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

SSS25-02 Room:312 Time:May 2 14:30-14:45

Development of Acoustic Frequency Comb technology by ACROSS appropriate for active monitoring of the earthquake field

KUMAZAWA, Mineo[1*] ; HIGASHIHARA, Hiromichi[2] ; NAGAI, Toru[1]

[1]Nagoya University, [2]University of Tokyo

Acoustic Frequency Comb technology by utilizing ACROSS (Accurately Controlled Routinely Operated Signal System) has been developed since 1994 at Nagoya Univ. and Earthquake Research Institute at Univ. of Tokyo for the active monitoring method of the subsurface structures. It is now being operated routinely in several locations in Gifu, Aichi, Shizuoka, Hyogo and Kagoshima prefectures.

A group of earthquake seismologists wrote in a book"Science of Earthquake Prediction"(UT Press, 2007) as follows: Whereas ACROSS is an indispensable element for earthquake prediction works, there are problems in stability of the instrumentations, methods of data analysis, etc. To resolve the problems raised by them, our own research works are demanded rather than to complain or to criticize.

1..In the current ACROSS transmitters, single force vector F as frequency-modulated signal is generated by centrifugal force by rotation of a rather small mass M ($\sim$ 100 kg) with a displacement amplitude u as constrained by equation of motion;

$F = M\, d^2u/dt^2 = -\omega^2 (Mu)$

The centrifugal force thus generated is transmitted towards the Earth's interiors through a transmitting antenna named 'ground coupler', which is a steel-reinforced concrete block of several meters in size and $\sim$ 100 tons in weight. As specified by the formula above, transmitted force amplitude is proportional to frequency squared, so that signal transmission is difficult in the useful low frequency range. The previous transmitters designed are practically limited for the use above 5Hz. To extend the frequency to the lower span, we propose the use of a linear motion of larger inertia mass M, 100 $\sim$ 100000 times larger the current transmitter to reduce the frequency by a factor of 10 $\sim$ 100. This could be simply realized by utilizing a large ground coupler as an inertia mass. Quantitative examination of this approach is found to be promising, and we have started the works on the technical realization of this observation system.

2. Low frequency acoustic signal below 1 Hz is useful for the stationary monitoring system covering everything in the whole Japanese Islands, once we build a transmitter array consisting of several tens transmitting statins, since the signal is easily detected up to 100 km distance without any environmental pollution. Local dense array of the signal sensors would provide us with the accurate data set on the swarm of local eigen-modes within the frequency range of the transmitted signals. This approach is the frequency comb interferometry much potential than the seismic daylight interferometry commonly applied nowadays. To make the structural inversion of the data by frequency comb interferometry, we have developed a new forward method named PANW, in which wave equation as a differential equation is converted to arithmetic equation in frequency and wavenumber domain on the basis of the theory of generalized functions.

3. The combined use of observation data by frequency comb ACROSS transmitter array and the data analysis method of frequency comb interferometry by PANW theory is expected to provide us with a potential tool for the practical active monitoring methodology. The contemporary application most relevant is the safety evaluation of artificial constructions such as buildings, tunnels and so on in contact with their subsurface structures.

The prediction and/or control of the earthquakes and volcanic activities will come to be our sound research target after the accumulation of data, our experiences on the 'evolving structural sensitivity' of the materials and its detailed nature at the target zone. Additional essential factor is the associated experimental and theoretical studies on the structural sensitivity of polycrystalline materials containing hydroxyl ions under stress.

We note that the developmental works of this method have been continued for a long period of time by collaboration of so many research workers of a variety of disciplines.

Keywords: Acoustic Frequency Comb, ACROSS, Structure Estimation