IAGA/ URSI Joint Working Group on

VLF/ELF Remote Sensing of Ionospheres and Magnetospheres Newsletter

Editor: Craig J. Rodger No. 28, December 2013

Dear Colleagues,

This is my last VERSIM newsletter as editor, and the 11th news letter I have helped prepare. As many of you will know, I stood down from the role as IAGA co-chair at the 12th IAGA Scientific Assembly in Mérida, Mexico (26 - 31 August 2013), having accepted the role at the 23rd IUGG General Assembly in Sapporo in 2003. I am delighted that Jacob Bortnik (UCLA, USA) accepted the nomination to replace me, and was elected by unanimous vote at our Business Meeting in Mérida. To aide the transition I offered to produce this years newsletter, although I expect this to be my last. But I step down happy, as the community is strong, as emphasised by this newsletter!

However, I hope you will still see my research work, and hear from me at VERSIM meetings and sessions. I am not retiring or leaving science (I'm only 41!). However, I feel that after more than a decade severing as VERSIM chairman it would be good for the community for someone else to take up the role.

This year the VERSIM community formally met at our business meeting in Mexico, while next year we will have two formal gatherings. As I hope you remember, the 6th VERSIM workshop is about a month away, 20-23 January 2014 at the University of Otago, in Dunedin (New Zealand). Then later in the year, we will gather in August at the 31st General Assembly and Scientific Symposium in Beijing from 16 - 23 August 2014.

Thankyou to all of you for supporting the VERSIM community in the time I have acted as chair – I would ask you to continue your scientific activities and support Jacob in his new role. Submit material to our newsletters, come to our business meetings, and most importantly work together to do interesting and stronger science. Finally, I hope to see many of you in New Zealand. I wish you a successful 2014!

Craig J. Rodger
outgoing IAGA co-chair VERSIM working group

Dear friends and colleagues,

Let me firstly convey my deep gratitude for being elected to the leadership of the VERSIM group. I am humbled to co-chair a group which was home to some of the true pioneers of radio science (and space science in general) and continues to be central, relevant, and integral to a host of related disciplines.

I am excited to see what developments take place in our field during my tenure, at a time when our planet's surface and the geospace environment is instrumented at unprecedented levels, storage and computation is cheap and powerful, and a plethora of techniques and algorithms is becoming available to extract insights that simply could not be gleaned otherwise.

How could I not be excited? I expect VERSIM to lead in this effort, and it is my pleasure and honor to be a part of it.

Jacob Bortnik
IAGA co-chair VERSIM working group

Upcoming meetings

- 6th VERSIM Workshop, Dunedin, New Zealand from 20 - 23 January 2014.
- 2014 Geospace Environment Modeling (GEM) Summer Workshop, Portsmouth, USA from 15 - 20 June 2014.
- 40th COSPAR Scientific Assembly, Moscow, Russia from 2 - 10 August 2014.
- 31st General Assembly and Scientific Symposium of URSI, Beijing, China CIE from 16 - 23 August 2014.
- AGU Chapman Conference on Low Frequency Waves in Space Plasmas, Jeju Island, Republic of Korea from 31 August - 5 September 2014.
- Geospace Revisited Conference, Rhodes, Greece from 15-20 September 2014.
- 2014 Fall Meeting of the American Geophysical Union, San Francisco, USA from 15 - 19 December 2014.

Reports from VERSIM research groups 2013

This based on information received by the outgoing IAGA co-chairman, Craig Rodger, by email from the VERSIM membership. Some reports have been slightly edited so the newsletter has consistent formatting. Hopefully this has not introduced any significant typos.

Belgium - Belgian Institute for Space Aeronomy (IASB-BIRA), Belgium, report by Fabien Darrouzet, Sylvain Ranvier, Herve Lamy, Johan De Keyser.

We continue our project to detect whistlers with VLF measurements. A VLF antenna has been installed in October 2010 in Humain, Belgium (Lat. ~50.11°N, Long. ~5.15°E), in order to detect whistlers and determine electron densities along propagation paths. The VLF antenna is made of two perpendicular magnetic loops, oriented N-S and E-W and with an area of approximately 50 m^2 each. The antenna is fully working since August 2011.

This antenna is part of AWDAnet, the Automatic Whistler Detector and Analyzer system's network. This network covers low, mid and high magnetic latitudes including conjugate locations. It has been initiated by Dr. J. Lichtenberger (Hungary). Worldwide; currently, 23 antennas are in operation and 21 are planned/in construction.

We have started some comparisons with density data measured by the WHISPER instrument onboard the 4 Cluster satellites. First results are promising, but a comprehensive study needs more investigation.

Statistical analysis and first comparisons with models and satellite data have been presented at the EGU General Assembly (Vienna, Austria) in April 2013 and at the IAGA Conference (Merida, Mexico) in August 2013.

We have started a study of feasibility to install another antenna at the Belgian Antarctic station (Lat. ~71.57°S, Long. ~23.20°E). This antenna would be composed by two search coils, without a mast in order to support the weather at such latitudes.

Czech Republic - Report by Ondrej Santolik, representing the Institute of Atmospheric Physics ASCR and Charles University.

We analyzed VLF electromagnetic waves with periodic time modulation of wave intensity, so-called quasi-periodic (QP) emissions. A systematic study based on the measurements of the low-altitude DEMETER spacecraft [1] inspired us to perform a case study of a QP event observed simultaneously on board the DEMETER and Cluster spacecraft allowed us to estimate the spatial and the temporal extent of the emissions [2]. The analyzed QP event lasted as long as 5 hours and it spanned over the L-shells from about 1.5 to 5.5. Curiously, the same QP modulation of the wave intensity was observed at the same time at very different locations in the inner magnetosphere. ULF magnetic field pulsations with a period roughly comparable to the period of the QP modulation were detected by the fluxgate magnetometers on board Cluster near the equatorial region, suggesting that these are likely to be related to the QP generation.

Encouraged by these results, we conducted a systematic survey of QP emissions observed by the Cluster spacecraft during the first 10 years of operation (2001-2010) [3]. A detailed wave analysis reveals that the wave vectors of the emissions are nearly field-aligned in the equatorial region, but they become oblique at larger geomagnetic latitudes. This suggests that the waves propagate unducted. ULF magnetic field pulsations were detected at the same time as QP emissions in 4 out of the 21 analyzed events. They were polarized in the plane perpendicular to the ambient magnetic field, and their frequencies roughly corresponded to the modulation period of the QP events.

We have also used VLF electromagnetic wave data measured by DEMETER (Detection of Electro-Magnetic Emissions Transmitted from Earthquake Regions) to check for the presence of statistically significant changes of natural wave intensity (due to signals from lightning) related to preseismic activity [4]. All the relevant data acquired by DEMETER during almost 6.5 years of the mission have been analyzed using a robust two-step data-processing schema. This enabled us to compare data from the vicinity of about 8400 earthquakes with an unperturbed background distribution based on data collected during the whole DEMETER mission and to evaluate the statistical significance of the observed effects. We were finally able to confirm previously reported results of a very small but statistically significant decrease of the wave intensity (by 2 dB) at frequencies of about 1.7 kHz. The effect is observed for a few hours before the times of the main shocks and occurs only during the local night.

We have installed and operated new ground-based broadband measurements ELF to HF) related to lightning research in collaboration with Laboratoire Souterrain a Bas-Bruit, Rustrel, France. The thunderstorm activity is continuously monitored in a favorable electromagnetic environment on the summit of La Grande Montagne (1028 m, 43.9410ºN, 5.4836ºE), Plateau d'Albion. These measurements are prepared as a ground-based counterpart of instrumentation which is being developed for spacecraft measurements in the frame of TARANIS and Resonance projects. Results from the previous campaign in Prague [5] demonstrate promising possibilities of these new broadband measurements.

References:

[1] Hayosh, M., D. L. Pasmanik, A. G. Demekhov, O. Santolik, M. Parrot, and E. E. Titova (2013), Simultaneous observations of quasi-periodic ELF/VLF wave emissions and electron precipitation by DEMETER satellite: A case study, J. Geophys. Res. Space Physics, 118, doi:10.1002/jgra.50179

[2] Nemec, F., O. Santolik, M. Parrot, J. S. Pickett, M. Hayosh, N. Cornilleau-Wehrlin, Conjugate Observations of Quasi-Periodic Emissions by Cluster and DEMETER Spacecraft, J. Geophys. Res., 118, 198-208, doi:10.1029/2012JA018380, 2013.

[3] Nemec, F., O. Santolik, J. S. Pickett, M. Parrot, N. Cornilleau-Wehrlin, Quasiperiodic Emissions Observed by the Cluster Spacecraft and Their Association with ULF Magnetic Pulsations, J. Geophys. Res., 118, 4210-4220, doi: 10.1002/jgra.50406, 2013.

[4] Písa, D., F. Nemec, O. Santolík, M. Parrot, and M. Rycroft (2013), Additional attenuation of natural VLF electro- magnetic waves observed by the DEMETER spacecraft resulting from preseismic activity, J. Geophys. Res. Space Physics, 118, 5286–5295, doi:10.1002/jgra.50469.

[5] Kolmasova, I., and O. Santolik (2013), Properties of unipolar magnetic field pulse trains generated by lightning discharges, Geophys. Res. Lett. 40, doi:10.1002/grl.50366.

Fiji - The University of the South Pacific, Suva, Fiji, report from Sushil Kumar.

We continue participating in the World Wide Lightning Location Network (WWLLN) since our joining in 2003. Using the WWLLN setup we are recording the narrowband data on six transmitter signals using SoftPAL data acquisition system.

The analysis of short-timescale (~1–100 s) perturbations (early VLF events) on four Very Low Frequency (VLF) transmitter signals (NWC, NPM, VTX, NLK), recorded at Suva (18.1°S, 178.5°E, L = 1.16), showed the most frequent occurrence on the NWC signal and least on the VTX. Daytime early/fast events on the NWC transmission are (0.2–0.5 dB) with only negative amplitude perturbations with comparatively lower recovery times (10–30 s) as compared with most nighttime events with amplitude perturbations of 0.2–1.5 dB and recovery times of 20–80 s. The World-Wide Lightning Location Network detected causative lightnings for 74 of 453 early VLF events out of which 54 (73%) were produced due to narrow-angle scattering, and by 20 (27%) due to wide-angle scattering (please see *Earth Planets Space*, 65, 25–37, 2013). VTX signal was analysed to investigate VLF perturbations associated with earthquakes occurring in the Indonesian region within fifth Fresnel zone along the TRGCP. The results of this analysis have been published in *JASTP*, 102, 71–80, 2013.

We also record the ELF-VLF data using the Atmospheric Weather Electromagnetic System for Observation Modeling and Education (AWESOME). The analysis of short-timescale perturbations on VLF transmitter signals recorded both with SoftPAL and AWESOME shows one to one correlation. The AWESOME recoding was conducted during January 213 at a remote side in the western Fiji. The results of this campaign will be presented in the forthcoming VERSIM workshop to be held during 20-24 January 2014 at Otago University, Dunedin, New Zealand. For our collaborative work with colleagues from different organisations, please read; *JGR (Space Physics)*, VOL. 118, 1–13, doi:10.1002/jgra.50089, 2013, M*onthly Weather Review*, 141, 1358-1574, 2013, *Natural Hazards and Earth System Sciences*, 13, 2331–2336, 2013, *JGR (Space Physics*, 118, 1–11, doi:10.1002/2013JA01908, 2013.

A GSV4004B receiver specifically designed for TEC and ionospheric scintillation measurements was installed this year in July. This can locate up to 11 GPS signals at two frequencies of L_1 and L_2 signals (1575.42 MHz and 1227.6 MHz) and measures phase and amplitude at 50-Hz rate and code/carrier divergence at 1-Hz rate for each satellite being tracked. It computes TEC from combined frequencies pseudorange and carrier phase measurements. This system along with the SoftPAL will provide an opportunity to study both lower (D-region) and upper (F-region) ionosphere particularly under the strong space weather (geomagnetic storm and solar flare) conditions. The data recoded during 2010-2011 have been analysed on which a students has been awarded the Master's degree.

The Research and International office of the University of the South Pacific (USP) has released its electronic research repository of the research (publications) generated during the staff affiliation with USP. For details please visit http://repository.usp.ac.fj/

Germany - University of Applied Sciences, Osnabrueck report by Ernst D. Schmitter.

Exploiting continuous amplitude and phase recordings from VLF/LF MSK transmitters again was the main topic of this year's activities at our mid latitude site (52°N, 8°E). These data provide the basis for our model of solar flare induced lower ionosphere changes. Besides looking for the effects of forcing from above some lightning caused long recovery events (~15 minutes relaxation time) have been seen with the VLF/LF data during a strong thunderstorm at the North Sea (4th of Nov. 2012). Extensive modeling of the involved EMP processes using precise time and location data provided by the WWLLN has been done and presented - especially at this year's URSI national meeting in Miltenberg, Germany, Sep. 23.-25., within a special session on the occasion of the 100th birthday of Professor Karl Rawer, a pioneer of ionospheric physics research in Germany and initiator of the IRI. In the presence of many international guests he followed the session.

Many of the current VLF/LF data plots (and a few months back) are available at: electricterra.com/Ernst

This years publications and presentations:

Schmitter, E. D, 2013, Modeling solar flare induced lower ionosphere changes using VLF/LF transmitter amplitude and phase observations at a midlatitude site, Ann. Geophys., 31, 765-773, 2013

Schmitter, E.D, 2013, Characterizing lower ionosphere forcing by a strong lightning stroke using VLF/LF radio wave remote sensing and propagation modeling, European Planetary Science Congress 2013 (EPSC2013), P53, Sept. 8.-13.,2013, London, UK

Schmitter, E.D, 2013, VLF/LF radio wave remote sensing and propagation modeling of lightning caused long recovery events within the lower ionosphere, Kleinheubacher Tagung, URSI national chapter Germany, Miltenberg, Sep. 23.-25., 2013, KHT2013-special session.3.3

Greece - University of Crete report by Christos Haldoupis.

The Ionospheric Physics Laboratory, at the Physics Department, University of Crete continued during 2013 the operation of an automated Stanford VLF narrow-band receiver. The Crete VLF station is part of the AWESOME VLF network (http://nova.stanford.edu/~vlf/awesome), which is designed to investigate globally the Earth's VLF environment.

In 2013, we have continued participating and supporting the EuroSprite campaigns and the TEA-IS (Thunderstorm Effects on the Atmosphere-Ionosphere System) European Science Foundation project. Our research focused on lightning relating VLF topics, among them the impulsive VLF signatures, known as early VLF events. These are sudden nighttime VLF perturbations associating with direct lightning effects in the D region ionosphere, which occur in close association with Transient Luminous Events (TLEs), mainly sprites and elves. In 2013, we continued collaboration with colleagues from institutions in USA, Denmark, Spain, Italy, Israel and New Zealand. For a summary of our activities, scientific contributions as well as paper reprints see: http://cal-crete.physics.uoc.gr/VLF-sprites/VLFmain.html

The highlight of our 2013 research (published in the Journal of Geophysical Research) is the identification of the VLF signature of elves. This relates to a subclass of early fast events which have rapid onsets but unusually long recoveries of many minutes, labeled as LOREs, an acronym for LOng Recovery Early events. We identified LORE as a distinct category of early VLF events, whose signature may occur either on its own or alongside the short-lived typical early VLF event. Since LORE onsets coincide with powerful lightning strokes of either polarity (±), we infer that they are due to long-lasting ionization changes in the uppermost D region ionosphere caused by electromagnetic pulses (EMP) emitted by strong ±CG lightning peak currents of typically >250 kA, which are also known to generate elves. The LORE perturbations are detected when the discharge is located within ~250 km from the great circle path (GCP) of a VLF transmitter-receiver link. The probability of occurrence increases with stroke intensity, and approaches unity for discharges with peak currents > ~300 kA. LOREs are nighttime phenomena that occur preferentially in winter and over the sea, when strong ±CG

discharges are more frequent and intense. The evidence suggested that LORE as a distinct signature representing the VLF fingerprint of elves, a fact which, although was predicted by theory, it escaped identification in the long-going VLF research of lightning effects in the lower ionosphere. More research, both observational and theoretical, is presently under way aiming to a better physical understanding of the LORE VLF phenomena.

2013 Publications and conference presentations:

Links between mesopause temperatures and ground-based VLF narrowband radio signals, Silber, I., C. Price, C. J. Rodger, and C. Haldoupis, J. Geophys. Res. Atmos. 118, doi:10.1002/jgrd.50379, 2013.

The VLF fingerprint of elves: Step-like and long-recovery early VLF perturbations caused by powerful ±CG lightning EM pulses, C. Haldoupis, M. Cohen, E. Arnone, B. Cotts, and S Dietrich, J. Geophys. Res., Vol. 118, 1-11, doi:10.1002/jgra.50486, 2013.

Long Lasting upper D region ionospheric modifications caused by intense +/- lightning discharges, C. Haldoupis, European Geosciences Union General Assembly, April, 07-13, Vienna, Austria, 2013.

Step-like and long recovery Early VLF perturbations caused by EM pulses radiated by powerful ±CG lightning discharges, C. Haldoupis, International Association of Geomagnetism and Aeronomy, 12th General Assembly, August 26-31, Merida, Mexico, 2013.

Hungary - Space Research Group, Eötvös University, Budapest report by János Lichtenberger.

The Space Research Group of Eötvös University continued the theoretical modeling and model-calculations of monochromatic and transient (Ultra Wide Band) electromagnetic signals and the evaluation and comparison of the results with the measured data-base recorded at terrestrial stations and on board of satellites.

In the field of the theoretical model development of the full wave solutions of the Mawell's equations, further work is made on the general solution of the electromagnetic wave propagation in general relativistic situations

In PLASMON EUFP7-Space project, we continued the development of the Automatic Whistler Detector and Analyzer Network, the installation of the Automatic Whistler Analyzer (AWA) algorithm has been installed and is under a thorough test at Tihany. The algorithm will be installed at other nodes of AWDANet soon. We made the first important step in the calibration of equatorial electron densities obtained from whistler inversion with in-situ cold plasma measurements: the electron densities derived from upper hybrid measurements on RBSP satellites were used to calibrate with densities from whistlers recorded at Rothera. The preliminary results show an excellent agreement between the data from two sources, confirming the validity of the physical models (wave propagation, field-aligned density distribution, equatorial electron density distribution and magnetic field) used in the inversion procedure.

Systematic investigation in archived DEMETER wave recordings were continued. Compartive study of one-hop whistlers, occurred simultaneously in ground stations, detected automatically by the AWDANet, and identified in on-board LEO satellite recordings, during nearby passes was performed. Preliminary results draw the probable extent whistler wavefronts in the topside ionosphere, and confirm the picture of local guided propagation. New detection algorithm, optimized for lightning generated fractional-hop whistlers, recorded on-board was developed, and applied in 6.5 years of burst wave data.

The Russian-Hungarian-Ukrainian Chibis-M microsatellite, with SAS3 ULF-VLF experiment on board has been properly operated since its successful launch to circular LEO orbit in February 2012. Detailed analysis of wave recordings is in progress, including time domain waveforms and VLF monitoring spectra, as well as in data sets of on board event-counting routine. Recordings of the Chibis-M satellite, being the sole ionospheric spacecraft currently performing regular wave recordings in the topside ionosphere, represent unique database in space weather research.

After successful delivery to the ISS in late 2012, the OBSTANOVKA complex space experiment, including a specific SAS3 wave analyzer instrument was installed on the external platform of the Russian ZVEZDA module in April 2013, during a space walk of two astronauts. The experiments started as scheduled.

India - Dept. of Electronics and Communication Engineering, R.B.S. Engg. Technical Campus, Bichpuri, Agra, report by Birbal Singh.

Effects of two events of X-ray bursts followed by solar proton events (SPEs) occurred on 22 September, 2011 and 06 July, 2012 on the variation of first mode Schumann resonance (SR) frequency monitored at a low latitude station, Agra (Geograph. lat. 27.2°N, long. 78°E) India are examined. The variation of average first mode SR frequency shows a sudden increase in coincidence with the X-ray bursts and a decrease associated with the peak flux of SPE. The increases in the frequency in the two cases are 8.4% and 10.9% and corresponding decreases are 4.3% and 3.3% respectively. The increases in the frequency are interpreted in terms of growth of ionization in the upper part of D-region ionosphere due to X-ray bursts and decreases are interpreted in terms of low ionization due to reduction in the height of the D-region ionosphere in the polar region. The variation of SR frequency is observed to be consistent with other observatories at middle and high latitudes. The effect of X-ray flares are also examined on the D-region of the ionosphere at low and equatorial latitudes by analyzing the amplitude data of VLF transmitter signal (NWC, f=19.8 kHz) monitored at Agra. The flare effect observed prior to sun-set hours shows increase and decrease of electron density in this region of the ionosphere also.

The results of solar flares induced D-region perturbation studies along a short path (GCP = 6690 km) lying entirely in the low and equatorial latitude region are studied and compared with those made along similar paths at middle and high latitudes. We use softPAL receiver and monitor NWC signal (f=19.8 kHz) transmitted from Australia (Geograph. lat. 21.8°S, long. 114.1°E), and received at Agra (Geograph. lat. 27.2°N, long. 78°E). We find that amplitude and phase perturbations are mostly enhancements type which show unlike those at middle and high latitude, low magnitudes but strong linear correlation(coefficient = 0.917) with increasing X-ray flux intensity. Similarly, the time delays between the peaks at the flux intensity and amplitude enhancements show a decreasing trend with the increase in the intensity. The zenith angle variation does not influence the data. The electron density variation shows exponential increase with increasing intensity and decreasing height.

Employing a dual frequency GPS-receiver, ionospheric total electron (TEC) measurements have been in progress at Agra station in India (Geograph. lat. 27.2°N, long. 78°E) since 1 April 2006. The TEC data have been analyzed for a period of

one month from 1 April-1 May 2013 to examine the effect of multiple earthquakes, some of which occurred on the same day of 16 April 2013, and others occurred in the same month of April, 2013 in India and neighbouring countries. We process the data using quartile and epoch analysis based statistical techniques and show that out of all the earthquakes, the one of the largest magnitude (M = 7.8) that occurred on Pakistan-Iran border caused anomalous enhancements and depletions in TEC 1-9 days before the occurrence of main sock. The E×B drift mechanism is suggested for the anomalies to occur in which the seismogenic electric field E is generated in a process suggested by Pulinets (2004).

India - KSK Geomagnetic Research Laboratory, Indian Institute of Geomagnetism, Allahabad report by Rajesh Singh.

From 2007 Indian Institute of geomagnetism continues to operate VLF stations in India at Allahabad (Geomag lat. ~16°N), Nainital (Geomag lat. ~20°N) and Varanasi (Geomag lat. ~16°N) in collaboration with Stanford University, USA. These stations are among the lowest latitude locations stations. Since 2011 we also installed under collaboration with our Hungarian colleagues from Space Research Group, Etvos University, Hungary an Automatic Whistler Detector (AWD) system for automatic detection of whistlers at all the three stations. The study concentrate in particular on phenomena like lightning discharges, radio atmospherics/tweeks, whistlers, VLF emissions etc. and D-region ionospheric perturbations by phenomena such as transient luminous events (TLE's), cosmic gamma-ray flares, terrestrial gamma ray flashes (TGF's), solar flares, solar eclipses, geomagnetic storms, Earthquake precursor and space weather study. During past 2-3 year we have been concentrating on the low latitude 'Whistlers' with the observation of good number of whistlers on various nights during last 2-3 years. In our recent publications we were able to determining the location of the causative lightning strikes around the conjugate region of recording station in Indian Ocean and ducted mode of propagation in low latitudes. Since 2012 we also operate two stations in India for the observation of 'Transient Luminous Events' (TLE's) and were able to recorded good number of TLE's for the first time in Indian subcontinent.

1. As. K. Singh, A.K. Singh, Rajesh Singh, R.P. Singh, Solar Flare induced D-region ionospheric perturbations evaluated from VLF measurements, Astrophysics and Space Sciences, DOI 10.1007/s10509-013-1699-4, 2013.

2. P.R. Srivastava, Sneha A. Gokani, Ajeet K. Maurya, Rajesh Singh, Sushil Kumar, B. Veenadhari, R. Selvakumaran, A.K. Singh, D. Siingh, J. Lichtenberger, One-to-one relationship between low latitude whistlers and conjugate source lightning discharges and their propagation characteristics, Advances in Space Research, http://dx.doi.org/10.1016/j.asr.2012.07.005, 2013.

3. S. Sripathi, N. Balachandran, B. Veenadhari, Rajesh Singh and K. Emperumal, Response of the equatorial and low-latitude ionosphere to an intense X-class solar flare (X7/2B) as observed on 09 August 2011, Journal of Geophysical Research, doi: 10.1002/jgra.50267, 2013.

4. A. K. Maurya, Rajesh Singh, B. Veenadhari, S. Kumar, and A. K. Singh Sub-ionospheric very low frequency perturbations associated with the 12 May 2008 M = 7.9 Wenchuan earthquake, Natural Hazard and Earth System Sciences, doi:10.5194/nhess-13-1-2013.

5. B. Veenadhari, R. Selvakumaran, Rajesh Singh, Ajeet K. Maurya, N. Gopalswamy, Sushil Kumar, T. Kikuchi, Coronal mass ejections-diven shocks and the associated sudden commencements/sudden impulses, Journal of Geophysical Research, doi:10.1029/2011JA017216, 2012.

6. B. Veenadhari, Sandeep Kumar, S. Tulasi Ram, Rajesh Singh, S. Alex, Corotating interaction region (CIR) induced magnetic storms during solar minimum and their effects on low-latitude geomagnetic field and ionosphere, Indian Journal of Radio & Space Physics, 41, 306-315, 2012.

7. Ashutosh K. Singh, Rajesh Singh, B. Veenadhari, A.K. Singh, Response of low latitude D-region ionosphere to the total solar eclipse of 22 July 2009 deduced from ELF/VLF analysis, Advances in Space Research, http://dx.doi.org/10.1016/j.asr.2012.07.005, 2012.

India - Department of Physics, University of Lucknow, Lucknow, report by Ashok K. Singh.

University of Lucknow, Lucknow (India) is a premier institution of higher education in Northern part of the country. Department of Physics is associated with many research activities including those in the field of Atmospheric and Space Sciences. Since December 2010, recording and analysis of whistlers and VLF emissions at lower latitude station Lucknow (Geomag. Lat., 17.60°N, Geomag. Long., 154.50°E) is continued in order to observe and detects whistlers and VLF emissions for estimation of various medium parameters. The VLF antenna at Lucknow is made up of two perpendicular magnetic loops, oriented N-S and E-W. This antenna will be part of AWDAnet, the Automatic Whistler Detector and Analyzer system's network. Using this VLF receiver, we have observed more than 300 tweeks of third or higher harmonics. Analysis provides electron density and reflection height of the D-region ionosphere. Fig. 1 shows a typical example of third harmonic tweeks recorded at our station.

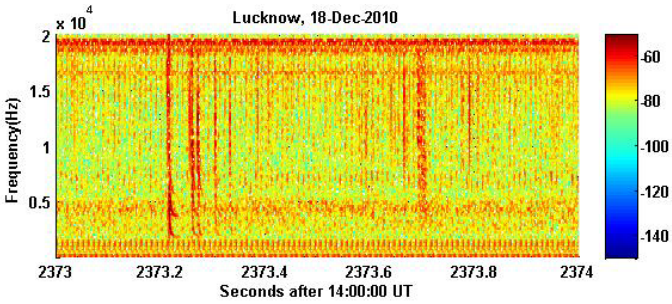

Fig. 1: A typical example of third harmonic tweeks recorded at Lucknow

In relation to this work, we have also started to work with the amplitude and phase measurements of fixed frequency VLF signals transmitted from ground based transmitters which are used in the study of the D-region perturbation phenomena. We are also involved in the study of solar flares, geomagnetic storms and their interpretation related with space weather phenomena.

Japan - Chiba University, Chiba, report by Hiroyo Ohya.

We have conducted Asia VLF observation network (AVON) in South-East Asia: Tainan (Taiwan), Saraburi (Thailand), Pontianak (Indonesia), Los Baños (Philippines) since 2007 (Figure 1). We have a plan of a new observation system in Vietnamese construction in December, 2013. The aim of the AVON is to investigate the D- and lower E-region ionosphere, lightning, and coupling between lightning and the lower ionosphere in South-East Asia [Adachi et al., 2008a]. Fourteen universities/institutes participate in AVON: Hokkaido University (Prof. Yukihiro Takahashi), Tohoku University (Dr. Fuminori Tsuchiya), Salesian Polytechnic (Dr. Kozo Yamashita), Nagoya University (Prof. Kazuo Shiokawa and Dr. Yoshizumi Miyoshi), JAMSTEC (Drs. Hisayuki Kubota and Miki Hattori), Tokyo Metropolitan University (Prof. Jun Matsumoto), National Cheng Kung University (Taiwan, Dr. Alfred B. Chen), Chularongkorn University (Thailand, Miss. Boossarasiri Thana), LAPAN (Indonesia, Mr. Timbul Manik), PAGASA (Philippines, Dr. Esperanza Cayanan), University of

the Philippines (Philippines), AMO (Vietnam, Dr. Hoang Gia Hiep), Hanoi University of Science (Vietnam, Dr. Thanh NGO-DUC), and Chiba University (Drs. Hiroyuki Nakata and Hiroyo Ohya).

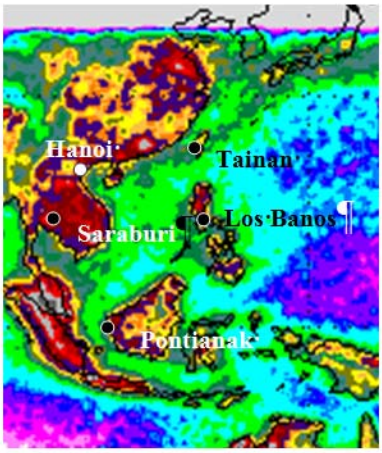

Figure 1. Observation sites of AVON. The color indicates total lightning flash counts by LIS/TRMM satellite in 1998-2011.

Using two orthogonal loop antennas, a monopole antenna, and a dipole antenna, electromagnetic waves originated from lightning and transmitters in the frequency range of 0.1–70 kHz are measured at each site. At each site, a set of orthogonal loop antennas is used to observe the horizontal magnetic field components of north–south (N-S) and east–west (E-W) directions induced by lightning discharges. A set of dipole and monopole antennas is also used to observe the vertical electric field of electromagnetic waves radiated by lightning and artificial transmitters. Signals are amplified by a pre-amplifier and a main amplifier and then recorded by three PCs together with the GPS time code signals. The first PC (PC1) is used for monitoring lightening, and the second (PC2) and third (PC3) PCs are used for monitoring the lower ionosphere. PC1 regularly records the waveforms of lightning atmospherics in both the electric and magnetic field components. The sampling frequency is 100 kHz. The obtained data allow us to detect the occurrence location and the timing of source lightning with accuracies of 10 km and 10 μs. Furthermore, because the system detects atmospherics in a wide frequency range of 1–70 kHz, it is possible to derive the current moment change of lightning, which is an important parameter in the production of transient luminous events (TLEs) such as sprites, elves, and blue/gigantic jets [Adachi et al., 2008b]. PC2 records the waveforms of two-component (N-S and E-W) magnetic-field data of tweeks for 2 minutes every 10 minutes. The measured frequency range is up to 10 kHz, with a sampling frequency of 20 kHz. PC3 records the vertical electric field of radio waves emitted from artificial transmitters with a sampling frequency of 200 kHz. By processing the real-time data, PC3 records the power and phase of the pre-set transmitter signals at a rate of 10 Hz. The obtained data are used for monitoring the D- and lower E-region ionosphere.

We have reported D-region response during a total solar eclipse of 22 July, 2009 using AVON data [Ohya et al., 2012]. In the paper, we reported that 16 tweek atmospherics were observed during the daytime solar eclipse at Moshiri, Japan, where the magnitudes of the solar eclipse were low to be 0.458. The average change in the phase delay of the LF transmitter signals was 109 degrees for the paths that crossed the eclipse path and 27 degrees for the paths that did not cross the eclipse path. Assuming a normal daytime height for LF waves of 65 km, a ray tracing analysis indicates that the variations in phase correspond to a height increase of 5–6 km for the paths across the eclipse and 1–2 km for partial eclipse paths.

We are preparing that quick-look files of the AVON magnetic component data can be used on Inter-university Upper atmosphere Global Observation NETwork (IUGONET). http://www.iugonet.org/en/index.html

1. Adachi et al., Monitoring of Lightning Activity in Southeast Asia: Scientific Objectives and Strategies, Kyoto Working Papers on Area Studies: G-COE Series, 11, 1-20, 2008a.

2. Adachi et al., Electric fields and electron energies in sprites and temporal evolutions of lightning charge moment, J. Phys. D: Appl. Phys., 41, 234010, 2008b.

3. Ohya et al., Reflection height of daytime tweek atmospherics during the solar eclipse of 22 July 2009, J. Geophys. Res., 117, A11310, doi:10.1029/2012JA018151, 2012.

New Zealand - University of Otago, Dunedin, report by Craig J. Rodger.

We continue to operate the following experimental measurements locally in Dunedin: 1) the VLF Doppler Experiment which monitors whistler-mode signals from VLF transmitters that have propagated through the plasmasphere, predominantly inside whistler ducts. 2) several narrowband receivers (OmniPAL, AbsPAL, SoftPAL and Ultra MSK) which log changes in the phase and amplitude of powerful VLF communications transmitters (~16-30 kHz) to study subionospheric propagation. 3) an Automatic Whistler Detector and Analysis (AWDA) receiver operating in collaboration with Eötvös University. 4) a receiver and central processing computer of the World Wide Lightning Location Network (WWLLN). We also operate UltraMSK narrow-band loggers in Antarctica (near Scott Base, with support from Antarctica New Zealand), and Ministik Lake (near Edmonton, Canada, with support from the University of Alberta). Narrow-band observations are also being made using some WWLLN receiver locations, testing new software capability. We play a core role of the AARDDVARK global network of subionospheric VLF monitors and also the real-time to the WWLLN lightning consortia.

We have visited both of our distant field sites. James Brundell and Craig Rodger visited the Ministik Lake VLF receiver in July 2013, and found it in good condition. In November 2013 James and Otago PhD student travelled to Scott Base to work on our receiver there. They found the weather conditions quite harsh (and cold)! In 2013 the group send 3 members to the IAGA conference in Merida, Mexico (Craig, PostDoc Ian Whittaker and PhD student Aaron Hendry), and also to the CAWSES-II International Symposium in Nagoya, Japan (Craig, and MSc students Kathy Cresswell-Moorcock and Jason Neal). This year all the younger members of the Otago research group have had research papers published, which I have listed at the end of our report.

This year Neil Thomson travelled to Alaska, Norway and Germany to make measurements of the powerful VLF transmitters. These campaigns are focused on understanding the typical electron number density profiles of the D-region, and particularly to determine the profiles suitable to describe subionospheric VLF propagation.

In 2013 Craig Rodger has again been mostly focused on the detection and effects of energetic electron precipitation from the radiation belts, and in particular trying to understand the impact of precipitation on the upper atmosphere and its coupling to Earth's climate. Through our collaborators we have been trying to expand our space-physics activities to examine

the atmospheric changes caused by precipitation as well as coupling to polar climate. This has been a very successful year for our group, with a high output. Craig recognises that his PostDoc, research students, and international collabotrators have had a big role in this output. We continue to enjoy working with the wider world, from our far-flung location in the South Pacific. An up to date listing of our publications is available from the Space Physics Group's website: http://www.physics.otago.ac.nz/nx/space/space-physics-publications.html. This includes PDFs of our published work, where-ever possible.

1. Rodger, C J, A J Kavanagh, M A Clilverd, and S Marple, Comparison between POES energetic electron precipitation observations and riometer absorptions: Implications for determining true precipitation fluxes, J. Geophys. Res., doi:10.1002/2013JA019439, 2013.

2. Newnham, D A, P J Espy, M A Clilverd, C J Rodger, A Seppälä, D J Maxfield, P Hartogh, K Holmén, and R B Horne, Observations of nitric oxide in the Antarctic middle atmosphere during recurrent geomagnetic storms, J. Geophys. Res., doi:10.1002/2013JA019056, 2013.

3. Whittaker, I C, R J Gamble, C J Rodger, M A Clilverd and J A Sauvaud, Determining the spectra of radiation belt electron losses: Fitting DEMETER IDP observations for typical and storm-times, J. Geophys. Res., doi:10.1002/2013JA019228, 2013.

4. Clilverd, M A, N Cobbett, C J Rodger, J B Brundell, M Denton, D Hartley, J Rodriguez, D Danskin, T Raita, and E L Spanswick, Energetic electron precipitation characteristics observed from Antarctica during a flux dropout event, J. Geophys. Res., 118, doi:10.1002/2013JA019067, 2013.

5. Cresswell-Moorcock, K, C J Rodger, A Kero, A B Collier, M A Clilverd, I Häggström, and T Pitkänen, A reexamination of latitudinal limits of substorm-produced energetic electron precipitation, J. Geophys. Res., 118, doi:10.1002/jgra.50598, 2013.

6. Verronen, P T, M Andersson, C J Rodger, M A Clilverd, S Wang, and E Turunen, Comparison of modeled and observed effects of radiation belt electron precipitation on mesospheric hydroxyl and ozone, J. Geophys. Res., 118, doi:10.1002/jgrd.50845, 2013.

7. Neal, J J, C J Rodger, and J C Green, Empirical determination of solar proton access to the atmosphere: impact on polar flight paths, Space Weather, 11, 420-433, doi:10.1002/swe.20066, 2013.

8. Lichtenberger, J, M A Clilverd, B Heilig, M Vellante, J Manninen, C J Rodger, A B Collier, A M Jorgensen, J Reda, R H Holzworth, R Friedel, and M Simon- Wedlund, The plasmasphere during a space weather event: First results from the PLASMON, J. Space Weather Space Climate,3 (A3), http://dx.doi.org/10.1051/swsc/2013045, 2013.

9. Silber, I, C Price, C J Rodger, and C Haldoupis, Links between mesopause temperatures and ground-based VLF narrowband radio signals, J. Geophys. Res., 118, doi:10.1002/jgrd.50379, 2013.

10. Seppälä, A, H Lu, M A Clilverd, and C J Rodger, Geomagnetic activity signatures in wintertime stratosphere-troposphere temperature, wind, and wave response, J. Geophys. Res., 118, doi:10.1002/jgrd.50236, 2013.

11. Carson, B R, C J Rodger, and M A Clilverd, POES Satellite Observations of EMIC-wave driven Relativistic Electron Precipitation during 1998-2010, J. Geophys. Res., 118, 1–12, doi:10.1029/2012JA017998, 2013.

12. Hendry, A T, C J Rodger, M A Clilverd, N R Thomson, S K Morley, T Raita, Rapid radiation belt losses occurring during high speed solar wind stream driven storms: importance of energetic electron precipitation, in Dynamics of the Earth's Radiation Belts and Inner Magnetosphere, Geophys. Monogr. Ser., vol. 199, edited by D. Summers et al., 213–223, AGU, Washington, D. C., doi:10.1029/2012GM001299, 2013.

Russia - Space Research Institute of RAS (IKI), Moscow, report by Ilya Kuzichev, David Shklyar, Elena Titova, and Dmitry Vavilov

The work on the problem of lower hybrid resonance (LHR) reflection of whistler-mode waves has been continued. For some ionospheric parameters, especially for those which are typical of daytime ionosphere, LHR reflection can take place in the F-layer of the ionosphere, at the heights of about 300 km. In this region, collision frequencies (mostly, electron to ion) are high enough, and the collisional damping of the wave should be taken into account. Hence, geometrical optics approach to the description of LHR reflection is not valid in the vicinity of reflection point, and we have developed a full-wave approach to the problem. With this method, the reflection coefficient as a function of wave frequency has been calculated. Wave absorption in the reflection region decreases the reflection coefficient so that it becomes less than unity. Interestingly, the reflection coefficient shows a non-monotonic behavior as a function of wave frequency. Such behavior is most evident in the night-time ionosphere (more precisely, for ionospheric plasma parameters typical of 10 pm local time, mid-latitude ionosphere), when two local maxima of LHR frequency are formed, with the global maximum in the F-region. Since the reflection coefficients play significant role in the theory of whistler-mode cyclotron maser, these results might be important not only for analyzing wave phenomena, but for self-consistent modeling of magnetosphere's dynamics. Also the strong collisional damping of the quasi-electrostatic whistler-mode wave in the F-region of the day-time ionosphere has been shown. It substantially reduces the efficiency of scattering of such waves from F-region irregularities into the transmission cone. This result is consistent with the fact that VLF waves are observed at the ground far more often at night than during the day.

Kuzichev I. V., D. R. Shklyar, Full-wave description of the lower hybrid reflection of whistler waves, Plasma Physics Reports, V.39, Is. 10, pp. 795-808, 2013

Kuzichev, Ilya; Shklyar, David, On the full-wave approach to the problem of lower hybrid reflection of whistler-mode waves in the ionosphere, IAGA 12th Scientific Assembly, 26-31 August, 2013

The problem of resonant wave-particle interaction between oblique whistler-mode waves generated by VLF transmitter and relativistic electrons populating the outer radiation belt has been investigated, with the main focus on particle capturing into resonance. In the case of monochromatic waves, when the well-known integral of motion exists, it is possible to express the resonant particle parallel momentum through this integral of motion and particle coordinate along the field line on which is the particle trajectory is centered. The topology of the resonant surface depending on the integral of motion has been studied. In general, for a given point along the field line, there are two roots for resonant parallel momentum: positive and negative. At some points these roots can merge into zero, giving rise to the so called relativistic turning acceleration discovered by Y. Omura for the case of longitudinal propagation. The main result of the study is the following: we found that for the case of interaction with oblique waves, the effective amplitude of interaction becomes essentially asymmetric with respect to the direction of the resonant particle motion, i.e. towards the geomagnetic equator and away from it. The consequences are twofold: on the one hand, this effect increases the efficiency of acceleration of trapped particles that cross the equator because the particles become detrapped soon after they crossed the equator due to oscillations of the effective amplitude. On the other hand, the same behavior of the effective amplitude holds for the particles which have a turning point before the equator: once the particle has turned, the effective amplitude starts to oscillate and particle becomes detrapped. This decreases the efficiency of relativistic turning acceleration as compared to the case of longitudinal propagation.

Kuzichev, Ilya; Shklyar, David, Resonant interaction of relativistic electrons with an oblique monochromatic whistler-mode wave, IAGA 12th Scientific Assembly, 26-31 August, 2013

Using the measurements from the DEMETER satellite for 3 years we have calculated the maps of the lower hybrid resonance (LHR) frequency over the globe, and the maps of VLF spectral intensity at the frequencies of Alpha navigation transmitters. These maps demonstrate a significant dependence of the spectral intensity in the transmitter conjugate region on the relation between the signal frequency and the LHR frequency above the observation point. Variations of plasma distribution and/or wave spectral features in the ionosphere were suggested by many authors as possible earthquake precursors, and the change of plasma density and temperature above seismic regions were reported in the literature. These quantities are known to influence the LHR frequency profiles in the upper ionosphere and the magnetosphere, which, in turn, strongly affects the propagation of quasi-resonance VLF waves with frequencies close to the maximum of the LHR frequency on the propagation path. This makes the VLF signals a tool of registration of ionospheric perturbations. Then, using the DEMETER data and the earthquake database from the US geological survey server we have performed a statistical analysis of the LHR frequency over seismic regions and found an appreciably different behavior of the LHR frequency before earthquakes, as compared to its regular behavior, for several seismic regions. Although this difference is statistically significant, in each particular case the ionospheric perturbations may be related to different processes in the Earth's atmosphere, ionosphere, and the magnetosphere, other than gathering earthquakes. Thus, the unexpected variations in the LHR frequency profile, revealed from the variations of VLF transmitter signals, should only be considered as one indicator in a list of possible earthquake precursors.

Vavilov, D. I., D. R. Shklyar, E. E. Titova, M. Parrot, Study of the lower hybrid resonance frequency over the regions of gathering earthquakes using DEMETER data, J. Atm. Sol.-Terr. Phys., V. 100, p. 1-12

Russia - Yu.G. Shafer Institute of Cosmophysical Research and Aeronomy SB of RAS, Yakutsk, report by Victor Mullayarov

The study of the effects of neutron observations using the standard neutron monitor during periods of the nearest lightning strikes have been continued. The sessions of fast registration (with microsecond resolution) of the neutron intensity during thunderstorm activity have been carried out. The results allow to make a conclusion on the exclusion of electromagnetic lightning interference as a possible reason of impulses recorded with the neutron monitor during periods of nearest lightning strikes.

We continue participating in the World Wide Lightning Location Network (WWLLN). The data of WWLLN are used, in particular, in the study of seismic effects in the lower ionosphere by data of the monitoring of electromagnetic lightning signals - atmospherics, passing over the earthquake's epicenters. Previously it has been found that the effects of earthquakes and their possible precursors in the form of increasing the average amplitude of atmospherics are registered for the strong (magnitude >5), not deep (depth <50 km) earthquakes. However, considering the case of strong (M = 8.2) earthquake on May 24, 2013, which has occurred not far from the Kamchatka Peninsula at a depth of over 600 km, we can see that the some strong deep-focus earthquakes can also cause disturbances in the lower ionosphere.

Slovenia/Serbia joint report - University of Nova Gorica (Slovenia) and Institute of Physics, Belgrade (Serbia) report by V. Žigman (UNG) and D. Šulić (IPB).

We have continued the monitoring of the VLF signals on short and long paths to Belgrade, namely from transmitters GQD, DHO, ICV and NAA, NWC respectively, mainly analyzing solar X-ray flares and the induced electron density enhancements.

The study of VLF data from the Antarctica stations Scott Base and Casey has been extended thanks to the active and helpful cooperation of Craig Rodger, Otago University, and Mark Clilverd, British Antarctic Survey. Through this collaboration we have been able to 'observe' flares occurring at nighttime UT, which have been frequent in the last flary period of October 2013. We have used these data in deducing enhancements of electron density at the upper ceiling of the D-region , ~90 km in height, relating the deviation of amplitude and phase of the VLF signal to the flare irradiance in the wavelength range of EUV and soft X rays as mesured by the LYRA radiometer on board of Proba2. A short progress report was presented during the ESWW10 (Brussels, 18-22 November 2013).

We have shown the outstanding efficiency of the VLF monitoring of solar proton events, by studying the Ground Level Enhancement event of December 13, 2006 (GLE70). The data on the NAA/24.0 kHz – Belgrade path have been used in parallel with the neutron monitor data as recorded by the neutron monitor network nmdb.eu. It has been shown that the VLF technique not only detects solar proton events but also reproduces the time structure of the event in remarkable agreement with the neutron monitor findings. In collaboration with the Department of Space Science of the Institute of Experimental Physics in Košice the results have been presented at the ESWW10 and a paper has been submitted to Advances in Space Research.

Taiwan - National Cheng Kung University, Tainan, report by Kaiti Wang.

Two papers related to observed emissions of ELF-signals at Lulin station and correlations with seismic activities are published this year.

1. Ho, S. M., K. Wang, A. B. C. Chen, H. T. Su, S. M. Huang, R. R. Hsu, T. S. Hsu (2013), Characteristics of magnetic signals observed at Lulin ELF station and their association with earthquakes in Taiwan, Terr. Atmos. Ocean.Sci, 24, No.2.

2. Liu, J. Y., K. Wang, C. H. Chen, W. H. Yang, Y. H. Yen, Y. I. Chen, K. Hatorri, H. T. Su, R. R. Hsu, and C. H. Chang (2013), A statistical study on ELF-whistlers/emissions and M≥5.0 earthquakes in Taiwan, J. Geophys. Res., 118, 3760–3768, doi:10.1002/jgra.50356.

United Kingdom - British Antarctic Survey, Cambridge, report by Mark Clilverd.

BROADBAND RECORDINGS in Antarctica:

Whistler-detection and data collection has continued at Halley (L=4.5) and Rothera (L=2.9) throughout 2013 using the Hungarian Automatic Whistler Detection (AWD) system. BAS also continues to operate a third AWD site, at Eskdalemuir in Southern Scotland (L=2.7). These sites operate as part of the PLASMON FP7 project.

The Stanford University AWESOME receiver has also operated at Rothera throughout 2013, logging broadband and

narrow-band data. The instrument is planned to return to BAS Cambridge for overhaul at the end of 2013.

VELOX RECORDINGS at Halley, Antarctica:
Continuous (since 1992) recordings of VLF activity in 10 ELF/VLF bands, at 1-s resolution (VELOX and VELOXNET) have been maintained at Halley in 2013. Some difficulties have been encountered with the aerial signal quality in 2013 as a result of wind damage, so VELOX data quality has been poor at times.

NARROW-BAND RECORDINGS:

'Ultra' narrow-band recordings have continued at Halley and Rothera (Antarctica), the Australian Casey station (Antarctica), Forks, Seattle (USA), Sodankyla (Finland), Ottawa, St Johns, and Churchill (all Canada), Eskdalemuir (Scotland), and Ny Alesund (Svalbard) throughout 2013. Basic data collection at all sites is undertaken with 0.1-1 s resolution. A limited amount of 'Ultra' data has been collected at a newly installed site in Reykjavik (Iceland) during 2013 (May-September). The status of the instrument is currently unknown.

The software VLF Doppler system has continued at Rothera station, Antarctica (L=2.8) in 2013, receiving whistler mode and sub-ionospheric signals primarily from NAA (24.0 kHz). A similar Doppler system has been in operation at Marion Island, South Africa (L=2.9) during 2013, hosted by the University of Natal, Durban.

WWLLN sites:
British Antarctic Survey has operated three World Wide Lightning Location Network systems in 2013. Rothera and Halley have successfully provided lighting location information all year. Ascension has become operational again in March 2013, after a fault throughout most of 2012.

United Kingdom - VERRI, Derbyshire, report by Andy Smith.

The VELOX instrument at Halley Antarctica, which records radio waves in 8 bands from 500 Hz to 10 kHz with a once per second sampling rate, began operating in January 1992 and has continued to the present. Thus there is now an almost uninterrupted two solar cycle long VLF/ELF data set. The most important statistical results from the first 16 years of operation (1992-2007), have been published (J. Atmos. Solar-Terr. Phys. 72 463-475, doi:10.1016/j.jastp.2009.12.018). We are now working with colleagues at British Antarctic Survey to extend this analysis to the present time, and to quantify some technical issues associated with the move of the receiver from Halley V to the new Halley VI site. A report will be given at the forthcoming VERSIM workshop in New Zealand.

Ukraine - Dept. of Remote Sensing, Usikov Institute for Radio-Physics and Electronics, Nat. Acad. of Sci. of the Ukraine, Kharkov, Ukraine, report by A. Nickolaenko.

The main attention of Kharkov group was concentrated at the following issues.

Extended treatment was developed in modeling the impact on ELF radio propagation of the ionosphere disturbance positioned above a future earthquake. The result was published in the following paper:

Nickolaenko A.P. and M. Hayakawa, Localized ionospheric disturbance over the earthquake epicentre and modifications of Schumann resonance electromagnetic fields, Geomatics, Natural Hazards and Risk, (2013), DOI: 10.1080/19475705. http://dx.doi.org/10.1080/19475705.2013.809557

The improved method was developed for estimating the effective ionospheric height and the propagation distance of the tweek-atmospherics. It implies compensation of the waveguide dispersion in the tweek-signal. This improves the accuracy of deducing the cutoff frequencies, especially in the presence of noise. Modeling was performed of the multimode tweek-atmospherics in the Earth-ionosphere waveguide with the exponential conductivity profile. We showed that accuracy of estimating the effective waveguide height reaches the 100-400 m level for the first and higher order tweek modes. This allows estimating the parameters of conductivity profile in a wider range of source distances: from a few hundred to a few thousand kilometers. Preliminary analysis of experimental records showed a decrease of the effective height with the increase of the mode number. The scale height of the conductivity profile was estimated by 0.4 – 2.5 km.

A.V.Shvets, T.M. Serdiuk, Y.V. Gorishnyaya,Y.Hobara3, and M. Hayakawa, Estimating the Lower Ionosphere Height and Lightning Location Using Multimode "Tweek" Atmospherics, Journal of Atmospheric and Solar-Terrestrial Physics. Accepted manuscript (unedited version) available online: 28-NOV-2013. DOI information: 10.1016/j.jastp.2013.11.007

We compared spectra and the waveforms of computed Q-bursts for a set of realistic ELF propagation models. Emphasize was made on the impact of a typical Schumann resonance receiver on the waveform. Such a receiver modifies the waveform, so that some problems might appear when identifying the source polarity. Shifted positions of the sub-peaks in the waveform might impede the correct source distance evaluation. Compensation of the phase distortions substantially improves the quality of the record. The paper in Russian will be published by Radiofizika, Nizhnii Novgorod.

The new book on the Schumann resonance studies was prepared: A. Nickolaenko and M. Hayakawa, "Schumann Resonance for Tyros". The book will be published by Springer, details can be found on their website (http://www.springer.com/earth+sciences+and+geography/geophysics/book/978-4-431-54357-2).

USA - University of Stanford, report by Morris Cohen.

A new VERSIM group is now established at Georgia Institute of Technology (Georgia Tech), in the School of Electrical and Computer Engineering, and will be led by Morris Cohen, previously of Stanford University. The group will focus on VLF remote sensing of lightning, using global VLF receivers, NLDN/GLD360, and will continue collaboration with Stanford. The group will also build on previous experimental results on transionospheric propagation of VLF signals. The group is brand new, and thus welcomes new collaborations and opportunities.

We'd like to briefly describe four sets of results from the past year:

(1) During the March 2011 M9.0 earthquake in Japan, we very fortuitously had a VLF receiver about 100 km from the epicenter, in about the closest possible place on land. Amazingly, the receiver operated prior to, and even 2 minutes during, the earthquake. We analyzed the data, and found remarkable and bizarre VLF signatures, as the power lines crumbled, rocks were stressed, and buildings shook. There's no way to really explain these observations or link them directly to their source, but there were very intense emissions in the few kHz range that corresponded to the arrival of the slow wave of the earthquake. We also searched for electromagnetic precursors in both the broadband and

narrowband data, and found none, despite the extremely fortuitous placement of the receiver near this extraordinarily rare earthquake. Full results are available in this GRL paper: http://onlinelibrary.wiley.com/doi/10.1029/2012GL052123/abstract

(2) We participated in three studies connecting the properties of early/fast events, including recovery time, size, and amplitude, to the properties of the lightning stroke, including peak current and polarity. These results came out of Stanford's AWESOME receiver network, and cover both European and North American Early/fast events. The full results can be found in these three papers: http://onlinelibrary.wiley.com/doi/10.1002/jgra.50448/abstract, http://onlinelibrary.wiley.com/doi/10.1002/jgra.50489/abstract, http://onlinelibrary.wiley.com/doi/10.1002/2013JA019087/abstract

(3) Stanford VLF receivers embedded in Vaisala's GLD360 network uncovered remarkable evidence that oceanic lightning unleashes, on average, particularly intense lightning. Because of GLD360's high detection efficiency (60% or higher), the distribution of peak currents for both land and oceanic lightning could be directly measured. The VLF radiation intensity allows GLD360 to quantify each event with reference to NLDN peak currents, with 6% error. Oceanic lightning was shown to be 65-121% stronger on average. Although the oceans see about 10 times less lightning than land, the majority of the Earth's >75 kA strokes actually occur over the ocean. Experiments are now underway to explain the physical reasons for this observation. Full results are available in this paper: http://onlinelibrary.wiley.com/doi/10.1002/jgrd.50508/abstract.

(4) Putting a bowtie on years of experiments, we've compiled nearly 100 days of ELF/VLF generation with HAARP HF heating, and put all the data into a massive database, with millions of individual observations. We observe the diurnal dependence of ELF/VLF generation with HF heating, noted a "startup effect" when the heater is turned on, which may be evidence of electron density changes, and also used theoretical modeling to infer the radiated ELF/VLF power generated by HAARP, statistically. Full results can be seen in this paper: http://onlinelibrary.wiley.com/doi/10.1002/jgra.50558/abstract

We send our regards to all our colleagues and look forward to future discussions and collaborations.

USA - University of California, Los Angeles, report by Richard M. Thorne and Jacob Bortnik.

The past year has been particularly busy for the UCLA group in light of the recently launched Van Allen Probes mission. We have published well over 20 journal papers at the time of this writing, dealing with topics that are generally focused on the dynamics of the Earth's radiation belts, and the numerous waves that control these dynamics. These include: a detailed explanation of the hiss-driven decay of the ultrarelativistic "storage ring" discovered in 2012 by Baker et al., a new technique to infer the spatiotemporal distribution of chorus waves throughout the whole inner magnetosphere, new evidence of chorus being the source of plasmaspheric hiss, a detailed analysis of the dayside auroral precipitation by measured chorus, a quantitative analysis of the excitation of equatorial magnetosonic waves by measured ion ring distributions, a model for the structure and distribution of the chorus wave normal evolution as function of latitude and a related observational study, and an experimental analysis of EMIC waves based on satellite data, together with numerical modeling of the excitation of these waves. A final study which deserves mention, due to be published in the journal Nature over the Christmas period, explains the unique formation of the belt of ultrarelativistic electrons during the Oct 9, 2012 geomagnetic storm, which persisted over a period of a few months thereafter. We will be glad to provide more information and copies of any of the above studies to interested parties upon request.

Merry Christmas and Happy New Year!

János Lichtenberger and Csaba Ferencz (Eötvös University, Hungary) in the mission control center of the International Space Station at Korolev (near Moscow, Russia) on 26 April 2013, when the OBSTANOVKA experiment was installed during a space walk by two Russian astronauts on the outer surface of the Russian ZVEZDA module.

Jacob Bortnik (UCLA, USA) taking a weekend getaway to the Hamptons, playground of the rich and famous (although the plebs only get to play off-season!). New York, USA

Dr. Craig Rodger (Otago University, New Zealand) beside the "Governor's Palace" in the ruined Mayan city of Uxmal, on the Yucatan Peninsula. This city is believed to have once had 15-25 thousand people living in it, but is now surrounded by jungle and visited by tourists. Craig was in Mexico to attend the 12th IAGA Scientific Assembly in Merida, Mexico [28 August 2013].