Remote Sensing by Multi-site Observation of Infrasound

*Ko Saito[1], Satoshi Mizumoto[1], Ryosei Sorimachi[1], Masa-yuki Yamamoto[1]

1. Kochi University of Technology

1. Introduction: We have been observing the infrasound generated by earthquakes, tsunami, thunder and other geophysical phenomena as wave sources. Some of the geophysical phenomena occur rarely, while the others occur at a relatively high frequency per year. In order to establish stationary monitoring observations of infrasonic waves with detectable intensities, we started comprehensive multi-site observation with infrasound sensors, cameras and radio wave reception system installed at 3 sites in Kochi pref. In this paper, we report the observation results and considerations about thunder and a bright meteor (fireball) simultaneously observed by the system.

2. Multi-site observation: Since December 2016, we have been operating multi-site comprehensive observation at three points of Kochi University of Technology (KUT) (Kami City), Geisei Astronomical observatory (Geisei Village), Midori Clock Tower (Otoyo Town) with infrasound sensors (Chaparral Physics Model 25), optical cameras, radio wave receiving systems. There is infrasound and radio wave observation system at Otoyo, and all three observation systems are constantly in operation at two other points. Operation status of each device at each remote site can be confirmed at KUT through the mobile network connection, and file transmission and reception is also possible.
Here, observatioal result of the lightning strike (thunder) occurred on 13th December 2016 and a meteor observed on 5th January 2017 are described. Sonic waves of thunder strikes occurred at 18:59 on December 13, 2016 were observed at every 3 observation site, and the lightning strike position and time were calculated from the time difference between them. In addition, the camera installed at KUT and radio wave receiving systems at each observation site observed luminescence and impulsive radio waves. N type atmospheric pressure waveform with on amplitude of 0.06 Pa was detected at Otoyo 24 km away from the lightning strike point.
Sonic waves generated by the meteor observed at 22:33 on January 5, 2017 were detected at two sites. A pressure waveform similar to a shock wave with an amplitude of 0.05 Pa was observed at Geisei. Radio waves (steady transmitted from Fukui National College of Technology) reflected by the ionizing column formed during the meteor entry into the atmosphere were observed at 2 sites and meteor video movie was observed by the camera at KUT.

3. Results and discussion: We found a one second delay between the thunder striking time obtained from the observed time-difference of infrasound impulse among each site and the time when the radio system observed the radio wave impulse. It is considered that this is due to assumptions such as constant sound speed, uniform wind direction, direction of discharge path, etc. In addition, there are some factors of the measurement error of the calculated lightning strike position, and an error of ±300 m is considered in this analysis. Sound amplitude attenuation by distance was calculated from the power spectrum of each site. There were 20 dB difference between KUT and Otoyo where the distance difference from the lightning strike point was 18 km at the maximum case.
Infrasound generated by the meteor entry into the atmosphere was observed at Geisei with shock wave type waveform of a period of 1.53 seconds. The power spectra of 10 seconds before and after the event about were compared, and it was confirmed that the power spectrum amplitude in lower frequency range of 10 Hz or less was 10 dB larger. It could be considered that this is because the detection of very low frequency disturbance when the shock wave occurred in the upper atmosphere passed. The camera

installed at KUT confirmed about 3 times of erupting light emission, which is considered to be relatively larger meteor (fireball) than the normal one. It is extremely rare to be observed for an infrasound generated by an object entering from the outer space into the atmosphere, and such observation is extremely difficult unless there exists stationary operated remote sensing.

4. Conclusion: When calculating the time and position of the event by the acoustic observation, the wind speed has a great influence as an error factor, so it is necessary to set a temperature sensor in each observation site in the future and take temperature information. Moreover, frequency attenuation can be confirmed by sensing the audible range. We have succeeded in observing very low frequency sound generated by geophysical phenomena by conducting steady remote sensing. We will continue to accumulate various observation data by comprehensive observation.

Keywords: Infrasound, Lightning, Thunder, Meteor