IAGA/ URSI Joint Working Group on

VLF/ELF Remote Sensing of Ionospheres and Magnetospheres Newsletter

Editor: Craig J. Rodger No. 23, December 2008

Dear Colleagues,

Once again I find myself typing up a short introduction to our communities yearly newsletter, after another busy year. Let me start by thanking all of the researchers who took the time to send me material for the newsletter, reflecting just how international our working group is. 2008 was a particularly "big" year for the VERSIM working group, with several important and core VERSIM gatherings. The first was the XXIX General Assembly of URSI in Chicago (USA) in August 2008, shortly followed by the 3rd VERSIM Workshop in Tihany (Hungary) in September 2008. I was very pleased to meet up with many of you at both meetings, and enjoyed the chance to talk "VERSIM Science".

At the August 2008 URSI General Assembly Prof. Umran Inan (USA) was awarded the Appleton Prize, and was also elected to the role of a URSI Vice-President. Umran Inan is a long-standing leader in the scientific efforts of the VERSIM community, and the VERSIM Business Meetings at the Chicago URSI and Tihany VERSIM Workshop expressed their congratulations. In addition, another very active VERSIM member, Ondrej Santolik was elected to the position of vice-chair of URSI Commission H at the 2008 URSI General Assembly. He received more than 3 times more votes than the next candidate, and clearly has a strong mandate.

As well as a successful URSI General Assembly, the 3rd VERSIM Workshop took place in September 2008 at the Balaton Limnological Research Institute (BLRI) of Hungarian Academy of Sciences, sponsored by Eötvös University and supported by IAGA and URSI Commission G and H. The workshop attracted slightly more than 50 participants from 15 countries, ranging from India and Serbia all the way to Brazil and the USA, and included 61 presentations. The 3rd workshop builds on the success on the previous 2 meetings, which were held in Sodankylä, Finland. With steadily more participants and more presentations at each VERSIM workshop, it is clear that the workshops are filling an important role for the VERSIM community. Many of the participants at the 3rd workshop commented that the quality of the talks had steadily improved with each VERSIM workshop, suggesting that the collaborations established through VERSIM workshops were leading to rapid forward motion in VERSIM-Science. Participants at the 3rd workshop agreed that the success of this workshop confirms the viability of recurring VERSIM workshop as part of our future scientific calendars. I'm pleased to note that the 4th VERSIM workshop will be held sometime in September 2010 in Prague (Czech Republic).

At the 3rd VERSIM workshop we started the process of identify Science "Topics" that are of current interest to the wider international community. The initial ideas are listed as part of the VERSIM Business Meeting minutes from that workshop. I'd be interested in any comments people have as to that idea, and to the specific topics listed.

Next year we have the IAGA 11th Scientific Assembly in Sopron (Hungary) in late August 2009, which is already shaping up to include a very large number of VERSIM relevant sessions. We had some success at influencing the conference timetable, and so I hope that not too many of our sessions will clash!

As always, I have enjoyed the chance to meet our community at various meetings this year, especially the chance to join with you for a drink or a meal while we talk over wider scientific issues. Please come along to the VERSIM Business Meeting during the IAGA conference in Sopron (time to be announced).I hope the New Year finds you prosperous, productive, and well. Best wishes to you all! Have a great summer or winter, depending on your hemisphere!

Craig J. Rodger
IAGA co-chair VERSIM working group

Forthcoming meetings

- *AGU Chapman Conference on Effects of Thunderstorms and Lightning in the Upper Atmosphere, University Park, Pennsylvania, USA. 10-15 May 2009.*
- *IAGA General Assembly, Sopron, Hungary. 23-30 August 2009.*
- *High Energy Energetic Particle Precipitation into the Atmosphere (HEPPA) Workshop 2009, Boulder, Colorado, USA,6-8 October 2009.*

Reports from VERSIM research groups 2008

This based on information received by the IAGA co-chairman, Craig Rodger, by email from the VERSIM membership. Some reports have been slightly edited so the newsletter has consistent formatting. Hopefully this has not introduced any significant typos.

Czech Republic - Report by Ondrej Santolik and Jaroslav Chum.

VLF phenomena are traditionally studied at two institutions in the Czech Republic: at the Institute of Atmospheric Physics and at *Charles University* in Prague, Faculty of Mathematics and Physics. Both institutions closely cooperate. Our VLF research is mainly based on spacecraft data (DEMETER, MAGION5, CLUSTER, Double-Star, Polar, Freja and Cassini). We very often collaborate with our colleagues abroad. We are interested in various types of VLF waves: lightning induced whistlers, magnetospheric line radiation, power line harmonic radiation, wave phenomena associated with possible seismo-ionospheric coupling, magnetospheric chorus emissions, equatorial noise, auroral hiss, and lion roars.

Summary of recent results

Data from the DEMETER spacecraft are extensively used in order to study VLF propagation of whistler-mode radiation from lightning strokes, power line harmonic radiation (PLHR) and magnetospheric line radiation (MLR) phenomena in the upper ionosphere. Both automatic and manual identification of events is employed. We have succeeded to analyze multicomponent measurements of whistlers which correspond to data from lightning detection networks [1]. A careful analysis of nearly one hundred PLHR events together with a numerical calculation of efficiency of coupling of electromagnetic waves through the ionosphere enabled to explain lower intensities of events observed by the satellite during the day as compared to those observed during the night [2]. The DEMETER data are also used to verify an existence of a possible correlation between seismic activity and observed intensity of electromagnetic waves. We have performed a statistical study of all available VLF electric field data and showed that there is a statistical significant decrease of wave intensity observed in the vicinity of large surface earthquakes a few hours before the time of the main shock [3]. We have continued our investigation of Whistler-mode chorus based on the data of the CLUSTER mission [4,5].

[1] Santolik, O., M. Parrot, and J. Chum, Propagation Spectrograms of Whistler-Mode Radiation from Lightning, IEEE Trans. Plas. Sci, 36 (4), 1166 - 1167, 2008. doi:10.1109/TPS.2008.920899

[2] Nemec, F., O. Santolik, M. Parrot, J. Bortnik, Power Line Harmonic Radiation Observed by Satellite: Properties and Propagation Through the Ionosphere, J. Geophys. Res., 113, A08317, doi: 10.1029/2008JA013184, 2008.

[3] Nemec, F., O. Santolik, M. Parrot, J. J. Berthelier, Spacecraft Observations of Electromagnetic Perturbations Connected with Seismic Activity, Geophys. Res. Lett., 35, L05109, doi: 10.1029/2007GL032517, 2008.

[4] Santolik, O., New results of investigations of whistler-mode chorus emissions, Nonlin. Processes Geophys., 15, 621-630, 2008.

[5] Santolik, O., E. Macusova, E.E. Titova, B.V. Kozelov, D.A. Gurnett, J.S. Picket, V.Y. Trakhtengerts, A.G. Demekhov, Frequencies of wave packets of whistler-mode chorus inside its source region: a case study, Ann. Geophys 26, 1665 - 1670, 2008.

Fiji - The University of the South Pacific, Suva, Fiji, report from Dr. Sushil Kumar and Dr. V. Ramachandran.

The amplitude and phase of seven VLF navigational transmitter signals are recorded using the SoftPAL data acquisition system and WWLLN VLF system installed at The University of the South Pacific. Initial observations of early VLF perturbations on signals from NWC (19.8 kHz) and NPM (21.4 kHz) transmitters have been published [*Kumar et al*., *JGR*, 113, doi:10.1029/2007JA012734, 2008]. The early/fast, early/slow, early/short (RORD), and step-like early VLF perturbations are observed on signals from both the transmitters. This study is being carried out in collaboration with Radio and Space Physics research group at University of Otago, Dunedin, New Zealand. The daytime early/fast VLF perturbations with faster recovery and step-like early VLF perturbations initiated and ended by the lightnings which are most likely associated with red sprites and/or elves occurring in the day-time are the important results of this study. The echo amplitude (M) and echo phase (ϕ) of typical early/fast events on NWC (19.8 kHz) signal were modelled to determine whether their recovery (decay) is exponential or logarithmic. Currently, efforts are taken to further analyse the perturbations associated with lightning and solar flares on subionospheric VLF signals.

The waveforms of lightning generated sferics using the WWLLN system and high sampling rate data logger are recorded on weekly basis. The sferic waveforms with multiple reflections have been recorded that are being utilized to study the reflection heights, propagation distance, and attenuation of sferics in the Earth-ionosphere Waveguide (EIWG). The tweeks recorded during September 03 – July 2004 were used to study the propagational features and reflection heights of tweeks in the EIWG [*Kumar et al*., *Ann. Geophys, 26,* 1451, 2008]. Mean equivalent electron density at mean tweek reflection heights and electron density profile have been estimated using the higher harmonic tweek sferics recorded between 21-03 hrs LT, during the period March-December 2006. In terms of the usually used exponential electron density profile, ionospheric reference height, the exponential sharpness factor, and scale height were estimated. The equivalent electron density profile of the nighttime lower ionosphere using tweek method shows lower values than those obtained using the IRI-2001 model. The results have been communicated for publication.

Germany - University of Applied Sciences, Osnabrueck report by Ernst D. Schmitter.

Over here (52ºN, 8ºE) we were busy this year improving our monitoring site for VLF, ELF and geomagnetic field observations. Constantly recorded are the the transmitters at 19600 Hz (GBZ) and 22100 Hz (GQD) and 20900 Hz (FTA). Additionally the local geomagnetic horizontal E-W field is monitored and compared to the local VTEC course (interpolated from IONEX data files). Daily uploads go to:www.electricterra.com/Ernst/

Additionally we extended our computational modelling activity by FDTD calculations. Our special interests are ionosphere model based VLF/ELF propagation simulations and comparison to our monitored data.

Relevant publications and/or presentations in 2008:

Schmitter, E.D. 2008. Modelling Geomagnetic Activity Data. WSEAS TRANSACTIONS on SIGNAL PROCESSING, Volume 4, pp. 6-11, 2008

Schmitter, E.D. 2008. Deriving Ionospheric System Parameters from VLF Transmitter Signal Analysis. Proceedings of the 12th WSEAS Int. Conf. on Systems (CSCC08), Heraklion, Crete, Greece, July 22-24, ID 591-102, pp. 59-63, 2008

Schmitter, E.D. 2008. System Analysis of a Negative Impedance Converter Receiver for Ultra Low Frequencies. Proceedings of the 12th WSEAS Int.

Conf. on Systems (CSCC08), Heraklion, Crete, Greece, July 22-24, ID 591-382, pp. 302-305, 2008
Schmitter, E.D. 2008. Correlating Magnetic Field Variations and ULF/ELF Data. 3rd VERSIM Workshop, 15th - 20th September 2008, Tihany, Hungary

Participation at the IAGA2009, Sopron, Hungary, Aug. 2009 with a presentation about our FDTD calculations is planned.

2008 papers:

Á. Mika, and Haldoupis, VLF studies during TLE occurrences in Europe: A summary of new findings, Space Sci. Rev., 137, 489-510, Doi:10.1007/s11214-008-9382-8, 2008.
Á. Mika, C. Haldoupis, and S. Shalimov, Modeling the relaxation of Early VLF perturbations occurring in relation with transient luminous events, submitted in J. Geophys. Res., 2008.

Greece - University of Crete report by Christos Haldoupis.

The Ionospheric Physics Laboratory, at the Physics Department, University of Crete continued the operation of an automated narrow band VLF receiver. The Crete VLF receiver station, which is a project in collaboration with Prof. Umran Inan and his group at Stanford University, participated in the latest *EuroSptite* 2008 campaign by providing VLF observations on a continuous basis for most of the campaign. The Crete VLF receiver is a component of the AWESOME ELF-VLF network organized by the Stanford University, in which there is a growing number of international participants from all over the world while it is sponsored by the United Nations International Heliophysical Year (IHY) and the National Aeronautics and Space Administration (NASA). Also we have continued our collaboration with colleagues and institutions from USA, Denmark, Israel, Finland and Russia. During May 18-24, 2008 we organized and hosted in the island of Crete the "12 International Symposium on Equatorial Aeronomy" (ISEA-12), a single session workshop attended by more than 170 scientists from 25 countries, with a few of them also coming from the VERSIM community. The conference produced a book of Tutorials which covers 6 research topics of the physics of the upper atmosphere and ionosphere, with one on "Lower and middle atmospheric electrodynamics". The book of tutorials can be downloaded from the ISEA-12 web page: (http://isea12.physics.uoc.gr/).

During 2008, we have continued the study of subionospheric early VLF events observed in relation with active thunderstorms in the troposphere and transient luminous events (TLEs, particularly sprites) in the upper atmosphere. The most important VLF research results obtained the last few years at the University of Crete were published in a Space Science Review paper and summarized here as follows: 1) A close relationship between sprites and early VLF perturbations was established which constitutes evidence of upper D-region electron density changes in association with sprites. 2) VLF backscatter from the sprite-affected regions exists but it occurs rarely. 3) Long-delayed sprites were present in a large percentage, contrary to previous reports; they occurred in relation to long-lasting continuing currents that contribute to the buildup of sprite-causative quasi-electrostatic fields. 4) Intracloud lightning was found to be the key-factor which determines the sprite morphological features. 5) A new subcategory of VLF events was discovered, termed *early/slow*, characterised by long onset durations from 100 ms up to about 2 s. The slow onsets, which were attributed to a gradual ionisation build-up, are driven by a dense sequence of intracloud electromagnetic pulses that accompany the sprite-causative discharge. 6) A D-region chemical model was applied to simulate the measured recovery phases of the early VLF perturbations. This led to estimates about the mean altitude and electron density enhancements of the sprite-related ionospheric perturbations. 7) Early VLF events were identified for the first time to occur in association with elves, providing evidence that corroborates theoretical predictions on lower-ionospheric ionisation production by lightning-emitted electromagnetic pulses.

Hungary - Space Research Group, Eötvös University, Budapest report by János Lichtenberger.

We have successfully derived the theoretical full wave solution of the Maxwell's equations in the case of ducted waves, excited by real non-monochromatic impulse transient signals. The used wave guide models are rectangular, filled by magnetized, cold, homogeneous electron plasma. We have applied the closed formed analytical solutions in the simulation, and it was possible to deliver a continuous theoretical description of some extraordinary, new phenomena registered by SAS2 measurement system on the board of COMPASS2 satellite. As a result of this investigation, it is possible to recognize from the dynamic spectrum, if an electromagnetic signal propagated in a wave-guide during its propagation through the magnetosphere. We have successfully determined the full wave, analytical, closed formed solution of the Maxwell's equations in moving, inhomogeneous media, in the frame of the special relativity.

We developed a new whistler inversion model comprising the following components: the full Appleton-Hartree dispersion formula as a wave propagation model, a recent empirical electron density distribution along the field line based on in-situ (Polar spacecraft) measurements and dipole field as magnetic field model. The new model predicts electron densities and propagation paths different from the earlier models. The validation of the model is difficult due to lack of in-situ measurements. A multiple-path whistler group model was introduced in addition to the whistler inversion model assuming a simplified (logarithmic) dependence of equatorial electron density. A new, time-frequency domain transformation of multiple path groups led us to validate the components of the whistler inversion model. Beside that, the model is capable of providing electron density profiles for the plasmasphere by the analysis of multiple-path propagation.

Systematic analysis of whistlers, recorded on LEO satellites (DEMETER and Compass-2) continued. Detailed investigation of incident direction of short-path fractional hop whistlers has been performed, based on 3-component DEMETER ELF magnetic (IMSC) recordings. This study resulted in wave normals, determined using matched filtering and parameter estimation, falling in the magnetic meridional plane, describing an oblique propagation in the ionosphere. Concurrent occurrences of one-hop whistlers in ground-based and satellite wideband VLF recordings were analyzed. Comparison of fine structures of corresponding whistler pairs was done, aiming to separate propagation effects of the magnetosphere and ionosphere on whistler signals.

India - Faculty of Engineering, R.B.S. College, Agra, report by Birbal Singh.

Seven cases of the effect of sprites have been recorded at Agra station during three years of monitoring phase and amplitude of VLF transmitter signals between the years 2002 and 2005. The signals monitored are NWC, NPM, and NAA, and the equipment included AbsPAL receiver and accessories. The results were reported at the 29th session of the URSI-GA

meeting held recently at Chicago, USA. A new project to study the TLEs and their influence on low latitude ionosphere has been sanctioned by the Department of Science and Technology (DST), Government of India to the Agra group for a period of three years. This study will be made by using the SoftPAL receiver imported from New Zealand.

A 3-component search coil magnetometer has already been functioning at Agra station to study Q-bursts, Schumann resonances, and magnetic field emissions associated with earthquakes. The results of earthquake related studies have already been published in JASTP, Current Science (India), Physics and Chemistry of Earth and other reputed journals.

A national workshop on Electrodynamical coupling of Atmospheric regions was held at Indian Institute of Geomagnetism, Mumbai during 25 -26 November, 2008. It was sponsored by DST, India. While the major thrust in this meeting was to study the generation of electric fields in the thunderstorm region and their propagation upwards to mesosphere and ionosphere region, and generation of TLEs and their effect on low latitude ionosphere, other topics including E-region electrodynamics with emphasis on the generation of electric fields through dynamo action provided by tidal winds and planetary waves, and high latitude- low latitude electrodynamic coupling at ionosphere heights due to solar wind – magnetosphere- ionosphere interactions with emphasis on electric fields of high latitude origin that appear at low latitudes, and space weather issues of relevance to global electric circuit was also discussed.

Israel - Department of Geophysics and Planetary Sciences, Tel Aviv University, report by Colin Price.

The Tel Aviv University VLF group (headed by Colin Price) has recently established a new continuous observing station on Mt. Hermon, on the northern tip of Israel. This adds to our first VLF site in the Negev Desert at Sde Boker. The online dynamic spectra are continuously updated at http://www.tau.ac.il/~yova/. Graduate student Yuval Reuveni has worked hard to get these two stations up and keeping them running continuously. We are recording both the synoptic broadband data, as well as the amplitude and phase of narrow band transmitters. The latest research of Yuval has been focused on the background VLF noise levels at our stations. We have detected a very clear and robust 27-day oscillation in our VLF data that we believe is linked to the 27-day solar rotation. This topic is the focus of our investigations at the moment, and we hope to submit a paper on this topic in the near future.

Another graduate student (Eran Greenberg) has been looking at our VLF broadband data (together with ELF data) in relation to sprites detected in Europe during the summer of 2005. We find that many sprites are associated with more than one +CG discharges, while some of the sprites that show VLF sferics in Israel do not have ELF transients associated with them.

Japan - Terrestrial Electromagnetic Environmental Studies Group and Research Station, University of Electro-Communications, Chofu, report by Masashi Hayakawa.

The study of winter lightning in the Hokuriku area of Japan and its associated sprites is still continued by means of coordinated measurements (optical measurement, ELF observation in Moshiri, VHF lightning observation (radar) and LF/HF/VHF radio noise measurement). In order to explain the unsolved sprite problems, we have also performed the computer simulations based on the EM code [Asano et al., JGR, 2008], and recently one more paper is accepted, emphasizing the importance of M components in the initiation of sprites [Asano et al., JGR, in press]. Furthermore, we have developed a cellular automation modeling to explain the fine structure of sprites [Hayakawa et al., Phys. Plasma, 2007]. Then, the direct effect of lightning discharges onto the ionosphere (so-called Trimpi effects) has been studied by means of subionospheric VLF/LF data from the Japanese network (for the study of seismo-ionospheric perturbations).

The ELF observation is still continued at Moshiri (Hokkaido) with the measurements of two horizontal magnetic field components and one vertical electric field. The sampling frequency is 4 kHz. We study the Schumann resonances and ELF transients. The diurnal and seasonal variations of Schumann resonance parameters have been studied [Sekiguchi et al., J. Atmos. Electr., 2008], which will be compared with the theoretical modeling. The Schumann resonance data at multiple stations are used to obtain the snapshot distribution of global lightning activity by means of inversion problem. The objective estimation of inverse problem has been established [Ando and Hayakawa, Radio Sci., 2007], so that we will apply this method to a huge amount of data (e.g., one year long) to study the diurnal and seasonal variations of lightning activities for different chimneys. ELF transients observed at Moshiri are used to obtain the global mapping of intense lightning discharges [Yamashita et al., 2008] and to study the correlation with lightning discharges in Africa (with American team).

The thundercloud VHF/UHF radiation on the lightning preliminary breakdown stage has been modeled on the basis of a three-dimensional computer simulation of microdischarge activity in thunderstorm clouds [Hayakawa et al., JASTP, 2008].

The study of electromagnetic phenomena associated with earthquakes, is still going on. The seismogenic ULF emissions have been observed in the Tokyo area by means of Tokyo ULF network. The subionospheric VLF/LF perturbations associated with earthquakes (this can be called, seismo-Trimpis) have been measured by Japanese VLF/LF network. Seismo-atmospheric perturbations are being studied by means of VHF observation (detection of over-horizon VHF noise) (especially we have developed an interferometric observation). Finally, we have published a monograph entitled "Seismo Electromagnetics and Related Phenomena: History and Latest Results" (Profs. O. A. Molchanov and M. Hayakawa) from TERRAPUB, Tokyo. This book deals with the electromagnetic and plasma phenomena associated with earthquakes.

New Zealand - University of Otago, Dunedin, report by C.J. Rodger.

We have been running the following experimental measurements locally: 1) the VLF Doppler Experiment which monitors whistler-mode signals from VLF transmitters which have propagated through the plasmasphere predominantly inside whistler ducts. 2) several narrowband receivers which log small changes in the phase and amplitude of powerful VLF communications transmitters (~13-30 kHz) to study subionospheric propagation. We operate OmniPAL, AbsPAL, SoftPAL and Ultra MSK receivers. 3) an Automatic Whistler Detector and Analysis (AWDA) receiver operating in collaboration with Eötvös University. 4) a receiver and central processing computer of the World Wide Lightning Location Network (WWLLN). We are continuing to collaborate with French researchers who operate the DEMETER spacecraft and this has provided invaluable observations.

In August 2008 Neil Thomson travelled to the north-west of Australia and the US state of Washington to make near-field measurements of powerful US Navy VLF transmitters. This is part of Neil's efforts to improve the description of the nighttime and daytime D-region electron density used in VLF propagation modelling. The first results of his efforts in this direction were published in 2006, and will be followed in due time. In December 2008 a 2-man team comprising of Craig Rodger and James Brundell travelled to Scott Base, Antarctica. They installed a new VLF receiver near the New Zealand laboratory at Arrival Heights (77° 50' S, 166° 39' E). This instrument is providing narrowband observations to the Antarctic-Arctic Radiation-belt (Dynamic) Deposition - VLF Atmospheric Research Konsortium (AARDDVARK) network of high-latitude receivers, and also to the World Wide Lightning Location Network (WWLLN).

The group has been active in multiple studies, including providing some of the first evidence that EMIC waves drive the precipitation of relativistic electrons from the radiation belts [Rodger et al., GRL, doi:10.1029/2008GL034804, 2008], examining the propagation of signals broadcast from VLF transmitters through the plasmasphere [Clilverd et al., JGR, doi:10.1029/2007JA012602, 2008], and the impact of solar proton events and red sprites upon the chemistry of the atmosphere [Rodger et al., JGR doi:10.1029/2008JD010702, 2008; Seppälä et al., JGR, doi:10.1029/2008JA013517, 2008; Rodger et al., GRL, doi:10.1029/2008GL033221, 2008]. PhD student Rory Gamble has been working with DEMETER data in collaboration with our French collaborators, and has recently been involved in 2 papers describing how power VLF transmitters can drive the precipitation of energetic electrons from the radiation belts [Sauvaud et a;, GRL, doi:10.1029/2008GL033194, 2008; Gamble et al., JGR, doi: 10.1029/2008JA013369, 2008]. The conclusions of this joint work was carried quite widely in the media, including the webpage of New Scientist magazine, and lead to a 3-page story in the American Institute of Physics magazine, *Physics Today* (August 2008).

An up to date listing of our publications is available from the Groups website: www.physics.otago.ac.nz/research/space/spacehome.html

This includes PDFs of our published work, where-ever possible.

Serbia/Slovenia joint report - Institute of Physics; Belgrade and University of Nova Gorica, report by D. Šulić, D. Grubor (IPB) and Vida Žigman (UNG).

The AbsPAL system, has been continuously operating throughout the year, and the VLF data basis formed in this and in the previous years (since 2003) have been the subject of the team's research efforts. Current research of D-region electron density enhancements during Solar X-ray flares, established on recordings from transmitters: NAA/24.0 kHz, NWC/19.8 kHz and GQD/22.1 kHz, resulted in classification of flares effects and a proposal of different mechanisms of the VLF signal behaviour in dependence of the flare strength (D. P. Grubor, D. M. Sulic and V. Zigman, 2008, Ann. Geophys., 26, 1731–1740).

Another line of research was directed to observation and analysis of Lightning-induced Electron Precipitation (LEP) recorded sporadically on the signals: GQD/22,1 kHz, NAA/24 kHz, HWV/18,3 kHz and IDC/20,27 kHz. By simulating the disturbed ionospheric profiles with the LWPCv21 code, regions of enhanced ionization have been identified, yielding the mapping of LEP events over middle and west Europe (3rd VERSIM Workshop, Tihany, 15-20 September 2008).

Since June 2008 our Observatory at the Institute of Physics, Belgrade, has been reinforced by yet another, new AWESOME VLF receiver (Stanford University), with the software that includes the station to the International AWESOME net. In November 2008, both Serbia and Slovenia have joined the new Cost Action, ES0803 'Developing space weather products and services in Europe'. The team has been strengthened by two young researchers, and a master thesis is in completion.

South Africa - University of KwaZulu-Natal, Durban, report by Andrew Collier.

The Space Physics Research Institute (SPRI) at the University of KwaZulu-Natal operates a number of experiments in the Antarctic, sub-Antarctic and in South Africa at Hermanus, Durban and Sutherland.

A small team, Sherry Bremner and Brett Delport, accompanied the annual relief voyage to Marion Island (46° 54' 45" S 37° 44' 37 " E) during the first half of the year. Research activities on Marion Island have traditionally focused on the biological sciences. However, for the last few years a number of physical science experiments have been run on the island. The equipment is housed in the emergency base, which is located a few hundred metres away from the main base. Unfortunately the emergency base does not have a network connection and is infested with mice. Neither of which are factors particularly conducive to science. We are happy though that when the new base is commissioned (hopefully during 2009), the equipment will be relocated to a laboratory with more connectivity and fewer rodents. During their time on the island the team performed maintenance on the existing equipment (broadband VLF and Doppler receivers), installed a whip antenna and UltraMSK receiver as well as an Automatic Whistler Detector and Analysis (AWDA). The data from the previous year was also retrieved.

The WWLLN node in Hermanus, which has been out of commission for most of the year, has been relocated to a new building where the antenna and preamp are more protected from the elements. The node is now back online.

Currently preparations are being made for the relief voyage to SANAE IV (72° 40' S 2° 51' W), Antarctica. A team of three students, Sherry Bremner (Chief Scientist), Brett Delport and Etienne Koen, will perform maintenance of the experiments running at the base and retrieve data for the last year. They will also be installing a WWLLN node and an AWESOME receiver.

We are exploring the possibility of relocating the AWDA receiver from Sutherland to the University of Fort Hare (near Alice), which is significantly closer to the conjugate point of Tihany. This will provide an excellent opportunity for conjugate whistler studies.

Andrew Collier and Arthur Hughes have been working on the correlation between whistlers observed in Tihany and global lightning activity. They have also been examining the latitudinal variation of lightning activity over Africa and how this relates to the location of the Intertropical convergence zone. A new collaboration has been established with Dr Agatha de Boer of the University of East Anglia which is focused on winter lightning over the Agulhas Current. Sherry Bremner (MSc student) has been using narrowband VLF data to explore the ionospheric effects of Gamma Ray Bursts. Etienne Koen (MSc student) has been performing a similar analysis for Solar

Flares. Brett Delport (MSc student) has been studying the various classes of VLF emissions observed at SANAE IV.

We will fly a VLF experiment on the second South African satellite, Sumbandila, which will be launched by a Russian rocket from Kazakhstan on 25th of March 2009.

United Kingdom - British Antarctic Survey, Cambridge, report by Mark Clilverd.

BROADBAND RECORDINGS at Rothera, Antarctica

The Hungarian Automatic Whistler Detection system was installed at Rothera in January 2008. Whistler-detection and data collection will continue into 2009.

The Stanford University AWESOME receiver was also installed at Rothera in January 2008. Broadband and narrowband data have been collected, with some data gaps throughout the year. Data collection will continue into 2009.

VELOX RECORDINGS at Halley, Antarctica:

Continuous (since 1992) recordings of VLF activity in 10 ELF/VLF bands, at 1-s resolution (VELOX and VELOXNET), have continued at Halley. The VELOXNET data collection at Halley will continue indefinitely, despite closure of the rest of the VLF science during the 2008-2012 station rebuild period.

NARROW-BAND RECORDINGS:

The narrow band receiver `OmniPAL' has operated through 2008 at Rothera base, Antarctica, Sodankyla, Finland, and Ny Alesund, Spitzbergen. Northern hemisphere transmitters in Europe and USA are being received at 0.1-0.2 sec resolution. At Sodankyla, and Ny Alesund, the systems have been upgraded to 'Ultra's during the year.

In May 2008 BAS re-installed an 'Ultra' narrow-band system at Churchill, Canada, following a long-term fault that occurred in November 2007. Northern hemisphere transmitters in Europe and USA are now being received at 0.1 sec resolution.

The Australian Casey station (Antarctica) has continued to operate as an amplitude-only narrow-band receiver throughout 2008. Southern hemisphere transmitters are being received with ~2 sec resolution, although a long-term problem has affected data quality since March 2007.

A VLF Doppler receiver has continued to operate at Rothera station, Antarctica (L=2.8), receiving whistler mode and subionospheric signals primarily from NAA (24.0 kHz). A sister experiment has been installed at Marion Island, South Africa, receiving whistler mode and subionospheric signals primarily from DHO (23.4 kHz) since May 2007.

WWLLN SITES:

British Antarctic Survey operated two World Wide Lightning Location Network systems in 2008. Rothera, Antarctica, and Ascension Island have provided lighting location information all year.

United Kingdom - VERRI, Derbyshire, report by Andy Smith.

At the VLF/ELF Radio Research Institute we have been analysing the (nearly) sixteen-year VELOX data set recorded at Halley, Antarctica, between January 1992 and October 2007. Continuous 1-second time resolution data in the range 0.3 - 10 kHz were obtained with 98% coverage. The data set provides a unique opportunity to study the statistics of ELF/VLF wave occurrence at a ground station and in particular the interplay between source and propagation functions.

Once the random non-periodic variations have been removed by averaging, the diurnal, annual and solar cycle periodicities in the data are revealed, as well as the long term trend. Results were presented at the VERSIM Workshop in Hungary and will be written up for the JASTP special issue.

VELOX data may be browsed and downloaded from the British Antarctic Survey website. A link to the VELOX page is provided on the VERRI website http://www.verri.org.uk/.

USA - University of California, Los Angeles, report by Richard M. Thorne and Jacob Bortnik.

1. The Origin of Plasmaspheric Hiss.

By tracing the ray paths of discrete whistler-mode chorus waves from their source in the outer radiation belt, taking Landau damping of oblique waves into account, we have demonstrated the some of the chorus can enter the plasmasphere and there merge into a continuum to form the incoherent emission know as plasmaspheric hiss. Access to the plasmasphere is most effective for low-frequency chorus waves on the dayside. Observation verification has recently been confirmed from simultaneous wave data on two of the THEMIS spacecraft and the modeling is described in two papers:

Bortnik, J., R. M. Thorne, and N. P. Meredith (2008), The unexpected origin of plasmaspheric hiss from discrete chorus emissions, Nature, 452, doi:10.1038/nature06741.

Bortnik, J., R. M. Thorne, and N. P. Meredith, Plasmaspheric hiss overview and relation to chorus, J. Atmos. Sol. Terr. Phys., submitted 2008.

Similar formation of low frequency hiss in the Jovian inner magnetosphere has been described in

Wang, K., R. M. Thorne, and R. B. Horne (2008), Origin of Jovian hiss in the extended Io torus, Geophys. Res. Lett., 35, L16105, doi:10.1029/2008GL034636.

2. The Excitation Mechanism for Chorus.

The linear phase of the excitation of night-side chorus has been modeled during observed anisotropic electron injection events on CRRES and THEMIS by evaluating the path integrated gain of waves with the HOTRAY code. Waves grow rapidly, with gain exceeding 50 bd, due to cyclotron resonance with 1-10 keV electrons over a confined source location near the equator.

Li, W., R. M. Thorne, N. P. Meredith, R. B. Horne, J. Bortnik, Y. Y. Shprits, and B. Ni (2008), Evaluation of whistler-mode chorus amplification during an injection event observed on CRRES, J. Geophys. Res., 113, A09210, doi:10.1029/2008JA013129.

Li, W., R. M. Thorne, V. Angelopoulos, J. W. Bonnell, J. F. McFadden, C. W. Carlson, A. Roux, O. LeContel, K. H. Glassmeier, and U. Auster (2008), Evaluation of whistler-mode chorus intensification during an injection event observed on the THEMIS spacecrafts, J. Geophys. Res., in press.

3. Role of Chorus in Diffuse Auroral Precipitation.

We have demonstrated that resonant interaction with chorus causes the scattering of plasmasheet electrons at a rate comparable to strong diffusion, leading to diffuse auroral precipitation.

Ni, B, R. M. Thorne, Y. Y. Shprits, and J. Bortnik (2008), Resonant scattering of plasma sheet electrons by whistler-mode chorus: contributions to diffuse auroral precipitation, Geophys. Res. Lett., 35, L11106, doi:10.1029/2008GL034032.

4. Non-linear Scattering by Large Amplitude Chorus.

Using a code to evaluate the scattering of electrons by finite amplitude chorus waves, we have demonstrated that while moderate amplitude emission produce stochastic scattering consistent with quasi-linear theory, the recently reported large amplitude chorus (~nT) results in non-stochastic scattering associated with phase bunching and trapping.

Bortnik, J., R. M. Thorne, and U. S. Inan (2008), Nonlinear interaction of energetic electrons with large amplitude chorus, Geophys. Res. Lett., 35, L21102, doi:10.1029/2008GL035500.

Merry Christmas and Happy New Year!

Dr. János Lichtenberger (Eötvös University, Hungary) and Dr. Craig Rodger (Otago University, New Zealand) at János' vineyard on the outskirts of the city of Budapest. This picture was taken a week after the 3rd VERSIM workshop on a day in which a group of researchers gathered to assist János with the harvesting of his grapes [26 September 2008].