

ESTABLISHMENT OF THE NEW ECUADORIAN SOLAR PHYSICS PHENOMENA DIVISION

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Abstract. Crucial physical phenomena occur in the equatorial atmosphere and ionosphere, which are currently understudied and poorly understood. Thus, scientific campaigns for monitoring the equatorial region are required in order to provide the necessary data for the physical models. Ecuador is located in strategic geographical position where these studies can be performed, providing quality data for the scientific community working in understanding the nature of these physical systems. The Quito Astronomical Observatory of National Polytechnic School is moving in this direction by promoting research in space sciences for the study of the equatorial zone. With the participation and the valuable collaboration of international initiatives such as AWESOME, MAGDAS, SAVNET and CALLISTO, the Quito Observatory is establishing a new space physics division on the basis of the International Space Weather Initiative. In this contribution, the above initiative is presented by inviting leaders of other scientific projects to deploy its instruments and to work with us providing the necessary support to the creation of this new strategic research center

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Introduction

There is a relatively new field of scientific research which is devoted to study the physical phenomena that take place in the atmosphere, in close connection with the Sun and its variable activity. This field has been denominated Space Science, inside of which there are a lot of interesting complex phenomena which are poorly understood and are waiting for more sensitive instruments and adequate physical models.

Fortunately, outstanding actions as the United Nations Basic Space Science Initiative (UNBSSI) through the Committee on the Peaceful Uses of Outer Space and the United Nations Office for Outer Space Affairs, for over two decades, provided tremendous support to establish regional centers for space sciences and technology education in developing countries. The United Nations initiative also played a pivotal role organizing the scientific community around the world through the realization of Space Science Schools, Symposiums and the annual United Nations workshops, as those on the basis of the International Space Weather Initiative (ISWI). These kind of scientific meetings, for sure, facilitate the communication between space science students, engineers and scientists, initiating educational programs, deploying instruments in new regions and enhancing the international cooperation in research projects.

In Space Science, one of the most interesting topics, due its general concern and direct life application, is connected with the study of the Sun influence on the Earth climate; this is the so-called Space Weather. In this context, the United Nations Space Weather Initiative (UNSWI) has congregated leading scientists from around the world to participate

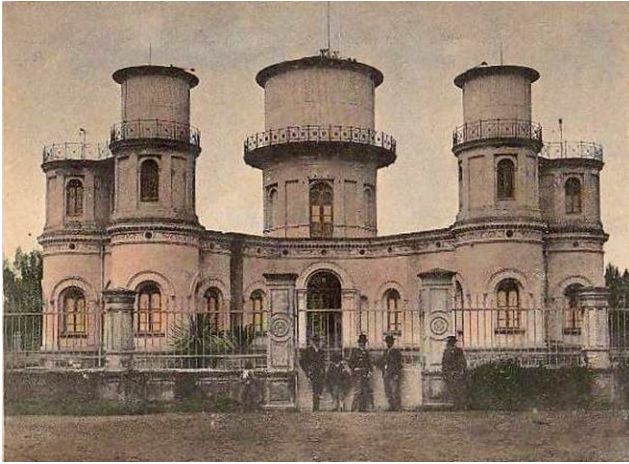
in a series of three workshops from 2010 through 2012, giving continuity to the tradition of the successful workshops on the International Heliophysical Year 2007 (IHY, 2005-2009). The first Workshop on ISWI was held in Helwan, Egypt and hosted by the Helwan University in 2010, for the benefit of nations in Western Asia. In 2011, the United Nations/Nigeria Workshop on ISWI was hosted by the Centre for Basic Space Science of the University of Nigeria at Nsukka, Nigeria, for the benefit of nations in Africa. The third ISWI workshop was hosted by the Quito Astronomical Observatory of the National Polytechnic School of Ecuador in 2012, for Latin America and the Caribbean.

Ecuador has hosted the final ISWI Workshop in which key decisions have been taken in order to give continuity to Space Science and technology research and education. We take advantage of this scientific meeting to promote space science studies in our country, starting with the creation of a new space station supported by the Quito Astronomical Observatory. This new station began to operate with the Atmospheric Weather Electromagnetic System for Observation Modeling and Education (AWESOME) instrument provided under the cooperation of Stanford University, United States of America. And, with the Magnetic Data Acquisition System (MAGDAS) instrument installed at the time of realization of the United Nations/Ecuador Workshop in 2012 and provided by the Kyushu University of Japan.

The current paper is mainly devoted to describe the establishment of this new Ecuadorian space station, named Solar Physics Phenomena, as a new division of the Quito Astronomical Observatory.

The Quito Astronomical Observatory

The Quito Astronomical Observatory is one of the oldest observatories in America. This was founded in 1873 by the Ecuadorian President Gabriel Garcia Moreno, as part of national government plan to invest resources to promote and develop education, sciences and technology, in those early days of the Republican life of Ecuador (Burgos, 2011).



QUITO — Observatorio Astronómico. (Astronomic Observatory)

Figure 1: Quito Astronomical Observatory (QAO) in its early decades (late 1899).

At the beginning, the government support was exceptional providing the necessary resources to make of this astronomical institution one of the best equipped in the world. However, after few years from its creation, the observatory fell into a deeply lack of financial support and of the governmental attention, to the point that its development and the scientific production were critically affected. This unfortunate situation, because in the country the benefits of sciences and particularly of astronomy have not been appreciated enough, was maintained along decades, being sadly reflected in the decadence and destruction of this historical observatory. The beautiful building was completely deteriorated, the old instruments and equipment were out of operation and abandoned, moreover all related physical and human aspects were unattended. A dark epoch of decadence that began soon after the first decades of the observatory founding (Lopez, 2005).

In recent times, as being part of the National Polytechnic School (since 1964), almost a decade was necessary to revert this situation and recovering the Quito Observatory. The work to re-establish this valuable astronomical heritage started in late 1996. Thanks to the dedicated and patient labor of several groups of students and technicians conducted by the dreams and persistence of a young Ecuadorian astronomer, Director of the Quito Observatory, this noble institution has been gradually restored in all of its aspects.



Figure 2: Dummies exposed in the astronomical museum: Garcia Moreno President of Ecuador (left) and the Founder of Quito Observatory; Jesuit Father Juan Bautista Menten, German astronomer, designer and first Director of QAO (right).

Nowadays, as the result of a hard and continuous work, the Quito Observatory looks magnificent, in great conditions and fully operational. Actually, this is the place, where a nascent active scientific life occurs, where young students, technicians and scientists have the serious conviction to devote their time and best efforts to make this observatory a serious and solid scientific institution, contributing to the understanding of the physical phenomena of the Universe.



Figure 3: Building of Quito Astronomical Observatory after the restoration (2010).

Currently, the Quito Astronomical Observatory activities mainly consist of three large fields: the first one is the scientific research in several areas of Astronomy, Space Sciences and Meteorology. The academic education in astronomy beside the public

courses and talks are in the second place and finally the communication with the public and outreach activities. In the following subsections these activities are described in more detail.



Figure 4: First QAO astronomical instruments, installed in 1873.



Figure 5: Meteorological instruments of the first station (1891).



Figure 6: First seismological station in Ecuador (1904), recently restored.



Figure 7: The Great Meridian Circle of the Quito Astronomical Observatory (1889)

a) Scientific activities

The research inside the Quito Observatory has been planned to be mainly within the frames of the theory and data analysis. This aspect is in close connection with the local earth-atmospheric conditions and the economic situation of the country. In Ecuador, there is no adequate place where an optical observatory can be established. The high occurrence of cloudy skies throughout the year is a serious impediment and a natural consequence of the singular topography of the Ecuadorian lands; high mountains in the cordillera surrounded by the neighbor tropical regions of the pacific coast and the eastern amazon jungle. Beside this natural phenomena, there is a permanent difficulty to raise funds from the local government; this means the necessary resources to provide adequate observational facilities. Consequently, the best choice will be to conduct the scientific institutional activities in the models and theory. However, the observational needs, mainly linked with the particular geographical position of the country on the equator line, are considered in a future project for the construction of a new radio astronomical observatory, which is designed appropriately to avoid the climate inconveniences.

The theoretical work, data processing and analysis have started with some interesting contributions inside of High Energy Astrophysics (Active Galactic Nuclei, Quasars, microquasars and Gamma Ray Burst) and cosmology (models with non-zero cosmological constant, microlensing and standard candles). In the future, new branches, as the radio astronomy and studies in the infrared region of the electromagnetic spectrum, will be incorporated.

The main idea behind the institutional plan is to organize scientific groups around leading researchers, having a large expertise and the capability to gathering students. In this way, it is expected to grow quickly and strongly with an appropriated competitive scientific level.

On the other hand, thanks to the United Nations contribution to promote the space sciences research, the Quito Astronomical Observatory has appreciated the importance to include in its institutional plan of scientific interests, the space science studies. Ecuador, located in a particular geographical position, is potentially interesting to install instruments from the International Space Science community, in order to provide a new source of valuable scientific data for the study of space weather influences on the Earth atmosphere. These actions will bring great benefit to the scientific community providing valuable information to understanding ionospheric and magnetospheric phenomena which are taking place in the equatorial zone.

b) Education in astronomy and space science.

Unfortunately, in Ecuador, formal education in astronomy is not provided at schools, high schools, nor at the university level. In the past, several attempts were made to incorporate subjects of astronomy in the student curricula, but there were no successful results.

Actually, we are looking for new opportunities to incorporate subjects of astronomy and space sciences into the education programs.

In these circumstances, the only one space that we have to provide formal education in astronomy is at the university level and only in some institutions where there is an interest. In this context, the Quito Astronomical Observatory plays a pivotal role for promoting the education in astronomy and space sciences in Ecuador.

The Escuela Politecnica Nacional is one of few institutions where the attention to the education in astronomy is devoted. This is thanks to the existence of the Sciences Faculty and its Physics Department, where students are formed to do research in several branches of physics and among these in astronomy and astrophysics. The professional astronomers that Ecuador has, initially have been formed in this Physics Department, and later on completed the postgraduate programs in astronomy in several countries abroad. The Quito Observatory is involved in the educational process of the Physics Department, and the education in astronomy has been provided by its staff. Currently, we are planning a more in-depth program to intensify the formal education in astronomy at the Polytechnic School and to promote the expansion to other academic institutions.

Beside the formal education in the classroom, scientific meetings, technical and academic lectures, stargazing sessions and other activities are organized regularly to stimulate the interest and to spread ideas among the students and professionals working in astronomy.

c) Promotion of astronomy and communication with the public

This is the third natural activity that the Quito Observatory carries out. Locally, news, data and reports on astronomy are provided by the Quito Astronomical Observatory. For the media this Observatory is the primary source of astronomical information.

On the other hand, in order to involve the community and, in particular, children and students with the sciences, the Observatory offers several facilities: the first Ecuadorian astronomical museum has been created on the basis of the old instruments and equipment of the Quito Observatory heritage. This new museum located inside of Observatory building, in the Alameda Park in the Quito downtown, opened in the summer of 2012. A large collection of astronomical, meteorological and seismological instruments are in permanent exhibition for the public.

Moreover, during the clear skies, the Observatory opens its doors to the public inviting to spend nights in stargazing sessions. Unfortunately, the quantity of clear nights in Quito and in general in Ecuador is low and often the best time to organize these observation campaigns, using the telescopes available in the Observatory, is during the summer season. The observations of astronomical event like eclipses,

comets, conjunctions, and so on, are accessible to everyone online. The telescope images and videos are broadcasted by the internet so everyone has the possibility to take part in these observations, without the necessity to be present in the observatory. This is the streaming astronomical system of the Quito Observatory.

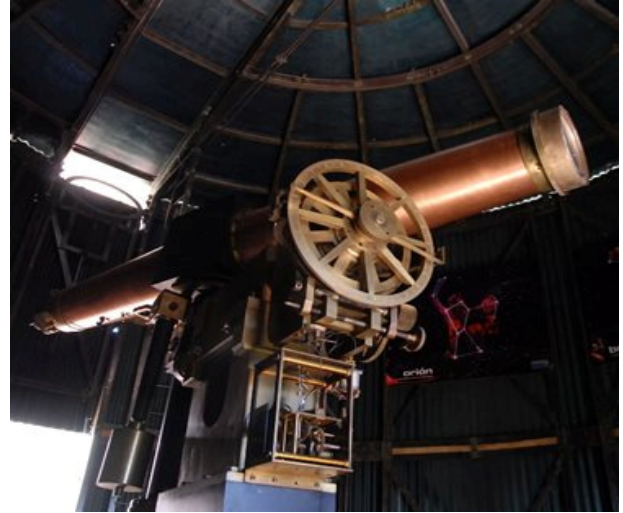


Figure 8: Equatorial Merz telescope made in Germany (1875)

Finally, the Observatory also organizes astronomic traveling fairs, visiting several cities of Ecuador. This is to involve the public and local schools in the knowledge of astronomy; with instrument exhibitions, discussions, games and night observations.

Beside these outreach activities, the periodic publications of the Observatory are made available, contributing to popularization and divulgation of astronomy and space sciences.

Solar Physics Phenomena Division

Thanks to the valuable support of the Office for Outer Space Affairs, many schools and workshops on the basis of the ISWI, have been realized around the world, providing the opportunity of instrument deployment and close international scientific collaboration. In particular, as an important result of this cooperation, in recent years Ecuador has been involved in space sciences research, so its leading institutions are deeply committed to dedicate efforts and resources to contribute to study the physical phenomena which occur in the equatorial atmosphere. As part of this interest, with the support of the Ecuadorian government, the United Nations, National Aeronautics and Space Administration (NASA) among other contributors, the United Nations/Ecuador Workshop hosted by the Quito Astronomical Observatory of the Escuela Politecnica Nacional was held in Quito from 8 to 12 October 2012. This was the twentieth in a series of Workshops on basic space science, the International Heliophysical Year 2007 and the ISWI. This workshop was mainly focused on space sciences and its main objective was to

provide a forum in which participants could comprehensively review achievements of the ISWI and further plans for the Initiative, as well as assess recent scientific and technical results in the field of solar-terrestrial interaction.

The 2012 United Nations/Ecuador Workshop was a valuable contribution that established the primary basis for inclusion of Space Sciences studies in Ecuador, in correspondence with parallel effort that make scientists and engineers from neighboring countries like Peru and Colombia. As a major result of this workshop, the agreement and support of our authorities and in particular of the National Polytechnic School were compromised, understanding the importance of carrying out space sciences studies in Ecuador. The authorities support started with the acceptance of the establishment of the Solar Physics Phenomena Division of the Quito Astronomical Observatory, which will have the responsibility to promote and execute studies of physical phenomena that take place in the equatorial region and are linked to the sun influence on the Earth atmosphere.

Currently, in the new space sciences station, two instruments are in operation: the Atmospheric Weather Electromagnetic System for Observation Modeling and Education (AWESOME) system, installed in 2010 under the collaboration of the United States (Dr. Umran Inan, scientific leader) and the Magnetic Data Acquisition System (MAGDAS) installed at the time of the 2012 United Nations/Ecuador Workshop, with the cooperation of Japan (Prof. K. Yumoto, and G. Maeda scientific leaders). Presently, both instruments are fully operational.

Other important collaborations are: the South American Very Low Frequency NETWORK (SAVNET) currently in implementation, the solar spectrometer Compound Astronomical Low-cost Low-frequency Instrument (CALLISTO) and the Dual frequency Global Positioning Systems (GPS) Network are expected to join in the near future to the group of instruments installed in Ecuador. The respective negotiations are in process, discussing the feasibility of these projects, their scientific benefit and the contribution to the space science studies.

In this context, the new Solar Physics Phenomena station of the Quito Astronomical Observatory potentially could be structured with 5 instruments that would provide unique data for the study of the space weather influences on the equatorial atmosphere. The data sets from this station will be distributed and publicly available to guarantee the mayor utility and applicability. The main goal we have is to create a well-established space sciences station, operating for the benefit of the local and the international scientific community, providing quality data for space science studies of the equatorial environment.

The Rector of Escuela Politecnica Nacional of Ecuador committed to the project for the creation of Quito Solar Physics Phenomena Division and as the maximum authority of the University, the necessary support for the construction of the new building for the

space sciences station is being provided. On the other hand, our students have been interested in space science topics and they have joined the Observatory staff to learn the physics of atmosphere and the data collection and processing technics. We expect the first scientific papers will soon be produced using AWESOME and MAGDAS instruments, currently in operation.

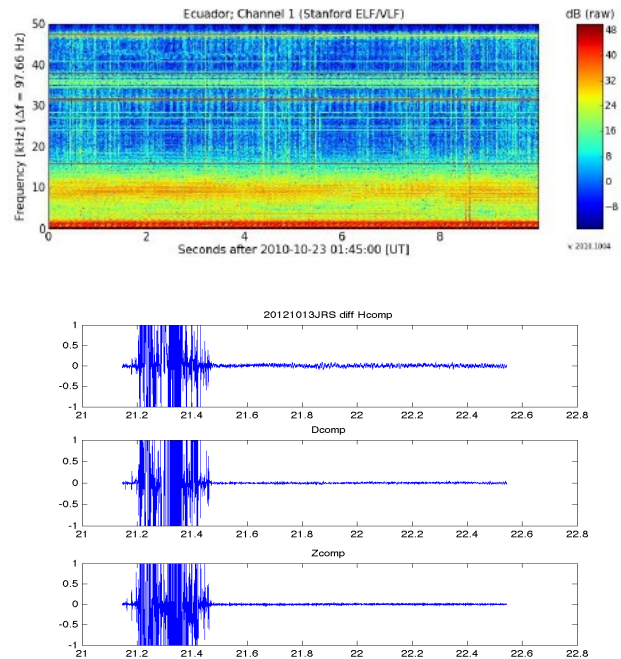


Figure 9: First spectra from the AWESOME (up) and MAGDAS (down) instruments installed in Ecuador

2012 United Nations/Ecuador Workshop on ISWI

Without any doubt a great event in the past year was the realization of the United Nations/Ecuador Workshop on the ISWI. This was possible mainly thanks to the huge support from the Office for the Outer Space Affairs, the Secretary of Higher Education, Sciences, Technology and Innovation of Ecuador (SENESCYT), NASA, the Quito Astronomical Observatory of National Polytechnic School of Ecuador (OAQ-EPN), among other important contributors and supporters. This scientific meeting was attended by about 100 participants from 20 countries, with oral and poster contributions within the Workshop topics: Observations of the Sun, Ionosphere and Magnetosphere, Very-Low Frequency (VLF) studies of Sun-Earth Connection, Climate Studies, Atmospheric Physics, Space Weather Modeling, Space Weather and its Effects on Global Navigation Satellite Systems and UNBSSI Follow-up Projects in Astronomy.

The United Nations/Ecuador Workshop was of benefit to Ecuador in order to promote and encourage the study of space sciences in the equatorial region, where no research on these issues has been done before. Now, under the umbrella of the Quito Astronomical Observatory and with the support

of the scientific community, we have the opportunity to contribute to understanding the physical processes behind phenomena, which take place in the Solar-Earth system. Scientists and students are being involved in operating the instruments and processing data for study the equatorial atmosphere.

We conclude that the United Nations/Ecuador Workshop, the third and final of the ISWI series, was very successful and brought a lot of new experiences and benefits to each participant. Particularly, in the case of Ecuador, we could summarize the following important outcomes of the Workshop: i) for the first time, Ecuador is measuring the local magnetic field right on the line equator in the village named Jerusalem, where the magnetometer of the MAGDAS net was installed.. ii) The Workshop was an essential component to consolidate the local support of our authorities for the creation of the new space sciences station in Ecuador, to which future collaborations from the nets: SAVNET, GPS NETWORK, CALLISTO, will join. iii) On the other hand, possible new space sciences events in Ecuador are coming for the realization in the near future, as the 2014 space science school on MAGDAS data processing. iv) Beside that, new students are interested and involved in space science studies. e) New contacts and future projects in joint research collaboration have been coordinated during the Workshop. v) However, from our point of view, a relevant result of this workshop is the fact that space science studies are better understood and appreciated by both the local authorities. This fact in turn could facilitate the development of space science studies, providing the required financial support. vi) Finally, the regional interest for mutual international cooperation and the Ecuador capability to carry out space science studies have been enhanced.

Outer Space Affairs and the Quito Astronomical Observatory (QAO). We considered important to highlight some of those recommendations with the purpose to assist in their dissemination (UN report, 2012):

- It is recommended that the ISWI continue the operation and development of existing arrays and deployment of new instrument arrays as appropriate.
- It is recommended that the ISWI 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 modeling of regions of interest (e.g. the equatorial ionosphere) in collaboration with modeling centers of the European Space Agency (ESA), Japan Aerospace Exploration Agency (JAXA), NASA, and others.
- It is recommended that data from ISWI 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. It is recommended that ISWI and GNSS communities collaborate in terms of data sharing and space weather research.
- It is recommended that the ISWI Space Science Schools and the annual United Nations workshops for ISWI continue indefinitely. United Nations/Basic Space Science workshops and Space Science Schools are an integral part of ISWI, to train early career and new researchers in instrument operation and the science of heliophysics. The partnerships already established with international scientific organizations need to be strengthened to assure that these capacity building activities are accomplished efficiently and for the benefit of all member states.
- It is recommended that new knowledge generated by ISWI activities be effectively communicated to the public and the scientific community at large via Newsletters, ISWI web site, and other media.

Given the enormous contribution that Japan has made to the astronomy and space science communities, it is not impossible for Japan to continue the operation of the Nobeyama radioheliograph on a long-term basis. The international scientific community will be grateful if the Nobeyama radioheliograph is made to survive and the effort will be recorded as another outstanding Japanese contribution to the humankind. Therefore, the participants of the United Nations/Ecuador workshop on the ISWI strongly recommend the continued operation of the Nobeyama Radioheliograph either by the current institution or by a consortium of new institutions (UN report 2012).

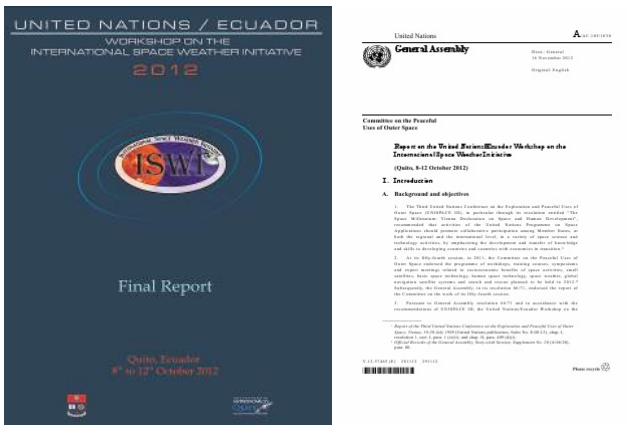


Figure 10: United Nations-Ecuador Workshop report and resolutions on the International Space Weather Initiative, October 12, 2012, Quito, Ecuador.

The United Nations/Ecuador Workshop was of key importance for decision-making to ensure the support and promotion of Space Sciences studies worldwide. In this context, essential recommendation has been made during the five-days meeting, resolutions incorporated in similar reports issued by the Office for

Conclusive Remarks

Since the Space Sciences studies and, in particular, the space weather is an international matter, a mutual effort from all nations should be done in order to promote the deployment of instruments in regions unobserved before, and to guarantee the continuity of high quality data acquisition, processing and modeling.

The International Heliophysical Year 2007 and the ISWI have made significant contributions to the installation of new instrumentation, and also providing appropriate environments, throughout the space science Workshops and Schools, in order to meet scientists and technicians working in space sciences, to exchange ideas, review new achievements, plan future activities and discuss mutual collaboration in specific projects.

Considering that the United Nations and Space Agencies contribution have been huge effective and determinant for the development of Space Sciences studies around the World, it is fundamental that this support will continue, 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.

The United Nations and Space Agencies initiative on the peaceful uses of outer space and space weather studies plays a pivotal role for promoting and organizing scientific studies around the world. This is a necessary component and irreplaceable for understanding the behavior of the Sun and its influence in the Earth-atmosphere and the global climate. Without this contribution, the efforts could be individual, isolated and in certain sense disordered, provoking a slow growing and development of the scientific activity in the space sciences field with the consequent misunderstanding or poor comprehension of the physical phenomena that take place in the Sun-earth-atmosphere system. Fortunately, this is not the case and the research activities in this field have been greatly promoted and boosted by the Space Sciences Initiative of the United Nations. Consequently, at the present level of development of the space science structures, the support of the United Nations and space agencies is fundamental, being necessary to preserve these studies for the benefit of the all nations.

Finally, we have the intention to organize a Space sciences school on MAGDAS data analysis and modeling, in joint collaboration with Japan. In the same way, we are ready to perform the necessary work to introduce the space science and technology education at the elementary, secondary and university level together with the astronomy.

We expect that this initial work inside of the Solar Physics Phenomena Division of the Quito Astronomical Observatory will be the basis to promote and strengthen space science studies in Ecuador, where a significant number of high level researchers and students could be potentially involved.

Acknowledgments

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