CO, NMVOCs, NOx, SO2, aerosols, and NH3 also directly or indirectly affect the radiative balance of the atmosphere. Among both sets of gases are precursors of and contributors to pollutants such as tropopospheric ozone, itself a strong greenhouse gas, particulate matter, and other pollutants that affect human health. Fossil fuel combustion, production, or transportation is a significant source for many of these substances. Climate policy can thus affect traditional air pollution or air pollution policy can affect climate. Health effects of acute or chronic exposure to air pollution include increased asthma, lung cancer, heart disease and bronchitis among others. These, in turn, redirect resources in the economy toward medical expenditures or result in lost labor or non-labor time with consequent effects on economic activity, itself producing a potential feedback on emissions levels. Study of these effects ultimately requires a fully coupled earth system model. Toward that end we develop an approach for introducing air pollution health impacts into the Emissions Prediction and Policy Analysis (EPPA) model, a component of the MIT Integrated Global Systems Model (IGSM) a coupled economics-chemistry-atmosphere-ocean-terrestrial biosphere model of earth systems including an air pollution model resolving the urban scale. This preliminary examination allows us to consider how climate policy affects air pollution and consequent health effects, and to study the potential impacts of air pollution policy on climate. The novel contribution is the effort to endogenize air pollution impacts within the EPPA model, allowing us to study potential economic effects and feedbacks. We find strong interaction between air pollution and economies, although precise estimates of the effects require further investigation and refined resolution of the urban scale chemistry model.

U31A-05 0925h

Local benefits of greenhouse gas mitigation in Mexico City

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For Mexico City, we estimate public health improvements due to air pollution reductions that could occur simultaneously with greenhouse gas emission mitigation, and we compare the costs and benefits of 5 specific policy measures. Reduced-form air quality models are used to calculate the impacts of changed emissions on exposure. Dose-response methodology is applied to estimate public health improvements, and several valuation metrics are applied to determine the monetized health benefits to society of the control measures. Implementation of these 5 measures in Mexico City could reduce annualized exposure to particulate air pollution by 1% and to maximum daily ozone by 3%, and also reduce greenhouse gas emissions by 2% (more than 300,000 tons C equivalent per year). We estimate that over 4400 quality-adjusted life-years (QALYs) per year could be saved, with monetized health benefits on the order of $200 million USD per year. In contrast, total costs are under $70 million USD per year. The mean cost per QALY is under $40,000. Of the measures considered, those that improve transportation efficiency are most promising for the simultaneous reduction of local and global pollution in the region.

URL: http://www.ine.gob.mx/dgicurg/cclimatico/benlg.html

U31A-06 0945h

A Synoptic Climatological Approach to Assess Possible Impacts of Climate Change on Human Mortality in South Central Canada

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Synoptic climatological approaches were used in this study to determine the synergistic impacts of severe weather and air pollution on excess mortality risks in south-central Canada. The derived relationships based on the past and current conditions were then used to determine the potential impacts of climate change on human mortality risks. This study used principal components analysis, an average linkage clustering procedure, and discriminant function analysis to automatically classify distinctive synoptic categories based on the differentiations and similarities of meteorological characteristics between and within weather types. Meteorological data for 1953-2001 were used in the analyses. The data included hourly surface observations of air temperature, dew point temperature, sea-level air pressure, total cloud cover, wind speed and direction. Three atmospheric levels of 6-hourly NCEP-NCAR upper-air reanalysis weather variables (air and dew point temperatures, wind speed and direction) were used for the period 1958-2000. Air pollution data, including O3, SO2, NO2, CO and COH, was retrieved from the National Air Pollution Surveillance (NAPS) network for the period 1974-2000. Mortality data from Statistics Canada included the daily total non-traumatic mortality (e.g., ICD-9: 001-799) for the period 1950-1998. The study area included 3 cities in Ontario (Toronto, Ottawa and Windsor) and 1 city in Quebec (Montreal). Using the above procedures, 14-20 major synoptic types were identified for the selected weather stations during both warm (Apr.-Sep.) and cold seasons (Oct.-Mar.). The statistical procedure was able to successfully identify 8-12 weather types (depending upon location), that were associated with high mortality rates. Excess mortality within the identified synoptic weather types were shown to be associated with temperature extremes (heat and cold) and air pollution. Using GCM outputs and statistical downscaling methods, discriminant function analysis was then used to estimate the projected frequencies of excess mortality-related weather types for future climate scenarios. Climate change scenarios from the Canadian GCMs (CGCM1 and CGCM2) and the U.S. GCM (GFDL R30 Coupled Climate Model) for the periods 2040-2059 and 2070-89 were used in the analysis. For estimation of the future air pollution conditions, there are two methods: 1) discriminant function analysis is able to assess the projected frequencies of weather types associated with high air pollution concentrations for the future climate change scenarios; 2) the downscaled climate change scenarios were applied to the historical regression models to estimate the future projected concentrations. The expected mortality rates due to modeled global warming and pollutant effects for both warm and cold seasons can then be estimated for the selected cities.

U31B MCC: Level 1 Wednesday 0830h

Recent Infrasound Studies, Phenomena, and Development I Posters

Presiding: **C Wilson,** Geophysical Institute, University of Alaska, Fairbanks**; L Liszka,** Swedish Institute of Space Physics

U31B-0001 0830h POSTER

Infrasound Signals from the Space Shuttle Columbia

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Infrasound signals from the shuttle Columbia were observed at the TXAR infrasound array on 1 February 2003. TXAR is in far Southwest Texas about 6oo km south of the shuttle's track across the panhandle of Texas. The signals were compared with those from STS 78 (7 July 1996) which had on almost identical track to Columbia (STS 107). Whereas the STS 78 signals had the characteristics of acoustic arrivals from a decaying N-Wave, the signals from STS 107 showed a number of sharp peaks superimposed on a background similar to the STS 78 data. Using a cross-correlation method, we estimated the back azimuths for eight of the peaks, and they agreed within ± 1 degree. We thus concluded that the peaks were multiple arrivals from a single explosive source. By crossing the mean back azimuth with the well known track of STS 107 we were able to determine the following parameters for the explosion. Location : 33.85 N, 101.92 W ± 20 km Time: 13 56.65 Z $\pm$ 0.1 min Height: 63.3 km Speed: Mach 16. Z Having the source location and time we were able to simulate the signals expected at TXAR using the InfraMAP program from BBN. This simulation showed arrivals that agreed with several of the observed impulsive signals to within a few seconds out of a total travel time of about 2000 seconds. The yield of the explosion was estimated using on AFTAC empirical formula based upon the dominant period of the signals, corrected for the elevation of 63.3 km. The estimated yield is 2 lbs. (0.9 kgm) HE (TNT). Because the signal to noise ratios for the observed arrivals at TXAR were large, we conclude that rocket experiments at White Sands involving explosions with yields of the order of 10 lbs at a height of 60 km should provide controlled infrasound sources that could be observed at a number of infrasound arrays.

U31B-0002 0830h POSTER

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Seismo-acoustics, VLP and ULP signals, and other comparisons of surface broadband and CALIPSO borehole data at Soufriere Hills Volcano, Montserrat, B.W.I.

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Project CALIPSO (Caribbean Andesite Lava Island-volcano Precision Seismo-geodetic Observatory) investigates with borehole and surface instruments the magmatic system at the very active Soufriere Hills Volcano (SHV), Montserrat, supplementing surface monitoring systems of the Montserrat Volcano Observatory, and those of other institutions including PSU and U Ark. Many aspects of andesitic magmatic system dynamics remain little understood despite significant monitoring and research efforts, and CALIPSO is expected to improve our understanding of SHV and of andesitic magmatic systems generally. As an example of such studies, we examine data from the 12-13 July 2003 major lava dome collapse and eruption of SHV. The analyses illustrate the opportunity to evaluate seismic and volumetric strain signals in very-long period (VLP, $\sim$10 s) and ultra-long period (ULP, $\sim$100 s) ranges, as well as the long period (LP, $\sim$1 s) and short period ($\sim$0.1 s) ranges typically considered. The strainmeters act as very-broad-band instruments, and not only detect quasi-static strain changes, but also dynamic strains equivalent to the response of a volumetric seismometer from high frequencies to ULP. Waveforms from several broadband seismometers and three strainmeters installed around the volcano indicate VLP and ULP signals in association with the explosive events. Additional information is derived from infrasonic microphones installed at two PSU surface broadband stations prior to the July 2003 events. Combining information from infrasonic pressure waves in the air with broadband seismicity and dynamic strain aids understanding of eruption dynamics and the physical eruptive processes.

U31B-0003 0830h POSTER

Observed dispersion curves of long period atmospheric acoustic waves

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Recently some groups reported Earth's background free oscillations even on seismically quiet days [e.g.

Nawa et al., 1998]. Statistical features of them and annual variations of their amplitudes with a peak in July suggest that atmospheric disturbance is the most probable excitation source [Nishida and Kobayashi, 1999; Nishida et al., 2000]. If the atmospheric excitation mechanism is effective, atmospheric acoustic free oscillations must be also excited persistently. In fact there is evidence of acoustic resonance of seismic free oscillations at around 3.7 and 4.4 mHz. The resonant amplitudes of the seismic records suggest the atmospheric excitation of the acoustic free oscillations but there is no direct observation of them. In an attempt to detect the long-period acoustic waves, we installed a cross array of barometers in a 10 km-wide university forest in central Honshu. The array has 28 micro-barometers employing quartz crystal resonator technology with station spacing of about 500 m. A special care was taken to design a sensor-recording system that runs with a precesion of better than 0.1 ppm in clock timing and sampling timing over a year by a single air battery. We analyzed 1-second continuous sampling records in a time period from March 2002 to March 2003. With an assumption of a stochastic stationary plane wave for the observed acoustic waves, we measured the time delay between every pair of all the stations. We determined the slowness vector of a plane wave as the one with which all the measured time delay are most consistent with each other. The plot of the measured slowness as a function of frequency has given for the first time the dispersion curve of atmospheric acoustic wave at frequencies down to 0.01 Hz. The slowness vector indicates two kinds of acoustic waves. (1) Acoustic waves traveling from the northwest (possibly from the mountaneous region) in a frequency range from 0.01 to 0.1 Hz with a phase velocity of about 400 m/s at 0.1 Hz and about 1500m/s at 0.01 Hz. Our array size is still not large enough to detect the expected acoustic free oscillations at frequencies around 3.7 and 4.4 mHz. (2) Microbaroms traveling from the southeast at frequencies from 0.1 to 0.5 Hz with a phase velocity of about 350 m/s. They are most likely to be excited by standing oceanic waves in the coastal region. The power spectra of these acoustic waves are compared to those of the seismic spectra obtained in the same university forest. Their spectral shapes are mutually coincident and change commonly with variable weather conditions.

U31B-0004 0830h POSTER

Seismo-Acoustic Observations near explosion sources in a Copper Mine

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For the last two years, Southern Methodist University has sporadically operated a network of 5 seismo-acoustic gauges on the perimeter of a copper mine recording seismic and acoustic signals from production mining blasts. The longest continuous data section, 180 days, provides an interesting comparison of seismic and acoustic waveforms from the mine. With typical delay fired seismic events, sometimes consisting of multiple patterns fired at once, only the first arrival (P) is clearly detected. Acoustic arrivals provide a second phase helpful in determining rough distances to the shots and allowing single station distance corrections. Seismic waveforms from delay fired patterns and multiple patterns are complex and have highly variable amplitudes, appearance, and durations. In contrast, acoustic arrivals at this 0.5-5 km distance are fairly simple with a few primary wave shapes and variations. Some aspects of mining blasting practice can be inferred from the near-source seismo-acoustic waveforms. These may then be compared with seismic or acoustic arrivals at regional distances.

U31B-0005 0830h POSTER

Infrasound From Explosions: Large, Medium and Small

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We will present analysis of infrasound signals of some recent high explosive (HE) events. The events include a recent explosive test, Watusi, at the Nevada Test Site (NTS) as well as some small explosions done under a Department of Defense (DOD) program, also at the NTS. Watusi, with a charge weight of 19 tons, was recorded at four Los Alamos National Laboratory/Department of Energy (LANL/DOE) infrasound arrays. Summary results will be presented, followed by a comparison to earlier HE data recorded by LANL arrays. These earlier data were from larger tests undertaken by the former Defense Nuclear Agency, now Defense Threat Reduction Agency. The Watusi data fit well with the earlier results for wind corrected amplitude versus scaled range. We also have recorded, from calendar year 2000 to the present, infrasound signals from 1000 to 2000 lb explosions executed at the NTS. These events were recorded at a range of 45 km by the LANL NTS array. These results show that detection at this range is fairly robust.

U31B-0006 0830h POSTER

Infrasound Signal Coherence Observations From Distant Sources - Source Effects, Path Effects and Near-Receiver Noise

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The numbers of modern infrasound arrays has been increasing rapidly in recent years. The availability of data from these arrays has resulted in a substantial increase in the number of both planned and opportunistic recordings of large sources at long ranges. This work presents a systematic study of signal coherence measured across baselines of 100 metres to 3 km from sources at ranges of 10^2 to 10^4 km. Coherence estimates can be robustly made at frequencies between roughly 0.4 and 4 Hz. At lower frequencies coherent noise makes coherence estimates unstable, and at higher frequencies signal to noise is too low. As well as coherence measurements which scale with frequency, signals show systematic variations with source type which may be useful for example for bolide signal identification. In addition, signals have a clear coherence dependence on range which we interpreted as due to atmospheric scattering. Coherence measurements are affected by local noise bursts at individual elements of an infrasound array. We compare observations of noise fields at infrasound arrays with simulations to develop a noise model that permits estimates of the probability of interference of a signal observation with noise bursts, and apply this to the question of optimal infrasound array configuration.

U31B-0007 0830h POSTER

Observation of a Rayleigh Wave Induced by Infrasonic Elephant Vocalizations: a Possible Communication Mode?

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A variety of animals such as arthropods, amphibians, reptiles, fish and rodents communicate by creating and sensing ground vibrations rather than, or in addition to, sound waves. There is evidence that this may be the case for elephants as well. We set out to characterize the Rayleigh wave generated by near-source coupling during elephant low frequency rumble vocalizations (25 Hz lasting 3-7 seconds), using standard engineering-scale seismology equipment. We used a 60-channel Geometrics^{TM} seismograph to record data from vertical and horizontal geophones and from microphones, placed along a 168-m cable near Salinas, CA. Seismic wave-speed for body waves (1400 m/s) and surface waves (440 m/s) and the air-wave velocity (340 m/s) were established using a sledgehammer source. Trained elephants vocalized on command at one end of our seismic recording spread. The vocalization was strongest at 25 to 28 Hz (with strong higher harmonics), with a duration of 3 to 4 seconds, and repeated multiple times with separations of 2 to 5 seconds. Unlike an explosive seismic source, the duration of the elephant vocalization is tens of times longer than the characteristic period of the source, lasting far longer than the total propagation time along our seismic recording spread (less than 500 ms), so that different propagating modes cannot be separated by different arrival times. Unlike a Vibroseis^{TM} sweep, the elephant rumble is relatively monotonic with no characteristic onset, ruling out the use of deconvolution techniques to recognize the signals. Using a semblance technique applied to linear moveouts on narrow-bandpass-filtered data, coupled with forward modeling, we demonstrate that the complex waves observed are the interference of an air wave and a Rayleigh wave traveling at the appropriate velocities. The Rayleigh wave appears to be generated at or close to the elephant, either by coupling through the elephant's body or through the air near the body to the ground. In our experiments, the amplitudes of both the elephant-coupled Rayleigh wave and the elephant-driven airwave had decayed to almost ambient noise levels at the end of our 168-m-long recording spread. This was most likely due to the high ambient-noise levels during our experiment. Free-ranging African elephants have been shown to respond to low-frequency calls of other elephants at ranges of 2 km with an ideal outer limit of 10 km. Because a surface wave decays at only 1/r, we speculate that wild elephants may detect the Rayleigh waves of other elephants via bone conduction or somatosensory reception or both, and hence may communicate at greater distances than possible using infrasonic calls transmitted through the atmosphere.

URL: http://biox.stanford.edu/iip_klemperer.html

U31B-0008 0830h POSTER

Avalanche-Generated Infrasound Signals

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Snow avalanches produce sub-audible acoustic pressure fluctuations in the low frequency infrasound spectrum that can be detected at significant distances. Although such signals have been previously observed and described, information detailing the characteristics of avalanche generated infrasound signals is scanty. During the winters of 2000/2001, 2001/2002, and 2002/2003 infrasonic monitoring systems operated at several locations in the Rocky Mountain West and collected data aimed at characterizing infrasonic signals produced by avalanche activity. Remote DC powered measurement systems providing a 1 - 10 HZ band limited infrasound signal were deployed within 2 kilometers of controlled and observed avalanche slide paths. Infrasonic microphones coupled to porous hose noise reducing filters were placed on the ground and subsequently covered by snowfall. Results obtained from these efforts have shown avalanche-generated infrasound signal amplitude levels approaching a 20 μbar dynamic range while occupying a 1 - 8 Hz frequency band. Additional infrasound insights on various avalanche control mechanism signatures, potential interfering event signatures, and ambient noise levels were also obtained. The catalog of data has been utilized to develop avalanche identification signal processing algorithms. Knowledge gained from research results will be applied during the 2003/2004 winter through the operation of a prototype near real-time avalanche alarming system on Teton Pass, Wyoming. Research efforts related to this study will were funded via a Small Business Innovative Research award obtained through the National Oceanic and Atmospheric Administration within the U. S. Department of Commerce.

U31B-0009 0830h POSTER

Auroral Infrasound Observed at I53US at Fairbanks, Alaska

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In this presentation we will describe two different types of auroral infrasound recently observed at Fairbanks, Alaska in the pass band from 0.015 to 0.10 Hz. Infrasound signals associated with auroral activity (AIW) have been observed in Fairbanks over the past 30 years with infrasonic microphone arrays. The installation of the new CTBT/IMS infrasonic array, I53US, at Fairbanks has resulted in a greatly increased quality of the infrasonic data with which to study natural sources of infrasound. In the historical data at Fairbanks all the auroral infrasonic waves (AIW) detected were found to be the result of bow waves that are generated by supersonic motion of auroral arcs that contain strong electrojet currents. This infrasound is highly anisotropic, moving in the same direction as that of the auroral arc. AIW bow waves observed in 2003 at I53US will be described. Recently at I53US we have observed many events of very high trace velocity that are comprised of continuous, highly coherent wave trains. These waves occur in the morning hours at times of strong auroral activity. This new type of very high trace velocity AIW appears to be associated with pulsating auroral displays. Pulsating auroras occur predominantly after magnetic midnight (10:00 UT at Fairbanks). They are a usual part of the recovery phase of auroral substorms and are produced by energetic electrons precipitating into the atmosphere. Given proper dark, cloudless sky conditions during the AIW events, bright pulsating auroral forms were sometimes visible overhead.

U31B-0010 0830h POSTER

Analysis of In Mine Acoustic Recordings for Single Fired Explosions

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In August of 2003, a series of single fired test shots were executed at a copper mine in Arizona. The ten shots, fired on August 18 and 19, 2003, ranged in size from 1700 lbs to 13600 lbs in simultaneously detonated patterns ranging from a single hole to eight holes. All were located within the same pit and within 100 m of each other. Both free face and bench shots were included. Southern Methodist University had previously deployed a set of acoustic gauges ringing the active production areas of the mine. The five Validyne DP250 sensors recorded not only the ten test shots, but also seven delay fired production shots over the four day period from August 18 to 21, 2003. Each recorded blast arrival was analyzed for peak amplitude and spectrum. Signals were then compared for the variability between shots and sensors as well as a comparison between fully contained and poorly contained shots. Blast yield, scale depth, and centroid depth were compared to the above measured quantities for each of the single-fired and production shots.

U31B-0011 0830h POSTER

Geomagnetic Storm Induced Infrasonic Waves at Low Latitude

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The continuous measurements of the surface pressure variation at low latitude station, Tirunelveli (8.7°N, 77.8°E), India has provided the opportunity to study the influence of geomagnetic storm on the tropospheric infrasonic waves. The polar ionosphere is the major source of infrasonic waves during severe geomagnetic storms. These waves propagate towards the equatorial latitude and is being deducted by the array of microbarograph. The infrasonic waves produced during severe magnetic storm (viz. 24 March 02, 20 Apr 02, 11 May 02, 23 May 02, 2 Aug 02, 4 Spt 02, 1 Oct 02, and 21 Nov 02) has been studied. The power spectral density obtained during these period shows the pronounced presence of waves of period about 10 seconds. The significant enhancement of microbarom has also been obtained in the present work. This could be due to the magnetic storm induced enhancement of ocean waves. The detailed results will be presented during the workshop.

URL: http://www.iigm.res.in

U31B-0012 0830h POSTER

The CTBT IMS Infrasound Network: Status of the Actual Installations and Examples of Infrasound Signals Recorded at the Existing Stations

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The International Monitoring System that is being established to ensure compliance with the Comprehensive Nuclear-Test-Ban Treaty includes a global 60-station network of infrasonic array stations The Provisional Technical Secretariat has completed a significant number of stations installations during the last years. The actual status of the Infrasound Network will be described. A variety of infrasonic events recorded at the stations actually sending data to Vienna will be presented.

U31B-0013 0830h POSTER

GINA - a Global INfrasound Archive

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Recent years have seen an explosion in the amount of infrasound data available as new arrays are constructed worldwide. In order to provide a convenient resource for interested researchers, and to encourage wider participation in infrasound research, the Geological Survey of Canada and the Royal Dutch Meteorological Institute have jointly launched an event-based infrasound archive known as GINA (Global INfrasound Archive). The archive works on the basis of free and open access. Waveform data and other associated information is contributed by station operators for defined events, and can be requested via a simple web interface. Data is stored internally in CSS3.0 and is available in a wide range of common formats.

U31B-0014 0830h POSTER

Recent Progress with Atmospheric Noise-Reducing Filters

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Wind noise is one of the key issues facing the community of acousticians who monitor the atmosphere for long-period signals from natural atmospheric phenomena or from man-made sources, such as nuclear weapons tests. Presently, a network of infrasound observing sites is being constructed to provide global coverage of acoustic sources in the atmosphere. It is well known that spatial filters can be used to attenuate noise due to atmospheric turbulence near the recording point and increase the ratio of signal-to-noise. Rosette spatial filters are currently used at the new infrasound monitoring stations and have been found to provide a significant reduction of noise across the frequency band of interest to the acoustic monitoring community. Research continues into modifications to existing rosette filters that might improve their performance. Additional research is providing insight into entirely different filters, such as wind barriers. Some of the monitoring system's array sites are located on oceanic islands at locations where spatially extensive noise filters will not be practical. This practical limitation fuels our interest in effective, spatially compact filtering methods. This presentation gives an overview of the various filters currently being used and research into improvements for these filters and into entirely different filter designs.

U31B-0015 0830h POSTER

Mechanical sensitivity of microbarometers MB2000 (France) and Chaparral5 (USA) to vertical and horizontal ground motion.

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Mechanical sensitivity of two pressure sensors MB2000 and Chaparral5, widely used in the International Monitoring System (IMS) infrasound network, has been examined using shake table at Saclay, Commissariat pour l'Energie Atomique (CEA) facility in France. Both sensors appeared to be sensitive to mechanical vibration with different level and shape of mechanical response. MB2000 mechanical response has been found to be similar to strong motion Guralp accelerometer CMG5T (flat in acceleration from DC - 50Hz) with sensitivity 0.81 V/m/s2. Chaparral5 microbarometer has about 40 times less sensitivity to mechanical vibrations than MB2000. Mechanical sensitivity of both sensors to ground motion allows to estimate the level of acceleration amplitudes generated by different size earthquakes or explosions, which can potentially induce the output signal from microbarometer above the acoustic background. Exceeding of the noise threshold for recording of seismic signals by MB2000 could be expected even for events with Mw=3.5 for epicentral distances about 1o. However, this detection could only happen in very quiet atmospheric condition, assuming very low acoustic background at the station. Seismic signal detection for Chaparral5 could happen yet for Mw=5.5 event with epicenter distance about 1o. In case of noisier conditions the exceeding of the acoustic background level should be expected for earthquakes with higher level of magnitudes. As summary the work results contain the graph of expected microbarometer signal-to-noise ratios for different earthquake magnitudes and epicentral distances. Further investigation of the coupling mechanism between ground motion and pressure sensors output will be beneficial for correct interpretation of signals recorded by infrasound stations of the IMS network.

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A Novel Piezoelectric-Cable Infrasound Sensor

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A novel infrasound sensor consisting of a long length of radially-poled commercially available piezoelectric polyvinylidene fluoride (PVDF) coaxial cable and a specially designed amplifier has been developed as a potential improved performance and lower cost replacement for microbarograph-based systems such as employed in the CTBT program. These cables are readily available and relatively inexpensive, supporting design of easily-replaced or expendable sensor elements. The purely electronic transduction mechanism provides uniform sensitivity to pressure along the sensor's length ("at lightspeed"). This automatically gives rise to continuous spatial averaging (i.e. array gain) of both signals and environmental pressure fields such as wind to provide noise reduction. Electronic transduction also allows for combination of signals from multiple sensors to enable signal processing options not possible with many other types of infrasound sensors. Prototype sensors of 30 and 100 m were installed several inches deep in trenches at UCSD's Pinon Flat Observatory in May 2003 and infrasonic data have been telemetered to UCSD in La Jolla continuously since then. The piezocable sensors have successfully detected acoustical events detected by the CTBT infrasound array and other diagnostic sensors at Pinon Flat with appropriate magnitude and good coherence. As anticipated, the longer sensors tend to be quieter than the shorter and appear to provide spatial filtering of higher acoustic frequencies. Two sensors placed at right angles appear to provide the potential to identify the direction of incoming signals within a 180 degree uncertainty. Work is continuing to further characterize the signal sensitivity and environmental noise of these sensors. This project has been carried out under a Small Business Innovation Research Contract from DTRA.

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Infrasound Noise Reduction using Inexpensive Microphones

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Inexpensive consumer microphones with noise canceling backs may be converted to infrasound microphones with the addition of a simple backing volume built from common PVC plumbing. By using a large number of elements within each microphone, instrument 0.5-5 Hz self-noise may be reduced to below ambient background levels for many locations. Such instruments have now been field tested for nearly 1 year in a 4 element mini-array. Instrument responses of the present implementation vary such that each instrument requires an individual instrument correction curve. Determining instrument response is done by comparison with a reference microphone using ambient laboratory noise. As an alternative to infrasound noise reduction using large passive pipe arrays or other passive geometries, small arrays of inexpensive microphones may be used to coherently improve infrasound signals. While this does not completely eliminate the need for passive pipe systems, it does provide an enhanced ability to acquire infrasound signals in the presence of noise.

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