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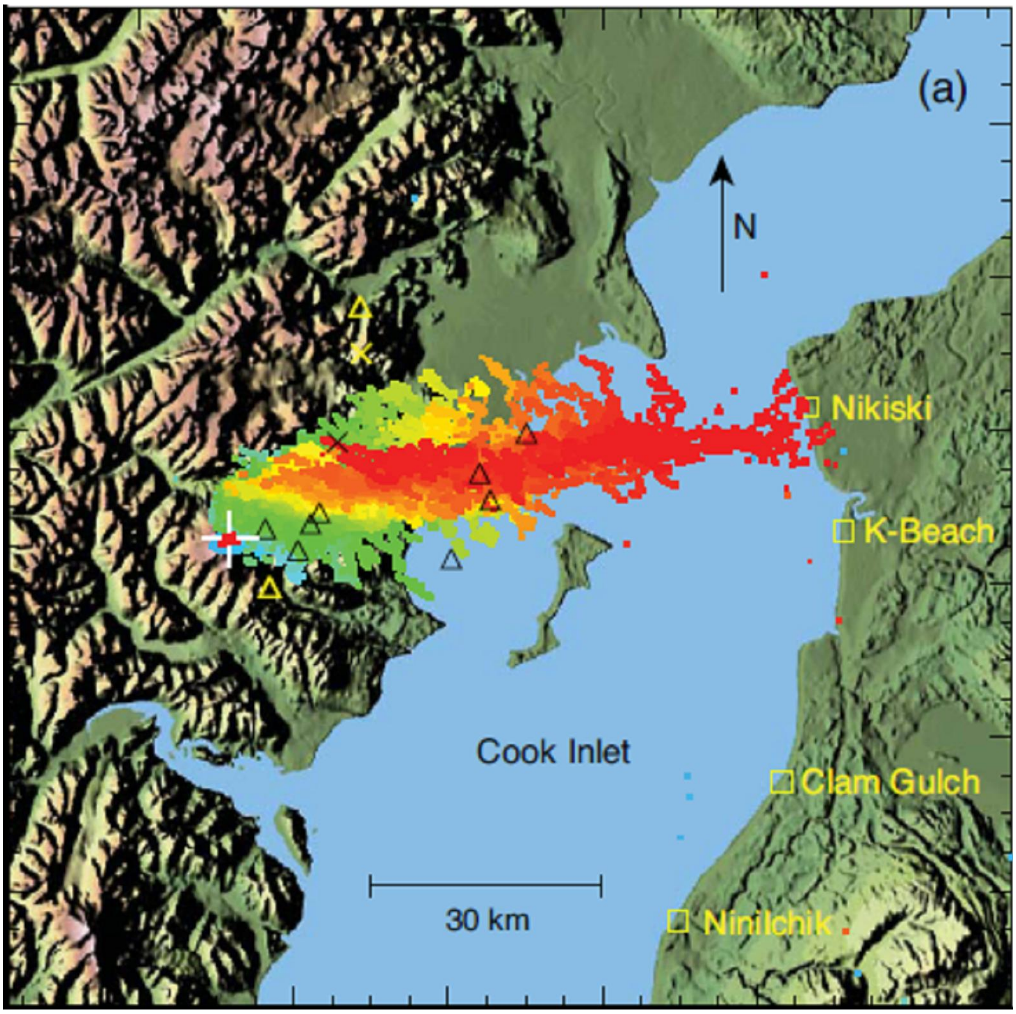


<u>Comment on the photo above</u>: *Intense lightning activity during the explosive eruption of the Mt. Redoubt volcano in Alaska at 23:20 UTC on 28 March 2009. The lightning began over Redoubt (marked with white cross-hairs) and continued for 40 min as the plume drifted 70 km eastward towards the Kenai Peninsula coast. The lightning sources were located by four portable Lightning Mapping Array (LMA) stations deployed across Cook Inlet from the volcano (yellow squares). Ten negative and two positive cloud-to-ground discharges (triangles and +) were detected by the U.S. Bureau of Land Management Lightning Detection System during the eruption.*

DEDICATION

Charles B. Moore, October 20, 1920 – March 2, 2010

Paul Krehbiel, New Mexico Tech, USA (krehbiel@ibis.nmt.edu)

Charles B. Moore (more familiarly known as 'Charlie', or C.B.) had a remarkable career studying a broad range of atmospheric electric and related meteorological phenomena. He was an experimentalist and observationalist extraordinaire, able to look at problems both from a practical and theoretical standpoint and to document the results in numerous publications.

Charlie was born in 1920 and, like many of his generation, his career was profoundly altered and influenced by the Second World War. Following Pearl Harbor he interrupted his undergraduate studies in Chemical Engineering at Georgia Tech to enlist in the Army Air Corps. He was enrolled in the Army Air Corps meteorological training school that led him to become Chief Weather Equipment Officer in the 10th Weather Squadron, setting up and operating remote meteorological stations behind enemy lines in the China-Burma-India theater. He served with distinction under rigorous conditions alongside Athelstan Spilhaus, Sr., who had been one of Charlie's instructors in the meteorology school.

Following the war, Charlie completed his undergraduate studies at Georgia Tech and in 1947 was recruited by Spilhaus to New York University to work on the Constant Altitude Balloon Project. Together, they pioneered the use of polyethylene balloons for atmospheric studies [Spilhaus, Schneider, and Moore, 1948]. The balloons were initially used during the top secret Project `Mogul' to monitor for the widely anticipated Soviet nuclear tests. An early test flight in New Mexico with neoprene balloons was not recovered and became the cause of the infamous `Roswell incident' of extraterrestrial notoriety. During his retirement Charlie documented the post-war activities that led to the development of polyethylene balloons in a detailed scientific contribution to a book on the Roswell incident [Moore, 1997].

Being a student of history and possessing an excellent memory, Charlie was an excellent source of knowledge about the people and history of things past, but almost never talked about his own, usually substantial role in things. One had to read between the lines, fill in the blanks, and seek other sources of information to ascertain his real and usually substantial role in things. By doing this, one finds out that Charlie was the first person to launch a modern polyethylene balloon, was the first person to pilot the new balloons, and played a major role in the first high-altitude photographic reconnaissance flight using the balloons. The latter flight produced spectacularly detailed pictures from 90,000 feet and led to the subsequent development of the U-2 surveillance aircraft. For these and his later accomplishments in the field of scientific ballooning, Charlie was awarded the Otto C. Winzen Lifetime Achievement award in 1997.

In 1953, Charlie joined the Arthur D. Little Corporation to work with Bernard Vonnegut. There he developed techniques for vaporizing sodium, cesium, and calcium from rockets for high-altitude studies of winds and sodium in the upper atmosphere. In 1959, Charlie and U.S. Naval Officer Malcolm Ross piloted the Strato-Lab IV polyethylene balloon to 81,000 feet altitude and used a 16-inch telescope and spectrograph to obtain the first evidence of water vapor on Venus. This pioneering experiment, conducted with John Strong of Johns Hopkins University, initiated a long string of studies on water in the Venusian atmosphere. (The 50th anniversary of the flight was recently commemorated on NPR's StarDate program of Nov. 29, 2009 - see http://stardate.org/radio/program.php?f=detail&id=2009-11-29.)

Charlie's work in atmospheric electricity commenced in 1953 with a three-year joint study with Bernie Vonnegut of dispersing fog by using electrical charge releases to upset the colloidal stability of the fog. The results of their few experiments on natural fogs were inconclusive, but the studies demonstrated that the atmospheric electric field could be substantially altered and enhanced over large areas downwind of the charge releases [Vonnegut and Moore, 1958; Vonnegut, Moore, et al., 1961].

In 1956, 1957, and 1958, to test the ideas of Vonnegut's convective hypothesis for the electrification of storms, Moore and Vonnegut conducted an amazingly comprehensive set of thunderstorm electrification studies atop Mt. Withington, New Mexico [Moore et al., 1959a and 1959b; Vonnegut et al., 1959a, 1959b]. The Withington studies were the first to identify a number of important electrical features of storms, such as electric field excursions associated with precipitation and the end of storm polarity oscillation. In a separate study of the Worcester, Massachusetts tornadic storm they determined that large severe storms might have an inverted polarity electrical structure [Vonnegut and Moore, 1959]. This was an amazingly prescient finding that was rediscovered some 40 years later during the STEPS 2000 project, which is continuing to raise major and definitive questions about storm electrification processes.

The Withington results challenged precipitation-based electrification ideas by indicating that electrical effects could be detected inside the cloud before the onset of detectable precipitation. The studies also showed that precipitation falling out of the cloud carried the opposite sign of charge than the precipitation mechanisms would predict. The results substantially enlivened the already lively debate on the relative merits of the various different electrification mechanisms. Charlie went on to become a leading critic of the then-currently popular precipitation mechanisms involving collisional charging of hail [e.g., Moore, 1965, 1975, 1977]. In further pursuit of the convective electrification ideas, between 1959 and 1964 Moore and Vonnegut made observations of lightning in warm (non ice-containing) clouds around the Bahama Islands [Moore et al., 1960], obtained intriguing results on the effect of releasing space charge into small cumulus clouds in Illinois [Moore et al., 1962], and made U2 flights above convective turrets in Florida storms [Vonnegut, Moore, et al., 1966]. Each of the studies lent additional credence to the convective electrification ideas.

Charlie came to New Mexico Tech as a faculty member in the Physics Department in 1965. I came to Tech in 1966 to work with Marx Brook, an advocate of precipitation-based electrification ideas. I got jump-started into the field of atmospheric physics and atmospheric electricity in a graduate course on the subject with Charlie. Charlie was a natural-born teacher and a font of knowledge on a wide range of topics in physics and chemistry for both colleagues and students alike.

It was at Charlie's recommendation to Brook in 1958 that Tech's Langmuir Laboratory for Atmospheric Research was conceived and built. Charlie had recommended that it be built on Mount Withington in the San Mateo Mountains further west of Socorro, but Tech president E.J. Workman instead built it on the southern end of the South Baldy ridge in the Magdalena Mountains, within line of sight of the Tech campus. Charlie arrived at Tech shortly after the Laboratory opened. He became the Laboratory's Director in 1969 and went on to establish it as a premier facility for studying airmass storms and lightning.

He designed and constructed a number of physical facilities for the Laboratory and a variety of instrumentation facilities for the Laboratory's scientific studies, including a 3 cm radar, networks of electric field mills, acoustic microphones, and rain gauges, and time-lapse camera stations. He also acquired two Special Purpose Test Vehicles for Atmospheric Research (SPTVAR) powered gliders from the Office of Naval Research, converted them from drones to manned aircraft, and working with colleagues William Winn and Dan Jones, outfitted them with innovative configurations of electric field mills and related instrumentation for in-situ storm measurements. To enable the SPTVAR and other research aircraft (as well as instrumented rockets) to probe storms unimpeded, Moore and Winn worked with the FAA to establish Restricted Air Space R5113, at the time the only restricted air space designated for non-military use. In 1980, working with the New Mexico congressional delegation, Charlie was instrumental in getting Public Law 96-550 passed by the U.S. Congress, establishing 31,000 acres around the laboratory as a preserve for scientific research, called the Langmuir Research Site. Among other things, this paved the way for Langmuir becoming a site for Long Term Ecological Research (LTER) studies and, more recently, the site of the Magdalena Ridge Observatory (MRO).

Charlie and Bernie were in deep conversation on the roof of the Langmuir Lab Annex building. This photo was taken by Dick Dick Orville during the TRIP '81 studies in 1981.

During his 16-year tenure as Director, Charlie and a number of colleagues and students conducted a steady string of investigations at Langmuir Laboratory. These included studies with Bill Winn of rocket soundings of electric fields inside storms [Winn and Moore, 1971; Winn, Schwede, and Moore 1974], which showed that the electric field strengths in storms were less than the values normally considered necessary to initiate lightning; studies of point discharge and ozone production beneath thunderstorms [Shlanta and Moore, 1972], which also laid the groundwork for Charlie's later lightning rod studies; electric field, conductivity, space charge, and particle charge measurements in the bases of storms from captive balloons [Rust and Moore, 1974; Binford, Moore, and Winn, 1975]; radar studies of precipitation development in storms [Holmes, Moore, et al., 1977; Szymanski et al., 1980]; aircraft measurements of electric fields and particle charges inside storms [Gaskell et al., 1977, 1978; Christian et al., 1980]; free balloon soundings of electric field profiles through storms [Winn, Moore, et al., 1978; Winn et al., 1980; Winn, Moore, and Holmes, 1981]; studies of lower positive charge regions in storms [Holden et al., 1980]; and continued charge release experiments that resulted in anomalous electrification in the lower parts of storms [Moore et al., 1986; Moore, Vonnegut, and Holden, 1989].

The above studies, and the numerous follow-up investigations spawned by the studies, have provided much of our current understanding of the electrical nature and properties of thunderstorms. Many of the experiments and techniques developed by Charlie and colleagues he recruited to become involved in the studies have become primary observational tools for the continuing studies of thunderstorm electrification. Of particular importance was the use of instrumented aircraft and free balloons for studying the electrical charge structure of storms [e.g., Gaskell et al., 1977; Winn, Moore, et al., 1978; Christian et al., 1983]. The free balloon sounding technique that Bill Winn and Charlie developed has played a continued and increasingly important role in understanding the electrical properties of the large and often severe Great Plains storms.

Charlie has not limited his research work to the questions of thunderstorm electrification but has actively pursued a number of related studies as well. Of particular note has been his work with rocket-triggered lightning, lightning rods, and volcanic lightning. His studies of volcanic lightning during the Surtsey eruption in 1963 [Anderson et al., 1965] and of the Heimaey volcano in 1973 [Brook, Moore, and Sigurgeirsson, 1974] have been the only ones of their kind, and showed that the lightning occurred as a result of the volcanic cloud becoming positively charged when molten lava contacted saline sea water. (As an aside, the Surtsey papers reflect Charlie's unselfish habit, picked up from Vonnegut, of often putting himself relatively far down the list of authors on papers, despite often having played the lead role in conducting the studies and of writing them up for publication. The volcano and triggered lightning papers are a few examples of this.)

Moore's early experiences at Mt. Withington and his studies of corona discharges from wires led to the understanding that fine wires or points tend to protect themselves from being hit by a lightning discharge. But a simple experiment conducted with the large Van de Graaff generator at the Boston Museum of Science demonstrated that fast-moving wires would actually trigger a discharge if the speed of the wire tip were faster than that of the ions it was releasing [Brook et al., 1961]. This result provided the major impetus to the idea that lightning could be triggered by small, wire-trailing rockets and led to the development of triggering techniques both in the U.S. and in France. Charlie and graduate student Ronald Standler first succeeded in triggering lightning at Langmuir in 1974; Charlie went on to conduct a long series of classified and unclassified experiments with the U.S. Air Force on the effects of lightning transients on sensitive electronic equipment and other objects, and using strong lightning transients to simulate the electromagnetic pulse of a nuclear explosion [e.g., Baum et al., 1983, 1987].

In 1970, Moore and Brook helped investigate the Apollo 12 lightning incident at Kennedy Space Center, Florida. They showed that the lightning had been triggered by the rocket, due to the rocket having a long electrical length and having been launched into a marginally electrified storm [Brook, Holmes, and Moore, 1970]. A significant aspect of the study was that it included the first application of analytic ellipsoidal formulations to the problem of electric field intensification at the tips of elongated objects, something that Moore introduced to the study and used to considerable advantage in his subsequent lightning rod studies. The recommendations of the study led to the installation at Kennedy Space Center (KSC) of a network of electric field mills and indirectly to the development of the automated Lightning Detection and Ranging (LDAR) system, both of which have been important atmospheric electric indicators for range safety operations at KSC and Cape Canaveral. Charlie also advised NASA that an umbrella-like catenary cable system be used to protect rockets from lightning while sitting on the launch pad; the recommendations were not followed until after two Skylab rockets were damaged by lightning strikes while awaiting launch. Since implementation of catenary protection no lightning damage occurred, despite numbers of strikes to the launch complexes.

As a result of his earlier studies and his work at KSC, in the early 1970s Charlie initiated a long and still-continuing series of investigations into the use of different types of lightning rods and schemes for lightning protection. This resulted in detailed studies of the response of sharp and blunt lightning rods to downward-developing lightning leaders as they approach ground [Moore, 1975, 1998; Moore et al., 2000a, 2000b], to experimental evaluations of the actual performance of different types of lightning protection techniques and devices [e.g., Moore et al, 2003], and to a series of publications on the theory and practice of lightning protection [Moore et al., 1981; Moore, 1983, Moore et al., 1998, 2002a].

Charlie retired from his formal teaching and faculty position in 1985, but continued to remain active and highly productive in his research work. Most of his lightning rod studies have been conducted during his ‘retirement’. From his observations that sharp objects tend to protect themselves from being struck, Charlie pioneered the idea that blunt rods make better lightning protectors than the sharp ones visualized by Benjamin Franklin and long considered a necessary and important feature of lightning rods. Charlie’s ideas in this regard have been supported by long-term field tests involving the two types of rods as well as other protection devices [e.g., Moore, Aulich, and Rison 2003]. The field tests have been sufficiently convincing that the mainstream lightning protection industry has rapidly moved toward adopting blunt rather than sharp lightning rods.

An important sidelight of the lightning rod studies has been that Charlie and colleagues William Rison and Graydon Aulich became involved in testing more esoteric types of lightning protection systems, in particular the so-called `early streamer emission' devices and various types of lightning `preventors'. Their tests have shown such devices to be essentially worthless. Despite this, some manufacturers of the devices threatened the U.S. National Fire Protection Association (NFPA) with major legal action because the Association would not grant a standard for the devices (the patents for which describe them as being `ornamental'). Under the substantial litigation threat the NFPA was intimidated into proposing that its NFPA 780 standard be dropped, a move that would have been a disaster for lightning protection in the U.S. In his usual, largely unsung manner, Charlie initiated a persistent effort to retain NFPA 780. The situation hung in the balance for several years but in 2000 was ultimately successful, thanks almost entirely to Charlie's persistence on the matter. Part of Charlie's contribution to saving NFPA 780 was a lengthy compendium of historical documents and quotes testifying to the beneficial effects that lightning rods have had over the 250 years since Franklin invented them.

At the beginning of his retirement, Charlie undertook a five-year study of helicopter charging. Such charging causes potentially lethal sparks between a cable lowered from jet-powered helicopters and a grounded object (such as a person undergoing rescue) -- a major concern for military operations. He and Marx Brook conducted an extended series of field tests to determine the mechanism of the charging (a positive-feedback induced charging effect from the jet exhaust) and devised a way of controlling the charging that was subsequently patented by the Navy. Like all his writings, the series of reports that he wrote on the helicopter charging studies were models of clarity and practical scientific exposition.

As a crowning glory to his career, in a special experiment made possible by his lightning rod studies, Charlie and his colleagues succeeded in detecting X-rays from lightning [Moore et al., 2001]. A number of investigators had attempted to do this ever since C.T.R. Wilson first suggested the idea 75 years ago, but it was Charlie's persistence in the pursuit of science that finally led to the observations.

Charlie's post-war ballooning expertise and studies wound up taking priority over him obtaining advanced academic degrees. In partial rectification of this, in 2003 Charlie was awarded an honorary Ph.D. degree in Physics from New Mexico Tech. The award went well beyond an honorary degree -- it was a belated and well-deserved recognition of his numerous and wide-ranging achievements. Among his earlier recognitions, Charlie became a Fellow of the American Association for the Advancement of Science in 1969, the American Meteorological Society (1976), and the Royal Meteorological Society (1978). In 1984 he was one of the first recipients of Tech's Distinguished Research Award. In 1993, he and longtime colleagues Bernie Vonnegut and Marx Brook were presented with special Lifetime Achievement Awards by the Atmospheric Electricity Community. Especially well-deserved and appreciated was his selection as a Fellow of the American Geophysical Union in 2005. In one of those particularly fitting, ironic, and poignant occasions, at the induction ceremony Charlie was congratulated by A. Fred Spilhaus, Jr., Executive Director of the AGU and the son of the person under whom he began his long career.

ANNOUNCEMENTS

New Book

A new book titled ***"Charge Evolution and Lightning in Storm Systems"*** by Tsutomu Takahashi has been published by University of Tokyo Press in Japanese.

Conferences

2010 American Electromagnetics, Ottawa, Canada, July 5-9

A special session on Lightning Electromagnetic Effects is organized by Prof. Vlad Rakov and Prof. Farhad Rachidi at the 2010 AMEREM (American Electromagnetics) International Conference which will be held in Ottawa, Canada, July 5-9.

30th International Conference on Lightning Protection (ICLP)

On behalf of the organizing committee we invite you to attend the 30th International Conference on Lightning Protection, ICLP 2010, to be held in Cagliari, in the beautiful island of Sardinia in Italy.

The ICLP 2010 conference continues the tradition of the preceding ICLP conferences, the last ones being held in Uppsala, Kanazawa, and Avignon. The ICLP offers a unique platform for the exchange of scientific and technical information on lightning physics and protection.

Topics of interest include: lightning discharge, lightning occurrence characteristics, lightning electromagnetic impulse (LEMP) and lightning-induced effects, lightning attachment, lightning protection (buildings, power systems, electronic systems, wind turbines), lightning deleterious effects, lightning testing and standards.

For more information, visit the conference web site: http://www.diee.unica.it/iclp2010/index.htm

ANNOUNCEMENTS

2010 AGU Fall Meeting

The fall meeting of AGU will be held on 13-17 December 2010, at the Moscone Center West, 800 Howard Street, San Francisco. For detail, please visit http://www.agu.org/meetings/fm10/.

14th International Conference on Atmospheric Electricity

Every four years from 1954, scientists on atmospheric electricity from all over the world have gathered traditionally somewhere in the northern hemisphere for about one week to present and discuss the most recent achievements on all aspects of atmospheric electricity. As a continuation of this tradition, in the coming year, 2011, on August 08-12, 14th International Conference on Atmospheric Electricity (14th ICAE) will be held first in the southern hemisphere. As many of you have already known, this conference is the largest and the most respectable conference organized by and for our community, so wish most of our colleagues will be able to participate and enjoy this meeting. Following the successful suit of the last two conferences, a special issue for the conference papers is under planning. For detailed information, please visit the conference website **http://www.icae2011.net.br/**. The abstract submission will start soon on June 1st, and end on October 31th, 2010.

Atmospheric Electricity Group (ELAT), Brazil

An innovative methodology for CG lightning forecast with advance of about one hour for regions with less than 1.000 km2 was developed using real-time CG lightning data provided by the Brazilian lightning detection network (BrasilDAT) together with IR satellite and weather radar images. A project carried on at Paraíba Valley (located throughout São Paulo and Rio de Janeiro States) using the methodology from Jan/2006 to Mar/2009 presented very good results. It was also performed a preliminary analysis comparing automatic warnings generated only by electric field-mill (EFM) triggers and warnings based only on occurrence of CG lightning strokes. The results show that, as expected, the EFM alone produced a high percentage of false warnings compared to the warnings based on CG lightning information only.

High-speed video recordings of two lightning flashes confirm that positive cloud-to-ground (CG) strokes can be produced by extensive horizontal intracloud (IC) discharges within and near the cloud base. These recordings constitute the first observations of CG leaders emanating from IC discharges of either polarity. In one case, the discharge began with a negative leader that propagated horizontally, went upward and produced an IC discharge. After the beginning of the IC discharge, a positive leader emanated from the lowest portion of the IC discharge, and initiated a positive return stroke. In the other case, the IC discharge began with a positive leader and then initiated a downward-propagating positive leader that contained recoil processes and produced a bright return stroke followed by a long continuing luminosity. These observations help to understand the complex genesis of positive CG flashes, why IC lightning commonly precedes them and why extensive horizontal channels are often involved.

The results of the observations of lightning characteristics in two distinct regions (Arizona, U. S. and São Paulo, Brazil) using the same high-speed camera instrumentation, supported by lightning location system data, was published. The use of these techniques allowed us to precisely measure the number of strokes in a flash, their polarity, the interstroke time interval, the number of ground contacts, and the durations of continuing currents in negative CG flashes. Statistical analyses did not show any significant differences in the lightning characteristics during the summer season in both locations. However, it was found large storm-to-storm variations in the multiplicity.

The first measurements of the intensity of the continuing current in Brazil were done. The study presents 81 CC intensity measurements obtained from electric field capacitive antenna. All variations observed in the electric field were simultaneously observed by high-speed cameras. Through GPS time stamping of each image recorded by the high-speed camera, it was possible to determine the distance of the stroke preceding the CC event to the antenna, comparing with the time provided by the Brazilian lightning location system. The arithmetic mean value of the CC intensities was 321 A. Maximum and minimum values are respectively 1400 A and 22 A.

Some important results were achieved by comparing flash rates in Brazil gathered by two different detection techniques: BrasilDAT LF network and LIS. Some differences in the lightning activity throughout the country revealed by the two different techniques, however, cannot be attributed only to dataset limitations and are probably related to regional behaviors associated with different types of meteorological conditions.

A book titled "Lightning in the tropics: from a source of fire to a monitoring system of climatic changes" was published by the Nova Science Publishers, making a comprehensive review of the lightning research in the tropical region.

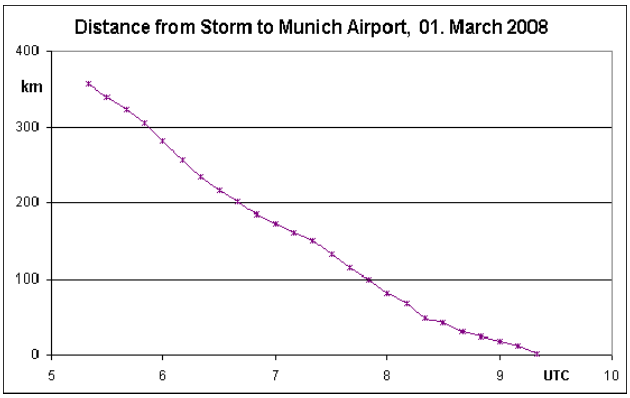
Ten papers were presented by the ELAT group in the ILDC/ILMC conferences in April in Florida.

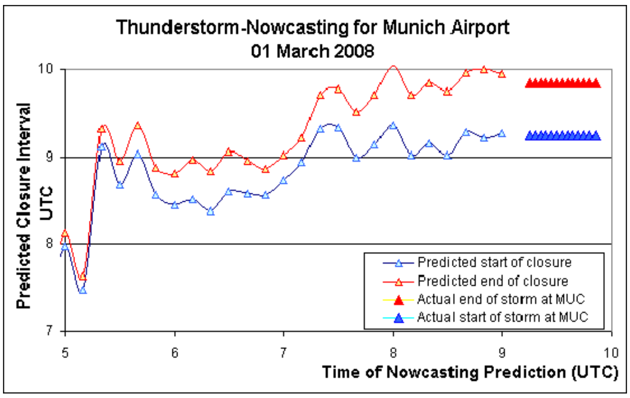
Atmospheric Electricity Group – Physics Department University of Munich, Germany

Hans D. Betz: hans-dieter.betz @ physik.uni-muenchen.de

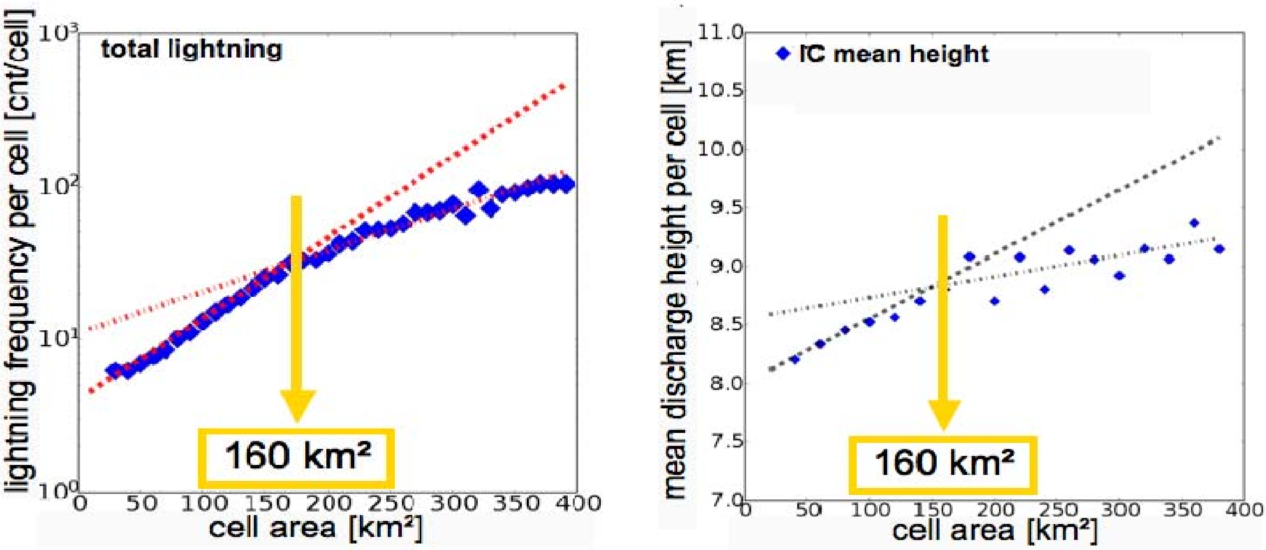
Since the operation of the European lightning detection network LINET the Munich research group investigates cell-tracking and improvements of nowcasting, based solely on real-time observation of lightning cells. In cooperation with DLR the research radar POLDIRAD was utilized in the attempt to control and interpret lightning data. During one of the current projects (RegioExAKT) aimed at investigation of more precise nowcasting for the Munich airport, it was found that many thunderstorms move in a predictable manner. The following Figures show the distance of a storm front from the airport, and the estimate of the time interval during which the airport would have to be closed because of lightning-related dangers. It becomes apparent that practical results could be achieved, which allow minimization of the closure without increased risk.

In course of this research project characteristics of lightning cells have been studied. A most striking observation concerns the 3D-size of lightning cells and their correlation with cell cycles. The following two Figures illustrate that both the total lightning rate and the emission height of IC strokes reveal two regimes of cell sizes, separated by a '*magic*' area of 160 km². A first interpretation refers to the occurrence of single- and multi-cells phases. We note that the rate is usually governed by the IC fraction, and the two parameters rate and height are independent of each other. Thus, the result implies relevance of the new 3D-technique for determining the emission height of IC strokes. All together, promising methods for advanced nowcasting with the inclusion of statistical estimates of the lifetime of cells are found and will be developed further.





Nowcasting of the storm EMMA in Europe, based on lightning data from the European network LINET.



Statistical analysis of some 5000 LINET lightning cells in Central Europe: a single cell can grow up to 160 km² and shrinks thereafter; larger lightning areas contain more than one cell in different life cycles; from Meyer, V., "Thunderstorm Tracking and Monitoring on the Basis of 3D-Lightning (LINET) and Conventional and Polarimetric Radar Data", PhD Thesis, Physics Department, University of Munich, and DLR (Deutsche Luft- und Raumfahrt, Wessling, Germany), 2010.

Central Research Institute of Electric Power Industry (CRIEPI), Yamaguchi University and Hawaii Group

Hokuriku winter snow cloud project: Soichiro Sugimoto (CRIEPI), Kenji Suzuki (Yamaguchi University), and Tsutomu Takahashi (Hawaii) launched 20 videosondes (balloon-borne surveyors of precipitation particle charge and morphology) into Hokuriku winter snow clouds from Kashiwazaki, small town in Hokuriku facing to the Japan sea, early this year (January–February 2010). This project aims to increase our understanding of precipitation particle growth processes during heavy snowfall. Analysis is currently underway. This coming December, an additional 30 Videosondes will be launched from the same location. We hope not only to refine our past work on electrification (Takahashi et al., JAS, 1999), but also to identify the key cloud physical processes active during heavy snowfall.

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How may activity before earthquakes affect the ionosphere? This question has been discussed by R.G.Harrison, K.L.Aplin and M.J.Rycroft in a paper published in the Journal of Atmospheric and Solar-Terrestrial Physics, 72, 376-381 (2010), and at a poster presentation at the European Geosciences Union meeting held in Vienna, from 3 to 7 May 2010. Their mechanism proposes that radon released by pre-seismic activity increases the conductivity of the air near the Earth's surface, and hence increases the vertical current density through the atmosphere in the fair weather part of the global circuit. The effect of the increased current density is to lower the ionospheric D-region above the earthquake region. Such changes have been observed via studies of ELF/VLF radio wave propagation both in the Earth-ionosphere waveguide and to the French DEMETER microsatellite at ~ 660 km altitude. Their modelling predicts that the magnitude of these effects is in broad agreement with the observations available at present. It would be desirable to conduct experimental campaigns to test the hypothesis further.

Geoelectromagnetic Monitoring Laboratory of Borok Geophysical Observatory, Schmidt Institute of Physics of the Earth, the Russian Academy of Sciences

Borok Geophysical Observatory [58°04′N, 38°14′E] is the unique middle-latitude geophysical observatory in the European part of Russia, making the continuous measurements of different geophysical and meteorological fields under conditions of "geoelectromagnetic preservation area" with low level of anthropogenic pollutions. The GemM Laboratory takes continuous measurements of air electric field, atmosphere electric current, meteorological fields (temperature, air pressure, humidity, wind, precipitation). It is also equipped with sodar (Doppler acoustic sounder) which continuously measures wind speed at various heights above the ground, and the thermodynamic structure of lower atmosphere layer. Every summer the field observations of air electricity are made.

The current researches of the GemM Laboratory team (Head of Laboratory is **D. Sc. (phys. & math.) S.V. Anisimov**) are focused on the development of the global electric circuit concept. The dynamic and fractal characteristics of air electric pulsations are obtained. The problems of formation of spatial characteristics of air electric structures are considered. The electrode active layers in planetary boundary layer are discovered and mechanisms of their formation are analyzed. The electrode layer in surface atmosphere is investigated.

The analysis of electric state of surface atmosphere is made by nonlinear dynamics methods. The databank of unimodular and polymodal air electric structures with corresponding quantitative fractal characteristics is created. Quantitative estimations of electric state of surface atmosphere by means of fractal and multi-fractal analysis are received. The phenomenological electrodynamics model of undisturbed surface atmosphere is constructed. (**PhD N.M. Shikhova**)

The numerical model of formation of electric active layers and electric stratification of surface atmosphere is designed. The model is based on the results of synchronous sodar and air electric measurements and takes into account their cross-correlation characteristics. The model allows to study the mechanisms of space electric charge transport, to identify space charge density, altitude and transport velocity in surface atmosphere by results of air electric and sodar measurements. (**Dr. S.V. Galichenko**)

The quasistationary one-dimensional model to calculate altitude profiles of air electric parameters of the surface atmosphere, taking into account the aerodynamic factors (temperature, pressure, turbulent mode), is investigated. Computer model calculations using the data of air electric field and meteorological observations during summer season of 2009 are made. The results of model calculations correspond to the surface electric field measurements. (**PhD E.M. Dmitriev**)

The investigation of surface atmosphere electric field dynamics is based on the original data of 10 years continuous observations in Borok Geophysical Observatory with 0.1 sec sample rate. It is shown that the time series of monthly averaged atmospheric electric field values at period 1998–2007 is stationary. It is also shown that the annual variation of air electric intensity has its maximum in February-April and minimum in October-November. The diurnal variation of air electric field in middle latitudes the most reliably follows a unitary variation in winter months. The spectrum of air electric field variations contains valid (with significance level $p < 0.1$) quasi-harmonics with the periods of 12 months, 24 hours, 11-14 hours, 1 hour, 25-40 minutes. The short-period pulsations of air electric field have self-similar degree spectra. (**D. Sc. (phys. & math.) S.V. Anisimov and PhD N.M. Shikhova**).

Sodar (Doppler acoustic sounder)

Possible mechanisms of modification of effective relaxation time for atmosphere electric space charge density and formations of air electric structures are studied. The spectra of short period pulsations of electric field and electric charge density, taking into account neutral gas turbulence and presence of air electric structures, are analyzed. The nonlocality of electric field intensity dependence on space charge density plays the leading part in the condition of spatially non-uniform turbulence. The model problems on spectrum of electric field fluctuations generated by uniform and "structured" turbulence with fluctuations of electric space charge, considered as a passive impurity, are solved. The spectra of short-period ($f \sim 0.001$–11 Hz) air electric field pulsations under fair weather condition and in fog are calculated. It is shown that air electric field pulsations in the surface atmosphere have degree spectra, both in fair weather condition, and in fog, in a frequency band 0.01–0.1 Hz. The spectrum exponent varies from –1,23 to –3,36 depending on experimental conditions, the most probable values of an exponent are in the range from –2,25 to –3,0. (**D. Sc. S.V. Anisimov and PhD N.M. Shikhova**).

HOLLE Meteorology & Photography, Oro Valley Arizona 85737, USA

Lightning casualties in the vicinity of buildings and dwellings: Lightning safety recommendations identify two reliable safe places. One is inside a large substantial building. The other is inside a fully-enclosed metal-topped vehicle. There has not been an extensive study of casualties within and near buildings. Recent cases have been summarized from available newspaper, web, broadcast, and other media reports. Hundreds of events will be described that involve at least one lightning-caused death or injury within or near all types of dwellings and other buildings. Results are divided into casualties within the U.S., and other than the U.S.

Within the U.S., nearly every lightning-caused death inside a substantial building was in dwellings, and involved the elderly, very young, and people with disabilities during house fires at night. Additional deaths occurred inside small unsubstantial structures such as beach pavilions when people seek safety from rain but not lightning. Deaths and injuries often occur in the yard and on the roof of all types of buildings. U.S. injuries occurred inside buildings to people in contact with electrical, plumbing, and corded telephone paths. Houses under construction provide inadequate lightning protection.

Outside the U.S., casualties were primarily in lesser-developed regions of the world. Frequent multiple-fatality cases occurred inside unsubstantial buildings that provided no protection from lightning. These structures were often small straw-roofed dwellings, schools, and other huts where people sought safety from rain but were unsafe from lightning. A person outside any type of building is exposed to the lightning threat.

Comparisons show that there are 18 times as many non-dwelling deaths per lightning casualty event outside the U.S. than within the U.S., and 4.2 times as many injuries. With regard to dwellings, there are seven times as many dwelling deaths per event outside the U.S. than within the U.S., and 1.8 times as many injuries.

Indian Institute of Tropical Meteorology, Pune

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A research work titled "Lightning activity in the Northeast India (NEI) as observed by the Lightning Imaging Sensor". Our lightning research area is bounded between 22oN and 30oN of latitude and 88oE and 98oE of longitude over NEI. The flash rate density in NEI is investigated using observations from the Lightning Imaging Sensor (LIS) on the NASA TRMM satellite (0.5o x 0.5o) data for a 10-year period (1998-2007). Results of the analysis show that maximum flash rate density (70 fl km-2 yr-1) over the western region of the NEI and northeast and eastern region have minimum flash rate density (8.75 fl km-2 yr-1). This is attributed to the topography and the geography of NEI along with the moisture availability over the region. The precipitable water content in the northern Bay of Bengal is high, and the intensity and location of the anticyclone contributes significantly to the incursion of moisture into different parts of NEI. The annual variation of lightning flash count over the NEI exhibits two peaks– one prominent peak in April and the other smaller peak in September. The first peak is associated with intense insolation and extension of moisture to lower tropospheric level caused by prevailing synoptic condition over the region. The second peak is mainly controlled by the moisture content in the air and the orography of the area. The cloud-base height and Convective Available Potential Energy (CAPE) in the premonsoon months i.e. March, April and May is about 3 to 4 times higher than in monsoon months i.e., June-September. Therefore both these conditions, i.e. lower cloud base height and low cloud condensation nuclei (CCN) concentration, may be the main causes for having maximum / minimum activity during pre-monsoon and monsoon season. The differences in the values for rain yield in the premonsoon and monsoon seasons may be due to the differences in the cloud microphysical and electrical properties. The explanation is that in the premonsoon season the land surfaces responds more strongly to the solar radiation and overlying boundary layer air becomes more strongly buoyant in relation to its surroundings. The larger cloud buoyancy leads to stronger continental updrafts. Larger updrafts are associated with the growth of larger particles in the solid phase by riming and with a large accumulation of ice in the mixed-phase region cause a more vigorous separation of positive and negative charge by ice particle collisions and gravitationally driven differential particle motions (Williams et al., 1989). A more vigorous charge separation process causes a greater lightning activity. Because the convection in the monsoon season is closer to the condition of moist neutrality and is significant less efficient in producing lightning (Williams et al., 1992; Williams et al., 2002). Maritime clouds can produce high rain rates because of the warm rain process, but since the moderate updrafts lead to only low electrification of the cloud, and produce only small flash count. The year to year variation in the magnitude of the first peak is mainly controlled by the wind over the region.

International Center for Lightning Research and Testing (ICLRT) at Camp Blanding, Florida, USA

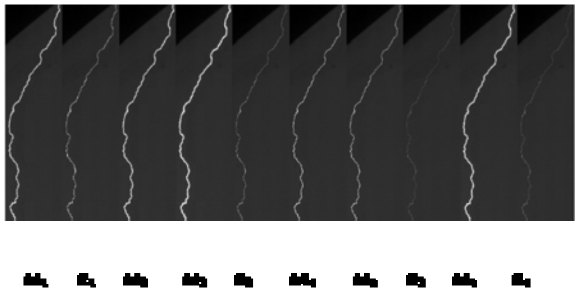
Lightning experiments and observations will continue in Summer 2010 at the International Center for Lightning Research and Testing (ICLRT) at Camp Blanding, Florida (for the 17th year), as well as at the Lightning Observatory in Gainesville (LOG), located at a distance of about 45 km from Camp Blanding and linked to the Camp Blanding facility by a dedicated phone line. A third field measuring station, at a few kilometers from the Camp Blanding facility will be established. Dr. Satoru Yoshida of Osaka University, Japan, will operate a 3D broadband VHF interferometer in the Camp Blanding area.

J. Howard, M.A. Uman, C. Biagi, D. Hill, J. Jerauld, and V.A. Rakov, in collaboration with J. Dwyer, Z. Saleh, and H. Rassoul of Florida Tech authored a paper titled "RF and X-ray source locations during the lightning attachment process". Using an eight-station array of electric field derivative(dE/dt) sensors and collocated NaI X-ray detectors, they have obtained 3-D RF source locations during the leaders and attachment processes of three first strokes initiated by stepped leaders in natural cloud-to-ground lightning and one stroke initiated by a dart-stepped leader in a rocket-and-wire triggered flash. Stepped leader and dart-stepped leader dE/dt pulses were tracked from a few hundred meters to a few tens of meters above ground, after which pulses of different characteristics than the step pulses were observed to occur at lower altitudes. These post leader pulses include: (1) the ''leader burst,'' a group of pulses in the dE/dt waveform occurring just prior to the slow front in the corresponding return-stroke electric field waveform; (2) dE/dt pulses occurring during the slow front; and (3) the fast-transition or dominant dE/dt pulse that is usually associated with the rapid transition to peak in the return-stroke electric field waveform. Additionally, the timing coincidence between X rays and dE/dt pulses on colocated measurements was used to examine the X-ray production by the post leader processes. Leader bursts (LBs) are the largest X-ray producers of the three post leader processes and exhibit propagation speeds that exceed the preceding stepped leader speeds by more than an order of magnitude. Slow-front (SF) and fast-transition pulses appear to originate from similar physical processes, probably the multiple connections of upward and downward leaders. However, more X-rays are coincident with slow-front pulses than with fast-transition pulses. The paper is published in the JGR - Atmospheres.

A. Nag, V.A. Rakov, and D. Tsalikis in collaboration with J.A. Cramer of Vaisala authored a paper titled "On Phenomenology of Compact Intracloud Lightning Discharges". They examined wideband electric fields, electric and magnetic field derivatives, and narrowband VHF (36 MHz) radiation bursts produced by 157 Compact Intracloud Discharges (CIDs). These poorly understood lightning events appear to be the strongest natural producers of HF-VHF radiation. All the events transported negative charge upward (or lowered positive charge), 150 were located by the U.S. National Lightning Detection Network (NLDN) and 149 of them were correctly identified as cloud discharges. NLDN-reported distances from the measurement station were 5 to 132 km. Three types of wideband electric field waveforms, were observed. About 73% of CIDs occurred in isolation, 24% occurred prior to, during, or following cloud-to-ground or "normal" cloud lightning, and 4% occurred in pairs, separated by less than 200 ms ("multiple" CIDs). For a subset of 48 CIDs, the geometric mean of radiation source height was estimated to be 16 km. It appears that some CIDs actually occurred above cloud tops in clear air or in convective surges (plumes) overshooting the tropopause and penetrating deep into the stratosphere. For the same 48 CIDs, the geometric mean electric field peak normalized to 100 km (inclined distance) was as high as 20 V/m and for 22 events within 10-30 km (horizontal distance) it was 15 V/m, both of which are higher than that for first strokes in negative cloud-to-ground lightning. The paper is accepted for publication in the JGR - Atmospheres.

Key Laboratory of Middle Atmosphere and Global Environment Observation (LAGEO), Institute of Atmospheric Physics, Chinese Academy of Sciences (CAS)

The Characteristics of M-Component and Continuing Current from Triggered-lightning: Shandong artificially triggering lightning experiment (SHATLE) has been continuously conducted in Binzhou, Shandong since the summer of 2005. By using the channel base currents and the high-speed camera records in SHATLE2009, characteristics of M-components were deduced. The flash 0902 contained a total of 26 M-components, all of which were superimposed on a slowly-varying current. The statistics were given for the following M-components parameters: duration, peak, half-peak width, rise time (10%~90%), M-component interval, preceding continuing current level, charge transferred and action integral. The statistic results indicated that the peak, half-peak width and charge transferred were obviously different from other researchers' statistic results. The main reason was the lightning included six large magnitude, exceeding 3kA, M-components. Generally, the channel was non-luminous preceding the return-stroke that indicated the cut-off of current, but our optical observation results indicated that a weak detectable luminosity or low current existed in whole channel preceding return stroke (RS). Similar to M-components, RS could also superimpose on a slowly-varying current and the continuing current and luminosity level of preceding RS was lower than that of M-component. The result showed cut-off of channel current was probably not necessary for RS.



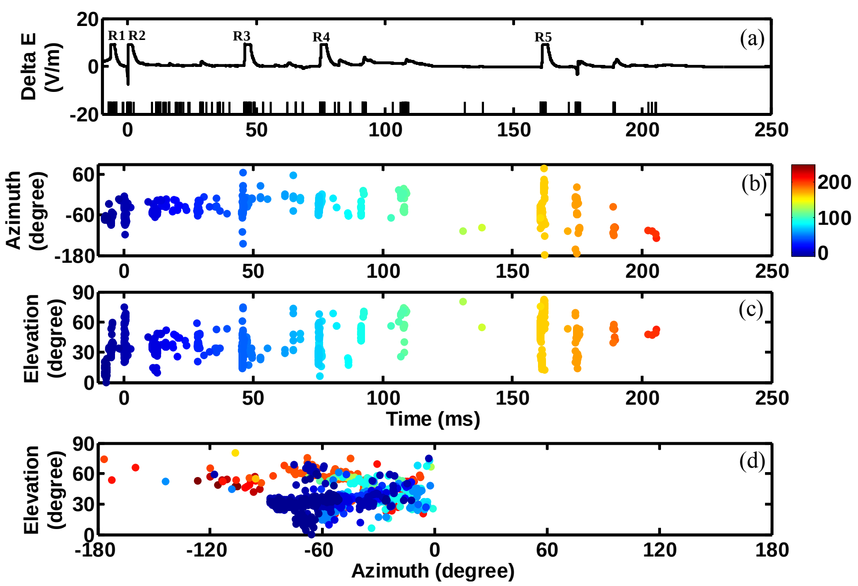
The channel luminosity preceding the return strokes and the six big peak M-components

Observations of VHF Source Radiated by Lightning using Short Baseline Technology: A new type lightning radiation locating system has been developed and tested which uses short baseline technique to investigate lightning discharges. The system uses broadband receiving system to detect direction of individual VHF electromagnetic impulses from lightning discharge processes. The differences of arrival time of pulses are used to measure the azimuth angle and the elevation angle from three of four horizontally spaced antennas. The phase difference method is improved using Fourier filtering method and a soft threshold wavelet denosing method. Radiation source direction and characteristics of electric field change have been analyzed for a multiple-stroke CG flash. Breakdown processes of stepped and dart leaders to ground are discussed, characteristics during and following return strokes are described. Analysis of these results reveals some details about lightning discharges and indicates that the system works well for close lightning discharges.

Evolution of the total lightning activity in a LLTS-MCS over Beijing: Data from Beijing SAFIR 3000 lightning detection system and

Doppler radar provided some insights into the three-dimensional total lightning structure and evolution of a LLTS-MCS over Beijing on 31 July 2007. Most of the lightning in the LLTS-MCS were intra-cloud (IC) lightning, while the ratio of CG/IC (cloud to ground lightning/IC lightning) =1:4, which is higher than the average number from previous studies. The majority of the CG lightning occurred in the convective region of the radar echo, particularly in the rearward of the leading line area. Only a small amount of IC lightning and a few +CG lightning occurred in the stratiform region. During the developing stage, most of the IC lightning happened at the altitude of about 9.5 km, and then the lightning rate reached to its maximum and the altitude of IC lightning reached to 10.5 km in the mature stage. When the thunderstorm came into the dissipating stage, the altitude of the IC lightning decreased gradually. The spatial distribution of lightning displayed a good correlation to the ground rainfall, while the peak value of rainfall appeared later than that of the lightning rate.

TRMM-based study of lightning activity and its relationship with precipitation structure of a squall line in south China: The data from LIS, PR, and TMI onboard TRMM satellite from 1998 to 2005 have been used to investigate the precipitation systems and thunderstorms over China and surrounding area. The results from the case analyses of squall line and Meiyu front heavy rain show that most lightning flashes occur near strong convective region (namely, radar reflectivity between 30dBZ and 50dBZ or PCT at 85GHz < 200K) in both of them, but there are some flashes occurring in the stratiform region in the squall line case, which should relate to the vigorous development of the stratiform region. There are very close correlation (ρ>0.85) between flash rate and precipitation-size ice mass at 7-11km asl at the convective cell level, and it seems that the relationship is very stable for either squall line and Meiyu front heavy rain.



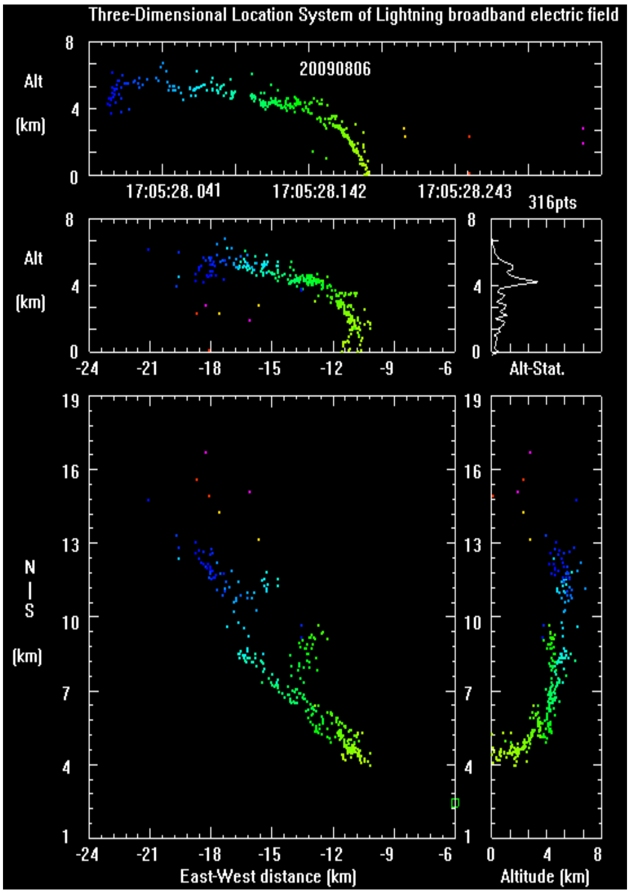
Radiation during a multi-stroke CG flash at 15:45:35 on July 19th, 2009: (a) fast electric field waveform recorded by the fast antenna, (b) azimuth angle of sources versus time, (c) elevation angle of sources versus time, (d) radiation source location.

Laboratory for Climate Environment and Disaster of Western China, Cold and Arid Regions Environmental and Engineering Research Institute, Chinese Academy of Sciences, Lanzhou, China

Plateau Thunderstorm Electricity Research Group

In the summer 2009 from 10th July to 22nd August, our group has performed a comprehensive lightning observation experiment in Datong of Qinghai province, China. Datong lies in the northeastern of the Qinghai-Tibet Plateau and its altitude ranges from 2280 m to 4622 m. The experiment aimed at locating lightning radiation sources in 3D for studying the characteristic of thunderstorm and the process of lightning discharge in Qinghai-Tibet Plateau.

Three locating systems, 3-D lightning VHF radiation source locating system (LLR), broadband electric field lightning mapping system and VHF radio interferometer system, were operated in the experiment. The first two of systems were used based on TOA technique. Each of them is composed of seven affiliated observational stations. Every station receives signals which were recorded in computers through A/D converter and synchronized by wideband electric field antenna triggering. The time of arrival is measured at each station using a high precision clock base on GPS. The digitized rate of the A/D converter used is 20MHz, so the locating system of lightning radiation sources has high temporal and spatial resolutions. The third locating system is the VHF radio interferometer system. Using this instrument the whole progression process in time and space of a lightning flash can be reconstructed with microsecond orders. Fast antenna and slow antenna also were used to provide complementary data. In addition, a Doppler radar which was ten miles away from center station is used to provide weather regime.



A three-dimensional image of a negative CG lightning occurred at 17:05:28 (Beijing Time) on August 6,2009 in Qinghai-Tibet Plateau. A downward stepped leader exhibit branching.

The experiment was the first to use high precision locating system of lightning in Qinghai-Tibet Plateau. Six thunderstorms were observed and one of them occurred with hailstones. The data is under analysis. We hope to get the characteristic of electrical structure and other information about thunderstorm in Qinghai-Tibet Plateau. Meanwhile, we want to study various processes of lightning discharges, especially the initial breakdown and charge transmission process of positive cloud-to-ground discharges. We hope we can compare the result from other areas in China.

The location accuracy of 3-D lightning VHF radiation source locating system (LLR) has also been investigated experimentally by using sounding balloon measurement. One example result is given in the following figure. Leader branches have been clearly located. This year, our group will continue the same experiments.

Laboratory of Lightning Physics and Protection Engineering (LiP&P), Chinese Academy of Meteorological Sciences, Beijing, China

Electromagnetic Radiation Spectrum Characteristics of Different Lightning Discharge Processes: The electromagnetic radiation produced by negative CG return strokes, initial discharge of intra-cloud (IC) flashes and narrow bipolar events (NBE) were analyzed using the Fourier method to obtain amplitude spectra from 0.1 to 40MHz. The results indicate that the spectral amplitude of all the three kinds of lightning discharges decrease in different rates with the frequency increasing, but with differences on radiation intensity and decreasing rate. The spectrum of the NBEs shows higher radiation energy over the entire frequency interval, especially above 10MHz, being 20 dB higher than that of other discharges.

Induced Overvoltage and SPD Residue Voltage Characteristics caused by Triggered Lightning on Transmission Line of AWS: The lightning protection on the power system of electronic equipment was tested, as AWS collectors nationwide have been frequently struck by lightning and failed to operate normally. Using the artificially triggered lightning techniques, the induced effects caused by the lightning and the key lightning protection techniques research were developed near the lightning channel. The induced overvoltage characteristics and SPD residue voltage characteristics caused by triggered lightning with multiple return strokes on the transmission line of an AWS, as well as the relationship with the triggered lightning, were analyzed. The results show that: (a) The return strokes of the near triggered lightning generate bipolar induced overvoltage on the overhead line, with peaks up to more than 10kV. The overvoltage can be divided into the main peak phase and the subsequent overvoltage phase, which last about 100μs and 4ms respectively on average. The period of the subsequent overvoltage is related to the fluctuation of the continuous current behind return stroke of the triggered lightning. (b) Overvoltage of 2kV or above can be induced at the initial continuous current phase. They last a long period of time and concentrate about 12ms, with the mean voltage being 332.5V. Its potential damage to the transmission line cannot be neglected. Residue voltages of SPD play an effect on limiting voltage and releasing current in a degree with stable performance, and there is positive correlation between its peak value and peak current of triggered lighting, the correlation coefficient is 0.86.

Relations between Lightning and Dynamical, Microphysical Processes: A thunderstorm process in Beijing is simulated using a 3D charging-discharging cloud model. The effects of big particles consisting of graupels, ices, hails and raindrops on lightning initiation are investigated. Temporal and spatial analysis on the model results, including the mass concentration and the charging velocity, shows that graupels and ices are the most important two particles which can affect the initiation of lightning in the cloud, the effects of hails are limited, and raindrops don't directly affect the lightning activities occurring in the main charge region.

A hailstorm case is analyzed to discuss the impact of the dynamical and microphysical processes on the electric characteristics and precipitation by using radar, SAFIR total lightning, electric field meter and AWS observation data. The results indicate that it is possible for the electric structure of a thunderstorm to change in its life period. During the hail shooting stage of the hailstorm, the electric structure is inverted. After that, the electric structure is adjusted rapidly and then forms normal inclined tripole. The three stages of the electric structures respectively correspond to the first active stage, the weak stage and the second active stage of the lightning discharges.

Research on Lightning Activity Prediction Method: Related studies have showed that there is the relationship between radar echoes in some specific height and density of lightning activity. Based on the relationship and the explicit cloud micro-physics scheme, the research about prediction of lightning activity has been carried out in GRAPES-meso. Experimentally, echoes produced mainly by ice particles in two specific stratification layers, -15 ℃ and -30 ℃, were chosen to be the predictors. Combining the characteristics of lightning activity in China, some factors in the relationship were adjusted. Simultaneously, because the relationship was a necessary, not sufficient condition for lightning activity, a limited condition about the cloud top temperature was added to determine whether there was lightning activity. Constrained by the aging of the explicit cloud scheme used here, the aging of the scheme is also in 6 hours. It has made greater progress in forecasting lightning activities than in the past.

According to the comparison with the data of lightning location system, the performance of the scheme in South China was satisfactory both in forecast of lightning activity area and in forecast of lightning density in order of magnitude. But because the relationship between radar echo and lightning density was summarized from lighting activities in tropic area, the performance of the scheme in middle and high latitudes was underperforming. It indicated that the application of parametric approaches for lightning forecast was restricted by some environmental conditions.

Lightning Research at National Space Science and Technology Center -NASA Marshall Space Flight Center, University of Alabama in Huntsville (UAH), National Weather Service Weather Forecast Office (WFO) - in Huntsville, Al

NSSTC lightning team members (W. Koshak, R. Blakeslee, D. Mach, M. Bateman, W. Petersen, L. Carey, D. Buechler, W. McCaul, G. Stano, J. Bailey, C. Schultz, P. Gatlin, other students, collaborators and software developers) are supporting the GOES-R Geostationary Lightning Mapper (GLM) through Algorithm Working Group (AWG), GOES-R Risk Reduction (R3) and GOES-R Proving Ground (PG) research activities. We closely collaborate with many other groups in this work. The AWG effort is presently focused on completing a flash cluster algorithm, based on Lightning Imaging Sensor (LIS) heritage, which will be used when GOES-R launches in 2015. GLM proxy data sets are being created for algorithm verification testing and R3 research. The R3 activity encompasses exploratory investigations that include cell tracking, lightning jump algorithms (see research result below), quantitative precipitation estimation, lightning prediction, aviation weather, and flash type discrimination. GOES-R PG activities are taking place during the Storm Prediction Center (SPC) spring program using real time GLM lightning proxy data derived from several Lightning Mapping Arrays (LMAs), as well as lightning predictions (McCaul) derived from Weather Research Forecast (WRF) model outputs. In addition, UAH (H. Christian, M. Stewart) and Ryco (H. Christian) are working as subcontractors to Lockheed Martin on GLM Instrument development.

In August/September, a Lightning Instrument Package (Blakeslee, Bateman, Mach, Bailey) will be flown on NASA's high altitude, long endurance Global Hawk unmanned aircraft in support of the Genesis and Rapid Intensification Processes (GRIP) hurricane field campaign. Then, in October, an LMA will be deployed in Sao Paulo, Brazil in support of the CHUVA field campaign (Dec 2010/Jan 2011) to acquire a unique GOES-R proxy data set in conjunction with Meteosat Second Generation (MSG) observations. Also, this summer, UAH researchers (Christian, P. Bitzer) continue to deploy and test a new electric field change network in North Alabama. Fruitful collaborations (with D. Smith, S. Cummer, G. Lu, others) continue to advance understanding of lightning/ terrestrial gammaray flashe (TGF) relationships. A new collaborations (Koshak with Y. Wang) has begun to investigate the production, distribution, transport, and modeling of regional lightning NOx. The Huntville WFO (C. Darden, D. Nadler, B. Carcione, others) continue to collaborate with the NSSTC/MSFC Short Term Prediction and Research (SpoRT) center to determine the operational benefits of total lightning. The NWS forecasters use information from the North Alabama LMA to supplement other real time diagnostic measurements in the nowcasting and warning decision making process (see recent paper published in the Bulletin of the American Meteorological Society that outlines this activity). Recent analyses (Mach, Blakeslee, Bateman, Bailey) of over 15 years of aircraft electric field and conductivity observations are providing new insights into storm current contributions to the global electric circuit.

As one illustration of current NSSTC research, C. Schultz, W. Petersen, and L. Carey published an article in the Journal of Applied Meteorology and Climatology in December 2009 that highlighted the initial accomplishments toward the development of an operational lightning jump algorithm (87 thunderstorms). As of May 1, 2010, they have expanded their database to 561 thunderstorms (152 severe, 409 non severe) from four regimes (Huntsville, Washington D.C., STEPS, and Oklahoma). An example of a lightning jump is provided in Figure 1.

Finally, it is with great pleasure that we report that the LIS instrument on the Tropical Rainfall Measuring Mission (TRMM) continues to provide global lightning observations from low Earth orbit after more than 12 years in space. This TRMM mission may now potentially continue until 2013 or 2014. A reanalysis of the LIS climatology to 0.25 degree resolutions is now underway (R. Albrecht, Buechler, Petersen).

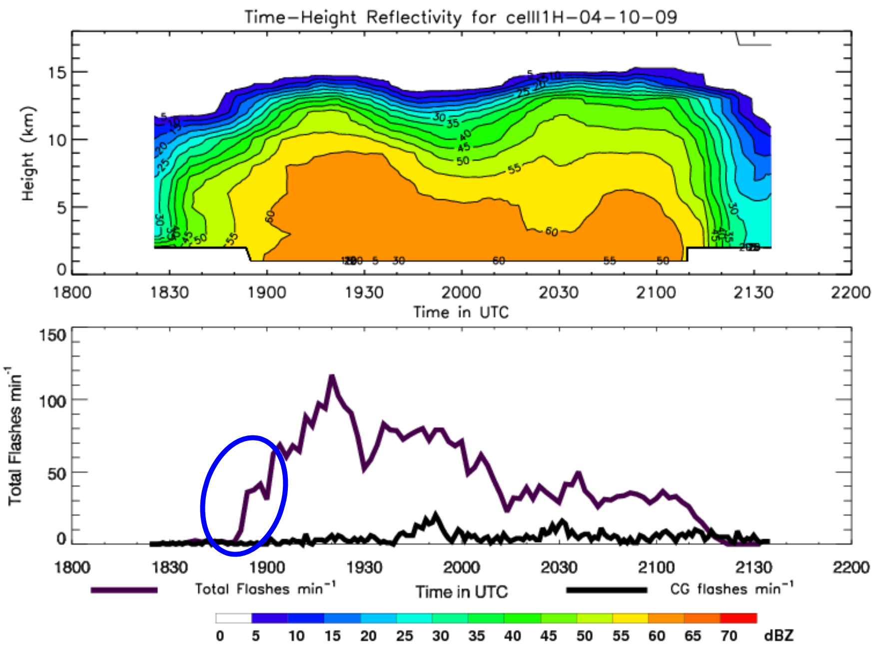
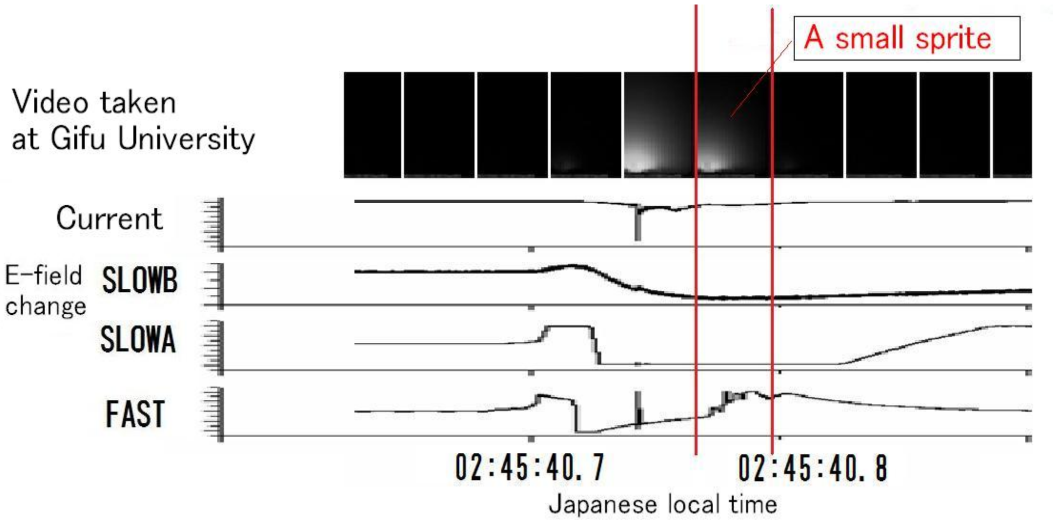


Figure 1. *Time height reflectivity plot (upper panel), total lightning observations (purple, lower panel) and cloud to ground totals (black, lower panel) for a severe thunderstorm that produced significant hail damage across the Huntsville metro area on April 10, 2009. There is a rapid increase in total lightning (blue oval) at 1854 UTC, which precedes the observance of dozens of 1.50+ inch hail across Madison and Huntsville, AL between 1900 and 1925 UTC.*

Lightning Research Group of Gifu University (Gifu, Japan)

We continued our long term observation experiments on the lightning that hit on a windmill and its lightning protection tower during last winter. Totally, we recorded 13 upward lightning discharges that hit either on the windmill or the tower. Of them, at least 8 are self-triggered ones, abnormally high percentage according to our previous experience. We have compared the ground based electric fields around the windmill and tower when the lightning hit, for both self-triggered and other-triggered lightning discharges. The electric fields for both types of lightning discharges are very low, such 2-4 kV/m for most of the cases. We are still trying to figure out why the lightning discharges can be self-triggered at such small electric fields. All these results will be reported in the coming 30th International Conference on Lightning Protection (ICLP). Interestingly during the experiment, we have recorded the electric current of a negative upward lightning that hit on the tower and likely produced a sprite as judged from the time and location information shown in the following figure. The small or weak sprite was viewed from our university about 135 km away from the windmill.

On the other hand, we are preparing a paper on the lightning shown on the cover page of last issue's newsletter.



A small sprite and the electric current and electric field changes of the lightning discharge that likely produced the sprite. All the data are synchronized with time.

Los Alamos National Laboratory, Los Alamos, NM

For the last two years, Los Alamos National Laboratory has sponsored an internal hurricane lightning project with four main goals: (1) To develop and deploy a new dual VLF/VHF lightning mapping array in the Mississippi River Delta south of New Orleans. (2) To develop a new hurricane forecast capability with fully prognostic cloud electrification and lightning discharge physics, based on a model framework developed at Oklahoma University. (3) To develop a new data assimilation approach for ingesting LANL lightning data into our forecast model that exploits the phenomenological relationship between lightning occurrence and intense convection. (4) To demonstrate that the assimilation of lightning data from the new LANL Gulf array into the hurricane forecast model improves the prediction of rapid intensification (RI), when RI is driven by eyewall adjustment (axisymmetrization) triggered by intense convective events (hot towers).

In support of this hurricane research project, a seven-station dual-band lightning mapping array (dB-LMA) was deployed south of New Orleans in the summer of 2009. Each sensor measures both the lightning VLF/LF waveforms and logarithmic VHF power. The former is similar to the original Los Alamos Sferic Array (LASA) that detects the field changes produced by discharge events. The latter is similar to New Mexico Tech's VHF lightning mapping array (LMA) that locates the

VHF radiation sources associated with the lightning breakdown processes. The purpose of dB-LMA is to map the 3-d structure of the lightning flashes and at the same time to understand the current/charge transfer associated with the individual discharge processes. The array began routine data collection July, 2009.

To demonstrate the utility of lightning to map out the evolution of convective events in the hurricane eyewall we have focused on analysis of three Atlantic major hurricanes. To help illustrate the importance of this information for possibly predicting rapid intensification, lightning data was categorized within the following three key topics: 1) The mapping of various lightning types within the hurricane eyewall and the abrupt increase in lightning count prior and during rapid intensification; 2) the general increase in height of a specialized lightning type, the narrow bipolar event, during rapid intensification; and 3) the evolution, as indicated by lightning, of select convective elements in the eyewall. The last topic is particularly revealing and suggests that the general increase in height of lightning is an aggregate consequence of numerous short-lived convective events rapidly rotating around the eyewall.

Modeling efforts include assimilation of dual-Doppler radar observations for rapidly intensifying hurricane Guillermo (1997). A unique aspect of Guillermo was that during the period of radar observations strong convective bursts, attributable to wind shear, formed primarily within the eastern eyewall. To reproduce this observed structure within a hurricane model, background wind shear of some magnitude must be specified; as well as turbulence parameters appropriately adjusted so that the impact of the shear on the simulated hurricane vortex can be realized. To help understand this complex nonlinear interaction between shear and modeled turbulence, an ensemble of simulations have been conducted during which these key parameters were varied.

Erin Lay, a postdoc in our group has used broadband negative cloud-to-ground (-CG) lightning emissions detected from 200-600 km away by Los Alamos Sferic Array (LASA) receivers as high-powered transmitters to probe the lower ionosphere with high spatial and temporal resolution. Ionospheric measurements made by use of this method with -CG lightning data from a storm on the night of 23 May 2005 in the Great Plains, USA suggest that atmospheric gravity waves are a perturbative mechanism at these time scales and distances.

Massachusetts Institute of Technology

A paper entitled: "On the Diurnal Variation of Global Thunderstorms and Electrified Shower Clouds and their Contribution to the Global Electrical Circuit" by C. Liu, E. Williams, E. Zipser and G. Burns) has appeared in the NAMMA Special Issue in JAS. This work was motivated in part by NASA MSFC's (Doug Mach, Rich Blakeslee and their associates) documentation of a large global population of electrified shower clouds in aircraft overflights that provide systematic upward current contributions to the global circuit, but which do not produce lightning. The NASA TRMM data set consisting of vertical reflectivity profiles on precipitating convection (with the Precipitation Radar) and lightning (with the Lightning Imaging Sensor) throughout the tropics and subtropics has been used to classify convective elements as 'warm' shower clouds (without ice), electrified shower clouds, and thunderclouds. Efforts to match the UT amplitude and phase variation of the Carnegie Curve with these TRMM observations support the earlier suggestion of Wilson (1920) that electrified shower clouds make a contribution to the DC global circuit comparable to that of thunderstorms. Furthermore, the widely recognized dominance of the Americas over Africa in the DC global circuit is attributable to the greater number of electrified shower clouds in the former than in the latter. The electrified shower cloud population is found to have a continental dominance, as is well known for thunderstorms. The flattening of the Carnegie Curve relative to the UT-diurnal global lightning variation is due to the dominance of electrified shower clouds in the Maritime Continent and their sparsity in Africa.

Carlos Morales (USP, Brazil) and Vasso Kotroni (NOA, Greece) have successfully integrated VLF lightning detections from ZEUS/Starnet sensors in Africa, Europe and the Americas to produce lightning maps for West Africa during the AMMA (African Monsoon Multidisciplinary Analysis) field campaign in 2006. Earle Williams and Michael McGraw-Herdeg have organized these observations into lightning Hovmoller diagrams, as in earlier work on West African tropical cyclones (Chronis et al., 2007). Numerous well-defined lightning 'stripes' are apparent with slopes well matched to MIT radar-verified propagation speeds for westward-moving squall line MCSs (SLMCSs), and with stripe lengths frequently exceeding typical wavelengths for African Easterly Waves (AEWs) (2000-3000 km). For SLMCSs within AEWs, the conventional wisdom (Reed and his associates, and many others) is that the SLMCS is initiated west of the trough and subsequently dies in the ridge of the AEW. Two hypotheses have been proposed to account for the contradictory observations: (1) shallow gust fronts are launched by the SLMCS and propagate through the ridge to the next AEW trough, where a new SLMCS is initiated, all at roughly the same phase speed, and (2) SLMCSs frequently form and propagate without the existence of an AEW, and so experience no barriers to westward propagation. The available observations show that new SLMCS initiation is frequently mediated by long-range gust fronts, the preferred explanation for the inconsistency in observations at present is offered by (2). Chris Thorncroft and Matt Janiga (SUNY Albany) have been key collaborators on the synoptic context of the SLMCSs.

After many months of effort in collecting, editing and standardizing formats in multi-station Schumann resonance observations, Vadim Mushtak has achieved a breakthrough in the inversion of such background observations in revealing global source behavior. Linearized iterative inversions have been performed on an hour-by-hour basis for a single day in January 2009, with a forward model that includes the day-night asymmetry of the Earth-ionosphere cavity, and show systematic westward source migrations (following the Sun) in both Africa and South America. The latest results were presented at the recent EGU meeting in Vienna. Work will now concentrate on inter-station calibration of ELF magnetic field so that accurate source strengths can be achieved in absolute units. Contributors to this global effort include Robert Boldi (Bahrain), Gabriella Satori, Jozsef Bor, and Tamas Nagy (Hungary), Colin Price and Eran Greenburg (Israel), Yasu Hobara and Masashi Hayakawa (Japan), Yuki Takahashi, Mitsu Sato and Kozo Yamashita (Japan), B.M. Pathan and Ashwini Sinha (India), Symasundar De (Calcutta, India), Mariusz Neska (Poland), Adriena Ondraskova, Pavel Kostecky, Sebastian Sevcik

(Czech Republic), Piotr Koperski and Andrzej Kulak (Poland), Yuri Bashkuev, D. Buyanova and M. Dembelov (Siberia), Alexander Koloskov (Ukraine) and Brian Miller (Arizona, USA). Other ELF stations are welcome to participate.

A paper by Steve McNutt and Earle Williams entitled: "Volcanic Lightning: Global Observations and Constraints on Source Mechanisms" has recently been accepted in the Bulletin of Volcanology, and serves to greatly enlarge the worldwide reports of this phenomenon. This work may shed additional insight on different lightning types observed in a variety of photographs from the currently active volcano in Iceland.

Tel Aviv University and the Open University of Israel

Yoav Yair (OUI) and Colin Price (TAU) together with colleagues from the Weizmann Institute of Science (**Orit Altaratz and Ilan Koren**) have recently published a paper in GRL showing the connection between fires in the Amazon and lightning activity in thunderstorms. The study (published in GRL) showed that for small amounts of smoke (AOT <0.25) the thunderstorms showed an increase in lightning activity with increasing aerosol loading. However, above AOT>0.25, the lightning activity diminished dramatically, choking the thunderstorms. It is hypothesized that the initial increase is due to microphysical reason, with small droplets being carried high into the mixed-phase region of the clouds, while the decrease about AOT~0.25 is a radiative effect, where the absorbing aerosols stabilize the atmosphere, reducing the initiation of convection.

Colin Price and graduate student **Yuval Reuveni** recently published a paper (JGR-Space Physics) showing that the 27-day solar rotation modulates the VLF lightning noise detected at our Negev Desert VLF field site. Even at solar minimum the solar rotation still modulates the UV radiation ionizing the lower ionosphere, impacting the propagation of VLF sferics in the Earth-ionosphere waveguide. VLF measurements of the background "noise" may provide a new tool for monitoring the solar rotation.

Colin Price, Eli Galanti and student **Moriah Kohn** have been working on nowcasting algorithms using lightning data. This work is part of the European Union project FLASH, coordinated by Colin Price. Real time nowcasts of thunderstorm activity across the Mediterranean and Europe can be seen at the project website (www.flashproject.org).

Yoav Yair and **Colin Price**, together with graduate student **Daria Dubrovin** and colleagues from The Netherlands (**Ute Ebert, Sander Nijdam and Eddie van Veldhuizen**) have recently published a paper (JGR-Space Physics) related to sprites on other planets. The experimental laboratory study investigated the physical and chemical characteristics of sprites in atmospheres similar to Venus and Jupiter. The results conclude that sprites should be observable on these planets, and it may be easier to see sprites above the clouds than the lightning itself within the clouds.

Colin Price and Yoav Yair will install two stations to measure the fair-weather current (Jc) with instruments designed and developed by G. Harrison (U. of Reading, UK). The stations will be mounted in Mt. Hermon in northern Israel and at the Wise observatory in the Negev desert, to monitor impacts of space weather on the global circuit.

The UK Met Office, Observations R&D Group – VLF Arrival Time Difference lightning location network (ATDnet)

Alec Bennett (alec.bennett@metoffice.gov.uk)

The UK Met Office long range lightning location network (ATDnet) is currently undergoing further expansion, with a new VLF sensor installed in Kyrgyzstan during December 2009. Repairs were made to a sensor which was previously out of service on La Reunion (southern Indian Ocean), resulting in the sensor being included into the network from March 2010. Initial analysis suggests that these two additional sensors have significantly improved the lightning location accuracy for eastern Africa and the Middle East, with median lightning location errors now expected to be 10km (reduced from 20km). A 6% increase in detection efficiency for these regions was also identified by running the network with and without the new sensors in parallel.

The recent eruption of the volcano under the Eyjafjallajökull glacier in Iceland produced several instances of volcanic lightning detected by ATDnet, approaching one event every two minutes during the most active periods of 17 April. Over 200 volcanic lightning strokes have been located over Iceland by ATDnet to date since the first large eruption on 14 April, with most occurring approximately 3km downwind of the crater. Initial analysis suggests a lightning production rate roughly proportional to plume height when the plume conditions are favourable to electrification. It is hoped that the ATDnet volcanic lightning analysis will be published later this year.

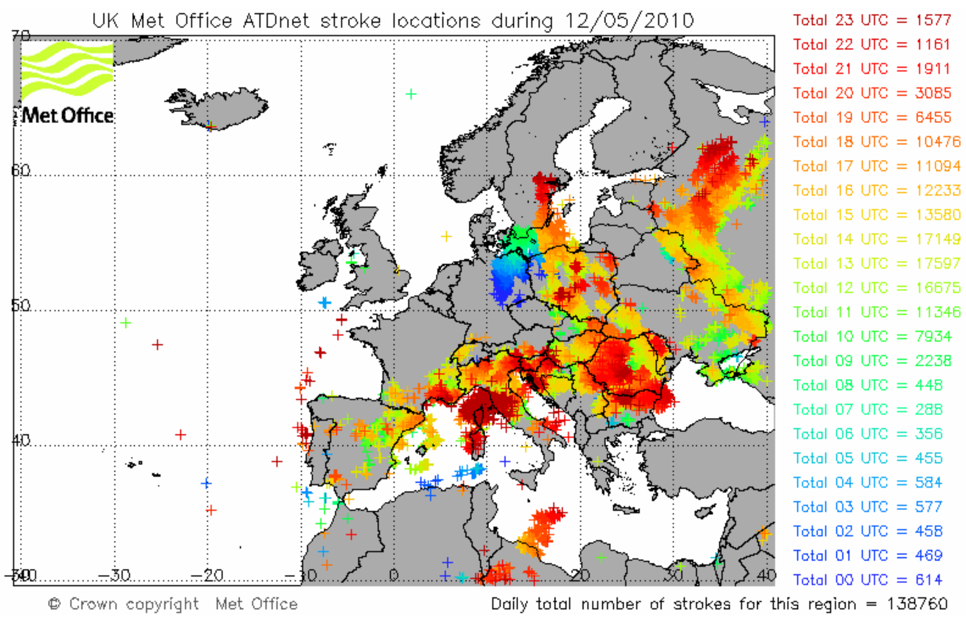


Figure 1 Lightning return strokes located by ATDnet during 12 May 2010 showing the progression of active storms over continental Europe and volcanic lightning from the eruption in southern Iceland. Lightning location colour corresponds to time.

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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 2010 winter issue of the newsletter is **Nov 15, 2010**.

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