Space Weather Research for Developing Countries

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Space Weather Research, and for that matter space research, need not be confined to the most affluent and most developed countries only. In many instances of space research, our entire planet can be considered as a space probe, thus development of space research programs in various geographic locations, locations not necessarily populated with economically affluent countries is very important. Along with these research opportunities for the developing countries and for the benefit of the world at large, the development of a very effective and efficient Information Technology network is necessary world wide – again both in economically affluent and developing countries. With today's global economy and interdependence of countries on each other, the quality of life for all societies is directly dependent on effective use of Information Technology for the whole of society.

There are 2 aspects to the Information Technology trends in science: the first is connected with the tools to provide the possibilities to the researcher to making new knowledge and the second is to share that crucial scientific information with society for timely and beneficial decision making. Even if the first challenge is met (new powerful research equipment, computers, user friendly interfaces, and physical and internet security), most of the scientific information necessary for critical decision making is hidden in scientific reports and special journals, not accessible to the decision makers. Unfortunately, very few crucial pieces of scientific data are easy to find on the Internet, and not all essential information is delivered to the "users" in time. The tragic example of the December 2004 Tsunami, gives an example of the very poor state of the distribution of critical information on upcoming catastrophes.

A good example of sharing scientific information with society is the Data Visualization Interactive Network (DVIN 1) platform, developed at the Cosmic Ray Division (CRD) of the Alikhanian Physics Institute in Armenia and the winner of the First World Summit on Information Society world-wide competition in the e-science category, December 2003, Geneva. The development of DVIN continues with enlarged functions of analysis and visualization. DVIN-2 the second generation version of DVIN-1 was the winner of the All Armenia competition in 2005.

Safeguarding the Technology infrastructure, information or otherwise, against natural disasters is critical to make any alert system reliable and robust. A very important example of natural catastrophes that can affect technologies is Space Weather, the particle showers, geomagnetic storms, and plasma clouds that come from the our star, the Sun. About 1000 satellites work continuously in space. The total cost of building these satellites exceeds $160 billion, launching them into orbit cost another $30 billion. To USA alone, the space-born technologies return $225 billion in profits each year and have rapidly become one of largest segments of the US Gross National Product. Space-based systems provide critical infrastructure that support the quality of life on Earth. Because of humanity's increasing dependence on space-based systems, spacecraft that can survive and operate through all space environment conditions are desired. It is not possible to achieve cost-effective, "all weather" space systems without accurate knowledge of Space Weather. Perhaps even then it is not necessarily possible to make an "all weather" space craft; however it is possible to control the operation of systems in space and on the ground to avoid the ill effects of space weather by putting electronics on standby for duration, or by switching off certain non-essential systems for a period. Space Storms directly or indirectly lead to loss of data, degradation of equipment, service outages, and, in extreme cases, the loss of satellites. Space weather can affect our everyday lives.

Some specific effects of Space Weather are listed here:

- For semiconductor microelectronics, the electric charge induced when a heavy ion passes through the part, or when particle has a nuclear interaction in the part, is often comparable with the spurious charge moving in device circuits. Thus, the device's state can be changed. This can result in various types of transient or permanent Single Event Effects (SEE) such as upset, latch-up, or burnout of the device.
- Space weather can raise the temperature in the outer reaches of the atmosphere, causing the atmosphere to expand, snatch satellites from orbit by increasing drag.
- The other main danger to satellites is the charging and electrical shorts caused by the magnetic activity and accelerated particles.
- Solar events occur at a magnitude of violent force and energy that equals the power of a billion hydrogen bombs, fortunately people on the ground are not at risk from solar storms, protected by the magnetosphere and atmosphere, but astronauts in space are at risk.
- A space Storm can causes power outage as it happened in 1989 when a power grid in Canada was tripped by a space weather storm and electricity from Quebec to Northern New Jersey was abruptly lost.
- Airline passengers on high altitude flights and particular over the poles, can experience as much as 10 chest X-rays equivalent dose of radiation
- In the late 1990s at least two key U.S. communications satellites were disabled by solar weather and radio communications were disrupted, causing interruptions in personal pagers, television broadcasts and some airline traffic communications;
- Space Weather can increase the probability of latent cancer formation in the astronauts and space travelers. It is necessary to consider the condition of space weather before embarking on a space mission or to have a radiation bunker in the spacecraft where humans can take refuge during the storm.

If alerted the operators of affected systems can take simple preventive steps to reduce the damage:

- Satellite operators can put satellites on standby.
- Airlines can reroute commercial flights or simply wait out the space Weather conditions.
- Astronauts can retreat into shielded bunkers in the space craft.

Accurate and Reliable forecasting and alerting of space weather is an important scientific challenge of the 21-st century. The quest to understand space weather and how to predict it relies on high level scientists, engineers and technicians and instruments such as space-born spectrometers and coronagraphs and surface based systems detection of radio-bursts and variations of cosmic rays. There is a desire to put these global space weather monitoring satellites closer and closer to the sun to acquire the information as quickly as possible, but these are not without problems of their own:

- Some instruments aboard the Solar Heliospheric Observatory (SOHO) satellite needed to be shut down during powerful flares to prevent damage. Others are operating at reduced capacity
- Some space borne devices produce less-than-perfect images because they get covered with "snow" that represents the charged particles streaming out from the Sun

Ground base system bring new information not possible on the satellites, and also serve as a back up system for when the satellites themselves are overwhelmed by space weather. The most energetic particles from the sun which are very few and detectable only by very large area ground based monitors, bring information about the upcoming storms 10 yours prior to the arrival of the shock waves.

The Aragats Space Environmental Center (ASEC) in Armenia, with ground base monitors, performs the following functions:

- Measure secondary CR fluxes with different energy thresholds;
- Monitor not only changing count rates, but also correlations between changing cosmic ray fluxes;
- Measure directional information;
- Use same detectors for both Space Weather and high energy Cosmic Ray studies;
- Perform simulation of the time-series registered by the ASEC monitors;
- Correlate surface and space-born detectors data accessible on the Internet;
- Fills a geographical gap in several world-wide networks of Space Weather monitors;
- Provides forecasting and alerts on severe conditions of the Space Weather.

Developing countries should find their ways to participate in the crucially important endeavor of understanding, forecasting and alerting space weather because:

- Most of the technical progress in the 21-st century will come from Space Operations;
- New Space visions have Space Weather research and forecasting as a vital element for Space Operations;
- Information from networks of surface based detectors measuring secondary cosmic rays complement the data from space-born particle detectors and can be used for reliable and timely Space Weather forecasting and developing countries can fill a geographic gap not necessarily populated by the wealthy countries;
- Developing countries should be a part of such networks to participate in the exploration of the Solar System and Universe;
- Necessary equipment is rather cheap and can be installed in scientific and educational institutions and schools, to make Space Research and Physics interesting and important for the future generation.

New generation Space Weather detectors, now under construction at the CRD, can serve as a good basis for the implementation of the regional scientific and forecasting network including Armenia, Bulgaria, Croatia, Georgia, Azerbaijan, Iran, Turkey, United Arab Emirates, and other countries. Installation and networking expenses will not exceed $50,000 and will permit the developing countries produce data vitally necessary for space operation, thus making a link to the science and technology of 21st century. The continuous development of the Data Visualization and Interactive Network (DVIN) will provide a reliable and robust forecasting and alerting tool for the network of countries involved in Space Weather research.