Towards Local Tomography Models with Uncertainties

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Station Distribution Around KamLAND

Nakajima et al. (2010)
Comparison of Tomography Models

\[ \frac{\delta V_p}{V_p} \]

Local Model (Nakajima et al. 2010)

\[ \frac{\delta V_p}{V_p} \]

All Japan Model (Matsubara et al. 2008)

\[ -10 \quad 10 \quad \% \]
Comparison of Tomography Models

\[ \delta V_p/V_p \]

Local Model (Nakajima et al. 2010)

\[ \delta V_p/V_p' \]

All Japan Model (Matsubara et al. 2008)

systematic offsets corrected
Comparison of Tomography Models

10 km

Comparison of Vp and Vs at 10 km depth for Local Model (red) and All Japan Model (green)
Impact on the Lithology Identification
Cause for the Discrepancies

Scheme for Geophysical Inversion

- observed data: \( d \)
- initial model: \( m_0 \)
- final model: \( m \)

\( \text{ad hoc assumption} \)

(uncertainty of the data)

(uncertainty of the initial model)

(uncertainty of the final model)

Bayesian Inference

junk
Method for Uncertainty Evaluation

Gudmundsson et al. (1990)

Bundle of seismic rays
with common source and receiver regions

\[ \delta t_i - \bar{\delta t} \]

variance of traveltime anomalies

depends on random data error
&
lateral heterogeneities
with scale length
smaller than the bundle size.
Implementation in this Study

- Discuss only the integrated signals as a first step.
- Discuss the ensemble average of the variance curves.

(stacking all the curves with common source depth and distance.)
Dataset Used in This Study

1,468,894 P arrival time measurements in the JMA unified catalogue

event depth: 0 – 30 km
distance: 0 – 100 km

KamLAND
Example Traveltime Variance Curve

Source Depth: 5-10 km

- Variance (s^2)
- Scale (km)
- Distance
Evaluated Random Data Errors

![Graph showing evaluated random data errors vs distance with different source depths.]

- Source depth:
  - 20 - 30 km
  - 15 - 20 km
  - 10 - 15 km
  - 5 - 10 km
  - 0 - 5 km

- X-axis: Distance (km)
- Y-axis: Random data error ($s^2$)
Cause for the Random Errors

(1) picking error

(2) phase misidentification

interface 1

interface 2

(3) event mislocations
Evaluated Random Data Errors
For Global Data

Gudmundsson et al. (1990)
Evaluated Integrated Signals

- Source depth:
  - 20 - 30 km
  - 15 - 20 km
  - 10 - 15 km
  - 5 - 10 km
  - 0 - 5 km

- Integrated signal vs. distance
  - Distance (km)
  - Integrated signal (s²)
Inverted Heterogeneity Intensities

Intensity of Heterogeneity \((10^{-5} \text{ s}^2/\text{km})\) \(\propto a \epsilon^2\)

![Graph showing intensity of heterogeneity versus depth.]
Reflector Imaging in This Region

Iidaka et al. (2009)
Reflector Imaging in This Region

Iidaka et al. (2009)
Summary

- Summary residuals in the Japanese catalogue contains useful information for data error and Earth’s heterogeneities.

- strongly heterogeneity

The regions with dense reflectors are highly correlated.

higher seismicity

The effects of cracks need to be considered to identify the lithology.