IAGA/ URSI Joint Working Group on

VLF/ELF Remote Sensing of Ionospheres and Magnetospheres Newsletter

Editor: Craig J. Rodger No. 24, December 2009

Dear Colleagues,

The end of 2009 is upon us, and I find myself wondering where the time has gone. But then I think back upon the workshops and major conferences, and the papers we have produced, and somehow I can see where at least some of my efforts went. As always, I would like to start by thanking all of the researchers who took the time to prepare and send me material for the newsletter. The newsletter contains 17 reports from 15 different countries, spanning both hemispheres and all longitudes. We are a very international community indeed!

The **IAGA General Assembly** was held in Sopron, Hungary from 23-30 August 2009, which included a VERSIM business meeting. A full report on this meeting can be found from our website. I would really like to thank the community for the attendance at this business meeting. There were 23 participants, which is likely to be a record for one of our IAGA business meetings. I hope you also found the IAGA General Assembly as stimulating and well run as I did. I think my only complaint associated with IAGA Sopron was the huge amounts of interesting and relevant science which was presented there. I found myself very tired once we reached the end. We did manage to influence the timetable to limit the number of clashes between VERSIM-relevant sessions, but it is essentially impossible to stop this from happened. Which is to say, I thought I had, but I didn't entirely succeed. Apologies to anyone who was badly affected.

As most of you will know, the VERSIM working group put forward an IAGA-resolution at Sopron to encourage the development of open-access scientific software. This suggestion originally came through the suggestion of L. R. O. Storey, and was supported by the community through emails and the VERSIM business meeting at IAGA. This is moving forward, if slowly, and there is a special report on the resolution in this newsletter. I should note that while our resolution was supported by IAGA's Division II, the IAGA drafting committee modified it following discussion at the IAGA Executive. I have placed the revised resolution on software on the VERSIM website. In addition, I would like to report that VERSIM also supported a Joint Divisions II and III Resolution on Radiation Belt studies which came up during the conference. This was not discussed at the VERSIM Business Meeting, as I was not aware of it at that time. I agreed VERSIM should support this resolution, and hope the community will not be troubled by this. The current version of this resolution, after the IAGA meeting can be found on the VERSIM website.

In 2010 I am particularly looking forward to the 4th VERSIM Workshop, which is to be held in Prague, Czech Republic from 13-17 September 2010. This meeting will be hosted by our colleagues from the Institute of Atmospheric Physics. By now many of you have been able to attend at least one VERSIM workshop, and will have seen the values of these events. I am convinced that the workshops have injected a new vibrancy into our community. I hope to see many of you there!

The Sopron meeting was a particularly good opportunity to meet and discuss with members of our community, and I very much enjoyed the discussions over wine at the poster sessions. I know I was not alone there, having found many people to talk to! I look forward to seeing people at the 4th VERSIM workshop, or indeed at other gatherings during the year. I hope the New Year finds you prosperous and happy, and of course scientifically productive too! Best wishes,

Craig J. Rodger
IAGA co-chair VERSIM working group

Forthcoming meetings

- 1st international conference on Very Low Frequency (VLF) Radio Waves: Theory and Observations (VELFRATO10) , Kolkata, India (14-18 March 2010).
- SCOSTEP's Symposium STP12, Berlin, Germany (12-16 July 2010)
- 38th COSPAR Assembly 2010, Bremen, Germany (18-25 July 2010)
- The 4th VERSIM Workshop is to be held in Prague, Czech Republic (13-17 September 2010).

Report on IAGA resolution on open-access scientific software

At the business meeting[1] held on 25 August 2009 during the IAGA Scientific Assembly, the members present put forward an IAGA resolution to encourage the development of open-access scientific software, based on a position paper[2] by L.R.O. Storey. Their resolution[3] was submitted to the drafting committee for IAGA Division II, where, after further modification, it was put first in the list of seven resolutions for 2009. We have copied the text below. However, the scope of this version is narrower than was proposed by VERSIM: our proposals are endorsed only insofar as they concern the needs for software in our discipline, and their implementation is entrusted to us, with support from IAGA in the form of space at the IAGA website. This and the other resolutions will not be adopted definitively until the IUGG Assembly in Melbourne, in June–July 2011.

Meanwhile, IAGA has been asked to make a small part (~10 GB) of the IAGA website available to us in the near future. If our request is granted, then this new website would be set up as soon as possible for the general public to download any content, but with the privilege of creating and editing content restricted to VERSIM members, at least initially. All would be invited by e-mail to upload their software to it, and those who accept would access these facilities using passwords authorized by the webmaster. By this means, we would meet one objective mentioned in our resolution, namely to "create a public space on the IAGA website, where researchers can freely upload their code, and download the code of their colleagues."

The next VERSIM Workshop will take place in Prague, in September 2010, and it would be appropriate that the agenda include another discussion of open-access software, with the following aims: firstly, to review what has been accomplished to date, and suggest improvements to the website; secondly, to determine how to attain another objective, which is to enable the site to be used also “as a portal by which larger items of software can be listed and described, and links to them provided." Lastly, suggestions as to what items of large-scale open-access software are needed, and how they could be developed, would be welcome for debate at this meeting.

Division II Resolution on software

IAGA, noting that

- the Association has played a prominent role in data management through its leadership of the Electronic Geophysical Year, and that IUGG has formed a new organization to support data management,
- nevertheless some other aspects of scientific research in the IAGA disciplines are still hindered by the scarcity of software in the public domain,

recognizing that

- despite increasing pressures on scientific budgets, there is a need to provide support for research in developing countries and encourage new collaborations,
- it is central to IAGA’s charter to promote international science by encouraging world-wide open access to the means for pursuing research,
- the necessary means include scientific software, in particular for modelling and for simulating physical processes (where excellent examples exist already in some areas of IAGA science), and for theoretical research,

resolves to

- through the URSI/IAGA Joint Working Group on VLF/ELF Remote Sensing of the Ionosphere and Magnetosphere (VERSIM), take an initiative similar to those already taken in data management, aimed at making software for data analysis, modeling, simulation and theoretical research more freely available to the scientific community,
- investigate
  - the need for large-scale open-access software,
  - how its development could be funded,
- for smaller items of software, create a public space on the IAGA website, where researchers can freely upload their code and download the code of their colleagues, and that this section of the website be also used as a portal by which larger items of software can be listed and described, and links to them provided.

[1] www.physics.otago.ac.nz/versim/VERSIM_business_meeting_IAGA_GA_2009.pdf
[2] Flashversim e-mailing, 11 August 2009.
[3] www.physics.otago.ac.nz/versim/IAGA_DivisionII_Resolution_software_Sopron_2009.pdf

Reports from VERSIM research groups 2009

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, representing the Institute of Atmospheric Physics and Charles University.

We have continued our investigation of VLF waves observed in the inner magnetosphere. We focused mainly on whistler mode waves. Traditionally we are interested in various types of VLF waves: chorus emissions, equatorial noise, auroral hiss, lion roars, lightning induced whistlers, magnetospheric line radiation, power line harmonic radiation, and in wave phenomena associated with possible seismo-ionospheric coupling. Our analysis has mainly been based on the spacecraft data from the DEMETER, CLUSTER, Double-Star, Polar, Freja and Cassini missions. In the case of lightning induced whistlers, we have also used data from lightning location networks.

The Institute of Atmospheric Physics will host the next VERSIM workshop in Prague, Hotel Globus, on 13-17 September 2010. The web site of the workshop is http://www.ufa.cas.cz/versim10. We invite the VERSIM community to come to Prague and contribute to the success of this meeting.

Santolik O. and J. Chum, (2009), The origin of plasmaspheric hiss, Science, Vol. 324. no. 5928, 729 - 730, doi: 10.1126/science.1172878

Santolik, O., M. Parrot, U. S. Inan, D. Buresova, D. A. Gurnett and J. Chum, (2009), Propagation of unducted whistlers from their source lightning: a casestudy, J. Geophys. Res., 114, A03212, doi:10.1029/2008JA013776

Chum, J., O. Santolik, and M. Parrot, (2009), Analysis of subprotonospheric whistlers observed by DEMETER: A case study, J. Geophys. Res., 114, A02307, doi:10.1029/2008JA013585.

Nemec, F., T. Raita, M. Parrot, O. Santolik, and T. Turunen (2009), Conjugate observations on board a satellite and on the ground of a remarkable MLR-like event, Geophys. Res. Lett., 36, L22103, doi:10.1029/2009GL040974.

Nemec, F., M. Parrot, O. Santoik, C. J. Rodger, M. J. Rycroft, M. Hayosh, D. Shklyar, A. Demekhov, Survey of magnetospheric line radiation events observed by the DEMETER spacecraft, J. Geophys. Res. 114, A05203, doi:10.1029/2008JA014016, 2009.

Nemec, F., O. Santolik, and M. Parrot (2009), Decrease of intensity of ELF/VLF waves observed in the upper ionosphere close to earthquakes: A statistical study, J. Geophys. Res., 114, A04303, doi:10.1029/2008JA013972

Chum, J., O. Santolik, D. A. Gurnett, and J. S. Pickett (2009), Oblique lower band chorus waves: Time shifts between discrete elements observed by the Cluster spacecraft, J. Geophys. Res., doi:10.1029/2009JA014366,in press.

Santolik, O., D. A. Gurnett, J. S. Pickett, J. Chum, N. Cornilleau-Wehrlin (2009), Oblique propagation of whistler-mode waves in the chorus source region, J. Geophys. Res., in press, doi:10.1029/2009JA014586.

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

We are participating in the *World Wide Lightning Location Network (WWLLN)* since 2003. Using the WWLLN set-up we have been running the SoftPAL data acquisition system and high speed data recorder to record waveforms of lightning generated sferics. The tweeks were used to determine mean equivalent electron density at mean VLF reflection heights and electron density profile 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 results have been published (Kumar *et al.*, *Earth Planet Space*, 61, 905-9, 2009).

Further study on the early VLF perturbations on signals NWC, NPM, VTX, and NLK transmitter signals received at Suva during November 2006-January 2007 was carried out. The results were presented in Chapman Conference on the Effects of Thunderstorms and Lightning in the Upper Atmosphere, Penn State University, USA, 10-15 May 2009. The first observations of early/slow events in the daytime of TRGCPs were presented. The results have been communicated for publication. The amplitude and phase of NWC signal have been utilized to determine the waveguide mode parameters. The experimental values of the parameters were found to be consistent with the theoretical values calculated using the mode theory of wave propagation in the waveguide.

A *state of* art ELF/VLF data recording and analysis System called Atmospheric Weather Electromagnetic System for Observation Modeling and Education (AWESOME) was installed in July 2009. It was provided to us by Stanford University for collaborative research on very low frequency (VLF) studies of ionospheric and magnetospheric electromagnetic phenomenon, being undertaken by STAR Laboratory of Stanford University, and The University of the South Pacific. This coordination comes in the context of the International Heliophysical Year (IHY-2007) supported by UN/NASA, and comes as part of Stanford's commitment to distribute scientific instruments for international collaborations.

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

Continuing last years activity 2 VLF receivers 35 km apart at 52N 8E are constantly monitoring VLF transmitters. Also the E-W magnetic field component is monitored. Daily uploads to: www.electricterra.com/Ernst/

Ongoing activity is concentrating on Finite Element Analysis (FEA) computer modelling of transient signal (lightning) and continuous wave propagation in the earth-ionosphere cavity.

During the participation at the IAGA2009, Sopron, Hungary, 2 talks have been given:

Schmitter, E.D. 2009. Modeling the earth-ionosphere cavity using FDTD. IAGA 2009, 107-WED-01430-0003, Sopron, Hungary, August 23-30, 2009;

Schmitter, E.D. 2009. VLf remote sensing of lower ionosphere disturbances at a medium latitude site and their correlation with high energy electron flux. IAGA 2009, 208-FRI-01545-0405, Sopron, Hungary, August 23-30, 2009

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 (Stanford University) receiver, which participated in the latest *EuroSprite* 2009 campaign by providing VLF observations on a continuous basis for most of the campaign. The Crete VLF receiver station has become a component of the AWESOME ELF-VLF network (http://nova.stanford.edu/~vlf/awesome) organized and administered by the Stanford University, in which there is a growing number of international participants from all over the world. It is sponsored by the United Nations International Heliophysical Year (IHY) and the National Aeronautics and Space Administration (NASA). Also we have continued/started

collaboration with colleagues and institutions from USA, Denmark, Finland, Hungary, Russia, Israel, and Spain.

During 2009, we continued research on the topic of subionospheric early VLF perturbations caused by tropospheric lightning and occurring in relation with transient luminous events. The most important scientific findings obtained have been published in the following papers:

1) Modeling the relaxation of early VLF perturbations associated with transient luminous events, C. Haldoupis, A. Mika, and S. Shalimov, J. Geophys. Res., 114, A00E04, doi:10.1029/2009/2009JA014313, 2009.
2) ELF/VLF signatures of sprite-producing lightning discharges observed during the 2005 EuroSprite campaign, E. Greenberg, C. Price, Y. Yair, C. Haldoupis, O. Chanrion, and T. Neubert. J. Atmos. Sol-Terr. Phys., 71 (12), 1254-1266, 2009.
3) Sprite and Early ionospheric VLF perturbations, C. Haldoupis, N. Amvrosiadi, B. R. T. Cotts, O. van der Velde, O. Chanrion, and T. Neubert, Submitted to J. Geophys. Res, December, 2009.

and presented in the following international conferences/workshops :

1) *EuroSprite* Studies of *Early* VLF Perturbations Occurring in Relation with *TLEs,* C. Haldoupis, American Geophysical Union Chapman Conference on the Effects of Thunderstorms and Lightning in the Upper Atmosphere, Penn State University , PA, USA, 10-14 May, 2009.
2) Crete VLF Studies of Transient Luminous Events, C. Haldoupis, Advancing VLF Science through the global AWESOME Network, Tunis, Tunisia, 30 May – 01 June, 2009.
3) Modeling the relaxation of early VLF perturbations associated with Transient Luminous Events, C. Haldoupis, A. Mika, and S. Shalimov, International Association of Geomagnetism and Aeronomy, 11th General Assembly, Sopron, Hungary, August 23-30, 2009.

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

We have continued the work on the theoretical full wave solution of the Maxwell's equations in two particular cases: we made further analysis of in the case of moving, inhomogeneous media and 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 extended the Automatic Whistler Detector and Analyzer Network with two new nodes at Antarctica: at Palmer (US) in cooperation with Stanford University and at Commandante Ferraz base (Brazil) in cooperation with Mackenzie University, Sao Paulo. We analyzed the first data acquired during the first 8 month of operation at Rothera (UK, also in Antarctic peninsula) to make a statistic of whistler rate. We found an extremely high whistler activity, about 5,000,000 whistler traces during this 8 months. We also made studies two locate the potential source area of these whistlers. The most probable area is over the sea east to the east-coast of US (200 km east to Charleston over the sea), but the Caribbean may contribute significantly.

Systematic analysis has been performed on archived Omnipal and UltraMSK data set using an automated procedure to select amplitude and/or phase perturbations in narrow-band VLF recordings. Occurrence rates of detected events are dominated by rapid perturbations, agreeing our preliminary expectation in the case of middle latitude paths. Temporal variation of recorded perturbation rates in short path TRGCPs exhibit clear correlation with regional thunderstorm activity, confirming the relevance of whistler induced precipitation along slot region latitudes.

We continued the hyperfine analysis of whistlers. Selected traces measured simultaneously on-board and ground stations were analyzed with high accuracy to understand the propagation and the coupling mechanism.

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

Whistler studies at Agra is almost three decades old. Recently, we have digitized all the recording and analysis systems and got good results. A new research project entitled "Remote sensing of low latitude ionosphere and magnetosphere using ground based whistler technique" has been sanctioned by the Department of Science and Technology, Government of India, New Delhi. The basic objectives of the project is to study low latitude whistlers and related phenomena using ground and satellite data, and D-region ionospheric perturbations caused by Transient Luminous Events, Solar flares, and Earthquakes.

We have procured SoftPAL (software based amplitude and phase data logger) receiver from New Zealand and made preliminary studies by monitoring phase and amplitude variation of NWC (f=19.8 kHz) signals transmitted from Australia. It is interesting to report that this experiment has provided very good result corresponding to the total solar eclipse seen in India on 22 July, 2009 in which the amplitude of the signal is sufficiently reduced during 0624-0628h LT when the solar disc was totally covered by the lunar shadow. Many cases of sudden amplitude and phase changes, possibly caused by sprites, have been recorded. A detailed study of these results is in progress.

Israel - Report by Colin Price (Tel Aviv University) and Yoav Yair (Open University of Israel)

Yoav Yair and Colin Price and their students have started the 5th season of the ILAN winter sprite campaign (http://www.tau.ac.il/~royyaniv/ILAN_website/ILAN.html). Calibrated optical measurements led by students Na'ama Reicher and Roy Yaniv will are conducted intermittently from Tel-Aviv and Mizpe-Ramon. Additionally, long-range observations will be attempted from Mt. Hermon (1500 m above sea-level) which will enable monitoring TLE activity as far as western Turkey and over the Mediterranean Sea as well as Jordan and Iraq in the east. Simultaneous measurements will be attempted from the Hebrew University campus in Jerusalem, led by Caryn-Elissa Erlich. This ground based capacity will become an asset for future space missions such as Taranis and ASIM.

Colin Price and Yuval Reuveni completed analyzing VLF data obtained from the Sde-Boker station in southern Israel, and found a strong signal in the VLF emission from terrestrial lightning activity with a 27-day periodicity, related to the solar rotation. They suggest that continuous monitoring of VLF radio noise at frequencies close to the waveguide cutoff could provide a new method of continuously monitoring changes in the solar rotation rate. This research was recently published [Reuveni, Y., and C. Price (2009), A new approach for monitoring the 27-day solar rotation using VLF radio signals on the Earth's surface, J. Geophys. Res., 114, A10306, doi:10.1029/2009JA014364.]

Colin Price, Yoav Yair and Lev Dorman (TAU) have started a research project focused on monitoring space weather from Earth's surface by measurements of various electrical parameters (electric field, conductivity, ELF and VLF emissions) in conjunction with observations of the cosmic-ray flux. The 3-year project is based on two stations, one on Mt. Hermon and the other in the Wise observatory in the Negev desert.

Japan - Space Earth Environment Laboratory, Tokorozawa, report by Tadanori .Ondoh.

Low Latitude Boundary of Polar Hiss in the Upper Ionosphere

Latitudinal variation of VLF hiss observed in geomagnetic quiet and disturbed periods are investigated by using VLF electric field (50 Hz – 30 kHz) data of ISIS-2 (circular polar orbit at 1400 km height) received at Syowa station, Antarctica. The VLF hiss observed are classified of the broad-band polar hiss and narrow-band plasmapause hiss. The wide band polar hiss is the whistler-mode Cerenkov emissions in the polar magnetosphere generated by energetic electrons (100 eV – 40 keV) precipitating from the plasmasheet boundary layer.

The plasmapause hiss is narrow-band whistler mode waves excited by the cyclotron instability of energetic electrons convected from the magnetotail. The low latitude boundary of polar hiss which depends on geomagnetic local time lies at a geomagnetic invariant latitude above 70 degrees in a geomagnetic quiet period, but it comes down to below 65 degrees in a disturbed period. We have not yet discussed on physical meaning of the low latitude boundary of polar hiss, that is, a latitudinal boundary of precipitating energetic electrons generating the polar hiss. Is this simply mean an inner boundary of precipitating energetic electrons generating the polar hiss or not ? This solution will give us some suggestion why wide-band polar hiss is not observed relatively near outside of the plasmapause, although the mid-latitude narrow–band VLF hiss is normally observed inside the plasmapause.

Japan - University of Electro-Communications, Chofu, report by Yasuhide Hobara and Masashi Hayakawa.

1. Observations of sprites and coordinated measurements

Coordinated observations for winter sprites in the Hokuriku area with a sensitive optical camera in coordination with ELF observation in Moshiri, VHF radio sferics (SAFIR), radar observation, field mill network observation etc. to elucidate the generation mechanism of transient luminous emissions. These would be compared with our computer simulations (EM code).

2. Subionospheric VLF/LF signals reception network in Japan.

Several VLF/ LF receiving stations (Moshiri, Chofu, Tateyama, Kasugai and Kochi at the moment) are in operation, in order to study the trimpi effects caused by deifferent agents including lightning discharges, earthquakes and any other effects (solar flares, gamma-ray bursts etc.).

3. Seismo-electromagnetics

Seismo-ionospheric perturbations have been monitored by the above VLF/LF network in order to study the lithosphere-atmosphere-ionosphere coupling. Also seismo-ULF emissions are monitored by means of the ULF network in the Tokyo area.

4. Inversion of ELF Schumann resonance data to deduce global lightning distribution

The first attempt of inversion by using the real Schumann resonance data (Moshiri, Rhode Island, Lekhta) has been done to deduce the global lightning distribution as a snapshot. This is just the result for only a few days, but we will finish the similar inversion over one year data. The distribution of background lightning as deduced from Schumann resonance will be compared with the corresponding distribution of huge lightning from ELF transients at Moshiri.

5. Ground and satellite ELF/VLF studies

The coordinated observation of ELF/VLF waves on the ground (in Japan) and on the satellite (Demeter) is being carried out in order to study the generation and propagation characteristics of ELF/VLF waves.

6. Satellite observation of magnetospheric plasma waves

Data from different satellites (Demeter, Clusters, THEMIS) are used to study (1) magnetosphere VLF/ELF emissions (their generation and propagation mechanisms), (2) solitary wave in the vicinity of the terrestrial bow shock (wave characteristics, generation and acceleration mechanisms), (3) shock scale of perpendicular shock, etc.

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

We have been running the following experimental measurements locally in Dunedin: 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 (OmniPAL, AbsPAL, SoftPAL and Ultra MSK) which log small changes in the phase and amplitude of powerful VLF communications transmitters (~13-30 kHz) to study subionospheric propagation. 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 additional measurements.

In October 2009 Neil Thomson travelled to the north-west of Australia and also Hawaii to make near-field measurements of powerful US Navy VLF transmitters, continuing his efforts to improve the description of the nighttime and daytime D-region electron density used in VLF propagation modelling. In December 2009 a 2-man team comprising of James Brundell and Rory Gamble travelled to Scott Base, Antarctica to gather data off our AARDDVARK receiver at Arrival Heights. We continue to be active in 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).

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.

Russia - Institute of Terrestrial Magnetism, Ionosphere and Radiowave Propagation (IZMIRAN), Troitsk, report by Boris Lundin

The quantitatively reliable dispersion law for plane waves of electron whistler mode have been found which is applicable in a cold multi-ion plasma of moderate density over the total whistler transparency frequency domain.

It is expressed through the characteristic frequencies corresponding to the spectral features of the plasma emissions and the relative content of two lightest ion species. The simplified model of ions' motion at frequencies near the whistler ion cutoff frequency is shown to be relevant when the more heavy ions and/or charged particulates contribute into the charge neutrality condition only. As a result the estimates of the relative content of two lightest ion species can be recovered using the measurements of highest ion cutoff frequency.

It was also revealed that the contamination of the background plasma by negative ions and/or negatively charged dust particulates can be the origin of manifold increase of lower cutoff frequency of electron whistler wave; the other new effect is the possibility of merging the ion cutoff frequencies of the electrons' and the adjacent ions' whistler mode waves.

Thus, in the following papers:

B.Lundin, C.Krafft, On the dispersion law of low frequency electron whistler waves in a multi-ions plasma, Ann. Geophys., v.26, 1606-1615, 2008.

B.Lundin, C.Krafft, On the electron whistler dispersion law in a cold plasma with light ions and heavy charged particulates, Physics of Plasmas, v.16, 052104(1-11), 2009.

B.Lundin, C.Krafft, On the minimal set of plasma parameters to determine the dispersion law of electron whistler waves, Plasma Physics Reports, v.35, N6, 502-509, 2009.

the problem of minimization of the set of plasma parameters needed to write the quantitatively reliable dispersion law of electron whistler waves in the near Earth multi-ion plasma have been discussed and solved. In plasma with two light ion species and much more heavy charged particulates, contributing mainly to the charge neutrality condition in a whistler wave field, all the necessary plasma parameters can be recovered using wideband wave receivers only, i.e. without onboard mass spectrometer.

Russia - Space Research Institute of RAS, Moscow, report by David Shklyar

An investigation into wedge-like spectrograms observed by DEMETER

D. R. Shklyar[1,2], M. Parrot[3], J. Chum[4], O. Santolik[4,5] and E. E. Titova[6]

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[2]Moscow Institute of Physics and Technology, Moscow region, Russia.
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[4]Institute of Atmospheric Physics AS CR, Prague, Czech Republic.
[5]Faculty of Mathematics and Physics, Charles University, Prague, Czech Republic.
[6]Polar Geophysical Institute, Apatity, Russia.

The LHR frequency is known to play a crucial role in VLF wave propagation in the plasmasphere, in particular, quasi-resonance VLF waves cannot propagate in a region where the LHR frequency exceeds the wave frequency. When such a wave propagates in the direction of increasing LHR frequency, it is reflected at the level where its frequency is close to the local LHR frequency. The intensity of quasi-resonance waves significantly increases close to LHR frequency due to substantial decrease of the group velocity. As a consequence, the LHR associated phenomena are among the most pronounced in the VLF measurements on satellites. This concerns first of all electric field measurements because of a quasi-electrostatic nature of resonance LHR waves. In this respect DEMETER is of particular value as it is orbiting in the region of upper ionosphere where the height profile of the LHR frequency forms a trough, so that the maximum of LHR frequency along the geomagnetic field line is above the satellite. The VLF phenomena studied, i.e. the formation of a wedge-like structures on overview spectrograms, are explained in terms of the wave propagation features and a specific position of the satellite with respect to the LHR maximum. In general terms, this explanation is as follows. WLE consists of whistler mode waves originating from lightning and, thus, is related to thunderstorm activity. The wedge as such is formed by whistler waves propagating in quasi-resonance regime. All quasi-resonance waves with frequencies below the LHR maximum are reflected above the satellite, which explains the lower frequency cutoff of the wedge like events, which is thus close to the maximum of LHR frequency above the satellite. The appearance of an upper cutoff frequency is due to another feature of unducted VLF wave propagation, which consists in trajectory merging into a limiting trajectory for waves with the same frequency, but starting from different latitudes in the opposite hemisphere. As the further increase of the initial latitude does not lead to an increase of the final L-shell in the opposite hemisphere, there appears a maximum L-shell on which the waves with the given frequency can be observed. This L-shell decreases with the increase of wave frequency due to a more pronounced bending toward lower L-shells for higher frequency waves. As the result, the accessible domain for quasi-resonance whistler-mode waves on the $(L-f)$-plane takes the observed wedge-like shape.

The results of this study will be published in JGR.

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

From this year the University of Nova Gorica has explicitly joined the list of VERSIM Institutions. We are pleased to be acknowledged as part of the VERSIM community. Thanks Craig!

In this period of deep Solar minimum, the previously monitored and compiled VLF databases have been further explored and analysed, in connection with sequential and solitary solar flares occurring in the period 2004-2007. Currently we aim at comparing the signatures of solar flares on VLF signals from NAA/24.0 kHz and GQD/22.1 kHz as registered by the Belgrade AbsPAL and other receivers on the northern hemisphere.

Both Slovenia and Serbia have actively joined the new COST ES0803 Action: *Developing space weather products and services in Europe (2008-2012),* and have participated at the Sixth European Space Weather Week, 16-20 November 2009, Brugge, Belgium (V. Žigman, D. Grubor, D. Šulic, *Electron density enhancements during solar X-ray flares from VLF monitoring of the lower ionosphere*).

The new AWESOME station installed at the Institute of Physics, Belgrade last year, has been brought to stable operation. The station is operated continuously and data have been compiled for periods during the last and this year. VLF measurements of lightning induced electron precipitations and their effects on the D-region electron density profile, D. Šulić, and V. Srećković has been presented at The First IHY International Workshop on Advancing VLF Science Through the Global AWESOME Network in Tunisia, Tunis.

A master thesis on the diagnostics of the lower ionosphere by VLF sounding has been successfully concluded at the Belgrade University and a diploma on space weather is in progress at the University of Nova Gorica. In October 2009, at the University of Ljubljana a lecture on the modelling of electron density enhancements during solar flares from VLF data has been given on the occasion of the negotiations of Slovenia to join the European Space Agency.

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.

Three MSc students, Sherry Bremner, Brett Delport and Etienne Koen, travelled to the SANAE IV base in Antarctica during the summer of 2008/9 to perform maintenance on various experiments. During this time they installed an AWESOME received purchased from Stanford. A WWLLN node was also installed at SANAE IV. Although there are some issues with the signal, this node is contributing to the WWLLN. The equipment at SANAE IV has functioned well through the year. However, we have encountered a number of problems with hardware. At least two hard disks have failed, which may lead to a significant loss of data. The pulsation magnetometer, a very old device, has also finally ground to a halt. It will be returned to South Africa this summer and replaced at the end of next year.

Later, at the end of the first quarter of 2009, Daleen Koch and Etienne Koen returned to Marion Island, a small South African territory located in the middle of the roaring fourties, to perform similar maintenance. The conditions on Marion Island are particularly harsh for equipment since it generally rains every day, the wind speeds are perenially high and there is a significant diurnal temperature variation The equipment on Marion Island is housed in the emergency base, which is located a few hundred metres away from the main base and did not have a network connection. However, during the takeover a wireless link was installed from the main base to the emergency base. The systems running on the island are thus now accessible from South Africa and we are able to monitor their operation. This is a significant improvement over the previous situation where we were unable to determine whether or not our systems were operational.

Brett Delport, Janos Lichtenberger and Peter Steinbach visited the University of Fort Hare in Alice, Eastern Cape, to determine whether it would be feasible to relocate the AWDA from Sutherland. They found a suitable site for the installation. Currently all of the hardware for this installation has been assembled and we are waiting for the hosts in Alice to prepare their facilities.

A paper documenting the correlation between whistlers detected at Tihany and global lightning activity was published during the first half of the year. The conclusions of this paper were that the majority of Tihany whistlers arise from lightning strikes with a few hundred km of the conjugate point but that there is a finite contribution from more distant strikes over South America and the Maritime Continent. A similar analysis was then conducted for whistlers detected at Dunedin, New Zealand. The results were somewhat surprising. The Dunedin paper is currently in review.

A fruitful collaboration is developing with Dr Eldo Avila of Cordoba, Argentina. We have been examining the annual and semi-annual components of the lightning activity over Africa and South America.

At the end of 2009 Dr Agatha de Boer of the University of East Anglia will be visiting the group to continue our work on lightning over the Agulhas Current.

Sherry Bremner (MSc student) extended her work on the ionospheric effects of Gamma Ray Bursts to explore the use of PCA for the analysis of subionospheric VLF data. Etienne Koen (MSc student) performed a similar analysis for Solar Flares. Brett Delport (MSc student) has been studying the various classes of VLF emissions observed at SANAE IV. All three of these students will have completed their theses by the end of the year. Brett and Etienne will definitely be starting on PhD studies. Ogbos Okike (PhD student) is looking at the relationship between cosmic rays and climate, using Forbush Events as reference epochs.

The group was involved in the VLF experiment onboard the second South African satellite, Sumbandila, which was launched on 17 September 2009 on a Soyuz-2 launch vehicle from the Baikonur Cosmodrome.

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

BROADBAND RECORDINGS at Rothera, Antarctica

Whistler-detection and data collection has continued throughout 2009 from the Hungarian Automatic Whistler Detection system.

The Stanford University AWESOME receiver has operated throughout 2009, logging broadband and narrow-band data, including the South Pole Beacon.

VELOX RECORDINGS at Halley, Antarctica:

Continuous (since 1992) recordings of VLF activity in 10 ELF/VLF bands, at 1-s resolution (VELOX and VELOXNET), including spheric counters, have continued at Halley in 2009. 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:

In February 2009 an ‘Ultra’ narrow-band system was installed at Rothera. After a month of overlap with the `OmniPAL' receiver the Omnipal was switched off.

The Australian Casey station (Antarctica) was upgraded to an ‘Ultra’ in February 2009, and has been operational throughout 2009.

At Sodankyla (Finland), Churchill (Canada), and Ny Alesund (Svalbard), ‘Ultra’s have continued to operate throughout 2009. Basic data collection is undertaken with at least 0.2 s resolution.

A software VLF Doppler system was installed at Rothera station, Antarctica (L=2.8) in January 2009, receiving whistler mode and subionspheric signals primarily from NAA (24.0 kHz). After a period of overlap with the old hardware Doppler, the Software system has taken on all data logging and the old system removed. A sister experiment at Marion Island, South Africa, has been receiving whistler mode and subionspheric signals primarily from DHO (23.4 kHz) throughout 2009.

WWLLN sites:

British Antarctic Survey operated two World Wide Lightning Location Network systems in 2009. Rothera and Ascension Island have provided lighting location information all year.

SFERIX sites:

British Antarctic Survey installed a SFERIX system (LF*EM, Dunedin, NZ) at Rothera in January 2009, providing lightning location information throughout 2009.

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

At the VLF/ELF Radio Research Institute we have completed an extensive analysis of the unique 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. We also analysed shorter but compatible datasets from the British Antarctic Survey Automatic Geophysical Observatories, and from Casey station.

The consistency, accuracy and reliability of the data have enabled the average spectrum and amplitude occurrence statistics to be determined with some confidence. The wave intensity variation with local time, season, latitude, solar cycle phase, and geomagnetic disturbance have been determined, and we have also looked at the behaviour of the wave polarisation and arrival azimuth. The results of the study are expected to be published in the Journal for Atmospheric and Solar-Terrestrial Physics.

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/. Although the VELOX data are no longer being recorded, similar VELOXnet data have continued to be taken at Halley, throughout the upheaval caused by the decommisioning of Halley V and construction of Halley VI, and may be browsed and downloaded from the same website.

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

In the past year, Jacob Bortnik continued to develop the theoretical model that describes plasmaspheric hiss as the superposition of a population of chorus elements that have propagated from their source in the plasmatrough, and merged into a continuum of waves inside the plasmasphere. With the aid of a student (Mr. Lunjin Chen), we showed how dayside chorus waves that are excited in the vicinity of plasmaspheric drainage plumes, can be deflected towards later MLT and propagate into the plume, through the dusk sector, and sometimes even around the entire globe before being Landau damped.

In addition, with the aid of another student (Ms. Wen Li), we identified a unique observation in the THEMIS data that showed a simultaneous recording of chorus and plasmaspheric hiss in different regions of space, that were correlated to each other extremely well, and offset by the few-second delay-time that was predicted by our model. This observation was reported in the journal Science, published in May 2009.

Over the last year the Thorne group at UCLA has published the following papers related to wave phenomena:

1. 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 (2009), Evaluation of whistler-mode chorus intensification on the nightside during an injection event observed on the THEMIS spacecraft, J. Geophys. Res., 114, A00C14, doi:1029/2008JA013554.

2. Shprits, Y. Y., L. Chen, and R. M. Thorne (2009), Simulations of pitch-angle scattering of relativistic electrons with MLT-dependent diffusion coefficients, J. Geophys. Res., 114, A03219, doi:1029/2008JA013695.

3 Bortnik, J., R. M. Thorne, and N. P. Meredith (2009), Plasmaspheric hiss overview and relation to chorus, J. Atmos. Sol. Terr. Phys., 71, 1636-1646.

4 Bortnik, J., W. Li, R. M. Thorne, V. Angelopoulos, J. Bonnell, C. Culley, O. LeContel, and A. Roux (2009), First observation linking the origin of plasmaspheric hiss to discrete chorus emissions, Science, 324, 775, doi:10.1126/science.1171273.

5. Chen, L., J. Bortnik, R. M. Thorne, R. B. Horne, and V. K. Jordanova (2009), Three-dimensional ray tracing of VLF waves in an asymmetric magnetospheric environment containing a plasmaspheric plume, Geophys. Res. Lett., 36, L22101, doi:10.1029/2009GL040451.

6. Li, W., R. M. Thorne, V. Angelopoulos, J. Bortnik, C. M. Cully, B. Ni, O. LeContel, A. Roux, U Auster and W. Magnes (2009), Global distribution of whistler-mode chorus observed on the THEMIS spacecraft, Geophys. Res. Lett., 36, L09104, doi:10.1029/2009GL037595 .

7. Meredith, N. P., R. B. Horne, R. M. Thorne, and R. R. Anderson, Survey of upper band chorus and ECH waves: Implications for the diffuse aurora (2009), J. Geophys. Res., 114, A07218, doi:1029/2009JA14230.

8. Chen, L., R. M. Thorne, and R. H. Horne (2009), Simulation of EMIC excitation in a model magnetosphere including structured high- density plumes, J. Geophys. Res., 114, A07221, doi:1029/2009JA014204.

Paper 1 evaluates the growth of nightside chorus using data from the THEMIS spacecraft and shows that waves can be experience strong amplification during injection events. Paper 6 describes the global distribution of chorus in the outer magnetosphere using THEMIS wave data. A new feature is the intense waves observed on the dayside at L>7.

We have published several papers (3, 4, 5) dealing with the origin of plasmaspheric hiss from chorus including an observational confirmation of the mechanism using THEMIS data from two spacecraft (4) and 3D ray tracing (5) that shows that chorus that enters the plasmasphere can propagate over a broad range of MLT and that chorus waves on the dayside can globally fill the entire plasmasphere including the nightside.

We have performed a survey (7) of the properties of chorus and ECH waves which contribute to diffuse auroral scattering and are now in the process of evaluating scattering rates in an attempt to understand the global structure of the diffuse aurora.

We have simulated the growth of EMIC waves in a model magnetosphere containing a plasmaspheric plume with fine scale density structure (8). Most intense EMIC wave gain is confined to regions with large negative density gradient. We have also modeled the MLT dependent scattering of relativistic electrons by chorus and EMIC waves (2) and shown that both types of waves are important in the loss of electrons.

Merry Christmas and Happy New Year!

Dr. János Lichtenberger (Eötvös University, Hungary) during a visit to Port Elizabeth, at the shore of the Indian Ocean. Recent work has identified lightning from this region is the primary source of Hungarian whistlers (Collier et al., 2009).

Dr. Craig Rodger (Otago University, New Zealand) outside the Seattle Space Needle, in the US state of Washington. Craig was visiting the University of Washington for a World Wide Lightning Location Network (WWLLN) management meeting [19 July 2009].