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IAGA/URSI
Joint Working Group on

V E R S I M

VLF/ELF Remote Sensing of the Ionosphere and Magnetosphere

Editor: A J Smith | Newsletter | No. 6 — January 1994

Dear colleagues,

This newsletter contains reports of the working group's activities at the recent general assemblies of our parent bodies — URSI and IAGA — held, respectively, in Kyoto and Buenos Aires. There is also some advance notice of future meetings, and news from members of our community in different countries around the world. This issue features in particular reports on VLF observations in Finland and in India. I would like to thank those who have contributed to this newsletter and I hope you find it of some interest. Contributions for the next issue are welcome.

XXIVth URSI General Assembly, Kyoto: 25 August – 2 September 1993

It was a pleasure for me to meet many of you in Kyoto and enjoy in the pleasant milieu of the ancient city of Kyoto some friendly and valuable discussions about our common interests in VLF/ELF phenomena and their use in studying the ionosphere and magnetosphere. The scientific programme of the assembly included several interesting and stimulating sessions of relevance to the scope of the VERSIM working group. We cannot fully report all these here, but mention a few, including the session on *Whistlers and particle precipitation* convened by Drs H.J. Strangeways and U.S. Inan.

Whistlers and Particle Precipitation

This well-attended session was held on 1 September 1993; about a dozen papers (including associated posters) were presented on a variety of topics based on ground-based and satellite observations and theoretical modelling work. The session was mainly devoted to the Trimpi effect and related topics. Highlights of some of the papers are summarized below:

M.J. Rycroft (Cranfield) Gave an invited review on the subject (published in *Reviews of Radio Science 1990-92*) and began by noting that the American longitude is a preferred one. He discussed recent work by INAN on VLF heating of the ionosphere by lightning, supported by TARANENKO *et al.*, and BURKE *et al.*'s Dynamics Explorer observations at $L = 2.5$ of a large upward flux of electrons. There were two pulses: (a) direct acceleration due to **E**; (b) due to gyroresonance. Other topics reviewed were KELLEY *et al.*'s observations made above intense thunderstorms, AOEs (anomalous optical events), the "early Trimpi" controversy (i.e. is this due to upward current (ARMSTRONG), transient electric fields (BURKE), or heating (INAN)?).

R.L. Dowden (University of Otago) characterised the Trimpi problem according to whether the scale size of the precipitation region was large compared to the geometric mean of the path length and wavelength (the geometrical optics approximation, i.e. regions not small or with fine structure); or small (the scattering case). He presented results for NWC ⇒ Dunedin (4 closely-spaced receiving stations) and Wellington. Amplitude and phase perturbations can have a different appearance even at neighbouring stations; this can be interpreted in terms of the increasing phase of the scattered phasor as you go from receiver to receiver on the chain. Sometimes simultaneous events were seen at Wellington; interpretation: the precipitation was on the great circle path to Wellington. Also discussed was "the case of the missing Trimpi", in which neither amplitude nor phase perturbation was recorded at one of the points on the network, whilst neighbouring stations (16 km away) did see an effect. A new type of event was described — RORDs (rapid onset rapid decay), consisting of a "spike" plus a Trimpi. The spike is of unknown origin; it is not broadband, but NWC signals are scattered. It adds to the Trimpi event to give the observed appearance. Summary: 1. Paths a few km apart give different Trimpis sometimes. 2. Simultaneous observations of Trimpis occur on paths 600 km apart; however this does not imply 600 km wide structure. 3. Lateral distribution of precipitation is usually not gaussian. 4. RORD LIEs appear simple in structure.

U.S. Inan (Stanford University) discussed a number of topics: the global importance of the Trimpi effect; onset and recovery signatures and their interpretation; and spread-spectrum remote sensing. Also treated were lightning-induced heating: new observations and kinetic modelling; and modification of the lower ionosphere by a transmitter. On the first topic, work by BURGESS has focussed on conjugate precipitation, strongly correlated with whistlers (locations ascertained by DF). The speculation that every whistler precipitates somewhere, and a calculation from world whistler rates, leads to an inferred energetic electron lifetime in the magnetosphere of about 5×10^4 day (cf. plasmaspheric hiss 10^3–10^4 day), so ducted whistlers may be as important as plasmaspheric hiss for particle loss from the radiation belts. On the second topic, recovery signatures tell us about D-region ionisation profiles. Different curvatures on different paths tell us about details of the spectrum of the precipitation. On the subject of signatures of LEP versus heating; only lightning on great circle paths is associated with heating events. LEP from lightning can be seen further away from the GCP. Confirmation of VLF heating has been found in Newfoundland (Gander) observations of NSS, when NAA switches off for maintenance. A similar effect was seen by NSS on NAA received at Huntsville. The spread-spectrum analysis technique involves a full digital demodulation of MSK, and non-linear processing.

A.J. Smith (British Antarctic Survey) described Trimpi observations made on MSK transmissions observed at Halley and Faraday stations, Antarctica.

D. Nunn (University of Southampton) described his model which is based on WAIT's, but generalised from the uni-modal case. The region of interest is described by a perturbation of the susceptibility tensor. The Born approximation is assumed, i.e. $\mathbf{E}' = 0$ or $\mathbf{D}' = 0$. The interpolation and scattering equations used were described. `MODEFINDR` is used to model the propagation. For modal scattering, the off-diagonal elements of the scattering matrix are significant (and profile-dependent). Modelling of the size and shape of a patch was illustrated. Paths considered were Ω-Australia ⇒ Dunedin (complex inter-modal situation), NWC ⇒ Dunedin, and NPM ⇒ Palmer/Faraday. The model needs different profiles from those of WOLF and INAN, in order to reproduce INAN's results (at high altitude: lower energy particles). Future upgrades to the model: relax the Born approximation; a better version of `MODEFINDR`; use the whole tensor; apply to the heating problem; apply to slant LIEs (lightning-induced ionisation enhancements).

H.J. Strangeways (University of Leeds) considered the size and shape of LIEs using a 3-dimensional duct model with more than one duct. Wave energy is focussed near the equatorial plane. ONDOH had found duct widths 10–20 km (at 90 km altitude these map to about 9 km). 3-D ray tracing shows that a whistler is confined to a small region at the equatorial plane (see modelling by LAIRD). There is an amplitude threshold effect. Fine duct structure (reported by the Eötvös group) implies a distribution of duct widths. Thus a LIE is unlikely to be a single gaussian structure; possibly a bigger structure in longitude than latitude.

Y.N. Taranenko *et al.*'s (Stanford University) paper was presented by Professor Inan and concerned optical emissions. Lightning (KRIDER and GUO, 1983) gives rise to typical fields $\sim 10\ \mathrm{Vm}^{-1}$ at 100 km altitude (decay time $\sim 100\ \mu$s). Lightning events near a perturbed patch (**Boeck** *et al.*, 1992) were considered. Lightning can lead to enhanced airglow in the D-region (Shuttle observations); there is an association with electrons up to 10 eV in energy. This work solved Maxwell's and Boltzmann's equations in the time domain. There was a 20% density enhancement due to the first flash, and more flashes before recovery. This increases reflection of all modes (resulting in an always positive amplitude Trimpi).

C. and O. Ferencsz (Eötvös University) presented four poster papers, giving a new non-monochromatic full-wave whistler model, involving a rigorous solution of Maxwell's equations. Various solutions, e.g. homogeneous, nonhomogeneous, etc., were described. Separation of the effects of sources and propagation (losses) is possible. Data from Halley station, Antarctica, and the Intercosmos-5 satellite were compared with theory. Artificial splittings are produced at amplitude minima.

K. Tang (CIE, Peking) described observations of whistlers and VLF emissions at Great Wall station, Antarctica, from 1984 onwards. VLF observations were made at the second Chinese station Zhongsan (near Davis) in 1988, but no whistlers were seen. What was described as a "harmonic whistler" was presented, though discussion from the floor suggested that such an effect could be due to cross-modulation in the equipment.

Forty Years of Whistlers

This stimulating and informative tutorial lecture was given by **R.A. Helliwell** and is published in *Modern Radio Science 1993* (edited by H. Matsumoto). It covered a wide range of related topics beginning with a historical review of the subject, including early work on whistlers by Barkhausen, Eckersley, and Storey. For historical interest, he showed a comparison of some of Storey's original whistler data recorded in Cambridge in 1951, and published in 1953, with recordings made in Cambridge (at British Antarctic Survey) in 1993, illustrating the enormous increase in VLF/ELF manmade radio noise in urban areas in the intervening 42 years. Other topics on natural phenomena included MR (magnetospherically reflected) whistlers, proton heating, and DRAGANOV *et al.*'s recent theory that whistlers can evolve into hiss, and that this can account for much of the observed plasmaspheric hiss.

Turning to whistler waves artificially stimulated by the Siple VLF transmitter, he discussed the concept of integration length and the second order resonance near the equatorial plane responsible for the so-called CWI (coherent wave instability). Fallers or risers are generated depending on which side of the equator the interaction region is located. The input signal amplitude in the equatorial plane is critical. He described the whistler simulation experiment: the peak amplitude is often the same as the saturation level. Other topics included: the predicted escape of whistler-mode signals on open field lines into the tail (which could possibly be observed at moon orbit); the threshold effect (path selective); suppression of the second frequency in 2-frequency experiments when they are close; sidebands; the strong effect of weak PLHR (power line harmonic radiation) and its relationship with natural MLR (magnetospheric line-structured radiation); the simulation of (pseudo) noise by the Siple transmitter and the development of "chorus" from "hiss"; frequency ramps and their effect based on the interaction length where $f' = f_H$ and $df'/dt = df_H/dt$ (f' is the Doppler-shifted wave frequency). The interaction will tend to join any pair of wavelets if you choose the right point on the field line.

Terrestrial Electromagnetic Environment

This session contained several papers of interest to the VERSIM community. **A.C. Fraser-Smith** discussed the $1/f$ power law for radio noise, with the notable exception of the minimum near the Earth-ionosphere waveguide cutoff. He noted that background levels due to manmade noise are rising all the time, so it is becoming increasingly difficult to make measurements of natural ELF/VLF electromagnetic noise, except in remote areas like Antarctica. Man's pollution of the electromagnetic environment is illustrated by the fact that fields near typical electrical appliances at

50 Hz are of order $\sim 10^7$ times higher than the natural level.

V.A. Rafalsky (Ukraine) described his work on atmospherics, from observations in Ukraine and on a ship in the Atlantic Ocean. The location of lightning and transverse resonances in the ionosphere (excited by spherics) were discussed. Cutoff frequencies increase with the order of the mode. Recording of E_z and two H components of the wave allows the range and direction of the source to be inferred. A model of terminator crossing is included in the analysis. The inferred lightning distribution shows source regions in Africa and South America.

M. Hayakawa (University of Electro-communications) also dealt with the location of lightning, by means of dispersion analysis and direction-finding. His technique allowed h, D and t_0 to be inferred from tweek dispersion. The signal is mixed with a "pseudo-spheric". The accuracy of the technique is $h < 700$ m; $d < 40$ km. Three stations are required to fix the location. The 'Field Analysis Method' was used for DF at one station, in the South China campaign. Near the cutoff frequency for the waveguide, the incidence angle $i \rightarrow 0$. Left-handed polarisation of whistlers is observed near to cutoff; there is some disagreement between theory and experiment.

A.J. Smith (British Antarctic Survey) described the new VELOX (VLF/ELF logger experiment) instrument recently deployed at Halley, station Antarctica ($L = 4.3$), and discussed some initial results from the system.

O. Molchanov (Institute of Earth Physics, Moscow) and **M. Parrot** (LPCE/CNRS, France) began with a review of PLHR (power line harmonic radiation) observed on spacecraft (see KIMURA *et al.*, 1987). Emissions stimulated by PLHR show geographical control and weekly effects (the Sunday effect has been reported). LHE (line harmonic emissions) are observed in the range 3–5 kHz. MLR has f = 30–500 Hz; df/dt = 0.3–4 Hz s^{-1}. Any theory needs to explain: (1) The amplitude and doppler shift of PLHR; (2) triggering and wave-particle interactions (coherent instability in the equatorial plane); (3) triggering in the upper ionosphere; (4) demodulation near the satellite. LEFEUVRE and BULLOUGH showed evidence of geographical control, though there were sceptics — e.g. LYONS, TSURUTANI, and THORNE. According to PARROT *et al.* (1991), power consumption is still increasing, so PLHR effects should be also. It is important to estimate the "power flux" compared to auroral effects. Aureol-3 findings were reported. There was an effect in electrostatic turbulence (72 Hz electric field component only), the magnitude of which (on average) decreased slowly from a peak on Monday to a minimum on Saturday (by a factor of about 2) with a slight increase on Sunday and a big increase to the Monday peak. The observations provide evidence for the ionospheric origin of PLHR-related emissions.

VERSIM

A meeting of the working group was held at Kyoto on 31 August 1993. 14 members were present, with A J Smith in the chair. After receiving the chairman's report on past activities, the meeting agreed to recommend the continuing existence of the working group, since fulfilled a need, serving as a forum for the VERSIM community. The meeting recommended that U.S. Inan should continue as URSI co-chairman for the next three years. The VERSIM Newsletter was endorsed as a useful medium of communication, especially during the intervals between scientific assemblies. It was noted that the sessions of interest to VERSIM, proposed for the 1996 URSI Assembly (see list below), were likely to be 'pared down' to 2 or 3, because of pressure of time. The remainder of the meeting was occupied by reports given by various members present.

A.R.W. Hughes (South Africa) reported that the new station at Sanae, Antarctica, was to be occupied in 1995. The VLF/DF programme continues, with an OMSKI receiver deployed at Sanae at the beginning of 1993. TV recordings of aurorae in the Antarctic are made together with correlated VLF, recorded simultaneously. They are purchasing "Omni-PAL" receivers from Otago University (R L Dowden); at present the software for this instrument is still being written. A system will be operated in Natal on a 150 km baseline (3 stations).

Gy. Tarcsai (Hungary) spoke of work on the digital matched filtering of whistlers, and a new rigorous solution of Maxwell's equations for whistler studies. The techniques have been applied to Aureol-3 data, Halley whistlers, Palmer whistlers, Roberval frequency ramps, and data from the SAS experiment on the ACTIVE satellite (260 M-Bytes of data), looking for nonlinear effects. A new SAS-2 instrument (5-component) is being developed for flight on the CESAR (Central European Satellite for Atmospheric Research) satellite. Trimpi recordings have been made for 2-3 weeks in Hungary. 20–30 good Trimpi events were seen on NAA and NSS; these will be analysed in collaboration with workers at Otago and British Antarctic Survey. A Trimpi receiving system will be operated together with German, French, and Hungarian scientists. He pointed out that the region is conjugate to South Africa (e.g. Sarajevo is conjugate to Durban!). Work is in progress on the automatic detection and analysis of whistlers; a powerful technique has been developed and will be used on the CESAR satellite.

J. Manninen (Finland) described VLF recordings made in northern Finland since 1989, some in connection with over-passes of the AKTIVNY satellite. Recordings are made only during campaigns, which were connected with EISCAT, etc. The sites used are very quiet and are located in the L-range 5–6. 15 hours of data have been collected on VHS videotape, including many VLF phenomena of interest. Collaboration is proceeding with the Polar Geophysical Institute (Apatity, Russia). There will be a campaign in November 1993, involving M. Rietveld (EISCAT). (For further information, see later in this newsletter.)

M.J. Rycroft (UK) described a developing array of VLF receivers around Europe. Outside the plasmapause, chorus-induced precipitation may be visible by this network. He noted in particular, that the NAA–Cambridge and NSS–Cambridge paths overlap, which may reduce the degrees of freedom in interpreting the data in terms of the effect of precipitation into the lower ionosphere.

F. Lefeuvre (France) mentioned work done using the Aureol-3 data which is held at Orleans. Future activities include participation in the INTERBALL mission (which is due to be launched in mid-1994). Theoretical studies include nonlinear effects due to VLF transmitters, and the use of neural networks to identify spherics, whistlers, etc. in the data.

U.S. Inan (USA) described the Palmer-Rothera-King George Island experiment to be conducted in 1994. VLF observations across the continental United States continue, and a special VLF heating experiment is in progress at Gander (Newfoundland) to look at heating of the lower ionosphere by the NAA transmitter, using NSS as the probe wave. VLF observations have started in Alaska to diagnose the D-region modified by the HIPAS HF Heating facility. The Automatic Geophysical Observatory program is moving along. Three new AGOs are to be deployed during austral summer 1993–94.

A.J. Smith (UK) reported on activities of the British Antarctic Survey. The first full year of data was now available from the new VELOX (filter-bank type) VLF/ELF receiver at Halley. Initial results were being reported in a paper at one of the sessions at Kyoto. Broadband and narrow-band recordings at Rothera were to be initiated in 1994 at part of an international US-UK-Brazil collaboration. The BAS AGO programme is now proceeding well, with the first deployment of an ELF/VLF receiver on one of the AGOs scheduled for the 1994–95 Antarctic summer season (for further information, see later in this newsletter).

7th IAGA Scientific Assembly, Buenos Aires: 8–20 August 1993

A meeting of VERSIM was held at Buenos Aires, on 14 August 1993; in the absence of both VERSIM co-chairmen, it was chaired by Dr **L.R. Piazza**. Those present exchanged news and views, and endorsed the continuation of the working group and the proposal for a VERSIM session at the 1995 IUGG (see below).

Forthcoming meetings

IUGG, Boulder, 1995

IAGA will be meeting during the 21st General Assembly of IUGG to be held in Boulder, Colorado, USA. For general information, contact: IUGG XXI General Assembly, c/o American

Geophysical Union, 2000 Florida Avenue NW, Washington DC 20009, USA.

A VERSIM half-day session on *Whistler Mode Waves and Particle Precipitation* (conveners A.J. Smith and U.S. Inan) has been scheduled for inclusion in the scientific programme.

In this session the focus will be on the precipitation into the ionosphere of energetic electrons by whistler mode waves, both natural and artificial. Papers on the observations of whistler-mode waves and associated wave-induced precipitation effects, as well as on theoretical and computer-based modelling of the interactions and the associated ionospheric effects, are invited.

The abstract deadline will be: **1 February 1995**. More details will be published in a forthcoming *IAGA News*.

URSI, Lille, 1996

The next URSI General Assembly will be held in Lille, France, in 1996. Some of the proposed sessions for this Assembly, of relevance to VERSIM, are:

Nonlinear wave theories and observations in space

Lightning and its interaction with the ionosphere

Whistler-mode waves at high latitudes

Electromagnetic coupling between the ground, the ionosphere, and the upper atmosphere

Transient effects in the ionosphere

IAGA, Uppsala, 1997

The 8th Scientific Assembly of IAGA will be held in Uppsala, Sweden. The proposed dates are 3–15 August 1997.

News from the VERSIM Community

Finland

From Mr **Jyrki Manninen** *Department of Physics, University of Oulu* and Dr **Tauno Turunen** *Geophysical Observatory, Sodankyla*

We have measured VLF waves in different parts of northern Finland since 1989. All measurements have been related to some specific project. During 1989 and 1990 we tried to receive VLF signals from the Russian 'Aktivny' satellite but without success. In December 1990 we coordinated VLF and EISCAT (incoherent scatter radar) measurements for the first time. Now we are preparing two papers related to impulsive precipitation events and dayside high-latitude magnetic impulse events.

In 1991 we included auroral TV observations and ULF measurements in our experiment. Accurate timing can be a problem when comparing different kinds of geophysical data from different data sets. For that reason, we now record all data on the same video tape. The ULF wave- form is recorded on the audio track using FM subcarriers, whilst the TV signal is recorded to the video track together with multiplexed time information.

In February 1991 we recorded more than 1000 whistlers within 6 hours. In that case the L-shells of the whistler ducts were changing with magnetic disturbance. That was natural, but sometimes there were even one-to-one correlations between changes of L-shell of the whistlers and the magnetic X-component.

In October 1991 very intense VLF waves were recorded after a strong magnetic storm (Kp exceeded 8). In the afternoon sector, numerous radio broadcasts, coming mostly from Russia, were detected by our equipment. We observed also some very strong PLHR events which we believe were related to a.c. currents flowing in the Swedish railway system at $16\frac{2}{3}$ Hz.

In 1992 and 1993 our measurements were mostly related to EISCAT/auroral campaigns. Many auroral substorms were recorded simultaneously with hiss and morning chorus. In any case, there are two very interesting phenomena: (i) radio broadcasts observed directly in VLF range, and (ii) whistler-triggered chorus which seems to be related to magnetic Pc-1 waves (like the events reported by SMITH *et al.*, 1985).

A recent campaign was related to an ionospheric heating experiment and EISCAT measurements. The data analysis is not yet complete but we have found that the radio broadcast we observe seems to be around 6 MHz. Of course the most natural explanations are related to equipment limitations, but we carried out a test in which the heater used 6 MHz modulated with sinusoidal VLF wave and we did not receive anything in the VLF range (the distance of the transmitter was 95 km from the VLF receivers). This proves that the explanation lies elsewhere than in the equipment. We also found some cases when a 1375 Hz sinusoidal heating signal produces harmonics, see a recent paper by BARR and STUBBE *Geophys. Res. Lett.*, **20** (1993) on harmonics from Tromso heating facility.

The VLF instrumentation used in 1989–1992 (spring) contains two orthogonal magnetic loops which have an effective area of 126 m^2 and theoretical sensitivity of 6.7×10^{-17} $Wm^{-2}Hz^{-1}$. Since 1992 (autumn) we have used new antennas which have an effective area of 1000 m^2, so their sensitivity is about 100 times better. The antenna is square (10 m $\times$ 10 m) with 10 turns. Since 1991 we have also had a two-component ULF magnetometer (magnetic coil with 4000 turns and very high quality amplifiers). It can see even weak Pc-1 pulsations. Since 1992 we have used a wide-angle and wide-wavelength diode-photometer (45° acceptance angle and 450–1200 nm wavelength). All wavelengths are integrated, so it cannot be used to distinguish different auroral emissions, but it can readily detect aurorae almost anywhere in the sky. We record the signal both in DC (total intensity) and in AC (just variation or pulsation) modes. All data are recorded by a HiFi video tape recorder which has two audio channels with 90 dB dynamic range and 20 Hz – 20 kHz frequency range, and one video track where we record the auroral TV image with multiplexed time information. The VLF frequency band we record at present is from 0.2 kHz up to 9.2 kHz.

We have started cooperation with PGI, Apatity, Russia (Dr E. Titova) and some contacts also exist with Hungary (Dr Gy. Tarcsai). We would welcome any other cooperation which would make use of our high-quality VLF data recorded in the auroral zone.

UK

By **A J Smith** and **M A Clilverd**, *British Antarctic Survey, Cambridge*

At Halley, Antarctica, we are continuing to make broad-band VLF goniometer recordings on a continuous, synoptic 1-in-5, or synoptic 1-in-15 basis. The analogue magnetic tape recorders were replaced by DAT (digital audio tape) recorders at the beginning of 1994. In addition we have continued to operate our VELOX VLF/ELF logger instrument (see VERSIM Newsletter No. 5 for a description). A condensed summary of the data is sent promptly and regularly to NASA as key parameters for the GGS (Global Geospace Science) mission, which are available centrally.

OMSK receivers, designed to study Lightning-induced Electron Precipitation through the study of Trimpi events, are planned to operate throughout 1994 at Halley and Faraday stations, Antarctica. Each receiver can record simultaneously the amplitude and phase of two Omega signals and two MSK signals. At Rothera (68° S, 68° W; $L = 2.8$) a short-term VLF experiment in collaboration with the USA (Palmer station) and Brazil (King George Island) will proceed during the winter of 1994, to study lightning-induced electron precipitation into the ionosphere. The Rothera equipment will consist of a Trimpi detector (OMSK receiver), and broadband (0–10 kHz) VLF recordings made synoptically every 1 minute in 5. At Faraday, the VLF Doppler experiment receiving whistler-mode signals from VLF transmitters continues in operation; the receiver software has recently been upgraded to extend the observable range of group delays, and further improvements are in the pipeline. Faraday will close as a British manned observatory in March 1996; some experiments (not including VLF observations) may be continued using automated systems. The VLF Doppler experiment is likely to be moved to Halley in the first instance.

Two BAS AGOs (Automatic Geophysical Observatories) have been operating in Antarctica since the 1991/92 season, at Halley (for testing) and at site 'A77' (77.5° S, 23.4° W). These each carry a three-axis magnetometer and a riometer. Both AGOs operated well through the 1993 winter. A third AGO is in the process of deployment on the Recovery Glacier at around

80.8° S, 20.4° W. It is planned to deploy the first AGO VLF/ELF instrument at this site during the 1994/95 summer season.

Czech Republic

From Dr **F Jiřícek** and Dr **P Tříska**, *Geophysical Institute of the Czech Academy of Sciences*

During the past two years, VLF/ELF waves observations and data processing have continued in the frame of the ACTIVE (Intercosmos 24 and MAGION 2) and APEX (Intercosmos 25 and MAGION 3) projects. The satellite VLF-broadband analogue data have been processed together with some plasma parameters (electron temperature, density and ion composition) with the aim of studying some LHR associated phenomena, e.g. the origin of LHR-whistlers, the occurrence and origin of some types of emissions, and plasmapause signatures in the outer ionosphere during disturbed periods. Special attention has been paid recently to the outer ionosphere phenomena associated with earthquakes. Two MAGION-type satellites are being prepared now as a Czech contribution to the INTERBALL project (1994–1996), each of them carrying a three-axis magnetometer, VLF/ELF instruments and plasma monitoring experiments.

India

From Dr **Birbal Singh**, *R.B.S. College, Bichpuri, Agra-283105*

Early Studies

Whistler studies in India were started in 1963 under the guidance of late Professor B.A.P. Tantry of Banaras Hindu University and continued until 1973. During this period, extensive ground based observations were carried out at two high altitude research stations: Gulmarg (geomagnetic latitude 24°N) and Nainital (geomagnetic latitude 19°N) and the bulk of whistler data collected. Analysis of the data indicated that: (i) the activity increased in the months of March and April; (ii) the majority of the whistlers occurred in the hours around midnight; and (iii) the activity increased sharply during periods of magnetic disturbance. A detailed ray-tracing study, with realistic low-latitude ionospheric models, indicated that the duct propagation of low latitude whistlers is unlikely.

During the period 1974–1988, whistler studies were conducted mostly at Agra station (geomagnetic latitude 17°N) and occasionally at Varanasi station (geomagnetic latitude 15°N). However, even during this prolonged period of study, some major problems like *whether ducts are formed in the low latitude ionosphere or not; if yes, then under what mechanism?*, *what is the duct lifetime?*, etc., could not be solved. On the other hand, evidence was found in support of the nonducted prolongitudinal mode of propagation for low- latitude whistlers and also the influence of ionospheric irregularities like spread-F and sharp density gradients on their propagation characteristics.

Whistler studies under AICPITS

Recently, in 1989, the Indian Department of Science and Technology sponsored a coordinated study of ionospheric irregularities over India under its All India Coordinated Programme of Ionosphere Thermosphere Studies (AICPITS). Under this programme, fourteen stations were established all over the country to monitor ionospheric irregularities by recording amplitude scintillations of VHF signals at 244.16 MHz from the FLEETSAT satellite. Four of these stations, namely Srinagar, Agra, Varanasi, and Bhopal, supported an additional experiment of whistler observations, side by side with that of the VHF scintillation observations. While the main object of the whistler observations was to solve the long enduring problems by simultaneous observations at multiple stations, the other object was to examine whether ionospheric irregularities like spread-F could influence the whistler propagation at low latitudes. If so, then both whistlers and scintillation should occur simultaneously. The results of three years of study along these lines have shown that: (i) the whistler occurrence at low latitude stations is very rare and sporadic; (ii) some new results such as higher harmonics of tweeks, daytime whistlers and daytime chorus emissions have been obtained for the first time; and (iii) on no occasions were whistlers and scintillations observed simultaneously.

Since the results found during this campaign period are not very conclusive, it has been decided to continue the studies for another period of four years with improved observation techniques augmented with a direction-finder at the higher latitude station of Jammu (geomagnetic latitude 24°N). The observations are to be computerised, and efforts are to be made to carry out real-time analysis of the data.

Japan

A conjugate campaign of VLF direction-finding observations was carried out in Iceland and at Syowa station, Antarctica, in September–October 1993. This project was to investigate the conjugacy of ELF/VLF waves between Iceland and Syowa, in order to study solar wind energy injection into the magnetosphere. For example: Are similar waves seen simultaneously at conjugate locations? Do they move the same way (both polewards or both equatorwards) at the same time? Are any scintillations similar (this will depend on the propagation through the conjugate ionospheres)?. Measurements are made at Syowa and two spaced stations in Iceland. VLF WDF (Wave Distribution Function analysis) and goniometry are done at each site, as well as auroral observations, etc. The campaign was scheduled in September/October when there is sufficient darkness to observe aurorae at both conjugate locations. The project is a collaboration between Chiba University and NIPR (National Institute of Polar Research).

Also at Chiba, **S. Shimakura** is planning to set up a Trimpi experiment using the path Ω-Japan to Chiba, on 10.2 kHz. In addition, a digital real-time receiving and analysis system will be installed on the Chiba campus. Measurement of two wave components (in winter only, as there is too much atmospheric noise in the summer) will give the arrival direction as well as range (i.e. the source location can be inferred) of lightning, and thus allow studies to be made of lightning propagation and source location distribution.

South Africa

From Dr **A R W Hughes** *Space Physics Research Institute, University of Natal, Durban.*

During an expedition to Marion Island from 19 April to 15 May 1993, it is planned to run the following instruments: (i) VLF goniometer, (ii) an Omnipal or OMSKI VLF receiver, (iii) a magnetometer, and (iv) a UV flux monitor. Simultaneously VLF observations close to the conjugate point may be made by Dr **Eigil Ungstrup** and Dr **Reiner Friedel**. One of the aims of the campaign is to study hiss enhancements occurring with a periodicity of ~40 s, which may be related to substorms.

Synoptic VLF Observations

This note is to remind VERSIM experimenters of the working group's recommendations regarding the timing of broadband synoptic VLF recordings, in order to facilitate detailed comparisons of data from different observing sites. For 1-minute-in-5 synoptic sampling, the minutes recorded should whenever possible be 00–01, 05-06, ... 55–56 past the hour; for 1-minute-in-15 sampling, the minutes recorded should be 05–06, 20–21, 35–36 and 50–51.

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 recently the scope has become 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 95 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.

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