IAGA/URSI
Joint Working Group on

VLF/ELF Remote Sensing of the Ionosphere and Magnetosphere

Editor: A J Smith | Newsletter | No. 9 — June 1996

Dear colleagues,

The 25th General Assembly of URSI (International Union of Radio Science), one of the working group's two parent bodies, is now less than 2 months away and will be held in Lille, France. I hope that many of the VERSIM community will be able to attend the assembly, and take the opportunity to meet and discuss matters of common scientific and technical interest in the VERSIM field. We plan to hold a meeting of the working group at Lille, where we will review recent VERSIM activities and consider what role the working group is or should be playing in the future, for example in sponsoring scientific symposia, experimental campaigns, or any another initiatives. If you have any views on this or related matters please bring them to the meeting. If there is any relevant topic which you particularly wish to raise, then it would be helpful if you could let the URSI co-chairman Professor Inan know in advance, so that we can put it on the agenda. This issue of the VERSIM newsletter contains information about the general assembly and other forthcoming meetings, and also news from members of our community in different countries around the world, for example about recent, current and planned experiments in our field. I would like to thank all those who have sent me contributions. I hope you find the newsletter of some interest and will continue to support it. I will look forward to seeing many of you in Lille.

XXV General Assembly of URSI

The XXV URSI General Assembly will be held in Lille, France, 28 August to 5 September 1996. Details about the Assembly were published in May 1996 in the *Provisional Scientific Programme*. To obtain this, or further information, contact AG URSI, Université de Lille 1, F-59655 Villeneuve d'Ascq Cedex, France; phone: +33-20-33-72-06; fax: +33-20-33-72-07; email: `agursi@univ-lille1.fr`. See also the WWW page `http://www.univ-lille1.fr/ursi`.

Whistler-mode waves and their effects on the radiation belts

A VERSIM half-day session on this topic (session H1; convenors A.J. Smith, U.S. Inan and J. Lemaire) will be held on the morning of Thursday 29 August, 0830–1230 (oral session). The posters for all URSI sessions will be displayed on the afternoon of Tuesday 3 September.

The provisional H1 programme is:

Oral session

1. **R.M. Thorne and B. Able,** Scattering and precipitation of energetic electrons in the inner magnetosphere. (Invited)

2. **A.L. Vampola,** Precipitation of energetic electrons by VLF transmitters. (Invited)

3. **M.A. Clilverd and R.B. Horne,** Ground-based evidence of latitude-dependent cyclotron absorption of whistler mode signals originating from VLF transmitters.

4. **R.L. Dowden,** Evidence for whistler-induced precipitation from the radiation belts in association with sprite events.

5. **O. Ferencz,** Rigorous computation of ion-cyclotron whistlers.

6. **M. Walt,** Trapped electron losses from ducted whistlers. (Invited)

7. **V.S. Sonwalkar, U.S. Inan, T.F. Bell and D.L. Carpenter,** Thunderstorm coupling to the magnetosphere: (1) whistler-lightning correlations, (2) contribution of lightning energy to the magnetosphere, (3) lightning as a source of hiss.

8. **R.M. Thorne and R.B. Horne,** Whistler absorption and electron heating near the plasmapause.

9. **D.S. Lauben, U.S. Inan and T.F. Bell,** Precipitation of radiation belt electrons by non-ducted whistler pulses.

10. **K. Kudela, M. Slivka, F. Jiricek, P. Triska, F.K. Shuiskaya and I.M. Martin,** Fine structure of precipitating energetic electrons: IK-24 measurements.

11. **D.M. Sulic,** Properties of the trough in guiding whistlers.

Poster session

1. **P.A. Bespalov,** The short periodic magnetospheric VLF emissions.

2. **P.P. Savtchenko,** Tweek mode propagation of hiss.

3. **V.A. Rafalsky,** A universal computer-based VLF receiver.

4. **A.V. Kostrov, A.I. Smirnov, A.A. Shaykin and T.M. Zaboronkova,** The structure of electromagnetic fields of frame radiators in magnetoactive plasma in the whistler frequency range.

5. **A.V. Kostrov, A.I. Smirnov, M.V. Starodoubtsev, A.A. Shaykin and I.V. Khazanov,** Nonlinear conversion of angular and frequency spectra of radiation of the dipole antenna in a magnetoactive plasma.

6. **B. Singh,** Resonant electron precipitation in the low latitude ionosphere.

7. **V.K. Jain,** Depletion of electron fluxes associated with man-made VLF signals in the inner magnetosphere.

8. **V.Y. Trakhtengerts and M.J. Rycroft,** A nonlinear reflection of whistler waves from the lower hybrid resonance level and its applications.

9. **A.G. Demekhov, D.L. Pasmanik, and V.Yu. Trakhtengerts,** Dynamics of whistler-mode cyclotron instability in the presence of energetic electron injection and adiabatic magnetic compression.

Other relevant sessions

Some of the other sessions scheduled for Lille are also of relevance to VERSIM:

E2.1 *The terrestrial electromagnetic environment* (convenors: M. Hayakawa, A.P. Nickolaenko), 0830–1230, 3 September;

H4 *Nonlinear theory and computer simulations on waves and particles in geospace plasmas* (convenors: H. Matsumoto, M. Ashour-Abdalla), 0830–1230, 4 September;

HG2 *Effects of lightning and VLF waves on the ionosphere* (convenors: D. Nunn, M.J. Rycroft), 1400–1720, 30 August;

HEG *Electromagnetic coupling between the ground (including seismic activity) the upper ionosphere and magnetosphere* (convenors: M. Parrot, O.A. Molchanov, T. Yoshino, A.C. Fraser-Smith), 0830–1230, 5 September;

VERSIM business meeting

There is planned to be a meeting of the VERSIM working group during the Lille Assembly;

the exact time and venue are to be announced (at the Assembly, or check the VERSIM WWW page shortly beforehand). 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. Election of IAGA Co-chairman for 1995-99; 5. Any other business. With respect to item 4, the following have already been suggested for the 1999 URSI General Assembly: *Thunderstorm-Ionosphere Coupling* and *Whistler-mode Wave-Particle Interactions* (the latter with particular reference to high latitude phenomena studied using data from the POLAR satellite and the new AGO networks in Antarctica).

Other forthcoming meetings

IAGA, Uppsala, 1997

The 8th Scientific Assembly of IAGA will be held in Uppsala, Sweden, 4–15 August 1997. For more details, contact the local organising committee [tel: +46-18-303600; fax: +46-18-403100; email: `iaga@irfu.se`; WWW: `http://www.irfu.se/iaga_97.html`].

There will be a half-day VERSIM session (Session 2.14) on *Localised ionospheric perturbations related to lightning and VLF transmitters*, Conveners: D. Nunn, A.J. Smith. This session will be concerned with the scattering of VLF radiation from D region ionospheric irregularities. 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 Trimpis. Papers are also solicited on scattering due to direct heating of the ionosphere and on Trimpis caused by Sprites and Blue Jets.

COSPAR, Birmingham, 1996

The 31st COSPAR Scientific Assembly will be held in Birmingham, UK, 14–21 July 1996. For more information, 'telnet' to `LINAX1.MPAE.GWDG.DE` or check the WWW page `http://www.mpae.gwdg.de/COSPAR/COSPAR.html`.

News from the VERSIM Community

USA

From: **U.S. Inan,** Stanford University

Worldwide Stanford University ELF/VLF measurement activities currently in progress include:

1. At **Palmer** Station, Antarctica, broadband (0.3–20 kHz) measurements continuously for 9-hrs/day, typically between 0100–1000 UT, plus narrowband observations (data sampled at 50 Hz/20-ms resolution) of the amplitudes and phases of NAA, NSS, NPM, NLK, NAU, and GBR during 0000–1200 UT.

2. At **South Pole** Station: continuous broadband (0.3–20 kHz) observations, typically for 3-hrs/day (variably between 0900–1400 UT), plus synoptic (1 out of every 15-mins, e.g., 0005–2351 UT) observations during 0000–0800 UT, plus continuous observations (with 1-s sampling rate) of the signal intensity in selected bands (e.g., 0.5–1, 1–2, 2–4, 11–13, 30–38 kHz).

3. At five high-latitude **Automatic Geophysical Observatory** sites: continuous observations (with 1-s data recording resolution) of the signal intensity in the 1–2, 2–4, and 30–40 kHz bands, plus broadband snapshot observations of the 1–3 kHz band for 2-s out of every 15-mins. The 2-s is selected to be the seconds 30-32 of the usual synoptic minutes.

4. In the continental **United States**: During 1995 and 1996, Stanford carried out observations at four sites deployed along the California coast in a VLF Holographic array configuration. Continuous measurements were conducted of NAA,NLK,NSS,NPM,NAU signal amplitudes and phases with 20-ms data resolution during 0000–1200 UT. At this time, Stanford has received a new grant from the National Science Foundation to establish two holographic arrays, one involving five sites in a north–south configuration across Colorado and another in-

volving five stations across the Alabama–Kentucky region. These stations are approximately 100-km apart; the program is called Holographic Array for Lightning research (HAIL). The novel feature of this system is that the data will be retrieved over the Internet and will be available on the WWW in near-real time. Data are being recorded with 20-ms resolution, and both amplitude and phases are measured, again during 0000–1200 UT. The Colorado array is being deployed in June 1996, while the eastern array will be in place by October 1996. The purpose of HAIL is to measure ionospheric effects associated with large thunderstorms, including those which produce sprites. The eastern array is geomagnetically conjugate to the regions monitored via measurements at Palmer Station.

5. Broadband ELF/VLF Measurements: A new Stanford ELF/VLF system is now being designed to capture the ELF content of sferics associated with sprites/blue jets. This receiver will have a large dynamic range over the range 10 Hz to 22 kHz and will record data continuously on Digital Audio Tapes. Two such systems are being built, for deployment in Colorado and Oklahoma.

South Africa

From: **A.R.W. Hughes,** University of Natal, Durban.

The new South African Antarctic base at Vesleskarvet, at about (71°S; 2°W), is expected to be operational by February 1997. The SHARE radar and a range of experiments including a pulsation magnetometer, a VLF direction finder, an "Omnipal" receiver and all-sky auroral cameras will be reintroduced. An addition to the programme is a proposed telemetry station to be operated for the Royal Institute of Technology, Stockholm, to take data from the Astrid-2 satellite. This will provide fine scale electric field measurements over auroral forms. We will also be measuring ozone column densities and UV fluxes. The new base is 200 km inland from the former South African base at Sanae-3.

Two VLF wave-particle campaigns were conducted in 1996. One was to Marion Island (46°S 38°E) in collaboration with the British Antarctic Survey, in which their VLF Doppler receiver was operated in conjunction with our VLF and Omnipal receivers. Initial comments by the experimenters (Mark Clilverd, BAS; Ken Rice and Andre Larisma, Natal) suggest that good data sets have been obtained. The other campaign was to make wave-particle measurements at three stations in Natal in collaboration with the tethered satellite experiment launched by the US Space Shuttle. Unfortunately the tether broke just before full deployment and no data were obtained. A future campaign is planned in conjunction with particle injection experiments on the MIR space station. Apart from our work in Antarctica we see much of our future in space physics in Natal as making these wave-particle measurements in association with satellite measurements made by other groups.

British Antarctic Survey

(**A.J. Smith** and **M.A. Clilverd**)

Rothera (67.6°S 68.1°W)

No further VLF recordings have been made since 8 October 1995, and the receiving system has now been removed.

Faraday (65.3°S 64.3°W)

The 2 narrow-band VLF experiments (OMSK and VLF Doppler receivers) and VLF broadband recordings finally stopped on 15 December 1995, prior to handover of the station to the Ukraine. The OMSK and broadband equipment has remained on the station (now known as *Vernadsky*) although operational schedules are unknown.

Halley (75.6°S 27.3°W)

VLF broadband (recording to DAT tape), OMSK narrowband ('trimpi'), VELOX (filterbank), and VLF Doppler observations continued through 1995. The OMSK programme closed in November 1995 but it is planned to replace it with a new and more flexible *OmniPAL* receiver in 1997. The other observa-

tions are continuing during 1996. Key parameters from VELOX and other experiments at Halley are routinely transferred into the ISTP database as part of the SESAME investigation of GGS (Global Geospace Study). For 1997, it is planned to enhance the VELOX with an additional tunable narrow-band channel capable of receiving signals from the proposed South Pole VLF beacon, and also an impulse counter for measuring spheric rates from global lightning at frequencies of 3 kHz and 10 kHz. For more information, consult the BAS Upper Atmospheric Sciences Division World Wide Web page `http://www.nerc-bas.ac.uk/public/uasd/`.

Automatic Geophysical Observatories

The first AGO-VELOX (AGO-based VLF/ELF receiver) was installed in the A80 AGO (80.9°S 22.3°W) when it was deployed on the Recovery Glacier 600 km south of Halley in January 1995. The power in frequency bands at 0.5, 1, 2, 3, 6 kHz is recorded every second, and other parameters every 10 s. A 0–6 kHz spectrogram is recorded every 15 minutes. A fuller description of the instrument was given in the last *VERSIM Newsletter*. The AGO instrument complement also included a magnetometer and riometer. Although all the instruments worked well, a fault in the main computer meant that no data were recorded after 26 February 1995. Nevertheless, 40 days of excellent data were taken, and provide an interesting comparison with simultaneous data from identical instruments at Halley. First results will be reported at the Western Pacific Geophysics meeting in Brisbane in July 1996. During the 1995–96 Antarctic summer the third of the four BAS AGOs, A81 ("High Sierra"), was deployed at (81.5°S 3.0°E), with the same instrument payload as A81. Two further instruments, supplied by US collaborators, were added to A80 and A81, namely a LF/MF/HF receiver to study auroral radio noise (**J. LaBelle**, Dartmouth College) and a pulsation magnetometer (**M. Engebretson**, Augsburg College). A late-season visit was made to all the AGOs, enabling a good coincident data set for about three weeks to be collected; this is currently being analysed.

Brazil

(**L.R. Piazza**, INPE)

As part of an international project with BAS and Stanford University, narrow band recordings have been made at Commandante Ferraz, the Brazilian Antarctic station, of NAA, NPM, NSS, NAU, and NLK for 12 hours per day (00-12 UT) throughout 1995. The data are currently being analysed for Trimpi event activity.

France

from **Y. Corcuff**, Signal Image Communications Laboratory, Université de Poitiers.

Our VLF receivers have now been installed at the "Futuroscope" site, near Poitiers, and since the beginning of April 1996 we have been monitoring signals from NAA, GQD, and HWU, in order to study the Trimpi effect. Unfortunately so far there has been very little Trimpi activity, possibly because geomagnetic disturbance levels have been low during this time.

Hungary

from **J. Lichtenberger**, Eötvös University

Beginning from April 1996, the Eötvös Geophysical Institute and the Department of Geophysics, Eötvös University, Budapest, restarted routine whistler recordings in Tihany, but in digital form. At the moment, two minutes of every half an hour is recorded digitally and analysed offline, but by the end of September a new automatic whistler detector is expected to be set up. This will monitor the received waveform continuously, and only the part of digitised signal that contains whistler(s) will be stored. Trimpi measurements are also made during the night-time hours

Czech Republic

From **F Jiřícek** and**P Tříska**, Institute of Atmospheric Physics of the Czech Academy of Sciences, Prague

During the period 1994–1995 (and to June

1996) VLF/ELF waves studies continued, mainly using satellite data from the ACTIVE and APEX missions. New data on wave phenomena have been recorded since August 1995 at the Panska Ves satellite TC/TM station within the INTERBALL mission. For this mission two MAGION-type satellites have been developed in the Czech Republic (Institute of Atmospheric Physics). The first, MAGION-4, a small satellite weighing 59 kg, was launched on August 3, 1995, as a part of the INTERBALL-1 spacecraft, and was separated from this "mother satellite" during the first orbit. The highly eccentric elliptical orbit (apogee 193000 km, perigee 793km, inclination 62.9°) enables measurements to be made in different parts of the Earth's magnetosphere and in the solar wind. The scientific payload of MAGION-4 was the result of extensive international cooperation, and includes magnetic field and particle measurements and a set of wave experiments using the following sensors: one double-probe electric dipole 1.7 m long for $f < 400$ kHz, three search coils for $f < 2$ kHz, and one search coil for $f < 40$ kHz. The onboard equipment includes a filterbank, ULF waveform digitizer, step frequency analyser and broadband analogue telemetry channels. The MAGION-4 orbit crosses the plasmasphere regularly, which allows us to observe plasmaspheric wave phenomena as LHR hiss, magnetospherically reflected whistlers, ELF auroral emission, etc. Observations of these types of ELF/VLF phenomenon are expected to continue, and to be extended after activation of another small (68 kg) Czech satellite, MAGION-5, with a payload similar to MAGION-4. It is to be launched in August 1996 as a part of the INTERBALL-2 project. The proposed orbit is: apogee 20000 km, perigee 800 km and inclination 63°.

Yugoslavia

from **D. Šulić**, Geomagnetic Institute, Belgrade

In August 1992 our whistler station at Grocka ($\Lambda = 43.8°$, $\Phi = 102.27°$) was badly damaged during a thunderstorm. At the end of last year we finished reconstructing it. During 3 minutes every hour, broadband (1–10 kHz) observations are recorded and analysed by a 486 PC-based digital acquisition system. The main problem now is that during last winter whistlers were recorded very rarely at our station , because of the high level of noise. However, some very unusual (and as yet unexplained) rising tone events in the range 2–5 kHz were recorded on 8 April 1996, at 1450-1452 UT, during quiet geomagnetic conditions.

Russia

from **A. G. Demekhov**, Institute of Applied Physics, Nizhny Novgorod

A specific precipitation zone of energetic electrons has been observed on the evening/ afternoon side after sufficiently strong magnetic storms. This zone has some remarkable features investigated using the data of low-altitude ($h \sim 10^3$ km) NOAA satellites. In particular, the moderate pitch-angle diffusion regime with a filled loss cone is evident, the precipitated electron fluxes being of the same order as the fluxes of trapped electrons, and the precipitation event having a specific cliff-like form along the satellite trajectory as it crosses L-shells. These quasi-steady events are often accompanied by the precipitation of protons located in the same LT sector but at higher latitudes. We suggest a theoretical model based on cyclotron resonant interactions to explain these observed phenomena. We consider that this electron precipitation zone is formed by energetic electrons which interact via the whistler wave cyclotron resonance instability with a region of relatively large cold plasma density. This region is caused by a restructuring of the plasmasphere during the magnetic storm. The source of energetic electrons is situated on the night side and they enter the interaction region by the process of magnetic drift. The isotropisation of the distribution function during the process of pitch angle diffusion is accompanied by the redistribution of the energetic electrons along the magnetic flux tube. This can lead to a large (by almost an order of magnitude) increase of the trapped electron flux measured at low altitudes. Based on self-consistent equations for the whistler cyclotron instability we obtained quantitative estimates for the parameters of the energetic electron precipitation zone which are in agreement with the observa-

tions.

For comparison of theoretical results with experimental data, it is obviously fruitful to employ simplified models for quickly estimating parameters that provide the best agreement with experiment. We considered the simplest dynamic model of the whistler cyclotron instability based on the so-called multi-level set of equations for the cyclotron maser, taking into account nonlinear modulation of the pitch-angle distribution of trapped particles. We tried to simulate two precipitation events for which satellite trapped energetic electron data and EISCAT data on the electron precipitation were available (*Manninen et al.*, J. Atmos. Terr. Phys., **58**, 97, 1996). We showed that the different precipitation time patterns in these events can be consistently related to the recorded plasma parameters.

These investigations are a part of a joint project coordinated by Dr. T. Turunen, Director of the Sodankylä Geophysical Observatory, and funded by INTAS.

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 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.

L.J.C. Woolliscroft, 1944–1996

We note with sadness the death in March this year of **Les Woolliscroft**, whose research career was mainly devoted to the study of plasma wave processes in geospace and the development of sophisticated rocket- and satellite-borne wave experiments. He was Principal Investigator and Project Engineer for the Plasma Wave Experiment on the AMPTE UKS spacecraft, and later Principal Investigator of the Digital Wave Processing (DWP) Experiment on one of the ESA/NASA cornerstone missions, the ill-fated CLUSTER (which, to the great dismay of space scientists everywhere, was destroyed when the Ariane-5 rocket exploded soon after launch from Kourou, French Guiana, on 4 June 1996). A full obituary of Les may be found in the MIST WWW page `http://www.nerc-bas.ac.uk/public/uasd/mist.html` .

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. I am planning to put an email directory of VERSIM scientists on the VERSIM WWW page. If anyone does *not* wish to be included, please let me know.

IAGA Co-chairman of the JWG:

A J Smith
British Antarctic Survey
High Cross
Madingley Road
Cambridge CB3 0ET, UK

Telephone: +44 1223 251544

FAX: +44 1223 362616
Electronic mail:
A.J.Smith@bas.ac.uk

URSI Co-chairman of the JWG:

U S Inan
STAR Laboratory
Dept of Electrical Engineering
Stanford University
Stanford, CA94305, USA

Telephone: +1 415 723 4994
FAX: +1 415 723 9251
Electronic mail:
inan@nova.stanford.edu

VERSIM World Wide Web page:

http://www.nerc-bas.ac.uk/public/uasd/versim.html.