Japan Geoscience Union Meeting 2014
(28 April - 02 May 2014 at Pacifico YOKOHAMA, Kanagawa, Japan)

MTT43-01 会場:311 時間:5 月 1 日 15:15-15:30

南極昭和基地周辺における多地点インフラサウンド観測
Multi-site infrasound observation around Syowa station, Antarctica

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Infrasound is one of the frontier fields in geophysics to observe atmospheric events. World wide infrasound observing network has been constructed as the CTBTO (Comprehensive Nuclear-Test-Ban Treaty Organization) to detect infrasound signal from huge artificial explosions, however, the CTBTO infrasound observing stations usually catch the natural infrasonic waves generated by many geophysical events, like volcanic eruptions, earthquakes, tsunamis, etc. For example, when a huge meteorite fall was observed near Chelyabinsk, Russia in 2012, the induced infrasonic waves reached to many distant CTBTO stations more than 10,000 km apart from. In the polar region, there exists local infrasound sources generated mainly by the ice sheets on ground, ice field, and glacier motions. Icequakes have been frequently monitored by seismic stations in polar region, however, monitoring of induced atmospheric infrasonic waves through lithosphere-atmosphere coupling is still in progress. We installed an infrasound sensor at Syowa station, Antarctica in 2008 during IPY (International Polar Year) period by JARE (Japanese Antarctic Research Expedition) 49 mission. However, the direction-finding of the infrasonic waves is significant to study the comparison between the seismic data, thus, 2 sensors were added on Syowa to make a triangle sensor array in 2013 by JARE 54. In addition, 5 more sensors were installed at 5 locations around Syowa in 2013 (Murayama et al., 2013).

The infrasound data observed at Syowa can be transferred to Japan via satellite connection, however, the data recorded by data logger at the stations near Syowa cannot be obtained without visiting there. In JARE 55 mission, we obtained one-year infrasound observation data recorded at several stations around Syowa and will return them back to Japan in March 2014. In this paper, we will introduce some preliminary results obtained in Antarctica as the first multi-site infrasound observation at the frozen continent.

キーワード: インフラサウンド, 南極, 多地点観測, 南極地域観測隊, 氷震
Keywords: ifrasound, Antarctica, multi-site observation, JARE, ice quake

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MTT43-02 会場:311 時間:5 月 1 日 15:30-15:45

南極のインフラサウンドデータでみられる各種波動の特徴について
Characteristic features of infrasound waves observed at Antarctica

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KANAO, Masaki[1*] ; MURAYAMA, Takahiko[2] ; YAMAMOTO, Masa-yuki[3] ; ISHIHARA, Yoshiaki[4] ; KAKINAMI, Yoshihiro[3] ; OKADA, Kazumi[5] ; MATSUSHIMA, Takeshi[6]

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Characteristic features of infrasound waves observed at Antarctica reveal the physical interaction involving surface environmental variations in the continent and surrounding Southern Oceans. A single infrasound sensor has been continuously recorded since 2008 at Syowa Station (SYO; 39E, 69S), the Lutzow-Holm Bay (LHB), East Antarctica. The continuously recording data clearly represent a contamination of the background oceanic signals (microbaroms) during whole seasons. In austral summer in 2013, several field stations by infrasound sensors are established along the coast of the LHB. Two infrasound arrays with different diameter size are installed at both SYO (by 100 m spacing triangle) and S16 area on continental ice sheet (by 1000 m spacing triangle). Besides these arrays, two isolated single stations are deployed at two outcrops in LHB. These newly established arrays clearly detected the propagating directions and frequency contents of the microbaroms from Southern Ocean. Microbaroms measurements are a useful tool for characterizing ocean wave climate, complementing other oceanographic and geophysical data in the Antarctic. Moreover, several kind of remarkable infrasound signals are demonstrated, such as regional earthquakes, together with a detection of the airburst shock waves generated from meteorite injection at the Russian Republic on 15 February 2013. Detail and continuous measurements of the infrasound waves in Antarctica could be a new proxy for monitoring a regional environmental change as well as temporal climate variations in high southern latitude.

キーワード: infrasound, array observations, Lutzow-Holm Bay, East Antarctica, microbaroms, surface environment
Keywords: infrasound, array observations, Lutzow-Holm Bay, East Antarctica, microbaroms, surface environment

Japan Geoscience Union Meeting 2014
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MTT43-03 会場:311 時間:5 月 1 日 15:45-16:00

インフラサウンドによる雪崩監視－雪崩遠隔監視システムの構築に向けて－
Monitoring snow avalanches by using infrasound with an object of establishing remote detection system of snow avalanches

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ARAI, Nobuo[1] ; MURAYAMA, Takahiko[1*] ; IWAKUNI, Makiko[1] ; TANIMOTO, Saki[2] ; TAKAHASHI, Daisuke[2] ; KURIHARA, Yasushi[2] ; ARAKI, Keiji[2] ; YAMAMOTO, Masa-yuki[3]

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It has been demonstrated that avalanches produce strong infrasonic vibrations in air during their movement (Bedard, 1988[1], Hejda, 1995[2]). These infrasonic vibrations propagate great distances and can follow the natural relief. This fact shows that it is possible to monitor remotely the snow avalanche by using infrasound detection system.

We aim to establishing remote detection system of snow avalanches. In order to study the feature of the signal associated with snow avalanches, as a first step, we carried out trial infrasound observation simultaneously with the video monitoring and the meteorological observation at mountainous region in Niigata Prefecture from January to April 2013. During the trial observation, some infrasound signals generated by snow avalanches were recorded. We analyzed these data and attempted to extract features from infrasound signals.

[References]
[1] Bedard, A. J. et al. 1988. On the feasibility and value of detecting and characterizing avalanches remotely by monitoring radiated sub-audible atmospheric sound at long distances. Proc. A Multidisciplinary Approach to Snow Engineering, Santa Barbara, CA.
[2] Hejda, D. 1995. Caracterisation de l'emission acoustique des avalanches, (These de diplome, E. P. F. Lausanne, Suisse.)
Keywords: Infrasound, Snow avalanches, Avalanche monitoring

Japan Geoscience Union Meeting 2014
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MTT43-04 会場:311 時間:5 月 1 日 16:15-16:30

降雨に伴う微気圧変動
Micro-barometric variation associated with rainfall

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IYEMORI, Toshihiko[1] ; SANO, Yasuharu[2*] ; HAYASHI, Taiichi[3] ; ODAGI, Yoko[1] ; AOYAMA, Tadashi[1] ; NAKANISHI, Kunihito[1]

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夏場の夕立など、急な降雨の開始と数十秒から数百秒周期の微気圧変動の間には明瞭な対応関係があることがわかった。その対応関係を定量的に調べるため、降雨と微気圧変動および BS 放送電波の受信強度観測データを毎秒値で記録した。その結果、降雨が始まる約 1 分前から気圧が上昇を始め、降雨が始まると、数分周期の振動が始まり、気圧上昇が元に戻り始めしばらくすると雨も小降りになる現象が頻繁に観測された。このような対応関係が生じる原因として、上空で雨滴が落下することによる動圧で大気が圧縮され、それが地表での降雨に先立ち気圧の上昇として観測されていると解釈できる。この解釈が正しいとすると、雨雲より上空では逆に減圧し、それが音波(希薄波) として上空に向かって伝搬する可能性が考えられる。この報告では、上記のような対応関係を多数の例について調べた結果について報告する。

キーワード: 微気圧変化, 重力波, 降雨, 重力音波
Keywords: micro-barometric variation, gravity wave, rainfall, acoustic gravity wave

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MTT43-05 会場:311 時間:5 月 1 日 16:30-16:45

火山の爆発的噴火に伴う電離圏擾乱：GNSS による観測
Ionospheric disturbances by volcanic explosions: Observations with GNSS

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地表での様々な自然現象や人為的現象により引き起こされた、大気中の内部重力波や音波は、地表約 300km 上空の電離圏 F 領域を揺さぶることが多数報告されている [Calais et al., 1998 GJI; Heki and Ping, 2005 EPSL]。火山噴火により発生した音波は、近傍では空振として観測されるが、上空に伝搬して電離圏擾乱も引き起こすことが知られている [Heki, 2007 GRL]。我々は国土地理院が日本全国に 1240 点展開している GNSS 連続観測網 GEONET の観測データから、電離圏全電子数 (Total Electron Content; TEC) を抽出し、最近の爆発的火山噴火による電離圏擾乱をとらえてその特徴を明らかにすることを目指している。

Heki [2006] は、GEONET データの解析から、2004 年 9 月 1 日 11:02 UT に浅間山で起こった噴火に伴い、真南から南西にかけての領域において TEC が 0.1 TECU 程度、変動したことを見出した。そして変動量から大気波動のエネルギーを求め、さらに既知のエネルギーを持つ人工的爆発がもたらした電離圏擾乱 [Calais et al., 1998] と振幅を比較することによって、火山噴火そのもののエネルギーを概算している。その後 Dautermann et al. [2009 JGR] は，西インド諸島 Montserrat 島火山の 2003 年の爆発的噴火に関して同様の研究を行っている．

今回、我々は同様の変動を、霧島新燃岳で 2011 年 1 月 31 日 22:54UT に発生した噴火について見出した。気象庁による霧島山の火山解説資料 (平成 23 年 1 月) によると、この噴火で 458 Pa の空振が発生し、鹿児島県霧島市で窓ガラスの破損する被害が生じている。また 2009 年 10 月に発生した桜島火山の爆発的噴火に伴って、Peak-to-peak で最大 0.2-0.3 TECU 程度の擾乱が熱圏の音速で南に伝搬してゆく様子も見出した。擾乱は音波が熱圏に達するのに要する 10 分程度経過してから現れる。また地震時地殻上下変動が励起する音波による電離圏擾乱が約 4 分の周期を持つのに対して、火山噴火による擾乱は 2 分弱と有意に短い周期を持つことがわかった。当日は、2011 年霧島新燃岳や 2009 年桜島の爆発的噴火による TEC 変動の事例を、浅間山など他の火山での事例と比較して議論する。

キーワード: GPS, GNSS, 空震, 音波, 火山噴火, 電離圏
Keywords: GPS, GNSS, infrasound, acoustic wave, volcanic explosion, ionosphere

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MTT43-06 会場:311 時間:5 月 1 日 16:45-17:00

下層大気で生成される音波が電離圏に与える影響のシミュレーション
Simulation of ionospheric variations caused by acoustic waves generated in the lower atmosphere

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地震、津波、火山、隕石落下、積雲活動、竜巻、台風、大規模爆発、ロケット発射などの突発性大気現象に伴うインフラソニック波や高周波の重力波などによって電離圏の変動が起きることはすでに知られている。しかし、大気圏、電離圏は極めて複雑かつ非線形のシステムであり、さまざまな要因で変動するため、これらの大気波動が具体的・定量的にどのようなメカニズムで電離圏変動を引き起こすのかは依然良く分かっていない。我々はこれまでに非静力学大気圏・電離圏結合モデルを開発し、それを用いて 2004 年のスマトラ沖地震や 2011 年の東北沖地震の際に観測された電離圏変動の再現を試みた。その結果、地震に伴って観測された電離圏変動が概ね再現できることがわかった。我々は、このモデルをさらに高精度化・精密化することにより、大気音波の発生・伝搬過程と電離圏変動メカニズムの定量的な解明を目指している。本発表では、これまでの結果と今後の展望について報告する。

キーワード: 音波, 下層大気, 超高層大気, 電離圏, シミュレーション, モデル
Keywords: acoustic wave, lower atmosphere, upper atmosphere, ionosphere, simulation, model

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MTT43-07 会場:311 時間:5 月 1 日 17:00-17:15

2013 年 10 月に福島県沖で発生したアウターライズ地震に伴う気圧変動シグナル
Low-frequency atmospheric pressure waves associated with the outer-rise earthquake on Oct. 25, 2013, 17:10 UTC.

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ARAI, Nobuo[1*] ; IWAKUNI, Makiko[1] ; MURAYAMA, Takahiko[1] ; NOGAMI, Mami[1]

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Sensitive microbarographs in and around Japan recorded unequivocal signals associated with the 2011 Off the Pacific Coast of Tohoku, Japan earthquake (Mw = 9.0) (*Arai et al., 2011*).

These signals retained the original shape of the tsunami and traveled in the atmosphere significantly faster than the tsunami waves in the ocean, therefore, we think that an establishment of a network of infrasound observation along the coast line facing the subduction zone would improve the tsunami warning system.

According to this idea, we deployed three (3) microbarograph stations in Ofunato City, Iwate last July as the first step of the establishment of a network of infrasound observation and are trying to observe atmospheric pressure changes continuously.

The outer-rise earthquake occurred off the Fukushima region on Oct. 25, 2013, 17:10 UTC and the tsunami waves with few tens centimeter heights observed at coastal area of Tohoku region. And some curious atmospheric pressure waves detected at our Ofunato sites. The characteristics of the observed signals are consistent with the features of the tsunami source produced by the outer-rise earthquake.

Reference:

Arai et al. , Atmospheric boundary waves excited by the tsunami generation related to the 2011 great Tohoku-Oki earthquake, Geophysical Research Letters, Vol. 38, L00G18, doi:10.1029/2011GL049146.

キーワード: インフラサウンド, 気圧変動, アウターライズ地震, 津波発生検知
Keywords: Infrasound, atmospheric pressure change, outer-rise earthquake, detection of tsunami

Japan Geoscience Union Meeting 2014
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MTT43-08 会場:311 時間:5 月 1 日 17:15-17:30

地形効果を考慮した津波発生時における極超低周波音波伝搬の数値解析に関する基礎検討
Examination on Numerical Simulation of Tsunami-Induced Extremely Low Frequency Sound Waves with Geospatial Information

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Air pressure changes associated with earthquakes and/or tsunami have been investigated previously. As for air pressure changes associated with tsunami, some observation results have been reported (T. Mikumo (1964), T. Mikumo, et al. (2008) and William L. Donn and Eric S. Posmentier (1964), Y. Tamura (2011), N. Arai, et al. (2011)).

We have measured the air pressure in the terrestrial atmosphere with other meteorological parameters (temperature, humidity, etc.) continuously at Hosokura outdoor observation station (HSK) in Miyagi Prefecture, Japan. The extremely low frequency sound waves (so-called micro barometric waves) are also detected as large changes of air pressure in the 2011 off the Pacific coast of Tohoku Earthquake (M 9.0, origin time;14:46.18JST) (K. Okubo, et al. (2011)).

Although the power failure was caused by the earthquake occurrence, our observation system had been maintained by the UPS system and the private power generation. Therefore, in this earthquake, our observation system successfully observed extremely low frequency sound waves induced by tsunami. The waves were detectable at the observation point on the ground surface sufficiently early before the arrival of tsunami waves at coastal areas, because sound waves propagate faster than ocean waves (tsunami).

These results can encourage early tsunami detection (S. Iwasaki (1992), T. Izumiya (1994)) using multi-site observation and arrival time difference method. That is, detection of tsunamis might be possible by monitoring extremely low frequency sound waves at ground surface observation sites and/or sea-level observation at relatively low cost. It is important to obtain information of tsunami as soon as possible; arrival time, area and scale.

In this study we present a fundamental examination on analysis and visualization of extremely low frequency sound waves caused by tsunami using numeral approach. We employ the numerical simulation using the Finite-Difference method in Time-Domain (FDTD method) (Yee, 1966) with geospatial information for the large-scale sound wave propagation. As an elementary study, it is applied to the estimation of extremely low frequency sound waves' propagation and time-series analysis of sound pressure.

Through our study, we show the numerical results of sound pressure distribution and estimate the propagation phenomena of sound waves, compared with the observed data at HSK. This examination may help the development of the design of early tsunami detection system. In the future, further efforts can suggest new systems for early warning of destructive tsunami using a combination of other measurements.

We are grateful to Hosokura Metal Mining Co. for the maintenance of our site. This research was partially supported by a Grant-in-Aid for Scientific Research from the Japan Society for the Promotion of Science.

キーワード: 数値解析, 津波, 音場変化, 微気圧波, インフラサウンド, 可視化
Keywords: Numerical Simulation, tsunami, sound field change, microbarometric wave, infrasound, numerical visualization

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MTT43-09 会場:311 時間:5 月 1 日 17:30-17:45

2010 年 Chile 大地震 (Mw8.8) による地殻変動から発生した長周期大気重力波
Atmospheric Gravity Waves from the 2010 Maule, Chile earthquake (Mw8.8)

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Atmospheric pressure waves were recorded after the 2010 Maule, Chile earthquake (Mw=8.8) by microbarographs at seven International Monitoring System (IMS) stations in the distance range up to 7,680 km. By applying bandpass-filtering, we extracted low frequency gravity waves, removing atmospheric noise and higher-frequency acoustic modes, and then estimated their phase velocities around 332-341 m/s. To compare with these observations, we constructed synthetic waveforms, referring to the source dimension and coseismic vertical ground displacements based on geodetic measurements (Moreno et al., 2012), and incorporating a standard atmospheric sound velocity structure up to a height of 220 km. The comparison between the observed and synthetic waveforms provides generally satisfactory agreement, and suggests the time constant of ground displacements between 2 and 3 min in the northern and southern segments of the entire source region extending for about 500 km..

キーワード: 2010 年チリ大地震, 地殻変動, 長周期大気重力波
Keywords: 2010Maule, Chile earthquake, Mw=8.8, low-frequency, Atmospheric gravity waves