

# Scientific Report

## First TEA-IS Summer School Torremolinos, Málaga (Spain), 17 – 22 June 2012

### Summary

The first summer school on Thunderstorm Effects in the Atmosphere-Ionosphere System (TEA-IS) was held at Torremolinos (Málaga, Spain) from June 17th to June 22<sup>nd</sup>, 2012. There were 95 registered participants, including 30 participants registered as students. The program, the list of participants, the proceedings and some additional information is presented in the web page of the summerschool:

<http://www.teais.trappa.es/>

### Presentations

In total, there were 90 scientific presentations in the summer school:

- 53 posters, each one of them including a short, two-minute flash presentation.
- 5 invited 50-minute tutorial talks, devoted to detailed reviews of each sub-field of the topics of the summer school.
- 17 invited 30-minute topical talks, dedicated to more particular aspects of current research.
- 14 student oral presentations, where young researchers presented their latest results.
- 1 special lecture dedicated to the memory of the late Dave Sentman, one of the pioneers of the field, who passed away last December.

### Networking

Networking among the participants was encouraged. The time allotted for these activities included nine 20-minute coffee-breaks, four 90-minute poster sessions, a conference dinner and 3 joint discussions.

### Planning for exchange and short visits

Since the summer-school was organized within the framework of the TEA-IS Networking Programme of the European Science Foundation (ESF), one of the aims of the organization was to encourage participants from TEA-IS supporting countries to apply for funds for short and exchange visits within the TEA-IS Programme. 10 applications were received by the steering committee, which are now being evaluated.

### Scientific content and discussion

In order to review the scientific content of the workshop, it is useful to go through each of the covered topics.

### **Outstanding issues in discharge physics**

This topic was introduced by a tutorial by V. A. Rakov (U. Florida, USA) who presented an “Introduction to the physics of Lightning.” One topic which is recently focused the attention of many researchers is the production of high-energy radiation from lightning discharges in the so-called Terrestrial Gamma Flashes (TGFs). This issue was represented by reviews from N. Østgaard (U. Bergen, Norway), who presented “Recent results in TGF research – observations and theories” and M. Füllekrug who talked about “Causes and Consequences of Energetic Particle Beams in the Atmosphere”. TGFs were also discussed in a number of student talks:

- Common, Long-Duration Gamma-ray Glows in Thunderclouds (N. A. Kelley, UC Santa Cruz, USA)
- How simulated fluence of photons from Terrestrial Gamma ray flashes at aircraft and balloon altitudes depends on initial parameters (R. S. Hansen, U. Bergen, Norway)
- The feedback theory concerning the production of terrestrial gamma-ray flashes (A. B. Skeltved, U. Bergen, Norway)
- Recent results from the new RHESSI TGFs (T. Gjesteland, U. Bergen, Norway)
- Cross sections and modelling results for TGF- and positron spectrum produced by a negative stepped lightning leader (C. Koehn, CWI, The Netherlands)
- 2012 Summer Campaign. Ground-based correlation between energy electrons and X-ray count increase and lightning (F. Fabró, UPC, Spain)

We also heard a student talk about the “Simulation of thunder propagation through a realistic atmosphere model,” by L. J. Gallin (CEA, France)

### **Fundamentals of charging and discharging of thundercloud particles**

There were two invited topical lectures on the microphysics of charging of cloud particles in thunderstorms. I. Koren (Weizmann Institute, Israel) talked about “Aerosol effects on convective clouds,” whereas E. E. Ávila (U. Córdoba, Argentina) gave an overview about “Experiments on charge transfer in graupel/crystal collisions.”

### **Perturbations to the ionosphere driven by thunderstorm fields**

The effect of thunderclouds on the upper layers of the atmosphere is one of the mayor topics inside the TEA-IS collaboration and therefore was well represented in the summer school. This topic includes, for example, the study of Transient Luminous Events (TLEs), including sprites, which are the most spectacular manifestation of the effects of a thunderstorm on the upper atmosphere.

The initiation of sprite discharges was reviewed in a tutorial by V. Pasko (Penn State U., USA) entitled “Toward better understanding of sprite streamers:

initiation, morphology and polarity asymmetry". Four topical talks were devoted to observations of TLEs, namely, S. Soula (U. Toulouse, France, replaced by O. van der Velde) talked about "Optical observations and conditions of production of transient luminous events (sprites, elves, gigantic jets)", Y. Takahashi (Hokkaido U., Japan) spoke about "Development of sprite streamers and preceding halos and elves observed in NHK Cosmic Shore Campaign," H. Stenbaek-Nielsen (U. Alaska Fairbanks, USA) reviewed "High Speed Sprite Imaging" and C. L. Kuo (National Chen Kung University, Taiwan) discussed the "Correlation between halos and their parent lightning".

C. Haldoupis (U. Crete, Greece) used radio measurements to introduce "D region Ionosphere sudden perturbations associated with lightning and TLEs" and R. Marshall (U. Stanford, USA) presented a numerical model of electromagnetic propagation in his talk "High-speed Observations and Modeling of Elves and Associated Ionospheric Effects."

In addition, we also listened to these student talks on the topic of perturbations to the ionosphere driven by thunderstorm fields:

- TLE observing in Finland (P. Lahtinen, Ursa Astronomical Association, Finland)
- Extra-terrestrial sprites: Laboratory Investigations in Planetary Gas Mixtures (D. Dubrovin, Tel-Aviv U., Israel)
- Evaluation of detection techniques of sprites based on infrasound signals measured in Equatorial Africa (M. R. Peris, National Space Institute, Denmark)
- Transient events in the upper atmosphere (V.S. Morozenko, INPMV, Russia)
- Early/fast VLF events: A comparison between theoretical models and spread-spectrum VLF scattering observations (D.A. Kotovsky, U. Florida, USA)

### **Electric field-driven microphysics of the atmosphere**

The electric fields associated with a thunderstorm are powerful drivers of many chemical processes in the atmosphere. The electric fields in the lightning discharge are an important ingredient in the production of NO<sub>x</sub>, as reviewed by J. P. Pommereau (LATMOS, CNRS, France) in his tutorial "Lightning NO<sub>x</sub>: impact of thunderstorms and TLE's on stratospheric ozone." Lightning discharges also impact the concentration of many pollutants, as discussed by H. Huntrieser (DLR, Germany) in her topical talk "Thunderstorms: Generator and exhaust for pollutants."

The possible chemical effects of TLEs in the upper atmosphere were commented by E. Arnone (ISAC-CNR, Italy) in his topical talk "Chemical sources and sinks in the middle atmosphere: relevance and detectability of thunderstorm-induced perturbations" and in the student talk by F.C. Parra-Rojas (IAA-CSIC, Spain) titled "Kinetics of CO<sub>2</sub> and nitrogen oxides in air plasmas produced by the action of sprites and halos in the Earth mesosphere."

### **Physics of the thunderstorm tropopause**

This topic was touched by K. Nielsen (DMI, Denmark) in his talk on “Water vapour transport to the stratosphere driven by thunderstorm activity.”

### **Gravity waves driven by thunderstorms**

The topic of “The gravity waves in the atmosphere; their relation with thunderstorm activity” was reviewed in a tutorial talk by F. Dalaudier (LATMOS-IPSL, France) and also covered in a student talk by R. Kramer (DLR, Germany) on “Monitoring strong gravity wave signatures in the stratosphere due to extratropical cyclones through high resolved radio sounding data.”

### **Discharge applications**

The application of electrical discharges in industrial processes and, in particular, the modeling of streamer discharges, which are the basic components of sprites, was reviewed by A. Bourdon (CNRS, France) in her talk “Physics of streamer discharges and lessons learned from the study of discharges in laboratories for the study of atmospheric electrical discharges”.

### **Lightning application in weather and climate**

Finally, the topic of “Lightning Applications in Weather and Climate” was introduced by C. Price (Tel-Aviv U., Israel) in a tutorial talk.

The use of electromagnetic sensors to detect and monitor lightning activity was covered in three topical talks, namely by S. Cummer (Duke U., USA), who talked about “Applications of Lightning Remote Sensing with Low Frequency Radio Measurements”, J. Montanyà (UPC, Spain), who discussed the “Features of lightning discharges observed by high speed cameras and VHF/VLF total lightning mapping systems at the Ebro Valley” and by H.-D. Betz (u. Munich, Germany) , who reviewed the “Principles of Lightning Detection.”

## **Assessment**

It is of course difficult to assess the scientific output of a meeting like this one. We believe, however, that the meeting was productive and that it fulfilled its objectives and enhanced Europe’s position in the scientific research of the covered topics.

The summer school succeeded in bringing together researchers from many different fields: meteorology, geophysics and plasma physics. This enabled useful discussion and will, hopefully, result in significant scientific progress.

Another aim of the summer school was to introduce students to the main results and theories in the topics of the TEA-IS programme. That purpose was served mainly by the long, tutorial talks provided by well-established researchers in each topic. But also the shorter topical talks had a strong didactical component aimed to students.

Finally, many participants in the summer school applied for support for short and exchange visits within the TEA-IS networking programme. We expect that these collaborations will lead to significant scientific results that can also be partly attributed to this summer school.

## Final Programme

### Sunday 17 June

16.30 Registration opens at Hotel Pueblo Camino Real Main Entrance's Desk  
19.30 Registration closes

### Monday 18 June

08:00 – 08:40 Registration opens at Conference Room and Posters Display

08:40 – 09:00 Official Opening (**A. Luque and F. J. Gordillo-Vázquez**)

#### **Morning chairperson: T. Neubert**

09:00 – 09:50 Introduction to the physics of Lightning (V. A. Rakov, INVITED TUTORIAL)

09:50 – 10:20 Recent results in TGF research – observations and theories (N. Østgaard, INVITED TOPICAL)

10:20 – 10:30 Poster reports (1A) - 4 flash presentations

10:30 – 10:55 Coffee Break

10:55 – 11:05 Poster reports (1B) - 4 flash presentations

11:05 – 11:35 Aerosol effects on convective clouds (I. Koren, INVITED TOPICAL)

11:35 – 12:05 Experiments on charge transfer in graupel/crystal collisions (E. E. Ávila, INVITED TOPICAL)

12:05 – 12:35 Physics of streamer discharges and lessons learned from the study of

discharges in laboratories for the study of atmospheric electrical discharges (A. Bourdon, INVITED TOPICAL)

12:35 – 12:45 Poster reports (1C) - 4 flash presentations

13:00 – 14:20 Lunch

#### **Afternoon chairperson: N. Østgaard**

14:20 – 14:30 Poster reports (1D) - 4 flash presentations

14:30 – 14:50 Common, Long-Duration Gamma-ray Glows in Thunderclouds (N. A. Kelley, STUDENT TALK)

14:50 – 15:00 Poster reports (1E) - 4 flash presentations

15:00 – 16:30 POSTER SESSION

16:30 – 16:55 Coffee Break

16:55 – 17:05 Poster reports (1F) - 4 flash presentations

17:05 – 17:25 Monitoring strong gravity wave signatures in the

stratosphere due to extratropical cyclones through high resolved radio sounding data (R. Kramer, STUDENT TALK)  
17:25 – 17:45 TLE observing in Finland (P. Lahtinen, STUDENT TALK)  
17:45 – 18:05 Extra-terrestrial sprites: Laboratory Investigations in Planetary Gas Mixtures (D. Dubrovin, STUDENT TALK)

18:05 – 18:35 Joint Discussion – **Chair: M. Füllekrug**

20:30 – 21:30 Welcome cocktail reception at Hotel Pueblo Camino Real swimming pool surroundings

## **Tuesday 19 June**

### **Morning chairperson: A. Luque**

09:00 – 09:50 Toward better understanding of sprite streamers: initiation, morphology and polarity asymmetry (V. P. Pasko, INVITED TUTORIAL)  
09:50 – 10:20 Applications of Lightning Remote Sensing with Low Frequency Radio Measurements (S. A. Cummer, INVITED TOPICAL)  
10:20 – 10:30 Poster reports (2A) - 4 flash presentations  
10:30 – 10:55 Coffee Break  
10:55 – 11:05 Poster reports (2B) - 4 flash presentations  
11:05 – 11:35 D region Ionosphere sudden perturbations associated with lightning and TLEs (C. Haldoupis, INVITED TOPICAL)  
11:35 – 12:05 High-speed Observations and Modeling of Elves and Associated Ionospheric Effects (R. A. Marshall, INVITED TOPICAL)  
12:05 – 12:35 Features of lightning discharges observed by high speed cameras and VHF/VLF total lightning mapping systems at the Ebro Valley (J. Montanyà, INVITED TOPICAL)  
12:35 – 12:45 Poster reports (2C) - 4 flash presentations  
13:00 – 14:20 Lunch

### **Afternoon chairperson: C. Hanuise**

14:20 – 14:30 Poster reports (2D) - 4 flash presentations

14:30 – 14:50 How simulated fluence of photons from Terrestrial

- Gamma ray flashes at aircraft and balloon altitudes depends on initial parameters (R. S. Hansen, STUDENT TALK)
- 14:50 – 15:00 Poster reports (2E) - 4 flash presentations
- 15:05 – 16:35 POSTER SESSION
- 16:35 – 16:55 Coffee Break
- 16:55 – 17:05 Poster reports (2F) - 4 flash presentations
- 17:05 – 17:25 Kinetics of CO<sub>2</sub> and nitrogen oxides in air plasmas produced by the action of sprites and halos in the Earth mesosphere (F. C. Parra-Rojas, STUDENT TALK)
- 17:25 – 17:45 The feedback theory concerning the production of terrestrial gamma-ray flashes (A. B. Skeltved, STUDENT TALK)
- 17:45 – 18:05 Simulation of thunder propagation through a realistic atmosphere model (L. J. Gallin, STUDENT TALK)
- 18:05 – 18:35 Joint Discussion – **Chair: J-L Pincon**

### Wednesday 20 June

#### **Morning chairperson: H. Stenbaek-Nielsen**

- 09:00 – 09:50 Lightning Applications in Weather and Climate (C. Price, INVITED TUTORIAL)
- 09:50 – 10:20 Optical observations and conditions of production of transient luminous events (sprites, elves, gigantic jets) (S. Soula, INVITED TOPICAL)
- 10:20 – 10:30 Poster reports (3A) - 4 flash presentations
- 10:30 – 10:55 Coffee Break
- 10:55 – 11:35 A Tribute to Dave Sentman (F. São Sabbas, DAVE SENTMAN MEMORIAL TALK) + additional testimonies of colleagues

12.00 - Free Afternoon

### Thursday 21 June

#### **Morning chairperson: F. J. Gordillo-Vázquez**

- 09:00 – 09:50 Lightning NO<sub>x</sub> : impact of thunderstorms and TLE's on stratospheric ozone (J.P. Pommereau, INVITED TUTORIAL)
- 09:50 – 10:20 Thunderstorms: Generator and exhaust for pollutants (H. Huntrieser, INVITED TOPICAL)
- 10:30 – 10:55 Coffee Break
- 11:05 – 11:35 Chemical sources and sinks in the middle atmosphere: relevance and

detectability of thunderstorm-induced perturbations (E. Arnone, INVITED TOPICAL)

11:35 – 12:05 The gravity waves in the atmosphere; their relation with thunderstorm activity (F. Dalaudier, INVITED TOPICAL)

12:05 – 12:35 Water vapour transport to the stratosphere driven by thunderstorm activity (J. K. Nielsen, INVITED TOPICAL)

13:00 – 14:30 Lunch

**Afternoon chairperson: B. E. Carlson**

14:30 – 14:50 Recent results from the new RHESSI TGFs (T. Gjesteland  
STUDENT TALK)

15:00 – 16:30 POSTER SESSION

16:30 – 16:55 Coffee Break

17:05 – 17:25 Evaluation of detection techniques of sprites based on  
infrasound signals  
measured in Equatorial Africa (M. R. Peris, STUDENT  
TALK)

17:25 – 17:45 Cross sections and modelling results for TGF- and  
positron spectrum  
produced by a negative stepped lightning leader (C.  
Koehn, STUDENT TALK)

17:45 – 18:35 Joint Discussion – **Chair: C. Halduopis**

20.30 – School Dinner in Málaga (Parador de Gibralfaro). Bus  
departures at 19.45 at 50 m from the Hotel Camino Real  
main Entrance. Returning at 24.00.

**Friday 22 June**

**Morning chairperson: U. Ebert**

09:00 – 09:50 Causes and Consequences of Energetic Particle Beams in  
the Atmosphere  
(M. Füllekrug, INVITED TUTORIAL)

09:50 – 10:20 Development of sprite streamers and preceding halos and  
elves observed in NHK Cosmic Shore Campaign (Y.  
Takakahsi, INVITED TOPICAL)



10:30 – 10:55	Coffee Break
11:05 – 11:35	High Speed Sprite Imaging (H. Stenbaek-Nielsen, INVITED TOPICAL)
11:35 – 12:05	Correlation between halos and their parent lightning (C. L. Kuo, INVITED TOPICAL)
12:05 – 12:35	Principles of Lightning Detection (H.-D. Betz, INVITED TOPICAL)
13:00 – 14:30	Lunch

**Afternoon chairperson: Ari-Matti Harri**

14:30 – 14:50	Transient events in the upper atmosphere (V.S. Morozenko, STUDENT TALK)
15:00 – 16:30	POSTER SESSION
16:30 – 16:55	Coffee Break
17:05 – 17:25	2012 Summer Campaign. Ground-based correlation between energy electrons and X-ray count increase and lightning (F. Fabró, STUDENT TALK)
17:25 – 17:45	Early/fast VLF events: A comparison between theoretical models and spread-spectrum VLF scattering observations (D.A. Kotovsky, STUDENT TALK)
17:45 – 18:00	Closing

**APPENDIX**

Posters for poster flash presentations (two slides in two minutes)

**MONDAY June 18**

**Session 1A**

1. Design and implementation of an automatic instrument to diagnose air plasmas produced by Earth mesosphere TLEs (M. Passas *et al.*)

2. Near infrared and ultraviolet spectra of TLEs (F. J. Gordillo-Vázquez *et al.*)
3. The relevance of electron associative detachment in upper-atmospheric electricity (A. Luque and F. J. Gordillo-Vázquez)
4. Kinetics of CO<sub>2</sub> and nitrogen oxides in air plasmas produced by the action of sprites and halos in the Earth mesosphere (F. C. Parra-Rojas *et al.*)

### Session 1B

1. High-speed observations and modeling of Elves and associated ionospheric effects (R. Marshall)
2. Infrasound from lightning measured in Ivory Coast (T. Farges *et al.*)
3. Gigantic jet discharges as possible inducers of sprites (Li-Jou Lee *et al.*)
4. Electromagnetic signatures of different forms of gigantic jets above typhoon (Sung-Ming Huang *et al.*)

### Session 1C

1. High order fluid model for simulations of streamers and sprites (A. Markosyan *et al.*)
2. Modelling the ion chemical impact of sprites at night and during daytime (H. Winkler and J. Notholt)
3. The principles of imaging devices for high energy photons from Terrestrial Gamma-ray Flashes (P. H. Connell)
4. Finding Schumann resonance transients using an automatic method (T. Nagy *et al.*)

### Session 1D

1. The TLE observation site in Sopron, Hungary – an overview (J. Bór *et al.*)
2. Statistics of TLE-causing lightning strokes at high latitudes – FinSprite results 2009-2011 (A. Mäkelä *et al.*)

3. Lightning activity during 2011 puyehue volcanic eruptions (M. G. Nicora *et al.*)
4. Terrestrial Gamma Ray Flash Imaging (V. Reglero *et al.*)

### **Session 1E**

1. Telescopic Observations of Streamer Splitting in Sprites (M. McHarg *et al.*)
2. A statistical analysis on the relationship between thunderstorms and Sporadic E Layer over Rome (V. Barta *et al.*)
3. Negative streamers branch like coral reefs (M. Arrayás)
4. X- and  $\gamma$ - emissions from runaway electrons associated with thunderstorms (D. Cinar *et al.*)

### **Session 1F**

1. Preliminary results from the DTU automatic camera pointing system for TLE detection (O. Chanrion *et al.*)
2. Common, long-duration Gamma-ray glows in thunderclouds (N.A. Kelley *et al.*)
3. On the breakdown electric field of the mesosphere (T. Neubert *et al.*)
4. Towards user-friendly, public domain simulations of the precursor of lightning: streamers (A. Sun *et al.*)

## **TUESDAY June 19**

### **Session 2A**

1. Small scale interferometric network of low frequency radio receivers (A. Mezentsev and M. Füllekrug)
2. Energetic radiation observations near meter-scale sparks in the laboratory (B. E. Carlson *et al.*)
3. On sanitizing background Schumann resonance observations from strong transient events for inversion calculations (V. Mushtak *et al.*)
4. Towards understanding the formation of lightning: simulating the inception of streamer discharges (J. Teunissen *et al.*)

## Session 2B

1. Early/fast VLF events: A comparison between theoretical models and spread-spectrum VLF scattering observations (D.A. Kotovsky *et al.*)
2. Fine structure of magnetic field waveforms from the first return stroke of inland Lightning (O. Santolík *et al.*)
3. The submicrosecond structure of unipolar magnetic field pulse trains generated by lightning discharges (I. Kolmašová and O. Santolík)
4. Study of X-ray emission in long sparks combined with ns-fast photography (P. Kochkin and A.P.J. van Deursen)

## Session 2C

1. Ponderomotive model of plasma confinement and border formation in astrophysical jets (A. Dubinova and V. V. Kocharovsky)
2. Diagnostics of hollow cathode low pressure air discharges as a tool for understanding Halo spectral features in the Earth mesosphere (F. C. Parra-Rojas, I. Tanarro *et al.*)
3. Positive streamer propagation due to background or photo ionization: Experiments and theory (S. Nijdam, G. Wormeester, U. Ebert)
4. The COBRAT project – scientific payload and misión (J.-L. Pinçon *et al.*)

## Session 2D

1. Ebro Lightning Mapping Array: Sprite-producing (O.A. van der Velde *et al.*)
2. Study of the High Energy Emissions Related with Lightning and Thunderstorm (R. Winkelmann and F. T. São Sabbas)
3. Preliminary Lightning Observations over Greece (T. Chronis)
4. Lightning distribution analysis for Natural Hazard (L. V. Sorokin)

## Session 2E

1. Neutron component of the radiation dose related to thunderstorm (A. Drozdov *et al.*)
2. ESA's Atmosphere-Space Interactions Monitor (ASIM) for the ISS (A. Orr on behalf of the ASIM scientific and industrial consortium)
3. Current Status and Future Collaborative Observation Plan of JEM-GLIMS Mission  
(M. Sato *et al.*)
4. TLE study in South America using triangulation (A. Morais and F. T. São Sabbas)

## Session 2F

1. Relationship between duration of optical emission of sprites and charge moment change of their parent CG (T. Kudo, *et al.*)
2. Comparing lightning activities with climatic reanalysis (Y. Sanmiya *et al.*)
3. Physical properties of sprite-producing MCS (R. R. Azambuja *et al.*)
4. Three-dimensional Structure of Sprite Streamers Derived from Aircraft Observations  
(N. Kobayashi *et al.*)

## **WEDNESDAY June 20**

### **Session 3A**

1. Thunderstorm activity as observed by the ARISE (E. Blanc *et al.*)
2. A self-consistent model of sprite influence on the chemical balance of mesosphere  
(A. Evtushenko *et al.*)
3. LATINELT – Latin American Collaborative Network for Observation of Transient Luminous Events (F. T. São Sabbas)