EMSEV Inter- Association (ElectroMagnetic Studies of Earthquakes and Volcanoes)
http://www.emsev-iugg.org/emsev/

2007-2010 report

EMSEV executive bureau

The Inter-Association Working Group EMSEV

In 2001, IUGG officially founded the Inter-Association Working Group of Electromagnetic Studies on Earthquakes and Volcanoes (EMSEV WG). EMSEV WG is linked to the three associations IAGA, IAVCEI and IASPEI because of the wideness of the involved research. Understanding earthquakes processes and volcanic eruptions, and the ability to detect and analyze EM signals related to active tectonic processes require expertise in many fields of research: physics of the Earth, physics of fault rupture and volcanic eruptions, laboratory experiments, physical mechanisms generating magnetic, electric and electromagnetic signals, role of fluids, gas and thermal fluxes in the crust, propagation of EM signals in the crust and towards the ionosphere.

The main objectives of EMSEV are (i) To promote international co-operation and collaboration between individuals and research groups focused on observations and research into electric and magnetic effects associated with earthquakes and volcanoes, (ii) To develop EM methods in developing countries based on joint field campaigns, workshops and educational plans and (iii) To support the dissemination and discussion of relevant data and research results.

But, EMSEV WG also strongly promotes the highest quality research in advanced countries (Japan, USA, Greece, Italy, France, China, Taiwan, India …), organizes sessions and meetings at international levels, endorses outstanding observations and results, and expands EM activities in different fields of research.

Organization

EMSEV is composed of an elected executive bureau, a nominated assembly of members with not more than a few from each country to strive for global representation, and a community interested in electromagnetic phenomena, called corresponding members.

From its inception in 2001 until the IUGG-Perugia meeting in 2007, Professor S. Uyeda headed EMSEV, with T. Nagao as Secretary, Y. Sasai, M.J.S. Johnston, and J. Zlotnicki as IAVCEI, IASPEI, and IAGA liaison members, respectively. Y. Ogawa was nominated corresponding liaison member of IAGA WG1-2. During the EMSEV business meeting in 2007, a new bureau was elected. J. Zlotnicki was appointed Chairperson M.J.S. Johnston Vice-Chairperson, S. Uyeda past Chairperson, and T. Nagao kept the Secretary position. T. Liu, Y. Sasai, and M.J.S. Johnston were elected IAGA, IAVCEI, and IASPEI liaison members whileT. Harinarayana was selected as liaison member from IAGA WG1-2. A new bureau will be elected during IUGG general assembly at Melbourne in 2011.

The WG members are nominated for their expertise in the EM field and scientific activity and promotion. A good balance between countries involved or interested in EM phenomena is looked for. The number of WG members is 44. The corresponding members are now more than 250.

T. Nagao regularly updates the EMSEV Web site (http://www.emsev-iugg.org/emsev/) and regularly informs the scientific community on EMSEV activities, meetings, scientific reports, business meetings and annual reports.

One plenary EMSEV business meeting is organized at least every year. During these reunions, opened to anyone, new projects, budgets, participation in regional and large-scale international meetings are discussed. Information on EMSEV is also presented at other geophysical meetings. The minutes of the business meetings and annual reports can be found on the EMSEV Web site.

Thanks to IUGG, IAGA, IASPEI and IAVCEI support, EMSEV sponsors and provides financial support for meetings, participation of researchers and students in EM meetings and field campaigns in developing countries with joint programs. In parallel, EMSEV members submit proposals to their own

funding sources to perform EMSEV activities, and to support their participation in these joint programs (i.e. Taal volcano in the Philippines).

Promoting Electromagnetic and other geophysical methods in International meetings

A complete description and understanding of Natural Hazards, in particular Earthquakes and Volcanic eruptions cannot be achieved by just one particular method. Therefore EMSEV promotes a multi-parameter approach of the study of EM phenomena and encourages multi-disciplinary contributions. EMSEV acts at three levels:

The EMSEV Inter-Association WG organizes an international EMSEV meeting every two years with an occasional focus associated on specific topics (e.g. the DEMETER mission in 2008). Following the Agra meeting in 2006, an EMSEV meeting, organized by Prof. D. Stanica, was held in 2008 at Sinaia (Romania). The next was in Santa Ana (USA) in 2010 with Professor R.P. Singh as local Chairperson. The 2012 meeting will be held in Japan. About 60 participants usually attend each meeting with about 10 to 15 countries involved. During these meetings, new observations and interpretations are discussed and evaluated, and new projects and cooperative programs emerge from them. New research activities in developing countries are also proposed and launched (Taal volcano in the Philippines and a study of physical mechanisms of induced earthquakes by EM signals in Kyrgistan is currently proposed).

EMSEV is also very active in the sponsorship of EM sessions at large international geophysical meetings. At the Perugia IUGG general assembly (Italy) in 2007, EMSEV organized four integrated sessions on 'Progress in electromagnetic studies of earthquakes and volcanoes'. In 2008, a session called 'New insights from EM investigations of active volcanoes and hydrothermal/geothermal fields' was set up at the Reykjavik IAVCEI meeting (Iceland). In 2009, two sessions on 'Earthquake source' and 'Prediction and Hazards and risk' were highlighted at the Cape Town IASPEI assembly. The session 'Crustal tectonic processes constrained by EM observations' was convened by EMSEV members during the Sopron IAGA meeting (Hungary) in August 2009. Also, EMSEV will convene five joint sessions during the upcoming 2011 IUGG general assembly in Melbourne.

EMSEV members and participants have made great contributions to the organization of specific sessions in other international meetings. In 2007, they were sessions at EGU (Vienna, Austria), Demeter workshop (Toulouse, France), Italy-Japan seminar (Chiba, Japan), IIIth international school seminar on EM soundings (Zvenigorod, Russia), 50 years of the IGY and EGY (Suzda, Russia), 80th China International Geo-EM workshop (Jingshou, China), IWSEM phenomena recent progress (Bandung, Indonesia) and AGU fall meeting (San Fransisco, USA). In 2008, sessions were convened at IWSEQ-2008 (Chiba, Japan), EGU (Vienna, Austria), AOGS (Busan, Korea), URSI GA (Chicago, USA), and AGU fall meeting in San Fransisco (USA). In 2009, there were sessions at EGU (Vienna, Austria), VESTO (Chiba, Japan), 2rd International seminar on Prediction of Earthquakes (Lisbon, Portuga), International conference EGY: State of Art (Pereslavl, Russia), AOGS (Singapore), and again the AGU (San Fransisco, USA). And in 2010, sessions were held at EGU (Vienna, Austria), CoV6 (Tenerife, Spain), AOGS (Hyderabad, India), AP-RASC (Toyama, Japan) and the AGU in San Fransisco (USA).

During EMSEV activities in developing countries, EMSEV organizes regional and international meetings such as EMSEV-PHIVOLCS meeting on 'Monitoring active volcanoes by electromagnetic and other geophysical methods-Application to Asian volcanoes' (Feb 24-27, 2010). EMSEV is now planning a meeting with Bishkek Institute on 'Understanding changes in the electric conductivity structure associated with seismic activity'.

EMSEV activities in developing countries

After promoting a better and better science during years, EMSEV has developed activities. The target is to stimulate joint multi-disciplinary research at the highest level and to apply this to specific earthquake and volcanic hazards.

Taal volcano in the Philippines. In 2003, PHIVOLCS (http://www.phivolcs.dost.gov.ph) and the IUGG Inter-Association EMSEV (http://www.emsev-iugg.org/emsev/) initiated a cooperative geophysical monitoring program on Taal volcano. Taal is responsible for serious hazards in the region such as pyroclastic flows, base surges, and violent phreatic explosions. In 2004, after a Memorandum

of agreement was signed, PHIVOLCS EM team and an EMSEV team started to image the hydrothermal system, the geological and tectonic discontinuities with combined magnetic, electric, ground temperature and soil degassing surveys. Audiomagnetotellurics and resistivity soundings, magnetic and bathymetric mappings of the inner acidic lake, and bottom lake temperature were also performed. Results are now used in information planning. One outcome is that intrusive activity is occurring under the northern part of the volcano and the region is apparently undergoing strong thermal transfers, degassing, and mineralization. Activity takes place along active E-W fissures possibly linked to intrusions at depth under the northern ring fault of the Crater. This could be the primary focus of the next eruptive activity. In such a case, strong seismic or intrusive activity could induce a collapse of a part of the northern crater rim into the Crater Lake. A real-time monitoring network based on electromagnetic and other geophysical parameters as magnetic and electric fields, ground temperature and gradients, seismicity, and tilt has been built. Data are automatically transferred to Taal observatory, PHIVOLCS headquarter and EMSEV servers. Thanks to the real-time network, anomalous signals were observed before and during the April to June 2010 strong seismic crisis. During this crisis, PHIVOLCS raised the alert level from 1 to 2, requiring a partial evacuation of the volcanic Island. Progressively, the international EMSEV community effort has now been enlarged by the addition of researchers from Greece, Italy, USA, and Belgium. PHIVOLCS is now a major contributor to the development of EM studies on Taal volcano and to the analysis of its ongoing activity as it was stated during the February 2010 EMSEV-PHIVOLCS international workshop on 'Monitoring active volcanoes by electromagnetic and other geophysical methods; Application to Asian volcanoes'. A new Memorandum of Agreement for the coming 5-years is the confirmation of long term and successful cooperation between PHIVOLCS and the Inter-Association working group EMSEV.

Further information can be found on EMSEV and PHIVOLCS web-sites (http://www.emsev-iugg.org/emsev/ and http://www.phivolcs.dost.gov.ph).

This cooperation was supported by an IUGG grant (2009-2010). 3 articles are published, 1 is submitted, and 2 are in preparation.

Proposal for cooperative studies between the Bihkek Institute and EMSEV. We plan to better understand the interrelation between changes in the electric conductivity structure associated with seismic activity under the Bishkek experimental MHD generator system.

The Russian Academy of Sciences (RAS), has conducted active monitoring of underground electrical conductivity for over thirty tears at the Bishkek Research Station in Kyrgyz (Director Anatoly Rybin, EMSEV member). The experiment involves injecting large 800-amp electrical currents through 4.5 km long dipoles. This is literally one of the world's largest scale electric/electromagnetic prospecting experiments. In its early stages (1983-1990), high power current pulses from the MHD generator were used. But now, more easily detected square wave pulses are injected several times every day (dipole moment = 4500 m x 800 amp). Important results obtained at Bishkek so far include: observations of changes in electrical conductivity of as much as several percent before moderate earthquakes and sharp increases in triggered local seismicity that results from the operation of the injection experiment. Furthermore, the receiving stations in Kyrgyz are extremely remote and are relatively free of artificial noise sources. This provides an ideal environment for checking high-resolution monitoring experiments such as SES proposed by the VAN group in Greece.
The following target experiments are suggested for cooperative studies with the Research Station in Kyrgyz:

- 3D modeling of the source region(s) where electrical conductivity changes are occurring,
- Detailed investigation of correlation between electrical conductivity changes and seismicity,
- Electromagnetic triggering processes and their implications,
- Distortion of electrical signals by regional tectonics and faults systems,
- Independent checking of VAN'S SES observations outside Greece,
- Physical mechanisms of EM signals generated by the MHD-generator.

We propose to organize an international cooperation agreement between the Bishkek Institute and the EMSEV working group. Within the framework of this agreement, EMSEV members will visit and conduct joint experiments with the Bishkek Institute.

Toward a better understanding of Natural Hazards

Keeping a good balance between the mother Associations, EMSEV community has focused the effort on the physics of pre-, co- and post-event EM phenomena related to earthquakes and volcanic eruptions. EMSEV has developed more intensive international cooperation at the frontiers of different disciplines. EM studies are now performed more and more accurately with sophisticated tools and data processing in association with other geophysical and remote sensing methods (EM, geodesy, seismology, hydrology, geochemistry, volcanology, and laboratory studies).

Earthquakes are now often studied from the source to the ionosphere by land and satellite observations, laboratory experiments and remote sensing combine different techniques and cross correlate observations for identifying anomalies above prone seismic areas. EM generation processes are deeply studied by several international research teams. Co-seismic effects are observed that scale with moment/magnitude deduced from source theory. DC to higher frequency (to 1000 Hz) EM signals before earthquakes have also been actively investigated. In even higher frequency bands (kilohertz to megahertz), anomalies have been reported before earthquakes by many radio scientists, Disturbances in the atmosphere ionosphere and magnetosphere are suspected to be the cause of anomalous transmissions. Monitoring of these regions with land based ionosondes, total electron concentration (TEC) derived from GPS data, time domain analysis of robust satellite techniques (RST) has been initiated. Such phenomena are collectively called Lithosphere-Atmosphere-Ionosphere (LAI) coupling. Some statistical evaluations on the correlation between these pre-seismic EM phenomena and earthquakes reveal positive results, but we need also to establish an unambiguous physical causal connection. Considering that many researchers in the EM field come from a wide variety of disciplines, including radio engineering, space physics, and solid state physics, bringing together these groups and integrating their data and ideas with those obtained in other related fields will be a daunting but worthwhile task.

On volcanoes, several examples unquestionably show that magnetic and electric, and resistivity signals may appear a long time before an eruptive event (Oshima, Miyake-jima, Merapi, volcanoes) and be associated with weak and sporadic eruptive activity (Etna, Taal). In such cases, stress changes, magma transport, thermal budgets and fluids are key issues for generating EM signals. EM measurements show clear changes associated with initial intrusions, final explosive eruptions and post-eruptive activity that reflect the physical processes within the volcano. For the last decade, the primary focus has been to use joint multi-disciplinary research tools at the highest level and to apply these to specific geophysical hazards. For instance, a growing international team (Philippines, Japan, France, USA, Greece, Italy, Belgium) combine a multi-disciplinary approach based on electromagnetic, geochemical, thermal fluxes, gas emission, tilt and seismicity observations for understanding the volcanic structure of Taal volcano and for monitoring its sporadic activity. Now, the real time observational system is in operation and an international network is built.