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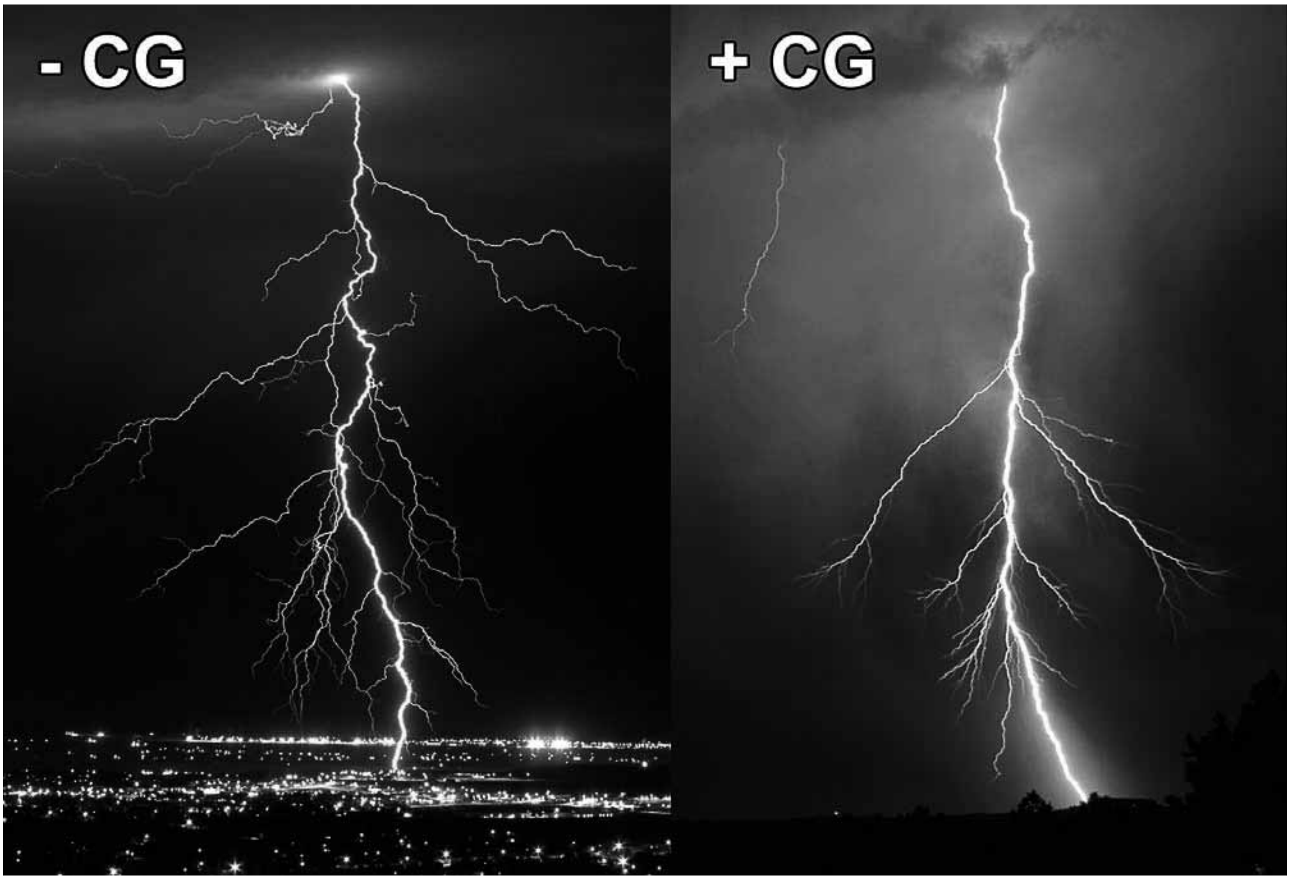
AGU COMMITTEE ON ATMOSPHERIC AND SPACE ELECTRICITY

EUROPEAN GEOSCIENCES UNION

SOCIETY OF ATMOSPHERIC ELECTRICITY OF JAPAN



Comment on the photo above: **Do positive and negative lightning look different? Please compare the two images taken with a digital still camera using 20 sec exposures. For the +CG, there was prolific recoil leader activity on the positive leader branches where you see many branches near the tips. The more erratic leader directional change is apparent in the negative leaders of the -CG flash. The negative leader branches also remain bright and do not branch profusely near their tips. The photos and the caption are contributed by Tom A. Warner, South Dakota School of Mines and Technology.**

DEDICATION

A Tribute to Dave Sentman

Fernanda São Sabbas

Dave Sentman was a Professor at the University of Alaska Fairbanks. I met him during a conference in Costa Rica in 1998. It was the COLAGE meeting, which stands for Latin-American Conference on Space Geophysics. Dave, as I learned over the years, was always a supporter of scientific development in developing countries, and there he was, as an invited speaker who was going to give a talk on Sprites and Blue Jets. That was the first time that many Latin-American scientists present in that conference heard about such phenomena. I was a graduate student at the time, getting a Master's Degree at INPE, the Brazilian National Institute of Space Research. My thesis topic was sprites, thus I had read Dave's early papers on the subject and was very excited to meet the professor who named the phenomena I was studying. In the following year I was on my way from São José dos Campos, Brazil, to Fairbanks, Alaska, to work on my PhD under Dave's supervision. When I graduated I did not have just a great PhD advisor but also a lifetime friend.

Dave is most known to all of us for his work on effects of lightning in the upper atmosphere. These effects have optical components, sprites being the most spectacular ones and by which they were discovered and high energy emissions, the Terrestrial Gamma-Ray Flashes (TGFs), electron and neutron beams, X-rays, and positrons. The optical emissions are collectively known as Transient Luminous Events (TLEs). Dave did not discover sprites but he is the person who playfully coined them with this "physics-free" name. With his never ending enthusiasm, starting in 1993 he pioneered the research on the impressive flashes above thunderstorms that had been discovered in 1989. In a series of airplane campaigns funded by NASA, Dave and several colleagues from the University of Alaska successfully documented these phenomena above the clouds, determined their main physical characteristics and laid the groundwork for all future research in the area.

More recently Dave also established the first estimate of the total sprite thermal energy deposited in the mesosphere to be less than ~ 1 GJ. The estimate was based on TLEs and circular gravity wave production by the same thunderstorm, observed by him and his colleagues during the 1999 campaign in the central United States. Dave also gave a great contribution to the field with his sprite chemistry model. He identified the main chemical species produced within the streamers. The model results showed that sprite re-ignition might be due to electron patches produced in the streamer heads and that persist for ~1 second, and predicted a 75% fractional enhancement of nitric oxide (NO) in the mesosphere, which if transported down to the stratosphere may have an impact on the ozone layer, since it is one of the key gases in its destruction cycle. The publication came out in 2008. In this same year, Francisco Gordillo-Vazquez and Y. Hiraki had also published chemical models that they had developed independently. The Chapman Conference at Penn State in May of 2009, which Dave led in organizing, addressed all of these phenomena.

Dave's creativity was limitless; his contributions are distributed among several research areas. With a BA degree in mathematics and a PhD degree in Physics, under James Van Allen's supervision at the University of Iowa, Dave started his scientific career working Jupiter's inner magnetosphere, studying energetic electrons associated with whistler waves. Curious by nature, he soon became interested in

Schumann Resonances, which are the normal electromagnetic modes of the Earth-ionosphere cavity. He made several contributions to this field, extending the theory by adapting the dual VLF ionospheric heights to the ELF range, advancing the use of Lorentzian fits for spectral analysis, and predicting Schumann Resonances in Jupiter.

Dave was a very friendly, warm hearted humane person. He would chat with anybody who would approach him to have a conversation, no matter what the social status of the person or his (or her) profession. He always had something to say and could always find a common theme to discuss. And when it came to discussing science with graduate students, Dave always had an encouraging advice or several creative suggestions on how to advance the work. His conversational skills also included telling amazing stories that would always entertain a small audience in conference dinners, and sitting in at his table was a guaranteed good time.

Dave Sentman, making a "typical tourist pose" with the Christ, on top of Corcovado mountain in Rio de Janeiro, Brazil, August 2011.

The last time I was with Dave was last August, during the ICAE conference in Rio de Janeiro, for the first time in Brazil. Dave had just been elected a member of the ICAE Commission. Besides having great science discussions with him, I had the pleasure to take him and Hugh Christian to visit the Christ on the top of Corcovado Mountain before saying good-bye to Dave for the very last time. At the age of 66, he had just received Emeritus Professor status at the UAF, after retiring, and had been named AGU Fellow, when he passed away last December, due to a vascular accident in his aorta. Two years before his death, recognized as a leader and a pioneer in the research on Transient Luminous Events, Dave was invited to give the Franklin Lecture, as part of the Atmospheric and Space Electricity AGU focus group during the

2010 Fall Meeting. The title of the talk, available online at the AGU website, was “Twenty-Five Years of New Discoveries in Atmospheric and Space Electricity”. Dave has stimulated us and contributed to our work and human development in a variety of ways. We will now continue to find inspiration and motivation from the example he left us, doing science for the benefit of humanity.

How the Sprite Got Its Name

Walt Lyons

While the title of this reminiscence may sound more like a Dr. Seuss book, it tells the tale of one of Dave Sentman’s more enduring contributions. Few scientists have the honor of naming an entirely new physical phenomenon. And as noted by Edward O. Wilson, “The beginning of wisdom is to get things by their right name.”

The late Jack Winckler, the first to actually capture the ephemeral transient luminous event, was understandably startled by what he saw on the night of 6 July 1989 in the skies over Minnesota. Gar Bering (University of Houston) commented that Jack Winckler’s discovery was as amazing as a biologist finding a new human body part.

During summer 1989, Jack and I talked back and forth about what it might be. The various odd reports in the William Corliss book “Handbook of Unusual Natural Phenomena” seemed to point us in the right direction. But in discussing with Jack what he had videotaped, the awkward term cloud-to-space lightning (CS) stuck simply because we had no other handy terminology. I mentioned many times to Jack that we needed a new name, since we did not know (1) if the phenomenon started at the cloud top, (2) which way it went (to vs. from?), (3) how to define “space” in this context, and (4) whether, in fact, we were actually dealing with lightning, however defined.

Thus, was the state of terminological affairs in mid-summer, 1993 when, unbeknownst to each other, NASA had funded both Dave and I to hunt for “cloud-to-space lightning.” We searched from the ground (our sponsors in the KSC space shuttle program were understandably concerned), and Dave’s team was to probe the night skies using the DC8 aircraft. In early July 1993, we both struck pay dirt, when each group, on its first mission, hauled in a large trove of “cloud-to-space lightning” events via video, showing they were far from rare. After being introduced to Dave though the intercession of Earle Williams, who was collaborating with both of us, Dave and I had more than a few late night cross-pollenating phone conversations as we both began writing follow-on papers describing what had been found. But we soon ran into the terminology problem. Dave shared my concerns for the “cloud-to-space lightning” nomenclature and the fact that it imposed more assumed knowledge on the possible physics of the phenomenon than our limited understanding at the time justified. We needed a more neutral term.

Several more weeks passed, and during that time both of us happened to attend summer festival Shakespeare plays. In both plays appeared, as characters, some mysterious “sprites.”

DEDICATION

"Every elf and fairey sprite: sing and dance trippingly"

William Shakespeare, A Midsummer Night's Dream

I distinctly remember the conversation where Dave blurted out that he had been talking with a friend about the naming issue and the nomenclature "sprite" was suggested. Having just seen A Midsummer Night's Dream myself, I thought it was a great idea. The ephemeral nature of the "sprite" certainly justified the name …though they were now no longer creatures of the researcher's over-heated imagination. (The late Marx Brook commented when we first presented our video at the AGU: "Oh, you are just seeing reflections in the window!" which was retracted as soon as we pointed out the cameras were outside during the observations.)

Thus was decided that sprite was to be the name. But several weeks later Dave said he had reconsidered since he thought the term might not have enough "gravitas" for the science community. I reminded him he works in a field that employs terms like whistler, tweaks, dawn chorus and lion's roar…and besides, can't atmospheric physicists engage in a bit of whimsy (and in the process maybe appear a bit less stodgy to young students making career choices). So, with some more arm-twisting, the name sprite was introduced to the community in our subsequent AGU presentations. Though I may claim to have engaged in a bit of midwifery, Dave Sentman was indeed the father of the name "sprite."*

In the late 1990s, I could give a public lecture and ask the audience how many had heard of sprites before they walked in the door. A few might raise their hand. Today, virtually every hand goes up.

Today, sprite is a term known not only to a small band of scientists but also to the general public. Just go on YouTube and search for sprites. Scientifically engaged citizens worldwide are happily deploying the new, low-cost, sensitive cameras in a burgeoning hobby - searching for the now famous sprites which "dance trippingly" across the night skies.

That is quite a legacy.

Thank you Dave.

Resonating with Dave Sentman

Earle Williams

One of Dave Sentman's many research interests was Schumann resonances (hereafter abbreviated to "SR"), the naturally occurring global electromagnetic phenomenon trapped between the conductive Earth and conductive ionosphere, and maintained by lightning activity worldwide. This subject lay dormant in the late 1970s until Dave revived it single-handedly in the early 1980s. His fascination with gadgets and new ways to measure things led to his pioneering use of the PC to record Schumann resonances, and this opened up a whole new quantitative approach to treating this sophisticated phenomenon. The literature celebration of Dave's contribution here is an article on SR in the premiere issue of Computers in Science in 1987. This powerful PC-approach has been followed by all SR researchers since. Dave also introduced Lorentzian line fitting to SR spectra and also exercised an important influence in translating the clever Greifinger/Greifinger treatment of the ionosphere from the VLF to the ELF frequency domains. Based on our first field experiment in the tropics (in Darwin, Australia in the late 1980s), we became interested in the relationship between lightning and temperature, and wondered about the possibility of a global relationship. By that time, Dave had established a pair of SR receiving stations at Table Mountain, California and in Northwest Cape, Australia, always concerned about verifying claims of global representativeness of lightning with simultaneous measurements from widely separated locations. My first extensive discussion with Dave took place at the Spring AGU meeting in 1991 where we quickly agreed on the value of joining forces to look for global variations of temperature with SR measurements. From 1993 to 1996 we shared an NSF grant to pursue this idea further, with strong encouragement from Ron Taylor at NSF. Our findings showed that lightning activity was correlated with temperature on the diurnal, the seasonal and the ENSO time scales, but the global warming issue on a longer time scale was still out of reach with the short records then available. NSF work together pointed up the need for a more quantitative global treatment of the resonances using multiple receivers, aimed at quantifying global lightning. Vadim Mushtak and I continue to work on this problem today, having learned from Dave how to make good measurements of SR, and having learned how to distinguish good and bad models for propagation within the Earth-ionosphere waveguide, with many beneficial discussions with Dave.

During the period of collaborative work on SR, Dave and I shared many long phone conversations (in the pre-email era) between Boston and Fairbanks on a variety of topics. One of them concerned a still unpublished study he had undertaken five or six years earlier with the Table Mountain receiver (this would have been in the late 80s) on the superlative excitations of the Schumann resonances called Q-bursts. Dave called them "bell-ringers" and one beautiful example was published in the Computers in Science article previously mentioned. He also recognized then that their predominant polarity was positive, but little did he know at that time that these exceptional lightning discharges were the causal agents for sprites in the mesosphere, a phenomenon he would later name and explore in considerable detail.

The sprite discovery came in rather special circumstances for me. In the morning of July 7, 1993 while participating in a radar field program in Albuquerque, New Mexico, I received a fax message from Walt Lyons in Colorado, hand-scrawled: "You'll never believe what we saw last night". Within an hour or so, almost by complete coincidence, Dave Sentman arrived at the radar site, en route to New Mexico Tech in Socorro to discuss possible flights with a research aircraft around Langmuir Laboratory. Both Walt and Dave were chasing sprites, Walt from the ground and Dave from the air, but at this stage neither one knew the other researcher. But Dave took a break with me from the sprite chase that afternoon to go out into more remote parts of New Mexico to have a look at the quality of SR signals with a new magnetometer coil he had brought along, and another gadget for speeding up the SR signals so that they populated the audio band and could be listened to as "music". On the next night, July 8, Dave and his aircraft crew detected sprites with an all-sky camera over Iowa. For years thereafter, he led sessions at the American Geophysical Union in San Francisco on this exciting new topic in Atmospheric Electricity.

Another recurrent topic of discussion in the work on SR, in which Colin Price in Israel also actively participated, was the question of the possible linkage between the SR and human brain waves. Since the

SR fundamental frequency close to 8 Hertz is set by the circumference of the Earth and the speed of light, one can be confident that mankind has been bathed in Schumann resonances for as long as lightning has graced the atmosphere. Furthermore, the magnetic field amplitudes of SR (picoteslas) are comparable to those of EEG spectra. Dave was skeptical about any linkage, primarily because he doubted that the Schumann fields could penetrate the human body and compete with electrical signals of internal origin. This skepticism clashed with Colin's and my enthusiasm that there might be something here, and with a skin depth calculation on blood that showed substantial field penetration at 8 Hz. But as with every other scientific area Dave immersed himself in, his strategy was the same: Let the argument be decided by a good experiment. The experiment Dave devised and implemented, following the International Conference on Atmospheric Electricity in Rio de Janeiro last August (the last time we discussed this problem face-to-face), was to let a birch tree outside his home in Alaska serve as the living organism. Dave allowed that if the global electromagnetic field of a Q-burst were successful in invading trees, then all the trees on the planet would "feel" the same excitation nearly simultaneously every time a sprite-producing lightning occurred. So having devoted the majority of his recent research time to sprites and sprite-related chemistry, Dave was returning to SR after a hiatus of about 16 years, and back again to new gadgets and to the PC in his living room. Dave sent several emails in the fall, reporting progress on finding a suitable amplifier and beating down the electrode noise level and the environmental noise from power line harmonics and local rf. I remember writing back to encourage him in these efforts, but cautioning about the oncoming winter and the likelihood that the birch tree would no longer resemble a living organism at -40C. In my last phone conversation with him in late October, just prior to a field trip to Brazil for me, Dave's birch tree was showing no indications of Schumann resonances.

While in Brazil in November, a student of Dave's former student Fernanda Sao Sabbas, asked me a question that I was confident Dave would shed light on. I suggested he email Dave, and that Dave was always prompt with a response. But this time, no response came. Shortly thereafter, Fernanda revealed to me that Dave was in a coma in Anchorage. The rest of this sad story is already widely known.

Let the research work continue that so strongly motivated Dave and which was so infectious to others.

My Memories of Dave Sentman

Colin Price

I first met Dave during my postdoc years at Lawrence Livermore National Lab in California from 1993-1995. Dave had done some work on Schumann resonances (SR) for the Dept. of Energy, and had worked with a friend of mine (Jerry Sweeney) on the topic. In addition, he was the first to get color images of sprites in 1993, and he presented them at AGU in San Francisco in December 1993. This blew us all away. I remember the excitement in the room when the first images were shown.

But while Dave published widely on the topic of both Schumann resonances, and sprites, there was one topic that was dear to his heart that was shared by only a few colleagues, including myself and Earle Williams. That was the possible connection between the environmental Schumann Resonances in the extremely low frequency (ELF) range, and human brain wave activity. The SR are standing waves produced between the Earth's surface and the upper atmosphere, similar to the ringing of a bell. A bell will ring at a frequency determined by its size. Small bells will have a high pitch, large bells a low pitch. While a bell produces pressure waves (acoustic waves) in the atmosphere, lighting produces electromagnetic waves and resonances. The fascinating topic of connecting the SR to brain activity was the subject of many long e-mails back and forth between Dave, Earle and myself, especially in the spring of 2004.

The question was whether humans, and other biological systems, were influenced in the past (on time scales of evolution) or even today by the environmental Schumann resonance fields, that are strikingly similar to electrical activity in the brain. While the atmospheric fields peak at 8Hz, 14 Hz, 20Hz and so on, the brainwaves display the alpha rhythms around 10Hz, beta rhythms around 16Hz and theta rhythms around 5Hz. Could long term "bathing" in the Earth's ELF fields over billions of years have influenced the patterns of electrical activity in our brains? What an idea! And if so, is there any link today?

Dave was intrigued by these questions, but so were some new-age non-scientists on the internet. You can find many articles about the "natural beat of the Earth" and how it benefits humans. There are some unfounded claims that the frequencies of the SR are changing over time. This is nonsense, since the frequency depends on the circumference of the Earth, and the speed of lightning, neither of which has changed much in the last few decades. Others claim that ELF waves are used for "brain warfare" due to the similarity in the frequencies. Dave was contacted by many of these folks asking about the SR and brain activity, including accusations that the HAARP facility in Alaska was a way of the US to manipulate brain waves of the enemy.

But we continued our scientific discussions, and Dave raised some interesting basic scientific questions. Can the weak ELF fields generated by lightning around the planet, penetrate into biological systems that are highly conductive to electric fields. Maybe the fields would be screened from entering the brain? Dave suggested some simple experiments like trying to detect the SR in trees. In fact, when Dave tragically died, he was trying to detect the SR in the trees in his back yard. We hope that some of his data can be found and analyzed. He also suggested taking a muskmelon (with similar size to the human head) and trying to detect the SR within. To imitate the brain, he suggested injecting saline solution into the melon to increase the conductivity. He even suggested hooking up a piece of meat to look for the SR within. I quote "A medium size ham, or perhaps a small, whole chicken, might work just fine. Accompanied with the right wine, this could be a fun experiment."

Unfortunately, it is too late to let Dave know, but I have returned to this problem in the last 6 months, and I have a PhD student working on this problem now. This is mainly due to the inspiration and support I received from him over the years on this topic. Who knows what we will find……

He will be greatly missed….

Summary of ILDC/ILMC Meetings, April 2012 in Colorado, USA

Ronald L. Holle and Amitabh Nag

Vaisala Inc., Tucson, Arizona, USA

The 22nd International Lightning Detection Conference (ILDC) and the 4th International Lightning Meteorology Conference (ILMC) sponsored by Vaisala were held in Broomfield, Colorado, April 2-5, 2012. The ILDC has been held every other year for the last 17 years, after taking place annually before that. Traditionally, ILDC/ILMC has been a forum where designers and operators of lightning detection networks and users of network data assemble to discuss the latest advances in technology, applications of lightning data for research and operational purposes, as well as technological innovations required to meet future operational challenges. Over 100 lightning scientists, meteorologists, and engineers, including several Vaisala staff, attended the ILDC/ILMC meetings this year. Nearly half of the attendees were from outside the United States, making this event a truly international forum for discussing the science of lightning detection and its applications.

The presentations at the conferences showcased the broad and continued growth in our understanding of the phenomena of atmospheric electrical discharges (lightning in particular), their complex relationships with other meteorological events, and the challenges posed to detection technology and network data applications. Five keynote speakers provided overviews of lightning physics, detection, phenomenology, applications of lightning data, and impacts of lightning in a wide variety of disciplines. The latest topics discussed at the conferences included total lightning mapping methods and high-speed videos of upward-initiated lightning from tall objects. The potential impact of terrain on the physical parameters of cloud-to-ground lightning such as the number of ground contacts in a flash was examined. In addition, another 75 presentations were made on a wide range of topics that included lightning-generated x-rays, lightning leader processes that are being observed and characterized for the first time, severe and tropical weather, nowcasting, forecasting, and climatological uses of lightning data.

According to the US National Oceanographic and Atmospheric Administration (NOAA) publication Storm Data, an annual average of 39 lightning-related deaths occurred in the United States between 2001-2010. About ten times as many individuals are injured by lightning each year in the United States. It is estimated that between 8,000 and 24,000 people are killed by lightning globally per year, and ten times as many are injured. Lightning causes on the order of several billion dollars in damages, mitigation expenses, and interruptions per year, including 5% of all U.S. residential-property-damage insurance claims. At the ILDC/ILMC, lightning safety and protection of human life and infrastructure were extensively discussed.

The continued evolution of science and technology involved in lightning detection enables us to advance the mitigation of the very large financial and personal effects of lightning. These impacts are global, and similar to its prior editions, ILDC/ILMC meetings in upcoming years will demonstrate the value of scientific innovation in addressing the continuously growing demands for protecting infrastructure and people from lightning.

ANNOUNCEMENTS

CONFERENCES

2012 AGU Fall Meeting

The fall meeting of AGU will be held on 3-7 December 2012, at the Moscone Center West, 800 Howard Street, San Francisco. There will be several sessions associated with atmospheric electricity. For detail, please visit http://fallmeeting.agu.org/2012/.

RESEARCH ACTIVITY BY INSTITUTIONS

Atmospheric Electricity Group (ELAT), Brazilian Institute of Space Research (Sao José dos Campos – Brazil)

The main activities developed by ELAT in the last semester were:

1. **Analysis of Singularities on the Spatial Distribution of Cloud-to-ground Lightning**

One of the most common applications of lightning data is providing lightning climatology to identify physical “singularities" on its distribution, i.e., patterns or trends associated with physical aspects. Data are collected by Lightning Location Systems (LLS) and this study focused on the improvement and development of techniques and methods to include and/or overcome performance effects of lightning detection systems on the CG lightning spatial analysis. The main development is related to the smoothing method for the lightning maps based on the confidence ellipses and is called KBBES. Other methods based on existing techniques are suggested in order to minimize the effects of spatial and temporal performance variations: filters for low peak current events, thunderstorm days, thunderstorm, and a method to identify the onset of storms called Thunderstorm Onset Technique - TOT. These methods are used, then, to analyze mainly the effects of the altitude. The proposed KBBES allowed the development of high-resolution maps without artificially affect the density values, which usually happens for the simple count method. The high-resolution maps showed a good agreement between elevation and lightning. Ideas to understand this relationship refer to the lightning channel attachment process, and inhibition of storms in the post-mountain environment. Spatial analysis of TOT for this case also indicated that the storms are related to the elevation. In summary, methods and techniques gave satisfactory results and significant advances to understand the physical aspects and singularities resulting from the detection systems have been achieved.

2. **Rammer Network Observations during Summer 2011/2012**

The RAMMER Project is a network of three high-speed cameras triggered automatically designed to observe lightning flashes in the region of Sao Jose dos Campos, Sao Paulo State, and Southeast Brazil. The cameras were assembled in weather proof boxes with all equipment necessary to automatic trigger lightning flash events and they are positioned in secure facilities covering a total area of ~1000 km2 and a common area of ~70 km2. Flashes over the common area may be captured by all three cameras simultaneously and the videos can be used for tridimensional reconstruction of the channel. During the summer of 2011/2012 it was conducted the first campaign with two cameras operating simultaneously and a third camera operation occasionally. Although some bugs were found through the course of the campaign, the overall detection efficiency estimated was close to 70%. Among the videos already analyzed, we observed spider lightning, closely connecting leaders, long lasting continuing currents (of more than 600 ms) and flashes recorded by two cameras that will be used to develop a tridimensional lightning reconstruction algorithm. During this period, it was also conducted a joint experiment with several institutions called CHUVA project. Some flashes recorded with all cameras will be discussed in the context of the other observations conducted in this joint experiment.

3. **Observations of Upward Flashes**

The first field campaign to study upward lightning was undertaken during the last summer in Brazil. A combination of high-speed video, standard definition video, fast and slow electric field sensors were used to record upward lightning flashes from multiple towers in Sao Paulo, Brazil. Observations made with these assets were analyzed along with BrasilDAT Lightning Detection Network and a lightning mapping array (LMA). A total of 15 upward flashes were recorded during 3 months. Most of them were triggered by nearby positive cloud-to-ground flashes.

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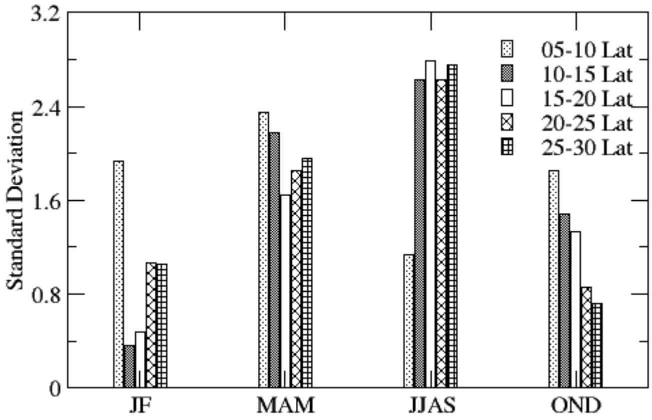
Considering important role of thunderstorm activities in bringing rain over the country and also in the context of climate change characteristic features of seasonal and latitudinal variability and trends in thunderstorm days over Indian region is studied for 15 years period from 1981 to 1995. Study reveals that on the seasonal scale, thunderstorm activity is more variable during summer monsoon season (JJAS) and less variable in winter season (JF) for all the belts north of 10°N. Opposite results are seen in lower latitudes. Study indicate increase in thunderstorm activity over Indian region almost for all seasons through positive trends, except over peninsular India during post-monsoon season which show negative trend over lower latitude. During first half of the study period, Indian region experienced four major drought years (1982, 1985, 1986 and 1987) based on summer monsoon rainfall less than one standard deviation below the mean (i.e., anomaly below -10%) and during latter half of the study period there were two flood years (1988 and 1994) based on summer monsoon rainfall in excess of one standard deviation above the mean (i.e., anomaly exceeding +10%). As a whole, seasonal summer monsoon rainfall for the country show positive trend for the 15 years period from 1981 to 1995. Thus the analysis indicate some link between changes in thunderstorm activity and changes in rainfall over the country, however further analysis with longer and dense data is required for the confirmation of the findings.



Seasonal variability of thunderstorm days in terms of standard deviation over different latitudinal belts during the season winter (JF), pre-monsoon (MAM), monsoon (JJAS) and post-monsoon (OND) over India.

Key laboratory of Meteorological Disaster of Ministry of Education (KLME), College of Atmospheric Physics, Nanjing University of Information Science & Technology (NUIST), Nanjing, China

The interaction of lightning-radiated electromagnetic fields with electric power lines and other electrical circuits can cause malfunction or destruction. In order to design a satisfied and adequate lightning protection system, it is very necessary to study the detailed field structure (e.g., vertical and horizontal electric field, azimuthal magnitude). For example, we have extended the Cooray-Rubinstein(C-R) formula into a smooth mixed propagation path, and found that it can predict an acceptable accuracy at close ditances of 100 m to 1000 m from the lightning channel by using FDTD. And then we have extended it to the case of the two dimension(2D) rough and mixed ocean-land path. It is noted that the effect of the ocean surface roughness on the horizontal field can be igored, and the initial negative field is primarily affected by the rough land section. In order to evaluate the Lightning Location Detection Network (LLDN) in China, we further extended it to the real irregular terrain around different DF site in Jiangsu province of China. In the analysis, we estimate the propagation of the lightning-radiated electromagnetic field along the real irregular terrain around Yangzhou DF site (E119°42', N32°39') and Nanjing DF site(E 118°46', N32°03'), remotely sensed by the Advanced Space-borne Thermal Emission and Reflection Radiometer (ASTER) Global Digital Elevation Model (GDEM). The results show that the rough irregular terrain results in the rapid attenuation of high frequency components and the increase of the rise-time of the field waveform. For example, for the Yangzhou DF site as the circumference of a radius of 45 km, the root-mean-squared height (RMSH) of the real irregular terrain varies from 7 m to 33 m, the extra field attenuation relative to the ideal ground surface ranges from 1 to 11% and the extra rise-time increment varies from 0.1 to 0.6 μs. Therefore, the extracted current peak of lightning return stroke may be underestimated from the remotely measured electromagnetic field, and the error varies along with different azimuths. For the lightning flashes striking in the mountain area or region, the propagation effect of the real irregular terrain on the lightning electromagnetic fields should be taken into account. In the future, we will attempt to examine the accuracy of the extended approximate formulae for the irregular terrain by using the three-dimensional (3D) FDTD technique.

We have recently performed numerical simulation of effects on atmospheric electric field distortion by tall building ’ s tip. In the simulation, we assumed that the building was an ideal conductor and fully connected with earth, forming a bottom boundary of an equipotential surface with potential of zero. Using two-dimensional finite difference method of calculation the Poisson equation, we obtained the potential distribution around the building of different grad spacings h. The effects on the atmospheric electric field distortion by the height, width and location of building’s tip were discussed, respectively.

The result shows that λi (distort coefficient of electric field above the tip’s top, equals electric field above the tip’s top divide the electric field of this point when building and tip are not exist) linearly increases with height. The λi is presented to be minimum in the middle and maximum on the edge when the tip locates from one edge to another across the center on the roof of a structure. And the λi declines exponentially with the tip's width.

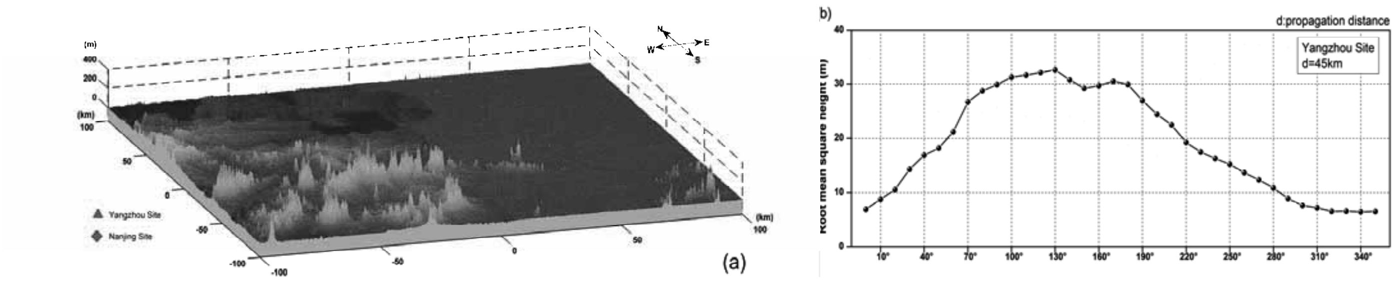


Fig. 1(a) Real irregular terrain map covering 200×200 square kilometers around the Yangzhou DF site in Jiangsu province of China and (b) depicts the root-mean-squared height (RMSH) from the azimuth 0^{o} to 360^{o}.

Furthermore, the contrast result indicates that different h can lead to the different uncertainties of the calculation results which embody in the value and change law of λi. Uncertainty provides the difference of distortion coefficient between simulation and reality. Since the actual λi cannot be measured, it has to be presented by theoretical value, which is the distortion coefficient calculated under the h reaching infinitesimal through extrapolation. According to the calculation, we obtained the negative exponent fitting equation by nonlinear fitting between λi and h, and then calculated λi as a theoretical value through infinitesimal h by getting the limit of it. The result shows that, the smaller h, the less uncertainty. Furthermore, the changing relationship of tip's electrical field's λi with geometric dimension of building is influenced by h, the smaller h, the larger slope of λi increasing with height and the greater decline rate (present the difference between the maximum and minimum of λi and corresponding width difference) of λi with width index.

In the future, we will try to build a formula between the geometric characters of building's tip and the theoretical value of λi, such as f (H, W). Furthermore, the influence of adjacent electric field distortion by more complex shape of buildings will be taken into consideration.

Key Laboratory of Middle Atmosphere and Global Environment Observation (LAGEO), Institute of Atmospheric Physics, Chinese Academy of Sciences (CAS), Beijing

The current research work of LAGEO mainly includes four parts, the characteristics and mechanism of artificially triggered lightning , studies of Mesoscale Convective Systems and deep convections by using lightning location data and TRMM data, and a lightning VHF radiation location system is updated and new data analysis method is developed.

The characteristics of M-component in rocket-triggered lightning

A modified mechanism of M-component that transfers negative charge to ground is proposed based on the comparison of the behaviors of current and electric field change of M-components. All of the M-components exhibited more or less V-shape current waveforms superimposed on the relative steady continuous current. The geometric mean values (GM) of peak current, 10%-90% rise time, half peak width, duration and charge transfer for 63 M-components were 276 A, 251 μs, 242 μs, 1.21 ms, 101 mC, respectively. The modified mechanism of M-component-mode for transferring negative charge to ground is assumed to involve two processes that propagate in opposite directions, with the charge being transported from the upper to the lower channel by the downward process and neutralized by the upward process.

Meanwhile, based on the measured channel base current in Artificial Triggering Lightning Experiment (SHATLE) from 2005 to 2010, two out of 22 triggered lightning flashes, involved six return strokes (and also, an RM event) exhibiting special current waveforms, of which the primary peaks were followed with one or two subsidiary peaks. The statistic characteristics of the subsidiary peak were summarized. The subsidiary peaks of the strokes were usually smaller than their first peaks and the amplitudes of the stroke subsidiary peaks varied from 5.4 kA to 15.86 kA while that of the first peak ranged from 8.53 kA to 16.34 kA. To know more about the subsidiary peak, a Heidler-function (HF) representative method was proposed for expressing return stroke current wave-shape with subsidiary peak in flash 0902. The simulated results indicated that the simulated HF component could reflect the physical feature of the primary and subsidiary peak in some degree.

The characteristics of global lightning activities and diurnal variation of deep convection by TRMM

The characteristics of global lightning activities are investigated by using the lightning data from the Optical Transient Detector (OTD) and the Lightning Imaging Sensor (LIS) for 11 years of 1995-2006. The results indicate that there are about 46.2 lightning flashes (both intra-cloud and cloud-to-ground) occurring around the globe every second, and nearly 78.1% of global lightning flashes occur in the area between 30°S~30°N. Moreover, the lightning density ratio of land to ocean is about 9.64:1. Furthermore, the monthly variations of lightning activities over both land and offshore areas clearly show a characteristic of single peak, with the maximum appearing in July.

Also, the spatial and diurnal variations of deep convections over the Asian monsoon region were analyzed by the data of Precipitation Radar (PR) and Microwave Imager (TMI) on board the Tropical Rainfall Measuring Mission (TRMM). The results show that the deep convections occurred mainly over land. During the pre-monsoon season, deep convections mainly located in the south of 20° N, and then moved markedly to the mid-latitude regions and located more densely in the south Himalayan foothills during the monsoon season. Deep convections occurred over the Tibet Plateau were more frequent than that on the central and eastern of China

Lightning activity of squall line

The evolution characteristics of cloud-to-ground (CG) lightning activity and its relationship with radar echo during a severe squall line in Shandong Peninsula on July 31, 2007 have been studied by using the CG lightning location data and the Doppler radar base data. The results show that CG lightning was quite active during this squall line, maximum CG flash rate was up to 1212 fl/10min. The correlation coefficient between CG flash rate and intense echo area (≥45 dBZ) is 0.89, but still there were a few CG flashes scattering in the regions with weaker echo. Compared with 35 dBZ and 50 dBZ, the relationship between CG flash rate and the top height of 45 dBZ is better, and their correlation coefficient is 0.71. In order to quantitatively analyze the relationship between convective intensity and flash rate, eight convective intensity indexes have been developed. Among these indexes, both the total of intense radar reflectivities (≥35 dBZ) above 0℃ level and the total of the products of intense radar reflectivities (≥35 dBZ) above 0℃ level and their heights appear steady relations with CG flash rate.

The characteristic of lightning VHF radiation based on lightning location system

A lightning VHF radiation location system based on short-baseline time-difference of arrival (TDOA) technology, namely short-baseline TDOA lightning VHF radiation location system, is updated. The hardware structure of the system, method of signal preprocessing and location algorithm is introduced in detail. Based on the orthogonal 10 m-baseline antenna array with four identical broadband flat plane antennas, this system receives broadband lightning VHF radiation signals and calculates TDOA between antennas in order to determine the location of lightning radiation sources in two dimensions (elevation and azimuth). To reduce noise and improve estimation accuracy of time delay, a general correlation time delay estimation algorithm based on direct correlation method and wavelet transform is proposed. Moreover, parabolic interpolation algorithm is used in the fractional delay estimation to improve time resolution of positioning system.

Laboratory of Environmental Physics, Institute of Physics, University of Tartu, Estonia

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The Laboratory of Environmental Physics continues the research in the field of atmospheric ionization, which started at the University of Tartu in 1937 and was extended in 1950s. Nowadays the main emphasis is laid on the research of atmospheric aerosols, especially on nanometer particles, but the traditional study of air ions also is carried out.

The Tahkuse Observatory is a long-standing centre for air ion measurements; it was founded in a sparsely populated rural region of Estonia in 1988. The basic stationary equipment comprises a complex of air ion spectrometers covering a mobility range of 0.00041–3.14 cm2V-1s-1. Since 2005, an Electrical Aerosol Spectrometer (EAS; particle diameter measuring range 3 nm – 10 µm) is continuously measuring the aerosol particle size distribution. Activity concentration of radon in the air is measured by AlphaGuard radon monitor (Saphymo GmbH) since 2007. Besides the basic equipment, several complementary instruments are applied for episodic measurements. For example, the balanced scanning mobility analyzer BSMA for precise measurements of small and intermediate ions was operating in summer and fall 2011, and the neutral cluster and air ion spectrometer NAIS is operating since July 2011. In the framework of Swiss Contribution - Cooperation Programme between the Republic of Estonia and Switzerland, it has been decided to extend instrumentation in the Tahkuse Observatory of the Laboratory of Environmental Physics at the Institute of Physics, University of Tartu, by analyzers of trace gases (SO2, NOx, CO, O3, H2S, VOC).

Since the Laboratory of Environmental Physics is located in the city of Tartu, several measurement campaigns were carried out in Tartu. One monitoring station of the Central Lab of the Estonian Environmental Research Centre records several ambient air components for characterizing the quality of the urban air. Since March 2011, the neutral cluster and air ion spectrometer NAIS and the electrical aerosol spectrometer EAS are operating at the mentioned monitoring station in Tartu. A novel apparatus, symmetrical inclined grid mobility analyzer SIGMA was operating in countryside, 50 km from Tartu, from June to October 2009 and in Tartu from April 2010 to November 2011. The third campaign of measurements in Tartu began on March 30, 2012.

The Institute of Physics is one of nine partners of the Nordic Network for Ionic Clusters in the Atmosphere (NICITA) http://www.atm.helsinki.fi/wiki/NICITA/. The Laboratory of Environmental Physics participated in the organization of the 3rd Joint NICITA Workshop at Pühajärve, Estonia, on April 25–27, 2012.

The Universities of Helsinki and Tartu and have organized regular international air ion and aerosol workshops http://www.borenv.net/BER/pdfs/ber12/ber12-237.pdf. The 16th workshop will be held at Pühajärve, Estonia, on June 12–14, 2012.

Laboratory of Lightning Physics and Protection Engineering (LiP&P), Chinese Academy of Meteorological Sciences (CAMS), Beijing, China

Characteristics of Unconnected Upward Leaders Initiated from Tall Structures

Characteristics of 45 unconnected upward leaders (UULs) occurred in 19 downward negative flashes observed in Guangzhou during 2009-2011 are analyzed. Each of them is upward positive leader initiated by downward negative stepped leaders before a new strike point is struck. For each UUL, several parameters are tried to be obtained mainly by using high-speed images: inception height, inception time prior to return stroke (RS), horizontal distance between the strike point and the UUL's inception point, two-dimensional (2D) distance between the nearest tip of downward leaders and the UUL's inception point when the UUL is initiated, 2D length, and 2D average propagation velocity. These parameters of UULs observed by us range from 40 m to 503 m (number of samples: 45), less than 0.1 ms to 1.32 ms (38), 20 m to 1.3 km (38), 99 m to 578 m (21), 0.48 m to 399 m (45), and 5.79 to 33.8 × 104 m s-1 (22), respectively. Statistical analysis of UULs characteristics shows the following: (1) No UUL with inception time prior to RS larger than 0.5 ms is initiated at a height lower than 300 m, and no UUL with inception height higher than 300 m is initiated less than 0.3 ms prior to RS. (2) Those UULs with inception heights lower than 300 m seldom exhibit 2D lengths longer than 50 m, and most (81%) of them have 2D lengths of shorter than 20 m. Most (86%) of those UULs with 2D lengths longer than 50 m exhibit inception heights higher than 300 m. (3) The 2D average propagation velocities of 22 UULs range from 5.79 to 33.8 × 104 m s-1, six of them are on the order of 104 m s-1 and 19 (86%) of them are smaller than 2.0 × 105 m s-1. (4) Those UULs with inception heights lower than 300 m only can be initiated by those lightning flashes within about 600 m far away, while those with inception heights higher than 400 m can be initiated by flashes over 1 km far away. (5) The maximum distances for downward leaders to attract the initiation of UULs with inception heights from 100 m to 200, 200 m to 300 m, and higher than 400 m are about 350 m, 450 m, and 600 m, respectively.

Figure 1. High-speed camera records of a downward negative flash struck a structure about 90 m high. Fig. 1a and 1b are captured at a sampling rate of 7,000 fps with a large view range: (a) the last frame before return stroke; (b) the frame about 0.28 ms after return stroke. Fig. 1c is a composite image of 66 images before return stroke captured at a sampling rate of 50,000 fps with a small view range.

Characteristics of Cloud-to-Ground (CG) Flashes in Trailing Stratiform Regions of a Squall Line

The characteristics of CG flashes in trailing stratiform regions of a squall line occurring in North China are analyzed basing on the stratiform-convective partition method using the data of two Doppler radar: one observed the developing stage of the squall line; another observed the declining stage. The primary results present that 1) the middle values of the proportion of stratiform CG flashes in the developing stage and the declining stage are 42.5% and 27.5% respectively; 2) the positive changes of CG frequencies in convective regions are always ahead of the positive changes in trailing stratiform regions; 3) with the distance to the convective regions increasing, the amount of CG flashes in trailing stratiform regions decrease in both stages; but 4) within 15 km, CG flashes in the declining stage are more than those in the developing stage and it is opposite out of 15 km; 5) only a little positive CG flashes are detected in the developing stage and they are all located out of 25 km to the convective regions; but in the declining stage, the number of positive CG flashes is obviously ascending; although the amount of positive CG flashes is reduced with the distance to convective regions increasing, but the proportion of positive CG flashes is increased gradually.

It indicates that lightning activity in trailing stratiform regions is closely linked to lightning activity in convective regions. The connection may work basing on ice particles advected from convective regions or directly on the charges on ice particles which are charged in convective regions and transported with wind to trailing stratiform regions. But the relationship between lightning activities in trailing stratiform regions and convective regions is probably diluted by some factors, such as the in situ charging mechanism in stratiform regions, so that the correlation coefficient of lightning activities in two regions is not conspicuous. Our work further confirms the relationship between lightning activities in trailing stratiform regions and convective regions and the possible important role of the in situ charging mechanism in stratiform regions is reflected in an indirect way. More analysis about the characteristics of CG flashes in stratiform regions and the possible mechanisms is in progress.

Characteristics of lightning activities in the hailstorm using the data from two types of lightning detection network

Hail is a small-scale phenomenon with short duration in summertime thunderstorms. In recent years, a large amount of observations have revealed that the characteristics of lightning activities in hailstorms are different from general thunderstorms. Hailstorms always have higher rate of IntraCloud (IC) flashes and higher proportion of Positive Cloud-to-Ground flashes (PCG). Simultaneously, rapid increase in total lightning activity is often observed tens of minutes ahead of hail event and many other obvious characteristics and relationships are revealed between lightning activities and hail events, which can perform as an index for hail warning decision.

Our study used two types of lightning detection networks, SAFIR and ADTD network of China, which covered the regions of Beijing, Tianjing and Hebei province. SAFIR can apply the information of total lightning (IC+CG) and ADTD network only detects CG flashes. 14 hail-bearing isolated thunderstorms in the region are examined. It is found that the peak of lightning frequency is often observed in advance of the occurrence of severe weather at the ground, and rapid increases of lightning frequencies are reported before hail events. The relationship between lightning activity and hail event is more stable using total lightning data than using only CG flash data. The average lead time of jump occurrence to hail event is obtained (Total lightning: 26.2min, CG: 19.6min) through the 2σ lightning jump algorithm. In the meantime, it is demonstrated that the diameter of hail and the duration of hail event are increased when the higher ratio of PCG flashes appears; while the NCG dominates, the diameter of hail is relatively smaller. The overall goal of this study is to obtain the characters of total and CG lightning occurrence trends in hailstorms, which might contribute to forecast the time of hailstorm occurrence and the size of hail by using lightning detection data.

Lightning Research Group of Gifu University (Gifu, Japan)

We have analyzed the initial speeds for 14 rocket triggered strokes recorded by using LAPOS (Lightning Attachment Process Observation System) at The International Center for Lightning Research and Testing (ICLRT) at Camp Blanding, Florida. We found that all the strokes show an initial propagation speed as low as that of a typical dart leader. The results will be submitted to GRL. Meanwhile, we have analyzed the leader-return stroke transition processes for all the return strokes and found different strokes have remarkably different transition characteristics. These results will be reported at the coming ICLP. In the coming summer, we will continue our observation at ICLRT.

We have reported the electric current and the electric field changes of three upward positive lightning triggered by nearby lightning discharge activities at The 22nd International Lightning Detection Conference (ILDC) and the 4th International Lightning Meteorology Conference (ILMC). All those three upward lightning contained only initial continuous current (ICC) stage. During the ICC stage three types of interesting electric current pulses have been identified and studied. Initial upward negative stepped leader pulses exhibited either unipolar positive pulse waveform or bipolar pulse with initial positive peak waveform. In contrast, a type of regular pulse burst, as shown in Fig.1, identified in each of the three upward lightning all exhibited 4 types of pulses: positive unipolar type, negative unipolar type, bipolar with initial positive polarity type and bipolar with initial negative polarity type. We assumed that the regular electric current pulses observed in this study are caused by a dart-stepped leader propagating along a defunct upward branch at a time when other branches are still carrying continuous currents. An electric current pulse with an amplitude of several tens of Amperes along a high structure has been observed to occur in response to a rapid electric change generated by either a nearby return stroke or K-change. This pulse tends to be immediately followed by even bigger (a few kA) and longer (a few ms) pulses in the cases when the lightning channel connecting to the tower is still conductive.

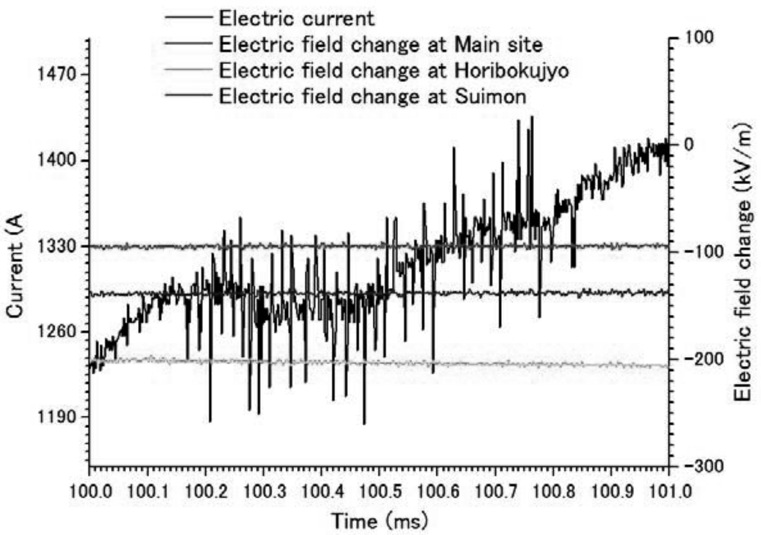


Fig.1 Example waveform of a type of regular electric current burst contained in the initial continuous current stage of positive upward lightning.

Meteorology Unit, Venezuelan Institute for Scientific Research

The UM-IVIC[1] (Meteorology Unit, Venezuelan Institute for Scientific Research) was created in late 2010 in direct evolution of virtual Meteorology Center[2] (CvM by his acronym in Spanish) to support Caribbean and Venezuela research in meteorology.

Initially, the CvM installed a storm tracker device in the “Dr. Humberto Fernandez-Morán” Building, headquarters of the IVIC’s Structural Biology Center3 and FEI´ Latin American Center For Cryo-Electron Microscopy (CLAFCME)[3] for alerting the scientists when thunderstorms approaching the region and enabling them to shutting down delicate instruments, thus preventing the delicate instrumental from damages.

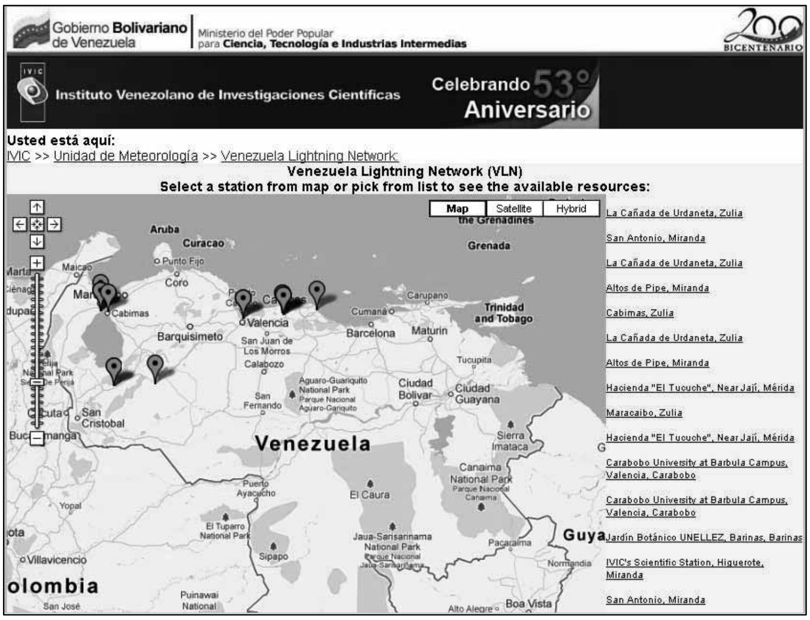
About 2005, the IVIC created two branches in Mérida[4] and Zulia[5] States, effectively opening the possibility of expanding the remote sensor networks to inner country.

The UM-IVIC in partnership with the CvM are currently setting up a wide national network for detecting lightning phenomena, the Venezuela Lightning Network-VLN[6] (see Figure). At the time writing this article, we have three fully operational sites, two sites under deploying plus four planned locations (some of these locations are subject to change). Every site has the following instruments: a Boltek Stormtracker PCI detector[7], GPS receiver for precise clock sync[8] and a desktop PC. Also four locations (CvM-Pipe, CvM-Altos Mirandinos, UM-Jají and UM-Palmarejo) have a Boltek EFM-100 Electric Field Mill[9]. For complement our observations, all sites will be equipped with Automated Weather Stations (AWS) reporting the weather conditions to CvM’s MeteoVEN network in real time every five minutes and via Twitter @meteoven every 60 minutes. This meteorological data is also ingested in the SAMMet-i[10] (Automated interactive Weather Modeling System) for precise forecast.

All data collecting process is totally automated, the files containing the last day data are uploaded automatically every midnight to our central server http://met.ivic.gob.ve using SFTP (Secure FTP) for later analysis. This process is executed in daily basis without any user intervention. Also, in the near future, the VLN will be capable of: Sending automated messages alerting about thunderstorms via e-mail and/or via Twitter @rayosvenezuela for preventing hazards; record statistics about type (Cloud to Ground, Intracloud), polarity, (positive or negative), and the geo-location of atmospherics discharges. For reference and calibration of VLN’s remote sensors, the UM-IVIC joined last year the World Wide Lightning Location Network (WWLLN)[11] hosting a detector at site UM-Palmarejo (Zulia State). The VLN is a national collaboration, and therefore institutions like the Venezuelan Scientific Modeling Center (Centro de Modelado Científico - CMC)[12] and FAYCIT are contributing in the expansion of the sensor network.

Presently CMC is developing a research project for the Lake Maracaibo Basin aimed to evaluate the predictability of lightning activity using the VLN data as predictand and both local observations and model output (e.g. CAPE, winds) as predictors in a canonical correlation analysis based methodology[13].

1 http://met.ivic.gob.ve
2 http://met.ivic.gob.ve/cvm
3 http://cbe.ivic.ve/clafcme/clafcme.html
4 http://www.ivic.gob.ve/ceif/
5 http://www.ivic.gob.ve/ceba/
6 http://met.ivic.gob.ve/vln/
7 http://www.boltek.com/stormtracker.html
8 https://buy.garmin.com/shop/shop.do?pID=13195
9 http://www.boltek.com/efm100.html
10 http://met.ivic.gob.ve/sammeti/meteomapa
11 http://wwlln.net/
12 http://www.cmc.org.ve/
13 Muñoz et al., 2012: “CAVEDE: hacia un sistema de pronóstico probabilístico de actividad electroatmosférica en la Cuenca del Lago de Maracaibo.” Memoirs of the I Venezuelan Meteorological Congress. Valencia. Venezuela.



Vene zuela Lightning Network (VLN) Station Map

MIT (Cambridge, MA, USA)

Earle Williams will visit Tokyo, Japan in May to attend the Japan Geophysical Union meeting on an invitation from Yasu Hobara at the University of Electrocommunications. In collaborative work with Alexander Shvets and Masashi Hayakawa, estimates will be made of global lightning activity inferred from two distinct inversion approaches (one developed by Shvets and the other by Vadim Mushtak), but both making use of the same multi-station data sets on January 1-3, 2009.

A global inventory of ELF station data has been assembled recently by Anirban Guha, Vadim Mushtak and Earle Williams, based on the set of all Schumann resonance stations known to be operational. This inventory includes a listing of all months each station has been operating, in addition to a list of station locations, receiver characteristics, and data archival procedure. Stations now in this list include locations in Antarctica, Australia, China, Czech Republic, Greenland, Hungary, India, Israel, Japan, Poland, Russia, South Africa, Sweden, Taiwan, the United Kingdom and the USA. The main purpose of this archive is to establish periods of data overlap for purposes of multi-station inversion of background observations.

Efforts are underway with Anirban Guha in India and Pascal Ortega in Tahiti to establish an additional Schumann resonance receiving site in Tahiti, in the central Pacific Ocean. Sites that are removed from the major thunderstorm activity are better suited for the determination of its characteristics at these long electromagnetic wavelengths.

The paper entitled "Resolution of the sprite polarity paradox: The role of halos" with co-authors E. Williams, C.-L. Kuo, J. Bor, G. Satori, R. Newsome, T. Adachi, R. Boldi, A. Chen, E. Downes, R. Hsu, W. Lyons, M. Saba, M. Taylor and H-.T. Su has been published recently in Radio Science.

RESEARCH ACTIVITY BY INSTITUTIONS

MIT Lincoln Laboratory (Lexington, MA, USA)

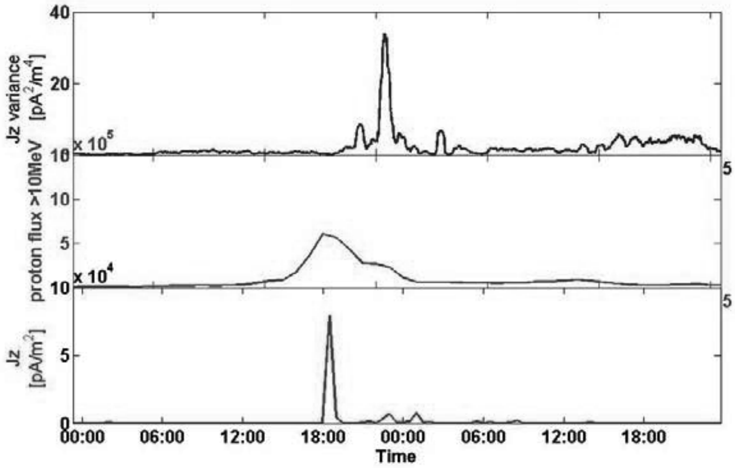
On April 11, 2012, multiple NEXRAD radars in Pennsylvania and New York newly outfitted with dual polarimetric capability were showing an abundance of negative differential reflectivity (ZDR) in scattered convection. Soundings showed the melting level was only 1200 meters altitude in these springtime showers in a barotropic atmosphere with randomly distributed shallow convection, with radar tops to 2-3 km MSL. On the basis of the consistent radar observations, conical graupel particles were predicted. The next day (April 12), similar meteorological conditions prevailed but the weather had progressed eastward to New England. Two showers of conical graupel occurred over Lincoln Laboratory, and the particles were collected and stored in a freezer. Observations from the Taunton (MA) NWS radar showed a tendency for negative ZDR values. Theoretical radar crossection calculations have since been performed on dielectric cones with spherical bases and characterized by an apex angle. These calculations show that negative ZDR values should be expected for apex angle less than 50 degrees. The observed apex angles for the collections at the surface are more like 60 degrees, leaving us puzzled.

Tel-Aviv University and the Open University of Israel

Yoav Yair (The Open University) and Colin Price (Tel-Aviv University) and their students are looking for effects of space weather and solar storms on the Global Electrical Circuit (GEC). Ph.D student Gal Elhalel has been measuring the vertical fair-weather atmospheric electrical current [J_z] from May 2011 continuously at the Wise astronomical observatory in the Negev desert, Israel. The instrument used is a modified version of the GDACCS design described by Bennet and Harrison (2008) which is capable of measuring the fair-weather current density with an accuracy of 0.4 pA m^{-2}. The results show a clear daily pattern in the fluctuation of the fair weather vertical current J_z measured at the surface, with a strong correlation found between the wind speed at the surface, the relative humidity and the J_z, suggesting the advection of space charge and aerosols, causing rapid changes in the atmospheric conductivity. Additionally, we note indications for a response in J_z to the external forcing of geomagnetic conditions, in the correlation between J_z and SPE (solar proton events) during CMEs. The figure shows the effects of the CME of October 24th, 2011.

Yoav Yair, MSc student Sigalit Shalev and colleagues Baruch Ziv (The Open University) and Hadas Saaroni (Tel-Aviv University) worked on 5 years of lightning data in Israel and the eastern Mediterranean. They used lightning stroke data together with NOx data from the national network of air-quality monitoring stations operated by the Israeli Ministry of Environmental Protection. Looking for the fingerprints of LtNOx within the general ambient concentrations, affected by pollution from urban sources, we looked only for cloud to ground strokes occurring with a radius of 3 km from the location of an air-quality monitoring station. This number of relevant cases in the 2004/5-2009/10 seasons was 1,897 strokes. A peak current threshold of > 60kA was applied, and the NOx data was available only for 35 events.

We used wind data to estimate the transport regime from the lightning strike-point to the monitoring stations, usually located ~20 m above ground. When considering only those events when the prevailing wind was in the direction from the stroke location toward the sensor (7 cases), a clear increase of few ppb following the stroke was observed in 5 cases. This increase is well correlated with the wind-speed, suggesting an effective transport from the stroke location to the sensor. Weaker winds allow dilution and result in smaller observed increases of LtNOx. This research will continue focusing on events with multiple strokes and low background NOx levels.



MSc student Shy Halatzi will attempt to find a correlation between the Jz variance and the concentrations and properties of airborne atmospheric aerosols, this in collaboration with Prof. Yigal Erel from the Hebrew University in Jerusalem.

During the summer of 2011, in the framework of the Japanese TV channel NHK "Cosmic Shore" project, Yoav Yair and MSc student Keren Mezuman joined a concentrated attempt to image sprites from the International Space Station (ISS). The methodology for target selection was based on that developed for the 2003 space shuttle MEIDEX sprite campaign (Ziv et al., 2004). The Aviation Weather Center (http://aviationweather.gov) daily significant weather forecast maps (SIGWX) were used for selecting regions with high probability for convective storms and lightning such that they were within the camera filed-of-view of the ISS, based in its trajectory and distance to the limb. Only storms with predicted "Frequent Cb" and cloud tops above 45 Kft (~14 km) were selected, as well as tropical storms and hurricanes over the oceans. The accuracy of the forecast method enabled obtaining the first-ever color images of sprites from space. In all, 12 confirmed events were found, including the first ever gigantic jet and sprite halo recorded in color from the ISS. The results are now being analyzed together with lightning data from ELF and VLF networks and satellite images. The ILAN team (http://tau-geo.tau.ac.il/ilan/) led by Keren Mezuman completed the winter sprite season with at least 40 new events, mostly in October-November storms above the Mediterranean Sea. A new Watec902 camera was recently installed at the Wise observatory, complementing the one operated from Tel-Aviv University's campus. Future observations of sprites and meteors will be done from both locations.

Barry Lynn (The Hebrew University of Jerusalem), Yoav Yair and Colin Price have been working on a new prognostic spatial and time-dependent variable, added to the Weather Research and Forecasting Model (WRF). This variable is the Potential Electrical Energy (Ep), and it was used to predict the dynamic contribution of the grid-scale resolved microphysical and vertical velocity fields to the production of cloud-to-ground (positive and negative) and intra-cloud lightning. The source of Ep is assumed to be the non-inductive charge separation process. The dissipation of Ep occurs when it exceeds pre-assigned threshold values and lightning is generated. Analysis of 4 case studies of severe storms in the US shows the capability of this scheme in predicting both cloud-to-ground and intra-cloud lightning. This dynamic algorithm forecasts was compared to existing statistical lightning forecasts and shows better skill. The scheme is being used operationally with Rapid Refresh (13 km) data; the skill scores in these operational runs were very good in clearly defined convective situations. A paper is now in review for Weather and Forecasting.

Thunderstorm Research Group in Bulgaria

Two types of research regarding thunderstorms are carried out in Bulgaria: (1) Numerical simulations of thunderstorms; (2) Field data analyses.

The joint modelling group of University of Sofia, Faculty of Physics (Rumjana Mitzeva -rumypm@phys.uni-sofia.bg, Savka Petrova - asavita@phys.uni-sofia.bg, Angelina Brandiyska imdnme@gmail.com) and National Institute of Meteorology and Hydrology (Boryana Tsenova - boryana.tsenova@meteo.bg, Andrey Bogatchev - andrey.bogatchev@meteo.bg) continued research on parameterizations for non-inductive charging. They proposed new parameterizations, which were incorporated in their 1.5-D cloud model, in 3-D RAMS and in the 3-D mesoscale cloud-resolving model MésoNH. A new hybrid scheme of cloud charging based on the conception that in different cloud regions different parameterizations have to be used was incorporated in RAMS. Comparative numerical studies on the impact of the parameterization of non-inductive charging based on the effective water content or the rime accretion rate were performed using simulations with 1.5 D cloud model. The preliminary results from numerical simulations also indicate that the difference in CCN may explain the difference between lightning activity in thunderstorms over land and sea. The study of the impact of ice nuclei on thunderstorm electrification is also carried out. The work on the operational computation of several atmospheric instability indices from ALADIN forecast data and the study of their relationship with the observed thunderstorms over Bulgaria is in progress.

The joint research group of University of Sofia, Faculty of Physics (Rumjana Mitzeva - rumypm@phys.uni-sofia.bg, Savka Petrova - asavita@phys.uni-sofia.bg), Hail Suppression Agency (Tsvetelina Dimitrova – dimitrova_tsvetelina@abv.bg) and National Institute of Meteorology and Hydrology – Varna (Boryana Markova - b_markova@abv.bg) continued research on relationship between lightning activity (flash rate, multiplicity and polarity), various radar data and precipitation for thunderstorms developed over Bulgaria. The preliminary studies reveal that there is a significant difference between lightning characteristics in summer thunderstorms producing heavy and weak rain, as well as between lightning characteristics in different types (multicell and supecell) severe thunderstorms producing hail.

Additionally, based on data analyses it is established that the environmental conditions at the development of thunderstorms in NE Bulgaria over land and Black sea are significantly different. The combination of instability indices can be used to discriminate the environmental conditions at the development of summer convective precipitating clouds (without lightning) from summer thunderstorm in east part of Bulgaria. Diurnal variation of lightning activity and its relation with precipitation over maritime, coastal and continental areas during summer in the Central and Eastern Mediterranean are also analyzed.

The thunderstorm research group in Bulgaria works in collaboration with colleagues from Laboratoire d'aerologie, Toulouse, France, from Institute for Environmental Research and Sustainable Development, NOA, Athens, Greece and from the Nowcast GmbH, Munich, Germany.

Thunderstorms Remote Sensing Laboratory (STORM-T), Department of Atmospheric Science, University of São Paulo (São Paulo, Brazil)

STORM-T Laboratory is operating a VLF long range lightning detection network, known as STARNET, over South America since 2006 [http://www.zeus.iag.usp.br]. STARNET is based on 7 VLF radio receivers that can detect up to 100 sferics per second and uses the Arrival Time Difference (ATD) method to locate sferics. In the next months, the system will be upgrade with 3 more antennas to increase its detection efficiency. Based on 3 years of measurements (2009-2011), Figure 1, it is possible to note that STARNET is capturing the main electrical active regions over South America. All data collected have been reprocessed and it is now available in our homepage. The users can follow the link ftp for realtime lightning or Data archive on reprocessed data to have access to the sferics measurements. For more information contact Carlos A. Morales (morales@model.iag.usp.br).

Additionally, STORM-T finished its participation at the CHUVA-GLM VALE field campaign (Nov-2011 to Mar-2012) that took place at São José dos Campos, Southeast Brazil. In addition to the rainfall measurements, 11 different ground base lightning networks were deployed in São Paulo area as a support for the upcoming geostationary lightning imaging sensors (GOES-R GLM and MTG-LI). STORM-T is currently working with CPTEC/INPE, MSFC/NASA and DLR/EUMETSAT scientists on a lightning intercomparison to understand what each lightning sensor is measuring in respect to the Lightning Mapping Array (LMA) and LIS sensors. CHUVA datasets are public available at http://chuvaproject.cptec.inpe.br. In the following 2 years, CHUVA will be conducting 3 more field campaigns at Santa Maria, Brasilia and Manaus (southern, center and northern Brazil) and scientists are welcome to participate and bring their instruments. More information is available in the CHUVA website or can be requested by sending an e-mail to Carlos A. Morales (morales@model.iag.usp.br) or Rachel Albrecht (Rachel.albrecht@cptec.inpe.br).

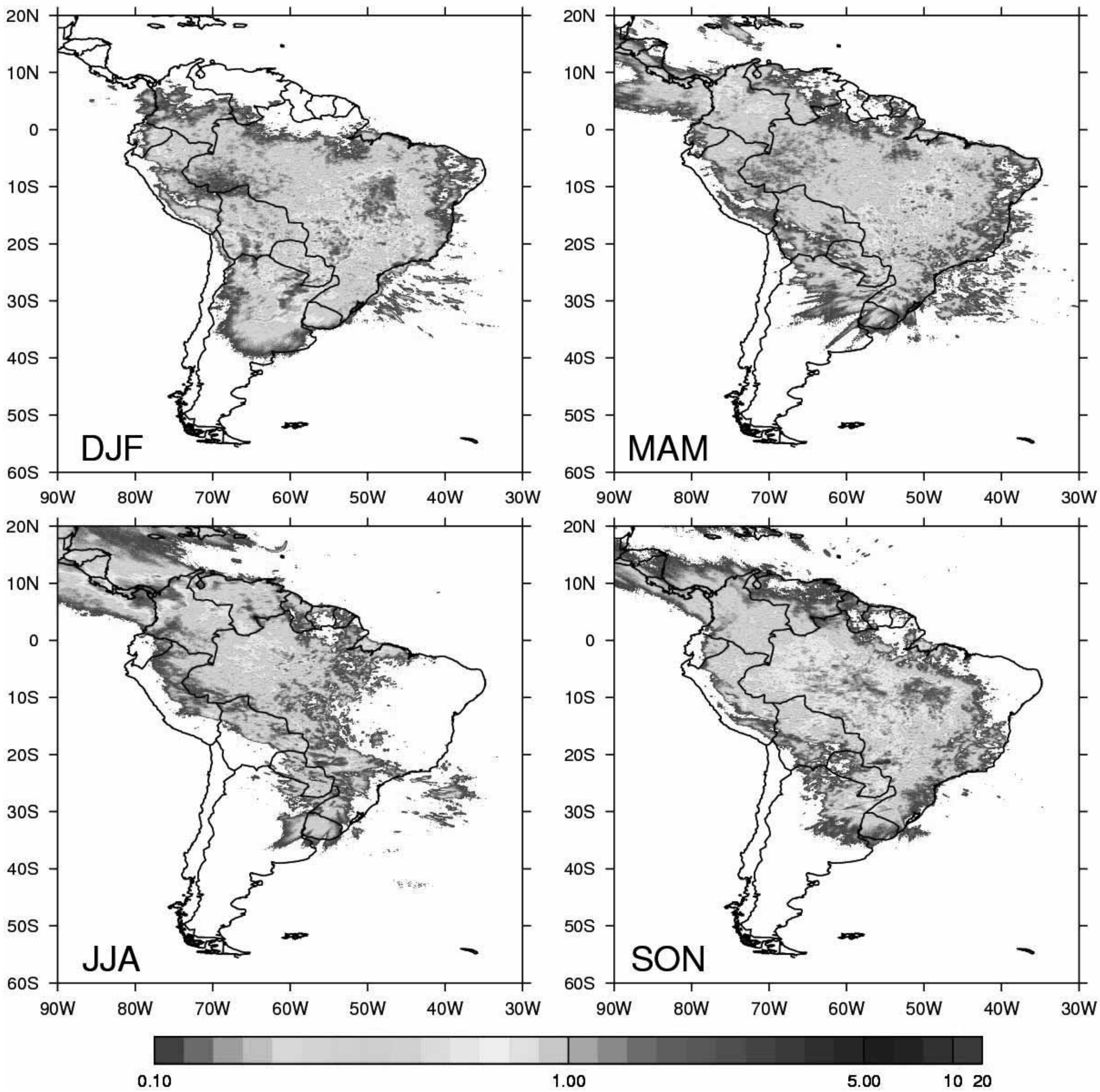


Figure 1. Seasonal sferics rate (sferics/km2/season) based on 3 years of STARNET measurements.

University of Florida (Gainesville, FL, USA)

Lightning experiments and observations will continue in Summer 2012 at Camp Blanding, Florida (for the 19th year), as well as at the Lightning Observatory in Gainesville (LOG), located at a distance of about 45 km from Camp Blanding. The two facilities are linked by a dedicated phone line. A third field measuring station, 3 km from the Camp Blanding site, has been set up in Starke. A Lightning Mapping Array will be operated (for the second summer) in the Camp Blanding area. Among the visiting researchers scheduled to perform experiments in the summer campaign from the new optical building are Dr. E.P. Krider and a grad student from the University of Arizona, Dr. Vince Idone and a grad student from SUNYA, Dr. Hugh

Christian and a grad student from University of Alabama Huntsville, and Dr. Daohong Wang and his students from Gifu University, Japan, in addition to UF faculty and students.

A. Nag (now at Vaisala) and V.A. Rakov authored a paper titled "Positive Lightning: An Overview, New Observations, and Inferences". They examined the various conceptual cloud charge configurations and scenarios leading to production of positive lightning with a view toward an explanation of its observed properties. Data for 52 positive cloud-to-ground flashes containing 63 strokes recorded in Gainesville, Florida, in 2007–2008 are presented and discussed. In 42 (81%) of the 52 flashes, the first (or the only) leader-return stroke sequence was not preceded by in-cloud discharge activity. The average number of strokes per flash is 1.2. Single-stroke flashes constitute 81%. In three (38%) of eight two-stroke flashes, the second stroke likely followed the channel of the first stroke, and in five (62%) flashes it likely created a new termination on ground. Eight (15%) of the 52 positive flashes had detectable preliminary breakdown pulse trains in their electric field records. Electric field waveforms of 14 (27%) first strokes (also of one third stroke) are preceded by pronounced pulses, apparently indicative of leader stepping. NLDN-reported peak currents for 48 positive strokes in 40 flashes ranged from 20 to 234 kA with a geometric mean value of 75 kA. The median charge transfers in 1, 2, and 40 ms after the beginning of return stroke electric field change for an assumed height of 12 km were estimated to be 13, 18, and 34 C, respectively. The paper is published in the JGR - Atmospheres.

J. D. Hill, M. A. Uman, and D. M. Jordan, in collaboration with J.R. Dwyer and H. Rassoul of Florida Tech authored a paper titled “"Chaotic" Dart Leaders in Triggered Lightning: Electric Fields, X-rays, and Source Locations”. They present the first observations of “chaotic” dart leaders in triggered-lightning discharges. They examine four leaders that exhibited “chaotic” electric field derivative (dE/dt) signatures in their final 10 to 12 us. The dE/dt signatures were characterized by bursts exhibiting widths of the order of hundreds of nanoseconds on which were superimposed irregular pulses with widths of the order of tens of nanoseconds. These unique signatures were dissimilar from the dE/dt waveforms observed from dart or dart-stepped leaders in triggered lightning. Three-dimensional locations for dE/dt pulses that radiated from the bottom 200 m of the leader channels were determined, as were emission times. A relatively continuous flux of energetic radiation (X-rays and gamma rays) was observed during the final 10–13 us of each “chaotic” dart leader. Some individual photons had energies more than 1 MeV. High-speed video images of three “chaotic” dart leaders were obtained at a frame rate of 300 kilo-frames per second (exposure time of 3.33 us). One image, in the frame immediately prior to the return stroke, shows an upward positive leader 11.5 m in length propagating from the launch facility and a downward negative leader above with a streamer zone length of about 25 m. Channel base currents preceding the four “chaotic” dart leaders were of unusually long duration and large charge transfer, and return strokes following them had larger than usual peak currents. The paper is published in the JGR - Atmospheres.

University of Reading (U. K.)

Giles Harrison (r.g.harrison@reading.ac.uk)
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The Space Weather and Atmospheric Electricity group at the University of Reading (http://www.met.reading.ac.uk/~spate/) continue to study the interactions between the heliosphere, atmospheric electricity and cloud processes, through data analysis, measurements and instrumentation development. Recent work on the atmospheric electricity aspects has concerned airborne measurement methodologies and the effects of ENSO on the global electric circuit. In a review paper entitled "Measurements of atmospheric electricity aloft" (*Surveys in Geophysics*, DOI: 10.1007/s10712-012-9188-9), Dr Keri Nicoll discusses the history of atmospheric electrical measurements aloft, from the earliest manned balloon ascents to current day observations with free balloons and aircraft. A range of electrical conditions is discussed including fair weather, non-thunderstorm clouds, polluted conditions, and thunderstorms. Prof Giles Harrison has recently published work on "Inferring convective responses to El Niño with atmospheric electricity measurements at Shetland" (*Environ. Res. Lett.*, DOI:10.1088/1748-9326/6/4/044028). The paper concerns the relationship between Pacific ocean temperature anomalies associated with the El Niño–Southern Oscillation (ENSO), and surface measurements of PG made in Scotland. Additionally, in collaborations with Prof Michael Rycroft (University of Bath) and Dr Karen Aplin (University of Oxford), the group has published work entitled "Recent advances in global electric circuit coupling between the space environment and the troposphere" (*J. Atmos. Sol.-Terr. Phys.*, DOI:10.1016/j.jastp.2012.03.015). Together with an earlier paper with Michael Rycroft, this paper provides an up to date discussion of both DC and AC effects in the global electric circuit, as well as variability in the GEC due to short and long term external influences. Implications of GEC variability for atmospheric processes are also considered.

University of Washington

WWLLN (World Wide Lightning Location Network) (http://wwlln.net) has been growing and the research with the data has also been growing this past year. The highlights include:

1. In the paper K. S. Virts et al, Geophys.Res. Lett., 38, L19803, doi:10.1029/2011GL048578. (see http://wwlln.net/publications/virts.2011GL048578.pdf) We demonstrated that "Composites of the daily NO2 observations regressed onto lightning frequency reveal a plume of enhanced NO2 following a day of enhanced lightning. Lightning and NO2 also vary coherently with the intraseasonal Madden‐Julian Oscillation (MJO) in a manner distinct from the cloudiness signature, with variations of up to ∼50% of the annual mean.
2. Hutchins, M.L., et al, JTech (J. Atmos. and Ocean. Tech. (AMS), V.20 (IN PRESS) 2012 demonstrated our new technique for measuring the

radiated VLF energy per stroke in a 1.3ms sample period. These data are now being generated routinely for all WWLLN data. Archival data files back to April 2009 have been used to calculate the energy per stroke back to that date. WWLLN hosts and customers can obtain the energy per stroke data back to that time. If you are a host or if you already purchased the regular WWLLN data, we will provide these new data for all strokes for free.

3. New lightning climatology using several years of WWLLN data have now been developed by Virts et al (paper in development, but you can look at the cool movies at http://wwlln.net/climate).

4. If you have used WWLLN data in any scientific publication please email Bob Holzworth so we can add your paper to our list of WWLLN papers at http://wwlln.net/publications.

5. We now provide hourly maps of WWLLN relative detection efficiency for the globe, so we can correct for variable global coverage of our sensors as the ionosphere changes daily. Contact bobholz@uw.edu for anything WWLLN related.

C/NOFS Lightning Studies in the Ionosphere.

The C/NOFS satellite is operating well in its equatorial orbit with inclination of 13 degrees, perigee of 400km and apogee of 850 km. All sensors are working fine, and several new papers have been published including:

Holzworth, R. H., et al Lightning-generated whistler waves observed by probes on the Communication/Navigation Outage Forecast System satellite at low latitudes, J. Geophys. Res., 116, A06306, doi:10.1029/2010JA016198, 2011.

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Jacobson, A. R., et al Initial studies with the Lightning Detector on the C/NOFS satellite, and cross-validation with WWLLN, Journal of Atmospheric and Oceanic Technology (JTech) DOI: 10.1175/JTECH-D-11-00047.1, V. 28, p. 1423, 2011.

We are always looking for highly qualified graduate students, as well as those who may have a hosted post doc. Our lightning studies group now includes these UW faculty members: R.H. Holzworth, M. P. McCarthy, A. R. Jacobson, J. N. Thomas, C. F. Mass, J. M. Wallace, G. J. Hakim, L. A. McMurdie, Jim Weinman and Robert Houze as well as their students.

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Reminder

Newsletter on Atmospheric Electricity presents twice a year (May and November) to the members of our community with the following information:

- ✧ announcements concerning people from atmospheric electricity community, especially awards, new books...,
- ✧ announcements about conferences, meetings, symposia, workshops in our field of interest,
- ✧ brief synthetic reports about the research activities conducted by the various organizations working in atmospheric electricity throughout the world, and presented by the groups where this research is performed, and
- ✧ a list of recent publications. In this last item will be listed the references of the papers published in our field of interest during the past six months by the research groups, or to be published very soon, that wish to release this information, but we do not include the contributions in the proceedings of the Conferences.

No publication of scientific paper is done in this Newsletter. We urge all the groups interested to submit a short text (one page maximum with photos eventually) on their research, their results or their projects, along with a list of references of their papers published during the past six months. This list will appear in the last item. Any information about meetings, conferences or others which we would not be aware of will be welcome.

Newsletter on Atmospheric Electricity is now routinely provided on the web site of ICAE (http://www.icae.jp), and on the web site maintained by Monte Bateman http://ae.nsstc.uah.edu/.

In order to make our news letter more attractive and informative, it will be appreciated if you could include **up to two photos or figures** in your contribution!

Call for contributions to the newsletter

All issues of this newsletter are open for general contributions. If you would like to contribute any science highlight or workshop report, please contact Daohong Wang (wang@gifu-u.ac.jp) preferably by e-mail as an attached word document. The deadline for **2012 winter** issue of the newsletter is **Nov. 15, 2012**.

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