Atmospheric Electricity

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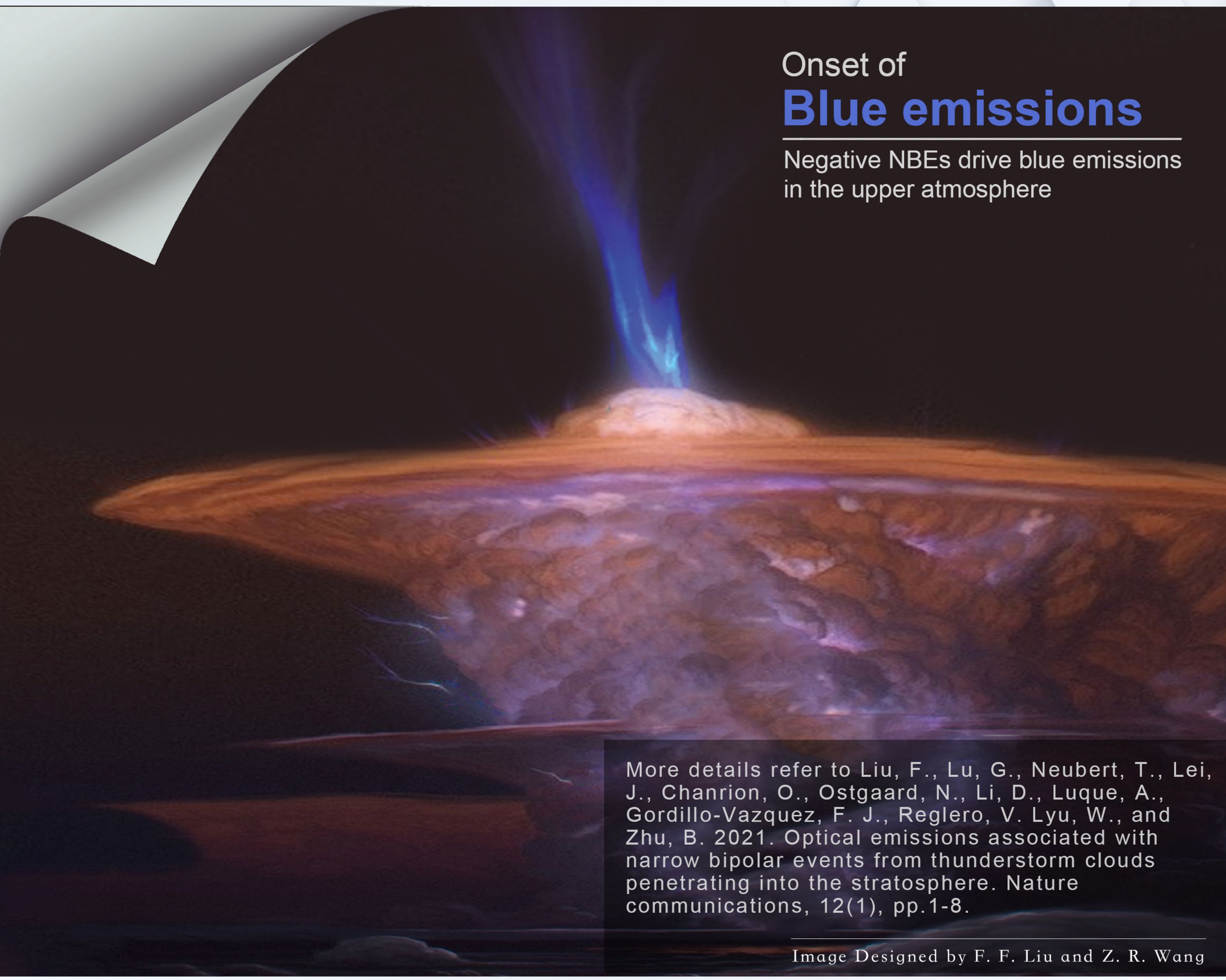


INTERNATIONAL COMMISSION ON ATMOSPHERIC ELECTRICITY
IAMAS IUGG
ICAE

*C*all for Abstracts - ICAE 2022

The deadline to submit Abstract of the 17th International Conference on Atmospheric Electricity was extended to 1 January 2022. The Committee encourages ALL to submit abstracts. There is no fee for submitting abstracts, so given the uncertainty of COVID, we invite all to submit abstracts at this time, without any commitment of physical attendance at this time. Please visit the website at https://www.icae2022.com/call-for-abstracts.

*I*CLP 2022, 2-7 October 2022, South Afirca

ICLP 2022, the 36th International Conference on Lightning Protection, continues the tradition of the preceding 35 conferences by offering a platform for the exchange of scientific and technical information related to lightning phenomena and protection against these phenomena. Hosted by the University of the Witwatersrand (Johannesburg), the conference will be held in 2-7 October 2022 in beautiful Cape Town. The deadline to submit Extended Abstract is 1 February 2022. Please visit https://iclp2022.org/ for more details.

*C*all for Papers - APEMC 2022

The 13th Asia-Pacific International Symposium on Electromagnetic Compatibility & Technical Exhibition (APEMC 2022) will be co-located with and held during the 2022 Beijing EMC Week, Beijing, China, from 8 to 11 May 2022. The Symposium will continue the APEMC spirit to engage and address the world-wide EMC community with a primary focus on the Asia-Pacific region. The deadline for full-paper and abstract is 8 January 2022. Please visit the website at https://apemc.org/call-for-papers/.

Changming Guo (1939–2021)

Changming Guo, a great scientist and our esteemed professor, died on November 13 from cerebral infarction in Shanghai, China. His research work on lightning optical and radiation field signatures, done at the University of Arizona in the early 1980s, is a milestone contribution in the field of lightning physics. He also made great contributions to the rocket-and-wire triggering lightning technology in China and the study of special thunderstorm electrical phenomena over the Loess Plateau in Northwest China.

Changming Guo was born in 1939 and spent his childhood in Shanghai. He entered Tsinghua University in Beijing in 1955 and earned his bachelor's degree in electrical engineering in 1961. After graduation, Changming was assigned to work in Lanzhou Institute of Geophysics, located in Lanzhou, Gansu province. Later, Lanzhou Institute of Plateau Atmospheric Physics, Chinese Academy of Sciences (CAS), was established, and Changming and his colleagues moved to this new Institute. Thereafter, they started to study artificial weather modification, particularly focusing on new methods for artificial rain enhancement and hailstorm prevention. They also developed observational equipment, including the field mill and lightning counter. With these instruments, Changming and his colleagues studied lightning flash rate in hailstorms and its application in hail suppression. Based on the electric field evolution and radar echoes of thunderstorm, they proposed the possible existence of special thunderstorm electrical phenomena with larger lower positive charge region in the Loess Plateau.

In the early 1980s, Changming Guo had the opportunity to study abroad with funding from the Chinese government. He was fortunate to have joined the group of Dr. Philip Krider at the University of Arizona in the United States as a visiting scholar from January 1980 to October 1982. During this period, his research interest shifted to lightning physics and detection. Supervised by Dr. Krider, he assembled a set of sensors for measuring lightning optical signal with fast temporal resolution. With this sensor set, he obtained many valuable lightning data during a summer campaign in Kennedy Space Center in Florida. Based on these data, he estimated the optical power radiated by return strokes and the energy dissipated by cloud-to-ground lightning flash. He also discovered some anomalous light output from dart leaders. Three coauthored papers by Changming Guo and Philip Krider were published in the Journal of Geophysical Research, which are well cited even nowadays.

After returning to China from the US, Changming Guo established an atmospheric electricity research group with his colleagues in Lanzhou Institute of Plateau Atmospheric Physics, CAS. With kind assistance from Dr. Krider and Dr. Uman, he introduced the 3-station lightning location system into China from Lightning Location Positioning (LLP) Company in the later 1980s, which subsequently promoted the lightning research in China significantly. Using this lightning location system, he launched the first joint observation of lightning location and weather radar in China. His team then studied successively the lightning characteristics in severe convective weather in Gansu province and Beijing.

Changming Guo initiated the development of the rocket-wire technique for artificially triggering lightning in China, as well as theoretical analysis of the physical requirements for successful triggering soon after he returned to China from the US. These pioneering efforts laid the foundation for the subsequent rocket triggered lightning experiments in China which have lasted for over 30 years, now mainly in Guangdong and Shandong provinces. Meanwhile, He supervised one of his students in studying the rocket triggering lightning, and another student in the study of the characteristics of lightning radiation in wide frequency bands from VLF to VHF. With his students and colleagues, he coauthored a well-received book titled “Lightning and Artificially Triggered Lightning” in Chinese. He was recognized with the Award of Natural Sciences from the Chinese Academy of Sciences for his research on “Detection and Research on Lightning Electromagnetic Radiation” in 1989, and the Award of Science and Technology Progress also from the Chinese Academy of Sciences for his work on “Lightning Positioning System and Its Experimental Research” in 1993.

Changming Guo was continuously dedicated to lightning research and protection, before and after his retirement. He served as a member of the International Commission on Atmospheric Electricity (ICAE) from 1980-2007. He participated in all the quadrennial meetings of the International Conferences on Atmospheric Electricity since the 7th conference in Albany, USA (1984) until the 13th conference in Beijing (2007), except for the 11th conference in Huntsville, USA (1999) and 12th conference in Versailles, France (2003) due to visa problem.

Changming Guo was a professor and director of the Lanzhou Institute of Plateau Atmospheric Physics, CAS from 1986-1993. In 1994, he moved to Shanghai and served as the director of Shanghai Typhoon Institute of China Meteorological Administration until his retirement in 1999. He made important contributions to the development and growth of the two Institutes during that period.

Xiushu Qie and Daohong Wang

Personal Remembrance of Prof. Changming Guo from Xiushu Qie

Prof. Changming Guo was my thesis advisor during both my master's and PhD degree studies at Lanzhou Institute of Plateau Atmospheric Physics, Chinese Academy of Sciences (CAS). Daohong Wang and I were the first two graduate students enrolled in the Institute to study atmospheric electricity. Prof. Guo was the leader of the atmospheric electricity group in the first year of our master's degree program, and later he was appointed as the director of the Institute.

At that time (mid-1980s), Prof. Guo had the highest level of English proficiency among the scientists in the Institute. He translated the book *Lightning Physics* by Dr. Matin Uman from English into Chinese, so that our group could have a quick start on lightning research. I learnt about lightning from this translation and became interested in lightning physics. Prof. Guo suggested that I start with taking measurements of lightning radiation field. I was very impressed by his intelligent ways of making measuring equipment and his strong abilities for hand-on experiments. His suggestions always enlightened me. Although very busy with administrative duties as the director of the Institute, he paid close attention to our research progresses and gave us timely guidance and help. Under his supervision, in 1987 I finished my master's thesis titled "Study on broadband electromagnetic radiation characteristics of lightning" based on measurements from fast antenna and radio receivers.

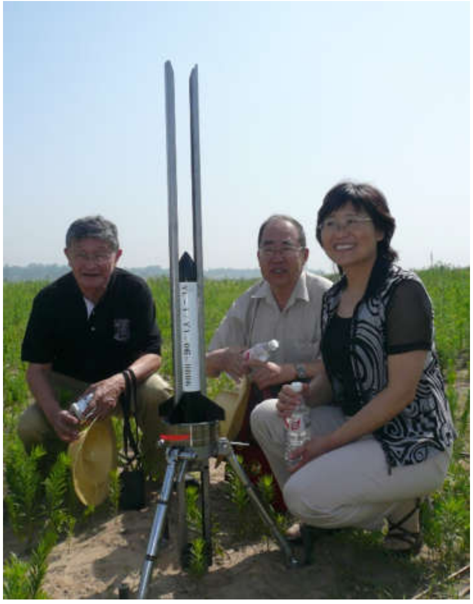
Prof. Guo was extremely supportive of all students in the group. He was always ready to offer his suggestions and comments during group meetings and personal discussions. He invited Dr. P. Krider from University of Arizona and Dr. T. Ogawa from Kyoto University to give us series of lectures on the frontier topics of lightning physics and atmospheric electricity. During those lectures, he was always the interpreter for the audiences because very few could understand English in China at the time. He arranged for me to accompany Dr. Krider and Dr. Ogawa in their leisure time and local sightseeing, so I had more time to talk with them and practice my

English. In 1988, Prof. Guo initiated a Sino-Japanese cooperative lightning observation experiment in Beijing with Dr. Z. Kawasaki and Dr. Sumi from Japan. That was a wonderful experience for all the students in the group. All these activities increased our interest and confidence in lightning research.

Prof. Guo was a brilliant and diligent scientist. He devoted his life to research work on lightning physics and protection. As a professor and director of Lanzhou Institute of Plateau Atmospheric Physics, he spent almost 8 years of busy and hard time alone in Lanzhou from 1986-1993, after his wife returned to Shanghai to work in order to better care for their elderly parents in 1985. As the director of the institute, he did not have enough time to participate in all summer lightning observation experiments with us, but he made sure that he visited us and stayed for a few days each summer, bringing delicious food and lots of joy to the team who was doing tough observations of rocket triggering lightning and special thunderstorm electrical phenomena in Gansu province, Loess Plateau in northwest China.

Prof. Changming Guo was a very strict and rigorous mentor in scientific research, and a very modest and generous person at the same time. We were invited to his house for dinner several times when his wife occasionally visited Lanzhou or during holidays. We discussed scientific issues, and he also told us interesting stories from his experiences, very pleasant and unforgettable moment.

Prof. Guo joined the lightning field campaign of Lanzhou group and gave constructive suggestions as long as he had time after he had worked in Shanghai. He was concerned with our scientific research and growth even after he had retired in Shanghai. In 2006, I moved to Beijing from Lanzhou to work in the Institute of Atmospheric Physics, CAS. Prof. Guo, as an invited scientist in my group, contributed to the research and development of a new generation of trailing-wire-rocket for triggering lightning, which has been used in China till now. He participated in some of our academic meetings almost each year. The last academic meeting he joined with us was held in Shanghai in January 2018.



In 2009, Changming Guo (left) took part in the first test of new generation of trailing-wire-rocket for triggering lightning, which has been used in China till now.

Changming Guo attended the International Symposium on Lightning Physics and Lightning Meteorology (ISLP&M) in Beijing in September 2017.

Changming Guo participated in the Thunderstorm and Lightning Meeting as an invited expert in Shanghai in January 2018.

I visited him in November 2019 when he just stayed in a nursing home not far from his home in downtown Shanghai, after a mild cerebral thrombosis. During my visit, he was still very talkative, asking questions about our high-tower lightning current measurement, rocket triggering lightning experiment, 3D lightning mapping array techniques, aircraft protection against lightning, and so on. In the last two years, we had many phone conversations. He was articulate with clear reasoning and quick responses. He even volunteered to be a handyman in the nursing home, helping with repair work for people living there.

Prof. Guo was a good friend and superb supervisor. His generosity, enthusiasm, and willingness to help others will always be remembered.

Xiushu Qie, Institute of Atmospheric Physics, Chinese Academy of Sciences

Personal Remembrance of Prof. Changming Guo from Richard Blakeslee

I was an atmospheric science graduate student at the University of Arizona when Professor Changming Guo arrived in 1980 with the first wave of visiting scholars from China. His three-year visit initiated a scientific and personal friendship that has now spanned more than forty years, and introduced me to a beautiful country, culture and people that had been previously shrouded in mystery. We quickly learned that Professor Guo was a brilliant, insightful and creative scientist, equally comfortable "in the field" working with instrumentation as he was "in the office" doing theoretical work. Science discussions and debates with him were always enjoyable and fruitful, as I am sure all colleagues who interacted with him would attest. Professor Guo had great humility and treated everyone with kindness and respect. During his visit to Arizona, his leadership and communication skills also were quite evident, and as a result he served as the informal spokesperson for the entire group of visiting scholars during that time. On a more personal note, I had the privilege of teaching him to drive a car (this also was perhaps the most daunting and challenging thing I have ever attempted). He was so proud to be able to personally pick up his wife Naixin at the airport when she joined him later during his visit (and much later I heard that he taught one of his daughters to drive). My last face-to-face visit with my good friend occurred during and following the 2007 International Conference on Atmospheric Electricity in Beijing. Appropriately, when I arrived at the conference center from the airport, the first familiar voice I heard as I exited the taxi was a cheerful "Hello Rich" – it was Changming who had just arrived at that very same moment! Following the conference, Changming and his wife served as gracious hosts (and tour guides) during a visit to their home in Shanghai. Professor Changming Gou will be greatly missed by the atmospheric electricity community. Fortunately, his memory and legacy lives on through his scientific contributions and through the lives of the many family, friends and colleagues he positively touched and impacted throughout his life.

Richard Blakeslee

Personal Remembrance of Prof. Changming Guo from Tsutomu Takahashi

It was sad to know I lost one of my best friends, Prof. Guo.

We worked together at the HEIFE project in 1992 at Pingliang, Gansu Province, China. Prof. Guo participated with us on this project with Prof. Gao.

Before the project, I was invited to Lanzhou Institute to give a seminar. During my talk, the projector stopped working. Prof. Guo, although he was the head of Institute, repaired the projector by himself. I asked him why he didn't ask a technician to repair it, since he had said that he had 100 technicians at the Institute. He replied that the technicians say "We work for the people of China, not for the scientists." It said a lot about his good humor and humility, as well as his technical skills.

Another time, he helped me recover a plane ticket. Even though I had reserved ticket, my ticket disappeared within the reservation system. Dr Guo disputed strongly for me for over hour, and finally he recovered the ticket for me.

Later, we met again when we were launching videosondes from Shanghai. We promised to sail along the Yanzi river together and drink beer. I regret that we will not be able to keep that promise.

Tsutomu Takahashi, Hawaii, USA

Personal Remembrance of Prof. Changming Guo from Daohong Wang

My first meeting with Prof. Changming Guo was in the spring of 1984 at the interview he gave me personally from a long way to my university after I passed the paper examination for entering the master course in the field of atmospheric electricity in Lanzhou Institute of Plateau Atmospheric Physics, Chinese Academy of Sciences (LIPAP, CAS). I still remember that during the interview he kindly asked me to explain how I did in the paper examination of electromagnetics. With his kind hint or induction, I was able to find the correct answers for all the problems I missed in the paper examination on a blackboard. This interview eventually led me to luckily become one of his only two master students (another one was Xiushu).

The influence Prof. Guo gave me since I became one of his students was huge. My master research project assigned by him was to artificially trigger lightning with the rocket-wire technique. He gave me several important papers to read, with some on rocket triggered lightning and some on upward lightning from tall structures, for he noted the similarity between those two types of lightning. Having benefitted from his insights and his kind supervision, although we couldn't succeed in triggering a lightning flash and obtaining any meaningful experimental data due to lack of thunderstorms and some logistics during my master study, I still succeeded in writing a master thesis titled "The criterion for propagation of the positive streamer and its application". With his guidance, my thesis was submitted to an international conference and later became a journal paper coauthored with him. This was my first scientific publication. Moreover, it was in English. He had to patiently do tremendous revisions which served a great opportunity for me to learn on how to write a good scientific paper in English.

In 1991, I left China to pursue a Ph. D in Japan with a scholarship from CAS, a rare opportunity at that time (I think Prof. Guo helped me somehow since at that time he was the director of LIPAP, but he never said anything about this to me). My personal communication with Prof. Guo continued. In 1996, with Prof. Teiji Watanabe of Gifu University as principal investigator (PI) on the Japanese side and Prof. Xinsheng Liu, the director of LIPAP as PI on the Chinese side, we organized a China-Japan joint observation campaign investigating lightning on the Chinese inland plateau. At that time, Prof. Guo, serving as the director of Shanghai Typhoon Institute of China Meteorological Administration, must have been very busy, but he still managed to come to our observation site near Lanzhou for help and stayed with us for about two weeks at a countryside elementary school for temporary dormitory. I still remember how he kindly advised Xiushu (on behalf of the China side) and me (on behalf of the Japan side) to write down an agreement in English to make sure our cooperation between the two sides successful. I also remember how he helped us launch a balloon for measuring space charge during a storm and open the gate of the school each time when our students came back from other observation sites after storms.

In 1999, after Prof. Guo retired as director of Shanghai Typhoon Institute of China Meteorological Administration, he told me he had an idea to write a lightning book for the younger generation and invited me to make a contribution. I accepted his invitation. However, during that time, I had to work in a completely new field and my writing was very slow. He gave me a lot of encouragement and patiently kept me moving. Finally, I completed the task he assigned to me. But all my contribution was in handwriting since at that time most computers in Japan didn't support Chinese. He had to do a lot of tedious work not only in editing my handwriting but also in making the handwriting understandable to be typed into a computer. Several months later, I received the book he sent me. When I first saw the book I was so surprised that he put my name as the first author of the book. No words. Prof. Guo was a person who always thought of others first.

My recent communication with Prof. Guo was either over phone or text message. Each time he still gave me knowledge, opinions, advice, encouragement and good wishes. He seldomly talked about himself. I will always have great respect for Prof. Guo and greatly miss him.

Daohong Wang, Gifu University, Japan

In Memory of Prof. Changming Guo from the lightning research group of CAMS

We are very sorrowful to hear that Prof. Changming Guo passed away. We lost a great scientist, outstanding mentor and an intimate friend. We, the lightning research group of the Chinese Academy of Meteorological Sciences (CAMS), offer our deep condolences to his family, relatives, and colleagues.

Prof. Guo pioneered the application of lightning observations to the monitoring of meso- and micro-scale weather systems in China. In 1986, the lightning research group of Lanzhou Institute of Plateau Atmospheric Physics, Chinese Academy of Sciences, which led by Prof. Guo, collaborated with CAMS and launched a project for the monitoring and research of meso- and micro-scale severe weather systems in Beijing-Tianjin-Hebei region. During this project, we conducted substantial field experiments on lightning detection techniques and successfully obtained the first set of lightning location data with space and time information in China. Prof. Guo supervised the comprehensive analysis on data of lightning location and weather radars, and laid a solid foundation for understanding the relationship between characteristics of lightning and severe convective weather.

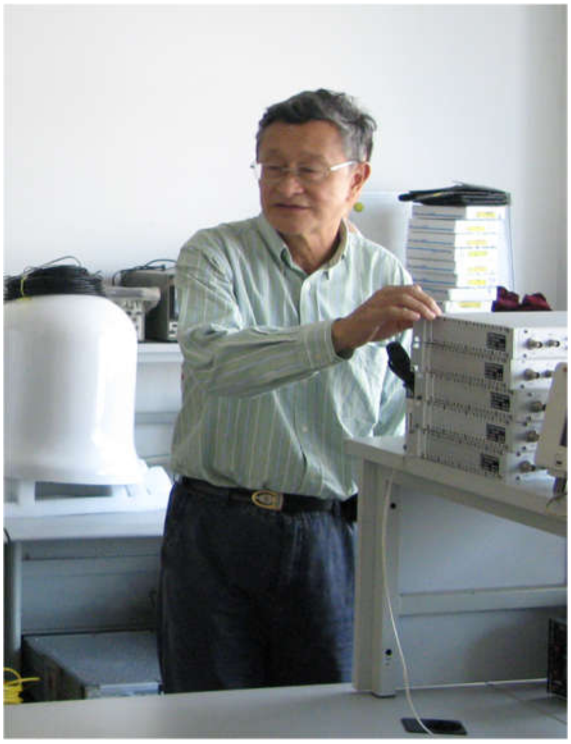
Prof. Guo has profound scientific attainments and persistent pursuit in the research of lightning detection technology. He was always considerate of and supportive of the lightning research group of CAMS. Prof. Guo was selfless and always ready to give help. He provided crucial instructions and suggestions to ~~the~~ lightning detection methods with single and multiple stations developed by CAMS. He assisted in the compilation of "The Functional Specification

Requirements of Lightning Location Systems" and "The Meteorological Standard for Lightning Location and Monitoring Systems" in China. Then according to the need for lightning detection networks from the Chinese meteorological department, Prof. Guo put forward constructive proposals and provided utmost assistance to the completion of the first construction scheme of lightning detection networks in China. He also paid close attention to the progress of the network designs and system tests. His major role in the development of lightning detection networks in China manifested in not only the design of networks, but also the sensor determination, the on-site expert guidance, and the network performance evaluation.

After Prof. Yijun Zhang joined CAMS in 2003, CAMS started to establish the Laboratory of Lightning Physics and Protection Engineering (LiP&P). Together with Prof. Zhang, Prof. Guo played a substantial role in the establishment of the LiP&P, the development of the research group, the arrangement of academic subjects, as well as the talent training. With his enthusiasm, positive attitude, and innovational ideas, the construction progress of the LiP&P went well and smoothly. In the very beginning, Prof. Guo successfully instructed our laboratory staff to conduct basic and practical research projects, which were also strategic and perspective, such as the "The Development of Ground-based Lightning Location Networks" and "The Development of Ground-based Lightning Optical & Electrical Simultaneous Observation Systems". He made significant contributions to the development of the LiP&P.

Since 2006, CAMS has established the field experiment observation site for lightning research in Guangzhou. Prof. Guo had paid close attention to the development of the observation site and provided valuable suggestions since then. He was particularly interested in the triggered lightning techniques. During the field experiments on lightning protection tests, he participated in not only the detailed measurement plan designs but also the data analysis to help solve issues. It was Prof. Guo's patient guidance that made the advance of the field observation site possible. He was open and valued international communications. He encouraged everyone to take part in international conferences, to discuss with and learn from the community, and guided students to prepare reports and corrected the English pronunciation. Prof. Guo was kind, gracious, and rich in knowledge. His expertise, wisdom, and pursuit of lightning physics and techniques will always be respected and greatly missed by all the researchers in our group.

In 2004, Prof. Guo participated in the consulting workshop on the establishment of the LiP&P, CAMS



In 2009, Prof. Guo worked at the LiP&P, CAMS

In 2009, Prof. Guo participated in the Workshop on Lightning Physics and Forecasting Techniques organised by the LiP&P, CAMS in Beijing

The lightning research group of CAMS

Yijun Zhang, Qing Meng, Weitao Lyu on behalf of the group

Ralph Markson (1931-2021)

Ralph Markson died on September 28, 2021 at age 90, after a short illness. He remained active almost to the end, after half a century of research in atmospheric electricity, engaging in a research project on a comparison of the global electrical circuits in his late 80s that was held up by the pandemic.

Ralph pioneered the aircraft measurement of the Earth's ionospheric potential Vi used to characterize the DC global electrical circuit. This initiative began with his PhD work with Bernard Vonnegut at the State University of New York at Albany. The new approach enabled the first coordinated, continuous measurements of the global circuit on sub-diurnal time scales in the early 1970s.

The shallow electrode layer of positive space charge, accessible in his aircraft observations of electric field less than 10 meters off the sea surface, became a topic of central interest in his research. The presence of this same feature over the ice sheet in Antarctica shown in earlier Belgian work made him skeptical about achieving globally representative measurements with surface observations alone over either land or sea. Accordingly, he measured electric field profiles to calculate Vi wherever he could go with his airplane: in New York, off the coasts of New Hampshire and Rhode Island, in Nova Scotia, in New Mexico, from his backyard near Boston, in Darwin (Australia), at Christmas Island, over the ocean in Bermuda, in Florida and at Spitzbergen in the Arctic. With this active program, he quickly surpassed all other investigators in total measurements of Vi (~ 500 measurements in all).

This special dataset on Vi enabled other global studies, addressed in an influential review paper (Markson, BAMS, 2007): the global circuit response to temperature on the UT diurnal time scale, the correlation of cosmic radiation with Vi, and the impact of atmospheric nuclear bomb testing in the 1960s on the global circuit. The positive response of Vi in the latter two investigations led Ralph to believe that the explanation lay in the source region for the global circuit, rather than in the fair weather load. Ralph's seminal contributions here lay important groundwork for the operational monitoring of the global circuit.

Earle Williams

African Centres for Lightning and Electromagnetics (ACLENet)

ACLENet, the African Centres for Lightning and Electromagnetics Network, continues to work to protect school children and educate Africans about the dangers of lightning. Currently, lightning protection is being installed at Mongoyo Primary School in Northern Uganda where 3 students were killed, and dozens hospitalized in October 2018. A generous donation by PolyTech, a global leader in wind turbine blade protection, along with the design expertise of ACLENet's all-volunteer Lightning Protection Working Group, and ACLENet's installation team are traveling to Mongoyo to install the second part of the project in early 2022.

A gift from the Rotary club in the Netherlands has allowed ACLENet to translate a public service announcement on lightning safety, shown across Uganda in December 2020, into Luganda, the primary indigenous language in Uganda, and to purchase broadcast time on both television and radio stations serving diverse audiences during December 2021 when families are home together viewing TV during the rainy holiday season.

Over this past year, ACLENet, along with SALNet and other lightning safety advocates, has taken the lead on establishing International Lightning Safety Day, 28 June 2021, the tenth anniversary of a single lightning strike that killed 18 children and hospitalized another 38 from Runyanya Primary School in central Uganda in 2011. Zoom conferences, necessitated by Covid, have allowed hundreds of people interested in lightning safety and injury prevention to participate in conferences they would never have received funding nor time to attend.

ACLENet operates solely on funding from grants and generous donors to prevent lightning injuries and deaths across Africa. Donations can be made through the website, https://ACLENet.org. The only paid staff are those in Uganda working to install lightning protection and educate the public.

Institute of Earth Physics and Space Science, Sopron, Hungary

Contributors in alphabetical order: Veronika Barta, Tamás Bozóki, József Bór, Attila Buzás, Ernő Prácser, Gabriella Sátori, and Karolina Szabóné-André

In Bozóki et al. (2021) long-term SR intensity records from eight different SR stations, each equipped with a pair of induction coil magnetometers, have been presented and analysed. All records exhibited a pronounced in-phase solar cycle variation and our aim was to reveal the underlying reason for this effect. The long-term SR intensity records were compared on the annual and interannual timescales with the fluxes of precipitating 30–300 keV medium energy electrons provided by POES NOAA satellites and on the daily timescale with electron precipitation events identified using a SuperDARN radar in Antarctica. The long-term variation of the Earth–ionosphere waveguide's effective height, as inferred from its cutoff frequency, was independently analyzed based on spectra recorded by the DEMETER satellite. It has been shown that, to account for all the observations, one needs to consider both the effect of solar X-rays and Energetic Electron Precipitation (EEP) which modify the quality factor of the cavity and deform it predominantly over low- and high latitudes, respectively (Figure 1). The increase in the quality factor of the cavity is suggested to be linked with the decreasing energy dissipation in the altitude range of the ELF 'magnetic' height where ionization by both X-rays and EEP increases the electrical conductivity. Our results suggest that SR measurements should be considered as an alternative tool for collecting information and thus to monitor changes in the ionization state of the lower ionosphere associated with EEP.

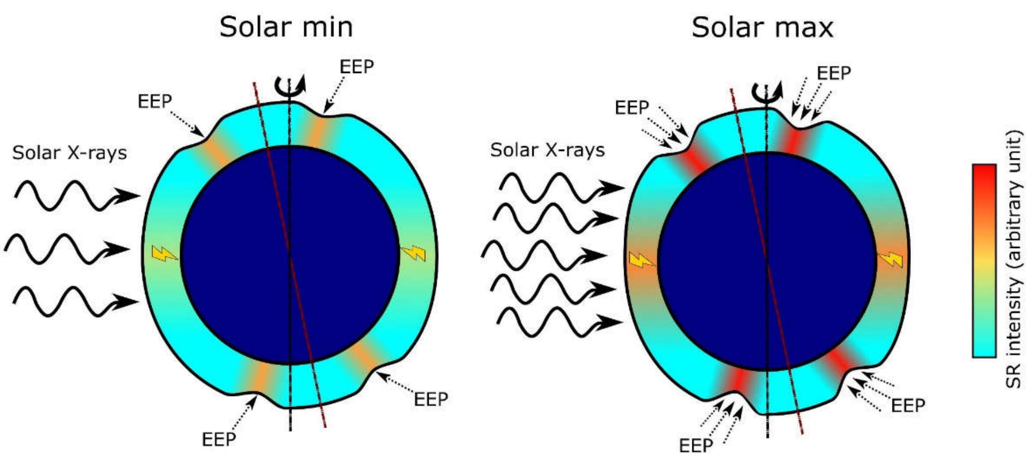


Figure 1. Illustration of the deformation of the Earth–ionosphere cavity at solar minimum and solar maximum. At solar maximum, X-rays and EEP reduce the cavity height more significantly

(dominantly over low- and high latitudes, respectively) which results in enhanced SR intensity values beneath the deformed regions.

A paper about the long-term variations between 1962 and 2009 in the fair-weather atmospheric electric potential gradient (PG) time series recorded at the Széchenyi István Geophysical Observatory, Nagycenk, Hungary (NCK, 47.632°N, 16.718°E) was published in Annales Geophysicae (Buzás et al., 2021). The results show that the time-dependent electrostatic shielding effect of nearby trees at NCK masked the true variations of the PG. A finite element numerical model was built to correct for the shielding effect. After the correction of site-specific electrostatic shielding effects, the actual long-term variation of PG at NCK has been revealed and compared to long-term PG data measured in Świder Geophysical Observatory, Poland (52,012° N, 21.233° E). The results of this study demonstrate that carefully selected and corrected PG data measured at different stations in the same region (i.e., in Central Europe) are intercomparable and can mirror similar long-term variations.

Co-located ELF-band measurements of the horizontal components of the atmospheric magnetic field, made in the Mátra mountains, Hungary on the surface on one hand and below it in a mine-shaft on the other hand, were compared to study the damping effect of the Earth's crust. Measurements on the surface and under the ground at a depth of 140 m were made in non-overlapping time intervals. ELF data from permanent ELF monitoring stations at Nagycenk, Hungary, and in Hylaty, Poland were involved in the study to circumvent this issue. Initial results of the analysis showed that Q-burst signals can be detected unambiguously in the mine-shaft, too. It seems plausible to use Q-bursts for the planned analysis as these events can be identified easily in all recorded time series and bear high signal-to-noise ratio. It has been demonstrated that the obtained damping of the magnetic field is frequency dependent and follows fairly well the expected exponential decay according to the formula of the skin depth. The obtained results were presented in the final meeting of the COST Action ELECTRONET and in the EGU general Assembly (Bór et al., 2021).

Dr. Dalia Buresova and Dr. Zbysek Mosna from the Institute of Atmospheric Physics, Academy of Sciences of the Czech Republic, experts of space weather and the physics of the upper atmosphere and ionosphere, visited our group between 18–22 October 2021 in the framework of a bilateral project of the Hungarian and the Czech Academy of Sciences. The visiting researchers gave two presentations about the impact of severe space weather events on the ionosphere, the coupling mechanisms between the magnetosphere and ionosphere, and their recent findings related to the sporadic E-layer research.

*L*aboratory of Lightning Physics and Protection Engineering, State Key Laboratory of Severe Weather, Chinese Academy of Meteorological Sciences, Beijing, China

A new method for connecting the radiation sources of lightning discharge extension channels. The connections of lightning radiation sources along channels are greatly affected by the radiation source density, and the channel length is geometrically scaled when neglecting repeated discharges in the same channel. Based on lightning mapping array (LMA) three-dimensional radiation source location data of two lightning flashes, this study presents a radiation source connection method considering the source density and repeated discharges in channels that includes two steps: the connection of radiation sources and the connection of segments. After increasing the spatial connection threshold determined by the source density, the stability of the channel scale under different detection capabilities (source densities) is improved compared with that of the traditional fixed spatial threshold method (Figure 1). The channel growth rate of the low-density case reaches 120.99%, which is close to the real situation, and the connection shape is consistent with the real situation. For repeated discharge paths, by limiting the time interval of the radiation source connection, the optimized threshold obtained in this paper can distinguish between discharges occurring in the same channel at different times. Compared with the geometric scale, the discharge scale is significantly larger (~2.8 times the geometric scale in one case) and can better characterize both the lightning discharge process and the affected area. These comprehensive results show that the proposed method can reduce the number of incorrect connections, increase the channel length, and obtain a more realistic discharge scale.

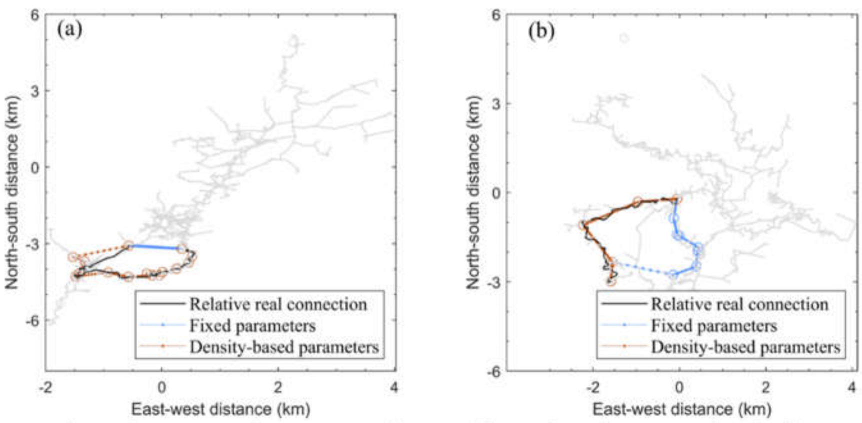


Figure 1. Comparison between the connections of low-density samples before and after adjusting the

parameters. The black line is the actual connection, the blue line is the connection with fixed parameters, and the red line is the connection with the density-based parameters. (a) Comparison of the connections from Flash1 using the original fixed parameters and the density-based parameters superimposed onto the real connection (grayscale image) of Flash1. (b) Same as (a) but from Flash2 using the original fixed parameters and the density-based parameters.

Electromagnetic characteristics of upward leader initiated from the Canton Tower: A comparison with rocket-triggered lightning. By using the synchronous observation data obtained at the Tall-Object Lightning Observatory in Guangzhou (TOLOG) of 2019, the electromagnetic characteristics of upward positive leader (UPL) ascending from the 600-m high Canton Tower are examined, and are compared with the magnetic field (*B*-field) radiation of UPL in rocket-triggered lightning. Before the inception of sustained UPL, small electric field (*E*-field) pulses are superposed on the fast *E*-field changes. The timescale of *B*-field pulses corresponding to the *E*-field pulses ranges from 5 to 9 μs, and the inter-pulse interval is about 30 µs, which are both similar to the *B*-field pulses associated with the precursors of rocket-triggered lightning. Measurements show that the precursor-like stage is likely common for upward lightning initiated from the Canton Tower. Moreover, the UPL channel of tower-initiated upward lightning extends significantly in the first several ms with the initial average two-dimensional (2-D) velocity of 8.77×10^5 m/s (3-D velocity of 11.0×10^5 m/s), which is one order of magnitude faster than the UPL initiated from the wire tip of rocket-triggered lightning, indicating that initiation of UPL from Canton Tower benefits from a substantial *E*-field enhancement of nearby lightning discharges. However, this favorable condition is rapidly consumed during the UPL development, causing the average 2-D velocity of UPL to decrease rapidly and maintain at about 0.5×10^5 m/s. It is noted that the variation in the 2-D speed of sustained UPL differs from tower-initiated upward lightning reported in the literature, which is possibly associated with the physical and geometric properties of the tower.

The two-dimensional (2D) first-return-stroke striking distances (SD) of lightning flashes to buildings with a height ranging from 100 to 600 m were analyzed. Based on the high-speed video records of 54 lightning flashes striking on a cluster of tall buildings in Guangzhou, we estimated the 2D SD by three different methods, including one proposed in this study. The results with different methods basically agree with each other (Figure 2) and show that the height and the top geometry of the structure on which lightning terminates are key factors that affect the SD. The correlation between the SD and the peak return stroke current appeared very scattered, particularly in the cases when each building was considered separately. Besides, we found that: (1) the estimated 2D average initiation speed of upward connecting leader (UCL) on different buildings are similar, ranging from 4.9 to 23 × 10^4 m/s, with an average of 13.4 × 10^4 m/s; (2) about 87% (27/31) flashes that struck on buildings with simple top shape only have one upward leader observed, while for buildings with complicated top shape, only 26% (6/23) flash cases have one upward leader observed; (3) for the 36 flashes to tall building with heights higher than 300 m, the 2D average speed ratio of the downward leader and the UCL is 0.74 during the last 0.1 ms before the first return stroke.

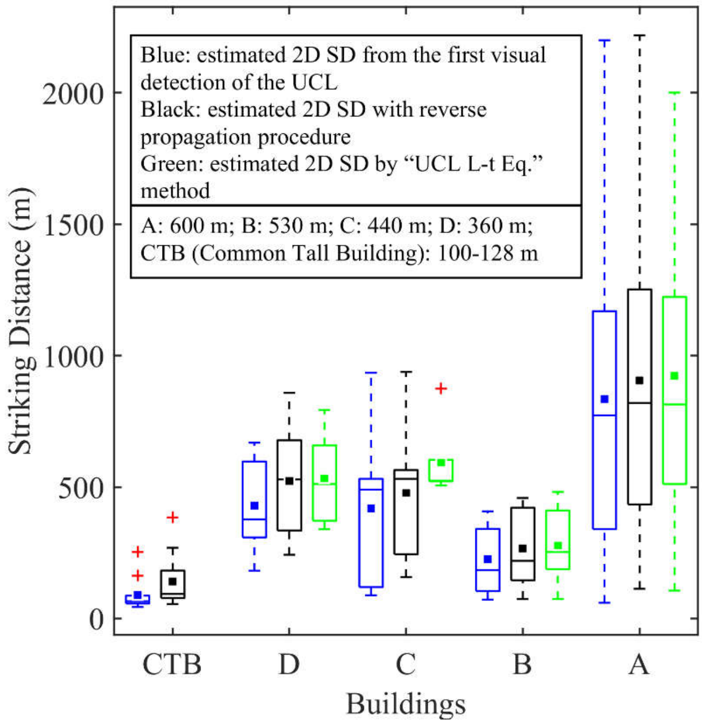


Figure 2. Striking distance of buildings numbered A to D and common tall buildings (CTB). Three different colors, blue, black and green represent the result estimated by three different 2D SD estimation methods. The horizontal lines and squares in the boxes represent the median and average values respectively.

Lightning Research Group of Gifu University (Gifu, Japan)

Compact lightning strokes in winter thunderstorms in Japan. With the observation of a 14-site FALMA in the Hokuriku region of Japan, we identified a special type of lightning stroke called "compact stroke" in winter thunderstorms. A compact stroke starts with a fast downward negative leader followed by a "compact return stroke." Compact strokes have the following characteristics that are not seen in normal lightning strokes: (a) Durations of preceding discharges (defined as the time difference between the return stroke and the start of the flash) are generally smaller than 200 µs. (b) Most compact strokes are inferred to be produced in small gaps between mountain tops and negative charge regions in winter thunderstorms. (c) Channel lengths of compact strokes are estimated to be shorter than 600 m with an average of about 300 m. (d) Characteristics of E-change waveforms of compact return strokes are closely related with durations of preceding discharges. (e) Peak currents of compact return strokes increase with increasing channel lengths. It seems that elevations of mountain surfaces where compact strokes occur are comparable to the altitude of the lower positive charge region, so we speculate that the mountain surface and the near-surface space carry positive charges when a storm is overhead and are virtually the lower positive charge region of a normal tripole structure. As a result, compact strokes are confined between the main negative and lower positive charge regions, and small pulses with short durations preceding compact return strokes are produced by downward negative leaders corresponding to the preliminary breakdown stage. Figure 1 shows E-change waveforms gradually transitioning from normal negative strokes (1a) to compact strokes (1g).

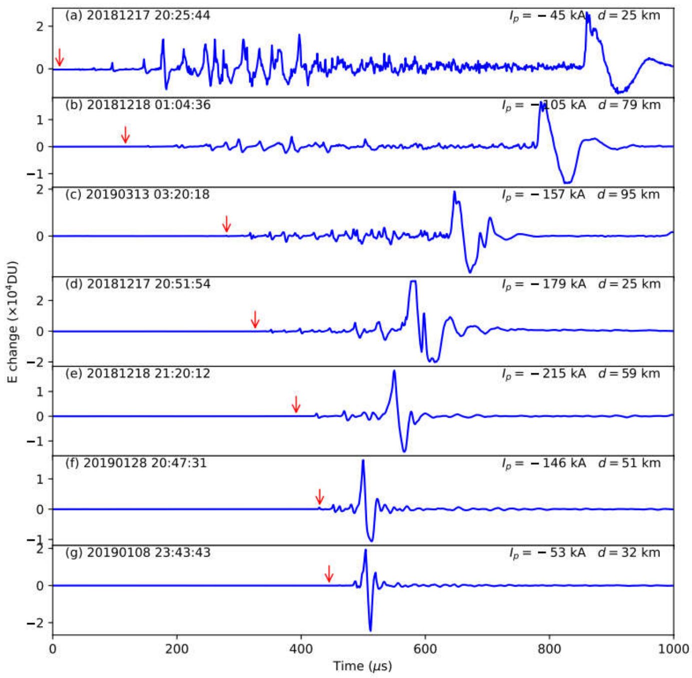


Figure 1. Examples of waveforms of strokes with short (<1 ms) preceding discharges. The value of I_p indicates the stroke peak current. The value of d indicates the distance between the stroke and the site recording the waveform. The red arrow indicates the first identified pulse.

The strongest negative lightning strokes in winter thunderstorms in Japan. Winter thunderstorms in Japan are well known for the frequent production of energetic positive cloud-to-ground (CG) lightning flashes. By contrast, strong negative CG flashes or negative return strokes in winter thunderstorms are largely unknown. In this study, we demonstrate that negative return strokes with peak currents larger than 150 kA (absolute value) in winter thunderstorms in Japan mostly produce electric field change waveforms that are different from those of normal return strokes. Due to their unusual waveforms, these strongest negative strokes have not been recognized as return strokes by the lightning research community. We further demonstrate that these strong negative return strokes are preceded by a fast downward negative leader with a short duration and strong peak current. We suggest that the fast and powerful downward negative leader may be associated with downward terrestrial gamma-ray flashes. We also present evidence that these strong negative strokes are likely “superbolts” observed from space. Figure 2 shows a −335 kA stroke observed by both the FALMA and the optical system LAPOS. Figures 2a and 2b show E-change waveforms recorded by FALMA sites at 56 and 6 km, respectively. Figures 2c and 2d show optical waveforms recorded by high sensitivity and low sensitivity photodiodes of the LAPOS, from which we can confirm that the stroke started with a downward leader with a velocity of about 5×10^6 m/s and followed by a return stroke with a velocity of about 1.5×10^8 m/s.

Recoil leader and associated discharge features observed during the progression of a multi-branched upward lightning flash. Using a high-speed video camera and a high-speed optical imaging system, we observed a multi-branched upward lightning flash that exhibited several special discharge features. One special feature is that a series of recoil leaders and the subsequent discharges caused by the connection of some recoil leaders to a conducting channel could extend a discharge channel like a leader, as shown in Figure 3. Another special feature is that the subsequent discharge could be similar to either a return stroke or an M-component or something between. It seems that when a recoil leader initiated in a more conductive channel with a closer distance to a conducting channel, its subsequent discharge is similar to an M-component. In cases with opposite conditions, the subsequent discharge will become similar to a return stroke. In conditions between the above two cases, a discharge that is intermediate between the return stroke and M-component will occur.

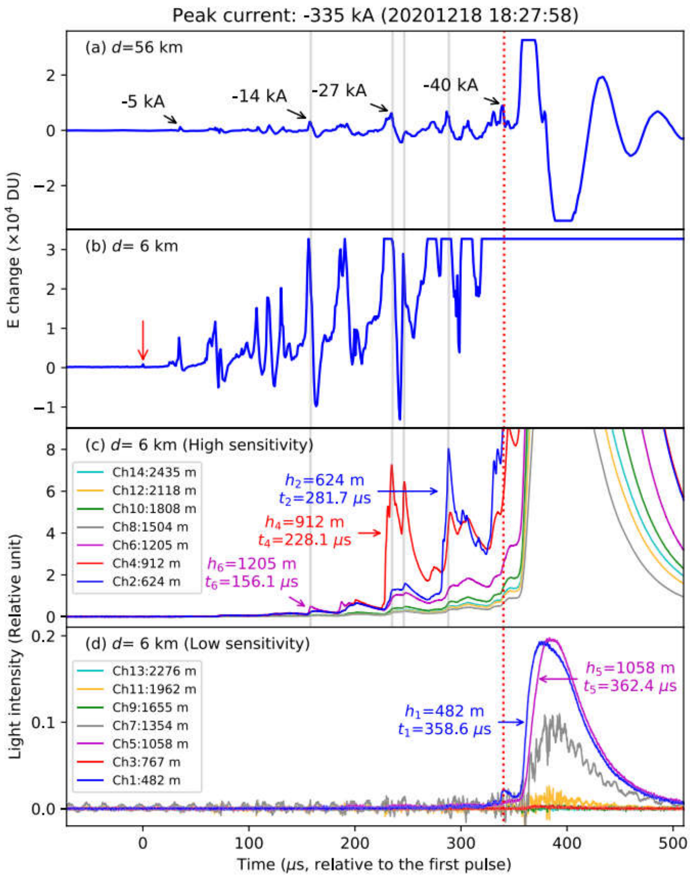


Figure 2. A stroke with a peak current of −335 kA observed by the LAPOS and the FALMA. E-change waveforms observed by FALMA sites at distances of (a) 56 km and (b) 6 km. Waveforms of light intensity observed by (c) High-sensitivity photodiodes and (d) Low-sensitivity photodiodes of LAPOS. The red arrow in panel (b) indicates the first identified pulse before the stroke. Values of *h* and *t* represent the height and onset time of light pulses observed by the LAPOS.

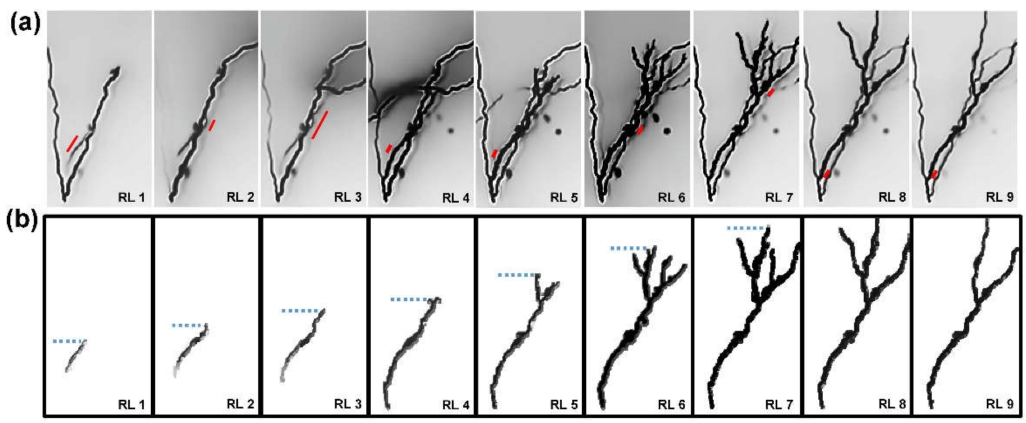


Figure 3. A series of recoil leaders from RL1 to RL9. (a) Images with the recoil leader initiation location marked by red lines. (b) Images with unrelated branches removed. Blue dotted lines illustrate the maximum channel heights of the corresponding discharge processes.

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

Side discharges from the active negative leaders in a positive cloud-to-ground lightning flash. Two kinds of side breakdowns from the active horizontal negative channel in a positive cloud-to-ground flash were found. During the propagation of the negative leader in the field-of-view, some decayed negative branches were reactivated, and most of them promoted the propagation of advancing negative leaders. The reactivations extended outward from the edge of the negative leader channel with an average speed of 2.2×10^6 m s^{-1}, but they produced no distinct VLF-VHF radiations, as confirmed by the lightning mapping results. The reactivations of decayed negative branches were different from recoil leaders in the decayed negative leader because we deduce the outward breakdown has changed its polarity. In addition, the negative channel that induced a downward positive leader was hot and conductive, as revealed by its brightness. The results indicate that disconnection or current cutoff on the negatively charged lightning channel is unnecessary for the inception of a downward positive leader.

In-cloud discharge of positive cloud-to-ground lightning and its influence on the initiation of tower-initiated upward lightning. A comprehensive observation of tower-initiated upward lightning (UL) during the summer season from 2012 to 2020 was conducted, using high-speed video and the Beijing Broadband Lightning Network (BLNET). A total of 25 UL flashes were observed, and 21 of them were triggered by nearby positive cloud-to-ground (CG) lightning. It is interesting to note that 8 (38%) of the parent +CG lightning flashes have more than one return stroke. The distance between the UL and the grounding point of its parent +CG lightning was 4-38 km, where 9 (43%) of the UL were triggered less than 2 ms after the positive return stroke (RS), and 11 (52%) of them were triggered after a long time delay of 5-187 ms. Based on high-speed video and mapping results, the short time delay was associated with the reactivation of the decayed established leader above the tower. The long time delay was associated with the negative leader extending to the region above the tower during the long continuing current. The positive E-field change during RS or continuing current period favored the inception of an upward leader. Although both preliminary breakdown (PB) and RS in a +CG flash produced positive E-field changes, an upward positive leader induced by PB aborted its sustained propagation after +RS.

Characteristics of rocket-triggered positive lightning flashes and propagation properties of their initial upward negative leaders. Twelve lightning flashes are successfully triggered under the positive atmospheric electric field condition. When lightning flashes are triggered, the average ground atmospheric electric field is around 5 kV/m, with a maximum value exceeding 13 kV/m. Except for one special event showing a discharge polarity reversal (from positive to negative) and producing multiple negative return strokes, none of the remaining 11 triggered lightning flashes involves the subsequent return stroke process. The discharge currents of these flashes are generally of the order of several hundred amperes. The successfully triggered lightning flashes start with the initiation and the upward propagation of negative stepped leaders, of which the average two-dimensional velocity is 1.85×10^5 m/s. For a total of 132 steps captured by the high-speed video camera, the step lengths range from 0.8 m to 8.7 m, with an average of 3.9 m. The mean value of pulse interval, current peak, charge transfer, half-peak-width and current rise time $T_{10\%\text{-}90\%}$ are 17.9 μs, 81 A, 364 μC, 3.1 μs, and 0.9 μs, respectively. The equivalent linear charge density of a single step is 118.5 μC/m. The branching of the leader channel generally takes place together with the stepping process in two ways: the first way is to implement the multiple connections of clustering space stems/space leaders to the leader head within an individual step cycle, and the corresponding current waveform presents a multi-peak structure, with a peak interval of about 2-3 μs (up to 6-7 μs); the second way is to reactivate those previously extinguished space stems/space leaders and to connect them to the lateral surface of the channel.

A new hybrid algorithm to image lightning channels combining the time difference of arrival technique and electromagnetic time reversal technique. Very-high-frequency (VHF) electromagnetic signals have been well used to image lightning channels with high temporal and spatial resolution due to their capability to penetrate clouds. A lightning broadband VHF interferometer with three VHF antennas configured in a scalene-triangle shape has been installed in Lhasa since 2019, to detect the lightning VHF signals. Using the signals from the VHF interferometer, a new hybrid algorithm, called the TDOA-EMTR technique, combining the time difference of arrival (TDOA) and the electromagnetic time reversal (EMTR) technique is introduced to image the two-dimensional lightning channels. The TDOA technique is firstly applied to calculate the initial solutions for the whole lightning flash. According to the results by the TDOA method, the domain used for the EMTR technique is predetermined, and then the EMTR technique is operated to obtain the final positioning result. Unlike the original EMTR technique, the low-power frequency points for each time window are removed based on the FFT spectrum. Metrics used to filter noise events are adjusted.

Detailed imaging results of a negative cloud-to-ground (CG) lightning flash and an intra-cloud (IC) lightning flash by the TDOA method and the TDOA-EMTR are presented. Compared with the original EMTR method, the positioning efficiency can be improved by more than a factor of 3 to 4, depending on the scope of the pre-determined domain. Results show that the new algorithm can obtain much weaker radiation sources and simultaneously occurring sources, compared with the TDOA method.

Lightning nowcasting with an algorithm of thunderstorm tracking based on lightning location data over the Beijing area. A thunderstorm tracking algorithm is proposed to nowcast the possibility of lightning activity over an area of concern by using the total lightning data and neighborhood technique. The lightning radiation sources observed from the Beijing Lightning Network (BLNET) were used to obtain information about the thunderstorm cells, which are significantly valuable in real-time. The boundaries of thunderstorm cells were obtained through the neighborhood technique. After smoothing, these boundaries were used to track the movement of thunderstorms and then extrapolated to nowcast the lightning approaching in an area of concern. The algorithm can deliver creditable results prior to a thunderstorm arriving at the area of concern, with accuracies of 63%, 80%, and 91% for lead times of 30, 15, and 5 minutes, respectively. The real-time observations of total lightning appear to be significant for thunderstorm tracking and lightning nowcasting, as total lightning tracking could help to fill the observational gaps in radar reflectivity due to the attenuation by hills or other obstacles. The lightning data used in the algorithm performs well in tracking the active thunderstorm cells associated with lightning activities.

Aerosol effects on electrification and lightning discharges in a multicell thunderstorm simulated by the WRF-ELEC model. To investigate the effects of aerosols on lightning activity, the Weather Research and Forecasting (WRF) Model with a two-moment bulk microphysical scheme and bulk lightning model was employed to simulate a multicell thunderstorm that occurred in the metropolitan Beijing area. The results suggest that under polluted conditions lightning activity is significantly enhanced during the developing and mature stages. Electrification and lightning discharges within the thunderstorm show characteristics distinguished by different aerosol conditions through microphysical processes. Elevated aerosol loading increases the cloud droplets numbers, the latent heat release, updraft and ice-phase particle number concentrations. More charges in the upper level are carried by ice particles and enhance the electrification process. A larger mean-mass radius of graupel particles further increases non-inductive charging due to more effective collisions. In the continental case where aerosol concentrations are low, less latent heat is released in the upper parts and, as a consequence, the updraft speed is weaker, leading to smaller concentrations of ice particles, lower charging rates and fewer lightning discharges.

Evaluating the performance of lightning data assimilation from BLNET observations in a 4DVAR-based weather nowcasting model for a high-impact weather over Beijing. The Beijing Broadband Lightning Network (BLNET) was successfully set up in North China and had yielded a considerable detection capability of total lightning (intracloud and cloud to ground) over the regions with complex underlying (plains, mountains, and oceans). This study set up a basic framework for the operational application of assimilating total lightning activities from BLNET and assesses the potential benefits in cloud-scale, very short-term forecast (nowcasting) by modulating the vertical velocity using the 4DVar technique. Nowcast statistics aggregated over 11 cycles show that the nowcasting performances with the assimilation of BLNET lightning datasets outperform RAD and the assimilation of GLD360 (Global Lightning) datasets. The assimilation of BLNET data improves the model's dynamical states in the analysis by enhancing the convergence and updraft in and near the convective system. To better implement of assimilating real-time lightning data, this study also conducts sensitivity experiments to investigate the impact of the horizontal length scale of a distance-weighted interpolation, binning time intervals, and different vertical profile or distance weights prior to the DA. The results indicate that the best forecast performance for assimilating BLNET lightning datasets is obtained in a 4DVar cycle when the lightning accumulation interval is 3 min, the radius of horizontal interpolation is 5×5, and the statistically vertical velocity profile and the distance weights obtained from cumulus cloud.

Lightning Research Group of Northwest Normal University (Lanzhou, China)

Effects of atmospheric attenuation on the lig htning spectrum. Spectrum carries important information reflecting atomic and molecular processes inside lightning channel. Accurate spectral diagnosis is vital in revealing the microscopic physical mechanism of the lightning discharge process. Considering the influence of atmospheric attenuation, grating efficiency, and camera response on the observed spectrum, corresponding correction was carried out thereby solving the problems of atmospheric attenuation in long distance lightning spectrum observations. Based on the restored spectrum, the temperature of the lightning return stroke channel was calculated by the ionic and atomic lines respectively. The result showed that corrected temperature at the initial stage of the return stroke, calculated by the ionic line, could reach up to 40000 K, which was about 10000 K higher than the values directly obtained from the observed spectrum. Atmospheric attenuation of the atomic spectral line in the near-infrared band is relatively weak; therefore, atmospheric attenuation has a relatively less effect on the channel temperature that was calculated by the atomic spectral lines. This work provided the attenuation ratio of the characteristic lines in lightning spectra with distance, as show in Figure 1, and can be used for more precisely quantitative investigation on the physical characteristics of the lightning process. It also has application value for improving the spectral diagnostic techniques on celestial body and other natural luminous process (Wan et al., 2021, JGR).

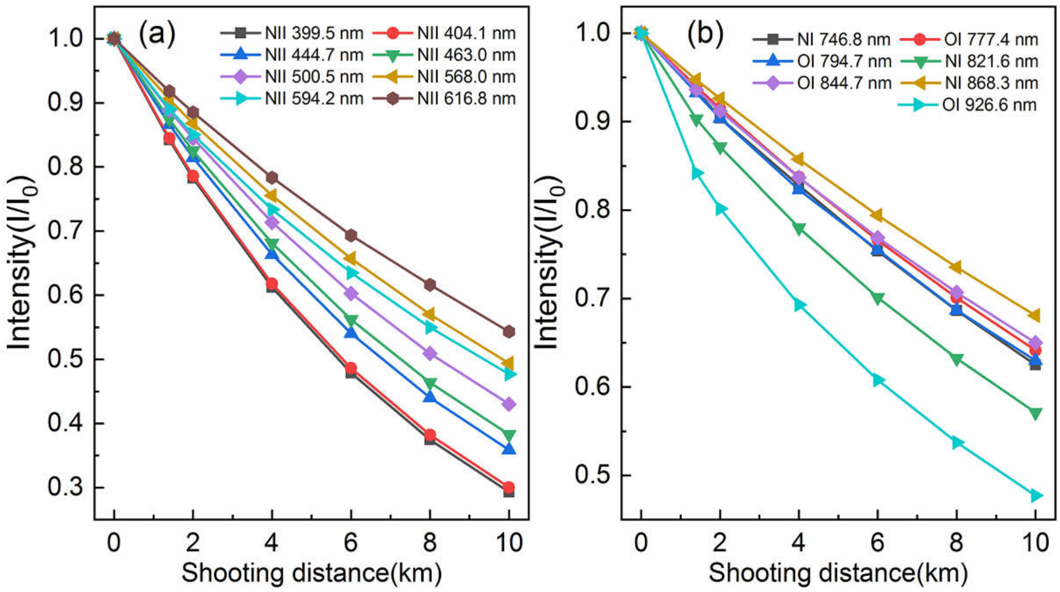


Figure 1. Attenuation rate for the intensity of characteristic lines in the lightning spectrum with dist ance under the visibility of 10.0 km. Panel (a) shows the atmospheric attenuation rate of NII spectra l line intensity; and (b) shows the atmospheric attenuation rate of NI and OI spectral line intensity.

Evolution of discharge characteristics along the positive cloud-to-ground lightning channel. Two positive cloud-to-ground lightning spectra have been captured by a slit-less spectrograph. In combination with the synchronous electric field change waveform, the discharge characteristics along the channel have been investigated. The results show that the total intensity of ionic lines in spectra and the electrical conductivity increase with the increase of channel height. From the positive correlation between the total intensity of ionic lines and the discharge current, it is deduced that the current intensity of downward positive cloud-to-ground lightning increases with the increase of channel height. Comparing it with the reported current attenuation along the channel of downward negative lightning, it is inferred that the increasing or decreasing of the current along the discharge channel is likely to be related to the current direction. (An et al., 2021, JGR)

Conductivity characteristics and corona sheath radius of lightning return stroke chan nel. The characteristics of lightning corona sheath are of common concern in the lightning physics and lightning protection research. Using the spectra of two natural cloud-to-ground lightning including multiple return strokes recorded by a slit-less spectrograph, we investigated the electrical conductivity distribution along the radial direction of the channel. The results indicated that a high conductivity channel of above 10^4 S/m existed within an average radius of around 1.8 cm and corresponded to the temperature of around 20000 K, which reflects the characteristics of the current-carrying channel. The electrical conductivity decayed steeply to about 500 S/m with increasing radius and then decayed slowly. Based on these results, it was estimated that the corona sheath radii of the return stroke channel were around 3.34–19.10 cm. The corona sheath radius was positively correlated with the leader charge quantity and the apparent diameter of the corresponding leader channel. A wide corona-channel radius corresponds to an intense discharge. (An et al., 2021, AR)

*M*assachusetts Institute of Technology

Hripsime Mkrtchyan completed a short Fulbright Foundation-supported post-doc study at MIT in September concerned with S-band radar observations of mountain storms producing Thunderstorm Ground Enhancements (TGEs) in strong surface electric fields of both polarities. A multitude of nuclear physics observations from the Aragats observatory in Armenia were generously provided by Ashot Chilingarian for this study. Distinct differences in the vertical development of radar reflectivities were documented for the two polarities, interpretable in the context of the temperature-dependent tripole structure of thunderstorms.

As part of an NSF-supported comparative study of the two global circuits, attention has shifted from the aircraft measurement of ionospheric potential to a balloon-based approach. Two different measurement methods of electric field with altitude are under consideration. Earle Williams participated in November in the annual meeting of the WMO-supported GRUAN network toward making use of multiple balloon sounding sites for the coordinated global measurements. Oceanic sites on small islands far from continents are currently highest priority.

The impact of the well-documented global reductions in aerosol concentrations (linked with the COVID-19 lockdown in 2020) on lightning activity is under exploration with the global lightning networks GLD360 and WWLLN and with Schumann resonance measurements. Preliminary findings were presented at the Nonlinear Wave Physics (NWP) conference in Nizhny Novgorod in September.

University of Florida

Istvan Kereszy (Advisor: V.A. Rakov) defended his Ph.D. dissertation titled "A Study of Energetic Radiation from Lightning Using Ground- and Aircraft-Based Detectors and Associated Modeling". Abstract of this dissertation is given below:

Energetic radiation is omnipresent in our atmosphere. It may play a role in lightning initiation, influence our understanding of the solar cycle and climate change, and potentially affect the health and well-being of passengers and crew onboard aircraft and spacecraft. Yet, despite recent progress in studying thunderstorm-related energetic radiation based on satellite observations, many questions about the mechanisms involved remain unanswered. In this dissertation I first provide an introduction of the field and an overview of the instrumentation used in our research. Then, I compare X-ray emissions from first- and subsequent-stroke leaders, discuss the role that warm channels may play in enabling subsequent-stroke leaders to be prolific X-ray producers, and present a clear case of X-ray emission during a leader burst signifying collision of opposite-polarity streamers during the lightning attachment process. Afterwards, a Terrestrial Gamma-ray Flash (TGF) that we detected at the Lightning Observatory in Gainesville (LOG), Florida, is shown. The context of this TGF is unique as it occurred during the initial leader phase of a subsequent negative stroke apparently entering the warm channel of a previous positive stroke, and as such it is the first TGF observed to be associated with a bipolar flash. Furthermore, dart-leader modeling is done to compute and better understand the electric field at the leader tip that may give rise to runaway electron avalanches and resultant energetic radiation emissions from lightning. Finally, our aircraft-based X-ray and gamma-ray search project is showcased, which included extensive laboratory calibration based on stationary and moving (artificial TGF) sources, as well as extensive measurements onboard commercial and general-aviation aircraft. The concluding chapter summarizes the results and provides recommendations for future research.

D.I. Iudin, V.A. Rakov, A.A. Syssoev, A.A. Bulatov, and M. Hayakawa authored a paper titled "From Decimeter-Scale Elevated Ionic Conductivity Regions in the Cloud to Lightning Initiation", in which they represented the lightning initiation scenario as a sequence of two transitions of discharge activity to progressively larger spatial scales: the first one is from small-scale avalanches to intermediate-scale streamers; and the second one is from streamers to the lightning seed. They postulated the existence of ion production centers in the cloud, whose occurrence is caused by electric field bursts accompanying hydrometeor collisions (or near collisions) in the turbulent thundercloud environment. When a new ion production center is created inside (fully or partially) the residual ion spot left behind by a previously established center, there is a cumulative effect in the increasing of ion concentration. As a result, the essentially non-conducting thundercloud becomes seeded by elevated ion-conductivity regions (EICRs) with spatial extent of 0.1–1 m and a lifetime of 1–10 s. The electric field on the surface of an EICR (due to its conductivity being at least 4 orders of magnitude higher than ambient) is a factor of ≥3 higher than ambient. For a maximum ambient electric field of 100 kV/m typically measured in thunderclouds, such field enhancement is sufficient for initiation of positive streamers and their propagation over distances of the order of decimeters, and this will be happening naturally, without any external agents (e.g., superenergetic cosmic ray particles) or extraordinary in-cloud conditions, such as very high potential differences or very large hydrometeors. Provided that each EICR generates at least one streamer during its lifetime, the streamers will form a 3D network, some parts of which will contain hot channel segments created via the cumulative heating and/or thermal-ionizational instability. These hot channel segments will polarize, interact with each other, and cluster, forming longer conducting structures in the cloud. When the ambient potential difference bridged by such a conducting structure exceeds 3 MV or so, it is assumed that the lightning seed, capable of self-sustained bidirectional extension, is formed. The paper is published in Nature Scientific Reports and is an extension of the previous work by the same authors, "Formation of Decimeter-Scale, Long-Lived Elevated Ionic Conductivity Regions in Thunderclouds", npj Climate and Atmospheric Science (2019) 2:46; https://doi.org/10.1038/s41612-019-0102-8.

*U*niversity of Science and Technology of China

Optical emissions associated with narrow bipolar events from thunderstorm clouds penetrating into the stratosphere (Figure 1). For decades the luminous features of NBEs were a mystery and somewhat under debate. NBEs have been thought to be relatively "dark" (non-luminous) compared to other fast lightning discharges. In this study, we present spectral measurements by the Atmosphere-Space Interactions Monitor (ASIM) on the International Space Station that are associated with nine negative and three positive NBEs observed by a ground-based array of receivers. We found that both polarities NBEs are associated with emissions at 337 nm with weak or no detectable emissions at 777.4 nm, suggesting that NBEs are associated with streamer breakdown. The rise times of the emissions for negative NBEs are about 10 μs, consistent with source locations at cloud tops where photons undergo little scattering by cloud particles, and for positive NBEs are ~1 ms, consistent with locations deeper in the clouds. For negative NBEs, the emission strength is almost linearly correlated with the peak current of the associated NBEs. Our findings first reveal the optical emissions of NBEs, which would provide a new means to measure the occurrences and strength of cloud-top discharges near the tropopause by ground-based radio signals. For more details, please visit https://doi.org/10.1038/s41467-021-26914-4.

Space-based observation of a negative sprite with an unusual signature of associated Sprite current. Using the Imager of Sprites and Upper Atmospheric Lightning (ISUAL) and the World-Wide Lightning Location Network (WWLLN), we have found an extremely rare case of negative sprite where the event is near the northern border of Bogotá, Colombia (5.21 N, 76.10 W). Although the sprite observations associated with negative cloud-to-ground (CG) strokes are very rare, it contains a distinct "sprite current" feature. Since the unusual red sprite was unrelated to the parent stroke and the atypical structure of CG, we analyzed the charge transfer time. It was found that the extraordinarily long charge transfer time (5.25 ms) after the parent negative CG stroke might play a critical role in the formation of the intense sprite current and the formation condition of the unusual sprite may also be attributed to the plasma irregularities in the mesosphere. For more detailed results, please visit https://agupubs.onlinelibrary.wiley.com/doi/10.1029/2020JD033686.

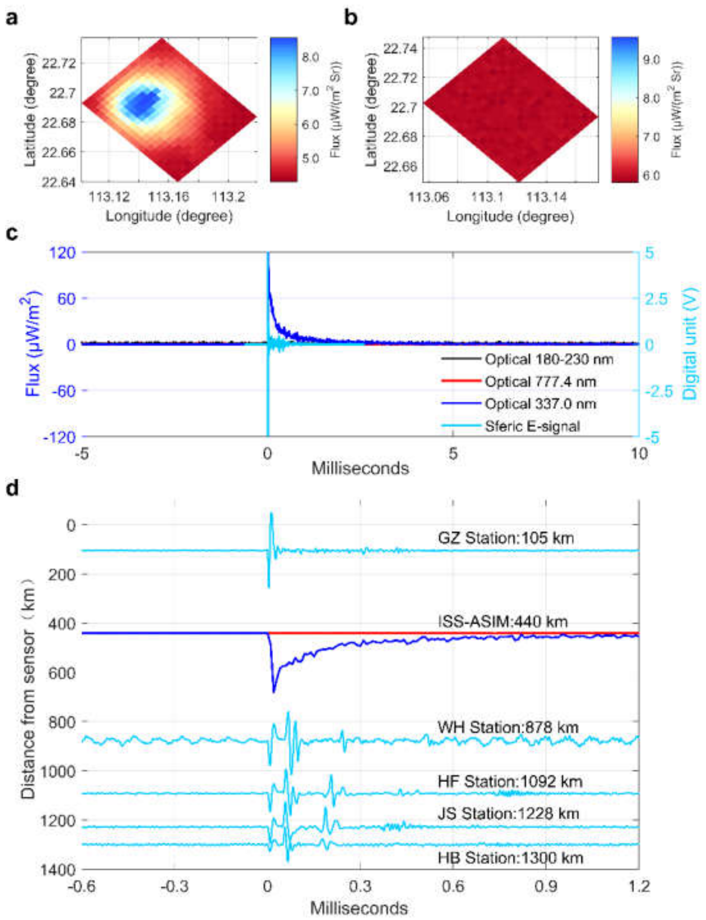


Figure 1. Optical and electrical signature of a negative NBE. a ASIM camera image in the 337 nm filter; b Camera image in the 777.4 nm filter. Color shade represents flux variations on logarithmic scale. c Comparison between the blue emissions detected by MMIA and the VLF/LF sferic waveforms recorded at GZ station. d Details of the optical signal and VLF/LF sferic waveform in five stations.

Meteorological and electrical conditions of two mid-latitude thunderstorms producing blue discharges. We report on two mid-latitude thunderstorms producing thirteen blue discharges observed simultaneously by ISUAL and ground-based lightning detection array. We found that blue discharges always occurred in the vicinity of the coldest cloud top (~195 K) and clustered within a bounded area near the convective surge leading to the overshooting thundercloud top into the stratosphere. The associated negative NBEs near the tropopause indicated that they are upward positive discharges initiated between the upper positive charge layer and the negative screening layer at the cloud top. In addition, the outbreak of negative NBEs in the altitude range of 16 km to 18 km was observed in conjunction with blue discharges observed from space. This suggests that there exists a strong upper positive layer with intense convection at this altitude of the thunderstorm. We infer that an overshooting thundercloud top with intense convective updraft could lead to a strong and high upper positive charge layer and therefore create favorable charge structures for initiating upward positive blue discharges. For more detailed results, please visit https://doi.org/10.1029/2020JD033648.

Ground observation of negative Sprites over a tropical thunderstorm as the embryo of Hurricane Harvey (2017). Using the Imager of Sprites and Upper Atmospheric Lightning (ISUAL), ultralow-frequency (ULF, <1–400 Hz) / very-low-frequency to low-frequency (VLF-LF, 0.5–470 kHz) magnetic field sensor system and the World-Wide Lightning Location Network (WWLLN), we have captured six red sprites produced by negative cloud-to-ground (CG) lightning strokes in a tropical thunderstorm that later evolved into Hurricane Harvey (2017), and analyzed these parent strokes characteristics. We studied 6 negative red sprites and 18 Gigantic Jets (GJs), which were mostly the sprite-parent CG strokes that occurred at the edge of deep convection cores (as inferred from cold cloud tops and high lightning density). It was found that tropical marine meteorological systems, such as tropical disturbances, depressions, and thunderstorms are more likely to be the main production systems of negative sprites. The frequent occurrence of 18 GJs produced by the same thunderstorm further indicates that the thundercloud charge structures of sprite-producing oceanic thunderstorms are significantly different from that of continental thunderstorms. For more detailed results, please visit https://agupubs.onlinelibrary.wiley.com/doi/10.1029/2021GL094032.

Comparison between high-speed video observation of sprites and broadband sferic measurements (Figure 2). Using an intensified high-speed camera, a low-light-level video camera (SpriteCam), several radio-frequency magnetic sensors, and the National Lightning Location Network (NLDN), a total of 51 sprites have been recorded over an MCS in the central United States. We have chosen two sprites with halo features to study, the first event was the brightest sprites observed on that night, while the second event was a dancing sprite event containing three sprite elements all following a single +CG. In this article, the lightning-induced E-field at halo and sprite altitudes have been calculated to separate the static component generated from the charge displacement and the induction term generated by the movement of charge with the TL model, and have further analyzed the lightning-induced E-field perturbation at the altitude of halo initiation. It is found that the E-field generated by the current pulse of charge transfer may be more important than that generated by the charge relocation for the initiation of halos. Furthermore, the traditional electrostatic field theory has been significantly supplemented. For more detailed results, please visit https://doi.org/10.1029/2021GL093094.

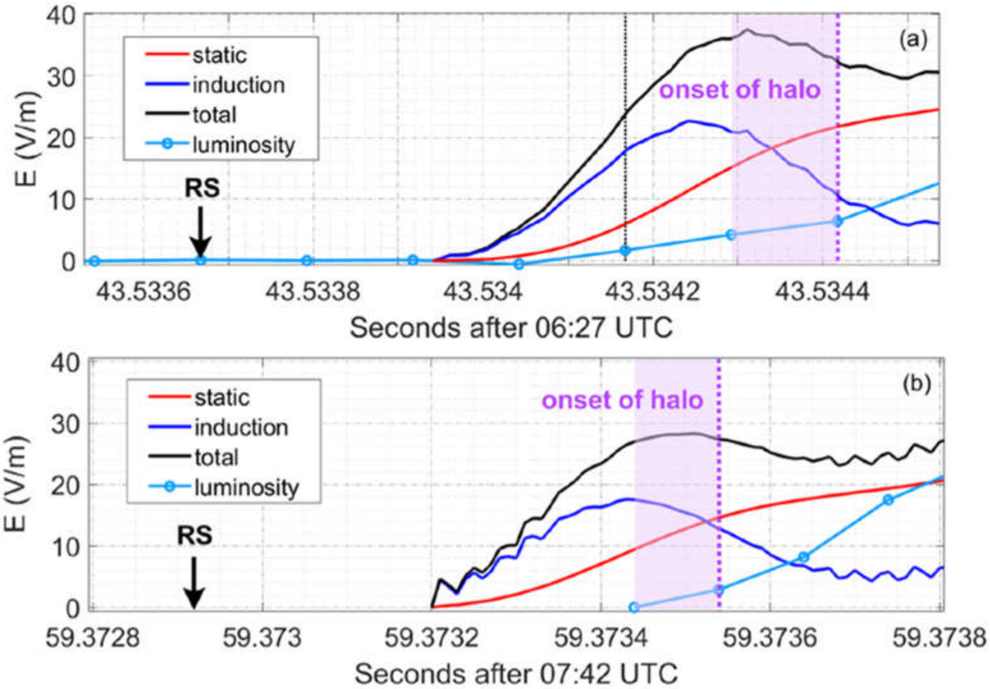


Figure 2. (a) Lightning induced E-field at halo initiation altitude of Event A at 0627:43 UTC; (b) lightning induced E-field at halo initiation altitude of Event B at 0742:59 UTC. The hollow circle on the luminosity curve represents the value in the red box area of each high-speed camera image, the black arrows point to the onset of RS (return stroke).

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.

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NEWSLETTER

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REMINDER

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

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

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

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

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

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

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 **2022 spring issue** of the newsletter is **May 15, 2022**.

PRESIDENT

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