ATMOSPHERIC ELECTRICITY

NEWSLETTER

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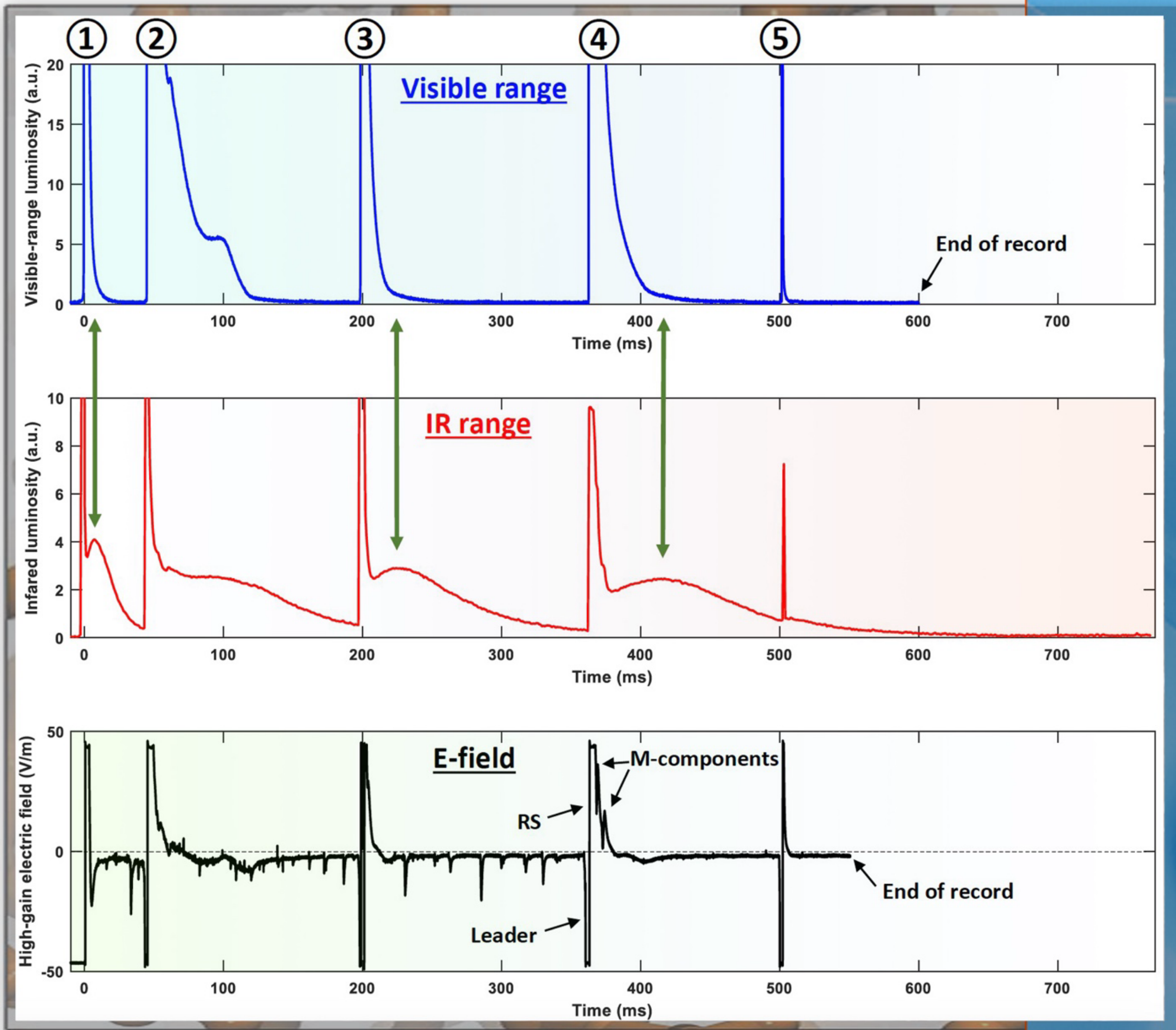

Cover Story :

Ziqin et al. (2024), using high-speed framing cameras installed at the LOG, Florida, compared, for the first time, the medium-to-far (3 - 5 μm) IR luminosity of lightning channels with the simultaneously recorded visible luminosity. The key findings include the persistent nature of IR luminosity throughout interstroke intervals, which is in contrast to visible luminosity that always decayed to an undetectable level before the following return-stroke onset. They inferred that the IR hump is associated with enhanced IR emission from nitric oxide (NO) molecules.

More details are found in the paper by Ziqin Ding, et al. 2024, *GRL*, e2024GL109291. https://doi.org/10.1029/2024GL109291

ICAE
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https://www.iamas.org/icae/

Open call for nominations for the prestigious ICLP Berger and Golde awards

We are pleased to announce that the call for nominations for the prestigious ICLP Berger and Golde awards is now open. Each ICLP conference year, the scientific committee of the ICLP bestows these awards upon up to four scientists for distinguished achievements in the science and engineering of lightning research, developing new fields in theory and practice, modelling and measurements (www.iclp-centre.org/awards).

Please introduce your nominations before August 1, 2024 online using the following link: https://forms.gle/LW9jiG7R5yYqPcr97 or sending an email to any of the Awards Committee members, whose names and addresses are given below, containing in a Word file or directly in the email text:

1) The award for which the nomination is given, Berger or Golde,
2) a one or two-line proposed citation, and
3) a description of the scientific/technical achievements of the nominee (maximum 4000 characters).

Once the nominations are in, a distinguished panel of judges consisting of the previous recipients of these awards will rank the nominees according to their standing in the research community and for their contributions to the field. Based on this ranking, the award committee will select the recipients of the two awards.

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Awards Committee of the ICLP

POLGEC Workshop 2024, 11-13 September 2024, Warsaw, Poland

In 2024 we organize an international workshop to support international scientific collaboration on the modelling of the Global Atmospheric Electric Circuit – the POLGEC Workshop 2024. The workshop will be in Warsaw, Poland, during 11-13 September. Please check our website: polgec.igf.edu.pl or email us at polgec@igf.edu.pl.

The workshop is supported by Poland National Science Centre, grant No 2021/41/B/ST10/04448.

African Centres for Lightning and Electromagnetics Network (ACLENet)

ACLENet has completed ten years of advancing lightning knowledge in Africa. The first decade was oriented toward building relationships between people mainly within Uganda and lightning interest around the world. The next decade will be focused on education through a wide variety of means that are under active development.

To mark these first ten years, Dr. Mary Ann Cooper, founding director of ACLENet, met with the First Lady of Uganda in April, the Honorable Minister Janet Museveni, an elected member of Parliament. As the Minister of Education and Sports, the idea of schools being destroyed with children inside was of keen interest to her. As a result of this meeting, she urged Uganda government agencies to support protecting school with proper lightning protection system designs and materials and to waive import duties that have been a significant portion of building costs.

This issue is a major one, since Uganda has one of the youngest populations in the world at 16.7 years. As a result, hundreds of new school buildings are constructed every year that may not have adequate lightning protection for students and staff.

Dr. Mary Ann Cooper hands over a document to First lady Mrs.Museveni

Figure 1. Click photo for Uganda Broadcast Company coverage of Cooper's meeting with the First Lady, Janey Museveni.

ACLENet continues to maintain the largest publicly available database of lightning deaths, injuries, and damages in the world at https://aclenet.org/news-publications/country-news/directory-of-countries.html.

You are invited to view the monthly ACLENet Newsletter that is now translated into French, Portuguese, Spanish, and Arabic at https://aclenet.org/news-publications/newsletters/mailing-list.html.

Readers of this Newsletter are encouraged to consider ways that they can support this wide-ranging activity in Africa through donations, in-kind support, connections and introductions to larger donors, as well as volunteering their expertise in management, finance, and other skills needed by all nonprofit organizations. See https://ACLENet.org and choose 'Contact Us'.

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

Contributors: József Bór, Tamás Bozóki, Attila Buzás, Mátyás Herein, Dániel Piri, Ernő Prácser, Marcell Pásztor, Gabriella Sátori, Karolina Szabóné-André, and Earle Williams

Professor Earle Williams's visit to the HUN-REN Institute of Earth Physics and Space Sciences (EPSS) was realized in October-December, 2023 in the framework of the distinguished visiting scientist programme of the Hungarian Academy of Science. Active discussion within the research unit of atmospheric physics of EPSS, with occasional involvement of additional researchers from ELTE University, Budapest, the Czech Republic, and Poland, resulted in significant progress in three main research topics: characterization of the four main seasons from the point of view of the global lightning activity, understanding the link between the evolution of regionally dominant thunderstorms and specific Schumann resonance (SR) frequency variations, and resolving contradictions between modelled and experimentally observed SR spectra. The progress made during the visit contributes significantly to the research project entitled 'Elaboration of new methods for studying the near-Earth environment by extremely low frequency radiation of lightning strokes' that is being currently elaborated in EPSS.

The visit also served to think further beyond the currently active research topics in EPSS and explore new topics that can be considered in the framework of a joint research activity likely in the near future. Such topics include exploiting the benefits of extremely low frequency (ELF) measurements conducted close to the geographical poles of the Earth from the point of view of quantitatively characterizing the relative contribution of the tropical chimney regions to the global lightning activity, finding alternative solutions to the problem of making globally representative DC AE measurements using ground-based measuring facilities, investigating further the link between polar cold air outbreaks (CAOs) to lower latitudes, and the corresponding globally detectable variations in lightning activity (see Bozóki et al. (2023) for reference). Current research provides evidence that CAOs predominantly occur as continental events, thus selectively influencing the lightning activity in particular chimneys.

We have studied the relationship between the variations of SR peak frequencies of the first three resonance modes and the global/regional lightning dynamics on different time scales based on SR observations of the vertical electric field component at the Széchenyi István Geophysical Observatory (known as NCK: Nagycenk). The peak frequencies of SR are known to vary with source-observer distance (SOD) while the daily frequency range (DFR: f_{max} - f_{min}) is indicative of the average size of thunderstorm regions. 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 moves towards NCK. DFR were studied in relation to the El Niño Southern Oscillation (ENSO). The frequency variations were interpreted with model calculations and supported with satellite-based optical lightning observations (OTD, GLM). A manuscript of the results was submitted to the JGR Atmosphere titled “Global lightning dynamics on different time scales as shown by Schumann resonance frequency variations” by G. Sátori, T. Bozóki, E.Williams, E. Prácser, R.I. Albrecht, R.P. Beltran, and a poster was presented at the EGU24 meeting (Sátori et al., 2024).

Infrasound signals from thunderstorms are routinely identified and categorized in the records of the Hungarian infrasound array (PSZI). The applied method relies on the spatial and temporal correlation between the electromagnetic and acoustic detections. The method was further developed to track thunderstorms in the region by assigning centroids to the thunderstorms. Records from stations of the Central and Eastern European Infrasound Network (CEEIN) were analyzed. The results were presented at the EGU24 conference (Pásztor et al., 2024).

Left to right: Dániel Piri, Ernő Prácser, Gabriella Sátori, Attila Buzás, Tamás Bozóki, Karolina Szabóné André, Earle Williams, József Bór

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

Convective properties and lightning activity in different categories of thunderstorms over the Beijing area during five warm seasons. Based on comprehensive observations, including total lightning, Doppler radar, precipitation, and other meteorological data, the variations of thunderstorm properties and lightning activity of different categories of thunderstorms over the Beijing area during five warm seasons were investigated. According to the morphology of radar echo, thunderstorms were classified into five categories, including single convective cells, multi-cells, linear mesoscale convective system (MCS), non-linear MCS, and weak convective precipitation system (WCPS). The diurnal variability of lightning, thunderstorm occurrence, and precipitation showed late-afternoon maxima, with the peak time of lightning frequency before that of precipitation. Despite WCPS having the lowest lightning frequency, the percentage of

+CG/CG was highest with large peak currents. The convective available potential energy (CAPE) of linear MCS, multi-cells, non-linear MCS, single cells and WCPS categories followed a pattern from largest to smallest. Meanwhile, warm cloud depth (WCD) exhibited a smaller value in the well-organized thunderstorm categories and a larger value in the WCPS. The topographic forcing mechanism and large wind gradient along mountain slopes facilitated convection occurrence and enhancement, further promoting lightning production. Meanwhile, the nocturnal convection mechanism significantly impacted the activity of non-linear MCS and WCPS. (D. Liu et al., 2024, Remote Sens.)

Lightning stroke strength and its correlation with cloud macro- and microphysics over the Tibetan Plateau. Lightning stroke strength and its correction with cloud macro and microphysics over the Tibetan Plateau (TP) are investigated by utilizing lightning data from the World Wide Lightning Location Network (WWLLN), the Chinese Cloud-to-Ground Lightning Location System (CGLLS) and reanalysis data from the ECMWF/ERA-5 and MERRA-2 reanalysis datasets during 2016–2019. Focused on the south-central (SC) and southeast (SE) of the TP, it reveals that SE-TP experiences strokes with larger average energy and peak currents. Strong strokes (energy ≥ 100 kJ or peak currents ≥ |100| kA) are more frequent and have larger average values over the SE-TP than the SC-TP, with diurnal distribution indicating peaks in energy and positive strokes in the middle of the night and negative strokes peaking in the morning. Stronger strokes are found to correlate with thinner charge zone depths and larger cloud ice water content fractions (CIWCFs) but stable warm cloud depths and zero-degree levels over the SC-TP. Over the SE-TP, stronger strokes are associated with smaller CIWCFs and show turning points for warm cloud depths and zero-degree levels. Thicker charge zone depths correlate with stronger negative strokes but weaker positive strokes. Generating strokes of similar strength over the SC-TP requires larger CIWCFs, thinner warm cloud depths, and lower zero-degree levels than over the SE-TP. (Wei et al., 2024, Remote Sens.)

Upgraded low-frequency 3D lightning mapping system in north China and observations on lightning initiation processes. The three-dimensional (3D) low-frequency lightning mapping system (LF-LMS) in north China has been updated. The lightning electric field derivative (dE/dt) sensor and continuous acquisition mode has been newly designed to ensure a capability of entire lightning processes detection, especially weak discharges during lightning the initiation process. The twice cross-correlation delay estimation and the grid iteration nested optimization location algorithm are used to realize the 3D location of the discharge channel, and the location resolution and calculation speed are balanced consequently. The location results of the rocket-triggered lightning demonstrated that the system achieved a high-resolution mapping of lightning discharge channels, which coincided well with the optical images. The horizontal and vertical location error for rocket triggered lightning was less than 40 m in both horizontal and vertical. Intra-cloud (IC) lightning flashes were observed to be initiated by three different discharge processes, initial breakdown pulse (IBP), narrow bipolar event (NBE), and initial E-change (IEC). The corresponding initial height was 10.5 km, 6.9 km, and 9.2 km, respectively. The upward negative leader was initially located, followed by scatter radiation sources and negative recoil leaders in the lower negative charge region for all cases. The electric field characteristics of the IEC and subsequent IBPs indicated that they are different discharge processes with the same current direction. The IEC process might correspond to the discharge process with continuous current and less noticeable current changes. (Figure 1, M. Liu et al., 2024, Remote Sens.)

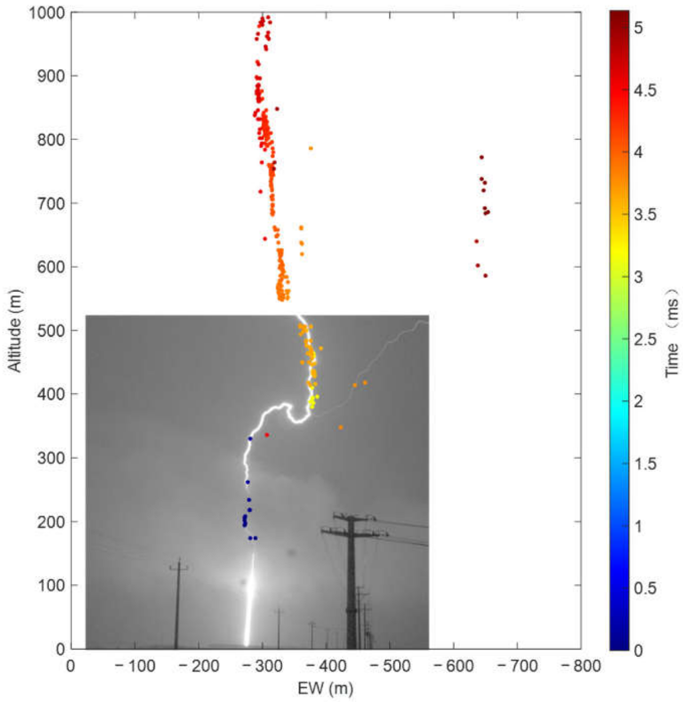

Figure 1. The location results of triggered lightning are displayed in 2D and overlaid with optical detection of the initial-stage frame, captured by a synchronized high-speed camera. The color changes from blue to red starting from the moment of the first location result.

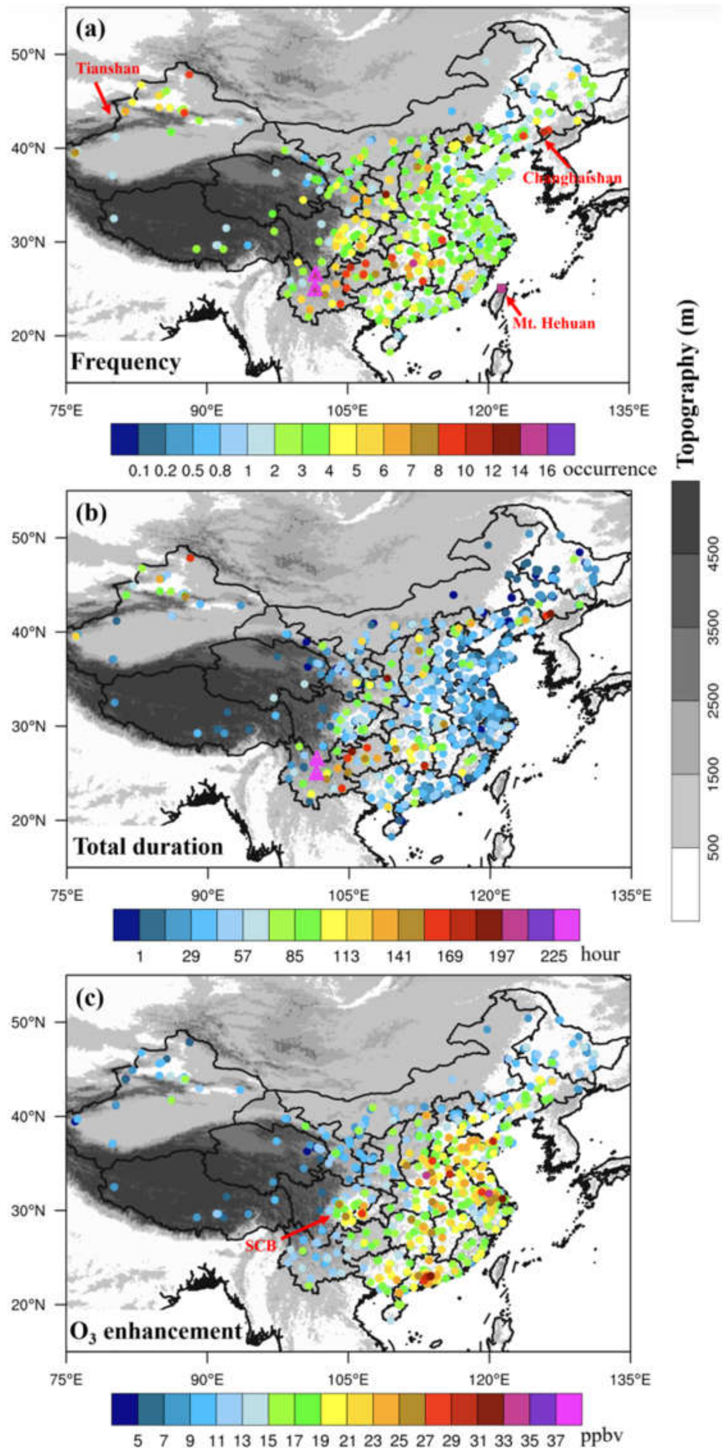

Figure 2. (a) The annual frequency (unit: occurrence per year), (b) the annual total duration (unit: hours per year) and (c) the surface O3 enhancements (unit: ppbv) of SITS events averaged over 2015-2022. Mt. Changbaishan, Tianshan and Hehuan are indicated in (a), and locations of Panzhihua and Chuxiong are marked by the magenta triangles. SCB in (c) refers to the Sichuan Basin. Source data are provided as a Source Data file.

Stratospheric intrusions exacerbate ozone pollution in China. The process of stratospheric intrusions to the surface (SITS) could bring the stratospheric "good" O3 downward into the troposphere and eventually reaches the ground where high O3 is poisonous. SITS is challenging to quantify on national scales and in long terms, owing to difficulty of resolving frequency, duration and intensity of SITS on large scales. Here, the challenge is addressed innovatively, basing on that stratospheric air is rich in O3 but poor in carbon monoxide (CO), both of which are routinely measured at the ground. Following the idea of lightning jump, this study screened out simultaneous and sharp spikes in the O3-CO pairs in spatiotemporally dense surface observations over China during 2015-2022, and achieved a robust statistical overview on SITS on basis of 27,616 SITS events identified at individual stations. The main findings include that SITS events occur preferentially in high-elevation regions, while those in plain regions are more intense. During SITS, surface O3 is enhanced by 20 ppbv on average and by >40 ppbv in 10% cases, contributing to 30-45% to surface O3 in affected areas. The SITS-induced O3 peaks in spring and autumn, while it exacerbates surface O3 pollution in warm months when background O3 is high. This study reveals seasonal and spatial variations in stratospheric impacts on surface high O3 episodes and thus provides scientific references for O3 mitigation policies in short and long terms. (Figure 2, Chen et al., 2024, Nat. Commun.

Tel Aviv University (TAU), Reichman University (RUNI), Ariel University, Israel

Prof. Yoav Yair (Reichman University) completed the 3rd successful run of the ILAN-ES (Imaging of Lightning And Nocturnal Emissions from Space) experiment on board the International Space Station, during the AX-3 private mission by Axiom Space. During the 21-day mission (18.1.2024-9.2.2024), the crew used the Nikon D6 camera and imaged 24 thunderstorm targets, that were forecasted according to the procedure used by our team in previous space missions. They downloaded 2 hours and 16 minutes of video data in total. Initial analysis showed that numerous TLEs were imaged, including sprites, Elves, blue corona discharges and gigantic jets. The data is being analyzed and we expect new papers to be submitted for publication in the coming months.

Meanwhile, results of imaging of Blue Corona Discharges obtained during ILAN-ES on the AX-1 mission (conducted in April 2022) were published in *Atmospheric Research* (Yair, Y.**,** M. Korzets, A. Devir, M. Korman and E. Stibbe (2024), Space-based optical imaging of blue corona discharges on a cumulonimbus cloud top. *Atmos. Res*., 305, 107445).

Prof. Colin Price (TAU) has continued his collaborative research with Russian colleagues at the Institute of Applied Physics (Nizhny Novgorod) on Arctic thunderstorms. While many new papers have pointed out that Arctic lightning has been increasing over the past decade (including more rain and less snow in the summers), a new paper by our group tries to explain the cause of this increase lightning in the polar region during summers. The increased baroclinic instability during the hot summers in northern Asia and Canada over the past years, caused by dramatic increases in north-south temperature gradients between the land areas around the Arctic Ocean, and the cold polar temperatures towards the pole, have driven stronger thunderstorms over the Arctic Ocean, with lightning being observed close to the North Pole during some of these storms!

Prof. Colin Price (TAU) with former student **Dr. Assaf Shmuel**, Prof. Lazebnik and Prof. Glickman are working on a machine learning model to estimate when lightning will produce a wildfire. The ML model is trained on all parameters related to meteorology and vegetation globally, together with data on “thunder hours” produced and published by Earth Networks. The ML model manages to duplicate with high accuracy the location and number of lightning-ignited fires globally. Conclusions about the changing number of lightning-caused fires are also provided.

Dr. Yuval Reuveni (Ariel University) with MSc. student **Nadav Mauda** collaborate with **Prof. Yoav Yair** (RUNI) on analyzing Thunderstorm Ground enhancement (TGE) signatures in storms occurring near Mt. Hermon in northern Israel, using gamma ray and atmospheric electric field measurements recorded at the Emilio Segre Cosmic Ray observatory of Tel-Aviv University located on the mountain (altitude 2040 m ASL). The analysis focuses on two suspected hours long TGE events in winter 2018, which are then divided into several sub-temporal events for a more detailed analysis. A significant increase in gamma ray count rate, accompanied by fluctuations in the atmospheric electric field during thunderstorm activity was observed. Interestingly, some of these fluctuations occur without any lightning being detected near the station throughout the course of the event. Results will be submitted for publication in the coming months.

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

Significant location accuracy changes resulting from lightning detection networks deployed on inclined terrains. This study investigates the location accuracy distribution of the lightning detection networks (LDNs) deployed on inclined terrains, an aspect frequently encountered in complex terrains but hitherto disregarded in previous studies. By designing 8-substation LDNs deployed on slope-type (ST), mountain-type (MT) and basin-type (BT) terrains, respectively, we employed Monte Carlo simulations to analyze their spatial location accuracy distribution based on time-of-arrival technology. The significant differences among these LDNs on inclined terrains and between them and the LDN on plain-type (PT) terrain were revealed. Compared to PT LDN, LDNs on inclined terrains exhibited a reduction in high-precision location regions and a shift in the distribution pattern of location accuracy. ST LDN showed marked deviations of high-precision vertical location toward the lower slope side with increasing elevation angle and consistently smaller high-precision vertical location areas compared to MT and BT LDNs. The variations in elevation angles of MT and BT LDNs had a substantial impact on the spatial distribution patterns of both horizontal and vertical location accuracy, with BT LDNs featuring larger vertical high-precision areas than MT LDNs. Our conclusions were further corroborated through an analysis of an actual LDN, which combined characteristics from both ST and MT terrain patterns.

Spatiotemporal distributions of the thunderstorm and lightning structures over the Qinghai–Tibet Plateau. Utilizing data from the Tropical Rainfall Measuring Mission (TRMM) satellite's precipitation radar (PR) and lightning imaging sensor (LIS), this study explores the spatiotemporal distributions of thunderstorm and lightning structures over the Qinghai–Tibet Plateau (QTP), an aspect that has not been explored previously. The structural aspects are crucial when considering the impact of thunderstorm and lightning activity in the atmospheric processes. Thunderstorms over the QTP show clear spatial variations in both vertical height and horizontal extension. In the southern region, the average heights of 20 dBZ and 30 dBZ echo tops typically exceed 11.2 and 9.3 km, respectively. Meanwhile, in the eastern part, the average coverage areas for reflectivity greater than 20 dBZ and 30 dBZ consistently surpass 1000 and 180 km^2, respectively. The spatial distribution of thunderstorm vertical development height relative to the surface aligns more closely with the horizontal extension, indicating stronger convection in the eastern QTP. The thunderstorm flash rate shows an eastward and northward prevalence, while the thunderstorm flash density peaks in the western and northeastern QTP, with a minimum in the southeast. Furthermore, in the eastern QTP, lightning duration, spatial expansion, and radiance are more pronounced, with the average values typically exceeding 0.22 s, 14.5 km, and 0.50 J m^{-2} sr^{-1} μm^{-1}, respectively. Monthly variations reveal heightened values during the summer season for thunderstorm vertical extension, areas with reflectivity greater than 30 dBZ, and lightning frequency. Diurnal variations highlight an afternoon increase in thunderstorm vertical and horizontal extension, lightning frequency, duration, and spatial scale. From a statistical perspective, under weak convective conditions, lightning length exhibits a positive correlation with thunderstorm convection intensity, contrasting with the opposite relationship suggested by previous studies. This article further analyzes and discusses the correlations between various thunderstorm and lightning structural parameters, enhancing our understanding of the distinctive features of thunderstorm and lightning activities in the QTP.

Massachusetts Institute of Technology

Single station access to the AC global electrical circuit. Following last year's visit to the HUN-REN Institute of Earth Physics and Space Science in Hungary and interaction with Schumann resonance (SR) colleagues (Gabriella Satori, Tamas Bozoki, Erno Pracser and Jozsef Bor), we have returned to further consideration of the monitoring of SR and global lightning activity from high latitude stations. On account of the fortuitous 90º longitudinal separation of the three continental lightning "chimneys", a pair of magnetometer coils at either pole can in principle independently monitor Africa in one coil, and America and Asia/Maritime Continent in the other perpendicular coil (roughly 12 hours apart in UT time).

Two key advantages of high-latitude SR magnetic receivers close to the poles: (1) At the fundamental magnetic 8 Hz mode, one has a flat response to lightning source strength with distance when lightning centroids are near 90º distant (10 Mm, typical of equatorial source distances from the poles). This circumstance eliminates the nonlinear source-receiver distance dependence of magnetic intensity on source strength in the SR normal mode equation which has long complicated multi-station inversion calculations. (2) High-latitude SR receivers are inherently far from active thunderstorms, which are well-recognized as local noise sources, as they can drown out the more distant activity.

Observations from two high-latitude stations, one in the Arctic (Hornsund, 77°N, operated by Poland) and one in Antarctica (Maitri, 71°S, operated by India), both at similar longitude, have now been intercompared over time periods of several months. The magnetic intensities at 8 Hz are remarkably well matched between like coils (correlation coefficient 0.94) on a continuous basis for these two stations separated by more than 16 Megameters, substantiating a globally representative signal. Chimney lightning strengths can be intercompared and ranked on a daily basis. The relative chimney ranking varies from day-to-day, with the possibility that any one chimney can dominate on a given day, and consistent with the idea that the "Carnegie Curve" for global lightning is not invariant.

NOAA/OAR National Severe Storms Laboratory and the Cooperative Institute for Severe and High-Impact Weather Research and Operations

New and Updated Observational Capabilities.

The research team here has a long history of flying balloon-borne electric field meters (EFMs, Figure 1) into thunderstorms to study their charge structures. Even so, we still only have a limited sampling of electric field profiles from the vast population of thunderstorms. Indeed, lack of information about the charge structure in the storm was identified as a key limiting factor for fully understanding and modeling lighting at the flash and storm scale at a recent lightning modeling workshop in Albuquerque, NM. Over the last few years, we have been undertaking a significant refurbishment of these balloon-borne EFMs, modernizing the circuits to use more readily available components, and adding functionality like two-way communication to the balloon tracking and cutdown packages. At the same time, we've revisited the demodulation methods used to extract the vector electric field measurement from the signal recorded by the spinning and rotating spheres of the instrument.

Figure 1. Electric field meter (left) with radiosonde (middle) and cutdown/letdown package (right) ready to launch in LEE.

The Oklahoma Lightning Mapping Array (LMA) has been running since 2003, with subsequent changes in hardware and the spatial footprint. While the installed network is supportive of studies in Oklahoma, many of the other ongoing meteorological projects our local colleagues participate in are nomadic in nature. In the past few years we have built out an additional LMA consisting of eight sensors which can be deployed for any length of time (Figure 2). Each station has a solar panel which remains attached to an aluminum, fold-flat frame, an antenna mast which mounts onto the frame, and an electronics enclosure. The network can be deployed by two teams with four sensors each in just a matter of hours. The majority of the deployment time is generally the time spent driving between sites to produce an LMA with a decent footprint for solution accuracy and sensitivity. When possible, potential deployment sites have been scouted ahead of the project for suitability. This array has integrated seamlessly with other networks, and opens up new opportunities for collaborative studies. The Long Wavelength Array (LWA) is a VHF radio telescope with arrays in several locations including New Mexico. It has been long known that the LWA is sensitive to lightning, and should be an excellent instrument for lightning studies, but analysis of the data was not straightforward. A toolkit has now been developed which can take the LWA observations, reconstruct the time series records from all 256 antennas in the array for both polarizations, and image the results at arbitrary time resolutions. The large number of antennas allows for exceptionally high sensitivity interferometric observations of lightning, including the ability to locate multiple simultaneously emitting lightning sources. These data continue to be examined, and the tools continue to be expanded, helping to enhance our understanding of lightning physics.

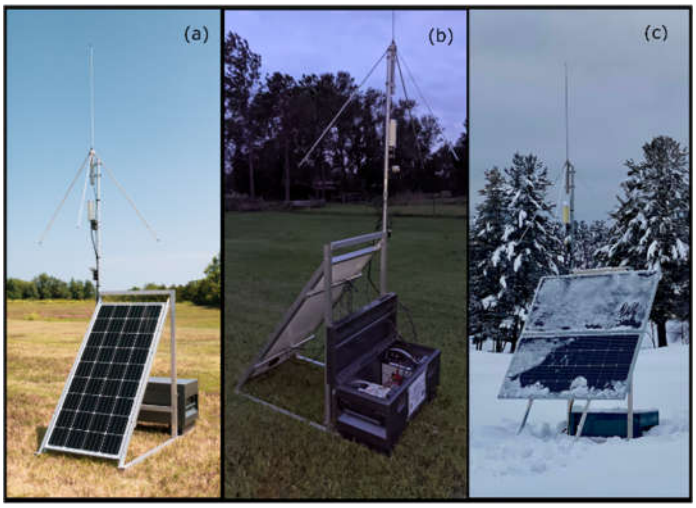

Figure 2. NSSL portable LMA stations deployed in (a) Oklahoma, (b) Florida, and (c) New York.

Recent Field Projects

With the new and updated observational platforms we have been able to coordinate deployment during multiple field projects. Highlights from some are described below, with additional analyses and publication development ongoing.

The Propagation, Evolution and Rotation in Linear Storms (PERiLS)

For the PERiLS field campaign, supported by NOAA and National Science Foundation (NSF), dozens of mobile in-situ and ground-based remote sensing platforms from many participating institutions were deployed in late winter and spring of 2022 and 2023 to characterize the near-storm environments and internal storm processes associated with tornado-producing quasi-linear convective systems (QLCSs) in the southeastern U.S. We deployed the eight-station mobile LMA in different locations, along with other mobile platforms, for each of nine intensive observation periods (IOPs). The LMA stations were typically deployed a day ahead of each event. Preliminary analyses include demonstrations that many tornadic regions had an increase in LMA flash initiation altitudes prior to tornadoes and that the highest flash rates were coincident with the largest equivalent potential temperatures deficits in the cold pools.

Lake Effect Electrification (LEE)

Between November 2022 and early February 2023, we participated in LEE to document the total lightning and electrical characteristics of lake-effect snowstorms in the lee of Lake Ontario over the Tug Hill Plateau in New York, where there are also several wind farms. This NSF-sponsored project was led by scientists at the State University of New York at Oswego, with several other participating institutions. A 16-station LMA was established for the study period using NSSL and Georgia Tech Research Institute (GTRI) sensors, which captured over 200 winter-season lightning flashes, many of which initiated over the wind turbines. There were eleven IOPs within the study period with coordinated observations from the mobile Doppler on Wheels, radiosondes, and NSSL's balloon-borne EFM and PASIV (Particle Size, Image, and Velocity) probe. We are using the unique combination of observations to study the variation of charge structures in these lake effect snow bands and the conditions necessary for them to produce lightning flashes.

Hurricane Ian

The development of the mobile LMA posed the opportunity to collect three-dimensional lightning data in a landfalling hurricane alongside other observation platforms from NSSL, including Mobile Mesonets, high-density soundings, and mobile radar. Hurricane Ian reached Category 5 status with maximum sustained winds of 160 mph over the Gulf of Mexico before weakening and making landfall on the southwest Florida coast on 28 September 2022. Seven mobile LMA stations (six standard stations as above plus one mounted on a Mobile Mesonet truck positioned near the coast) were deployed across central and western Florida shortly before landfall. The eyewall of Hurricane Ian was exceptionally electrically active during the intensification period over the Gulf of Mexico prior to landfall with lightning preferentially initiated around 10 km in altitude, well above the melting level (which was around 5 km in our onshore soundings). A substantial drop off in the lightning activity and altitudes occurred as the hurricane made landfall and moved into Florida.

Datasets:

Calhoun, K., and Coauthors, 2023: LEE: NSSL Balloon-Borne Electric Field Meter (EFM) Data. Version 1.0. UCAR/NCAR - Earth Observing Laboratory, URL https://data.eol.ucar.edu/dataset/622.012, doi: 10.26023/2N8N-D62E-MM01.

Chmielewski, V., and Coauthors, 2023: PERiLS_2023: NSSL Deployable Lightning Mapping Array Data. Version 1.0. UCAR/NCAR - Earth Observing Laboratory, URL https://data.eol.ucar.edu/dataset/626.004, doi: 10.26023/YNDP-KDMP-5K0G.

Chmielewski, V., and Coauthors, 2023: LEE: Combined NSSL and GTRI Lightning Mapping Array Data. Version 1.0. UCAR/NCAR - Earth Observing Laboratory, URL https://data.eol.ucar.edu/dataset/622.006, doi: 10.26023/HBAP-PKQM-XE0X.

Chmielewski, V., and Coauthors, 2023: LEE: NSSL LMA Raw Station Data. Version 1.0. UCAR/NCAR - Earth Observing Laboratory, URL https://data.eol.ucar.edu/dataset/622.008, doi: 10.26023/51B6-HXYN-1E07.

Universitat Politècnica de Catalunya Group

The upgrade of the Ebro Lightning Mapping Array (eLMA). The eLMA started its operation on 2011 at the Ebro Valley region (northeast of Spain). In 2022 we started the upgrade renewing all the stations. The eLMA is now online! elma.upc.edu or direct link: http://elmaservices.upc.edu/lma/.

The eLMA network has been upgraded with 15 new LMA sensors. In addition, the Catalan Weather Service (SMC) is installing 15 LMA sensors that will form a large LMA network.

The old LMA stations are upgraded as well and prepared to be used for dedicated campaigns. In June 2023 we participated in the ALOFT campaign installing a LMA in the island of San Andrés (Colombia).

Oscar van der Velde is building an interactive LMA visualization tool based on the Julia language. Its processing speed enables flash rate, 3D leader speed and polarity analyses (initially presented at ICAE 2018 in Nara, Japan) in real time. It also will overlay MTG-LI and GLM optical lightning data and evaluate their performance. Details will be presented at the JuliaCon 2024 (Eindhoven, Netherlands, 9-12 July 2024).

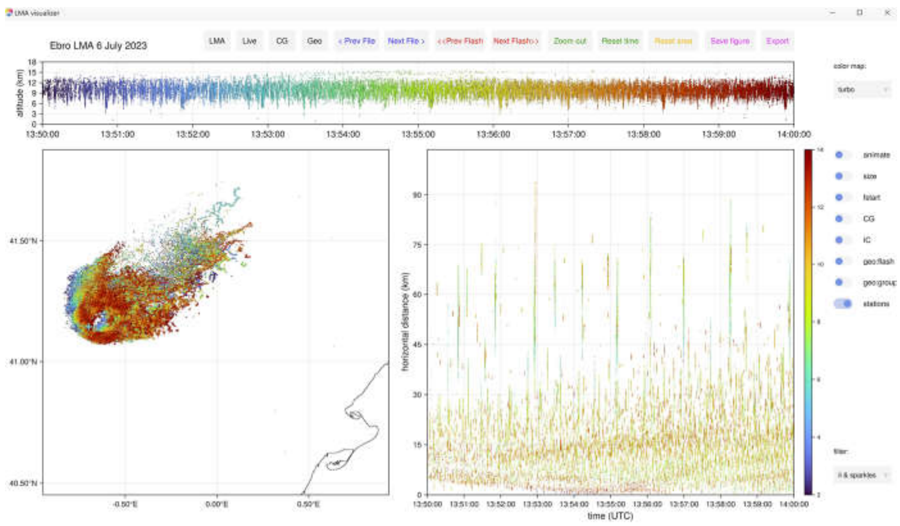

Figure 1. Examples: 10 minutes of lightning data of a large hail-producing supercell thunderstorm with a clear lightning hole observed over eastern Spain on 6 July 2023. The top panel in these figures is time-altitude, the left panel a longitude-latitude plan view. The right panel shows a time-distance-altitude plot, which can be used for lightning leader analysis but also for quickly revealing the flash rates and sizes of storms across the viewing area.

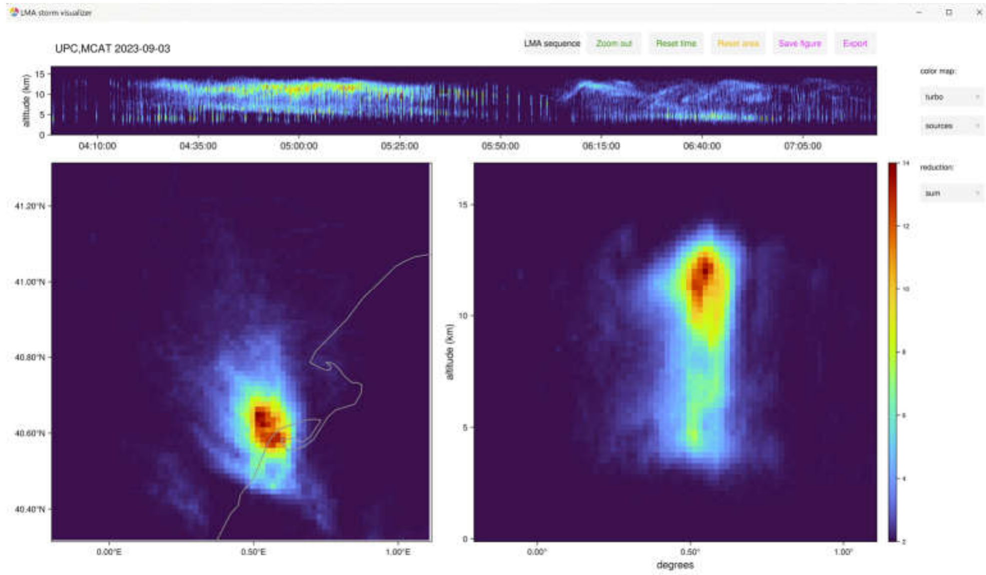

Figure 2. Three hours of lightning activity near the Ebro River Delta in eastern Spain on 3 September 2023, showing interesting time-altitude activity developments. In the bottom figure, the right panel shows a longitude-altitude sum of activity across the latitude axis. The resolution is 0.25 km (vertical) by 1.5 km (horizontal) and 15 s (time).

University of Florida

Z. Ding, V.A. Rakov, Y. Zhu, I. Kereszy, S. Chen, and M.D. Tran authored a paper titled "Comparison of Lightning Channel Luminosity Versus Time Profiles in the Infrared and Visible Ranges". Lightning is usually imaged in the visible (0.4-0.8 µm) range, although it also produces significant infrared emission. In this study, using high-speed framing cameras installed at the Lightning Observatory in Gainesville (LOG), Florida, we compared, for the first time, the medium-to-far (3-5 µm) infrared (IR) luminosity of lightning channels with the simultaneously recorded visible luminosity. The key findings include the persistent nature of IR luminosity throughout interstroke intervals, which is in contrast to visible luminosity that always decayed to an undetectable level before the following return-stroke onset. After the last stroke, IR luminosity persisted much longer (up to about 1 s) than visible luminosity. We discovered that the IR luminosity often exhibited a hump occurring some milliseconds to tens of milliseconds (mean = 11 ms) after the return-stroke onset, when visible luminosity was monotonically decreasing or already undetectable. We inferred that the IR hump is associated with enhanced IR emission from nitric oxide (NO) molecules whose concentration is expected to be maximum around 3400 K, and, hence, it can be used as indicator of the cooling channel temperature passing through the 3400 K point. This temperature for an atmospheric-pressure air plasma corresponds to the residual current of about 60 mA. It follows that lightning current can gradually fall from tens of kiloamperes (during the return-stroke process) to tens of milliamperes (by roughly a factor of 10^6) on a time scale of the order of 1-10 ms. We also examined a number of factors influencing IR afterglow duration, such as the number of preceding strokes, return-stroke peak current, and the occurrence of M-components. The above results contribute to the very limited literature on the infrared emission from lightning and provide new insights into the dynamics of lightning channel cooling process. This paper is published in the Geophysical Research Letters.

S. Chen, V.A. Rakov, Y. Zhu, and Z. Ding authored a paper titled "Clusters of Compact Intracloud Discharges (CIDs) in Overshooting Convective Surges". Using electric and magnetic field measuring systems installed at the Lightning Observatory in Gainesville (LOG), Florida, we observed five clusters of upper-level compact intracloud discharges (CIDs) moving positive charge up over land and over water in Florida. The clusters each contained 3 to 6 CIDs (a total of 24), and the overall cluster duration ranged from 27 to 58 s. On average, the CIDs in a given cluster occurred 11 s apart and were separated by a 3D distance of about 1.5 km. Some CIDs within a cluster were essentially collocated, while being separated in time by up to several tens of seconds. For each of the clustered CIDs, the height, mostly in the 18-20 km range, was greater than the tropopause height, typically in the 15-17 km range, and, therefore, they were likely associated with kilometer-scale convective surges that penetrated the stratosphere. The electrical conditions at those altitudes are considerably more favorable for the formation of electron avalanches and streamers than at the altitudes at which ordinary lightning discharges are initiated. The existence of electric fields exceeding the positive-streamer propagation threshold is evidenced by the well-documented (e.g., Krehbiel et al., 2000) VHF-emitting small-scale discharges in overshooting cloud tops. The average periodicity of CID occurrence within a cluster (every 11 s) was comparable to the periodicity at which the average cluster area is expected to be bombarded by $\geq 10^{16}$ eV cosmic-ray particles (every 5 s). Each of such energetic particles gives rise to a cosmic ray shower (CRS) and, in the presence of sufficiently strong electric field over a sufficiently large distance, to a relativistic runaway electron avalanche (RREA). We infer that each of our upper-level CIDs is likely to be caused by a CRS-RREA traversing, at nearly the speed of light, the electrified overshooting convective surge and triggering, within a few microseconds, a multitude of streamer flashes along its path, over a distance of the order of hundreds of meters (as per the mechanism recently proposed for lightning initiation by Kostinskiy et al. (2020)). It is likely that the upper-level CID clustering was made possible by (a) the recurring action of omnipresent energetic cosmic rays and (b) the rapid recovery of the negative screening charge layer at stratospheric altitudes. That recovery (via attraction of negative ions from clear air above the cloud) serves to restore the electric field relaxed by individual CIDs within a cluster on a time scale of the order of 10 s or less, which is comparable to or smaller than the 11-s average inter-CID time interval within a cluster in our study. These results are published in the Journal of Geophysical Research - Atmospheres.

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Help Uncover Climate Insights with the New "Atmospheric Electricity for Climate" Project on Zooniverse.

Lightning is now designated an Essential Climate Variable by the World Meteorological Organisation, which has focussed attention on recovering direct and indirect data sources of past information in atmospheric electricity. Locating the archive sources physically is one aspect, but keying the data for processing in digital form is another essential stage, which can be a huge undertaking for long data series. Citizen science projects have shown great promise in this second stage of archive data recovery, which can also build interested communities and encourage broader understanding of the related science.

Our citizen science project has now been launched for this on Zooniverse, and we want to both alert the ICAE community to this and seek further support in encouraging broad participation. The "Atmospheric Electricity for Climate" project aims to investigate the connections between atmospheric electricity and climate change. Volunteers are sought to assist in the current stage of digitizing historical data. You can join this project here: AtmosEleC - Atmospheric Electricity for Climate — Zooniverse. (https://rdg.ac/electricity).

AtmosEleC is concerned with the data from the UK geophysical observatories of Kew, Eskdalemuir and Lerwick (Figure 1), and focuses initially on historical atmospheric electricity data from Lerwick Observatory in

Shetland, UK. Lerwick Observatory was established in 1921 and is at a fascinating location, nestled in the scenic Shetland Islands of Scotland. Scientists at this observatory have conducted groundbreaking research on atmospheric electricity, cosmic rays, cloud properties, geomagnetic activity, and space weather forecasting.

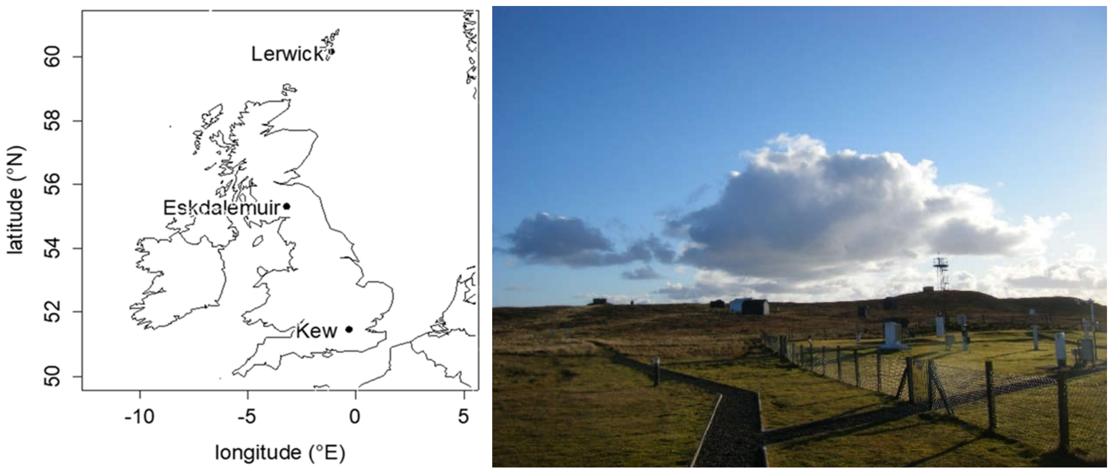

Figure 1. (a) Observatories in the UK. (b) Lerwick Observatory.

Lerwick became an important site for Potential Gradient (PG) measurements in 1925. PG measurements were systematically continued – hourly - by the observatory staff until 1984. Almost all these archive measurements have now been physically recovered, including many original handwritten records. The atmospheric electricity measurements at Lerwick are described in Harrison and Riddick, 2022.

Such long datasets are now recognised as precious resources for modern atmospheric science. However, to unlock the scientific opportunities of this remarkable information source, the data must first be accurately transcribed and digitized. Initially, we are focusing on digitizing the handwritten records. Once digitized, this data will be available for analysis by researchers worldwide, potentially leading to significant advancements in our understanding of atmospheric electricity and its relationship with climate variations.

As is well known, the potential gradient (PG) represents the electric potential measured at a fixed point above the ground, determined using a sensing electrode and a voltage recording device. This measurement is demanding, requiring excellent insulation and a highly sensitive electrostatic voltmeter. Maintaining the necessary insulation quality in all weather conditions is challenging, particularly given the often quite variable conditions at Lerwick. At Lerwick Observatory, a radioactive probe served as the sensing electrode, which was connected to an electrometer and chart recorder to facilitate continuous recordings. This recording paper apparatus was known as an "electrograph". The Benndorf design of electrograph – a mechanical device was used from 1925-1960. After then, a Brewer valve electrometer and chart recorder was installed, providing the remainder of the records until 1984. The potential probe was mounted on the outside of the main observatory building, exposed to atmospheric air, with the electrometer and chart recorder housed inside the building (see Figure 2 below). The paper chart records produced were called "electrograms", for consistency with other meteorological charts (barograms, thermograms…) and figure 2a gives an example of a Lerwick electrogram.

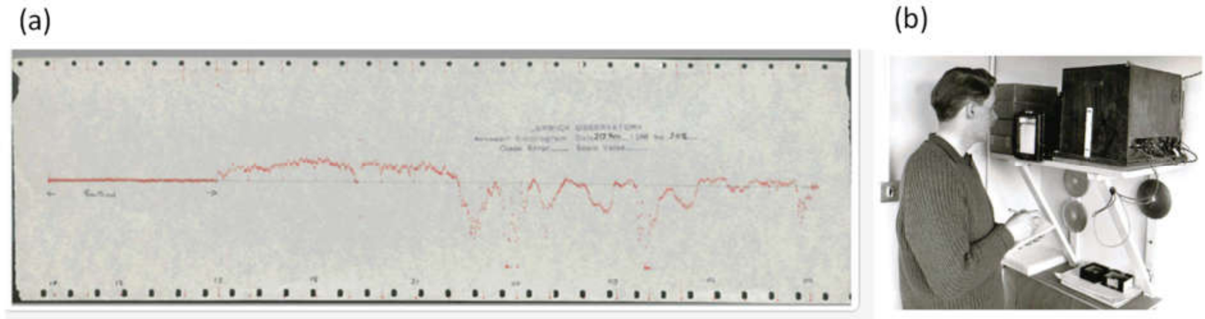

Figure 2. (a) Paper chart electrogram from the Benndorf electrograph (for 2nd Nov 1960) (Image credit: National Meteorological Archive). (b) PG recordings being taken from the Brewer electrograph by Lerwick meteorologist Monty Georgeson (Image credit: Lerwick Observatory Archives, 1966).

The hourly PG values on the record sheets were also averaged and tabulated as monthly sets of daily values in the annual volumes of the Observatories' Yearbook until 1967, and thereafter on individual summary sheets until 1984, stored in the National Meteorological Archive. Figure 3 shows an example.

A new application of PG measurements involves their close association with global thunderstorm activity and its variations, facilitated by the Global Electric Circuit (GEC) that links disturbed weather areas with fair weather regions. With the Lerwick dataset, one of our initial research goals is to further explore how El Niño events impact the GEC (Slyunyaev et al, Harrison et al).

Citizen science projects like AtmosEleC are central for advancing scientific research and Zooniverse provides an excellent platform for these and related endeavours. It is the world's largest platform for citizen science projects, enabling volunteers to support scientists in a wide range of research tasks where there is a need of human input. These include classifying galaxies, transcribing ancient manuscripts, monitoring wildlife, and now, digitizing handwritten records of atmospheric electricity. Volunteers engaging with Zooniverse have the unique opportunity to participate in cutting-edge research, significantly contributing to advancements in these fields.

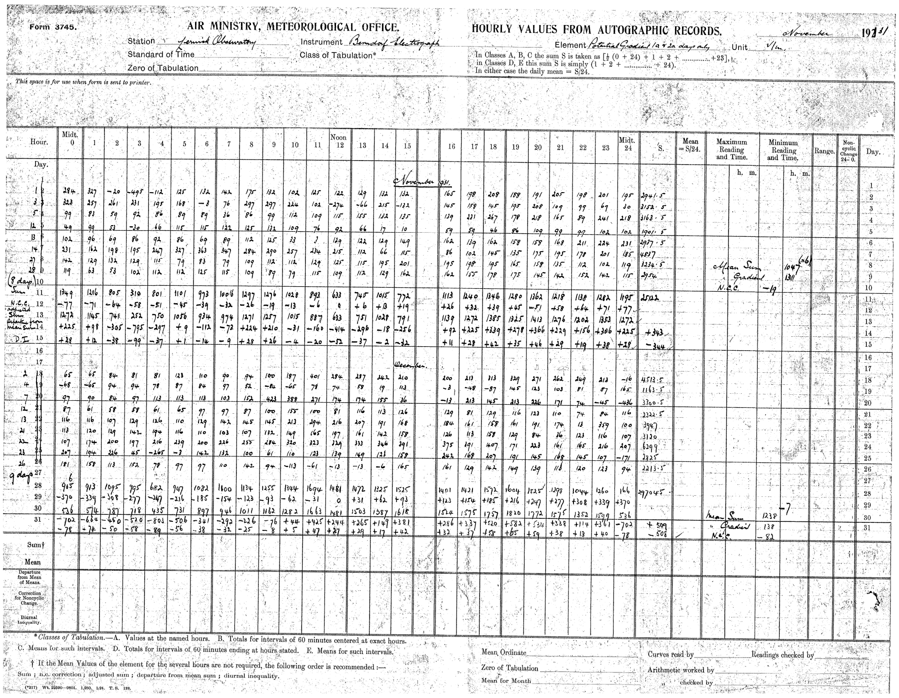

Figure 3. PG data record sheet of archive data (Image credit: Lerwick Observatory Archive).

Working with Zooniverse is a rewarding and valuable task, to help current and future researchers in our science area by providing new data for scientific analysis. All help is welcome (and necessary), so please distribute this information to your groups and collaborators - join us on Zooniverse in this task! Go to: https://rdg.ac/electricity.

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ATMOSPHERIC ELECTRICITY

NEWSLETTER

Vol.35 No.1 2024 May

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 **2024 winter issue** of the newsletter is **Nov 15, 2024**.

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