United Nations A/AC.105/1026

General Assembly

Distr.: General
6 December 2012

Original: English

Committee on the Peaceful Uses of Outer Space

Report on the United Nations/Austria Symposium on Data Analysis and Image Processing for Space Applications and Sustainable Development: Space Weather Data

(Graz, Austria, from 18 to 21 September 2012)

I. Introduction

A. Background and objectives

1. The Third United Nations Conference on the Exploration and Peaceful Uses of Outer Space (UNISPACE III), in particular through its resolution entitled "The Space Millennium: Vienna Declaration on Space and Human Development", recommended that activities of the United Nations Programme on Space Applications should promote collaborative participation among Member States, at both the regional and international levels, in a variety of space science and technology activities, by emphasizing the development and transfer of knowledge and skills to developing countries and countries with economies in transition.[1]

2. At its fifty-fourth session, in 2011, the Committee on the Peaceful Uses of Outer Space endorsed the programme of workshops, training courses, symposiums and expert meetings related to the socioeconomic benefits of space activities, small satellites, basic space technology, human space technology, space weather and global navigation satellite systems (GNSS) to be held in 2012.[2] Subsequently, the General Assembly, in its resolution 66/71, endorsed the report of the Committee on the work of its fifty-fourth session.

[1] *Report of the Third United Nations Conference on the Exploration and Peaceful Uses of Outer Space, Vienna, 19-30 July 1999* (United Nations publication, Sales No. E.00.I.3), chap. I, resolution 1, sect. I, para. 1 (e)(ii), and chap. II, para. 409 (d)(i).

[2] *Official Records of the General Assembly, Sixty-sixth Session, Supplement No. 20* (A/66/20), para. 80.

V.12-57887 (E) 160113 170113

3. Pursuant to General Assembly resolution 66/71 and in accordance with the recommendations of UNISPACE III, the United Nations/Austria Symposium on Data Analysis and Image Processing for Space Applications and Sustainable Development: Space Weather Data was held in Graz, Austria, from 18 to 21 September 2012. The Austrian Academy of Sciences hosted the Symposium on behalf of the Government of Austria.

4. Organized by the United Nations, the Austrian Academy of Sciences and Joanneum Research, and supported by the Austrian Federal Ministry for European and International Affairs, the European Space Agency (ESA), the Austrian state of Styria, the city of Graz and Austrospace, the Symposium was the first in a new series of symposiums designed to address space-based data analysis and workflows, the status of data availability and data-sharing, and relevant opportunities, with a view to facilitating better and easier access to such data and resulting analytical products for general and wide-scale scientific benefit and in support of decision-making processes.

5. As 2012 saw the successful conclusion of the United Nations Conference on Sustainable Development, as well as intense discussions in the United Nations framework for the development of a post-2015 global development strategy, this new series of symposiums will consider how the availability and analysis of various space-based data could support that global development agenda, and how they could help address or monitor the various sustainable development goals and targets set by the United Nations and its Member States in achieving sustainable development globally.

6. The objective of the symposium was to consider space weather science and related data analysis in the light of the expected period of maximum solar activity in the 2012-2013 period and in connection with the successful International Space Weather Initiative to build and promote observation, understanding and prediction of space weather phenomena.

7. The International Heliophysical Year 2007 provided a successful model for the deployment of arrays of small scientific instruments (such as magnetometers, radio antennas, Global Positioning System (GPS) receivers, all-sky cameras and particle detectors) in new and scientifically interesting geographic locations to provide for global data collection on heliospheric phenomena; more than 70 countries were involved in the Initiative during a two-year period from February 2007 to February 2009. Scientists from many countries now participate in the data collection, analysis, and publication of scientific results based on these instruments. Some of that work was highlighted at the Graz symposium, ensuring also that the recommendations agreed upon at that symposium were closely linked to the outcomes of the concluding workshop on the International Space Weather Initiative, held in Quito from 8 to 12 October 2012 (see A/AC.105/1030).

8. The present global distribution of the above-mentioned instruments is available from the website of the International Space Weather Initiative secretariat (www.iswi-secretariat.org) in the form of tables giving location names and accurate geographic positioning. Tables arranged by instrument array were also to be compiled and made available to the delegates attending the fiftieth session of the Scientific and Technical Subcommittee in a conference room paper, in order to better highlight the extent and success of the efforts to improve data availability in

the context of the International Space Weather Initiative, at a time when the Initiative was concluding its activities.

B. Programme

9. The programme of the Symposium was prepared based on the submitted abstracts selected for presentations, with a programme committee established early in the preparation phase. After a formal plenary opening session, a series of technical presentations by experts renowned in the field of space weather data analysis were grouped into plenary presentation sessions, with sufficient time set aside for discussions and for other short presentations by participants on their relevant activities.

10. During the opening session of the Symposium, statements were made by representatives of the Institute for Space Research of the Austrian Academy of Sciences (on behalf of the host institution), the Austrian Federal Ministry for European and International Affairs, the city of Graz, ESA and the Office for Outer Space Affairs.

11. Following the formal opening of the Symposium, keynote addresses were delivered by experts from the National Aeronautics and Space Administration (NASA) of the United States of America, the International Center for Space Weather Science and Education of Kyushu University in Japan, ESA, the Office for Outer Space Affairs and the Norwegian Space Centre. The presentations provided an introduction to space weather, an overview of the objectives of and the topics to be addressed by the Symposium, an update on developments with regard to space weather observations and data collection, and information on international collaboration and ongoing efforts.

12. The presentation sessions were organized to provide a review of the worldwide space weather data collection instrument arrays and other data sources, as well as of data and analysis tools and any availability issues, and to consider data access and sharing issues; established collection, storage and analysis standards; and the resulting analytical products. The selected speakers, who came from developed and developing countries, presented papers and a few posters. Ample time was planned for questions and answers or discussions at the end of each presentation session.

13. In addition to the various technical presentation sessions, time was allocated on the third day of the Symposium, in a workshop format, for a series of hands-on exercises, training sessions and demonstrations of relevant software tools. The trainers from the International Center for Space Weather Science and Education provided hands-on training in use of the Magnetic Data Acquisition System (MAGDAS) for data analysis, and also presented metadata tools. The representative of ESA provided an overview and a demonstration of the new ESA space weather data portal and its various functionalities, inviting all participants to test it by creating accounts and then providing feedback.

C. Attendance

14. Scientists and data analysis experts from developing and industrialized countries from all economic regions were invited by the United Nations and the local organizers to participate in and contribute to the Symposium. Participants were selected based on their scientific background and their experience, as well as on the proposed presentation topics and their relevance to space weather data collection or analysis. Selected participants held positions at universities, research institutions, national space agencies and international organizations. The preparations for the Symposium and the selection of participants were overseen and carried out by an international honorary committee, a programme committee and a local organizing committee.

15. Funds provided by the United Nations, the Government of Austria through the Federal Ministry for European and International Affairs, ESA, the state of Styria, the city of Graz and Austrospace were used to cover the travel, accommodation and other costs of participants from developing countries. Based on the available funds, 17 participants were selected for such travel support. A total of 47 experts in space weather attended the Symposium, joined at times by several students and additional staff members of the host institution.

16. The following 20 Member States were represented at the Symposium: Austria, Bulgaria, Burkina Faso, Canada, Croatia, Egypt, Ghana, India, Iraq, Japan, Kenya, Nigeria, Norway, Romania, Russian Federation, Rwanda, Slovakia, United States of America, Viet Nam and Zambia.

II. Summary of presentations

17. Copies of the presentations made during the Symposium were made available to all participants and subsequently posted on the International Space Weather Initiative website (http://iswi-secretariat.org).

18. On the first day, presenters gave an overview of the United Nations Basic Science Initiative (UNBSSI), with an emphasis on the participation and contributions of Japan. UNBSSI was an activity that focused on data analysis, and which had led to the establishment of United Nations-affiliated regional centres for space science and technology education, the donation of telescopes and planetariums by the Government of Japan, the build up of instrument arrays, and the collection, sharing, analysis and publication of data on space weather.

19. Contributions of the International Heliophysical Year 2007 and the International Space Weather Initiative to Africa were also presented. These had resulted in over 17 magnetometers (MAGDAS and the African Meridian B-field Education and Research (AMBER) instrument array), more than 25 GPS receivers (the Scintillation Network Decision Aid (SCINDA) and others) and well over 50 ionospheric RF sounders (Sudden Ionospheric Disturbance (SID) monitors and the Atmospheric Weather Educational System for Observation and Modelling of Effects (AWESOME)) being deployed across the continent, offering capabilities for data analysis and allowing for graduate study opportunities and capacity-building through many African universities.

20. Presentations followed on analysing the equatorial region night-time F-region currents using Challenging Minisatellite Payload (CHAMP) satellite data, on Halo coronal mass ejections as huge explosive solar phenomena and their neural network model-based analysis, as well as on space weather in extrasolar planetary systems.

21. On the second day, topics covered included the analysis of radiation effects data and radio emissions and radio bursts, analysis using satellite data and ground-based data on space weather phenomena, data analysis tools and specific instrument-based investigations. New project developments such as a space-based riometer were also introduced.

22. The discussion following those presentations touched upon the difference between online data used for immediate forecasting and other data archives that were used for building new physical models and improving forecast tools. Operational space monitoring systems geared towards online forecasting were not presented at the Symposium.

23. It was agreed that the results of analysis using different models should be easily comparable, and that sources of online space monitoring data should be well known and more easily accessible. Metadata from physical models should also be easily accessible not only for the scientific community but also for private companies from the related business sectors, while it was important to consider ways of merging and integrating data from different locations. Ultimately, prediction accuracy was a very important factor for any operational monitoring, and the quality of the data and results should be routinely monitored before such results were provided to end users. The main recommendations for each discussion are presented at the end of the present report.

III. Current distribution of the International Space Weather Initiative instrument arrays as operational data sources

24. The Symposium took note of the number and distribution of deployed space weather instruments, which now belonged to 16 instrument arrays in 98 nations. The full list of instruments and their geographic distribution (location coordinates) was also to be presented to the Scientific and Technical Subcommittee at its fiftieth session in a conference room paper highlighting the wide geographic spread and diversity of the arrays and their importance as sources of space weather observations.

25. Since the preparations for the International Heliophysical Year 2007 started in 2005, followed by the activities related to the International Space Weather Initiative from 2010 to 2012, these space weather instrument arrays (presented in more detail in document A/AC.105/1030) became operational, enabling extensive data collection, archiving and data access for scientific purposes that led to significant developments in data analysis and data modelling for predictions and forecasts.

26. These instrument arrays are deployed based on specific instrument concepts and can be grouped into four classes: solar telescope network, ionospheric network, magnetometer network and particle detector network. To date, these established networks compose the mentioned 16 arrays, with nearly 1,000 individual operating

instruments in place and their locations accurately reported by operators. The arrays are described in the table below.

Table
Instrument arrays

Instrument array	*Instrument provider*	*Description*
AGREES: African GPS Receivers for Equatorial Electrodynamics Studies	United States	Contributed to understanding unique structures in the equatorial ionosphere, low/mid-latitude plasma production and the effect of ionospheric and plasmaspheric irregularities on communications.
AMBER: African Meridian B-field Education and Research	United States	Increased understanding of low-latitude electrodynamics, ultra-low-frequency (ULF) pulsations and the effect of Pc5 ULF waves on the MeV electron population in inner radiation belts.
AMMA: African Monsoon Multidisciplinary Analyses	France	Increased the number of real-time dual-frequency GPS stations worldwide for the study of ionospheric variability and the response of the ionospheric total electron content during geomagnetic storms over the African sector.
AWESOME: Atmospheric Weather Electromagnetic System for Observation and Modelling and Education	United States	Facilitated research on lightning, sprites, elves and their relation to terrestrial gamma ray flashes, whistler-induced electron precipitation and conjugate studies.
CALLISTO: Compound Astronomical Low-cost Low-frequency Instrument for Spectroscopy and Transportable Observatory	Switzerland	Studied the magnetic activity of a wide range of astrophysical objects, with an emphasis on the Sun and cool stars.
CHAIN: Continuous H-alpha Imaging Network	Japan	Observed solar activity, flares, filaments and filament eruptions.
CIDR: Coherent Ionospheric Doppler Receivers	United States	Deployed to tomographically reconstruct the ionosphere and to provide input to data assimilation models.
GMDN: Global Muon Detector Network	Japan	Operated to identify the precursory decrease of cosmic ray intensity that takes place more than one day prior to the Earth-arrival of shock driven by an interplanetary coronal mass ejection.
MAGDAS: Magnetic Data Acquisition System	Japan	Studied the dynamics of geospace plasma changes during magnetic storms and auroral substorms, the electromagnetic response of the iono-magnetosphere to various solar wind changes and the penetration and propagation mechanisms of DP2-ULF range disturbances.
OMTIs: Optical Mesosphere Thermosphere Imagers	Japan	Recorded the dynamics of the upper atmosphere through nocturnal airglow emissions.

Instrument array	*Instrument provider*	*Description*
RENOIR: Remote Equatorial Night-time Observatory for Ionospheric Regions	United States	Studied the equatorial/low-latitude ionosphere/thermosphere system, its response to storms and the irregularities that can be present on a daily basis.
SAVNET: South American Very Low Frequency Network	Brazil	Studied the South Atlantic Magnetic Anomaly region at low ionospheric altitudes and its structure and dynamics during geomagnetic perturbations.
SCINDA: Scintillation Network Decision Aid	United States	Studied equatorial ionospheric disturbances to aid in the specification and prediction of communications degradation owing to ionospheric scintillation in the Earth's equatorial region.
SEVAN: Space Environmental Viewing and Analysis Network	Armenia	Operated to improve short and long-term forecasts of dangerous consequences of space storms.
SID: Sudden Ionospheric Disturbance Monitor	United States	Facilitated research on lightning, sprites, elves and their relation to terrestrial gamma ray flashes, whistler-induced electron precipitation and conjugate studies.
ULF-ELF-VLF: Ultra-low, extremely low and very low frequency network	Israel	Monitored geomagnetic storms, ionospheric Alfven resonances and ULF pulsations.

IV. Observations and recommendations

27. Space weather is an important influence on sustainable development, and the world increasingly relies on space technology for education, business, transportation and communications. Particle storms from space disrupt global navigation satellite systems (GNSS) and long-distance radio transmissions. Modern oil and gas drilling frequently involve directional drilling to tap oil and gas reservoirs deep in the Earth, which depends on very accurate positioning using GNSS systems. Energetic particles at the magnetic poles often force the rerouting of polar flights, resulting in delays and increased fuel consumption. Ground-induced currents generated by magnetic storms cause extended power blackouts and increased corrosion in critical energy pipelines. Atmospheric effects of solar activity create drag on satellite orbits and alter the distribution of space debris.

28. Significant scientific progress was made over the past decade in developing physics-based space weather models. These models have been data-starved, however, limiting their accuracy. Guaranteed and continuous space weather data streams for proper analysis and modelling are therefore crucial.

29. The International Heliophysical Year 2007 and the International Space Weather Initiative have made significant progress in the installation of new instrumentation for the understanding of the impact of space weather on Earth's upper atmosphere, generating the needed new data streams that were useful for forecasting previously unobserved space weather in certain regions.

30. Nevertheless, the participants of the Symposium noted, as they had in earlier forums, that many crucial areas of the globe remained poorly instrumented despite the very successful work done during the period of the International Space Weather Initiative, and that many developing nations were ideally located to fill those continuing critical gaps. Also, the Initiative was largely designed as a research programme, and therefore most of the instruments and host institutions could not and cannot provide data in an operational manner. This was therefore an area of further consideration as space weather efforts continued to grow and evolve, and as data access needs for various analysis purposes continued to increase.

31. The participants of the Symposium therefore recommended that:

(a) A future Symposium could explore in detail the costs and impact on infrastructure of space weather, in order to better define its overall societal impact, referencing also existing reports, results and evaluations such as those provided by the National Academy of Sciences and the Federal Emergency Management Agency of the United States or the conclusions of the international conference on space weather and its challenges for modern society, held in Oslo from 22 to 24 October 2012;

(b) The scientific community should work with existing virtual observatories, e.g. those which gather solar, heliospheric, ionospheric and magnetic field data, to improve data archiving and access;

(c) The scientific community, supported by relevant authorities, should continue to develop harmonized tools for data archiving and discovery;

(d) Data collection stations and instruments should be networked for more real-time access and continuous data acquisition. Any support provided by Governments, telecommunications providers and other donors in resolving access to adequate power supply and Internet connectivity, where needed, should be encouraged. Data mirroring, with good data documentation and metadata on all datasets, was advisable;

(e) All data related to space weather should be made available to the scientific community as openly and freely as possible and through standard means of access services, which should include the development and provision of improved metadata, ultimately enabling better forecasts;

(f) The use of solar power as an efficient power supply for continuous data collection should be widely recognized, and the use of power-saving equipment for instrumentation should be widened to create more efficiency, as Internet connectivity, both wired and wireless, was improving globally, making real-time access to data easier;

(g) Further training of local scientists and space weather instrument operators was needed to ensure that local expertise was available in a cost-efficient way for maintenance and troubleshooting, when necessary, with the possibility of providing regional assistance, if needed. Good practices, such as summer schools operated under the International Space Weather Initiative, the Scientific Committee on Solar-Terrestrial Physics and the Magnetic Data Acquisition System, already existed and should be recognized, as well as expanded upon;

(h) Continuity of operation should be ensured for important sensors and instrumentation, such as the Solar and Heliospheric Observatory (SOHO), the Geostationary Operational Environmental Satellite (GOES) and the NASA Advanced Composition Explorer (ACE);

(i) Online courses and e-learning tools should be developed for working with space-weather-related satellite imagery and other solar data;

(j) More low-cost spacecraft to carry more tools and sensors for calibration and increased observation capacity should be considered;

(k) Since many models for data analysis existed, often for online use, there was a need to take a better inventory of them for an easily accessible global "repository", with regional analysis centres taking the lead;

(l) Testing prediction accuracy could be an intermediate step between research and operational models, as some models had the potential for operational prediction capability;

(m) Reference stations of the African Geodetic Reference Frame (AFREF) project and the Preparatory Commission for the Comprehensive Nuclear-Test-Ban Treaty Organization could be enlisted for data collection, considering dual-purpose stations; the build-up of national networks by AFREF was to be encouraged;

(n) There was a need to list all web resources on data discovery and access, such as the ESA space weather data portal presented at the Symposium. The secretariat of the International Space Weather Initiative and/or the Office for Outer Space Affairs could take the lead in that regard;

(o) Iridium next-generation and other spacecraft payload opportunities should be considered for carrying new instruments for space weather observation. That required instruments to have already been developed when an opportunity arose, and therefore budgets for their design and preparation in advance would be needed;

(p) Donor mechanisms might exist for supporting further global instrumentation expansion and maintenance work, where needed, and therefore such opportunities should be explored;

(q) The development of a database of damages resulting from solar weather events should be considered, both for awareness-raising and in support of further investment in observations.

32. The participants also recommended that the next symposium in the series should continue to focus on space weather data and address the status of instrument arrays, the availability of collected data and space weather data modelling. The United Nations/Austria Graz Symposium in 2013 could thus provide a good venue for further space weather science cooperation, as a follow-up to the successfully completed International Space Weather Initiative.

V. Conclusions

33. The multitude of space-weather-related workshops and conferences during 2012 indicates that space weather is a topic of exponentially growing interest in

many nations, especially those operating satellite resources. Coupled with concern about the possible wide-ranging societal impacts that space weather phenomena could cause, this has created a need to better understand and predict such events.

34. The Symposium, by also bringing together data analysis experts and instrument hosts from around the world, contributed successfully to highlighting that need and proposing a good number of recommendations to be considered by the scientific community and relevant decision makers, including recommendations related to addressing issues of continuity of operations, sustainability of data collection networks and continued focus on space weather research.

35. It is seen as very important therefore to develop a science and technology programme at the international level, with adequate United Nations support, following the successful model of past multi-year initiatives such as the International Space Weather Initiative.