ATMOSPHERIC ELECTRICITY

NEWSLETTER

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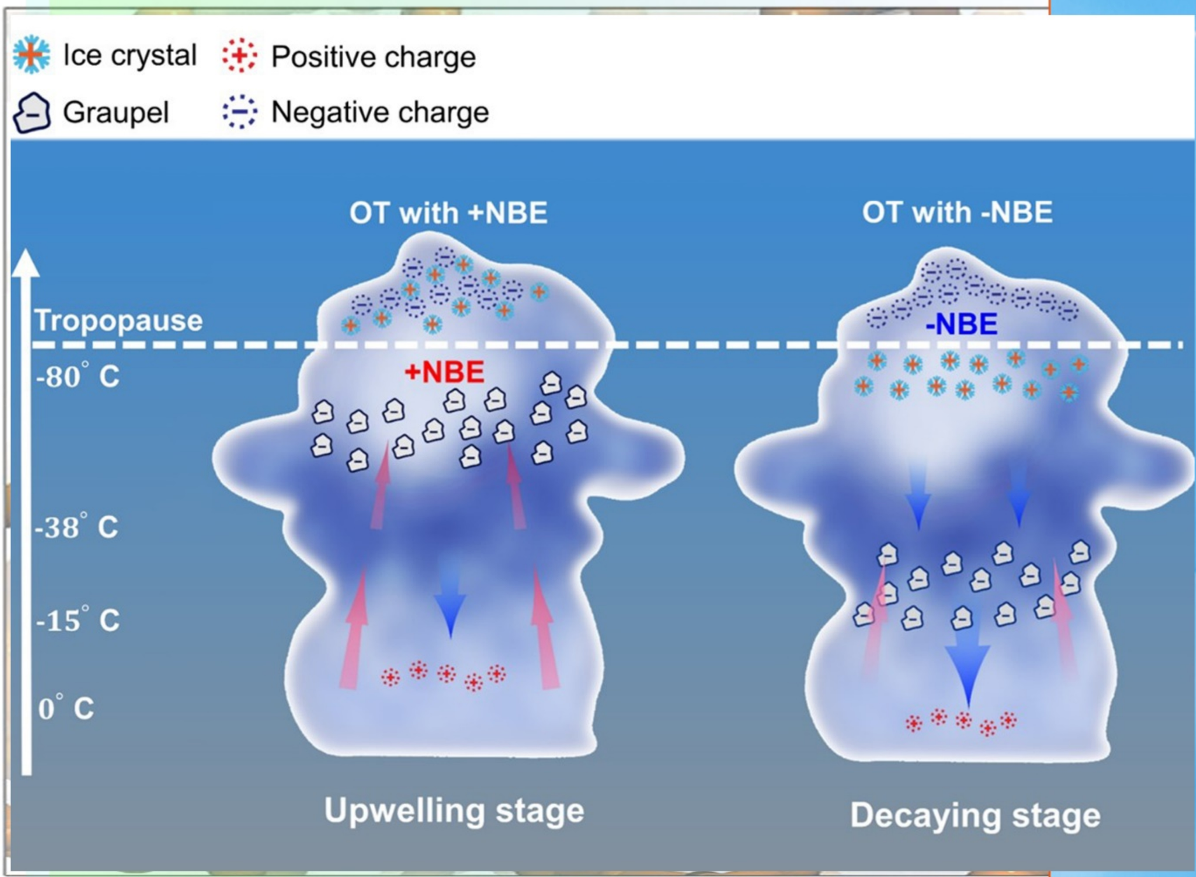

Cover Story :

Narrow bipolar events are often generated in thunderclouds penetrating into the stratosphere. While their production appears to depend on convection, the cause and nature of such discharges are not well known. Liu et al. (2024) show the first observations of unusual amounts of NBEs during a tropical storm on the coastline of China. They find that the dominant polarity of NBEs in the overshooting cloud depends on the phase of the storm cells.

More details refer to Liu, F., Neubert, T., Chanrion, O., Lu, G., Wu, T., Lyu, F., Lyu, W., Köhn, C., Li, D., Zhu, B. and Lei, J., (2024). Polarity transitions of narrow bipolar events in thundercloud tops reaching the lower stratosphere. *Nature Communications*, 15(1), p.7344.

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*B*ACO 2025 Atmospheric Electricity Session M14

M14 Lightning, Thunderstorms and Atmospheric Electricity

Convener(s)

Colin Price (Tel Aviv University, Israel)

Co-Convener(s)

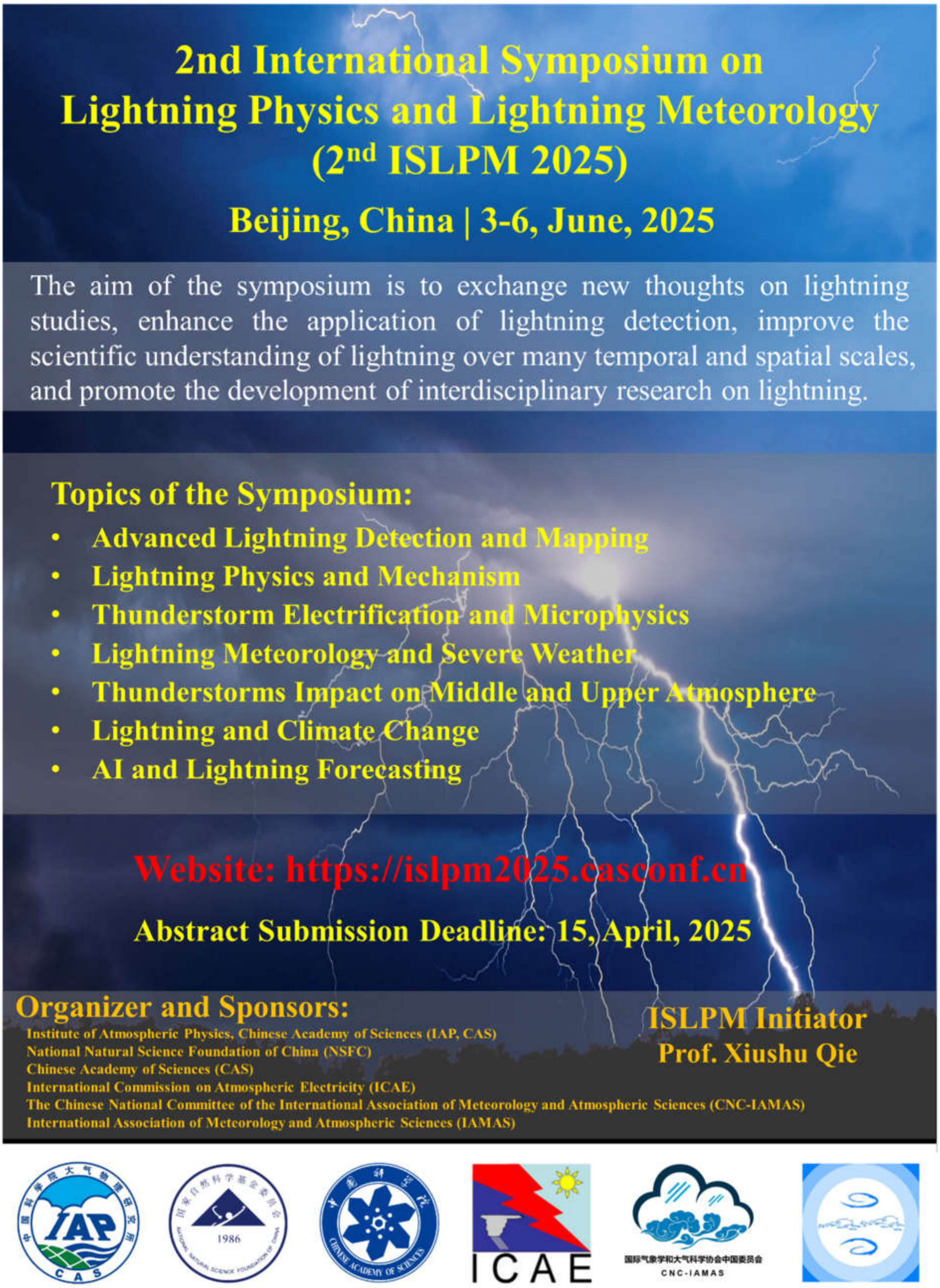
Xiushu Qie (Institute of Atmospheric Physics Chinese Academy of Sciences, China)

Description

Thunderstorms and lightning are closely related to the dynamical and thermodynamic processes in the atmosphere. In addition, global thunderstorms impact fair weather electricity as part of the global electric circuit. The session aims at presenting on-going research activities on thunderstorm electricity as well as the impacts of lightning and thunderstorms on the upper atmosphere and the global electric circuit. Topics of interest cover lightning detection techniques and data processing, observational and modeling-based studies of thunderstorm electricity, lightning-based thunderstorm nowcasting, lightning data assimilation, artificial intelligence (IA) and lightning, effect of lightning on atmospheric composition, TLEs and energetic radiation, fair weather electricity, and the use of lightning records as an essential climate variable. Results from field and laboratory experiments, space observation, theoretical work and numerical modeling are welcome.

Abstract submission open: 16 November 2024 - 15 April 2025.

2nd ISLPM 2025, Beijing, China



*E*GU 2025 Atmospheric Electricity Session NH1.6

*L*ightning Modeling Grand Challenge Roadmap Workshop, 1-3 April 2025, Texas Tech University, Lubbock, Texas, USA

Development of a holistic physical model for lightning is a grand challenge that relies on linking meteorological, chemical, plasma, optical, and radio process models together into a system that can handle physics on scales from millimeters to hundreds of kilometers.

A roadmap outlining a strategy for implementing such a model was developed following a preliminary workshop in 2024, led by a panel of eight who helped author the roadmap document following input from 60 members of the community. The roadmap is available on the workshop website: http://lightning.ttu.edu/workshop/.

The purpose of the 2025 hybrid workshop is to (1) provide a venue to foster community discussion of the roadmap; (2) coordinate the efforts of the lightning physics and meteorology community to review scientific hurdles to progress and discuss solutions, updating the roadmap document; (3) work together in a focused way on pragmatic implementation plans and identification of resources needed to engineer a concrete, interconnected lightning model.

Sessions to introduce the roadmap are planned at the December 2024 AGU Annual Meeting in Washington, DC, USA and at the January 2025 AMS Annual Meeting in New Orleans, LA, USA.

Please indicate your interest in attending on the pre-registration form available on the workshop website. Contact Eric Bruning, eric.bruning@ttu.edu, with any further questions.

APL 2025, 17-20 June, Indonesia

Calling out international students, lecturers, researchers, and professionals!

The 13th Asia-Pacific International Conference on Lightning (APL 2025) will be held in Bali Indonesia on 17-20 June 2025. Started in Beijing in 2003, APL is now a bi-annual lightning conference organized in Asia-Pacific Region. The conference program will feature keynote sessions, technical paper presentations and technical exhibition. Distinguished speakers will be invited to deliver keynote speeches and invited talks on emerging technologies in the field of lightning discharge and lightning protection. Attendees will have the opportunity to interact with experts from all related fields. The aim of this conference is to bring together academicians, students, researchers and practicing engineers from all over the world to present emerging topics on emerging technologies in the field of lightning discharge and lightning protection.

This year, Engineering Research and Innovation Center (ERIC), Faculty of Engineering, Universitas Gadjah Mada held the 13th Asia-Pacific International Conference of Lightning (APL 2025). We are pleased to invite you to register yourself for the conference.

Important dates:

Submission of Full Paper Deadline: January 17, 2025

Notification of Acceptance: March 19, 2025

Early Bird Registration Deadline: March 31, 2025

Normal Registration Deadline: May 19, 2025

Camera Ready Deadline: May 19, 2025

Conference Date: June 17-20, 2025

Submission Guidelines:

The submitted full-paper must not be currently under review in any other conference or journal and has not been previously published. All papers submitted to the APL 2025 must be written in English and using the IEEE Templates to prepare your paper (use A4 only).

All papers must be submitted electronically through EDAS Conference papers submission system. If you do not have EDAS account, please create an account to submit your contribution. It is suggested that you use Firefox or Chrome instead of Internet Explorer. The decision regarding the acceptance of the papers is at the discretion of the Technical Program Committee.

For more information check our website https://apl.ugm.ac.id.

Should you have any further questions or require additional information, please do not hesitate to contact us at apl@ugm.ac.id.

We look forward to welcoming you to 13th Asia-Pacific International Conference of Lightning (APL 2025). Thank you.

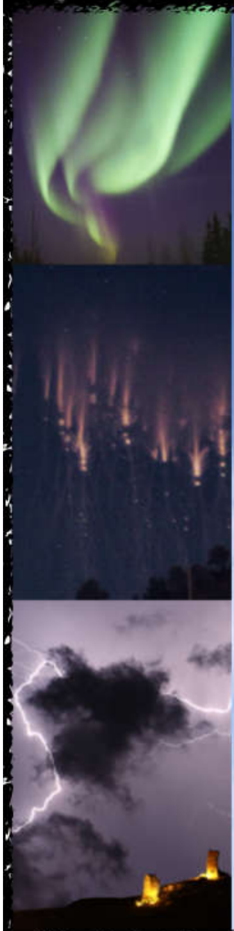
Best Regards,

Ir. Lesnanto Multa Putranto, S.T., M.Eng. Ph.D., IPM., SMIEEE

General Chair of the APL 2025

*I*AGA 2025, Lisbon

IAGA in Lisbon, August 31st - September 5th, 2025



AC/DC Global Circuit for Atmospheric Remote Sensing

This session explores the remote sensing of the atmosphere from the boundary layer up to the lower ionosphere with AC global circuit measurements, such as extremely low frequency radio waves, and DC global circuit measurements, such as the atmospheric electric field, air-earth current and air conductivity. These observations, corresponding theories and simulations enable studies of the impact of thunderstorms and lightning on the Earth's atmospheric layers. The session solicits contributions which advance knowledge in the areas of the global electric circuit, including thunderstorm quasi-static electric fields, Schumann Resonances, lightning discharges and their electromagnetic radiation including continuing current, transient luminous events, terrestrial gamma ray flashes and narrow bipolar events. Interdisciplinary studies which emphasize the connection between atmospheric layers and climate change on all time scales are particularly welcome.

Program:

- Thunderstorms - quasi-static electric fields, thunder days/hours
- Lightning and its effects on the mesosphere and ionosphere
- Transient Luminous Events and Terrestrial Gamma Ray Flashes
- Coupling of atmospheric layers
- Relations of AC/DC global circuit to climate and change on all time scales
- Solar-Terrestrial Relations and Space Weather

Conference website: https://iaga-iaspei-lisboa-2025.isel.pt
Abstract Deadline: March 12th, 2025
Registration Deadline: May 21st, 2025

*S*pecial issue in *Atmosphere*: Atmospheric Electricity

atmosphere

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Atmospheric Electricity (2nd Edition)

Guest Editors:

Prof. Dr. Masashi Kamogawa
Global Center for Asian and Regional Research, University of Shizuoka, Shizuoka 420-0839, Japan

Prof. Dr. Yoav Yair
School of Sustainability, Reichman University (IDC Herzliya), 8 University Street, Herzliya 4610101, Israel

Deadline for manuscript submissions:
20 March 2025

Message from the Guest Editors

This Special Issue is the second edition of the Special Issue entitled "Atmospheric Electricity" (https://www.mdpi.com/journal/atmosphere/special_issues/atm published in *Atmosphere*; it will cover all aspects of atmospheric electricity issues.

Although atmospheric electricity has a long research history, epoch-making discoveries have been made in each period. In recent decades, lightning/thunderstorm-induced energetic radiation, transient luminous events such as sprites and elves, as well as terrestrial gamma-ray flashes, have been discovered.

This Special Issue on atmospheric electricity is, therefore, open for submissions of multidisciplinary and various other studies focused on a conventional research field, such as global electric circuit, lightning physics, aerosol and cloud microphysics, and thunderstorm electrification, as well as a modern research field, such as lightning/thunderstorm-generated energetic radiation, transient luminous events, and the evolution of the Earth's climate.

mdpi.com/si/197898

Special Issue

*P*osition of Post-Doctoral Researcher at Institute of Atmospheric Physics of the Czech Academy of Sciences

As the lightning group at Institute of Atmospheric Physics (IAP) of the Czech Academy of Sciences is involved in several lightning projects now, we offer a position of Post-Doctoral Researcher in this field. The conditions of the call are described below.

Requirements:

- Ph.D. in physics, atmospheric sciences or related disciplines, received in 2019 or later
- Demonstrated publication activity
- Experience in the relevant research field
- Active knowledge of the English language
- Computer programming and data analysis skills

The preferred topics include (but are not limited to):

- Atmospheric electricity: analysis of ground based/spacecraft electromagnetic and optical data related to different lightning phenomena,
- Advanced modelling of lightning phenomena, application of AI to larger data sets

We offer:

- Start date: 1 February 2025 or later
- Full-time employment
- 2-year contract with a possibility of extension
- Opportunity to work with unique dataset of broad-band ground based electromagnetic waveform measurements obtained by the Department of Space Physics at 8 sites in Europe (Czechia, France, The Netherlands, Slovakia)
- Supportive scientific working environment
- Competitive financial compensation

Candidates should submit:

- curriculum vitae with list of publications,
- brief (1 page maximum) summary of their proposed work program for 2 years
- copy of their PhD diploma

Contact person for queries regarding applications: Dr. Ivana Kolmasova, e-mail iko@ufa.cas.cz.

Applications should be sent to: iko@ufa.cas.cz.

Deadline for applications: **31 January, 2025.**

African Centres for Lightning and Electromagnetics Network (ACLENet)

Lightning continues to have major impacts in Africa as indicated by two recent mass casualty events. ACLENet sent teams to document both incidents that are available at https://aclenet.org.

On 31 July 2024, lightning struck at or near a school and injured 77 students and faculty in Uganda (Figure 1). Several schools sent teams from the area to Nebbi School to have a soccer (football) tournament. When rain started, many people sought refuge from the rain but not the lightning inside a building while others stood under the overhanging eaves of the school building roof. Some of the injuries may be lifelong. Several parents of visiting schools blamed Nebbi school for calling down lightning onto the students.

In November, lightning struck a church in a refugee camp in Udanda and killed 14 people and injured 34 more. The victims were children rehearsing music in the open when it started to rain and they sought shelter inside a tin-roofed food distribution storage structure with bamboo walls. Two additional events with multiple casualties in Uganda refugee camps are known to have occurred in the last two years.

Figure 1. Nebbi school in Uganda where many of the 77 students and faculty were injured by lightning on 31 July 2024. Red flags indicate the locations of the injured pupils and teachers.

Besides these high-profile events, lightning continues to affect large numbers of people in Africa in events with one or a few people killed or injured, as listed in the ACLENet Newsletter for each month. Essentially none of the public or private buildings in Africa have lightning protection but ACLENet has recently completed the fully vetted lightning protection system for a 9th school in Uganda. At this time, 18,500 students have been protected by these installations over the last decade.

CMA Key Laboratory of Lightning, State Key Laboratory of Severe Weather, Chinese Academy of Meteorological Sciences, Beijing, China

Does the scenario of connection between the positive leader tip and the lateral surface of the negative leader exist? In the lightning attachment process, the leader connecting behavior is an interesting topic. In the attachment process of a negative CG lightning flash, the "Tip to Tip (negative leader tip to positive leader tip)" and "Tip to the lateral surface (negative leader tip to the lateral surface of positive leader)" connection types have been widely observed, and researchers have carried out a series of studies and discussions on the characteristics and the physical mechanisms of the leader connecting behavior. However, is there an opposite polarity connection type, like "the lateral surface and tip (the lateral surface of negative leader and positive leader tip)" connecting behavior?

Based on the high-speed video observations obtained at the Tall-Object Lightning Observatory in Guangzhou (TOLOG), the attachment processes of three lightning flashes seem to belong to the connections between "the lateral surface of negative leader and positive leader tip" which had never been reported before were investigated. The leader connection processes of these flashes were examined in detail, and a mechanism behind connecting behavior between the lateral surface of negative leader and positive leader tip was discussed. In –CG lightning flash, negative leaders usually have abundant branches. Although some may extinguish, they still maintain a certain conductivity. When the positive leader tip comes close to the lateral surface of the negative leader (usually a few tens of meters), the previously disappeared short branch can be reactivated. It is easier for the positive leader tip to connect the tips of these branches (whether they have been extinguished or not).

To explain the mechanism behind this phenomenon, the schematic diagram of the positive leader tip connecting to the tip of the negative leader branch is presented in Figure 1.

Based on former research and this study, we believe that in the final attachment process, the negative leader is more "active" compared to the positive leader. Whether it is in a -CG lightning flash or a +CG ground lightning flash, for the connection between negative and positive leaders during the attachment process, there are common "tip-to-tip" and "tip-to-lateral surface" types, and until now, no convincing "lateral surface and tip" type is observed. It should be noted that all the lightning cases reported in this study are from high buildings, and upward connecting leaders can propagate much longer. For an ordinary building, a branching downward negative leader could induce many short-connecting leaders, and the leader connection has a strong possibility of ending with a common "tip-to-tip" type.

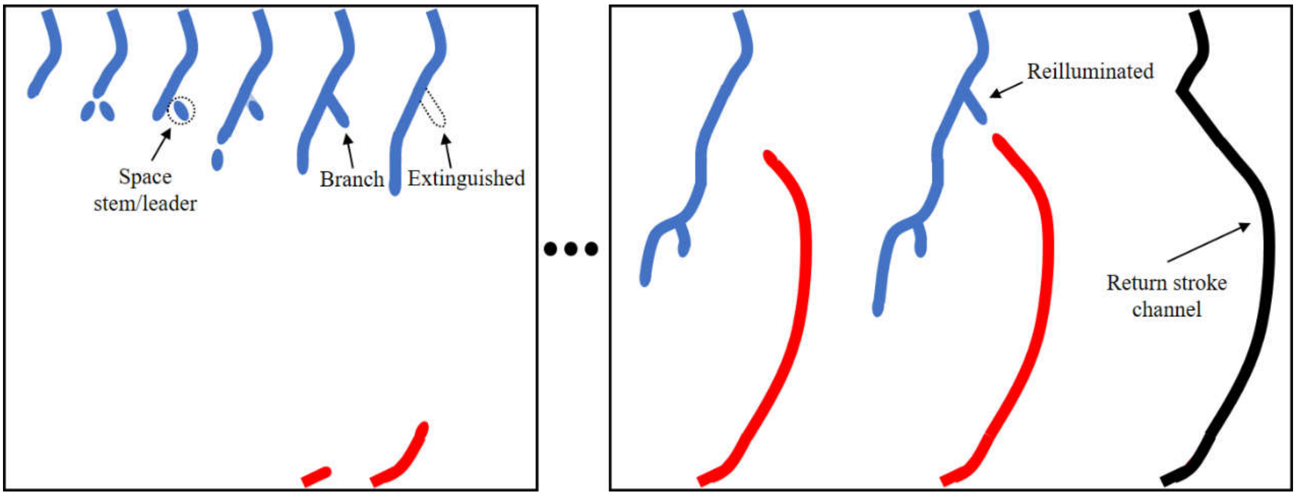

Figure 1. The schematic diagram of the positive (red) leader tip connects to the tip of the negative (blue) leader branch, which was once extinguished and then reilluminated. A space stem/leader (in the dashed circle) connects to the existing leader channel (lateral surface) via a low-level luminosity region, which becomes bright, evolving into a new short negative leader branch, then it will be extinguished. When the upward positive leader tip is close enough to the lateral surface of the negative leader, the negative leader branch may reilluminate and finally connect to the positive leader tip, ending as a return stroke.

Interactions and multifrequency radiation characteristics of bidirectional leaders in altitude-triggered lightning. Altitude-triggered lightning provides favorable conditions for the research of bidirectional leader system. In the summer of 2023, altitude-triggered lightning experiment was conducted on the Field Experiment Base on Lightning Sciences, China Meteorological Administration. The multifrequency radiation characteristics of bidirectional leaders and the interactions of both ends during the propagation are analyzed. Specifically, the discharge processes that produce LF-MF magnetic radiations from bidirectional leaders are revealed by high-speed images, and these LF-MF radiations correspond to the VHF radiations generated by bidirectional leaders well. Unlike the strong correlation between LF-MF radiation strengths and discharge intensities, the VHF radiation strengths exhibit significant variation even among similar-intensity discharge events, as VHF radiations correspond to the random and microscopic discharge processes associated with streamers. Furthermore, the changes in leader speed and channel brightness before and after the initiation of bidirectional leaders indicate that the development of the two ends of bidirectional leaders is mutually reinforcing.

Future increase in lightning around the South China Sea under climate change. The impact of global warming on lightning flash rates remains relatively unknown. In this study, the South China Sea (SCS) and the surrounding areas within Southeast Asia were selected to examine the long-term trend and future projection of lightning activity based on the currently longest satellite-based lightning data set available and climate models. Our study revealed a reduction in the observed lightning flash rates around the SCS, with a linear trend of -0.11 fl km^{-2} yr^{-2} during 1996–2013. In contrast, the precipitation around the SCS exhibited an increasing trend and was negatively correlated with the local lightning flash rate. The sea surface temperature gradient over equatorial Pacific Ocean, latent heat flux over the equatorial Indian Ocean, local convective available potential energy, precipitation and aerosol changes collectively accounted for 82% of the variance in the lightning fluctuations over the SCS and Southeast Asia. Multiple linear regression proxies of lightning flash rates were constructed and applied to the climate models. The models indicated that lightning activity around the SCS is projected to intensify by 10% and 12% by the end of the 21st century under SSP245 and SSP370, respectively.

Department of Space Physics, Institute of Atmospheric Physics of the Czech Academy of Sciences

Contributed by Ivana Kolmasova

The collaboration between the Institute of Atmospheric Physics of the Czech Academy of Sciences (IAP) and the Laboratory of Physics and Chemistry of the Environment and Space (LPC2E), Orleáns, France in the frame of the **STRATELEC** (STRatéole2 ATmospheric ELECtricity) project led by Eric Defer from the Laboratoire d' Aerologie, CNRS, Toulouse, France resulted in the preparation of the instrumentation package for the next stratospheric CNES balloon campaign **STRATEOLE2**.

XSTORM instrument developed at LPC2E will detect high-energy radiation in the stratosphere, focusing on gamma ray glows and terrestrial gamma ray flashes (TGFs) produced by thunderstorms. Two types of scintillators will be used: BGO and EJ-276. The scintillation particle detector will time-tag each count.

RIP (Radio Instrument Package) developed at IAP will measure radio-frequency signals emitted by different lightning processes and lightning-induced phenomena using a broadband digital FPGA-based radio receiver. Combined electric field sensors will be able to measure the quasi-electrostatic electric fields in the low frequency band as well.

Science questions to be answered are based on simultaneous RIP and X-STORM measurements.

- *At which stage of the evolution of individual lightning flashes are the Terrestrial Gamma ray Flashes (TGF) produced?*
- *Which types of intracloud discharges produce detectable high-energy radiation?*
- *What are the temporal variations of electromagnetic emissions linked to the gamma glows?*
- *Are the flickering TGFs really radio silent?*

To prepare the training dataset for the neural network dedicated for the onboard recognition of different lightning phenomena based on the radio waveforms we are now intensively working on the analysis of the data recorded by the radio receivers operated by IAP at several places in Europe.

HUN-REN Institute of Earth Physics and Space Science, Sopron, Hungary

Contributors: József Bór, Gabriella Sátori, Tamás Bozóki

A new Schumann-resonance (SR) monitoring station has been established in Hungary, relatively close to the western border of the country towards Austria, in the Arboretum of Jeli (47.08 N, 16.89 E). The horizontal components of the atmospheric magnetic field are recorded by a LEMI-423 data acquisition system of 24 bits. The signals from two LEMI-120 magnetic induction coils are digitized and recorded at a sampling rate of 250 Hz. The coils have been oriented in the geographical north-south (NS) and east-west (EW) directions, taking into account the actual declination of the geomagnetic field in the west part of Hungary. The location was selected considering the safety of the measuring system, and test measurements confirmed the suitability of the site for making ELF-band radio observations. The system has been in operation since September 4, 2024. Example spectrograms of the two field components are presented in Figure 1. The first 4 and 5 SR modes appear fairly clearly at around 8, 14, 20, 26, and 32 Hz in the EW and NS field components, respectively. In all SR modes, the intensity of the EW field component peaks at 13-16 UTC when the African lightning chimney is the most active. At the same time, the intensity has a local minimum in the NS field component. The NS field component has intensity peaks in the 7-12 UTC and 20-24 UTC time intervals on this day, which corresponds to the usual activation time of the Indonesian and American lightning chimneys, respectively. The quasi-constant peak at 16.66 Hz is there due to the electrified railway lines in Austria. This new station will be used to complete the data of the long-time-running first SR monitoring station in Hungary near Nagycenk (NCK, Sátori et al., 1996; Bór et al., 2020, doi:10.5194/hgss-11-53-2020), where only the electric field component is suitable for SR research recently due to the strong ambient noise (Bozóki et al., 2021, doi:10.55855/gor2020.2). This station has been established in the framework of the project “Elaboration of new methods for studying the near-Earth environment by extremely low frequency radiation of lightning strokes” (NKFIH K138824) and will serve the corresponding research work.

We studied the relationships between the variations of SR peak frequencies of the first three resonance modes and the global/regional lightning dynamics based on long-term SR observations of the vertical electric (E_Z) field component in the Széchenyi István Geophysical Observatory at Nagycenk (NCK), Hungary (Sátori et al., 2024). Variations of the peak frequencies were considered on the annual, seasonal and diurnal time scales as well as during a specific event when squall-line formation of lightning activity in South America moved toward NCK. We interpreted the frequency variations with model calculations and supported them with satellite (OTD/LIS, GLM) observations. Daily frequency ranges (DFRs) were studied in relation to the El Niño Southern Oscillation (ENSO). Increasing area of lightning activity in mid-high Northern hemisphere latitudes has been identified by DFR variations during the transition from warm to cold episodes of the ENSO in 1998 and 2010. The extension of the lightning area was considered as a consequence of energy released in the tropics and exported to higher latitudes with some months of delay from the end of the El Niño episodes. These results emphasize the importance of SR peak frequency observations in climate research.

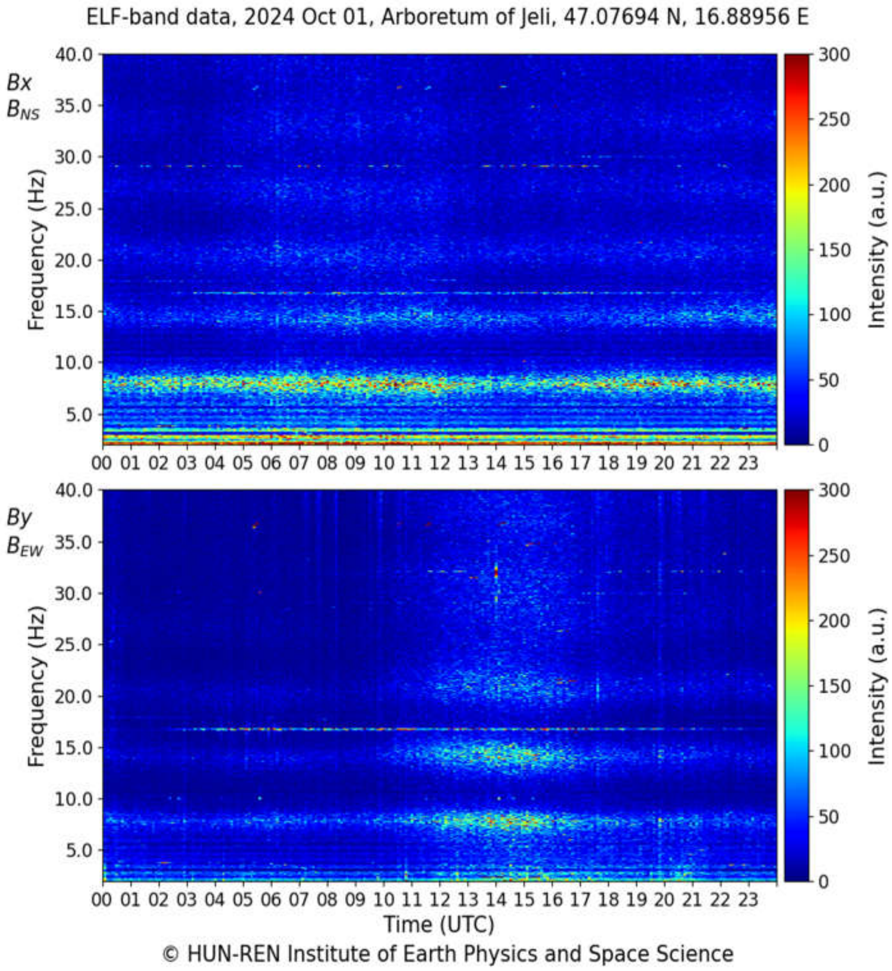

Figure 1. Variation of the spectral content in the horizontal magnetic field components on October 1, 2024, in the Arboretum of Jeli, Hungary. The intensity scale shows the squared spectral amplitudes obtained from 6-minute-long time windows.

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

The 20th Anniversary of the SHAndong Triggering Lightning Experiment (SHATLE) and the Yellow River Delta Weather Modification Symposium was successfully held in Binzhou City, Shandong Province, China on 24-26 November 2024 (Figure 1). More than 150 experts and scholars in the research fields of atmospheric and space electricity, meteorology, and weather modification from more than 30 academic research and operational units attended the symposium. The symposium reviewed the 20-year history of triggering lightning research in Shandong, and the achievements in the technology development of a dedicated lightning triggering rocket system and comprehensive lightning detection systems, the findings on critical parameters of lightning strike, the insights into the physical characteristics and mechanisms of various lightning discharge processes, the applications of lightning data, the testing of lightning protection technology, and so on. The symposium featured discussions and exchanges on the latest advances in lightning and its effects, weather modification science and technology, and the intersection of atmospheric physics and atmospheric chemistry.

Figure 1. Conference photo.

A new lightning data assimilation scheme has been implemented in the WRFDA. Lightning is closely related to updrafts of thunderstorms, providing extra convective information for forecasts and warnings of severe weather. In this lightning data assimilation (DA) scheme, the lightning flash rates are converted to the maximum vertical velocity using an empirical relationship. Such kinematic information is further expanded in vertical direction guided by a normalized profile of vertical velocities. The lightning-derived profiles of vertical velocity can be directly assimilated with the control variable of *w*. Another way is to assimilate pseudo divergence, converted from vertical velocity, to adjust the horizontal winds with the control variables of *u*/*v*. Additionally, a scheme to assimilate pseudo water vapor (*qv*) inferred from lightning flash rates is also added. In this humidity assimilation scheme, the mixing ratio profiles of pseudo *qv* are retrieved from the locations where a rapid increase in lightning flash rate is detected. The new features are implemented in the newly released WRF model (WRF-V4.6; https://github.com/wrf-model/WRF/releases).

Charge structure and lightning discharge in a thunderstorm over the central Tibetan Plateau. The evolution of charge structure involved in lightning discharge of a thunderstorm over the central Tibetan Plateau is investigated for the first time, based on the data from very high frequency interferometer, radar and sounding, which are summarized in Figure 2. At the initial stage, the radar reflectivity exceeding 30 dBZ is located primarily below the level of −15°C. A shallow WCD suppressed the droplet growth resulting in more small droplets being lifted into the mixed-phase region to form ice-phase particles such as graupel and ice crystals. Under certain conditions, graupel particles gain positive charge from roughly 0°C to -10°C level in the mixed-phase region. At the mature stage, a bottom-heavy tripole charge structure is clearly presented, with a strong lower positive charge center (LPCC) at temperatures above -10°C, a middle negative charge region between -30°C and -15°C, and an upper positive charge region at T < -30°C. As the LPCC was depleted, the charge structure evolved into a normal tripole with a pocket LPCC. The merging between different convective cells resulted in the formation of two adjacent negative charge regions located directly and obliquely above the LPCC, and horizontally arranged different charge regions were simultaneously involved in the same lightning discharge. At the late-mature stage, the magnitude of LPCC was gradually weakened due to the positive charge carriers (graupel or hail) converting into liquid drops and falling to the ground. The thunderstorm demonstrated a tripolar charge structure with a main negative charge region between −15°C and −30°C levels, a pronounced upper positive charge region (T < −30°C) and a pocket LPCC

(T > −10°C). Consequently, lightning discharges initiated in the lower inverted dipole structure occurred frequently and the negative leader easily reached the ground from the weak bottom positive charge region, generating more -CG flashes. (Liu et al., 2024, Geophysical Research Letters)

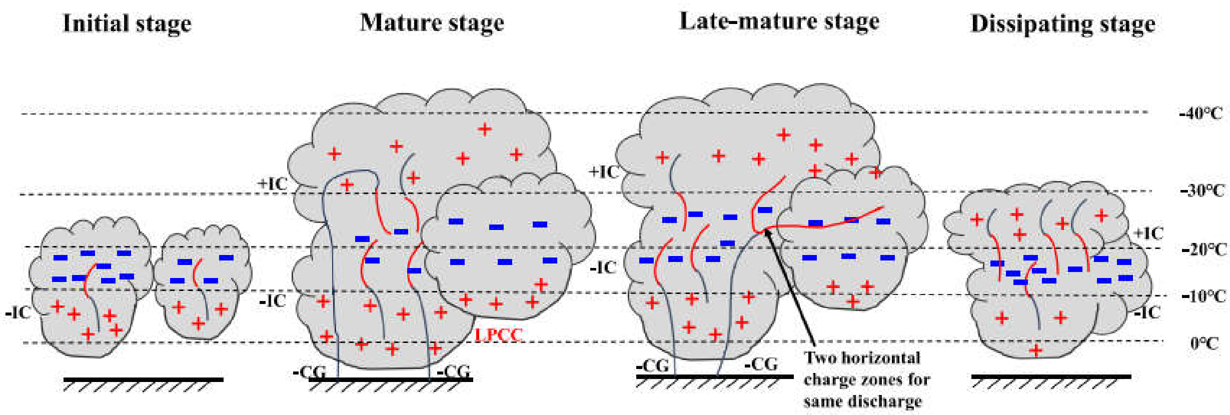

Figure 2. Schematic diagram of the evolution of the charge structure and the different types of lightning discharge. Blue “-” and dark red “+” stand for the negative and positive charge regions, respectively. Red (blue) lines represent the positive (negative) lightning channels and black dashed lines indicate the environmental temperature.

Concurrence of high dust aerosol and stratosphere-intruded ozone pollution in super sandstorms. Air quality in China has been substantially improved in recent years, however, sustained increases in surface ozone (O_3) are observed. There are still occurrences of complex heavy pollution episodes that have close linkage with weather. Two severe sandstorms occurred successively in the early spring of 2021 in north China, producing record-breaking values of dust aerosols and extreme low visibility. Along with the arrival of sandstorms, surface O_3 also increases substantially, despite the unfavorable environmental conditions for O_3 photochemical reactions such as high wind speed and reduced solar radiation. Based on in-situ observations, meteorological reanalysis data and trajectory model, it is found that the stratospheric origins of airmass penetrating southeastward and downward into north China during the severe sandstorms (Figure 3). The stratosphere-intruded O_3-rich airmass directly promote the surface O_3 concentrations, but reduced other gaseous pollutants such as CO, NO_2 and SO_2. Though multiple studies have been conducted to reveal the synoptic reasons for the sandstorm outbreaks, the impact of stratospheric intrusions associated with Mongolian cyclones on air quality during sandstorms is often ignored. Thus, this study can provide some new insights into the air quality changes during the sandstorms. (Chen et al., 2024, Science Bulletin)

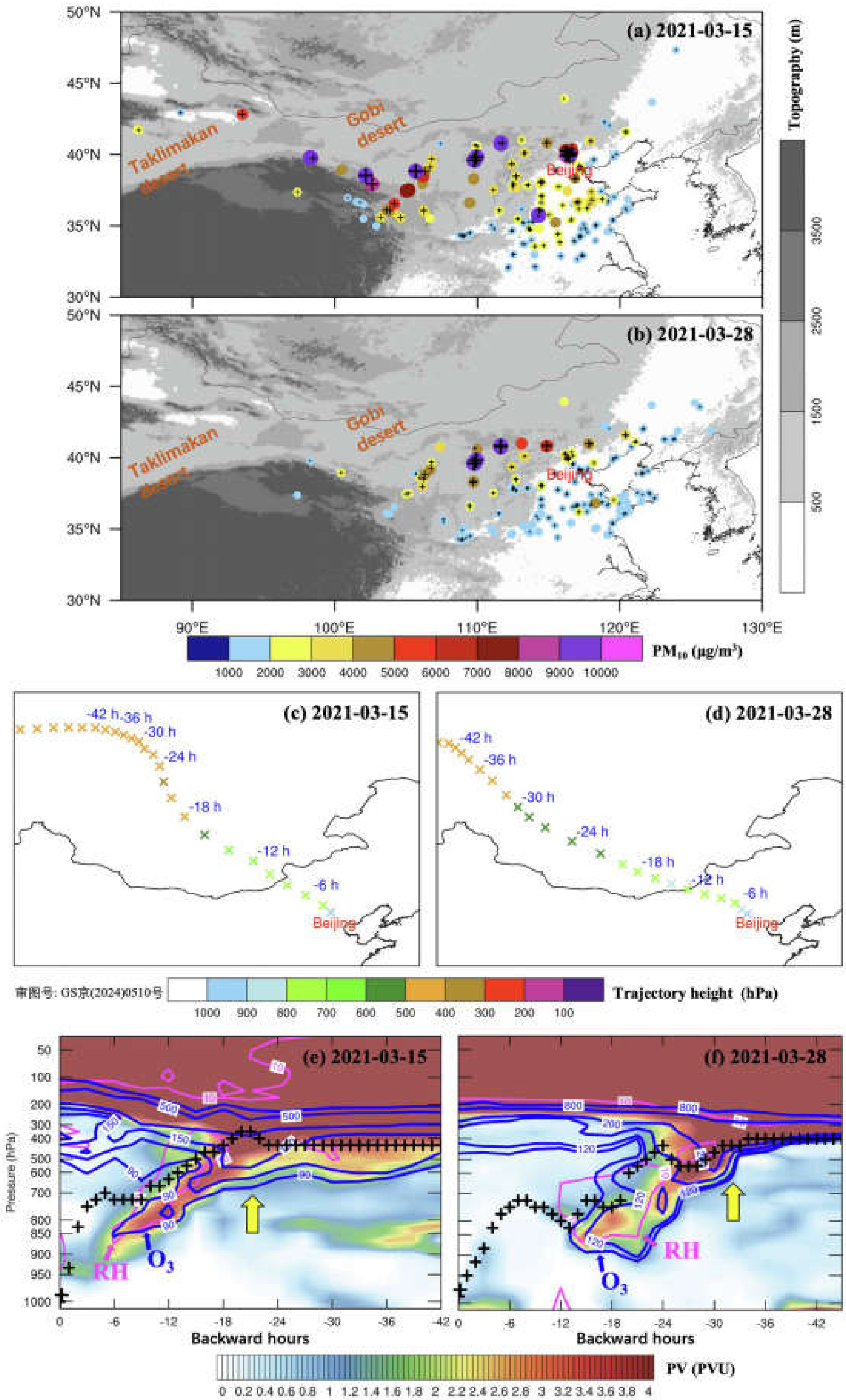

Figure 3. Maximum values of surface PM10 concentrations during two successive sandstorms (color-coded circles, unit: μg/m^3) on (a) 15 March and (b) 28 March 2021. The "+" symbols within the color-coded circles indicate a pronounced increase in O_3 and decrease in CO when the PM10 concentration peaked at each station. The topographic distributions in North China are shown by the shaded gray contours (unit: m). (c–f) The transport pathways and vertical potential vorticity (PV)

structure of air parcels that reached Beijing when sandstorms arrived on 15 and 28 March 2021 based on the HYSPLIT trajectory model. In (c, d), the horizontal trajectory position and pressure height (unit: hPa) are shown by the color-coded "×" symbols, and the backward travel time is shown in the blue text. In (e, f), the temporal evolution of the vertical structures of PV (shaded, unit: PVU; 1 PVU = 10^{-6} $m^2K/(s\ kg)$), O_3 concentration (blue lines, unit: ppbv) and relative humidity (RH; magenta lines, unit: %) in each backward travel hour along the trajectory are extracted from the MERRA-2 reanalysis data. The black "+" symbols represent the vertical location of each trajectory position in each backward travel hour, and the yellow arrows indicate the time when stratospheric air detached from the upper troposphere and lower stratosphere (UTLS) regions.

Initiation of downward positive leader beneath the negative leader channel. Positive cloud-to-ground flash attracts more attention than its negative counterpart because it is more hazardous. Previous studies have confirmed the close relationship between intracloud (IC) lightning and positive cloud-to-ground (+CG) lightning. Downward positive leaders forming +CG can originate from branching of intracloud lightning or even from negative polarity leader channels. However, due to the weak radiation from positive leaders during their development within the cloud, common lightning detection devices, such as LF/VLF fast antennas and VHF antennas, find it very difficult to detect positive leaders. Consequently, our understanding of how positive leaders initiate within the cloud and reach the ground remains limited. In this study, we comprehensively utilized lightning channel mapping results and high-speed video to investigate a case of +CG. We found that the occurrence of downward positive leaders around the negative leader channel is facilitated through multiple side breakdowns, events that continue even after the return stroke. Therefore, we propose that the multiple positive side breakdowns beneath the reactivated negative leader channel are responsible for generating positive leaders from the negative lightning channel. These side discharges play a crucial role in the generation of +CG lightning. (Zhu et al., 2024, Geophysical Research Letters)

Israel Atmospheric Electricity Group: Reichman University, Tel Aviv University, Hebrew University of Jerusalem and Ariel University

Prof. Colin Price (Tel Aviv University) with undergraduate students Aviv Shay have been studying the impact of lightning and thunderstorms over Europe on commercial airlines flight paths. This is part of a NATO project looking at big data cubes and the combination of large data sources from many different disciplines (https://cube4envsec.org/). We are analyzing the climatological lightning activity around key airports in Europe, while analyzing whether detours in flight paths in fixed routes are linked to thunderstorms on those days.

Prof. Colin Price (Tel Aviv University), **Prof. Yoav Yair** (Reichmann University) and **Dr. Eric Defer** (CNRS) are part of a project to launch two small satellites to simultaneously look at clouds and thunderstorms. The joint French-Israel project called C3IEL (https://asri.institute/space-missions/c3iel/) will be launched in 2028 and will have two small satellites with lightning optical sensors to observed lightning at spatial resolutions of 150 meters during day and night. The additional scientific instruments on the C3IEL satellites will be studying cloud updraft velocities and water vapor around the storms.

Prof. Colin Price (Tel Aviv University) together with postdoc **Prof. Assaf Shmuel** (Bar Ilan University) have carried out a study using machine learning to estimate the probability of lightning fires around the globe. The study uses thunder-hour data together with satellite fire data to differentiate between anthropogenic and lightning-caused fires. The study also investigates the changes expected in lightning-caused fires due to climate change (https://www.arxiv.org/abs/2409.10046).

Prof. Yoav Yair is working with PhD student **Menahem Kurzets** on the data obtained from the ILAN-ES campaign conducted on board the AX-3 mission (completed in February 2024). The summary of data from both missions is listed below. The latest results on Blue Corona Discharges (BLUEs) were published in Yair et al. (2024) and two additional papers are pending submission.

	Mission Duration	Targets Uploaded	Targets Executed	Observation Time	TLEs detected
AX-1	9.4 - 25.4.2022 15 days (ISS)	82	46	2 h 17 min	9 sprites, 7 Elves 1 halo > 45 BLUEs
AX-3	8.1 – 9.2.2024 18 days (ISS)	80	24	2 h 16 min	9 sprites, 3 Elves 2 blue jets, 2 halos > 50 BLUEs

Dr. Roy Yaniv together with **Dr. Asaf Hochman** (Hebrew University of Jerusalem) and **Prof. Yoav Yair** (Reichman University) worked on the relationship between Potential Gradient changes and the passage of cold fronts of Cyprus Lows in southern Israel, and found a potential relationship that may enable predicting flash floods due to such weather systems. The results were published recently in *Atmospheric Research*.

Dr. Yuval Reuveni (Ariel University) with MSc. student **Nadav Mauda** collaborate with **Prof. Yoav Yair** (Reichman University) are finalizing their study on Thunderstorm Ground enhancement (TGE) signatures using gamma ray and atmospheric electric field measurements recorded at the Emilio Segre Cosmic Ray observatory on Mount Hermon (altitude 2040 m ASL). This study examines two TGE events observed in January 2018 at Mount Hermon, Israel, under rain-free conditions to exclude radon washout/rainout effects. Both events showed gamma-ray peaks (3,500 counts/min on January 4–6 and 1,600 counts/min on January 14) coinciding with electric field fluctuations. Notably, while negative electric fields typically drove gamma-ray enhancements, the January 14 event featured a positive field due to a lower positive charge region (LPCR). Spearman analysis revealed significant disruptions in gamma-ray and cosmic-ray relationships during TGEs. Lightning showed no direct correlation, emphasizing the role of electric fields and cloud charge dynamics in gamma-ray production. A paper will be submitted for publication in the coming weeks.

Dr. Yuval Reuveni (Ariel University) with Ph.D. student **Muyiwa Paul Ajakaiye** are finalizing their study on Imprints of intense geomagnetic storm on Low Frequency (LF) radio waves over the Mediterranean region. They studied the impacts of the 23-24 March 2023 geomagnetic storm (GMS) observed from VLF/LF measurements conducted from Ariel University. We applied several methods including the cross-wavelet coherence (WTC) correlation as a novel method to detect obvious and underlying impacts of the storm on the ionospheric D-region. Their findings include varying degrees of signal enhancement (attenuation) during distinct progression phases of the storm. They noted the existence of significant delay or time misalignment in the D-region responses to magnetosphere-ionosphere changes due to energy deposits from solar wind through magnetic reconnection associated with the storm to range from minutes to a few hours and the dependence of such delay on the choice of analysis approach. WTC revealed maximum correlation values ranging from ±0.9084 to ±0.9364 on the N/S signal channel and ±0.9188 to ±0.9363 on the E/W channel between amplitude deviation and SYM-H geomagnetic index. The results not only substantiate and align significantly with previous findings but also provide new insights.

Prof. Carynelisa Haspel (Hebrew University of Jerusalem) continued the collaboration with **Prof. Yoav Yair** (Reichman University) to further develop their model for predicting the regions of possible sprite inception above thunderstorms. The model is specifically designed to handle non-symmetric charge configurations in 3D over a large domain with sufficient time resolution and with the same efficiency as it handles symmetric charge configurations. Moreover, for the same 3D charge configuration, the model is designed to be more numerically stable, more accurate, and less sensitive to the choice of spatial resolution than finite-differencing schemes. A time-independent version of the modeling scheme was published in Haspel et al. (2020), and a time-dependent version of the modeling scheme was published in Haspel et al. (2022). In the newest version, a time-dependent electron contribution to the atmospheric conductivity was added to the model, to investigate effects that cannot be simulated with an axisymmetric model, such as the effect of lightning discharges in neighboring cloud cells offset from one another in space and time, and the effect of vertical wind shear and charge center offsets. The model is also being used to investigate phenomena that are not necessarily non-symmetric but that are simulated efficiently with this modeling scheme, such as the effect of meteoritic ablation products and the phenomenon of long delayed sprites. Comparison with space-based sprite observations obtained from the AX-1 and AX-3 missions confirms the model assumptions. See Haspel et al. (2020, 2022) and (Haspel and Yair, 2024a, b).

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Massachusetts Institute of Technology

Contributed by Earle Williams

Dr. Anirban Guha visited MIT from Tripura University in India for six weeks this Fall to continue work on the global detection and characterization of lightning Q-bursts by time-of-arrival methods, using the 6-station HeartMath ELF network (with stations in California, Canada, Lithuania, Saudi Arabia, South Africa and New Zealand). Global incidence maps for positive events show clear evidence for the population of continental baroclinic zones in both hemispheres, where squall lines are often present. Negative events in contrast are most prevalent in the near equatorial zone and at the land/ocean boundary. The compositing of positive and negative Q-bursts in time using WWLLN strokes shows evidence for Q-burst doublets (separated in time by the round-the-world propagation time), and for a distinct quieting of stroke activity in advance of negative polarity events which are sources for ELVES. These lightnings exhibit the largest peak currents in the atmosphere, suggesting a physical linkage to high cloud potential that can be achieved by the observed quieting in stroke activity beforehand.

Dr. Qianqian Wang from the Institute of Urban Meteorology in China arrived at MIT last month and will work initially in addressing the evidence for mean storm flash rate increasing systematically away from the equator over land and ocean alike, and later on the relationship between the Schumann resonance background and transient (Q-burst) activity.

Earle Williams presented findings on new single-station access to the AC global circuit in the Workshop on the Global Electric Circuit in Warsaw, Poland in September, at the kind invitation of Anna Odzimek. Valuable discussion with Marek Kubicki proceeded in

Warsaw on possible access to the DC global circuit through the use of long unenergized power transmission lines for intercepting the air-earth current in fair-weather conditions. In Hungary, Daniel Piri and Jozsef Bor have been successful in monitoring the air-earth current without 50 Hz interference from neighboring energized power lines. Efforts are underway with Amedeo Andreotti in Naples, Italy to find longer (up to 100 km long) for testing purposes. A key objective at present is the verification of global representativeness of measurements of air-earth current from different geographical locations.

A paper showing evidence for a downturn in global lightning activity during the COVID pandemic, when global aerosol has also diminished due to reduced global energy consumption, and led by Yakun Liu, is currently in review at the Journal of Geophysical Research. A major challenge in this work has been the disentanglement of the effects of the La Nina episode and the pandemic onset in the same year (2020).

The prevalence of gamma radiation from thunderstorms shown earlier at Aragats in Armenia and more recently in the ALOFT campaign in Florida/Gulf of Mexico/Caribean Sea continues to raise questions about the failure of B.J.F. Schonland and C.T.R. Wilson to verify electron runaway in the 1930s. A paper on the subject with Ashot Chilingarian, Hripsime Mkrtchyan and Gagik Hovsepyan is currently in review at the Journal of Geophysical Research.

Nanjing University of Information Science and Technology, Nanjing, China

Research on the initiation of multiple upward leaders from an isolated building based on an improved lightning attachment model. More and more optical records have exhibited that multiple upward leaders (MULs) occur frequently on a building in the flash attachment process. An interesting issue is why a building can continue to launch upward leader (UL) after the first one appears. Considering the influence of the leader behaviors on the ambient electric field, an improved 3-D fine-resolution lightning attachment model with MULs is established to simulate cloud-to-ground flash events with diverse leader spatial morphologies. The simulation results show that MULs may initiate almost simultaneously or with an obvious delay and the variation range of UL length is large. The simulation results of lightning terminating on a 300 m-height structure were divided into the following four scenarios: A, FUL and SUL initiate almost simultaneously; B, SUL is triggered much later than FUL; C, a single UL with short length occurs on the structure; D, the building launches only one long-length UL. It was found that the spatial location of downward leader, the length and propagation direction of the first UL and the time interval from the inception of the first UL to final jump significantly affect the electric fields at top corners of building and further affect the inception of the second UL. (Lin et al, 2024, Journal of Geophysical Research: Atmospheres).

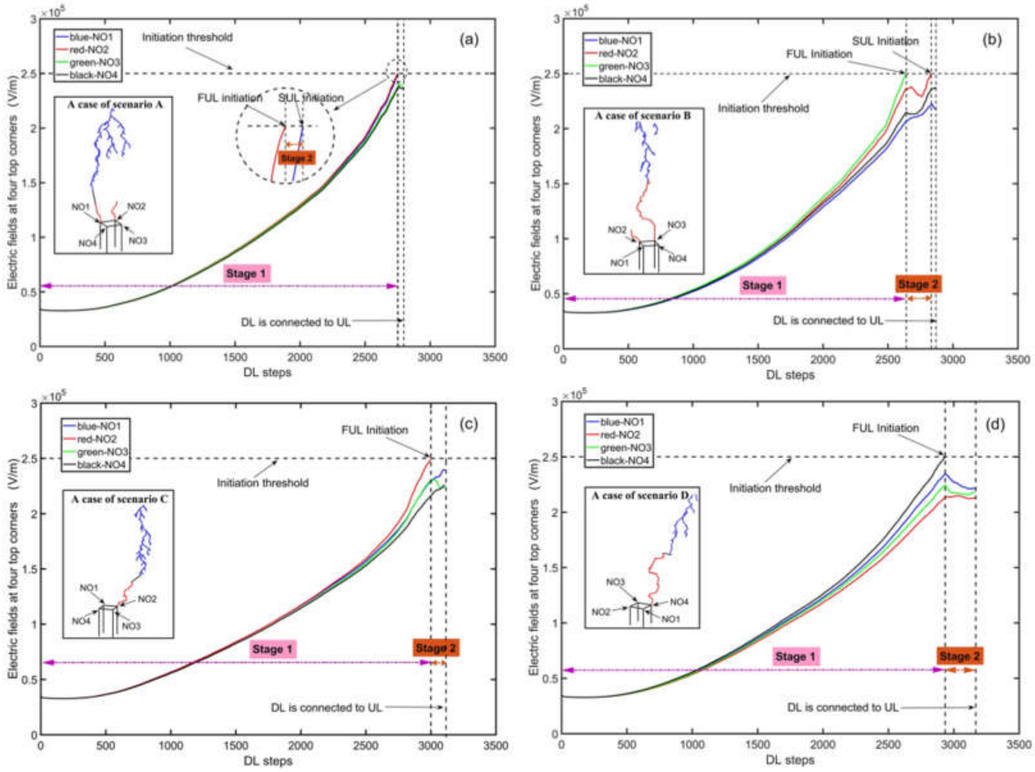

Figure 1. Variation of electric fields at the top corners with DL extension in four examples corresponding to the four scenarios.

Quantitative spectral analysis of natural lightning return stroke followed by continuing current with M-components. Using time-resolved spectra from three cloud-to-ground (CG) and one tall-object lightning return stroke with continuing current (CC) process and M-components, the temperatures and electron densities calculated from the different sets of ionic and neutral line emissions for long-duration (nearly one millisecond) visible channels with lengths of several hundred meters were quantitatively analyzed. Our analysis showed the following results: (1) The temperature and electron density calculated from the singly ionized lines were noticeably higher than those calculated from the neutral atomic lines. (2) The temperature calculated using the singly ionized lines during the CC process was lower than that of the corresponding return stroke for three lightning. The remaining one lightning return stroke was closely followed by two consecutive M-components. The temperature calculated using the singly ionized lines for the second M-component was higher than that of the corresponding return stroke. The electron density calculated using the singly ionized lines during the CC process was higher than that of the corresponding return stroke. (3) The temperatures and electron densities calculated using the singly ionized lines decreased as the height of the channel increased, while those calculated using the neutral atomic lines increased with increasing channel height. (4) The maximum gradient values of the temperatures calculated from ionic and neutral lines along the channel were 22,200 K/km and 9000 K/km, respectively, which were observed in the first M-component of lightning B. These results verified that the lateral corona discharge was predominantly responsible for the continuing current process. (Wang et al, 2024, Atmospheric Research).

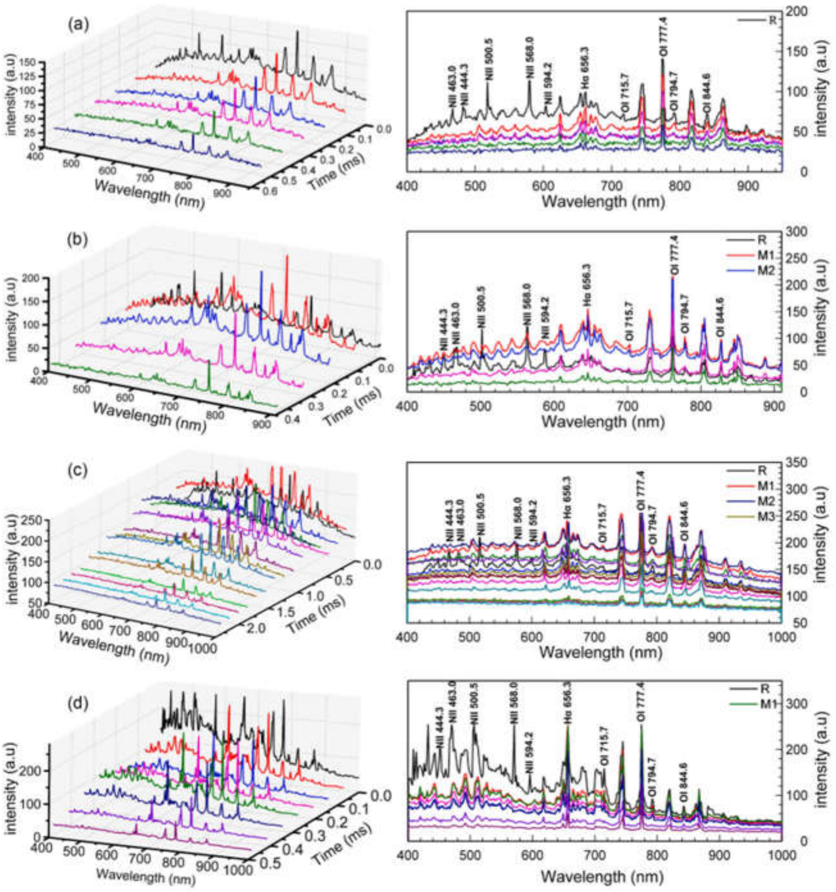

Figure 2. Time-resolved spectra for lightning A-D (a-d) at channel heights of 432, 218, 329, and 574 m. Three-dimensional time evolution spectrogram in the left column. Two-dimensional spectra of marked spectral lines in the right column.

Northwest Normal University, China

Development and thermodynamic characteristics of cloud lightning channels with ultrashort-path. The time-resolved spectra of four ultrashort-path cloud lightning were taken by a high-speed slit-less spectrograph. Based on the spectra, the temperature, electron density, and development characteristics of the ultrashort-path cloud lightning channels were investigated for the first time. For these four ultrashort-path cloud lightning, the minimum length of the channel in the horizontal direction is approximately 130 m and that in the vertical direction is approximately 50 m. The average development velocity of their leader is 10^6~10^7 m/s. Intense ionic lines with high excitation energies radiated at the initial stage of the leader. When the entire channel formed, no intense pulse of light radiation with high excitation energy (ionic lines) occurred like that of the return stroke of cloud-to-ground (CG) lightning. That is, high charge density appeared at the initial moment of the leader, indicating that there may be a strong energy pulse during the initial stage of the leader. The temperatures of the channel near the cloud base, the initial and terminal ends are higher than those at other positions. According to the spectral characteristics, the current of ultrashort channel cloud lightning should be much smaller than that of normal cloud and CG lightning. It is inferred from the development of ultrashort-path cloud lightning, the range of cumulonimbus clouds with opposite charges over the plateau mountainous region should be much smaller than the typical values in other regions.

Using the space-time evolution spectrum to investigate the transmission characteristics of lightning return stroke current. Exploring the physical characteristics of lightning discharge channels based on spectrum can help to reveal the microscopic mechanism of the discharge process and provide a theoretical basis for lightning protection research. According to the spectra of six CG lightning return stroke processes and plasma conduction theory, we investigated the evolution of the total intensity of ionic and atomic lines in the spectra, conductivity, and other parameters along the discharge channel at different stages of the return stroke. The results show that the intensity of ionic lines in the spectrum present an obvious decaying trend with increasing height along the channel during the initial current-rise phase of the return stroke. In the later stages, the decay of ionic line intensity along the channel height slowed down. The intensity of the atomic lines varied slightly with increasing height along the channel during the entire return stroke process. The different space-time evolution characteristics of the spectral line intensity with different excitation energies reflect the differences in the mechanism of light radiation in the core current-carrying and surrounding thermal channels. The spectral characteristics further confirm that the ionic line with higher excitation energy directly relates to the physical process in the core current-carrying channel, and its intensity can roughly reflect the change in current along the channel. The attenuation of the return stroke current along the channel was mainly manifested in the initial stage of the return stroke. The decay rate of conductivity along the channel height is slower than that of the ionic line intensity throughout the return stroke stage, which is related to the channel diameter, it is another key parameter affecting the current transmission in the discharge channel.

Exploring the relationship between lightning discharge current and plasma spectrum. Lightning return stroke discharge current is a key parameter being concerned in lightning protection design. Since the current of natural lightning is difficult to be directly measured, and the existing experimental methods cannot obtain the information of the current change along the channel, the correlation between the current intensity and the corresponding spectral characteristics makes it possible to investigate the current transmission characteristic. The high time resolution spectra of the whole channel outside the cloud for multi-return CG lightning discharges were captured by using a high time-resolved slit-less spectrograph, and the light radiation characteristics of the discharge plasma channel have been investigated. Based on plasma spectral diagnosis method, combined with the synchronous electric field change waveform caused by lightning, using the relationship between electric field variation amplitude and the corresponding discharge current, the dependence of spectral characteristics on discharge current intensity was analyzed. We found that the intensity of the ionic lines in the spectrum is positively correlated with the current intensity. Semi-empirical data fitting shown that for most of the lightning studied in this work, there is a good quadratic correlation between ionic lines intensity and peak current. The correlation between spectral characteristics and discharge current intensity depends on the radiation mechanism of spectral lines with different excitation energy. The intensity of the ionic lines in the spectrum can reflect the current intensity in more detail than the total luminous intensity. This work provides a new research way for studying the transmission characteristics and microscopic mechanism of lightning discharge current. It also has potential practical application value in improving lightning current detection and analysis systems.

Spectral Study of Rare Upward Developing, Circling, and Branching CG Lightning. The development of CG lightning channel is one of the main bases reflecting the discharge characteristics. Time-resolved spectra of CG lightning with eight return strokes were recorded by a slit-less high-speed spectroscope. We found an unusual phenomenon in which a branch developed upward from a node following a circling structure into the cloud after the first return stroke, as show in Figure 1. To investigate the propagation properties of this lightning, characteristic parameters such as the two-dimensional speed of the leader, node temperature, and electron density are analyzed. The physical mechanism of the branch is discussed. Spectral analysis reveals that the main channel temperature and electron density are approximately 2.72-3.07×10^4 K and 0.23-2.03×10^{18} cm^{-3}, respectively. We found that the brightness of the node was higher in the early stage of its formation, followed by a decreasing trend. When the lightning leader develops to the node, the node brightness becomes larger and the speed becomes slower. Furthermore, the circular channel maintains a high temperature and high electron density. The temperature and electron density of the branch channel approaching the bottom of the cloud are slightly larger than those of the main channel, similar to the characteristics of the leader channel approaching the ground. Due to the complex spatial electric field distribution between the cloud and ground in the mountainous, the phenomenon of the branch developed from the node to the cloud, which may be related to the formation of the branch in the return stroke process and the strong negative charge region in the cloud. This study provides a reference for further theoretical and experimental studies on the microcosmic mechanism of the CG lightning development process.

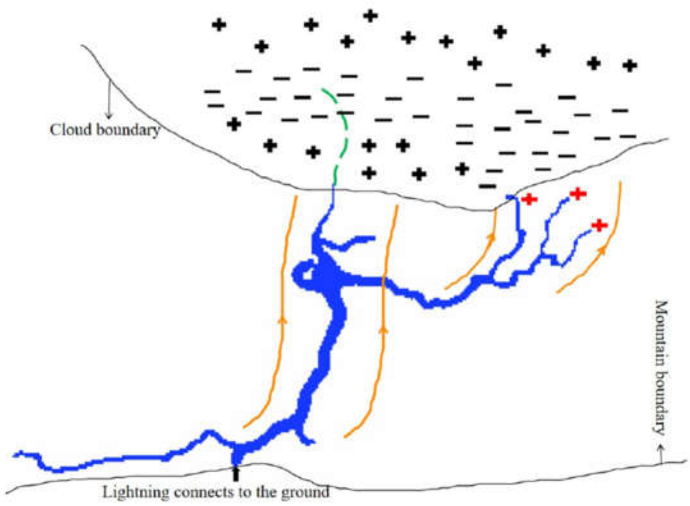

Figure 1. Flash schematic of the branch toward the clouds. The orange lines with arrows indicate the direction of the electric field, the green line is the hypothetical leader channel in the cloud, and the blue lines are the lightning channels.

Collisional-radiative modeling of the 2p3*l* (*l* = *p*, *d*) spectra of N II and application to lightning. The excitation energies, transition rates, collisional-excitation cross sections, and collisional-excitation rate coefficients of N II ions have been calculated by the relativistic configuration-interaction method with the implementation of the flexible atomic code. A large number of electrons, atoms and ions exist in lightning channel, the complex interaction between them is closely related to the optical radiation characteristics of lightning. Considering some important microscopic physical processes, a reasonable collisional-radiative model has been constructed to simulate the 2p3s–2p3p and 2p3p–2p3d spectra, which were in reasonable agreement with the lightning data presently obtained in experimental measurements. Through accurately matching the theoretical intensity-ratio with the experimental one, three intersections of contours of line-intensity ratios in the two-dimensional plane of T_e-n_e (Electron temperature and electron density) is derived, the T_e and n_e in lightning channel were diagnosed simultaneously. Precise spectral analysis method and plasma diagnostic technique are the basis of researching other physical characteristics of lightning discharge, this work also has application value in artificially triggered lightning, laser-guided lightning, arc discharge, etc.

Abundance determination of atoms and ions in the channel plasma of lightning. In lightning spectroscopy, Boltzmann plots are commonly used to diagnose the temperature of the lightning plasma, and the traditional Boltzmann plot method requires the use of spectral lines that are interference-free mono spectral lines. Unfortunately, interference-free singlet in lightning spectra is extremely rare to build reliable Boltzmann plots. For more overlapping multiplet spectral lines, spectral line separation is usually performed using software. However, spectral line separation is a rather imprecise process and, in addition, requires significant computational costs. In this work, we propose a Boltzmann diagram method for multiplet that eliminates the need to separate overlapping spectral lines and enables the use of both singlet and unresolved multiplet. Reliable Boltzmann diagrams were constructed using this method and the temperature of the lightning plasma was obtained. In addition, the mathematical technique of calibration-free laser-induced breakdown spectroscopy (CF-LIBS), which is commonly used for laboratory plasmas, was applied to the lightning spectra to obtain the abundance of atoms and ions in the channel. It was found that there is a dependence between the intercept of the Boltzmann diagram and the ion abundance of the plasma and that the differences in the abundance of the different particles are attributed to the varying amounts of nitrogen and oxygen in the air. The final measured ion abundance data indicate that N II ions are the most abundant in this flash, while N III and O III ions are extremely rare.

NSSL and CIWRO

Teams at NSSL and CIWRO continue to develop products using lightning data, and explore methods to improve lightning forecasts. These efforts include LightningCast, a total lightning product, thunderstorm "First-Flashes" and lightning prediction metrics in lake-effect snow storms.

LightningCast. LightningCast is a deep-learning model that uses images from geostationary VIS/IR imagers to predict the probability of lightning in the next hour (Figure 1). LightningCast was trained on visible, near-infrared, and longwave-infrared imagery from NOAA's GOES-East Advanced Baseline Imager (ABI) at their native resolutions (0.5 km to 2 km). The truth or target metric was GOES-East Geostationary Lightning Mapper (GLM) flash-extent density accumulated in the ensuing hour from an ABI scan.

In the last two years, LightningCast has been used by NOAA's National Weather Service (NWS) experimentally to aid in their decision support forecasts for airports, stadiums, concerts, and other entities vulnerable to lightning. LightningCast often provides 20 minutes or more of actionable lead time to lightning initiation in developing thunderstorms, allowing many users to take mitigating action to protect life and property.

Using data from Japan's Advanced Himawari Imager (AHI), LightningCast has also been deployed in Asia and the western Pacific Ocean, namely in support of the NWS Guam's area of responsibility. LightningCast will be officially operational at NOAA in 2025. A parallel effort at the University of Wisconsin – Madison will allow other users to operate the LightningCast model in locations within the Himawari, GOES-West, or GOES-East domains. A beta release of the software will be available in September 2024 (https://cimss.ssec.wisc.edu/csppgeo/).

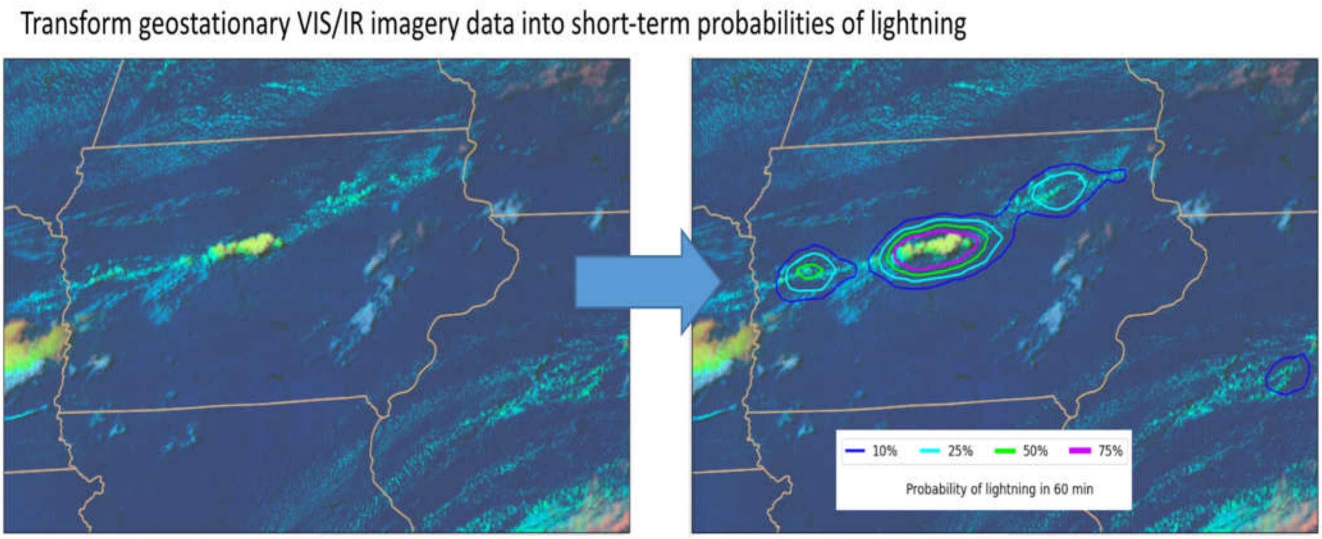

Figure 1. LightningCast probabilities

Merged lightning grids. Several different forms of lightning data from ground-based and spaceborne measurement platforms make their way into operations, where total lightning informs about a number of applications, including convective intensity and outdoor safety. A new real-time unified lightning dataset is in production to combine the strengths of lightning radio frequency measurements from global ground networks and optical image measurements from the two GOES GLMs into a single product over the contiguous United States (CONUS).

First steps of this effort include implementation of adaptive parallax correction to accurately locate GLM lightning footprints before combining them with other data. At present, the GLM Lightning Cluster-Filter Algorithm (LCFA) uses a lightning ellipsoid model to fit a height of cloud light emission that varies between 14 km at the equator and 6 km at the poles. Virts and Koshak (2020, https://doi.org/10.1175/JTECH-D-19-0100.1) demonstrated location improvements by applying height corrections that vary over the GOES viewing areas by region and month. The GOES ABI Cloud Top Height (CTH) product offers another model for real-time parallax correction. Over 30,000 1-minute GLM lightning footprints, parallax corrected using each model, have been compared with the locations of ground-based network lightning detections. The regional-seasonal correction consistently improves on the LCFA lightning ellipsoid. However, the ABI CTH product provides substantial location improvements for large footprint regions during the overnight hours. Work is ongoing to implement these adaptive corrections in real-time.

Location-corrected gridded GLM optical imagery data are next combined with point-location lightning detections from the National Lightning Detection Network and the Earth Networks Total Lightning network. The first level of combination is a unified lightning occurrence grid (Figure 2). Next steps include implementing the unified lightning data in a real-time process, as well as building upon unified lightning data grids to add information about the characteristics of lightning flashes uniquely observed by each detection technology.

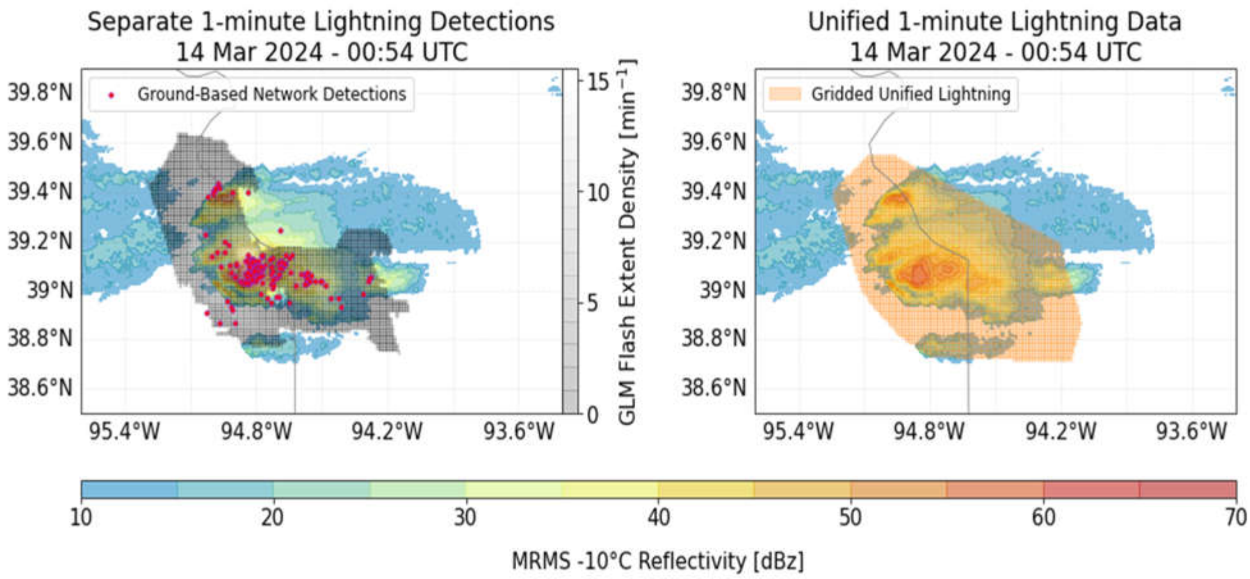

Figure 2. Lightning occurrence grids

Thunderstorm 'First-Flashes' from the GOES-R GLM. The first lightning flash that a thunderstorm produces is one tool used, in concert with radar reflectivity and satellite imagery, to identify the development of a deep convective updraft associated with thunderstorms. Deployment of the GOES-R GLM provides near-continuous monitoring of lightning activity over CONUS. By studying the 'first flash' of a convective updraft over large temporal and spatial scales, developing convection can be characterized by its corresponding radar and satellite observations along with its convective environments. The study collected GLM first flashes across the CONUS throughout 2022, investigating their flash characteristics, spatiotemporal distribution, and their corresponding radar and satellite signatures (Figure 2).

Over three thousand potential first flashes were manually categorized to identify the optimal identification criteria for the larger study, with approximately 175,000 first flashes collected across the CONUS in 2022. GLM flash area and duration were lowest during periods of peak convective instability daily (12-16 LST) and seasonally (summer: JJA). Peaks in first flash occurrence coincided spatially with the monsoon season in the southwestern CONUS and sea-breeze convection in the southeastern CONUS. First flashes corresponded with isothermal reflectivity values at -10˚C of 30-45 dBZ, and infrared imagery at 13.3 µm of 220-240 K. Future work will integrate environmental fields into the analysis, and leverage these datasets to create a machine-learning model targeting the probability of convective development.

Lightning in Lake-Effect Snow. While the majority of lightning occurs with warm-season storms, there are also lightning risks during winter. The Lake Effect Electrification (LEE) project investigated electrified lake-effect snow storms in the lee of Lake Ontario in New York. Early analysis of radar and Lightning Mapping Array data indicates that terrain, land cover, and convective intensity within the lake-effect snow storms play complementary roles in determining when lightning is produced. Almost all of the lightning observed during the LEE project was over the Tug Hill Plateau, and much of that initiated near wind turbines or towers located on the raised terrain. If a storm cell within the lake-effect snow band reached a sufficient horizontal size or produced sufficient vertically integrated ice within 12 km or 11 minutes of reaching the wind farm on the plateau, it was much more likely to produce lightning than if any single one of the conditions were missing.

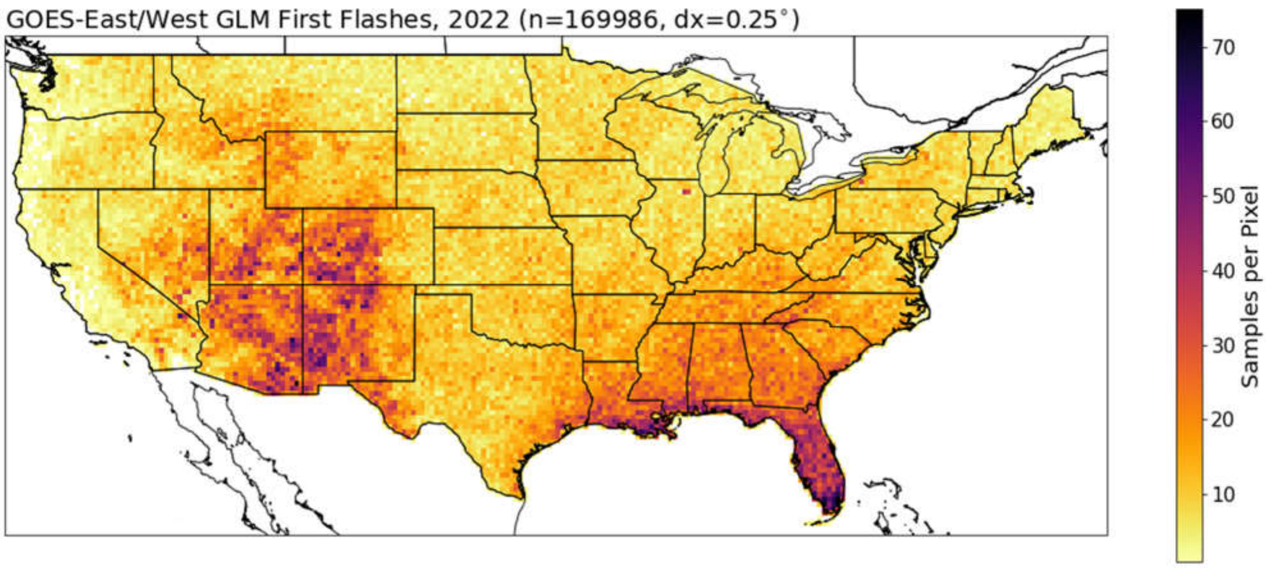

Figure 3. GLM First Flashes densities

RTL-3D: Collaborative Study of Kindai University in Japan, Universiti Teknikal Malaysia Melaka (UTeM), and Universiti Tenaga Nasional (UNITEN) in Malaysia

Real-Time Lightning 3D Imaging and Forecasting Project for Sustainable and Reliable Supply of Energy and Storm Disaster Early Warning (RTL-3D). The RTL-3D project seeks to reduce lightning-related fatalities, injuries, and property damage caused by lightning strikes and flash floods in Malaysia specifically, and in the world generally, by leveraging advanced solutions capable of forecasting lightning hazards before their occurrence.

Advanced algorithms are being developed to map lightning and charge distribution in three dimensions with exceptional precision, achieving an accuracy of less than 10 meters. This innovation greatly enhances understanding of lightning activity and its impact on infrastructure and communities. To validate these algorithms, rocket-triggered lightning (RTL) experiments are conducted, providing controlled measurements of lightning strikes for precise evaluation (Figure 1). A key outcome of the project is the development of algorithms to forecast flash flood events with over 90% accuracy based on lightning parameters. These state-of-the-art systems, integrated with advanced ICT infrastructure, aim to minimize the risks of flash floods and lightning strikes, thereby safeguarding lives and property.

Complementing these efforts, lightning sensors and weather monitoring networks have been installed at selected locations across Malaysia, including Kuala Lumpur, Selangor, Negeri Sembilan, and Melaka. These systems enable real-time monitoring of lightning activity, providing critical data for disaster preparedness. By integrating monitoring capabilities with advanced forecasting tools, the project aims to enhance safety, deepen knowledge, improve quality of life, and promote sustainable socio-economic development in Malaysia.

The project also extends its social impact by developing real-time monitoring and forecasting dashboards and applications. These tools are specifically tailored for end-users such as fishermen in Melaka, engineers at Tenaga Nasional Berhad (TNB), and personnel at the Malaysian Meteorological Department (METMalaysia). These resources ensure the dissemination of timely and actionable information, enhancing safety and decision-making.

The RTL-3D project is part of the Science and Technology Research Partnership for Sustainable Development (SATREPS) programme, a joint initiative by the Japanese and Malaysian governments implemented by the Japan International Cooperation Agency (JICA) and the Japan Science and Technology Agency (JST). The project, which commenced in June 2023 and will run until May 2028, is a collaborative effort involving Kindai University in Japan, Universiti Teknikal Malaysia Melaka (UTeM), and Universiti Tenaga Nasional (UNITEN) in Malaysia. It is led by Professor Takeshi Morimoto (Kindai), Associate Professor Dr. Mohd Riduan Ahmad (UTeM), and Associate Professor Dr. Farah Hani Nordin (UNITEN).

For updates and activities, we invite you to follow the RTL-3D Facebook page at https://www.facebook.com/rtl3d.

Figure 1. Inaugural Rocket Triggered Lightning (RTL) experiment at Kanazawa, Ishikawa, Japan in January 2024.

University of Florida

Ziqin Ding defended his Ph.D. dissertation titled "Studies of Lightning Processes Based on Optical (Including IR and UV) Observations Coordinated with Radio-Frequency Field Measurements". He is currently a postdoc at the University of Florida, continuing his lightning studies at the Lightning Observatory in Gainesville (LOG), Florida.

Z. Ding and V.A. Rakov authored an overview paper titled "Observations of very unusual behavior of lightning discharges". Based on their recent observations at the Lightning Observatory in Gainesville (LOG), Florida, they presented three examples of very unusual behavior of cloud-to-ground (CG) lightning flashes: (a) One +CG and one tower-terminated -CG separated by 11 km, were briefly coupled, so that positive charge was in effect drawn from the ground at the position of –CG and injected into the ground at the position of +CG. That unusual interaction was accomplished by the initiation of M-component incident wave in the +CG channel by the leader of the first stroke of the –CG. (b) A branched positive leader intermittently extended via bidirectional transients separated by inactive intervals of about 5 ms, on average. One of the bidirectional transients, moving negative charge in the backward direction, triggered a downward negative leader, resulting in a three-stroke –CG. (c) A subsequent-stroke negative leader, moving through virgin air, entered the lower part of residual (non-luminous) first-stroke channel, in addition to creating a new ground termination about 950 m away. Studying unusual lightning behavior helps to improve our understanding of the variability of basic lightning processes and to identify new potential lightning hazards to various objects and systems. This paper is published in the Electric Power Systems Research.

In a collaborative Doshisha University/UF paper, Shota Ueda, Masahiro Hasegawa, Yoshihiro Baba, and Vladimir A. Rakov, using the FDTD method for solving Maxwell's equations, studied wave guiding properties of a large cylinder, which had a radius of 100 m, $\varepsilon = \varepsilon_0$, and $\mu = \mu_0$, for four values of conductivity, $\sigma = \infty$, 10^{-3} S/m, 10^{-4} S/m, and 10^{-5} S/m. The conductivity value of the order of 10^{-5} S/m is expected for various essentially cold streamer formations, including compact intracloud discharges (CIDs), with the other three values being considered just for comparison. The cylinder was excited by a Gaussian voltage pulse whose HPW was 1, 3, or 10 μs (excitation by a current pulse yielded essentially the same results). Currents, electric and magnetic fields, and Poynting vectors were computed at 100, 300, and 500 m from the source. Their findings can be summarized as follows.

(1) In all considered cases, the cylinder was capable of guiding current waves, with the propagation speed being of the order of 10^8 m/s.

(2) The radial electric field E_r on the cylinder surface was a factor of 10 to 55 higher than the longitudinal electric field E_z for σ = 10^{-3} S/m, a factor of 3 to 10 higher for $\sigma = 10^{-4}$ S/m, and ranged from 0.6 to 3 for $\sigma = 10^{-5}$ S/m (smaller values correspond to larger distances from the excitation point and smaller voltage-pulse HPWs).

(3) After propagation over 400 m, the current peak was about 70% to 90% of its original value for $\sigma = \infty$, about 60% to 80% for $\sigma = 10^{-3}$ S/m, about 40% to 60% for $\sigma = 10^{-4}$ S/m, and about 10% to 20% for $\sigma = 10^{-5}$ S/m.

(4) The current attenuation distances, over which the amplitude decreases to 1/*e* (about 37%) of its original value, for $\sigma = 10^{-5}$ S/m were roughly 120, 170, and 220 m for HPW = 1, 3, and 10 μs, respectively.

These results suggest that CIDs that are essentially cold streamer formations, whose conductivity is expected to be about 10^{-5} S/m and whose lengths are usually a few hundreds of meters, may involve traveling wave phenomena, such as reflections. The paper is published in the IEEE Transactions on EMC.

University of Wisconsin

How much lightning actually strikes the United States? The number of cloud-to-ground (CG) flashes over the contiguous United States (CONUS) has been estimated to be from as small as 25 million per year to as many as 40 million. In addition, many CG flashes contact the ground in more than one place. To clarify these values, recent data from the National Lightning Detection Network (NLDN) have been examined since the network is performing well enough to make precise updates to the number of CG flashes and their associated ground contact points. The average number of CG flashes is calculated to be about 23.4 million per year over the CONUS, and the average number of ground contact points is calculated as 36.8 million per year. Knowledge of these two parameters is critical to lightning protection standards, as well as better understanding of the effects of lightning on forest fire initiation, geophysical interactions, human safety, and applications that benefit from knowing that a single flash may transfer charge to the ground in multiple, widely spaced locations. Sensitivity tests to assess the effects of misclassification of CG and in-cloud (IC) lightning are also made to place bounds on these estimates, and the likely uncertainty is a few percent.

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NEWSLETTER

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

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 **2025 spring issue** of the newsletter is **May 15, 2025**.

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