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Committee on the Peaceful Uses of Outer Space

Report on the United Nations/Ecuador Workshop on the International Space Weather Initiative

(Quito, 8-12 October 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 the international level, 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 socioeconomic benefits of space activities, small satellites, basic space technology, human space technology, space weather, global navigation satellite systems and search and rescue planned 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.

3. Pursuant to General Assembly resolution 66/71 and in accordance with the recommendations of UNISPACE III, the United Nations/Ecuador Workshop on the

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[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.

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International Space Weather Initiative was held in Quito from 8 to 12 October 2012. The Quito Astronomical Observatory, Escuela Politécnica Nacional, hosted the Workshop on behalf of the Government of Ecuador.

4. Organized by the United Nations, the European Space Agency (ESA), the National Aeronautics and Space Administration (NASA) of the United States of America and the Japan Aerospace Exploration Agency (JAXA), the Workshop was the twentieth in a series of workshops on basic space science, the International Heliophysical Year 2007 and the International Space Weather Initiative proposed by the Committee on the Peaceful Uses of Outer Space on the basis of discussions of its Scientific and Technical Subcommittee, as reflected in the report of the Subcommittee on its forty-seventh session (A/AC.105/958, paras. 162-173). Previous workshops in the series had been hosted by the Government of Egypt in November 2010 (see A/AC.105/994) and the Government of Nigeria in October 2011 (see A/AC.105/1018). The workshops were a continuation of the series of workshops on the International Heliophysical Year 2007 held between 2005 and 2009, hosted by the United Arab Emirates in 2005 (see A/AC.105/856), India in 2006 (see A/AC.105/882), Japan in 2007 (see A/AC.105/902), Bulgaria in 2008 (see A/AC.105/919) and the Republic of Korea in 2009 (see A/AC.105/964).[3] Those workshops were a continuation of the series of workshops on basic space science held between 1991 and 2004, hosted by the Governments of India (see A/AC.105/489), Costa Rica and Colombia (see A/AC.105/530), Nigeria (see A/AC.105/560 and Add.1), Egypt (see A/AC.105/580), Sri Lanka (see A/AC.105/640), Germany (see A/AC.105/657), Honduras (see A/AC.105/682), Jordan (see A/AC.105/723), France (see A/AC.105/742), Mauritius (see A/AC.105/766), Argentina (see A/AC.105/784) and China (see A/AC.105/829).[4] All workshops were co-organized by the International Astronomical Union (IAU) and the Committee on Space Research.

5. The main objective of the Workshop was to provide a forum in which participants could comprehensively review achievements of the International Space Weather Initiative, in terms of the status of deployment of low-cost, ground-based, worldwide space weather instruments, and further plans for the Initiative, as well as assess recent scientific and technical results in the field of solar-terrestrial interaction. Furthermore, the Workshop was to recommend ways and means of updating and upgrading the website (www.iswi-secretariat.org) and newsletter of the Initiative.

B. Programme

6. At the opening of the Workshop, statements were made by a representative of the Government of Ecuador, the Rector of the Escuela Politécnica Nacional, the Director of the Quito Astronomical Observatory, and representatives of JAXA,

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[3] Information on the International Heliophysical Year 2007 and the United Nations Basic Space Science Initiative is available on the website of the Office for Outer Space Affairs of the Secretariat at www.unoosa.org/oosa/SAP/bss/ihy2007/index.html.

[4] Details on all the workshops of the United Nations Basic Space Science Initiative organized jointly with the European Space Agency have been made available at http://neutrino.aquaphoenix.com/un-esa.

NASA and the Office for Outer Space Affairs of the Secretariat. The Workshop was divided into plenary and working group meetings. Presentations by invited speakers, describing their achievements with regard to organizing events and carrying out research, education and outreach activities related to the International Space Weather Initiative and its instrument arrays, were followed by brief discussions. Invited speakers, who came from both developed and developing countries, presented papers and posters. Poster presentation sessions and working groups provided participants with an opportunity to focus on specific problems and projects related to the International Space Weather Initiative, particularly its instrument arrays and their status of operation and coordination.

7. The Workshop focused on the following topics: national coordination of the International Space Weather Initiative, operational instrument arrays of the Initiative and distribution of Initiative instruments by country. Case studies were presented on the development and operation of instrument arrays as part of the Initiative, in particular for the benefit of developing countries and countries with economies in transition. In that regard, the Workshop was to develop elements of a resolution for the continuation of the International Space Weather Initiative beyond 2012. The Workshop was also to consolidate the large number of International Space Weather Initiative instrument arrays, as reported at previous workshops on the Initiative hosted by the Government of Egypt in 2010 (see A/AC.105/994) and by the Government of Nigeria in 2011 (see A/AC.105/1018).

8. In brief statements, organizers of and other participants in the Workshop expressed their appreciation for the long-term, substantive contributions made to the development of the International Space Weather Initiative, in particular for the benefit of developing countries, by NASA, JAXA, the International Center for Space Weather Science and Education of Kyushu University, Fukuoka, Japan, and a number of distinguished scientists.

C. Attendance

9. Scientists, engineers and educators from developing and industrialized countries from all economic regions were invited by the United Nations, NASA, JAXA, the International Committee on Global Navigation Satellite Systems (ICG), the International Center for Space Weather Science and Education of Kyushu University and the Quito Astronomical Observatory of the Escuela Politécnica Nacional, to participate in and contribute to the Workshop. Workshop participants, who held positions at universities, research institutions, national space agencies and international organizations, were involved in the implementing activities of the International Space Weather Initiative covered by the Workshop. Participants were selected on the basis of their scientific, engineering and educational backgrounds and their experience in implementing programmes and projects in which the Initiative played a leading role. The preparations for the Workshop were carried out by an international scientific organizing committee and a local organizing committee.

10. Funds provided by the United Nations, NASA, JAXA and the Government of Ecuador were used to cover the travel, accommodation and other costs of

participants from developing countries. More than 100 specialists in the International Space Weather Initiative attended the Workshop.

11. The following 20 Member States were represented at the Workshop: Argentina, Brazil, Bulgaria, Croatia, Ecuador, Egypt, France, Germany, India, Indonesia, Israel, Japan, Kazakhstan, Morocco, Nigeria, Peru, Slovakia, United States, Uruguay and Viet Nam.

II. Summary of presentations

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

III. Current status of the International Space Weather Initiative instrument arrays in operation

13. The Workshop took note of the number of deployed space weather instruments, belonging to 17 instrument arrays, in 98 countries or areas, as summarized in the table.

International Space Weather Initiative instrument distribution by country or area

Country or area	*Number of instruments*	*Type of instrument(s)*
Algeria	6	AMBER (1), AWESOME (1), CHAIN (1), GPS-Africa (1), MAG-Africa (1), SID (1)
Antarctica	2	AWESOME (1), SID (1)
Argentina	1	SAVNET (1)
Armenia	3	SEVAN (3)
Atlantic Ocean	4	SCINDA (4)
Australia	15	CALLISTO (2), GMDN (1), MAGDAS (11), OMTI (1)
Austria	2	CALLISTO (1), SID (1)
Azerbaijan	3	AWESOME (1), SID (2)
Belgium	1	CALLISTO (1)
Benin	1	GPS-Africa (1)
Bosnia and Herzegovina	1	SID (1)
Botswana	1	GPS-Africa (1)
Brazil	20	CALLISTO (2), CSSTE (1), GMDN (1), MAGDAS (2), RENOIR (2), SAVNET (6), SCINDA (3), SID (3)
Bulgaria	3	SEVAN (1), SID (2)
Burkina Faso	3	GPS-Africa (2), SID (1)
Cameroon	2	AMBER (1), SCINDA (1)
Canada	10	MAGDAS (1), OMTI (2), SID (7)

Country or area	*Number of instruments*	*Type of instrument(s)*
Cape Verde	1	GPS-Africa (1)
Central African Republic	1	MAG-Africa (1)
Chile	2	SCINDA (1), SID (1)
China	8	SID (8)
Colombia	3	SCINDA (1), SID (2)
Congo	6	SCINDA (3), SID (3)
Costa Rica	1	CALLISTO (1)
Côte d'Ivoire	4	MAGDAS (1), MAG-Africa (2), SCINDA (1)
Croatia	2	SEVAN (1), SID (1)
Czech Republic	2	CALLISTO (1), SID (1)
Djibouti	1	SCINDA (1)
Egypt	8	AWESOME (1), CALLISTO (1), CIDR (1), MAGDAS (2), SCINDA (1), SID (2)
Ethiopia	11	AMBER (1), AWESOME (1), MAGDAS (1), MAG-Africa (1), SCINDA (2), SID (5)
Fiji	1	AWESOME (1)
Finland	2	CALLISTO (2)
France	4	SID (4)
Gabon	2	GPS-Africa (2)
Germany	21	CALLISTO (2), SID (19)
Ghana	1	GPS-Africa (1)
Greece	2	AWESOME (1), SID (1)
Guyana	1	SID (1)
India	18	AWESOME (2), CALLISTO (4), CSSTE (1), MAGDAS (1), SEVAN (1), SID (9)
Indian Ocean	1	SCINDA (1)
Indonesia	7	MAGDAS (6), SID (1)
Ireland	10	AWESOME (1), CALLISTO (4), SID (5)
Israel	4	AWESOME (1), ULF-ELF-VLF (3)
Italy	34	CALLISTO (2), MAGDAS (1), SID (31)
Japan	12	CHAIN (1), GMDN (1), MAGDAS (6), OMTI (4)
Jordan	1	CSSTE (1)
Kazakhstan	1	CALLISTO (1)
Kenya	8	CALLISTO (1), GPS-Africa (1), MAGDAS (1), SCINDA (2), SID (3)
Kuwait	1	GMDN (1)
Lebanon	6	SID (6)
Libya	3	AWESOME (2), SID (1)
Madagascar	1	MAG-Africa (1)
Malaysia	6	AWESOME (1), CALLISTO (3), MAGDAS (1), OMTI (1)
Mali	4	GPS-Africa (2), MAG-Africa (2)
Mauritius	3	CALLISTO (3)
Mexico	7	CALLISTO (1), CSSTE (1), SAVNET (1), SID (4)

Country or area	*Number of instruments*	*Type of instrument(s)*
Micronesia (Federated States of)	1	MAGDAS (1)
Mongolia	13	CALLISTO (2), MAGDAS (1), SID (10)
Morocco	4	AWESOME (1), CSSTE (1), GPS-Africa (1), RENOIR (1)
Mozambique	3	GPS-Africa (1), MAGDAS (1), SID (1)
Namibia	4	AMBER (1), GPS-Africa (1), MAG-Africa (1), SID (1)
Netherlands	1	SID (1)
New Zealand	3	SID (3)
Niger	1	GPS-Africa (1)
Nigeria	26	AMBER (1), CSSTE (1), MAGDAS (3), SCINDA (4), SID (17)
Norway	1	OMTI (1)
Pacific Ocean	3	SCINDA (3)
Peru	8	CHAIN (1), CIDR (1), MAGDAS (2), SAVNET (3), SCINDA (1)
Philippines	7	MAGDAS (6), SCINDA (1)
Poland	1	AWESOME (1)
Portugal	1	SID (1)
Puerto Rico	2	SID (2)
Republic of Korea	3	CALLISTO (2), SID (1)
Romania	2	SID (2)
Russian Federation	12	CALLISTO (1), MAGDAS (9), OMTI (2)
Sao Tome and Principe	1	GPS-Africa (1)
Senegal	3	GPS-Africa (1), MAG-Africa (1), SID (1)
Serbia	2	AWESOME (1), SID (1)
Slovakia	3	CALLISTO (1), SEVAN (1), SID (1)
South Africa	21	GPS-Africa (7), MAGDAS (2), MAG-Africa (2), SCINDA (2), SID (8)
Spain	2	CALLISTO (1), MAG-Africa (1)
Sri Lanka	2	CALLISTO (1), SID (1)
Sudan	1	MAGDAS (1)
Switzerland	6	CALLISTO (5), SID (1)
Taiwan Province of China	1	MAGDAS (1)
Thailand	4	OMTI (1), SID (3)
Tunisia	3	AWESOME (1), SID (2)
Turkey	3	AWESOME (1), SID (2)
United Arab Emirates	1	AWESOME (1)
United Kingdom of Great Britain and Northern Ireland	8	CALLISTO (1), MAG-Africa (1), SID (6)
United Republic of Tanzania	3	GPS-Africa (1), MAGDAS (1), SCINDA (1)
United States of America	161	AWESOME (2), CALLISTO (2), CIDR (6), MAGDAS (2), SID (149)
Uganda	3	GPS-Africa (1), SCINDA (1), SID (1)
Ukraine	1	CALLISTO (1)
Uruguay	3	SID (3)

Country or area	*Number of instruments*	*Type of instrument(s)*
Uzbekistan	2	AWESOME (1), SID (1)
Viet Nam	2	AWESOME (1), MAGDAS (1)
Zambia	4	GPS-Africa (1), MAGDAS (1), SID (2)

14. The Workshop was informed that one MAGDAS space weather instrument would be installed in Ecuador as an immediate follow-up to the Workshop. That was done, and the instrument is now operational.

15. The Workshop also noted that a number of space weather instruments were operated at the United Nations-affiliated regional centres for space science and technology education with the support of the executive secretariat of ICG, which is located in the Office for Outer Space Affairs.

16. From 2005 to 2012, during the time when United Nations workshops have addressed the International Heliophysical Year 2007 (from 2005 to 2009) and the International Space Weather Initiative (from 2010 to 2012), the following 16 space weather instrument arrays have become operational:

AMBER: African Meridian B-field Education and Research

AWESOME: Atmospheric Weather Electromagnetic System for Observation Modeling and Education

CALLISTO: Compound Astronomical Low-cost Low-frequency Instrument for Spectroscopy and Transportable Observatory

CHAIN: Continuous H-alpha Imaging Network

CIDR: Coherent Ionospheric Doppler Receiver

GMDN: Global Muon Detector Network

GPS-Africa: African Dual Frequency GPS Network

MAGDAS: Magnetic Data Acquisition System

MAG-Africa: Magnetometers in Africa

OMTI: Optical Mesosphere Thermosphere Imager

RENOIR: Remote Equatorial Nighttime Observatory for Ionospheric Regions

SAVNET: South Atlantic Very Low Frequency Network

SCINDA: Scintillation Network Decision Aid

SEVAN: Space Environment Viewing and Analysis Network

SID: Sudden Ionospheric Disturbance Monitor

ULF-ELF-VLF: Ultra-low, extremely low and very low frequency network

IV. Observations and recommendations

17. Space weather is important to humankind, which increasingly relies on space technology for education, business, transportation and communications. Particle storms from space have disrupted global navigation satellite system (GNSS) reception and long-distance radio transmissions. Modern oil and gas drilling frequently involve directional drilling to tap reservoirs deep in the Earth, which depends on accurate positioning using GNSS systems. Energetic particles at the magnetic poles have forced the rerouting of polar airline flights, resulting in delays and increased fuel consumption. Induced ground currents generated by magnetic storms have caused extended power blackouts and increased corrosion in critical energy pipelines. Atmospheric effects of solar activity have created drag on satellite orbits and altered the distribution of space debris.

18. Space weather affects Earth's climate. For example, the seventeenth-century Maunder Minimum, a 70-year period almost devoid of sunspots, coincided with prolonged, very cold winters in the northern hemisphere.

19. Space weather is inherently an international matter. Solar and magnetic storms affect large regions of the Earth simultaneously, and equatorial ionospheric disturbances occur routinely around the world. It was therefore appropriate for the United Nations to promote improvements in space weather modelling and forecasting for the benefit of all nations.

20. Significant scientific progress was made over the past decade in developing physics-based space weather models and large-scale coupled (near real-time) space plasma simulations. However, those models were data-starved in important spatial space-weather domains, limiting their accuracy. Guaranteed continuous space weather data streams were crucial.

21. The International Heliophysical Year 2007 and International Space Weather Initiative made significant progress in the installation of new instrumentation for the understanding of space weather impacts on Earth's upper atmosphere, generating new data streams useful for space weather in regions unobserved before. With the support of the Office for Outer Space Affairs, the International Space Weather Initiative facilitated the operation of nearly 1,000 instruments operating in about 100 United Nations Member States. The data from those instrument arrays was a unique resource for the study of space weather influences on Earth's atmosphere. The International Heliophysical Year and International Space Weather Initiative schools trained several hundred graduate students and young scientists, many of whom are becoming mature scientists, as evidenced by their publications. The annual United Nations workshops on the International Space Weather Initiative facilitated instrument deployment and close international scientific collaboration. Thanks to the Initiative, many scientists in developing countries were able to develop and sustain research efforts in their own countries. Finally, pursuant to the resolution, adopted by the United Nations/Nigeria Workshop on the International Space Weather Initiative, hosted by Nigeria in 2011, the International Center for Space Weather Science and Education was established at Kyushu University, Fukuoka, Japan on 1 April 2012.

22. The participants in the Workshop noted the success of the International Space Weather Initiative/MAGDAS school, held from 17 to 26 September 2012. In

partnership with the Scientific Committee on Solar Terrestrial Physics (SCOSTEP), lectures, an instrument workshop and a teacher workshop were conducted. The International Space Weather Initiative/SCOSTEP partnership will continue for the schools in Africa in 2013 and Latin America and the Caribbean in 2014.

23. The participants in the United Nations/Ecuador Workshop therefore recommend that the International Space Weather Initiative be continued as part of the "Space weather" agenda item of the Scientific and Technical Subcommittee of the Committee on the Peaceful Uses of Outer Space, in 2013 and beyond.

24. Specifically, it is recommended that:

(a) The International Space Weather Initiative continue the operation and development of existing arrays and deployment of new instrument arrays as appropriate;

(b) The Initiative undertake a process to examine data sets to determine data utility, to develop connections with virtual observatories to make data more readily available, and to facilitate collaborative modelling of regions of interest (e.g. the equatorial ionosphere) in collaboration with modelling centres of ESA, JAXA, NASA and other appropriate entities;

(c) Data from International Space Weather Initiative instrument arrays be combined with space-based and other ground-based data to advance space weather science, leading to robust research output and scientific papers in international journals, and that the International Space Weather Initiative and GNSS communities collaborate in terms of data sharing and space weather research;

(d) The International Space Weather Initiative space science schools and the annual United Nations workshops on the Initiative continue in the future. United Nations basic space science workshops and space science schools have been an integral part of the Initiative, for the training of less experienced researchers in instrument operation and the science of heliophysics. The partnerships already established with international scientific organizations need to be strengthened to ensure that such capacity-building activities are accomplished efficiently and for the benefit of all Member States;

(e) New knowledge generated by International Space Weather Initiative activities be effectively communicated to the public and the scientific community at large via the Initiative's newsletters, its website and other media.

25. The participants in the United Nations/Ecuador Workshop on the International Space Weather Initiative noted that:

(a) The Quito Astronomical Observatory of the Escuela Politécnica Nacional of Ecuador had offered to act as a regional centre for space weather science and education;

(b) The Space Weather Monitoring Centre at Helwan University, Egypt, had offered to act as a regional centre for space weather science and education;

(c) The Centre for Basic Space Science at the University of Nigeria had offered to act as a regional centre for space weather science and education.

V. Basic space science: Sinai observatory initiative

26. The participants in the United Nations/Ecuador Workshop on the International Space Weather Initiative took note of the outcome of a meeting of the Sinai observatory initiative group that took place during the IAU General Assembly in Beijing in 2012. The group proposed to build a centre of excellence dealing primarily with astronomy to serve scientists from Western Asia. The core activity of the centre would be the operation of a first-class major astronomical telescope. The meeting proposed that the prospective location of the observatory might be Mount Saint Katherine in central Sinai, pending the conclusion of a site-testing exercise.

27. Considering the continuing efforts of the Basic Space Science Initiative of the United Nations Programme on Space Applications of the Office for Outer Space Affairs to advance observational astronomy worldwide, as expressed in the recommendations of the 1994 Workshop on Basic Space Science (A/AC.105/580), and considering the current status of development of observational astronomy in Western Asia, the participants in the United Nations/Ecuador Workshop support the advancement of observational astronomy through the establishment of an astronomical observatory as a centre of excellence, particularly for countries in Western Asia, as proposed.

VI. Heliophysics: the Nobeyama Radioheliograph

28. The Nobeyama Radioheliograph has observed the Sun since 1992, providing high-quality images useful for the subjects of solar physics, solar-terrestrial physics, space weather events and solar impact on Earth’s climate. It is a sophisticated instrument that for the past 20 years has produced high-quality interferometric images of the Sun on a daily basis. All data have been open and available for research, education and outreach purposes. A symposium was organized to mark the twentieth anniversary of the Radioheliograph in Nagoya, Japan, from 20 to 23 November 2012.

29. The Nobeyama Radioheliograph continues to make important contributions to the study of both short- and long-term variability of the Sun. It is a unique and a valuable asset that needs to be sustained for the benefit of the world scientific community.

30. The participants in the United Nations/Ecuador Workshop noted that the Nobeyama Radioheliograph was still operational but that, owing to budgetary limitations, its closing was planned for the beginning of 2014. This would be a great loss to the international space weather community, given the continuous and uniform coverage of the Sun and space weather events that the Nobeyama Radioheliograph has provided.

31. Japan has made enormous contributions to the astronomy and space science communities, and it might still be possible for Japan to continue the operation of the Nobeyama Radioheliograph on a long-term basis. The international scientific community would be grateful if the Nobeyama Radioheliograph were enabled to continue operating; the effort would be recorded as another outstanding Japanese contribution to humankind.

32. The participants in the United Nations/Ecuador Workshop on the International Space Weather Initiative strongly recommend the continued operation of the Nobeyama Radioheliograph, either by the current institution or by a new consortium of institutions.