Atmospheric Electricity

http://www.icae-iamas.org

NEWSLETTER

Vol.31 NO.1 May 2020

INTERNATIONAL COMMISSION ON ATMOSPHERIC ELECTRICITY

IAMAS IUGG

ICAE

Hannes Tammet (August 5, 1937–March 5, 2020)

Hannes Tammet began to study physics at the University of Tartu, Estonia in 1954. In 1956 he decided for the field of air electricity. His diploma thesis in 1959 contained many new results in the theory of air ion aspiration measurement devices. These results were published in several peer-reviewed journal articles in 1960. The study of aspiration methods for air ion measurements continued and was completed with the defense of PhD thesis in 1964. The study yielded a number of new results, which were summarized in a monograph in Russian (1967) and in English (1970)[1].

From 1967 to 1983 Tammet had employment at the Tallinn Pedagogical Institute, but his scientific research for the most part continued at the University of Tartu, specifically at the Air Ionization and Electroaerosol Laboratory. For example, the first multi-channel automatic air ion mobility spectrometer was designed and built under the general instruction of Tammet in 1971-1973. A scanning mobility spectrometer of cluster air ions UT-7509 was designed and built also under his instruction in 1974-1975. The results of comprehensive studies were summarized by Tammet in the Doctor of Sciences thesis under the title Spectrometry of Air Ion Mobilities. The thesis has been defended in the Main Geophysical Observatory, St. Petersburg in 1978 (D.Sc was a higher doctoral degree in the Soviet Union). In 1979 Tammet became a professor in the Tallinn Pedagogical Institute.

In 1983 Tammet returned to the University of Tartu, and he was appointed the Head of the above laboratory. Under his suggestion the laboratory was renamed into Air Electricity Laboratory (AEL). One of large projects of the lab was the establishment of Tahkuse Observatory for long time measurements of air ion mobility spectra at rural area. A novel air ion mobility spectrometer (AIS) for cluster ions operated there 1985-1986. Stationary AIS for wide mobility range started its operation in July 1988. The AIS records air ion fraction concentrations in a mobility range 0.00032-3.2 $cm^2V^{-1}s^{-1}$ for both polarities. The instrumentation has been extended and improved during subsequent years, and is operating even now. An overview of the dataset for 2004-2014 years is available[2].

After Estonia had regained independence, a major structural reform was undertaken in the University of Tartu, a system of institutes and chairs was established in 1992. The AEL became a part of the chair for geophysics that was under the leadership by professor Tammet. In 1993 he became the Head of the Institute of environmental physics. The AEL continued research with traditional topics. In 2002 Tammet gave up his leader position and continued as professor emeritus and senior researcher.

One of his important theoretical results is a new mobility model of nanoparticles (1995)[3], which more exactly describes the relationships between mobility, mass and size of nanoparticles. Tammet gave substantial contribution to the theory of small air ion balance in the atmosphere. He paid much attention to various questions of global atmospheric electrical field. He is known as one of the discoverers of short-period global variations in the atmospheric electric field[4]. The theory of horizontal long-wire antenna collecting the atmospheric electric vertical current is another topic of his study.

In the last two decades, on the initiative and active participation of Tammet, an extensive observational research has been carried out to understand the processes and conditions of the formation of nanoparticles in the atmosphere. The premise of this was the development of original air ion and nanoparticle mobility spectrometers. In 2000s Tammet designed and built three state-of-the-art air ion mobility spectrometers: IGMA, BSMA and SIGMA[5]. A special chapter of his work is a global dataset of fair-weather atmospheric electricity[6].

Tammet published presentations in all the International Conferences on Atmospheric Electricity since the 6-th conference in Manchester (1980) until the 14-th conference in Norman (2015). He was the member of the International Commission on Atmospheric Electricity since 1980, and Vice-President of the Commission (1988-1992). Since 2003 he was the honorary member of the ICAE.

Tammet's long-term scientific activity results in 340 publications, 8 doctoral theses and 4 master's theses defended under his supervision. He received several international awards for his fruitful research. E.g. he was a Fulbright Fellow at the University of Minnesota (1994), a visiting professor (Visby program fellow) at the Uppsala University (1998-1999) and the Indian Institute of Tropical Meteorology (1998). His work was recognized with the award of Republic of Estonia in the field of exact sciences for the research topic "Investigation of the formation and evolution of atmospheric aerosols and air ions, development of air ion mobility spectrometry methods and apparatus" in 2010.

Hannes Tammet's large-scale scientific and publicistic legacy, which includes his academic autobiography (in Estonian), research papers, study materials, etc., is publicly available on his website http://ael.physic.ut.ee/tammet/ and in the digital archive DSpace of the University of Tartu http://dspace.ut.ee/handle/10062/50167 .

--Colleagues from the University of Tartu

1. Tammet, H. (1970) The aspiration method for the determination of atmospheric ion-spectra. IPST for NSF, Jerusalem.
2. Dataset Tahkuse_2004_2014:
https://datadoi.ee/bitstream/handle/33/43/Tahkuse_data_2004_2014_guide.pdf?sequence=1&isAllowed=y
3. Tammet, H. (1995) Size and mobility of nanometer particles, clusters and ions. Journal of Aerosol Science, 26 (3), 459–475, DOI: 10.1016/0021-8502(94)00121-E.

4. Ruhnke, L.H., Tammet, H., and Arold, M. (1983) Atmospheric electric currents at widely spaced stations. In *Proc. in Atmospheric Electricity*, Deepak Publ., Hampton (Virg.), pp. 76–78.

5. Tammet, H. (2011) Symmetric inclined grid mobility analyzer for the measurement of charged clusters and fine nanoparticles in atmospheric air. Aerosol Science and Technology, 45 (4), 468−479, DOI: 10.1080/02786826.2010.546818.

6. Tammet, H. (2009) A joint dataset of fair-weather atmospheric electricity. Atmospheric Research, 91, 194–200, DOI: 10.1016/j.atmosres.2008.01.012.

In Memoriam of Hannes Tammet

Personal Remembrance of Hannes Tammet

I had an opportunity to closely interact, both at personal and academic levels, with Dr. Hannes Tammet when our institute (Indian Institute of Tropical Meteorology, Pune, India) had invited him as a visiting scientist for a couple of months. During this period, he presented several seminars and intensely interacted with several members of our group on atmospheric electricity. Our group greatly benefited from his deep understanding on the Physics of ion characteristics and their measurements.

Although, most of our discussions evolved around various aspects of atmospheric electricity, sometimes we talked about and exchanged our views on the Indian and Estonian cultures. Often he preferred to travel by local public transport, roam around in the city and relish local dishes. As it usually happened, we got to know about his such adventures(!) later on through some third party.

I will always remember him as a simple, sophisticated, straightforward speaking person of great dignity.

--A.K.Kamra, Indian Institute of Tropical Meteorology, Pune, India

Personal Remembrance of Hannes Tammet

I was deeply saddened to know the passing away of Prof. Hannes Tammet. I just know his name and work when I joined my parent Institute in 1999. During my Post-Doctoral Fellowship in 2007 at Tartu, where I worked under the supervision of Dr Urmas Horrak, I had great pleasure of meeting Prof Tammet and interact with him. He was very simple person and used to chat with entire group members during tea at Institute's library and discuss some scientific problems. I have great memories from interacting with him during my visit at Tartu in the air ion measurements and calibration of NAIS instrument. I learned a lot from these interactions and from his scientific papers, especially generation and growth of intermediate ions during the nucleation. It is a really great loss to me personally and to Atmospheric Electricity scientific community. I offer my heartfelt condolences to the bereaved family

--Devendraa Siingh, Indian Institute of Tropical Meteorology, Pune, India

Remembrance of Hannes Tammet

As a person, Hannes was always polite, decent and friendly. He had a marvellous dry sense of humor. He was enthusiastic about nearly everything he did or said. He was an open-minded and a widely read person.

When looking back at the scientific excellence of Prof. Hannes Tammet in the area of aerosol science, it needs to be noted that he had both theoretical and experimental expertise. He was a specialist both in measurement techniques and the so called 'regularization methods', the term which he used for the theoretical inversion methods of aerosol and air ion size distribution measurement data.

For us, he represented the community of air electricity, but it was clear that he had extended his knowledge via ions and charged particles to the dynamics of ambient aerosol particles. And from our perspective, he was a pioneer specifically in the area of charged aerosol nanoparticles, a topic on which he had applied the measurement techniques which they had developed in his laboratory. For us, he was a direct link from Nikolai Fuchs to the modern mobility measurement of aerosol nanoparticles.

In fact, we believe that Hannes was one of the first people to really consider the charged molecular ion – cluster – aerosol nanoparticle interface. The people in Tartu used the term 'intermediate ions', but for aerosol community meant electrically charged atmospheric aerosol nanoparticles in the size range of 2-10 nanometer, thus, ultrafine aerosol nanoparticles.

When we were younger—much younger than today—we visited the Air Electricity Laboratory, Tartu in January 1991. We met Hannes and the creative people he was leading. We were impressed. Ever since we have had a close connection to him. He was Jorma's opponent in his PhD defense. "Erudite, tough in science, but friendly", remembers the candidate. During his research visit to Hyytiälä Atmospheric Measurement Station in 1994, he inspired Jyrki and boosted the idea of a long-term atmospheric measurements of ultrafine aerosol particle formation and growth, which turned out to be a quite fruitful research topic in the years to follow.

We hold the memory of Hannes in very high esteem.

--Jorma Keskinen, Jyrki M. Mäkelä, and Matti Lehtimäki, Aerosol Physics Laboratory, Tampere University

Personal Remembrance of Hannes Tammet

Hannes Tammet was an admirable person in many ways. I had the privilege of meeting him and his charming wife Eve during a Yale visit (mid nineties), when I could appreciate first hand his goodness and humanity. These virtues he confirmed in all our interactions by the help he was always generously willing to provide, requested and unrequested.

Hannes had a considerable influence on my scientific development, even though I am a stranger to his main field of atmospheric research. This influence was in great part due to his ability to cultivate both the basic physics, as well as the technical detail of complex instruments. I shared these two interests, with considerable less dedication. I do not remember how we first interacted, but at some point in the mid nineties he presented me with a photocopied version of his book "The Aspiration Method for the Determination of Atmospheric-ion Spectra", translated to English in 1974. I thought I was familiar with the literature on particle mobility instrumentation, but this book was not yet well known in the West, and to me it was a complete revelation. Fortunately I became aware of it before the publication of our first serious study on the diffusion-limited resolving power of DMAs (1996), which he was the first to analyze. The book now has a respectable 141 citations in Google Scholar, though it is far less than it ought to have. This volume is singular in the breath and freshness with which it considers its subjects, whereas most of Hannes' western colleagues had considered primarily the differential mobility analyzer geometry.

The other study from Hannes that had a lasting impact on my research was his 1995 J. Aerosol Science article " SIZE AND MOBILITY OF NANOMETER PARTICLES, CLUSTERS AND IONS". Again, Tammet's description of the richness of what I had taken to be a simple subject caught me by surprise. One of the many things he discussed was the importance of the ion-dipole interaction, central in atmospheric ion physics. The non-intuitive notion that a massive ion (such as Au^+) in air, no matter how physically small, has a substantial mobility diameter continues to surprise informed colleagues, as it did me in 1995. Just on this subject, my students and I have spent thousands of hours following Hannes' lead.

Dear Hannes, I hope you are in God's presence, with no need for our gratitude, but you still have it.

--Juan Fernandez de la Mora, Yale University

Remembrance of Hannes Tammet

Last week we heard sad news about decease of Prof. Hannes Tammet. We offer our condolences to relatives and colleagues in the case of the loss of Hannes Tammet.

We remember Prof. Tammet not only as a pioneer of measurements of air ions and other atmospheric electrical phenomena, but also as a developer of Estonian-Finnish co-operation in the field of aerosol research and as a scientist whose eagerness and curiosity about his field of research till the end of his life will serve as an example for future generations.

With respect,

--Miikka Dal Maso (Chairman), Jussi Malila (Vice-Chairman), and Paxton Juuti (Secretary), Finnish Association for Aerosol Research

Personal Remembrance of Hannes Tammet

On April 2, 1990 Hannes Tammet was waiting for me at the airport of Tallinn. I was on a lengthy travel visiting several institutes of the former Soviet Union. The travel has shown me Novosibirsk, Odessa, Moscow, and Leningrad with well-known research institutes working on atmospheric aerosols. And also visiting the Air Electricity Laboratory at the University of Tartu. The visit at the Air Electricity Laboratory was like emerging in a model research atmosphere. I was shown all the ongoing research in every detail. Many of the visited institutes before at that time were hiding and not showing their work.

Hannes Tammet in 2003

The scientists in Tartu have spent all their time investigating every detail of the aerosol measuring system they developed. It was a two-way differential Gerdien-condenser. They had built all parts themselves. They had many problems with the Russian computer using. But they tackled the problems. Their work was very much in contrast to western approach. Western approach was to bring new instruments to market as soon as possible, even denying science to a certain degree. The instrument the Air Electricity Laboratory developed was later and today a very useful and successful device in atmospheric aerosol research.

We were welcomed at the institute with overwhelming hospitality. Hannes Tammet and his wife Eve received us later also in their apartment and we have been friends since then. Hannes was a well-organized person and an exemplary scientist from nature. I know many scientists of the world and judge their honesty and reliability. In this respect, Hannes Tammet is unparalleled honest and reliable. Hannes Tammet has shaped the laboratory and his science with his extraordinary personality. He will be remembered as the real scientist.

--Ruprecht Jaenicke, Institute for Physics of the Atmosphere, University of Mainz, Germany

African Centres for Lightning and Electromagnetics (ACLENet)

During 2019-20, the African Centres for Lightning and Electromagnetics Network (ACLENet, https://ACLENet.org) was funded by the Ludwick Family Foundation and the Leuthold Family Foundation to:

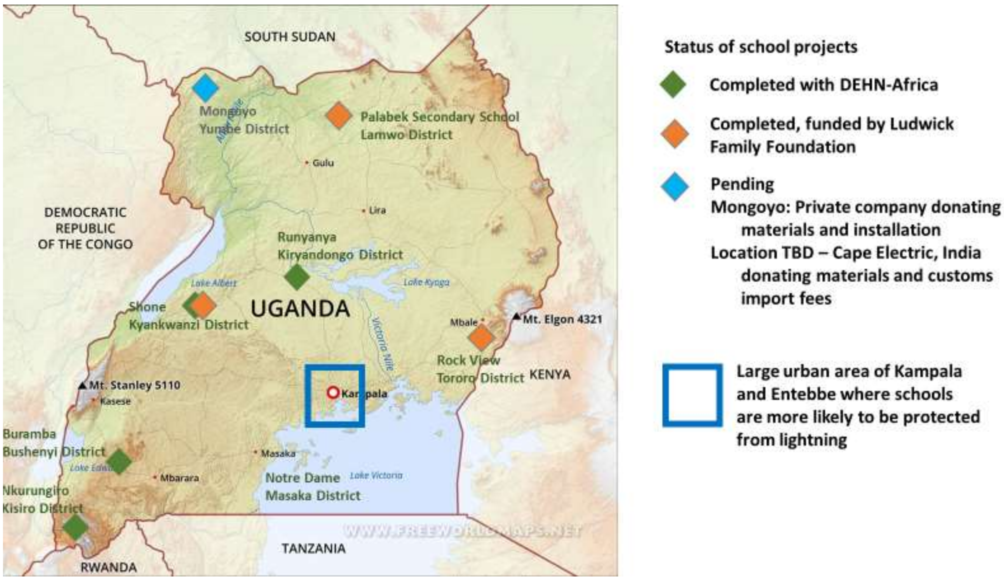
1. Form the Lightning Protection Working Group (LPWG) of LP experts, many of whom serve on international code committees. These experts from the USA, South Africa, Uganda, and Denmark all volunteer their time and expertise. Our thanks to these volunteers!
2. Protect three more schools in Uganda (map attached). Mongoyo School LP in planning.
3. Publish newspaper inserts for public education about lightning risk and lightning safety (available at https://aclenet.org/news-publications/publications/newspaper-inserts.html). Newspaper inserts have been successfully used to prevent HIV infection and teenage pregnancy in Uganda. Teachers often use inserts as posters or as lesson plans.
4. Fund two television broadcasts in Uganda on lightning science and safety.
5. Develop a maintenance program for schools with LP installed by DEHN-Africa in 2016-7.

ACLENet has signed a Memorandum of Understanding with the Ugandan Ministries of Education and Sports and of Disaster Preparedness and Refugees to protect schools across Uganda and provide public education on lightning safety as well as lightning protection to Uganda's engineers, installers and others.

Shipping of LP materials, import/customs fees, and airport storage are all expenses that prevent ACLENet from doing more public education and protecting more schools. As the LPWG gains more experience with Africa, we are exploring decreasing costs using locally sourced materials instead of expensive imports as well as designing templates for typical school buildings that can be used throughout Africa.

ACLENet maintains the most complete and extensive record of lightning injuries and property damage across Africa, currently reporting on over 30 countries https://aclenet.org/news-publications/country-news/.

There is more news in The African Flash, ACLENet's monthly newsletter (see past issues at https://aclenet.org/news-publications/newsletters/). To subscribe, contact Dr. Mary Ann Cooper at macooper@uic.edu or subscribe at https://aclenet.org/news-publications/mailing-list.html.



Announcing WALDO: Massive public repository of ELF/VLF radio data

We enthusiastically announce a massive repository of ELF/VLF/LF radio data collected over decades at sites all over the world by Stanford University, Georgia Tech, and University of Colorado Denver. As recently written up in EOS (https://eos.org/science-updates/returning-lightning-data-to-the-cloud), the database is known as the World Archive or Low-frequency Data Observations, WALDO, and can be accessed at http://waldo.world. I don't know about you, but I can't think of anything more fun to do during a pandemic quarantine than analyze ELF/VLF/LF data!

These data already include or will include many valuable recordings, amongst them

- Antarctic recordings at Palmer Station and South Pole over decades
- Siple Station Antarctica experiment recordings from 1974-1986
- Alaska VLF recordings in conjunction with HAARP experiments
- VLF/LF Data from the 2017 Great American Solar Eclipse
- Narrowband data from global IHY/ISWI/AWESOME receivers
- VLF recordings preceding the 2011 Tohoku M9.0 earthquake
- Our hope is for the broader community to think of new ways to analyze these datasets that have not been previously considered.

The raw data are in a common format and available for direct download, along with quick-look plots. WALDO includes detailed data descriptions and some available scripts (Matlab with python coming soon) to view and analyze the data.

WALDO is jointly managed by Georgia Tech (Morris Cohen) and University of Colorado Denver (Mark Golkowski). Currently there are nearly 200 TB of data, with many 100s more TBs awaiting upload in the coming weeks and months. Currently we are focusing on uploading data previously collected by Stanford University's VLF group (stored on 10s of thousands of DVDs), but will also be augmenting it with more recent data collected by CU-Denver and GaTech's receiver networks. If there a specific dataset you know was recorded that is not yet up at WALDO that you would like to see, please contact us. We can let you know if it still exists, and/or prioritize it if you have a specific interest.

We encourage anyone interested in ELF/VLF and wanting to work with data to use the data. We are happy to answer any questions about the data, as well, or interested in any feedback in how the WALDO portal is working.

We also welcome anyone else collecting ELF/VLF data who would like to join WALDO and contribute their data as an official partner, please contact Morris Cohen (mcohen@gatech.edu) and Mark Golkowski (mark.golkowski@ucdenver.edu)

-Morris Cohen, Georgia Tech
-Mark Golkowski, University of Colorado Denver
http://waldo.world

Special issue on atmospheric electrical observatories

The open access journal History of Geo- and Space Sciences has a special issue about atmospheric electrical observatories edited by Dr Karen Aplin, available here https://hgss.copernicus.org/articles/special_issue1042.html.

Congratulations to the Hungarian team for preparing the first paper. Submissions both to the special issue and to the ongoing compilation of historical observations (see link in the introductory article) are welcomed! The issue will remain open indefinitely.

Atmospheric Electricity Group, INPE, Brazil

The Lightning Observation Project at INPE/Brazil has already started during the last summer. We are studying the attachment processes to short towers inside and nearby INPE facilities in S. Paulo/Brazil (Fig. 1). We are also measuring X-rays emissions from leaders (Table 1). The flash density Ng for the region is about 11 flashes/km².year and the following instrumentation is already set up.

Figure 1 X-ray sensor, electric-field and other sensors placed nearby 40-m height towers.

Table 1 Instrumentation available.

Sensor	Instrument	Limits
Camera	Still Cameras (Nikon D200, D300, D800)	Exposure of 20 s and triggered mode
	High Speed Cameras (Phantom V9.1, V711, and V2012)	Up to 120 kfps
	Standard cameras	Up to 100 fps
Current	Shunt 1	Up to 10A
	Shunt 2 (LEMSYS ISM500)	Up to 100 kA
	TC (Pearson 301X)	Up to 50 kA
Electric field	Slow E-field	100 kS/s
	Fast E-field	5 MS/s - 60 MS/s
	Field Mill	50 S/s
X-rays	NaI (Tl) crystal + PMT	30 MS/s
Datalogger	PXI National Inst.	60 MS/s
	PCI National Inst.	5 MS/s

The proximity of the sensors, especially of the high-speed camera and the high frame rate will allow us to see some interesting details that may improve the understanding of the lightning discharge, the attachment process and, consequently, the lightning protection engineering. Thanks to the use of several cameras at different angles, it will be also possible reconstruct the 3D trajectory of the leaders. This will help to improve the understanding of the characteristics of the upward connecting leaders that normally precede a connection to the target structures below and may also result from connections to nearby structures. Hopefully, enough data will be soon gathered to study topics shown in Table 2.

Anyone interested in installing instrumentation in the facilities during our summer (October to April) is very welcome and may contact Dr. Marcelo Saba (marcelo.saba@inpe.br).

Table 2 Topics to be studied.

Leader characteristics:	speed of the downward leader
	the length and speed of the Upward Connecting Leader
	current and charge of upward leaders
	electric field changes due to leader propagation
Attachment process:	striking distance
	final jump
Return stroke:	peak current intensity
	di/dt
	charge transfer
Continuing current and M-components:	amplitude
	duration
	charge transfer
X-rays:	processes that produce them
	intensity

*I*offe Institute, St. Petersburg, Russia

Review article on ball lightning research by Mikhail L. Shmatov (Ioffe Institute, St. Petersburg, Russia) and Karl D. Stephan (Texas State University, San Marcos, Texas, USA). This review paper by the authors (Shmatov and Stephan, 2019) summarizes theoretical, observational and experimental work on ball lightning since approximately 2000.

Several recently proposed models of ball lightning and the possibilities to check some of them in experiments, in particular with the use of ordinary or triggered lightning, are considered. Some already-performed experiments of the formation of ball lightning and its analogues are also considered. Recent notable quantitative observation of ball lightning and candidate ball lightning objects are described and analyzed. In particular, arguments according to which a candidate object reported by Cen et al. (2014) was a power-line-arc rather than ball lightning and the results according to which ball lightning observed in the New York State town of Poughquag in 2008 emitted UV or/and other ionizing radiation (Stephan et al., 2016) are presented. Hazards associated with both contact and contactless influence of ball lightning on humans and objects are analyzed using mainly observational data. The possibility to explain several reports about contactless influence of ball lightning within the framework of model proposed by Shmatov (2003) is mentioned. Recommendations for future ball lightning research, related, in particular, to the use of scientific instruments and videocameras, are presented.

*I*sraeli Atmospheric Electricity Research

A new cubesat project between Israel and France has entered the Phase A of planning. The project called CIEL will have lightning sensors on 2 or 3 cubsats, looking at the same thunderstorm for a period of 200 seconds. Colin Price (Tel Aviv University -TAU), Yoav Yair (Interdisciplinary Center – IDC), and Eric Defer (University of Toulouse) are working together on the lightning sensors for this mission. Planned launch 2024.

Yuval Reuveni (Ariel University), Colin Price and graduate student Tamir Tzadok (Tel Aviv University) are finalizing the results from 2 years of gamma radiation measurements on top of Mt. Hermon, northern Israel: climatology and analysis of sporadic events. Continuous gamma-ray measurements (both integrated and discrete energy levels) at Mt. Hermon geophysical site are analyzed with fair weather atmospheric electricity parameters. Yuval Reuveni (Ariel University) - A new E field (Ez) measuring station has been installed At Ariel University for assessing changes in atmospheric conductivity as a result from air pollution. Yuval Reuveni (Ariel University) - We also continue analyzing ULF data along with gamma ray measurements, GPS-IWV and different atmospheric parameters during several earthquake evented occurred in 2018, in order to assess the possibility for detecting earthquake precursors.

Yoav Yair (IDC) is collaborating with Itzhak Katra (Ben-Gurion University of the Negev), in planning and executing SANDEE - Sand transport during Aeolian processes in the Negev

Desert - Electrical Effects and their implications for Mars.

SANDEE will conduct field experiments in conjunction with the AMEDEE-2020 Analog Mars Mission, planned for October-November 2020 in the Ramon Crater in southern Israel and led by the Austrian Space Forum. During SANDEE, they will deploy a portable wind-tunnel (Fig. 2) near the Habitat, and Analog Astronauts will record particle movements in conditions that simulate sand storms of varying speeds. Local Negev desert, as well as Mars-simulant soil samples will be used, and particles' dynamic and electrical characteristics as they are blown by wind inside the tunnel will be observed. A JCI 114 portable electric field detector will be used for measuring the amplification of the ambient electric field during sand movement. A vertical array of traps oriented along the wind-tunnel axis will be used for sampling particles, in order to calculate the related sand fluxes and to analyze particle characteristics. The experiment will be repeated at night under dark conditions, in order to observe if light is emitted from electrified dust, due to corona discharges.

Figure 2 The portable wind-tunnel during SANDEE.

Colin Price (TAU) and graduate student Maayan Harel (TAU) recently published a paper looking at the trends of thunderstorm activity over the African continent (Harel and Price, 2020). The study used a clustering scheme to bin the WWLLN data into thunderstorms clusters, and then we built an empirical model to relate large scale meteorological parameters to the number and size of thunderstorms. The results show a significant increase in thunderstorm number and area over the last 70 years, with the largest increases in since 1990.

Another recent study by Judi Lax (TAU), Colin Price (TAU) and Hadas Saaroni (TAU) has shown a possible new idea for generating renewable energy based on thunderstorm electrification (Lax et al., 2020). The research shows that different metals start to gain charge in the laboratory when the relative humidity passes 60%. Below that threshold no potential is observed, but when the relative humidity rises about 60% the metals are charged up to around 1Volt. We are looking into ways to improve the efficient of the charging, while thinking of ways of scaling up our results to a proto-type battery.

Mustafa Asfur (Ruppin Marine Laboratory, Israel) and Colin Price (TAU) have been looking at laboratory experiments of discharges into water (simulating the oceans). We have found a surprising link between optical brightness of flashes and the salinity of the water into which the flash discharges. We find that the increasing salinity of the water dramatically increases the brightness of the flashes with all other parameters held constant. This may explain the observations of more intense lightning discharges over the oceans relative to the continents (Asfur et al., 2020).

In a new review paper by Colin Price and Gal Elhalel (TAU), Earle Williams (MIT) and our deceased colleague Dave Sentman (U. Alaska), we revived an old discussion that has been ongoing for around 20 years. The discussion deals with the similarity between the Schumann resonances ELF spectra measured in the atmosphere (due to lightning) and the similarity with the electrical spectra measured in many living organisms, from zooplankton to our brains. Some new recent research strengthens this connection, and the collection of evidence is presented in a new paper (Price et al., 2020).

*L*aboratory of Lightning Physics and Protection Engineering, Chinese Academy of Meteorological Sciences, Beijing, China

Measurements of magnetic pulse bursts during initial continuous current of negative rocket-triggered lightning. During the SHandong Triggering Lightning Experiment (SHATLE) in summer of 2014 and 2015, and the Guangdong Comprehensive Observation Experiment on Lightning Discharge (GCOELD) campaign in 2018, we have conducted the observations of the magnetic pulse bursts (MPBs) during the initial continuous current (ICC) in negative rocket-triggered lightning. The MPBs are commonly recorded at the main site of SHATLE (970 m from the rocket launch site), but the synchronous magnetic field (*B*-field) measurements at close site of SHATLE (78 m from the rocket launch site) show the slow variations with small MPBs superposing on them. Note that both the charge transfer and the relative brightness increase notably during the appearance of the MPBs. After shifting up the operation frequency of the magnetic sensor, the MPBs can be observed at close distance (80 m from the rocket launch site) obviously in GCOELD. Observations show that the radiation sources of MPBs originate from the breakdown in the vicinity of the leader tip, but the sources of the initial magnetic pulses (IMPs) measured at the very initial stage of triggered lightning are from the radiation of the whole steel wire. The continuous current measured at the channel base during the MPBs cannot reflect the characteristics of breakdown current, because the current is attenuated and dispersed when propagating along the high-impedance leader channel. The average peak current associated with the MPBs is estimated to be on the order of kA.

Simulation of Cloud-to-ground Lightning Strikes to Objects Based on an Improved Stochastic Lightning Model. An improved stochastic method for computer simulation of lightning leaders is developed based on the results from optical observation data. The development and attachment process of downward negative cloud-to-ground lightning in the near-ground area is simulated. The distribution of lightning strike points influenced by tall objects is statistically analyzed. The results show that when downward negative leaders initiate at 1,500 m height over an object, the relative strike frequency for the object increases at a decreasing rate as the object height increases. The striking frequency for a 600 m tall object is approximately 3.6 times that for a 100 m tall object. Additionally, the object may attract some lightning to hit itself and shift nearby ground strike points toward the object. For taller objects, the deviation effect is more apparent. It is stipulated in this study that if the ground strike density in the vicinity of the object is no more than 5% of the average density, then the object has a sufficient protective effect on this area. The data indicate that there is a positive correlation between the protection distance and the height of the object. The protection distances of objects of 100-600 m in height are 200 m, 280 m, 350 m, 400 m, 450 m, and 480 m approximatively, which show a declining rate of increase.

High-speed video observations of the abrupt elongations of the positive end of the bidirectional leader. Based on the synchronization data of high-speed video camera and electric field change, this paper analyzs in detail the phenomenon of the abrupt elongations of the positive end of the bidirectional dart leader before and after the return stroke in an Canton-Tower upward flash. The results show that the positive end of the second dart leader intermittently extended into the virgin air. there are three abrupt elongations of the second dart leader of the positive end, and the second abrupt elongation is caused by the connection between the positive end and the floating channel in which the tip of the positive end appeared. After the second subsequent return stroke, there are two abrupt elongations of the channel tip. The 2-D average speed of the three abrupt elongations of the positive end is approximately 2.3×10^6 m/s, and the average length of the three abrupt elongations is approximately 115 m. After the return stroke, the 2-D average speed of the two abrupt elongations of the channel tip is approximately 4.3×10^6 m/s, and the average length of the two abrupt elongations is approximately 212 m.

Radar Reflectivity of Lightning Flashes in Stratiform Regions of Mesoscale Convective Systems. A total of 254 flashes observed in 14 mesoscale convective systems in Chongqing, China during the summers of 2014–2015 were used to investigate the characteristics of lightning flashes in stratiform regions (stratiform lightning flashes). The data were analyzed and combined with data from an S-band Doppler radar system. The results show that the reflectivity characteristics of stratiform lightning flashes are different from those of convective lightning flashes. More than 90% of the stratiform lightning flashes had close spatial relationship with the areas in which bright bands were identified in the vertical direction. The reflectivity at the first detected very high frequency sources of most stratiform lightning flashes decreased with increasing core reflectivity within the lightning extension area. Further investigations showed that only a small proportion (≤10%) of the stratiform lightning flashes were directly initiated by the charge corresponding to the reflectivity cores. It suggests that the relationship between the reflectivity cores (mostly bright bands) and stratiform lightning flashes is close in spatial, but different in causality. Some *In situ* electrifications in stratiform regions, such as non-riming non-inductive electrification and melting electrification, are inferred to cause this relationship. The stratiform lightning flashes initiated from lower altitudes tended to have a lower maximum reflectivity within their lightning areas, but a higher maximum reflectivity in the vertical direction of their initiation locations than flashes initiated at higher altitudes.

Vertical Reflectivity Structures near Lightning Flashes in the Stratiform Regions of Mesoscale Convective Systems. Using S-band Doppler radar data and a very high frequency (VHF) radiation source location system, 254 lightning flashes occurring in stratiform regions (stratiform lightning flashes) of 14 mesoscale convective systems (MCSs) in Chongqing, China, were observed and used to analyze the structure of vertical reflectivity in the area around the lightning channel. In most stratiform lightning flashes, the vertical reflectivity structures can be grouped into three general categories: single-layer, double-layer, and triple-layer. Single-layer structure flashes are the most numerous (65.0%), followed by double-layer (26.8%) and triple-layer (1.2%) flashes. The regions with the single-layer structure and the double-layer structure are inferred to have mesoscale updrafts of different intensity in the middle of stratiform region. Around 62.3% of single-layer structure flashes initiate within 0–4 km above the vertical reflectivity core, and the main initiation range of these flashes widens with increasing value of the vertical reflectivity cores. Around 49.2% and 12.7% of double-layer structure flashes initiate within 3–6 km and 1–2 km above the vertical reflectivity core, respectively. The probability of lightning initiation at a greater distance to the vertical reflectivity core is higher than that at a shorter distance. This may imply that some electrifications occurring during the melting process are not as strong as expected and a non-riming non-inductive charging process occurring in a weak but broad mesoscale updraft in the middle of stratifom region may be more important for initiation of stratiform lightning flashes.

Quantifying the contribution of tropical cyclones to lightning activity over the Northwest Pacific. This study quantifies the impacts of tropical cyclones (TCs) to the geographical and seasonal lightning activity over the northwest Pacific (5°–35°N, 100°–160°E), and examines the connection between the occurrence of TC lightning and El Niño–Southern Oscillation (ENSO). Lightning data from the World Wide Lightning Location Network (WWLLN) and best-track data from the China Meteorological Administration are used to investigate 263 TCs for TC seasons (Jun–Nov) in the years 2005–2017. Results show that, on average, TCs account for about 4.9% of all lightning in the domain. The highest contributions occur in the northern South China Sea and the ocean northeast of the Philippines. The monthly TC contribution varies from 2.6% to 6.1% with the greatest in July and the lowest in June. The peak location of lightning center contributed by TCs are observed a poleward shift from early summer (Jun–Jul) to late summer (Aug–Sep), and an equatorial shift from late summer to autumn (Oct–Nov). In terms of TC intensity, tropical storm strength TCs are the dominant lightning contributor (2.0%) over the northwest Pacific. A greater likelihood of lightning activity in tropical storms than in typhoons is observed during the landfall, especially within the inner core region. Super typhoons produce lightning in more eastward longitude and more equatorward latitude than weaker strength TCs. The relationship between TC lightning and ENSO reveals that TCs contribute greater lightning during La Niña periods (5.0%) than El Niño periods (3.2%) over the northwest Pacific. In El Niño years, super typhoons contribute the greatest lightning amounts (1.8%), while in La Niña years tropical storms contribute the greatest (2.2%). Infrared satellite observations indicate that the high contribution of lightning in tropical storms is due to the large occurrence of very deep convection in these storms during their landfall.

Simulation of inverted charge structure formation in convective regions of mesoscale convective system. The charge structure evolution of a mesoscale convective system with an anomalous or inverted charge structure, observed in the Severe Thunderstorm

Electrification and Precipitation Study, a field project on the Colorado–Kansas border in summer 2000, is simulated using the Weather Research and Forecasting (WRF) model coupled with electrification and discharge processes. Two noninductive electrification schemes are used, based on the liquid water content (LWC) and the graupel rime accretion rate (RAR). The simulation with the LWC-based electrification scheme cannot reproduce the inverted charge structure with a positive charge region sandwiched by two negative charge layers, while the RAR-based electrification scheme produces the evolution process of a normal–inverted–normal charge structure in the convective region, which is consistent with the observations (Fig. 3). In the low RAR (< 2 g m^{-2} s^{-1}) region, graupel is mainly negatively charged when it bounces off ice crystals, while the ice crystals take up positive charge. However, in the zone where the inverted charge structure forms, a strong updraft (>16 m s^{-1}), high LWC (>2 g m^{-3}), and high RAR (>4.5 g m^{-2} s^{-1}) region appears above the height of the −20°C layer, so that a positive graupel charging region is generated above the −20°C layer of the convective region, resulting in a negative dipole charge structure with negatively charged ice crystals above the positively charged graupel. The negative dipole is superposed on the positive dipole (positive above negative) charge structure at the lower position to form an inverted tripole charge structure.

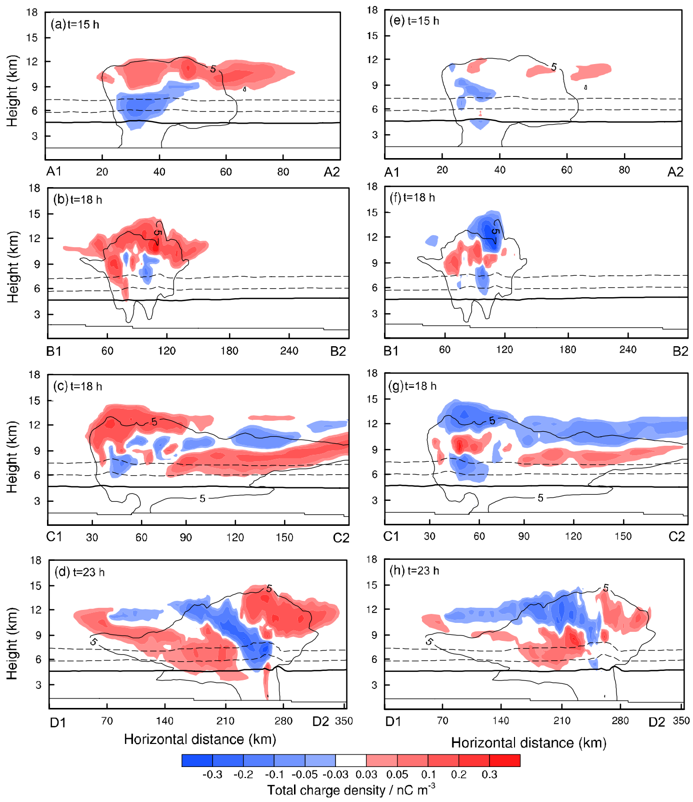


Figure 3 Vertical cross-sections of total charge density (nC m^{-3}; shaded) at 15, 18, and 23h. (a)–(d)

show the simulation results with the TGZ scheme and (e)–(h) show the simulation results with the SP98 scheme. The horizontal lines represent the isotherm lines of −20, −10 (dashed lines), and 0°C (solid line). The solid line labeled "5" represents the contour line of 5 dBZ.

*L*ightning Research Group of Institute of Atmospheric Physics, Chinese Academy of Sciences (IAP, CAS), Beijing, China

Origin of an uncommon multiple-stroke positive cloud-to-ground lightning flash with different terminations. An uncommon three-stroke positive CG lighting flash was mapped by BLNET, and the results show that three positive strokes grounded at different points approximately 4-8 km apart and times intervals between neighboring CGs were 85 ms and 222 ms. The locations of termination points on the ground were just below the pre-established horizontal IC discharge channels, and the 3 strokes, associated with shared horizontal IC discharge channels, were linked with each other. There were stepping pulses less than 0.4 ms before the first and second RS, and their location results were distributed nearby the following RS. The first and second positive strokes occurred when the horizontal in-cloud negative channel stopped extending, while the third positive stroke occurred below the opposite end of an advancing negative leader in the cloud (Fig. 4). (Yuan et al., 2020, JGR, under review)

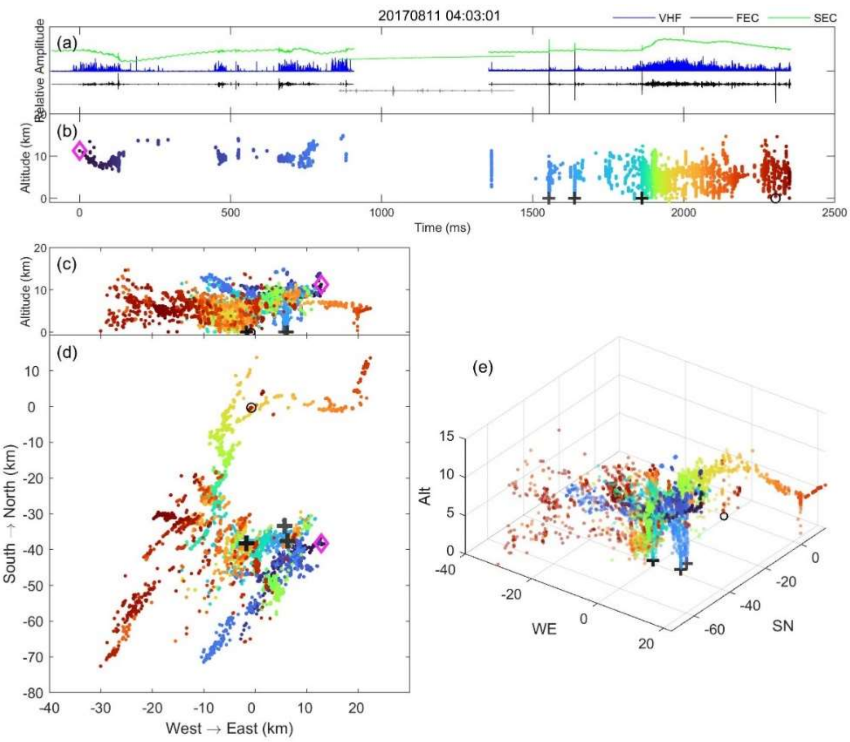


Figure 4 Image of the whole process containing the preceding IC discharge and following +CGs.

Significant day-time ionospheric perturbation by thunderstorms. The equatorial Congo has been recognized as the most active lightning chimney region in the globe. Deviations in ionospheric total electron content (TEC) and its direction of propagation associated with thunderstorm was analyzed using the method of polynomial filtering, by utilizing the TEC measured from the equatorial Global Positioning System (GPS) receivers stations along the west African region-Congo Basin. The TEC deviations due to the thunderstorms were found to be mostly propagated in the specific direction from the point of the event. The internal dynamics of the equatorial ionosphere have been found to be suppressed by large thunderstorm effects during daytime, with negligible impact at night. (Ogunsua et al., 2020, SR)

Investigating lightning characteristics of thunderstorm in Beijing. (1) The spatial and temporal distribution characteristics of lightning flashes in seven years were investigated, and the average lightning flash density in Beijing is about 1.9 flashes km^{-2} a^{-1}. The weak thunderstorms are more in number but produce fewer lightning flashes, while the super thunderstorms are fewer but produce more lightning flashes. The lightning activity is more likely to occur during the daytime in the mountainous area, and it increases rapidly in the afternoon, with the main peak appearing at 1800 Beijing time. However, the peak lightning activity in the plain occurs at evenings. (Wang, et al., 2020, Chin. J. Atmos. Sci., in Chinese); (2) Electrical characteristics of an isolated supercell storm in Beijing were investigated, and positive cloud-to-ground (+CG) lightning took a high percentage of CG lightning. The discharge concentrated in the convective region with graupel particles and hailstones, whereas graupel, snow and ice crystal in the stratiform region. Based on the distribution of lightning radiation sources and the profile of radar reflectivity, the supercell demonstrated an inverted tripole charge structure before the hail event, which converted to a normal tripole structure after the hail event. (Liu et al., 2020, AAS). (3) Characteristics of lightning activity and radar reflectivity structure of a severe thunderstorm with several hail-fall stages was analyzed. The thunderstorm consisted of three isolated cells triggered in sequence and finally merged together. The total lightning frequency increased significantly during the four analyzed hail-fall stages, and IC flashes accounted for more than 80% of the total lightning. Lightning radiation sources mainly distributed in the altitude layer from 6 km to 10 km throughout the hailstorm process, which was consisted with a strong radar echo region. (Sun et al., 2020, Chin. J. Atmos. Sci., in Chinese)

Lightning activity in the Tibetan Plateau. Lightning activity over Tibetan Plateau is investigated using LIS/OTD data for period of 1995-2014, and the surface thermodynamics on lightning activity is examined using the reanalysis datasets from the NCEP. The geographical distribution of lightning flash density shows a gradual decrease from east to west across the Tibetan Plateau, from 4.3 fl·km^{-2}·yr^{-1} on average over Eastern Tibetan Plateau to 1.7 fl·km^{-2}·yr^{-1} over Western Tibetan Plateau. The results show that humidity and sensible heat fluxes play a vital role in the occurrence of lightning over the Tibetan Plateau. A new parameter, product of rainfall, Bowen ratio, and surface specific humidity, is proposed and shows a better correlation with lightning activity. (Li et al., 2020, AR, under review)

Potential effects of aerosol on lightning activity in Beijing. Based on lightning data from BLNET and PM2.5 data from 35 automatic air-monitoring stations, spatiotemporal distributions of total lightning activities and aerosols have been analyzed in Beijing. The response of lightning activities to aerosols is further investigated for a total of 117 thunderstorm days. The results indicated both spatial distributions of lightning density and pollutant demonstrated a gradual increase from northwest to southeast of Beijing metropolitan region. Correlation analysis of PM2.5 prior to occurrence of thunderstorms to lightning density showed a significant positive correlation when PM2.5 lower than 130 μg·m^{-3}. On the contrary, as PM2.5exceeded 150 μg·m^{-3}, total flash showed a negative relationship to PM2.5. (Sun et al., 2020, Chin. J. Geophys., in Chinese)

*L*ightning Research Group of Gifu University

Optical observation of two upward leaders with opposite polarities. We have observed an upward negative lightning flash initiated from the 100-m-tall windmill protection tower located at Uchinada, Ishikawa prefecture in Japan by using a high-speed video camera operated at 330,000 fps. As shown in Fig. 5, this is a positive leader with two discernable branches. Both branching leaders exhibited discontinuous fashion (also named “step”) during their propagation. Through analyzing the change of the luminosity and the geometry of the positive leaders, we found that during each step in the positive leaders, the luminosity increased with the extension of the leader channel. In other words, the luminosity pulses correspond to the change of the leader geometry.

Through analyzing their so-called differential luminosity profiles along leader channels, we found that the steps of positive leaders can be classified into two types. The type I step luminosity is similar to the luminosity produced by a negative leader step and is generally featured with a rapid increase near the leader tip and accompanied by a backward propagation along the leader channel. The type II step is featured with continuous luminosity variation along the leader channel. Backward propagation of luminosity, if any, is not apparently presented.

We also compared the high-speed images during the step formation process of positive leaders and negative leaders. Based on the comparison result, we proposed a possible mechanism of two types of positive steps. The detailed analysis of this lightning can be found in the JGR paper "Comparative study on the discontinuous luminosities of two upward lightning leaders with opposite polarities".

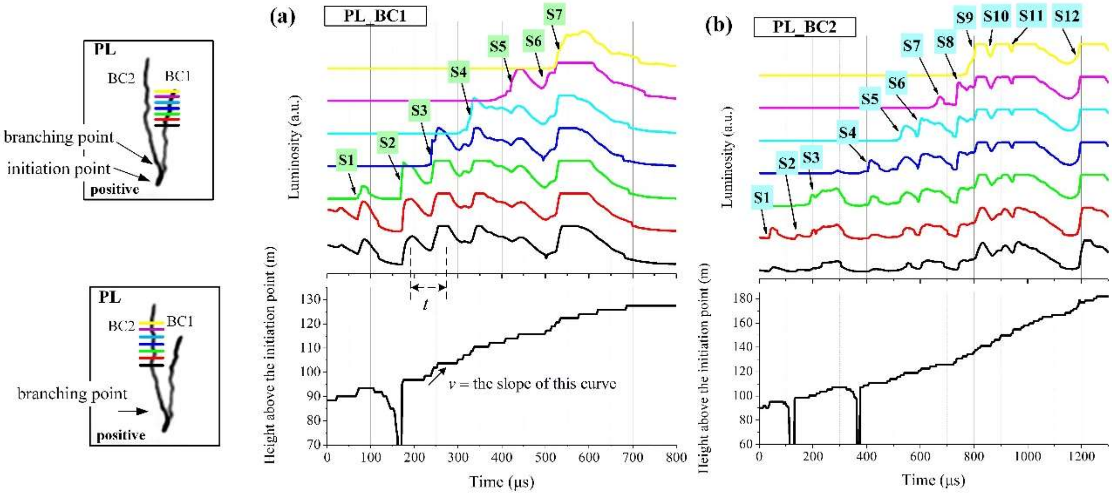


Figure 5 The time-varying luminosity and the corresponding tip distance from the leader initiation point of (a) PL BC1, (b) PL BC2. The color bars in the high-speed images mark the positions chosen to observe the luminosity. The leader steps are numbered with S1, S2 … in colors. Several flat portions in the luminosity waveforms are caused by the saturation of the CMOS sensor of the high-speed camera.

A -CG flash starting without classic preliminary breakdown pulses. A special negative cloud-to-ground (-CG) flash imaged by the Fast Antenna Lightning Mapping Array is reported in this paper. Figure 6 shows the 3-D mapping result of this flash. This flash initiated at a high altitude of about 11 km. The initiation location is inferred to be the lower edge of the upper positive charge region. Both initial positive and negative leaders had downward propagations, but during the initial 500 ms the negative leader had little development. An important feature of this -CG flash is that it did not start with classic preliminary breakdown (PB) pulses; there were only a few very small and narrow (~1 μs) pulses during the initial 100 ms. The absence of PB pulses was a direct result of the inactive initial negative leader, which was caused by the high initiation altitude. We suggest that lightning flashes, including CG and intracloud flashes, initiating at high altitudes (roughly >10 km) mostly start without classic PB pulses. This paper has been published in the Journal of Atmospheric Electricity.

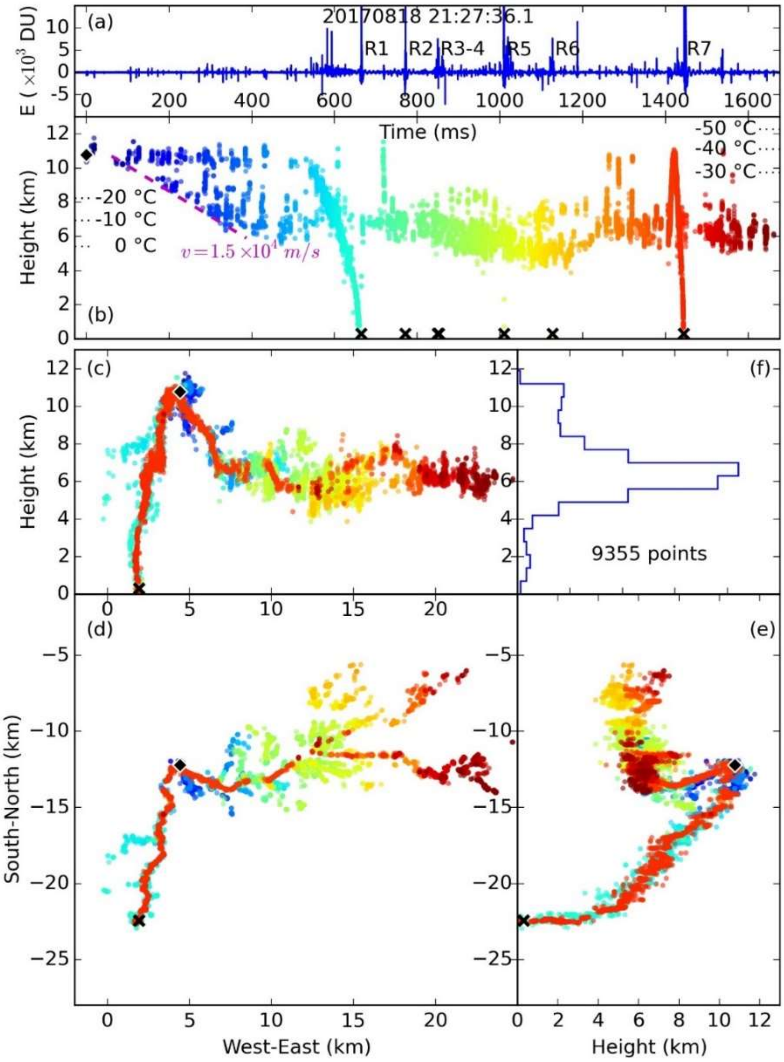


Figure 6 The 3-D mapping result of a special -CG flash.

*M*assachusetts Institute of Technology (Cambridge, MA)

MIT (Earle Williams) and Airborne Research Associates (Ralph Markson) have joined forces to make coordinated measurements of the two global electrical circuits—the classical DC global circuit characterized by ionospheric potential and the AC global circuit (aka, Schumann resonances). The outstanding scientific objective is to bring resolution to a long-standing puzzle we refer to as the "global circuits paradox". The DC global circuit has long been recognized to maximize near 19 UT in the diurnal cycle, when America is most active. In contrast, the global lightning activity and the AC circuit are often found to maximize when Africa is most active (near 15 UT). A likely key player in this paradox are the electrified shower clouds (Wilson, 1920) that contribute to the DC global circuit but not to the

AC circuit. Two possible resolutions to the paradox are (1) electrified shower clouds are more abundant in America than in Africa and/or (2) the greater cloud condensation nuclei concentrations (CCN) in Africa are enhancing the lightning activity in Africa relative to that in America. Coordinated measurements on individual days are planned to test these ideas. CCN concentrations over Africa and America will be measured and compared with the satellite method devised by Danny Rosenfeld (Rosenfeld et al., 2016). ELF time series from many generous contributors worldwide will be used for the AC global circuit analysis.

A second component of this global circuits study (led by post-doc Yakun Liu) has been the implementation of a kinematic calculation using the 3D wind field now available with the ECMWF ERA 5 global reanalysis product, to quantify and compare the upward mass flux in each of three continental "chimneys", the major source regions for the two global circuits. These calculations are also planned for individual days and with hourly resolution. The Maritime Continent leads the mass flux ranking, as discussed earlier by Newell et al., (1972) in the context of the global Walker Circulation and by Williams (Atmos. Res., 2005) in the global circuit context.

A recent revisitation of lightning behavior in oceanic ship tracks in the South China Sea, with lightning observations from both Earth Networks (Jeff LaPierre, Michael Stock and Stan Heckman) and GLD360 (Ryan Said), has shown enhancements in the IC/CG lightning ratio within the shipping lane, in comparison with the adjacent pristine ocean. The enhancements in overall lightning in the polluted shipping lanes are consistent with earlier findings by Thornton et al. (2017). These findings appeared recently in Geophysical Research Letters (Yakun Liu, et al., GRL, 2020).

The ongoing global COVID-19 calamity presents an interesting period in the Earth's history to monitor the global circuits. In April 2020 the International Energy Agency has reported an unprecedented 28% reduction in global consumption of fossil fuels. The shipping industry has also experienced a like reduction (~30%) in oceanic container transport. Global reductions in aerosol and along oceanic shipping lanes are expected, along with consequent reductions in lightning activity, globally and regionally.

Prof. Fernando Galembeck at the University of Campinas in Brazil has shared some fascinating video imagery of the electrification of rapidly growing dendrites spontaneously ejecting charged branches. This phenomenon was studied qualitatively in the 1970s by Vincent Schaefer and Roger Cheng in Albany and quantitatively by Jim Rydock at MIT in the 1980s (Rydock and Williams, QJRMS, 1991). The explanation for the spontaneous ejection of consistently negatively charged ice fragments is now under new investigation.

Research Centre for Astronomy and Earth Sciences, Geodetic and Geophysical Institute, Hungary

Bór, J., Bozóki, T., Buzás, A., Szabóné-André, K., Barta, V., Prácser, E., Sátori, G.

The Working Group of the Atmospheric Electricity in the Geodetic and Geophysical Institute (GGI) deals both with the AC (Schumann resonances; SR) and DC (potential gradient; PG) field components of the global electric circuit (GEC) and transient luminous events (TLEs). The SR and PG measurements are conducted in the Széchenyi István Geophysical Observatory (SZIGO) and TLEs are observed from Sopron (West Hungary) and Baja (South Hungary) during summer seasons.

In the frame of maintenance the ball antenna for recording the E_Z field component of SR was renewed. We have been looking for less disturbed field site for the magnetic induction coils because the SZIGO became rather noisy in the last decade due to the increasing electromagnetic noise pollution.

Recently the changes of global lightning activity during the transition periods between the cold and warm phase of the two super El Nino events in 1997/98 and 2015/16 have been studied based on the long-term background SR measurements in the SZIGO and other distant SR field sites in the frame of international cooperation (Gabriella Sátori, Tamás Bozóki).

Schupy, an open-source python package modeling Schumann resonances was developed applying the solution of the 2-D telegraph equation obtained for uniform cavity. It is able to determine the theoretical SR spectrum for arbitrary source-observer configuration (Tamás Bozóki, Ernő Prácser).

A lesser-known analytical treatment and a new numerical approach to model electromagnetic wave propagation in the lowest part of the ELF band (< 100 Hz) have been developed that takes into consideration the day-night asymmetry of the Earth-ionosphere cavity. Numerical tests show that the two models produce practically the same output. Our result is an important step towards inferring the distribution and intensity of global lightning activity based on Schumann resonance (SR) measurements (Ernő Prácser, Tamás Bozóki). There is a close cooperation on the SR inversion and other phenomena related to the GEC between the MIT Research Team (Earle Williams) and our Working Group.

Development of an automatized Q-burst (SR-transient) finding code made possible to start studying the space and time distribution of Q-bursts in the days of different seasons based on the long-term SR records in the SZIGO (Karolina Szabóné-André, József Bór).

Optical observations of TLEs in 2019 were pre-processed and time point, type, and approximate source location were regularly sent to the EuroSprite database and also uploaded to the ASIM data center (https://asdc.space.dtu.dk) (József Bór, Karolina Szabóné-André).

The main goal of studying PG records to identify the local, regional and global influences based on simultaneous measurements in more stations. Investigation of historical PG (recorded at NCK since 1962) and thunderday (TD) records in Central Europe is going to disclose long-term trends in the regional variation of thunderstorm activity, i.e., regarding the sources of Q-bursts (Attila Buzás, József Bór, Veronika Barta).

Footprint of meteor showers in ionograms recorded by the Digisonde in SZIGO is a new project with promising preliminary results (Veronika Barta).

The University of Manchester (Manchester, UK)

C. Emersic and C. P. R. Saunders authored a paper titled “The influence of supersaturation at low rime accretion rates on thunderstorm electrification from field-independent graupel-ice crystal collisions”. In this experimental laboratory study, the polarity of graupel charging was measured during collisions with ice crystal, with focus on rime accretion rates of < 1 g m^{-2} s^{-1}. Figure 7 reveals that when varying only cloud supersaturation, the polarity of particle charging can be reversed. This observation adds further understanding to graupel-ice crystal charging. Qualitative explanations are provided for the varied range of observed charge reversal profiles made with an identical facility. These explanations rely on the influence of cloud supersaturation and ice crystal thermal preconditioning and size on particle diffusional growth rate prior to collision. The observations are fully consistent with Relative Diffusional Growth Rate hypothesis. The wide range of cloud temperatures and liquid water contents that both polarities of graupel charging have been observed in the laboratory supports recent published studies suggesting that primary electrification is likely driven by field-independent ice collisions described by relative surface diffusional growth rates. The implications for numerical modelling studies are also discussed. Recommendations are provided for future laboratory experimental measurement practice to avoid ambiguity during interpretation between studies, including the need to directly measure cloud supersaturation during charge transfer. The paper is published in Atmospheric Research.

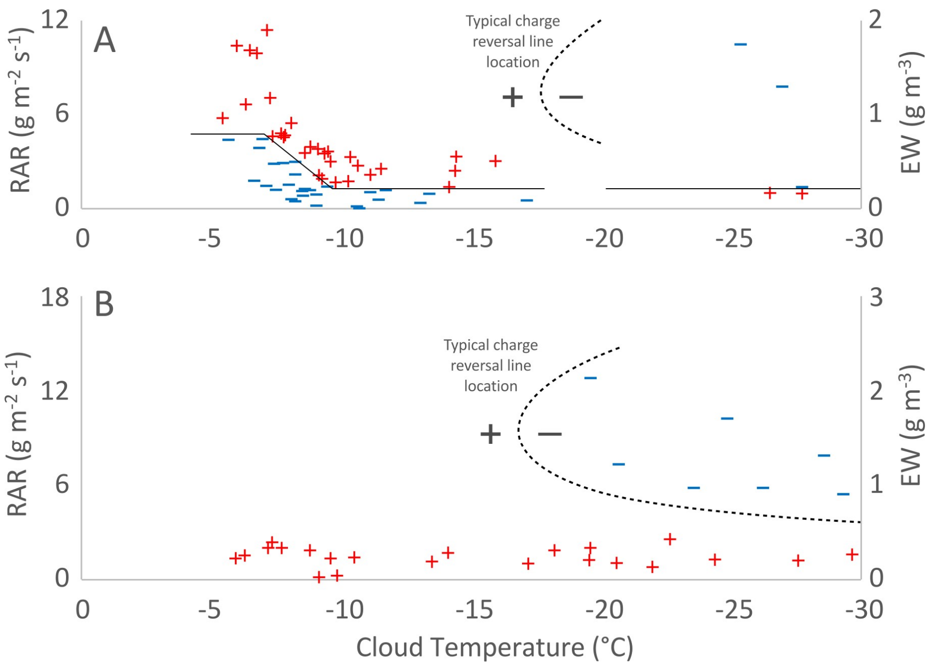


Figure 7 Charge to graupel as a function of rime accretion rate and cloud temperature. A: lower cloud supersaturation; B: higher cloud supersaturation.

*U*niversity of Florida

V. A. Rakov and M. D. Tran authored a paper titled "The breakthrough phase of lightning attachment process: From collision of opposite-polarity streamers to hot-channel connection". In this paper, recent progress in studying the breakthrough phase (BTP) of the attachment process in lightning and long sparks has been integrated, expanded, and summarized in order to clarify the nature of this poorly understood lightning process. The main focus is on the new insights gained from recent observations for 3 types of electric discharges: natural lightning (Nag et al., 2012; Tran and Rakov, 2017a, c), rocket-and-wire triggered lightning (Howard et al., 2010; Hill et al., 2016), and long sparks (Kostinskiy et al., 2016). The BTP (also known as the final jump) starts when the poorly-conducting streamer zones, developing ahead of the hot channels of negative downward leader (DL) and positive upward connecting leader (UCL), come in contact and a common streamer zone (CSZ) is formed. The beginning of BTP (establishment of CSZ) is usually marked by an abrupt current rise, a burst of dE/dt pulses (referred to as leader burst or LB), and hard X-ray emission. During the BTP, hot channels of both DL and UCL extend toward each other inside the CSZ, resulting in its shrinking, until the high-impedance CSZ is eliminated and lowimpedance connection of DL to the grounded object is established. The process of bridging of CSZ by hot leader channels is accompanied by the formation of slow front (SF) in the channel current and in electric and magnetic field waveforms at both close and far distances from the channel. Attempted or relatively weak hot-channel connections producing current surges and associated field pulses superimposed on the SF (SF pulses) can occur. The SF lasts some microseconds and ends at the onset of the submicrosecond scale fast transition (FT), which signifies the end of BTP. During the BTP, the current rises from the UCL level of the order of tens to hundreds of amperes to about 50% of the overall (SF+FT) current peak, which is of the order of tens of kiloamperes. This two orders of magnitude current rise during the BTP occurs before the collision of hot leader channels inside the CSZ; that is, before the onset of return stroke proper. For one observed CSZ, the initial electric conductivity was estimated to be 3×10^{-5} S/m. The corresponding dc resistance of CSZ was 17 kΩ, which is about an order of magnitude lower than the expected resistance of 10-m long section of pre-dart-leader channel having a radius of 3 cm and conductivity of 0.02 S/m. Results of this study are published in the Electric Power Systems Research.

Y. Zhu, Z. Ding, V. A. Rakov, and M. D. Tran authored a paper titled "Evolution of an upward negative lightning flash triggered by a distant +CG from a 257-m-tall tower, including initiation of subsequent strokes". Using the high-speed optical and electric field records acquired at LOG, in conjunction with ENTLN and radar data, the authors examined in detail the morphology and evolution of an upward negative flash containing 6 downward leader/upward return stroke sequences terminated on a 257-m tower in Florida. The upward flash was induced (triggered) by a single-stroke 50-kA +CG that occurred about 45 km from the tower. The in-cloud part of +CG was optically detected to extend toward the tower and appeared to stop at a height of about 3 km above the tower top. The 6 leader-return-stroke sequences were each initiated by a bidirectional leader utilizing the remnants of branches created during the initial stage. Electric field signatures of bidirectional leaders were similar to K-changes. The upper end of the return-stroke channel in all 6 cases exhibited branching and appeared to extend to higher altitudes or/and move closer to LOG with increasing stroke order. This flash was unique in that its channels were optically detectable up to an altitude of 10 km or so. Results of this study are published in the Geophysical Research Letters.

Vaisala

Patent issued number US20190187197A1: Identification of cloud-to-ground lightning strokes with continuing current. Systems and methods are disclosed to detect cloud-to-ground (CG) strokes that include or are followed by continuing current. As an example, earth-based lightning data may be generated for one or more lightning pulses detected in an environmental space using multiple earth-based lightning detection sensors. Space-based lightning data may be received for one or more optical signals detected in the environmental space using one or more space-based lightning detection sensors. It may be determined whether one or more lightning pulses is a CG stroke based on the earth-based lightning data. In response to determining that a given one of the one or more lightning pulses is a CG stroke, it may be determined whether the CG stroke includes or is followed by continuing current based on the space-based lightning data.

Continuing current product released by Vaisala. Fewer than 10% of lightning strokes have continuing current. They are likely to cause extreme heat damage or start a fire. So if you are concerned about wildfires, or lightning damage to wind projects, or electric transmission/distribution networks; when a thunderstorm blows through, the Continuing Current Dataset is designed for the identification and location of lightning events most likely to have caused damage through heating, so you can more effectively prioritize inspections, and prevent further damage.

Vaisala's Continuing current Dataset has been developed to identify the small fraction of cloud-to-ground lightning strikes with continuing current; they are the events that can be the most destructive, and are most likely to initiate wildfires, put holes in wind turbine blades and damage other electro-mechanical assets.

Counter intuitively, the majority of these destructive events are not higher peak current events, in fact quite the contrary. They cause extreme heating, having a duration up to 1000 times longer than the other 90% of strokes, as they transfer significantly more electric charge to whatever they contact.

In April 2020 Vaisala was awarded the patent for a technique that combines lightning information from ground-based lightning detection networks with satellite-borne lightning sensors, in this instance, on the two GOES satellites over the Atlantic and Pacific Oceans.

Vaisala’s NLDN and GLD360 lightning networks accurately distinguish cloud-to-ground lightning strokes from cloud lightning and precisely identify their location, by analysis of the electromagnetic signal.

The Geostationary Lightning Mappers, the sensors on the NOAA/NASA GOES satellites, while not distinguishing between cloud and cloud-to-ground lightning, are able to detect the duration of each lightning flash, by analysis of the optical signal. USA coast-to-coast coverage is achieved by employing the data from both GOES East and West satellites through a clever technique, that integrates data from both the satellite and ground-based technologies, we can deliver a data feed that includes the identification of strokes with continuing current and their duration.

Comparisons of lightning rates and properties from the U.S. National Lightning Detection Network (NLDN) and GLD360 with GOES-16 Geostationary Lightning Mapper and Advanced Baseline Imager Data. Flash-level comparisons between the Geostationary Lightning Mapper (GLM; primarily from GOES-16), the U.S. National Lightning Detection Network (NLDN), and the Global Lightning Dataset GLD360 have been done at quasi-climatological scale and in smaller samples of both severe and nonsevere thunderstorms. A small sample of data from GOES-17 has also been analyzed. These comparisons show that the total lightning detection efficiencies of the GLM instruments drop off within about 2,000 km of the edges of their fields of view, particularly over terrestrial areas. In severe storms, low detection efficiency by GLM is clearly associated with very high midaltitude reflectivity, consistent with the idea that large multiple scattering path lengths, together with absorption of the near-infrared signals by water (in all of its phases), depresses the GLM detection efficiency. This effect appears to be coupled with additional factors, including time of day, flash energetics, and the incident angle at the GLM sensor. The "lightning jump," the sought-after signature of severe storms in lightning observations, tends to be poorly correlated between NLDN and GLM unless the storms are fairly isolated, not close to the edge of the GLM field of view, and have moderate midaltitude reflectivity.

Fatalities related to lightning occurrence and agriculture in Bangladesh. Large numbers of Bangladesh lightning fatalities during the pre-monsoon season have resulted in speculation about causes for this annual event. The present study addresses the situation with lightning occurrence, lightning fatality, and agricultural data. Of the 1,434 lightning deaths from 2013 to 2017 in Bangladesh, an average of 1.73 deaths occur per day in the pre-monsoon season, 0.71 in the monsoon, and very small averages in other seasons. More than half of the deaths are related to agriculture. Population-weighted fatality rates are large in several northeastern districts. Lightning fatalities are frequent in April and especially May during both morning and afternoon. Based on 37.2 million strokes from the Global Lightning Dataset GLD360 network over Bangladesh from 2013 to 2017 (Fig. 8), lightning is also most frequent in the northeast from mid-April through early June at all hours of the day.

Several districts with large lightning stroke densities and fatality rates are the same as with the greatest farming participation. A common crop is Boro rice harvested during April and May in several districts with frequent lightning. As a result, temporal and spatial connections exist among lightning fatalities and occurrence, and agricultural workers. This study identifies the lightning fatality maximum during the premonsoon season as frequent lightning coincident with labor-intensive agricultural practices in specific locations. As a result, measures can be taken to address the underlying lightning vulnerability. Additionally, agricultural studies at the times and locations identified here need further exploration. The final steps are to provide meteorological warnings and lightning-safe locations for the most vulnerable population.

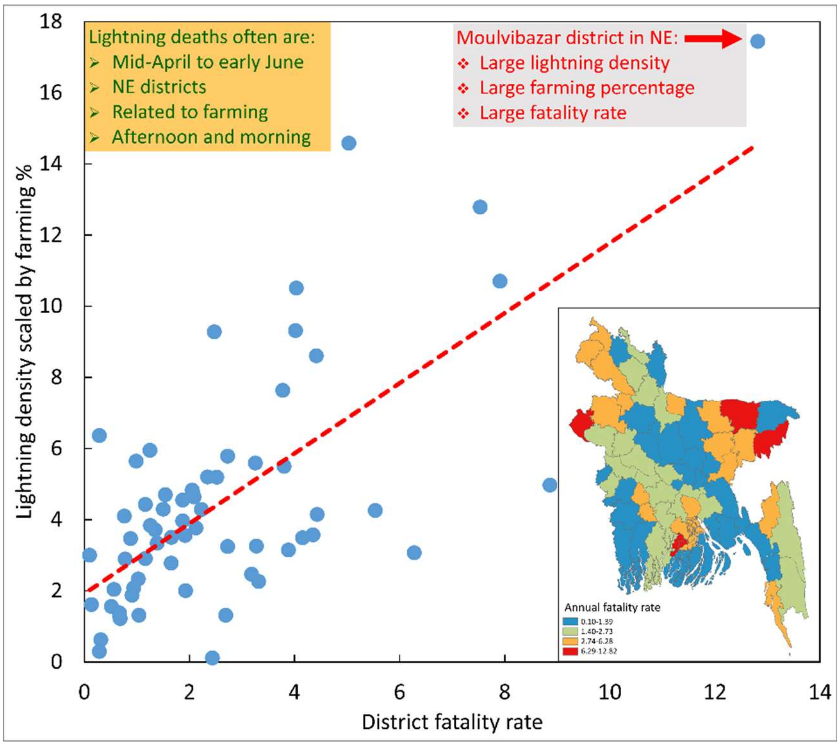


Figure 8 District GLD360 stroke density scaled by farming percentage versus district lightning deaths per million per year in Bangladesh from 2013 to 2017.

This list of references is not exhaustive. It includes only papers published during the last six months provided by the authors or found from an on-line research in journal websites. Some references of papers very soon published have been provided by their authors and included in the list. The papers in review process, the papers from Proceedings of Conference are not included.

Adekitan, A.I., Rock, M. 2020. The impact of space point definition on dynamic electro-geometrical model of lightning strike probability. Electr. Pow. Syst. Res., 184, doi:10.1016/j.epsr.2020.106336.

Albert, J.M., Starks, M.J., Selesnick, R.S., et al. 2020. VLF transmitters and lightning-generated whistlers: 2. Diffusion of radiation belt electrons. J. Geophys. Res. Space Physics, 125, doi:10.1029/2019JA027030.

Allen, D.J., Pickering, K.E., Bucsela, E., et al. 2019. Lightning NOx production in the tropics as determined using OMI NO2 retrievals and WWLLN stroke data. J. Geophys. Res. Atmos., doi:10.1029/2018JD029824.

Arnone, E., Bór, J., Chanrion, O., et al. 2020. Climatology of transient luminous events and lightning observed above Europe and the Mediterranean Sea. Surv. Geophys., 41, 167-199.

Arshad, N.S., Abdullah, M., Samad, S.A., et al. 2019. Lightning severity classification technique using Very Low Frequency signal feature extraction. J. Atmos. Sol.-Terr. Phy., 195, 105136, doi:10.1016/j.jastp.2019.105136.

Asfur, M., Price, C., Silverman, J., et al. 2020. Why is lightning more intense over the oceans? J. Atmos. Sol.-Terr. Phy., 202, doi:10.1016/j.jastp.2020.105259.

Azadifar M., Rubinstein, M., Li, Q., et al. 2019. A new engineering model of lightning M-component that reproduces its electric field waveforms at both close and far distances. J. Geophys. Res. Atmos., 124, 14008-14023.

Bagheri, M., Dwyer, J., McConnell, M.L. 2019. On the linear polarization of TGFs and X-rays from natural and rocket-triggered lightning and its association with source geometry. J. Geophys. Res. Space Physics, 124, 9166-9183.

Blaylock, B.K., Horel, J.D. 2020. Comparison of lightning forecasts from the high-resolution rapid refresh model to Geostationary Lightning Mapper observations. Weather Forecast., 35, 401-416.

Bór, J., Sátori, G., Barta, V., et al. 2020. Measurements of atmospheric electricity in the Széchenyi István Geophysical Observatory, Hungary. History of Geo-and Space Sciences, 11, 53-70.

Bozóki, T., Prácser, E., Sátori, G., et al. 2019. Modeling Schumann resonances with schupy. J. Atmos. Sol.-Terr. Phy., 196, 105144.

Bruning, E.C., Tillier, C.E., Edgington, S.F., et al. 2020. Meteorological imagery for the Geostationary Lightning Mapper. J. Geophys.

Res. Atmos., 124, 14285-14309.

Bucsela, E.J., Pickering, K.E., Allen, D.J., et al. 2019. Midlatitude lightning NOx production efficiency inferred from OMI and WWLLN data. J. Geophys. Res. Atmos., 124, 13475-13497.

Carey, L.D., Schultz, E.V., Schultz, C.J., et al. 2019. An evaluation of relationships between radar-inferred kinematic and microphysical parameters and lightning flash rates in Alabama Storms. Atmosphere, 10, 796, doi: 10.3390/atmos10120796.

Charalambous, C.A., Dimitriou, A., Kioupis, N., et al. 2020. Wall fusion of buried pipelines due to direct lightning strikes: field, laboratory, and simulation investigation of the damaging mechanism. IEEE T. Power Deliver., 35, 763-773.

Chilingarian, A., Khanikyants, Y., Rakov, V.A., et al. 2020. Termination of thunderstorm-related bursts of energetic radiation and particles by inverted intracloud and hybrid lightning discharges. Atmos. Res., 233, doi:10.1016/j.atmosres.2019.104713.

Choudhury, B.A., Konwar, M., Hazra, A., et al. 2020. A diagnostic study of cloud physics and lightning flash rates in a severe pre-monsoon thunderstorm over northeast India. Q. J. Roy. Meteor. Soc., doi:10.1002/qj.3773.

Couto, F.T., Iakunin, M., Salgado, R., et al. 2020. Lightning modelling for the research of forest fire ignition in Portugal. Atmos. Res., 242, doi:10.1016/j.atmosres.2020.104993.

Cummer, S.A. 2020. Indirectly measured ambient electric fields for lightning initiation in fast breakdown regions. Geophys. Res. Lett., 47, doi:10.1029/2019GL086089.

Dragović, S., Yamauchi, M., Aoyama, M., et al. 2020. Synthesis of studies on significant atmospheric electrical effects of major nuclear accidents in Chernobyl and Fukushima. Science of the Total Environment, 733, 139271.

Emersica C., Saunders, C.P.R. 2020. The influence of supersaturation at low rime accretion rates on thunderstorm electrification from field-independent graupel-ice crystal collisions. Atmos. Res., 242, 104962. doi:10.1016/j.atmosres.2020.104962.

Enno, S.-E., Sugier, J., Alber, R., et al. 2020. Lightning flash density in Europe based on 10 years of ATDnet data. Atmos. Res., 235, doi:10.1016/j.atmosres.2019.104769.

Fan, Y., Lu, G., Li, X., et al. 2019. Measurements of magnetic pulse bursts during initial continuous current of negative rocket-triggered lightning. J. Geophys. Res. Atmos., 124, 11710–11721.

Galuk, Y.P., Kudintseva, I.G., Nickolaenko, A.P., et al. 2019. Scattering of ELF radio waves by a localized non-uniformity in the lower ionosphere. J. Atmos. Solar-Terr. Phys., 194, doi:10.1016/j.jastp.2019.105093.

Harel, M., Price, C. 2020. Thunderstorm trends over Africa. J. Climate, 33, 2741-2755.

Harkema, S.S., Berndt, E.B., Schultz, C.J. 2020. Characterization of snowfall rates, totals, and snow-to-liquid ratios in electrified snowfall events identified by the Geostationary Lightning Mapper. Weather Forecast., 35, 673-689.

Holle, R.L., Dewan, A., Said, R., et al. 2019. Fatalities related to lightning occurrence and agriculture in Bangladesh. International Journal of Disaster Risk Reduction, 41, 15.

Hui, W., Huang, F., Liu, R. 2020. Characteristics of lightning signals over the Tibetan Plateau and the capability of FY-4A LMI lightning detection in the Plateau. Int. J. Remote. Sens., 41, 4603-4623.

Islam, M.S., Schmidlin, T.W. 2020. Lightning hazard safety measures and awareness in Bangladesh. Natural Hazards, 101, 103-124.

Iudin, D.I., Rakov, V.A., Syssoev, A.A., et al. 2019. Formation of decimeter-scale, long-lived elevated ionic conductivity regions in thunderstorms. Climate and Atmosphere Science, 2, 46, doi:10.1038/s41612-019-0102-8.

Jiang, R., Lyu, W., Wu, B., et al. 2020. Simulation of cloud-to-ground lightning strikes to structures based on an improved stochastic lightning model. J. Atmos. Sol.-Terr. Phy., 203, 105274.

Karunarathne, N., Marshall, T.C., Karunarathne, S., et al. 2020. Studying sequences of initial breakdown pulses in cloud-to-ground lightning flashes. J. Geophys. Res. Atmos., 125, doi:10.1029/2019JD032104.

Koehler, T.L. 2020. Cloud-to-ground lightning flash density and thunderstorm day distributions over the contiguous United States derived from NLDN measurements: 1993-2018. Mon. Wea. Rev., 148, 313-332.

Kong, R., Xue, M., Fierro, A.O., et al. 2020. Assimilation of GOES-R Geostationary Lightning Mapper flash extent density data in GSI EnKF for the analysis and short-term forecast of a mesoscale convective system. Mon. Wea. Rev., 148, 2111-2133.

Koochak, Z., Fraser-Smith, A. 2020. Single-station lightning location using azimuth and time of arrival of sferics. Radio Science, 55, doi:10.1029/2018RS006627.

Kourtidis, K., Szabóné André, K., Karagioras, A., et al. 2020. The influence of circulation weather types on the exposure of the biosphere to atmospheric electric fields. Int. J. Biometeorol., doi: 10.1007/s00484-020-01923-y.

Lapierre, J.L., Laughner, J.L., Geddes, J., et al. 2020. Observing US regional variability in lightning NO_2 production rates. J. Geophys. Res. Atmos., 125, doi:10.1029/2019JD031362.

Lax, J., Price, C., Saaroni, H. 2020. On the spontaneous build-up of voltage between dissimilar metals under high relative humidty conditions. Nature Scientific Reports, 10, 7642.

Li, D., Luque, A., Rachidi, F., et al. 2019. The propagation effects of lightning electromagnetic fields over mountainous Terrain in the earth-ionosphere waveguide. J. Geophys. Res. Atmos., 124, 14198-14219.

Li, S., Qiu, S., Shi, L., et al. 2020. Observations of the wire destruction and plasma channel reestablishment process during the initial stage of triggered lightning. Geophys. Res. Lett., 47, doi:10.1029/2019GL086001.

Li, Y., Zhang, G., Zhang, Y. 2020. Evolution of the charge structure and lightning discharge characteristics of a Qinghai-Tibet Plateau thunderstorm dominated by negative cloud-to-ground flashes. J. Geophys. Res. Atmos., 125, doi: 10.1029/2019JD031129.

Liu, D., Qie, X., Chen, Y., et al. 2020. Investigating lightning characteristics through a supercell storm by comprehensive coordinated observations over north china. Adv. Atmos. Sci., doi: 10.1007/s00376-020-9264-x.

Liu, M., Jiang, R., Li, Z., et al. 2020. Circuitous attachment process in altitude-triggered lightning striking a 30-m-high tower. Atmos. Res., 244, 105049, doi: 10.1016/j.atmosres.2020.105049.

Liu, N., Liu, C., Chen, B., et al. 2020. What are the favorable large-scale environments for the highest-flash-rate thunderstorms on Earth? J. Atmos. Sci., 77, 1583-1612.

Liu, Y., Guha, A., Montanya, J., et al. 2020. Effects of single impulse current and multiwaveform multipulse currents on aluminum alloy in lightning damage analysis. IEEE T. Plasma Sci., 48, 1146-1153.

Lu, Z., Qiu, S., Wang, R., et al. 2020. Orientation of initial breakdown pulses and leader discharges by magnetic direction finder. J. Geophys. Res. Atmos., 125, doi:10.1029/2019JD031407.

Mach, D.M. 2020. Geostationary Lightning Mapper clustering algorithm stability. J. Geophys. Res. Atmos., 125, doi:10.1029/2019JD031900.

Marchand, M., Hilburn, K., Miller, S.D. 2019. Geostationary lightning mapper and earth networks lightning detection over the contiguous United States and dependence on flash characteristics. J. Geophys. Res. Atmos., 124, 11552-11567.

Marshall, R.A., Xu, W., Sousa, A., et al. 2019. X-ray signatures of lightning-induced electron precipitation. J. Geophys. Res. Space Physics, 124, 10230-10245.

Martinez-Calderon, C., Bortnik, J., Li, W., et al. 2020. Comparison of long-term lightning activity and inner radiation belt electron flux perturbations. J. Geophys. Res. Space Physics, 125, doi:10.1029/2019JA027763.

Mills, B. 2020. An updated assessment of lightning-related fatality and injury risk in Canada: 2002-2017. Natural Hazards, doi:10.1007/s11069-020-03942-9.

Morrow, R. 2019. The origin of ball and bead lightning from an expanded lightning channel. J. Atmos. Sol.-Terr. Phy., 195, 105116, doi:10.1016/j.jastp.2019.105116.

Murphy, M.J., Said, R.K. 2020. Comparisons of lightning rates and properties from the U.S. National Lightning Detection Network (NLDN) and GLD360 with GOES-16 Geostationary Lightning Mapper and Advanced Baseline Imager Data. J. Geophys.

Res. Atmos., 125, doi:10.1029/2019JD0331172.

Neubert, T., Ostgaard, N., Reglero, V., et al. 2020. A terrestrial gamma-ray flash and ionospheric ultraviolet emissions powered by lightning. Science, 367, doi:10.1126/science.aax3872.

Ogunsua, B. O., Srivastava, A., Bian, J., et al. 2020. Significant day-time ionospheric perturbation by thunderstorms along the West African and Congo sector of equatorial region. Scientific Reports. 10, 8466, doi: 10.1038/s41598-020-65315-3.

Pavan, C., Fontanes, P., Urbani, M., et al. 2020. Aircraft charging and its influence on triggered lightning. J. Geophys. Res. Atmos., 125, doi:10.1029/2019JD031245.

Peterson, M., Rudlosky, S., Zhang, D. 2020. Changes to the appearance of optical lightning flashes observed from space according to thunderstorm organization and structure. J. Geophys. Res. Atmos., 125, doi:10.1029/2019JD031087.

Peterson, M., Rudlosky, S., Zhang, D. 2020. Thunderstorm cloud-type classification from space-based lightning imagers. Mon. Wea. Rev., 148, 1891-1898.

Pineda, N., Figueras, J., Romero, D., et al. 2019. Meteorological aspects of self-initiated upward lightning at the Santis Tower (Switzerland). J. Geophys. Res. Atmos., 124, 14162-14183.

Pleshinger, D.J., Alnussirat, S.T., Arias, J., et al. 2019. Gamma ray flashes produced by lightning observed at ground level by TETRA-II. J. Geophys. Res. Space Physics, 124, 9229-9238.

Price, C., Williams, E., Elhalel, G., et al. 2020. Natural ELF fields in the atmosphere and in living organisms. Int. J. Biometeorology, doi:10.1007/s00484-020-01864-6.

Pu, Y., Cummer, S. 2019. Needles and lightning leader dynamics imaged with 100-200 MHz broadband VHF interferometry. Geophys. Res. Lett., 46, 13556-13563.

Qie, K., Tian, W., Wang, W., et al. 2020. Regional trends of lightning activity in the tropics and subtropics. Atmos. Res., 242, doi:10.1016/j.atmosres.2020.104960.

Qin, Z., Chen, M., Lyu, F., et al. 2020. A GPU-based grid traverse algorithm for accelerating lightning geolocation process. IEEE T. Electromagn C., 62, 489-497.

Ren, T., Rapp, A.D., Mecikalski, J.R., et al. 2019. Lightning and associated convection features in the presence of absorbing aerosols over Northern Alabama. J. Geophys. Res. Atmos., 124, 13375-13396.

Ripoll, J.-F., Farges, T., Malaspina, D.M., et al. 2020. Analysis of electric and magnetic lightning-generated wave amplitudes measured by the Van Allen probes. Geophys. Res. Lett., 47, doi:10.1029/2020GL087503.

Romps, D.M. 2019. Evaluating the future of lightning in cloud-resolving models. Geophys. Res. Lett., 46, 14863-14871.

San Segundo, H., Lopez, J.A., Pineda, N., et al. 2020. Sensitivity analysis of lightning stroke-to-flash grouping criteria. Atmos. Res., 242, doi:10.1016/j.atmosres.2020.105023.

Sanderson, D.L., White, E.D., Geyer, A.J., et al. 2020. Optimizing the lightning warning radii at spaceport Florida. Weather Forecast., 35, 523-536.

Shindo, T., Miki, T., Saito, M., et al. 2020. Lightning occurrence characteristics around Tokyo skytree. IEEJ T. Electr. Electr., 15, 976-977.

Shmatov, M.L., Stephan, K.D. 2019. Advances in ball lightning research. J. Atm. Sol.-Ter. Phys., 195, 105115, doi: 10.1016/j.jastp.2019.105115.

Smirnov, S. 2020. Negative anomalies of the Earth's electric field as earthquake precursors. Geosciences, 10, 10, doi:10.3390/geosciences10010010.

Smirnov, S., Mikhailov, Y., Mikhailova, G.A., et al. 2019. Features of winter thunderstorms in Kamchatka. Geomagnetism and Aeronomy, 59, 696-703.

Sokol, Z., Minarova, J. 2020. Impact of 1-and 2-moment cloud microphysics and horizontal resolution on lightning Potential Index within COSMO NWP model. Atmos. Res., 237, doi:10.1016/j.atmosres.2020.104862.

Srivastava, A., Jiang, R., Yuan, S., et al. 2019. Intermittent propagation of upward positive leader connecting a downward negative leader in a negative cloud-to-ground lightning. J. Geophys. Res. Atmos., 124, 13763–13776.

Starks, M.J., Albert, J.M., Ling, A.G., et al. 2020. VLF transmitters and lightning-generated whistlers: 1. Modeling waves from source to space. J. Geophys. Res. Space Physics, 125, doi:10.1029/2019JA027029.

Stolzenburg, M., Marshall, T.C., Karunarathne, S. 2020. On the transition from initial leader to stepped leader in negative cloud-to-ground lightning. J. Geophys. Res. Atmos., 125, doi:10.1029/2019JD031765.

Syssoev, A.A., Iudin, D.I., Bulatov, A.A., et al. 2020. Numerical simulation of stepping and branching processes in negative lightning leaders. J. Geophys. Res. Atmos., 125, e2019JD031360, doi:10.1029/2019JD031360.

Takahashi, T., Sugimoto, S., Kawano, T., et al. 2019. Microphysical structure and lightning initiation in Hokuriku winter clouds. J. Geophys. Res. Atmos., doi:10.1029/2018JD030227.

Vendrasco, E.P., Machado, L.A.T., Araujo, C.S., et al. 2020. Potential use of the GLM for nowcasting and data assimilation. Atmos. Res., 242, doi:10.1016/j.atmosres.2020.105019.

Virts, K.S., Goodman, S.J. 2020. Prolific lightning and thunderstorm initiation over the Lake Victoria basin in East Africa. Mon. Wea. Rev., 148, 1971-1985.

Wada, Y., Enoto, T., Nakamura, Y., et al. 2020. High peak-current lightning discharges associated with downward terrestrial gamma-ray flashes. J. Geophys. Res. Atmos., 125, doi:10.1029/2019JD031730.

Wang, F., Liu, H., Dong, W., et al. 2019. Radar reflectivity of lightning flashes in stratiform regions of mesoscale convective systems. J. Geophys. Res. Atmos., 124, 14114-14132.

Wang, F., Zhang, Y., Liu, H., et al. 2020. Vertical reflectivity structures near lightning flashes in the stratiform regions of mesoscale convective systems. Atmos. Res., 242, 104961, doi:10.1016/j.atmosres.2020.104961.

Wang, H., Chen, D., Yin, J., et al. 2020. An improvement of convective precipitation nowcasting through lightning data dynamic nudging in a cloud-resolving scale forecasting system. Atmos. Res., 242, doi:10.1016/j.atmosres.2020.104994.

Wang, T., Shi, L., Qiu, S., et al. 2020. Continuous broadband lightning VHF mapping array using MUSIC algorithm. Atmos. Res., 231, 104647, doi:10.1016/j.atmosres.2019.104647.

Wang, X., Wang, D., He, J., et al. 2020. A comparative study on the discontinuous luminosities of two upward lightning leaders with opposite polarities. J. Geophys. Res. Atmos., 125, e2020JD032533, doi:10.1029/2020JD032533.

Wang, X., Zhao, X., Cai, H., et al. 2020. Comparisons of optical characteristics of two upward lightning flashes triggered by a nearby positive cloud-to-ground lightning. J. Atmos. Sol.-Terr. Phy., 198, doi:10.1016/j.jastp.2020.105193.

Wu, T., Wang, D., Takagi, N. 2020. A negative cloud-to-ground lightning flash initiating at a high altitude and starting without classic preliminary breakdown pulses. Journal of Atmospheric Electricity, 39(1), 16-32.

Xu, L., Zhang, Y., Wang, F., et al. 2019. Simulation of inverted charge structure formation in convective regions of mesoscale convective system. J. Meteor. Soc. Japan, 97, 1119–1135.

Yamamoto, J., Baba, Y., Tran, T.H., et al. 2020. Simulation of the propagation of lightning electromagnetic pulses in the earth-ionosphere waveguide using the FDTD method in the 2-D spherical coordinate system. IEEJ T. Electr. Electr., 15, 335–339.

Yutthagowith, P., Tran, T.H., Baba, Y., et al. 2020. PEEC simulation of lightning over-voltage surge with corona discharges on the overhead wires. Electr. Pow. Syst. Res., 180, 106118, doi:10.1016/j.epsr.2019.106118.

Zhang, D., Cummins, K.L. 2020. Time evolution of satellite-based optical properties in lightning flashes, and its impact on GLM flash detection. J. Geophys. Res. Atmos., 125, doi:10.1029/2019JD032024.

Zhang, L., Tinsley, B., Zhou, L. 2020. Low latitude lightning activity responses to cosmic ray forbush decreases. Geophys. Res. Lett., 47, doi:10.1029/2020GL087024.

Zhang, W., Hui, W., Lyu, W., et al. 2020. FY-4A LMI observed lightning activity in Super Typhoon Mangkhut (2018) in comparison with WWLLN data. J. Meteor. Res. 34(1), 1-17, doi: 10.1007/s13351-020-9500-4.

Zhang, W., Zhang, Y., Zheng, D., et al. 2020. Quantifying the contribution of tropical cyclones to lightning activity over the

Northwest Pacific. Atmos. Res. 239, 104906. doi: 10.1016/j.atmosres.2020.104906.

Zhu Y., Lyu, W., Cramer, J., et al. 2020. Analysis of location errors of the U.S. National Lightning Detection Network using lightning strikes to towers. J. Geophys. Res. Atmos., 125, doi:10.1029/2020JD032530.

Atmospheric Electricity

http://www.icae-iamas.org
NEWSLETTER
Vol.31 NO.1 May 2020

REMINDER

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

announcements concerning people from atmospheric electricity community, especially awards, new books...,

announcements about conferences, meetings, symposia, workshops in our field of interest,

brief synthetic reports about the research activities conducted by the various organizations working in atmospheric electricity throughout the world, and presented by the groups where this research is performed, and

a list of recent publications. In this last item will be listed the references of the papers published in our field of interest during the past six months by the research groups, or to be published very soon, that wish to release this information, but we do not include the contributions in the proceedings of the Conferences.

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

Call for contributions to the newsletter

All issues of this newsletter are open for general contributions. If you would like to contribute any science highlight or workshop report, please contact Weitao Lyu (wtlu@ustc.edu) preferably by e-mail as an attached word document.

The deadline for **2020 fall issue** of the newsletter is **Nov 15, 2020**.

PRESIDENT
Xiushu Qie
Chinese Academy of Sciences
E-mail: qiex@mail.iap.ac.cn

SECRETARY
Weitao Lyu
Chinese Academy of Meteorological Sciences
E-mail: wtlu@ustc.edu

Edited by: Wenjuan Zhang (CAMS) and Haiyang Gao (NUIST)