

Frequency analysis of EQ echoes associated with large earthquakes in Hokkaido and relationship to meteorological variables

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An empirical earthquake prediction method based on monitoring anomalous VHF-band radio waves transmitted from an FM radio station beyond the line of sight was first introduced by Kushida and Kushida (1998). They had only four observation stations for all of Japan. To further confirm the quantitative relationship between anomalous transmission of VHF-band radio waves and earthquakes, a new data-collection system was designed. Observatories in Hokkaido began collecting data in December 2002. The Tokachi-oki earthquake ($M_j=8.0$, $d=45\text{km}$) and the southern Rumoi sub-prefecture earthquake ($M_j=6.1$, $d=7\text{km}$), occurred in Hokkaido in September 2003 and December 2004, respectively. These large earthquakes produced anomalous transmissions of VHF-band radio wave that were clearly recorded. Two types of anomaly (we call EQ echo here after.) were observed in these earthquakes. An EQ echo typically increases abruptly in intensity by about 5 to 20 db and continues for several minutes to several hours, including multi-pulse forms. Echoes appear once to several times per day, from few days to several weeks before earthquake occurrence. This type of anomaly is referred to as step anomaly. Another type of anomaly is the increase baseline thickness (referred as BT anomaly). Sometimes BT anomaly superposed the step anomaly.

The Tokachi-oki earthquake produced EQ echoes that were recorded at the Teshikaga observatory from the Hiroo FM station (160 km separation). EQ echoes were recorded on 4 September and persisted until 18 September, after which there were 9 quiet days prior to the earthquake. The cumulative total duration of EQ echoes documented was about 1000 minutes. A wavelet filtering was applied to documented data and separated high and low frequency components. Frequency analysis of the step and BT anomalies revealed characteristic of frequency components. The BT anomalies include some high frequency perturbations.

Fukumoto et al.(2002) and Fujiwara et al. (2004) showed that the received intensities of scattered waves were stronger when the antenna was at a shallower angle, which implied that the scattering body was in the middle atmosphere rather than in the ionosphere. Hayakawa et al. (2007) described a generation mechanism of atmospheric disturbances resulting from changes in geochemical quantities associated with earthquakes and the effect of long-range VHF wave propagation is usually due to tropospheric ducting. For these results, we investigated relation between meteorological variables and appearance of the EQ echoes. But, we have not found clear relation to the wether condition of the Tokachi area.

The second example is the southern Rumoi sub-prefecture earthquake that occurred in the upper crust, of 14 December 2004. A protracted interval of EQ echoes on the 83.8 MHz channel began at the ERM observatory on 30 November 2004. By 13 December, the cumulative duration of EQ echoes exceeded 900 minutes. These echoes were the signal from an FM radio station in Haboro, which is 20 km from the epicenter of earthquake and 280 km from the ERM observatory. We observed two types of step anomaly; abruptly increase type and slowly increase type, associated with the EQ but not observed isolated BT type anomaly. And the relation to the meteorological variables has not observed for this EQ.