COST

Domain Committee "Materials, Physics and Nanosciences "

COST Action P18

Start Date 24/06/2005
End Date 24/10/2009

"The Physics of Lightning Flash and its Effects"

FINAL EVALUATION REPORT

This Report stems from the relevant Domain Committee.
It contains four parts:

I. Management Report *prepared by the COST Office/Grant Holder*
II. Scientific Report *prepared by the Chair of the Management Committee of the Action.*
III. Evaluation Report *prepared by the "ad hoc" Evaluation Panel, established by the Domain Committee, and edited by the COST Office.*
IV. DC General Assessment *prepared by the Domain Committee*

Appendices:

Confidentiality: the documents will be made available to the public via the COST Action web page except for chapter *II.D. Self evaluation* and *IV. DC General Assessment.*

Executive summary of the Scientific Report (max.250 words):

The main objective of the Action was to increase the knowledge of the physics of the lightning discharge and of its effects on natural and man-made systems. To achieve the objectives, the activities were organized into 5 working groups: WG1 on measurement of properties of various types of lightning discharge, WG2 on phenomenology and modelling of the processes in the lightning flash, WG3 on physics and models for the lightning attachment to objects, WG4 on inverse source problems in lightning, and WG5 on mesospheric transient luminous events associated with lightning. The Action had participation from 21 COST countries and 8 non-COST institutions, providing a common platform for scientists in diverse fields such as physics, meteorology, space physics, engineering, chemistry, but all studying lightning. Four symposiums in Vienna, 4 workshops in different cities and one training school in Kiten, Bulgaria were conducted to present and discuss the research methodology and results. To provide research training to Ph.D. students and young researchers 27 STSMs were performed. A dedicated journal called Journal of Lightning Research was started. A lightning safety brochure for general public was produced as one of the activity of the Action. This was translated into several other European and non-European languages. Joint experiments between several groups were conducted at the instrumented tower on mount Gaisberg in Austria and this facility became a training place for Early Stage Researchers in lightning observation and measurement techniques. Within working group WG3, the so-called non-conventional lightning protection technologies, including ESE, were analyzed by

*I. **Management Report** prepared by the COST Office*

I.A. COST Action Fact Sheet

Action P18 Fact Sheet

Title

The Physics of Lightning Flash and its Effects

Contacts

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Details

This Action has stopped running in the 6 last months.

Draft Mou:		Mou:	265/05
Start of Action:	24/06/2005	Entry into force:	27/04/2005
End of Action:	23/10/2009	CSO approval date:	15/03/2005

Objectives

The main objective of the Action is to increase the knowledge of the physics of the lightning discharge and of its effects on natural and man-made systems.

Parties							
Country	Date	Country	Date	Country	Date	Country	Date
Austria	31/05/2005	Belgium	24/05/2005	Bulgaria	19/08/2005	Cyprus	19/07/2005
Denmark	16/06/2005	Finland	21/04/2005	Former Yugoslav Republic of Macedonia	21/06/2006	France	19/07/2005
Germany	21/04/2005	Hungary	21/04/2005	Israel	16/08/2005	Italy	15/06/2005
Netherlands	13/05/2005	Poland	21/04/2005	Portugal	15/03/2006	Serbia	11/07/2005
Slovenia	30/08/2005	Spain	02/06/2005	Sweden	16/06/2005	Switzerland	29/06/2005
United Kingdom	27/04/2005						

Total: 21

Intentions to accept the MoU							
Country	Date	Country	Date	Country	Date	Country	Date

Total: 0

Participating Institutions from non-COST countries	
Japan	Doshisha University, Department of Electrical Engineering
Ukraine	National Technical University of Ukraine Kyiv Polytechnic Institute
Ukraine	Usikov Institute for Radio-Physics and Electronics, Department of Remote Sensing
United States	University of Florida, Department of Electrical and Computer Engineering
United States	University of Alaska
Canada	McMaster University, Department of Engineering Physics
Canada	Ryerson University, Electrical and Computer Engineering Department
Canada	University of Toronto, Department of Electrical and Computer Engineering

Working Groups
WG1: Measurement of properties of various types of lightning discharge – WG leader Dr. Gerhard DIENDORFER ► WG2: Phenomenology and modeling of the processes in the lightning flash – WG leader Dr. Marcos RUBINSTEIN ► WG3: Physics and models for the lightning attachment to objects – WG leader Prof. Vernon COORAY ► WG4: Inverse source problems in lightning – WG leader Dr. Pierre LAROCHE ► WG5: Mesospheric transient luminous events associated with lightning – WG leader Dr. Martin FüLLEKRUG

Website
http://www.costp18-lightning.org/

I.B. Management Committee member list

Management Commitee		
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I.C. Overview activities and expenditure

Action P18 - budget from 18-juin-2005 to 31-déc-2009

Generated on 11-déc-2009

Meetings

Meeting Type	Date	Place	Paid part	Cost	Status	Total
Kick-off	24-juin-2005	Brussels (BE)	20	13112.71	Paid	
Joint Management Comm	14-nov-2005	Lausanne (CH)	23	17850.9	Paid	
In conjunction with Works	03-avr-2006	Vienna (AT)	27	14847.82	Paid	
Management Committee	09-oct-2006	Barcelona (ES)	55	46265.59	Partly paid	
Working Group	09-nov-2006	Salzburg (AT)	15	10286.87	Paid	
Management Committee	07-sept-2007	Kiten (BG)	9	7909.61	Paid	
In conjunction with Works	14-avr-2008	Vienna (AT)	44	31269.56	Paid	
Working Group	27-juin-2008	Corsica (FR)	7	6708.12	Paid	
Joint Management Comm	09-oct-2008	Châtillon (FR)	19	13156.95	Paid	
In conjunction with Works	25-mai-2009	Vienna (AT)	52	39034.1	Paid	
Final Evaluation Conferer	23-nov-2009	Stockholm (SE)	23	20149.29	Scanned	
						220591.5

STSM

Beneficiary	Date	From	To	Cost	Status	Total
Mr Davide Pavanello	03-déc-2005	Lausanne (CH)	Uppsala (SE)	1000	Paid	
Mr Oscar van der Velde	13-déc-2005	Toulouse (FR)	Tel Aviv (IL)	1810	Paid	
Mr Hannes Pichler	28-mai-2006	Vienna (AT)	Uppsala (SE)	900	Paid	
Ms Savka Petrova	04-juin-2006	Sofia (BG)	Athens (GR)	970	Paid	
Dr Grzegorz Maslowski	01-juin-2006	35-959 Rzeszow (PL)	Gainesville, FL 32611, Ins	1000	Paid	
Ms Vesna Javor	03-juil-2006	Nis (CS)	Krakow (PL)	1000	Paid	
Mr József Bór	21-août-2006	H-9400 Sopron (IE)	2100 Copenhagen O (DK	1000	Paid	
Ms Michal Ganot	05-sept-2006	Tel Aviv (IL)	Toulouse (FR)	1250	Paid	
Dr Marek Szczerbinski	15-sept-2006	Krakow (PL)	Nis (CS)	1000	Paid	
Mr YUVAL REUVENI	25-sept-2006	TEL-AVIV (IL)	Sodankyla (FI)	2150	Paid	
Mr Pooyan Manoochehrn	21-janv-2007	Lausanne (CH)	A-1190 Wien (AT)	1880	Paid	
Dr Jovan Cvetic	02-avr-2007	Belgrade (RS)	Neubiberg (DE)	1000	Paid	
Mr Nelson Theethayi	11-avr-2007	Uppsala (SE)	Bologna (IT)	1000	Paid	
Mr Abbas Mosaddeghi	20-mai-2007	Lausanne (CH)	Uppsala (SE)	900	Paid	
Dr Davide Pavanello	20-mai-2007	Lausanne (CH)	Uppsala (SE)	900	Paid	
Mr Konrad Sobolewski	19-août-2007	Warsaw (PL)	Munich (DE)	1000	Paid	
Pr Anders Larsson	02-sept-2007	n/a (SE)	Châtillon (FR)	840	Paid	
Mr Marley Becerra Garcia	07-oct-2007	Uppsala (SE)	Eindhoven (NL)	660	Paid	
Mr Keyhan Sheshyekani	18-févr-2008	Lausanne (CH)	Bologna (IT)	840	Paid	
Mr Helin Zhou	26-oct-2008	Uppsala (SE)	Vienna (AT)	1800	Paid	
Mr Abdolhamid Shoory	30-nov-2008	Lausanne (CH)	Bologna (IT)	840	Paid	
Dr Mario Paolone	14-déc-2008	Bologna (IT)	Lausanne (CH)	940	Paid	
Mr Abbas Mosaddeghi	02-mars-2009	Lausanne (CH)	Vienna (AT)	700	Paid	
Ms Daria Dubrovin	23-févr-2009	Tel Aviv (IL)	Eindhoven (NL)	1500	Paid	
Ms Rosy Raysaha	18-mai-2009	Stockholm (SE)	Wien (AT)	1000	Paid	
Mr Helin Zhou	14-juin-2009	Stockholm (SE)	Vienna (AT)	1250	Paid	
Mr József Bór	08-oct-2009	Sopron (HU)	Ra\`anana 43107 (IL)	1750	Paid	
Dr Boryana Tsenova	12-oct-2009	Sofia (BG)	Paris (FR)	1760	Paid	
						32,640

Workshops

Title	Date	Place		Cost	Status	Total
"The Physics of Lightning	14-nov-2005	Lausanne (CH)		2,000	Paid	
First international Sympos	03-avr-2006	Vienna (AT)		3,200	Paid	
MC and WG meetings "T	09-oct-2006	Barcelona (ES)		4,028	Paid	
Workshop meeting of the	09-nov-2006	Salzburg (AT)		2,550	Paid	
Third International Sympo	14-avr-2008	Vienna (AT)		4,709	Paid	
Joint MC & WG4 meetin	09-oct-2008	Paris (FR)		2,902	Paid	
4Th Annual International	25-mai-2009	Vienna (AT)		8,294	Paid	
Final MC & Evaluation Co	23-nov-2009	Stockholm (SE)		3,030	TBR	
						30,713

General Support Grants

Title	Date			Cost	Status	Total
General	20-oct-2006			2,000	Paid	
General	14-mars-2007			2,000	Paid	
General	10-oct-2008			2,000	Paid	
						6,000

Schools

Type	Date	Place	title	Cost	Status	Total
SCHOOL_LECTURERS	04-sept-2007	Kiten (BG)	Training School on "Lighr	8136.86	Paid	
SCHOOL_ORGANISER	04-sept-2007	Kiten (BG)	Training School on "Lighr	1410	Paid	
SCHOOL_STUDENTS	04-sept-2007	Kiten (BG)	Training School on "Lighr	7980	Paid	
						17526.86

Honoraria

Title	Date	Expert		Cost	Status	Total
Final MC and Evaluation (	23-nov-2009	KRIDER E.PHILIP		500	TBR	
Final MC & Evaluation Co	23-nov-2009	PIANTINI ALEXANDRE		500	TBR	
Final MC and Evaluation (	23-nov-2009	KAJCSOS ZSOLT		500	TBR	
						1,500

Grant

Grant Holder	Date			Cost	Status	Total
Gerhard Diendorfer	19-avr-2007			36,000	Paid	
						36,000

Dissemination

Title	Date			Cost	Status	Total
						0

Action Total **344971.3**

II. ***Scientific Report*** *prepared by the Chair of the Management Committee of the Action (same layout as in the Monitoring Progress Report)*

The scientific activities of the Action are mainly carried out in the 5 Working Groups, and the STSM's. Therefore the results achieved in the WG's and STSM's are reported in this section.

II.A. Results achieved during the period 2005 to 2008

WG -1 Measurement of properties of various types of lightning discharge

In September 2006 WG-1 organized a WG meeting in Salzburg to discuss joint projects for measuring the electromagnetic fields from lightning to the Gaisberg Tower. As decided during this meeting two fast field antennas at close distance to the tower on Gaisberg were installed in cooperation of research groups from Austria (ALDIS), Sweden (Uppsala University) and Switzerland (EPFL, Lausanne).

The measured electric and magnetic field data in combination with the already existing measuring infrastructure on the Gaisberg site (lightning current at the tower top and corresponding fast E-fields at 150 m and 80 km distance) provide a unique dataset to gain some more insight in the physics of the lightning discharge and the effect of the elevated object on the measured fields.

First correlated measurements of current and far fields show interesting details regarding propagation delay between measured current at the tower top and field peak observed at 78.8 km for fast and slow rising current pulses, respectively. Comparisons with model calculations are planned for 2008 to verify the observed effects.

During September and November 2007 numerous flashes have been recorded at the Gaisberg site. First comparisons of current waveforms and field data show interesting features that need now careful and detailed analysis. Calibration of the field measurements is a critical issue and is scheduled as a major task for the next WG-1 meeting planned in June 2008 in Sweden. Another issue introducing difficulties in the analysis of recorded field data is the complex metallic structure of the radio tower with its numerous grounding connections.

An outdoor photo camera with two different lenses (Model: Mobotix with one wide-angle and one telephoto lens) was installed in spring 2008 by the Austrian group. This camera should allow

collecting extra information about the type of discharge to the tower (upward or downward initiated) and possibly information about the details of stroke attachment to the lightning rods at the tower top. During summer 2007 several images of lightning flashes to the tower have been successfully collected and they will be analyzed in the near future.

In 2008 lightning data measured at the Gaisberg tower were analyzed in more detail by Helin Zhou. He is a student at the Univ. of Uppsala, Sweden and visited ALDIS in course of a STSM for 3 weeks. During the visit, current measurements data recorded in Gaisberg tower from 2000-2007 was used to do some statistics on upward lightning parameters. A total of 296 negative upward flashes without return strokes and 132 negative upward flashes with return strokes were analyzed. Special attention was paid to the duration of the initial stage (IS) of flashes and to the parameters of continuing currents (if any existed in a flash record).

Fig.1 shows as an example the result of the distribution of IS duration for the two distinct flash types (with and without return strokes following the IS)

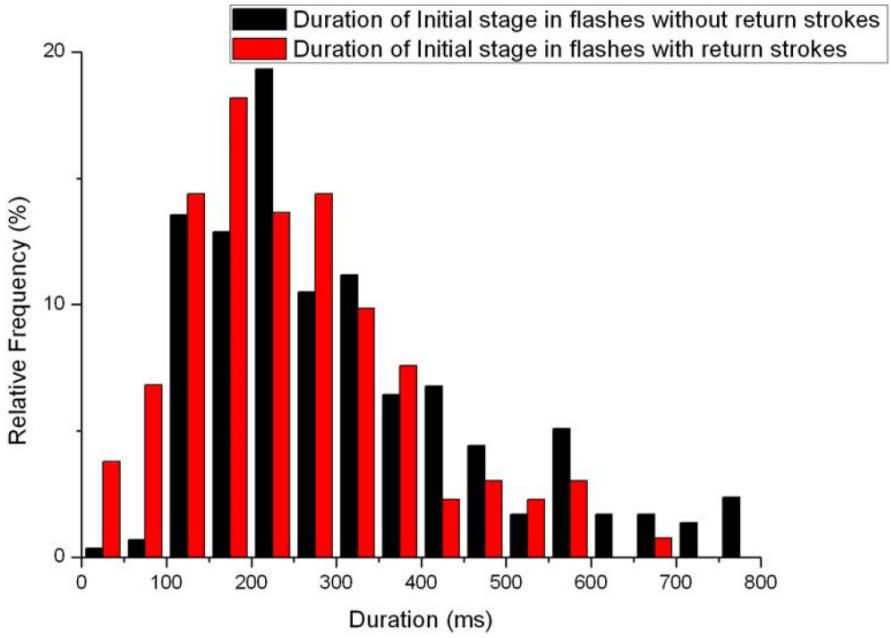

Fig. 1

A campaign for the calibration of the electric and magnetic field antennas installed at the Gaisberg tower site was conducted in summer 2008. Simultaneous field records from distant lightning were conducted to be able to determine the enhancement factor for the individual antennas installed by EPFL, Lausanne and ALDIS at various distances from the tower. As part of a STSM by Abbas Mosaddeghi the recorded data will by analyzed and compared in the beginning of 2009.

A paper entitled “Some Parameters of Negative Upward Initiated Lightning to the Gaisberg Tower (2000 - 2007)” has been prepared in 2008 and is accepted for publication in a special issue on lightning in the IEEE Journal on Electromagnetic Compatibility.
Significant differences in some lightning parameters examined from measurement of lightning to different towers and from triggered lightning emphasized the question of the effect of local site conditions on the resulting lightning parameters.
In cooperation with the Department of Meteorology und Geophysics of the University of Vienna some meteorological instruments (Micro Rain Radar, Disdrometer for the classification of the precipitation spectrum) have been installed in summer 2008. In combination with existing meteorological instruments in the Salzburg area (weather radar, meteorological stations in the city of Salzburg, etc.) we should be able to get in the future a better picture of the conditions, when lightning to the GBT occurs.
With the instrumentation of Säntis Tower in Switzerland in 2009 and the Peissenberg Tower in Germany in 2008 we expect a very fruitful exchange of collected lightning data within the scientific community. Data from three towers at different locations and heights above sea level and of different height of the tower structure itself should allow a better understanding of the effects of the tower structure and the local site conditions.

The work within WG1 is contributing to the following sub-objectives of the Action. *a) To understand and model the different physical processes in the lightning channel. b) To understand and model the lightning attachment to objects c) Measurement of characteristics of lightning flashes in Europe and an establishment of a data bank on the lightning parameters, including a databank on the characteristics of the electromagnetic radiation of lightning from ELF to gamma rays.*

WG-2 Phenomenology and modeling of the processes in the lightning flash

The main scientific and technical results of the COST P18 action related to WG2 are 1) The initiation of work towards the clarification of the source representation in return stroke modeling through a cooperation between the Swiss Federal Institute of Technology of Lausanne and the University of Uppsala. A publication on the subject is in the works. 2) Agreement by the members of the Action on the need to define guidelines for the reporting of lightning data to improve the data’s value and reusability. Work has started to produce a document containing these guidelines. 3) The Swiss Federal Institute of Technology has obtained important theoretical and experimental results that shed new light on the remote determination of the return stroke current in lightning strikes to elevated objects.
The main activities and results in 2007 related to WP2 are:

1. The submission and approval of a project to instrument the Säntis tower, close to the Swiss city of Saint Gallen.
2. The presentation of 4 papers at the Progress in Electromagnetic Research Symposium PIERS in Beijing:
-Discussion on the Influence of the Time Derivative of the Current and the Charge Acceleration on the Radiation Fields from Lightning Channels, Marcos Rubinstein HEIG-VD, Switzerland, Rajeev Thottappillil, Uppsala University, Sweden, and Farhad Rachidi, EPFL, Switzerland
-Equivalent Approaches for Computing Electromagnetic Fields from an Extending Lightning Discharge, Rajeev Thottappillil, Uppsala University, Sweden and Vladimir A. Rakov, University of Florida, USA
-On the Determination of the Spatial-temporal Behavior of the Lightning Return Stroke Current by Multiple Field Measurements, Davide Pavanello, EPFL, Switzerland, Marcos Rubinstein, HEIG-VD, Switzerland and Farhad Rachidi EPFL, Switzerland
-On the Need for Guidelines for the Reporting of Electromagnetic Field Measurements from Lightning, Marcos Rubinstein EIGD-VD, Switzerland, Davide Pavanello, EPFL, Switzerland, and Farhad Rachidi, EPFL, Switzerland
3. The setup of a Wiki for the collaborative work on the guidelines for the reporting of lightning measurements.

The main activities and results in 2008 related to WG2 were:
1. Work towards the instrumentation of the Säntis tower in northeastern Switzerland.
2. Collaboration in the writing of various papers presented at the COST P18 symposium in Vienna in April 2008 in Vienna and at the International Conference on Lightning Protection in Uppsala, related to unusual features in the field signatures from lightning, the effect of nearby structures on the enhancement and reduction of measured distance electromagnetic fields from lightning, the remote estimation of currents from lightning strikes to towers, the fields from towers at close range, and the link between lightning incidence and the climate.
3. Collaboration in the writing of the lightning safety brochure and its translation.

The results under WG2 contributes to the sub-objectives of the Action a) *To understand and model the different physical processes in the lightning channel. d) Develop models for the inverse source problem in lightning, that is, inferring the characteristics of the processes in the lightning channel from remote measurements of the electromagnetic waves associated with lightning.*

WG-3 Physics and models for the lightning attachment to objects

From the work carried out within the scope of this working group several advancements have been made concerning the problems related to the lightning interception of structures. A model, based on the physics of electrical breakdown, is developed to investigate the attachment of lightning flashes to grounded structures. The model includes the analysis of upward leaders initiated under the influence of the electric field produced by a dominant negative cloud charge and due to the combined action of a negative thundercloud and a descending downward stepped negative leader. Thus, a self-consistent model based on the physics of leader discharges is developed for the evaluation of the attachment of lightning flashes to any kind of grounded structure. The predictions of the model have been found to be in good agreement with the results of laboratory long air gap experiments and with classical and altitude rocket triggered lightning experiments.

This lightning interception model is simplified so that it can be utilized by engineers without resorting to advanced mathematical computations. It has been discovered that the lightning interception depends not only on the magnitude of the background electric fields produced by the stepped leader but also on the rate of change of the electric field. The rate of electric field depends on the speed of propagation of the stepped leader. This new feature is now included into the model, i.e. dynamic leader inception model. The leader inception model is now applied to several structures to detect the lightning strike points. The results show that the model developed can be used to predict the strike points to any given structure.

Due to the high application level and predictive power of the developed model, several contributions to the physical understanding of factors influencing the initiation and propagation of upward positive leaders during thunderstorms have been made in 2008. For instance, it has been found that the initiation of upward connecting leaders is strongly affected by the average velocity of the downward stepped leader. Similarly, it is shown that the switching voltage impulses used in the laboratory do not “fairly approximate” the electric fields produced by a descending downward leader, as claimed by supporters of Early Streamer Emission (ESE) devices. Furthermore, it is found that the space charge layer created by corona at ground level significantly increases the thundercloud electric fields required to initiate upward lightning leaders from tall objects. On the other hand, it is also shown that the upward leader velocity depends on the downward leader average velocity, the prospective return stroke current, the lateral distance of the downward leader channel and the ambient electric field.

By implementing the model to the analysis of complex structures, it has been observed that the corners of actual buildings struck by lightning coincide rather well with the places characterized by

low leader inception electric fields. Besides, it has been found that the leader inception zones of the corners of complex structures do not define symmetrical and circular regions as it is generally assumed.

Work carried out so far contributes to the sub-objective of the Action *b) to understand and model the lightning attachment to objects.*

WG-4 Inverse source problems in lightning

Three distinct topics related to inverse source problems are addressed in WG4:

a) How to retrieve lightning currents characteristics from remote measurements performed at ground?

A proportional linear relation between far Electromagnetic field measurements at ground and return-stroke currents is generally assumed to infer lightning current from remote electromagnetic field measurements. Lightning peak currents measured at the Gaisberg tower (100-m tall) have been correlated to lightning peak currents reported by the Austrian Lightning Detection and Information System (ALDIS), showing very good agreement, the differences between the directly-measured and indirect estimates being in the range of measurement errors of both systems. The performance characteristics of the U.S. National Lightning Detection Network (NLDN) were evaluated by the University of Florida Lightning Research Group using rocket-triggered lightning data, reporting also a reasonably good agreement. For taller structures such as the CN Tower in Toronto, recent investigations have shown that remote current estimates need to be corrected using the so-called tower factor.

b) How to use remote observations of lightning activity to improve the knowledge on lighting physics?

Many places in Europe are covered by electromagnetic lightning mapper working in Medium Wave frequency range like the IMPACT system or in VHF range like the Vaisala's SAFIR lightning system. Projects to implement lightning mapper for scientific applications exist in France. The PROFEO program, partly funded by the Ile de France District, consists in a 3D high temporal and spatial resolution VHF lightning mapper which will survey a zone of about 200 km by 200 km over Paris area. Data from this equipment will be freely accessible to the scientific community and collaborative international campaigns of observations will be organized in the future during the summer season. Also envisaged, is the installation of a LDAR mapper in South West of France; LDAR is a 3D VHF Difference Time Of Arrival mapper developed by the New Mexico Institute of Mining and Technology in Socorro near Albuquerque. Those equipments provide detailed information on the physical processes involved in the propagation of lightning discharges. The

University of Catalonia made recent observations of cloud to ground lightning activity. Low positive peak current value (< 10kA) and a large number of inverted electrical polarity storms had been observed. University of Catalonia plans to improve its Intra-Cloud observation method to start evaluation of nitrogen oxide production by lightning. Enhance exchange between Finland National Weather Service (NWS) and Aerology laboratory of Paul Sabatier University in Toulouse France are foreseen to study the relation of Intra-cloud lightning activity and precipitation.

c) How to use the detection and localization of ligtning activiy as a proxy of cloud dynamic?
Lightning data are used by the Finland NWS team as a complement and a proxy for short term evolution of the cloud. They use a Vaisala SAFIR VHF Interferometer lightning mapper whose range covers the South Western part of Finland. These types of observation are best fit for the detailed study of local and isolated storm. Finland NWS also use the observations from an IMPACT Medium Wave frequency lightning mapper, covering the all country territory. They gathered 10 years of cloud to ground lightning flashes observation from which climatology of the storms and a characterization of the relation between lightning activity and storms were inferred. Despite the expected effect of global warning, Finland NWS observes a significant decrease of lightning activity. The four last years have an activity less than half the level of the average.
Recent observations were made also in Poland showing storm producing small tornados. Lightning information are provided by SAFIR (VHF interferometer) and LINET (2D version of this MW mapper) network. Observation is that at tornado onset return stroke density is small. This type of observation is consistent with similar observation performed in the past in US and in Sweden.

The activities within this WG contributes to the sub-objective of the Action *d) Develop models for the inverse source problem in lightning, that is, inferring the characteristics of the processes in the lightning channel from remote measurements of the electromagnetic waves associated with lightning.*

WG-5 Mesospheric transient luminous events associated with lightning

A number of European initiatives in the arena of sprite research are now on their way. Two space missions (ASIM and TARANIS) are planned to tackle the question if relativistic energetic particles are accelerated by lightning electric fields as a result of a relativistic breakdown of air in the stratosphere and in the mesosphere. This new physical mechanism is predicted by theory but it can not be studied in the laboratory such that observations from space are necessary. Both missions are no in phase B (design).

A number of ground based sprite studies in Europe tackle the question of sprite initiation by particularly intense and/or oceanic lightning discharges. These studies combine video observations of sprites above thunderstorms with low frequency radio wave measure-ments of lightning discharges.

The framework of the COST action enables for the first time the calibration of charge moment estimates, which are critically important for sprite generation. The sprite community is also planning to maximise the outreach of sprite research by organising international sprite conferences, which are thought to be supported by an international consortium of funding agencies headed by CNRS.

The two European sprite space missions ASIM and TARANIS are in their design phase (phase B) and they both draw the interest of the scientific community towards sprites research. A number of ground based observations are under way. Sprite observations are done with a network of cameras in southern France, over the Mediterranean in Israel, and the first sprite observations in Hungary have been reported. The current ground based observations and the planning of the two satellite missions fuel a number of meetings on sprite research. The European Geosciences Union (EGU) hosted one sprite and one lightning session and it is planned for next year to have one session dedicated to all aspects of sprite physics. During the EGU 2007, a splinter meeting was held to plan for a Groupement de Recherche Europeenne (GDRE) of the Centre National de la Recherche Scientificque (CNRS), denoted E-CANES (Electromagnetic Coupling of the Atmosphere with Near-Earth Space). A workshop on 'Streamers, sprites, leaders, lightning: from micro- to macroscales' was held at the Lorentz-Center in Leiden, Netherlands. The International Space Science Institute (ISSI) in Bern hosted a meeting on Wave Field Measurements (WFM) in preparation of the TARANIS satellite mission.

European measurements of transient luminous events and the associated lightning discharges continued most successfully during 2008. It is planned to expand these observations in the coming years. A number of scientific meetings were conducted during 2008 and new meetings are currently in preparation.

A number of ground based sprite studies in Europe tackle the question of sprite initiation by particularly intense and/or oceanic lightning discharges. These studies combine high speed video observations of sprites above thunderstorms with low frequency radio wave measurements of lightning discharges. Four sprite observing cameras in southern France do now routinely deliver observations of hundreds of sprites each summer and extremely high speed imagery of sprite

streamer propagation. The experimental setup allows for a triangulation of individual streamer channels, the three dimensional imaging of sprites, and the branching of streamer channels in particular. The first observations of sprites from Poland have been reported. The ground based campaigns of winter thunderstorms in the eastern Mediterranean and associated TLEs continued this year with multiple stations in Israel allowing the study of the 3D arrangement of sprites elements.
The COST action co-sponsored a 'Workshop on Coupling of Thunderstorms and Lightning Discharges to Near-Earth Space' in Corsica in June 2008. The workshop was a great success with a dominant attendance from European reseachers and almost 100 participants from around the world. The workshop exemplified the dynamics of the field and new areas of promising future research were identified. The European Geosciences Union (EGU) hosted one sprite/lightning session in 2008 and a similar session is planned for 2009. The International Space Science Institute (ISSI) in Bern hosted a meeting in preparation of the TARANIS satellite mission and the ASIM experiment planned on the International Space Station.

The activities within this WG5 is contributing to the Action sub-objective *f) To understand the connection between the particular characteristics of lightning flashes and the associated observation of luminous events in the mesosphere and the lower ionosphere.*

Short Term Scientific Missions

The Action considers STSM's to be an important instrument in promoting the realization of scientific objectives of the Action. There were 27 STSM's carried out. They are summarized below, including the results. STSM's contributed to the general objective of the Action 'to increase the knowledge of the physics of the lightning discharge and of its effects on natural and man-made systems.' In particular, it contributed to the following sub-objectives of the Action. a) To understand and model the different physical processes in the lightning channel. b) To understand and model the lightning attachment to objects. f) To understand the connection between the particular characteristics of lightning flashes and the associated observation of luminous events in the mesosphere and the lower ionosphere.

2005/12/03 – 2005/12/10, Scientist: Davide Pavnello, Switzerland, Host: Rajeev Thottappillil and Vernon Cooray – Uppsala University, Sweden,Topic: Modeling lightning strikes to tall structures and the associated EM radiation. This STSM allowed the participant to improve his knowledge of

the propagation effects on the electromagnetic field radiated from a lightning strike, in particular regarding the investigation of the propagation effects on the vertical electric field radiated by a lightning strike to ground (or to a tall structure) at closer distances.

2005/12/13 – 2005/12/19, Host: Colin Price - Tel Aviv University, Israel, Scientist: Oscar van der Velde, France, Topic: Assisting the Sprite observation campaign in Israel. The scientist has experience in conducting sprite observations in France by remotely controlled camera systems, analysis of data, and knowledge of the meteorology of thunderstorms and storm electrification. This knowledge was shared with the Israeli team attempting Sprite observation.

2006/05/28 – 2006/06/02, Scientist: Mr Hannes Pichler, University of Technology, Vienna, Vienna(AT). Host: Rajeev Thottappillil, Division for Electricity and Lightning Research, Uppsala(SE). Topic: Lightning Field Measurement. The objective of the STSM was to install an Austrian designed continuous E-field measurement system in Sweden and that can be used to evaluate the performance of the Swedish lightning location network in some aspects.

2006/06/01–2006/06/30, Scientist: Grzegorz Maslowski, Rzeszow University of Technology, Department of Electrical and Computer Engineering, Host: Vladimir Rakov, University of Florida, USA. Topic: Lightning Return Stroke Modeling. Developed a model for interpreting the unique measurement of extremely close (0.1 m to 1.6 m from the channel) electric field data in triggered lightning.

2006/06/04 – 2006/06/11, Scientist: Ms Savka Petrova, Faculty of Physics, Sofia(BG), Host: Vassiliki Kotroni,Institute of Environmental Research, National Observatory of Athens, Athens(GR). Topic: Relation between lightning activity and precipitation.
Main purpose of this STSM was to understand how to use the lightning data recorded by the ZEUS system operated by National Observatory of Athens (NOA) in the problem of correlating precipitation and lightning.

2006/07/03 – 2006/07/17, Host: Marek SZCZERBINSKI – University of Science and Technology, Department of Electrical Power Engineering, Krakow (Poland), Scientist: Vesna Javor, University of Nis, Serbia&Montenegro, Topic: Laboratory Test of Various Lightning Protection Systems
Main purpose was to exchange research experience and chart out future collaboration.

2006/08/21 – 2006/08/27, Scientist: Mr József Bór, Geodetic and Geophysical Research Institute

of the Hungarian Academy of Sciences,H-9400 Sopron (IE). Host: Torsten Neubert, Danish National Space Center, 2100 Copenhagen O (DK).Topic: Learning experiences on observing lightning and related optical phenomena
Main objective of the mission was to take part in the scientific discussions of the Research Training Network with the name 'Coupling of Atmospheric Layers (CAL)' and in the discussion of the results of the experimental campaign EURO-SPRITE 2005, both programmes funded by EU.

2006/09/05 – 2006/09/20, Scientist: Ms Michal Ganot, Tel Aviv University, Tel Aviv(IL), Host: Serge Soula, Laboratoire d`Aérologie, OMP, Toulouse(FR). Topic: Sprites observation over Europe. To participate in the Eurosprite 2006 summer sprite campaign in France. The first successful winter sprite observation over Mediterranean was made during this STSM (http://geophysics.tau.ac.il/personal/ilan). Two Journal publications are under preparation.

2006/09/15 – 2006/09/30, Scientist: Marek SZCZERBINSKI – University of Science and Technology, Department of Electrical Power Engineering, Krakow (Poland), Host: Vesna Javor, University of Nis, Serbia&Montenegro, Topic: Computer simulations and analysis of the LEMP screening effects for some Lightning Protection Systems. Main purpose was to exchange research experience and chart out future collaboration.

2006/09/22 – 2006/10/06, Scientist: Mr YUVAL REUVENI, TEL-AVIV UNIVERSITY, TEL-AVIV(IL). Host: JYRKI MANNINEN, SODANKYLA GEOPHYSICAL OBSERVATORY, Sodankyla(FI). Topic: Lightning VLF Radiation. Main objective was to attend the 2nd VERSIM Workshop 2006, which was an international meeting on VLF phenomena and related research. Plans for research collaboration on VLF measurement with a research group in Fiji made. Connection made to EU project LAPBIAT (Lapland Atmosphere-Biosphere project).

7/10/2007 - 13/10/2007, COST Scientist, Mr Marley Becerra Garcia, Uppsala University (SE)
Host: Ute Ebert , Eindhoven University of Technology, Eindhoven (NL). Topic: Streamers, sprites, leaders, lightning: from micro- to macroscales. It was an excellent opportunity to learn and share views regarding the state of the art in the subject of theory, experiments and observations of streamers and sprites in the upper atmosphere.

01/04/2007- 06/04/2007. Scientist, Dr Jovan Cvetic, Faculty of Electrical Engineering Belgrade, Serbia, Host: Fridolin Heidler, Institut für Energieversorgung EIT 7, Fakultät für Elektrotechnik und Informationstechnik, Neubiberg (DE). Topic: Lightning current measurements at high towers.

The main objective of the visit was to familiarize with the equipment for the lightning measurements and the data acquisition installed at Peißenberg tower near Munich in Germany . Very similar equipment for the lightning measurements and the data acquisition system was recently purchased in Serbia and it should to be installed at the new TV/touristic tower (204m) at the top of the mountain Avala in the vicinity of Belgrade. The tower is at the very beginning of the construction. This was an ideal opportunity to use the experience and the knowledge from the colleagues from Germany on installing the equipment to get the best possible results in the lightning measurements in future.

21/01/2007 - 03/02/2007. Scientist: Mr. Pooyan Manoochehrnia, Swiss Federal Inst. of Technology (EPFL), Lausanne(CH) , Host: Wolfgang Schulz, Austrian Lightning Detection and Information System ALDIS,A-1190 Wien (AT), Topic: Lightning statistics in Switzerland. The aim of the project was to collect and analyze various statistical data of lightning activity in Switzerland using the data produced by Lightning Location Systems, LLS. As Switzerland is a part of EUCLID network, during this short mission at ALDIS in Vienna they provided the necessary data and applications to generate the necessary statistics.

20/05/2007 - 26/05/2007. Scientist**:** Mr. Abbas Mosaddeghi, Swiss Federal Institute of Technology, Lausanne(CH), Host: Rajeev Thottappillil, Uppsala University, Uppsala(SE), Topic: Preparation for the Lightning Measurement Campaign, Gaisberg Tower. The aim of this STSM was to coordinate the experimental campaign in Austria (summer 2007) and perform preliminary testing and calibration of the measuring equipment.

20/05/2007 - 26/05/2007. Scientist: Dr. Davide Pavanello, Swiss Federal Institute of Technology, Lausanne (CH), Host: Rajeev Thottappillil, Uppsala University, Uppsala (SE). Topic: Development of a Rogowski coil for the measurement of lightning current. The goal of this STSM was to contribute to the development of a first prototype that can be used for the measurement of lightning currents at the base of the Gaisberg Tower.

19/08/2007 - 25/08/2007. Scientist, Mr. Konrad Sobolewski, Warsaw University of Technology, Department of High Voltage Technology and Electrical Apparatus, Warsaw, Poland, Host: Hans-Dieter Betz, Ludwig-Maximilians-Universitat Munchen, Faculty of Physics, Munich, Germany, Topic: Linet– acquisition and analysis of lightning data in Poland. Main objective was to learn the basics of LINET lightning location system and the analysis of lightning distribution pertaining to Poland.

11/04/2007 - 17/04/2007, Scientist**:** Dr. Nelson Theethayi, Uppsala University, Uppsala (SE) , Host: Mario Paolone, University of Bologna, Bologna (IT), Topic: Modeling Corona and Buried Conductor Systems for Lightning Electromagnetic Pulse. During this STSM, multi-conductor transmission line model for lightning interaction with buried conductors to study crosstalk mechanisms were investigated and a model for corona to calculate lightning induced voltages in overhead wires was developed.

02/09/2007 - 07/09/2007, Scientist: Dr. Anders Larsson, Swedish Defense Research Agency, Sweden (SE), Host: Philippe Lalande,ONERA,Châtillon(FR), Topic: Lightning Strike to Aircraft. The objective of the short-term scientific mission is to make an overview over the topic of how the lightning channel attaches to an aircraft and how the lightning channel sweeps along its body during
flight. The STSM resulted in a manuscript for a book chapter.

26/10/2008 - 15/11/2008, Scientist: Mr. Helin Zhou, Uppsala University, Sweden (SE), Host: Dr. Gerhard Diendorfer, Austrian Electrotechnical Association, Vienna, Austria (AT), Topic: Analysis of continuous current in upward lightning to Gaisberg tower. The purpose of this STSM was to analyze the upward lightning data to the communication tower at Gaisberg. The focus was on the study of current records & high-speed video in upward lightning from Gaisberg tower to obtain new insights into the behavior of initial continuous currents and the current pulses superimposed on it.

14/12/2008 – 21/12/ 2008, Scientist: Dr. Mario Paolone, University of Bologna, Bologna, Italy (IT), Host:Dr. Farhad Rachidi, Swiss Federal Institute of Technology, Lausanne, Switzerland (CH), Topic: Measurement of lightning current on elevated strike objects: setup of specific measurement equipments. This STSM mission was aimed at setting up a measurement system with peculiar characteristics for lightning parameters estimation planned to be installed on the Säntis tower, Switzerland. In particular, it focused on the installation of the equipment that composed of two measurement points and on the development of the software that realizes the dialog between each measurement point and the industrial PC.

30/11/2008 - 05/12/2008, Scientist: Mr. Abdolhamid Shoory,Section de génie électrique et électronique,Lausanne, Switzerland (CH), Host: Dr. Carlo Alberto Nucci,Dipartimento di Ingegneria Elettrica,Bologna(IT), Topic: Investigating the Effects of Direct or Indirect Lightning Strike Using the FEM Method, The objective of this STSM was to investigate the effects of direct and indirect lightning strike on underground cables and wind turbines using a Finite Element Method (FEM). The technique takes advantage of multi physics solution to deal with the realistic case of electromagnetic heating problem.

21/2/2009 until 17/3/2009, Scientist: Ms. Daria Dubrovin, Tel Aviv University, Israel
Host: Ute Ebert, Eindhoven University of Technology, (NL): Topic: Studying sprites in other planetary atmospheres by streamer experiments in various gas mixtures

2/03/2009 to 6/03/2009, Scientist: Mr Abbas Mosaddeghi, Swiss Federal Institute of Technology, CH
Host: Gerhard Diendorfer, Austrian Lightning Detection and Information System (ALDIS): Topic:

18/05/2009 to 30/05/2009, Scientist: Ms. Rosy Raysaha, Royal Institute of Technology, (SE)
Host: Gerhard Diendorfer,Austrian Electrotechnical Association (OVE-ALDIS),Wien(AT), Topic: Field Data along with Simultaneously Measured Current in the Lightning struck Tall Grounded Objects

14/06/2009 to 23/06/2009, Scientist: Mr. Helin Zhou, Royal Institute of Technology (SE)
Host: Gerhard Diendorfer,Austrian Electrotechnical Association (OVE-ALDIS),Wien(AT), Topic: Analysis of upward bipolar lightning flashes initiated from the Gaisberg tower

11/10/2009 to 26/10/2009, Scientist: Mr József Bór,Geodetic and Geophysical Research Institute of the Hungarian Academy of Sciences,Sopron(HU)
Host: Yoav Yair,The Open University of Israel, Topic: Collaboration on optical calibration of TLE camera and ELF data acquisition and analysis

12/10/09-25/10/09: Scientist: Dr Boryana Tsenova, Bulgarian Weather Office (Bulgaria)
Host: Dr Eric Defer, LERMA (Observatory of Paris), France: Topic: The Use of Satellite and Ground-based Lightning Observations for Thunderstorms

II.B. Dissemination of results

Action related Publications and Reports

A brochure on COST Action P18 is published in 2005. Brochure was reprinted with minor corrections in 2006.

Book of Abstracts.
The First International Symposium on Physics of Lightning and its Effects, Vienna, April 03-04, 2006.
The Second International Symposium on Physics of Lightning and its Effects, Vienna, April 19-20, 2007.
The Third International Symposium on Physics of Lightning and its Effects, Vienna, April 14-15, 2008.
The Fourth International Symposium on Physics of Lightning and its effects, Vienna, May 25-26, 2009.

In the Barcelona MC meeting (October9-10, 2006), a group was formed for writing a public interest scientific brochure on lightning safety, after reconciling several and often conflicting instruction leaflets on lightning safety issued by several organizations. The final version for printing is prepared.

A manual on the procedures for reporting lightning measurement data is prepared. This make it easier to compare different lightning data sets and also to share lightning data for scientific purposes.

Publications that explicitly acknowledge support from COST P18

The following is a non-exhaustive list of publications directly resulting from the cooperation initiated within the COST P18. Several other papers are under preparation and are expected to be submitted in 2010 and 2011.

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Mäkelä, J.S., E. Karvinen, N. Porjo, A. Mäkelä, T. Tuomi: Attachment of natural lightning flashes to trees: statistical Characteristics. *J. Lightning Research*, accepted 2009.

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Jérôme Kasparian, Pierre Béjot, Jean-Pierre Wolf and John M. Dudley, Optical rogue wave statistics in laser

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Conference and Workshops

April 3 - 4, 2006, Vienna, Austria

The first Symposium on Lightning Physics and Effects held jointly with the Third International Workshop on EM Radiation from Lightning to Tall Structures. There were 41 participants from more than 20 countries attending the symposium and the Work Group meetings held on April 04. At the symposium 26 scientific papers were presented and discussed. A book of abstracts was published. The programme is given below.

Monday April 3, 2006

Morning Sessions

09:00-09:50		**Registration (Coffee)**
09:50-10:00	Opening Session	**Welcome message of R. Thottappillil, COST P18 Chair, W. Janischewskyj, IPLT Chair, G. Diendorfer, OC Chair**
10:00-12:30	Session 1	**Lightning and Climatology** (**Chair: C. Price**)
	10:00-10:20	**T. J. Tuomi (Finland)** Rain and Flash Cells in July 2003
	10:20-10:40	**A. Mäkelä (Finland)** Some Comparisons between Weather Radar and Lightning Data in Finland in the Summer of 2005
	10:40-11:00	**C. Price and M. Asfur (Israel)**, Lightning and Climate – The Water Vapor Connections
	11:00-11:20	**C. Price and B. Federmesser (Israel)**, Lightning-Rainfall Relationships in Mediterranean Winter Thunderstorms
	Session 2	**Lightning Measurement** (**Chair: G. Diendorfer**)
	11:20-11:40	**M.M.F. Saba, M.G. Ballarotti, O Pinto Jr. (Brazil)** Possibility of High Peak Current Strokes Followed by Long Continuing Current in Ground Flashes
	11:40-12:00	**H. Pichler G. Diendorfer, M. Mair and W. Schulz (Austria)** Offset Compensated Integrator for the Measurement of Lightning Electric Fields
	12:00-12:20	**H.D. Betz, W.P. Oettinger, K. Schmidt, B. Fuchs, H. Höller (Germany)** Total Lightning Utilizing VLF/LF Networks: Procedures, Results and Open Questions

	12:20-12:40	**F. Heidler (Germany)** Resumption of the Lightning Current Measurement at the Peissenberg Tower in Germany
12:40-13:30	***Lunch Break***	

Monday April 3, 2006

Afternoon Sessions

13:30-15:30	Session 3	**Lightning Phenomenology and Modeling** **(Chair: M. Rubinstein)**
	13:30-13:50	**M. Arrayás, M.A. Fontelos and J.L. Trueba (Spain)** Notes on Negative Ionization Fronts
	13:50-14:10	**E.A. Mareev, A.V. Biryukov, S.S. Davydenko, A.A. Evtushenko, S.A. Yashunin (Russia)** Quasi-Stationary and Lightning Currents in the Global Atmospheric Electric Circuit
	14:10-14:30	**A.G. Keul, A. Geiswinkler and O. Stummer (Austria)** European Ball Lightning Research Focus
	14:30-14:50	**J. Cvetic, M. Raickovic, M. Buljan, V. Novakovic, B. Mijovic, I. Gligorijevic, M. Stefanovic, Z. Celicanin (Serbia and Montenegro)** Optical Signal Radiated from the Lightning Channel: Comparison of Different Return Stroke Models
	14:50-15:10	**R. Thottappillil (Sweden) and V.A. Rakov (USA)** Far Fields at an Elevation from Lightning Return Strokes
	15:10-15:30	**G. Maslowski (Poland)** Estimation of Lightning-Induced Effects in Complex Systems using Engineering Return Stroke Models
15:30-16:00	***Coffee Break***	
16:00-17:20	Session 4	**Lightning to Tall Structures** **(Chair: F.Rachidi)**
	16:00-16:20	**G. Berger and S. Aït-Amar (France)** Lightning Attraction of an Elevated Building
	16:20-16:40	**I Boev, W. Janischewskyj (Canada)** Current Reflections and Reflection Coefficients Related to Lightning at Tall Structures
	16:40-17:00	**D. Pavanello, F. Rachidi (Switzerland), W. Janischewskyj (Canada) M. Rubinstein (Switzerland), A.M. Hussein, E. Petrache (Canada), V. Shostak (Ukraine), C.A. Nucci (Italy), J.S. Chang, I.**

		Boev, W.A. Chisholm (Canada), M. Nyffeler (Switzerland) Three-Station EM Field Measurements of CN Tower Lightning Strikes
	17:00-17:20	**V. Shostak (Ukraine), W. Janischewskyj (Canada), F. Rachidi (Switzerland), A.M. Hussein, J.S. Chang, E. Petrache (Canada), M. Rubinstein, D. Pavanello (Switzerland) and W.A. Chisholm (Canada)** Suggestion on Experimental Estimation of Current Portion Measured by Rogowski Coil at the 474-m Level of the CN Tower

Tuesday April 4, 2006

08:30-10:30	Session 5	**Lightning Observations and Inverse Source Problems** (**Chair: P. Laroche**)
	08:30-08:50	**P. Baranski, M. Loboda (Poland)** Electric Field (E) Waveform Signatures of the First and Subsequent Return Strokes in Cloud-to-Ground (CG) Lightning Flashes Recorded during Summer'2005 Thunderstorms in Poland
	08:50-09:10	**G. Satori and J. Bor (Hungary)** Studying Individual and Global Lightning by Schumann Resonances
	09:10-09:30	**V. Djurica and J. Kosmac (Slovenia)** Comparison of Lightning Data Collected by LLS and RLDN
	09:30-09:50	**E. Defer (France) and D. Lalas (Greece)** Lightning Activity sensed by the National Observatory of Athens VLF ZEUS European Network
	09:50-10:10	**C. Price, Y. Yair, M. Ganor, E. Greenberg, Y. Sherez, R. Yaniv, A. Devir, B. Ziv and E. Katz (Israel),** Ground-based observations of Sprites and other Transient Luminous Events in Eastern Mediterranean winter thunderstorms
	10:10-10:30	**P. Laroche, P. Lalande, P. Blanchet (France),** Lightning Physic information deduced from Lightning Mapping System
10:30-11:00	***Coffee Break***	
11:00-11:40	Session 6	**Lightning Return Stroke Modeling and Effects** **(Chair: V. Shostak)**
	11:00-11:20	**R. Thottappillil and N. Theethayi (Sweden)** Realistic Sources for Modeling Lightning Interaction with Towers
	11:20-11:40	**F. Napolitano, M. Bernardi, A. Borghetti, C.A. Nucci, M. Paolone (Italy), F. Rachidi (switzerland)** Voltages induced by cloud discharges on overhead power lines
11:40-12:30		**Open Discussion and Conclusive Remarks**

		(Chair: R. Thottappillil)
12:30-13:30	***Lunch Break***	
13:30-17:00	**COST P18 Working Group Meetings**	

November 9 -10, 2006 Salzburg, Austria

The Salzburg workshop of WG1 discussed joint projects for measuring the electromagnetic fields from lightning to the Gaisberg Tower. There were 19 participants from 10 countries. Installation of Field-mills at ground level and the tower top and of fast field antennas at various distances is planned for the lightning season summer 2007 in cooperation of research groups from Austria, Sweden and Switzerland. The program of the workshop is given below.

WG 1 Workshop

9-10 November 2006, Salzburg (Austria)

Program

Thursday Nov., 9th 09:00 – 09:01 Opening

09:10 – 10:30 Current experimental setup at the Gaisberg tower – Data analysis and archiving (Diendorfer, Pichler)

10:30 – 11:00 *Coffee break*

11:00 – 12:30 Presentation of background and goals of future joint experiments (Univ. Uppsala, EPFL Lausanne)

12:30 – 13:30 *Lunch*

13:30 – 17:00 Visit of the GAISBERG tower site (bus transfer from Meeting place to Gaisberg)

Friday Nov., 10th

09:00 – 10:30 Discussion - How to measure lightning parameters correctly (Moderator: Rubinstein)

10:30 – 11:00 *Coffee Break*

11:00 – 12:30 Detailed planning of joint projects (Hardware, Installation, Triggering, Communication, Data analysis, Archiving, etc.)

12:30 – 13:30 *Lunch*

13:30 – 15:00 Next steps, Timetable, TODO List

15:00 – 15:30 *Coffee Break*

15:30 – 16:00 Closing

April 19-20, 2007, Vienna, Austria

The second Symposium on Lightning Physics and Effects was held in Vienna. There were 50 participants from 19 countries attending the symposium. The Work Group meetings were held on April 20. At the symposium 33 scientific papers were presented and discussed. A book of abstracts was published. The programme is given below.

Thursday April 19, 2007

Morning Sessions

09:00-09:50		**Registration (Coffee)**
09:50-10:00	Opening Session	**Welcome message of R. Thottappillil, COST P18 Chair, Diendorfer, OC Chair**
	Session 1	**Lightning and Climatology, Sprites & Jets**

10:00-11:45		**(Chair: C. Price)**
	10:00 – 10:15	**Chanrion, O. and T. Neubert:** A semi-autonomous optical observatory for sprite observations
	10:15 – 10:30	**M. Fullekrug and R. Roussel-Dupre:** Mesospheric runaway breakdown in LF radio
	10:30 – 10:45	**Neubert, T**.: Co-ordinated ground observations in support of the ASIM and TARANIS missions
	10:45 – 11:00	**Pechony, O., C. Price:** Schumann resonances: applications in lightning research
	11:00 – 11:15	**Price, C. , Y. Yair and M. Asfur:** East African lightning as a precursor of Atlantic hurricane activity
	11:15 – 11:30	**Sátori, G., I. Lemperger, J. Bór:** Modulation of the annual and semiannual areal variations of global lightning on the 11-year solar cycle
	11:30 – 11:45	**Yair, Y., C. Price, M. Ganot, E. Greenberg, B. Ziv, R. Yaniv, Y. Sherez, A. Devir, K. Ehrlick and E. Vadislevski:** Summary of the 2005/6 and 2006/7 winter sprite campaigns in Israel
	Session 2	**Lightning Measurement and Simulation (Chair: G. Diendorfer)**
11:45-12:45	11:45 – 12:00	**Mimouni, A., M. Paolone, F. Rachidi and P. Zweiacker:** On the Use of Shielded Cables in Lightning Protection Systems
	12:00 – 12:15	**Paolone, M., K. Yamabuki, A. Borghetti, F. Napolitano, C.A. Nucci, M. Bernardi:** A Distributed Measurement System for Correlating Faults to Lightning in Distribution Networks
	12:15 – 12:30	**Solà, G., J. Montanyà, D. Romero and V. March:** The 2007 objectives of the Eagle Nest Tower
	12:30 – 12:45	**Radovanovic, N. S., M. S. Savic, M. B. Kostic, J. Cvetic:** Response of the grounding loop backfilled with bentonite to the lightning impulse current
12:45–13:45	***Lunch Break***	

Thursday April 19, 2007

Afternoon Sessions

	Session 3	**Lightning Phenomenology and Modeling (Chair: M. Rubinstein)**
13:45–15:15	13:45 – 14:00	**Javor V. and Predrag D. Rancic:** Using of the new function for the lightning return stroke channel-base current in calculation of lightning electromagnetic field
	14:00 – 14:15	**Szczerbinski, M.:** Lightning protection "Mesh Method": can it be analysed with electro-geometrical theory?
	14:15 – 14:30	**Rahman M. and V. Cooray**: X-ray production in laboratory discharges
	14:30 – 14:45	**Ebert, U., T.M.P. Briels, G.J.J. Winands, E.M. van Veldhuizen, A.J.M. Pemen, A. Luque, C. Li, W.J.M. Brok, J.J.A.M. van der Mullen, W. Hundsdorfer:** Recent experiments and new simulational tools for streamers in strong fields: towards the streamer-leader process and runaway electrons
	14:45 – 15:00	**Cooray,V., M. Rahman and V. Rakov** On the NOx production in lightning flashes
	15:00 – 15:15	**Thottappillil, R. and V.A. Rakov:** Review of Equivalent Methods for Computing Electromagnetic Fields from an Extending Lightning Discharge
15:15-15:45	***Coffee Break***	
	Session 4	**Lightning to Tall Structures (Chair: F.Rachidi)**
15:45–16:45	15:45 – 16:00	**Mosaddeghi, A., D. Pavanello, F. Rachidi, M. Rubinstein:** Electromagnetic Environment at Very Close Range from a Tower Struck by Lightning
	16:00 – 16:15	**Pavanello, D., F. Rachidi, V. Shostak, W. Janischewskyj, M. Rubinstein, A.M. Hussein, J. S. Chang:** Field Enhancement Effects for Lightning Strikes to a Tall Structure: Theoretical Prediction and Validation using NALDN Data
	16:15 – 16:30	**Theethayi, N., M. Becerra, R. Thottappillil, G. Diendorfer, V. Cooray, F. Heidler and V. Rakov:** On the Effective Height of Towers on Mountaintop from the Perspective of Lightning Attachment
	16:30 – 16:45	**Skarka, V., N.B. Aleksic and V.I. Berezhiani:** Propagation and Filamentation of Singular Optical Pulses in Air

Friday April 20, 2007

	Session 5	**Lightning Observations and Inverse Source Problems (Chair: P. Laroche)**
08:30-11:15	08:30-08:45	**Hans D. Betz, V. Djurica, K. Schmidt, W. P. Oettinger:** Far-Field Observation of Tower-Induced Lightning
	08:45-09:00	**Loboda,M., P. Baranski, K. Sobolewski**: Project on new local lightning detection network (LLDN) in the region of Warsaw
	09:00-09:15	**Mäkelä, A**.: Time differences of VHF and LF lightning locations in Finland in 2006
	09:15-09:30	**Maslowski, G., P. Baranski, S. Michnowski**: Analysis of electric field spectrograms of lightning discharge components
	09:30-09:45	**Tuomi, T. and J. Mäkelä and N. Oyj:** Sub-millisecond time differences between located strokes: Occurrence and statistics
	09:45-10:00	**Mäkelä, J., N. Porjo, T. Tuomi and A., V. Cooray**: Sub-millisecond time differences between located strokes: Waveform recordings
	10:00-10:30	***Coffee Break***
	10:30-10:45	**Varga, B. and D. Ablonczy:** Improving the Localization Accuracy of the Safir VHF Interferometric Receivewrs in the Hungarian Network with GPS based Measuring Techniques
	10:45-11:00	**Ramos R., Prior V., Correia S., Deus R.:** Portuguese Lightning Detection Network (2003-2006)
	11:00-11:15	**Defer, E., P. Blanchet, P. Lalande, P. Laroche, H. D. Betz , K. Schmidt and W. P. Oettinger:** Concurrent Observations of Lightning Flashes from ONERA RF-Efield sensor and LINET network
	Session 6	**Lightning Return Stroke Modeling and Effects (Chair: V. Shostak)**
11:15-12:15	11:15-11:30	**Rancic, P.D. and V. Javor**: New Two-image approximation of Sommerfeld's integral kernel in calculation of electromagnetic field of vertical mast antenna in frequency domain
	11:30-11:45	**Mosaddeghi, A., D. Pavanello, F. Rachidi, M. Rubinstein, P. Zweiacker:** Effect of Nearby Buildings on Electric and Magnetic Fields from Lightning
	11:45-12:00	**Trueba, J.L. and M. Arrayás:** Photoionization effects in electric discharges
	12:00-12:15	**Rubinstein, M., R. Thottappillil, and F. Rachidi:** Discussion on the influence of the time derivative of the current and the charge acceleration on the radiation

		fields from lightning channels
12:15-13:15	***Lunch Break***	
13:15-13:45	**Montandon, E.:** Facts and solutions in the real world concerning Lightning Protection for installations and equipment connected to the low voltage power supply distribution networks. (Invited Talk)	
13:45-14:00	**Berger G.:** Lightning Safety Brochure	
14:00-15:00	**COST P18 Working Group Meetings (WG1, WG2)**	
15:00-15:30	***Coffee Break***	
15:30-17:00	**COST P18 Working Group Meetings (WG3, WG4, WG5)**	

April 14-15, 2008 Vienna, Austria

The Third International Symposium on Lightning Physics and Effects was held in Vienna. There were 49 participants from 20 countries attending the symposium. The Work Group meetings were held on April 15. At the symposium 38 scientific papers were presented and discussed. A book of abstracts was published. The programme is given below.

SYMPOSIUM TIMETABLE
Monday April 14, 2008
Morning Session

08:30-09:00 **Registration (Coffee)**
09:00-09:10 Opening Session
Welcome message of R. Thottappillil, COST P18 Chair,
Diendorfer, OC Chair
Invited Talks
(Chair: R. Thottappillil)
09:10 – 09:50 **Marshall T.C. and M. Stolzenburg:** Effect of Lightning Charge Deposition on Storm Electrical Structure 09:10-10:30

09:50 – 10:30 **Stolzenburg M. and T. C. Marshall:** Typical and Extreme Electric Fields in Lightning-Producing Clouds
10:30-11:00 ***Coffee Break***
Session 1
Cloud/Lightning Physics
(Chair: R. Thottappillil)
11:00 – 11:15
Maslowski G. and P. Baranski: Examination of the slow front and fast transition in electric field waveforms produced by first and subsequent lightning strokes detected during summer thunderstorms near Warsaw
11:15 – 11:30 **Arrayás M., J.P. Baltanás and J.L. Trueba:** Fluctuation charge effects in ionization fronts
11:30 – 11:45 **Kasparian J., L. Bonacina and J.-P. Wolf:** Laser-induced electric events in thunderclouds
11:45 – 12:00
Betz H.-D., E. Defer, K. Schmidt, W. P. Oettinger, A. Würl, Z. Dziewit, W. Gajda, J. Konarski, P. Laroche, P. Blanchet, F. Dombai, B. Varga, D. Ablonczy and M. Loboda: Observation of Initial Breakdown in Cloud Lightning
11:00-12:15
12:00 – 12:15 **Berger G. and T. Tuomi:** The Outstanding Contribution of Jacques de Romas to the Experiments on the Electric Nature of Lightning
12:15-13:15 ***Lunch Break***

Afternoon Session

Session 2
Lightning to Towers
(Chair: V. Shostak)
13:15 – 13:30
Pavanello D., F. Rachidi, W. Janischewskyj, M. Rubinstein, V. Shostak, C. A. Nucci, K. L. Cummins, A. M. Hussein and J.-S. Chang: Current Peak Estimates Provided by Lightning Location Systems for Lightning return Strokes to Tall Towers
13:30 – 13:45
Rubinstein A., F. Rachidi, D. Pavanello, M. Rubinstein, G. Diendorfer and C. A. Nucci: Instrumentation, Monitoring and Control System for Lightning Measurements on the Säntis Communications Tower
13:45 – 14:00
Diendorfer G., A. Mosaddeghi, D. Pavanello, H. Pichler, F. Rachidi and M. Rubinstein: Electromagnetic Fields from Lightning Strikes to the Gaisberg Tower
14:00 – 14:15 **Pichler H., G. Diendorfer and W. Schulz:** Calibration of the fast E-Field Antenna at the Gaisberg Tower
14:15 – 14:30
Theethayi N., R. Thottappillil, G. Diendorfer, M. Mair and H. Pichler: Lightning Currents Shared by a Buried Grounding Strip Connected to Communication Tower Legs
13:15–14:45
14:30 – 14:45 **Grcev L., A.P.J. van Deursen and S. Grceva:** Distribution of Lightning Current between Horizontal and Vertical Earthing Conductors
14:45-15:15 ***Coffee Break***
Session 3

Lightning Modelling
(Chair: F. Rachidi)
15:15 – 15:30 **Keul A. G.:** Testing Lightning Folk Beliefs in Austria
15:30 – 15:45 **Cvetic J., M. Kostic and A. Nesic:** Dynamics of the Lightning Discharge Using Generalized Travelling Current Source Return Stroke Model
15:45 – 16:00 **Javor V.:** Approximating Decaying Part of the Lightning Return Stroke Channel-Base Current
16:00 – 16:15 **Aslan N. and M. Korachi:** Atmospheric Pressure Corona Discharge & Its Bacteriocidal Effect
15:15–16:30
16:15 – 16:30 **Skarka V. and N.B. Aleksic:** Possible Relation between Lightning and Solitons
19:00 Social event: Visit to a Vienna "Heurigen" Restaurant

Tuesday April 15, 2008

Morning Session

Session 4
Sprites & Jets
(Chair: C. Price)
09:00 - 09:15 **Bór J., G. Sátori and H. D. Betz**: TLE Observations in Central Europe from Hungary in 2007
09:15 - 09:30 **Chanrion O. and T. Neubert:** The 2008 NSI optical observatory for sprite observations
09:30 - 09:45
Tonev P., A. Blagoev and P. Velinov: Parameters of Lightning Discharge and Atmospheric Conductivity Needed for Sprite-Producing Quasi-Electrostatic Fields
09:45 - 10:00 **Vadislavsky E., Y. Yair, C. Erlick and C. Price:** An Investigation of the Three Dimensional Spatial Organization of Sprite Elements in the Mesosphere
09:00-10:15
10:00 - 10:15
Sátori G., M. Neska, J. Szendrői and T. Nagy: Global Lightning Observation by Schumann Resonances at a North Polar Station and in two European Field Sites
10:15-10:45 ***Coffee Break***
Session 5 **Lightning Observation Technology**
(Chair: M. Rubinstein)
10:45 - 11:00 **Neubert T.:** Status and Planning for the Atmosphere-Space Interactions Monitor (ASIM) mission on the International Space Station
11:00 - 11:15 **Mäkelä J.:** Narrowband lightning detection: Capabilities and Limitations
11:15 - 11:30 **Schulz W. and Cummins K.:** A method to determine relative stroke detection efficiencies from multiplicity distributions
11:30 - 11:45 **Loboda M., P.Baranski and K.Sobolewski:** Local Lightning Detection Network (LLDN) in Region of Warsaw

10:45-12:00
11:45 - 12:00 **Varga B. and D. Ablonczy:** Objective comparisons between the SAFIR (VHF/LF) and LINET (VLF/LF) networks in respects of IC discrimination and detection efficiency
12:00-13:00 ***Lunch Break***

Afternoon Session

Session 6
Lightning Observation
(Chair: G. Diendorfer)
13:00 - 13:15 **Manoochehrnia P., C. Price, F. Rachidi, M. Rubinstein and W. Schulz:** A Regional Study on the Link between Lightning Activity and Temperature
13:15 - 13:30 **Mäkelä A.:** VHF Lightning Location Statistics in Finland in 2006

13:30 - 13:45 **Price C., Asfur M. and Y. Yair:** Lightning activity in Atlantic Hurricanes
13:45 - 14:00 **Tuomi T.:** Spatial and Temporal Relations between LF- and VHF-located Lightning
13:00-14:30
14:15 - 14:30 **Ramos R., L. Amorim, S. Correia and V. Prior:** Using IMPACT sensors to study Lightning Climatology in Portugal
14:30-15:00 ***Coffee Break***
Session 7 **Lightning strikes to objects**
(Chair: C.A. Nucci)
15:00 - 15:15 **Bouquegneau C.:** Are Blunt Lightning Rods significantly better than Sharp Rods?
15:15 - 15:30 **Szczerbinski M. and P. Wolski:** Lightning Strikes the Tree: Some Physical Models
15:30 - 15:45 **Szczerbinski M. and T. Wojdyla:** Lightning Side Flash from the Tree: Some Physical Models
15:45 - 16:00 **Djurica V. and G. Milev:** A Multiple Power Line Corridor and Lightning Error Ellipse Spatial Processor for Real-Time Correlator
15:00-16:15
16:00 - 16:15 **Sheshyekani K., M. Paolone, S. H. H. Sadeghi, R. Moini and F. Rachidi:** Performance of Lightning Arresters Considering the Frequency-Dependence of the Grounding System: A MoM-AOM Approach

WG5 Workshop, June 27 Corcsica

The meeting was sponsored by WG-5: "Mesospheric transient luminous events associated with lightning", in conjunction with the International Workshop on Coupling of Thunderstorms and Lightning Discharges to Near-Earth Space that took place during 23-27 June 2008 at the University of Corsica in Corte.

The session was scheduled right after the end of the regular meeting sessions and was well attended, with 20-30 people present. It formally lasted from 1630 through 1830, with discussions and interaction between the attending scientists well after the official closure.

Although the session was sponsored by WG-5, it dealt with a variety of lightning-related issues, thus properly reflecting the broad coverage of our COST Action P-18. Below is the list of speakers and the titles of their talks.

Hardware development for observations of TLEs in Hungary Bo'r Jo'zsef

Sprite research in Brazil – an overview (Invited) - Fernanda Sao-Sabbas

Historical development of the Global Circuit concept and its application to future measurements. Karen Aplin

The ILDAS airborne lightning strike detection system Vuong Nguyen

Calibration of CCD cameras for TLE brightness measurements Roy Yaniv

Modeling of thunderstorm electromagnetic environment (Invited) Stanyslav Davydenko

Marine navigation distortion by lightning Martin Fullekrug

On the possibility of sprites on other planets Yoav Yair

The variety of topics – ranging from modeling to engineering and application, from historical overview to hands-on technical operation - and the fact that speakers were from several different European countries - shows that the lightning community in Europe is robust and strong.
The invitation of two guest experts (from Brazil and Russia) gave an additional dimension and enabled the scientists attending the WG-5 meeting to obtain further insights into the complex relationship between thunderstorms and TLEs.

WG4 Workshop, October 9, Paris

The meeting was conducted at ONERA 29 avenue de la Division Leclerc in conjunction with the MC meeting. Retrieving lightning currents characteristics from ground measurements, remote observation of lightning activity, and lightning activity as a proxy of cloud dynamic were the topics discussed.

EUROPEAN COST ACTION P18 *4TH INTERNATIONAL SYMPOSIUM ON* LIGHTNING PHYSICS AND EFFECTS, VIENNA, AUSTRIA, MAY 25 TO 27, 2009

A total of 60 scientists from 21 countries were participating this final COST P-18 Symposium in Vienna lasting for two and a half day. The 42 presentations (detailed symposium program and book of abstracts is attached to this report) covered all subjects of the 5 Working Groups within COST P18 action.

An invited lecture was given by Ute Ebert entitled “Streamer discharges in experiment and theory: a review of recent results”. The leader processes are fundamental for the understanding of the initiation, propagation and the final attachment of the leader to the ground striking point.

As in previous years several presentations were done by young scientist, giving them the opportunity to discuss their approaches and results with the European experts in this very specific area of research.

This year two presentations covered very interdisciplinary topics related to the physics of lightning. One presentation discussed “Lightning on the Giant Planets with Focus on Saturn”, given by G.Fischer et al. An overview about the current knowledge of lightning activity on the planets was given and lightning parameters were compared to observations on earth. A second presentation was given by B. Schalke, a neurologist, and entitled “Neurological and neuropsychological sequelae in long term lightning survivors”. This presentation described the potential injuries and long term symptoms observed by persons that have been struck by lightning. In many cases these patients suffered from symptoms which could not be explained and understood by the treating

doctors or the experts of the casualty insurance. The authors suggest that all long term survivors of a lightning strike should be repeatedly examined by medical and neuropsychological experts in lightning trauma over the years to avoid misinterpretation of apparently unexplainable neurological, neuropsychological and psychic symptoms.

SYMPOSIUM TIMETABLE
Monday May 25, 2009
Morning Session

09:00-09:50		**Registration (Coffee)**
09:50-10:00	**Opening Session**	**Welcome message of R. Thottappillil, COST P18 Chair, Diendorfer, OC Chair**
	Session 1	**Lightning Electromagnetic Fields (Chair: C. A. Nucci)**
10:00-12:00	10:00 – 10:20	**Fischer G., D.A. Gurnett, W.S. Kurth, P. Zarka, A. Lecacheux, U.A. Dyudina, J.-M. Grießmeier, W.M. Farrell, M.L. Kaiser:** Lightning on the Giant Planets with Focus on Saturn
	10:20 – 10:40	**Borghetti A., F. Napolitano, C. A. Nucci, M. Paolone:** Calculation of the Indirect-Lightning Performance of Overhead Distribution Lines
	10:40 – 11:00	**Shostak V., E. Shulzhenko, D. Pavanello:** Electric Field Simulation for Insulated Lightning Current Downconductor
	11:00 – 11:20	**Stelmashuk V., P.J. van Deursen:** Window sensor for the lightning current measurements
	11:20 – 11:40	**Pichler H., G. Diendorfer, M. Mair:** Some parameters of correlated current and radiated fields pulses from lightning to the Gaisberg Tower
	11:40 – 12:00	**Mosaddeghi A., A. Mimouni, F. Rachidi, M. Rubinstein, G. Diendorfer, H. Pichler, D. Pavanello:** Vertical and Horizontal Components of the Electric Field Associated with Lightning Strikes to the Gaisberg Tower
12:00-13:30	***Lunch Break***	

SYMPOSIUM TIMETABLE
Monday May 25, 2009
Afternoon Session

	Session 2	Lightning Physics (Chair: Shostak V)
13:30–15:10	13:30 – 13:50	**Skarka V., N.B. Aleksic**: Solitonic Nature of Lightning
	13:50 – 14:10	**Arrayás M., J. L. Trueba:** Motion of Electrons in Electromagnetic Knots
	14:10 – 14:30	**Yordanov V., A. Blagoev:** A Study of the Breakdown in the Plasma Focus Device
	14:30 – 14:50	**Rubinstein M., C. Romero, F. Rachidi**: Lightning Location Information From Field Peak Amplitude Attenuation
	14:50 – 15:10	**Flache D., V.A. Rakov, F. Heidler, W. Zischank, R. Thottappillil:** Leader/Return Stroke versus M-Component Mode of Charge Transfer to Ground in Initial-Stage Pulses of Upward Lightning
15:10-15:40	***Coffee Break***	
	Session 3	**Lightning Protection (Chair: R. Thottappillil)**
15:40–17:00	15:40 – 16:00	**Shoory A., M. Paolone, F. Rachidi, A. Borghetti, C.A.Nucci**: On the Application of Finite-Element Method for the Analysis of Lightning Protection of Wind Turbines
	16:00 – 16:20	**Mäkelä J., E. Karvinen, N. Porjo, A. Mäkelä, T. Tuomi:** Attachment of natural lightning flashes to trees
	16:20 – 16:40	**Blaj A., F.B.J. Leferink:** Lightning Protection of Ships on Maritime and Costal Environment
	16:40 – 17:00	**Bargboer G., A.P.J. van Deursen:** Current injection on a pharmaceutical plant, measured and modelled

SYMPOSIUM TIMETABLE
Tuesday May 26, 2009
Morning Session

	Session 4	Sprites & Jets (Chair: C. Price)
08:30-09:50	08:30 - 09:10	**INVITED LECTURE** **Ebert U.:** Streamer discharges in experiment and theory: a review of recent results
	09:10 - 09:30	**Neubert T.:** Status of the Atmosphere-Space Interactions Monitor (ASIM) for the International Space Station and plans for ground campaigns in 2009 and beyond
	09:30 - 09:50	**Chanrion O., T. Neubert:** Production of runaway electrons in conventional electric discharges
09:50-10:20	***Coffee Break***	
	Session 5	**Lightning and Meteorologie (Chair: Neubert T)**
10:20-12:00	10:20 - 10:40	**Varga B.:** Lightning Climatology – Tendencies, Extremities, Severe Weather probability based on 11 years of Central European lightning data
	10:40 - 11:00	**Price C., M.Asfur, Y. Yair:** Electric Hurricanes
	11:00 - 11:20	**Mitzeva R., Ts. Dimitrova, B. Stoilova:** Analysis of Lightning Activity and Radar Reflectivity in Multicell Convective Cloud
	11:20 - 11:40	**Manoochehrnia P., C. Price, F. Rachidi, M. Rubinstein, W. Schulz:** Lightning Activity Link with Temperature and Precipitation in Switzerland
	11:40 - 12:00	**Gajda W., P. Barański, J. Parfiniewicz**: Lightning Activity Accompanying the Supercell Event with Tornado and Two Heavy Hail Gushes – the severe weather incident in Poland on 20 July 2007
12:00-13:30	***Lunch Break***	

SYMPOSIUM TIMETABLE
Tuesday May 26, 2009
Afternoon Session

	Session 6	Modeling (Chair: G. Satori)
13:30-15:10	13:30 - 13:50	**Javor V., P. Rancic:** One Electromagnetic Model for Representing Lightning Attachment to the Lossy Ground
	13:50 - 14:10	**Shoory A., F. Rachidi, M. Rubinstein, R. Moini, S.H.H. Sadeghi**: A Discussion on the Inversion of Polarity of Lightning Far Electromagnetic Fields
	14:10 - 14:30	**Raysaha R. B., U. Kumar:** Role of Channel Conductivity and Corona Sheath on Return Stroke Current Evolution
	14:30 - 14:50	**Maslowski G., J. Bajorek, P. Baranski:** Modeling of shoulders within the lightning current front assuming generation of two waves in attachment point
	14:50 - 15:10	**Cvetic J., F. Heidler, A. Nesic, I. Tesnjak:** The Generalized TCS Model with the Current Reflections at Ground and at the Upper End of the Lightning Channel
15:10-	***Coffee Break***	
	Session 7	**Lightning Safety (Chair: G. Diendorfer)**
15:40-17:00	15:40 - 16:00	**Montag B., H.-D. Betz, W. P. Oettinger, A. Würl:** Lightning-Based Cell-Tracking for Storm-Alert at Airports
	16:00 - 16:20	**Łoboda M., K. Sobolewski:** Lightning Injuries and Deaths in Poland
	16:20 - 16:40	**Kleiter I., R. Lürding, R. Fexer, W. Schulte-Mattler, U. Bogdahn, B. Schalke:** Neurological and neuropsychological sequelae in long term lightning survivors
	16:40 - 17:00	**Berger G., A.G. Keul:** COST P-18 European Lightning Protection Information

19:00 Social event: Visit to a Vienna “Heurigen” Restaurant
(information, see enclosed sheet)

SYMPOSIUM TIMETABLE
Tuesday May 27, 2009
Morning Session

	Session 8	Lightning to Towers (Chair: Heidler F)
08:30-09:50	08:30 - 08:50	**Zhou H., G. Diendorfer, R. Thottappillil, H. Pichler, M. Mair:** A Preliminary Analysis of Bipolar Lightning Observed to the Gaisberg Tower from 2000 to 2007
	08:50 - 09:10	**Zhou H., N. Theethayi, G. Diendorfer, R.Thottappillil, V.A. Rakov:** Effective Height of Towers on Mountain Tops in Lightning Incidence Studies: Sensitivity Analysis
	09:10 - 09:30	**Rubinstein A., C. Romero, M. Paolone, M. Rubinstein, F. Rachidi, P. Zweiacker:** Instrumentation, Monitoring and Control System for Lightning Measurements on the Säntis Communications Tower
	09:30 - 09:50	**Heidler F., M. Manhardt, K. Stimper:** Resumption of Lightning Measurements at the TV-Tower "Hoher Peissenberg"
09:50-10:20	***Coffee Break***	
	Session 9	**Lightning Location Systems (Chair: M. Rubinstein.)**
10:20-12:00	10:20 - 10:40	**Djurica V., G. Milev:** An Evaluation of LLS Accuracy Improvements Considered by Measurements Collected by RLDN
	10:40 - 11:00	**Tuomi T. J.:** A Case-Study Update of LF/VHF Relations of Located Lightning
	11:00 - 11:20	**Sátori G., P. Bencze, F. Märcz, J. Bór, T. Nagy:** Half Century of Lightning Related Observations at Nagycenk, Hungary
	11:20 - 11:40	**Mäkelä A., J. Mäkelä, T. Tuomi, N. Porjo, E. Karvinen:** Lightning location accuracy in Finland verified by strikes to trees
	11:40 - 12:00	**Correia S., V. Prior, J. Batista, A. Silva:** Last 6 Years Lightning Network Evaluation
		Closing of the Symposium
12:00-13:30	***Lunch Break***	

SYMPOSIUM TIMETABLE
Wednesday May 27, 2009
Afternoon Session

	13:30 – 16:00	**Joint WG Meeting – Future of COST P18**
		Progress report of WG1 and future plans
		Progress report of WG2 and future plans
		Progress report of WG3 and future plans
		Progress report of WG4 and future plans
		Progress report of WG5 and future plans
		Summary of action plan

16:00	***Closing***	

Web site

Dedicated Website for the Action is created. This is www.costp18-lightning.org
The website has a public area and a member area. All documents related to the co-operation within this Action will be appearing at the website. The website includes Background information to this COST Action, MC minutes, Publications (Published journal and conference papers, discussion manuscripts), Links to other lightning related websites, Breaking news in lightning research, Activities of the Work Groups etc. Website is being improved and updated on a continuous basis.

Transfer of results

It is decided to arrive at a consensus on the definition or meaning of the scientific terms associated with lightning. For this purpose the glossary of lightning terms used by scientific/standardization organizations in different disciplines are being compiled and put at the website for discussion among the participants.

A **training school** was conducted during Sept. 03-07, 2007 in Kiten, Bulgaria. There were lectures from experts on Lightning Physics, Lightning Detection and Applications, Properties of Cloud-to-Ground lightning, Engineering Aspects of Lightning, and Lightning in the Middle and Upper Atmosphere. The topics, covered in the course are shown in table. There were 11 lecturers and 21 attendees. The lecture notes were gathered into a CD ROM.

Tuesday, September 4	Morning	**Lightning Physics** V. Rakov, *University of Florida, Gainesville, USA*
	Afternoon	**Lightning Detection and Applications** G. Diendorfer, *ALDIS, Vienna, Austria* P. Laroche, *ONERA, France* M. Rubinstein, *Western Univ. Applied Sciences, Switzerland*
Wednesday, September 5	Morning	**Lightning Parameters** G. Diendorfer, *ALDIS, Vienna, Austria* **Lightning Electromagnetic Field Computations** R. Thottappillil, *Uppsala University, Sweden* **Lightning Interaction with Towers** F. Rachidi, *Swiss Fed. Inst. Technology, Lausanne*
	Afternoon	**Lightning Protection Principles and Applications** G. Berger, *Supelec, Paris, France* C. Bouquegneau, *Mons Polytechnic, Belgium* **Lightning Protection of Power Systems** F. Napolitano, *University of Bologna, Italy*

Thursday, September 6	Morning	**The Influence of Lightning to Climate and Climate to lighning** C. Price, *Tel Aviv University, Israel* **Introduction to the physics of sprites, elves and intense lightning discharges** Michael Rycroft, *CAESAR Consultancy, UK*
	Afternoon	**Lightning Effects in the Middle and Upper Atmosphere** Y. Yair, *Open University of Israel*

The newly started Journal of Lightning Research, where the editor (Prpf. Vernon Cooray) and several of the associate editors are MC members of COST P18, will be one of the vehicles for disseminating scientific results. The first issue appeared at the website http://www.jolr.org/ on January 01, 2007. This is a web-based journal and the first issue had 13 articles covering interdisciplinary aspects of lightning. To achieve long-term sustainability the publication responsibility was transferred to Bentham publishers.

Contacts in the ERA

Some members of the MC are engaged in the Atmosphere – Space Interactions Monitor (ASIM) experiment on the International Space Station to be launched in a few years. Other programmes where MC members of this Action are involved are EURO-SPRITE 2006, COST 286, Research Training School 'Coupling of Atmospheric Layers (CAL),' LAPBIAT (Lapland Atmosphere-Biosphere project).

Projects and funding you received as a result of COST P18

COST Institution	**Project and Funding Source**
University of Geneva	Swiss State Secreateriat for Education and Research (SER): Contract C06.0114, CHF 230'000
Swiss Federal Inst. of Technology (EPFL)	Project on measurement of electromagnetic field radiation from lightning to the Gaisberg tower, funded by Swiss State Secretariat for Education and Research (SER): (Grant No C05.0149) - Project on the Instrumentation of the Säntis Tower in Switzerland, funded by the Swiss National Science Foundation (Project No. 200021-122457)
HEIG-VD, Switzerland	Project on the Instrumentation of the Säntis Tower in Switzerland, funded by Swiss State Secretariat for Education and Research (SER): (Project No. C07.0037)
Geodetic and Geophysical Research Institute of the Hungarian Academy of Sciences	K 72474 project supported by the Hungarian Scientific Research Fund
University of Belgrade	Funding received from the Ministry of Science of Republic of Serbia for the Serbian researchers involved in the COST P18 action.
National Technical University of Ukraine "Kyiv Polytechnic Institute"	Partial support from the Lightning Studies Group of the University of Toronto and from the EMC Group of Swiss Federal Institute of Technologies (Lausanne), and from lightning protection related companies *for* participation at two International Conferences on Lightning Protection (Japan 2006, Sweden 2008).
Warsaw University of Technology Institute of Geophysics, Polish Academy of Sciences	Research Project No. COST/204/2006 granted from Polish Ministry of Science and Higher Education titled "Multiple cloud-to-ground lightning flashes – their development, parameters, hazard for people and risk of damages" is under evaluation in frame of scientific cooperation between Warsaw University of Technology, Institute of Geophysics, Polish Academy of Sciences and Institute of Meteorology and Water Management in Poland in years 2007-2009 (in progress). The project leader is dr Marek Loboda – Warsaw University of Technology.

University of Bologna, Italy	Correlation between faults in distribution systems and lightning events – funded by CESI (2006) Lightning protection of wind turbines with particular reference to large size units – funded by Leitner (2006)
Uppsala University, Sweden	Lightning Interaction with Tall Towers, Funded by Swedish Research Council 2006-2008

New collaboration and contacts initiated as a result of COST Action P18

COST P18 Institution	Collaboration
Universidad Rey Juan Carlos	ASIM mission of the ESA
University of Geneva	- H.D. Betz, Ludwig Maximilian Universität München, Germany: discussion about a possible implementation of a lightning detector on our university building - F. Rachidi, EPFL, Lausanne, Switzerland: discussions about the interpretation of our results about laser-triggered electric activity in thunderclouds and a possible common field campaign in the Swiss alps
EPFL and HEIG-VD (Switzerland), ALDIS (Austria) University of Bologna (Italy) KTH (Sweden)	- Measurement of lightning current and electromagnetic fields associated with strike to the Austrian Gaisberg Tower - Instrumentation of the Swiss Säntis Tower
Geodetic and Geophysical Research Institute of the Hungarian Academy of Sciences	- Collaboration with Mariusz Neska from the Belsk Observatory, Poland in studying global lightning based on Schumann resonance observations at Nagycenk, Hungary and in Belsk as well as in Spitsbergen (Polish SR stations) - Collaboration with Colin Price'c group (Israel) in applying SR transients to determine lightning parameters (location, polarity, charge moment change) of distant energetic lightning strokes - Collaboration with Earle Williams (USA) in studying global lightning distribution on the ENSO time scale based on Schumann resonance and satellite lightning observations. - Co-operation in the installation of LINET stations in Hungary. - Collaboration with the LINET lightning detection network in connection with observing transient luminous events (TLEs). - Collaboration with the Astronomical and Geophysical Observatory in Modra, Slovakia (non P18 member) in connection with observing TLEs. - Collaboration with more members of the EuroSprite team in connection with observing TLEs. - Collaboration with the Hungarian Meteorological Service in connection with TLE observations. - Collaboration with Yasuhide Hobara, Japan in connection with TLE observations. - Consultation with Davis Sentman, USA in connection with TLE

	observations. - Contacts with amateur astronomists in connection with TLE observations. - Contact with Marcelo Saba, Brasil, in connection with examining the relation of continuing current and ELF/Schumann resonance transients. - Contact with Gerhard Diendorfer in connection with examining the relation of tower lightning and ELF transients.
University of Belgrade, Serbia	Initiation of a new collaboration with Prof. Fridolin Heidler from the University of the Federal Armed Forces Munich, EIT 7, Germany, Prof. Jovan Cvetic from the University of Belgrade, Serbia, and Vesna Javor from the University of Nis, Serbia. A new collaboration with Prof. Vladimir Rakov from University of Florida (USA) and Prof. Grzegorz Maslowski from Department of Electrical and Computer Engineering, Rzeszow University of Technology (Poland). Also useful contacts are established with Profs. Marcos Rubinstein and Farhad Rachidi from EPFL (Switzerland).
CWI Amsterdam and TU Eindhoven	The COST-action facilitated contacts and exchange in Europe. E.g., several researchers participated in my workshop on "Streamers, sprites and lightning" in Leiden in Oct. 2007, http://www.lorentzcenter.nl/lc/web/2007/265/info.php3?wsid=265, with COST-funding. The COST-action allowed Prof. Ute Ebert (CWI) to learn more about current lightning research. X-ray measurements near lightning towers might be a very interesting outcome of the COST-action, but only after the termination of the program.
University of Sofia	- New connections were established with Dr. V. Kotroni and Dr. K. Lagouvardos (and their Ph D student D. Katsanos and N. Mazarakis), who hosted Savka Petrova at the National Observatory of Athens and provided the available lightning data. A paper was issued as a result of joint study with Dr. Kotroni. - As a result of the MC meeting in Barcelona, lightning detector from the LINET network was installed in Bulgaria (provided free of charge by Dr. Hans Betz) during the Summer 2007. The study of the relation between lightning activity and radar reflectivity in summer thunderstorms over Bulgaria were presented on the Symposium in Vienna, 25-27 May 2009
National Technical University of Ukraine "Kyiv Polytechnic Institute"	- Development of new studies in collaboration with Lightning Studies Group of the University of Toronto and with the EMC Group of Swiss Federal Institute of Technologies (Lausanne).

	Also several new contacts were developed with the colleagues from Polish Universities (Crakov, Warsaw), and LP related companies in Ukraine and Germany. As a result of this collaboration, some papers were published, diploma works were prepared and the Ukrainian student was invited to Germany for training (2008, 2009).
The Open University of Israel Tel Aviv University	- Collaboration on lab experiments with Ute Ebert's group from Eindhoven - Collaboration with Gabriela Satori's group at the Geodetic Observatory in Sopron, Hungary. Data analysis of lightning ELF emission and relationship to sprite properties. - Data exchange and participation in on-line sprite observations of the Eurosprite campaigns, following COST-sponsored meetings, summer school and seminars, with O. van der Velde, Joan Montanyà, Serge Soula and others. - Collaboration with Gerhard Diendorfer and Wolfgang Shulz regarding lightning data from the EUCLID network. - Collaboration with Hans Betz regarding exchange of LINET lightning data.
Warsaw University of Technology Institute of Geophysics, Polish Academy of Sciences	- with prof. H. Betz to improve the LINET lightning detection network in Poland - with dr J. Montanya from the Technological University of Catalunia (Spain) to find some validation procedures for the SAFIR lightning detection networks operated in Catalonia and Poland by using an additional independent LF E–field sensor with own recording system and GPS time stamps - with M. Sc. M. G. Ballarotti from the National Institute of Space Research (Sao Jose dos Campos, Brazil) to share experience how to prepare a digital high-speed camera for observations of CG flashes and to combine them with simultaneous E-field change recordings
Polytechnic University of Catalunya	- University of Munich group (Prof. H.D. Betz): We are cooperating with this group setting up sensors for lightning detection in Spain. It has been a very good cooperation because now we have access to lightning data in real time. - EMC group of the EPFL (Prof. Farhad Rachidi): We cooperate in the field of lightning effects on wind turbines. - Universidad Rey Juan Carlos (Prof. M. Arrayas): we started our cooperation thanks to the COST P18 action. Now we are involved in national projects for research in transient luminous events observations and modelling of streamers.

	- University of Bologna (Prof. C.A. Nucci): we cooperated in finite element modelling of lightning attachment. These models are very useful for lightning protection of wind turbines.
Denmark National Space Center Technical University of Denmark	Collaboration has been established between groups in Israel and in Denmark in two important areas. The first concerns annual observation campaigns of lightning in the mesosphere above thunderstorms conducted by the Danish team and collaborators every summer in Southern France and Northern Spain. While the two groups have had the knowledge of each others existence, a real collaboration relating to the campaigns has been facilitated via the COST action. A joint paper has been published of observed ELF radiation from the discharges and the associated ionospheric disturbance [Greenberg et al., 2009]. A second area is related to a space mission prepared by ESA for the International Space Station: The Atmosphere-Space Interaction Monitor (ASIM). Expected launched in 2013, the mission will observe the atmosphere above thunderstorms. The COST action has facilitated connection between the ASIM team and one of the world leaders in cloud-aerosol interactions at the Weizmann institute in Israel. This area is largely unknown to us but can be studied with ASIM instruments. The established connection is expected to enhance the science output of the mission. The COST action has allowed the ASIM mission to be presented to a larger community represented in COST P18. It is expected that ground experimental activities, both before the mission and co-ordinated with overflights of the Space Station during the ASIM mission will be conducted. This is expected to bring more diverse groups into the science exploitation of the mission and consequently to enhance the science output.
University of Bologna	Some new contacts and collaboration have been initiated and strengthen during the COST action P18. In particular the collaboration with the EMC group of Prof. Farhad Rachidi at the Swiss Federal Institute of Technology, Lausanne, Switzerland and with Marcos Rubinstein, Ecole d'ingénieurs du Canton de Vaud, Switzerland has been developed with new projects (see also the description of the STMs at points 1 and 2). Contacts with Prof. Vernon Cooray, Uppsala University, Sweden, Dr. Gerhard Diendorfer and Dr. Wolfgang Schulz of the Austrian Electrotechnical Association, Austria, and with Prof. Rajeev Thottappillil, Royal Institute of Technology (KTH), Sweden, have been developed and will continue also with the common cooperation to the Cigré WG C4.407 Lightning Parameters for Engineering Applications.

Other outreach activities: public lectures, expert advice etc.

Finnish Meteorological Institute	The project of lightning and trees has involved a lot of volunteers and raised a high public interest, further supported by the publication in JLR. Personal safety advice has always had high importance at FMI, but the coming guide will give more international authority to this.
University of Geneva	- "*Vers la maîtrise de la foudre*", G. Méjean, J. Kasparian, J. P. Wolf, Météo Magazine **2**, 27 (2008) - Over 60 news reports (including in major media worldwide) about the results obtained
Geodetic and Geophysical Research Institute of the Hungarian Academy of Sciences	- Four public lectures during 2008 on the upper atmospheric / mesospheric luminous events and about their observation from Sopron, Hungary in Hungarian. - Participation in translating the Lightning Safety Brochure to Hungarian.
University of Belgrade	In the frame of the COST P18 activities concerning a new lightning current measurements and the application of improved measurement techniques, the installation of the lightning current sensors is planned at the top of a new tower (Avala, 204m) near Belgrade, Serbia. The tower will be finished in 2009-2010. The equipment is already bought and ready to install.
CWI Amsterdam	See http://homepages.cwi.nl/~ebert/PublPubl.html
University of Sofia	Public lectures for fusion plasma, Pleven 2007, Blagoevgrad 2009. Audience – high school teachers.
National Technical University of Ukraine "Kyiv Polytechnic Institute"	6.1. Public lectures: Lectures at Training Courses for engineering and managing personnel from power industry (totally 23 lectures during Action P18). Two presentations on the new LP related IEC Standards at the International Forum and Exhibition "Protection-2006" (Kyiv, 2006). Invited lecture at Dehn Company on Lightning studies at tall structures (Germany, 2008). 6.2. TV interviews: Interview on public lightning safety at "STB" TV channel (Kyiv, 2006). Interview on lightning protection and safety at "1+1" TV channel (Kyiv, 2007). 6.3. Expert advises: Project on LP for new Entertainment and Sport Center (Brovary, Kyiv Region, 2005). Project on LP for Printing plant (Fastiv, Kyiv Region, 2005).

	Project on LP for Railway Station (Karavajevi Dachi, Kyiv, 2007). Project on LP for Pulmonology Medical Center (Kyiv, 2007-2009). Wind turbine lightning related accidence on Novoazovsk power generating station – participation at the State Investigation Commission, consultation (Doneck Region, 2007/2008). Project on LP for new tall multistory office center (Kyiv, 2008). Project on LP for Lisichansk glass factory (Lugansk Region, 2008). Lightning related accidence at the factory on manufacturing of electric cables and at its communication facilities (Kyiv Region, 2009). Project on LP for new plant on producing bioethanol (Cherkasy Region, 2009). 6.4. Expert reviews: Reviews of journal papers related to Action topics (15). Reviews of the new Ukrainian Standard on Lightning Protection (2006-2009).
The Open University of Israel Tel Aviv University	a. Interview in Israeli TV channel 2 after lightning strike hit 3 construction workers (01/09) b. Public lecture at the Open University on lightning and the emergence of life (03/09) c. Popular science article in the Israeli magazine "Galileo" on sprites and Elves (December 2008 issue) d. Lectures at High schools in Israel on topics related to severe weather
Warsaw University of Technology Institute of Geophysics, Polish Academy of Sciences	- Scientific seminar at Warsaw University of Technology, Dept. of High Voltage Engineering and Electrical Apparatus on New Local Lightning Detection System over Region of Warsaw – lecture presented by dr Marek Loboda on May 20th 2009. - Expert advices for insurance companies on recorded lightning discharges and their parameters in lightning season 2009.
Polytechnic University of Catalunya	- Convener of European CENELEC group (CLC/TC81X/WG5) for standardizing lightning detection for warning proposes. - Public lectures in two Spanish meteorological associations. - Cooperation with Discovery Channel, we gave some vide footage of our high speed observations of transient luminous events and lightning. - Expert advice in the field of lightning protection of wind turbines in three Spanish companies. - Expert advice in the field of lightning protection of a lightning protection company.
EPFL, HEIG-VD (Switzerland) KTH, Uppsala University (Sweden) University of Bologna (Italy) ALDIS (Austria)	- Tutorial on EMC Aspects of Lightning, (Singapore, Feb. 27 – March 3, 2006) - Tutorial on EMC Aspects of Lightning, at the 2007 IEEE Electromagnetic Compatibility Symposium (July 8-13, 2007, Honolulu, U.S.A.).

IV. DC General Assessment *prepared by the Domain Committee*

'The DC notes that the COST Action P18 titled "The Physics of Lightning Flash and its Effects" launched with the objective of increasing "the knowledge of the physics of the lightning discharge and of its effects on natural and man-made systems", indeed fulfilled the expectations at a high level. As this was the first larger-scale cooperation in this field, this Action has played an essential role in forming and organizing a new European research society.

The Action covered both the fundamental physical and the large portion of the wide-spread technological aspects of the "lightning flash" thematics and has created also a "security guidebook" translated already into numerous languages. The idea to produce a children-oriented poster with educational aims is also highly appreciated. The Action has attracted high-level research groups from inside and outside of Europe. The future goals of the active members of this Action to launch further joint research projects based on the achievements of this Action are highly encouraged.'