Long-period teleseismic detectability and its response to cryosphere variation around Syowa Station, Antarctica since 1967

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*金尾 政紀[1]
*Masaki Kanao[1]

1.国立極地研究所
1.National Institute of Polar Research

Phase identifying procedure for teleseismic events at Syowa Station (69.0S, 39.6E; SYO), East Antarctica have been carried out since 1967 after the International Geophysical Year (IGY; 1957-1958). From the development of INTELSAT telecommunication link, digital waveform data have been transmitted to the National Institute of Polar Research (NIPR) for utilization of phase identification. Arrival times of teleseismic phases, P, PKP, PP, S, SKS have been reported to the International Seismological Centre (ISC), and published by "JARE Data Reports" from NIPR. In this paper, hypocentral distribution and time variations for detected earthquakes are demonstrated over the last four decades in 1967-2010. Characteristics of detected events, magnitude dependency, spatial distributions, seasonal variations, together with classification by focal depth are demonstrated. Besides the natural increase in number for occurrence of teleseismic events on the globe, a technical advance in observing system and station infrastructure, as well as the improvement of procedure for reading seismic phases, could be efficiently combined to produce the increase in detection number in last few decades. Variations in teleseismic detectability for longer terms may possibly by associate with cryosphere dynamics and evolution, meteorological environment, as well as the sea-ice spreading area around the Antarctic continent. Recorded teleseismic and local seismic signals have sufficient quality for many analyses on dynamics and structure of the Earth’s as viewed from Antarctica. The continuously recorded data are applied not only to lithospheric studies but also to Earths deep interiors, as the significant contribution to the Federation of Digital Seismological Network (FDSN) from high southern latitude.

キーワード：teleseismic event、ISC、sea-ice variation、Antarctica、phase detection
Keywords: teleseismic event, ISC, sea-ice variation, Antarctica, phase detection

南極昭和基地で記録された氷震微動の分類と季節性
Classification of ice tremor recorded at Syowa Station in Antarctica

*田中 佑弥[1]、平松 良浩[1]、石原 吉明[2]、金尾 政紀[3]
*Yuya Tanaka[1], Yoshihiro Hiramatsu[1], Yoshiaki Ishihara[2], Masaki Kanao[3]

1.金沢大学、2.宇宙航空研究開発機構、3.国立極地研究所
1.Kanazawa Univ., 2.JAXA, 3.NIPR

南極での地震観測によって、これまでにテクトニック地震の存在や氷によって発生する振動（以下、氷震微動）の存在が明らかとなった。氷震微動とは、海氷のぶつかり合いやクラックの開閉、氷山の崩壊などで発生する微動のことである（Kanao et al., 2012）。しかし、南極で観測される氷震微動の波形の特徴や発生数の季節性に関しての詳しい報告例は少ない。本研究では、昭和基地で観測された氷震微動を波形の特徴に基づき分類し、その発生数の時間推移季節性について明らかにすることを目的とする。
本研究で使用するデータは、昭和基地のSTS-1地震計で記録された地震波形データの南北成分である。解析期間は2014年1 -12月とした。地震波形データから、地震波形画像とスペクトログラムを作成し、目視で氷震微動を計測した。本研究では、5分以上継続しP波やS波が不明瞭な震動を氷震微動と定義した。
2014年の1年間で計231回の氷震微動を確認した。氷震微動の月別回数は1 -3月を除いて、月別の累積微動継続時間は1月を除いて昭和基地での平均気温の変化と同じ傾向で推移している。2月は氷震微動回数が少ないにもかかわらず、累積微動継続時間は最も長い。また、氷震微動の波形とそのスペクトルの時間変化の特徴に基づき、本研究では氷震微動を以下の４タイプに分類した。継続時間が長く（数万秒）、一様に振幅の小さい波形（タイプA）、卓越周波数が時間と共に不規則に変化する波形（タイプB）、卓越周波数が時間とともに減少し、オーバートーンが見られる波形（タイプC）、継続時間が短く（数百秒）、徐々に振幅が大きくなり、徐々に振幅が弱くなる波形（タイプD）である。
微気圧データは、海の波環境を特徴づける重要な指標である（Ishihara et al., 2015）ため、微気圧データを地震データとの比較に用いた。気温が高い時期は、地震波形及び微気圧の振幅が大きくなっており、タイプAの氷震微動波形のピークと微気圧波形のピークが概ね一致していることから、タイプAの氷震微動は海の波によって励起していると考えられる。気温が低い時期は、微気圧の振幅のみが大きくなっており、これは、発達した海岸線の氷による減衰の影響が大きくなるため（Grob et al., 2011）、氷震微動の波が観測されにくくなっていると考えられる。また、2006年4月に南極のノイマイヤ基地で、氷震微動が記録され、発生源は氷山であると推定された（Eckstaller et al., 2006）。その氷震微動のスペクトル的特徴は、タイプCの氷震微動と類似しており、タイプCの氷震微動の発生源も氷山に関連している可能性が示唆される。

キーワード：南極、昭和基地、氷震微動、微気圧
Keywords: Antarctica, Syowa Station, ice tremor, microbarom

東オングル島における地震計アレイで観測された波形の特徴

Characteristics of seismic waveform recorded by seismic array at East Ongul Island, Antarctica

*中元 真美[1]、宮町 宏樹[2]、松島 健[1]、金尾 政紀[3]、山本 真行[4]
*Manami Nakamoto[1], Hiroki Miyamachi[2], Takeshi Matsushima[1], Masaki Kanao[3], Masa-yuki Yamamoto[4]

1.九州大学大学院理学研究院附属地震火山観測研究センター、2.国立大学法人　鹿児島大学大学院理工学研究科 、3.国立極地研究所 、4.高知工科大学　システム工学群
1.Institute of Seismology and Volcanology, Faculty of Science, Kyushu University, 2.Graduate School of Science and Engineering, Kagoshima University, 3.National Institute of Polar Research, 4.Department of systems engineering, Kochi University of Technology

In polar region, various vibration phenomena are exited in association with physical interaction between solid earth, atmosphere, ocean and cryosphere systems. These phenomena can be observed as seismic and infrasonic waves, and it is important to investigate their features and generation process in order to reveal relationship between their occurrence and environmental variations. An array observation helps us to get information of incident waves on the stations. In order to detect source locations of seismic event around Showa station, East Ongul Island, East Antarctica, we carried out a seismic array observation from January 2 to February 2, 2015. We installed 7 temporary seismic stations in a rocky area located at 1 km away from Showa station, consisting of 1-Hz three-component seismometers with a site spacing of about 100 m. During this period, two characteristic waveforms were recorded. One occurred from January 11 at 22:40 (UTC) to January 12 at 11:20 (UTC), corresponding to ice-breaking by a ship. The peak frequency was about 10 Hz. The other occurred on January 14 at 3:45 (UTC) and its duration was about 13 minutes. Peak frequencies of the tremor were about 2, 4 and 6 Hz, and these peaks varied over time. It seems that the tremor arrived from south-southeast direction with a small slowness by semblance analysis. We will reveal characteristics of these seismic events in more detail and estimate location of their sources by using data recorded at other seismic and infrasound stations around East Ongul Island.

キーワード：地震計アレイ、微動、南極
Keywords: seismic array, tremor, Antarctica

東南極リュツォ・ホルム湾で捉えたインフラサウンド・シグナルと表層環境
Infrasound signal detected at the Lützow-Holm Bay region, East Antarctica, and their relation to surface environment

*村山 貴彦[1]、金尾 政紀[2]、山本 真行[3]、石原 吉明[4]、松島 健[5]、柿並 義宏[6]、中元 真美[5]、竹内 由香里[7]
*Takahiko Murayama[1], Masaki Kanao[2], Masa-yuki Yamamoto[3], Yoshiaki Ishihara[4], Takeshi Matsushima[5], Yoshihiro Kakinami[6], Manami Nakamoto[5], Yukari Takeuchi[7]

1.日本気象協会、2.国立極地研究所、3.高知工科大学、4.宇宙航空研究開発機構、5.九州大学、6.台湾中央大學、7.森林総合研究所
1.Japan Weather Association, 2.National Institute of Polar Research, 3.Kochi University of Technology, 4.Japan Aerospace Exploration Agency, 5.Kyushu University, 6.National Central University, Taiwan, 7.Forestry and Forest Products Research Institute

A single infrasound sensor has been making continuous recordings since 2008 at Syowa Station (SYO; 69.0S, 39.6E) in the Lützow-Holm Bay (LHB) of East Antarctica. The continuously recorded data clearly show the contamination of background oceanic signals (microbaroms) throughout all seasons. In austral summer 2013, several field stations with infrasound sensors were established along the coast of the LHB. Two infrasound arrays of different diameters were set up: one at SYO (with a 100-m spacing triangle) and one in the S16 area on the continental ice sheet (with a 1000-m spacing triangle). In addition to these arrays, isolated single stations were deployed at two outcrops in the LHB.
Detailed and continuous measurements of infrasound waves in Antarctica could prove to be a new proxy for monitoring regional environmental change as well as temporal climate variations in high southern latitudes.
Until now, these arrays clearly detected the propagation direction and frequency content of microbaroms from the Southern Ocean. In addition to the microbaroms, several other remarkable infrasound signals were detected, including regional earthquakes, and so on.
In this presentation, we would introduce detected infrasound signals.

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キーワード：インフラサウンド、地震波、南極、マイクロバロムス、氷震、センサアレイ
Keywords: Infrasound, Seismic waves, Antarctica, Microbaroms, icequake, Sensor array

Multi-Sphere interactions in the coastal and marine environment inferred from infrasound and seismic data at Teranova Bay, west Antarctica

Multi-Sphere interactions in the coastal and marine environment inferred from infrasound and seismic data at Teranova Bay, west Antarctica

*村山 貴彦[1]、金尾 政紀[2]、石原 吉明[3]、山本 真行[4]、大井 琢磨[5]
*Takahiko Murayama[1], Masaki Kanao[2], Yoshiaki Ishihara[3], Masa-yuki Yamamoto[4], Takuma Oi[5]

1.日本気象協会、2.国立極地研究所、3.宇宙航空研究開発機構、4.高知工科大学、5.東邦マーカンタイル
1.Japan Weather Association, 2.National Institute of Polar Research, 3.Japan Aerospace Exploration Agency, 4.Kochi University of Technology, 5.Toho Mercantile Co., Ltd

Characteristic features of infrasound waves observed in the Antarctic reveal physical interaction involving surface environments around the continent and Southern Ocean. An infrasound array (100 m spacing) by using three sensors (Chaparral Physics Model 25, with a detectable frequency range of 0.1-200 Hz), together with a broadband barometer (Digiquartz Nano-Resolution Model 6000-16B Barometer, with a detectable frequency range of 0-22 Hz) were installed at Jang Bogo Staion, Tera Nova Bay, West Antarctica in December 2015 by the Korea Arctic and Antarctic Research Program (KAARP). The initial data recorded by the broadband barometer include several signals originated surrounding surface environment, in addition to the local wind noises such as katabatic signals. Clear signals from background oceanic origin (the "microbaroms") are continuously recorded at the austral summer on mid-December with predominant frequency around 5 s. Variations of their frequency context and strength appeared in Power Spectral Density are affected by evolution of the sea-ice surrounding the Tera Nova Bay. In contrast, several infrasound monitoring stations have been conducting around the Lützow-Holm Bay (LHB), East Antarctica by Japanese Antarctic Research Expedition (JARE) since 2008. Two infrasound arrays with different diameter triangles have been deployed at both inside the Syowa Station (100 m spacing) and on the continental ice sheet (1000 m spacing). Besides the arrays, isolated single stations are deployed at three outcrops. These arrays in LHB clearly identified the predominant propagating directions in NWN and their frequency content variations of "microbaroms" from Southern Indian Ocean. In this presentation, characteristic features recorded by the initial data observed at Jang Bogo Staiton is presented, as compared with that obtained at the LHB. Microbaroms measurement is a useful tool for characterizing ocean wave climate, complementing other oceanographic, cryospheric and geophysical data in the Antarctic. Detail and continuous observations of infrasound waves in Antarctica is a new proxy for monitoring a environmental changes such as global warming affecting on polar regions.

キーワード：インフラサウンド、南極、韓国北極・南極研究計画、日本南極観測隊
Keywords: Infrasound, Antarctica, KAARP, JARE

GLISN計画による日米共同地震観測(2011-2015)
Seismic observations in Greenland by a joint USA and Japanese GLISN team (2011-2015)

*豊国 源知[1]、Childs Dean[2]、金尾 政紀[3]、東野 陽子[4]、姫野 哲人[5]、坪井 誠司[6]
*Genti Toyokuni[1], Dean Childs[2], Masaki Kanao[3], Yoko Tono[4], Tetsuto Himeno[5], Seiji Tsuboi[6]

1.東北大学　大学院理学研究科　地震・噴火予知研究観測センター、2.IRIS PASSCAL Instrument Center、3.国立極地研究所、4.文部科学省、5.滋賀大学　経済学部、6.海洋研究開発機構
1.Research Center for Prediction of Earthquakes and Volcanic Eruptions, Graduate School of Science, Tohoku University, 2.IRIS PASSCAL Instrument Center, 3.National Institute of Polar Research, 4.Ministry of Education, Culture, Sports, Science and Technology , 5.Faculty of Economics, Shiga University, 6.Japan Agency for Marine-Earth Science and Technology

Global climate change is currently causing melting of the Greenland ice sheet. Recently, a new type of seismic event, referred to as a “glacial earthquake”, has been recognized. Such earthquakes are generated by the movements of large masses of ice within the terminal regions of glacier, and represent a new approach for monitoring ice sheet dynamics. In 2009, the GreenLand Ice Sheet monitoring Network (GLISN) was initiated as international project to monitor changes in ice sheet by constructing a large broad-band seismological network in and around Greenland.

Japan is a partner country from when the GLISN project was launched, and has been sending an expedition team every year since 2011. In 2011, the joint USA and Japanese GLISN team installed the dual seismic-GPS station ICESG-GLS2 in the middle of the Greenland ice sheet. During 2012-2015, we conducted maintenance of the three stations on ice (ICESG-GLS2, DY2G-GLS1, and NEEM-GLS3), and three stations on bedrock in coastal region (NUUK, DBG, and SOEG).

Especially, in 2014, we had succeeded in real-time transmission of broad-band continuous seismic waveform data from the three ice stations. It was the first time in the world that the seismic data with such a high sampling rate is transferred from the ice sheet. The data is now open to the public and available from the IRIS Data Management Center (http://www.iris.edu/ds/nodes/dmc/). Also in 2015, we relocated a seismic sensor at the station ICESG, which had been covered by snow of 5 m depth due to accumulation for four years. All of the excavation and reinstallation processes were achieved within two days by human labor of only three workers.

This presentation will summarize our field activities, and introduce the future plans. The Japanese GLISN team has been supported by JSPS KAKENHI 24403006.

キーワード：グリーンランド、地震観測、氷床
Keywords: Greenland, Seismic observation, ice sheet

北極域の地震活動・構造・テクトニクス - レビュー -

A review of seismicity, structure and tectonics in the Arctic region

*戸田 茂[1]、金尾 政紀[2]、豊国 源知[3]、坪井 誠司[4]
*Shigeru Toda[1], Masaki Kanao[2], Genti Toyokuni[3], Seiji Tsuboi[4]

1.愛知教育大学教育学部地学教室、2.国立極地研究所、3.東北大学　大学院理学研究科　地震・噴火予知研究観測センター、4.海洋研究開発機構
1.Department of Earth Sciences, Faculty of Education, Aichi University of Education, 2.National Institute of Polar Research, 3.Research Center for Prediction of Earthquakes and Volcanic Eruptions, Graduate School of Science, Tohoku University, 4.JAMSTEC, Center for Earth Information Science and Technology

The “Arctic” region, where the North Pole occupies the center of the Arctic Ocean, has been affecting the environmental variation of the Earth from geological time to the present. However, the seismic activities in the area are not adequately monitored. Therefore, by conducting long term monitoring of seismic phenomenon as sustainable parameters, our understanding of both the tectonic evolution of the Earth and the dynamic interaction between the cryosphere and geosphere in surface layers of the Earth will increase. In this paper, the association of the seismicity and structure of the Arctic region, particularly focused on Eurasian continent and surrounding oceans, and its relationship with regional evolution during the Earth’s history is studied. The target areas cover representative tectonic provinces in the Eurasian Arctic, such as the wide area of Siberia, Baikal Rift Zone, Far East Russia, Arctic Ocean together with Greenland and Northern Canada. Based on discussion including characteristics of seismicity, heterogeneous structure of the crust and upper mantle, tectonic history and recent dynamic features of the Earth’s surface in the Arctic are summarized.

キーワード：北極域、地震活動、地殻構造、テクトニクス、氷河地震
Keywords: Arctic region, seismicity, crustal structure, tectonics, glacial earthquakes

