IAGA/URSI
Joint Working Group on

VLF/ELF Remote Sensing of Ionospheres and Magnetospheres

Editor: A J Smith | Newsletter | No. 10 — December 1996

Dear colleagues,

The 25th General Assembly of URSI (International Union of Radio Science), one of the working group's two parent bodies, was held in Lille in August–September 1996, and a very good assembly it was too. It was particularly pleasing to have the opportunity to meet and talk to many VERSIM members. This issue of the *VERSIM Newsletter* contains reports from the Assembly. Looking to the future, next August's 8th Scientific Assembly of IAGA in Uppsala, Sweden, is now not far ahead and may be of particular interest to the VERSIM community. Some details and a call for papers are to be found below (note the deadline for submission of abstracts is **28 February 1997!**). I hope many of you will be able to participate at Uppsala and I look forward to seeing you there.

XXV General Assembly of URSI, Lille, August-September 1996

Whistler-mode waves and their effects on the radiation belts

This was a very successful session which attracted a large audience. The focus was on the resonant cyclotron pitch angle scattering of trapped electrons by whistler mode waves, and the importance of the latter as a loss mechanism. The three invited speakers (Thorne, Vampola, Walt) reviewed the current theoretical and experimental knowledge.

Thorne reported modelling work with Abel which showed that Coulomb scattering was an effective loss mechanism only for $L < 1.2$. Except for pitch-angles very close to 90°, where Landau resonance was important, pitch angle scattering by cyclotron resonance was the dominant process in determining electron lifetimes over essentially all of the radiation belts. Using estimates of whistler mode wave intensity distributions and spectra in different regions, it was estimated that signals from VLF transmitters were most important in the inner region, hiss in the outer region, and lightning whistlers in the intermediate region.

Vampola reviewed the satellite evidence on the scattering of resonant electrons into the drift loss cone by powerful VLF transmitters. The frequency, modulation format and particularly longitude were all important factors. One of the most effective transmitters had been the Soviet UMS transmitter. The precipitation patterns around each transmitter and its conjugate, formed by scattering into the bounce loss cone, were also discussed. The "natural" radiation belts in the absence of VLF transmitters have never been observed and it is an intriguing question what the effect will be if/when all the VLF transmitters are turned off (this trend has already begun with the recent closure of the NSS transmitter in Maryland and the planned shutdown of the Omega system on 30 September 1997).

Walt reviewed LEP as seen by low altitude satellites such as SEEP. Calculations of trapped electron lifetimes due to interactions with ducted whistlers (which Trimpi event ev-

idence suggests are more important than unducted whistlers) were critically dependent on poorly known quantities such as the size and distribution of whistler ducts. He pointed out that the spatial extent of LEP as seen by low-altitude satellites could be used to infer the size of ducts; the limited cases so far studied suggested duct sizes of order 100 km, leading to an estimate of electron lifetime of only 17 days (changing the size to 25 km would increase this to 270 days).

Sonwalkar reported a study relating cloud–ground lightning seen by the SUNY network, and whistlers observed on the DE-1 satellite. There were some interesting conclusions, e.g. that one-to-one correlations were seen only on 6 days out of three years examined. On those days, more than half the cloud-ground (C–G) lightning discharges resulted in an observable whistler, but there were more whistlers seen than C–G lightning, suggesting that cloud–cloud and intra-cloud discharges also make a contribution.

Inan discussed the importance of nonducted vs. ducted whistlers using a test-particle model. Although the interaction with trapped electrons is much less efficient for the nonducted waves, the magnetospheric energy density of non-ducted whistlers is believed to be higher than for ducted whistlers, and thus their effect may therefore need to be considered.

Horne discussed the guiding and focussing effect of the plasmapause, estimated using the HOTRAY code. In particular this can lead to large wave damping (and thus electron heating) at the higher frequencies, and to upper cutoffs well below half the gyrofrequency.

Sulic reported ray-tracing results of ducted whistler propagation in field-aligned troughs, rather than the enhancements normally considered. The results, for $L = 2.7$, showed that although guiding by troughs is theoretically possible, in practice for a dipole geometry and realistic density models, the waves were always guided by the inner edge of the trough, equivalent to guiding by a one-sided ledge. The study was 2D; it remains to be seen whether the same conclusions would be reached for a more realistic 3D field model.

Dowden put forward evidence that LEP associated with sprites could back-scatter VLF transmissions and therefore had to be compact and highly structured ("stalactites"). O. **Ferencz** applied the non-monochromatic approach to the investigation of ion-cyclotron wave modes by the rigorous solution of Maxwell's equations. The results were evaluated by computer and displayed as spectrograms.

Effects of Lightning and VLF waves on the ionosphere

This was a session dealing with both direct (e.g. heating, sprites etc.) and indirect (LEP) effects of lightning on the ionosphere. It was co-convened by Nunn and Rycroft.

Strangeways gave a good review which is now published in *Review of Radio Science 1993–1996* (Oxford, 1996) as *Lightning, Trimpis, and Sprites*. It contains a lengthy bibliography and should serve as a useful reference source even though parts will soon become dated in this rapidly developing subject area.

Inan and **Dowden** (in separate papers) discussed the various mechanisms proposed for sprite formation: EMP (electromagnetic pulse), QE (quasi-electrostatic) fields, and runaway electrons from cosmic ray secondaries under the action of large QE fields. **Hayakawa** presented a new finite-element 2D model for VLF propagation perturbed by arbitrarily sharp discontinuities, while **Yeo** reported preliminary results from his LEP scattering model.

Steinbach reported on a trimpi receiver network now set up in Hungary, though no results were shown. **Smith** described Trimpi observations from Rothera and Faraday (Antarctica) in 1995; the dramatic decrease in event occurrence between the NPM–FA and NPM–RO paths, and the small percentage of simultaneous events, were interpreted, respectively, in terms of the poleward edge of the LEP region and the spatial size of the individual LEP patches compared to the RO–FA separation.

In the poster session, **Corcuff** had two papers on the Trimpi effect: the first compared the application of two different propagation models to signals from European transmitters to Poitiers; the second investigated the depen-

dence of LEP on magnetic storm activity using data from the NWC to Kerguelen path. **Reising** addressed the question why only a small fraction of lightning discharges of comparable intensities produce sprites. Using spheric data from Palmer he claimed that sprite-related spherics had long ELF "tails" and others did not. **Nagano**'s poster paper was supported by a video shown on a handheld battery-operated VCR; he had done a full wave analysis of the spatial and temporal structure of the electromagnetic fields due to a lightning discharge, involving waves which are reflected from and transmitted through the ionosphere.

Terrestrial Electromagnetic Environment

This was an interesting and useful session, especially with regard to lightning noise and Power Line Harmonic Radiation. **Smith** gave a presentation on the increasing trend in 10 kHz noise at Halley, Antarctica, and the interpretation in terms of global lightning activity. **Fraser-Smith** reviewed seasonal variations in ELF/VLF noise statistics from the eight-station Stanford radiometer network (only Stanford and Arrival Heights are still operating). He also reiterated how difficult it is becoming all over the world to make meaningful measurements of the natural noise background because of contamination from anthropogenic sources.

Llanwyn Jones discussed the detection and source location of "Q-bursts", which are rare but very intense signatures of certain lightning discharges. **Hayakawa** reviewed electromagnetic phenomena associated with earthquakes. **Parrot** reviewed power line harmonic radiation; spectral lines spaced 50–60 Hz apart in the magnetosphere and generally observed to drift in frequency. The "Sunday effect" had been used confirm an anthropogenic source (no natural 7-day period). He speculated on an atmospheric/ionospheric link between PLHR and the greenhouse effect (in addition to the usually quoted increase in CO_2 emissions associated with power generation), which could increase in importance as electrical power consumption continued to increase.

Sentman reported long-baseline long-term measurements of Schumann resonances (sites in Alaska, California, South Africa, Australia and Brazil; data collected since 1993 and ongoing). Differences were due to global effects (night–day asymmetry and polar–equatorial asymmetry) as well as local effects due to nearby (<2 Mm) thunderstorm regions. **Thomson** described the statistical distributions of induced earth potentials across long trans–oceanic cables, with particular reference to the extremes of the distributions important for engineering design. **Kaiser** give an interesting presentation on terrestrial HF transmissions as seen by the WAVES instrument of the WIND satellite. The broadcast bands are clearly visible on a spectrogram, and are modulated as the Earth turns, with most power being received when the most populous parts of the Earth (Asia) face the spacecraft. Estimates using a BBC-rented transmitter in California suggest that about 4% of the radiated power escapes into space. Some transmissions at MF (2–4 MHz), well below the normal F-region critical frequency, were unexplained but might have originated from radars in Antarctica.

VERSIM business meeting at URSI-Lille

The meeting was held in Lille at 1400 on 4 September 1996, with U S Inan (USA) in the chair. Others present were A J Smith (UK), the IAGA co-chairman, and Cs Ferencz (Hungary), O Ferencz (Hungary), M Füllekrug (USA), D Hamar (Hungary), M Hayakawa (Japan), R A Helliwell (USA), I Kimura (Japan), J Lemaire (Belgium), J Lichtenberger (Hungary), J Manninen (Finland), A Oikarinen (Finland), M Parrot (France), V S Sonwalkar (USA), H J Strangeways (UK), M Tixier (France), K H Yearby (UK), M Walt (USA).

Chairman's introduction and report

The chairman noted that because it had not been possible to schedule the working group meeting in advance of the Commission G/H business meeting, some matters which ideally should have been discussed by the working

group had already been decided upon. He then presented his report for the preceding triennium.

Future of the working group

It had already been decided in the G/H business meeting that the working group was fulfilling a useful role in serving as a forum for researchers in the VERSIM field and therefore its existence should be continued for the next triennium 1996–99. In discussion, two changes of scope were agreed. The first, suggested by Professor Hayakawa, was that the range of topics of covered by the working group should include VLF/ELF waves in the ionosphere and magnetosphere resulting from seismic activity. The second, suggested by Professor Helliwell, was that the scope of the group should be extended to planetary ionospheres and magnetospheres other than the Earth's. This seemed appropriate as the underlying physics is the same for all planets. Dr Smith pointed out that the change could be accommodated by a minor alteration in the name of the working group, to *VLF/ELF Remote Sensing of Ionospheres and Magnetospheres*, without changing the acronym "VERSIM".

URSI Co-chairmanship

Professor Inan announced that he would be stepping down as URSI co-chairman after 12 years in that role (since the Florence General Assembly in 1984) and that Dr Parrot would be replacing him. Dr Smith thanked Professor Inan on behalf of the working group for all his work over those years. [As a joint URSI/IAGA working group, VERSIM has an URSI co-chairman and an IAGA co-chairman. The IAGA co-chairman is currently A J Smith.]

Symposia for future assemblies

The chairman noted that a VERSIM sponsored session on *Localised ionospheric perturbations related to lightning and VLF transmitters* was scheduled for the 1997 Uppsala IAGA General Assembly.

Since the VERSIM session on *Whistler-mode waves and their effects on the radiation belts* held during the current assembly at Lille had been very successful and well-supported, it had been proposed to have a similar session at the next URSI General Assembly (Toronto, 1999) entitled *Pitch angle scattering and acceleration of trapped particles by waves in magnetospheres* (conveners: Smith, Lemaire and Inan). The scope had been broadened to encompass waves other than whistler-mode, and magnetospheres other than Earth's.

Reports from Research Groups

This item took up the remainder of the meeting, as representatives summarised current VERSIM activities; a brief précis is given here.

USA

Inan described the International Lightning induced Electron Precipitation (ILEP) project using data from British, US, and Brazilian VLF observatories on the Antarctic Peninsula. Measurements were continuing at Palmer station including both broadband and narrowband (Trimpi) recordings during the time interval 0–10 UT (20–06 MLT) each day. Also in Antarctica were ELF/VLF receivers on the US AGOs (Automatic Geophysical Observatories) and at South Pole. In the continental US, HAIL—a Holographic Array for Investigating Lightning—is being constructed to monitor signals from NAA and NLK at closely spaced receiver sites; the project will be aimed at studying sprites and LEP—both resulting from lightning.

Sonwalkar described a proposal to the National Science Foundation for an ELF/VLF observing station near Fairbanks, Alaska, to receive polar and auroral hiss and chorus and quasiperiodic emissions. The study was aimed at relating whistler mode waves with other auroral phenomena, particularly in the context of Space Weather investigations.

UK

Smith reported on work in progress at the British Antarctic Survey. VLF narrowband and broadband recordings had been made at both Faraday ($L = 2.3$) and Rothera ($L = 2.8$) stations in 1995 but operations there had now

ceased. Faraday station had been taken over by the Ukraine and renamed *Vernadsky*. At Halley ($L = 4.3$), VLF broadband synoptic and multichannel (VELOX) recordings were continuing, as were VLF Doppler observations of whistler mode signals from northern hemisphere VLF transmitters. The latter type of measurements were also made at Marion Island during a one month collaborative campaign with the University of Natal, South Africa. At Halley, Trimpi observations were discontinued at the end of 1995 but are due to resume in 1997 using the newer OmniPAL type of receiver. VLF/ELF receivers were deployed on two of the BAS AGOs located on the Antarctic ice sheet south of Halley, A80 and A81 (near latitudes 80°S and 81°S respectively). The first data have been returned from Antarctica and are currently being analysed.

Yearby said that he had been employed on the CLUSTER team at Sheffield, but had also spent some time recently working with BAS VLF data on whistler direction finding and on pulsations in whistler mode signals from VLF transmitters.

Strangeways described work on whistler ducting and on the Trimpi effect. He also mentioned the proposed establishment of an LF Trimpi network in the UK, using the newly established amateur radio band at 73 kHz. Low power transmitters of 2 kHz bandwidth could be used and, with the cost of receivers around £100, it was hoped to interest amateurs all over the UK in taking part in the experiment.

Hungary

Ferencz reported the work of his group on the Trimpi effect, the fine structure of and direction-finding on whistlers (using whistler data from Halley), and theoretical modelling of whistler propagation. A new network of four Trimpi receivers was being set up near Budapest. Digital VLF whistler recordings had commenced at Tihany observatory (Lake Balaton). At the end of 1998 or early in 1999 the Central European satellite CESAR was due for launch, and this would have on board a new version of the SAS whistler detector and analyser, and would also be used to search for signatures of seismic activity.

Finland

Manninen reported on observations of VLF waves and aurorae made during three 2–3 week campaigns at quiet sites in Northern Finland near $L = 6$. One of the campaigns was in coordination with an ionospheric heating campaign by Dick Barr. The data were freely available on the World Wide Web. He also reported artificial VLF signals observed during magnetically disturbed times which were apparently due to the ionospheric cross-modulation of high power short wave broadcasts.

France

Parrot described a number of VERSIM related satellite projects. The loss of the CLUSTER mission had been very disappointing, but the good news of a few days previously was that the Interball-2 (auroral probe) had been successfully launched and the experiments were due to be switched on shortly. The mission would include studies of auroral kilometric radiation and signals from VLF transmitters on the ground. Dr Parrot also discussed the Mars-96[1] mission (the payload of the probe contained a wave experiment ELISMA to study the Martian ionosphere) and the IBIZA two-satellite mission which would be suitable for studies of PLHR (power line harmonic radiation). He described theoretical work on data processing, involving neural networks, which was in progress to support Ibiza.

Tixier reported on studies of LEP using 6-channel narrowband Trimpi receivers located near to Poitiers. The data were being analysed using two different propagation codes. VLF observations were no longer being made at Kerguelen.

Belgium

Lemaire discussed a code he had been working on for describing the plasmasphere-plasmapause region and using CRRES data for studies of detached plasma regions. A radiation belt modelling meeting had been held re-

[1] Unfortunately the launch of MARS-96 on 16 November 1996 was unsuccessful.

cently in Brussels and the proceedings were to be published as an AGU monograph. A book about the discovery of the plasmapause, co-authored with Gringauz and Carpenter, was also due to appear soon.

Japan

Kimura mentioned that the Akebono satellite was still working very well seven years after launch, and had produced many scientific results. These included the analysis of Omega VLF signals for determining plasma density distributions. Recently there had been collaborations with Freja investigators, and also a collaboration with Rietveld and Barr involving the reception on the satellite of VLF signals radiated from the ionosphere using modulated ionospheric heating.

Hayakawa discussed a proposed conjugate experiment with Dick Dowden involving receivers in northern Australia; the project was aimed at studying LEP and sprites. It involved video observations of sprites near Darwin and VLF measurements in the conjugate region of Japan. He also described modelling work on the Trimpi phenomenon, work on Schumann resonances, studies of lightning whistlers on Jupiter and the remote electromagnetic sensing of earthquake activity.

On a light-hearted note to end the meeting, Dr Hamar gave out chocolate bars called "Whistler", which are apparently now on sale in Germany.

IAGA, Uppsala, 1997

The 8th Scientific Assembly of IAGA will be held in Uppsala, Sweden, 4–15 August 1997. A circular providing information about the meeting was published in November 1996. Details are available from the local organising committee [IAGA 97, Swedish Institute of Space Physics, S-75591 Uppsala, Sweden; tel: +46-18-303600; fax: +46-18-403100; email: `iaga@irfu.se`; WWW: `http://www.irfu.se/iaga_97.html`].

Localised ionospheric perturbations related to lightning and VLF transmitters

There will be a half-day VERSIM session (Session 2.14) on *Localised ionospheric perturbations related to lightning and VLF transmitters*, conveners: D. Nunn and A.J. Smith. This session is scheduled for the morning of Monday 11 August 1997 and will be concerned with the scattering of VLF radiation from D region ionospheric irregularities.

Call for Papers Papers are invited on observations of VLF 'Trimpis', and on the theory and modelling of VLF scattering. A topic of particular interest is that of VLF holography, in which particle precipitation may be mapped by multi-site observations of VLF Trimpi events. Papers are also solicited on scattering due to direct heating of the ionosphere and on Trimpis caused by Sprites and Blue Jets. Please submit your abstract, as described in the IAGA-97 circular and Web page, to the local organising committee, with a copy to the first convener: Dr D Nunn, Dept. of Electronics and Computer Science, Southampton University, Southampton SO17 1BJ, UK; fax: +44-1703-592865; email: `dn@ecs.soton.ac.uk`.

VERSIM business meeting

There will be a meeting of the VERSIM working group during the Uppsala Assembly, at 1900 on Wednesday 6 August 1997. The draft agenda is: 1. Chairman's Report; 2. Future of the working group; 3. Reports from VERSIM research groups; 4. Symposia at future IAGA and URSI Assemblies; 5. Any other business. If you have any specific issues you would like to discuss, please let one of the co-chairmen know (see below for addresses, etc.)

Other forthcoming meetings

EGS, Vienna, 1997

The XXII General Assembly of the European Geophysical Society will be held in Vienna, Austria, 21–25 April 1997. For more information, contact the EGS Office, Max-Planck-Str.

1, 37191 Katlenburg-Lindau, Germany; Tel: +49-5556-1440; Fax: +49-5556-4709; email: EGS@LINAX1.MPAE.GWDG.DE or check the WWW page:
http://www.mpae.gwdg.de/EGS/egsga/egsga.htm.

The session *ST9 New approaches to studies of wave-particle interactions in the magnetosphere* (conveners: M.J. Rycroft, L. Eliasson, R. Horne and V.Yu. Trakhtengerts) should be of interest to VERSIM scientists.

AGU Spring meeting 1997

The 1997 Spring Meeting of the American Geophysical Union will be held in Baltimore, Maryland, 27–30 May 1997. For more information, contact: AGU Meetings Department, 1997 Spring Meeting, 2000 Florida Avenue N.W., Washington, DC 20009, USA; Tel: +1-202-462-6900; Fax: +1-202-328-0566; email: meetinginfo@kosmos.agu.org or check the WWW page:
http://www.agu.org/meetings/sm97top.html.

URSI, Toronto, 1999

The XXVIth URSI General Assembly will be held in Toronto, Canada, in the middle of August 1999; see the WWW page: http://intec.rug.ac.be:8080/www/u/ursi/URSIGA.html.

Sessions for Toronto include:

H1: Active experiments involving space plasmas Convener: W.J. Raitt

H2: Wave-particle interactions: quantitative comparison between observations, theory and simulations Conveners: R.R. Anderson, I. Nagano and D. Nunn

H3: Pitch-angle scattering (and acceleration) of trapped particles by waves in magnetospheres Conveners: A.J. Smith, J. Lemaire and U.S. Inan. A VERSIM sponsored session which is a follow-up to the successful "waves and the radiation belts" session at Lille, broadened to include waves other than whistler mode and radiation belts other than Earth's

HG3: Theory and simulations of nonlinear processes in space plasmas Conveners: Y. Omura and M.A. Abdalla

HG5: Wave propagation: observations and data analysis Conveners: F. Lefeuvre and K. Hashimoto

News from Finland

(From Jyrki Manninen, University of Oulu) In recent years Finland has arranged four ELF/VLF campaigns which have partly been related to heating experiments. Campaigns have usually lasted one or two weeks, when continuous wide band (230Hz–9.2kHz) recordings have been made. Our VLF receiving site was at Porojärvi (69.17°N, 21.47°E, $L \simeq 6.1$) during the November 1993 and 1995 campaigns and at Kalkkoaivi (68.73°N, 22.11°E, $L \simeq 5.9$) during the October 1994 campaign. Both sites are situated in Northern Finland quite far from power lines and thus free from interference. The fourth campaign, in September 1995, was related to Dr R. Barr's heating experiment using the Tromsø heater. Our receiving site was near Sodankyla (Nutsortonen, 67.69°N, 26.26°E, $L \simeq 5.3$). The VLF receiver can detect waves with intensities above 10^{-8} pT^{2}Hz^{-1} (10^{-18} Wm^{-2}Hz^{-1}). The system was calibrated by an artificial 1 kHz signal which exists in the data at least during heating experiments.

Information about our previous campaigns and list of available data can be found from the internet (http://satellite.oulu.fi/vlf/vlfmeas.html). All data have been recorded on VHS videotapes (PAL system, half speed). Unfortunately, we are not yet able to make synoptic VLF recordings but we are planning to have a VLF receiver capable of operating continuously.

Man-made phenomena

Many observations of PLHR related emissions have been made. It seems that PLHR can control many more natural emissions than has usually been believed. Recently a cooperation was started with Dr. M. Parrot searching for PLHR-related events in the Freja satellite data

which have been recorded simultaneously with our ground-based observations.

Almost every VLF researcher has observed some HF radio broadcasts in their recordings. Usually the phenomenon has been interpreted as due to demodulation by non-linearities in the receiver electronics. Identification of the detected broadcasts was done by an experienced radio amateur. Three different RF receivers were used, spanning the frequency range 30 kHz to 30 MHz; although these could receive all kind of transmissions (CW, SSB, FM, AM, etc.), only AM broadcasts seemed to be detected in the VLF frequency range. A spectrum analyser was used to investigate the power distribution across a broad frequency band (~1–10 MHz). The available transmitter identifications showed that the distance to the transmitter was often quite long. Only one station at a time has usually been heard, showing that the process is very selective. It is also common that the event shows clear periodicity. Usually demodulated signals seem to favour speech and "classical" music.

There seems to be no correlation with magnetic activity. The observed broadcast in the VLF band is not necessarily the strongest station in the AM band. Periodicity, selectivity and long distances from the transmitters, together with lack of a clear relation to magnetic activity, do not favour the well-known explanation in which ionospheric current is modulated by powerful RF waves causing electron temperature variations. The source, however, cannot be very far in the magnetosphere because no detectable dispersion has so far been recognised. The tendency of the signal to "move" from one orthogonal component to another seems to indicate that it is linearly polarised.

Heating experiments

The main aim has been to produce artificial VLF waves in the ionosphere using the EISCAT heating facility. Other aims were ULF and API (Artificial Periodic Inhomogeneities) experiments. The EISCAT heater is situated at Ramfjordmoen (69.6°N, 19.2°E, $L \simeq 6.2$) near Tromsø, Norway. More information can be found from the homepage of the heater (`http://seldon.eiscat.no/heater.html`).

Campaigns were usually in early winter: 9–18 November 1993, 2–9 October 1994 and 15–29 November 1995. The VLF receiving site Porojärvi is about 96 km magnetic SE from the heater and Kalkkoaivi is 145 km magnetic SE. Usually in the VLF experiments the HF heating beam is pointed in a fixed direction and the beam is amplitude modulated with the VLF frequency. In October 1994 and November 1995 we tried a method called beam swinging. By varying the phases of HF waves in rows of antennas in the transmitting antenna array the beam direction can be moved. We tried to swing the beam with the wanted VLF frequency and produce the VLF waves in that way. In our experiments we used sinusoidal swinging. The heating beam amplitude modulation source can also be voice. This is obtained simply replacing the signal generator by an ordinary tape recorder. The heating beam is then modulated by the output of tape recorder. We thus tried to produce some speech and music in the ionosphere.

During these three campaigns 700 hours of wideband VLF data were recorded. Heating generated VLF waves were produced over 30 hours and they were detected for nearly the whole duration of the experiments. The most interesting result was obtained in an experiment where VLF waves were produced by amplitude modulation and beam swinging by turns. The VLF waves generated by the beam swinging were more intense than those made by amplitude modulation. This trend was clearer with the harmonics of the signal. The harmonics of the beam swinging were almost a magnitude stronger than the harmonics of the amplitude modulation. We managed to get some response from the voice modulation experiments.

In September 1995 we made VLF recordings about 370 km magnetic SE from the Tromsø heater. Transmitted HF signals were amplitude modulated by a square wave in the frequency range 505–8080 Hz. Most times the VLF signal was detected clearly. Dr Barr made his own recordings at Lavangsdalen which is near the heater (17 km). Detailed analysis is still going on, but some interesting results will be published later.

The role of the VERSIM Working Group

The working group serves as a forum for workers studying the behaviour of the magnetosphere and ionosphere by means of ELF and VLF radio waves, both naturally and artificially generated. Originally the emphasis was on probing of the magnetosphere by whistlers, but later the scope became somewhat broader. The group aims to promote research in this field by facilitating the exchange of ideas, information and experience between active research workers and other interested scientists. This is done through regular meetings at IAGA and URSI Assemblies, and via the circulation of a newsletter. The group has also been active in sponsoring scientific symposia at IAGA and URSI Assemblies, in areas relevant to its field of interest, and in coordinating observational campaigns. There are currently ~100 scientists from 22 different countries (Australia, Austria, Belgium, Brazil, China, Czech Republic, Denmark, Finland, France, Germany, Hungary, India, Japan, New Zealand, Norway, Russia, South Africa, Sweden, Ukraine, UK, USA, and Yugoslavia) on the VERSIM mailing list.

Please send any information of interest to other members of the working group, for publication in the next newsletter, to the editor, **A J Smith**, at the address given below; electronic mail preferred, otherwise mail or fax. The **VERSIM email directory**, mentioned in the last *VERSIM Newsletter*, is now up and running on the VERSIM WWW site. Please send additions and corrections to A J Smith.

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