MTT41-01 Room:203 Time:May 26 09:00-09:15

Interdisciplinary physical phenomena within multiple spheres in polar regions inferred from infrasound and seismic waves

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Several characteristic waves detected by seismographs in Antarctic stations have been recognized as originating from the physical interaction between the solid-earth and the atmosphere - ocean - cryosphere system surrounding the Antarctic and may be used as a proxy for characterizing ocean wave climate. A Chaparral type infrasound sensor was installed at Syowa Station (SYO; 39.6E, 69.0S), East Antarctica, in April 2008 during the International Polar Year (IPY2007-2008). Matching data are also available for this time period from the existing broadband seismic recorder located close by. Continuous infrasound data for 2008-09 includes background signals (microbaroms) with a broad peak in the wave period between the values of 4 and 10 seconds. Signals with the same period are recorded by the broadband seismograph at SYO (microseisms). This period band is identified as Double-Frequency Microseisms/baroms (DFM). The DFM has relatively lower amplitudes during winter. We suggest that this is due to the sea-ice extent around the coast causing a decreased ocean loading effect. In contrast, the Single Frequency Microseisms/baroms (SFM) with a peak in period between 12 and 30 seconds are observed under storm conditions, particularly in winter. On the infrasound data, stationary signals are identified with harmonic overtones at a few Hz to lowermost human audible band, which we suggest is due to local effects such as sea-ice cracking and vibration. Microseism measurements are a useful proxy for characterizing ocean wave climate, complementing other oceanographic and geophysical data. At SYO, continuous monitoring by both broadband seismograph and infrasound contributes to the Federation of Digital Seismographic Networks, the Comprehensive Nuclear-Test-Ban Treaty in the high southern latitudes, and the Pan-Antarctic Observations System under the Scientific Committee on Antarctic Research.

Keywords: infrasound, seismic waves, physical interaction, multi-spheres, polar regions

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Long Term Trend of Infrasound Signals Observed at Syowa Station, East Antarctica

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Infrasound is sub-audible sound whose frequency range is about 3 mHz to 20 Hz. Because this frequency is common between atmospheric, oceanic and solid earth vibrations, those waves are interacting with each other and interaction itself generates infrasound. At polar region, cryosphere also play an important role for generation and propagation of infrasound. Last decade, for the purpose of monitoring nuclear tests, a global infrasound network is constructed by CTBTO. The CTBT-IMS infrasound network has 47 working stations (as of September 2014) and each station consists at least 4 infrasound sensors (arrayed observation), they can detect a some-kiloton TNT level atmospheric explosion in range of some 1000 kilometers. The network is almost enough for monitoring nuclear tests, but much sparse for detecting and analyzing in detail of natural infrasound phenomena. Especially at Antarctica, CTBT-IMS has only two stations and is most insufficient observation area.

The Japanese Antarctic infrasound observation started at April 2008 as one sensor pilot observation. A Chaparral-type infrasound sensor was installed at Syowa Station (SYO) in Lutzow-Holm Bay (LHB) of East Antarctica, as a part of the International Polar Year (IPY2007-2008). And then, following success of pilot observation, in austral summer in 2013, we extended one-sensor observation at SYO to 3-sensor arrayed observations, and installed a few field stations along the coast of the LHB.

In this study, we will show the trend of infrasound signals observed at SYO during whole observation period (2008 - 2014). Characteristic infrasound waves observed at SYO demonstrate physical interaction involving environmental changes in the Antarctic region. Continuous recording of infrasound, from April 2008 to present, clearly indicate existence of the background atmospheric vibration generated by ocean-atmosphere interaction (microbaroms) with peaks of 0.1 to 0.25 Hz observed during entire period. Because larger amount of sea-ice extending around the LHB near SYO suppress ocean wave, the microbaroms become weak during austral winter. Newly established SYO array clearly detected the propagating directions and frequency contents of the microbaroms from Southern Ocean.In addition, we found harmonic signals around lowermost human audible band, however, currently unclear how and what generating hamonic signals. Those signals are recorded under windy condition. Since our system has no mechanical resonance at those frequency ranges, we speculate that the characteristic harmonic signals are probably related to local surficial phenomena such as ice sheet vibration generated by katabatic winds.

Infrasound measurement at Antarctica could be a new proxy for monitoring a regional environmental change in high southern latitude. In such point of view, we will continue and improve the observations at and around SYO, Antarctica.

Keywords: Infrasound, Antarctica

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SWARM observation of small scale field-aligned currents generated by acoustic waves and their signature on the ground

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From the SWARM satellite observations during the initial two months after the launch, we could confirm that the small magnetic fluctuations with apparent period about 10-30 seconds along the orbit observed in middle and low latitudes are the manifestation of small spatial scale (50-250km) field-aligned currents. We estimated the temporal scale of the variation of the field-aligned currents to be roughly 200 - 350 seconds or less. That is, the source of the current is suggested to be the acoustic mode atmospheric waves. In this paper, we show the method of the estimation, its results and a comparison with the ground magnetic and micro-barometric observations.

Keywords: acoustic gravity wave, ionospheric dynamo, field-aligned current, SWARM satellites, micro-barometric oscillation, magnetic oscillation

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Radio acoustic sounding of the thermosphere by ionosonde tracking of infrasound wavefronts launched by seismic waves

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It is well known that atmospheric waves excited by intense earthquakes induce ionospheric disturbances. At remote distances greater than ~500 km, Rayleigh waves are the major source of infrasounds that propagate upward in the atmosphere. Acoustic waves interact with the ionospheric plasma through collision between neutral particles and ions. Ionospheric disturbances caused by Rayleigh waves near the low frequency part of the Airy phase (a period of several minutes) are detected as a change in the total electron content since the wavelength of induced acoustic waves in the thermosphere is comparable to the ionospheric slab thickness. On the other hand, Rayleigh waves near the high frequency part of the Airy phase (a period of several tens of seconds) cause distortion of ionogram traces, which is characterized by a multiple cusp signature (MCS). The vertical separation of the ledge corresponding to each cusp is the wavelength of the infrasound in the thermosphere. Thus, the MCS ionogram is considered to be a snapshot of the wave that propagates upward.

We conducted rapid-run operation of ionosonde with a frame rate of 1 min at Kazan, Russia. After the 2010 M8.8 Chile earthquake (epicentral distance was 15,162 km), ionospheric disturbances showing MCSs in ionograms were observed for several tens of minutes. The seismogram obtained at Obninsk near Moscow, Russia (epicentral distance was 14,369 km) recorded Rayleigh waves with a period of ~17 s responsible for the ionospheric disturbances showing MCS (the seismogram was shifted by the time corresponding to the difference of epicentral distances between the two locations by assuming a Rayleigh wave speed of 3 km/s). The vertical wavelength of the acoustic wave launched by the Rayleigh waves was 8.5~12 km in the thermosphere. The sound speed calculated by a model was 500~700 m/s at the height of the bottomside ionosphere and wavefronts should propagate 30~42 km upward during the intervals of ionograms, which is smaller than the bottomside depth of the ionosphere. Thus, we could track acoustic wavefronts between consecutive MCS ionograms.

This observation bears an analogy with radio acoustic sounding system (RASS), in which atmospheric perturbation induced by acoustic sounds is tracked by a radar technique and the sound speed (and corresponding virtual temperature) at high altitudes is remotely measured. In a like manner, we compared the sound speed estimated by the MCS analysis and that calculated by the MSIS thermospheric model. The determined sound speed (and corresponding temperature) was slightly higher than the model.

Keywords: ionosonde, multiple cusp signature, 2010 Chile earthquake, Rayleigh waves, infrasounds, thermosphere

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Surface pressure variation excited by cumulus convection

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It has been established that the free oscillations of solid earth are always excited with a small amplitude by some sources other than earthquakes(Nakajima and Notsuhara, 2001; Shimazaki and Nakajima, 2008). One of the candidate for excitation is acoustic waves excited by cumulus convection in the atmosphere. To examine this scenario, a numerical model that can simulate all kinds of atmospheric waves including acoastic waves is required. Tashima and Nakajima (2007) developed a numerical cloud model with full-compressible system of equation, and simulate the development of convective cloud and its ability to excite acoustic waves. The model, whose spatial resolution is 167m, covers 20km in the horizontal direction and extends up to 120km in the vertical direction to represent the 3.7mHz acoustic mode without severe distortion. Standard three category cloud physical parameterization is included. They also employed a linearlized one-dimensional model, which is used as a diagnostic tool to identify which of various cloud processes are responsible for the excitation of acoustic waves possibly related to the earth's free oscillation. In this presentation, short wavelength components, which would correspond to the pressure variations observed by networks of high precision barometers, will be examined.

Numerical experiment reproduced a typical life cycle of convective cloud. We examine the temporal evolution of the horizontal average of surface pressure, whose horizontal wavenumber (zero) is the nearest to the wavenumber of the earth's free oscillation (O(1/1000km)) in all of the waves in the model. The result shows that the temporal variation of surface pressure contains both a slow variation corresponding to the development of cloud as a whole and much faster variation, whose frequency corresponds to that of the enhancement of the earth's free oscillation.

The pressure variation is compared with the runs of the linearlized one-dimensional model driven by the horizontal averages of various non-linear or diabatic terms sampled in the full model. The result shows that the slow variation is mainly excited by the sink of water vapor due to condensation and the drag force of liquid water, whereas the fast component is excited by the latent heating of condensation.

On the other hand, non-averaged pressure time series contains much higher frequency components. The details will be examined in the presentation.

Keywords: cumulus convection, microbaroms, free oscillation, infrasound

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Severe weather phenomenon detected by pressure sensors -thunderstorm-

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Recently, meteorological disturbances and localized concentrated heavy rainfall drastically developed thunderclouds, which can be attributed to global warming, cause disasters like debris. In order to detect such a localized concentrated heavy rainfall, X-band polarimetric radar information network system (XRAIN) is gradually deployed and operated in Japan. The radar system can detect regional scale distribution of cloud water and growing process of localized concentrated heavy rainfall. However, spacial scale of thunder and tornado is smaller than the resolution of the radar system.

Infrasound signal is generated by rapid compress atmospheric such as thunder and vortex rotation by wind. Infrasound array system can detect arrival direction, but it is difficult to estimate the distance from source to observation point only one Infrasound array system.

Many meteorological disturbance in combination with thunder occurred on the Kanto region in the summer of 2014. In order to evaluate meteorological disturbance more accurately, we set up new Infrasound array system in Saitama Prefecture in addition to the existing in Chiba Prefecture.

The back azimuth of signals at two Infrasound array system intersect, and the place was high precipitation intensity on XRAIN image.

Keywords: Infrasound, severe weather phenomenon, XRAIN, thunderstorm