# POSTERS

## SESSION 1:

P1.1 "IMPROVEMENT OF INFRASOUND NETWORK AND DATA ANALYSIS TECHNIQUES IN CÔTE D'IVOIRE." by **Kouassi Benjamin**

P1.2 "IS42 Graciosa (Azores): a new IMS infrastructure for infrasound monitoring and collaborative research." by **Nicolau Wallenstein,** P. Campus, P. Mialle, J.L. Gaspar, IS42 team

P1.3 "**Mesospheric temperatures derived from three decades of hydroxyl airglow measurements from Longyearbyen, Svalbard (78°N).**" by **Silje Holmen,** Margit Dyrland, Fred Sigernes

P1.4 "O2 and OH nightglow climatology with GOMOS data from 2002 to 2010." by **Christophe Bellisario,** Keckhut, Simoneau, Hauchecorne, Blanot

P1.5 "Temperature Lidar observation in mid-latitude NDACC station at Río Gallegos (51°36' S, 69° 19' W), Patagonia Argentina." by **Jacobo Omar Salvador,** E. Wolfram, F. Orte, R. D'Elia, D. Bulnes Romero, E. Quel

P1.6 "The Geohazards monitoring and services in the Republic of Vanuatu" by Esline Garaebiti

P1.7 "OHP MB2005 based infrasound network for the ARISE project." by **Guillaume Nief,** Denis, Millier

P1.8 "Middle-atmospheric wind profile measurements with an upgraded version of the ground-based microwave Doppler-spectro-radiometer WIRA." by **Rolf Rüfenacht,** N. Kämpfer, A. Murk, P. Eriksson, S. Bühler

P1.9 "First results of detection and location of infrasound events in Central Eurasia using data of IS46 Zalesovo station along with data from the new Kurchatov infrasound array in the northeast Kazakhstan." by **Alexandr Smirnov**

P1.10 "Wind surface effects on background noise power of I33MG" by **Andry Ramanantsoa**, Fanomezana Randrianarinosy, Tahiana Rakotoarisoa, Jean Bernardo Andrianaivoarisoa,Gérard Rambolamanana, Alexis Le Pichon, Elisabeth Blanc

P1.11 "Short period waves in the Doppler type ionospheric measurements. Ionospheric manifestation of infrasound or geomagnetic micropulsations?" by **Tereza Sindelarova**, J. Chum, Z. Mosna, J. Lastovicka, J. Base, F. Hruska

P1.12 "The Swedish-Finnish Infrasound Network" by **Johan Kero,** Ludwik Liszka, Lars Eliasson

P1.13 "Rayleigh lidar: New instrument in La Réunion and other prospectives" by **Philippe Keckhut**

P1.14 "Stereoscopic imaging of the hydroxyl emissive layer." by **Guy Moreels,** Nadjib Kouahla, Michaël Faivre, Jacques Clairemidi, Michel Hersé

P1.15 "Detecting infrasound modulation of airglow emissions – a technique for remote sensing of the Earth's upper atmosphere." by **Andrew Wilson,** Frank Mulligam

**SESSION 2:**

P2.1 "Long-term trends in winds and atmospheric waves in the middle atmosphere." by **Jan Lastovicka**

P2.2 "Towards understanding the sources of gravity waves at mid and high latitudes." by **Sergey Khaykin,** Alain Hauchecorne

P2.3 "Simultanous observations of infrasound thunders and electrostatic field: Discussion to infrasound production" by **Jaroslav Chum**, J. Laštovička, T. Šindelářová, G. Diendorfer, D. Burešová, J. Baše, F. Hruška

P2.4 "Acoustic-Gravity waves in the ionosphere from multi-point Doppler sounding" by **Jaroslav Chum,** J. Laštovička, T. Šindelářová, G. Diendorfer, D. Burešová, J. Baše, F. Hruška

P2.5 "Tentative Polar Low detection and tracking using Infrasounds, Satellite images and Lightning localization : Results, Discussions and Questions." by **Francis Dalaudie,** Guo Quan

P2.6 "Lidar and SkYiMET meteor radar GW variances comparison at low latitudes" by **P. P. Batista**,

P2.7 "Stratospheric processes as measured by collocated Lidar and infrasound measurements" by **Alexis Le Pichon,** E. Blanc, L. Ceranna, C. Pilger, P. Keckhut, A. Hauchecorne, R. Rüfenacht , N. Kämpfer, C. Schmidt, M. Bittner, S. Wuest

P2.8 "Characteristics of gravity waves during tropical cyclone events in ECMWF analyses" by **Fabrice Chane Ming**

P2.9 "Some characteristics of West African wind observed with a wind profiler VHF radar" by **Bodoun Etienne HOUNGNINOU,** H. KOUGBEAGBEDE, B. CAMPISTRON

P2.10 "Vertical distribution of gravity wave potential energy from long-term Rayleigh lidar data over OHP (43.93° N, 5.71° E)" by **Nahoudha Mzé,** A. Hauchecorne, P. Keckhut, M.Thétis

**SESSION 3:**

P3.1 "Location of space debris by infrasound." by **Vladimir Asming,** Yuri Vinogradov

P3.2 "Near-real time integration of the infrasound network performance predictions to improve infrasonic source detection." by **Aurélien Dupont,** Le Pichon

P3.3 "Lightning characterization through acoustic measurements" by **Louis-Jonardan Gallin,** François Coulouvrat, Thomas Farges, Régis Marchiano

P3.4 "Analysis of infrasound event of NPE 2012 at Turkish NDC using PMCC" by **Cem Destici,** N.M. Ozel, K.U. Semin O. Necmioglu, S. Kocak, U. Teoman

P3.5 "The Russian meteor impact of 2013 as seen from Israel" by **David Applbaum,** Roy Yaniv, Colin Price

P3.6 "3D Lattice-Boltzmann strategies: New insights into Volcanic Jet Dynamics and Infrasound" by **Federico Brogi,** C. Bonadonna, M. Ripepe, B. Chopard

P3.7 "Numerical simulation of acoustical shock wave in turbulent atmosphere." by **David Luquet,** François Coulouvrat, Régis Marchiano, Institut Jean le Rond d'Alembert

P3.8 "Multi year Etna Volcano Monitoring" by **Mohamed Kallel**

P3.9 "A Ground Truth Database of Seismo-Acoustic Events in Northern Europe" by **Steven J. Gibbons,** Tormod Kværna

P3.10 "NATURAL SOURCES DETECTED BY I33MG." by **Fanomezana Randrianarinos,** Fanomezana Randrianarinosy, Tahiana Rakotoarisoa, Jean Bernardo Andrianaivoarisoa,Gérard Rambolamanana, Alexis Le Pichon, Elisabeth Blanc

P3.11 "Use of the Plostina infrasound array to monitor extreme events generated by natural and anthropogenic acoustic sources" by **Daniela Ghica,** Constantin Ionescu, Bogdan Grecu

## SESSION 1

**IMPROVEMENT OF INFRASOUND NETWORK AND DATA ANALYSIS TECHNIQUES IN CÔTE D'IVOIRE.**

Abstract No.: **P1.1** Authors: **Kouassi Benjamin**

ABSTRACT MISSING

**IS42 Graciosa (Azores): a new IMS infrastructure for infrasound monitoring and collaborative research.**

Abstract No.: **P1.2** Authors: **Nicolau Wallenstein,** P. Campus, P. Mialle, J.L. Gaspar, IS42 team

After several years and attempts to establish an International Monitoring System (IMS) infrasound station in the Azores Islands, located in the middle of the North-Atlantic Ocean, the cooperation between the Preparatory Commission for the Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO), the Azores Government, the Centre of Volcanology and Geological Risks Assessment (CVARG) of the University of Azores and the Santa Cruz da Graciosa Municipality, led to the construction, installation and certification of the IS42 station (I42PT) during the year 2010. CVARG assures the management, operation and maintenance of the station, on the behalf of the International Monitoring System (IMS).

Installed in a heavily forested area in the middle of the Island, the array is composed by eight elements and one central recording facility (CRF), where the data are collected before being transmitted via the GCI interface to Vienna. Each array element has 230V independent power supply from the public grid and all the elements are linked to the CRF via optical fibre, in order to guarantee reliability, robustness and high performance, as already evidenced by the high data availability (around 100%) and detections recorded since the time of its certification.

Located in the North Atlantic, IS42 covers a key position for CTBTO monitoring purposes and will offer also the opportunity to study a number of natural events, like volcanic and seismic activity, as well as weather perturbations crossing the Atlantic Ocean. This will set the ground not only for a complementary use of infrasound data by CVARG (tasked by the Azores Regional Government to monitor local volcanic and seismic activity), but also for a number of interactions with other infrasound research groups across Europe and beyond, as already started with the Department of Earth Sciences, University of Florence, in the study of the detections of the 2011 eruptive activity of the Etna Volcano, in Italy, already presented in previous communications.

**Mesospheric temperatures derived from three decades of hydroxyl airglow measurements from Longyearbyen, Svalbard (78°N).**

Abstract No.: **P1.3** Authors: **Silje Holmen,** Margit Dyrland, Fred Sigernes

The airglow hydroxyl temperature record from Longyearbyen, Svalbard, is updated with data from the last seven seasons (2005/2006 – 2011/2012). The overall daily average mesospheric temperature for the whole temperature record is 206 K. This is 3 K less than what Dyrland and Sigernes (2007) reported in their last update on the temperature series. This temperature difference is due to cold winter seasons from 2008 to 2010, which can be explained by strong Sudden Stratospheric Warming (SSW) events. 2009/2010 was the coldest winter season ever recorded over Longyearbyen, with a seasonal average of 185 K. Temperature variability within the winter seasons is investigated, and the temperature difference between late December (local minimum) and late January (lo-cal maximum) is approximately 8 K.

**O2 and OH nightglow climatology with GOMOS data from 2002 to 2010.**

Abstract No.: **P1.4** Authors: **Christophe Bellisario,** Keckhut, Simoneau, Hauchecorne, Blanot

GOMOS (Global Ozone Monitoring by Occultation of Stars) is an instrument dedicated to atmospheric chemistry with the principle of stellar occultation. The signals from the both IR spectrometers coupled with the CCD detectors, initially used for noise estimates, were investigated in order to observe the night airglow composed of O2 and OH emissions respectively at 761.9 nm and 930 nm. First airglow retrievals are presented and discussed according to instrument characteristics, earth coverage, altitude resolution. The climatology of both signals is described for seasonal variations from 2002 until 2010.

**Temperature Lidar observation in mid-latitude NDACC station at Río Gallegos (51°36‘ S, 69° 19‘ W), Patagonia Argentina.**

Abstract No.: **P1.5** Authors: **Jacobo Omar Salvador,** E. Wolfram, F. Orte, R. D’Elia, D. Bulnes Romero, E. Quel

Since June 2005, the CEILAP group with the support of JICA (Japan International Cooperation Agency) and cooperation with French LATMOS and Japanese researches has carried out systematic measurements of ozone profile and UV radiation in the southern part of Argentina (51° 55’S, 69° 14’W) using a Differential Absorption lidar (DIAL). This place has been called Atmospheric Observatory of Southern Patagonia (OAPA). Since 2008 other products were retrieved in addition to the ozone profiles from the DIAL measurements, such as stratospheric aerosols and temperature profiles using the off-wavelength signal at 355 nm.

Temperature profiles from Rayleigh lidar are validated through intercomparisons with measurements made by MLS instrument (Microwave Limb Sounder) onboard the NASA AURA satellite platform, SABER and NCEP data re-analysis. Perturbation on temperature profiles are observed and characterized.

**The Geohazards monitoring and services in the Republic of Vanuatu**

Abstract No.: **P1.6** Authors: **Esline Garaebiti**

Two main activities and services for the Vanuatu Geohazards: the programs of monitoring and advisories for volcanic eruptions, earthquakes and tsunami and the coordination of Geohazards research programs in volcanology, seismology, Geodesy and geo-tectonics. These programs are involving the use of different systems such as seismic, geodetic, acoustic and geochemical technologies in collaboration with a variety of regional and international partners including research institutes and geological hazards observatories. Internal alert systems are recently set up to improve the Vanuatu Early Warning systems for the hazards concerned; these became the example to other neighboring countries. Therefore the Vanuatu Geohazards is one of the leading agencies for the establishment of the regional networks in the pacific for seismic monitoring and data sharing as well as for volcano monitoring in the Melanesian countries.

**OHP MB2005 based infrasound network for the ARISE project.**

Abstract No.: **P1.7** Authors: **Guillaume Nief,** Denis, Millier

A temporary infrasound network has been installed by the CEA/DASE at the Observatoire de Haute Provence, France (OHP) in the framework of the ARISE project. This network is made of 4 acquisition sites (triangular topology with one centred point) with an aperture of around 3 km. It is operational since July 2012. The measuring chain is composed of MB2005 sensors and TAURUS digitizer connected to a spatial wind noise filtering system rosette type of 32 inlets. The poster will explain the instrumentation specification. Some details will be given about the transfer function of the sensor, metrology procedure at DASE and stability of the low frequency response that allows gravity waves recording in very good conditions. A new digital microbarometer under validation with calibration capability will be at last presented demonstrating the CEA/DASE level of expertise in infrasound technology.

**Middle-atmospheric wind profile measurements with an upgraded version of the ground-based microwave Doppler-spectro-radiometer WIRA.**

Abstract No.: **P1.8** Authors: **Rolf Rüfenacht,** N. Kämpfer, A. Murk, P. Eriksson, S. Bühler

Today, the wind data for the upper stratosphere and lower mesosphere are commonly extrapolated using models or calculated from measurements of the temperature field, but are not measured directly. Still, such measurements would allow direct observations of dynamic processes and thus provide a better understanding of the circulation in this altitude region where the zonal wind speed reaches a maximum. Observations of middle-atmospheric winds are also expected to provide deeper insight in the coupling between the upper and the lower atmosphere, especially in the case of sudden stratospheric warming events. Furthermore, as the local chemical composition of the middle atmosphere can be measured with high accuracy, wind data could be beneficial for the interpretation of the associated transport processes. In future, middle-atmospheric wind measurements could help to improve atmospheric circulation models.

Aiming to contribute to the closing of this data gap the Institute of Applied Physics of the University of Bern built a new ground-based 142 GHz Doppler-spectro-radiometer with the acronym WIRA (WInd RAdiometer) specifically designed for the measurement of middle-atmospheric wind.

First horizontal wind time series of 11 and 10 months have been obtained for mid and high latitudes (Bern, 46°57’ N, 7°26’ E; Sodankylä, 67°22' N, 26°38' E) before the instrument was substantially upgraded for the measurement campaign of the ARISE project at the site of the Observatoire de Haute-Provence (OHP).

Besides a short overview about the technical properties of the instrument our contribution will present time series wind profiles that have been obtained with a novel retrieval approach for wind radiometry based on optimal estimation.

**First results of detection and location of infrasound events in Central Eurasia using data of IS46 Zalesovo station along with data from the new Kurchatov infrasound array in the northeast Kazakhstan.**

Abstract No.: **P1.9** Authors: **Alexandr Smirnov,**

National Nuclear Center of the Republic of Kazakhstan KNDC (Kazakh National Data Center) acquires and processes data from seismic and infrasound stations located on the territory of Kazakhstan and adjacent Central Asia countries. At the present time, KNDC receives data from three infrasound arrays - IS31, IS46 and Kurchatov. The new infrasound array Kurchatov, North-East Kazakhstan, was installed on December 2010; IS46 Zalesovo infrasound array of the IMS located 560 km north-east of it has been operating since 2006. In 2010 – 2011, 38% of infrasound arrivals in REB are from IS46. Most IS46 arrivals associated with mining activity (Green 2011). Automated bulletins of infrasound detections are compiled in KNDC using infrasound stations data. The PMCC detector is used. Epicenters of infrasound events were located by known backazimuths from the stations IS46 and Zalesovo. First results of this technique application showed that data of these two stations allow to locate large number of infrasound sources quite accurately. In future, a database of ground truth events can be compiled for Central Eurasia using origin times for these events taken from seismic bulletins compiled in KNDC.

**Wind surface effects on background noise power of I33MG.**

Abstract No.: **T1.10** Authors: **Andry Ramanantsoa**, Fanomezana Randrianarinosy, Tahiana Rakotoarisoa, Jean Bernardo Andrianaivoarisoa,Gérard Rambolamanana, Alexis Le Pichon, Elisabeth Blanc

Sixty infrasound stations are installed around the world within the framework of the International Monitoring System (IMS). The purpose of these stations is the detection of a nuclear test of more than 1 kiloton, but they also detect infrasound signals from natural sources such as MAW, ocean swells, thunderstorm activities etc. Since 2001, data collected by I33MG has been processed systematically by WinPMCC based on Progressive Multi-Channel Correlation. Wind surface has effects on background noise. It can be expressed by calculating background noise power using recursive filter in different bands of frequency centred at 0.0625 Hz, 0.25 Hz and 1Hz. These bands of frequency are related to natural sources observed by I33MG. Empirical laws are formulated to explain these correlations at first order.

**Short period waves in the Doppler type ionospheric measurements. Ionospheric manifestation of infrasound or geomagnetic micropulsations?**

Abstract No.: **P1.11** Authors: **Tereza Sindelarova**, J. Chum, Z. Mosna, J. Lastovicka, J. Base, F. Hruska

High frequency continuous wave Doppler shift sounding is an effective method for monitoring the ionospheric oscillations of periods from tens of seconds to tens of minutes. Thus, Doppler type sounding is a suitable tool for observations of infrasound in the upper atmosphere. However, the waves do not carry any sign that would distinguish ionospheric infrasound from short period ionospheric oscillations generated by other sources. One of the frequent sources of such oscillations is geomagnetic micropulsations. A good idea how to distinguish ionospheric infrasound from oscillations of geomagnetic origin is to compare ionospheric measurements with records of the local geomagnetic field.

We analysed 2-6 min ionospheric oscillations that occurred on 10 July 2011 between 00:00 and 02:00 UT. Intense convective storms - a potential source of infrasound - were passing over the Czech Republic in the studied time interval on one hand and on the other hand, the Doppler sounding frequency 3.59 MHz was close to critical frequency of the F2 layer (foF2), which forms convenient conditions for observations of ionospheric manifestation of geomagnetic micropulsations.
We included records of local geomagnetic field at geomagnetic observatories Budkov (49°04'N, 14°01'E) and Niemegk (52°04'N, 12°41'E) located nearby our Doppler sounding system (receiver at 50°02'N, 14°29'E) to examine the origin of observed 2-6 min waves. We computed correlations between ionospheric oscillations and fluctuations of geomagnetic field at each geomagnetic observatory and we also computed correlations between geomagnetic fields at both observatories. This method reduces the chance that an incidental local disturbance of geomagnetic record at a single station leads to misinterpretation of studied Doppler records containing infrasound.

**The Swedish-Finnish Infrasound Network.**

Abstract No.: **P1.12** Authors: **Johan Kero,** Ludwik Liszka, Lars Eliasson

Continuous observations of infrasound started in Sweden 1972. Three tripartite microphone arrays in Northern Sweden were later completed with an array in Uppsala. In 1996 the system was upgraded with new microphones and from single frequency 2 Hz recording to broad-band 0.45–9 Hz digital recording. The Uppsala-array was moved in 2006 to Sodankylä, Finland starting the Swedish-Finnish Infrasound Network (SFIN), a co-operative project between the Swedish Institute of Space Physics and the Sodankylä Geophysical Observatory. The data collected by SFIN are accessible for the scientific community on the internet.

**Rayleigh lidar: New instrument in La Réunion and other prospectives.**

Abstract No.: **P1.13** Authors: **Philippe Keckhut,**

ABSTRACT MISSING

**Rayleigh lidar: Stereoscopic imaging of the hydroxyl emissive layer.**

Abstract No.: **P1.14** Authors: **Guy Moreels,** Nadjib Kouahla, Michaël Faivre, Jacques Clairemidi, Michel Hersé

Observatoire des Sciences de l'Univers, Institut UTINAM/CNRS, 41 bis avenue de l'Observatoire, 25000 Besançon, France

The hydroxyl nightglow emissive layer is an excellent tracer of the dynamical processes propagating in the atmosphere at the mesospheric level. CCD images in the near infrared taken from the ground at slant angles reveal the presence of wave fields extending over areas larger than ~1000 km. The dynamic parameters are typically the following : horizontal wavelengths ~20-40 km and temporal periods ~15-30 min. An oxygen-hydrogen model is used to evaluate the response of the emissive layer to a progressive density wave. It shows that the altitude of the layer is slightly modulated with an amplitude of 0.8-1.8 km. A stereo-imaging observational program was conducted at two sites distant of 600 km. Simultaneous near-IR images were taken in opposite directions at an elevation angle of 18° over the horizon. The relief altitude map of the emissive layer is retrieved in calculating the normalized cross-correlation coefficient of both images. It clearly shows the periodic perturbation of the nightglow layer resulting of the propagation of the density wave.

**Detecting infrasound modulation of airglow emissions – a technique for remote sensing of the Earth's upper atmosphere.**

Abstract No.: **P1.15** Authors: **Andrew Wilson,** Frank Mulligam

Infrasound (0.003 Hz – 20 Hz) monitoring offers the potential to study the atmosphere through the propagation of sound waves from both natural and artificial sources. Disturbances in the troposphere can be amplified to significant wavelength in the upper atmosphere due to the exponential decrease in density with altitude. Geo-hazards are one source of infrasound. Waves propagating from such hazards at the speed of sound can reach distant locations before the arrival of the hazard itself thus utilizing infrasound as a method of early warning as well as detection.

Although acoustic waves can be ducted and refracted they can also propagate vertically through the atmosphere and can interact with regions of the upper atmosphere which may otherwise difficult to access. The coldest layer in the atmosphere known as the mesopause (mean altitude ~ 87 km) is one such region. Airglow emanating from the mesopause offers the possibility to detect the propagation of infrasonic waves. The brightest airglow emission originating in the mesopause comes from the hydroxyl OH* radical. Cascading transitions down from the 9th vibrational state of this radical creates emission in the near infrared.

Infrasound monitoring at NUI Maynooth employs a radiometer which records airglow brightness in the wavelength range 1.2-1.6 μm at high temporal resolution (10 Hz) during the night. It is fitted with a thermoelectrically cooled Indium Gallium Arsenide (InGaAs) detector and a tuning fork chopper. The chopper provides a reference for a lock-in amplifier to perform phase sensitive detection. Fourier and wavelet analysis of the resultant time series data enables dominant frequencies to be detected. Correlation of the time series data with seismometer data may help to identify potential sources of the dominant periodicities. Details of the instrument, analysis and preliminary results will be presented.

## SESSION 2

**Long-term trends in winds and atmospheric waves in the middle atmosphere.**

Abstract No.: **P2.1** Authors: **Jan Lastovicka,**

Long-term changes in greenhouse gas concentrations, stratospheric ozone content and probably also some other parameters evoke long-term trends in the middle atmosphere. Trends have been studied mostly in temperatures, less in winds and atmospheric wave activity. Very little is known about trends in winds in the stratosphere. In the mesosphere and, particularly, in the mesopause region the trends in winds are significantly different for different regions. Based on satellite data, a global map of stratospheric gravity wave activity was established, which displayed "hot spots" of gravity wave activity like southern Andes and Antarctic Peninsula. However, little is still known about trends. There are some studies on long-term behavior of planetary wave activity in the stratosphere. In the mesosphere, rather little is known about trends in wave activity but available information suggest that all three types of waves, gravity, tidal and planetary, have regionally different trends (if any). Change of the trend of the NH midlatitude stratospheric ozone in the mid-1990 (1995-1997) is known to affect significantly trends in temperatures; in winds and waves this effect seems to be less pronounced. Brief information about trends in winds and atmospheric wave activity in the middle atmosphere will be presented.

**Towards understanding the sources of gravity waves at mid and high latitudes.**

Abstract No.: **P2.2** Authors: **Sergey Khaykin,**

COSMIC GPS satellite temperature data are used to derive the potential energy Ep of gravity waves with vertical wavelength less than 7 km at mid and high latitudes. In search of the gravity wave sources, the spatiotemporal variability of Ep is compared against various parameters, such as ERA-Interim wind speed and divergence, convective precipitation and thunderstorm activity around Observatorie d'Haute Provence. Wave activity is shown highly correlated with the local wind divergence suggesting generation of waves by geostrophic adjustment of unbalanced flow or jet dynamics. Examples of tropospheric and stratospheric wave generation are provided. No apparent correlation is found between Ep and convective precipitation or thunderstorm activity, which might be due to incapability of COSMIC temperature observations to detect small-scale gravity waves, generated by local synoptic events. The enhancements of potential energy in the Arctic winter stratosphere are shown related to polar vortex dynamics during sudden stratospheric warming (SSW) events, suggesting planetary wave activity as a source for gravity waves.

**Simultanous observations of infrasound thunders and electrostatic field: Discussion to infrasound production.**

Abstract No.: **P2.3** Authors: **Jaroslav Chum**, J. Laštovička, T. Šindelářová, G. Diendorfer, D. Burešová, J. Baše, F. Hruška

We present observations of narrow (~1–2 s) infrasound pulses that followed, with ~11 to ~50 s delays, rapid changes of electrostatic field during thunderstorm activity in the Czech Republic. A positive pressure fluctuation (compression phase) always preceded decompression; the compression was usually higher than the decompression. The angles of arrival (azimuth and elevation) were analyzed for selected distinct events (infrasound thunders) using an array of 3 microbarometers. Comparisons of distances and azimuths from the center of microbarometer array with lightning locations determined by EUCLID lightning detection network show that most of the selected events can be very likely associated with intra-cloud (IC) discharges. Dominant frequencies (from ~0.25 to ~3 Hz) of the infrasound thunders, preceding rapid changes of electrostatic field, their potential association with IC discharges, and high elevation angles of arrival for near infrasound sources (~4–7 km) indicate that an electrostatic mechanism is probably responsible for their generation. It is discussed that none of published models of electrostatic production of infrasound thunder explains the presented observations precisely, and that a modification of the current models, probably based on consideration of at least two charged layers, and further theoretical and experimental investigations are needed to get better description of the generation mechanism.

**Acoustic-Gravity waves in the ionosphere from multi-point Doppler sounding.**

Abstract No.: **P2.4** Authors: **Jaroslav Chum,** J. Laštovička, T. Šindelářová, G. Diendorfer, D. Burešová, J. Baše, F. Hruška

We present results of investigation into propagation of Gravity Waves (GWs) in the ionosphere obtained by multi-point Continuous Doppler sounding system that was installed in the Czech Republic, South Africa and Argentina. Simultaneous measurements of near-by ionosondes are used to estimate reflection heights of the Doppler system. Most of the waves are observed at altitudes from ~150 km to ~250 km, i.e. mainly in the F layer.

Our statistical study of small-scale GWs shows that most frequently observed horizontal velocities of GWs are from ~100 to ~150 m/s. In mid-latitudes (Czech Republic and Western Cape in South Africa), the analyzed GWs propagated roughly against the neutral winds obtained from the HWM07 model, so the intrinsic velocities were about 30 to 70 m/s higher than the observed velocities. The propagation directions of GW showed seasonal and diurnal dependence. The analyzed waves propagated roughly poleward in the local summer, whereas approximately equatorward propagation dominated in the local winter. The estimated horizontal wavelengths of the analyzed waves are ~100–300 km. In the northern Argentina (Tucuman region), in the vicinity of Andes, the seasonal (diurnal) dependence has not been observed; the observations however show clear preference for Northward or Southward direction of propagation.

An additional Doppler sounding system operating at another frequency was installed in the Czech Republic by the end of 2012. Different reflection heights of different operating frequencies make it possible to analyze GW propagation in 3D. The preliminary results show that wave vectors have mostly downward oriented vertical components, indicating an upward flow of energy. Unfortunately, the uncertainties in determining the values of vertical components of wave vectors have usually been large, often higher than their absolute values. The investigation is continuing.
Another Doppler sounding system will be installed on Taiwan in 2013.

**Tentative Polar Low detection and tracking using Infrasounds, Satellite images and Lightning localization : Results, Discussions and Questions.**

Abstract No.: **P2.5** Authors: **Francis Dalaudie,** Guo Quan

This poster is a progress report about possible detection and tracking of a polar low using infrasound signals. Initial investigation and findings were reported on a poster during previous ARISE meeting. A short account for this previous work will be given in order to set the context. Further progresses allow assigning an anisotropic probability distribution to the geographical localizations obtained from two infrasound stations. However, analysis of the elevation of received infrasound, associated with angular error estimation, suggest that the infrasound propagation from the polar low to the receiving station is impossible. This problem, joined with the long persistence (more than one day) of the received signal after the end of the "associated" polar low, as reported by satellites images, pushes to question the very nature of this signal.

**Lidar and SkYiMET meteor radar GW variances comparison at low latitudes**

Abstract No.: **P2.6** Authors: **P. P. Batista**,

Na LIDAR and SkYiMET meteor radar observations of the Mesosphere/Lower Thermosphere region (MLT) were made over a 2-year period at Sao Jose dos Campos (23° S, 46° W) and Cachoeira Paulista (22,7°S, 45,0°W), respectively. The Na LIDAR data yielded temperature profiles that were used to estimate the buoyancy frequency allowing us to estimate the RMS horizontal winds. We also estimate the RMS horizontal wind amplitudes for the meteor radar by Hocking's technique (see details in Hocking, 2005). Estimates of the RMS horizontal winds from concurrent radar and LIDAR measurement were obtained on 76 nights. These two sets of RMS wind estimates are processed by a common method. The analysis yields vertical profiles of the RMS winds which were found not to grow exponentially with altitude, indicating that the gravity wave field is saturated throughout this altitude region. Both techniques reveal a semiannual variation with maximum RMS horizontal winds at the equinoxes. The meteor radar estimates are systematically larger than LIDAR estimates at higher altitudes.

**Stratospheric processes as measured by collocated Lidar and infrasound measurements.**

Abstract No.: **P2.7** Authors: **Alexis Le Pichon,** E. Blanc, L. Ceranna, C. Pilger, P. Keckhut, A. Hauchecorne, R. Rüfenacht , N. Kämpfer, C. Schmidt, M. Bittner, S. Wuest

To better initialize weather forecasting systems, a key challenge is to understand stratosphere-resolving climate models. The ARISE project aims to design a novel infrastructure integrating different atmospheric observation networks to accurately recover the vertical structure of the wind and temperature from the ground to the mesosphere. This network includes Lidar and mesospheric airglow observations, complemented by continuous ground-based infrasound measurements. It will help to better describe the interaction between atmospheric layers from the ground to the mesosphere and the influence of large scale waves on the atmospheric dynamics. Systematic multi-year comparisons between Lidar soundings at several stations part of the international Network for the Detection of Atmospheric Composition Changes (NDACC) and ECMWF models are performed. Below 50 km altitude, they highlight differences as large as ~20°K, more specifically during stratospheric warming events. At some sites, comparisons with collocated infrasound measurements provide additional useful integrated information about the structure of the stratospheric waveguide. We investigate possible correlation between unexpected infrasound propagation paths and unresolved atmospheric perturbations in the stratosphere. Such collocated observations from different complementary sounding techniques offer a unique opportunity to provide detailed information on upper atmospheric processes from seasonal to daily scales and study their interaction with the mean circulation.

**Characteristics of gravity waves during tropical cyclone events in ECMWF analyses.**

Abstract No.: **P2.8** Authors: **Fabrice Chane Ming,**

Now, current operational numerical weather prediction models are likely to produce high-quality analyses in the UT/LS. Indeed, high-quality temperature information in ECMWF data is now provided in the UT/LS, more particularly in the southern hemisphere, ever since the assimilation of GPS radio occultation bending angles beginning in late December 2006 and thus tropical cyclones (TCs) are better described. The ECMWF global model is capable of resolving a large fraction of the observed stratospheric inertia-gravity wave spectrum with horizontal wavelengths >100 km and vertical wavelengths <2 km. So the present study focuses on characteristics of TC-related GWs in the southern west-Indian basin for TC seasons between 2006 and 2011.

**Some characteristics of West African wind observed with a wind profiler VHF radar.**

Abstract No.: **P2.9** Authors: **Bodoun Etienne HOUNGNINOU,** H. KOUGBEAGBEDE, B. CAMPISTRON

Rainfall variability in West Africa has socio-economic and environmental impacts on the region (Nicholson 1981, 1993, Quan et al. 2003; Messenger et al., 2004; Afiesimama et al. 2006; Abiodun et al. 2008). This variability is partly related to the disruption of existing jets. To understand this variability proper, it would be necessary to know the local and global characteristics of the atmospheric circulation in the region. This work aims at highlighting the vertical profile of the winds in the troposphere and the tropopause profile in North Benin, observed by VHF wind profiler radar used from 2006 to 2007 during the African Monsoon Multidisciplinary Analysis (AMMA) campaign. The radar was installed in Djougou precisely in Nangatchori (9.7 ° N, 1.7 ° E) and observed hourly vertical wind profile between 2 and 16km altitude and the altitude of the tropopause. The Analysis on an annual cycle (May 2006 to April 2007) of the data obtained during this campaign shows the real existence of the West subtropical jet, about 10 m/s at 10 km altitude during gradual drying period. Similarly, the East African Jet has been obtained at 3km altitude with a maximum average speed of 14 m/s observed in June during the wet period. During the same period of observation, the East Tropical Jet located at altitude of 10km with 10 m/s appears in August. As per the tropopause, it amounts the average of 11km in altitude from May to December and then increases up to 17 km altitude average from January to April.

**Vertical distribution of gravity wave potential energy from long-term Rayleigh lidar data over OHP (43.93° N, 5.71° E).**

Abstract No.: **P2.10** Authors: **Nahoudha Mzé,** A. Hauchecorne, P. Keckhut, M.Thétis

Rayleigh lidar provides vertical profiles of the total density of the atmosphere from about 30km to 90km depending on the signal-to-noise ratio. In order to have access to perturbations with shorter time and vertical scales, at least on a statistical sense, we analyse lidar signals with a variance method. This method is based on the computation of the signal perturbations for short time and vertical intervals and on the summation of the square of these perturbations over a large number of elementary intervals, which give an estimation of their variance. We present an estimation of the gravity wave potential energy in the middle atmosphere at Haute-Provence Observatory (OHP) by the use of a simple and robust method. This study investigates 19 years of measurements and the results of the climatology, seasonal changes and inter-annual variability are reported.

**SESSION 3**

## Location of space debris by infrasound.

Abstract No.: **P3.1** Authors: **Vladimir Asming,** Yuri Vinogradov

After an exhausted stage has separated from a rocket it comes back to the dense atmosphere. It burns and divides into many pieces moving separately. Ballisticians can calculate an approximate trace of a falling stage and outline a supposed area where the debris can fall (target ellipse). Such ellipses are usually rather big in sizes (something like 60 x 100 km).

For safety reasons all local inhabitants should be evacuated from a target area during rocket's launch. One of problems is that the ballistician can not compute the traces and areas exactly. There were many cases when debris had fallen outside the areas. Rescue teams must check such cases to make changes in rockets. The largest pieces can contain remains of toxic rocket fuel and therefore must be found and deactivated.

That is why the problem of debris location is of significant importance for overland fall areas. It is more or less solved in Kazakhstan where large fragments of 1st stages can be seen in the Steppe but it is very difficult to find fragments of 2nd stages in Altai, Tomsk region and Komi republic (taiga, mountains, swamps).

The rocket debris produces strong infrasonic shock waves during their reentry. Since 2009 the Kola Branch of Geophysical Survey of RAS participates in joint project with Khrunichev Space Center concerning with infrasound debris location. We have developed mobile infrasound arrays consisting of 3 microphones, analog-to-digit converter, GPS and notebook. The aperture is about 200 m, deployment time is less than 1 hour. Currently we have 4 such arrays, one of them is wireless and consists of 3 units comprising a microphone, GPS and radio-transmitter.
We have made several field measurements by 3 or 4 such arrays placed around target ellipses of falling rocket stages in Kazakhstan ("Soyuz" rocket 1st stage), Altai and Tomsk region ("Proton" rocket 2nd stages). If was found that a typical 2nd stage divides into hundreds of pieces and each one generates a shock wave. This is a complicated problem to associate signals registered by different arrays.

We developed an approach based on modeling of realistic fragment trajectories. We assume that until some time t0 all stage is moving along the predicted theoretical trajectory. At the time t0 (disintegration) the pieces receive different ballistic coefficients and random increments of velocity. We continue the trajectory (solving 2nd order differential equation) using the coordinates at t0 and velocities with random increments as initial conditions and with different ballistic coefficients. Thus we obtain a 'pipe' of trajectories each one can in principle occur in reality. For each trajectory of the pipe we compute theoretical times and azimuths of shock wave arrivals to the arrays. If they are in agreement with the measured arrivals we consider that the trajectory has occurred in reality and its end is the landing place of a rocket fragment.

The experiment of "Soyuz" 1st stage location in Kazakhstan has shown that errors of such location are less than 2 km that is acceptable to use the method in practice.

**Near-real time integration of the infrasound network performance predictions to improve infrasonic source detection.**

Abstract No.: **P3.2** Authors: **Aurélien Dupont,** Le Pichon

Our work is focused on the detection of infrasonic sources on dense infrasound arrays (i.g. USArray). The detections are made using the Reverse Time Migration algorithm. We show how this robust method can be improved if taking into account frequency dependent attenuation relations of Le Pichon et al. (2012) which combine a near-field and far-field term, and the effects of both geometrical spreading and absorption. This approach incorporates the daily ECMWF specifications and provides a realistic physical description of long-range infrasound propagation. This optimization will help to built a large reference event database, repetitive or permanent, well constrained in space and time which could be included in the ARISE reference database and used also as remote sensing infrasound inversion methods.

**Lightning characterization through acoustic measurements.**

Abstract No.: **P3.3** Authors: **Louis-Jonardan Gallin,** François Coulouvrat, Thomas Farges, Régis Marchiano

Lightning generated acoustic shock waves are the most frequent natural explosion like signals: they are good candidates to probe meteorological local properties of the acoustic propagation medium over distances of less than 100 km. The goal of my work is to study the transformation the thunder undergoes (amplitude, spectrum) during its travel from the lightning channel towards a detector (microphone, microbarometer). The work is based on two complementary approaches. First, simulations of acoustic propagation using the Flhoward software (UPMC), designed to simulate the propagation of acoustic shock waves through a realistic atmosphere model (including temperature gradients, rigid ground, and winds) will be performed with different configurations relative to the complexity of the lightning channel geometry and temperature change. Secondly, acoustic measurements (audible signals and infrasounds) recorded during strong thunderstorms in the frame of the HYMEX campaign (Autumn 2013) will be analyzed . The results of data analysis and simulation will be compared to better characterize the lightning properties.

**Analysis of infrasound event of NPE 2012 at Turkish NDC using PMCC.**

Abstract No.: **P3.4** Authors: **Cem Destici,** N.M. Ozel, K.U. Semin O. Necmioglu, S. Kocak, U. Teoman

National Data Preparedness Exercises (NPE) are important events for National Data Centers (NDC) representing Signatory Member States of the Comprehensive Nuclear Test Ban Treaty (CTBT) opened for signature on 24 September 1996. The CTBTO verification system is under continuous development, also making use of the state of the art technologies and methodologies. In light of the underground nuclear explosion test conducted by the Democratic People's Republic of Korea in 2006, NDCs felt the need to conduct independent tests regularly to assess their readiness and to evaluate the processing and analysis procedures required for the analysis of suchevents.

The Turkish NDC, having also participated in the earlier NPEs, also participated in NPE12 by making use of all available technologies, namely Seismic, Infrasound and Radionuclide. The analysis of the Infrasound data carried out with PMCC software provided by CEA-France whereas the Radionuclide and the seismic analysis were performed using the PTS provided software WebGrape and Geotool. The possible events had infrasound detections, such as at the Russian Federation IMS station I46RU, which were interpreted as indication of a man made mining or quarry explosion. The seismic and infrasound data were requested from IDC using the AutoDRM, and analysed with Geotool and PMCC respectively. The analysis indicated that the events occurred on May 6 (05/06/2012 04:51, 05/06/2012 06:44) are the best possible sources for the NPE2012.

**The Russian meteor impact of 2013 as seen from Israel.**

Abstract No.: **P3.5** Authors: **David Applbaum,** Roy Yaniv, Colin Price

The impact and break-up of a meteor over Russia on February 15th was the largest infrasonic event ever recorded by the International Monitoring System of the Comprehensive Nuclear Test Ban Treaty Organization. As part of our project to determine how major events manifest themselves in the data collected from the two infrasound stations in Israel, we attempt to locate this event in our data. In this way, we hope to continue to make progress towards examining the efficacy of our monitoring system, and to suggest what improvements might be made.

**3D Lattice-Boltzmann strategies: New insights into Volcanic Jet Dynamics and Infrasound.**

Abstract No.: **P3.6** Authors: **Federico Brogi,** C. Bonadonna, M. Ripepe, B. Chopard

Recent studies highlighted the great potential of infrasound measurements for real time detection of volcanic plume source parameters [Ripepe, 2013]. This is especially relevant in the case of bent over plumes, where the relation between mass eruption rate and plume height is made more complex by the interaction with the surrounding wind field and classical formulation do not apply. Pressure variation detected through acoustic data could be used to determine the exit velocity of the gas jet, which can be related to mass eruption rate, based on the geometric constrain of the vent and the mixture density. However, a source theory for volcanic infrasound is far from being complete. Woulff and McGetchin [1976], based on classical source model theory, proposed that the turbulence within small-scale volcanic jet may act as quadrupole source or as dipole source if solid particles or boundaries are present. Although large Vulcanian and Plinian eruptions can be seen as the result of a turbulent free-shear-jet flow, sound radiation pattern measurements has proven challenging and have shown poor scaling between acoustic and eruption intensity [Matoza, 2009; Johnson, 2005]. A better knowledge of the link between the acoustic radiation and actual volcanic fluid dynamics processes is required. New insigths in this subject could be given by the study of realistic areoacustics numerical simulation of a volcanic jet. Lattice Boltzmann strategies provide the opportunity to devolop an accurate, computationally fast, 3D physical model for a volcanic jet and wave propagation [Chopard, 2002]. Our work mainly focuses on developing and validating such numerical model to determine when and how classic model source theory can be applied to explain volcanic infrasound data.

B. Chopard, et al. Cellular automata and lattice boltzmann techinques: An approch to model and simulate complex system. Advances in Complex Systems, pages 103–246, 2002.
G. Woulff and T. McGetchin. Acoustic noise from volcanoes: theory and experiment. Geophysical Journal of the Royal Astronomical Society, 45(3):601–616, 1976.
R. S. Matoza, et al. Infrasonic jet noise from volcanic eruptions. Geophysical Research Letters, 36(8), Apr. 2009.
J. B. Johnson, et al.. Poor scaling between elastic energy release and eruption intensity at Tungurahua Volcano, Ecuador. Geophys. Res. Lett., 32(15):L15304–, Aug. 2005.
M.. Ripepe, C Bonadonna, A. Folch, D. Delle Donne, G. Lacanna, E. Marchetti, A. Höskuldsson. Ash-Plume Dynamics and Eruption Source Parameters by Infrasound: the 2010 Eyjafjallajökull Eruption, Earth and Planetary Science Letters, 2013.

**Numerical simulation of acoustical shock wave in turbulent atmosphere.**

Abstract No.: **P3.7** Authors: **David Luquet,** François Coulouvrat, Régis Marchiano, Institut Jean le Rond d'Alembert

We will present the development of a three dimensional parallel software for simulating non linear acoustic propagation through the atmosphere taking into account local meteorology. First results for the two dimensional parallel version of the code will be discussed.

**Multi year Etna Volcano Monitoring.**

Abstract No.: **P3.8** Authors: **Mohamed Kallel**

The International Monitoring System (IMS) technologies can have civil and scientific applications other than its primary mission which is the verification of the Comprehensive Nuclear-Test-Ban Treaty (CTBT). One of those applications is volcano Monitoring. The Italian volcano Etna is one of the active volcanoes in the world and its activity is detected by more than one IMS station such as IS48, which is located in Tunisia and is about 550KM away from Etna. In this Poster, we will present some of the NDC-TN results pertaining to the Etna activity monitoring over many years. We will try to show the general trend in signal backazimuth between winter and summer and the effect of the seasonal reversal of the stratospheric winds.

**A Ground Truth Database of Seismo-Acoustic Events in Northern Europe.**

Abstract No.: **P3.9** Authors: **Steven J. Gibbons,** Tormod Kværna

The international network of infrasound sensors records a continuous datastream containing signals from events of both known and unknown origin. For events of known origin, i.e. with the location and time well-determined, we are able to validate and improve upon our characterization of the wind and temperature structure of the atmosphere, since we can compare directly infrasonic observations with model predictions. For events of unknown origin, such as unannounced or accidental explosions or extreme natural phenomena, infrasound should ideally be exploited to locate the event(s) in time and space and to characterize the source(s). The ability to do this will clearly improve with an improved atmospheric specification and modeling capability.

"Ground Truth", or GT, denotes events for which the origin time and source location are known. Calibration experiments (explosions of specified yield, time and location) have been performed in order to validate atmospheric specifications and propagation models and to investigate the detectability of infrasound over networks. However, such explosions are extremely expensive to execute and so can only sample the evolving atmosphere on a very limited number of occasions. Fortunately, many other types of explosions occur regularly. These include detonations of expired ordnance by militaries and routine quarry blasting. There are many such sources in northern Europe which generate infrasound signals detected at distances from many hundreds to several thousands of kilometers, but which also generate seismic signals which have been recorded by stations in Fennoscandia for over 25 years. The seismic signals generated by events at a given location, recorded on any given seismometer, are like a fingerprint for that source region and pattern recognition methods (e.g. waveform correlation and Empirical Matched Field Processing or EMFP) can attribute a signal to a particular source given sufficient calibration information. The seismic signals can constrain the event origin time to within under a second and the source location to within a few hundred meters, depending upon the a priori information available.

Events at repeating sources have been characterized as far back as 1987 when data from the ARCES seismic array first became available. For some known sources, such as the ammunition destruction blasts at Hukkakero in Northern Finland, many hundreds of explosions have been identified using simple correlation detectors on the seismic waveforms. For ripple-fired quarry blasts, such as the large explosions at Khibiny and Olenegorsk on the Kola Peninsula, correlation detectors struggle due to the dissimilarity between waveforms from subsequent explosion sequences. However, EMFP identifies the source of these events very effectively based upon the spatial characteristics of the seismic wavefronts over arrays. Infrasound observations on the network of arrays in Fennoscandia have revealed several new sites (all open-cast mining operations) which have been identified using a combination of careful seismic network event location, commercial satellite imagery and published documentation from the mine operators. This work has been performed under the ARISE (Atmospheric dynamics Research InfraStructure in Europe) Design Study project funded by the FP7 European Commission under the Capacities Programme.

**NATURAL SOURCES DETECTED BY I33MG.**

Abstract No.: **P3.10** Authors: **Fanomezana Randrianarinos,** Fanomezana Randrianarinosy, Tahiana Rakotoarisoa, Jean Bernardo Andrianaivoarisoa,Gérard Rambolamanana, Alexis Le Pichon, Elisabeth Blanc

Madagascar IMS infrasound station I33MG has operated and collected data since 2001. The detection of the station is dominated by 3 natural sources each specified by their own frequency band. From 0.015 to 0.1 Hz, the main source detected is the mountain associated waves (MAW) generated as hydrodynamic infrasound in the turbulent wind-stream in the lee of high mountain range; from 0.1 to 0.5 Hz, we have signals from ocean swells commonly called microbarom and for a frequency higher than 0.5 Hz the station detects signals from thunderstorm activities such as lightning or sprite occurring in Madagascar and the surrounding region. WinPMCC based on the Progressive Multi-Channel Correlation (PMCC) is used to process data. MAW and thunderstorm activities are mostly observed during austral summer but microbarom is present all over the year.

**Use of the Plostina infrasound array to monitor extreme events generated by natural and anthropogenic acoustic sources.**

Abstract No.: **P3.11** Authors: **Daniela Ghica,** Constantin Ionescu, Bogdan Grecu

Plostina infrasound station is a 2.5-km aperture array deployed in the central part of Romania and consisting of 6 elements. Since January 2013, all array instruments are Chaparral Physics microbarometers. The infrasound array is part of an integrated monitoring system, which also includes seven seismic elements (3C BB sensors and accelerometers), three 3C magnetometers, an electrometer and a weather station. Seismo-acoustic data and information on electric, magnetic and electromagnetic fields are continuously collected and real-time transmitted to the Romanian NDC, in Magurele.

The infrasound array is used for the monitoring of various acoustic sources such as naturally occurring geophysical phenomena (volcanoes, earthquakes, thunderstorms) and man-made events (chemical explosions, mine and quarry blasts). We present several examples of such extreme events detected and identified using infrasonic data, together with atmospheric and electric records. Applying the DFX-PMCC detector, the acoustic signals from accidental explosions (ammunition depot in Bulgaria and regional gas pipeline in Russia), eruptive episodes of Etna volcano, regional mining blast (Turkey), local quarry blasts (Dobrogea), and strong thunderstorms observed at Plostina site, were detected and characterized.