



VLF/ELF Remote Sensing of Ionospheres and Magnetospheres Newsletter

Editor: Craig J Rodger

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Dear Colleagues,

The 23rd General Assembly of the *International Union of Geodesy and Geophysics* (IUGG), which encompasses IAGA, was held in Sapporo, Japan, 30 June - 11 July 2003. There was a meeting of the VERSIM working group during the Sapporo Assembly. A report on this meeting can be found on the VERSIM website (www.physics.otago.ac.nz/versim). At this business meeting Craig Rodger (New Zealand) was nominated to take up the role of IAGA co-chairman, and elected by those present. Craig immediately proposed a vote of thanks on behalf of our working group to Andy Smith for all of the efforts he has undertaken to support the VERSIM community. This was supported by the meeting, and is surely agreed by the rest of the working group who could not attend.

In the time since the IUGG meeting the VERSIM website (www.physics.otago.ac.nz/versim) and email listing has been moved to New Zealand. Details on how to send messages to the community can be found on the website. This issue of the *VERSIM Newsletter* contains information about forthcoming meetings, together with news provided by a wide range of VERSIM groups. I'd like to emphasize the *ELF/VLF Radio Phenomena Workshop* to be held in Sodankyla, Finland late next year. This very strongly focused on our science, and I'm hoping a very large number of the community can attend. The first call for this workshop can be found on VERSIM website. Best wishes to you all.

IAGA Guides

Our working group has been contacted by Charles Barton (IAGA vice-president) concerning IAGA Guides. IAGA is now producing 3 guides on the topics of Noctilucent Clouds, Magnetic Observatories, and Magnetic Repeat Station Surveys. These guides are intended to provide practical advice about IAGA-recommended methodologies and standards. This type of information seldom appears in scientific journals. The guides may contain some scientific review but this is not their main purpose, and they are not intended to compete with scientific review journals. It has been proposed that the VERSIM community may wish to suggest a new IAGA guide. One topic suggested in the communication was Solar-terrestrial interaction/space weather/climate change, although this is only a suggestion, the community may wish to recommend an entirely different topic (and propose authors to undertake the project).

Forthcoming meetings

- *AGU Fall Meeting*, San Francisco, USA, 8-12 December 2003.
- Asia Oceania Geosciences Society General Assembly, Singapore, 5-9 July 2004.
- NATO Advanced Study Institute on "Sprites, Elves and Intense Lightning Discharges", Corte, Corsica, 21-30 July, 2004.
- 2nd *Asia-Pacific Radio Science Conference* (AP-RASC04), Qingdao, China, 24-27 August 2004
- *ELF/VLF Radio Phenomena Workshop*, Sodankyla, Finland, 27 September - 1 October 2004. **Supported by the VERSIM working group!**
- *IAGA 2005* Toulouse, France, 18-29 July 2005.
- *URSI 2005* New Delhi, India, 23-29 October 2005. This meeting is to include a VERSIM session, "ULF, ELF, and VLF impacts on the radiation belts"

Reports from VERSIM research groups 2003

This based on information received by the IAGA co-chairman, Craig Rodger, at meetings during 2003 or by email from the VERSIM membership.

Greece Christos Haldoupis (University of Crete) reports that a narrow-band VLF receiver is to be deployed in Crete to monitor several VLF stations in Northern and Western Europe. This location is favourable for the red sprite campaigns to be undertaken in Europe, particularly given lightning activity levels in the Adriatic. The receiver is from Stanford, and the data will be passed to Stanford for analysis.

Finland Our colleagues in Finland will be running a Workshop which is highly relevant to the VERSIM community. The workshop is entitled ELF/VLF radio phenomena: generation, propagation and consequences in observations, theory and modeling. This will be held at the Sodankyla Geophysical Observatory (SGO), from 09.00 on Monday, 27th September to 11.30 on Friday, 1st October 2004. Send pre-registration by e-mail to Jyrki.Manninen@sgo.fi before Wednesday 31st December 2003. More information on the VERSIM pages.

France Le Laboratoire de Physique et Chimie de l'Environnement (LPCE) report from Michel Parrot.

The launch of LPCE's microsatellite project, DEMETER is currently expected in May-June 2004 from Baikonur on a Russian rocket with a polar orbit at 710 km. Payload testing is now underway. There will be a call for guest investigators at the end of December 2003. More information can be found at: <http://smc.cnes.fr/DEMETER/> and

http://lpce.cnrs-orleans.fr/fr/experim/t_exper9-1-1-3detail.htm

In addition, this group will be deploying a wideband VLF receiver (up to 50 kHz), close to Orleans, in the forest to the south of city. This receiver is being supplied by Umran Inan (Stanford), and will be used to support European sprite observations in July 2004, plus DEMETER observations. It will initially be used for campaign recordings, with the data passed to Stanford for analysis.

New Zealand Craig Rodger (University of Otago) reports group was undertaking long term recordings by Neil Thomson's Doppler experiment which runs every night plus continuous OmniPal/AbsPal narrowband recordings looking at transmitters in our region. The group is undertaking experimental and theoretical work on electron and proton precipitation, both the effects on the ionosphere and the implications of this precipitation as a loss mechanism from the radiation belts. Neil Thomson in particular is continuing his efforts at looking at solar flares and their effects on the ionosphere particularly the *D* region. In addition this group is operating campaign based wideband VLF recordings with the IMAGE satellite every 22-days and undertook campaign wideband recordings in association with passes of the Kolibri nano-satellite launched from the ISS in 2002.

Richard Dowden's (LF*EM) VLF lightning detection network is still growing. There are currently 14 partner institutions in this network, of which the University of Otago group is one. There are firm plans to add stations in Israel, India, Tahiti, and Mexico, plus another station in Brazil. The network is growing quite quickly and quite successfully, and provides real practical data for use in related experiments. At the IUGG conference there was a report on the Israeli sprite hunting experiment from the US space shuttle who used the web based lightning maps from this network to orient the shuttle towards probable thunderstorm locations (6 hours in the future). Currently historic data access is available to the hosts, and other institutions should discuss data access with the PI, Dick Dowden. As the network development has not been supported by government grants, there may be some costs for data access, although current maps are available on the web (http://ritz.otago.ac.nz/~sferix/TOGA_network.html).

India Birbal Singh (R.B.S.College) has provided a detailed report on his groups activities, primarily based at their Bichpuri, Agra campus (Geomag. Lat. 17.1° N, *L*=1.15). Recently, the work of this group has been oriented towards the study of ULF/VLF electromagnetic precursors to earthquakes and ionospheric perturbation, focusing on some major Indian earthquakes. The following experimental facilities have been created at the centre:

Vertical electric field measurement using a borehole antenna. A 120 m borehole antenna is installed at Bichpuri in a rural area ~12 km west of Agra city. The induced voltages in the antenna are amplified, filtered at the VLF frequency of 3 kHz, peak detected, and originally recorded using a DC ink chart recorder. Now this analog recording has been replaced

by digital recording using PCL 206 ADC and LABTECH software. This is being used to examine lithosphere-atmosphere coupling and lightning activity.

An AbsPAL receiver logging the absolute phase and amplitude measurements of fixed frequency transmitter signals passing over Indian longitudes through earth-ionosphere waveguide mode propagation has been installed at Bichpuri and for the last year continuous data collection has been undertaken at the 3 frequencies of 19.8 kHz (NWC, Australia), 21.4 kHz (NPM, Hawaii) and 24 kHz (NAA, Cutler Maine). Preliminary data analysis suggests that signal amplitudes may decrease linked to seismic activity.

Measurements of ULF magnetic field emissions using a 3-component (B_x , B_y , and B_z) search coil magnetometer ($f = 0.01 - 30$ Hz) from the Agra centre. Enhancements have been observed due to seismic activity in the Indian regional earthquake prone regions.

The full report, which contains additional details, research conclusions and collaborations, and recent publications, is available here (www.physics.otago.ac.nz/versim/Birbal_VERSIM_2003.pdf)

Serbia and Montenegro Desanka Sulic (Institute of Physics) reports that his institute has installed an AbsPAL narrow-band VLF recording system in Belgrade, From September 2003 they have undertaken continuous logging of 4 VLF signals, with time resolution of 0.1s:

AWV, Le Blanc, 18.30 kHz

NAA, Cutler Maine, 24.00 kHz

Japan, 22.10 kHz

NWC, Australia 19.80 kHz

The chief of the project is Dr. Anatolij Mihajlov.

Sprite Summer School Organisation of the planned NATO Advanced Study Institute on "Sprites, Elves and Intense Lightning Discharges", is continuing, with significant contributions from VERSIM members. The Summer School is primarily funded by NATO and the European Science Foundation, with the intention that it is to be a true teaching environment providing opportunity for people to come along to get an understanding of the interlinked but disparate scientific areas relevant to this field of study. There are to be lectures and practical sessions from "experts" in the field, quite a number of whom are VERSIM members. The Summer School should produce a textbook aimed at getting say-MSc level people quickly up to speed with the techniques and jargon. More information can be found from weblinks on the VERSIM webpage.

UK British Antarctic Survey report from A.J. Smith and M.A. Clilverd (December 2003)

Synoptic broadband VLF recordings at Halley station, Antarctica (*L*=4.3), using Digital Audio Tape, have continued on a 1-minute-in-15 synoptic schedule, with occasional recordings at 1-minute-in-15 or continuous.

Continuous (since 1992) recordings of VLF activity in 10 ELF/VLF bands, at 1-s resolution (VELOX), including spheric counters, have continued at Halley. A whole solar cycle of data (1992-2002) are now available.

A narrow-band tunable receiver at Halley, previously tuned to 21.4 kHz was re-tuned to 19.3 kHz at the start of 2003 and was the first to detect signals from the South Pole VLF beacon in January 2003. Currently it is tuned to 19.4 kHz to receive the transmissions from the beacon.

1-s resolution data are available on the Web using the BAS Data Access & Browsing System (DABS) <http://dabs.nerc-bas.ac.uk/>

Daily summary plots 1992--2002 are on the Web at <http://www.nerc-bas.ac.uk/uasd/data/dataserv.html>

VLF precipitation detection ("Trimpi"): The "OmniPAL" at Halley was withdrawn at the end of 2001, but is now operating at Sodankyla, Finland (Oct 2002 - June 2003), and Ny Alesund, Spitzbergen (since June 2003).

A VLF Doppler receiver has continued to operate at Rothera station, Antarctica ($L=2.8$), receiving whistler mode and subionspheric signals from NAA and other VLF transmitters. From December 2003 it is also being used to monitor the South Pole Beacon transmissions at 19.4 kHz at 1 second resolution.

AGOs (Automatic Geophysical Observatories) programme: VELOX receivers on A80 ($L=6.3$) and A84 ($L=8.1$) are continuing to operate.

A latitudinal chain of VELOX receivers (VELOXnet), aimed at substorm research using SCEs (substorm chorus events), is being deployed in both hemispheres; in addition to Halley, receivers are operating at Sodankyla (Finland), Casey station (Antarctica) and Churchill (Canada). For details, see: http://www.antarctica.ac.uk/BAS_Science/Programmes/MRS/Substorms/veloxnet/index.html

Mullard Space Science Laboratory report from Nigel Meredith:

In the last year we have published several papers on the role of whistler-mode chorus waves in the acceleration of electrons to relativistic energies during magnetically-disturbed periods. We have also looked at diffuse auroral scattering by ECH waves and whistler mode waves during an isolated substorm. A short report follows:

We examined 26 magnetically-disturbed periods during the CRRES mission and showed that relativistic electron flux enhancements were associated with prolonged substorm activity, enhanced fluxes of seed electrons and enhanced lower-band chorus wave power [Meredith *et al.*, 2003a]. Further evidence in support of the chorus-driven electron acceleration mechanism was provided by the energy-dependence of the spectral hardening [Summers *et al.*, 2002] and the energy-dependent flat-topped pitch angle distributions [Horne *et al.*, 2003a] seen during the recovery phase of the October 9, 1990 magnetic storm. Furthermore, O'Brien *et al.* [2003] used the occurrence of MeV electron microbursts as a proxy for VLF chorus to infer that electron flux peaks observed near $L=4.5$ may be caused by local chorus-driven acceleration whereas ULF waves could be more effective at higher L near geosynchronous orbit and beyond. We also performed statistical studies of the lower-band chorus magnetic field intensity and the ratio f_{pe}/f_{ce} and showed that electron acceleration to relativistic energies is likely to be most significant for equatorial chorus in the region $4 < L < 6$ between 0300 and 1000 MLT and for mid-latitude chorus in the region $4 < L < 6$ between 0600 and 1400 MLT [Meredith *et al.*, 2003b].

We analysed a case event where whistler-mode hiss, chorus and ECH waves were intensified during a weak substorm injection event to identify the source of particle precipitation. We discovered that the ECH waves were responsible for the formation of the pancake distribution and were probably the main component of the diffuse auroral precipitation during this event [Horne *et al.*, 2003b].

Summers, D., C.Ma, N.P. Meredith, R.B. Horne, R.M. Thorne, D. Heynderickx and R.R. Anderson, Model of the energization of outer zone electrons by whistler-mode chorus during the October 9 1990 geomagnetic storm, *Geophys. Res. Lett.*, 29, 24, 2174, doi:10.1029/2002GL016039, 2002.

Horne, R.B., N.P. Meredith, R.M. Thorne, D. Heynderickx, R.H.A. Iles, and R.R. Anderson, Evolution of energetic electron pitch angle distributions during storm-time acceleration to mega-electron volt energies, *J. Geophys. Res.*, 108, A1, 1016, doi:10.1029/2001JA009165, 2003A.

Meredith, N.P., M. Cain, R.B. Horne, R.M. Thorne, D. Summers, and D. Heynderickx, Evidence for chorus-driven electron acceleration to relativistic energies from a survey of geomagnetically disturbed periods. *J. geophys. Res.*, 108, A6, 1248, doi:10.1029/2002JA009764, 2003a.

Horne, R.B., R.M. Thorne, N.P. Meredith, and R.R. Anderson, Diffuse auroral electron scattering by electron cyclotron harmonic and whistler mode waves during an isolated substorm, *J. Geophys. Res.*, 108, A7, 1290, doi:10.1029/2002Ja009736, 2003b.

O'Brien, T.P., K.R. Lorentzen, I.R. Mann, N.P. Meredith, J.B. Blake, J.F. Fennel, M.D. Looper, D.K. Milling, and R.R. Anderson, Energization of relativistic electrons in the presence of ULF power and MeV microbursts: Evidence for dual ULF and VLF acceleration, *J. Geophys. Res.*, 108, A8, 1329, doi:10.1029/2002JA009784, 2003.

Meredith, N.P., R.B. Horne, R.M. Thorne, and R.R. Anderson, Favored regions for chorus driven electron acceleration to relativistic energies in the Earth's outer radiation belt, *Geophys. Res. Lett.*, 30, 16, 1871, doi:10.1029/2003GL017698, 2003b.

USA Mark Engebretson (Augsburg College) has reported that has has been collaborating with Andy Smith (British Antarctic Survey) and the Stanford VLF comparing ULF and VLF emissions. He is currently finishing off a statistical and case study of QP and PE emissions observed at multiple Antarctic ground stations.