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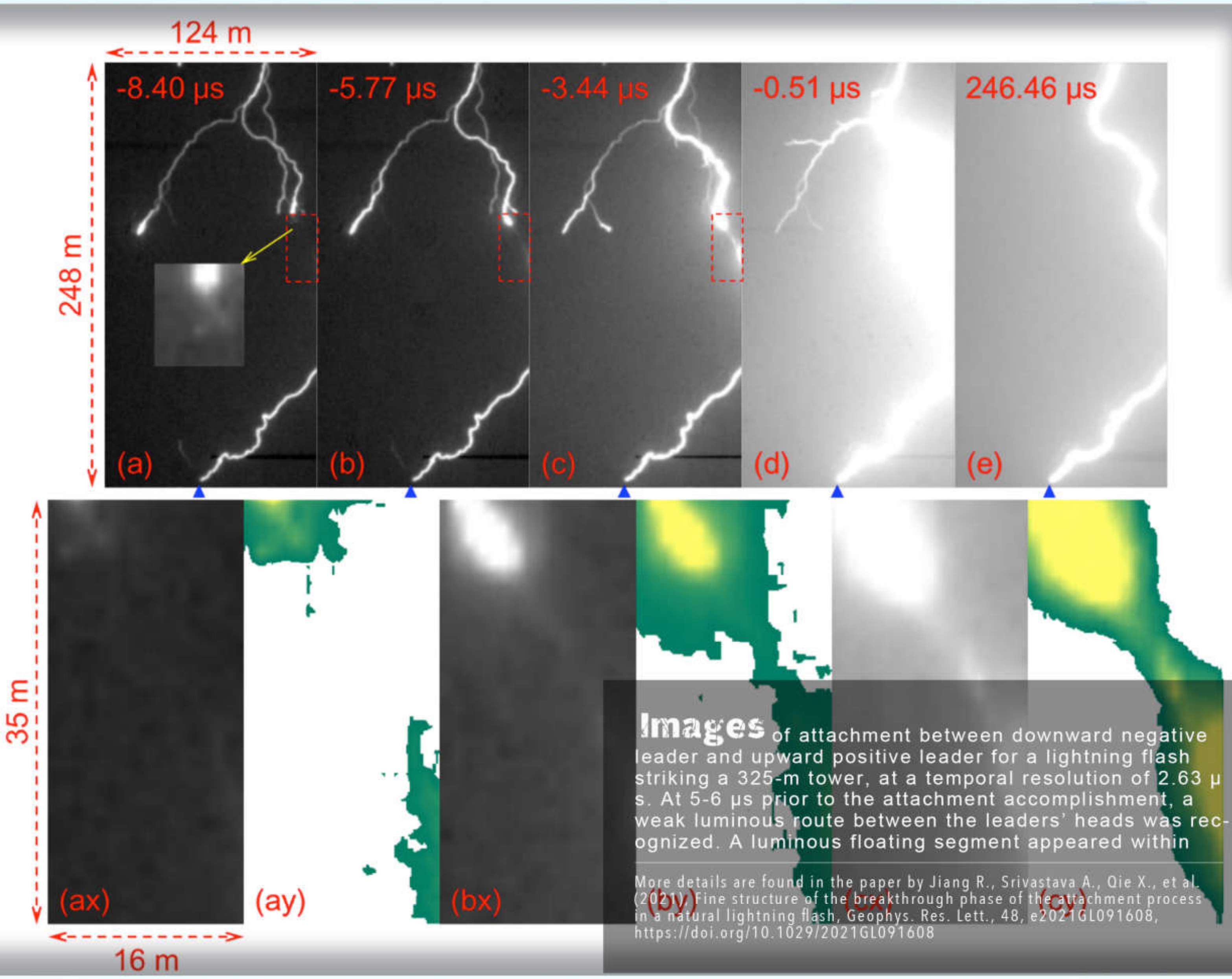

Images of attachment between downward negative leader and upward positive leader for a lightning flash striking a 325-m tower, at a temporal resolution of 2.63 μs. At 5-6 μs prior to the attachment accomplishment, a weak luminous route between the leaders' heads was recognized. A luminous floating segment appeared within

More details are found in the paper by Jiang R., Srivastava A., Qie X., et al. (2021), Fine structure of the breakthrough phase of the attachment process in a natural lightning flash, Geophys. Res. Lett., 48, e2021GL091608, https://doi.org/10.1029/2021GL091608

INTERNATIONAL COMMISSION ON ATMOSPHERIC ELECTRICITY
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*C*all for Abstracts - ICAE 2022

Prof. Price and Prof. Yair are organizing the next ICAE 2022 conference for our community, and welcome all members to attend the meeting in a year from now. We invite all interested parties to visit the conference website at https://www.icae2022.com/. We look forward to welcoming you all next year in Tel Aviv!! Shalom, Salam, Peace.

Journal of Atmospheric Electricity is online for open access

The Society of Atmospheric Electricity of Japan is pleased to announce that all previous issues of Journal of Atmospheric Electricity, including its former name of Research Letters on Atmospheric Electricity, are online for open access (papers over a period of more than 40 years!). We hope many of these papers could interest you, so please feel free to have a visit at https://www.jstage.jst.go.jp/browse/jae.

Special Issue "Remote Sensing of Lightning and Its Applications to Atmospheric Electricity Studies" of Remote Sensing

Guest Editors: Dr. Stefano Federico, Dr. Gaopeng Lu, Dr. Yang Zhang, Dr. Fanchao Lyu

A Special Issue on “Remote Sensing of Lightning and Its Applications to Atmospheric Electricity Studies” (ISSN 2072-4292) is now open for submission. This Special Issue invites manuscripts that focus on advancements in remote sensing of lightning properties, their application to understanding the lightning effects in our environment, and the monitoring and forecasting of lightning-associated deep convections that could also cause devastating weather.

More information and the paper submission link can be found here: https://www.mdpi.com/journal/remotesensing/special_issues/lightning_electricity

Deadline for manuscript submissions: 31 December 2021.

New Book

Below is a link to the book just published with the title " Geomagnetic disturbances impacts on power systems: Risk analysis and mitigation strategies".

https://www.routledge.com/9780367680862

This book deals with the impacts of space weather disturbances on power systems etc with special reference to risk analysis and mitigation strategies, and is written by Dr. O. Sokolova, St. Petersburg Polytechnic University, Prof. N. Korovkin, St. Petersburg Polytechnic University, and Prof. M.

Hayakawa, University of Electro-Communications. The bibliographical description is as follows: ISBN 9780367680862, published on March 9, 2021 by CRC Press, 268 pages.

International Space Station Lightning Imaging Sensor Marks Four Years on Orbit

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[2]University of Alabama in Huntsville, Huntsville, Alabama, USA

The International Space Station Lightning Imaging Sensor (ISS LIS) recently completed four years on orbit. The instrument is part of the 5th Space Test Program – Houston (STP-H5) payload, which was launched and integrated on the ISS in early 2017. The updated climatology (Figure 1) shows consistency with the three-year climatology presented by Blakeslee et al. (2020), along with a general trend toward increasing smoothness due to the additional year of samples. Version 1 near-realtime (NRT) and quality-controlled ISS LIS data may be found here: https://ghrc.nsstc.nasa.gov/lightning/data/data_lis_iss.html, with Version 2 data that improve viewtime estimates expected soon. Open-source software to assist with geolocating ISS LIS background images (as well as other ISS-based camera imagery) is available from https://github.com/nasa/ISS_Camera_Geolocate. ISS LIS data contributed to two recent notable publications. Schultz et al. (2020) used ISS LIS to validate a new method for automatically detecting nighttime lightning in high-definition television video streams from the ISS, while Lang (2020) used ISS LIS along with scatterometers to explore whether maritime thunderstorms are associated with stronger near-surface winds than non-thunderstorms. ISS LIS recently passed through the NASA senior review process and is expected to operate through at least late 2023. This will enable the mission to assist with validation of the forthcoming Meteosat Third Generation Lightning Imager (MTG-LI).

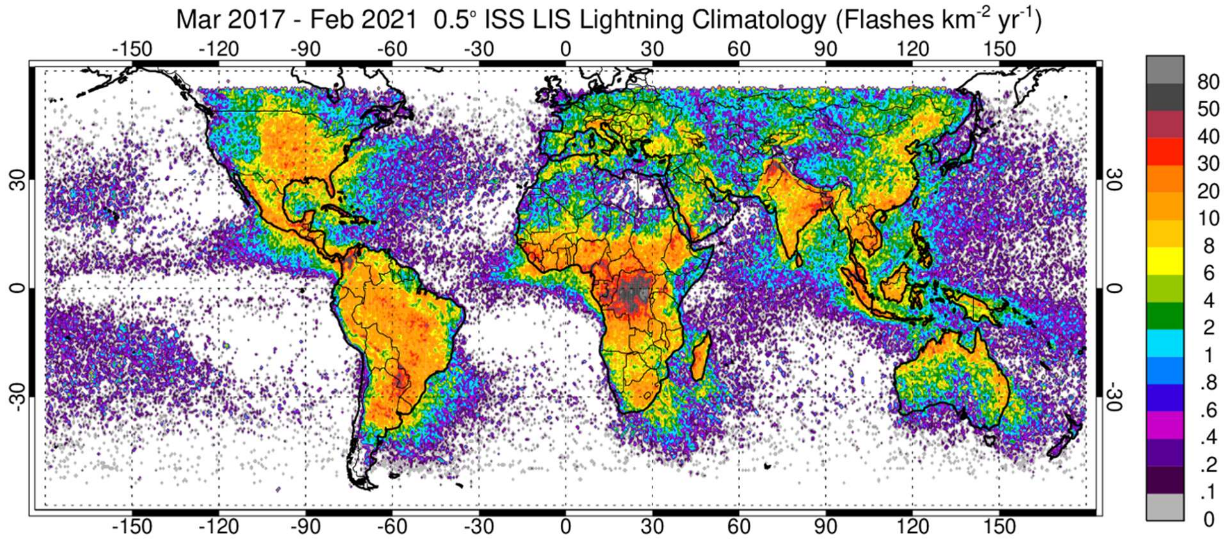

Figure 1. Four-year climatology of total lightning flash rate density from ISS LIS.

ISS LIS overlapped with the Cloud-Aerosol Transport System (CATS) lidar on the ISS during March-October 2017. Several thousand near-nadir flashes occurred during this time and were compared to near-simultaneous cloud-top information provided by CATS (Figure 2). This analysis is assisting with ISS LIS validation, particularly for LIS radiance estimates, which depend on assumptions about cloud-top height. The period of analysis covered much of the boreal warm season, and so the results in Fig. 2 are weighted toward the northern hemisphere. Cloud-top heights associated with lightning in the tropics are generally 16 km or taller, with a steady reduction toward 12-14 km in the mid-latitudes, consistent with the well-known tropopause height variability. There is also a small population of much shorter clouds (< 10 km) associated with lightning, which appears to be related to lightning in stratiform precipitation regions and/or limitations of the comparison methodology due to the narrow CATS swath. Regardless, this proof-of-concept analysis demonstrates the value of incorporating lidar data into thunderstorm studies, and serves as a pathfinder for future work, especially in relation to other spaceborne lidars and the Geostationary Lightning Mappers (GLMs).

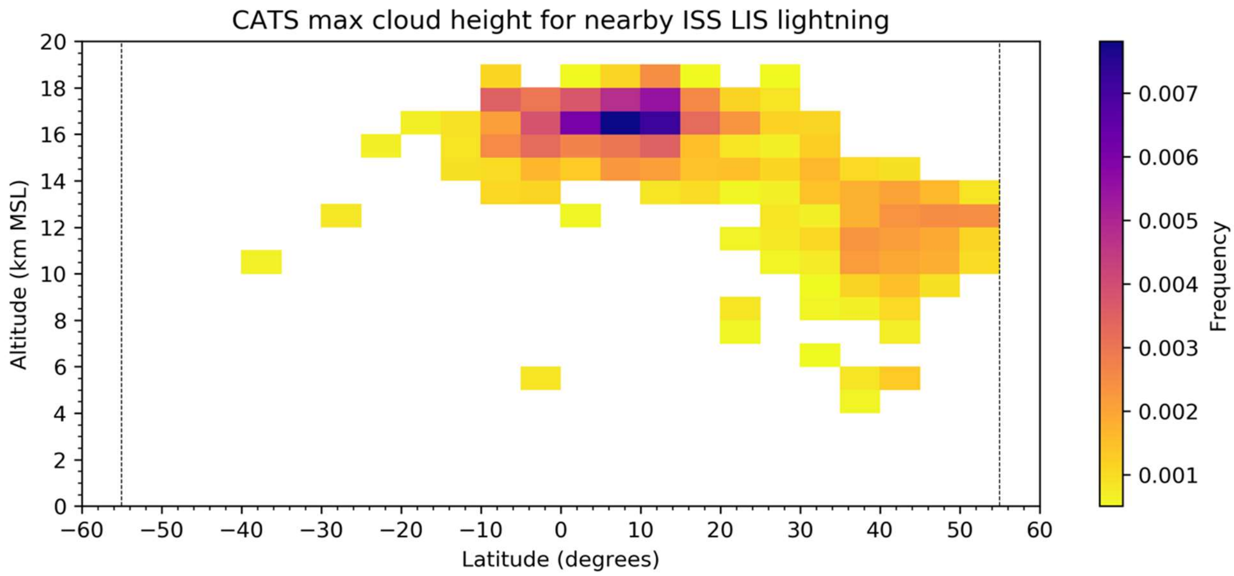

Figure 2. Two-dimensional normalized histogram of maximum cloud-top height derived from CATS when ISS LIS detects lightning near the CATS laser's ground track. Bin size is 5° latitude by 1-km altitude. Date range is 1 March through 30 October 2017. Very small frequencies below the colorbar range are masked.

John Latham
(1937 – 2021)

John Latham died on 27 April 2021, after some years living with dementia. He is well-known scientifically for his work at Manchester on thunderstorm electrification, and, more recently, his proposal for geoengineering through cloud brightening. In later years he spent much time in Colorado, until he returned to the UK in 2018, moving to an old house in the small village of Frodsham, near Chester, where he was born.

John studied Physics at Imperial College, London and then joined Professor B J (John) Mason's Cloud Physics research group to study for his PhD. His laboratory studies of thunderstorm electrification of graupel charging by ice crystals revolved around the concept of a temperature difference between the graupel and ice crystal surfaces. With John Mason, he developed the Temperature Gradient Theory, published as three papers in the Proceedings of the Royal Society. This work was also presented in Mason's Bakerian Lecture to the Royal Society in 1971, however, like all theories of thunderstorm electrification, it was controversial. Marx Brook, in New Mexico, also studied crystal/graupel interactions in the laboratory, and he and John had several lively discussions in the pages of the Royal Meteorological Society's *Quarterly Journal*.

John joined the Physics Department of the Faculty of Technology in the University of Manchester (later UMIST) in 1961 where he started the Cloud Physics Research Group. He constructed the first of several cold rooms in which, together with his first research student C D Stow, snowstorm electrification could be studied. Then he wondered whether an applied electric field of thunderstorm strength could influence the aggregation of crystals on graupel. In the cold room, a droplet cloud could be supercooled, nucleated, and the ice crystals drawn past a stationary ice target representing a graupel pellet. Fields above 800 V/cm led to increased aggregation.

Laboratory work in atmospheric electricity was continued by John's research students - Abul Azad (liquid evaporative charging, 1968), Clive Saunders (effects of thunderstorm electric fields on ice particle aggregation, 1969), Mohe Abbas (instability of charged water drops, 1967), Peter Brazier-Smith (numerical model of drop disruption, 1969), Mike Smith (drop disruption in electric fields, 1970), Gerard Jennings (drop collisions in electric fields, 1971), Richard Griffiths (corona from drops, 1973), John Crab (lightning triggering, 1973), Mike Gay (terminal velocities of drops in electric fields, 1974), Robert Warwicker (splashing of supercooled drops, 1978), Eva Barker (the raingush, 1978), Tej Verma (the raingush, 1979), Alan Barlow (charged raindrop scavenging, 1980), Carolyn Allen (drop splashing, 1980), Peter Kinsey (discharge biogenesis, 1986).

John's international standing was reflected in his appointment, in 1975, as President of the International Commission on Atmospheric Electricity. The 1980 ICAE Conference was originally planned to be held in Russia, but politics interfered. John volunteered Manchester instead and he set-to with enthusiasm enrolling his research group in helping the organization of the meeting. The conference was a great success thanks to John's efforts as Chair, including lively discussion between Marx Brook, Charlie Moore, Tsutomu Takahashi and the Manchester group involving the processes of thunderstorm electrification. John continued to attend conferences after his retirement. He was a legendary after-dinner speaker, giving banquet speeches at several ICAE conferences including Norman, Oklahoma, 2014, where he told stories about the unknown discoveries of several famous scientists. At the 2016 International Cloud Physics Conference in Manchester, he gave a brilliant speech in memory of his PhD supervisor, Sir John Mason.

In 1965 John spent a year on sabbatical at NCAR in Boulder, Colorado. He loved this part of the world so much that he bought a cabin in Gold Hill, in the hills above NCAR. John made several visits to Marx Brook, Charlie Moore and Paul Krehbiel in NMIMT Socorro. Vigorous debates ensued about thunderstorm charging - the particle charging mechanism versus the convective theory of Moore and Vonnegut. The debates, which continued in the pages of the *Quarterly Journal*, were always in good spirit. Bernie Vonnegut's brother, Kurt, strongly defended his brother's ideas and a tongue in cheek series of discussions followed between John and Kurt. Kurt wrote that "...nothing I have written matches the grace and cheerful music in your letter to me." At John's invitation, Kurt gave the after dinner speech at the ICAE conference in Albany in 1984. He gave up his Chair at UMIST and was appointed as a Senior Research Associate at NCAR in 1988.

In 1966, John and Dave Stow collaborated in aircraft studies of thunderstorms over Flagstaff Arizona. They measured electric field and particle charge and concluded that the gross electrical characteristics of complex clouds are often explicable in terms of the Reynolds-Brook theory. In 1976, John, with Anthony Illingworth, Bill Gaskell and Charlie Moore joined in an airborne project in Socorro to measure the charge on cloud particles. The ONR/NMIMT research aircraft carried a Manchester designed particle charge and size device. The team concluded that substantial electric currents were often carried by precipitation, and that the large charges observed on individual precipitation elements could not be explained by the inductive mechanism of thunderstorm electrification. Importantly, this pointed to a need for other explanations.

John worked with many scientists on atmospheric electricity across the World. He had long collaborations with Hugh Christian on satellite lightning detection and with Marcia Baker, for example on lightning frequency and thunderstorm parameters. John, with Brad Baker, Marcia Baker and members of the Manchester group, put forward a theory of thunderstorm electrification involving the influence of particle diffusional growth rates on the charge transfer accompanying rebounding collisions between ice crystals and soft hailstones.

John, together with several members of the Manchester group, participated in the Cooperative Convective Precipitation Experiment (CCOPE) in Montana, involving multiple aircraft studies of the evolution and micro-physics of developing cumulus congestus clouds.

John's interests moved into cloud particle development with studies of particle growth, mixing and entrainment, with Roger Reid (cloud mixing, 1975), Andy Chittenden (droplet sizes, 1976), Tom Choularton (ice particle initiation and growth, 1977), Rob Corbin (droplet size distributions, 1979), Tej Verma (the raingush, 1979), Colin Mill (droplet collisions, 1980), Barry Gardiner (entrainment in clouds and fogs, 1982), Alan Blyth (entrainment effect on droplets, 1982) and Peter Moody (cloud mixing, 1983). This led to his interest in the debate about droplet growth to form clouds. Together with Marcia Baker from The University of Washington, Seattle, and several research students, he developed a theory of inhomogeneous mixing in a study of the influence of entrainment on the evolution of cloud droplet spectra.

Following his work on cloud droplet development, John was struck by pictures of ship tracks over the sea near California, demonstrating that clouds could be modified to increase albedo and thereby reduce global warming. He worked tirelessly on this marine cloud brightening project with colleagues including Alan Gadian, Alan Blyth and Stephen Salter.

The Atmospheric Research Group, now the Centre for Atmospheric Science, moved to the main University of Manchester Campus with a three story cold room and extensive new laboratories. In John's honour, they were named "The Latham Laboratories" in 2008.

John was a brilliant writer, both in the clarity of his many scientific papers and in his other life of poetry and literature. John knew that dementia was on its way and he wrote about it in his poems; two of these poems were read at his funeral. His last poetry reading in Frodsham in 2017 was retrospective, his younger life portrayed in vibrant, magical poetry. Of his several prize winning books of poetry, *From Professor Murasaki's Notebooks* was especially well received. An accolade from the Dundee University Review of the Arts could perhaps be interpreted as a more general epitaph: "Latham keeps a weather eye on life, seeking out new connections and things not yet discovered."

Clive Saunders and Giles Harrison

Representative of ICAE

Memories of John Latham

John Latham was my tutor at UMIST in 1962 - he joined as a new lecturer in 1961 fresh from his PHD in London and I arrived the same year as an undergraduate in the Physics Department. When I was asked whether I had thought of doing research after graduation, it took only a moment to say that I wanted to work with Dr Latham. So charismatic, enthusiastic and interesting. John had a new cold room and he showed me how to initiate and grow ice crystals in the cloud chamber. John impressed us all in group seminars where he covered the chalk board with his latest calculations and theories of thunderstorm electrification and developments in cloud physics.

John was a great sportsman - he played cricket for the UMIST team and beat us all at badminton, even playing left handed to give us a chance.

John was so supportive of all his many students, he suggested that I should visit Marx Brook and Paul Krehbiel in Socorro, New Mexico. A wonderful experience that introduced me to real thunderstorm research. John came out to Socorro on his way to fly in thunderstorms over Flagstaff, and we had lively conversations with Marx, Paul, Bernie Vonnegut and Charlie Moore about thunderstorm electrification.

John arranged for me to join him and Vince Schaeffer in winter expeditions to Yellowstone Park where we studied the natural ice crystals and their collisions with riming graupel pellets simulating thunderstorm charging processes. Those trips were great social occasions with John and other scientists from various fields enjoying discussions over substantial steak dinners in the evenings. John and I, on one of our snowshoe mini-expeditions were tracking an elk - a naturalist in the party, Steve Wilson, caught up with us and asked what we were up to - then he asked "You do know which way round elk feet go?" On another occasion we met a group of snowcoach tourists - they asked what we doing, so John told them we were trekking across the US - they were very impressed.

On one of these expeditions with John, I met Archie Khan of the Bureau of Reclamation - he told me that I should study ice crystals on Elk Mountain in Wyoming. This led to a wonderful two years as a visiting Professor in Wyoming and collaborations with NCAR scientists. The move meant selling our house and for while we lived, at John's generous invitation, in the basement of his house in Manchester, before moving to Laramie. John was closely associated with NCAR and we had several meetings there discussing cloud physics with leading scientists.

Later, John lived in Gold Hill, Colorado, where I visited many times and enjoyed wonderful hikes and met good friends Jim and Sharon Conlin. On a trip to Montana for the CCOPE project many of the Manchester contingent spent a night with Jim and Sharon before John drove us up to Miles City.

John also had a house back in England where we were welcomed many times with other friends. John was always so hospitable - and a great cook too.

John was always a brilliant writer and he invited some of us to a poetry reading at his house. We were at John's last poetry reading, there was little sign of his illness, he read his poems beautifully. He returned to Gold Hill for a while. But he soon returned to England and stayed in a nursing home where he spent his time writing important research proposals to save the planet. During lockdown we could not visit and so the last time we saw John was in the home, where he hardly new us.

A sad end to a joyous life - we remember his enthusiasm, generosity, shear love of life, and as Marx Brook said "John is great at telling jokes against himself".

Clive Saunders

Remembrances of John Latham

I first met John at an AMS conference on cloud physics in Reno Nevada in 1965, while I was writing up and finishing my PhD under Peter Hobbs. This was one of the early conferences that John attended as a young professor. I don't remember all the people attending but I do remember John. He was active with questions and comments during the conference and also active with the social life during the evenings, characteristics that were common for John throughout his life.

One of the things that comes to mind was his very modest manner in giving a presentation, a seminar or even starting a paper. He often would start out by saying that a very simplistic way to approach this problem is .... and then proceed to put together a straightforward rationale that often would capture the essence of a scientific issue. His simple approach was often disarming but went to the heart of that problem. The area in which I am most familiar with his work and contributions is in cloud electrification. At the time he started his scientific career there was much debate of whether the main charging mechanism was precipitation based or a convective mechanism. And if precipitation based was it via inductive charge separation between colliding particles (ice or water) or via a non-inductive mechanism. John's early laboratory work suggested that it was via the non- inductive mechanism but his following work and the work of many students and co- workers under his direction at UMIST examined these processes in detail. Ultimately research has shown that the non-inductive mechanism of collisions between graupel and ice crystals is primary, a view that John had held since his graduate studies. When I was working on publishing a paper with many co-authors on the airborne study of a small Montana thunderstorm, John put forth an idea for extending the paper which lead to a joint paper by he and I. His vision was far ranging and general while mine was more detail oriented.

John not only put forward creative, original ideas but continued to think about and investigate these ideas until they were either validated or shown to be incorrect.

Jim Dye

Institute of Earth Physics and Space Science (ELKH EPSS), Sopron, Hungary

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

From April 2021, the Geodetic and Geophysical Institute (GGI) of the Research Centre for Astronomy and Earth Sciences (RCAES) became an independent research institute and continues its mission as the Institute of Earth Physics and Space Science (EPSS). The Atmospheric Electricity working group of the institute remains committed to explore electromagnetic (EM) phenomena in the Earth's atmosphere with the main focus on the DC and AC parts of the global electric circuit (GEC) as well as to continue the operation of the uniquely long observation of Schumann Resonances (SR) (from 1993) and potential gradient (PG) (from 1961) at the Széchenyi István Geophysical Observatory (SZIGO) in Nagycenk, Hungary.

Financial support has been received to extend the set of instruments measuring the parameters of atmospheric electricity (AE) in SZIGO. A recently re-designed version of the programmable ion mobility spectrometer (PIMS, Aplin and Harrison, 2001) is to be obtained and installed during 2021. In the framework of the same project, a present weather and visibility sensor and a LIDAR ceilometer will also be installed to extend the capabilities on-site for automatic local determination of fair and foul weather conditions. With these new instruments, it is expected that atmospheric electricity measurements in SZIGO will provide greater coverage in environmental monitoring which can serve a more comprehensive scientific investigation of AE-related phenomena as it was pointed out earlier by Dragovic et al. (2020).

Two new algorithms have been developed to model lightning-generated EM fields in the lowest part of the extremely low frequency (ELF) band (<100 Hz) that takes into consideration the day-night asymmetry of the Earth-ionosphere cavity (Prácser et al., 2021). The models are based on the analytical and numerical solutions of the two-dimensional telegraph equation (TDTE) and are planned to be used in the inversion of SR records with the aim of reconstructing the distribution and intensity of global lightning activity (Párcser et al., 2019). Numerical tests showed conspicuous conformity between the output of the two models (the relative difference between them is less than 0.4%) which can be regarded as the validation of the two independent approaches.

By processing multi-station observations of SR it has been shown that SR intensity records document a common behavior in the evolution of continental-scale lightning activity in the transition from cold to warm phase preceding two super El Niño events, occurring in 1997/98 and 2015/16 (Williams et al., 2020). SR-based results were strengthened by comparison with independent lightning observations from the Optical Transient Detector (OTD) and the World Wide Lightning Location Network (WWLLN), which also exhibit increased lightning activity in the transition months. It has been suggested that SR intensity variations might be applied in the future to predict the occurrence of these extreme climate events. The development of the SR inversion process and the investigation of the SR relation with the ENSO phenomenon is carried out in a strong collaboration with Earle Williams (MIT) and his team.

Links between the variations of atmospheric electricity parameters and continental scale atmospheric circulation types (CT) in Europe have been studied in order to examine the sensitivity of the biosphere to variations of the electrical state of the atmosphere. It was shown that different CT unquestionably affect the near-ground electrical state of the atmosphere but in different ways, especially when dust/particle transport is involved in the air circulation. It was concluded that the atmospheric electrical environment deserves to be included in CT-related bioclimatic studies (Kourtidis et al., 2021).

Members of our team contributed to a glossary which has been produced and published to support interdisciplinary research in the fields of atmospheric electricity and life sciences (Fdez-Arroyabe et al., 2021).

The maximum emission altitude (84.3 km) and the altitude of the brightest emissions (69 km) in red sprites were determined for events detected in South Africa. According to the results, moderate positive correlation can be found between the charge moment change of the sprite-parent lightning stroke (CMC) and the top altitude of the produced emissions, and there is weak positive correlation between the CMC and the height of the brightest emissions (Mashao et al., 2021).

Long-term variations between 1962 and 2009 in the fair-weather PG data recorded at the SZIGO have been identified and analyzed. After the correction of site-specific electrostatic shielding effects, the actual long-term variation of PG at SZIGO has been revealed and compared to long-term PG data measured in Swider Geophysical Observatory, Poland. The results of this study show 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. The main findings were presented at the annual meeting of the CA15211 COST action (ElectroNet) in 2021 and at the EGU General Assembly 2021 (Buzás et al., 2021).

Israel Atmospheric Electricity Group

Prof. Yoav Yair (Inter-disciplinary Center, IDC) and Prof. Colin Price (Tel Aviv University, TAU) will be leading the ILAN-ES campaign, scheduled to launch to the International Space Station in early 2022, with the second Israeli astronaut Eytan Stibbe. ILAN-ES (Imaging of Lightning And Nocturnal Emissions from Space) aims to study electrical phenomena above thunderstorms (Transient Luminous Events). Observations are aimed to enhance our understanding of the coupling processes between the lower and upper atmosphere. Space imaging by an on-board Nikon D5 camera will be augmented by a global ground-based campaign, with lightning location networks in different spectral ranges (ELF, VLF) as well as optical cameras operated by international research groups and a network of schools and amateurs. Daily operations will rely on forecasts of thunderstorm targets that will be relayed to the astronaut on-board the ISS, in a similar manner to the MEIDEX that was conducted on-board space-shuttle Columbia in 2003 by the late Col. Ilan Ramon.

Prof. Colin Price (TAU), together with Dr. Mustafa Asfur (Ruppin College) and Jack Silverman (Israel Oceanographic & Limnological Research center, IOLR) have published a number of papers in the last year looking at the link between the optical brightness of lab-produced discharges in water, and the salinity, pH and alkalinity of the water. The findings were quite surprising, showing that the optical brightness increases dramatically as the conductivity of the water increases. These results may shed light on why ocean lightning is generally observed to be more intense compared with continental lightning.

Prof. Price together with Dr. Anirban Guha (India) is studying the link between convection, lightning and upper tropospheric water vapor (UTWV). We find that the ENSO cycle is strongly linked to fluctuations in UTWV, with El Nino years resulting in more tropical convection and more UTWV, while La Nina years suppress global convection resulting in minima in UTWV. An additional study looking at tropical cyclones also shows the important role of tropical storms on the UTWV concentrations. Papers are in preparation.

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A +CG flash caused by a sequence of bidirectional leaders that served to form a ground-reaching branch of a pre-existing horizontal channel. High-speed video and electric field change data were used to analyze the initiation and propagation of four predominantly vertical bidirectional leaders making connection to a predominantly horizontal channel previously formed aloft. The four bidirectional leaders sequentially developed along the same path and served to form a positive branch of the horizontal in-cloud channel, which became a downward positive leader producing a 135-kA positive cloud-to-ground (+CG) return stroke. The positive (lower) end of each bidirectional leader elongated abruptly at the time of connection of the negative (upper) end to the pre-existing channel aloft. Thirty-six negative streamer-like filaments (resembling recently reported "needles") extended sideways over ~110 to 740 m from the pre-existing horizontal channel at speeds of ~0.5 to 1.9 $\times 10^7$ m/s, in response to the injection of negative charge associated with the +CG (Figure 1).

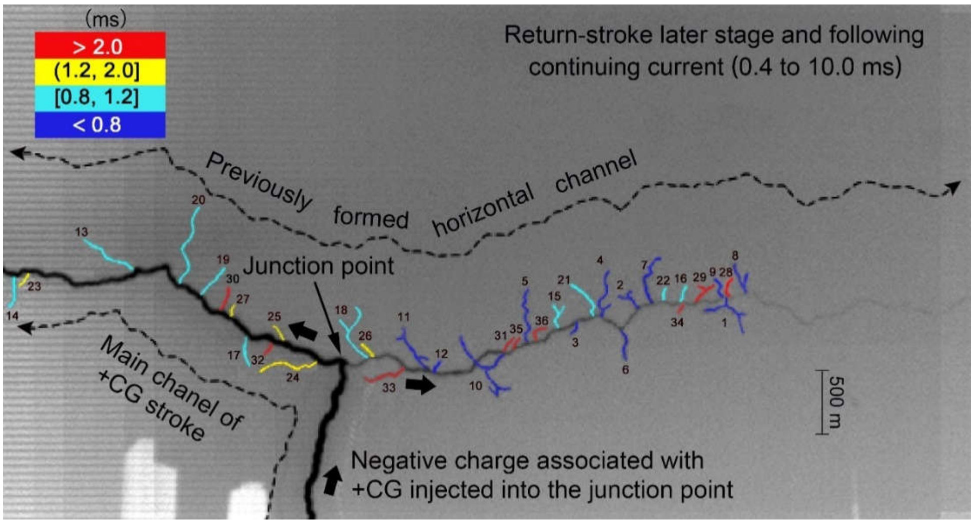

Figure 1. Composite image of 480 selected frames (from 0.4 to 10.0 ms) obtained using HC-2 (20-μs interframe interval) showing side branches (different colors indicate their occurrence time relative to the RS onset) originating from the horizontal channel during the return-stroke later stage and continuing current. The composite image was inverted and contrast enhanced. Thick arrows indicate the direction of motion of negative charge associated with the +CG return stroke and continuing

current along the vertical and horizontal channels. Discernible side branches (streamer-like filaments) are numbered 1 to 36 in the order of their occurrence relative to the RS onset.

Fast and fine location of total lightning from low frequency signals based on deep-learning encoding features. Lightning location provides an important means for the study of lightning discharge process and thunderstorms activity. The fine positioning capability of total lightning based on low frequency signals has been improved in many aspects, but most of them are based on post waveform processing, and the positioning speed is slow. In our study, artificial intelligence technology is introduced to lightning positioning of low-frequency electric-field detection array (LFEDA). A new method based on deep-learning encoding features matching is also proposed, which provides a means for fast and fine location of total lightning. Compared to other LFEDA positioning methods, the new method greatly improves the matching efficiency, up to more than 50%, thereby considerably improving the positioning speed. Moreover, the new algorithm has greater fine-positioning and anti-interference abilities, and maintains high-quality positioning under low signal-to-noise ratio conditions. The positioning efficiency for return strokes of triggered lightning was 99.17%, and the standard deviation of the positioning accuracy in the X and Y directions was approximately 70 m.

Characteristics of negative leader propagation area of lightning flashes initiated in the stratiform regions of mesoscale convective systems. To investigate the characteristics of extension areas (mainly the propagation areas of negative leaders in this study), the lightning location data of 254 lightning flashes initiated in the stratiform regions (stratiform lightning flashes) of 14 mesoscale convective systems (MCSs) are analyzed. The results show that most of the flashes have a relatively small lightning area (LA) (≤100 km^2) although they are initiated in the stratiform regions. In small or developing MCSs, most negative leaders of stratiform lightning flashes concentrate within the 9–12-km altitude range. In other MCSs with a large-sized and developed stratiform region, besides being in this high-altitude range, the negative leaders are also found to propagate more frequently in a low-altitude range of 5–7 km. Further analysis indicates that most of the stratiform lightning flashes with a large LA (> 100 km^2) propagate their negative leaders within the high-altitude range no matter where they are initiated (Figure 2). Moreover, the stratiform lightning flashes with or near the largest LA tend to be initiated 4–6 km below their negative leaders, while most of the stratiform lightning flashes usually propagate their negative leaders horizontally within ±1 km of the first detected VHF radiation source. It is inferred that some in situ electrifications occurring before and during the formation of the high reflectivity layers in the low-altitude range contribute to these flashes, although the influence of the advection charges from the convective regions still cannot be totally ruled out.

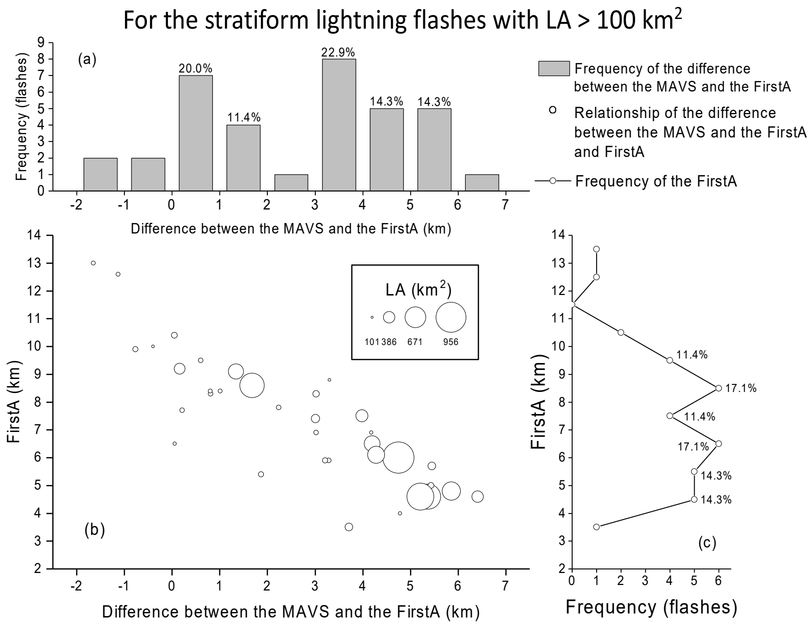

Figure 2. Frequencies of (a) the difference between the MAVS and the FirstA and (c) the FirstA, and (b) the relationship between the difference between the MAVS and the FirstA and the FirstA for the stratiform lightning flashes with LA > 100 km^2. The size of the circle in (b) shows the LA.

Spatiotemporal lightning activity detected by WWLLN over the Tibetan Plateau and its comparison with LIS lightning. Herein, we compared data on the spatiotemporal distribution of lightning activity obtained from the World Wide Lightning Location Network (WWLLN) with that from the Lightning Imaging Sensor (LIS). The WWLLN and LIS both suggest intense lightning activity over the central and southeastern Tibetan Plateau (TP) during May–September. Meanwhile, the WWLLN indicates relatively weak lightning activity over the northeastern TP, where the LIS suggests very intense lightning activity, and it also indicates a high-density lightning center over the southwestern TP that is not suggested by the LIS (Figure 3). Furthermore, the WWLLN lightning peaks in August in terms of monthly variation and in late August in terms of 10-day variation, unlike the corresponding LIS lightning peaks of July and late June, respectively. Other observation data were also introduced into the comparison. The blackbody temperature (TBB) data from the Fengyun-2E geostationary satellite (as a proxy of deep convection) and thunderstorm-day data support the spatial distribution of the WWLLN lightning more. Meanwhile, for seasonal variation, the TBB data are more analogous to the LIS data, whereas the cloud-to- ground (CG) lightning data from a local CG lightning location system are closer to the WWLLN data. It is speculated that the different WWLLN and LIS observation modes may cause their data to represent different dominant types of lightning, thereby leading to differences in the spatiotemporal distributions of their data. The results may further imply that there exist regional differences and seasonal variations in the electrical properties of thunderstorms over the TP.

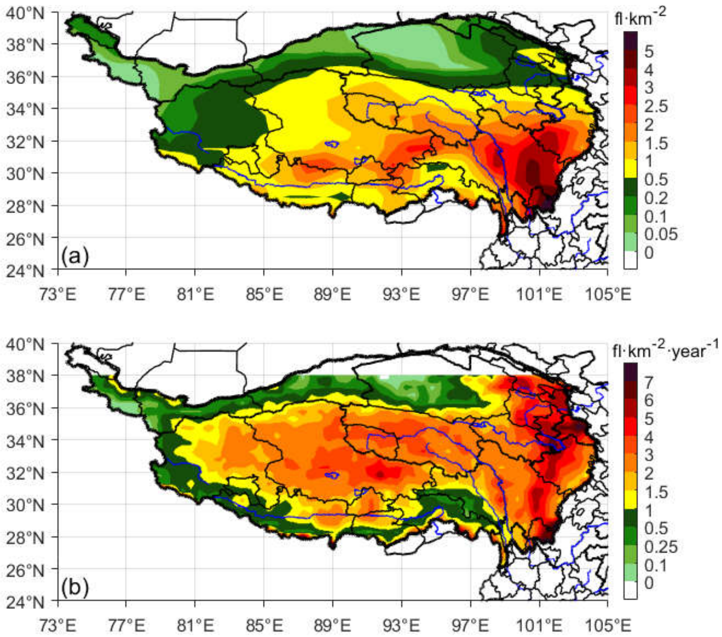

Figure 3. Spatial distributions of the lightning density obtained from the (a) WWLLN and (b) LIS over the TP. The statistical grids of the WWLLN and LIS data are $1° \times 1°$ and $0.5° \times 0.5°$, respectively. The WWLLN data were adjusted using the relative detection efficiency of the WWLLN over the TP.

Lightning Research Group of Gifu University (Gifu, Japan)

Electric charge structure of winter positive CG flashes in Japan. Using a lightning mapping array (LMA), we have observed 24 positive cloud-to-ground (CG) flashes occurred in three thunderstorm days. These flashes can be apparently grouped into 5 clusters according to their occurrence times. We have obtained the charge structures for both the individual flashes and clusters. It was found that 4 out of 5 clusters of positive CG flashes exhibited either inverter dipolar or tri-polar charge structures. This result indicates that the high percentage of positive CG flashes in Hokuriku winter thunderstorms originated from the inverted charge structure rather than the various deformations of normal charge structures widely accepted in literatures. The flash positive charge appeared to distribute usually in a layer with its thickness of around 1 km, its horizontal area of more than 100 km^2 and its bottom altitude of around 1-2 km above the ground. The charge structure of an example positive CG flash is shown in Figure 1. For each of the flash, we have also obtained its duration, length, duration before the first stroke and convex area. It was found that all flashes with a large peak return stroke current had short durations before their first return strokes. For more detailed result, please visit https://onlinelibrary.wiley.com/doi/full/10.1002/tee.23310.

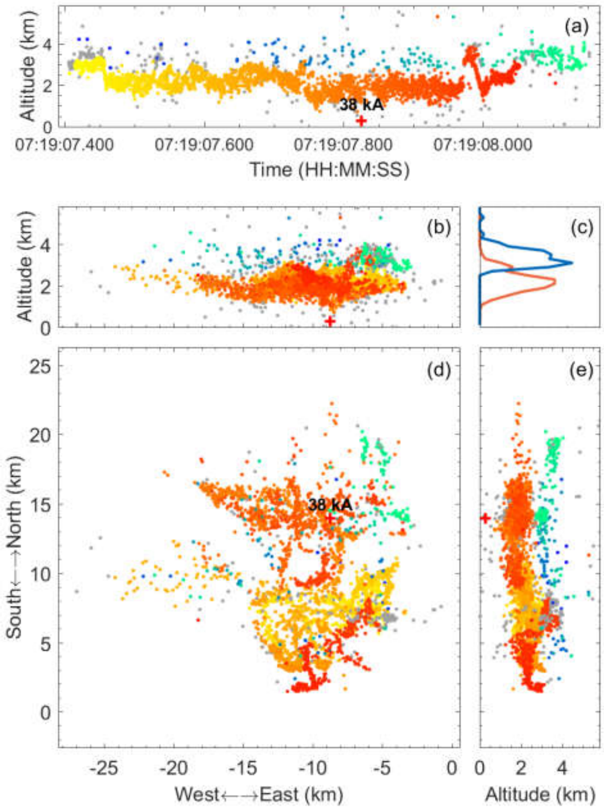

Figure 1. The charge structure of a typical PCG lightning flash. (a) radiation source altitude versus time, (b) west-east view of altitude distribution, (c) percentage distribution of the number of sources in different polarities, (d) top view of 2D distribution, and (e) north-south view of altitude distribution. Warm color coded in time indicates the positive charge region, while the cold color indicates the negative charge region. The gray dots indicate sources whose polarities couldn't be identified. Red cross denotes the return stroke point estimated by the JLDN.

Characteristics of electric currents in upward lightning flashes from a windmill and its lightning protection tower in Japan, 2005 – 2016. We examine the lightning current of 81 upward lightning (UL) initiated from a windmill and its lightning protection tower in Japan under winter thunderstorms from 2005 to 2016. Among 81 UL, the negative, positive and bipolar lightning account for 64%, 12% and 24%, respectively. After checking the current waveforms during the initial stage (IS) of negative UL, we found that self-initiated negative UL have larger peak value and shorter rise time compared to other-triggered ones, although two types of negative UL show no significant difference in charge transfer and duration. Among 18 self-initiated negative UL, half of them are initiated from the windmill. On the other hand, only two of 27 other-triggered negative UL are from the windmill and both of them have smaller current peak value, shorter duration and smaller charge transfer. According to whether or not the IS current waveforms exhibit pulsation, we have classified UL into type S (smooth), SP (transition from smooth to pulsation) and P (pulsation, which indicates stepping mode). We found that the rate of slow current rise for most type P UL is larger than 0.1 kA/ms, whereas for all type S UL the rate is smaller than 0.01 kA/ms as shown in Figure 2. The type SP UL show a slow current rise rate ranging from 0.01 kA/ms to 0.1 kA/ms. We found that the current pulsation of type P UL corresponds to the stepwise propagation of a positive leader. Based on these results, we have discussed the effect of the lightning protection tower and the stepwise propagation of positive leaders. For detail, please visit https://agupubs.onlinelibrary.wiley.com/doi/10.1029/2020JD034346.

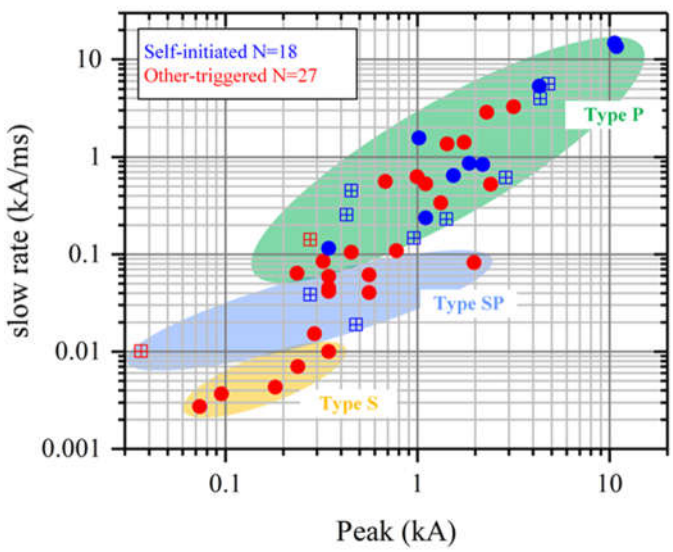

Figure 2. The scatterplot of the rate of slow current rise and the corresponding current peak value during the initial portion of IS. The distribution zones of type S, SP and P lightning are painted in

yellow, blue and green, respectively. The UL of different types and initiation places are also plotted with different marks and colors for reference.

Initial results of long-term continuous observation of lightning discharges by FALMA in Chinese inland plateau region. We started a long-term continuous observation of lightning discharges in the Chinese inland plateau region using a fast antenna lightning mapping array (FALMA). During the first year of observation, 2019, we recorded lightning discharges on 25 days in Yinchuan city, the capital of Ningxia. Most of the lightning discharges appeared to occur in the afternoons of individual thunderstorm days in August. We studied the cloud-to-ground (CG) flash percentages, lightning dis-charge source spatiotemporal distributions, and preliminary breakdown (PB) process characteristics for the two thunderstorm cases that produced the most frequent lightning flashes in 2019 over a wide area. It was found that (1) CG flashes in these two thunderstorms accounted for 28.4% and 32.5% of total lightning flashes, respectively; (2) most lightning discharge sources in these two thunderstorms occurred at temperatures between 5 and -30 °C, with a peak at around −10 °C; and (3) more than 90% of well-mapped PB processes of intracloud (IC) flashes propagated downward. By overlapping the altitudes and the progression directions of the PB processes on the lightning source spatiotemporal distributions, we inferred that the main negative charge of the two storms observed in Ningxia, China, was at a height of around -15 to -25 °C (7 to 9 km) and the main positive charge was at a height of around 5 to 0 °C (2 to 4 km) which is significantly different from that observed by a similar FALMA in Gifu, Japan, low land area as compared in Figure 3. For detail, please visit https://www.mdpi.com/2073-4433/12/4/514.

Fine progression features of return stroke luminosity at the bottom of rocket-triggered lightning channels. We have performed a study on the luminosity waveforms of 13 return strokes (RSs) in 4 rocket triggered lightning flashes recorded by a high-speed optical imaging system LAPOS5 with a time resolution of 35 ns and a spatial resolution of about 2 m. It was found that as the return strokes propagate upward over the bottom 10 m to 26 m of the lightning channels, which is above their initiation heights, on average the RSs optical waveforms decrease their peaks by 41%, lengthen their 20-90% rise times and 100-80% decay times, and change the relative times of the fastest rising points by 0.38 μs, 0.51 μs, and 0.15 μs. We have also estimated the propagation speeds for all the return strokes by using their 20% peak light intensity points and fastest rising points as reference points for time difference measurements, respectively. It was found that the average RS speed obtained with the 20%

peak light intensity points (1.11× 108 m/s) is about twice that obtained with the fastest rising points (0.67× 108 m/s). In addition, we found that for different RSs in an individual lightning flash, the RS with faster propagation speed tends to have a less distorted optical waveform at the higher height. This paper has been published in the Journal of Atmospheric Electricity. https://www.jstage.jst.go.jp/article/jae/39/2/39_1/_article/-char/en.

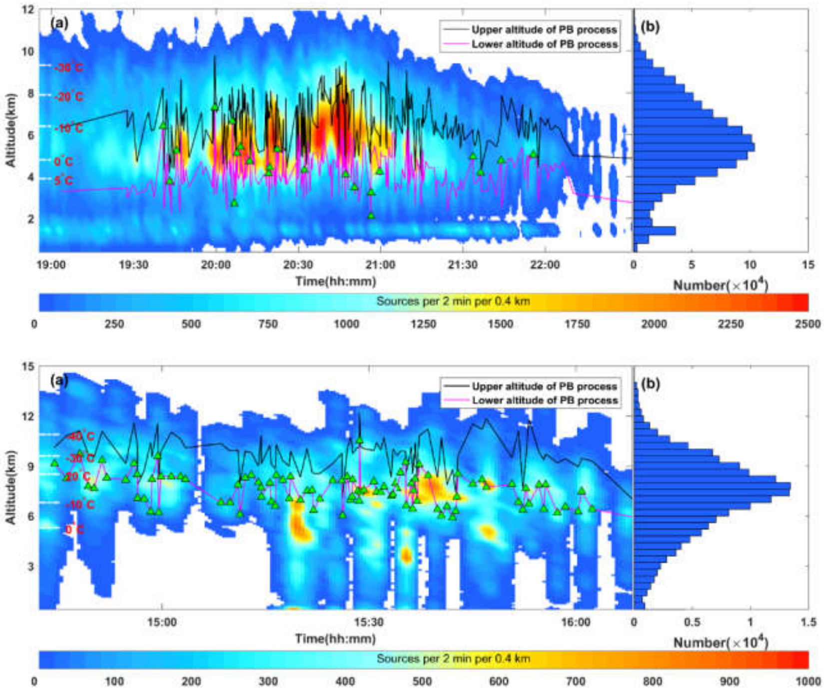

Figure 3. Comparison of spatiotemporal distributions of PB processes in lightning flashes in a storm in Ningxia (top panel) and in a storm in Gifu, Japan (bottom panel). (a) Lightning source density as a function of altitude and time. The shaded area represents the source number counted in 2 min intervals and with a 0.4 km height bin, as shown by the bottom color bar. Black and pink curves indicate the upper and lower altitudes of PB sources in each flash. In particular, the initiation heights of upward PB processes are marked by green triangles. (b) Distribution of lightning sources with height.

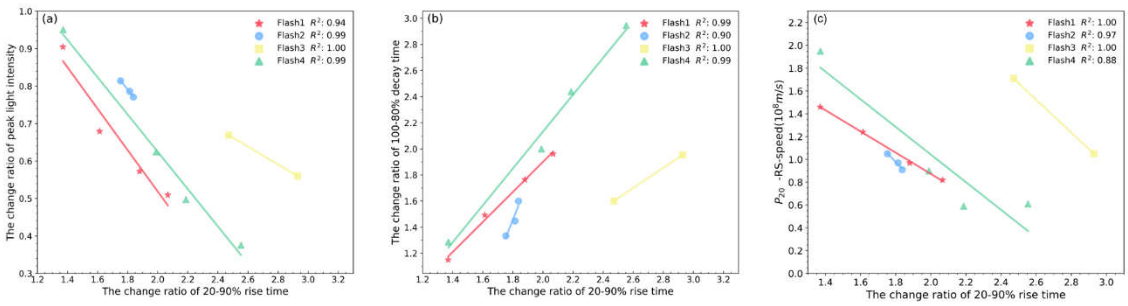

Figure 4. Scatter plots of (a) the change ratio of 20-90% rise time versus the change ratio of the peak

light intensity; (b) the change ratio of 20-90% rise time versus the change ratio of 100-80% decay time and (c) the change ratio of 20-90% rise time versus the P20%-RS-speed with different colors and shapes for different flashes. The linear regression line for each individual lightning flash is also plotted. For return strokes in a lightning flash, the larger increase of the rise time is linearly related with the larger decay of the peak light intensity, the larger change of the decay time and smaller P20%-RS-speed.

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Evaluation of Fengyun-4A Lightning Mapping Imager (LMI) performance during multiple convective episodes over Beijing. We investigate the characteristics of space-borne LMI and their relationships with cloud properties using ground-based total lightning observations from the Beijing Broadband Lightning Network (BLNET) and cloud information from S-band Doppler radar data. LMI generally showed consistent lightning spatial distributions with those of BLNET and yielded a considerable lightning detection capability over regions with complex terrain. The ratios between the LMI events, groups, and flashes were approximately 9:3:1, and the number of LMI-detected flashes was roughly one order of magnitude smaller than the number of BLNET-detected flashes. However, in different convective episodes, the LMI detection capability was likely affected by cloud properties, especially in strongly electrified convective episodes associated with frequent lightning discharging and thick cloud depth (Chen et al., 2021, Remote Sens).

Fine structure of the breakthrough phase of the attachment process in a natural lightning flash. A lightning flash striking a 325-m tower was captured using a high-speed camera operated at 380 kfps and the characteristics of breakthrough phase (BTP) were recorded in two consecutive frames (Figure 1). The fine time-resolved images indicate that the common streamer zone (CSZ) formed when the bright tips of negative and positive leaders were ≥23 m apart from each other. During BTP, both the negative and positive leaders extended their channels with enhanced luminosity and the gap between them was shortened to 16 m in the frame prior to return stroke. A space leader-like luminous segment was found within the route of leader connection. This route is inferred to have already been determined at the initial formation of CSZ, by the interconnected streamers of approaching leaders. The dominant growth of this route is interpreted as a new scenario for the conversion of a high-impedance CSZ to a hot plasma channel during BTP (Jiang et al., 2021, GRL).

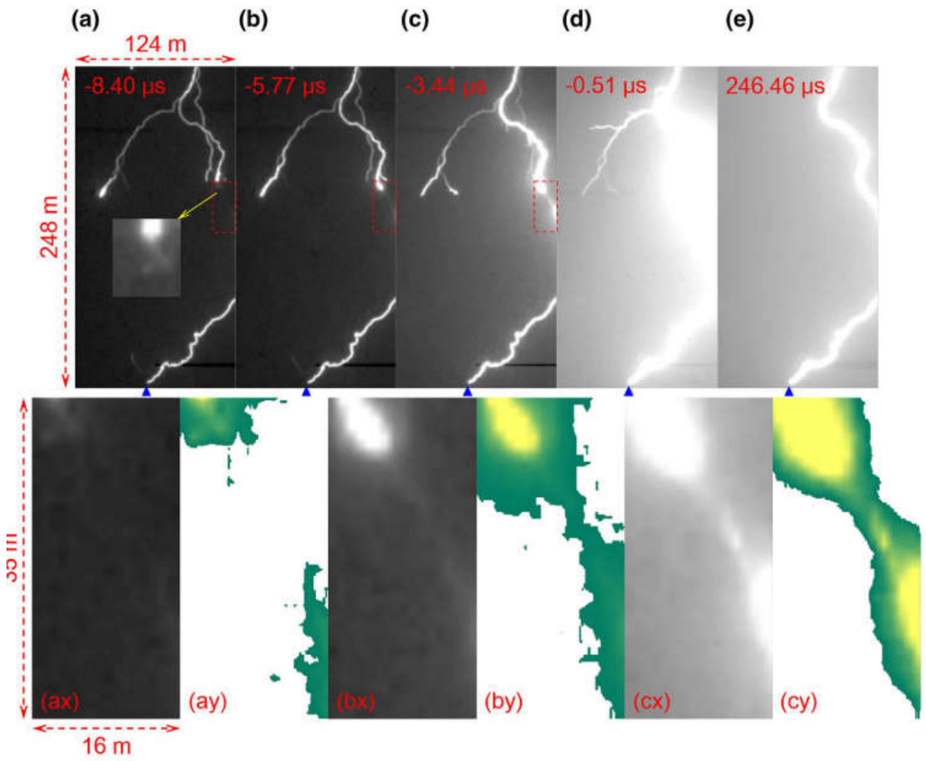

Figure 1. High-speed video frames of the attachment process between leaders of opposite polarities. The upper panel (a–e) shows the full-view records with a time interval of 2.63 μs. The lower panel shows an expanded view of the area marked by the red rectangles (ax, bx, and cx) and the corresponding color maps (ay, by, and cy). The blue triangles mark the tip of the 325 m high meteorology tower.

A rocket-triggered lightning flash containing negative-positive-negative current polarity reversal during its initial stage. A rocket-triggered lightning flash containing negative-positive-negative current polarity reversal during its initial stage is analyzed using multiple synchronized observation data. The flash was triggered under a thunderstorm transition zone between the convective region and the stratiform region. The upward positive leader branched and developed toward the stratiform region. When the negative initial continuous current was decreasing, a negative stepped leader was transformed from a recoil leader on a preexisting positive branch. As the negative leader developed toward the convective region, a breakdown process initiated on a preexisting positive channel and propagated toward the back end of the negative stepped leader, accompanied with a positive electric field change pulse. The current polarity changed from negative to positive about 0.22 ms after the onset of the breakdown process. The negative leader terminated after propagating for 71.08 ms, while scattered discharges on other positive branches maintained to develop, and then the ICC polarity changed from positive to negative (Li et al., 2021, JGR).

The charge structure in a thunderstorm based on three-dimensional electric field sonde. A thunderstorm electric-meteorological integrated sounding system was constructed in combination with weather radiosonde to measure the comprehensive sounding data of electric field, temperature, and relative humidity. In the summer of 2019, the field experiment was carried out in the North China Plain. The sounding system was released during the dissipation stage of a mesoscale convective system and passed through the weak echo region of the thunderstorm. The sounding results show that there were five charge regions in the thunderstorm and the charge polarity altered in the vertical direction, containing the positive-negative-positive charge layer at 4.4~5.6 km, 3.6~4.4 km, and 1.0~3.6 km, respectively. Besides, there was a negative shielding charge region below 1 km and the top of the thunderstorm, respectively. Furthermore, the electric field sounding system experienced the stages of rising, falling, and rising again during 3.6~4.4 km, which were in the range of the middle negative region. The sounding data indicates that the dynamic field inside the cloud was complicated, and the detailed charge structures of the three stages in the negative charge region were similar but different, which reflected the real charge structure inside the thunderstorm was very complicated and inhomogeneous spatiotemporally (Zhang et al., 2021, in Chinese).

On the terrestrial gamma-ray flashes preceding narrow bipolar events. Narrow bipolar events (NBEs) are occasionally reported to occur within a few ms after Terrestrial Gamma-ray Flashes (TGFs), while the formation mechanism remains mysterious partially due to the lack of sufficient observations. Here, nine more TGFs of this scenario are reported with concurrent LF sferics and lightning location data. The gamma-ray production in these TGFs preceded the occurrence of NBEs by a minimum of 60 µs up to 13.5 ms, and no other fast leader discharge was found within 20 ms before the TGF. The TGF-preceded positive NBEs occurred at altitudes of 8.6–11 km in thunderstorms, likely in the high electric field (E-field) region of lightning initiation. The analyses show that the NBE- preceding TGFs bear a harder energy spectrum with a larger proportion of high-energy photons than EIP- related TGFs produced in association with the lightning leader. Our findings support the relativistic feedback mechanism of gamma-ray generation in the large-scale thunderstorm E-field. (Zhang et al., 2021, GRL).

Lightning activity during convective cell mergers in a squall line and corresponding dynamical and thermodynamical characteristics. The convective cell mergers and their impact on lightning activity during an extremely severe squall line system that occurred over the Beijing Metropolitan Region (BMR) have been investigated. During the merger, the external and local multi-cells were connected by triggering new cells between them, and subsequently, cloud bridges formed at 1–5 km AGL. The total flash rate (TFR) of the whole storm decreased slightly at the beginning of the merger, increased sharply later, and peaked when the merger was completed. The vertical profiles of radar reflectivity illustrated that the merger process tended to weaken the rear cell and strengthen the front cells in spatial scale and intensity, presented as a rear-cell feeding merger. The results from the Variational Doppler Radar Analysis System (VDRAS) are used to derive the corresponding dynamical and thermodynamical processes. The rear-inflow jet (RIJ) penetrated the trailing-stratiform region and extended into the lower layer of the front cells of the storm during the merger period. The resulting strong convergence and updraft of front cells brought water vapor from the bottom to the upper layers, which is conducive to the formation of ice particles, the possibility of noninductive electrification, and the subsequent lightning flashes (Lu et al., 2021, AR).

Five-year climatological lightning characteristics of linear mesoscale convective systems over North China. The lightning characteristics of 89 linear mesoscale convective systems (MCSs) that occurred over the Beijing area from the year 2007 to 2011 were analyzed by lightning data and S-band radar information. According to different morphology of radar echo, linear MCSs were classified into six categories: leading convective lines with a trailing stratiform region (TS for short), leading stratiform region with a trailing convective region (LS), leading convective lines with no stratiform region (NS), bow echo of leading lines (BE), leading convective lines with a parallel stratiform region (PS), and broken line stratiform (BL). The results showed that linear MCSs frequently occurred over the Beijing area in the summer; in particular, TS, LS, and PS modes totally accounted for 73% of linear MCSs. On average, lightning mainly concentrated in the linear convective region, and a small amount of lightning occurred in the stratiform region. From the distribution of +CG/CG in three archetypes of linear MCSs, it is found that PS MCSs with highest the proportion of +CG/CG, and then followed by LS MCSs while the lowest ratio appeared in TS MCSs. The relationship between lightning frequency and volume of 40 dBZ radar echo exhibited linear correlation in three distinct archetypes of linear MCS. Environmental factors of linear MCSs exhibited that high CAPE (Convective Available Potential Energy) value and the larger wind shear of 0–6 km played an important role in sustaining the convective development of TS, LS, and PS MCSs (Liu et al., 2021, AR).

*M*assachusetts Institute of Technology

The evidence for greatly enhanced lightning activity offshore of the Australian continent during the exceptional bushfire season of 2019-2020, and organized by Yakun Liu, has recently been accepted for publication in Geophysical Research Letters: Liu, Y., E. Williams, Z. Li, A. Guha, J. LaPierre , M. Stock , S. Heckman , Y. Zhang , and E. DiGangi, Lightning Enhancement in Moist Convection with Smoke-laden Air Advected from Australian Wildfires, Geophysical Research Letters, in press, May 2021.

Several teams involved with research on Schumann resonances (SR) (Hungary, India, Japan, Poland, Scotland, Ukraine and USA) have pooled their ELF observational resources to investigate the deformational effects of Energetic Electron Precipitation (EEP) events on the Earth-ionosphere cavity, on both the short time scale (hours) of individual EEP events and on the 11-year solar cycle time scale. Synchronous changes in SR magnetic intensity have been documented at SR stations in opposite magnetic hemispheres. Physical interpretation has relied on the ionization modification of the upper characteristic ('magnetic') height of the SR cavity, but the relative contributions of changes in cavity height and changes in cavity Q-factor remain to be clarified. To improve on the evaluation of the Q-factor contribution, further multi-station study of the solar flare event in September, 2011 studied earlier by Dyrda et al. (2015) is planned.

Work continues with Ashot Chilingarian, Gagik Hovsepyan and Hripsime Mkrtchyan toward resolving Schonland's failure to produce evidence for electron runaway in South African thunderstorms, in marked contrast with the abundance of evidence in mountain thunderstorms in Armenia. Important recent insight has been obtained from discussion with Brian Austin, Schonland's biographer ("Schonland: Scientist and Soldier") who elaborates on Schonland's laboratory experience (1922-1928) with the scattering of cathode/beta rays in a variety of materials (originally under Rutherford's supervision at the Cavendish Laboratory), and his work with C.T.R. Wilson in 1928 on the design of a sensitive ionization chamber leading up to the thunderstorm searches by Schonland (1930) and Schonland and Viljoen (1933).

University of Florida

Z. Ding, V.A. Rakov, Y. Zhu, M.D. Tran, A.Yu. Kostinskiy, and I. Kereszy authored a paper titled “Evidence and inferred mechanism of collisions of downward stepped-leader branches in negative lightning”. Using visible-range and medium-to-far infrared (3-5 μm) high-speed video cameras, they observed collisions of adjacent branches in downward negative stepped leaders. Typically, a lagging (chasing) branch approached a leading branch from aside at about 90° angle and connected to the lateral surface of the leading branch within some tens of meters or less of its tip. This phenomenon (collision of hot channels of the same branched leader) has never been reported before, although collisions of laboratory streamers (e.g., Nijdam, 2011) and streamers in sprites (e.g., Cummer et al., 2006) have been observed. The authors inferred that collisions could be facilitated by the attracting force of upward moving positive-charge wave associated with stepping at the leading branch tip. Outcomes of branch collisions differed. The chasing branch may be absorbed by the leading branch, rebound, or temporarily bridge two branches. It appears that a heavily-branched negative stepped leader creates a highly-structured and rapidly-changing electric field pattern inside the volume it occupies. The paper is published in the Geophysical Research Letters.

N. Kato, J. Yamamoto, Y. Baba, T.H. Tran, and V.A. Rakov, as part of long-term collaboration between Doshisha University, Japan, and the University of Florida, authored a paper titled “FDTD simulations of LEMP propagation in the earth-ionosphere waveguide using different lightning models”. Vertical electric fields (including skywaves) produced by lightning return strokes at distances ranging from 100 to 958 km have been computed using the finite-difference time-domain (FDTD) method in the 2-D spherical coordinate system. The return stroke was represented by the original transmission-line (TL) model (with no current decay with height and abrupt current termination at the channel top), the modified TL model with linear current decay with height (MTLL model), the modified TL model with exponential current decay with height (MTLE model), or the Hertzian dipole (HD) model. All the TL-type models include propagation delay, while in the HD model (still used in LEMP calculations), current changes with time, but does so simultaneously in all channel sections; that is, without any propagation delay. The HD model predicts considerably higher fields than the TL-type models, if the same channel length (7 km) is employed. The HD model with an unrealistically small channel length of 0.7 km generates electric field peaks similar to those produced by TL-type models with a 7-km channel. Ground waves and skywaves computed using the HD model have faster rise and decay times (shorter pulse widths) than those computed using a TL-type model. Electric fields produced by a longer-risetime current are less attenuated due to propagation over lossy ground when a TL-type model is used, while they are more attenuated if the HD model is employed. The opposite trends are related to the fact that the radiation field peak is proportional to the product of the current and propagation speed for a TL-type model, while for the HD model it is proportional to the product of the time derivative of current and channel length. In the TL model, abrupt termination of significant current at the channel top results in the so-called mirror image (abrupt radiation field polarity change). This artefact does not occur in the framework of the MTLL model and is negligible in the MTLE model with $\lambda = 2$ km and $H = 7$ km. The paper is published in the IEEE Transactions on EMC.

Vaisala

Recent history of upgrades to the U.S. National Lightning Detection Network. The U.S. National Lightning Detection Network (NLDN) underwent a complete sensor upgrade in 2013 followed by a central processor upgrade in 2015. These upgrades produced about a factor-of-five improvement in the detection efficiency of cloud lightning flashes and about one additional cloud pulse geo-located per flash. However, they also re-aggravated a historical problem with the tendency to misclassify a population of low-current positive discharges as cloud-to-ground strokes when, in fact, most are probably cloud pulses. Furthermore, less than 0.1% of events were poorly geo-located because the contributing sensor data were either improperly associated or simply under-utilized by the geo-location algorithm. To address these issues, Vaisala developed additional improvements to the central processing system, which became operational on November 7, 2018. This paper describes updates to the NLDN between 2013-2018 and then focuses on the effects of classification algorithm changes and a simple means to normalize classification across upgrades.

Lightning occurrence and casualties in U.S. national parks. National park visitors travel primarily to view natural features while outdoors; however, visits often occur in warmer months when lightning is present. This study uses cloud-to-ground flashes from 1999 to 2018 and cloud-to-ground strokes from 2009 to 2018 from the National Lightning Detection Network to identify lightning at the 46 contiguous United States national parks larger than 100 km^2. The largest density is 6.10 flashes per kilometer squared per year within Florida's Everglades, and the smallest is near zero in Pinnacles National Park (Figure 1). The six most-visited parks are Great Smoky Mountains, Grand Canyon, Rocky Mountain, Zion, Yosemite, and Yellowstone. For each of these parks, lightning data are described by frequency and location as well as time of year and day. The four parks west of the Continental Divide have most lightning from 1 July to 15 September and from 1100 to 1900 LST. Each park has its own spatial lightning pattern that is dependent on local topography. Deaths and injuries from lightning within national parks have the same summer afternoon dominance shown by lightning data. Most casualties occur to people visiting from outside the parks' states. The most common activities and locations are mountain climbing, hiking, and viewing canyons from overlooks. Lightning fatality risk, the product of areal visitor and CG flash densities, shows that many casualties are not in parks with high risk, while very small risk indicates parks where lightning awareness efforts can be minimized. As a result, safety advice should focus on specific locations such as canyon rims, mountains, and exposed high-altitude roads where lightning-vulnerable activities are engaged in by many visitors.

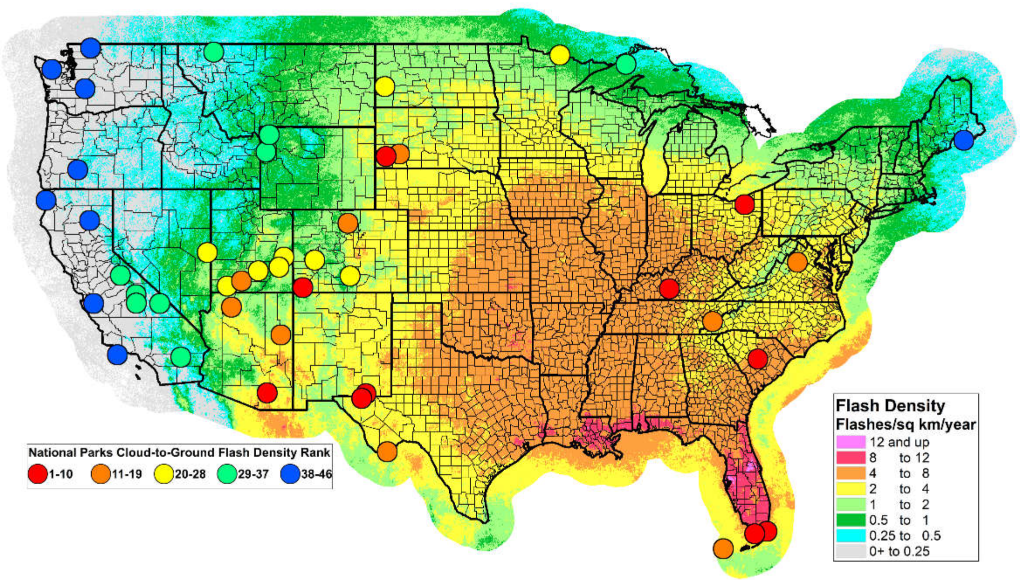

Figure 1. Cloud-to-ground flash density on a 2-km grid from the National Lightning Detection Network for 1999–2018 overlaid with the ranking (color circles) by CG flash density of the 46 contiguous United States national parks larger than 100 km^2. The scale for the national map is in the lower right.

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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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 **2021 fall issue** of the newsletter is **Nov 15, 2021**.

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