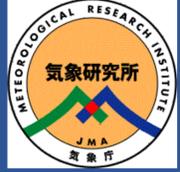


Array observation of strong ground motion for estimating current wavefield in real time

Masashi Ogiso (mogiso@mri-jma.go.jp), Naoki Hayashimoto, Mitsuyuki Hoshiba (Meteorological Research Institute, Japan Meteorological Agency, Tsukuba, Japan)

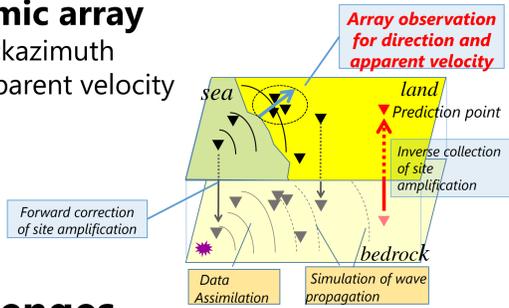


Background

- Next generation of Earthquake early warning: predict ground motion directly from observed wavefield
- Observed wavefield: amplitude distribution in dense seismic network (Hoshiba and Aoki, 2015)
- Other observations?

Seismic array

- Backazimuth
- Apparent velocity

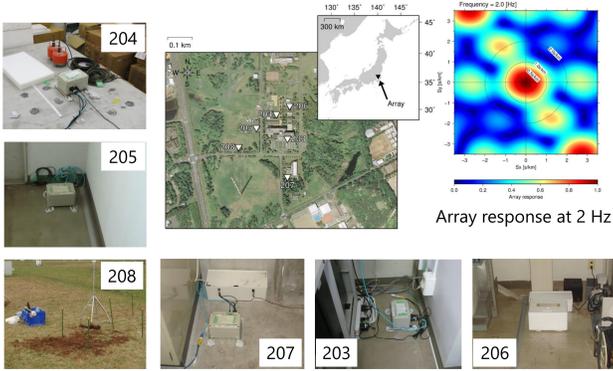


Challenges

- Evaluation of observation
- Effective calculation
 - Application in EEW: calculation in real time (within 1 s)

Array network information

Place	Premises of our institute
Seismometer	Tokyo Sokushin CV-374 Accelerometer
Sampling frequency	500Hz
Measurement range	record continuous waveform ±2000gal
Seismometer location	Pier (204) 20cm buried (208) floor of the building (others)



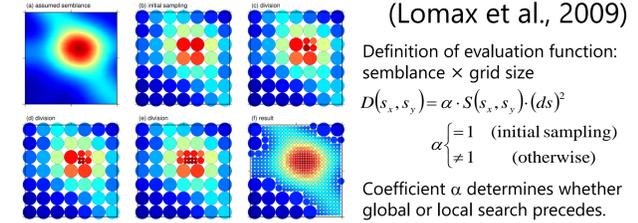
Calculation of backazimuth and apparent velocity

- Semblance (Neidell and Taner, 1971)

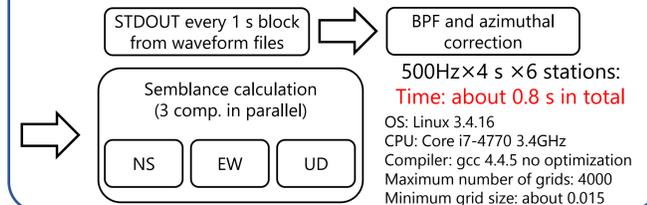
$$s(s_x, s_y) = \frac{1}{N} \frac{\sum_{i=1}^N \left(\sum_{j=1}^M u_i(t_x + (s_x \cdot x_j + s_y \cdot y_j)) \right)^2}{\sum_{i=1}^N \sum_{j=1}^M u_i^2(t_i)}$$

Search appropriate slowness s_x and s_y

- Effective grid search: Oct-tree Search (Lomax et al., 2009)

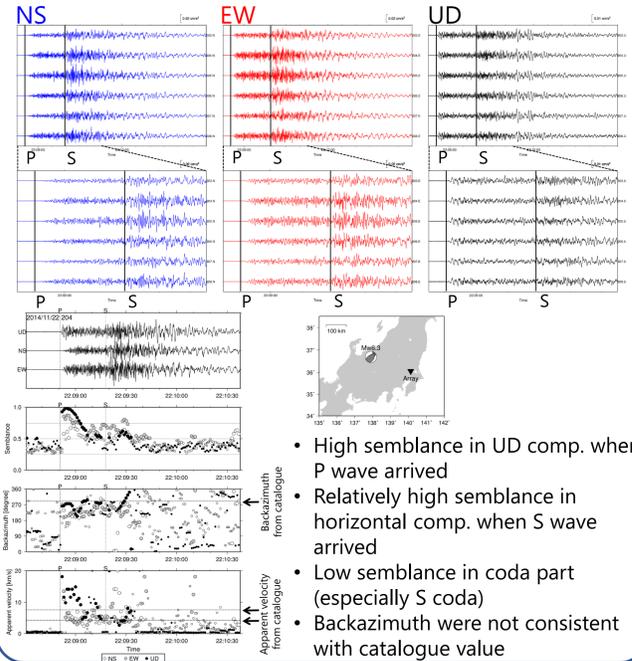


The grid which have large evaluation function are subdivided into 4 grids and evaluation function is calculated in each grid. Calculation ends when number of grids exceeds its limit.

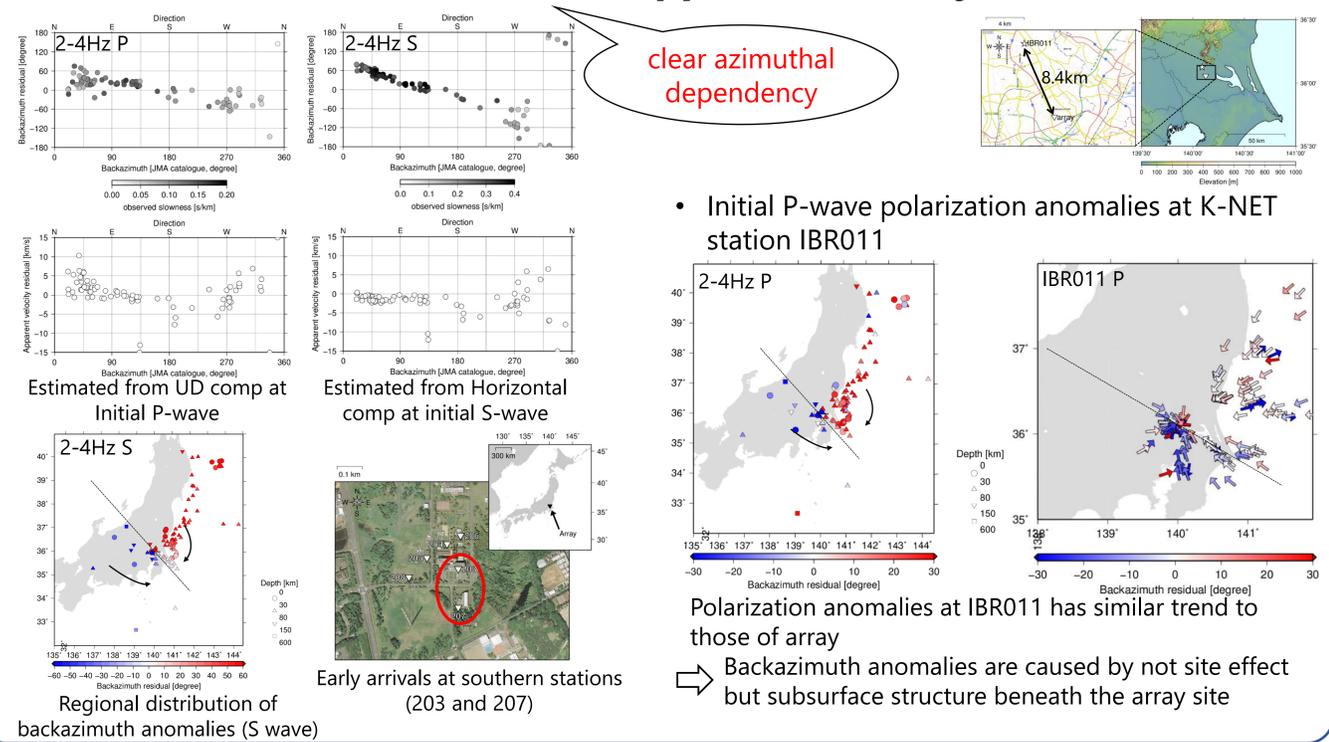


Observed waveforms and semblance calculation

- 2014/11/22 Northern Nagano eq. (M_w 6.3)



Anomalies of backazimuth and apparent velocity

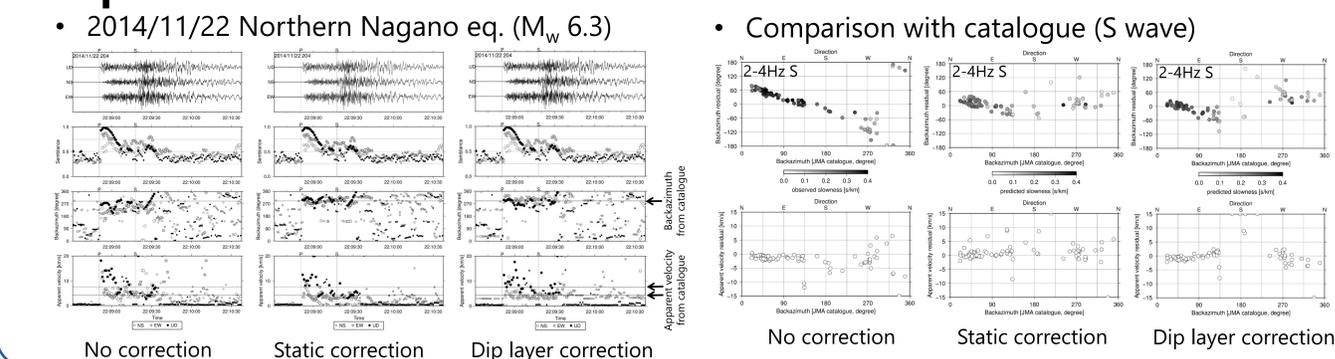


Methods of anomaly correction

- Static correction
 - Travel time differences between assumed velocity model and observations
 - Dip layer correction
 - Affects local earthquakes as well as regional to teleseismic earthquake (e.g. Meng et al., 2014)
 - From model to observation: Niazi (1966) conduct grid search of strike and dip amount at the top of seismic bedrock
 - seismic basement: $V_p=4.8\text{km/s}$, $V_s=2.84\text{km/s}$
 - sedimental layer: $V_p=2.0\text{km/s}$, $V_s=0.50\text{km/s}$
 - From observation to model: Maki et al. (1987); Hao and Zheng (2010)
- ⇒ **Strike 69 deg., Dip 9 deg.**

S-wave Velocity (m/s) Velocity structure around array (Cho et al., 2006)

Comparison between two correction methods



Summary

- High sampling seismic array observation for estimating current wavefield
- Real time calculation: every 1 s calculation using 4 s time window
- Backazimuth anomalies: can be interpreted that caused by subsurface structure
- Correction of anomalies are needed for estimating current wavefield, either static or dip layer correction
- Application to the real time ground motion prediction
 - Evacuation of observation error
 - Data assimilation technique

Acknowledgments

We used K-NET waveforms operated by the National Research Institute for Earth Science and Disaster Prevention (NIED), Japan. We used aerial photographs and digital topographic map produced by the Geospatial Information Authority of Japan (GSI).