Transient Luminous Events: Education and Public Outreach

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Abstract. Sprites, jets and elves, also referred to as "Transient Luminous Events (TLEs)", are phenomena well-suited for educational purposes as well as for public outreach activities. This paper gives an introduction to what is meant by "Education and Public Outreach (EPO)", and emphasizes the usefulness and effectiveness of such activities in scientific projects. In 2002 the "Coupling of Atmospheric Layers (CAL)" research training project was funded by the European Commission to study TLEs. CAL consisted of ten scientific work-packages and two work-packages specifically dedicated to the training and outreach program of the project. CAL is an example and inspiration of how a scientific research project can be a unique opportunity to provide EPO learning activities to both young and senior scientists.

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INTRODUCTION

It has become evident that there are not enough young people pursuing scientific and engineering fields in many of the industrialized countries such as the U.S.A. and countries in Europe. A strong need to improve science education and science literacy in these parts of the world is vital if we are to have the workforce necessary in the future to sustain our way of living in this technical age of our civilization. Our reliance on technology for our daily existence truly emphasizes this necessity. Therefore, the participation of scientists in collegial partnership with educators and outreach specialists is of the utmost importance to meeting this need.

A decade ago, NASA Administrator Daniel S. Goldin (1999) stated before the Committee on Science, United States House of Representatives: "The NASA Strategic Plan makes it the responsibility of each of our Strategic Enterprises to "embed" education into its program. No longer is it an acceptable practice to say, "we are too busy." Research, knowledge generation and education are all equal components of the NASA mission. We must combine our traditional methods of involving the education community with new and innovative ways so that the impact NASA has on education is greater."

Indeed the tendency of scientists saying "we are too busy", due to the fact that EPO activities are not always given as much credit as scientific research is, is much too common in our scientific world. However, the tendency is slowly and positively changing in Europe and other parts of the world. EPO sessions at annual meetings

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(e.g., of the European Geosciences Union, of the American Geophysical Union), organizing public outreach events, as well as incorporating EPO activities into scientific programs are becoming more common practice.

Some science and engineering topics are, of course, better suited for EPO activities than others. Optical celestial phenomena have throughout times intrigued humanity, especially the beautiful and mysterious aurora that can be seen with the naked eye. An image of an aurora is a perfect starting point for making space physics relevant to daily life (public outreach), as well as for introducing students to subjects related to chemistry and physics. More recently the world of sprites, jets and elves, also referred to as "Transient Luminous Events (TLEs)" was revealed. Discovered in the early 1990s they are now studied world-wide. Sprites and jets are discharges (sudden currents flowing through the air that normally acts as an insulator) associated with the electrostatic discharge occurring in the parent lightning strike, whereas elves are a result of atmospheric heating due to the lightning electromagnetic pulse. They occur above thunderclouds and are short-lived (less than 1 second) optical phenomena. Fig. 1 is a schematic representation of these phenomena. TLEs are both visible and spectacular, exactly what is needed to attract the attention of people, especially students.

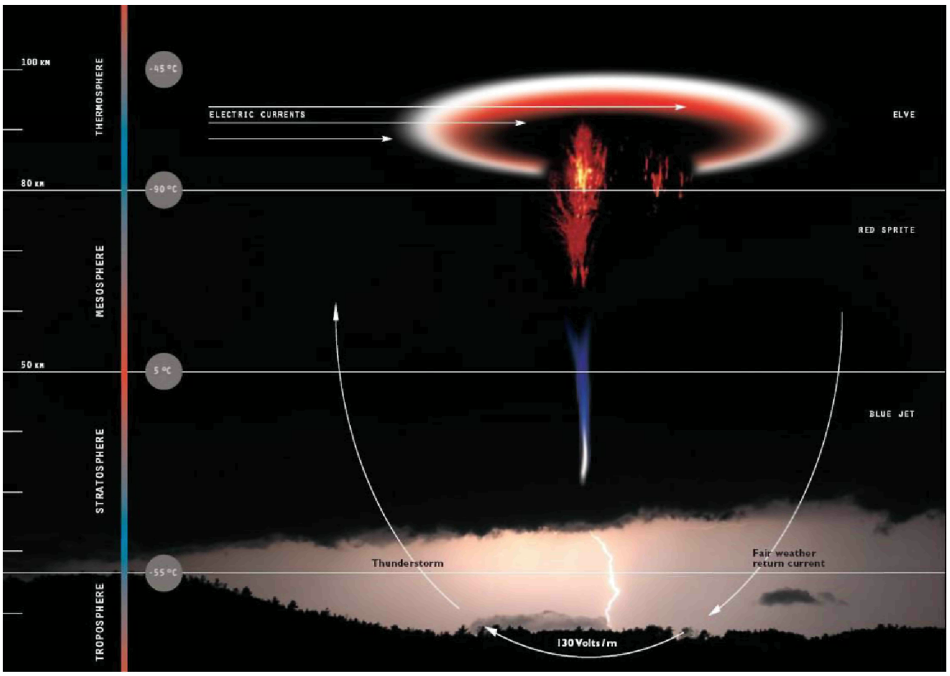

FIGURE 1. Schematic picture of optical phenomena occurring above thunderstorms.
Design: Geluck, Suykens & Garcia.

Introducing EPO into a research project is an opportunity for enriching the scientific and/or technical community with important tools for communicating research. The "Coupling of Atmospheric Layers (CAL)" Research Training Network project, funded by the European Commission within the Marie Curie Actions was a four year project (2002-2006), and studied unanswered questions relating to TLEs, and their effects on the atmosphere. CAL included ten scientific work-packages, as well as two work-packages dedicated to training and outreach.

In this paper an overview of, and a presentation of what is meant by, EPO are given. This is followed by an introduction to the CAL project, and the training as well as the EPO activities that were performed in the scope of the project. A Section on using TLEs in general, as an educational topic follows. The paper ends with a short summary.

EDUCATION AND PUBLIC OUTREACH

The 3-circle Venn diagram presented in Fig. 2 offers a conceptual framework for planning education and public outreach programs associated with scientific research programs. Each region is labeled with a letter that refers to an associated text box listing representative products or activities. A two page white paper entitled "A Framework for Planning Education and Public Outreach Programs Associated with Scientific Research Programs" by Morrow (2000) offers a more complete description of this diagram.

"Formal education" (Region A in Fig. 2) directly involves or affects student and teacher learning in the formal education system. It usually occurs in a classroom but can also be home-based via the web, TV, or the post. This form of education targets smaller audiences, where more contact time and a deeper understanding of the information is given.

By contrast, "Public outreach" efforts (e.g., educational radio, TV programs, or magazines, etc. – Region E in Fig. 2) are outside the classroom and target larger audiences. This form of communication reaches a wider public, for example in their homes or cars where they may listen to the radio. Here there is less contact time and a shallow understanding of the material is given.

"Informal education" provides strong linkages to both "Formal education" and "Public outreach". However, it typically requires a person to travel to unique settings (e.g., nature centers, museums, aquariums, zoos, national or state parks, club meetings, career fairs, eclipse locales).

Compared to formal education, individual public outreach events are generally opportunities on short-time scales that provide larger audiences with relatively new information that both excites interest and arouses curiosity. Such events are often entertaining, although they tend to retain a more substantive educational value compared to "Marketing – Region F on Fig. 2" or "News Media Support (NMS) – Region G on Fig. 2" events.

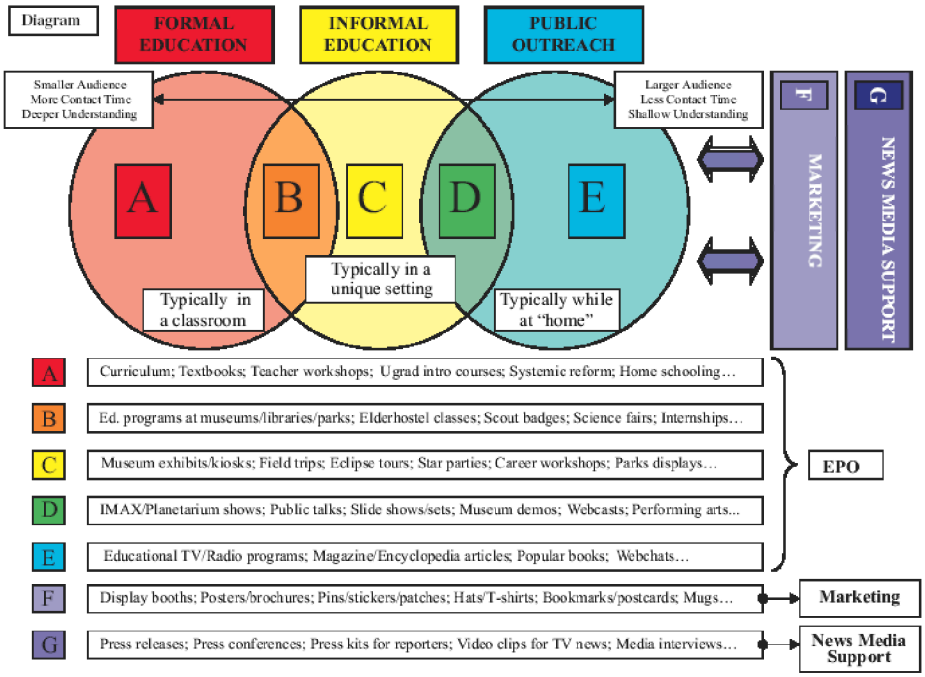

FIGURE 2. This 3-circle diagram offers a conceptual framework for planning education and public outreach programs associated with scientific programs. Courtesy of the Space Science Institute, Morrow (2000).

Marketing products and activities (e.g., brochures, posters, and conference displays/booths) are generally developed on short time scales (weeks or months). They are intended to market the worth of programs and products to targeted customers or special interest groups (e.g., teachers, aerospace or other industry, politicians, retired people, physicians).

NMS efforts are intended to inform reporters (print, radio, and television media) about the latest newsworthy events. These products often have very short deadlines (hours or days).

CAL PROJECT

The CAL Research Training Network project began in November 2002. During its four-year duration CAL members studied unanswered questions relating to TLEs, and their effects on the atmosphere. For more information regarding the science behind TLEs and results originating from the CAL project, the reader is referred to the recently published review paper by Neubert et al. (2008).

Led by the Danish National Space Center, the CAL project consisted of scientists (senior and young) from ten European institutes. As previously mentioned CAL consisted of ten scientific work-packages and two work-packages dedicated to the

training and outreach aspects of the project. Moving abroad, international collaborations, interdisciplinary scientific work (theoretical and practical) and new cultural experiences, were all part of the CAL project and are all examples of learning experiences that make people more open-minded, flexible and tolerant. As one CAL young scientist stated: "Hands-on scientific work forces people to communicate and solve problems as a group" (Crosby, 2006). In the following the training and outreach activities of the CAL project are described.

CAL Training Activities

Educational activities in the CAL project were based on the following four elements: 1.) National Ph.D. programs, 2.) Activities at CAL- and other meetings, 3.) Observational campaigns, 4.) A dedicated "summer-school".

Twelve young European scientists, of which six were PhD students (pre-docs) and six were post-doctoral scientists, were hired through the CAL project. Because of the cross-disciplinary nature of the CAL subject matter, the young scientists were connected with groups and topics that were new to them, allowing them to apply their areas of expertise (e.g., scientific methods) to new problems.

Central elements of the CAL training activity were the two EuroSprite observational campaigns in Southern Europe: "EuroSprite2005" [19 July 2005 to 15 November 2005] and "EuroSprite2006" [1 July 2006 to 18 November 2006]. These annual observational campaigns were completely under the responsibility of the CAL young scientists. More information about the Eurosprite observational campaigns can be found in Chanrion et al. (2007) and in the following Section "TLEs and Education".

In July 2004 the NATO Advanced Study Institute (or "Summer School") on "Sprites, Elves, and Intense Lightning Discharges" was held at the University of Corsica, Corte, in Corsica, France. The summer school was organized by CAL network members and was co-sponsored by the CAL network. Most of the young scientists of the CAL network attended the "summer school" as part of their training. The summer school is described in more detailed in the following Section "TLEs and Education".

In summary, the CAL young scientists were educated in a broad range of atmospheric disciplines and in a diverse range of scientific methods, as well as in how to collaborate across disciplinary boundaries, and coordinate and implement larger collaborations. Documentation needed to organize meetings and campaigns was written with the active involvement of the young scientists. In parallel they also learned to communicate scientific results to the public, i.e. they were trained to perform outreach activities.

CAL Outreach Activities

Spectacular images of high-altitude discharges make the subject of the CAL network ideal as outreach material for the general public. Activities of the CAL outreach program included the preparation of popular/semi-popular articles, press releases, interviews, an educational web site [http://www.eurosprite.net, built in three

levels: “beginners”, “intermediate” and “advanced”], and a public CAL web site (servicing the network teams and the public).

As part of their CAL work, all CAL young scientists were required to produce educational material concerning their research for middle school levels and above. As a result each young scientist gained experience in constructing a web site, writing an “outreach” article, and giving a presentation to the general public and in schools.

In November 2006 two of the young scientists and one of the senior scientists participated in the “Communicating European Research” 2005 international conference held in Brussels, Belgium, by preparing and presenting an exhibit about CAL (see Fig. 3). For this event, a brochure about CAL was made which introduced the CAL project, TLEs in general (see Fig. 1), as well as the associated CAL training and outreach activities.

TLES AND EDUCATION

TLE research is an inter-disciplinary topic matter allowing the student to acquire both scientific (theory, data analysis and modeling) knowledge as well as practical observing experience.

The NATO ASI “Summer School” that was referred to in the previous Section was an example of a unique environment for educating people on a specific topic, in this case TLEs. The themes of TLE research are classified in four categories:

- Meteorology and intense lightning discharges needed to produce sprites, elves and blue jets
- Optical observations of sprites, elves and blue jets
- Electromagnetic radiation of intense lightning discharges and sprites
- Theory and modeling in the above categories.

The summer school utilized the following “teaching tools” to optimize learning: 1.) Thematic lectures, 2.) Tutorials (group work discussions), 3.) Experimental work (operation of optical cameras for imaging sprites), and 4.) Presentation of research studies by participants, including the young scientists (i.e. a “poster” evening).

In recent years much literature has been published on TLEs. This not only includes scientific papers, but also educational material. An important output of the above-mentioned summer school was a NATO ASI book entitled “Sprites, “Elves and Intense Lightning Discharges” targeted towards postgraduate students (Füllekrug et al., 2006). The paper “Elementary model of sprite igniting electric fields” concerns sprite theory and has been written for undergraduate students (Füllekrug, 2006). Recently, a paper targeted towards school teachers has been written on electromagnetic measurement technology “Exploration of the Electromagnetic Environment” (Füllekrug, 2009).

The most efficient way to learn how an experiment works is to actually run it yourself. A central element of the CAL training activity were the two EuroSprite observational campaigns (“EuroSprite2005” and “EuroSprite2006”), conducted in Southern Europe during the summer months. Both campaigns were organized and implemented mostly by the CAL young scientists with little assistance from the senior

scientists. The young scientists enhanced their organisational skills by sharing tasks in the preparation of the instruments and the observation schedule, by relieving one another during the four months and by performing their own nightly sprite observations. They also wrote the tutorial for performing observations and constructed the annual sprite catalogues. And they especially gained experience in learning how to solve problems when they emerge – trouble-shooting.

Sprite observing is not only for the young and senior scientists. Last summer at the "Workshop on Coupling of Thunderstorms and Lightning Discharges to Near-Earth Space", held at the University of Corsica, Y. Takahashi from Tohoku University in Japan presented results of sprite observations performed by school children. If such an experience can inspire some of these young people to consider scientific or technical careers, then one has come a long way.

SUMMARY

Education and public outreach activities are opportunities for enriching the scientific community with important tools for communicating science. By promoting such activities in the early years of a scientist's career, skills such as communications are enhanced. Scientists and engineers speak "different languages" and must learn to speak together. By working on an inter-disciplinary project the young scientist betters his/her communications skills also in this respect.

TLEs have shown to be a perfect topic to teach students both, science (theory, data analysis and modelling) knowledge, as well as technology (practical observing experience). Indeed the cross-disciplinary nature of the topic makes it ideal teaching material both at high-school level as well as at the university.

The CAL project is an example and inspiration of how a scientific research project can be a unique opportunity to provide EPO learning activities to both young and senior scientists. The objective is that these young scientists will continue pursuing EPO activities in their future careers and thus teach the next generation of young scientists their EPO skills. It is highly recommended that all research projects include training and outreach activities into their respective programs.

EPO is becoming more recognized as a value-added tool for enhancing science and technology awareness in the public. Presentations in a classroom or a public setting are not the only way for scientists to contribute to education and public outreach. There are many other roles that scientists can play in EPO that are suited to his/her own talents and interests.

FIGURE 3. The CAL exhibit presented at the "Communicating European Research" 2005 International Conference, Brussels, Belgium.

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REFERENCES

1. O. Chanrion, N. B. Crosby, E. Arnone, F. Boberg, O. Van der Velde, A. Odzimek, A. Mika, C.-F. Enell, P. Berg, M. Ignaccolo, R. Steiner, S. Laursen and T. Neubert, *Advances in Geosciences*, **13**, 3-9, 2007.
2. N. B. Crosby, "Enter the World of sprites, Jets and elves, *Science Connection*, December 2006, edition 14, (French and Dutch version).
3. D. S. Golden, 1999, available online at https://mira.hq.nasa.gov/history/ws/hdmshrc/all/main/ResultSet;jsessionid=E0294E850B15983B1062B2F843064556?m=121
4. M. Füllekrug, *Physics Education*, (in press), 2009.
5. M. Füllekrug, *American Journal of Physics*, **74(9)**, 804-805, 2006.
6. "Sprites, elves and intense lightning discharges", edited by M. Füllekrug, E. A. Mareev and M. J. Rycroft, Nato Science Series II (Mathematics, Physics and Chemistry), **225**, Springer, Dordrecht, The Netherlands, *2006*. ISBN 1-4020-4627-8
7. C. Morrow, "A Framework for Planning Education and Public Outreach Programs Associated with Scientific Research Programs", 2000, the paper is available online at

http://www.spacescience.org/education/extra/resources_scientists_cd/Source/Venn.pdf
8. T. Neubert, M. Rycroft, T. Farges, E. Blanc, O. Chanrion, E. Arnone, A. Odzimek, N. Arnold, C.-F. Enell, E. Turunen, A. Mika, C. Haldoupis, R. Steiner, T. Bösinger, O. van der Velde, S. Soula, P. Berg, F. Boberg, P. Thejll, B. Christiansen, M. Füllekrug, M. Ignacollo, P. Veronen, J. Montanya, and N. Crosby, *Surveys of Geophysics*, **29**, 71-137, 2008.
9. Y. Takahashi (private communication).