Regional cooperation in the field of space weather studies and applications in the southeastern and east central Europe and in the Caucasus region

**Elchin Babayev** [1], **Katya Georgieva** [2]


[2] Bulgarian Academy of Sciences, Bulgaria
INTERNATIONAL HELIOPHYSICAL YEAR
2007 – 2009

Advancing our Understanding of the Fundamental Heliophysical Processes that Govern the Sun, Earth and Heliosphere

Continuing the tradition of international research and advancing the legacy on the 50th anniversary of the International Geophysical Year

Demonstrating the Beauty, Relevance and Significance of Space and Earth Science to the World

International Geophysical Year
Continuing a Tradition of International Collaboration on the 50th Anniversary of IGY 1957

IGY Gold History Program

SCIENCE  OBSERVATORY DEVELOPMENT  OUTREACH  HISTORY

about | organization | get involved | newsroom | events | resources | contact
One of six main goals of an international programme of scientific collaboration - the **International Heliophysical Year (IHY) – 2007** was the fostering international scientific cooperation in the study of heliophysical phenomena.

Major planning activities have taken place for all aspects of the IHY programme:
- national, regional and international planning conferences and meetings have occurred;
- teams have been formed for implementing IHY activities in all the regions of the globe on the basis for the four main programmatic thrusts of IHY (science, IHY/UNBSSI (the United Nations Basic Space Science) programme, outreach and history).

A **regional network** have been established in June 2005 to promote space weather studies in southeastern and east central Europe and in the Caucasus region.

The main impetus behind establishing **the Balkan, Black Sea, and Caspian Sea Regional Network on Space Weather Studies** (hereinafter: Network) was to strengthen activities in the region in the field of space science - especially space weather-related studies – not only under the umbrella of the IHY, but also to promote in the future the collaboration between participating countries in basic space sciences.
PROTOCOL
OF THE REGIONAL IHY PLANNING MEETING
FOR THE BALKAN AND BLACK SEA REGION

Regional IHY Planning Meeting for the Balkan and Black Sea Region (hereafter Meeting) was organized by the Solar Terrestrial Influences Laboratory at the Bulgarian Academy of Sciences (STIL-BAS) and was supported by the Bulgarian Academy of Sciences and European Office of Aerospace Research and Development (EOARD). The Meeting was held from 6 to 8 June 2005 at Sozopol, Bulgaria.

Representatives of 11 countries (Bulgarla, Armenia, Azerbaijan, Croatia, Georgia, Greece, Poland, Romania, Russia, Serbia and Montenegro, Ukraine) participated in the Meeting and scientists from Czech Republic, Slovakia and Turkey who were unable to attend the Meeting, expressed their wish to be included in the planned activities. There were reported about 50 papers: scientific papers, reviews, information about current researches in their countries.

The plans on the future activities and collaborations were discussed and relevant decisions were made on consensus basis which are summarized in the following as

MEMORANDUM OF UNDERSTANDING.

1. Agreement on creation of the Black Sea and Caspian Sea Regional Network on Space Weather Studies (hereafter Regional Network) consisting of the following countries: Bulgaria, Armenia, Azerbaijan, Croatia, Czech Republic, Georgia, Greece, Poland, Romania, Russia, Serbia and Montenegro, Slovakia, Turkey, Ukraine. The Regional Network is open to other countries willing to participate in its activities.
2. The Regional Network will maintain a special web site.
3. The Regional Network will publish an International referred Scientific Journal “SUN and GEOSPHERE” with international editorial board. Proceedings of the Meeting will be published in the first issue of this Journal.
4. To coordinate the activities on popularization of knowledge on Solar Terrestrial Physics, particularly, the Space Weather, by means of scientific-popular articles written by the members of the Regional Network in English with further translation into different languages for publishing in the web site of the Regional Network and in domestic periodicals.
5. To organize Annual Summer (or Winter) Schools on Solar Terrestrial Physics in different member countries. It is reasonable to use opportunities of the big scientific events to hold these Schools as satellite events.
6. To provide possibility of training of young scientists from member countries in different participating institutions.
7. To create both a scientific database as well as a database on each member country - their activities and participants.
8. To promote bilateral and multilateral joint projects and collaborations among member countries.
9. Concrete actions covering the items 1-8 were identified during the Meeting. They are listed in the Appendix.

Member country representatives:

Armenia, A. Chilingarian
Azerbaijan, E. S. Babayev
Bulgaria, K. Georgieva
Croatia, D. Rosa
Georgia, M. Sh. Goglashvili
Greece, A. Nindos
Poland, Z. Kobylinski
Romania, G. Maris
Russia, Y. Yermolaev
Serbia and Montenegro, I. Vince
Ukraine, O. Lytvynenko
• This talk summarizes the activities of the network and will present the research projects which have been proposed, completed and planned.

• Briefly focuses on some space weather applications, particularly, on navigation and communication systems, ionospheric VLF studies, so on.
• Resources and experience in the member countries

• **Network activities**
  – organizational
  – scientific
  – educational
Proposal for establishing of a regional network
A coordinating committee consisting of representatives of all countries and a regional coordinator on rotational basis.

Proposed scientific topics
– The physics of solar eruptive events and which ones are potentially hazardous;
– Atmospheric changes caused by solar UV irradiation variability at different time-scales;
– Comparative study of geomagnetic, ionospheric and seismic effects of Coronal Mass Ejections and High Speed Solar Wind;
– Participation in the scientific program of the Russian Academy of Sciences.

Proposed instrumental networks
– New networks by installing in the participating countries of:
  • cosmic ray detectors - related to solar activity influences on space weather (Armenia will share experience in installing the detectors);
  • radio receivers for Doppler frequency spectrum monitoring - related to solar activity influences on seismic activity (Ukraine can provide the receivers).
– New networks based on existing instruments:
  • - ionospheric
  • - magnetometric
  • - seismic
  • - meteorological

Proposed observational campaigns:
– expeditions for measuring geomagnetic parameters during the total solar eclipse
– ground-based observations during the operation of OBSTANOVKA experiment aboard the International Space Station

Necessary new instruments and upgrade of existing scientific instruments
– Hα telescope in Larissa, Greece
– CIMEL photometer in Stara Zagora, Bulgaria
– CCD camera in Abastumani, Georgia
– radiotelescopes URAN-4 and UTR-2 for measuring sporadic solar emissions and ionospheric sounding in Ukraine

Proposals for a web site of the Regional Network
– Information on regional and global activities
– Proceedings of this Meeting
– Space Weather Alerts for the public
– Form for submitting research and observational proposals
– Database of scientific data publicly available
  • Greece provides solar telescope data
  • Romania provides data on active regions studied with helioseismis holography
  • Armenia provides access to data on changing fluxes of particles during solar events
  • Bulgaria provides data on NO2 and O3
  • Webmaster provides links to other databases
– Database on member countries activities and participating scientists
– Database of scientific publications by participating scientists on subjects related to IHY
– Popular papers written by members of the Regional Network

Public outreach and education
– A series of popular articles on IHY related topics written by members of the Regional Network and published monthly in the Regional...
http://www.stil.bas.bg/IHY/

Good Afternoon and welcome to the WEB-SITE of:

Balkan, Black Sea and Caspian Sea Regional Network on Space Weather Studies

The Regional Network members:

<table>
<thead>
<tr>
<th>Armenia</th>
<th>Azerbaijan</th>
<th>Bosnia and Herzegovina</th>
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<tr>
<td>Bulgaria</td>
<td>Georgia</td>
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<td>Croatia</td>
<td>Romania</td>
<td>Russia</td>
</tr>
<tr>
<td>Serbia and Montenegro</td>
<td>Ukraine</td>
<td>Turkey</td>
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</tbody>
</table>

This website will contain information about current and proposed regional and worldwide activities, and scientific database as well as a database on each member country activities and participants.

Bilateral and multilateral joint projects and collaborations among member countries will be promoted.

To coordinate the activities on popularization of knowledge on Solar Terrestrial Physics, popular scientific articles will be written by the members of the Regional Network and will be published monthly in the web site of the Regional Network and in domestic periodicals of the member countries.

Early to be updated for possible changes.
Promoting Space Weather Studies in Eastern Europe and Western Asia

Norma B. Crosby
Belgian Institute for Space Aeronomy, Brussels

Elchin S. Babayev
Shamakhy Astrophysical Observatory, Baku, Azerbaijan

Abstract

A regional network and an international refereed scientific journal have been established to promote space weather studies in southeastern and east central Europe and in the Caucasus region. The main impetus behind establishing the Balkan, Black Sea, and Caspian Sea Regional Network on Space Weather Studies is to strengthen activities in the region in the field of space science—especially space weather–related studies—under the umbrella of the International Heliophysical Year (IHY).

Published 8 April 2008.
Promoting Space Weather Studies in Eastern Europe and Western Asia

A regional network and an international refereed scientific journal have been established to promote space weather studies in southeastern Europe, east central Europe and in the Caucasus region. The main impetus behind establishing the Balkan, Black Sea, and Caspian Sea Regional Network on Space Weather Studies is to strengthen activities in the region in the field of space science—especially space weather-related studies—under the umbrella of the International Heliophysical Year (IHY).

The network promotes bilateral and multilateral joint projects and collaborations among network countries; the training of young scientists from network countries at participating institutions; and the organizing of annual regional summer/winter schools and colloquia on solar-terrestrial physics and network meetings in different network countries. In addition, the network promotes activities to popularize the knowledge of solar-terrestrial physics through network network also promotes school competitions for proposals for joint/collaborative astrophysical observations. It also promotes “astronomy olympiads,” a competition to test young people on their knowledge of astronomy that remains popular in former Soviet block countries.

An initiative begun by scientists from Azerbaijan and Bulgaria, the network was established during the IHY Balkan and Black Sea regional planning meeting in Sozopol, Bulgaria, on 6–8 June 2005, and it was supported by representatives of 11 countries (Armenia, Azerbaijan, Bulgaria, Croatia, Georgia, Greece, Poland, Romania, Russia, Serbia and Montenegro, and Ukraine) attending the meeting. Although scientists from the Czech Republic, Slovakia, and Turkey could not attend, they expressed their intent to be included in the planned activities. Bosnia and Herzegovina later joined the network, which is also open to participation by other countries. Representatives from France and the European Office of Aerospace Research and Development par-

30 March to 1 April 2006, followed the 29 March 2006 total solar eclipse and combined observational activities with a scientific meeting. Future annual meetings will be held during the 2–6 June 2008 United Nations Workshop on the International Heliophysical Year 2007 in Sozopol, and during a proposed spring 2009 International Astronomical Union symposium in Azerbaijan.

The *Sun and Geosphere* journal, also established during the 2005 meeting in Bulgaria, promotes space weather activities in eastern Europe and western Asia. The journal—published at least twice yearly on paper, CD-ROM, and online—is peer reviewed by international referees and has published papers by scientists from many countries. The editorial board consists of members from eastern European and western Asian countries as well as from other European and Asian countries and the United States, and each issue of the journal is managed by a guest editor. Coauthor Elchin S. Babayev, of the Shamakhy Astrophysical Observatory, Baku, Azerbaijan, is editor in chief.


—NORMA B. CROSBY, Belgian Institute for Space
Balkan/Black Sea/Caspian Sea Regional Network SWS Activities

Caucasus countries
Bosnia and Herzegovina
Bulgaria
Croatia
Georgia
Greece
Romania
Russia
Serbia and Montenegro
Turkey
Ukraine
Modular Particle Monitor for Neutral and Charged Cosmic Ray fluxes

**SPONSOR Provides:**
- 8 scintillator slabs each of 50 x 50 x 5 cm;
- 2 photomultipliers;
- Electronics board with counters, discriminators, optional temperature and pressure sensors and PC interface;
- High voltage units for the photomultiplier;
- DAQ, analysis and WEB software;
- Access to DVIN data bases;
- Training of students;
- Documentation

**RECIPIENT Provides:**
- Mechanical parts, including lead.
- Purchase computer with GPS;
- Uninterruptible electricity and Internet access;
- Transportation of equipment from Yerevan;
- Cover travel and stay expenses of sponsor experts (if necessary).
Middle-to-Low Latitude Particle Detector Network for Space Weather Research
Azerbaijan

• Shamakhy Astrophysical Observatory - Shamakhy
• Batabat Astrophysical Observatory - Nakhchivan
• Departments (Astrophysics, etc.) of the Baku State University, Azerbaijan Technical University

POTENTIAL PARTICIPANTS

• Research Institutes of the Azerbaijan National Academy of Sciences:
  – Institute of Physics
  – Institute of Radiation Researches
  – Institute of Cybernetics
  – Institute of Mathematics and Mechanics
  – Institute of Information Technologies

• National Aero-Space Agency
three main scientific trends in astronomical studies:

- physics of stars and nebulae
- solar physics
- solar-terrestrial relations
- investigation of the solar system bodies


Space Weather effects and SW influences on the different technological and biological systems, including the human life and health:

• influence on technical, engineering and ecological systems (scintillation of microwave radio signals, oil production activity and functioning of oil-gas transportation pipelines, electric power grids, Caspian Sea level, climate, traffic, etc.);

• affects on human life and health (virus-epidemic diseases, human brain functional state, cardiovascular diseases, sudden cardiac deaths, etc.).

• Space weather education and outreach: special academic courses, mass-media, daily and weekly columns in newspapers, summer schools, young scientists conference
Bosnia and Herzegovina

- Solar physics group in the University of Banja Luka
Bulgaria

- Bulgarian Academy of Sciences
  - Institute of Astronomy
    - Rojen observatory
    - Belogradchik observatory
  - Solar-Terrestrial Influences Laboratory
    - Stara Zagora observatory
      - in situ measurements aboard the ISS during IHY
  - Institute of Space Research
  - Institute of Geophysics
    - Sofia ionospheric station
    - Panagyurishte magnetic observatory
- Sofia University – Center for Space Research
- Shumen University – Astronomical center
- 10 people’s observatories with planetarium
Croatia

- Zagreb university
- Hvar observatory
- Visnjan observatory
- Planetarium at the Technical Museum
Georgia

National (Abastumani) Astrophysical Observatory
Solar and Heliospheric Physics
Center of Plasma Astrophysics
Institute of Geophysics
Observatory of Cosmophysics
Dushet Geophysical Observatory
Department of Ozone and Aerosol Physics
Tbilisi State University
Ionospheric Observatory
Laboratory of Extraordinary Phenomena
Serbia and Montenegro

- Belgrade observatory
- Belgrade University, Faculty of Mathematics
- Institute of Physics
  Ionospheric station
- Institute of geomagnetism
  Magnetic observatory
Ukraine

- Crimean Astrophysical Observatory (optical and radio)
- Astronomical Observatory of the Odessa National University
- Space Radiophysics Department – Harkiv University
- Radioastronomical observatory - State University “Taras Shevchenko” (Kyiv)
- Academy of Sciences
  - Main astrophysical Observatory
  - Institute for Space Research (Kyiv, Lviv)
- State Institute of Ionosphere – Academy of Sciences and Ministry of Science and Education (ionospheric station)
- Institute of Radioastronomy (Odessa)
- Institute of Geophysics (Poltava) URAN system
- Institute of Physics and Mechanics (Lviv)
URAN – a system of radiointerferometers with extra long baseline in the decameter range including 5 radiotelescopes

Two proposals for IHY

• Use of the radioastronomical data for space weather forecast

  development of a space weather forecast method based on using of the data radioastronomical observations of the Sun in wavelengths range from millimeter up to decameter.

• Ionosphere disturbance above Vranch region

• radiotelescope URAH-4, GPS permanent GPS stations (total electron contents) and Doppler spectrum measurement of radio station signals (Doppler radioreceivers network).

  Elaboration of multi-channel portative Doppler radioreceivers
Network’s activity

Scientific Research proposals

• The physics of solar eruptive events and which ones are potentially hazardous;
• Atmospheric changes caused by solar UV irradiation variability at different time-scales;
• Comparative study of geomagnetic, ionospheric and seismic effects of Coronal Mass Ejections and High Speed Solar Wind;
• Participation in the scientific program of Russian AS
• Use of the radio-astronomical data for space weather forecast
• Ionospheric disturbances above Vranch epicenter
Network’s activity

Scientific

- Deployment of instruments
  (cosmic ray monitors, Doppler radio-receivers…)
- Bilateral and multilateral collaborations
- Databases
  (cosmic rays, high speed solar wind, solar flares, CME’s)
Network’s activity

Scientific - Annual regional Summer/Winter Schools on Solar-Terrestrial Physics

• August 2006 – Odessa, Ukraine – VI Gamow summer astronomical school
• II- IV Summer Astronomical School on Solar and Solar-Terrestrial Physics, Azerbaijan
  (review papers, contributed papers, proceedings published)
A scientific refereed journal "Sun and Geosphere" has been established in June 2005.

- Peer-reviewed regular papers, thematic papers from conferences/workshops of Network (after strong reviewing), etc.
SUN and GEOSPHERE: The International Journal of Research and Applications

Is founded in 8 June 2005, peer-reviewed and published two times per year by the Balkan, Black Sea and Caspian Sea Regional Network on Space Weather Studies [http://www.still.bas.bg/IHY/]

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ONLINE VERSIONS:

http://www.shao.az/SG/

http://www.still.bas.bg/IHY/SUN_GEO.html

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Network’s activity

Scientific

Annual regional meetings/conferences
- First regional planning meeting – June 2005, Sozopol, Bulgaria
- Second regional meeting - 30 March – 1 April 2006, Antalya, Turkey
- Third regional meeting – 5-11 November 2007, Zvenigorod, Russia
- Fourth regional meeting – 2-6 June 2008, Sozopol, Bulgaria
- Next meeting: Šibenik, Croatia (7-13 September 2009)
Network’s activity

Educational

- Scientific-popular articles – www.stil.bas.bg/IHY

  written by members of the network in English, translated into local languages and published in local periodicals and online on popular websites

- school competitions for high school students
- formulating problems for astronomy olympiads
- school competition for experiments aboard the ISS
- School/university satellites, i.e., Tatyana - MSU
Black Sea and Caspian Sea Regional Network on Space Weather Studies

International Heliophysical Year

Educational Outreach

Following the decision of the Regional planning meeting: "To coordinate the activities on popularization of knowledge on Solar Terrestrial Physics, particularly, the Space Weather, by means of scientific-popular articles written by the members of the Regional Network in English with further translation into different languages for publishing in the web site of the Regional Network and in domestic periodicals", this page contains the papers written so far.

<table>
<thead>
<tr>
<th>Author</th>
<th>TITLE</th>
<th>Format</th>
<th>Lang</th>
</tr>
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<tbody>
<tr>
<td>1. Marina GIGOLASHVILI, Dr.Sc</td>
<td>Sun’s Magnetism</td>
<td>HTML</td>
<td>Eng.</td>
</tr>
<tr>
<td>5. Stenka Stoeva</td>
<td>Sun and Spaceweather poster</td>
<td>PDF</td>
<td>Bul.</td>
</tr>
<tr>
<td>7. Nadya Kiskinova</td>
<td>Astronomy for all part 1</td>
<td>PDF</td>
<td>Bul.</td>
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</table>
"Circling the Earth in the orbital spaceship I marvelled at the beauty of our planet. People of the world! Let us safeguard and enhance this beauty - not destroy it!"

- Yuri Gagarin
Network’s activity

Educational

• Training of young scientists from member countries in different participating institutions
• Tutoring and co-tutoring of PhD students by members of the network
Collaboration within Network activities

- İNTAS - YSF Collaborative Call with Azerbaijan 2006
- INTAS Ref. Nr 06-1000015-6408
  - 2 years
    “Solar and geomagnetic activities influence on the human health state, some biological and ecological systems in middle latitudes and its possible societal-economic impacts”
    - Shamakhy Astrophysical Observatory named after N.Tusi, Department of the Sun and Solar-Terrestrial Relations, AZ NAS
    - Bogazici University Turkey, Kandilli Observatory and Earthquake Research Institute, Astronomy Laboratory, Istanbul, Turkey
    - Solar-Terrestrial Influences Laboratory, Bulgarian Academy of Sciences, Bulgaria
Problems
(and what help we could use)

- Educational materials
  (papers, movies, etc.)
- Travel grants
- New instruments and upgrade of existing instruments
- European and international programs
  (FP7, …)
SPACE WEATHER AND SCINTILLATION OF TRANS-IONOSPHERIC RADIO WAVES
SPACE WEATHER refers to:

“...conditions on the Sun and in the solar wind, magnetosphere, ionosphere and thermosphere that can influence the performance and reliability of space-borne and ground-based technological systems and can endanger human life or health…”

TEC MAP (height = 450.0 km) at 2002/05/25,01:00:00
EAO/AADC IONEX file containing the COMBINED IGS TEC MAPS and DCBe

- Latitude (deg)
- Longitude (deg)
- TEC (TECU)
SOLAR AND GEOMAGNETIC ACTIVITY DEPENDENCE OF THE SCINTILLATION

- The probability of scintillation’s occurrence increases with solar activity.

- The measurements made until now show that scintillation activity is directly proportional to solar activity, but is generally independent of the planetary geomagnetic index $K_p$.

- The severity (and its intensity) of the ionospheric scintillation varies with sunspot cycle along with other factors.

- Disturbance effects due to the ionospheric scintillation are most significant near solar maximum period, especially in the high- and low-latitude areas.

- In years of high solar flux, transionospheric propagation through polar and equatorial regions has experienced deep fading at frequencies ranging from 54 MHz to 4 GHz.

- The equatorial anomaly region (two belts of enhanced electron density at ~15° North and South of the magnetic equator) is the worst source of scintillation: during the sunspot maximum years, the fades exceeding peak-to-peak 27 dB at Global Positioning Systems’ (GPS) L1-frequency (1.5 GHz) are often registered in this region (at Ascension Island) after sunset while only 5-6 dB fades occur within a few degrees of the magnetic equator.
Statistics of polar scintillation at solar maximum period show much lower values of occurrence of strong fading than at the equatorial anomaly region.

Although scintillation at middle latitudes is generally not as intense as at equatorial and high-latitudes, weak to moderate levels of scintillation occur. Some cases of severe scintillation have been recorded in mid-latitudes. During a magnetic storm on March 22, 1979, peak-to-peak scintillation of 18, 10, 15 and 3.5 dB were recorded at 136 MHz, and 1.7, 4, and 12 GHz, respectively, on different paths in and around Japan.

Irregularity structures can cause scintillation simultaneously on several satellites during magnetically quiet nights. On magnetically disturbed nights ($K_p > 7$) nearly all satellites can be affected at varying levels, most of the night.

The near solar minimum observations showed that long periods of scintillation occur under both magnetically quiet and disturbed conditions.
Morphological studies have showed that the high frequency (above 1 GHz) ionospheric scintillation characteristics and correlation can be characterized as follows:

(a) **Sunspot number dependence**
- No strong correlation between individual scintillation event occurrences and daily sunspot number;
- Strong correlation between the amplitude of the scintillation and the monthly sunspot number;
- Strong correlation between annual scintillation occurrence and the annual sunspot number.

(b) **Temporal and geographical dependence:**
- Annual scintillation activity varies in an 11-year cycle in concert with solar sunspot cycle;
- Peak annual scintillation activity occurs at or just after the equinox periods. For equatorial GHz scintillation, peak activity around vernal equinox and high activity at the autumnal equinox have been observed;
- Peak daily scintillation activity occurs approximately one hour after sunset at the ionospheric height;
- GHz ionospheric scintillation of any significant amplitude only occur within approximately ± 30° of the magnetic equator for the geostationary communication satellite links.
Signal intensity vs. time, Baku

Probability of received signal intensity, Baku

Channel availability, Baku

Average duration of fades, Baku
Intensity (blue) and phase (red) spectrum of received signal, Baku

Electron density as a function of height, Baku

Frequency = 1570 MHz
10.7 cm solar flux = 200 Jansky
Elevation angle = 10 deg
Irreg. Scale-size = 500 m
Ratio = 0.2
Drift velocity = 50 m/s
Slope = 3
### Middle latitudes

| Scintillation activity level | Generally very quiet to moderately active. The probability of occurrence of scintillations as well as their intensity is very low at middle latitudes. |
| Cause of scintillation | The daytime **random** scintillations occur because of the sporadic-$E$. The nighttime **random** scintillations are caused by the spread-$F$. **Quasi-periodic** scintillations originate from traveling ionospheric disturbances ($TIDs$) mainly in the $F$ region on from sporadic-$E$ disturbances. |
| Frequency dependence | Usually scintillation index $S4 \propto f^{-n}$, where $n=1.38$ for nighttime, and $n=1.52$ for daytime. The percentage of occurrence decreases with the frequency. |
| Diurnal Dependence | The occurrence peaks between 2000 LT and 2100 LT in summer. In other seasons they occur between 2400 LT and 0400 LT. According to the solar cycle, they are also observed rarely during daytime, between 0900 LT and 1500 LT. Maximum – nighttime; Sporadic – daytime. |
| Seasonal dependence | **Random** scintillations occur mainly in the summer and seldom during the other seasons. **Quasi-periodic** scintillations occur mainly in summer. Maximum: winter Minimum: equinox and early summer (May-July) |
| Solar activity dependence | The probability of scintillations occurrence and their intensity increases with the solar activity. |
| Magnetic activity dependence | Generally independent of $Kp$ |
• IHY scientists from UNBSS member states now participate in the instrument operation, data collection, analysis, and publication of scientific results, working at the forefront of science research.

• It is proposed to continue the highly successful collaboration with the UNBSS program to continue the study of universal processes in the solar system that affect the interplanetary and terrestrial environments, and to continue to coordinate the deployment and operation of new and existing instrument arrays aimed at understanding the impacts of Space Weather on Earth and the near-Earth environment.
Space Weather Monitors
Stanford SOLAR Center

The AWESOME Monitor

Atmospheric Weather Electromagnetic System for Observation Modeling and Education
Very Low Frequency (VLF) remote sensing studies of the lower ionosphere in middle latitude site of the Azerbaijan using AWESOME receiver

- Ground based observations of Extremely Low Frequency (ELF) / Very Low Frequency (VLF) (300 Hz 30 kHz) waves are considered as an important remote sensing tool for the investigation of the ionosphere and the magnetosphere. VLF waves find their origin in various natural and artificial phenomena; the natural sources include thunderstorms, lightning and associated phenomena. Sub-ionospheric VLF transmissions propagating inside the Earth-ionosphere wave-guide is also being widely used for investigating sudden ionospheric perturbations (SIDs) in lower part of the ionosphere.

- We monitor VLF signals continuously at Pirgulu location in Azerbaijani sector with the help of AWESOME (Atmospheric Weather Educational System for Observation and Modeling of Electromagnetics) VLF receiver from Stanford University. It was installed in Azerbaijan by Prof. U. Inan and his colleagues in the context of the IHY/UNBSS program for 2007 as part of the United Nations initiative to place scientific instruments in developing countries.
VLF receiver enables handling of data that is used by researchers conducting ionospheric and space weather research. With the use of simple square air-core magnetic loop antennas of a couple of meters in size, the sensitivity of these instruments allows the measurement of magnetic fields in the frequency range of ~300 Hz to 50 kHz.

AWESOME VLF receivers are capable of collecting both broadband (used for the study of natural signals) and narrowband (sub-ionospheric VLF signals corresponding to VLF transmitters) data.

Sub-ionospheric VLF observations allow the measurement of the lower ionosphere, normally not accessible with other instruments.

The obtained data will enable us to understand the generation and propagation mechanism of naturally occurring VLF waves in middle latitude region such as radio atmospherics from lightning flashes, magnetospheric whistlers, VLF emissions, to conduct remote sensing of the lower ionosphere, lightning and thunderstorms, to investigate long-term trends of magnetospheric parameters such as electron density, total electron content in a flux tube and electric fields during quiet and active solar periods, to find correlation between VLF wave activity and geomagnetic activity, and other phenomena.

Narrowband sub-ionospheric VLF signals (remote sensing) and planned ground-based geomagnetic data in Azerbaijani middle latitude region will help us to study sudden ionospheric disturbances associated with transient phenomena like solar flares, geomagnetic storms, giant cosmic gamma-ray flares, lightning induced electron precipitation (LEP), effects of lightning discharge, sprites, elves, blue jets, gravity waves etc.

Sub-ionospheric VLF signals are also helpful in the study of VLF waves as a precursor to earthquakes.

AWESOME VLF receiver provides an open-ended potential for exploration and also can be used for educational outreach.
Earthquake $M=2.4$

DHO – Burlage, Germany
Earthquake M=4

GBZ – Rugby, UK
The highly successful collaboration between the heliophysics science community and UNBSS program will be continued within IHY program’s continuation: International Space Weather Initiative (ISWI) for years 2010-2012. ISWI was adopted as an UN supported program on 18 February 2009 during the session of the Science and Technical Subcommittee of the UN Committee of Peaceful Use of the Outer Space (COPUOS).
THE 5TH
UN/ESA/NASA/JAXA WORKSHOP
ON BASIC SPACE SCIENCE AND THE INTERNATIONAL HELIOPHYSICAL YEAR 2007

22 ~ 25 September 2009
HYATT REGENCY JEJU IN KOREA

Topics
- Fundamental Physics
- Astronomy and Astrophysics
- Solar-Terrestrial Interaction and its Influence on Terrestrial Climate
- Planetary and Atmospheric Studies
- Origin of Life and Exo-Biology

Hosted by Korea Astronomy and Space Science Institute (KASI)
on behalf of Korean Ministry of Education, Science and Technology (MEST)
Thank you!