IAGA/URSI
Joint Working Group on

VLF/ELF Remote Sensing of the Ionosphere and Magnetosphere

Editor: A.J. Smith | Newsletter | No. 3 — October 1991

Dear colleagues,

This newsletter contains reports of the working group's activities at Vienna, together with a variety of items of news from workers in the VERSIM research area in various parts of the world. It seems that interest is continuing to grow in the use of the 'trimpi' technique for studying LEP (lightning induced electron precipitation), and networks of trimpi receivers are continuing to be developed around the world. As in the newsletter of December 1990, and following the recommendation passed at the meeting of the working group in Vienna, we again have a special section devoted to news of such work. I would like to take this opportunity to all those who have contributed to this newsletter. I hope you enjoy reading it and will send me any updates, corrections, etc., for inclusion in the next issue. The views expressed by contributors are not necessarily those of the editor.

20th IUGG General Assembly, Vienna: 11–24 August 1991

It was good to meet many of you in Vienna and enjoy some friendly and valuable discussions about our common interests in VLF/ELF phenomena and their use in studying the ionosphere and magnetosphere. There were several interesting and stimulating sessions of relevance to the scope of the working group, including one which was proposed by the group, on *Wave-induced Particle Precipitation*; a report on this session, contributed by Dr **U.S. Inan** (one of the conveners), is given in the following section.

Symposium on Wave-induced Particle Precipitation

This session, held on 17 August 1991, was well attended by up to 25–35 scientists, and 17 papers (including posters) were presented on a variety of topics including satellite observations of waves and particles, ground based observations and theoretical modeling work. Highlights of some of the talks are summarized below: **Paranicas** *et al.*, reported the observations on the CRRES satellite of electrostatic $n+1/2$-type emissions which exhibited banded structure, possibly associated with structure in the plasma (30 eV to 40 keV electrons). **Vampola** *et al.* presented electron spectrometer data from the CRRES satellite obtained during chemical releases. Increases in 100–600 keV electron fluxes were observed when the satellite was in the diamagnetic cavity. **Schriver** *et al.* presented results of computer simulations of artificial aurora that would be induced by the precipitation of energetic electrons by intense whistler waves that build up in the dense lithium plasma cloud in CRRES experiments. Calculations indicate that fluxes at the levels of diffuse aurora can be produced. There are as yet no experimental results. **Cornilleau-Wehrlin** *et al.* presented results of the analysis of extensive wave/particle data from the GEOS-1 satellite during quiet times when the spacecraft was within the plasmasphere. In 48 different cases observed, the strongest hiss (0.1–3 kHz) intensities corresponded to the largest fluxes of 15-300 keV electrons, and the flux levels in all cases were found to be sufficiently high to produce growth of hiss waves to observed levels in a single pass through the geomagnetic equator. **Hayakawa** *et al.* reported results of broadband VLF measurements of whistlers and whistler triggered emissions at Ceduna, Australia ($L = 1.93$), with many events (especially triggered hiss) being observed. **Inan** gave a review of recent subionospheric VLF measurements of lightning-induced electron precipitation effects. The location of disturbed ionospheric regions are clearly identified by means of multiple point measurements on collinear VLF paths, and information on the altitude profiles of disturbed regions (and hence the energy spectrum of precipitated electrons) can be deduced by means of selective perturbation of high order waveguide modes on short (< 1000 km) VLF paths. **Poulsen** *et al.* presented a new 3-D model of subionospheric VLF propagation in the presence of localized ionospheric disturbances. The model is general and takes into account the altitude profile of ionization in disturbed regions (rather than treating the disturbances as merely a reflection height change). Results indicate that amplitude and phase changes at receivers on typical Great Circle Paths are highly sensitive to the details of the altitude profile. **Dowden** *et al.* presented results of VLF observations on a 1200 km array of five stations across New Zealand. Coherent observations of signals from the NWC transmitter allow the localization and 'imaging' of lightning- induced ionization enhancements (LIEs). In different cases disturbances were deduced to have dimensions of ~ 100 km or smaller (tens of km). **Smith** *et al.* described statistical results on more than 2000 trimpi events from a whole year (1989) of operation of OPAL- type receivers at Faraday and Halley, Antarctica. By comparison with models, it was possible to deduce the typical location ($2 \lesssim L \lesssim 3$) and size ($\sim$ 50–100 km in latitude and $\sim$ 200– 500 km in longitude). **Friedel** and **Hughes** presented results of test particle simulations of gyroresonant scattering of electrons at low L-values ($L < 2$), showing that very large (100 nT) wave amplitudes are needed to explain observed events unless the wave- particle interaction region is temporarily lengthened by geomagnetic field changes (e.g. Pc5 pulsations). **Burgess** and **Inan** showed new evidence of disturbance of conjugate ionospheres in individual lightning events. Direction-finding analysis on whistlers observed at Palmer Station, Antarctica indicate that most trimpi events observed at Palmer may be caused by ducted whistlers. **Fennell** *et al.* presented results of a comprehensive statistical analysis of data from the SCATHA satellite, which indicates that Electron Cyclotron Harmonic (ECH) wave intensities are too weak to explain the observed diffuse auroral fluxes. In most cases the electrons are found to be not in strong diffusion. **Kozyra** *et al.* described results of theoretical analysis of anomalous Doppler shifted cyclotron resonance interaction between protons and ducted plasmaspheric hiss. Computed lifetimes for scattering of protons into the loss cone are consistent with ring current decay. **Friedel** and **Hughes** reported observations of low latitude trimpi events at Durban ($L = 1.7$) using an OMSKI receiver on paths to the north (GCPs from NAA, Omega Reunion, etc.); most occurred in a two hour interval when there were thunderstorms over South Africa. **Singh** *et al.* discussed the relationship between ionospheric irregularities over India derived from high frequency scintillation measurements, and whistler ducts inferred from observations of low latitude whistlers at Varanasi.

Meeting of the Working Group at Vienna

A meeting was held on 21 August 1991, the following being present: A.J. Smith (UK, chairman), W.C. Burgess (USA), R.H.W. Friedel (South Africa), U.S. Inan (USA), M.J. Kosch (South Africa), F. Lefeuvre (France), M. Parrot (France), L.R. Piazza (Brazil), O. Pokhotelov (USSR), H.J. Strangeways (UK), D.M. Šulić (Yugoslavia), P. Triska (Czechoslovakia).

A.J. Smith reported briefly on activities of the working group since the last IAGA Assembly in Exeter. The change in name of the group had now been completed, with approval having been given by the two parent bodies-URSI and IAGA. A meeting of the working group had been held during the URSI Assembly at Prague (reported in the December 1990 newsletter). Three newsletters had been circulated to a mailing list now standing at around

80 scientists.

Reports were presented to the meeting on VERSIM activities in Brazil, Czechoslovakia, New Zealand, South Africa, UK, USA, Yugoslavia. These are included later in this newsletter.

The meeting noted the increase in the number and extent of 'trimpi networks' of VLF narrow band receivers for imaging of regions of transient energetic electron precipitation. It was considered that the VERSIM working group is the natural body for coordinating such networks, and it was agreed that information about them should be circulated in future issues of the newsletter.

A.J. Smith mentioned the plans of several countries (e.g. UK, USA, Japan) to deploy AGOs (Automatic Geophysical Observatories) in Antarctica, which would or could be used as platforms for VLF receivers, to extend the rather limited coverage provided by manned observatories, and briefly described the AGO project of the British Antarctic Survey.

O. Pokhotelov presented to the meeting a proposal to set up an international working group on *Geosphere response to man-made activities* including the effects of VLF/ELF radiation from transmitters and power lines. This proposal is reproduced later in the newsletter.

U.S. Inan reported briefly on the status of plans for a Wave Injection Facility in Antarctica. This would be a successor to the highly successful Siple VLF transmitter, but would be able to address new scientific questions because of its more advanced design, lower transmission frequency (down to 500 Hz), more extended antenna array, and higher latitude location. He also discussed the phenomenon of D- region ionospheric heating by high power VLF transmitters, and its detection by the effect on subionospheric propagation.

The question of symposia on VERSIM topics at future URSI and IAGA assemblies was discussed. It was decided that in view of the symposium already scheduled for the URSI meeting in Kyoto in 1993, a proposal would not be made for the IAGA meeting in Cordoba, Argentina in the same year. However it was clear that the session at Vienna had been successful and well supported, and it was therefore decided to propose that a 1-day session on *Whistler mode waves and particle precipitation effects* be included in the programme for the 1995 IAGA (IUGG) Assembly in Boulder, USA.

The future of the working group was discussed, and it was decided that it played a very useful role in bringing together scientists with a common interest in VLF and ELF wave phenomena as a means of investigating the behaviour of the magnetosphere and ionosphere, and that it should therefore continue in existence. **A.J. Smith** was elected to continue as IAGA co-chairman of the group.

A proposal was made by **R. Friedel** for a standard 'quicklook' format for broadband VLF data; this is described in more detail later.

24th URSI General Assembly 1993

The Assembly will be held in Kyoto, Japan. A symposium which has been scheduled for the Assembly, and will be of interest to members of this working group, is on *Whistlers and Precipitation*; it will be convened by **H.J. Strangeways** and **U.S. Inan**.

Trimpi networks and related matters

Brazil

From Dr **L.R. Piazza** (Centro de Radio-Astronomica e Aplicações Espaciais, São Paulo): A 6-channel tunable VLF receiver, dedicated to receiving trimpi events at the Brazilian Antarctic station Cmte. Ferraz (60° S; 58° W; $L = 2.2$), will be constructed at Stanford University during 1992. After testing in Brazil, at Itapetinga Radio Observatory, São Paulo (23° S; 46° W; $L = 1.2$), observations are planned to begin in Antarctica in 1993.

France

From Dr **Y. Corcuff** (University of Poitiers): A new VLF receiver has been installed at Kerguelen, capable of recording the amplitudes of signals from various transmitters as well as the phase of Omega signals. Night time recordings began on 15 February 1991. A preliminary examination of the data showed trimpi events observed on the NWC (22.3 kHz) signal on 4 out of 27 nights in March 1991 during moderate (6 March) and intense (25–27 March) magnetic disturbance. At the peak of the storm (night of 25/26 March) the events had unusually short recovery times, less 10 s and on occasion as short as 3–4 s. Whistler analysis implied than the plasmapause had moved very close to the Earth in the course of the magnetic storm, suggesting that the unusual nature of the trimpi events was due to the precipitation of very energetic particles from outside the plasmasphere. We envisage extending the Kerguelen work to look at signals from transmitters other than NWC. It is also possible that in the near future a Stanford-pattern trimpi receiver may be operated in France, in the vicinity of Poitiers.

Hungary

Dr **Gy. Tarcsai** (Eötvös University) and coworkers have begun a 4-year study of magnetospheric wave-particle interactions in collaboration with Tihany Observatory (operated by the Hungarian Geophysical Institute) and the Geodetical and Geophysical Research Institute of the Hungarian Academy of Sciences. Initial attempts to observe trimpi events in Hungary were unsuccessful (probably on account of poor signal/noise). The group have now acquired a University of Otago OMSK receiver and will shortly begin observations with that. At $L = 1.9$, a receiver in Hungary could "look across" the $L = 2$–3 trimpi zone to higher latitude transmitters such as GBR, Omega-Norway, NAA, etc. A cooperation has been set up with the University of Natal group (**R. Friedel**, **A.R.W. Hughes**); Budapest is nearly conjugate to Durban.

Japan

From Dr **M. Hayakawa** (University of Electro-communications, Tokyo): The data from the conjugate experiment of the reception at Ceduna (Australia) of the Kharbarovsk (USSR) ($L = 1.93$) VLF transmitter (15.0 kHz and 23.9 kHz) signals, are being analyzed to study linear and nonlinear wave-particle interactions and the associated particle precipitation. VLF wide-band measurements were simultaneously carried out at Ceduna in order to study whistler-triggered emissions and the associated particle precipitation. The correlation of the region of electron precipitation determined by subionospheric VLF signals, with the location of the causative whistler, will be extensively studied.

New Zealand

The University of Otago group (Professor **R.L. Dowden** and Dr **C.D.D. Adams**) have extended their New Zealand array of "OMSK" receivers for imaging LEP using VLF propagation paths from NWC and Omega transmitters in Australia. In addition to receivers at the University campus in Dunedin and Swampy Summit, some 9 km distant, they have now established roughly collinear receivers at Tumai and Horse Range, respectively 31 km and 47 km from the University. In the future it is planned to extend this linear array on a larger scale, with receivers at Oamaru, Mount John, Wellington (already in use), and Kaeo (respectively 90 km, 200 km, 600 km, and 1200 km from Dunedin. This enables measurement of the phase and amplitude of the perturbation versus distance along the array. From this the position and lateral dimensions of the ionisation can sometimes be determined. The variation of phase and amplitude of the perturbation with distance can be quite rapid in some cases, necessitating the close spacing at the southern end.

South Africa

From **R. Friedel** (University of Natal): "Trimpi" studies are in progress, using an "OMSKI" receiver. We are looking at low-latitude trimpi events seen at Durban ($L = 1.7$) on signals from Omega La Reunion, Omega Argentina, NAA, and NWC. The system has been running since April 1991. This is a joint project with Professor **R.L. Dowden** of Otago University (equipment source) and **Dr A.J. Smith** of British Antarctic Survey, Cambridge, using identical receivers in a TrimpiNet with existing receivers at Halley and Faraday stations. A second receiver will be installed, initially at Durban, at the end of 1991. Trials are planned at both Marion and Gough Islands before one of the receivers is send to SANAE (1992/93 takeover) to join the existing BASnet of receivers at Halley and Faraday. As an extension to the above project, the Durban receivers (SHOMSKIs: Sferics, Hiss, Omega and MSK Instrument) will also be equipped to receive telemetry signals from the ELBBO project, which uses VLF receivers on extremely long-life high altitude balloons to investigate the longitudinal variation of both sferic and VLF hiss activity.

UK

British Antarctic Survey will resume trimpi observations at Faraday and Halley stations, Antarctica, early in 1992, after a pause of a year. New Zealand pattern "OMSK" receivers are used (two MSK and 2 Omega transmissions are received at each site). During winter 1983 it is planned to operate a receiver at Rothera station on the Antarctic Peninsula (68°S; 68°W; $L = 2.8$), as part of meridional linear array in conjunction with receivers at Faraday and Palmer stations on the Peninsula and Ferraz on King George Island in the South Shetlands.

USA

Dr **U.S. Inan** (Stanford University) continues to operate an extensive network of trimpi receivers in North America (US, Canada, Puerto Rico) and in the southern hemisphere at Palmer station, Antarctica. Some of these are sited such that certain of the transmitter-receiver GCPs of interest pass over or very close to other receiver sites; this allows some rather precise inferences to be drawn about the location and size of the precipitation regions. Palmer is well placed with respect to the North American network for studies of linked conjugate precipitation. It may in the future form part of an Antarctic Peninsula chain (see above).

Other news

Czechoslovakia

From Dr **P. Triska** (Geophysical Institute of the Czechoslovak Academy of Sciences): Ground observations of whistlers and VLF emissions in the frequency range 1–10 kHz started at the Panska Ves Ionospheric Observatory ($L = 2.18$) in 1959. The regular synoptic program (2 minutes broadband analogue records from 50 to 52 minutes after every hour) continued for nearly 33 years until August 1991. The broadband analogue VLF records will continue as an irregular programme, especially as simultaneous ground based records with VLF satellite broadband real time telemetry data recorded at the Panska Ves Satellite Telemetry Station (the same location).

During the 1989–1991 period, the main research programme has been connected with the ACTIVE project, launched on 28 September 1989 as a pair of satellites: INTERCOSMOS-24 and MAGION-2 (the second Czechoslovak satellite). ELF/VLF wave phenomena and plasma parameters have been measured simultaneously on board the two ACTIVE-project spacecraft with orbital parameters 500/2500 km altitude and 82.5° inclination.

Another active project is now being prepared, and is due for launch about the end of 1991: APEX—Active Plasma EXperiment. This project is again a part of the INTERCOSMOS cooperative program. The main sources of plasma activation are electron- and ion-beam accelerators. Two satellites of the APEX project are intended to be launched using the same (common) launch vehicle into the elliptical orbit (500/3200 km, 82.5° inclination). The electron and ion beams can be modulated with frequencies covering the VLF band. Both the main satellite and the sub-satellite (INTERCOSMOS-25 and MAGION-3) are equipped with similar plasma and wave diagnostic payloads, with the aim of obtaining information on space- and time-structures of the observed phenomena. Ground based ELF/VLF observations will be coordinated with the APEX project data acquisition phase.

Hungary

From Dr **Gy. Tarcsai**: The SAS experiment on the ACTIVE satellite is still working. Recordings have been in progress, during passes of the satellite, at Grocka (Yugoslavia) and Sodankyla (Finland). Ground recordings have not been made in Hungary, since the Tihany observatory now suffers too much interference. Telemetered data from the satellite has continued to be taken at Budapest, though there have been problems with SAS reception on 460 MHz due to the increase of mobile radiotelephones in Budapest which use that frequency. Most other experiments on the main satellite are still working, though the subsatellite failed in November 1990. The on-board VLF transmitter has been operated from time to time, but to date no signal has been observed on the ground, presumably because of the incorrectly deployed antenna.

Whistler detection routines are to be developed, using the digital matched filtering technique, for use on the next version of SAS, called A-SAS, to be flown on APEX. The Eötvös University group are also teaming up with France and USSR on a seismic-induced-wave satellite experiment "SEISM" (led by Drs **M. Parrot** and **F. Lefeuvre**). USSR are to provide the launcher; France the wave receiver.

Japan

From Dr **M. Hayakawa**: Hiss-triggered chorus observed on the GEOS satellites is being currently investigated using spectral analysis with high frequency resolution and direction finding. Fine structure analysis indicates the presence of coherent wavelets even in hiss bands and such wavelets near the upper edge of the hiss band might be responsible for triggering chorus emissions through a coherent wave- particle interaction. Computer simulations are being performed in order to understand the underlying microphysics.

Electrostatic ion-cyclotron (EIC) emissions have been observed in the polar region by different satellites (Isis-1, -2, Exos-C and -D), and the distribution of polar EIC emissions and their relationship to auroral hiss and direction finding measurements of saucer emissions are being investigated.

Power line radiation at the fundamental frequency has been measured on the ground, balloons and satellites. The Exos-satellite was successful in estimating the global distribution of power-line fundamental radiation, and the observed distribution of power-line radiation in and around Japan is being compared with corresponding theoretical numerical calculations. Additionally the global distribution of natural VLF/ELF magnetospheric emissions is also being obtained, which will be used in the study of wave-particle interactions.

The use of a sophisticated signal processing system has given new life to studies of classical tweek sferics. The small dispersion of those tweek sferics is being extensively used to deduce the range of distant lightning and the ionospheric height with surprisingly good accuracy. This provides a new high-accuracy location method for distant lightning strikes on the basis of wide-band observations at a few stations. Furthermore, this new method will be used to study large-scale irregularities in the D-region such as are caused by planetary waves. Our field-analysis direction-finding, based on the simultaneous measurement of three wave field components, has been applied to tweek sferics, and this has yielded the frequency dependence of the incident angle and the wave polarization of the 0th and 1st order waveguide modes. This new experiment has provided an insight into the formation of Earth-ionosphere waveguide modes from a lightning discharge, and the energy leakage into the ionosphere from the whistler mode.

The observation of earthquake-associated radio emissions has been continued at three spot frequencies (36 Hz, 1.525 kHz and 81 kHz) using a network of receivers in the Tokyo area. In addition to this network observation, we plan to carry out sophisticated direction-finding at least at two additional stations. The new system will be composed of two frequency parts, (i) ULF waveform (0–10 Hz) recording of three magnetic and three electric field components (including one borehole antenna), and (ii) the simultaneous recording of the waveforms (1.525 kHz ± 5 Hz) of multiple field components. This measurement will enable us to measure the wave impedance, polarization, and direction of arrival (from above or from below the ground). One node of our network was installed very close ($\sim$ 3 km) to Mt. Unzen in Dyushu, which is now in a very active phase. The observation is continuing and new interesting results are being obtained, which will be reported shortly.

The ground-based direction finding technique using the wave distribution function is under improvement. The former maximum entropy inversion is not subjective, and so we have developed a new method incorporating regularization together with subjective judgement of the optimum wave distribution.

New Zealand

An experiment to fly OMSK receivers as part of a long-life balloon payload (ELBBO = Extended Life Balloon-Borne Observatory), is underway in collaboration with the University of Washington (Professor **R. Holzworth**). The first balloon was launched in February 1991 from Christchurch, the second from Texas in August 1991, and a further test flight from New Mexico is scheduled for this month. A further 5 balloons are planned to be launched from Christchurch in February, and are expected to drift slowly west at an altitude of about 26 km and constant geographic latitude. As well as measuring the amplitude and phase of 8 Omega stations and 2 MSK stations, the receiver on each payload will also determine the intensity of VLF hiss in the 4–5 kHz frequency range. Data telemetry will be via HF to the ground (200 bps MSK at 14 MHz), and via UHF to ARGOS.

South Africa

From **R. Friedel** (Space Physics Research Institute): VLF recordings have been made at the South African Antarctic base SANAE (70°18′S, 2°15′W, $L = 4.14$) since 1970, and we currently operate a goniometer direction-finder similar to the system operated by the British Antarctic Survey (BAS) at both Halley and Faraday.

Synoptic recordings (1 minute 5) are being made in the 0–10 kHz band for about nine months of the year (March–November). Continuous recordings are made during periods of high activity and during all auroral displays recorded by our low-light-level TV auroral research programme.

All data analysis, e.g. routine determination of plasmapause position and electron density from whistlers, is currently being done at SPRI in Durban, using the AVDAS system developed by BAS and Sheffield University.

A "quick look library" of archived VLF recordings is being produced using a Ubiquitous spectrum analyser. Spectra from synoptic data are digitised in the 0–8 kHz range and printed on a laser printer producing 3 pages of data per day. 1989 data are currently being processed. We plan to use the data in this format for long-term studies of the variability of sferic, hiss, chorus and whistler activity at SANAE.

Other related research topics include the following: (1) Studies of ion composition and low latitude whistlers using ISIS-2 data. (2) Study of the gyroresonance interaction at low L-values in the presence of magnetic field distortions using a new model for the earth's magnetic field and a relativistic test-particle simulation to compute overall pitch angle changes due to the interaction. (3) Ray-tracing of VLF in models of multiple duct structures in the neighbourhood of the plasmapause. Results show that rays may be trapped in more than one duct during a single pass. (4) Search for fine structure whistler trace splitting on common data sets from Halley and SANAE (collaboration with Dr. **J. Lichtenberger** of Eötvös University, Budapest).

A receiving system has been developed by Dr. **A.R.W. Hughes** and **P. Caldeira** to take VLF data from the ACTIVE satellite, a collaboration with Eötvös University, Budapest. Budapest is close to Durban's magnetic conjugate point. Testing of the system is in progress.

A new Antarctic base is in an advanced stage of planning and will be constructed on rock, at a new site, $\sim$ 100 km from the current site, at Vestlaskarvet mountain (71°S 2°W). Start of building will be during the 1991/92 takeover, with the main construction during the 1992/93 takeover with occupation of the new base.

UK

At Halley, all VLF experiments will be restarted early in 1992, after a break of a year. This will occur after the completion of the transfer of all scientific experiments from the old station (Halley-4) to a new one (Halley-5, some 16 km distant). The old station, which is now at some depth below the ice, will be abandoned. The new station is built on platforms which will be raised a metre or so each year to keep them above the snow surface.

In addition to the OMSK receiver already mentioned, we will run a broadband VLF goniometer, and a new multichannel narrowband logger known as VELOX (VLF/ELF Logger Experiment). This will have channels with the following centre frequencies (bandwidths): 0.5 (0.5), 1.0 (1.0), 1.5 (1.0), 2.0 (1.0), 3.0 (1.0), 4.25 (1.5), 6.0 (2.0), 9.3 (1.0), 10.2 (0.1) kHz and a tunable (10-30 kHz) channel of 100 Hz bandwidth. The channels have been selected for compatibility with previous and planned ELF/VLF loggers at Halley and elsewhere. For each channel, a number of parameters such as mean power, mean log power, polarisation, azimuth, peak, minimum, etc., will be computed over a time frame in the range 1- -60 s (but typically 1 s), and recorded to optical (WORM) disc. One- minute averages of the 1 kHz and 3 kHz power will form part of the set of key parameters for the GGS mission.

At Faraday also, recordings will restart at about the same time, using a similar broadband goniometer to that operated at Halley, and a VLF Doppler experiment receiving whistler mode signals from the NAA and NSS transmitters in the conjugate region. The latter experiment is sensitive to plasma drifts and fluxes near $L = 2.5$.

USA

Apart from the trimpi network, described above, Stanford University are also running broadband VLF receivers at Palmer and South Pole stations in Antarctica, and in addition intend to run a low power VLF transmitter at South Pole. With regard to the full Wave Injection facility proposal (a much enhanced successor to the Siple VLF transmitter), there were problems in the original plan, owing to the closure of Rosskaya station which was to have been used for logistic support. Sites near Syowa, using Japanese logistic support, and also Molodezhnaya, were considered, but this region is at too high an L- value for the science to be done, and also there no convenient conjugate ground station. A detailed costing and feasibility study is to be carried out on this major and probably long-term but undoubtedly exciting proposal.

Yugoslavia

Dr **D.M. Šulić** (Geomagnetic Institute, Grocka) has been making whistler recordings (1–10 kHz) at Grocka, near Belgrade, for the past 10 years. She has developed a system for producing spectrograms for studying whistler fine structure, using a personal computer. She plans to change from analogue to digital recording in the future. In an recent study with **G. Gustafsson** (Swedish Institute of Space Physics) of Viking data for March–October 1986, whistlers were seen on only 30 orbits, and were closely related to hiss. Events lasted a few to 20 minutes, and were seen at longitudes 30– 135° E, and $L = 2.2$–5.4, inside the plasmasphere or near the plasmapause. More were observed in the afternoon and during quiet times.

AGOs in Antarctica

There are currently efforts to deploy AGOs (Automatic Geophysical Observatories) in Antarctica, to extend the rather limited coverage provided by manned observatories, especially into geophysically important regions such as polar cusp, the nightside auroral region, and the polar cap. This activity is being coordinated internationally by a Steering Group under the auspices of SCAR, chaired by Dr **J.R. Dudeney** (British Antarctic Survey).

BAS intends to deploy 4 AGOs to the south of Halley, under the field of view of the PACE radar. The geographical locations are ‘A1’: 77.5° S, 23.4° W; ‘A2’: 81.4° S, 25.0° W; ‘A3’: 81.5° S, 3.0° E; ‘A4’: 82.0° S, 47.0° E, as shown in the accompanying figure. ‘A1’ is scheduled for deployment in 1991/92. It is intended that each AGO will carry a magnetometer, riometer, photometer, and VLF/ELF receiver. The latter will be a version of the VELOX logger described earlier, but will record only a subset of the data and will be limited to the 0.5, 1, 2, 3, and 6 kHz channels (though the instrument is very flexible, and the centre frequencies and bandwidths of any of the channels can be reprogrammed without hardware changes). In addition there will be a broadband "snapshot mode". The AGOs will be powered by batteries recharged by wind- and solar-powered generators. Data will be mostly accumulated on site, on optical discs, for collection during the annual service call; a small subset may be returned by via polar orbiting satellites.

The US AGO programme ('PENGUIN') has encountered some technical setbacks (with the power system), and a modified prototype is currently under test near South Pole, with a second system near McMurdo. It is planned to deploy three stations in 1992/93, and a further three the following year. Each AGO will carry a set of instruments which will include a VLF instrument from Stanford University. Like the BAS AGO VLF receiver, the latter will have a number of narrow band channels and a broadband "snapshot mode"; it will also comprise a trimpi receiver. A prototype for this instrument has been designed and constructed.

The Japanese have also expressed an intention to deploy AGOs in Antarctica, but no information about this has been received.

VLF field strengths in Europe

The following information was contributed by Dr **N.R. Thomson** (University of Otago, New Zealand, but currently on sabbatical at British Antarctic Survey, Cambridge).

VLF field strength measurements are being made with a calibrated portable loop at a variety of sites around continental Europe and the UK. British transmitters monitored are GBR (100 baud MSK, 16.0/15.95 kHz), GBZ (100 baud MSK, 19.55/19.6 kHz), and GQD (50 baud FSK, 19.0/19.05 kHz). Also being monitored are two powerful transmitters in Western Europe, not well known to VLF experimenters, one in France and the other in (West) Germany. The purpose of the measurements is to help characterize the parameters (β, h) which give the best fits and hence the best modal representation in the NOSC subionospheric computer program.

The French transmitter radiates about 200 kW of 200 baud MSK at a frequency of 18.25/18.35 kHz. It has the nice features of phase-stable carrier and modulation and transmits (what appears to be) random code continuously apart from a few hours off (for maintenance) on Wednesdays. It is thus just like the large US Navy communication transmitters (NAA, NSS, NAU, NLK, NWC, NPM, NDT). This French transmitter is located at 46° 42.5′N, 1° 14.5′E, near the village of Rosnay about 70 km east of Poitiers. Its antenna appears to be currently tuned 20–30 Hz above 18.300 kHz and is thus favouring the upper sidebands. This is not a significant disadvantage for most purposes though (the radiated frequency is not affected) and presumably this will be corrected—it is certainly in their interests to do so!

The German transmitter seems to be radiating about 300 kW at 23.4 kHz with some form of non-phase-stable 50 baud FSK. It is located at 53° 5′N, 7° 37′E near the town of Ramsloh (about 80 km west of Bremen. It is most unfortunate that this transmitter is radiating on exactly the same frequency as the US Navy's 600 kW, 200 baud MSK, phase-stable transmitter on Hawaii. Admittedly NPM cannot be received in Northern Europe, probably because the path goes over highly-attenuating Greenland, but all of these VLF transmitters inevitably have world wide penetration. Over a large part of the Earth's surface each must be rendering the other unusable. Even in New Zealand, where NPM is very much stronger, we find that whistler-mode signals from NPM are destroyed when the German transmitter is radiating from half a world away. If anyone knows how to get the owners (military/Government in both cases) to talk to each other, we should all be better off!

A standard format for VLF spectrograms

Recently it has become increasingly difficult to support the traditional, analogue-based methods of producing spectrograms of VLF and whistler data recorded on the ground, (e.g. the use of photographic film). It seems likely that other experimenters in the VERSIM field may have experienced similar problems, and that it should be possible to devise a better way of achieving an equivalent output using modern digital techniques. No doubt many experimenters have already done this.

When it is desirable to compare data from different stations, there is a need to use the same format, and this is likely to be increasingly necessary in the future, with the greater use of global VLF networks, AGOs and the like for investigating scientific problems of a global nature. Clearly it is quite easy in principle to reprogramme a digital system to produce the data in any desired format, for any specific purpose. However when it comes to producing large numbers of plots of archived data, which can be easily scanned when searching for a particular type of activity, it is clearly important to make a good choice of format at the outset. A standard format would be desirable for this purpose, as well as for initial interchange of data between experimenters. The latter may be increasingly important as experimenters move from the once-standard analogue magnetic tape recording of broadband VLF data, to a variety of digital recording media (e.g. DAT, DCC, WORMs, VHS etc), and it becomes less easy to exchange the original data because of incompatibilities in playback systems.

Given that we need a standard format, how should we decide what it is to be? Clearly the VERSIM working group is a suitable forum for discussing and hopefully agreeing this. While no single format will be optimum for all purposes, any candidate for a standard spectrogram format should satisfy certain criteria:

- The frequency range should be adequate to show most common signals of interest (e.g. whistlers, chorus, etc).
- As far as is possible, time and frequency resolution should be set so as to show most details of interest. It should be borne in mind that improving performance of output devices is likely to improve the achievable resolution corresponding to any given time and frequency scales.
- For reasons of economy, as much data as possible (subject to the need for clarity and legibility) should be printed on a standard size page. There will be a trade-off between this requirement and the previous one.
- Each page should begin at a standard time (e.g. the start of an hour) so that in pages corresponding to different stations, simultaneous data will correspond to the same position on the page.
- Date, frequency and UT time scales, and station name should be clearly legible.
- Any format should be as straightforward as possible to implement technically on widely available equipment (e.g. IBM compatible PCs, HP Laser-jet printers, and compatibles).

The following contribution by **R. Friedel** of the University of Natal describes a scheme in use at his institute, similar to that outlined above, which was described briefly at the Vienna VERSIM meeting, and could perhaps be considered as a first draft for such a standard. Please write with any comments you may have to me (A.J. Smith, address given below) or the author at SPRI, Department of Physics, University of Natal, Durban 4001, Republic of South Africa (Tel: (031) 8162775; FAX: (031) 2616550; Telex: 621231 SA).

VLF Quicklook : A proposal to VERSIM

During the recent VERSIM working group meeting at Vienna I presented an example of a VLF "Quick Look" format as currently being used by the Space Physics Research Institute in Durban. The idea is to find a means to present large volumes of VLF spectrogram data in a format which is both condensed but shows the main VLF activities (whistlers, hiss, chorus, emissions) over long periods at a glance. Moreover this format should be widely adopted by the VLF research community in order to facilitate a quick comparison of datasets from several sites covering the same period.

Previously large volumes of data were recorded on film. This method is labour intensive and expensive, although the result is a record of good dynamic range and resolution. Another printing step is required to produce hard copies of the data.

At the S.P.R.I. a method was developed to use the high resolution of laser printers to produce grey-scaled pictures at a lower (16 grey level, 75 dpi) resolution. A hardware device (Ubiquitous Spectrum Analyser) was interfaced to a PC and condensed spectra were obtained in software, converted to laser printer format and printed. The system as it stands simply requires an operator to load a data tape, enter the tape information and press "go". An example of a typical laser printer output is shown in Figure 1. This is a free running quick look with no timing, to obtain maximum density per page. 16 lines of 575 spectra per line, 50 points per spectrum in the 0–8 kHz range, giving a coverage of 8 hours 1 in 5 data per page.

This system attracted some interest at the VERSIM meeting, and at a later meeting between myself and Andy Smith of BAS we decided to try to establish a common format for an international "Quick Look" system. The purpose of this article is to fathom out the interest in such a system amongst the VLF research community and to suggest a standard for such a system.

Since the existing software was developed at the S.P.R.I we are prepared to write and distribute a general user-friendly package. We assume here that any interested group will be able to use their individual hardware devices to produce a file of spectra in digital format which can be read on an IBM compatible PC, and that they will have access to a Laser Printer compatible with the HP Laserjet family of printers. We suggest the following "Quick Look" formats, to fit on American A size page (276 × 214 mm). The numbers in brackets refer to the format for synoptic one-in-five recordings:

1. Each page of output has 10 (12) spectrogram lines of 6 (30) minutes each, in portrait mode.
2. At 75 dpi and 90 spectra per minute each line will be 182.9 mm (182.9 mm) long.
3. Each spectrum consists of 50 points in the 0–8000 Hz range, giving a resolution of 160 Hz per point. At 75 dpi each spectrogram is 16.93 mm high.
4. Below each spectrum will be a time axis 3 mm high with the time indicated every minute and ticks every 10 s.
5. The total height of each spectrum and axis will be 19.93 mm, which will fill 199.33 mm (239.2 mm) of a page leaving room at the top for one line of header.
6. For continuous recordings, one hour of data fits on one page and will always start on the hour. For synoptic recordings, six hours fit on one page and will always start on hour 0, 6, 12 or 18. Multiple files of various lengths will be handled in software.
7. Timing will be simple and depend only on the known start time of data files and the period between spectra.

This is the "standard" format. Different formats can be easily achieved by changing the time between spectra. To identify whistlers on the traces we suggest 180 spectra per minute (3 Hz) giving about 6 spectral lines per whistler or about 2 mm, which is just enough for identifying whistlers. The spectra per minute parameter will be an input parameter and any value is allowed; however not all values will give an integral number of minutes per line. Only the main format (540 spectra per line, 10 lines per page for continuous, 12 lines per page for synoptic, 50 points per spectrum) remains fixed. Table 1 shows a range of suitable values.

Spectra/ minute	*Rate (Hz)*	*Min./ line*		*Min./ Page*		*Pages/ day*	
		(con)	*(syn)*	*(con)*	*(syn)*	*(con)*	*(syn)*
22.5	0.375	24	120	240	1440	6	1
45	0.75	12	60	120	720	12	2
90	1.50	6	30	60	360	24	4
180	3.00	3	15	30	180	48	8
270	4.50	2	10	20	120	72	12
540	9.00	1	5	10	60	144	24

Table 1

We would like to ask anyone interested in this system to comment on the suggested format and to indicate their participation in this scheme. Please send your suggestions either to myself or to the editor of VERSIM (Andy Smith). Once the overall format is agreed on, we will suggest a suitable file standard for the digital spectrum data: any suggestions in this area are also welcome (ASCI, Fortran, Pascal or 'C'?).

Manmade effects

From Dr **O. Pokhotelov** (Institute of Physics of the Earth, Moscow):

The consequences of anthropogenic influences on nature are well known. These problems are broadly discussed both by scientists and the mass media. However, one aspect of human technical activity has not attracted the proper attention so far, this is the "electromagnetic ecology", that is the influence of human activity on the state of the electromagnetic field in the vicinity of the Earth. During millions of years of existence, humanity has developed in natural electromagnetic levels of activity. Now man is beginning to alter the electromagnetic geophysical environment at a growing rate. Namely:

1. An increase in the high power broadcasting has taken place, particularly in the ELF and VLF frequency ranges. As a result, radio emission levels appear to be much higher than throughout history, which leads to a negative influence on flora, fauna and human health.

2. The electromagnetic radiation generated on the surface of the Earth penetrates to ionospheric levels. The effects of ionosphere modification under the influence of powerful electrical transmission lines are well known. Further effects may occur due to energetic particle precipitation into the ionosphere induced by powerful radio transmissions.

3. Launches of satellites and rockets are accompanied by the injection of chemicals and water vapour into the ionosphere leading to changes in ionospheric composition and associated depletion of the ozone layer.

4. Acoustic waves generated during industrial explosions and military activity result in electromagnetic disturbances in the ionosphere and increased turbulence.

5. Aerosols released into the atmosphere during explosions may be electromagnetically active.

6. It is important to note that the influence of man-made electromagnetic fields on the biosphere may not be straightforward. Indirect coupling may occur in schemes such as the following: electromagnetic field → ionosphere → neutral atmosphere → weather → climate → biosphere.

7. These processes may have been more active during the war in the Persian Gulf.

8. A single event like an explosion or launch of a rocket causes a local short-lived disturbance in the electromagnetic field. In the case of repeated actions there could be accumulation effects, which could cause irreversible changes in the spectrum and intensity of the background electromagnetic field, the conditions for radio wave propagation, weather, and so on.

The study of all these effects and their ecological consequences requires coordination of the efforts of specialists in different fields and in different countries. It is of great importance to minimize negative effects on human activities.

I think it is important to assess, forecast and mitigate anthropogenic seismic or non-seismic effects on the geosphere through an interdisciplinary and multi-disciplinary approach. It would be of great benefit organize two subprojects:

1. *Artificially triggered seismicity (ATS)* led by IASPEI (Chairman: Professor **H. Gupta**)

2. *Man-made induced natural disasters (MIND)* led by IAGA/URSI (Professor **O. Pokhotelov**)

under an umbrella project *Geosphere response to man-made activities (GRMA)*

Proposed committee members: H. Gupta (India, chairman), D. Prochazkova (Czechoslovakia, secretary), J. Bonnin (France), P. Knoll (Germany). 1st sub-project: A. Alekseev (USSR), A. Shapira (Israel), J. Green (USA), M. Parrot (France); 2nd sub-project: P.F. Biady (Italy), O. Pokhotelov (USSR, vice-chairman). Of course the list of Committee members is open.

For more information, contact:
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Mailing list

We now have 89 scientists on the mailing list, from 21 different countries. If you are not on the mailing list, and would like to be, please contact one of us (addresses etc. given below).

Please send any information of interest to other members of the working group, for publication in the next newsletter, to A.J. Smith at the address given below; electronic mail preferred, otherwise mail or fax.

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