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Newsletter on Atmospheric Electricity

Vol. 26 • No 2 • Nov 2015

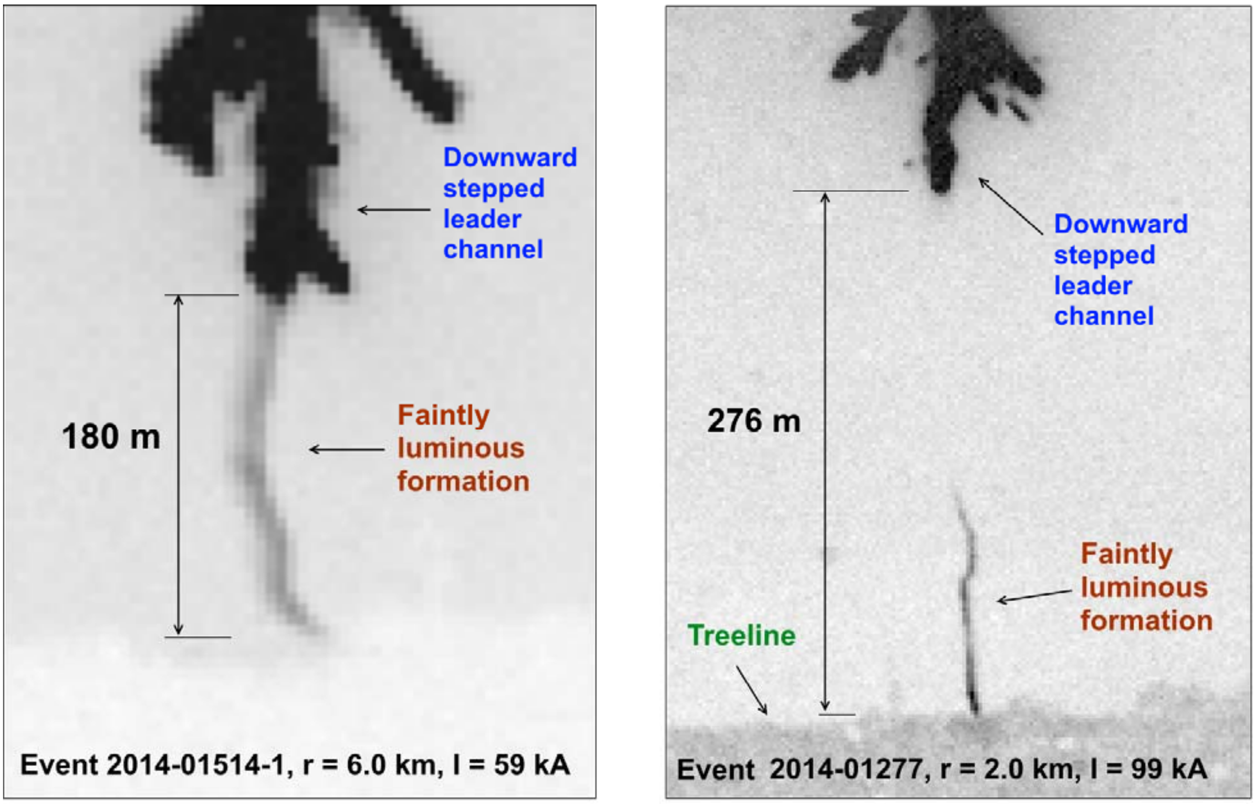
INTERNATIONAL COMMISSION ON ATMOSPHERIC ELECTRICITY (IAMAS/IUGG)

AMS COMMITTEE ON ATMOSPHERIC ELECTRICITY

AGU COMMITTEE ON ATMOSPHERIC AND SPACE ELECTRICITY

EUROPEAN GEOSCIENCES UNION

SOCIETY OF ATMOSPHERIC ELECTRICITY OF JAPAN



(a) (b)

Comment on the photo above: **Attachment process of two negative first strokes in natural lightning imaged with a high-speed video camera at the Lightning Observatory in Gainesville (LOG), Florida. Shown in (a) is the break-through (final-jump) phase. The faintly luminous formation (FLF) is a common streamer zone with an estimated average electric field of about 0.3-0.4 MV/m. Shown in (b) is most likely an 11-m-long positive UCL with a long streamer zone. In both cases the return stroke occurred in the next frame. About one-third of 50 examined records showed FLFs as seen in (a) and (b). Adapted from a paper published in JGR by M.D. Tran and V.A. Rakov (University of Florida).**

CONFERENCES

2016 International Lightning Detection and International Lightning Meteorology Conferences

The 24th International Lightning Detection Conference and 6th International Lightning Meteorology Conference will be held from 18 to 21 April 2016 in San Diego, California, USA. The conferences will be hosted by Vaisala at the Embassy Studies San Diego Bay.

The list of topics for the 2016 conferences includes the following:

- Lightning Physics, Chemistry, and Associated Modeling
- Lightning Occurrence Characteristics
- Lightning and Upper Atmospheric Discharges
- Use of Lightning Data by the Power Industry
- Lightning Interaction with Tall Objects, including Wind Turbines
- Lightning Detection Technology
- Winter Lightning
- Lightning Protection of Structures and Systems
- Lightning Warning, Nowcasting, Forecasting
- Applications of Ground-Based and Satellite-Based Lightning Data
- Lightning Safety, Medicine, and Education

The conference **Keynote Speech** entitled "Lightning current and electromagnetic field measurements at the Säntis Tower in Switzerland" will be given by Dr. Farhad Rachidi of the Swiss Federal Institute of Technology, Switzerland.

In addition, the following lectures will be given by **Invited Speakers**:

ILDC

Dr. Yoshihiro Baba, Doshisha University, Japan
"Application of the FDTD method to lightning electromagnetic pulse simulations"
Dr. Vernon Cooray, Uppsala University, Sweden
"Concepts used in creating engineering return stroke models and their unification"
Dr. Caitano L. da Silva, Dartmouth College, U.S.
"Recent efforts in investigating IBPs, CIDs, TGFs, and their relationship with intracloud lightning leader dynamics"
Dr. Silvério Visacro, University of Minas Gerais, Brazil
"Insights into lightning processes based on simultaneous records of current, electric field and high speed video camera"

ILMC

Dr. Larry Carey, University of Alabama, Huntsville, U.S.
"The relationship of the lightning jump to thunderstorm kinematics, microphysics and severe weather"
Dr. Mary Ann Cooper, Professor Emerita, University of Illinois at Chicago, U.S.
"Lightning safety education in the developing world and the formation of ACLE"
Dr. Ted Mansell, National Severe Storms Laboratory, U.S.
"Using model storms to simulate lightning, and using lightning to stimulate model storms"
Dr. Xiushu Qie, Institute of Atmospheric Physics, Chinese Academy of Sciences, China
"Study on dynamic-microphysical-electrical processes in severe thunderstorms and lightning hazards in China"

The abstract submission deadline has passed. Early registration ends on 4 January 2016, and final papers are due on 15 February 2016. For full information, visit www.vaisala.com/ildc.

ICLP2016

The deadline for paper submission to ICLP2106 is Feb. 1st, 2016. For detailed information, please visit http://iclp2016.org/index.asp.

International Conference on Cloud Physics

International Conference on Cloud Physics will be held in Manchester, UK, 25 to 29 July 2016. Papers on Atmospheric Electricity are welcome. The abstract deadline is 15 January 2016. For more information http://www.meeting.co.uk/confercare/iccp2016/ .

The European Geosciences Union General Assembly 2016

The European Geosciences Union General Assembly 2016 will be held at the Austria Center Vienna (ACV) in Vienna, Austria, from 17–22 April 2016.

We invite you to submit your abstracts to our session **NH1.2/AS1.6**

Convener: Yoav Yair
Co-conveners: Giles Harrison, Serge Soula, Colin Price, Hans-Dieter Betz and Yukihiro Takahashi

CONFERENCES

Atmospheric Electricity, Thunderstorms, Lightning and their effects
http://meetingorganizer.copernicus.org/EGU2016/session/20295

This session seeks contributions from research in atmospheric electricity on:

- Atmospheric electricity in fair weather and the global electrical circuit
- Cloud microphysics, charge separation and lightning discharge physics
- Atmospheric chemical effects of lightning and the climate impact of LtNOx
- Transient Luminous Events: observations and theory
- Global lightning patterns in an era of climate change
- Thunderstorms and lightning in hurricanes and typhoons
- Now-casting and forecasting of thunderstorms and severe weather
- Lightning detection networks and sensors from ground and space platforms
- Lightning protection

Note that in recent years the number of submissions to the Atmospheric Electricity sessions at the EGU (our session together with the AS4.29 "High Energy from Thunderstorms and Lightning" session) has been growing steadily and we have reached "a critical mass". This allows a full day of oral talks and two poster sessions. Please consider this when planning your annual conference travels.

We would like to draw your attention to session **AS4.12**:
Sebastien Celestin, Thomas Gjesteland, and Martino Marisaldi

High Energy Radiation from Thunderstorms and Lightning
http://meetingorganizer.copernicus.org/EGU2016/session/20005

During recent years, high energy radiation from lightning and thunderclouds have been measured from space, aircraft, and ground level. Thunderclouds produce bursts of gamma rays, electrons, and antimatter into space. They also produce continuous energetic radiation, which has been measured at ground level and by aircraft. High energy radiation has also been detected in association with lightning leaders and laboratory sparks. The physical processes associated with these phenomena are not well established yet, neither are the effects of this radiation on the upper atmosphere and the near space environment.

In this session, we welcome contributions about observational and theoretical studies related to the production of energetic particles from thunderclouds and lightning discharges. Especially, phenomena such as terrestrial gamma ray flashes (TGFs), terrestrial electron beams, gamma ray glows, thunderstorm ground enhancements, and X-ray observations from lightning and laboratory discharges, as well as their relationships to one another are of great interest.

The Abstract Submission Rules are described on
http://egu2016.eu/abstract_management/how_to_submit_an_abstract.html

DEADLINE for Receipt of Abstracts is 13 January 2016, 13:00 CET

We particularly encourage young scientists to apply for the Young Scientist's Travel Award (YSTA) (deadline: 1 December 2015).
Please visit http://egu2016.eu/support_and_destinction.html

More information about the EGU General Assembly 2016 can be found at: http://www.egu2016.eu/.
We look forward to seeing you in Vienna!

Workshop on Terrestrial Gamma-ray Flashes

The University of Alabama in Huntsville (UAH) and its Center for Space Plasma and Aeronomic Research (CSPAR) will host a 2.5 day long workshop on Terrestrial Gamma-ray Flashes on 27-29 June 2016. Additional information will be made available at http://spacephysics.uah.edu/tgf2016/.

The LIghtning and COsmic Rays in Natural Environment (LICORNE)

Subatech (École des Mines de Nantes, CNRS/IN2P3, Université de Nantes), **LERMA (**Observatoire de Paris, École Normale Supérieure, Université Paris VI Pierre et Marie Curie et Université de Cergy-Pontoise), **LA** (CNRS/INSU, Observatoire Midi-Pyrénées et Université Toulouse III Paul Sabatier), **LPC2E (**CNRS/INSU, Université d'Orléans), **LATMOS (**CNRS/INSU, Université Versailles Saint Quentin, Université Paris VI Pierre et Marie Curie, Institut Pierre-Simon Laplace), **Météorage** (French National LLS operator).

The **LI**ghtning and **CO**smic **R**ays in **N**atural **E**nvironment (LICORNE) is a French brand-new transverse multi-disciplinary research project gathering experts working in the fields of High-energy Astroparticles and Atmospheric Sciences. The primary objective of the LICORNE project aims at providing key insights on the possible relationships between lightning occurrence and air showers from high-energy cosmic rays on the specific topic of lightning initiation. Indeed, the physical processes that trigger a lightning flash are still unknown, as the ambient macroscopic electric field inside the cloud is typically one order of magnitude less than that required for dielectric breakdown. It is hypothesized that a lightning flash can be triggered by an avalanche of runaway electrons created by cosmic ray-induced extensive air showers with energy in excess of 10^{16} eV (Gurevich et al, 1992 and 1999), but this remains to be experimentally evidenced.

The LICORNE project will use, for the cosmic ray part, the CODALEMA instruments operated by Subatech and located in the radio-astronomy station of Nançay, France (Torres Machado et al, 2013, Martin et al, 2014). All cosmic ray events are measured by a particle detector array (13 plastic scintillators) allowing on its own a reconstruction of the primary cosmic ray main characteristics (arrival direction and energy). Additional measurements may be provided for many of them by two radio arrays, one consisting of 57 autonomous stations sensitive to the electric field transient emitted by the air shower initiated by the primary cosmic ray (between 20 MHz and 200 MHz), the other one being a highly-sensitive compact array of cabled and phased antennas over 150 m x 150 m area triggered by the particle detector array (Lecacheux et al, 2014). Complementary observing systems for lightning and thunderstorms are a local weather station, a professional electric field mill and possibly a microphone array from the CEA (Farges and Blanc, 2010; Gallin et al., 2014) to map the acoustic lightning sources in 3D. Finally, total lightning data are provided by the high resolution French National Lightning Locating System, Météorage, which operates in the VLF/LF bandwidth.

LICORNE has just started with a first one-year boot strapping phase during which correlation of available lightning and air shower records will be investigated to provide first observational-based insights. In parallel an exhaustive literature review (observation, modelling) will be performed. By the end of the first year, the main results will provide the inputs for a realistic Science Plan that will drive the LICORNE second phase with a coherent observational and modeling strategy with mitigation plan, including the opportunity to complete the measurement systems with an 8-station Lightning Mapping Array.

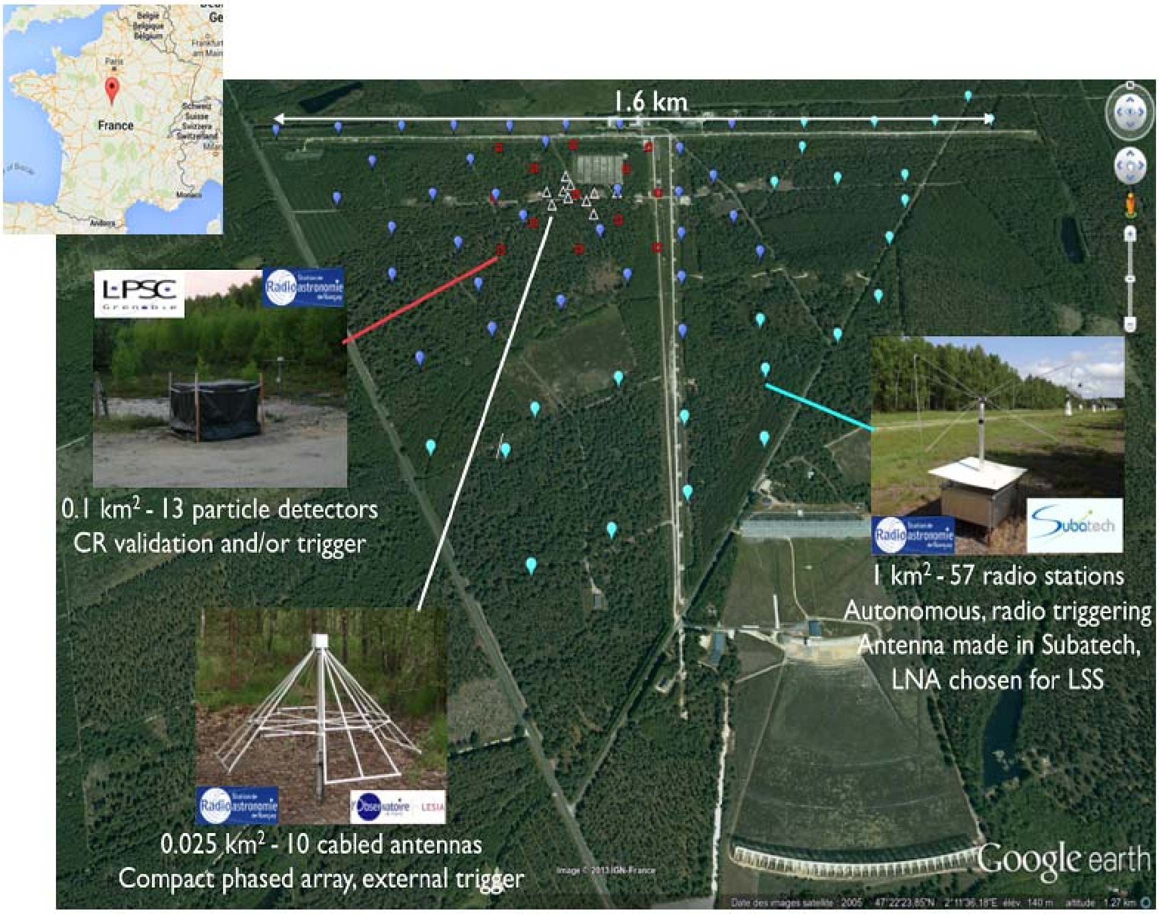


Figure 1 – General overview of the radio astronomy station in Nançay (see location in upper-left panel). We also present the various detectors of the CODALEMA experiment, dedicated to the observation of air showers initiated by high energy cosmic rays.

***Gurevich**, A. V., G. M. Milikh, and R. Roussel-Dupre (1992), Runaway electron mechanism of air breakdown and preconditioning during a thunderstorm, Phys. Lett. A, 165: 463 – 468.*

***Gurevich**, A. V., K. P. Zybin, and R. Roussel-Dupre (1999), Lightning initiation by simultaneous effect of runaway breakdown and cosmic ray showers, Phys. Lett. A, 254, 79-87.*

***Torres Machado**, D. et al, Latest upgrades and results from the CODALEMA experiment, July 2013,33rd ICRC, Rio de Janeiro.*

***Martin**, L. et al, Investigating the extensive air shower properties using the polarization and*

frequency features of the radio signals measured by the CODALEMA autonomous station array, June 2014, ARENA conference, Annapolis.
Lecacheux, *A. et al, A dedicated antenna array for radio detection of Extended Air Shower, June 2014, ARENA conference, Annapolis.*
Farges, T., *and E. Blanc (2010), Characteristics of infrasound from lightning and sprites near thunderstorm areas, J. Geophys. Res., 115, A00E31, doi:10.1029/2009JA014700.*
Gallin *L et al, Acoustic characterization of lightning discharges, 8th HyMeX Workshop, 2014.*

Volcanic lightning studies at Sakurajima Volcano, Japan

In March 2015 a two-year NSF-funded research project was started to investigate charging processes and lightning in volcanic eruptions. Sakurajima Volcano in Kyushu, Japan, was selected as the subject volcano for these studies for its relatively predictable and regular pattern of explosive eruptions, with several events per day producing ash plumes typically reaching between 5,000 and 15,000 ft altitude.

Our earlier lightning mapping studies of volcanic lightning, at Augustine and Redoubt volcanoes in Alaska as well as Eyjafjallajökull in Iceland, have shown that electrical discharges in volcanic ash clouds can take several different forms, from small-scale lightning flashes that are tens to hundreds of meters in extent and that occur close to the vent, to large-scale lightning flashes in the eruption cloud that resemble natural lightning in thunderstorms. In addition, a previously undetected type of discharge was identified, which manifests itself as a continual production of VHF emissions that occur at or very close to the vent, and have since been referred to as continuous RF. Continuous RF occurs at the onset of ash emission from a vent and can last anywhere from a second to over a minute in time.

It is not known what causes continuous RF. One of the main goals of the present studies of Sakurajima Volcano is to understand what process(es) are responsible for the production of continuous RF in volcanic eruptions. In addition, the studies focus on electrical charging in volcanic ash clouds as well as other volcanic eruption processes in a much broader sense.

In May and June of 2015 we deployed a 10-station Lightning Mapping Array (LMA) around Sakurajima Volcano that provided full 3-D mapping of lightning over the volcanic vent in the high-rate mode of 10 microseconds. We also installed an array of instruments to record waveforms of electromagnetic radiation at a wide range of frequencies: “slow” and “fast” electric field change antennas, a flat-plate broadband VHF antenna (20-80 MHz bandwidth), an electric field mill, and 63 MHz log-RF derived from one of the LMA stations. In addition, we installed two seismometers with infrasound sensors, and operated two high-speed video cameras, a low-light Watec camera for both daytime and nighttime observations, a forward-looking infrared (FLIR) camera, and still cameras. The FLIR and Watec cameras are especially helpful for studying plume dynamics and growth. Finally, the proximity of the volcano at about 3.5 km distance allowed for the collection of ash samples. We ran a two-week intensive observation effort from late May to early June, observing 24 hours per day collecting data for a number of eruptions. A few instruments including the LMA were left installed during the summer. We returned to Sakurajima in September for a second two-week observation period and to retrieve the LMA and other instrumentation.

The research team includes Sonja Behnke, Stephen McNutt, and Cassandra Smith from the University of Southern Florida Tampa; Ronald Thomas and Harald Edens from New Mexico Tech; Corrado Cimarelli and Valeria Cigala from Ludwig Maximilians University of Munich; and Alexa Van Eaton from USGS Cascades Volcano Observatory. We received invaluable assistance from the research group of Sakurajima Volcanic Observatory (SVO), under the leadership of Masato Iguchi.

Our initial findings will be presented at the 2015 AGU Fall Meeting in San Francisco.

Sakurajima volcano lightning

RESEARCH ACTIVITY BY INSTITUTIONS

Department of Physics, National Cheng Kung University, Taiwan

Yen-Jung Wu

Along with the work on the physical origin of the D-region ledge with Dr. Earle Williams of MIT, the hydroxyl (OH*) nightglow is also located in a similar height range of elves and the D-region ledge in electron density. The Imager of Sprite and Upper Atmospheric Lightning (ISUAL) onboard the Taiwanese satellite Formosat-2 provides solid evidence for this collocation , and shows that over 95% of documented elves are found in the same pixel as the hydroxyl (OH*) nightglow emission. This kind of collocation is not a coincidence, as the correspondent species monatomic oxygen serves to link the meteoric smoke particles from meteor ablation and the electromagnetic and photochemical phenomena together. With the monatomic oxygen as the reactant, the sharp increase in the electron density at the ledge height would also enhance the emission of hydroxyl (OH*) nightglow. This connection assures that the elves and OH* nightglow have the brightest column emission rate at a similar height. ISUAL is now on its 12th year of operation in orbit and the colleagues of the ISUAL team calibrate the instruments regularly so that the data quality is maintained above a certain level, despite the shade on the imager that blocks a part of the field of view.

Duke University, Electrical and Computer Engineering Department, Durham, NC USA

Our group continues to use radio emissions from lightning to measure key parameters of those lightning processes. We provided our measurements to research led by several different research groups, including studies of negative polarity sprites, gigantic jets, and the lightning-meteorology relationship. Our own work has largely focused on applications of LF radio measurements in three areas: terrestrial gamma ray flashes (TGFs), highly energetic in-cloud lightning, and radio mapping of in-cloud lightning structure.

Cummer et al. [GRL, 2015] analyzed LF lightning radio emissions at the time of TGFs to work towards a better understanding of the lightning context of TGF production. We searched our LF radio data for known Fermi-GBM TGFs to identify those where the TGF is surrounded by LF radio pulses that are sufficiently clear that their source altitude can be inferred from multiple ionospheric reflections. There are not many, but in Cummer et al. [GRL, 2015] we analyzed three and found that all of them follow a similar pattern: TGFs are produced several milliseconds after IC leader initiation and when the leaders had reached 1-2 km in length (see Fig. 1 for an example). In all cases the leader continued to propagate upward for several more km after the TGF terminated. The lightning leader time-altitude sequences appear ordinary except for a fast upward propagation speed of roughly 10^6 m/s in all cases. These measurements provide some key details of the lightning processes that occur before, during, and after TGF production.

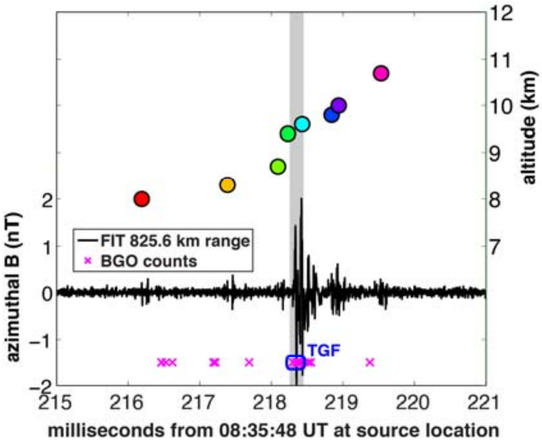


Fig. 1. Example of IC leader altitude-time plot for TGF-producing lightning. The TGF is produced about 2 ms after the upward leader initiation, when the negative leader tip had ascended 1.5 km from its initiation altitude. The leader continues upward for another 1.5 km after the TGF. Adapted from Lyu et al., GRL, 2015.

Lyu et al. [GRL, 2015] examined detailed LF radio emissions from lightning identified by the NLDN as in-cloud, very high peak current (>150 kA) events. Quantitative features in the LF waveforms (mainly time scale and the presence of other emissions nearby in time) of these events naturally sort these in-cloud events into two classes: classic narrow bipolar events (NBEs), and a previously unappreciated class of lightning that we call energetic in-cloud pulses (EIPs). Both positive and negative EIPs exist (but positive is much more common), and the LF radio context shows that EIPs are produced during upward (for +EIPs) or downward (for –EIPs) propagation of a previously initiated negative leader. A small handful of previously reported TGFs are associated with very high peak current events that appear to be EIPs. We are working towards better understanding the link between these two unusual lightning processes.

Lastly, Lyu et al. [GRL, 2014] showed that a compact LF sensor array could be used as a 3D lightning mapping array (LMA) and produces lightning images that are remarkably similar to VHF LMA images (see Fig. 2) despite the 1000x frequency difference. The key step is computing 2-station time differences with submicrosecond resolution via windowed cross-correlation, which is equivalent to broadband interferometry. This approach images both stepped and dart leaders and produces a fairly complete image of in-cloud and cloud-to-ground lightning channel development.

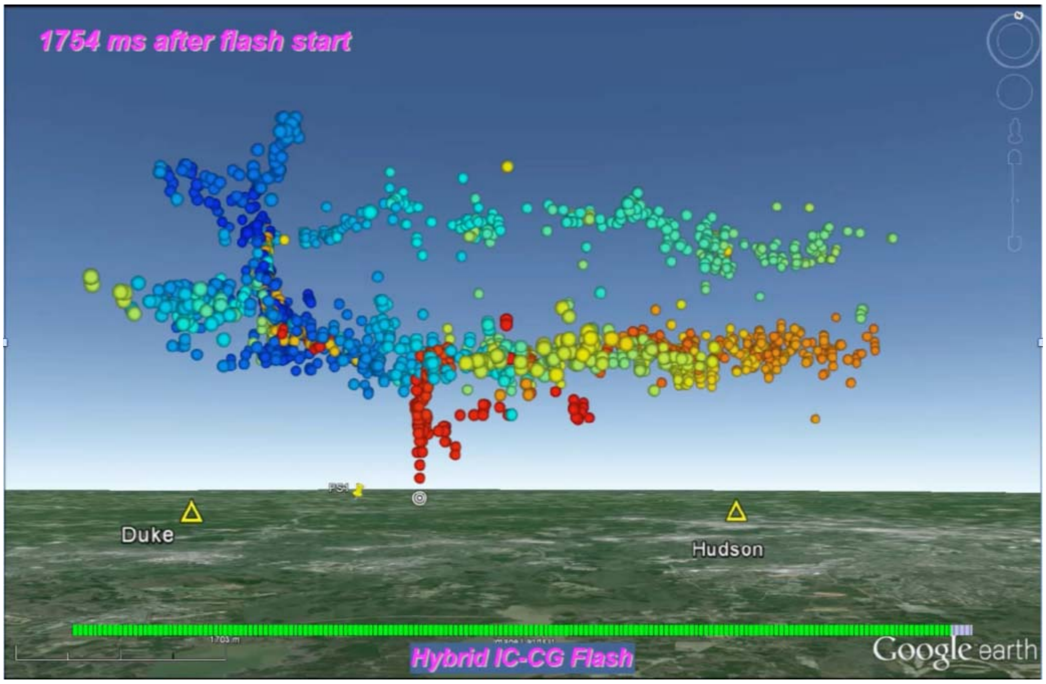


Fig. 2. Plot of low frequency LMA source points for a hybrid IC-CG lightning flash. Color reflects the time of the source (blue=old, red=current). This image was created using the data and processing approach described by Lyu et al., GRL, 2014.

Environment Canada, Toronto, Ontario, Canada

In spring 2014, David Sills and Helen Yang of Environment Canada, with the help of Bill Rison, Dan Rodeheffer and others from LMA Technologies LLC of New Mexico, USA, successfully began operation of the Southern Ontario Lightning Mapping Array (SOLMA). The array is composed of 14 solar-powered LMA stations located in and near Toronto. Paul Joe (Environment Canada) and Steve Goodman (NOAA/USA) also provided scientific and technical guidance.

SOLMA was installed with the primary objective of investigating the use of total lightning flash density and rate change data to improve the nowcasting of thunderstorm intensity in the Toronto area. This was of particular importance during the summer 2015 Pan Am / ParaPan Am Games in Toronto when new science techniques and technologies were tested and evaluated.

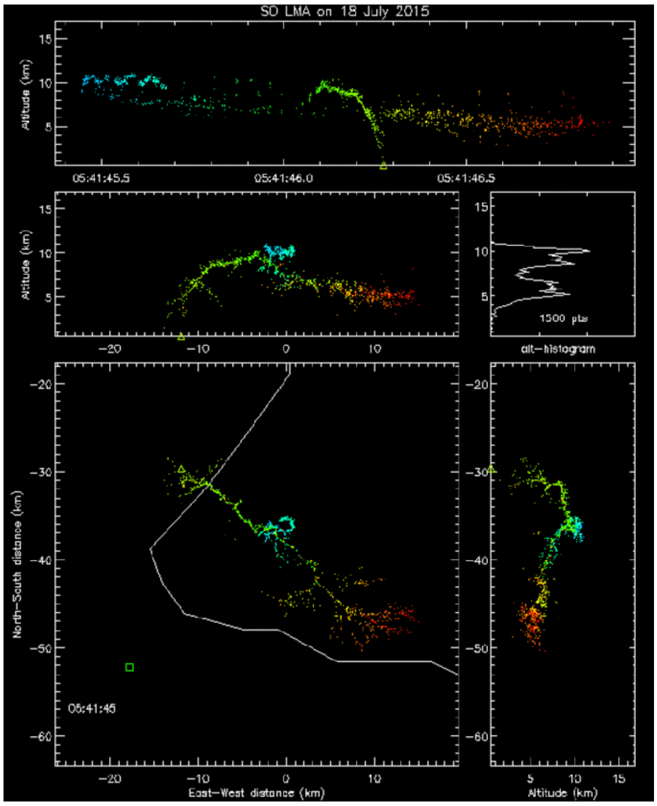
Secondary objectives include using SOLMA to evaluate lightning data from model parameterizations and other lightning detection networks including the Canadian Lightning Detection Network (CLDN), becoming familiar with the use and benefits of total lightning in advance of its availability via the Geostationary Lightning Mapper (GLM) that will be aboard the GOES-R satellite when launched, and generally increasing knowledge of lightning characteristics in the southern Ontario area, including winter lightning associated with intense lake-effect snow events.

Over 2014 and 2015, hundreds of

convective storms were sampled. A 'lightning jump' case and a lake-effect snow event, both from fall 2014, are discussed in Sills et al. (2014, below). More recently, in July 2015, a 'bolt from the blue' event was recorded. A local storm enthusiast, David Piano, captured the lightning flash shown in the photograph below. The corresponding flash recorded by SOLMA is also shown as an animation. The 'bolt from the blue' in the photograph appears in the animation as the negative leader rapidly extending to the NW and reaching towards ground. The CLDN detected a negative cloud-to-ground flash there as well. We intend to spend more time investigating this interesting case.

A recent visit by Earle Williams (MIT/USA) not only increased our knowledge of lightning science, but led to our knowledge of this newsletter, and subsequent submission of this news item. Thanks Earle!

SOLMA is expected to be in operation until at least fall of 2018. More details can be found in the following conference paper. Sills, D., H. Yang and P. Joe, 2014: A Lightning Mapping Array in southern Ontario, Canada: uses for severe weather nowcasting. *Extended Abstracts, 27th AMS Conference on Severe Local Storms*, Madison, WI, Amer. Meteorol. Soc., Paper 83. [PDF]



Top left – Dave Sills, Dan Rodeheffer and Helen Yang installing one of the 14 LMA stations in spring 2014. Bottom left – Photo by David Piano showing the 'bolt from the blue' extending from a thunderstorm over Lake Ontario to Burlington, ON, on the north shore. Right – Animation over approximately 1.5 seconds showing the evolution of the flash that included the 'bolt from the blue'. Blue indicates the oldest sources, red the newest. The 'bolt *from the blue' extends rapidly toward the NW. The small green triangles indicate the location of a CLDN-detected cloud-to-ground flash. The small green square indicates the location of one of the LMA stations. The grey outline indicates the shore of Lake Ontario.*

High-energy radiation at the University of California, Santa Cruz

David M. Smith, Nicole Kelley (U.C. Berkeley), Gregory Bowers, Alexander Infanger

Our group has been using detectors sensitive to gamma-rays and high-energy particles to study Terrestrial Gamma-ray Flashes (TGFs) and long-lived atmospheric radiation enhancements ("glows", also known as "Thunderstorm Ground Enhancements" when observed from the ground).

We have recently reported the discovery that a glow observed between the upper positive charge center and negative screening layer of a thunderstorm on the Georgia coast of the United States was intense enough that the currents it produced could have significant influence on the charge balance in the cloud, perhaps discharging it at a rate comparable to the time-averaged rate from lightning. This observation was made by our instrument, the Airborne Detector for Energetic Lightning Emissions (ADELE), in 2009, aboard the NCAR/NSF Gulfstream V aircraft (N. A. Kelley et al. 2015, Relativistic electron avalanches as a thunderstorm discharge competing with lightning, Nature Communications 6, 7845). ADELE has been flying on a NOAA P3 "Hurricane Hunter" aircraft this summer and last. The ADELE collaboration includes Prof. Joseph Dwyer of the University of New Hampshire. During the same 2009 flight, ADELE saw what appeared to be bursts of positrons annihilating in the plane, identified by their characteristic gamma-rays at 511 keV, and accompanied by a discharge from the plane. We have estimated the number of positrons in these 200ms-long events but do not have a clear model for their origin (J. R. Dwyer et al. 2015, Positron clouds within thunderstorms, Journal of Plasma Physics, 81, 475810405).

Our new ground-based instrument, Gamma-ray Observations During Overhead Thunderstorms (GODOT), carries a similar array of scintillation detectors to ADELE. It has a higher time resolution but lower maximum count rate. GODOT was hosted this summer at the High Altitude Water Cherenkov Observatory (HAWC), an astrophysical facility on Sierra Negra in central Mexico at 4100 m altitude; we thank the HAWC collaboration for their generous assistance. Last winter and this winter, GODOT has been/is being hosted by our collaborator Prof. Masashi Kamogawa of Tokyo Gakugei University at sites on the Noto peninsula by the Sea of Japan, a region known for low-lying winter thunderstorms. GODOT has seen several faint glows at both sites, and analysis is in progress. GODOT and ADELE have been supported by the National Science Foundation.

We continue the analysis of TGF data

from NASA's Reuven Ramaty High Energy Solar Spectroscopic Imager (RHESSI) satellite. A preliminary TGF data set, combining the events picked out by our group's algorithms and the second-generation algorithm from Thomas Gjesteland (University of Agder) and Nikolai Ostgaard (University of Bergen), is available to the public at http://scipp.pbsci.ucsc.edu/rhessi/. This interactive website, designed by former student Paul Buzbee, allows you to map different categories of TGF, compare the different catalogs, and examine individual events. Note that only the "Grefenstette" catalog (former student Brian Grefenstette's algorithm from 2009) is thought to consist entirely of genuine events; the larger catalogs have some contamination by false triggers. Contact David Smith (dsmith8 (at) ucsc.edu) for assistance in using the website.

Indian Institute of Tropical Meteorology, Pune, India

M.K. Kulkarni , Devendraa Siingh (devendraasiingh@tropmet.res.in)

Thunderstorm days and Lightning activity in association with El Nino (M.K. Kulkarni). Analysis of the lightning data from LIS, a space borne Lightning Imaging Sensor, aboard the Tropical Rainfall Measuring Mission (TRMM) revealed following.

On an average, the annual variation of lightning flash distribution, during study period of 1998-2013, followed a biannual variation, i.e. two peaks of lightning flashes in April and September respectively. The lightning activity picks up from the month of January and reaches the peak in the month of April (25.9). From April onwards it starts decreasing through May to August and again increases in September to reach the second peak. After September, the lightning activity starts decreasing through October to December. This is the characteristic feature of thunderstorm and lightning activity over the Indian Land region. The first higher peak in the lightning activity in the pre monsoon season months indicate the high electrical state of thundercloud as the electrical intensity of the thunder cloud is measured by the frequency and intensity of the lightning flash. The second peak in September is attributed to the withdrawal phase of southwest monsoon season and the western disturbances. The decline in the lightning activity (May to August) is due to the advent of monsoonal regime during which the electrical vigor of thunderstorms/lightning activity is significantly reduced due to weaker convection.

The percentage of lightning flashes along the Indian latitude fallows an unmodal variation with strong activity at 26° N. Overall, the lightning activity is widespread from 14° N to 35° N. This appears to be consistent with the general view that thunderstorm and lightning activity are most frequent over the moist humid regions of equatorial low-pressure belt and that their frequency decrease with increase in latitude.

Warm and humid, sun heated tropical land surface favors the development of thunderstorms because heating is strong close to the tropics than at higher latitudes. Up to 14°N, during the period of 1998-2013, lightning activity is not much prominent. The activity picks up from 14°N and is highest at 26°N and thereafter the lightning activity starts decreasing. 26°N latitude is the Northeast part of Indian subcontinent. It is well known that northeast of India is the seat of severe thunderstorm activity. During pre monsoon season quite a big number of thunderstorms and intense lightning are registered in this area. The highest of percentage of lightning flash (11.2) has been at 26°N.

Among the data utilized in the study (1998-2013), four episodes of El Nino have occurred viz. 2002, 2004, 2006, and 2009. During all these four years of El Nino, frequency of thunderstorm days is reduced but the frequency and average lightning flashes are increased. This indicates that though thunderstorm days are declining, the intensity and frequency of lightning flash is increasing. This supports earlier studies by Manohar et al, (1999) Kulkarni, et al., (2013). Manohar, et al., (1999) used thunderstorm day's data for a period of 10 years and found that thunderstorm days decrease during El Nino episodes. Present observations are also in agreement with the research carried out by Prof. Colin Price and his group. Their results indicate that during El Niño years, which occur in the Pacific Ocean, Southeast Asia gets warmer and drier and produce fewer thunderstorms, but 50% more lightning activity is observed. Drier conditions are expected to produce lesser thunderstorms. The fewer thunderstorms that occurred during El Niño episodes are more intense, convectively more active and therefore produce more lightning.

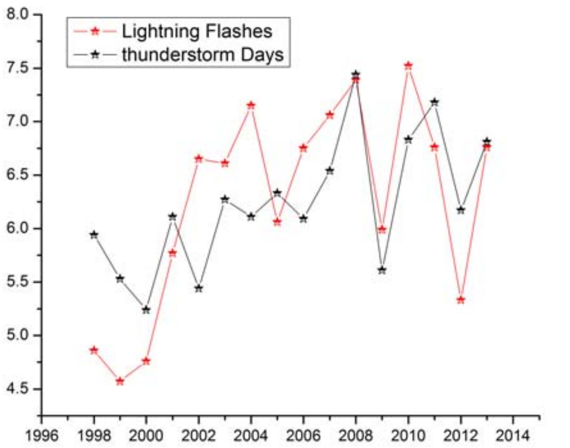


Fig. 1. Yearly vatiation of thunderstorm days and Lightning flashes

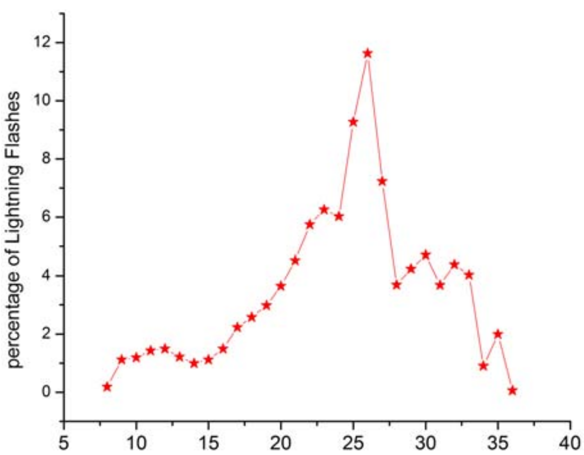


Fig.2 Latitudinal variation of Lightning Activity over the Indian land mass

Devendraa Siingh: Continuous measurement of different categories if atmospheric ions from Neutral Cluster and Air Ion Spectrometer (NAIS) is going in the premises of Indian Institute of Tropical Meteorology, Pune from 2010 along with SMPS. The example of the new particle events are shown in Figure 3. The main objective of this measurement is to study the generation mechanism of new particle formation in tropics. We have been also participating in different field experiment for the measurements of ion and aerosol from time to time. Our group's working on the problem of solar activity, lightning and climate issues, Global electric circuit, Thunderstorm and lightning, sprites etc.

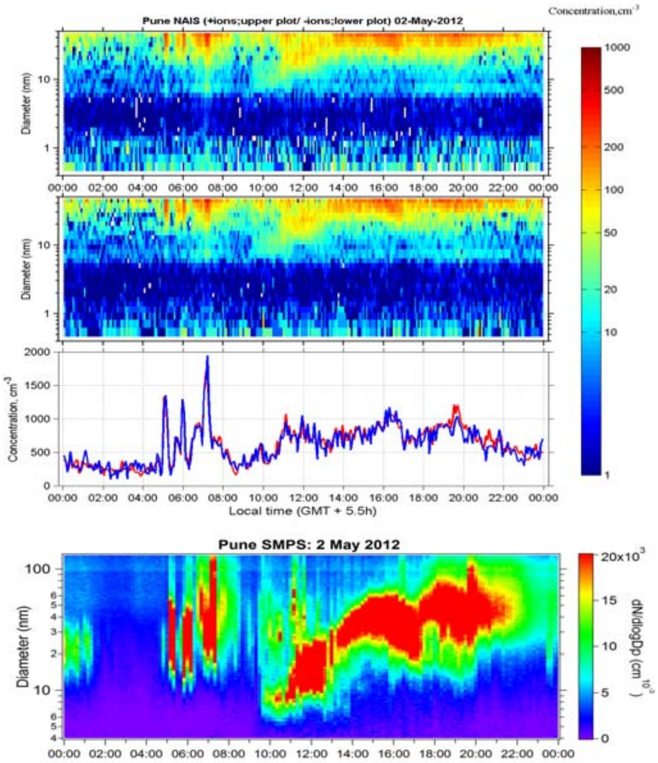


Figure: 3. Neucleation events observed from NAIS and SMPS at Tropical station Pune on dated 2 May 2012.

Lightning Research Group of Gifu University (Gifu, Japan)

With the support from the lightning research group of University of Florida (UF), we have continued our high speed optical observation experiments at The International Center for Lightning Research and Testing (ICLRT) at Camp Blanding, Florida by using two LAPOSs (Lightning Attachment Process Observation System). Wang et al. have finally gotten the lightning processes of three onsite natural lightning published in JGR. All strokes contained in the three lightning initiate at a height above ground, and propagate bi-directionally from that height, similar to the return strokes of artificially initiated (triggered) lightning previously reported by Wang at al. [2013, 2014]. Though the data are quite limited, these natural return strokes suggest a correlation between larger peak current and greater initiation height. Initiation heights determined here span 12 - 60 m with a typical uncertainty of less than 10 m. The initial upward return stroke speeds range from (0.8±0.2) to $(2.0±0.4)\times10^8$ m/s. Two first return strokes downward speeds are assessed as (1.6±0.3) $\times10^7$ m/s and $(1.4±0.3)\times10^8$ m/s. One of the first return strokes appeared to be initiated with a stepping pulse discharge of its leader as an inseparable part of the return stroke. Wang et al. have also analyzed the optical data on the discharges occurring at the tip of dart stepped leaders of rocket triggered lightning recorded with a time resolution of 0.1 s and a spatial resolution of about 1 m. Most of the discharges are found to progress in a bi-directional manner. The progression features in two opposite directions are different. The upward progression tends to have a more or less constant speed of a few 10^7 m/s. In contrast, the downward progression usually exhibit a similar initial speed as the upward progression, but the speed drops to a value about one order of magnitude smaller than the upward speed after propagating a distance of about 2 m. The detailed results will be reported at the 2016 ILDC be held 18-21 April 2016 at the Embassy Suites San Diego Bay in San Diego, California, USA.

Our observation on lightning that strike on a rotating windmill and its nearby lightning protection tower during winter seasons has been continuing for 11 years. In this winter, we will start a few new experiments. Hopefully we can get some results for ICLP 2016.

MIT Parsons Laboratory (Cambridge, MA, USA)

Earlier this year, Earle Williams completed a 3-month Visiting Fellowship supported by the Hungarian Academy of Sciences in Sopron, Hungary. During this period he and Gabriella Satori as primary authors completed a manuscript entitled “Effects of Energetic Solar Emissions on the Earth-Ionosphere Cavity of Schumann resonances“. Multiple-station ELF observations were used to document the effects of exceptional solar events (the Bastille Day event of July 14, 2003 and the longer-duration Halloween Event of October/November 2003) on the two characteristic ionospheric heights affecting Schumann resonances. Distinct variations of the modal frequencies were documented for both X-ray and proton events. But despite the exceptional energy of these events, their impact on the Schumann resonance intensities was only marginally detectable, consistent with theoretical predictions. These finding substantiate the idea that variations in lightning activity within the Earth-ionosphere cavity will largely dominate the intensity variations at ELF.

During the Hungary visit, Gabriella Satori, Veronika Barta and Earle Williams visited Martin Friedrich and Klaus Torkar in Graz, Austria for very useful discussion on the structure of the lower ionosphere and the documentation of the conspicuous ledge in electron density near 85 km altitude with rocket soundings.

Earle Williams participated with Luiz Machado and Rachel Albrecht in the doctoral thesis defense of Enrique Mattos at INPE in Sao Jose dos Campos, Brazil, in April. This work was concerned with the behavior of dual pol X-band radar observations and lightning type from the first radar echo for 74 isolated thunderstorms. Single stroke multiplicity was strongly dominant for first CG flashes in this special collection of compact storms.

Work continues with Yen-Jung Wu of the ISUAL satellite team in Taiwan on the physical origin of ionospheric structure in the height range of predominant elve production (80-90 km). The working hypothesis for the conspicuous nighttime ledge in electron density and electrical conductivity in this height range is the ablation of meteors. These meteors are below visible detection and far more numerous than the “shooting stars”. Meteoric smoke particles, the product of ablation, are recognized sinks for electrons (Plane et al., 2014). The classical model for ablation predicts an incoming meteor speed of 15 km/s to explain a height of ablation onset near 85 km. This prediction is consistent with the early analysis of Havana, Illinois meteor radar observations (Southworth and Sekanina, 1973) and with more recent ionization efficiency corrections to velocity observations published for the Arecibo radar (Janches et al., 2014). It has also been shown that the ledge height represents the boundary of the global VLF waveguide, under the condition that conduction current is matched with displacement current over a wide frequency range at VLF.

Joan Montanya visited MIT from Barcelona, Spain for four months beginning last April to work on topics of Schumann resonances (based on his new operational ELF receiving station in the Cape Verde Islands off Africa) and the behavior of DC arcs in air. A large DC power supply (+/- 65 kV, 3 amperes) was resurrected and powered (with variac control) with a diesel generator. Tortuous writhing arcs between vertically-aligned electrodes and with lengths up to 2 meters are initiated with fuse wires and documented with high speed video, courtesy of Jim Bales from the MIT Edgerton Center, and in collaboration with Robert Golka and Mike Valente. A conspicuous behavior is the abrupt short-circuiting of channel loops extending horizontally about of their initial vertical discharge paths. This occurs repeatedly to shorten the arc. Notable voltage/current increases/decreases are detected prior to these events, consistent with negative differential resistance, followed by a surge in current when the short-circuiting occurs. This phenomenon may be related to the M components superimposed on continuing current channels in lightning.

Alexei Korolev invited Earle Williams to visit Environment Canada in Toronto recently to discuss the electrostatic ‘chaining’ of ice crystals that has been documented in earlier lab studies by Clive Saunders and which is increasingly evident in aircraft observations of the upper regions of deep convection.

Mohd Riduan Ahmad arrived at MIT from Malaysia in September to begin post-doc work on narrow bipolar events. He worked earlier with Vernon Cooray in Uppsala, Sweden. He has some interesting documentation of precursory microwave emission for several NBEs recorded in Malaysian thunderstorms.

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

The Atmospheric Electrodynamics and Chemistry (LED-KÉM) Research Group of GGI invited the Schumann resonance (SR) group from Krakow (Andrzej Kulak, Janusz Mlynarczyk, Michal Dyrda, Zenon Nieckarz and Rafal Iwansky) to visit the ELF research team in Sopron, Hungary for some days in the middle of October, 2015. Two years ago Veronika Barta, József Bór, and Gabriella Sátori from the LED-KÉM group in Sopron visited the Polish group in the Astronomical Observatory, belonging to the Jagellonian Universty. Later, Earle Williams (MIT, USA) as guest professor in Hungary and Gabriella Sátori met the Polish group in Krakow in October, 2014. These exchange visits provided excellent opportunities to know each other's work and discuss specific questions in the ELF (SR) topic. E. Williams joined the discussion by Skype in one occasion in the most recent October meeting, 2015. One of the main topics is how the standing and travelling waves can be separated in the SR frequency range. A closely related issue is how efficient the 4-parameter Lorentzian fit can be in removing the distance-dependent frequency variations from the eigenfrequencies of the Earth-ionosphere cavity as suggested in the decomposition method by Kulak et al. (2006) and applied by Dyrda et al. (2015) based on SR observations in a single SR station at Hylaty, Poland.

Zenon Nieckarz, one of the Polish guests spent longer time, two weeks, in GGI in the frame of Short Term Visit supported by the TEA-IS ESF foundation. The main goal of his visit was to compare dynamic power spectra (DPS) below 5 Hz calculated from the measurements of the horizontal magnetic field components (H_{EW} and H_{NS}) recorded in Poland (HYL, 49.2°N, 22.5°E) and in Hungary (NCK, 47.6°N, 16.7°E) during selected periods of solar activity. Two of the considered phenomena are the strong geomagnetic storm and the Ionospheric Alfvén Resonance (IAR) excited by lightning activity . Their occurrence induce ULF electromagnetic waves in the magnetic field observed at frequencies below 5 Hz (Fig.1). Further joint work is planned on this topic.

A project has been started which aims at examining the possibilities of utilizing ELF/SR transients in the exploration of the geo-electromagnetic environment. As a first step, the effect of anisotropic conductivity in the Earth's crust and in the lower ionosphere on the polarization of TEM mode ELF waves detected at NCK station was studied. It was confirmed that anisotropic conductivity at the boundaries of the Earth-ionosphere waveguide close to the detections station introduces systematic bias in the orientation of the polarization plane of magnetic field (Bór et al, 2015).

The effect of lightning strokes on seismic records was further studied. The contribution of lightning-induced noise to the overall noise level of a seismic station was examined and the influence of lightning activity near a station on the earthquake detection efficiency was discussed. It was found that lightning-induced noise in the seismogram can hinder or even prohibit the detection of small earthquakes (Kiszely et al., 2015).

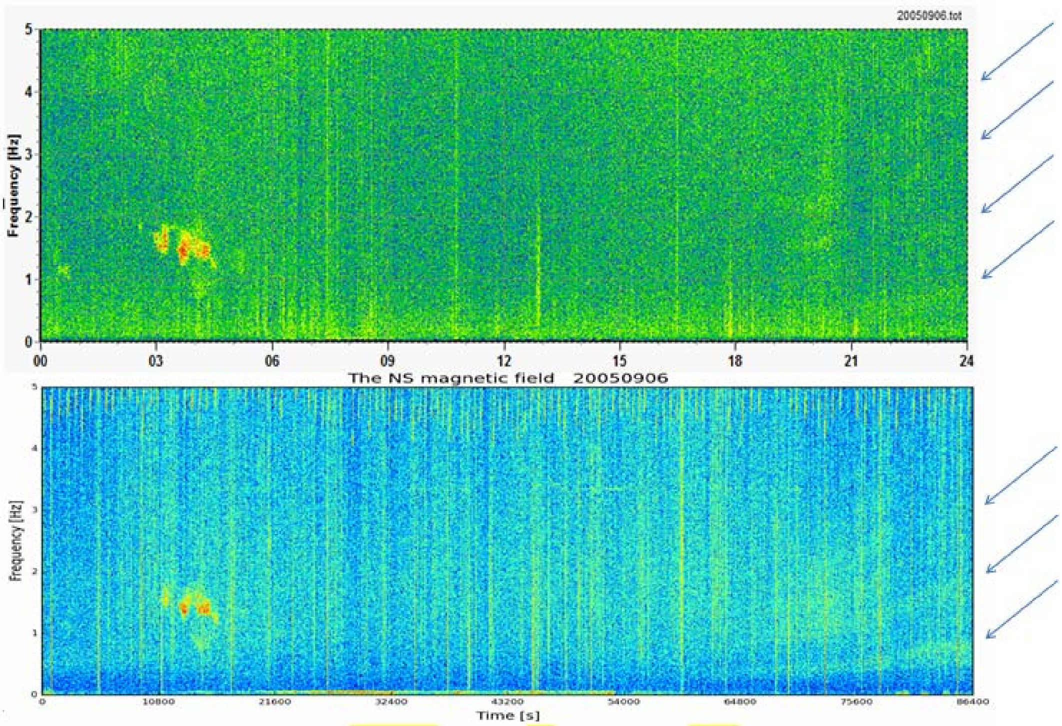


Fig.1. *Dynamical power spectra computed from the horizontal magnetic field components recorded at the Hylaty station, Poland (top panel) and Nagycenk station, Hungary (bottom panel) for Sept 6, 2005 in the frequency range below 5 Hz. The common Pc1 pulsations in the morning UT hours (left portion of the plots) are readily identified. Ionospheric Alfvén resonances in the evening UT hours are indicated by arrows (on the right).*

Special Laboratory of Physics, Department of Physics, University of Shkodra

Florian Mandija, f_mandija@yahoo.com

Our ultimate collaborations with other laboratories and observatories consisted on the estimation of the Saharan dust intrusions during 2012-2013 over two

AERONET/EARLINET Spanish stations; in Granada and Barcelona. The collaborations were carried out with the CEAMA (Andalusian Institute for Earth System Research, Andalusian Center for Environmental Research) in Granada as well as with the Department of Signal Theory and Communications (TSC) at Polytechnic University of Catalonia.

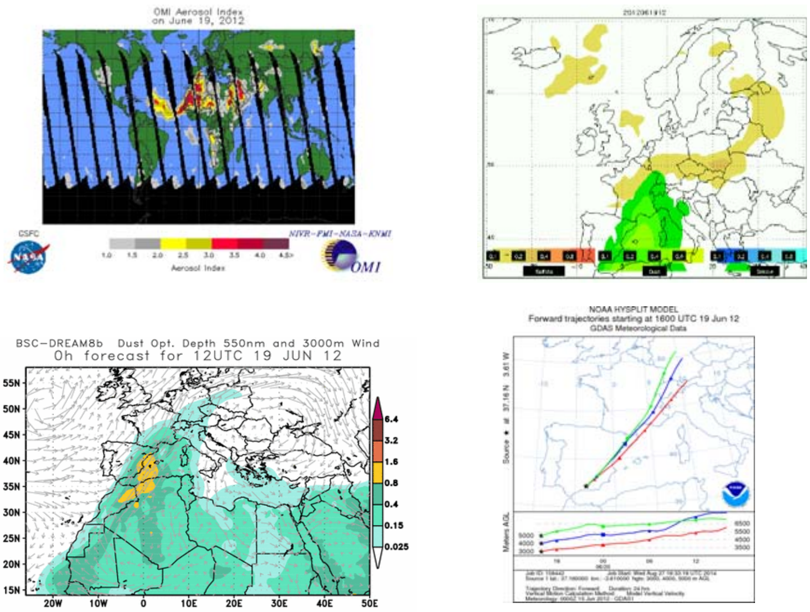


Figure 1. Tools used for aerosol analysis

Data taken from sunphotometers were used to identify dust events over the investigated area. Principal aerosol parameters taken into consideration were: aerosol optical depth at 500 nm, Angstrom exponent 440-870 nm, coarse mode fraction 500nm, etc. After that, the synergic usage of MODIS images with the models like BSC-DREAMS8b (Dust REgional Atmospheric Model) and NAAPS (Navy Aerosol Analysis and Prediction System) gave additional information about the scenarios of dust intrusions (Fig. 1). More detailed information about these intrusions was carried out from the cluster analysis of HYSPLIT (Hybrid Single Particle Lagrangian Integrated Trajectory Model) back-trajectories. The usage of the HYSPLIT back-trajectories was done to find the potential sources and the pathways of dust intrusions over Iberian Peninsula (IP). The last step of these analyses was done using the profiles of back-scattering coefficient obtained from the lidar systems. The differences between aerosol properties during the dust transport from Granada to Barcelona were investigated in order to deduct conclusions about the variation of these properties with the pathways of these dust intrusions. Three principal Saharan dust sources were found.

Moreover, these dust intrusions come over IP, through two principal pathways; Atlantic and Atlas Mountains (Fig. 2). Some of the results of this investigation are presented by the Figures 3.

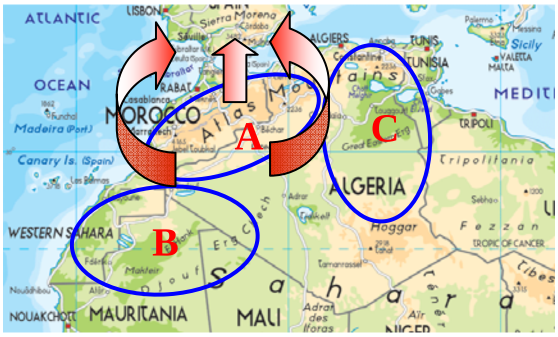


Figure 2. Principal dust sources and their pathways

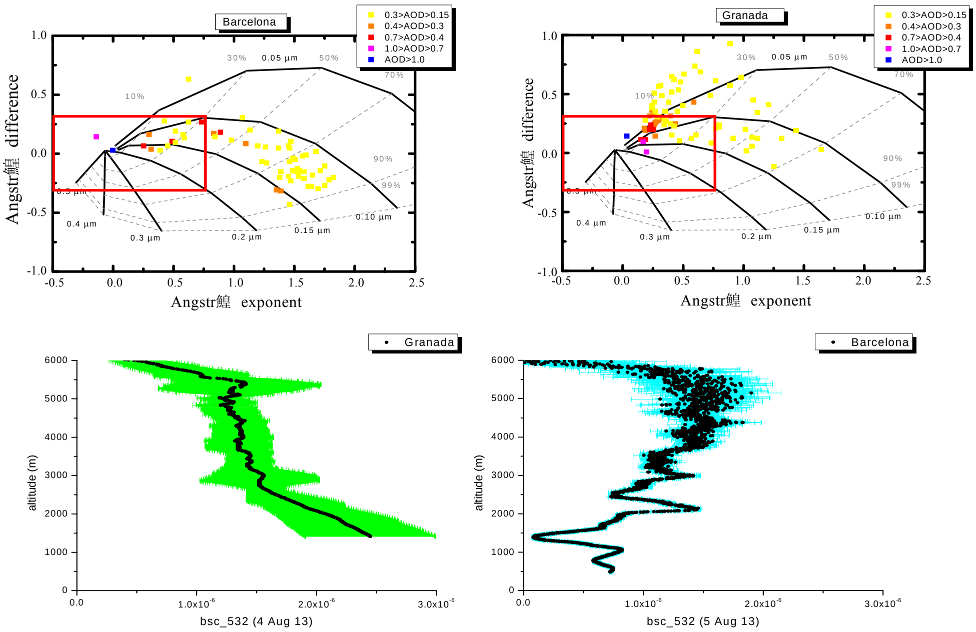
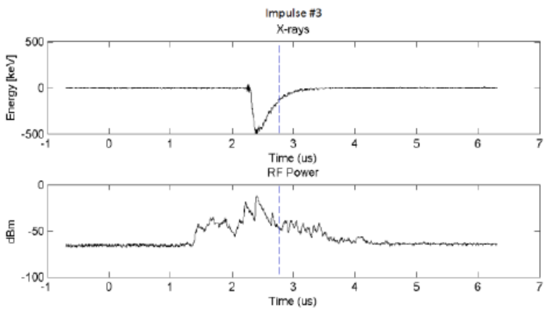
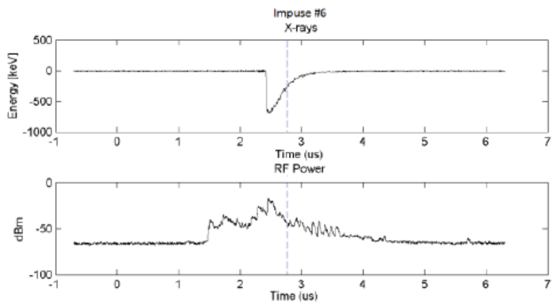


Figure 3. Aerosol analysis using spectral dependence of Angstrom and lidar profiles

Universitat Politecnica de Catalunya (UPC, Barcelona, Spain)

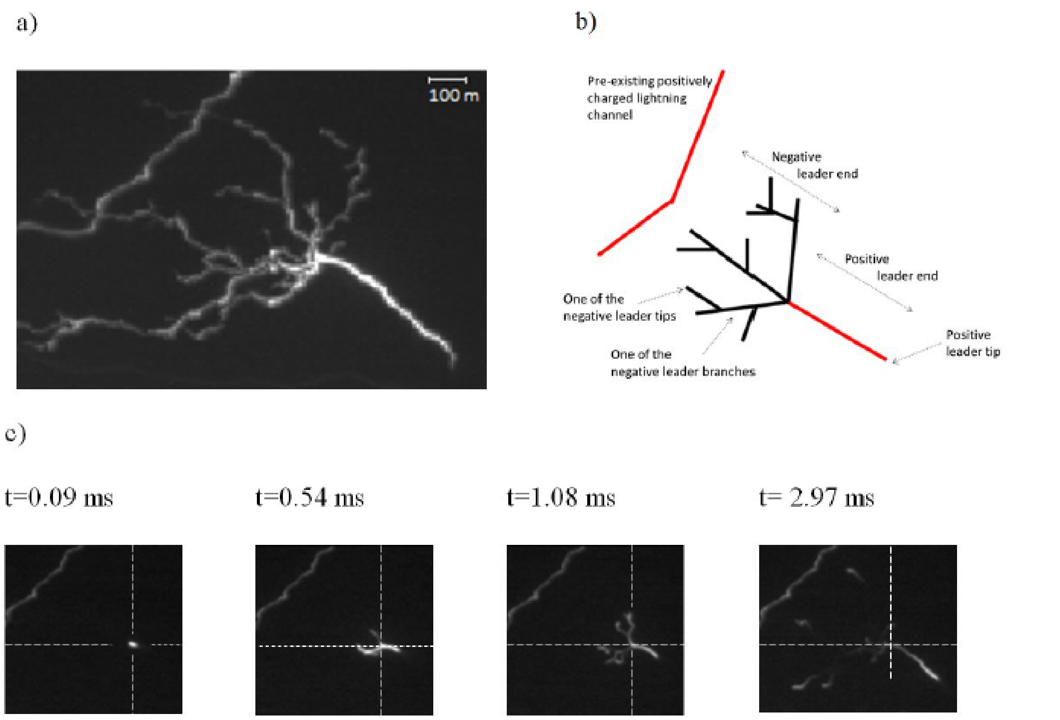
In the paper of “X-rays and microwave RF power from high voltage laboratory sparks” by Montanyà J., F. Fabró, V. March, O. van der Velde, G. Sola, D. Romero and O. Argemí (2015), we showed the simultaneous occurrence of x-rays and RF microwave emissions by high voltage laboratory sparks. The following figure is X-rays and RF power at ~2.4 GHz for two negative voltage impulses. Left plot corresponds to a voltage impulse of -775 kV whereas the right most plot -786 kV. Vertical dashed line indicates the breakdown time.

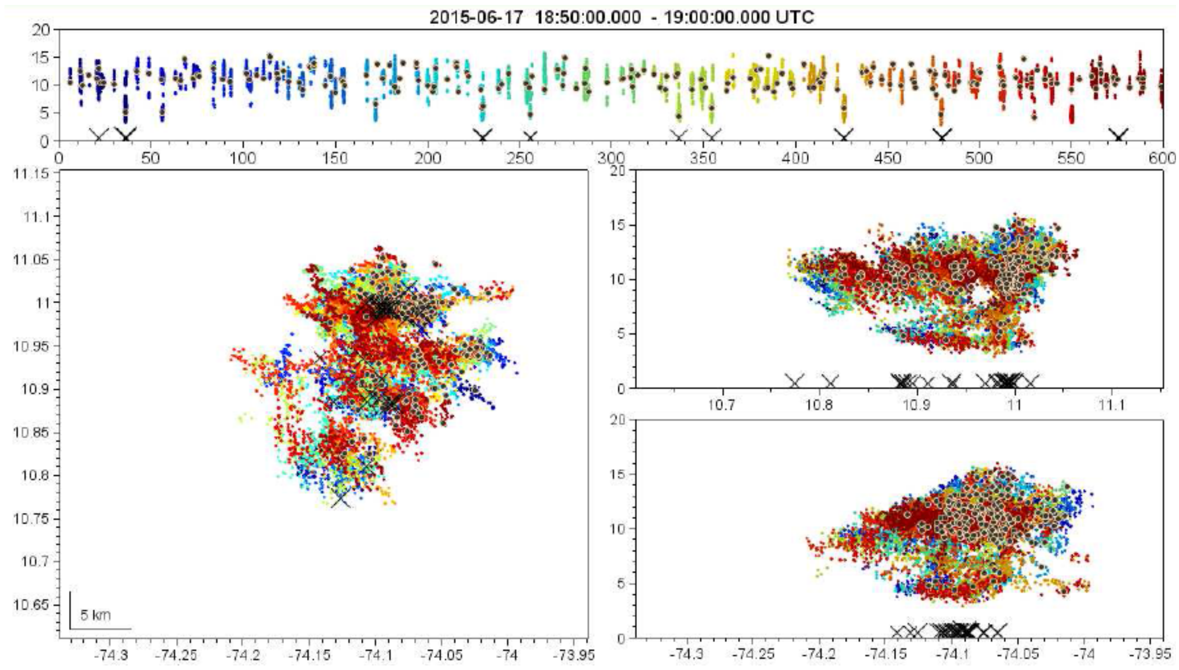




In the publication of “The start of lightning: Evidence of bidirectional lightning initiation” by Montanyà J., O. van der Velde, and E. Williams (2015), we describe the development and asymmetries of a high speed video observation of a bidirectional leader.

Ongoing activities: (1) Observations of TLE from Curaçao. A high-speed video camera system started to operate since May 2014 observing to the southwest direction over Lake Maracaibo and surrounding areas, including Catatumbo (Venezuela). (2) Colombia Lightning Mapping Array (COLMA) is now in operation. The figure below corresponds to 10 minutes of lightning activity. As expected, we see lightning leader development at higher altitudes compared to mid-latitude storms.





University of Florida (Gainesville, FL, USA)

A total of 21 full-fledged lightning flashes were triggered in 2015 at Camp Blanding (CB), Florida. Eighteen flashes contained leader/return stroke sequences (a total of 97) and three were composed of the initial stage only. Thirteen triggered flashes with return strokes, besides being recorded at CB, were also recorded at the Lightning Observatory in Gainesville (LOG) and at the Golf Course station in Starke, at distances of 45 and 3 km, respectively.

The IEEE Electromagnetic Compatibility Society presented 2015 Richard Schulz Transactions Prize Paper Award Honorable Mention to the authors of the paper titled "Positive lightning peak currents reported by the U.S. National Lightning Detection Network", IEEE Trans. on EMC, Vol. 56, No. 2, April 2014, pp. 404-412, DOI 10.1109/TEMC.2013.2280000, A. Nag, V.A. Rakov, and K.L. Cummins.

M.D. Tran and V.A. Rakov authored a paper titled "When does the lightning attachment process actually begin?". High-speed video and electric field records of 43 first and 7 new-ground-termination subsequent strokes in negative lightning flashes, obtained at the Lightning Observatory in Gainesville, Florida, were examined. Eighteen (36%) of these strokes exhibited faintly luminous formations (FLFs) below the downward leader tip just prior to the return stroke. All the 18 FLFs were connected to the strike object on the ground, with 14 of them being also in contact with the downward leader tip. For 11 located events showing FLFs in contact with the downward leader tip, the FLF 2-D length ranged from 51 to 200 m and the time interval between the end of exposure of the FLF frame and the return stroke onset were unexpectedly large, ranging from 42 to 106 µs. The authors inferred that the FLFs mostly consisted of relatively low conductivity streamers (as opposed to being upward connecting leaders), based on the following observations and estimates. (a) The rates at which the 11 FLFs were replaced by channels capable of guiding return stroke waves ranged from 0.7×10^6 m/s to 2.2×10^6 m/s, which is comparable to leader speeds in virgin air (in the same records) and at least an order of magnitude lower than the speeds of downward return stroke waves traversing upward connecting leader channels. (b) The overwhelming majority of downward leaders continued stepping while being connected to ground via FLFs. (c) The average electric field along FLFs is 1 to 2 orders of magnitude higher than expected for hot, leader-like channels. Since in all cases the FLF determined the strike point, the authors concluded that the initiation of these streamer formations might have signified the beginning of the lightning attachment process. It appears that the streamer connection between the grounded object and the downward leader tip can occur well before the formation of upward connecting leader. The paper is published in the Journal of Geophysical Research - Atmospheres.

F. L. Carvalho, M. A. Uman, D. M. Jordan, and T. Ngin authored a paper titled "Lightning current and luminosity at and above channel bottom for return strokes and M-components". They measured current and luminosity at the channel bottom of 12 triggered lightning discharges including 44 return strokes, 23 M-components, and 1 initial continuous current pulse. Combined current and luminosity data for impulse currents span a 10–90% risetime range from 0.15 to 192 µs. Current risetime and luminosity risetime at the channel bottom are roughly linearly correlated. They observed a time delay between current and the resultant luminosity at the channel bottom, both measured at 20% of peak amplitude, that is approximately linearly related to both the luminosity 10–90% risetime and the current 10–90% risetime. At the channel bottom, the peak current is roughly proportional to the square root of the peak luminosity over the full range of current and luminosity risetimes. For two return strokes we provide measurements of stroke luminosity vs. time for 11 increasing heights to 115 m altitude. They assumed that measurements above the channel bottom behaved similarly to those at the bottom and found that (1) one return stroke current peak decayed at 115 m to about 47% of its peak value at channel bottom, while the luminosity peak at 115 m decayed to about 20%, and for the second stroke 38% and 12%, respectively; and (2) measured upward return stroke luminosity speeds of the two strokes of 1.10×10^8 and 9.7×10^7 m/s correspond to current speeds about 30% faster. These results represent the first determination of return stroke current speed and current peak value above ground derived from measured return stroke luminosity data. The paper is published in the Journal of Geophysical Research - Atmospheres.

University of Mississippi, Oxford, MS USA

Our group [T.C. Marshall, M. Stolzenburg, post-doctoral researcher S. Karunarathne, research associate N. Karunarathna, and physics graduate students N. Karunarathne, S. Bandara, and R. Sidlecki] continues to examine data collected around NASA Kennedy Space Center in Florida during the summers of 2010 and 2011. The lightning dataset includes 3-D VHF mapping data (LDAR2), VLF/LF return stroke locations (CGLSS), surface electric field mill (LPLWS) data, WSR-88D (NEXRAD) radar data, high-speed video observations, and data from an array of ten slow and fast E-change antennas. Recent results from our analyses include the following, all reported in JGR-Atmospheres:

Stolzenburg et al. [2015a] presented observations of abandoned stepped leader branches that briefly reconnect to the main stepped leader trunk or another active branch during the negative stepped leader's advance in natural CG lightning strokes. The transient luminous features described were termed *sparks*. High-speed video data, with 20 µs image interval, show these sparks are common, bright, and fast. They typically reach their maximum visible extent of a few hundred meters or less and peak intensity of one to three times that of their parent leader within 40 µs. Most sparks connect to a parent leader within their first 20 µs and are visible for less than 120 µs. Generally, there are several milliseconds (average 3.3 ms) before the spark during which its branch is visibly abandoned, i.e., apparently neither propagating nor connected to the active stepped leader system. Sparks tend to occur late in the stepped leader advance, averaging 900 µs before the return stroke for 90 sparks in 14 strokes. Sparks were observed at altitudes at least as high as the visible stepped leader top (about 3000m in these data), but they have not been observed below 500m altitude. Parent leaders typically get brighter below the connection point after the spark, and in some cases, their speed of advance increases after the spark. Nearby time-correlated electric field change data show a distinct spark signature characterized by a relatively large bipolar pulse, followed by a slower decrease over 40-100 µs, ending with another relatively large pulse.

Karunarathne et al. [2015a] modeled one full negative stepped leader and four partial negative stepped leaders preceding five separate CG lightning return strokes. For each, the model was constrained to match E-change measurements from three or four sites within 30 km of the leader. The time evolution and 2-D locations of stepped leaders were obtained from high-speed video data. A modified version of the Lu et al. (2011) time-dependent multidipole model was used, with a time step equal to one video frame, 20 µs. At each time step, negative charges were deposited at stepped leader tips based on measured light intensity, and an equivalent positive charge was deposited at one of the locations of the initial breakdown pulses that preceded the stepped leaders. This method has the unique advantage of obtaining locations of CG stepped leaders *including* branches *all the way* to the ground. Three main quantities of the stepped leaders obtained from the model were total charge transfer (−1.50 to −7.51 C), average line charge density (−0.113 to −0.413 mC/m, mean = −0.196 mC/m), and average current (−0.084 to −0.456 kA, mean = −0.31 kA). From the video data, the estimated 2-D stepped leader speeds were 2.43–4.95×10^5 m/s, and the cumulative lengths of all the branches in each leader system were 3.5 to 9.2 times the vertical distance traveled by the visible stepped leader.

Karunarathne et al. [2015b] studied waveforms of 226 positive narrow bipolar pulses (NBPs) that were obtained at five to eight E-change measuring stations on one day in east-central Florida. The NBPs had typical average parameters: 10–90% rise time of 2.6 µs, full width at half maximum time of 2.8 µs, zero cross time of 9.9 µs, and range-normalized amplitude at 100 km of 11.0 V/m. Among these, four main types of positive NBP waveforms were identified: Type A had a simple bipolar waveform with a positive peak and a negative overshoot peak (1% of NBPs), Type B had extra peak(s) superimposed on the overshoot peak (67%), Type C had extra peak(s) on or just after the main positive peak (13%), and Type D had extra peak(s) before the main positive peak (19%). Regardless of type, each NBP waveform maintained its basic shape across a range of 10 to 130 km from its origin. NBP locations, obtained with a time of arrival technique, seemed unrestricted in their horizontal distribution across the array (except for Type C), while NBP altitudes ranged from 7 to 19 km with an average of 13 km. Estimated peak currents were 2–126 kA with an average of 30 kA. Isolation of NBPs from other lightning events was determined for both temporal (660 ms) and spatial (>10 km) quantities; 37% of NBPs were isolated, 38% occurred within 660 ms before a flash, 19% occurred within flashes, and 11% occurred within 660 ms after a flash. The total RMS power radiated by NBPs within 1 kHz–2.5 MHz bandwidth had a range of 5.0 × 10^6 –6.1 × 10^8 W with an average of 7.8 × 10^7 W.

Stolzenburg et al. [2015b] utilized high-speed video and E-change data to describe a seven-stroke lightning flash in which the fifth return stroke occurred 0.80ms after the fourth RS connects to a different ground location 3.3 km away. The fifth RS was 0.34ms after an M component started down the different channel. The fifth stroke involved a dart leader traveling concurrently, though slower than the M component, in a prior channel to ground. There was no indication of leader advance along this path earlier during the fourth RS. The fourth stroke involved a stepped leader that started from the end of an observed prior dart leader branch which did not previously propagate to ground. The concurrent M component and dart leader were preceded by an in-cloud event evidenced by a large-amplitude, fast electric field change pulse, at 6.1 km estimated altitude, inferred as the connection to the channel for the M component. The M component apparently initiated the dart leader about 40 µs later. A visible channel length of 10,400m allowed the 2-D propagation speed of the M component luminosity to be estimated in the range of 1.0 to 1.2 × 10^8 m/s. The concurrent dart leader traveled a visible length of 3445m with 2-D speed of 1.7 × 10^7 m/s, similar to other dart leaders in the flash. Estimated optical risetimes of three separate M components in the flash were 80–200 μs at 520m above ground.

Karunarathna et al. [2015] have superimposed the locations of 172 positive NBPs found on one day in Florida on radar reflectivity data. All 172 NBPs were within the reflectivity (Z ≥ -10 dBZ) of a thundercloud or at the edge of the reflectivity. The NBPs were classified into three groups: (I) in or above the high reflectivity core of the storm, (II) in the convective region but not Group I, or (III) in the anvil region. Groups I, II, and III had, respectively, 79%, 17%, and 4% of the NBPs. Of the 136 NBPs in Group I, 43% occurred within the reflectivity core (Z ≥ 30 dBZ), and 57% occurred above the core. Examination of a sequence of 34 positive NBPs during one hour of one storm suggests that the majority of NBPs occurred during the rapid growth of two thunderstorm cells. The study also found that positive NBPs had a tendency to recur in some storm locations; 67 (39%) of the NBPs were part of a recurrent set. The 28 cases of NBPs recurring in approximately the same location (within 600 m horizontally and 1500 m vertically) included 22 doublets, 3 triplets, 2 quadruplets, and 1 sextuplet. Analyses of one quadruplet and one sextuplet showed that these 10 positive NBPs occurred just above and/or right beside the high reflectivity core on the downshear side of the core. The analyses lead us to a hypothesis that NBPs occurring at altitudes between the thunderstorm's main upper positive charge and uppermost negative screening charge are initiated by the large E due to small-scale charge regions in which positive charge is *above* negative charge, or opposite the orientation of the large-scale storm charges.

In separate work on a much older dataset, Stolzenburg et al. [2015c] examined the initial electrification of three New Mexico thunderstorms using balloon-borne and surface E measurements, along with data from the New Mexico Tech LMA, Langmuir Lab radar, and Socorro multiparameter radar. The earliest deflection of E measured at the surface was 5–8.6 min before the first flash and coincident with the development of substantial radar reflectivity (40 dBZ) above -5°C. Rapid growth of surface E (>5 V/m/s) started 2.4–3.1 min before the first flash, when 40 dBZ reflectivities reached above the -15°C level. In two cases with clear surface E records, radar reflectivity indicators (40 dBZ echo through -10°C and echo top through -15°C) would yield longer warning times before the first flash than the E record. The first flash in each storm initiated at altitudes between 7.4 and 8.8 km; hence, the temperatures where the largest (negative) E for normal intracloud lightning initiation had developed during the initial electrification were -10°C to -20°C. Negative and positive charge regions associated with the first flash in each cell were centered at -8°C to -16°C (6.9–8.0 km) and -20°C to -24°C (9.0–9.2 km), respectively. In two cases, balloon data indicate the only substantial charge regions present before the first flash were those involved in the flash. Another case shows an initial period of opposite polarity E deflection at the surface coincident with substantial low-level positive charge within the cloud, although this charge was not involved in the first 8 min (first 17 flashes) of lightning activity. The findings support the notion that the initial electrification resulted from charging via the noninductive ice-ice collisional mechanism.

University of Toulouse (Toulouse, France)

During the Special Observation Period 1 (SOP1) of HyMeX (Hydrological Cycle in Mediterranean Experiment) in south-eastern France, important means of observation have been gathered, especially to detect the flashes and their characteristics during stormy periods. These means included the HyMeX Lightning Mapping Array (HyLMA) for three-dimensional description of all lightning flashes at high-resolution, various recordings of the radiation produced by lightning at low and very low frequency, several systems for the detection of lightning ground impacts, radar and space-based observations to identify the characteristics of the storm clouds. In addition, ground-based optical cameras were used to detect TLEs above the storms monitored during the campaign.

During the night of 22-23 October 2012, optical observations of sprite events were performed above a leading stratiform Mesoscale Convective System (MCS). Twelve sprite events occurred during the last third of the lightning activity period, and well after the coldest satellite-based cloud top temperature (-62°C) and the maximum total lightning flash rate (11 min^{-1}). Thanks to the lightning detection systems, an analysis could be performed at the scale of the overall activity during the storm lifetime and at the scale of several +CG lightning flashes, associated or not with optical observations of sprites.

Each sprite event was associated with a +CG (SP+CG) stroke detected by the operational lightning detection network. The peak current values of these positive strokes ranged from 14 to 247 kA. The delay between the SP+CG stroke and the sprite allowed classifying the events within two categories, short-delayed (< 20 ms) and long-delayed (> 20 ms). Some of the sprite events seen by both video cameras could be triangulated. Some characteristics have been inferred from the comparisons between SP+CG strokes and +CG strokes that did not trigger sprites on one hand, and between long-delayed and short-delayed sprites on the other hand. (i) The CMC associated with the stroke, from 625 to 3086 C km for the SP+CG strokes, was confirmed as a good predictor of the sprite production. (ii) The peak current and the iCMC were on average much larger for the SP+CG strokes. (iii) The SP+CG strokes producing long-delayed sprites had a relatively low iCMC. (iv) Long-delayed sprites, most of the time carrot sprites, were associated with current moment waveforms of low amplitude and long duration (~100 ms), VLF sferics and VHF emissions during a few tens of ms after the SP+CG stroke, which shows the lightning process continues after the SP+CG stroke and can play a role in the sprite triggering. (v) The +CG flashes that did not trigger sprites were initiated outside the main convective core, had much lower CMC values, and in average, shorter durations and shorter distances of propagation.

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Reminder

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

- announcements concerning people from atmospheric electricity community, especially awards, new books...,
- announcements about conferences, meetings, symposia, workshops in our field of interest,
- brief synthetic reports about the research activities conducted by the various organizations working in atmospheric electricity throughout the world, and presented by the groups where this research is performed, and
- a list of recent publications. In this last item will be listed the references of the papers published in our field of interest during the past six months by the research groups, or to be published very soon, that wish to release this information, but we do not include the contributions in the proceedings of the Conferences.

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

Newsletter on Atmospheric Electricity is now routinely provided on the web site of ICAE (http://www.icae.jp), and on the web site maintained by Monte Bateman http://ae.nsstc.uah.edu/.

In order to make our news letter more attractive and informative, it will be appreciated if you could include up to two photos or figures in your contribution!

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 Daohong Wang (wang@gifu-u.ac.jp) preferably by e-mail as an attached word document. The deadline for **2016 spring** issue of the newsletter is **May 15, 2016**.

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