Newsletter on Atmospheric Electricity

Vol. 28, No. 2, Dec 2017

International Commission on Atmospheric Electricity (IAMAS/IUGG)
AMS Committee on Atmospheric Electricity
AGU Committee on Atmospheric and Space Electricity
European Geoscience Union
Society of Atmospheric Electricity of Japan

This two-stroke Cloud-to-ground lightning flash with two ground terminations was photographed by Mike Olbinski in southern New Mexico on July 10, 2015 using a 10 s exposure. The first stroke (on the right) struck the ground about 460 m from the camera (+/- 24%) and also initiated at least 12 unconnected, upward leaders (or "streamers") near the ground termination. Attachment occurred when an upward-propagating positive leader reached an inferred height of about 20 m above local ground (Attachment 1). The second stroke (on the left) struck ground about 740 m from the camera, and the height of its attachment is estimated to be 15 m. The estimated lengths of the unconnected upward leaders in the two-dimensional plane of the first stroke range from 1.8 to 8 m, and all appear to be located within 15 m (2-D) of the main ground termination (total of 28 m separation), with 24% uncertainty. Many of the unconnected upward leaders (inferred to be positive) exhibit multiple upward branches, and most of those branches have upward-directed forks or splits at their ends. This is the first report showing such extensive branching for positive upward leaders in natural lightning striking flat ground. In terms of lightning safety, this photo demonstrates that numerous upward leaders can be produced near a lightning strike point and have the potential to result in damage or cause injury at more than one specific point on the ground.
The paper describing the detailed analysis of this flash is available online at the link below through January 20, 2018, and will appear in Atmospheric Research in April, 2018.
Cummins, K.L., E.P. Krider, M. Olbinski, R. Holle (2018), A case study of lightning attachment to flat ground showing multiple unconnected upward leaders, *Atmos. Res.*, 202, pp169-174.
https://authors.elsevier.com/a/1WAT0_3t6lc8dS

Announcements

GRADUATE FELLOWSHIPS IN ATMOSPHERIC ELECTRICITY OFFERED

"New Mexico Tech's Physics Department and the Langmuir Laboratory for Atmospheric Research would like to let the community know that they have multiple graduate fellowships available for students entering in September 2018 with interests in atmospheric electricity and/or atmospheric physics. Interested students should apply by January 15, 2018 for maximum consideration. Go to physics.nmt.edu for links to apply, or contact department chair richard.sonnenfeld@nmt.edu with questions."

Richard Sonnenfeld
Professor of Physics, New Mexico Tech
Research Scientist, Langmuir Laboratory
Physics Dept Chair (2016-2019)
Telephone: 575-835-6434

ANNOUNCEMENT for the ICAE newsletter

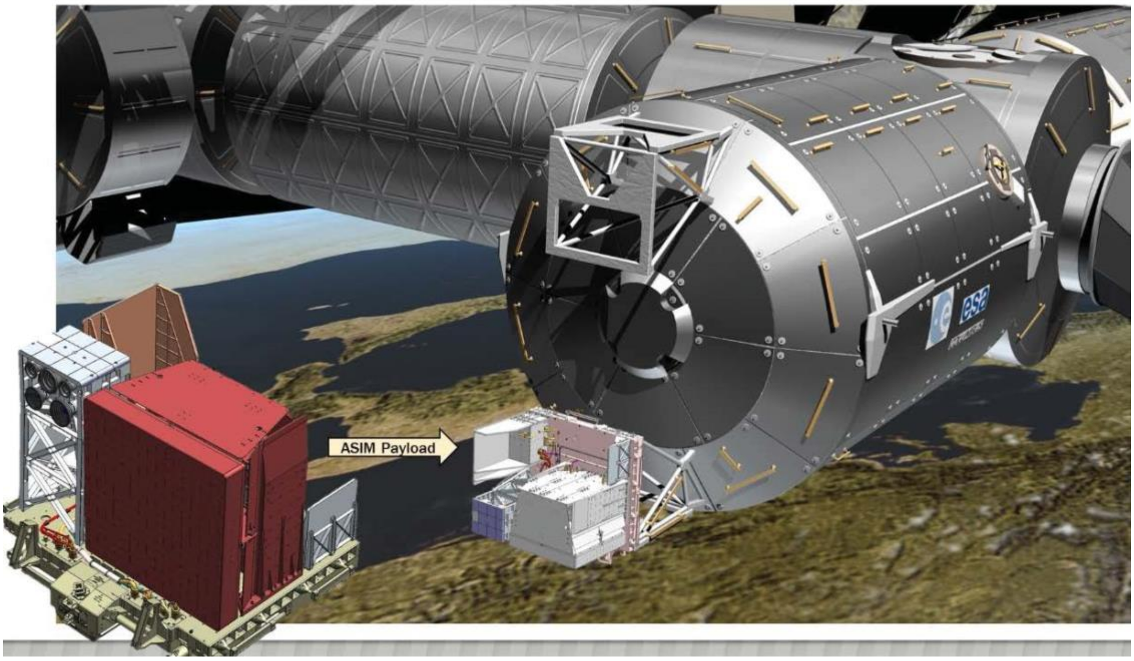
The Atmosphere-Space Interactions Monitor (ASIM) on the International Space Station is scheduled for launch 13. March, 2018

From: Torsten Neubert, National Space Institute, Technical University of Denmark (DTU Space); neubert@space.dtu.dk
With: Nikolai Østgaard, University of Bergen, Norway, Victor Reglero, University of Valencia, Spain, and Elisabeth Blanc, CEA, France.

The Atmosphere-Space Interactions Monitor (ASIM) is an instrument suite for the International Space Station for measurements of lightning, Transient Luminous Emissions (TLEs) and Terrestrial Gamma-ray Flashes (TGFs). The instruments include an X- and Gamma-ray monitor with direction-finding capabilities of TGFs (coded mask) measuring photons from ~20 keV to 20 MeV, and an array of three photometers and two cameras measuring in the bands: 240-300 nm, 337 nm and 777 nm. The photometers sample at 100 kHz and the cameras at 12 Hz with ~400 m resolution on the ground.
The payload is developed in the framework of the European Space Agency (ESA) and is scheduled

for launch on SpaceX-14 on March 13, 2018, to be mounted on an external platform on ESA's Columbus module of the Space Station.

We expect to invite the international community to participate in the mission with a call for collaboration to be issued within the near future.



You are invited to attend the 2018 International Lightning Detection and International Lightning Meteorology Conferences

The 25th International Lightning Detection Conference and 7th International Lightning Meteorology Conference (ILDC/ILMC) will be held March 12-15, 2018, at the Pier Sixty-Six Hotel and Marina in Fort Lauderdale, Florida, USA. The ILDC/ILMC is a scientific conference focused on lightning detection topics and meteorological applications for lightning data. Organized every other year, the conference brings together global participants and lightning experts to present new detection technologies, research findings, and applications. The theme of the 2018 conference is **Connecting Research & Applications**, and the agenda will include presentations, a poster session, and roundtable discussions. The Scientific Committee is now reviewing numerous abstract submissions, and registration will open in November 2017. For full conference details, visit www.vaisala.com/ildc.

Research Activity by Institution

Curtin University, Bentley, Western Australia, Australia

A database of lightning-related deaths and injuries in Bangladesh was developed from 1990 to mid-2016 from a variety of sources that contains a total of 5468 casualties, composed of 3086 fatalities and 2382 injuries. Spatial, temporal, and demographic aspects of these lightning casualties are evaluated in order to aid relevant entities in effective management of lightning-related meteorological hazards. The annual averages for Bangladesh are 114 fatalities and 89 injuries over the entire period. Weighting by population reveals a fatality rate of 0.92 per million people per year and an injury rate of 0.71. In contrast, the latest 6 years have a fatality rate of 1.6 and injury rate of 1.4. The rural portion of lightning fatalities is 93%. Most fatalities occurred between early morning (0600 LST) and early evening (2000). Through the year, more fatalities occur during the premonsoon season of March through May than during the monsoon season (June–September). The interannual time series of fatalities indicates an increase since the late 2000s, which is a result of greatly improved communications leading to better media reporting of lightning casualties. Bangladesh has also become much more populous in recent years. As a result, the most recent 6 years have 251 fatalities per year, which may be considered as the current estimate. The majority of lightning-related deaths occurred to males. Farming is the major activity at the time of lightning fatalities followed by being inside a dwelling and returning home or walking around homesteads/courtyards.

Reference

Dewan, A., M.F. Hossain, M.M. Rahman, Y. Yamane, and R.L. Holle, 2017: Recent lightning-related fatalities and injuries in Bangladesh. Weather, Climate, and Society, 9, 575-589.

Geophysical Monitoring Laboratory of Borok Geophysical Observatory, Schmidt Institute of Physics of the Earth (Russia)

Borok Geophysical Observatory IPE RAS [58°04´N, 38°14´E] is the unique middle-latitude geophysical observatory in the European part of Russia, operating under conditions of “geoelectromagnetic preservation area” with low level of anthropogenic pollutions. So the Geophysical Monitoring Laboratory makes the continuous observations of natural geophysical and meteorological fields, including observations of natural geomagnetic field, air electric field, atmosphere electric current, meteorological fields (temperature, air pressure, humidity, wind, precipitation). The continuous measurements of altitude profiles of wind speed (by Doppler acoustic sounder) and temperature (by meteorological temperature profile) have been developed during recent years. The Laboratory also carried out measurements of radon isotopes (^{220}Rn and ^{222}Rn) activity and light ions concentrations in ground air.

The season field observations of air electricity were taking from April till September 2017. The ground-based measurements of atmosphere electric field, electric conductivity, aerosol concentration and radon activity were carried out. The simultaneous ground-based meteorological measurements of air temperature, wind speed, atmospheric pressure and humidity were taken by two automated ultrasonic systems placed at 2 m and 10 m altitudes.

The observed data are used in numerical simulation of electric processes in low atmosphere. The effects of the atmospheric boundary layer turbulence along with variable radon exhalation rate and aerosol load on the fair-weather atmospheric electricity are investigated. Vertical turbulent transport of radon, its progeny and electrically charged particles is described under Lagrangian stochastic framework, which is the next step to develop a consistent model for the formation of electrical conditions in the atmospheric boundary layer. The quantitative estimates of contribution of global and local perturbations to diurnal variation of electric field at the earth's surface are obtained. The variations of the atmospheric electricity associated with the atmospheric boundary layer dynamics are found to be significant in comparison with the variations attributed to the changes in global parameters.

The Geophysical Monitoring Laboratory staff took part in organizing of two scientific conferences holding in Borok Geophysical Observatory this year: the 21st All-Russia Conference of Young Scientists "Atmospheric composition. Atmospheric electricity. Climatic processes" (Borok, June 6 – 10, 2017) [http://wwwbrk.adm.yar.ru/satep] and the 3rd All-Russia Conference on Global Electric Circuit (Borok, September 25 – 29, 2017) [http://geodata.borok.ru/gec/2017/index]. The detailed information about 3rd All-Russia Conference on Global Electric Circuit is presented in this issue. The reports on atmosphere electricity topics were presented also at a theoretical and practical conference "Middle-latitude geophysical observations", in commemoration of the centenary of V. A. Troitskaya birth and of the sixtieth anniversary of Borok Geophysical Observatory (Borok, October 16 – 19, 2017) [http://wwwbrk.adm.yar.ru/jubilee].

Conference Report

The Third All-Russia Conference on Global Electric Circuit (GEC-2017), Borok, Russia, September 25–29, 2017

Formation of Global Electric Circuit (GEC) is a key problem in atmospheric electricity researches. Borok Geophysical Observatory of Schmidt Institute of Physics of the Earth of the Russian Academy of Sciences, located in Borok, a scientific settlement in Yaroslavl region, with financial support from Russian Foundation for Basic Research has organized biannual All-Russia Conferences on Global Electric Circuit since 2013. The conferences make possible for leading scientists working on GEC investigations to meet together and to present the most significant results of the researches.

The Third All-Russia Conference on Global Electric Circuit was held on September 25 – 29, 2017. Working language of the conference was Russian, but presentations in English were welcomed too. More than 30 participants from 14 leading scientific centers of Russia, including Shmidt Institute of Physics of the Earth (Moscow), Borok Geophysical Observatory (Borok), Institute of Geosphere Dynamics (Moscow), Pushkov Institute of Terrestrial Magnetism, Ionosphere and Radio Wave Propagation (Troitsk, Moscow), Space Research Institute (Moscow), Fedorov Institute of Applied Geophysics (Moscow), Ioffe Institute (Saint Petersburg), Institute of Applied Physics (Nizhny Novgorod), Institute of Computational Modeling (Krasnoyarsk), Skobeltsyn Institute of Nuclear Physics of Lomonosov Moscow State University (Moscow), Vladimir State University (Vladimir), Tomsk State University (Tomsk), Southern Federal University (Rostov-on-Don) and others, participated in the conference. They presented oral reports and poster papers in six sections:

- Mathematical modeling of GEC as geophysical object;
- Electricity of lower atmosphere in GEC;
- GEC dynamics: thunderstorm electricity, lightning, ionosphere and magnetosphere activity;
- Electricity of middle and upper atmosphere, high-energy processes in the atmosphere;
- GEC, meteorology and climate, ecological aspects of GEC;
- GEC monitoring: field observations and databases.

The conference was characterized by the high scientific level of the reports. The conference promoted open exchange of interdisciplinary geophysical information, discussion of mathematical, instrumental and methodical base of modern geophysics. The topical fundamental problems of atmospheric electricity, geoelectrodynamics, mathematical modeling of processes in global electric circuit, interpretation of natural atmospheric electric observations and geoinformatics were discussed.

More information about GEC-2017 can be found at: http://geodata.borok.ru/gec/2017/index

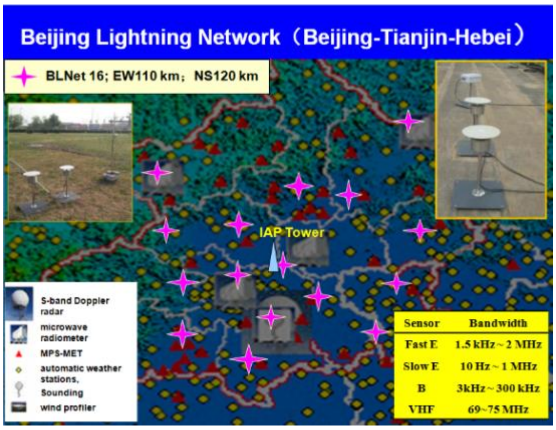
LAGEO, Institute of Atmospheric Physics, CAS, Beijing, China

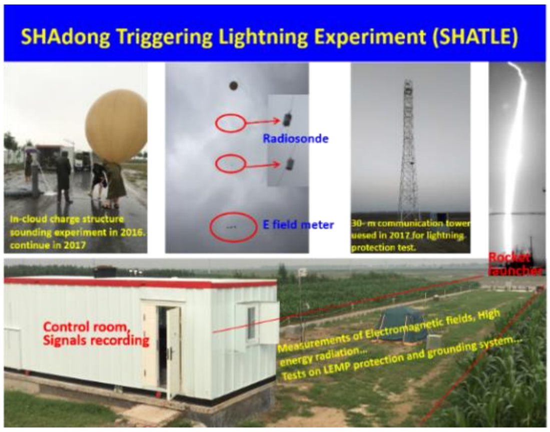
The 1st International Symposium on Lightning Physics and Lightning (ISLP&M 2017): In order to exchange new thoughts on lightning studies, further enhance the application of lightning detection, improve the scientific understanding of lightning over many temporal and spatial scales, and promote the development of interdisciplinary research on lightning, the 1st ISLP&M was successfully held in Beijing, China, during 24-27, September, 2017. About 120 participants from 9 countries and regions attended the symposium, with 12 invited experts presenting their recent important advances. Meanwhile, 42 oral presentation and 36 posters were fully discussed in the symposium. The organization of the symposium had promoted the exchange of academic ideas, the potential cooperation and the friendships between different lightning researchers.

Program of Dynamic-microphysical-electrical Processes in Severe Thunderstorms and Lightning Hazards (STORM973): Program STORM973 is granted by the Ministry of Science and Technology of China as National Key Basic Research Program of China, with a joint effort of several institutions and universities in China. The project is desired to 1) develop 3D lightning location network and establish comprehensive observational dataset of severe thunderstorms; 2) reveal interaction between dynamic, microphysical, and electrical processes in severe thunderstorms and associated mechanism; 3) clarify physical mechanism of lightning occurrence and development, effect of electromagnetic radiation, and hazard causes; 4) develop schemes for assimilating lightning data into weather forecast models, and forecasting and early warning for severe thunderstorms and lightning hazards.

Beijing Lightning NETwork (BLNET) and the performance assessment: For tracking and monitoring the lightning activities in Beijing-Tianjin-Hebei urban cluster area, the BLNET had been developed from the year of 2008, with both research and operational purposes. It is consisted of 16 stations equipped with fast and slow antennas, VHF antenna, and LF magnetic field sensor. BLNET locates both IC and CG lightning radiation pulses in 2D in real time for severe thunderstorm warning, maps IC and CG lightning in 3D for research, and records electromagnetic field waveforms for lightning characteristics analysis. Srivastava et al. (2017) evaluated the performances of BLNET in terms of detection efficiency and relative location accuracy with a self-reference method, for which fast antenna waveforms have been manually examined. Based on this work, the average detection efficiency of BLNET is 97.4 % for IC, 73.9 % for CG and 93.2 % for total flashes. Result suggests the CG detection is highly precise when the thunderstorm passes the regional dense network; however it changes day to day when the thunderstorms are outside the network. Ye Tian got his PhD dissertation with title of Upgrading and Evaluation of Beijing Lightning Network (BLNet) and Study on Bipolar Cloud-to-ground Lightning.

Three-dimensional thunderstorm E-field sonde system and the field experiment: a 3D E-field sonde system has been newly developed with kindly help from Prof. Tom Marshall. Three E-field profiles were acquired through stratiform region of a MCS during its mature stage. The analysis shows that there were six charge regions in the stratiform region and charge polarity was alternate in a vertical direction with a lowest positive charge region near 0°C. An NBE location method is also developed based on single-station measurement of LF magnetic fields to infer charge structure in strong convective region. By combining E-field sounding and charge region deduced with NBE locations, the overall charge structure of the MCS is outlined. Hongbo Zhang just got his PhD dissertation with title of Development of 3D Thunderstorm Electric Field Sounding System and Study on the Electric Charge Structure inside Thunderstorms.

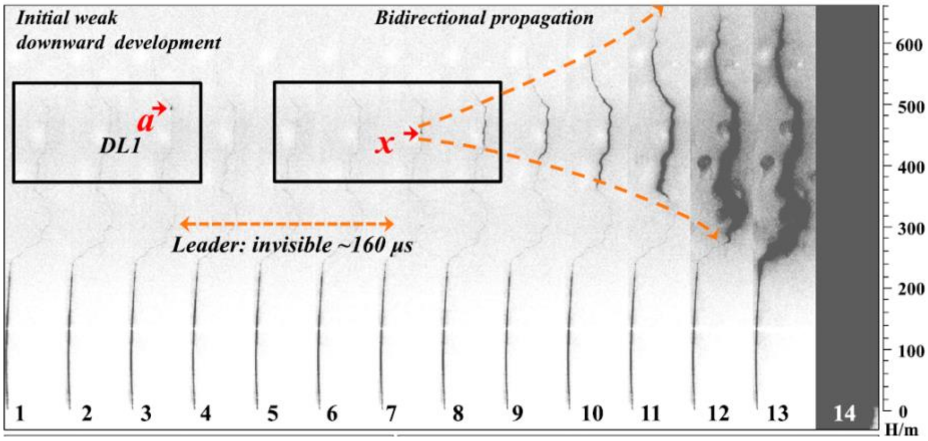




The stepwise development of an upward positive leader from high tower： Using a camera at 150 kfps, Wang et al. (2016) documented the first optical evidence for the stepping processes of an upward positive leader during its self-sustained propagation from a 325 m tower, which was just published in Journal of Geophysical Research–Atmospheres. The leader developed with definitive intermittent pauses and re-establishment with abrupt jump of the leader top. Obvious brush-like corona zone emitting outward from the leader top was identified in the frame of stepping, and the luminosity waves propagated downward along the already formed channel from the leader top immediately following the stepping, indicating that a current wave was generated at the leader top and subsequently traveled down the channel. The positive leader experienced an average interstep interval of 61.7 μs, average 2-D speed 8.1×104 m/s, transient step jump speed of larger than 7.3×105 m/s, and an average step length of 4.9 m

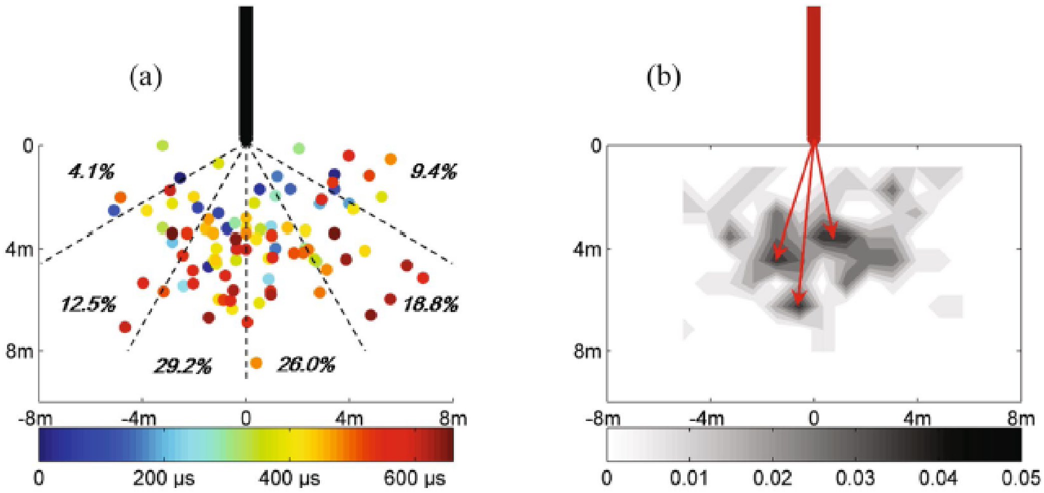
Bidirectional leader development in a preexisting channel: Qie et al. (2017) identified two cases of bidirectional leader developing in preexisting channel of rocket-triggered lightning for the first time. The paper was published in *Journal of Geophysical Research－Atmospheres*. The bidirectional leaders emerged below a decaying dart/dart-stepped leader that terminated before reaching the ground. The positive end started earlier and propagated faster than the negative end. The negative end extended downward and eventually culminated in a return stroke. Since the bipolar leader was tracing the single channel of a decayed dart leader with negative polarity, the observational facts give solid evidence for the occurrence of rare recoil leader with opposite polarity to the traditional one which develops in the remnants of positively charged channel.

Upward negative leader in triggered lightning： Most of the rocket-triggered lightning flashes were of negative polarity and the positive lightning was hardly triggered. By successfully triggering the rare positive lightning, comprehensive observation on the associated upward negative leader (UNL) was available and the quantitative data was obtained, shedding new insight into the question of how negative lightning leaders initially start and behave. Pu et al. (2017) conducted detailed analysis on the characteristics of UNLs as they emerged from the wire tip and propagated upward. The charge transferred in each step of the upward negative leader was found to be nearly an order of magnitude greater than the upward positive leader, indicating that the breakdown of negative leader step requires more energy. Initial extension of the main leader channel was significantly influenced by the neighboring branches.



Bidirectional leader development in preexisting channel as observed in a rocket-triggered lightning flash

Channel branching and zigzagging in negative cloud-to-ground lightning: Jiang et al. (2017) analyzed the optical observation of two negative CG flashes with high temporal resolution of 180 kps. It is found that the clustered space leaders formed in parallel ahead of the channel tip during an individual step process. The leader branching is due to the multiple connection of the clustered space leaders with the same root channel tip, which occur almost simultaneously, or successively as some space leaders/stems resurrect after interruption. Meanwhile, the irregularity of angles between the clustered space leaders and the advancing direction of leader tip is the origin of channel tortuosity. The statistical analysis on 96 steps shows that more than 50% steps occurred within an angle range of ±30° from the advancing direction of the leader.



Length and relative direction of each individual steps, and the probability density distribution.

Upward lightning on the 325 m meteorology tower and its thunderstorm conditions: With the comprehensive observation on lightning striking the 325 m meteorology tower conducted in Beijing, Yuan et al. (2017) found that most upward lightning in negative polarity (84.2%, 16/19) were triggered by nearby preceding +CGs. Analysis suggests that the approaching of negative leader process through in-cloud horizontal channel is vital for the initiation of upward leader. The nearby preceding +CG can lead to a significant enhancement of the continuous current process as well. All the upward lightning flashes tend to occur at the dissipation stage of the thunderstorm when the meteorology tower was underneath stratiform region with a relatively low cloud top height and weak radar echo. The transient electric filed change transition over the tower caused by nearby +CGs near could trigger the upward leader initiation. When the charge layer is lower and wind speed is higher, favored by the charge transfer from the convective region, the upward leader could initiate even without nearby preceding discharge.

Sprites produced by two distinct lightning flashes: Relationships between the sprites and the underlying thunderstorm and lightning activities have been investigated based on case studies by Yang et al. (2017). One very unusual and unique positive sprite event may be produced jointly by two distinct positive cloud-to-ground lightning flashes (+CGs). The charge moment change (CMC) due to the two +CGs is smaller than those of the parent CGs for other two sprites recorded over the same thunderstorm, and the vertical extension and brightness of sprites correspond well with their parent CG CMC values. Another case of single sprite did not occur at the time period in which the thunderstorm maximum area was reached and the sprite occurrence corresponded well with the decay of the thunderstorm convection. No significant relationship between the sprite occurrence and the increase of 30-35 dBZ and 35-40 dBZ interval has been found. The sprite occurred during the parent flash continuing current process.

Lightning Activity and Its Relationship with Typhoon Intensity and Vertical Wind Shear for Super Typhoon Haiyan (1330): The temporal and spatial distributions of lightning activity for super typhoon Haiyan (1330) occurred in 2013 were analyzed by Wang et al., which is published *J. Meteor. Res.* in 2016. Three distinct regions were identified in the spatial distribution of daily average lightning density, with the maxima in the inner core and the minima in the inner rainband. The lightning density in the intensifying stage of Haiyan was greater than that in its weakening stage. During the time when the typhoon intensity measured with maximum sustained wind speed was between 32.7 and 41.4 m s

$^{-1}$, the storm had the largest lightning density in the inner core, compared with other intensity stages. In contrast to earlier typhoon studies, the eyewall lightning burst out three times. The first two eyewall lightning outbreaks occurred during the period of rapid intensification and before the maximum intensity of the storm, suggesting that the eyewall lightning activity could be used to identify the change in tropical cyclone intensity. The flashes frequently occurred in the inner core, and in the outer rainbands with the black body temperature below 220 K. Strong vertical wind shear (VWS) produced downshear left asymmetry of lightning activity in the inner core and downshear right asymmetry in the rainbands.

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Thunderstorm climatology over the Mediterranean area

A 10-year dataset of thunderstorms in the Mediterranean area was analyzed in order to determine the thunderstorm climatology and the thunderstorm's physical characteristics. For that reason, a clustering algorithm was applied to the cloud-to-ground (CG) lightning stroke data, derived from ZEUS lightning detection system which is operated by National Observatory of Athens, in order to identify thunderstorms from 2005-2014 in the Mediterranean region. In our knowledge, this is the first time that Mediterranean thunderstorms are tracked and their climatological aspects (size, duration, speed, intensity, relation to rainfall) are analyzed. This work has been submitted for publication in the Atmospheric Research and is under revision (Galanaki et al., 2017).

To perform thunderstorm cluster analysis in the Mediterranean, we build a clustering methodology which takes as input CG lightning strokes. To identify a new thunderstorm cluster, initially, one CG lightning event is used as the "lightning core" of the new cluster. All the lightning events which have distance less or equal than 0.1° and time difference less or equal 16 min are considered as events of this cluster. The previous step is repeated for every new lightning event added at the cluster. It is considered that the thunderstorm cluster has finished when there is no other lightning event which meets the two thresholds (16min for time difference and 0.1° for spatial difference). The values of the thresholds were selected after performing several sensitivity tests and visual analysis of selected cases. Results showed that the annual thunderstorm days are modulated by the diurnal cycle of insolation and the underlying topographic features of the region. The mean propagation direction of the thunderstorms is from south-west to north-east direction. Thunderstorm occurrence is dominant over the land and the coastal areas during spring and summer while during the coldest period of the year it is dominant over the sea. On average winter thunderstorms are less frequent, have less mean CG lightning intensity, tend to last longer, have greater cluster sizes and are associated with greater values of velocity than summer thunderstorms. Furthermore, Mediterranean thunderstorms intensity and rainfall over the Mediterranean region have been found to be correlated. The rain yield was estimated to be about 1.8 10^8 kg of rainfall per CG lightning and is maximum in winter and minimum in summer.

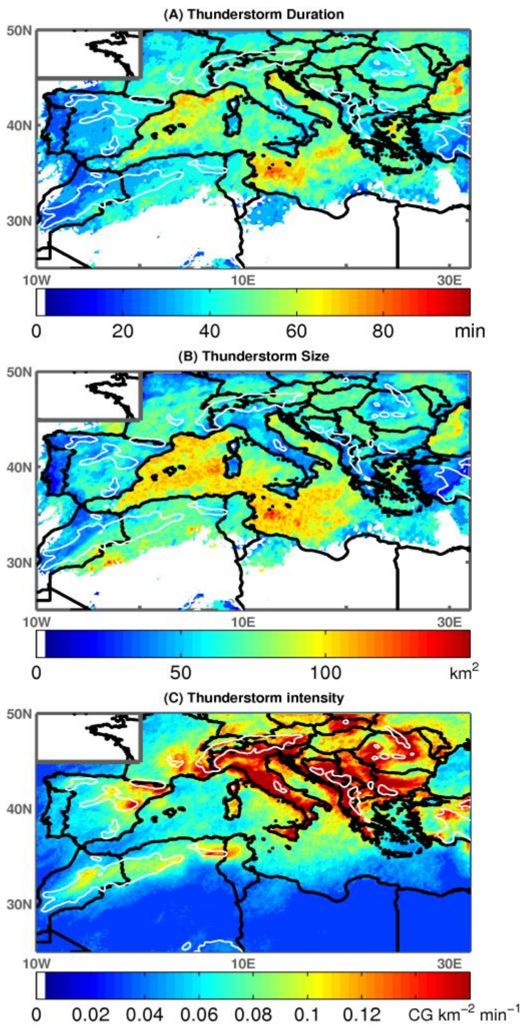


Fig. 1. Spatial distribution of the average (a) thunderstorm total duration, (b) thunderstorm size and (c) mean thunderstorm intensity over the Mediterranean area estimated for the period 2005–2014. The white solid line depicts the 1000-meter elevation contour. For clarity, grid points with less than 20 thunderstorms were removed.

Figure 1 shows the spatial distribution of the average duration, size and intensity of the thunderstorms over the Mediterranean area along with the major topographic characteristics of the study area. As thunderstorm intensity has been defined the number of lightning strokes/km^2/min at the time of the mature phase of the thunderstorm lifecycle (when lightning activity is maximum). Maritime thunderstorms are related to high values of thunderstorm duration (>100min), especially over the Balearic, Adriatic, north Aegean, the central Mediterranean and the Black Sea (Fig. 1a). Thunderstorms of high duration that occur over the western and eastern Mediterranean Seas are also associated with large sizes (>150 m^2; Fig. 1b). Thunderstorm associated with large sizes and long durations are not favoured in areas of terrain elevation. Thus, orographically triggered thunderstorms tend to be of relatively short duration and size, while there are associated with greater intensity (Fig. 1c).

Contribution from the Chinese Academy of Meteorological Sciences

Observations of precursor process during the initial stage of a rocket-and-wire-triggered lightning discharge. During 2016, collaborating with the New Mexico Institute of Mining and Technology, we developed continuous interferometer which can accurately locate and detect the

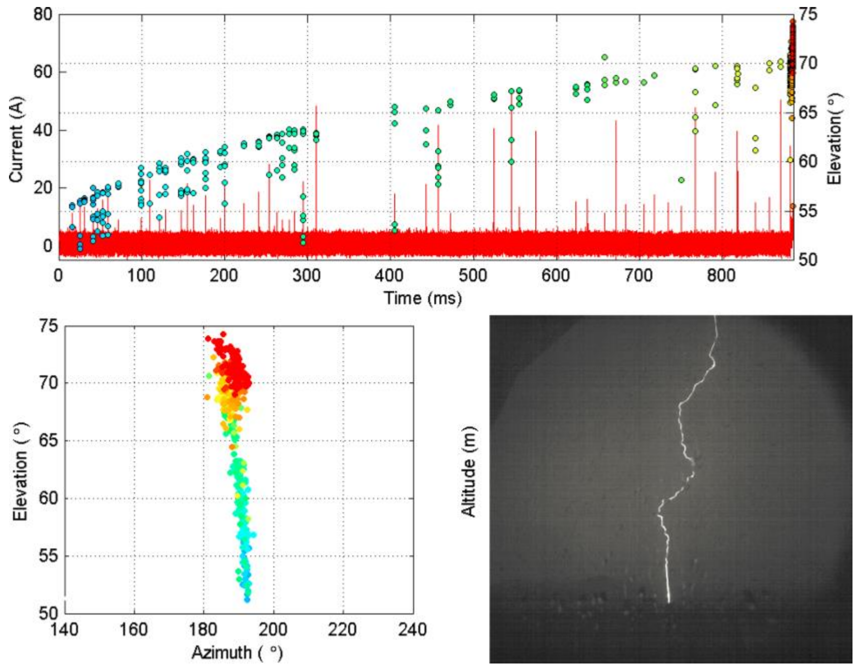


Figure 1. (a) Elevation angles of the VHF radiation sources (dots) versus time during the rocket ascent, and (b) in 2-D elevation versus azimuth format (colored by time), relative to (c) discharge channel of the triggered lightning, as shown by a single frame from the high-speed video images.

breakdown activity with sub microsecond and meter-scale resolution. The processing code is the same as that developed for the lightning initiation study by Rison et al. [2016] and is based upon the analysis techniques of Stock et al. [2014]. We observed a triggered lightning obtained on 9 June 2016 during the Guangdong Comprehensive Observation Experiment on Lightning Discharge. The discharge produced 54 precursor current pulses (PCPs) over 883 ms during the rocket's ascent. The interferometer observations show that the PCPs were produced by breakdown at the ascending tip of the rocket, and that individual PCPs were produced by weak upward positive breakdown over meters-scale distances, followed by more energetic, fast downward negative breakdown over several tens of meters distance (Figure 1). The average propagation speeds were ~5×10^6 m s^{-1} and ~3×10^7 m s^{-1}, respectively. The sustained upward positive leader (UPL) was initiated by a rapid, repetitive burst of 14 precursor pulses. Upon initiation, the VHF radiation abruptly became continuous with time. Our research provides valuable insights into the triggering mechanism and positive breakdown processes.

Characteristics of the initial stage and return stroke currents of rocket-triggered lightning flashes in southern China. The initial stage (IS) and return stroke (RS) currents of 50 triggered lightning flashes (TLFs) that were conducted in southern China were investigated (Figure 2). The IS of the negative TLFs has a longer duration and larger average current, charge transfer, and action

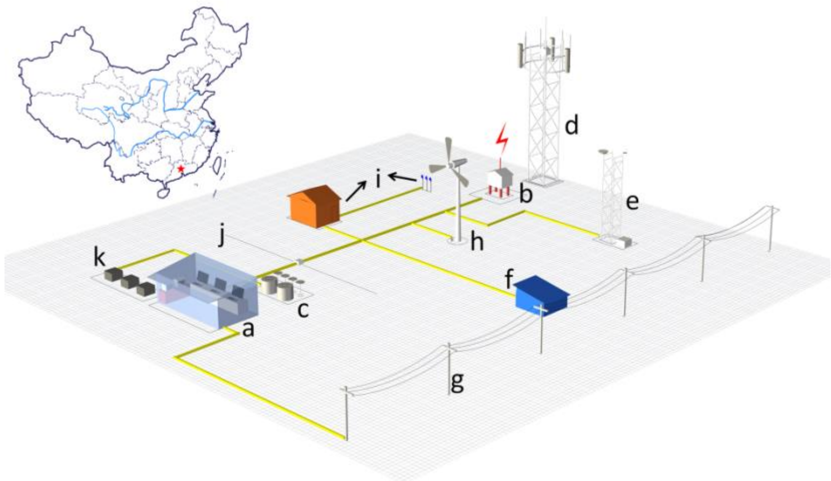


Figure 2. Location (top left map) and layout of the test equipment at the TLF field site. a: Control room (rocket launches and data acquisition are conducted from here). b: Wooden house (the lightning rod is installed above it, and the current measuring equipment is covered by it). c: Region for measurement of electric parameters. d: Iron tower (a model of a communications tower). e: Automatic weather station. f: Region for test of surge protection devices. g: 10 kV overhead line. h: Wind turbine. i: etrochemical instrument (sensor and power of distribution control system). j: Buried cables. k: Shields constructed by brick, concrete, and steel mesh, respectively.

integral than those reported elsewhere, with geometric means (GMs) of 347.9 ms, 132.5 A, 45.1 C, and 10.0×10^3 A^2 s, respectively. Two positive TLFs containing no RS have much greater average currents, charge transfers, and action integrals in the IS when compared with the negative TLFs. The RS has a greater peak current (17.2 kA; GM, same to below), charge transfer within 1 ms (1.3 C), and action integral within 1 ms (5.8×10^3 A^2 s), and shorter 10% to 90% rise time (0.4 μs) than elsewhere. The peak current is prominently correlated with the rate of rise, charge transfer within 1 ms, and action integral within 1 ms. Furthermore, when the total duration of the RS and any following continuing currents is longer than 40 ms, the peak current, charge transfer within 1 ms, and action integral within 1 ms of the RS are seldom greater than 25 kA, 2.6 C, and 15×10^3 A^2 s, respectively. It is indicated that TLFs containing RSs tend to have a longer duration but a smaller charge transfer during the IS than those without RS. The peak current of the RS is weakly correlated with its preceding silence period when there was no channel base current.

Low-frequency E-field Detection Array (LFEDA)—Construction and preliminary results. In recent years, locating total lightning at the VLF/LF band has become one of the most important directions in lightning detection. The LFEDA consisting of 9 fast antennas was developed by the Chinese Academy of Meteorological Sciences in Guangzhou between 2014 and 2015. We document the composition of the LFEDA and a lightning-locating algorithm that applies to the low-frequency electric field radiated by lightning pulse discharge events (LPDEs). Theoretical simulation and objective assessment of the accuracy and detection efficiency of LFEDA have been done using Monte Carlo simulation and artificial triggered lightning experiment, respectively. The former results show that having a station in the network with a comparatively long baseline improves both the horizontal location accuracy in the direction perpendicular to the baseline and the vertical location accuracy along the baseline. The latter results show that detection efficiencies for triggered lightning flashes and return strokes are 100% and 95%, respectively. The average planar location error for return strokes of triggered lightning flashes is 102 m. By locating LPDEs in thunderstorms, we found that LPDEs are consistent with convective regions as indicated by strong reflectivity columns, and present a reasonable distribution in the vertical direction (Figure 3). In addition, the LFEDA can reveal an image of lightning development through mapping the channels of lightning (Figure 4). Based on three-dimensional locations, the vertical propagation speed of the preliminary breakdown and the changing trend of the leader's speed in an intra-cloud and a cloud-to-ground flash are investigated. The research results show that the LFEDA has the capability for three-dimensional location of lightning, which provides a new technique for researching lightning development characteristics and thunderstorm electricity.

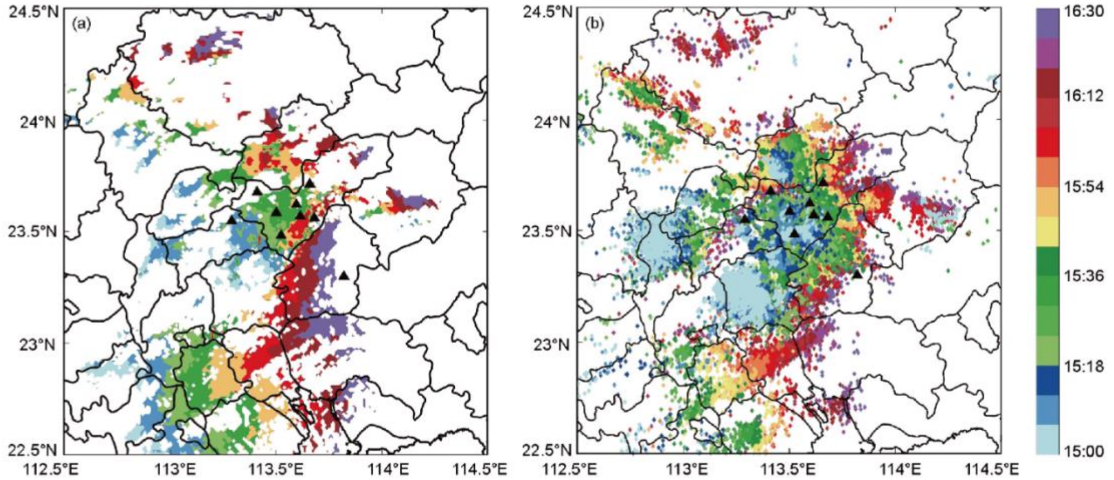


Figure 3. Horizontal distribution and movement of reflectivity larger than 50 dBZ (a) and LPDEs located by the LFEDA (b) in a thunderstorm from 15:00 to 16:30 BT on August 15, 2015.

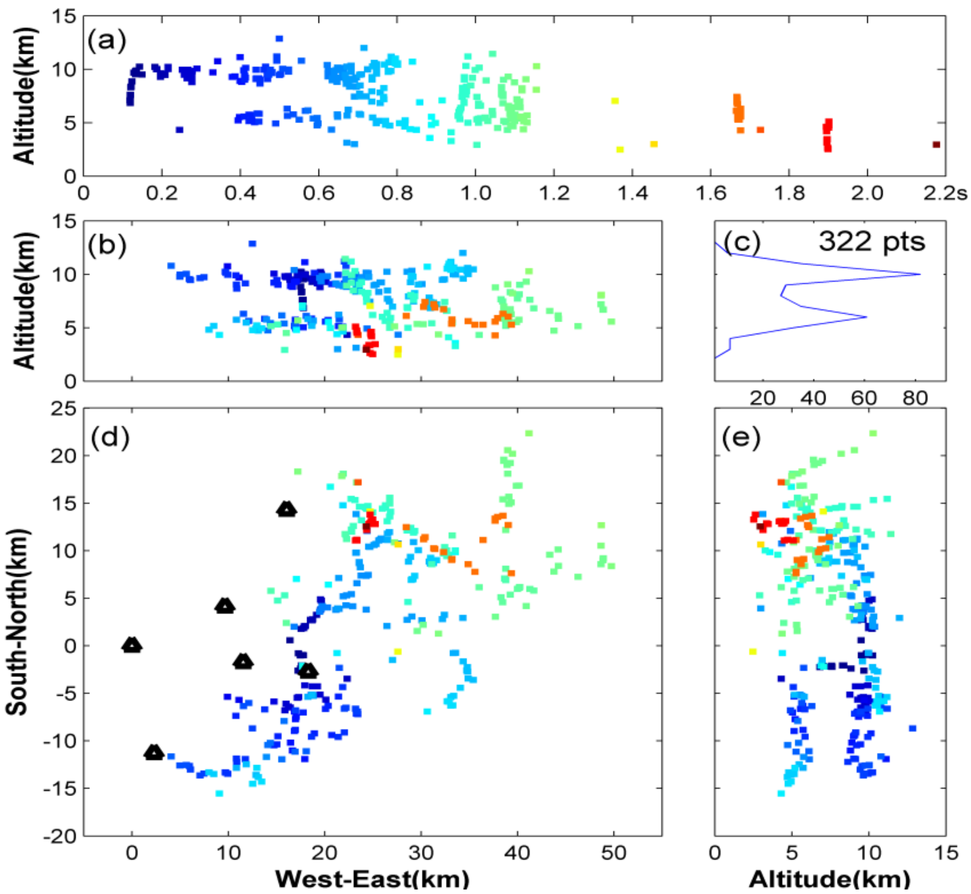


Figure 4. Three-dimension locations of IC flash that occurred at 16:26:24 (BT) on August 15, 2015: (a) LPDEs altitude versus time; (b) east-west vertical view; (c) LPDEs frequency versus altitude; (d) planar view; (e) north-south vertical view.

Spatial-temporal characteristics of lightning flash size in a supercell storm. The flash sizes of a supercell storm, in New Mexico on October 5, 2004, are studied using the observations from the New Mexico Lightning Mapping Array and the Albuquerque, New Mexico, Doppler radar (KABX). First, during the temporal evolution of the supercell, the mean flash size is anti-correlated with the flash rate, following a unary power function, with a correlation coefficient of −0.87. The mean flash size is linearly correlated with the area of reflectivity > 30 dBZ at 5 km normalized by the flash rate, with a correlation coefficient of 0.88. Second, in the horizontal, flash size increases along the direction from the region near the convection zone to the adjacent forward anvil. The region of minimum flash size

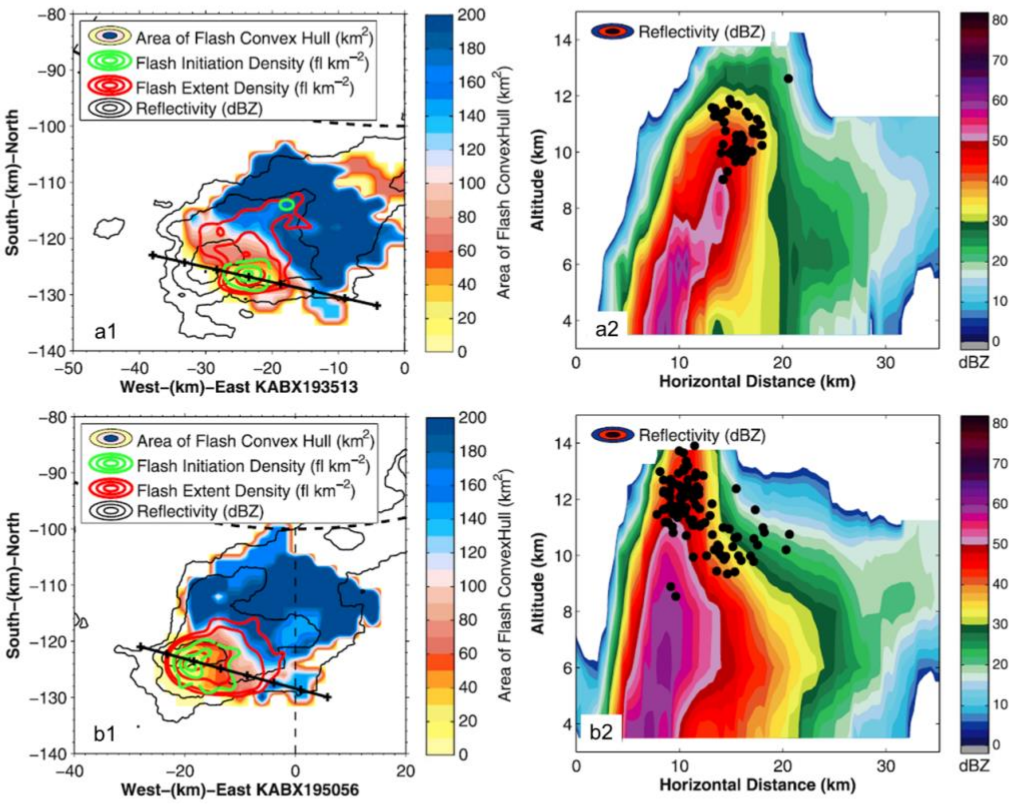


Figure 5. Horizontal distribution of flash size combined with horizontal and vertical storm structures. The shaded regions in a1 and b1 correspond to the mean area of the flash convex hull at the times of the radar volume scans, 1935 UTC and 1950 UTC, which is calculated as the mean area of different flash convex hulls in the same pixel (2 km ×2 km). Black curves correspond to the 4 km reflectivity contours of (from outside to inside) 10 dBZ, 30 dBZ, 50 dBZ, and 60 dBZ, with horizontal resolution of 0.4 km× 0.4 km. Black straight lines are the cross-section lines. Contours of the flash initiation density are shown in green: (from outside to inside) 0.5 fl km^{-2}, 3 fl km^{-2}, and 5 fl km^{-2}. Red contours correspond to the flash extent density of 1.5 fl km^{-2}, 3 fl km^{-2}, 10 fl km^{-2}, and 20 fl km^{-2}. Panels a2 and b2 show the cross sections at the same time as (a1) and (b1), with a horizontal resolution of 0.4 km and vertical resolution of 0.5 km. Black points indicate the location of initial points within 2 km of the cross section.

usually corresponds to the region of maximum flash initiation and extent density (Figure 5). The horizontal correspondence between the mean flash size and the flash extent density can also be fitted by a unary power function, and the correlation coefficient is > 0.5 in 50% of the radar volume scans. The quality of fit is positively correlated to the convective intensity. Third, in the vertical direction, the height of the maximum flash initiation density is close to the height of maximum flash extent density, but corresponds to the height where the mean flash size is relatively small. The distribution of the small and dense charge regions when and where convection is vigorous in the storm, is deduced to be responsible for the relationship that flash size is temporally and spatially anti-correlated with flash rate and density, and the convective intensity.

Assimilation of total lightning data using the three-dimensional variational method at convection-allowing resolution. A large number of observational analyses have shown that lightning data can be used to indicate areas of deep convection. It is important to assimilate observed lightning data into numerical models, so that more small-scale information can be incorporated to improve the

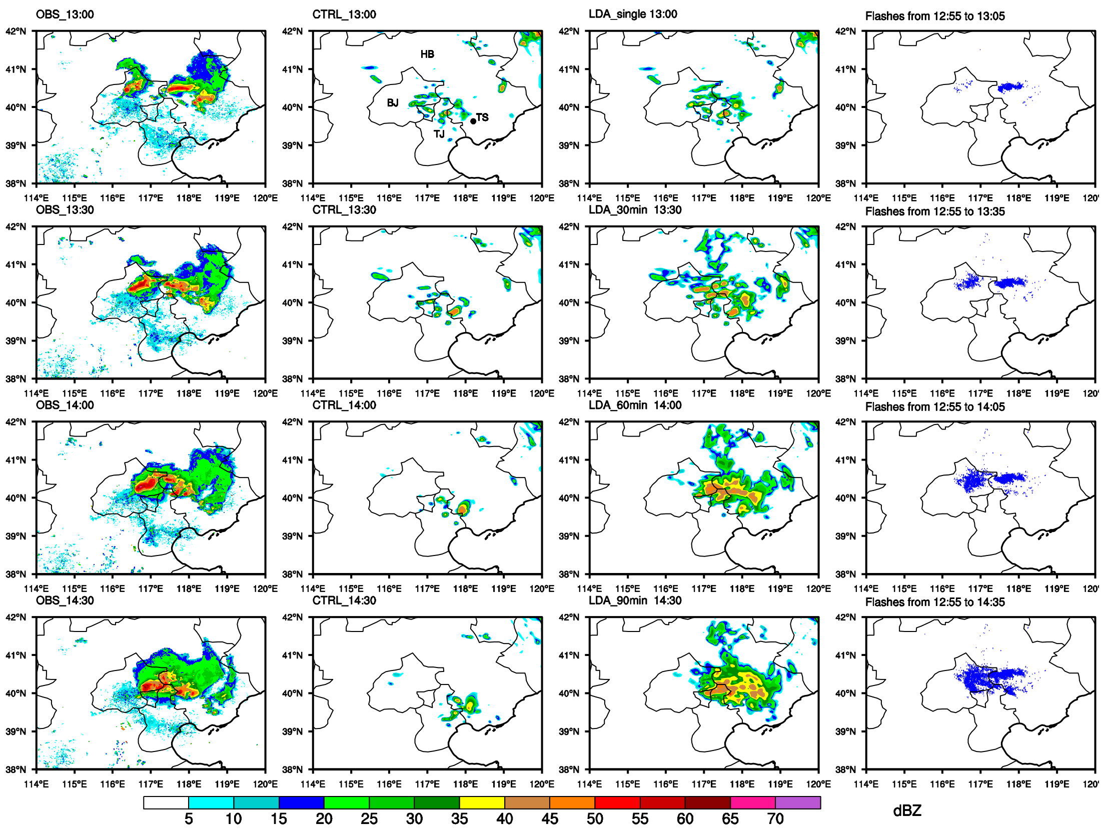


Figure 6. Composite reflectivity of observation, control (CTRL), and lightning data assimilation (LDA) experiments, as well as the total flashes used in each LDA experiment.

quality of the initial condition and the subsequent forecasts. In this study, the empirical relationship between flash rate, water vapor mixing ratio, and graupel mixing ratio was used to adjust the model relative humidity, which was then assimilated by using the three-dimensional variational data assimilation system of the Weather Research and Forecasting model in cycling mode at 10-min intervals. To find the appropriate assimilation time-window length that yielded significant improvement in both the initial conditions and subsequent forecasts, four experiments with different assimilation time-window lengths were conducted for a squall line case that occurred on 10 July 2007 in North China. It was found that 60 min was the appropriate assimilation time-window length for this case, and longer assimilation window length was unnecessary since no further improvement was present. Forecasts of 1-h accumulated precipitation during the assimilation period and the subsequent 3-h accumulated precipitation were significantly improved compared with the control experiment without lightning data assimilation. The simulated reflectivity was optimal after 30 min of the forecast, it remained optimal during the following 42 min, and the positive effect from lightning data assimilation began to diminish after 72 min of the forecast. Overall, the improvement from lightning data assimilation can be maintained for about 3 h (Figure 6).

Semi-idealized modeling of lightning initiation related to vertical air motion and cloud microphysics. To better understand the dynamical and microphysical characteristics of the initiation sites of lightning flashes, a three-dimensional charge–discharge numerical model is used to analyze the characteristics of vertical speed (W_{ini}) and graupel mixing ratio ($q_{\mathrm{g\text{-}ini}}$) at lightning initiation site. The results show that: (1) The W_{ini} correlates well with the $W_{\mathrm{cell\text{-}max}}$. The adjusted R_2 of the cubic polynomial fitting between them is about 0.97. After the maximum vertical speed in the thunderstorm cell ($W_{\mathrm{cell\text{-}max}}$) falls to about 10 m s^{-1}, most lightning initiation sites begin to appear in positions with negative weak vertical speed, the maximum of which never exceeds –3 m s^{-1}. When the $W_{\mathrm{cell\text{-}max}}$ is less than 5 m s^{-1}, the W_{ini} begins to rise towards zero. Only during the last few minutes of the lightning activity is W_{ini} primarily located within the positive range of 0–1 m s^{-1}. (2) Most lightning flashes initiate from the upper part of the graupel distribution region, which is consistent with previous observations. Further analysis indicates that $q_{\mathrm{g\text{-}ini}}$ has a good linear correlation with $q_{\mathrm{g\text{-}cell\text{-}max}}$ and the lightning initiation height (z_{ini}). The coefficients reach 0.86 and 0.85, respectively. This linear correlation is especially strong during the middle and later stage of lightning activity. (3) The zero-charge zone between positive and negative charge layers is an important area for lightning initiation. It normally lies between the area above the graupel center and the upper edge of the graupel distribution region. Within the zero-charge zone, the ratio of ice crystal mixing ratio to graupel mixing ratio at the grid of lightning initiation (RIG) has an exponential relationship with the q_{g} at most grids with large electric field intensity. This provides clues for identifying regions with large electric field intensity in the zero-charge zone. The above results reveal the dynamical and microphysical characteristics at lightning initiation sites and provide some quantitative relationships regarding the W_{ini} and $q_{\text{g-ini}}$ with the $W_{\text{cell-max}}$ and the maximum graupel mixing ratio in the cell ($q_{\text{g-cell-max}}$). The findings are beneficial towards further our understanding of the environmental conditions of lightning initiation. Also, these relationships can be used in numerical models without charging and discharging schemes to effectively estimate the high-risk area of lightning initiation.

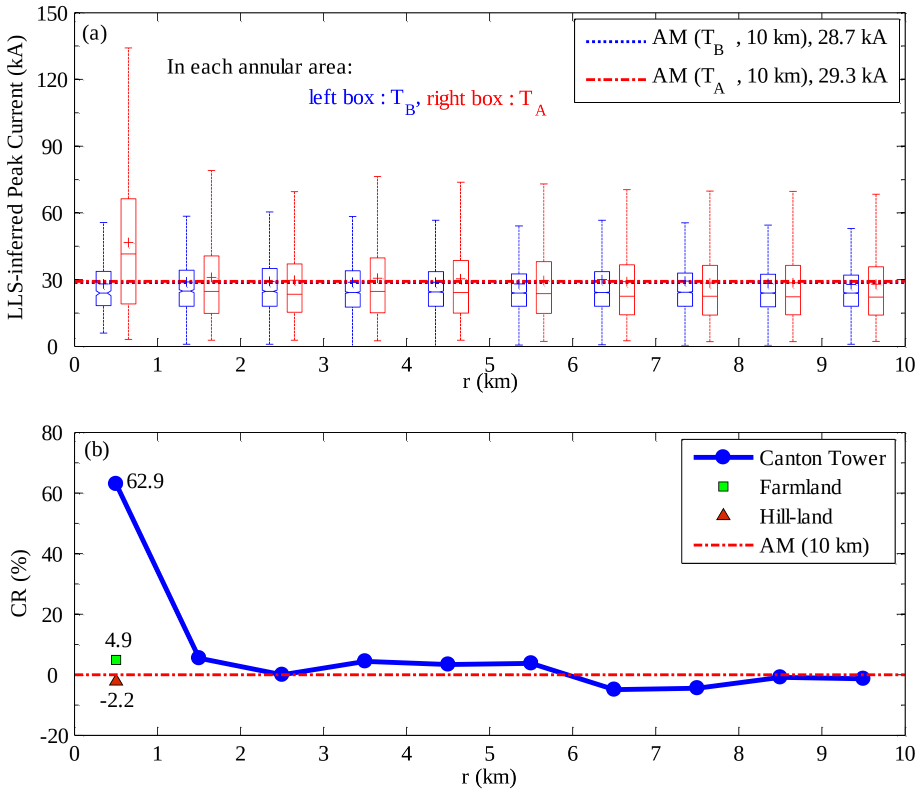


Figure 7. (a) LLS-inferred peak current of Canton Tower during T_B and T_A periods, and (b) the change rate of the AM value of LLS-inferred peak current in the annular vicinity of the Canton Tower as a function of distance (r). The bottom and top edges of the boxes in (a) represent the 25th and 75th percentiles (referred to as q_1 and q_3, respectively). The bottom and short top whiskers represent the value of $q_1 - 1.5(q_3 - q_1)$ and $q_3 + 1.5(q_3 - q_1)$, respectively; the factor 1.5 corresponds to approximately $\pm 2.7\sigma$ and 99.3% coverage if the data are normally distributed. Data exceed the whiskers were not shown. The plus sign (+) and the middle line (−) in the box represents the AM and median current, respectively. The dot line and dash dot line in (a) represent the AM value within 10 km radius around the Canton Tower during T_B and T_A periods, respectively; the dash dot line in (b) represents the change rate of the AM value within 10 km radius around the Canton Tower.

Influence of the Canton Tower on the cloud-to-ground lightning in its vicinity. With the development of socioeconomics and population increases, there are more and more tall structures constructed in large cities. Guangzhou is a metropolis with numerous tall structures in China. Zhujiang New Town is the main component of the Guangzhou Tianhe Central Business District, which has crowded tall structures with heights over 300 m, such as the Canton Tower (600 m high), Guangzhou International Finance Center (GIFC, 440 m high), and Guangsheng Building (GS Building, 360 m high). We analyzed the influence of the Canton Tower on cloud-to-ground (CG) lightning in its vicinity based on the data obtained by Lightning Location System (LLS) of the Guangdong Power Grid Corporation from 1999 to 2015. The LLS data obtained before (1999-2005) and after (2010-2015) the erection of the Canton Tower were compared. The flash/stroke density showed a significant increase in the immediate vicinity around the Canton Tower within a radius of 1 km, and a clear decrease in the annular vicinity with a radius from 1 km to 4 km. The arithmetic mean and median LLS-inferred peak current of strokes occurred in 1 km radius area around the Canton Tower exhibited a significant increase, while that of the strokes occurred beyond 1 km did not show a clear change (Figure 7). The percentage of negative flashes (ratio of negative flashes to total flashes) showed a slight increase in the immediate vicinity around the Canton Tower, which could be caused by the upward lightning (often negative) initiated from the tower. Due to the existence of the Canton Tower, the lightning multiplicity presented a decreasing trend to some extent within 4 km radius around the tower compared with the arithmetic mean value within 10 km radius. It is speculated that the Canton Tower induced lots of upward flashes and attracted some downward flashes around it within several kilometers radius to itself.

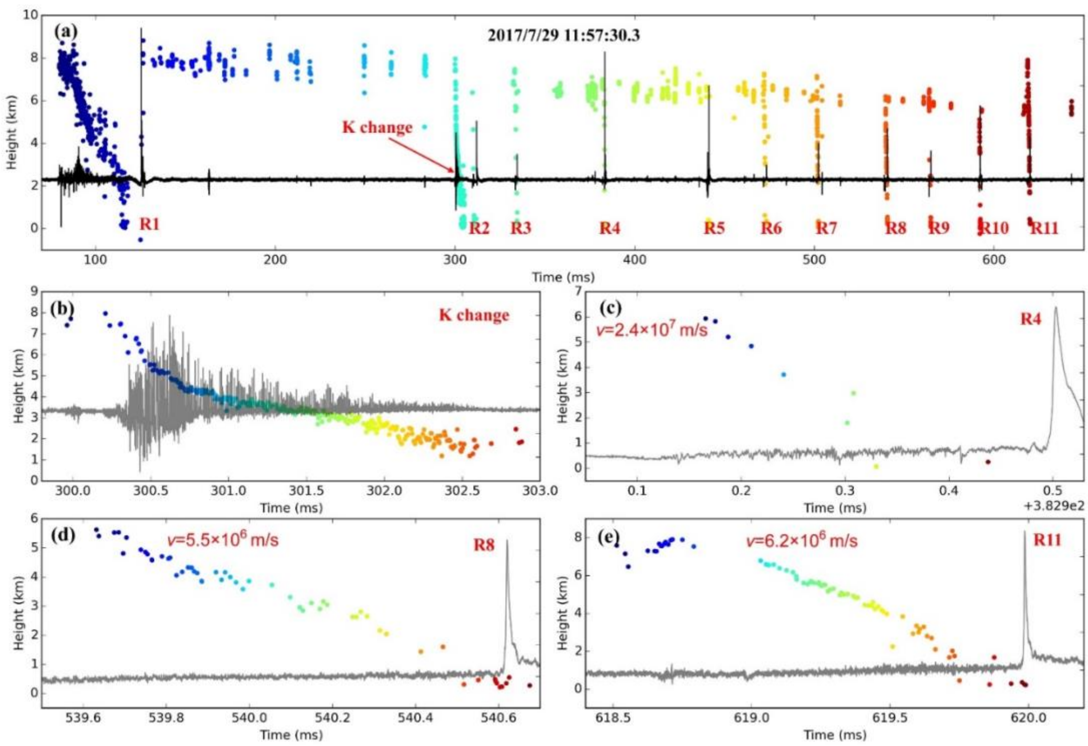
Lightning research group of Gifu University (Gifu, Japan)

Development of Fast Antenna Lightning Mapping Array (FALMA)

We are developing a three-dimensional lightning mapping system using an array of fast antennas. First observation has been made with an array of 12 fast antennas in Gifu and Aichi Prefecture of Japan during the summer of 2017. Preliminary results show that this system can image 3D structures of lightning flashes in great detail, similar to the results obtained by Lightning Mapping Array (LMA) in VHF band. We will call this system Fast Antenna Lightning Mapping Array (FALMA).

We have made significant improvement on both the hardware and software of the system, and as a result, for a typical lightning flash, thousands of location points can be determined, which is about one order of magnitude larger than other fast antenna systems. A preliminary analysis of the location accuracy of this system has been performed by comparing locations of multiple return strokes in the same flash. The result shows that typical horizontal distances of multiple return strokes are around 20 m, indicating the horizontal location accuracy is about 20 m. The altitudes of return strokes are mainly between 100 and 400 m, indicating the height accuracy at the ground level is several hundred meters. Considering the fact that the height accuracy is significantly lower at lower altitudes, it is expected that the height accuracy for discharge processes inside the cloud is much higher.

Location results for a cloud-to-ground flash including 11 return strokes are shown in Figure 1. All plots in Figure 1 show height-time view of the location results. From Figure 1a we can see that some sources are located for all leaders of the 11 return strokes. The leader of R1, which is a stepped leader, has a speed of about 1.9×10^5 m/s, much slower than other leaders. Figure 1b shows a K change. This K change developed very close to the ground but did not lead to a return stroke. Figure 1c shows a dart leader. Several location points are determined for this dart leader and its speed is estimated to be 2.4×10^7 m/s. Figure 1d and 1e show two relatively slow dart leaders. The speed is 5.5×10^6 m/s and 6.2×10^6 m/s, respectively. For relatively slow leaders, we can get a quite clear image of their channels. The animation of this flash can be seen at
https://youtu.be/B6t6L_s7J-0
More than 5000 flashes have been located during this summer. Detailed analyses including the analyses of leader, return stroke, preliminary breakdown and narrow bipolar event are under way.



Research Centre for Astronomy and Earth Sciences, Hungarian Academy of Sciences Geodetic and Geophysical Institute (GGI), Sopron, Hungary

Contributors in alphabetical order:

Veronika Barta, Attila Buzás, Tamás Bozóki, József Bór, Ernő Prácser, Gabriella Sátori

Possible thunderstorm – sporadic E (Es) layer coupling effects were investigated during two measurement periods, one in 2013 and one in 2014 (Barta et al., 2017). The analysis was based on ionospheric observations obtained from a Digisonde at Pruhonice, the Czech Republic, an ionosonde at Nagycenk, Hungary, and a 3.59 MHz five-point continuous HF Doppler system located in the western part of the Czech Republic. The latter is capable of detecting ionospheric wave-like variations caused by neutral atmospheric waves generated by thunderstorms. The study discusses possible impacts of two active thunderstorms on Es layers. One thunderstorm was passing across the Czech Republic on June 20, 2013 (19:00–01:00 LT), and one through Hungary on July 30, 2014 (11:00-01:00 LT). During these two time periods, presence and parameters of Es layer were inferred from ionograms, recorded every minute at Pruhonice and every two minutes at Nagycenk, whereas concurrent lightning activity was monitored by the LINET detection network. In addition, transient luminous events (TLEs) were also observed during both nights from Sopron, Hungary and from Nýdek, the Czech Republic. It was noticed that ongoing Es layer activity was reduced and the Es layer completely disappeared during part of the time in both of the traversing thunderstorms. The analysis indicated that the critical frequency foEs dropped below ionosonde detection levels in both cases possibly because of thunderstorm activity. The conclusion was, however, that this relationship needs further confirmation from more case studies in order to be more substantiated.

As part of the international efforts led by Earle Williams (MIT, USA), Ernő Prácser and Tamás Bozóki continued working on the method which will be used to evaluate the global thunderstorm activity via joint inversion of Schumann resonance (SR) data measured at several stations at distinct locations all over the Earth. Connecting to the same project, Gabriella Sátori and József Bór contributed to a study which discusses the effect of Q-bursts of large amplitudes on the spectrum of the ELF band time series to be used in the inversion. The importance of proper sanitation of the SR background time series is emphasized and a practical threshold for the detection and removal of interfering Q-bursts is suggested (Guha et al., 2017). In addition to that, Tamás Bozóki and Gabriella Sátori have been studying the background Schumann resonance intensity on the base of multi-station observations. The goal of this ongoing examination is to separate the SR intensity variations due to the global lightning activity from those caused by possible space weather effects.

Gabriella Sátori, Veronika Barta, Tamás Bozóki, and József Bór attended the Batsheva de Rothchild Seminar on The Atmospheric Global Electric Circuit (GEC) held in Israel in February, 2017. During the visit, atmospheric electrical potential gradient (PG) measurements were made simultaneously with a portable electric field mill and the local instrument at two measuring sites in Israel: the WISE observatory in the Negev desert near Mitzpe Ramon (MR) and at the Mt. Hermon Cosmic Ray Observatory (HCRO). The same way, parallel measurements were conducted in the Széchenyi István

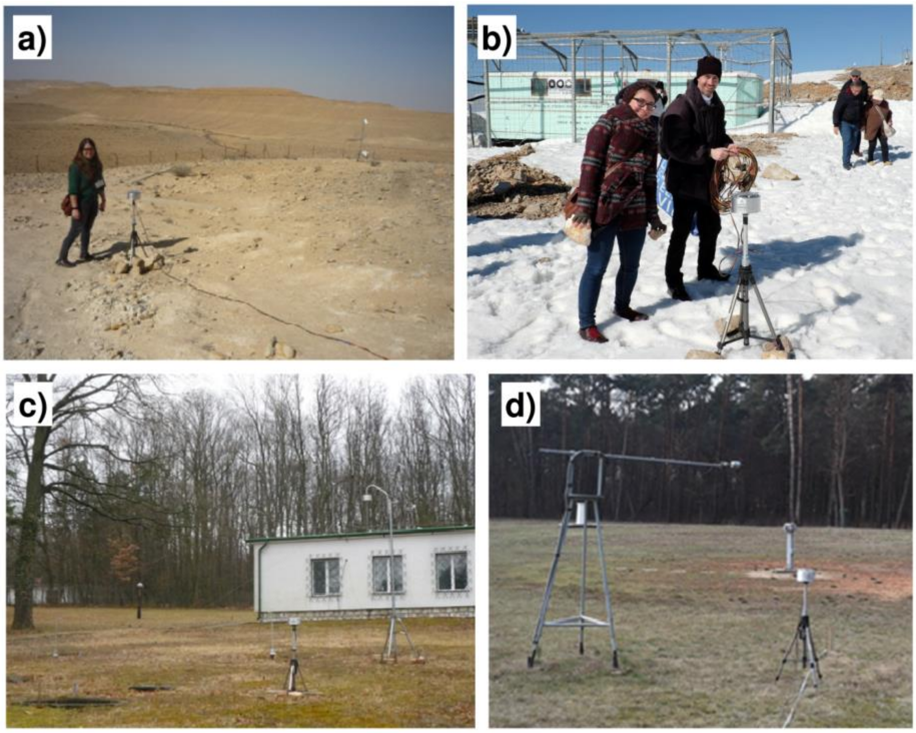


Figure 1. Parallel PG measurements by locally used fixed and portable field mills. a) WISE observatory, Israel, with Veronika Barta ; b) József Bór and Veronika Barta are setting up the portable field mill in HCRO, Israel; c) NCK observatory, Hungary; d) Swider Geophysical Observatory, Poland

Geophysical Observatory (NCK) in Hungary, and in Swider, Poland (Figure 1). Additionally, the possible shielding effect of objects (buildings, trees) surrounding the measuring sites were surveyed by making use of the portable field mill in NCK and Swider observatories. These activities were committed in accordance of the main aims of the ESF COST Action CA15211 (ELECTRONET, https://www.atmospheric-electricity-net.eu), specifically with the purpose to aid the intercomparison and standardisation of PG measurements from different measuring sites.

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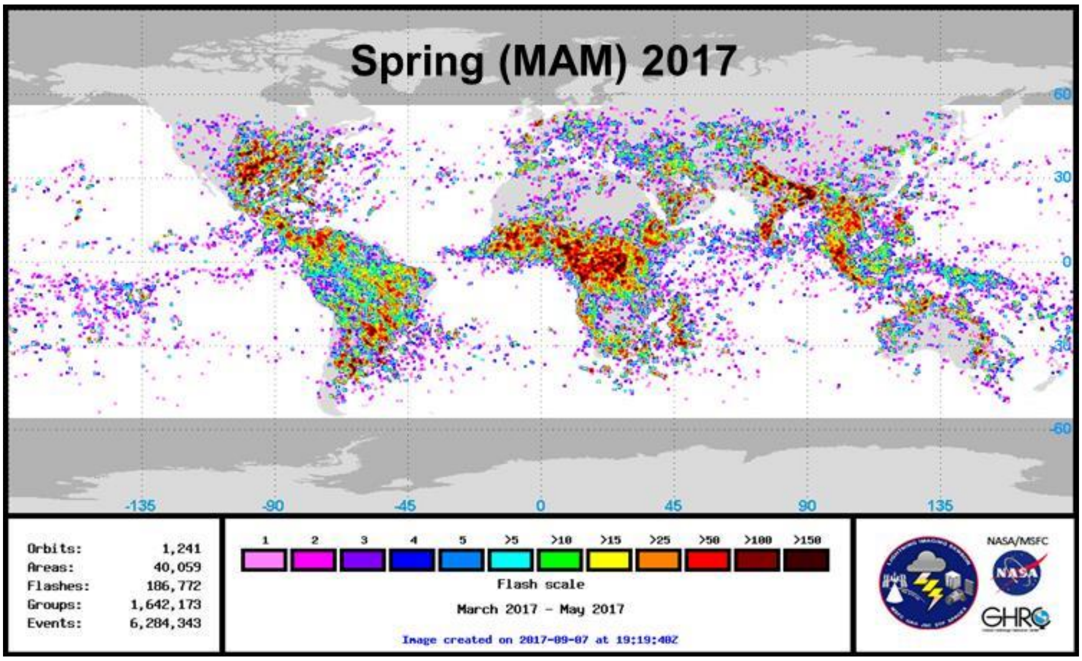
Guha, A., Williams, E. R., Boldi, R., Sátori, G., Nagy, T., Bór, J., Montanya, J., Ortega, P. (2017), Aliasing of the Schumann resonance background signal by sprite-associated Q-bursts, Journal of Atmospheric and Solar-Terrestrial Physics, 165-166, pp. 25–37, doi:10.1016/j.jastp.2017.11.003

ICAE November Newsletter - LIS on ISS Contribution (Richard Blakeslee/National Space Science and Technology Center with Marshall Space Flight Center and University of Alabama in Huntsville)

On February 19, NASA's Lightning Imaging Sensor (LIS) was successfully launched to the International Space Station (ISS) aboard the SpaceX Cargo Resupply Services-10 (SpaceX CRS-10) mission as a hosted payload on the Department of Defense Space Test Program - Houston 5 (STP-H5) mission for a nominal 2-year mission. A mission extension will be sought though the NASA Senior Review Process.

On February 27, LIS saw first light when it was powered-on and successfully completed a two week checkout and commissioning. Since that time, LIS has operated continuously and undergone a detailed assessment to evaluate the processing and data products prior to publically releasing this data to the science community. The LIS Science Team now anticipates making a public announcement for the initial release of the Level 2 LIS dataset in December 2017. LIS on ISS gridded data products will still not be available until a later date. The LIS data will be accessible through the Global Hydrology

Resource Center, one of NASA's Distributed Active Archive Centers (DAACs), which has leveraged the well-established and robust processing, archival, and distribution infrastructure used for the Tropical Rainfall Measuring Mission LIS (TRMM LIS) for the ISS mission. As noted in the Spring



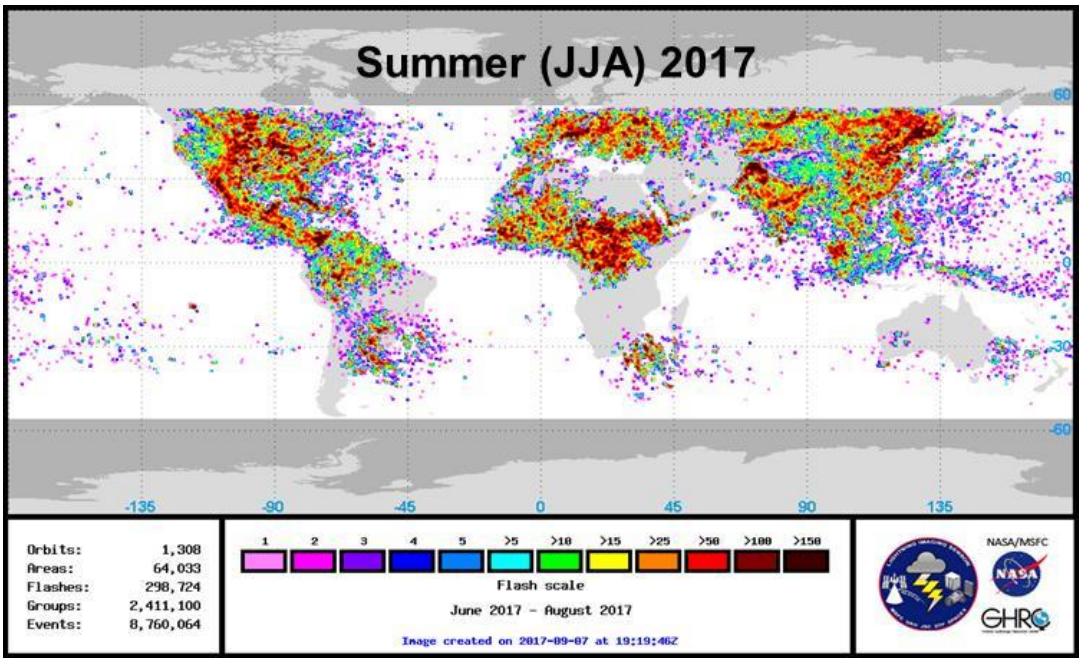


Figure Caption: *These figures show the seasonal global lightning detections from LIS on ISS during its first 6 months on orbit. These preliminary results are in good agreement with similar results from OTD and TRMM LIS as a similar point in their mission.*

2017 Atmospheric Electricity Newsletter, LIS on ISS data users should see little or no change from TRMM LIS in terms of data products, formats, software or access. However, in addition to maintaining the legacy data format, LIS products will also be cast in more modern formats such as HDF-5 and netCDF.

Contribution to ICAE Newsletter, November 27, 2017

Massachusetts Institute of Technology

The comparative behavior of the two global electrical circuits (the classical DC circuit and AC circuit, otherwise known as Schumann resonances) has been investigated with archived data. Measurements of the ionospheric potential V_i (from the archive of Ralph Markson) have been plotted at specific UT hours and Day of Year against the climatology on global lightning flash rate (Cecil et al., 2014) at the same time. A least squares fit through the data shows a value of Vi at zero flash rate which is more than half of the mean value of V_i (~250 kV). This finding supports the idea of C.T.R. Wilson (1920) that electrified shower clouds (without lightning and without contribution to Schumann resonances) make an appreciable contribution to ionospheric potential. Bob Boldi will report on these findings at the upcoming AGU meeting.

The work on the straightening instability of long, tortuous 1 A DC laboratory arcs, now called 'avulsion' after the same phenomenon in meandering river channels, has now been submitted by Yakun Liu and Earle Williams and accepted at IEEJ, following the International Symposium on Winter Lightning in Japan. This work was also updated at the recent International Symposium on Lightning Physics and Meteorology (ISLPM) in Beijing. Yakun is presently exploring ways to verify the presence of this instability in DC arcs with currents of order 100 A, more representative of continuing current in lightning.

Work continues on the multi-station inversion of Schumann resonance observations for global lightning activity, with Anirban Guha and Yakun Liu at MIT and in collaboration with the Geodetic and Geophysical Institute in Hungary. Full diurnal variations (with hourly resolution) of chimney-resolved global lightning activity in absolute units of $coul^2\ km^2/sec$ for more than thirty separate days have been derived using a variety of ELF stations for input. (The number of operational ELF stations exceeds 25.) Comparisons have been made with two independent sets of nine stations each, and were reported in September at the ISLPM. The inversion results agree on chimney centroid locations and UT diurnal timing of individual chimneys, but the ranking of chimneys can differ between sets. Non-uniqueness linked with diametrically-opposite sources (Americas and the Maritime Continent), and associated with small eigenvalues in the inversion, is currently under exploration. Results based on

18 station- inversions (the maximum used so far) are most closely matched with global (optical) lightning climatology (LIS/OTD).

At a recent radio science symposium at Haystack Observatory, Earle Williams learned from space physicists at the University of New Hampshire about an archive of ELF magnetic observations at the geographic South Pole, beginning in early 2009 and extending until present, and with bandwidth in the Schumann resonance region. From this unique location, the three prominent lightning ‘chimneys’ (Americas, Africa, Maritime Continent) are roughly equidistant, in all seasons. Furthermore, the orientation of the two magnetometers there is fortuitously favorable for detecting Africa in one coil and the Americas and the Maritime Continent (12 hours out of phase) in the perpendicular coil. These favorable aspects allow for quantitative measurement of the three-chimney source strengths (in $coul^2\ km^2/sec$) from this single measurement site, and may provide another important constraint on the chimney ranking determined with the multi-station inversion calculations.

Ph.D. Research Assistantship, Texas Tech University, Department of Geosciences Atmospheric Science Group

The Atmospheric Science Group in the Department of Geosciences has an immediate opening for a PhD student to work on problems related to atmospheric electricity, lightning, and the turbulence kinetics of deep convection, using two summers of data from the Kinematic Texture and Lightning Experiment, our recent field campaign sponsored by the National Science Foundation. Data from the West Texas Lightning Mapping Array provided information about the way lightning fills the volume of the cloud, and the distribution of lightning flash sizes, which are related to the energy dissipated by each flash. Continuous, 10s RHI data along intersecting, perpendicular planes from the TTU Ka-band mobile radars at 9 m range and 0.33 deg azimuthal resolution provided a novel view of the turbulence kinetics, including the prospect of resolving the outer length scale of turbulence in deep convection. Sounding data collected in the near-storm environment are suitable for use in simulations of the observed storms. Together, these data allow for the study of the fundamental processes that couple the fluid and electrical properties, and their scale-dependent spatiotemporal distributions, in real thunderstorms. The ideal applicant will have an interest in the quantitative study of the fluid physics of turbulence, linking theory to the radar observations to quantify the eddy scale kinetics. In collaboration with others in the lightning group, we expect to find insights concerning the eddy-scale distribution of charge and its subsequent effects on the distribution of lightning flash sizes. Proposals for related research using these or similar data are welcome as well. Interested applicants should contact eric.bruning@ttu.edu with any questions.

Images and current measurements of upward leaders from lightning rods

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The physical mechanism of lightning attachment to grounded structures is the basis for the design of the lightning protection systems. In order to understand the parameters that control the efficiency of lightning rods, our group has installed Pearson Coil current sensors (see figure) to measure the intensity of upward connecting leaders and of unconnected upward leaders.

We are now monitoring the current flowing through lightning rods of an ordinary residential building (two buildings under 60 m in São Paulo City, Brazil).

The measurements are made simultaneously to the high-speed video observation of the progression of the upward leaders at tens of thousands images per second. Some events have been already recorded and will be present in future conferences.

Atmospheric Science Group, Department of Geosciences, Texas Tech University

Lightning Exhibit at the Museum of Texas Tech University

Over the past three years the lightning and atmospheric electricity research group at Texas Tech has been working with Tina Fuentes, an artist and professor in the Texas Tech School of Art, to develop an education and outreach exhibit. This work is part of our US National Science Foundation award to study lightning and its relationship to turbulence in thunderclouds. In the exhibit, *Marcando el Relámpago* (*Marking the Lightning*), Fuentes has produced a series of abstracted paintings that capture the energy and texture of the paths of lightning channels, and the motions and shapes of clouds. In addition to static paintings, a video piece projects brush strokes as they were being applied, and is reminiscent of the development of lightning channels. The exhibit is paired with radar and Lightning Mapping Array observations rendered in large format. 3D printed channels reconstructed from LMA data make apparent the vast difference in scales of the in-cloud portion of lightning flashes. The exhibit runs through January 2018. A catalog describing the exhibit has been prepared; contact eric.bruning@ttu.edu if you wish to receive a copy.

Vaisala Entries for November 2017 ICAE Newsletter

21 November 2017

Vaisala

On August 18, 2015 Vaisala launched an algorithm upgrade to the network that generates the GLD360 Global Lightning Dataset. This software upgrade focused on improving the yield, temporal stability, and spatial resolution of the lightning data. Extensive studies into the resulting improvements to the relevant performance metrics, including flash detection efficiency, location accuracy, and peak current accuracy, are ongoing and will be published in upcoming conference proceedings.

The figure shows monthly GLD360 event counts since 2011. Before the algorithm update, monthly counts varied from about 40 to 100 million, with the higher counts occurring during the northern hemisphere summer months. After the upgrade, the counts roughly doubled, ranging from about 100 to 200 million per month. The majority of this increase in counts is due to improved detection of weak cloud-to-ground strokes and cloud pulses.

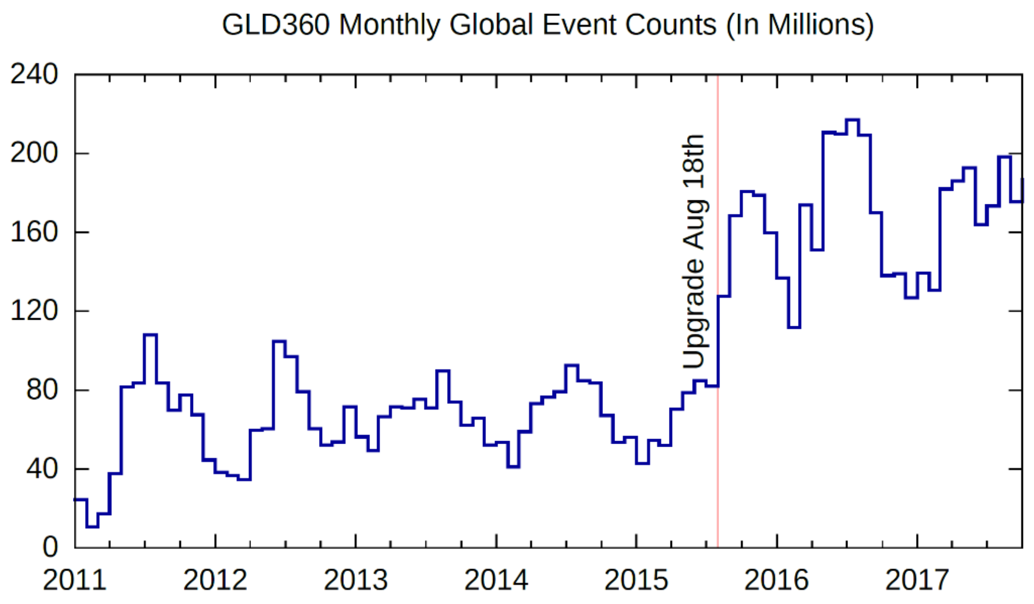

Fig. 1. Monthly totals for GLD360 global event counts since the beginning of 2011. The upgrade date is marked with a vertical red line.

Holle, R.L., and M.J. Murphy, 2017: "Lightning over three large tropical lakes and the Strait of Malacca: Exploratory analyses", *Monthly Weather Review*, 145, 4559-4573.

Abstract — Lightning stroke density measured by the Global Lightning Dataset (GLD360) has shown several strong maxima around the globe. Several of these extremes are located over large tropical water bodies surrounded by terrain features. Four prominent maxima are examined and compared in this study: Lake Maracaibo in South America, the Strait of Malacca in equatorial Asia, Lake Victoria in East Africa, and Lake Titicaca in South America. Specifically, the authors observe that all four water bodies exhibit sustained maxima in lightning occurrence all night, the peak lightning frequency occurs very late at night or the following morning at three of the four sites, and the nocturnal maxima are out of phase at the four locations even though the afternoon maxima over the surrounding terrain all occur between 1500 and 1700 local solar time. The meteorological factors affecting the diurnal cycle of lightning occurrence over these four water bodies, which are all adjacent to mountains, are explored in this study.

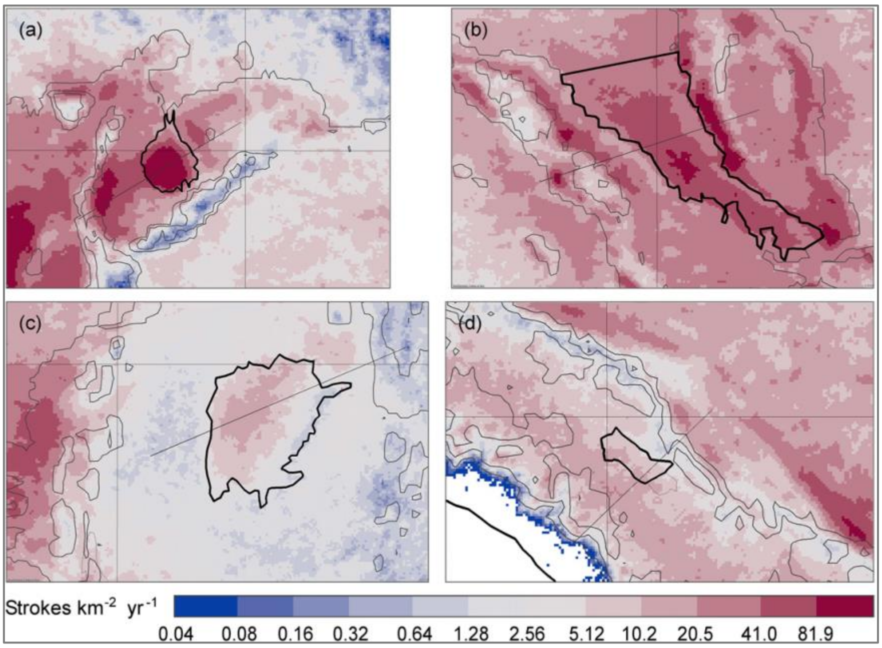

Fig. 1. Annual stroke density detected by the GLD360 over and surrounding (a) Lake Maracaibo, (b) Strait of Malacca, (c) Lake Victoria, and (d) Lake Titicaca in a 5 km x 5 km grid from 2012 to 2015. Terrain altitude contours are shown in black at altitudes of 0, 1000, and 2000m in (a),(b); 1000, 2000, and 3000m in (c); and 2500, 3500, and 4500m in (d); and the water bodies are outlined in black. The Pacific Ocean coastline is in black in (d). Black southwest–northeast lines indicate locations of the cross sections in subsequent figure.

WMO Activities - New Lightning Extremes Identified

Committee Members: *Timothy L. Lang, Stéphane Pédeboy, William Rison, Randall Cerveny. Joan Montanyà, Serge Chauzy, Donald R. MacGorman, Ronald L. Holle, Eldo E. Ávila, Yijun J. Zhang, Gregory Carbin, Edward R. Mansell, Yuriy Kuleshov, Thomas C. Peterson, Manola Brunet, Fatima Driouech, Daniel S. Krahenbuhl*

A World Meteorological Organization (WMO) weather and climate extremes committee has judged that the world's longest reported distance for a single lightning flash occurred with a horizontal distance of 321 km (199.5 mi) over Oklahoma in 2007 (Fig. 1a), while the world's longest reported duration for a single lightning flash is an event that lasted continuously for 7.74 seconds over southern France in 2012 (Fig. 1b).

The longest-distance flash (321 km; Fig. 1a) occurred in a large mesoscale convective system (MCS) and lasted 5.7 seconds. It initiated in the leading convective line and moved into the stratiform precipitation region. During that time, it propagated roughly east to west while producing at least 12 cloud-to-ground (CG) and 4 intracloud (IC) events as detected by the National Lightning Detection Network (NLDN). Two sprites were observed from two positive CGs. The longest-duration flash (7.74 s; Fig. 1b) also involved the stratiform region of an MCS, and was 160 km long. The flash propagated roughly northwest to southeast, and produced at least 8 CGs and 4 IC pulses as detected by the European Cooperation for Lightning Detection (EUCLID) network.

Due to the extreme nature of these flashes, the WMO committee unanimously recommended amendment of the American Meteorological Society (AMS) Glossary of Meteorology definition of lightning discharge as a "series of electrical processes taking place within 1 second" by removing the phrase "within one second" and replacing with "continuously." Validation of these new world extremes (a) demonstrates the recent and on-going dramatic augmentations and improvements to regional lightning detection and measurement networks, (b) provides reinforcement regarding the dangers of lightning, and (c) provides new information for lightning engineering concerns.

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Driouech, and D.S. Krahenbuhl, 2017: WMO World Record Lightning Extremes: Longest Reported Flash Distance and Longest Reported Flash Duration. Bull. Amer. Meteor. Soc., 98, 1153–1168, https://doi.org/10.1175/BAMS-D-16-0061.1

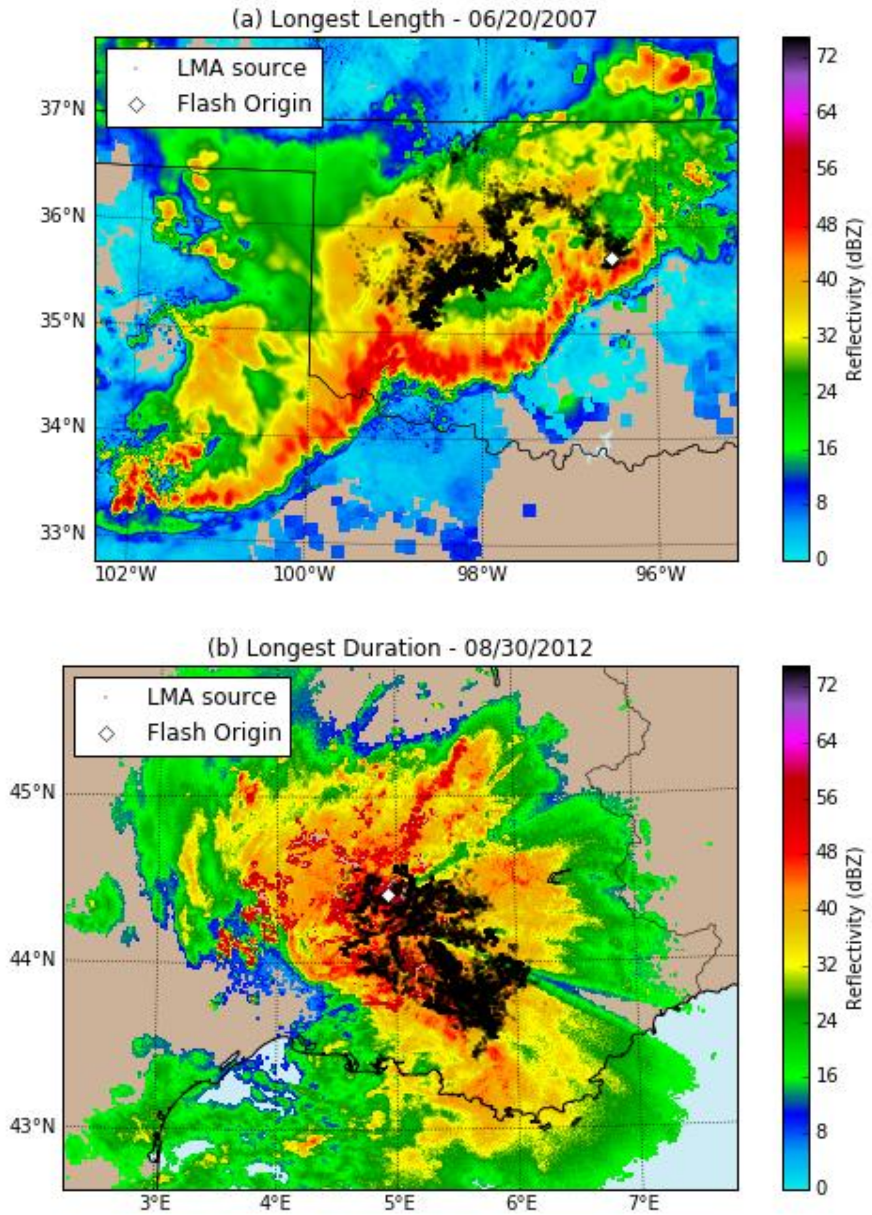

Figure 1. (a) Mosaic radar reflectivity at 1 km MSL, valid at 0603 UTC 20 Jun 2007. Also shown is a plan projection of the VHF sources encompassing the longest-length flash, which occurred around 0607:22 UTC on this day. (b) Reflectivity from the Aramis (Bollène) radar at 0.8° elevation angle, valid at 0415 UTC 30 Aug 2012. Ground clutter has not been edited from these data. Also shown is a plan projection of the VHF sources encompassing the longest-duration flash, which occurred around 0418:50 UTC on this day. Both flash origins are set as the median of the first 10 sources.

UF Contribution to the November 2017 Issue of the Newsletter on Atmospheric Electricity

There was no lightning triggering in 2017 at Camp Blanding (CB), Florida. The Lightning Observatory in Gainesville (LOG) operated normally, focusing on natural lightning observations.

Yanan Zhu (advisor V.A. Rakov) defended his Ph.D. dissertation titled “Characterization of Florida lightning with emphasis on the preliminary breakdown process, bipolar lightning, and lightning interaction with a 257-m tower”.

M.D. Tran and V.A. Rakov authored a paper titled “A study of the ground-attachment process in natural lightning with emphasis on its breakthrough phase”. Synchronized high-speed (124 or 210 kiloframes per second) video images and wideband electromagnetic field records of the attachment process were obtained for 4 negative strokes in natural lightning at the Lightning Observatory in Gainesville, Florida. The majority of imaged upward connecting leaders (UCLs) and upward unconnected leaders, inferred to be mostly initiated from trees, exhibited a pulsating behavior (brightening/fading cycles). UCLs, whose maximum extent ranged from 11 to 25 m, propagated in virgin air at speeds ranging from 1.8×10^5 to 6.0×10^5 m/s with a mean of 3.4×10^5 m/s. Within about 100 m of the ground, the ratio of speeds of the downward negative leader and the corresponding positive UCL was about 3–4 for 2 events and 0.5 for 1 event. The breakthrough phase (final jump) was imaged for 2 events. The initial length of the common streamer zone (CSZ) was estimated to be about 30–40 m. For 2 events, speeds of positive and negative leaders developing toward each other inside the CSZ were found to be between 2.4×10^6 and 3.7×10^6 m/s. For 1 event, opposite polarity leaders were observed to accelerate inside the CSZ. The current at the end of the breakthrough phase, lasting on average 4.7 μs, was estimated to be approximately one-half of the overall current peak. Thus, about one-half of the current peak traditionally attributed to the return-stroke process is actually associated with two leaders extending toward each other to collision inside the CSZ. The paper is published in the Springer Nature Scientific Reports (an Open Access journal).

Hare, B., J. R. Dwyer , L. H. Winner, M. A. Uman , D.M. Jordan , D. A. Kotovsky, J. A. Caicedo , R. A. Wilkes, F. L. Carvalho , J. T. Pilkey, T. K. Ngin, W. R. Gamerota, and H. K. Rassoul authored a paper titled “Do cosmic ray air showers initiate lightning?: A statistical analysis of cosmic ray air showers and lightning mapping array data”. It has been argued in the technical literature, and widely reported in the popular press, that cosmic ray air showers (CRASs) can initiate lightning via a mechanism known as relativistic runaway electron avalanche (RREA), where large numbers of high-energy and low-energy electrons can, somehow, cause the local atmosphere in a thundercloud to transition to a conducting state. In response to this claim, other researchers have published simulations showing that the electron density produced by RREA is far too small to be able to affect the conductivity in the cloud sufficiently to initiate lightning. In this paper, the authors compare 74 days of cosmic ray air shower data collected in north central Florida during 2013–2015, the recorded CRASs having primary energies on the order of 10^{16} eV to 10^{18} eV and zenith angles less than 38°, with Lightning Mapping Array (LMA) data, and they show that there is no evidence that the detected cosmic ray air showers initiated lightning. Furthermore, they show that the average probability of any of their detected cosmic ray air showers to initiate a lightning flash can be no more than 5%. If all lightning flashes were initiated by cosmic ray air showers, then about 1.6% of detected CRASs would initiate lightning; therefore, the authors conclude that they do not have enough data to exclude the possibility that lightning flashes could be initiated by cosmic ray air showers. The paper is published in the Journal of Geophysical Research - Atmospheres.

World Meteorological Organization

The WMO Commission for Climatology published an article which in part addressed lightning deaths in the American Meteorological Society journal *Weather, Climate, and Society* (May, 2017) https://doi.org/10.1175/WCAS-D-16-0120.1

The article was entitled "WMO Assessment of Weather and Climate Mortality Extremes: Lightning, Tropical Cyclones, Tornadoes, and Hail" with authors R.S. Cerveny, P. Bessemoulin, C.C. Burt, M.A. Cooper, Z. Cunjie, A. Dewan, J.Finch, R.L. Holle, L. Kalkstein, A. Kruger, T.-C. Lee, R. Martínez, M. Mohapatra, D.R. Pattanaik, T.C. Peterson, S. Sheridan, B. Trewin, A. Tait and M.M.Abdel Wahab

ABSTRACT: A World Meteorological Organization (WMO) Commission for Climatology international panel was convened to examine and assess the available evidence associated with five weather-related mortality extremes: (a) lightning (indirect), (b) lightning (direct), (c) tropical cyclones, (d) tornadoes, and (e) hail. After recommending for acceptance of only events after 1873 (the formation of the predecessor of the WMO), the committee evaluated and accepted the following mortality extremes: a) "Highest mortality (indirect strike) associated with lightning" as the 469 people killed in a lightning-caused oil tank fire in Dronka, Egypt, on 2 November 1994; b) "Highest mortality directly associated with a single lightning flash" as the lightning flash that killed 21 people in a hut in Manica Tribal Trust Lands, Zimbabwe [at time of incident, eastern Rhodesia], on 23 December 1975; c) “Highest mortality associated with a tropical cyclone” as the Bangladesh [at time of incident, East Pakistan] Cyclone of 12-13 November 1970 with an estimated death toll of 300,000 people; d) “Highest mortality associated with a tornado” as the 26 April 1989 tornado that destroyed the Manikganj district, Bangladesh, with an estimated death toll of 1,300 individuals; and e) “Highest mortality associated with a hailstorm” as the storm occurring near Moradabad, India, on 30 April, 1888 which killed 246 people. These mortality extremes serve to further atmospheric science by giving baseline mortality values for comparison to future weather-related catastrophes and also allow for adjudication of new meteorological information as it becomes available.

November 15, 2017

UPDATE – African Centres for Lightning and Electromagnetics –

1. As an outgrowth of ACLENet's School Lightning Protection program, the Ugandan Ministry of Education and Sports asked ACLENet to consult on lightning protection for the 184 NEW schools they are building this year and to train their engineers and installers. We thank three of our expert consultants who volunteered their time and expertise to review the MoES plans.

2. ACLENet has submitted grants with Uganda Institute of Professional Engineers and the Dept of Engineering at Makerere University to improve the quality of engineering in Uganda by offering training in lightning protection. Once the mechanism for these trainings is established, they can be broadened to include other topics of continuing professional development to improve the quality of engineering in Uganda.

3. The Global Resilience Partnership Grant (Rockefeller, USAID, SIDA) that has supported much of our work in 2016-17 came to audit the output of the five partners to determine whether a 3-4 year scale-up grant to spread what we've accomplished in Uganda to the region.

4. National Centers have come on board in Malawi and Kenya with ACLENet's Third Scientific Symposium being planned for 2018. We expect that South Africa will have ACLE-RSA organized in the next year, in plenty of time for ICLP2022 in South Africa.

5. ACLENet is partnering with the new South African Earthing Lightning Protection Association (ELPA, https://elpasa.org.za), a credentialing organization to improve lightning

protection, to broaden the impact of both organizations across all of sub-Saharan Africa over time.

6. Website revision in progress – look for the new website in the next few weeks under the same URL.

Please consider donating to ACLENet (*ACLENet.org*) to support our work in saving lives.
ACLENet wishes you a wonderful holiday and prosperous, happy and healthy 2018!

Meteorology group, Institute of Atmospheric Physics, Czech Academy of Science, Czech Republic

Sokol, Zbyněk & Minářová, Jana

Involved in research **project Cosmic Rays and Radiation Events in the Atmosphere CRREAT** (2016—2022) that is supported by European Regional Development Fund from European Union, we investigate the implementation of explicit treatment of cloud electrification and lightning in the non-hydrostatic numerical weather prediction (NWP) model COSMO (Steppeler at al., 2003), which was developed by COSMO consortium.

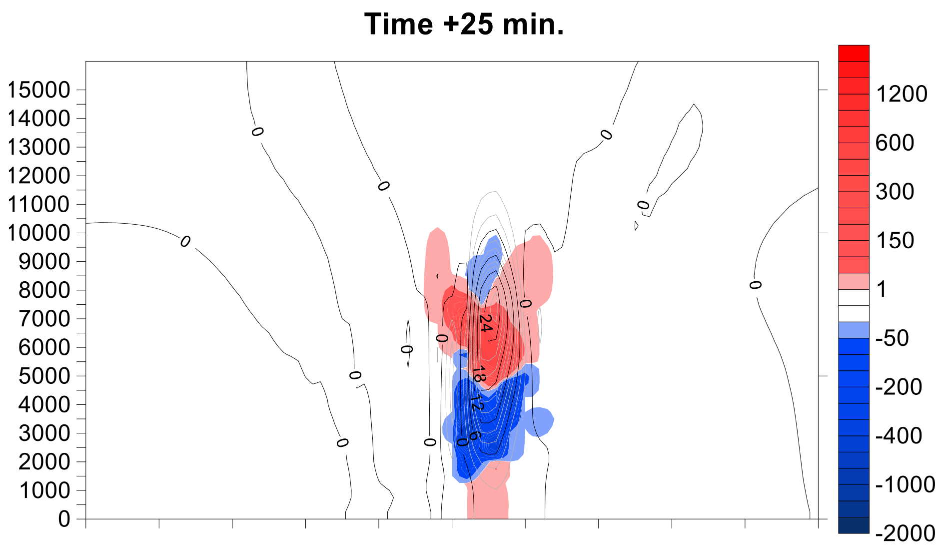

Fig. 1 Vertical profile [m] of electric charge [nC] and vertical velocity (contours) in the idealized thunderstorm at simulation time of 0+25min. The positively and negatively charged regions are depicted in red and blue, respectively.

The electrification in a thundercloud is driven by convection and related strong updrafts, and presence of the ice phase and supercooled water. The charging mechanism considered in our model is based on works of Mansell et al. (2005) and other researchers. The model of cloud electrification (MCE) including lightning parameterization is included into to dynamical core of the COSMO model and in the two moment Seifert-Beheng cloud microphysics. The MCE model considers small positive and negative ions and six classes of hydrometeors (cloud, rain, ice, snow, graupel, hail). It models both inductive and non-inductive electrification. At present the model and its application to real data is under development. We have a limited experience with its application to idealized storm data.

We tested the MCE at the prototyped thunderstorm (WK82). The time step during the simulation was six seconds at 2 km horizontal resolution and 41 non-equidistant vertical levels (vertical extension of the model up to 22 km above the ground level). An example of a model output is presented in Fig. 1, which shows a vertical cross-section through the storm center in the direction of the motion of the storm. The figure shows that the electric field gives layers of different electric charges after 25 minutes of model integration, which remind a tripole structure (positively charged regions in the upper part and near the base of the cloud and a negatively charged region in between) often observed during thunderstorm observations. Thus the model enables the charge to separate and the cloud to electrify. Currently, we test the implementation in the COSMO model using observed data during three convective storms that affected the Czech Republic (Central Europe) in 2016.

Currently we are developing the explicit model of cloud electrification by including the flash discharges (lightning) since it is essential in the modelling of thunderstorms. The explicit description of lightning in the model proceeds from the bidirectional concept of the flash leader. The concept of bidirectional leader is used to simulate the vertical propagation of the flashes (discharge channels) initiated along the electric field. The propagation of the flashes in horizontal direction consists of a probabilistic branching algorithm which is based on dielectric breakdown concept Pinty et al., 2013).

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