists Make Dozens of Storms in the Abu Dhabi Desert? Claims of Manmade Rain Clouds Spark Skepticism," *National Geographic*, January 18, 2011.
17. http://www.meteo-systems.com/
18. http://australianrain.com.au/resources/
19. "Two Cloud Ionisation Stations To Come Up In Sohar, Dima Wa Al Taien To Boost Rainfall," by Swapna Tarafdar, April 1, 2015, Muscat-Daily.com http://www.muscatdaily.com/Archive/Oman/Two-cloud-ionisation-stations-to-come-up-in-Sohar-Dima-Wa-al-Taien-to-boost-rainfall-3y3m

plant being constructed in the San Diego area of California will have a capacity of 50 million gallons per day (a production rate comparable to the rainfall increase in Oman), but will require 38,000 times more power to operate, 38 megawatts (producing freshwater at 10.8 million joules per cubic meter).

This brings us back to the interesting characteristics of the atmospheric component of the water cycle. The Sun has already provided the bulk energy input to evaporate (and desalinate) the ocean water, placing it into the atmosphere, but a properly-tuned weak force (galactic cosmic radiation or ground-based ionization systems) can play a major role in tapping into this large potential.

Proposal for California

Based on discussions with the individuals involved in these operations, and this author's understanding of the published results, it appears that the ionization stations employed in the UAE, Australia, and Oman are designed to operate on a slightly smaller scale than the ELAT technology that has been used in Russia, Mexico, and Israel. Also, it appears that the leaders of Australian Rain Technologies are being very conservative with their assessments and claims for the potential of ionization technologies.

While it is clear that these systems can increase rainfall under certain conditions and at certain times, it is not yet clear to what scale they can be developed and what conditions can be overcome.

A crash effort should be made to develop an array of these ionization systems along the California coast, with different sets of stations employing the different variations of the technology (ELAT, Atlant, etc.), and employing different power levels and settings, to accelerate our understanding of the potential of these systems, while at the same time providing immediate relief to California based on their already well-demonstrated capabilities.

The immediate goal will be to determine how to best utilize an array of such stations—to create the pressure gradients needed to draw inland new atmospheric moisture (from over the Pacific Ocean). This was a basic facet of the ELAT operations in Mexico, and is a key design feature of the proposals to utilize these technologies in California and other locations. This would ensure that these systems can expand the volume of the water cycle, by bringing in new sources of water.

A critical part of the testing of these systems will be to develop new insights into how the atmospheric component of our water cycle functions, insights which will be directly connected to our understanding of the relationship between our Solar System and our Galaxy, as expressed in the processes of water and climate.

This galactic perspective on the atmospheric component of the global water cycle provides a revolutionary basis to better develop all aspects of the water cycle. In the case of California, we are dealing with the development of the interaction between the Pacific Ocean and North America. Beginning to control the atmospheric component of this process, can enable greater stability for the existing reservoirs, rivers, lakes, and groundwater stores involved in the surface water management and transfer systems of the region. We can work to ensure that the expected atmospheric moisture-flows and precipitation patterns continue as desired, and, where needed, bring in new flows, providing water to the catchment basins which provide water to the rivers and reservoirs already being depended upon.

This might even increase the feasibility and reliability of large-scale water transfer systems, but before addressing this aspect, we will discuss the potential development of the opening stage of the cycle, the desalination of ocean water to ensure regular and steady clean water for coastal urban populations.