

Development of Regional Earthquake Early Warning System with Structural Health Monitoring Function and Real-time Ground Motion Prediction Using Front-Site Waveform Data

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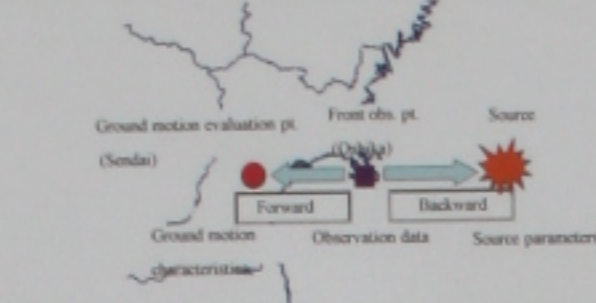
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Introduction

Background

- * General Operation of EEW System by JMA
- * The approach to Miyagi-ken Oki earthquake
- * Limitation of National (JMA/NIED) EEW System
 - Applicability to Near-source earthquake
 - Accuracy of the predicted ground motion parameters

Forward use of the waveform data at front site



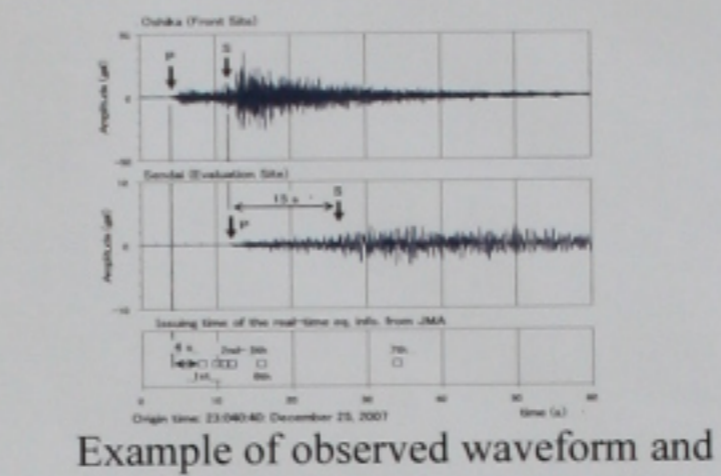
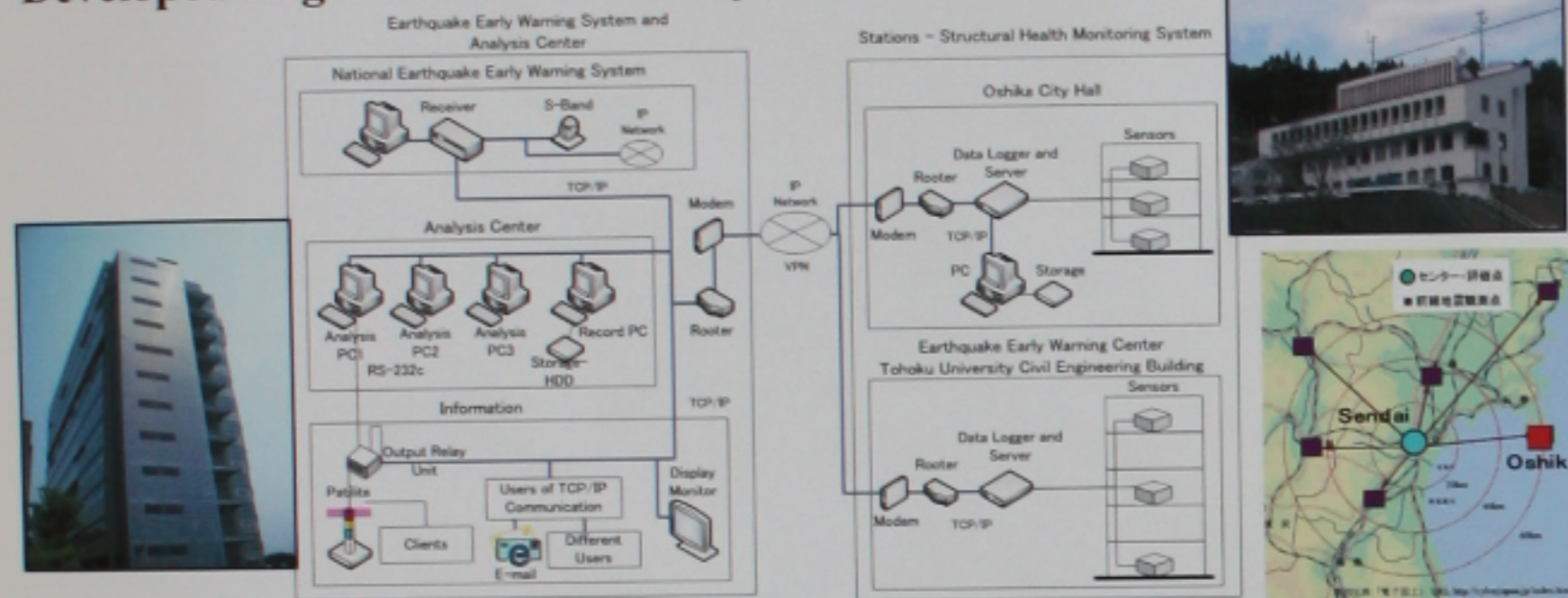
- * Waveform data is used only to determine the source parameters as a point source
- * Conventional attention formula is used for ground motion prediction based on the determined point source

Objective

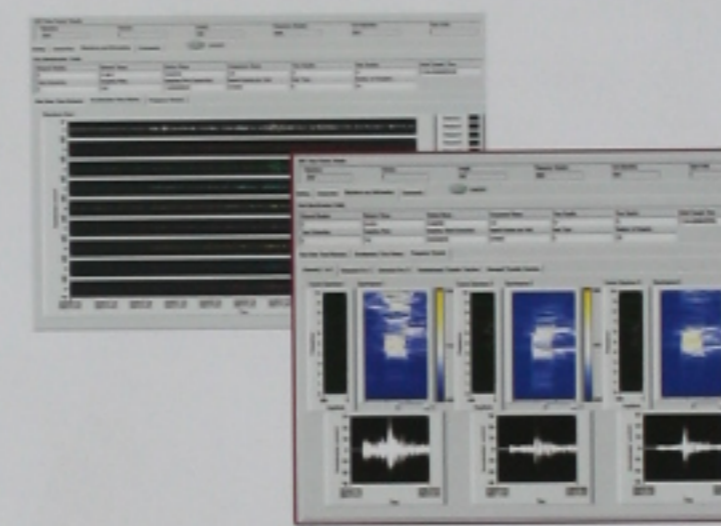
- * To enhance the accuracy and the immediacy by combining the 'On-site' and 'Regional' EEW System with the National EEW System
- * To add Structural Health Monitoring as daily Function
- * To investigate the Forward use of the Front-Site Waveform Data

Regional Earthquake Early Warning System with Structural Health Monitoring Function

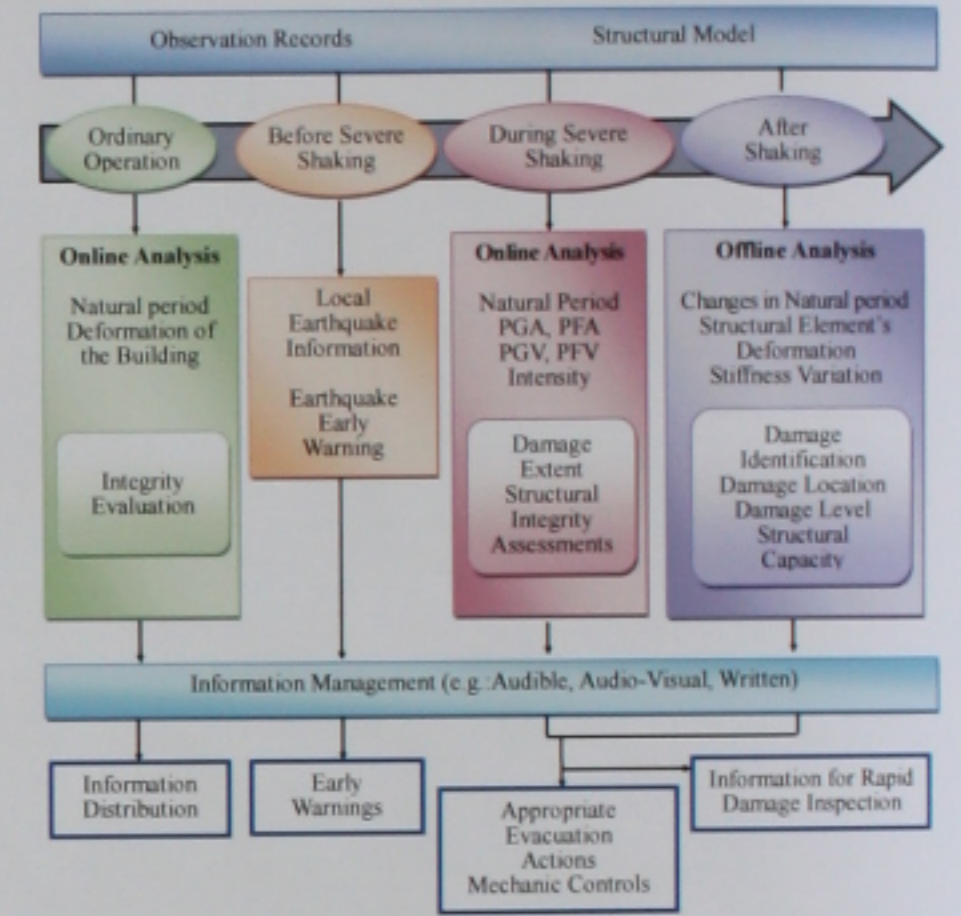
Developed Regional EEW/SHM System



Example of observed waveform and the issuing warning time from JMA



Online waveform and SHM display



Dispatch of the SHM information along the time series

Specification of Developed System

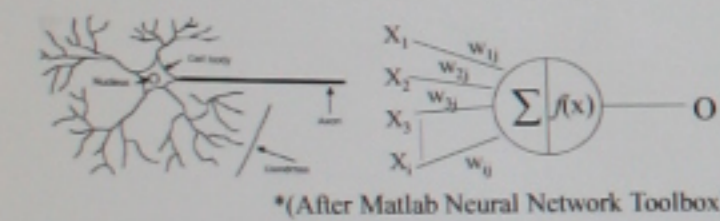
- * 120 dB, 24 bit observation system
- * Real-time data transmission based:
 - Variable packet-length, Variable sampling-rate,
 - Ordinal operation: 0.2 s and 100 Hz
- * TCP/IP connection (combination to UDP connection)
- * P-wave detection at the on-site and the front site
- * SHM of the dominant frequency

Real-time Ground Motion Prediction based on Artificial Neural Network

Outline of the Methodology

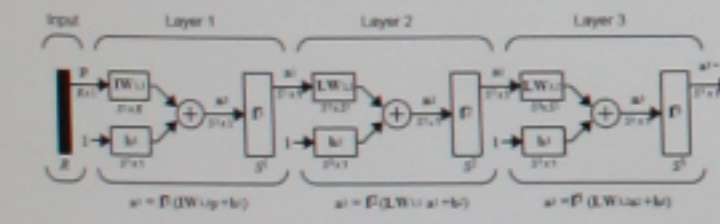
Artificial Neural Networks*

Basic units & Neuron cells (units)



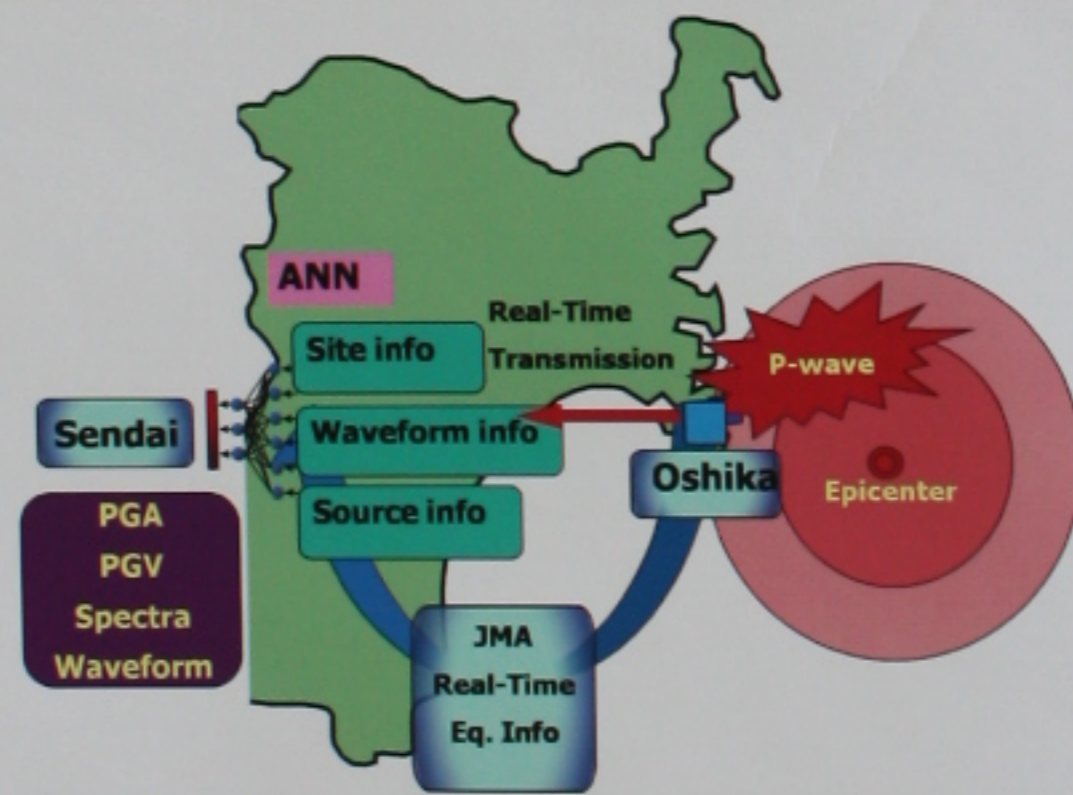
*(After Matlab Neural Network Toolbox)

At the neural level the learning happens by changing of the synaptic strengths, eliminating some synapses, and building new one.



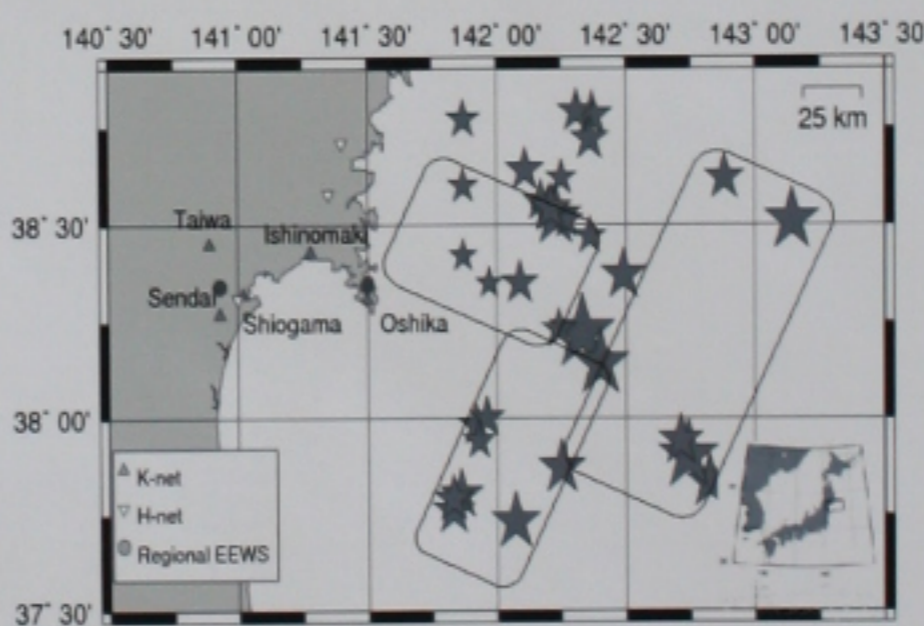
*(After Matlab Neural Network Toolbox)

Matrix representation of Neural Network

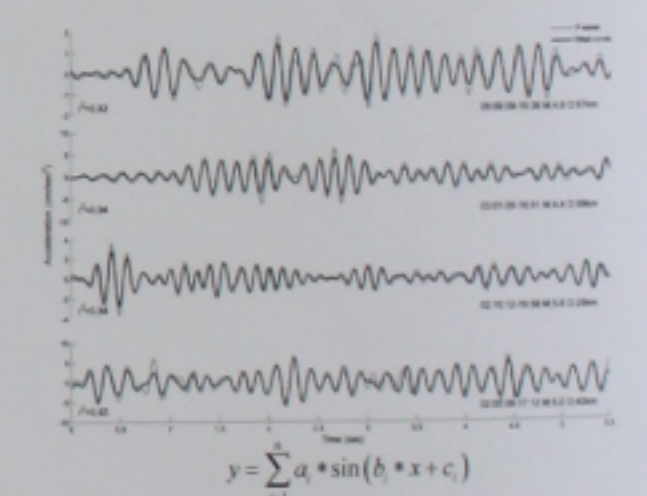


Conception of the accurate real-time ground motion prediction based on the regional EEWs combined with real-time earthquake information from JMA

Used Database for Training and testing

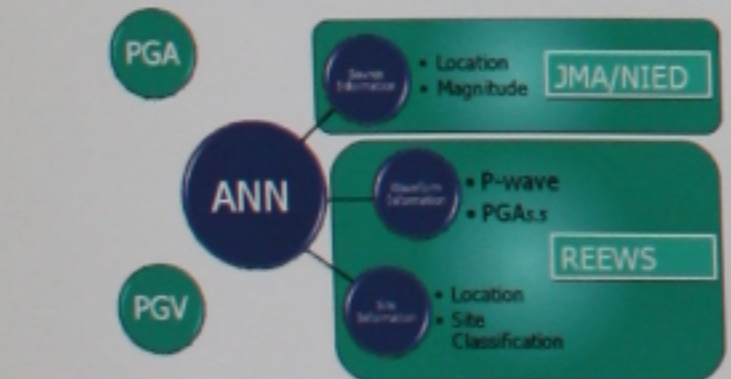


Location of the K-NET observation sites and the epicenter distribution of the 39 earthquakes occurred in Miyagi-ken Oki area



Waveforms of the initial part (5.5 s) and the approximated waveforms

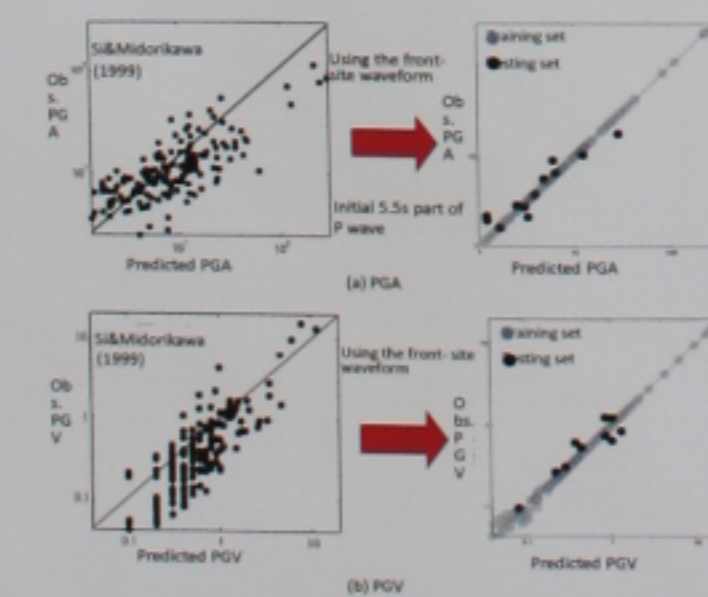
Forecasting Peak Ground Motion parameters: PGA and PGV



Information for ANN construction in the peak ground motion forecasting

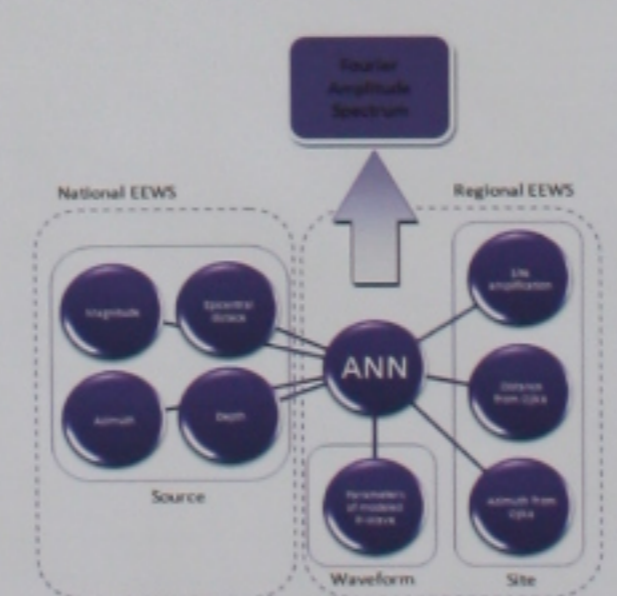
	Training set		Testing set		Total set	
	Mean	Std. deviation	Mean	Std. deviation	Mean	Std. deviation
PGA	1.00	0.01	0.98	0.32	1.00	0.09
PGV	1.00	0.10	0.98	0.33	1.00	0.12
PGA					1.33	0.97
PGV					1.97	1.20

Comparison of the average and standard deviation

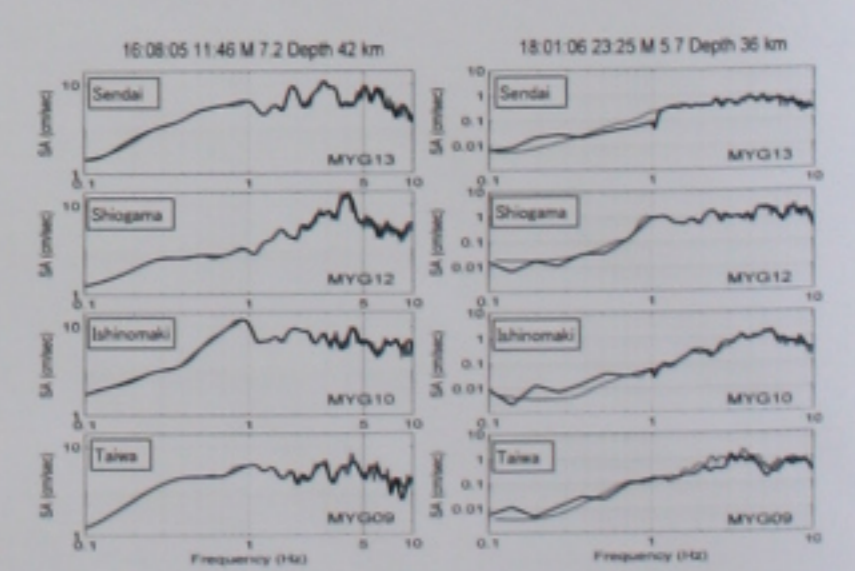


Comparison of the results in the peak ground motion prediction

Forecasting of Spectral Ground Motion, Fourier Amplitude Spectra



Information for ANN construction in the spectral ground motion prediction



Comparison of the predicted and observed Fourier Spectra of ground motions (left: Training data, right: Testing data)

Concluding Remarks

- * The Regional EEW/SHM System combined with the real-time earthquake information from JMA has been developed.
 - * The developed EEW/SHM system makes it possible to enhance the accuracy and the immediacy of the real-time ground motion prediction.
 - * The standard specification of online data transmission for the regional EEW/SHM would be needed regarding packet-length, connection way, TCP/IP connection and/or UDP connection.
 - * The advanced method of the real-time ground motion prediction using the front site waveform data based on ANN and its verification and the validity were described.
 - * The ANN based ground motion forecasting method make it possible the accurate spectral ground motion before arrival S-wave for the approaching Miyagi-ken Oki earthquake.
 - * The accurate ground motion forecasting would be applied to the making the band-pass filtered information for various period range of interest and advanced engineering applications, e.g. Feed-forward structural control.
- Accurate spectral forecasting in Sendai is possible before S-wave arrival using the front site Oshika waveform information for the approaching Miyagi-ken Oki earthquake!*

Acknowledgements

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References

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