IAGA/URSI
Joint Working Group on
VLF/ELF Remote Sensing of the Ionosphere and Magnetosphere

Editor: A.J. Smith | Newsletter | No. 1 — December 1990

Dear colleagues,

Change of name

As you will no doubt have noticed, the working group has changed its name; it was formerly the "IAGA/URSI Joint Working Group on Passive Electromagnetic Probing of the Magnetosphere". This is the first newsletter of the renamed group. The name change was proposed at the IAGA meeting in Exeter in 1989 by members of the working group that who felt that the name no longer reflected well the interests of the group members, due to changes in both techniques and scientific emphasis in the years since the working group was established. Thus much work now, such as the various imaging networks, rely heavily on the use of VLF transmitters and thus the technique is not truly passive. It was also felt desirable to specify the frequency range of interest, i.e. VLF/ELF, in the title, to avoid any overlap with for example the ULF community. The new name was approved in meetings of the working group held during the IAGA Assembly in Exeter and the 1990 URSI Assembly in Prague. The name change has now been ratified by IAGA and URSI.

23rd URSI General Assembly, Prague: August–September 1990

It was good to meet many of you at URSI in the beautiful old city of Prague. There were several interesting and stimulating sessions of relevance to the scope of the working group, e.g. *Ionospheric and magnetospheric effects of lightning*, which was largely concerned with the topic of LEP (lightning-induced electron precipitation) and its detection using the trimpi effect; *VLF Triggered Emissions*; *Characterisation of terrestrial and power line sources*, in which the discussion was mainly on the relative importance of lightning, transmitters, and power lines as terrestrial sources influencing the distribution of ELF/VLF noise in the magnetosphere; *Radio propagation in the ionosphere and magnetosphere: theory and application* which featured several papers on ELF/VLF propagation.

Working Group meeting at Prague

A meeting of the working group was held at Prague, Czechoslovakia on 5 September 1990, during the URSI Scientific Assembly.

Present A.J. Smith (UK, chairman), R.H.W. Friedel (South Africa), M. Hayakawa (Japan), U.S. Inan (USA), F. Jiricek (Czechoslovakia), A. Mendes da Costa (Brazil), M. Parrot (France), A.W.V. Poole (South Africa), J.V. Rodriguez (USA), B. Ryabov (USSR), D.D. Sentman (USA), W.R. Sheldon (USA), D.R. Shklyar (USSR), H.J. Strangeways (UK), T. Yoshino (Japan).

In his opening remarks, the chairman noted that the working group served as a forum for researchers using whistlers and VLF/ELF waves as a means of studying the physics of the ionosphere and magnetosphere and the interactions between them. Main areas of in-

terest were: Plasma structures and boundaries, wave-particle and wave-wave interactions, wave-induced particle precipitation, and wave propagation in the ionosphere and magnetosphere. Activities of the working group included facilitating coordinated observational campaigns and data exchange, and reporting of scientific results and exchange of ideas and information, both through meetings and a newsletter. Since the last URSI Assembly, four newsletters had been circulated to the mailing list of about 60 scientists in several countries. Since the newsletter is the principal means of communication within the working group, Smith invited contributions for the next newsletter to be sent to him. It was reported that at a joint URSI Commission G/H business meeting held earlier in the Assembly, it had been decided that the working group should continue in existence but under its new name.

M. Hayakawa gave a brief report on the work of his group; for a more detailed report, see below.

U.S. Inan reported on US activities, first describing the United States AGO (Automatic Geophysical Observatory) programme. He went on to discuss the development of a trimpi network based in the USA (see below), and then described an active experiment in December 1989, involving the DE-1 satellite and a transmitter at Archangelsk. Finally he mentioned the proposed WIF (Wave Injection Facility) in Antarctica, which would be capable of transmissions at frequencies as low as 500 Hz, thus enabling new science to be done on a variety of topics.

A.J. Smith reported on current and future activities of the British Antarctic Survey (see below for more details).

R.H.W. Friedel described VLF experiments at Durban and Sanae (see below for a more detailed report).

A.W.V. Poole described a proposal to place a digital ionosonde, imaging riometer, and pulsation magnetometer, on Gough Island, close to centre of the South Atlantic Geomagnetic Anomaly. The site was also well placed for trimpi studies, and it was possible to consider putting a suitable VLF receiver there.

F. Jiricek gave a report on the status of the ACTIVNY mission. The main VLF transmitter was not working, but the passive mode works well. It is planned to continue with operations at conjugate points. Studies of LHR associated phenomena and DPE (Discrete Plasmaspheric emissions) were in progress.

20th IUGG General Assembly, Vienna

The Assembly will be held in Vienna 11–24 August 1991. More information may be obtained from the Local Organising Committee, IUGG 1991, c/o Prof. Dr H. Sünkel, Mathematical Geodesy and Geoinformatics, Graz University of Technology, Rechbauerstrasse 12, A- 8010 Graz, Austria.

A scientific session which may be of particular interest to the working group is:

GAM 3.18: **Wave-induced particle precipitation**. Convenors Dr A.J. Smith and Dr U.S. Inan. A Call for Papers is enclosed with this newsletter and is also to be found in IAGA News Number 29. The latter also contains instructions for preparing and submitting abstracts. The abstract deadline is **28 February 1991**.

During the Assembly, a meeting of the working group will be arranged. Details to be announced later.

24th URSI General Assembly 1993

The Assembly will be held in Kyoto, Japan. A symposium which has been proposed for the Assembly, and will be of interest to members of this working group, is on *Whistlers and Precipitation.*

News from Japan

From Dr M. Hayakawa (Solar Terrestrial Environment Laboratory, Nagoya University, Japan). Please note that the name of Dr Hayakawa's institute has changed recently.

Experiments on wave-particle interactions in the inner magnetosphere

Conjugate experiment at middle latitudes (Japan/Russia collaboration)

- VLF transmitter, Kharbarovsk (f = 23.9 kHz)
- Conjugate measurement of 3 field components at a point near the conjugate point (Ceduna, Australia)
- Simultaneous measurements of natural VLF signals. (N.B. 15 kHz from this transmitter was recorded on the DE satellite by the Stanford University group, and related particle precipitation by Professor Dowden using NWC signal reception).

Conjugate experiment at lower latitude ($L \sim 1.6$) (mid 1990)

- Decca signals (80–110 kHz) transmitted from Hokkaido
- Reception of those signals at a few points near the conjugate point in Australia, Doppler shift detector, multichannel narrow-band filters etc.

DF for equatorial-latitude whistlers

We carried out this spaced DF measurement for very low latitude whistlers (in China) in 1988, and the summary of this campaign was presented at the Prague URSI Assembly.

Bi-spectrum analysis for Omega signals

These were observed over Japan on the ISIS satellite and showed evidence of non linear wave-wave interaction.

Development of the DF technique

- Development of the WDF method for the ground-based DF method
- 3-station simultaneous measurements of 3 possible field components (planned for winter 1990/91), in order to examine the accuracy (or error) of different kinds of DF-methods, our field- analysis method, WDF, and other methods.

News from UK

From A.J. Smith (British Antarctic Survey, Cambridge, UK)

Currently, the following observations are being made: broadband VLF recordings at Halley and Faraday; a VLF imaging network for precipitation mapping, by the trimpi effect (in collaboration with the University of Otago, New Zealand), using OPAL (Omega phase and amplitude logger) receivers, now upgraded to receive signals from MSK transmitters as well as Omega; group travel time, and Doppler shift measurements of whistler mode signals from VLF transmitters, for monitoring plasma density and drift characteristics and large scale electric fields in the plasmasphere; and digital whistler recordings for studying whistler fine structure. Recently, special observations have been made in is connection with the AKTIVNY mission, at times when the main satellite was nearly conjugate to Halley. Future plans include participation in international programmes such as ISTP, CLUSTER, etc., and deployment of an AGO network in Antarctica. At present, work is proceeding on a prototype AGO which will be tested at Halley. It is then proposed that six AGOs been deployed at sites south of Halley, on the Antarctic ice-sheet. Each AGO will carry a magnetometer, riometer, photometer and ELF/VLF receiver. In preparation for the move of all experiments to new station buildings at Halley in the austral summer of 1991/92, it in planned that there will be no VLF observations of any kind, at either Faraday or Halley, during the year of 1991.

News from South Africa

From Mr R.H.W. Friedel (Space Physics Research Institute, Department of Physics, University of Natal, Durban, South Africa).

VLF recordings have been made at the South African Antarctic base Sanae (70°S, 2°W, $L = 4.1$) since 1970 and we currently operate a Goniometer direction finder, similar to the system operated by the British Antarctic Survey (BAS) at Halley and Faraday. Recordings are made for one minute in five in the 0–10 kHz band for about nine months of the year. Continuous recordings are made during periods of high activity and during all auroral displays recorded by our low light level TV auroral research programme.

VLF data (from Sanae and other sources) are analysed in Durban using an AVDAS (Advanced VLF Data Analysis System). For joint data analysis with visual auroral data, the AVDAS spectrum analyser has been interfaced to a PC-based image processing system.

"Live" VLF data are also received at Durban, using a simple whip antenna and are processed using an older (Ubiquitous) spectrum analyser and averager, interfaced to a PC.

Experimental Work

Satellite studies (Dr A.R.W. Hughes) on the AVDAS using ISIS-1 and ISIS-2 data, including

- the measurement of whistler dispersion as a function of latitude, particularly at low latitudes,
- studies of the effect of ions on whistler dispersion,
- the measurement of proton concentrations from proton whistler cross-over frequencies.

Joint VLF and aurora analysis (M.J. Kosch) including

- temporal resolution (25 Hz) correlations between super-fast auroral waves and chorus elements,
- correlations between long period (5 s) auroral pulsations and VLF intensities (0–5 kHz band).

"Live" data collection and analysis (R.H.W. Friedel) including

- monitoring the amplitude of transmitter signals in the VLF range up to 40 kHz (Omega, US Navy transmitters, etc.) received at Durban, for trimpi events,
- simultaneous collection of data from up to 30 transmitters, with a maximum sampling frequency of 6.5 Hz,
- averaging up to 1024 spectra over 52 s to study long-term variations of signal strength.

Routine Analysis

- Plasmapause position and electron density determination from whistlers using the AVDAS,
- Generation of a "quick-look library" of archived VLF recordings using the Ubiquitous system. 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 spheric, hiss, chorus and whistler activity at Sanae.

Theoretical work:

- studies of electron cyclotron resonance (including relativ istic effects) and its relation to trimpi events and whistler amplification at low latitudes (Dr A.R.W. Hughes),
- study of the gyroresonance interaction at low L-values using a relativistic test-particle simulation to compute overall pitch angle changes due to the interaction (R.H.W. Friedel).

New working group on *Terrestrial and Planetary EM Noise*

Dr M. Hayakawa sends news of a working group which has been set up under the auspices of URSI Commission E (Electromagnetic Noise and Interference). The chairmen of the working group are Dr Hayakawa and Professor E.K. Smith, (Department of Electrical

Engineering, University of Colorado, Boulder, USA). The objectives of the working group are as follows.

1. Study of characteristics of terrestrial noise in a wide frequency range from ULF/ELF to UHF.
   (a) General characteristics of terrestrial noise of both natural and man-made origins.
   (b) Statistical description and modelling of such terrestrial EM noise.
   (c) Physical processes and mechanisms underlying the generation of terrestrial noise.
2. Study of planetary noise
   (a) General characteristics of planetary (extra-terrestrial) EM noise environments at higher frequencies, above $\sim$ 20 MHz.
   (b) Physical processes and mechanisms involved in the generation of planetary EM noise.
   (c) Comparative study of planetary noise environments with the terrestrial one.

Thus the principal objective of this working group will be to provide more up-to-date and complete information about the properties of terrestrial and planetary noise (both natural and man-made) than is currently available. In other words, general noise characteristics are studied with a view towards the interests of CCIR. The second objective is to study the physical processes involved in the generation of noise. Of course, other URSI Commissions will deal with these subjects as well.

For more information, and if you would like to be on the mailing list to receive the working group newsletters, please contact Dr Hayakawa at the Solar Terrestrial Environment Laboratory, Nagoya University, Tokokawa, Aichi 442, Japan (telephone: (+81) 5338-6-3154; fax: (+81) 5338-9-1539; telex: 4322311).

Trimpi networks

There seems at present to be an increasing interest in deploying networks of narrowband, short time constant, VLF receivers, tuned to a selection of VLF transmissions, in order to provide a network of crossing paths for use in the detection and imaging of particle precipitation through use of the trimpi effect (e.g. Helliwell et al., *J. Geophys. Res.* **78**, 4679, 1973; Smith and Cotton, *J. Atmos. Terr. Phys.* **52**, 341, 1990; Inan et al., *J. Geophys. Res.* **95**, 17217, 1990). It seems appropriate that this working group be a means of exchanging information about the current status of such networks, such as receiver sites, frequencies, transmissions recorded, receiver types, operating schedules, etc. Clearly if such networks continue to develop and expand, then given the long subionospheric propagation distances at VLF, there is the scope for truly global measurements and imaging of precipitation, with attendant scientific benefits, provided that the appropriate coordination and interpretation can be achieved. In order to facilitate this, I am listing below the information which I have immediately to hand on planned or currently operating networks. If the information is incomplete or incorrect, I should be glad if the investigator concerned would contact me so that a suitable update can be included in the next letter.

UK

British Antarctic Survey have been operating University of Otago pattern OPAL (Omega Phase and Amplitudes Logger) receivers at Halley and Faraday, Antarctica, since early 1989. These receivers recorded the amplitude and phase, averaged over an Omega segment ($\sim$ 1 s), of all five transmitted frequencies (10.2 kHz, 11.05 kHz, 11.33 kHz, 13.6 kHz, and a unique frequency) for a selected set of four out of the eight Omega transmitters. These were chosen to be Argentina, Liberia, North Dakota and Hawaii at Halley; Argentina, Liberia, Hawaii and Reunion at Faraday.

It was found that the signal-noise ratio was too large for trimpi events of typical size ($\lesssim 1^\circ$ in phase and $\lesssim 0.1$ dB in amplitude) to be seen on the weaker transmissions, so in 1990 the

OPAL receivers were modified to record amplitude and phase of signals from two Omega transmitters and two MSK transmitters. The data from the latter, being continuous, can be recorded with a choice of averaging times (0.4 s or 1.25 s in the current design). Optionally, the upper and lower frequencies present in each MSK signal can be recorded separately rather than averaged, allowing for the possibility of "group trimpis" being detected (Dowden and Adams, *J. Geophys. Res.* **95**, 4135, 1990). Current transmitter selections are at Faraday: Omega Argentina, Omega Hawaii, NAA, and NPM; and at Halley: Omega Argentina, Omega Liberia, NAA, and NSS. (Note: unfortunately, Omega Liberia ceased operation indefinitely in mid 1990). Currently a receiver is also being operated intermittently at BAS HQ in Cambridge.

USA

At the Prague URSI meeting, Dr U.S. Inan showed results from the Stanford University trimpi network which uses a variety of paths over North America. Receivers are located at Stanford, Huntsville (Alabama), Arecibo, and Lake Mistissini (Quebec), with a further receiver in the southern hemisphere at Palmer station (Antarctica). Transmitters used include NAA, NSS, NLK, NPM, NAU, and a 48.5 kHz transmitter located in Nebraska. One subset of paths in this network was a line consisting of two transmitters and two receivers (NLK, Nebraska, Huntsville, Arecibo). A case study was presented with a precipitation region on this line near to Huntsville (perpendicular paths, e.g. NAA–Stanford etc. were not perturbed). In one hour of trimpi activity, events were seen up to 15 dB(!) in perturbation amplitude. A detailed study of the spheric to trimpi onset delay time, and the shape of the trimpi rise/fall, could be used to extract information about the precipitation energy profile. An effect in which (for negative amplitude trimpis) a short rise was seen just before the main decrease in amplitude, and which was only seen on the shortest path (Nebraska to Huntsville) at quite low latitudes, was interpreted as being due to very high energy electrons which arrive before those in the main part of the pulse, and penetrate deeper into the atmosphere. A case study of conjugate trimpi events was also described.

New Zealand

The University of Otago (Professor R.L. Dowden and Dr C.D.D. Adams) have deployed their OPAL receivers, and later OMSK receivers (Omega- MSK) at a variety of sites including Dunedin, Macquarie Island, and Campbell Island. They have also used a closely spaced (less than a wavelength) receiver array based on Dunedin, for direction finding on observed trimpi events. An experiment to fly OMSK, receivers as part of a long life balloon payload, is underway in collaboration with the University of Washington (Professor R. Holzworth).

France

Dr Yvonne Corcuff that informs me that she and Professeur Pierre Corcuff (both of the Laboratoire de Signaux et Communication, University of Poitiers) plan to deploy a VLF experiment at Kerguelen early in 1991. This will make amplitude and phase measurements of Omega-Reunion on 10.2 kHz, 11.33 kHz, and 13.6 kHz, and also NWC on 22.3 kHz. The receiver is of the Stanford University design. Broadband measurements and narrowband measurements in 5 bands, of VLF noise, will also be made.

South Africa

The University of Natal group are in the process of joining the international OPAL-MSK net of receivers to monitor Omega and US Navy MSK transmissions in both amplitude and phase. This is a joint project by Dr A.R.W. Hughes and R.H.W. Friedel with Prof R.L. Dowden of the Department of Physics, Otago University, New Zealand and Dr A.J. Smith of BAS, Cambridge, UK. The new receivers will be initially set up in Durban in December 1990 with possible trial runs at both Marion and Gough Islands before going to Sanae in 1992 to join the existing BASnet of receivers at Halley and Faraday.

As an extension to the above project, the Durban receivers (SHOMSKI's: Spherics, Hiss,

Omega and MSK Instrument) will also be equipped to receive telemetry signals from the ELBBO project (13.45 MHz MSK). This project involves extremely long-life high altitude balloons which will carry a VLF receiver into the trade-winds around Antarctica in an attempt to establish the longitudinal variation of both spheric and hiss VLF activity. This is a joint project with Prof R.L. Dowden of the Department of Physics, Otago University, New Zealand and Prof Robert Holzworth of the Space Sciences Division of the University of Washington, USA. A test flight was made on 30 October 1990, and the first proper launch is expected to take place in January 1991.

Brazil

As reported in the last newsletter, Dr L.R. Piazza (CRAAE, San Paulo) has been operating a modified VLF Tracor receiver at the Brazilian Antarctic station Ferraz since February 1989, in an experiment to detect trimpi events.

Mailing list

We now have 73 scientists on the mailing list, from 19 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.

With very best wishes for Christmas and the New Year, and hoping to see some of you at IUGG in Vienna.

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