Newsletter on Atmospheric Electricity

Vol. 28, No. 1, May 2017

International Commission on Atmospheric Electricity (IAMAS/IUGG)
AMS Committee on Atmospheric Electricity
AGU Committee on Atmospheric and Space Electricity
European Geoscience Union
Society of Atmospheric Electricity of Japan

ICAE 2018: Call for Abstracts Open Now

The 16th International Conference on Atmospheric Electricity (ICAE) will be held June 17-22, 2018, at Nara Kasugano International Forum/IRAKA, Nara, Japan. The ICAE brings together scientists from all over the world to discuss the latest research on atmospheric electricity.

The call for abstract is open until October 1, 2017. A list of topics includes:

- Lightning Physics
- Lightning and Meteorology
- Meteorological Applications of Lightning Data
- Energetic Radiation from Lightning and Thunderstorms
- Thunderstorm Electrification and Microphysics
- Lightning Effects on the Middle and Upper Atmosphere
- Lightning Climatology and Chemical Effects
- Lightning and Thunderstorm Detection Technologies
- Satellite Measurements
- Lightning Hazards and Mitigation
- Fair Weather and Atmospheric Ions
- Global Electric Circuit
- Related Topics

For more details, visit http://icae2018.saej.jp.

Dedication

Dr. Dave Rust

Dave Rust, our esteemed colleague, died on May 9 from complications related to Parkinson 's disease. He had been in hospice care at home since late March and was with family at home in Norman, Oklahoma, when he died.

Throughout his 40+ year career studying the electrical nature of storms, Dave was an outstanding observationalist who devoted his considerable talents to developing and using new means for measuring the atmosphere. Because he recognized that good measurements are essential for good science, he insisted on rigorously verifying that the observations he reported were correct. He used those measurements to develop new paradigms of lightning and thunderstorm charge structure.

Dave had a productive career, authoring or co-authoring over 80 journal papers, two book chapters, and an award-winning textbook published by Oxford University Press. For his ground-breaking contributions, he was elected a Fellow of the American Meteorological Society in 2010 and a Fellow of the American Geophysical Union in 2014. Other honors he received included the Outstanding Paper Award from the Office of Atmospheric Research of the National Oceanic and Atmospheric Administration in 2000, the U.S. Department of Commerce Silver Medal Award in 1976, the U.S. Department of Commerce Gold Medal Award in 1995, the Langmuir Award for Excellence in Research in 1994, the NASA Robert H. Goddard Trophy: Viking Mission to Mars in 1977, a NASA Space Flight Awareness Team Award in 2010, a Scientific Achievement Award from NOAA's Office of Atmospheric Research in 2012,and three NASA Group Achievement Awards spanning 1976-1986. The following are among his many contributions to our science:

1. He produced by far the most extensive set of electric field soundings of many types of warm-season storms, thereby establishing that
   a. The stratiform precipitation region of mesoscale convective systems (MCSs) and the anvil of many severe thunderstorms are highly electrified and can have charge densities and electric fields comparable to those in deep convection.
   b. The vertical distribution of charge in thunderstorms outside of updrafts typically is much more complex than a vertical dipole or tripole.
   c. Neither the magnitude of charge nor the number of charge layers in MCSs can be explained by simple advection from deep convection.
   d. The polarity of the vertical distribution of charge in some warm-season storms is inverted

from the usual polarity, particularly in the High Plains of the United States of America and in those storms in which most cloud-to-ground flashes lower positive charge to ground.

2. Using simultaneous video and electric-field documentation beginning in 1978, Dave established that (1) positive cloud-to-ground flashes can be produced naturally in warm-season storms, particularly in severe storms, and (2) like negative ground flashes, positive ground flashes have downward leaders followed by bright return strokes, but typically have longer continuing currents and larger action integrals.
3. Dave was a pioneer in harnessing his and others' storm-chaser enthusiasm to make mobile scientific observations, a capability that has been essential for many field programs, including VORTEX, VORTEX2, STEPS, TELEX, and DC3. Eventually he developed and became director of the Field Observing Facilities of the National Severe Storms Laboratory.

Dave also contributed significantly to the atmospheric electricity community overall:

He freely shared his knowledge, resources, and data with colleagues.

He advised and mentored undergraduates, graduate students (he was the research advisor for students earning eleven M.S. degrees and six Ph.D. degrees in meteorology and physics), and one postdoctoral research associate.

He headed a research division of the National Severe Storms Laboratory for over 20 years.

He served on the IUGG/IAMAS Commission on Atmospheric Electricity.

He co-taught a graduate atmospheric electricity course several times and used that experience to co-author a textbook, *The Electrical Nature of Storms,* which a review by Phil Krider said was "the best compilation of material on storm electricity that exists today."

As he made all these contributions, Dave approached life and his career with humility and a wry sense of humor. He was quick to give credit to those around him and encouraged their efforts; collaborating with him was a pleasure.

--Don MacGorman

Personal Remembrance of Dave

My friendship and collaboration with Dave Rust began in 1978, when I began working as a National Research Council postdoc with him and Bill Taylor at the National Severe Storms Laboratory. Our collaboration continued unbroken until he retired over 30 years later, when his Parkinson's disease had progressed to the point that he could no longer work full time. Dave was a wonderful colleague, helping me in many ways when I pursued on my own research projects and contributing a lot when we collaborated on a project together. I could not have asked for a better co-author when we worked together on our graduate textbook, *The Electrical Nature of Storms*.

Both together and separately, we carried out a lot of interesting field projects and learned a lot about lightning and about the electrical structure of storms. For that, I will always be grateful to him and to the atmospheric electricity community within which we worked. I also will always miss Dave. But I hope to honor him by carrying forward in my life the many things I learned from him about treating people with courtesy and respect and about the care and integrity with which one must make scientific measurements in order for those measurements to be useful in advancing scientific understanding. Those traits are well worth imitating.

--Don MacGorman

Remembrance of Dave Rust

I first met Dave Rust in 1970 while he was working on his Ph.D. at Langmuir Laboratory, flying electric-field meters into the bases of thunderstorms on tethered aerostats. Henry Houghton, my advisor at MIT, had persuaded Bernie Vonnegut to bring me out to the mountain for the summer to learn something about Atmospheric Electricity and, with luck, to find a dissertation topic.

Charlie Moore and Bernie convinced me to work on an experiment that Bernie had proposed earlier and in which Ralph Markson had been involved. I was to record the fair-weather ambient atmospheric potential at the aerostat by nulling out the local field there using a ground-based, high-voltage power supply to energize the conducting tether.

Dave was in charge of operating and using the aerostats. Soon I, who at this point had some theoretical understanding of what was going on but no practical experience in the field, was trying to help him on storm days, and he was helping me on fair-weather days. Dave seemed to me amazingly brave, handling the aerostats outdoors in the middle of thunderstorms, but was almost always patient with me and taught me a lot. This and a second summer in 1972 eventually led to a joint paper on the fair-weather atmospheric potential at balloon altitudes and its near-real-time monitoring with Bernie's technique. It did, indeed, set me on the road to a dissertation on the theory of convection currents in the fair-weather atmospheric boundary layer.

An incident that I remember especially well occurred during one of my best flights, when the aerostats had been roughly 1.4 km above the ridge for over 1.5 hr and I was obtaining the most detailed recording of the experiment. A small aircraft blundered into the restricted airspace over the mountain, and Dave ordered me to dump the power supply. My immediate reaction, looking at the great data rolling in, I was to ignore what seemed a negligible chance that the aircraft could hit the tether, but Dave lost patience and pointed out that he and his crew could be killed by the high voltage if it cut the cable. This was a lesson for a theoretician about the realities of field work that he has never forgotten. God speed, Dave.

-- John Willett, 5/12/17

My First Interaction with Dave

Dr. David Rust was a member of my PhD committee. He was an energetic and exact researcher, who ran the "balloon barn" like a tight ship. Checklists and orderliness kept the researchers safe and led to many successful storm-chasing missions. I ran a computer system in a storm-chasing van that recorded transmissions from the balloon-borne radiosonde telemetry. I got this job after telling Dr. Rust that I would not get car sick. He replied, "That's what I like to hear." The scary part of this job was linking the computer system, which was initiated with punch cards, with the radiosonde signal while being in radio contact with Dr. Rust. Dr. Rust would be directly under an active lightning storm, holding a balloon with other researchers, and waiting for me to give an "Affirmative" to release the balloon. Thankfully, no one was ever hurt. When it was time to leave the balloon barn to begin a mission or Braum's after a break, Dr. Rust would simply say, "Let's mosey", and we'd be off on another adventure. I will always have great respect for Dr. Rust.

--Heidi E. Morris

Messages in memory of Dave Rust

From Maribeth Stolzenburg: Several years ago, I was asked by a colleague for my comments regarding Dave’s mentorship to students. I wrote the following:

1. Dave was an absolute expert in real-world data collection under any conditions. His logistical skills and abilities to prepare for the seemingly endless small and large difficulties encountered in mobile ballooning are unmatched. Along with this, he recognized the importance of students getting fully hands-on experience in all aspects of field work. Levels of involvement varied according to the student's level of interest, ability, and experience, but we were all exposed to the full range of training in the daily operations. Students working with him soon knew their own responsibilities and were familiar enough with the other duties to be able to help in those tasks whenever needed. Dave's knowledge and experience in field work rubbed off on his students because he was always fully dedicated to the project underway.

2. Dave always seemed to thrive on experimentation. I worked very closely with him through eight different field projects in the 1990's (as his graduate student then as a post-doc elsewhere). I cannot recall a year when we were not trying something fundamentally new: Linux-based data acquisition software, GPS radiosondes, tunable transmitters, polyethylene balloons, etc. Everything--from rain gear and balloon rigging to A/D converters, filters, and receivers--was eligible for improvement. He always wanted to take advantage of the latest improvements, while having the opportunity to test and further improve worthy new technologies. Although one might expect that since Dave had been taking data successfully for so long, he might have a tendency to use the same stuff year after year, this was never the case if there was something available that was potentially better.

3. He had very good listening skills, especially with students trying to flesh out scientific ideas. In my experience, once we convinced Dave that our ideas were sound, he was ready to support us and our ideas through all the criticism of other faculty, colleagues, and reviewers. This level of advisor support is rare but extremely important for students.

4. Dave exhibited what I would call "true mentorship," in the sense of taking one from the level of student to peer. While students working with Dave were always treated by him with respect, we were also expected to rise in our range of knowledge and in our ability to communicate the science in which we were involved. In our own projects, we were guided and prepared for conference presentations through practice sessions, first one-on-one and then to the entire "Storm Electricity & Cloud Physics Research" (SECPR) group at NSSL (of which Dave was long-time Chief). Master's students were strongly encouraged to submit their thesis work for publication; for Ph.D. students, journal submission was a requirement of Dave's before he would sign the dissertation. In requiring us to achieve this milepost, he forced us to rise to the level of a colleague. The process also made us realize that the work we were doing had to be relevant and scientifically worthy.

5. (This I added later, after more thought.) We women students were treated essentially the same as

the men students. In all the time I worked closely with Dave in mobile ballooning and data analysis, I do not remember him ever indicating women could not do certain difficult tasks or should be expected to undertake some easier parts of the work. Whether it was driving trucks or moving helium tanks or cleaning up the mobile lab after a long intercept, everyone took a turn if they were ready, willing, and able. I did not realize at the time how important this gender-blind inclusiveness was to the way we all got the job done and to how we felt about our resulting accomplishments.

My personal and professional debt to Dave Rust is enormous. I left behind family and friends in hopes of working with Dave at NSSL; the opportunity changed everything for me. Six years later, when asked to be a groomsman in our wedding, Dave had to decline because the event conflicted with the 1996 ICAE conference in Japan. At that meeting, Dave was presenting (in part) my dissertation research that he had guided. Dave and I transitioned from teacher-student to colleague and friends through many hours of field campaigns and through work on our 16 co-authored papers between 1994 and 2007. His impact on our field has been enormous, as well, and is more far-reaching than most can recognize or fully appreciate. His encouraging smile, his friendly Texas wit, his post-chase driving of NSSL1 home through the night, his infectious desire for the latest and greatest new techniques, and his always-humble attitude in science will be forever missed. Somewhere, Dave's "Saddle Up!" call resounds through space.

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From Tom Marshall: Dave Rust was a close colleague and a good friend. I worked closely with Dave on 16 different field projects, beginning in 1982 and ending in 1999. This started when I, with PhD just completed under the guidance of Bill Winn at New Mexico Tech, was hired at the University of Mississippi partly to work with Roy Arnold who at that time was studying acoustics in thunderstorms. It was Roy Arnold and the UM "Sound Chase" van that first brought together Dave's expertise in storm intercept and my experience in balloon-borne instrumentation. Through the following years, I sometimes stayed with Dave and family while in Norman for the annual field campaigns. Our joint work extended throughout the Great Plains (12 years) and to Alabama (in 1986), to Langmuir Lab in several years (where my son got to join us), and to Kennedy Space Center once (where Dave's daughter Amy took a turn at helping with data collection). Dave also guided a string of successful students who took part in ballooning and conducted their research with the sounding data.

Most of our projects involved flying instrumented balloons into thunderstorms to measure the electric field. These projects helped provide information about the electrical structure and charge structure of various types of thunderstorms as detailed in 30 refereed publications coauthored by Dave, me, and (usually) others. I am so fortunate to have worked with Dave because he was a great scientist and a wonderful colleague. Dave had an excellent sense of humor that eased tense situations as we chased storms across Oklahoma, Texas, and Kansas. Many things can go wrong when chasing storms and launching balloons in high winds and heavy rain or hail. Dave was always working on ways to improve our chances of getting to a storm safely, of successfully launching an instrumented balloon, and of collecting the data telemetered from the balloon instruments. Dave was also a humble man without pretensions. No job was too small for him as indicated by the following short list: he washed all of our raingear in special soap to make them work better, baked water repellent on the balloon rigging lines (in his oven at home) to make them non-conductive, tacked little bags inside the balloon truck to hold small balloon line loops needed to quickly connect instruments to the balloons just before a launch, and made long check lists of all the things needed in each chase vehicle so we would have all the tools and parts we needed wherever we were. The goal was to collect data, and he did everything he could to help us reach that goal. Once we had the data, Dave was an incisive scientist with an open mind for the ideas of others as we worked to combine the electric field measurements with radar data of the storms and with thermodynamic data recorded on the balloons to determine where the main electric charges were located in the storms. I will miss Dave a lot -- he was an inspiring, generous colleague and a gracious, humble friend.

A message about Dave Rust

I was deeply saddened to learn of the passing of Dr. David Rust, a long time colleague and friend. I will be forever grateful to Dave for getting me interested in lightning in the early 80's when I had the great pleasure and opportunity to meet both him and Don MacGorman at NSSL and later work with them in the 1985 PRE-STORM experiment. We went on to work together in several of the NSSL spring programs such as COPS and MeAPRS, and later in the STEPS 2000 field campaign. Oh how I looked forward to going down to NSSL and participating in those experiments. Dave was not only a great mentor to me during those campaigns, but to my students as well. Dave had a special talent for getting in just the right place to launch a EFM balloon into a MCS or supercell! How fun that was. I will forever have special memories of Dave, an outstanding scholar and a true gentleman. I will miss his warm and inquisitive smile very much.

--Steven Rutledge (Colorado State University)

A message about Dave Rust

Dave Rust was a real giant in our field, and a really nice guy to boot. His development of the mobile balloon-based measurements of thunderstorm electric fields provided an enormous contribution to our understanding of cloud electrification. I have great memories from interacting with him both at conferences and in the field (MEaPRS and STEPS). I learned a lot from his papers, as well as from his textbook. I feel privileged to have been a co-author with him on the STEPS BAMS article, and I am proud to have played a small role in making sure he got elected AGU Fellow. My condolences go out to his family, friends, and his NSSL colleagues.

--Timothy Lang

A message about Dave Rust

Dave Rust was an outstanding scientist who was always very generous with resources and his time. When I arrived in Norman he loaned me equipment and parts to build instruments, and helped me re-start my research career after 6 years as a bureaucrat. Over the years he served as an extremely valuable member of many of my graduate students' committees, sharing his knowledge of ballooning techniques and instrumentation design and development. He set a standard for collaboration that is an example for all of us. He epitomized the AGU motto "Unselfish Cooperation in Research". He will be sorely missed in the atmospheric electricity and lightning research communities and at OU.

-- William H. Beasley

A message about Dave Rust

"Dave Rust's unpretentious excellence and collaborative spirit was an important part of the glue that held our small atmospheric electricity community together. He will be greatly missed."

-- Richard Sonnenfeld, New Mexico Tech

Dr. Nobu Kitagawa (1919-2017)

Now memorialized in the name of a special component of a lightning flash called "K-change" that he did much to expose and understand, Nobu Kitagawa died on February 14, 2017 at age 98. His two main tools for lightning investigation were optical and electric field detectors operated simultaneously. With them he produced two first-authored papers that are now classics in lightning physics: "A Comparison of Intracloud and Cloud-to-Ground Lightning Discharges" (Kitagawa and Brook, 1960) and "Continuing Currents in Cloud-to-Ground Lightning Discharges" (Kitagawa, Brook and Workman, 1962). His lifelong interest in atmospheric electricity extended well beyond the workings of the lightning flash, as with investigations of the effect of lightning on the human body, the use of thunder day records to examine climate change in Japan, and the examination of the electrical structure of winter storms. He often characterized the latter as “large flat clouds”, a description that mirrored his general scientific approach: simple analysis that captured the essence and which was often quite accurate.

--Earle Williams

In memory of Professor Nobu Kitagawa (1919-2017)

Professor Nobu Kitagawa passed away on 14th February 2017 at the age of 98 having enjoyed a long professional career and then a happy retirement living in Saitama, Japan, with his wife Chiyoko san and regularly visited by his daughter Fumi san. Nobu helped inspire many people, through his warmth to family and friends, his highly collaborative approach to scientific investigation, his interest in classical music as well as his love of travel.

On Sunday 16th April 2017 a group of colleagues, friends and family met for dinner in Tokyo to remember Nobu and to celebrate his life and achievements. Professor Tomoo Ushio and Professor Koichiro Michimoto attended the dinner on behalf of the Society of Atmospheric Electricity of Japan. Koichiro spoke very kindly about Nobu’s interests in lightning research and as a mentor to the next generation of researchers. I, as Nobu’s son-in-law, also shared the honour of speaking of Nobu and his journey in life.

Nobu was born in 1919 and as a child lived in Kiryu with his family who owned a very successful silk and textiles business. One of the first great decisions to shape Nobu’s journey in life was to study physics at the University of Tokyo in preference to working in the family business. Nobu went on to apply this interest in physics by joining the meteorological office of Japan as researcher. This work contributed towards Nobu’s Ph.D. which was awarded by the University of Tokyo in 1958. Next, Nobu moved to the USA for three years to join the science faculty at New Mexico Tech where he pursued his research interest in meteorology and, in particular, the fundamental science of lightning phenomena. After returning to Japan Nobu continued his interests in lightning research at the meteorological office and then in 1969 he was appointed as a professor at the department of electrical engineering at the University of Saitama. Nobu developed this interest into the research of lightning accidents and then, in due course, the development of a lightning safety code which was published across Japan. In Nobu's career of science Nobu was a man of great precision, great dedication and a great inspiration to his students. Recognition for his science came in three forms:

First, Nobu was the first president of the predecessor organisation to the Society of Atmospheric Electricity of Japan (to which Professor Ushio is the current president). Second, Nobu was the first recipient of the Kitagawa international medal for contribution to keraunomedicine research which he received at ICOLSE in 2003; and third, Nobu appeared on Japanese television over many years as 'Professor lightning' offering advice to the public on prevention of lightning accidents when outdoors. In the last few weeks as Fumi and I have been learning more about Nobu's research career we made contact with Professor Mary Ann Cooper at University of Illinois, Chicago, who describes Nobu as one of the early pioneers of lighting research together with Professor Masajiro Ohashi who also recently passed away. Both Professor Cooper[1] and Professor Michimoto[2] have written essays which reference Nobu's contribution to science.

Nobu had a great interest in classical music with Dvořák and Mahler as his favorite composers and Nobu and Chiyoko often enjoyed live classical music concerts in Saitama. Also, Nobu had a life-long interest in hi-fi sound systems which spanned his early experiments with stereo broadcasts in the late 1930's, through to owning a rather high end Bose audio system in the 1970's (which is still a pleasure to listen to), through to TV surround sound which interested Nobu up until last year. In fact, as Nobu perfected his sound system for enjoying Sunday classical NHK TV broadcasts, in recent years be would ask Chiyoko san to visit the Bose shop in Akihabara, Tokyo, to collect the latest gadget to improve sound quality.

Nobu's research and international travel created a great opportunity for Kitagawa family adventures to places such as New Zealand, North America, Guadeloupe and widely across Europe. Some of the happiest moments I have shared with Nobu, Chiyoko and Fumi have been our visits to the Nasu mountains of Japan. Here we have shared stories of family pets, Haiku poetry of Basho,

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[1] Cooper M. A (2012) A Brief History of Lightning Safety Efforts in the United States http://www.vaisala.com/en/events/ildcilmc/Documents/Safety/A%20Brief%20History%20of%20Lightning%20Safety%20Campaigns%20in%20the%20United%20States.pdf, International Lightning Detection Conference/International Lightning Meteorology Conference, April, 2012;
Cooper M.A and Holle R. L (2012) Lightning Safety Campaigns – USA Experience, 2012 International Conference on Lightning Protection (ICLP), Vienna, Austria ;
Cooper M.A (2016) An (In complete) History of Lightning Safety http://www.acofi.edu.co/womel/wp-content/uploads/2016/04/Mary-Ann-Cooper.pdf, World Meeting on Lightning, 6-8 April, 2016.

[2] Michimoto, K (2017) Memorial of Professor Nobuchiro Kitagawa, The Society of Atmospheric Electricity of Japan, April 2017 (in Japanese). [to be published]

picnics in shade of the summer sunshine and touring adventures in the family Prius – yes – Nobu had a great personal interest in electric vehicles too.

Nobu made important contributions to science and maintained his interest in electricity and lightning into his long and happy retirement in Saitama with his wonderful wife Chiyoko san. He is missed by all who knew him.

--Dr Clive Reeves-Kitagawa

Dr. Roger Lhermitte (May 28, 1920 - Nov 21, 2016)

Pioneer without peer for five decades in Doppler methods in radar meteorology, Roger Lhermitte died on November 21, 2016 at age 96. Key scientific contributions include the VAD (Velocity Azimuth Display) for wind field analysis (1961), the conceptualization of the velocity couplet for mesocyclone detection in severe storms (1964), the design of the pulse pair processor for efficient access to the mean Doppler velocity (1972), and the development of multi-Doppler methods for three-dimensional thunderstorm analysis (1970s). A short-baseline triple Doppler network was a major component of the Thunderstorm Research International Program (TRIP) from 1976-1978 at the NASA Kennedy Space Center to probe the convective and electrical structure of thunderstorms. In later years, Lhermitte applied Doppler methods with sonar (1980s) to measure water flow and in situ turbulence.

--Earle Williams

Dr. Ninel Nikolaevna Nikiforova (1932-2016)

It is with great sadness that we say goodbye to Nela Nikiforova, a long a close collaborator of the Institute of Geophysics, Polish Academy of Sciences. Her person and her generous support of the atmospheric electricity research conducted by the Institute lives in the memory.

Ninel (Nela) Nikolaevna Nikiforova was born on February 6, 1932, in Moscow. In 1954 she graduated from the Moscow Geological Prospecting Institute (MGRI). She began her professional career at the Schmidt Institute of Earth Physics of the Russian Academy of Sciences (IPE RAS) where she worked until retirement. There she studied magnetotellurics and co-developed the pioneering method of the magnetotelluric sounding (MT) which is still used in geophysics. In the early 70's she got interested in the AC electric fields in the atmosphere because of the need for the inclusion of their components to the theory of the MT method.

The long-term, systematic registration sof the vertical component of the atmospheric field Ez in Poland in the Geophysical Observatory of the Institute of Geophysics in Swider and of the geomagnetic field in the nearby Geophysical Observatory in Belsk gave the opportunity to study a variety of correlations between these values. Nela Nikiforova, already collaborating with the Department of Magnetism at the Institute of Geophysics, seized this opportunity and began working with the Laboratory of Atmospheric Electricityand joined its research programme. Together with Stanislaw Michnowski, the ehad of the Laboratory she conducted the study of short-term ripple component of the electric field and magnetic field components, the results of which were presented at the International Conference on Atmospheric Electricity in Garmich-Partenkirchen. Along with the Polish colleagues from the Laboratory of Atmospheric Electricity she has started working on the interpretation of electric field recordings at Polish polar station in Hornsund (Spitsbergen) and the observatory in Swider, then led by Stanislaw Warzecha, and in following years by Marek Kubicki, against the background of comprehensive geophysical, magnetic and meteorological observations conducted there. These studies led to the discovery of the effect of magnetic storms on the ground-level electric field not only in the polar regions but also at middle latitudes. The first observation of this phenomenon by Nela Nikiforova is an achievement on a global scale. These studies have been continued by professor Natalya Kleimenova, on the basis of materials from Swider and Hornsund. Results of the research, published in many works, have contributed to the development of the field of research on the influence of the solar wind, magnetosphere and ionosphere on the electric field in the lower atmosphere.

An important achievement of Nela Nikiforova was the experimental finding of the electric field in Swider as a precursor of the Carpathian earthquake in 1986. Conducive to its previous interest and research in the IPE RAS. She presented the results of the studies of this effect at the IUGG international conference in Boulder in 1995, and cataloged similar cases in a valuable publication.

The fruitful cooperation with Nela Nikiforova was possible, among other things, thanks to her great personal talents. She was a person fascinated with science. Her extraordinary perseverance, camaraderie and patience in overcoming a wide variety of science problems made it possible to overcome difficulties in finding the regularities in the complex relationships between atmospheric electricity and changes in the geomagnetic field and other geophysical elements.

Ninel Nikolaevna Nikiforova died in Moscow on 22 July 2016. Institute of Geophysics is grateful to Nela Nikiforova for her hard work and her great contribution to the joint research.

--Stanislaw Michnowski and Anna Odzimek

Announcements

32nd General Assembly and Scientific Symposium of International Union of Radio Science (URSI) – August 19-26th, 2017, Montreal, Canada

Joint Session Organized by Commissions H, G and E: Atmospheric, Ionospheric, Magnetospheric and High Energy Effects of Lightning Discharges

The recent discovery that lightning discharges can cause energetic radiation, relativistic particles, and transient luminous events has marked a profound advance in our understanding of the Earth's atmospheric and ionospheric electrodynamics. This session explores these novel processes and their impact on the near-Earth environment. The session solicits contributions that advance knowledge in the areas of the global atmospheric electric circuit, lightning physics, transient luminous events, energetic radiation, relativistic particles, and their impact on the Earth's atmosphere, ionosphere, and magnetosphere. One key focus of the session will be novel observations onboard space platforms, such as the lightning imagers on geostationary satellites, the TARANIS satellite, the ASIM payload on the International Space Station, and related ground based observations and their modelling. Interdisciplinary studies, which emphasize the connection between atmospheric layers and the relation between atmospheric electricity and climate change are particularly welcome.

The web page http://www.ursi2017.org/ contains general information and abstract submission instructions and guidelines.

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XIV International Symposium on Lightning Protection (SIPDA 2017)

Photo credits: praiasdenatal.com.br

Prof. Alexandre Piantini, Chairman of the XIV International Symposium on Lightning Protection (SIPDA 2017), is very pleased to announce the symposium, which will be held in Natal, Brazil, from 2nd to 6th October, 2017. The event is organised by the Institute of Energy and Environment of the University of São Paulo (IEE/USP) with the technical co-sponsorship of the Institute of Electrical and Electronics Engineers (IEEE) and support of the National Institute for Space Research (INPE) and the Federal University of Minas Gerais (UFMG). The aim of the symposium is to present and discuss recent developments concerning lightning modelling and measurement techniques, as well as grounding and lightning protection.

The papers presented at the symposium will be published in the IEEE Xplore database. In addition, as in the previous SIPDA editions, a special issue of the Electric Power Systems Research is being planned to publish extended and improved versions of selected papers.

Prof. Vladimir Rakov (USA), Prof. Shigeru Yokoyama (Japan), Prof. William Chisholm (Canada) and Prof. Carlo Alberto Nucci (Italy) will deliver invited lectures at the conference.

For more information, please contact sipda@iee.usp.br or visit the symposium website at http://www.usp.br/sipda.

The 1st International Symposium on Lightning Physics and Lightning Meteorology (1st ISLP&M 2017 Beijing, China, September 24-27, 2017)

The aim of the Symposium is to exchange new thoughts on lightning studies, further enhance the application of lightning detection, improve the scientific understanding of lightning over many temporal and spatial scales, and promote the development of interdisciplinary research on lightning.

Topics of Symposium:

1. Lightning Physics
2. Lightning Detection Technologies
3. Thunderstorm Electrification and Microphysics
4. Lightning Meteorology and Severe Thunderstorm
5. Lightning Effects on Middle and Upper Atmosphere
6. Lightning Attachment and Protection

Committee members:

Paul Krehbiel (USA)	Pierre Laroche (France)	Ted Mansell (USA)
Joan Montanya (Spain)	Xiushu Qie (China, *Chair*)	Vladimir Rakov (USA)
Xuan-Min Shao (USA)	Serge Soula (France)	Daohong Wang (Japan)
Earle Williams (USA)	Yijun Zhang (China)	

Deadlines:

Abstract submission: June 30, 2017.

Notification of acceptance: July 31, 2017

For more information, please visit the symposium website at: http://islpm2017.csp.escience.cn/

2018 International Lightning Detection and International Lightning Meteorology Conferences

The 25th International Lightning Detection Conference and 7th International Lightning Meteorology Conference (ILDC/ILMC) will be held **March 12-15, 2018**, at the **Hyatt Regency Pier Sixty-Six in Fort Lauderdale, Florida, USA**. The ILDC/ILMC is a scientific conference focused on lightning detection topics and meteorological applications for lightning data. Organized every other year, the conference brings together global participants and lightning experts to present new detection technologies, research findings, and new applications. The theme of the 2018 conference is **Connecting Research & Applications**.

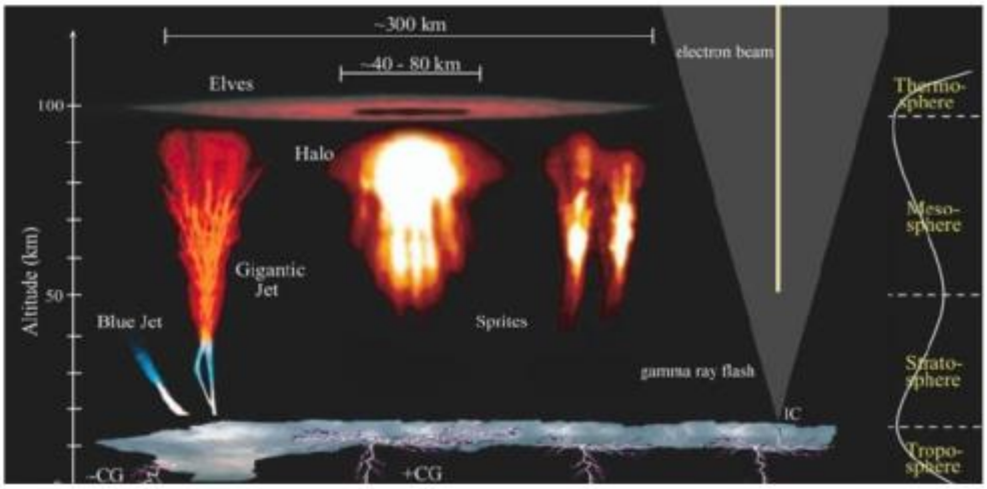
The call for abstracts is open until **October 16, 2017**. Authors are encouraged to submit their abstract for a verbal presentation or poster session. A list of suggested topics for the 2018 conference includes:

- Lightning Physics, Characteristics and Measurements
- LLS Technology and Performance
- Tower-Initiated and Rocket Triggered Lightning

- Lightning Interactions with Transmission Lines and Wind Farms
- Lightning Effects on the Atmosphere (Upper Atmosphere, Ionosphere, NOx)
- Merged Ground-based and Satellite Lightning Data: Research and Applications
- Cloud Processes, Thunderstorm Electrification and Lightning
- Applications of Lightning Data: Insurance Claims, Fire Risk, Mining, etc.
- Applications of Lightning Data: Community events, Advanced Warnings
- Meteorological and Climatological Studies Including Lightning
- Meteorology: Numerical Modeling
- Aviation and Other Unique Uses of Lightning Data
- Lightning and Lightning Casualty Occurrence

For details, visit www.vaisala.com/ildc.

12 Ph.D. scholarships are open within the EU H2020 Marie Skłodowska-Curie Project SAINT (Science and Innovation with Thunderstorms)



SAINT will study (1) Terrestrial Gamma-ray Flashes (TGFs) from thunderstorms, (2) Transient Luminous Events (TLEs) of electric discharges in the atmosphere between thunderstorm cloud tops and the ionosphere, the Sprites, Blue Jets and Gigantic Jets, and (3) conventional lightning. SAINT will conduct research into the fundamental physics of these phenomena by analyzing data from dedicated space missions, conducting ground-based observations of thunderstorms and High-Voltage laboratory experiments, and by developing advanced simulation codes. The space missions include the Atmosphere-Space Interactions Monitor (ASIM) for the International Space Station with launch in March 2018 and the Lightning Imaging Sensor (LIS) already installed on the space station.

The Ph.D. Scholarships are:

1. **Simultaneous TGFs and optical emissions observed by ASIM and ISS-LIS;** at DTU Space, Lyngby, Denmark. http://www.dtu.dk/english/career/job?id=0bb2ef75-63a6-4ec0-8ca3-b01d7a21ddad

The objective is to understand the electric discharge processes that generate the Terrestrial Gamma-ray Flashes and to determine if TGFs are associated with an optical signature in lightning detection cameras deployed and planned for geostationary monitoring satellites (GOES-R and MTG). Data are interpreted with optical and X-ray observations in High-Voltage laboratory experiments in collaboration with other Ph.D. students in the SAINT project.

2. **Lightning and TLEs observed simultaneously by ASIM and ISS-LIS;** at DTU Space, Lyngby, Denmark. http://www.dtu.dk/english/career/job?id=0bb2ef75-63a6-4ec0-8ca3-b01d7a21ddad

The objective is to identify the signatures of TLEs in ASIM data, to characterize their spectral and temporal properties and global distribution, and to determine the leader-streamer nature of Jets and Gigantic Jets. Analysis with simultaneous LIS data will give inputs to the design of L2 algorithms for the lightning imaging camera planned for geostationary monitoring satellite MTG and to plasma chemistry models developed by other Ph.D. students in the SAINT project.

3. **TGFs observed by ASIM simultaneously with lightning from the ground;** at University of Bergen, Norway. Contact address: martino.marisaldi@uib.no

The objective is to determine what type of lightning generates TGFs, to characterize the source properties and global distribution of TGFs, and to develop a conceptual design of an algorithm to recognize the signature in 3D lightning detection network data of high-energy radiation events. The space and ground data are interpreted using laboratory experiments and simulations in collaboration with other Ph.D. students in the SAINT project.

4. **Lightning observed simultaneously by ASIM/ISS-LIS, and from the ground;** at University of Bath, U.K. https://www.bath.ac.uk/jobs/Vacancy.aspx?ref=CT4909

This project investigates the relationship between electromagnetic waves from transient luminous events and their causative lightning discharges in different parts of the spectrum. In particular, the optical emissions from transient luminous events are recorded from the vantage point of space for comparison with the radio waves emitted by the causative lightning discharges and subsequent transient luminous events that are recorded on the ground. The comparison at different wavelengths yields critical information on the physical processes associated with transient luminous events.

5. **Thundercloud and lightning observed simultaneously from space and from the ground;** at University Paul Sabatier, Toulouse, France. www.adum.fr/as/ed/voirproposition.pl?site=adumfr&matricule_prop=14865

The objective is to characterize the physical processes of TLEs (sprite, ELVES) and their relationships with lightning flash associated and thundercloud. Optical observations will be performed from several sites to triangulate the events, by using sensitive and fast cameras, especially above storms occurring over the site instrumented in Ebro delta. Data about cloud physics and lightning physics will be associated to identify the cloud charge involved in TLE-producing flashes. Collaborations with other Ph.D. student in the SAINT project will allow to associate optical events and lightning processes recorded from ground to energetic radiations and optical events recorded from space.

6. **The electric current of lightning processes;** at University of Bath, U.K. https://www.bath.ac.uk/jobs/Vacancy.aspx?ref=CT4909

This project investigates the properties of exceptional lightning discharges. In particular, the polarity, intensity, and the spatial and temporal evolution of outstanding discharges processes will be determined. These important properties of lightning flashes are inferred from the remote sensing with radio wave measurements. The radio waves are recorded with arrays of radio receivers on various spatial scales ranging from thousands of km down to just one km. These measurements of radio waves on different scales are used to determine critically important information on the physical processes associated with exceptional lightning discharges.

7. **High-energy radiation from lightning strikes;** at University of Catalunia, Barcelona, Spain. http://lrg.upc.edu/en/available-phd-positions

The objective is to investigate of the mechanism of high-energy emissions produced from lightning strikes to ground and its possible relations on the source of Terrestrial Gamma ray Flashes. In order to advance the actual knowledge, the project includes as a main goal the development of a high-resolution VHF broadband digital interferometer that will join the existing facilities such as the Ebro Lightning Mapping Array, high speed cameras and the Eagle’s Nest multi-instrumented tower. These unique experimental facilities will allow to investigate precisely lightning leader processes at the time of energetic radiation. Numerical modeling will be conducted in collaborations with other PhD students in the SAINT project.

8. **Ultrafast spectroscopy and modeling of lightning;** at Institute of Astrophysics of Andalusia (IAA - CSIC), Granada, Spain. http://www.iaa.es/empleo/announcement-one-phd-position-transient-plasmas-planetary-atmospheres-group-trappa

This PhD project focuses on exploiting the scientific capabilities of our newly designed and recently built *GrAnada LIghtning Ultrafast Spectrograph* (GALIUS) in combination with the modeling of lightning dynamics. GALIUS is a portable, high spectral resolution imaging spectrograph that achieves unprecedented high speeds designed to work in the ultraviolet, visible and near infrared spectral ranges. The PhD project aims at determining key spectral properties (electron density and temperature, electric current electric field, ...) of the different temporal phases (streamers, leaders, return stroke and arcs) of lightning in order to understand lightning dynamics and the chemical influence of lightning in the atmosphere. Thus, the project also involves the use and/or development of lightning leader models to compute the production of nitrogen oxides (NOx) and other chemical species (ozone, ...) in lightning processes using inputs from the spectral characterization of lightning. A number of spectroscopic + imaging campaigns will be undertaken in high-voltage facilities (where lightnings are mimicked) and different locations (for natural and/or triggerd lightning) in coordination with colleagues of collaborating groups.

9. **Mesoscale models of streamers and leaders;** at CWI, Amsterdam, The Netherlands. Position already filled
10. **Modelling of bursts and high-energy radiation from negative leaders;** at CWI Amsterdam, The Netherlands. Position already filled

The 2 PhD students at the national Center for Mathematics and Computer Science (CWI) in Amsterdam, The Netherlands, will develop theory and computations of atmospheric discharges, together with the other students within the modeling work package, and with other colleagues studying atmospheric or technological discharges. The modeling will be based on previously developed theory and computational codes. One student will specifically concentrate on developing computational codes and reduced models for streamer and leader discharges and their interaction, and the other on modeling high energy emissions like Terrestrial Gamma-ray Flashes from negative lightning leaders.

11. **Modelling of lightning attachment to moving structures;** at DTU Space, Lyngby, Denmark. http://www.dtu.dk/english/career/job?id=0bb2ef75-63a6-4ec0-8ca3-b01d7a21ddad

The objective is to understand how lightning is stimulated by moving structures such as wind turbine blades. The project will adapt existing numerical codes to simulate streamer development in the environment of wings by approximating effects of realistic blade materials, neutral atmosphere turbulence and space charge clouds around the blades. The simulation model and interpretation of results will be done in collaboration with other Ph.D. students in the SAINT project

12. **Macroscopic electrodynamic modelling of streamers and leaders;** at CSIC, Granada, Spain. http://www.iaa.es/empleo/phd-computational-models-lightning-discharges

This position concerns the theoretical understanding of a lightning discharge. A lightning channel that progresses towards the ground is surrounded by a multitude of thin ionized filaments forming the so-called lightning corona. A corona is a complex, multi-scale and nonlinear process whose dynamics are currently poorly understood. How do all the filaments interact between each other? How is the corona determining the propagation of the lightning channel? Can we develop simplified statistical models that encapsulate enough of the corona dynamics without resorting to large-scale computations? Are these large-scale computations feasible? These are the questions that this project seeks to answer. Our main tool will be the numerical simulation of the microphysical processes involved in electric discharges but we will also seek simpler models with explanatory power. As coronas not only pose fundamental scientific questions but are also highly relevant for high-voltage applications, this project combines pure science with industrial applications.

13. **Lightning location for airport safety;** at Biral, Bristol, U.K. https://www.bath.ac.uk/jobs/Vacancy.aspx?ref=CT4909

This project uses data from a unique single-site electrostatic lightning detector recently developed by private industry to warn of local thunderstorm activity at airports. The unique dataset provided by this instrument shall be used to investigate changes in the atmosphere's electric field between 1-45 Hz, associated with all forms of lightning, including the search for signals from Transient Luminous Events (TLEs) in the upper atmosphere. Anomalously strong signals from lightning several hundred kilometres away is of particular interest to this project, since these new observations are not consistent with current theory.

14. **Leader-streamer characterization for lightning protection;** at DENA, Barcelona, Spain. http://lrg.upc.edu/en/available-phd-positions

The objective is to investigate streamer and leader properties to be used in lightning warning and protection. This research will be applied to design 'smart' lightning rods able to detect conditions for corona and leader inception and to obtain data from the lightning events. These smart lightning rods will be the next generation of lightning protection. The research includes experimental and theoretical work. Experiments will be conducted at DENA's high voltage laboratory (up to 3 MV and 100 kA). Experimental data will be used to develop models to be used in lightning protection. Some experiments and modelling will be done in collaboration with other Ph.D. students in the SAINT project.

15. **Laboratory experiments on lightning;** at TU/e, Eindhoven, The Netherlands. Position already filled

The project at the Eindhoven University of Technology will study fundamental aspects of lightning using laboratory experiments. Its main focus will be on the inception of lightning: how is it possible that lightning starts while the fields inside a thundercloud are too low for breakdown. We use advanced diagnostics to study streamer-like discharge inception close to ice-like particles.

SAINT is a highly integrated network. In all Ph.D. projects, the candidates will be exposed to satellite observations, ground observations, laboratory experiments and numerical modelling, and all projects will to some degree involve the results obtained by others in the network.

All Ph.D. projects will involve travels to two summer and three winter schools of the SAINT network, and to other partners of the network.

Application

Please submit your online application for the positions described above by using the web-links and specified at each position.

Apply only for one position. If you could be interested in several positions, state these in the cover letter of the application.

The application deadline is June 15, 2017 at 17:00 CET.

Please note that candidates are subject to the H2020 mobility rule. A candidate must not have resided in the host country for more than 12 months in the 3 years immediately prior to the date of recruitment (and not have carried out their main activity (work, studies, etc.) in that country) and must be in the first four years of his/her research career at the date of recruitment. Candidates may apply prior to obtaining their master's degree, but cannot begin before having received it.

Qualifications

Candidates should have a master's degree in a relevant field, or a similar degree at a level equivalent to the master's degree.

Approval and Enrolment

The scholarships for the PhD degree are subject to academic approval, and the candidates will be enrolled in one of the general degree programmes of the host institution.

Salary and appointment terms

The salary and appointment terms are consistent with the current EU rules for PhD degree students. The period of employment is 3 to 4 years (depending on the host institute).

All interested candidates irrespective of age, gender, race, disability, religion or ethnic background are encouraged to apply.

Research Activity by Institution

<u>National Cheng Kung University, Taiwan</u>

Yen-Jung Wu, La6971049@phys.ncku.edu.tw

This work is the collaboration between ISUAL team at National Cheng Kung University and Dr. Earle Williams at MIT, and has been accepted for publication*. The purpose is to understand the relationship between elves and OH* nightglow , which are usually collocated. The observation from the ISUAL instrument onboard the Formosat 2 satellite found that 91% of the 291 limb elves are located within +/- 5 km of the altitude of brightest OH* nightglow emission. The importance of atomic oxygen in both phenomena is explained by the environmental-adjusted elve model. The uniqueness of this work is the application of the variable electron density profile as an input to the conventional elve model to ascertain the height of maximum brightness. We take the profile of O_2, N_2, O from the NRLMSISE-00 atmospheric model and the meteoric dust particle profile from *Plane et al.* [2014]. We also consider the absorption of Lyman-α by O_2 above the target height to reconstruct a profile of electron density in the upper D-region. The proposed electron density profile in steady state is verified with a rocket sounding at the same location and time. It shows clearly from the model that h_{elve} is higher when the ledge in the atomic oxygen profile is higher, and vice versa. This explains the mechanism of the semi-annual oscillation observed in both OH* nightglow and elves, which the phenomena is further evidence linking elves, OH* nightglow and the VLF upper waveguide boundary.

In addition to the latitudinal pattern, the significant land-ocean difference (Fig. 1) in elve and OH* height observed by ISUAL is a reminder that the longitudinal variation is related to the wavenumber-4 structure in the mesosphere shown in both the OH* nightglow and VLF reflection height. Since lightning is the major terrestrial VLF source and the pronounced land-ocean contrast in lightning activity is well known, the stronger electrification and updraft speed of thunderclouds over land suggests a bottom-up influence from the troposphere to the ionosphere. The wavenumber-4 structure of OH* is the result of the atomic oxygen perturbed by the tidal motions, therefore a question remains since the tides is not phase locked to the three tropical continental regions. Overall, the collocation of the elve and OH* nightglow heights observed directly by the space-borne imager provides a hint that one might have a useful relationship between the emission intensity of the OH* nightglow and the electron density. This prospect may initiate a new method for sensing the D-region electron density from space

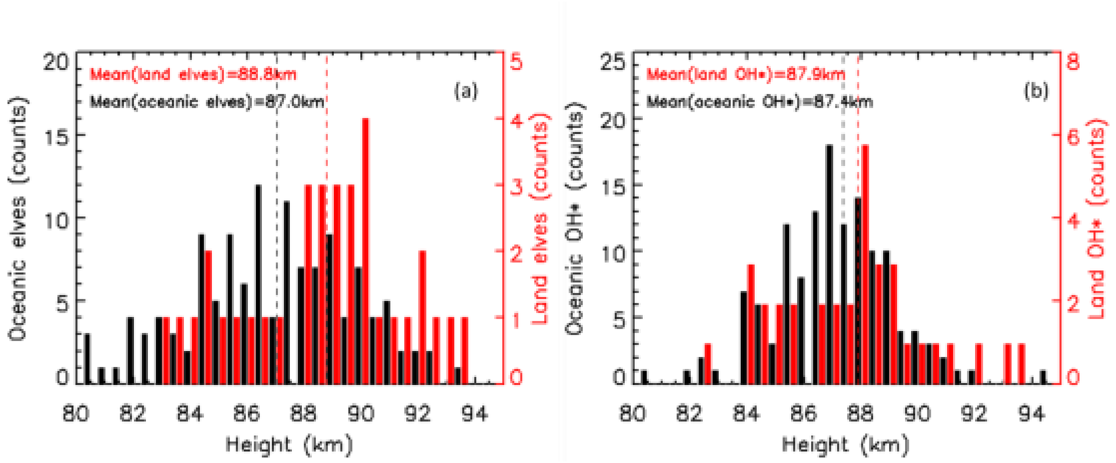


Figure 1: (a) The height distributions of elves over land (red) and ocean (black) within +/- 20° latitude of the equator. The mean height of 134 oceanic elves is 87.0 km (black dashed) while the mean of 35 land elves is 88.8 km (red dashed). (b) The height distributions of the OH* nightglow over land (red) and ocean (black) within +/-20° latitude of the equator. The mean heights of the oceanic OH* and land OH* are 87.4 km (black dashed) and 87.9 km (red dashed).

ACLENet - Saving Lives and Decreasing Property Damage from Lightning in Africa

ACLENet, the African Centres for Lightning and Electromagnetics Network, Inc (ACLENet.org), is a non-profit organization incorporated in the US and Uganda with a mission of decreasing deaths, injuries and property damage from lightning. ACLENet, a network of national centres, was formed as a result of Science and Technology conferences sponsored by the Non-Aligned Movement (NAM S&T) in Sri Lanka, Nepal, and Uganda (https://aclenet.org/publications) after finding that large numbers of lightning deaths occur in Africa. Portions of East-Central Africa, particularly the Democratic Republic of the Congo, have some of the highest lightning densities in the world but most African countries are either ill-equipped by training or lack resources to prevent lightning damage.

Lightning is a threat not only to humans, but also to their wealth, often measured in livestock. It also impacts the economic development of already compromised countries whenever electrical transmission lines, electronics, solar power stations, and industries such as aviation, mining, and banking are affected by lightning strikes and the transients created by it.

A stellar group of Research Advisers (https://aclenet.org/about-us/research-advisors) from around the world have stepped forward to help with the following ACLENet goals:

1. Fostering graduate education (University of Zambia and others),
2. Working with governments to assure adoption of internationally recognized standards,
3. Public education on lightning safety,

4. Research in both public health as well as physics and electrical engineering,
5. Working with meteorological and other stakeholder organizations to improve forecasting and warning systems (https://aclenet.org/projects/severe-weather-early-warning-systems),
6. Conducting local 2-3 day professional development courses for engineers on lightning protection, and
7. Providing protection to schools.

In developed countries, lightning safe areas such as substantial buildings and all metal vehicles are almost always readily available. In Africa, 90% of sub-Saharan buildings are not lightning safe (Fig 1). Workers and entire families are at risk 24/7. Even worse, in one survey more than half of the deaths reported in the news were to school children while they were at school. Reports of 3-18 deaths and many more injuries to children from a single incident are common.

Schools tend to be the most substantial buildings in many African villages. In 2014, ACLENet challenged ICLP participants to volunteer to protect a school (https://aclenet.org/projects/save-a-life-in-africa). DEHN-Africa stepped forward and, so far, three schools in Uganda, all with reports of multiple deaths and injuries in the last decade, have been protected (Fig 2). ACLENet is working with the Ugandan government to protect more schools and welcomes referrals from any readers on grants and charities that might be tapped for help with this life-saving campaign as well as ACLENet's other goals (https://aclenet.org/about-us/our-objectives).

Please contact anyone on ACLENet's leadership team (https://aclenet.org/about-us/leadership) to be a part of our work.

Fig 1 – Typical housing and work structures in developing countries involve mudbrick walls with a combination of flammable thatch and ungrounded metal roofs, often held down by stones. (courtesy Mary Ann Cooper)

Fig 2 – School children at Runyanya school, the first school protected by ACLENet and DEHN-Africa. In 2011, 18 children were killed and 32 injured by lightning (http://www.telegraph.co.uk/news/weather/8606238/Lightning-strike-kills-18-children-in-Uganda.html), the second lightning incident at this school in less than ten years.

NOTE: if these pictures are not clear enough, I have many others that I can send. MACooper

Duke University, Electrical and Computer Engineering Department, Durham, NC USA

Our group's research continues to focus on terrestrial gamma ray flashes (TGFs), strong in-cloud lightning processes, and radio-based lightning imaging. We have two main new research results to describe in this summary. First, building on our initial demonstration of a low frequency interferometric lightning mapping array [Lyu et al., GRL, 2014], we recently analyzed data acquired with this portable array in a focused imaging study of the initial development of negative leaders in intracloud lightning [Lyu et al., GRL, 2016a]. This work showed that nearly half of the detected and mapped initial breakdown pulses are not involved with the main channel extension but instead originate in nonpropagating side branches. Stepping statistics were presented (including means of approximately 300 meter step length and 1.0 ms inter-step interval), and we also found that the overall upward leader channels are typically tilted by at least 10 degrees away from vertical. The significant non-vertical orientation of individual steps and the overall channel may imply significantly non-vertical beaming for typical TGFs.

Our second result is more exciting (in our opinion). Following our recent work that identified energetic in-cloud pulses (EIPs) as a distinct high peak current lightning process [Lyu et al., GRL, 2015], we were motivated to explore the relationship between EIPs and TGFs, given the similarity of their low frequency waveforms for at least some TGFs. We first assembled a database of EIPs from a combination of NLDN data and our LF waveforms. We then identified those EIPs that were within 500 km horizontal range of the Fermi spacecraft, on which the GBM instrument would be likely to detect any associated TGF. There were only three such EIPs at the time of paper writing. However, all three of these EIPs produced simultaneous TGFs. We have since processed another year of data and have now found 7 EIPs within 500 km of Fermi, and all 7 are also simultaneous TGFs. This indicates that most, and maybe all, EIPs are also TGFs, and opens the possibility of identifying probable TGFs from ground-based radio data alone. Our work on this topic continues in order to better quantify this intriguing EIP-TGF connection.

GOES-R contribution (Steve Goodman/NOAA)

The first operational lightning mapper in geostationary earth-orbit was launched November, 19, 2016. The NOAA Geostationary Lightning Mapper (GLM) is a wholly new capability in the 40 year history of the Geostationary Operational Environmental Satellite (GOES) Program. The GOES satellite is the US sentinel in space that provides continuous monitoring of a wide range of high impact environmental phenomena including severe weather and tropical cyclones across the western hemisphere.

Fig. 1. 2016 GLM Science Team Meeting held at the University of Alabama in Huntsville.

The GLM collected its first light image on January 7, 2017 when the post-launch in-orbit testing of the spacecraft and instruments commenced. A field campaign was held March 21-May 18 in conjunction with the post-launch test to provide well calibrated SI-traceable measurements to validate the GLM performance and derived application products. These data are being archived in an open access field campaign and GLM data portal. On June 9 the GLM operational products will undergo their initial beta validation maturity review called the Peer Stakeholder- Product Validation Review (PS-PVR). Following a successful review the GOES-R GLM, the pre-operational GLM data will then be made publicly available on June 12 to the National Weather Service (NWS) and those users who have a GOES-R ReBroadcast receiving station. The GLM will have its provisional maturity validation review in December 2017 at which time the data are determined to be fit for operational use and subsequently available to users through the internet as well as direct broadcast. For further information and GOES-R multi-media and public imagery visit http://www.goes-r.gov (Steve Goodman/NOAA).

Lightning research group of Gifu University (Gifu, Japan)

We have been making observations of the lightning attachment process using LAPOSs (Lightning Attachment Process Observation System) at the International Center for Lightning Research and Testing in Florida since the summer of 2011. A recent paper by Wang et al. published in the Journal of Geophysical Research – Atmospheres reported the observation of leader step formation processes of eight luminous steps in three dart-stepped leaders of rocket-triggered lightning flashes using a LAPOS. The LAPOS has a time resolution of 0.1 μs and a spatial resolution of about 1.4 m, allowing it to reveal the leader step formation processes in great detail. The observation showed that a stepped leader is effectively a series of bidirectional pulse discharges. Each pulse discharge appears to initiate at a location immediately below the bottom of the previous pulse discharge and propagates bidirectionally. Both of the upward and downward progression waves have a speed on the order of 10^7 m/s, but the downward wave tends to slow down significantly as it propagates for a distance of about 2 m. Based on the observations, a conceptual model describing how a stepped leader progress is given in the paper.

We have also been making winter lightning observation in the Hokuriku region of Japan using various types of instruments for many years. During the winter of 2014, a nine-site LMA (Lightning Mapping Array) was established in the region for the observation of lightning discharges from the windmill and its lightning protection tower. Recent analysis of the LMA data by Wu et al. showed that the LMA had observed numerous radiation sources produced by corona discharges from the windmill and the tower, and corona discharges from the windmill and the tower turned out to be distinctly different. Fig. 1 shows locations of all corona discharge sources with locations of the windmill and the tower. We can see that some sources are located around the windmill while some around the tower, and windmill coronas apparently have larger radiation powers than tower coronas. Source height of corona discharges is also analyzed. The result shows that windmill coronas are more likely to occur at higher altitudes, although the location error may also have certain influence. Windmill coronas occur in periodic bursts due to the periodic rotation of the windmill. An interesting feature is that corona discharges produced from different blades have different powers. Possible reason for this phenomenon are discussed. The relationship between corona discharges and lightning flashes is also investigated. There is no evidence that corona discharges can increase the chance of upward leader initiation, but nearby lightning flashes can increase the source rate of corona discharges right after the flashes. These results have been published in the Journal of Geophysical Research – Atmospheres.

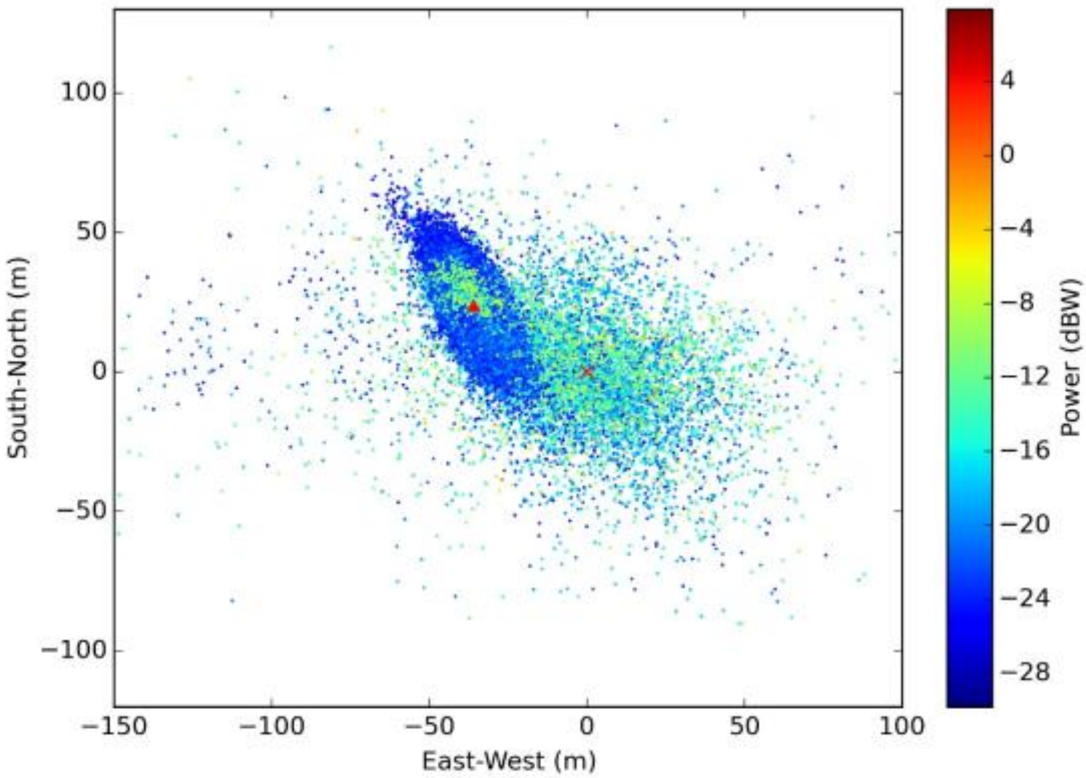


Fig. 1. Locations of corona discharges and the windmill (red cross) and the tower (red triangle). Color indicates radiation power.

Russian Federal Nuclear Center - VNIIEF, Institute for Laser Physics Research

In connection with the lightning initiation problem a positive streamer formation around charged needle-shaped ice hydrometeors in an external (thundercloud) electric field was analyzed. The hydrometeor was modeled by a cylinder with two hemispherical caps attached to its ends; the cylinder symmetry axis is aligned with the external (thundercloud) field vector $\vec{E}_{\text{ext}}$. 2D numerical simulations of the streamer discharges in selfconsistent electric field were executed allowing for the ice dielectric polarization and conductivity. At the pressure 0.4 atm. (≈ 8 km altitude) for different cylinder diameter d_{hm}, length l_{hm} and charge magnitudes, the external field intensity E_{ext} was computed, at which stable streamer development is possible. For this, the minimum value of the streamer velocity observed at STP conditions $\upsilon_{s,\min} \approx 10^5$ m/s was used as a criteria to be compared with the computed streamer velocity, i.e. a velocity, with which the field maximum at the streamer front propagates. At $E_{\text{ext}} = 2$ kV/cm velocity magnitudes are less than $\upsilon_{s,\min}$, do not reach a stationary value, and the electron number densities decrease as the streamers leave the enhanced field region around the hydrometeor. At this field intensity magnitude the streamer initiation is impossible. Stable streamers, capable of propagating outside the region around the hydrometeors, are generated for E_{ext} values above 2 kV/cm. The minimum field for the stable streamer inception is then for the chosen hydrometeor configurations of 3.2 kV/cm corresponding to 8 kV/cm at STP. The required charge $Q_{\text{hm}} \approx 200$ pC is within the range of measured precipitation charges, while the required E_{ext} is higher than observed in thunderclouds. We conclude, therefore, that a second mechanism for amplification of thundercloud fields is required for the streamer inception. Results are published in article **Babich L.P., Bochkov E.I., and Neubert T., The role of charged ice hydrometeors in lightning initiation. J. Atmos. Sol-Terr. Phys. 154, 43 - 46, 2017.**

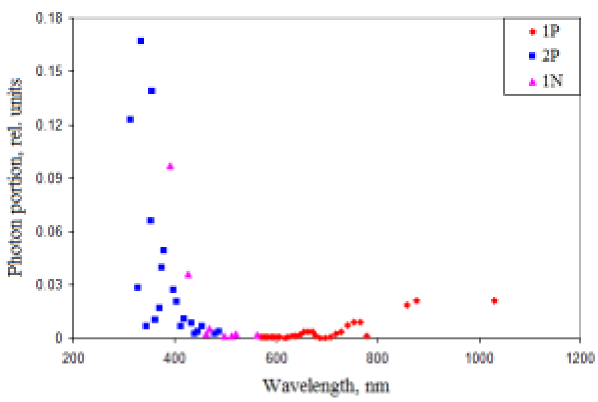


Figure 1. Fluorescence spectrum.

Using 2D model of the atmospheric discharge developing in the mode of relativistic runaway electron avalanche (RREA) in selfconsistent electric field without the relativistic feedback (RFB), a spectrum and space - time evolution of the intensity of the atmosphere fluorescence excited by high-energy electrons was computed for the bands $2PN_2$, $1PN_2$ and

1N N_2^+. According to the simulations by Dwyer at al. with allowing for the RFB, the discharge developing in the RREA mode emits mainly into the band 1N N_2^+; the emission duration is of 100 μs. We obtained that emissions into the second positive system 2P of the nitrogen dominate, as typically observed in the laboratory discharges in air including those developing in the runaway electron mode, and the fluorescence duration is of 5 μs. Though the discharges developing in the RREA mode, are rather dark we show that the RREA excited fluorescence can be registered by chambers conventionally used for registering the TLEs. Results will be published in article **Babich L.P. and Bochkov E.I., The fluorescence excited in thunderstorm atmosphere by relativistic runaway electron avalanches. J. Exp. Theor. Phys., 118, no. 5, 2017.**

Laboratory of Lightning Physics and Protection Engineering, Chinese Academy of Meteorological Sciences, Beijing

1. Model study of relationship between updraft core and graupel non-inductive charging regions

Using a 3-D charging-discharging cloud resolution model, an isolated thunderstorm was simulated based on the sounding data in Beijing for investigating the spatial relationship between the updraft core (where the updraft speed w>5 m/s) and the Graupel Non-inductive Charging Region (GNCR). The characteristics of updraft in GNCR were also analyzed. The results showed that the GNCR mainly distributed in and around the updraft core. The non-inductive charging processes in the GNCR always had a Relatively High Charging Efficiency (RHCE) with the absolute value greater than 0.1nC/m^3. In the region of updraft speed center, graupel can still obtain charges through the non-inductive charging processes. But too strong updraft speed was disadvantageous for appearance of More Efficient Non-inductive Charging Efficiency (MENCE), which absolute value was greater than 0.5nC/m^3. In this simulation case, the RHCE almost appeared only when the maximum updraft speed was higher than 5 m/s. The regions with RHCE were usually distributed in the regions with the updraft speed range from -4 m/s to 28 m/s. Although the area with MENCE would extend wider and its position would be closer to the updraft center while the maximum updraft speed became stronger, the center of the area with MENCE never overlapped with the updraft center, and always appeared in the region with the updraft speed less than 20m/s. Additionally, the height of the updraft speed center was approximately coincident with the height of inverted temperature. It could be used to separate the regions where graupels obtained negative and positive charges respectively through the non-inductive charging processes in operation in the future: during most of the time the updraft core existing, graupel in the regions near or above this height will obtain negative charge dominantly; graupel in the regions beneath this height will be charged by positive charge.

2. Characteristics of cloud-to-ground lightning strikes in the stratiform regions of mesoscale convective systems

To better understand the characteristics of cloud-to-ground lightning (CG) strikes in the stratiform regions of mesoscale convective systems (MCSs), radar and CG data from 10 MCS cases in China are comprehensively analyzed. Results show that stratiform CGs have characteristics distinct from those of convective CGs. A significant polarity bias appears in convective CGs, but the polarity bias in stratiform CGs is either undetectable or opposite that of the bias of convective CGs. The medians of the first return stroke current for positive and negative stratiform CGs have mean values of 59.7 kA and -37.3 kA, respectively; these values are 26% and 24% higher than the corresponding mean values for positive and negative convective CGs, respectively. In contrast to stratiform CGs, the first return strokes of convective CGs have polarized currents. Most convective CGs have relatively low currents, but most CGs with maximum currents in MCSs also fall within convective CGs. In the 10 MCSs studied, most stratiform CGs strike the ground at or near the edge of a region whose maximum reflectivity (≥30 dBZ) occurs at 3–6 km height (e.g., Fig. 1). The characteristics of reflectivity across this region are consistent with the reflectivity characteristics of the brightband; thus, this study provides important evidence for the relationship between the brightband and stratiform CGs. A charging mechanism based on melting of ice particles is speculated to be the key to initiating stratiform lightning. This mechanism could induce the propagation of lightning from the convective region to the stratiform region, thereby explaining the observed strikes on the ground nearby.

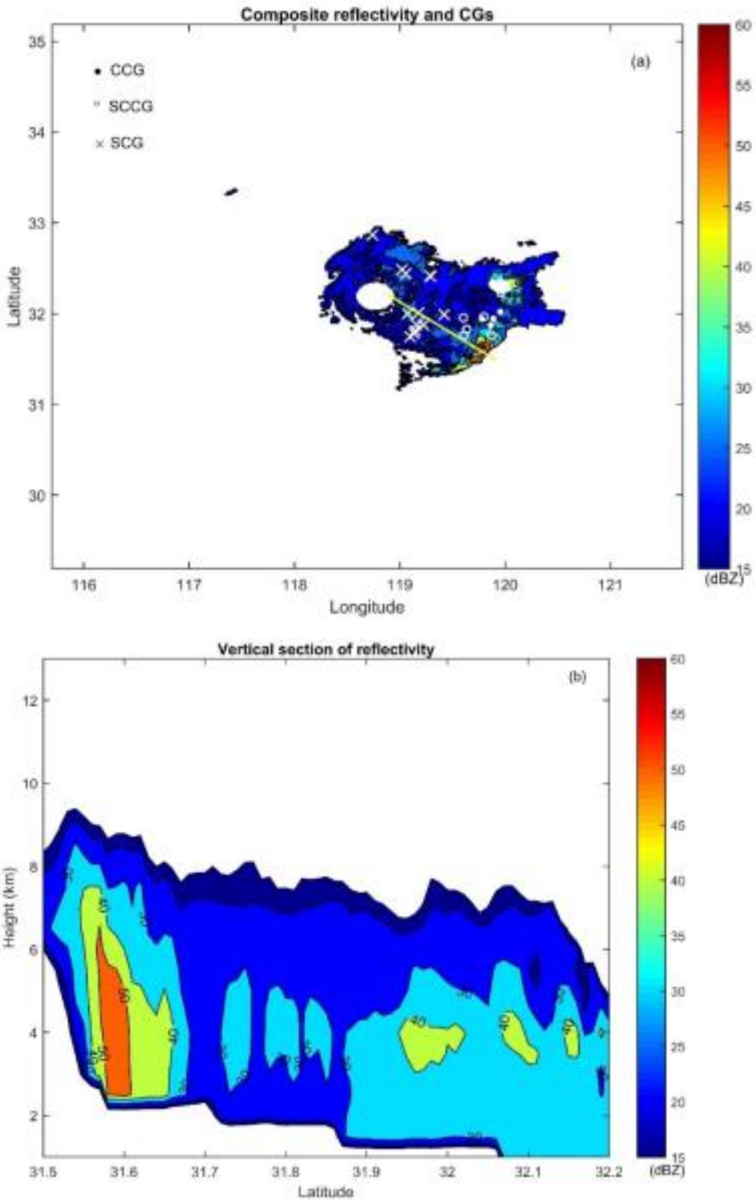


Fig. 1 Radar composite reflectivity, overlain with the return stroke points of CCGs (white ●), SCCGs (○) and SCGs (×). (a) Reflectivity and stroke points for the 6 min window of case 2. (b) Vertical reflectivity profile at 1200 UTC along the yellow straight line in (a).

3. Relationship between lightning activity and vertical airflow characteristics in thunderstorms.

Using CG lightning data, wind field data derived from dual-Doppler radars and the radar echo data, we have analyzed the relationship between vertical airflow characteristics in thunderstorms and lightning activity. A new method was developed to identify the thunderstorm cells based on the aggregation of flashes, and helped to pick out a total of 22 thunderstorm cells. Three aspects of the relationship were investigated: (1) spatial correspondence, (2) quantitative correlation during the evolution of thunderstorms, and (3) comparison of dynamic conditions of thunderstorms corresponding to the start and end of CG flashes. The conclusions are as follows:

(1) Approximately 79% of the CG flashes are located in the regions dominated by weak updraft and downdraft (from −5 to 5 m s^{-1}) at the 0 °C level, with more occurring in the weak updraft area (46.5%) than the weak downdraft area (32.6%). The PCG flashes are more likely than NCG flashes to occur in the region featuring weak downdraft (39.5% vs. 28.4%). The probabilities for CG flashes occurring in the weak updraft region are 2.1, 1.6 and 1.2 times those in the weak downdraft region during the initial, mature and dissipating stages, respectively.

(2) The relationships between CG flash rate and dynamic parameters including the volume of updraft and the precipitation ice mass flux are examined in the different stages of thunderstorms, and the linear regression equations are given. The strongest correlations appear between CG flash rate and the volume of airflow with vertical velocity exceeding 5 m s^{-1} above the −20 °C layer (r = 0.60) during the initial stage, that exceeding 10 m s^{-1} above the 0 °C layer (0.70) during the mature stage, and that exceeding 5 m s^{-1} above the 0 °C layer (0.66) during the dissipating stage. The sum of the absolute precipitation ice mass flux, in the levels from 7 to 11 km, of thunderstorm cells has the best linear relationship with the CG flash rate, yielding correlation coefficients of 0.73, 0.73, 0.71, and 0.74 during the whole lifetime, initial stage, mature stage, and dissipating stage of thunderstorms, respectively.

(3) Although the ratio of the updraft volume to the total volume of thunderstorms is much smaller when the last CG flash occurs than when the first CG flash occurs (18% vs. 79%), the maximum updraft speed values at the 0 or −10 °C levels and the maximum height of the 10 and 20 m s^{-1} updraft speeds are close at both these times, indicating the stronger dependence of lightning occurrence on the strength of updraft than on the volume of updraft.

We further gave a discussion and attempted to provide the explanation on the phenomenon that while the CG lightning frequency is positively correlated with the dynamic and microphysical processes (linear correlations of CG lightning with updraft volume and precipitation ice mass flux in Section 3.2), the CG flashes are mainly located in the region featuring weak vertical airflow.

LIS on ISS Contribution (Richard Blakeslee/National Space Science and Technology Center with Marshall Space Flight Center and University of Alabama in Huntsville)

On February 19, NASA's Lightning Imaging Sensor (LIS) was successfully launched to the International Space Station (ISS) aboard the SpaceX Cargo Resupply Services-10 (SpaceX CRS-10) mission. The LIS was delivered to the ISS in the Dragon trunk as a hosted payload on Department of Defense's (DoD's) Space Test Program-Houston 5 (STP-H5) mission and robotically installed in an external Earth viewing location. From this vantage point, LIS continuously detects the amount, rate, and radiant energy of global lightning, acquiring during both day and night 90% or more of the lightning that falls within its field of view, extending to 54 degrees north and south latitude.

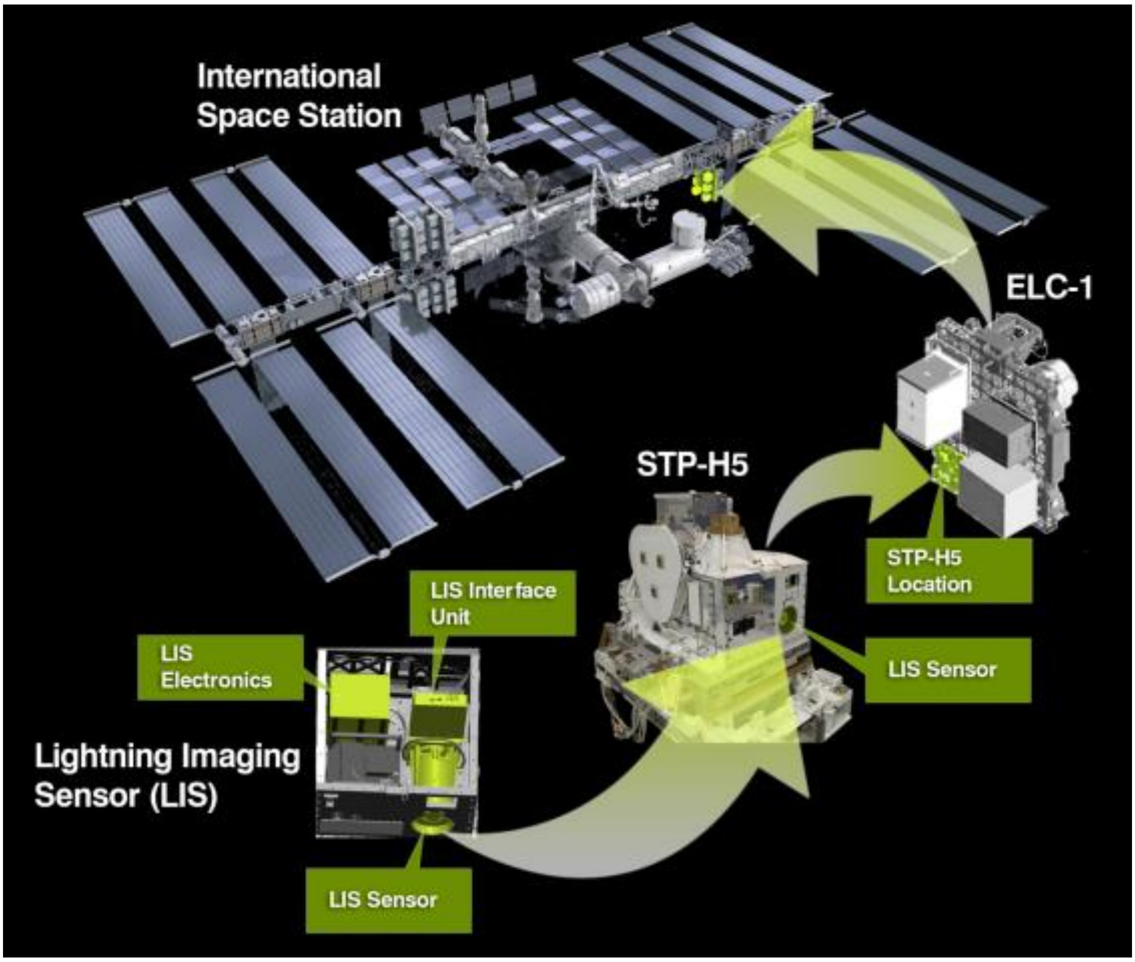
The LIS on ISS is an exact copy – the backup flight spare in fact – of the LIS that operated for an impressive 17 years on the Tropical Rainfall Measuring Mission (TRMM). Therefore placing LIS on ISS provides a great opportunity to not only extend this 17-year record of tropical lightning measurements but also to expand that coverage to higher latitudes missed by the previous mission. The LIS observations, being well characterized from the TRMM mission, will support cross platform calibration and validation with the new Geostationary Lightning Mapper (GLM), an instrument based on LIS heritage that was launched November 2016 on NOAA's newest weather satellite, GOES-16. Also, one of the most important science objectives of this mission will be to better understand the processes which cause lightning, as well as the connections between lightning and subsequent severe weather events, as this understanding will contribute to improving weather forecasts and saving lives and property in the United States and around the world. In addition, real-time data, available for the first time with this mission, will be made available to interested users in partnership with NASA's Land, Atmosphere Near rea-time Capability for EOS (LANCE) and NASA's Short-term Prediction and Research Transition (SPoRT) programs.

The LIS science and operations are managed from the newly established LIS Payload Operations Control Center (LIS POCC) located at the National Space Science and Technology Center (NSSTC) in Huntsville, Alabama. The LIS data handling involves a partnership between the LIS Science Team and the Global Hydrology Resource Center, one of NASA's Distributed Active Archive Centers (DAACs), and is leveraged upon the well-established and robust processing, archival, and distribution infrastructure used for TRMM that was adapted for the ISS mission.

LIS on ISS saw first light on February 27 when it was powered-on and successfully completed a two week checkout and commissioning. It is now undergoing a two to three month assessment to carefully evaluate the processing and data products prior to publically releasing this data to the science community. LIS data users should see little or no change from TRMM LIS in terms of data products, formats, software or access. However, in addition to maintaining the legacy data format, LIS products will also be cast in more modern formats such as HDF-5 and netCDF.

Figure Caption: *Picture shows the legacy LIS Electronics and Sensor Units, along with the new*

Interface Units integrating into the STP-H5 package and installed in an Earth viewing location on the ISS for a nominal 2-year mission. A mission extension will be sought through the NASA Senior Review Process.



UF Contribution to the May 2017 Issue of the Newsletter on Atmospheric Electricity

F. L. Carvalho, M. A. Uman, D. M. Jordan, J. D. Hill, S. A. Cummer, D. A. Kotovsky, and R. C. Moore authored a paper titled "Triggered lightning sky waves, return stroke modeling, and ionosphere effective height". The presented ground waves and sky waves measured 209 km and 250 km south of six triggered lightning flashes containing 30 strokes that occurred in the half-hour before sunset on 27 August 2015. They used a cross-correlation technique to find the ionospheric effective reflection height and compare their results to previous techniques that calculate effective height based on the time delay between ground wave and sky wave time domain features. From the first flash to the last flash there was, on average, a 1.6 km increase in effective ionospheric height, whereas no change in effective ionospheric height could be discerned along the individual strokes of a given flash. They showed to what extent the triggered lightning radiation source can be described (using channel-base current, channel geometry, and channel luminosity versus time and height) and speculated that a well-characterized source could allow a more accurate determination of the electromagnetic fields radiated toward the ionosphere than has been done to date. They show that both channel geometry and the change in return stroke current amplitude and waveshape with channel height (inferred from measured channel luminosity versus height and time) determine the waveshape of the ground wave (and presumably the upward propagating wave that results in the sky wave) and that the waveshape of the ground wave does not appear to be related to the current versus time waveform measured at the channel base other than a roughly linear relationship between the two peak values. The paper is published in the Journal of Geophysical Research - Atmospheres.

M.D. Tran and V.A. Rakov authored a paper titled “Initiation and propagation of cloud-to-ground lightning observed with a high-speed video camera”. Complete evolution of a lightning discharge, from its initiation at an altitude of about 4 km to its ground attachment, was optically observed for the first time at the Lightning Observatory in Gainesville, Florida. The discharge developed during the late stage of a cloud flash and was initiated in a decayed branch of the latter. The initial channel section was intermittently illuminated for over 100 ms, until a bidirectionally extending channel (leader) was formed. During the bidirectional leader extension, the negative end exhibited optical and radio-frequency electromagnetic features expected for negative cloud-to-ground strokes developing in virgin air, while the positive end most of the time appeared to be inactive or showed intermittent channel luminosity enhancements. The development of positive end involved an abrupt creation of a 1-km long, relatively straight branch with a streamer corona burst at its far end. This 1-km jump appeared to occur in virgin air at a remarkably high effective speed of the order of 10^6 m/s. The positive end of the bidirectional leader connected to another bidirectional leader to form a larger bidirectional leader, whose negative end attached to the ground and produced a 36-kA return stroke. The paper is published in the Nature Scientific Reports (an Open Access journal).

F. L. Carvalho, M. A. Uman, D. M. Jordan, and R. C. Moore authored a paper titled “Frequency domain analysis of triggered lightning return stroke luminosity velocity”. Fourier analysis was applied to time domain return stroke luminosity signals to calculate the phase and group velocities and the amplitude of the luminosity signals as a function of frequency measured between 4 m and 115 m during 12 triggered lightning strokes. They showed that pairs of time domain luminosity signals measured at different heights can be interpreted as the input and the output of a system whose frequency domain transfer function can be determined from the measured time domain signals. From the frequency domain transfer function phase they found the phase and group velocities, and luminosity amplitude as a function of triggered lightning channel height and signal frequency ranging from 50 kHz to 300 kHz. They showed that higher-frequency luminosity components propagate faster than the lower frequency components and that higher-frequency luminosity components attenuate more rapidly than lower frequency components. Finally, they calculated time domain return stroke velocities as a function of channel height using two time delay techniques: (1) measurement at the 20% amplitude level and (2) cross correlation. The paper is published in the Journal of Geophysical Research - Atmospheres.

Y. Zhu , V. A. Rakov, and M. D. Tran, in collaboration with A. Nag of Florida Tech, authored a paper titled “A study of National Lightning Detection Network responses to natural lightning based on ground truth data acquired at LOG with emphasis on cloud discharge activity”. The U.S. National Lightning Detection Network (NLDN) detection efficiency (DE) and classification accuracy (CA) for cloud discharge (IC) activity (identified here by a sequence of non-return-stroke-type electric field pulses not accompanied by channels to ground) were evaluated using optical and electric field data acquired at the LOG (Lightning Observatory in Gainesville), Florida. Their ground truth “IC events” include 26 “isolated IC events” (complete IC flashes), 58 “IC events before first return stroke,” and 69 “IC events after first return stroke.” For the total of 153 IC events, 33% were detected by the NLDN, and the classification accuracy was 86%. For complete IC flashes, the detection efficiency and classification accuracy were 73% and 95%, respectively, and the average number of NLDN-reported cloud pulses was 2.9 per detected event. For 24 preliminary breakdown pulse trains in CG flashes, the detection efficiency and classification accuracy were 46% and 82%, respectively. They have additionally estimated the DE and CA for return strokes in CG flashes. Irrespective of stroke order and polarity, the DE was 92% (339/367), and the CA was also 92% (312/339). The DEs for negative first and subsequent strokes were 98% and 90%, respectively. The paper is published in the Journal of Geophysical Research - Atmospheres.

Massachusetts Institute of Technology, Cambridge, MA, USA

Station data from 30 ELF sites worldwide have now been collected (thanks to the generosity of many contributing teams), edited, FFT’d and Lorentzian-fitted in preparation for inversion of these multi-station parameters for global lightning activity. Anirban Guha and Yakun Liu are main players in this activity. Considerations for avoiding the time-consuming process of data collection from the multiple sites by performing all major computations with the ELF time series on site and sending the few fit parameters back to MIT for inversion are now in the works.

Bob Boldi has made detailed comparisons between the NASA LIS/OTD optical data sets on global lightning and the Schumann resonance measurements in West Greenwich, Rhode Island, with the (caveated) conclusion that when the global flash rate is zero, the Schumann resonance intensity is also zero. A paper has been submitted to JGR on this issue.

A "snow dipole", inverted in polarity in comparison with the widely-recognized positive "graupel dipole" of thunderstorms, was introduced at the recent International Symposium on Winter Lightning as a possible framework for the energetic positive CGs in winter storms in Japan. The summertime manifestations of this snow dipole were argued to be the inverted dipole in the End of Storm Oscillation (Marshall et al., 2009) and the inverted dipole in the +CG/sprite-producing trailing stratiform region of squall lines (Shepherd et al., 1996; Williams et al., 2010; and many others). In the wake of this Symposium, discussions with Tsutomu Takahashi, Andy Detwiler, Jim Dye, Yasu Hobara, Noryasu Honma, Adarsh Kamra, Sunil Pawar, Vaughan Phillips, Xiushu Qie, Steve Rutledge, Maribeth Stolzenburg, Soichuro Sugimoto, Daowong Wang and Satoru Yoshida are debating the pros and cons of this idea.

Two papers, both related to special heights in the mesosphere (elve height, OH airglow layer height, nighttime ledge height in electron density) and both developing from the PhD thesis work of Yen-Jung Wu in the ISUAL team in Taiwan, have been accepted recently for publication:

Wu et al., (2017), The leading role of atomic oxygen in the collocation of elves and hydroxyl nightglow in the low-latitude mesosphere, J. Geophs. Res. Space Physics, 122, doi:10.1002/2016JA023681

Williams, E.R., Y.-J. Wu, J. Chau and R.-R. Hsu, Intercomparison of radar meteor velocity corrections using different ionization coefficients, Geophys. Res. Lett. (accepted, May 2017).

Work by Yakun Liu continues on the avulsion phenomenon in 1 meter DC arcs carrying current of the order of 1 ampere. Digital imagery from high-speed video is being analyzed to quantify the changes in channel luminosity before and after avulsion events, when sections of channel are cutoff and abandoned. The evidence for this phenomenon was presented at the recent International Symposium on Winter Lightning.

Hayakawa Institute of Seismo Electromagnetics, Co. Ltd. (Hi-SEM), University of Electro-Communications Alliance Center, Chofu Tokyo (Masashi Hayakawa)

We have been engaged in the study of wave phenomena over a wide frequency range from ULF, ELF, VLF and even higher for many years. Here let us give you a brief description of the above university-originated venture company, which was established in 2010 after the retirement of M. Hayakawa from the university. Its main purpose is to develop techniques of short-term earthquake (EQ) prediction and to perform the actual EQ forecast in Japan, but we are still interested in different atmospheric phenomena as well.

The main interest of this venture is to establish again a VLF/LF network (composed of five observing stations all over Japan at the moment) of receiving subionospheric VLF/LF signals from two Japanese transmitters (JJY (Fukushima) and JJI (Miyazaki)) and from three foreign transmitters (NWC, NPM and NLK) in order to predict any huge EQs mainly in the Kanto (Tokyo) area by detecting precursory ionospheric perturbations. This practical EQ forecast release is based on the establishment of our statistical correlation between VLF anomalies (ionospheric perturbations) and EQs (with magnitude greater than 6 and with shallow depth) on the basis of several-years long-term data (Hayakawa et al.,JGR, 2010). Improvement of EQ prediction accuracy is only possible with much more coordinated measurements not only of the ionospheric, but also atmospheric and lithospheric parameters. For example, we started observation of ULF/ELF (sampling of 100 Hz) effects at two stations in the Kanto area, and we also plan to include the detection of line-of-sight VHF signals to monitor the near-surface condition. Of course, the final goal of our seismo-electromagnetics is to elucidate the mechanism of lithosphere-atmosphere-ionosphere coupling.

The latest Kumamoto EQ in April 2016 was predicted beforehand with the use of VLF perturbations (seismogenic Trimpis), but our predicted magnitude was unfortunately smaller than the actual one because of the lack of VLF stations in Kyushu island. ELF impulsive emissions (can be called seismogenic Q-bursts) were also detected a few days before the EQ by the Chubu University (Prof. K. Ohta and Dr. J. Izutsu) ELF network in the Nagoya area. A summary of those ionospheric, atmospheric and lithospheric effects for this particular EQ is underway.

We have published several monographs on ULF and ELF electromagnetic waves during the last few years: (1) Nickolaenko and Hayakawa, Schumann resonances for tyros, Springer, 2014, (2) Surkov and Hayakawa, Ultra and extremely low frequency electromagnetic fields, Springer, 2014, (3) Hayakawa, Earthquake prediction with radio techniques, John Wiley, 2015, (4) Sorokin, Chmyrev, and Hayakawa, Electrodynamic coupling of lithosphere-atmosphere-ionosphere of the Earth, Nova pub, 2015. We hope that those would be useful for the society of atmospheric electricity. We here present some works related to atmospheric electricity. A model of the formation of intracloud lightning discharges, has been proposed, which is described by a stochastic growth of branching discharge channels determined by the electrostatic field (Iudin et al., 2015). Then Surkov and Hayakawa (2016) have considered a spherical plasma inhomogeneity located at mesospheric altitudes in a thundercloud quasi-electrostatic field as a possible cause of sprite initiation. A simple semi-analytical model of ionization instability in a quasi-electrostatic field, the value of which is larger than the air breakdown value, is developed on the assumption that the ball conductivity is controlled by impact ionization and electron attachments to neutrals. The estimates indicate that the predicted expansion rate and acceleration of the plasma inhomogeneity boundary are close in magnitude to the values observed in the high-speed imaging of sprites.

Finally, reviews have been published on ELF waves including stationary ELF Schumann resonances, nonstationary ELF waves, and vertical electron density profiles (Nickolaenko, Shvets and Hayakawa, IEEE Encyclopedia, 2016, and Int'l J. Electronics and Applied Research, 2016).

Israel Atmospheric Electricity Group (Tel Aviv University and InterDisciplinary Center)

Report on The Batsheva de Rothschild Seminar on the Atmospheric Global Electric Circuit (GEC)

During the week of 5-10 February, 2017, fifty researchers and students from 16 countries gathered in the remote Negev Desert in southern Israel to discuss the latest developments and directions in the field of fair weather Atmospheric Electricity and the Global Electric Circuit (GEC). Today we know that there is both a direct current (DC) and alternating current (AC) part of the GEC. One major question in the study of the GEC is how well correlated are the DC and AC circuits? While the DC circuit depends on the global area coverage of electrified clouds (thunderstorms and shower clouds), and the conductivity of the lower atmosphere (aerosol loading, radioactivity, clouds), the AC circuit depends on the global number if lightning discharges, and properties of the lower D-region of the ionosphere (waveguide). While both DC and AC circuits are linked to thunderstorms, each is influenced by different aspects of the electrified clouds. What can we learn from the temporal variability of the DC and AC circuits, and their comparison?

In recent years there has been a notable revival in the studies of the GEC, due to the links found between atmospheric electricity and air pollution, radioactivity, cloud microphysics, dust outbreaks, climate change, biological processes and even space weather. While atmospheric electricity can be used as a sensitive diagnostic of local changes in our environment, one controversial topic is related to the possible feedbacks on weather and climate. The vertical conduction current may impact the charging of cloud edges, influencing droplet interactions and possibly large-scale cloud properties themselves, impacting the weather and climate. More research is needed to investigate and quantify these feedbacks, if they exist. New technologies (drones, balloons and UAVs) will allow us to expand the frontiers of atmospheric electricity research to answer some of these questions.

One innovative idea arising from the workshop was the suggestion that the atmospheric science community support the inclusion of affordable electric field meters and charge sensors on regular

meteorological radiosondes launched every day by national Met Offices. Adding such small, cheap, disposable sensors will allow us to significantly advance our understanding of the GEC, its interaction with clouds, aerosols, cosmic rays and space weather, while allowing us to monitor long term changes in the GEC, and hence long term changes in global thunderstorm activity. For more information about the presentations and posters, you are referred to the website http://cgprice.wixsite.com/gec2017.
Colin Price (Tel Aviv University, Israel) and Yoav Yair (IDC Herzliya, Israel)

Seminar participants visiting the Mt. Hermon Geophysical Observatory of Tel Aviv University surrounded by a large Faraday cage for protection against lightning strikes.

Atmospheric Electricity Group (ELAT/CCST), INPE, Brazil

We have installed current sensors to measure lightning current through two lightning rods of ordinary residential building located in São Paulo City, Brazil. Some current measurements were already obtained and are under analysis. The current measurements were obtained together with high-speed videos.

It is very difficult to record high-speed video images of a lightning connection to a common building: cameras need to be very close to the structure chosen to be observed and a long observation time is required to register one lightning strike to a particular structure.

We have just published a new study in Geophysical Research Letters that provides results from high-speed video observations of lightning attachment to low buildings that are commonly found in almost every populated area around the world (Figures 1 and 2). The videos show in slow motion the moment when the down-coming leader of the lightning strike connects to the upward leader initiated from the tip of the lightning rods of twin buildings in São Paulo City, Brazil.

The proximity of the camera and the high frame rate allowed the authors to see interesting details that will improve the understanding of the attachment process and, consequently, the models and theories used by lightning protection standards.

Read the full paper here: http://onlinelibrary.wiley.com/doi/10.1002/2017GL072796/abstract

Videos of lightning attachment:

https://www.facebook.com/pg/AmericanGeophysicalUnion/videos/?ref=page_internal

Figure 1 – Negative cloud-to-ground flash striking one of the buildings under observation (25 February 2015).

Figure 2 – Frame from high-speed video showing the upward connecting leaders from buildings in response to a negative CG flash (9 February 2014).

Or (if you would like it as a cover image…)

Comment on the photo above: Frame from high-speed video (10,000 fps) showing the upward connecting leaders from buildings in response to a negative CG flash on 9 February 2014. This and other two upward connecting leaders from common buildings are described in the paper published by Marcelo Saba and co-authors in Geophysical Research Letters: http://onlinelibrary.wiley.com/doi/10.1002/2017GL072796/abstract

A product for real-time monitoring of tropical cyclones with lightning and satellite data: Requesting beta testers

Natalia Solorzano, Jeremy Thomas, Connor Bracy, and Robert Holzworth (U. of Washington, DigiPen Institute of Technology, NorthWest Research Associates)

We have developed a real-time monitoring system that integrates and visualizes lightning and microwave satellite data for all tropical cyclones globally. Key to the investigation is the World Wide Lightning Location Network (WWLLN), which provides real-time lightning locations globally by measuring the electromagnetic radiation generated by lightning strokes. Microwave data are from satellites such as NASA's GPM and NOAA's DMSP, and infrared data are from satellites such as the recently launched GOES-R. Data for all tropical cyclones are archived back to 2009. Storm track and intensity (wind and pressure) data are from the Naval Research Laboratory. Abundant research has shown physical connections between lightning incidence, convection, and tropical cyclone intensity change. Thus, our product enables forecasters to better characterize storm tracks and intensity.

We are now accepting beta testers, who will receive a password and be invited to provide feedback by taking an online survey. Contact Jeremy Thomas at jnt@uw.edu to receive login/password information. The URL for the product website is: http://wwlln.net/storms/. The product is free and after beta testing will be open to the public.

More details about this product are below.

Tropical cyclones kill about 10,000 people and cause about $26 USD billion damage globally each year. These numbers are predicted to increase with climate change. However, tropical cyclone nowcasting and forecasting suffers from a lack of observational data because these storms originate and evolve over the oceans typically far from land-based sensors such as radars. Moreover, high quality satellite microwave data are only available for one or two 3-min snapshots of the storm each day. To solve the tropical cyclone data sparsity problem, we have developed a publicly available website that integrates and visualizes lightning along with satellite data for all tropical cyclones in real-time throughout the world. The WWLLN (http://wwlln.net) provides real-time lightning locations globally by measuring electromagnetic pulses generated by lightning strikes at collection of more than 70 receiver stations across the world. The lightning pinpoints regions of convection, where the storm is most intense. Convective cells in storms are short lived, lasting less than 30 minutes. Knowing where and when the active regions of convection occur is important to understanding tropical cyclones. These regions of convection where lightning occur also produce cloud ice that is sensed by satellites. Thus, lightning can act as a proxy for the satellite cloud observations and fill in satellite data gaps, as shown in a recent paper by Solorzano et al.: http://onlinelibrary.wiley.com/doi/10.1002/2016JD025374/abstract. The study described in the link has shown how WWLLN lightning data and satellite data relate to each other and how WWLLN lightning stroke rates can be used to reconstruct microwave radiometer data.

The potential users our real-time visualization of lightning and satellite data are meteorologists that nowcast and forecast tropical cyclones and lightning scientists/researchers in general. The data visualizations allow nowcasters and forecasters to better characterize tropical cyclone tracks and intensity. Additionally, these data are critical for commercial and government interests in air transport and shipping, where weather observations over the ocean are scarce. The real-time visualization is also an interactive tool for secondary school and college students, as well as the general public, to learn about tropical cyclones and lightning. Sample screenshots of the product are shown in Figure 1.

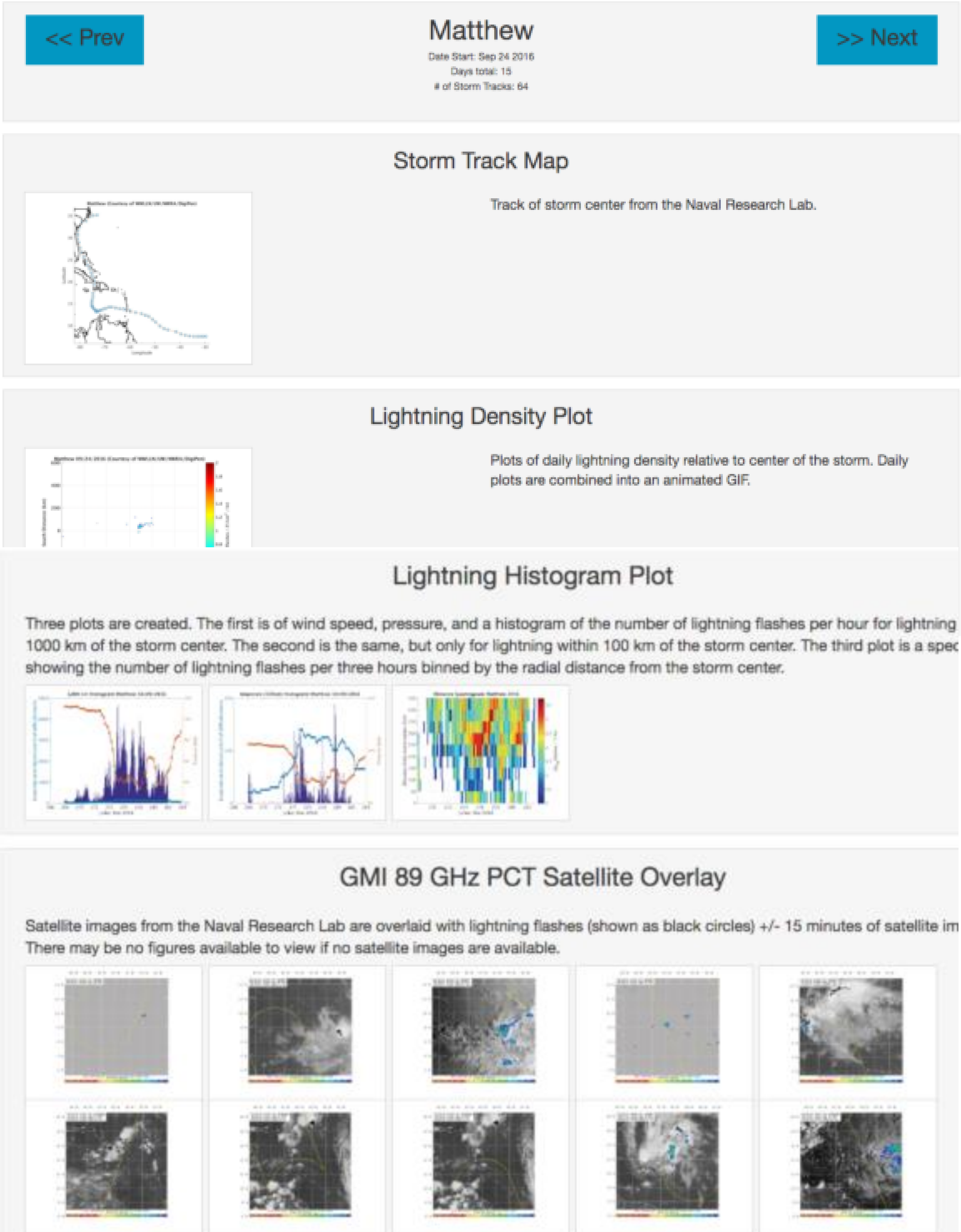


Figure 1: Screenshots of lightning and satellite visualization product for tropical cyclones.

Recent Publications

Carvalho F L, M A Uman, D M Jordan, J D Hill, S A Cummer, D A Kotovsky and R C Moore. 2017. Triggered lightning sky waves, return stroke modeling, and ionospheric effective height. J. Geophys. Res. Atmos., 122:3507–3527, doi:10.1002/2016JD026202.

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