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# Exploitation, dissemination, education and outreach in the frame of the COST action ES0803 “developing space weather products and services in Europe”

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## ABSTRACT

COST (European Cooperation in Science and Technology) is one of the longest-running European frameworks supporting cooperation among scientists and researchers across Europe. Its action ES0803 “Developing Space Weather Products and Services in Europe” involves the task “Exploitation, Dissemination, Education and Outreach”. To meet the objectives of this task, we describe how we developed and maintained the *Space Weather Portal*, initiated the electronic *Journal of Space Weather and Space Climate*, took care of the scientific organization of the annual *European Space Weather Week* conference and of two schools for scientists and students from the space weather community. We also describe several dissemination projects supported by the action, which target the non-specialist in the field of space weather.

## 1. Introduction

Since its start in 2008, the COST Action ES0803 supported outreach and communication activities in the field of space weather. To make their efforts more efficient, the action members analyzed the needs, the targets and the possible ways of achieving these targets, and used this analysis to develop a communication plan. A communication plan is a flexible guide that supports effective communication. It addresses the following questions:

- To whom? – The audience or receiver,
- What? – The message you want to get through,
- When? – About timing and frequency,
- Why? – What are the objectives and what do you want to achieve,
- How? – What tools and which strategy will you use,
- By whom? – The team that will make the communication possible and especially the communicator him/herself,
- Evaluation? – Performance.

This paper links the theory of communication and a communication plan with the COST Action ES0803 and with space weather in general. We define our audiences and identify our goals. We discuss the tools and models that can be used for communication. We take a closer look at some examples of

COST Action ES0803 communication efforts. To conclude, we assess how well we performed within the goals and frame of the project.

## 2. A space weather communication plan

### 2.1. Target groups

Space weather is a multidisciplinary discipline, ranging from fundamental science to observations, applications, monitoring activities and forecasts. Space weather has an impact on a large variety of domains and even on our daily life. It poses a threat to aircraft crew and passengers because of incident energetic particles. Space weather is a concern for power companies, which fear a breakdown of their networks. Solar flares can also impact navigation systems and cause a radio blackout. Aurora is a visual impressive effect of space weather. More information about how space weather impacts our society can be found in [Bothmer & Daglis \(2006\)](#), [Lilensten & Bornarel \(2006\)](#), [Fisher & Kunches \(2011\)](#), [Lilensten et al. \(2009\)](#), [Thomson et al. \(2011\)](#), [Turner \(2012\)](#).

Space weather affects a large variety of people. In this respect, space weather communication should have a wide scope to serve a diverse audience. We categorized our audience into seven distinct groups ([Kennedy 2006](#)). The classification is

based on their background, needs and interest and was made by the members of the workgroup based on their experience with past communication activities.

1. *The non-professional and non-scientific community* includes the general public, local institutes, schools and press. The characteristics of this group are strongly linked to individual countries, languages and educational systems. Scientific jargon has to be translated into an understandable vocabulary.
2. *Young children* form a separate group. They have an open mind and a natural curiosity about the world they live in and are often particularly interested in space.
3. *The non-professionals with a strong scientific interest* include radio amateurs, amateur astronomers and solar observers. They often belong to local or national groups or societies, e.g., an amateur astronomy group, and tend to be knowledgeable and well informed.
4. The group that seeks *a scientific education* for professional reasons includes students both at undergraduate and graduate level as well as scientists who are new to the field of space weather. This group needs more in-depth but specialized education in the different space weather domains, starting at a basic level. Linguistic differences do not tend to pose an issue for this group, English can serve as the working language, and general scientific terms tend to be understood.
5. *The scientists of the space weather community* are people involved in research, instrumentation, observation or space weather applications. The main needs of this group are opportunities to bridge the gaps between the different space weather domains and platforms to share information and knowledge.
6. *The class of commercial entities* gathers companies and institutes that are identified as space weather end users. Satellite operators and companies involved in radio communication, for example, have a commercial interest in space weather applications such as space weather monitoring and forecasts. Several other commercial entities may not yet know about the possible impacts of space weather on their business and could be made aware.
7. *Political entities* like governments, national agencies, national science policy makers, and international political structures form another important group. They have an impact on which scientific research is funded and how much it is funded. These entities should be well informed about space weather, its possible effects and the research performed in this field, in order for them to recognize its importance and continue the funding for research and service development.

## 2.2. Benefits of communication

The benefits of communicating to a specific audience are the following:

- **Justification of the relevance of space weather:** Space weather may become important for the non-professional and non-scientific public when the need for relevant information arises or grows because of changing societal preferences. For example, the general public may want to know when polar lights occur. Space missions and exploration can be motivated both by scientific need and by the

desire of nations to display power (Crosby et al. 2012). The future development of space tourism may result in space weather gaining a wider importance, also commercially.

- **Education of the media professionals:** The press, part of the non-professional and non-scientific community, has the task of passing the information onto the general public. We have to make sure that they disseminate the correct information.
- **Education of and collaboration with the non-professionals with a strong interest in science:** They often perform important scientific tasks, e.g., sunspot observations for the World Data Centre for the Sunspot Index (Vanlommel et al. 2004), and meteor soundings made by radio amateurs for the BRAMS project.<sup>1</sup> This active involvement of interested citizens in the various disciplines of space weather is very valuable, and we need to foster this collaboration.
- **Attracting new students:** Undergraduate students are given a taste of science and in particular space weather. High-level space weather education is necessary for PhD students and people new to the field since they are the first in line to join the group of space weather scientists.
- **Strengthening the communication and interaction between scientists.** This is referred to as community building. A communication cell can provide the tools and platforms for scientific discussion.
- **Ensuring perennial funding:** When there is an economic and commercial interest in space weather, political entities will strengthen the environment and improve the conditions for our scientific performance – read: fund our science.

## 2.3. Tools and models used for communication

We communicate to the identified audiences with tools, techniques and tactics appropriate for each group. Possibilities are a media events, online posts, paper products, social media like twitter, Facebook, and YouTube, TV/radio/podcasts, letters, speeches, conferences, games etc. The tools and techniques used and the information conveyed, will influence the composition of the communication team. Needed are people to create the technical environment and people to do the actual communication or provide the content. The information offered can be static or dynamic. A forecast is an example of dynamic information that changes either regularly on different time scales, or upon alert. An informative text is static. The information provided through social media is per definition dynamic: information needs to be added on a regular basis otherwise you lose the interest of your audience.

A communication plan defines whether the communication will be done according to the deficit model or the dialogue model (Cheng et al. 2008). In the deficit model you disseminate in its strict meaning – this is a one-way communication from experts with knowledge to an audience. The dialogue model is a two-way communication that reflects on the experience of the public. For the dialogue model, you first have to establish a contact with the receiver. A two-way communication offers the opportunity to get feedback – in both directions: from receiver to sender and from sender to receiver. This is interactive

<sup>1</sup> <http://brams.aeronomie.be>

communication. Both models, the deficit and the dialogue model, can coexist within a communication centre.

### 3. Community building

In 2003, the space weather community in Europe started to organize itself. This resulted in the development of a concerted plan, addressing the audiences listed above. The plan aimed to build a strong basis for communication through a portal, a journal, a regular meeting and a forecasting centre. Only the first three are relevant to this article and are discussed here.

An action website was used to communicate, leaflets and articles were made to promote the action. These will be addressed in more detail below.

Community building was addressed through professional education of young and future space weather scientists. Further below we report on the organization of and output from two space weather schools.

#### 3.1. The European space weather portal

The European Space Weather Portal (ESWeP)<sup>2</sup> is an integrated website providing a centralized access point for the space weather community to share their knowledge and results. Initiated under the COST Action 724<sup>3</sup> and hosted by the Belgian Institute for Space Aeronomy (BIRA-IASB),<sup>4</sup> the ESWeP was further developed in the framework of COST Action ES0803.

The website provides information in three different formats for three different target audiences which are (i) the general public, (ii) commercial entities, (iii) scientists.

First, the portal targets the general public that has no professional link with space weather. We address the general public in their mother tongue. Scientists translated parts on a best effort basis. The European definition of space weather was translated into 56 languages. The translations were sometimes challenging as the scientists were not professional translators and English space science terminology does not always exist in other languages.

Besides the general public, the portal also addresses commercial entities. The ESWeP offers an interface to the COST Space Weather Catalogue. This catalogue is the output of the COST Action ES0803, subgroup 2.1 *Identification of current space weather resources*. The space weather community was asked to provide input. The catalogue (in English) is freely accessible and gives an overview of available space weather products. Contact between the product provider and the user has to be initiated by the user. The catalogue is accessible by registered users<sup>5</sup>.

The ESWeP is also a tool to share research experience. The website provides a showcase of a large variety of Space Weather related models. The results of these models can be accessed in both graphical and numerical formats.

The ESWeP offers forecasts and nowcasts on the plasma-pause location (developed by the Belgian Institute for Space Aeronomy, BIRA-IASB), the plasmasphere density (developed by BIRA-IASB), SEP events (developed by the University of Málaga) and geomagnetic disturbances (developed by the

University of Alcalá de Henares). These products contain information for space weather application. The forecasts and nowcasts are available for registered users. Registration is free. Actual registered users include some Regional Warning Centres of the International Space Environment Service (ISES).

Space weather research and services can only be organized efficiently with an adequate reference system. The ESWeP offers a third service for the scientific community: an online repository where professionals can upload and share their technical documents, research papers, presentations, and reference documents. The repository can provide added value to the management and dissemination of project documents. The SOTERIA (FP7/2007-2013, grant agreement no. 218816) and eHEROES (FP7/2012-2015, grant agreement no. 2844621) projects use this service. Documents can be made available either solely to the project or are open to the whole space weather community, depending on the project requirements. The repository is in general an online collection point for digital material used for scientific, informative and educational purposes.

#### 3.2. The journal of space weather and space climate

The *Journal of Space Weather and Space Climate*<sup>6</sup> was launched in October 2010. This online open access journal collects and publishes scientific results that were in the past spread through a variety of journals. It offers room to technical and programmatically papers and papers discussing outreach activities in the fields of space weather, including the scientific results of the COST Action ES0803, to the scientific community.

#### 3.3. European space weather week

Space weather is quickly growing in professionalism and becoming mature in Europe and as elsewhere. The EU 7th Framework Programme (FP7) and the Space Situational Awareness (SSA) Program of the European Space Agency (ESA) invested significantly in Space Weather. From the increasing number of space weather programs, we conclude that space weather is overall gaining in importance. Indeed, our vulnerability to its effects is increasing as our technology is getting more advanced.

This growing interest has been evident at the annual European Space Weather Week (ESWW) meetings. The ESWW is a yearly conference where scientists, users, commercial entities, students and funding agencies meet to discuss developments, services, new insights and the science policy.

The European Space Weather Week offers the opportunity for different groups to meet both formally and informally. Activities offered so far included plenary sessions, numerous splinter sessions and side events, e.g., the tutorial, the space weather fair and the debate evening. Scientists, engineers, space weather product developers, students, EU delegates etc. attended the meeting. Starting from the sixth ESWW in 2009, the COST Action ES0803 has been represented on the Program Committee (PC). The PC is responsible for the content of the ESWW. It was from this fifth week onwards, that numerous side events were organized.

The scientific program was partially predefined with several main sessions. Besides the plenary sessions the participants can apply for splinter meetings. These meetings provide the

<sup>2</sup> <http://www.spaceweather.eu>

<sup>3</sup> [http://www.cost.eu/domains\\_actions/essem/Actions/724](http://www.cost.eu/domains_actions/essem/Actions/724)

<sup>4</sup> <http://www.aeronomie.be>

<sup>5</sup> <http://www.spaceweather.eu/en/repository/show?id=463>

<sup>6</sup> <http://www.swsc-journal.org>

opportunity to meet in smaller groups and address key issues in a workshop style that compliments the formal plenary sessions. Their number doubled between the fifth and the ninth edition of ESWW.

Typically, several side events are organized during an ESWW:

- *Space Weather Tutorial and quiz.* The tutorial has grown into a diverse range of activities. The fifth and the sixth ESWW offered only two classical lectures with a concluding quiz. The tutorial of the ESWW7 was expanded to include a demonstration of the Planetrella (a polar light simulator). The ESWW8 tutorial consisted of an introduction, a sequence of four small workshops, a “Question & Answers” session and a “true or false” speed quiz. The ESWW9 program offered an even broader range of subjects: an introductory talk about the future of space weather, “Space Weather Shopping” during which participants moved in small groups from one expert to the next (six in total), a “Scientists in the Sofa” talk show where three scientists presented their passion for science, and a preview of the Battle of the Solar Titans, i.e., an online quiz that ran for the entire week. The last tutorial has been the most interactive to date. Usually around 120 people participated in the tutorial. We attracted only participants of the ESWW. However, in 2011, we had one commercial company that participated, in 2012, two journalists were present.
- At the *Space Weather Fair*, users, service providers and scientists can interact in an informal working environment. The fair is an opportunity for non-academics to present their activities and learn what exists in the field of space weather. The success of the fair has grown throughout the years with 6 stands in 2008, 7 in 2009, 12 in 2010, 16 in 2011 and 13 in 2012. A beer tasting – *Science Café* – follows the fair.
- *Contest: “The Best of”.* Young scientists competed to win the title for the best oral or poster presentation. Students are encouraged to give clear and understandable presentations that catch the attention of the audience. Each edition had about 15 applicants.
- The *First Attendees Meeting* (FAM) aimed at people new in space weather and those coming to the Space Weather Week for the first time. The meeting introduced the concept of the ESWW and took the form of a press conference with “Question & Answers”. The panel was formed by members of the scientific organizing committee on one side and the audience on the other side. The audience perceived the meeting as positive. The FAM was merged with the Space Weather Tutorial during later ESWWs.
- *The 1-h scientific debate.* The format is relatively simple: a panel, a moderator and an audience. The debate is open to the press, the public and the scientific community. Journalists joined for the 2009 and 2010 edition. The rest of the audience consisted of the ESWW participants, except for the 2011 edition where an amateur astronomer was present. 150 participants were welcomed each time. Interaction with the public was not encouraged, except for the 2012 edition. At the debate during ESWW9, almost all the input and questions came from the public.
- The *End users’ lunch* is a closed event that can be attended only upon invitation. Each year, a theme is chosen. Depending on the theme, a list of potential partici-

pants is invited for lunch. We had 18 subscriptions for the 2010 edition. The participants however did not have the desired profile. For the 2011 and 2012 edition, special care was taken to invite the users with the most appropriate background. The 2011 and 2012 editions could attract the public with interest in the subject.

- The subject of the *Keynote Lecture* is always related to the ESWW. For the ESWW8 edition, local political authorities were invited. We had the pleasure to welcome the Belgian Federal Minister of Science Policy, the Governor of Namur and the Deputy of Namur.

A Google calendar and a mobile ESWW8 and ESWW9 website with a QR code for easy online access for smart phones were developed.

The number of participants has grown steadily from 200 to 300 participants in 2011. The ESWW9 edition was so far the most successful one with 329 participants.

The COST Action ES0803 gave a new momentum to the ESWW by initiating several side events. Equilibrium was found between the main organizers: Solar-Terrestrial Centre of Excellence (STCE), ESA, COST Action ES0803 and the scientific Space Weather Communities like the Space Weather Working Team (SWWT). The content was equally balanced between science, observations, services and applications. ESWW differs from other conferences in the sense that here also political and funding issues are considered in the program.

#### 3.4. Communication tools inherent to COST Action ES0803

The COST Action ES0803 website<sup>7</sup> has been developed at the beginning of the action to provide the possibility to the action members to remotely upload documents and upgrade the content. The website was based on Plone software, an Open Source Content Management System and mainly used for internal communication. On the website, information about the action, minutes, presentations and reports were posted. The website acted also as a platform to post information about the workshops organized in the frame of the COST Action ES080.

To promote the action among a larger audience of scientists, stakeholders and the public, two articles about the action were published in American and European journals.

1. **Belehaki et al. (2009)** wrote a programmatic article at the beginning of the action. It focuses on the scientific and operational goals, on the organization of the work, and on the expected impacts at the European and the world-wide level.
2. **Belehaki et al. (2011)** wrote an article at mid-term which was published in *International Innovation*<sup>8</sup> by Research Media Ltd., an open-source journal defined as a leading global dissemination resource for the wider scientific, technology and research communities. The article illustrates the achievements so far and the vision for the future after the end of the action. Research Media Ltd. also provided a set of brochures with a printed version of the article for distribution.

The articles were published in journals, which have a solid reputation among the scientific, technological and stakeholder communities. Furthermore, because these journals publish both

<sup>7</sup> <http://www.costes0803.noa.gr>

<sup>8</sup> <http://www.researchmedia.eu>

electronically and in paper form, this guarantees the widest distribution of the information.

### 3.5. Education

Education of graduate students and young scientists was one of the goals of this COST Action. Education was performed by means of training schools, following the success of the 2006 Space Weather School organized in the frame of COST Action 724. The training schools are in general organized in close interaction with other space weather related projects, institutes, and agencies, e.g., ESA.

1. A primary goal of COST is to attract the interest of university students and young scientists. Training schools are one of the tools to fulfil this mission, as they offer the framework for scientific collaboration among the participants and teachers. Two training schools have been co-organized in the frame of the ES0803 activities:
2. First European School on Fundamental Processes in Space Weather: A Challenge in Numerical Modeling, Spineto, Italy, 2012.
3. International Advanced School on Space Weather Modeling and Applications, International Centre for Theoretical Physics (ICTP), Trieste, Italy, 2010.

The school of 2010 took place at the Abdus Salam International Centre for Theoretical Physics (ICTP) from 18 to 29 October 2010. Endorsed by ICTP as a co-sponsored activity, it has been co-funded by ICTP, the COST Action ES0803, EC FP7 SOTERIA, the Italian National Institute for Astrophysics (INAF), and the European Space Agency (ESA). ICTP provided the school secretariat, meeting rooms for the lectures, the informatics laboratory for the practica and the logistics for board and lodging for directors, lecturers and attendees.

The total number of participants was 86, including directors, lecturers, students, young scientists and ICTP associates. 62 attendees were admitted after a preliminary screening among a larger number of applications and ICTP associates, i.e., researchers from developing countries that participate in ICTP mid- to long-term research programs. In the selection process, the following aspects were carefully taken into account: the COST and EC scientific, educational and dissemination objectives, as well as the mission of ICTP, which is the initiation and implementation of various schemes of support and assistance to scientists from developing countries, and good practices like gender balance. This led to the following percentages: (a) Gender: 56%, Males, 44%, Females – (b) Nationality: 53% Non-EU; 47% EU. Twenty-four lecturers (75% Males, 25% Females; 96% EU, 4% Non-EU) were invited.

The program of the School was tailored to provide fundamental knowledge on space weather science and modelling, whereas a series of computer-based practica offered hands-on experience with space weather forecasting, modeling, and applications. During the closing session, the participants expressed a very positive evaluation of the school. However, the students would have liked to see more exercises being carried out during some practica. The students also asked for a possibility to present their work, e.g., through poster presentations.

Information on the program, a list of lecturers and sponsors can be found on the ICTP web site<sup>9</sup>. The lecture notes were also

put online. The participants and lecturers received these also on a CD-ROM. In this way, the content of the lectures was disseminated and available after the school had finished.

The second school took place in Spineto, Italy, from 4 to 9 June 2012. Also here the concept was that such an advanced school is co-organized by projects and institutes with the relevant know-how and facilities. In this case it was the Space Weather Integrated Forecasting Framework<sup>10</sup> (SWIFF), Centro Interuniversitario per il Calcolo Automatico<sup>11</sup> (CINECA) and the COST Action ES0803.

The school addressed PhD students and young researchers with a background in plasma physics. Participants were introduced to the theory of fundamental processes in plasma physics like magnetic reconnection, instabilities in space and turbulence. It gave an overview of the most important numerical models in plasmas, using the fluid and kinetic approach and their implementation on the largest computing resources available today in Europe. Free time at CINECA supercomputers was offered to selected projects.

Out of 50 applications submitted, the School Committee selected 35. The COST Action ES0803 supported the participation of 12 attendees.

This school focused on modelling and numerical simulation of space weather processes, which made it complementary to the Trieste school. The latter was instead devoted to providing a broader overview at the expense of a smaller level of detail. Furthermore, modelling and numerical simulation techniques are key aspects of the state-of-the-art space weather forecasting. Hence this school represented a fundamental building block in high-level education and dissemination among young scientists.

## 4. Outreach to the non-specialist

In Europe there is growing acknowledgment of the importance of public engagement. Communication with non-specialists has often only been done on a local or national scale due to the hindrances imposed by linguistic and institutional borders. This COST action can offer ideas for national and international activities. The repository of the ESWeP acts as a platform to gather digital material like presentations and movies. Within the COST Action ES0803, two outreach activities with an international collaborative nature were set up:

1. “*I love my Sun*” is an educational project for children between 7 and 11 year. The main objective is to make children aware of space weather, the Sun, Sun-Earth relations and how they are part of this global picture. The project is discussed in [Tulunay et al. \(2013\)](#).
2. The *Planeterrella* project, a demonstrator of the polar lights, goes beyond outreach for the non-specialist and school children. The project also incorporates science and training facilities for scientists. The history and the goals of the experiment and international collaborations are presented in [Lilensten et al. \(2013\)](#).

The COST community supports national public engagement activities, both one-off events and events that occur over a longer time frame or are repeated.

We mention the following one-off activities organized by members of the COST Action ES0803: contribution to

<sup>10</sup> <http://www.swiff.eu>

<sup>11</sup> <http://www.cineca.it>

<sup>9</sup> [http://cdsagenda5.ictp.trieste.it/full\\_display.php?ida=a09174](http://cdsagenda5.ictp.trieste.it/full_display.php?ida=a09174)

nationally organized activities like “University for all”, “Open university”, “Researchers’ Night”, “Space Week”, “Festival of Science”, “Science Picnic”, satellite technology days, open doors of an institute or research centre, invited talks for national astronomer groups, educative presentations and workshop in schools, lectures, online publications of stories of common interest with a scientific undertone, press releases, publication of books or contribution to a book (examples: Mierla 2010; Popovici 2010), answering questions from the general public and the press, and interviews for radio and television. These single event examples address the non-professionals, schools and non-professionals with a strong interest in science. The aim is to popularize science and make it accessible and interesting.

The long-term projects include *Proba2@school*. This project was initiated in 2010 and is still ongoing. It was developed in collaboration with the Vliebergh-Senciecentrum (VSC), which is part of the “Academisch Vormingscentrum voor Leraren” – “Academic educational centre for teachers” of the KU Leuven, Belgium. The centre offers teachers and representatives of educational studies the opportunity to follow extra courses to keep up with new developments in the field of education and scientific research. The goal of the project was to capture the attention of teachers in high schools in Flanders and to give them information about space weather and the PROBA2 satellite.

Two-way communication is very important for the project, and teachers have been active in shaping the project. The presentations and workshops for the students given by the outreach officers of the STCE are also interactive.

In the framework of the PROBA2 project, we published a booklet for teachers in Dutch: *Ruimte weer waarnemen met een Belgische satelliet – A view on space weather with a Belgian satellite* (D’Huys & Vanlommel 2010) containing information on space weather and on the spacecraft. The information found in the brochure was also presented orally to the teachers, followed by a discussion on their comments, requirements and wishes.

In the second phase, we worked together with the interested teachers to develop concrete courses and exercises for students of the third grade, age 16–18. Several applications are possible in statistics, mathematics, physics and geography. A master student in mathematics at KU Leuven, Berdien Peeters developed such a course on mathematical applications in the framework of her master thesis *Wiskunde achter detectie van zonnephenomenen op basis van satellietbeelden. Projecten in de derde graad van het secundair onderwijs – Mathematics behind the detection of solar phenomena by satellites, projects for the 3rd grade of high schools* (Promotor: Prof. Dr. Dirk Janssens, mentor: Katrien Bonte)

Three schools asked to organize a dedicated PROBA2@school project day for their 3rd grade students. While the program was adapted to fit the needs of each student group and school, it consisted typically of a 10-min introduction to space weather, three parallel workshops and a 10-min interactive quiz to conclude. The 20-min workshops were held in smaller groups. Depending on the on-site facilities and the person available to lead a workshop, we chose between five themes: PROBA2, space weather prediction, solar flare prediction, calculation of the speed of solar wind structures and calibration and image processing. One school visited the STCE, which gave the students the opportunity to also visit the PROBA2 Science Centre and receive a guided tour of the solar telescope.

Another long-term activity is the Flemish interdisciplinary educational project “Junior College”, organized by the University of Leuven (KU Leuven). It provides challenging courses for high school students in their last year. The aim is to bridge the gap between high school and university and to spark the interest in science.

Among other sciences, Junior College provides material for courses in mathematics related to diverse themes. A new inspiring course is *Mathematics behind the observation and detection of Space Weather phenomena*. This work is an initiative of a PhD student, Katrien Bonte from the Centre for mathematical Plasma- Astrophysics (CmPA, the Department of Mathematics, KU Leuven) as a side-result of her research. The course was developed in collaboration with the Junior College team.

The project offers a closer look at mathematics behind the detections of Coronal Mass Ejections (CME’s) on one hand, and behind satellite data processing on the other hand. These two modules deal with the transformation of co-ordinate systems, the Hough transform, projective geometry, matrix transformations, etc. Through the online Junior College platform, Geogebra applets are provided to the students to get an optimal feeling of the mathematical operations.

The Junior College course was launched in March 2012. Nine schools subscribed, which suggests that we reached more than 150 students. The participating students and their teachers were invited to the university for an introductory seminar on space weather, given by colleagues of the STCE. After being immersed in the world of space weather, students and teachers then received all material (Bonte et al. 2012) needed for 15 h of mathematical classes. Towards the end of the project (end of May 2012), the participating schools were invited to a closing seminar, again at the university. This seminar was about numerical simulations in space weather research, another example of applied mathematics in this context.

The feedback received from the participating schools during a first evaluation in June 2012 was very positive. The larger number of subscriptions for the academic year 2012–2013 confirms the success of the project. The message has been clear: space weather is an attractive science to further investigate and an increasingly actual topic.

The COST Action ES0803 also supported different initiatives that are still ongoing after the closure of the action. We mention “Gouttes de Science” (Drops of Science), whose aim is to provide 90 s animated TV shows, each explaining one scientific idea. The first demonstrator discussed the magnetic field and its relation to space weather. The intention is to get this show broadcasted on a national TV channel in France during primetime. French scientific institutions, e.g., CNRS, INSERM support this initiative. The COST Action ES0803 served as a brainstorming forum for this project.

## 5. Conclusions

Many European scientists have not been actively participating in public engagement. In spite of efforts by different governing bodies (Davison et al. 2008), the efforts in this field almost completely depend on personal interest and enthusiasm. Science communication is a full-fledged job. A vision on science communication is still missing. Science communication is often limited to communication to the non-specialist. But communication should not be restricted solely to this group; it should consider a wide range of different target audience groups. It

is vital to establish a focused communication venue containing a valuable message which is promoted using the correct tactics, tools and evaluation methods and which involves dedicated specialists with communication skills, knowledge about the content, and IT & PR support. For efficient and broad communication a team is required. Communication is a demanding and time-consuming effort with specific and specialized tasks. It is impossible for one person to reach all audiences involved, for that a communication team is needed. Each member of this team should perform specific tasks.

During the last decade, space weather has gained more prominence in the media. At the same time the very nature of the media is changing and developing, with information being provided almost instantly over the Internet. This has created a unique challenge and opportunity for scientists; we can engage with the public and communicate our science clearly and correctly to them at any moment. Such science communication has many advantages, not least the opportunity to influence public opinion and the opinion of policy makers, government institutions and politicians.

The message that scientists wish to communicate needs to be formulated with a target audience in mind. The communication is done with the appropriate tactics and tools. The final goal is to clarify and emphasize the importance of space weather for that particular audience. A focused message is the key to get a maximal transfer of information.

COST Action ES0803 devoted a full working group to this task. The European Space weather portal, the COST Action ES0803 web site, the Journal of Space Weather and Space Climate, publicity for the COST Action ES0803, the series of European Space Weather Week conferences, training schools, and outreach activities to the non-specialist were deliverables of the workgroup “Exploitation, Dissemination, Education and Outreach”.

We list the strengths of the deliverables that have been completed in the frame of this action:

- The European Space Weather Week received a boost from the COST involvement: additional events such as the space weather tutorial, the space weather fair, and the debate were organized, the number of splinters sessions and participants grew.
- The Journal of Space Weather and Space Climate is an achievement of the COST Action ES0803. It is a scientific journal, with a unique scope that also covers technical, data and outreach-related papers.
- The goal “Education of graduate students and young students” was met through the organization of two training schools on space weather. The topics addressed were relevant to the COST Action ES0803. The schools were well received by the students as can be concluded from their feedback.
- The European Space Weather Portal is a service provided to the scientific community offering space weather applications and tools. In particular the scientific repository crossed the boundaries of the COST Action ES0803 as other projects, e.g., FP7 SOTERIA and FP7 eHEROES make use of this free service. Besides this, the ESWeP repository is also an online collection point for digital outreach material.
- Within their local environment, members of the COST Action ES0803 organized a large number of outreach activities aimed at the non-professionals. These activities

were local and national initiatives and not coordinated on a European level. The Planeterrella project, however, became an international public-outreach project. The Planeterrella turned out to serve educational goals as well as scientific goals. The project benefited from the collaborative goals of the COST Action ES0803. The other example of an international initiative is the “I love my Sun”-project at elementary schools.

Areas where there is scope for improvement include:

- The European Space Weather Portal could target better the scientific community, while another website provides relevant and understandable information for the non-professional. Each audience needs a specific approach. A website needs to be maintained and updated regularly. Dedicated people are needed to do this. The public may be involved, e.g., amateur astronomers could provide content about subjects that lie in their field of interest.
- Further effort could be made to set up tools to share documents and experiences on national outreach activities. A complete European coordination is not possible, but the actions such as COST Action ES0803 could serve as a pool for ideas and material.

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