AGU PUBLICATIONS

Journal of Geophysical Research – Solid Earth

Supporting Information for

Crustal structure of the Ionian basin and eastern Sicily margin: results from a wide-angle seismic survey.

David Dellong (1,2), Frauke Klingelhoefer (2), Heidrun Kopp (3), David Graindorge (1), Lucia Margheriti (4), Milena Moretti (4), Shane Murphy (2), Marc-Andre Gutscher (1)

(1) IUEM, Univ. Brest, CNRS, Laboratoire Géosciences Océan, Plouzane, France,

(2) Géosciences Marines, Ifremer, Centre de Brest, Plouzané, France,

(3) Geomar Helmholtz Centre for Ocean Research, Kiel, Germany,

(4) Istituto Nazionale di Geofisica e Vulcanologia - INGV, Rome, Italy

Contents of this file

Introduction: Uncertainty analysis

In order to estimate the velocity and depth uncertainty of the final velocity models, we performed a perturbation analysis for the Moho interface supposed to have the greatest uncertainties due to it large depth and by extension its limited ray coverage. The depth of the Moho interface, and the velocities of the lower-crustal layers, was varied systematically to test the trade-off effects of these two parameters on the Moho discontinuity. After, a statistical F-test (or Fisher test; **Figure S1**) was applied to determine if a significant change between newly created models and the unperturbed model could be detected. Results from this analysis show that our preferred model allows a maximum of picks to be explained, with a minimum resulting misfit between the picked travel-times and arrivals predicted from the modeling. Solutions leading to better fits explain a lower number of picks **(Figure S1)**.

Forward modelling methods can take into account secondary reflections, irregular instrument deployments and information from coincident reflection seismic data (e.g. low velocity layers underneath salt or basalt layers), the resulting model can be dependent on a priori ideas of the interpreter. Monte Carlo methods produce a large quantity of random models and test if any of those present better or equal fit to the data. They have the advantage of eliminating possible bias regarding the interpretation and provide valuable insights in the uncertainties along the forward model. We used the "Vmontecarlo" **(Loureiro *et al.,* 2016)** software to produce 50000 independent random models, of which those who fit the threshold parameters (explain at least 95% of the picks of the preferred model and having a rms error not higher than twice that of the preferred model) were selected for an uncertainty analysis **(Loureiro *et al.,* 2016)**. All velocity nodes and the depth nodes of the crustal layers were tested, however the sedimentary depth layers being additionally constrained by the reflection seismic data were omitted. Also layer having pinch outs can potentially produce a high amount of random models characterized by unrealistic crossing layers. The resulting uncertainty sections show good uncertainties not exceeding 0.6 km/s in the upper-crustal layers and 0.8 in the lower-crustal layers **(Figure S2).** The high uncertainties along the deeper interfaces are due to velocity-depth trade off along the layer boundary. Here, different models may have the same interface at different depths and thus, the same cell can have velocities sampled from the layer above or below **(Loureiro *et al.,* 2016)**. The layer boundaries of the models showing the smallest error are following closely the model boundaries of the preferred model, however, they show a larger variability which might imply that small artefacts are being fit, which we avoided following the minimum structure approach.

The **Figure S3 and S4** of the supporting information show the ray coverage separated for the sedimentary layers, the crustal layers and the Moho interface, and also the "fit" between the data picked on the OBS and the modelled arrivals.

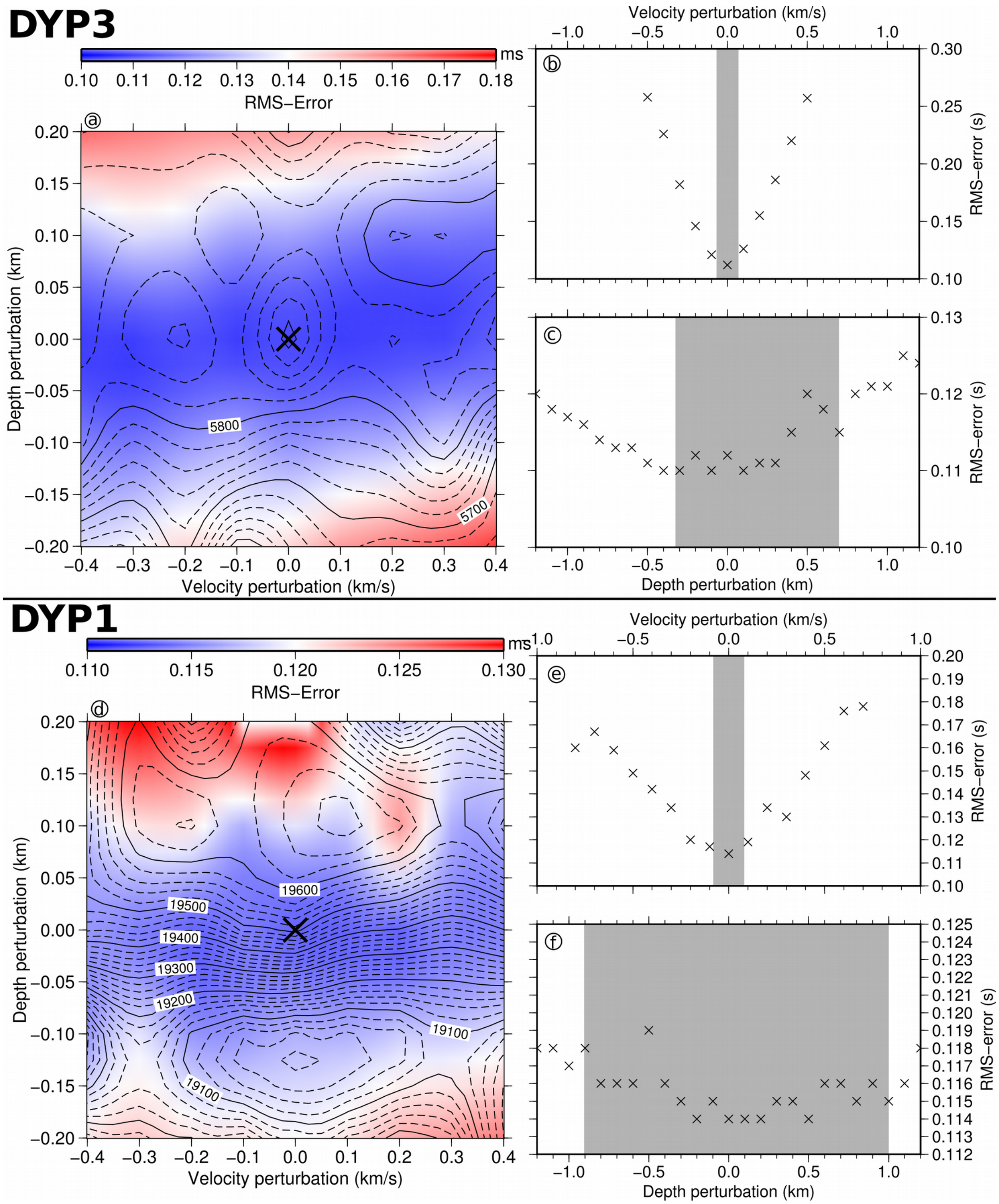

DYP3
ms
0.10 0.11 0.12 0.13 0.14 0.15 0.16 0.17 0.18
RMS−Error
ⓐ
Depth perturbation (km)
Velocity perturbation (km/s)
5800
5700
ⓑ
ⓒ
Velocity perturbation (km/s)
RMS−error (s)
Depth perturbation (km)
DYP1
ms
0.110 0.115 0.120 0.125 0.130
RMS−Error
ⓓ
19600
19500
19400
19300
19200
19100
ⓔ
ⓕ

Figure S1. Perturbation analysis for the Moho interface on both velocity models (Top DYP3 and bottom DYP1). The Map (a and d) present the RMS-error distribution (in color) according to velocity and depth perturbation of the preferred model (Black-cross at zero-perturbation). Contour-line show the number of picks used for the corresponding velocity models. The velocity perturbation against the RMS-error is presented in b and e panels; and the depth perturbation against the corresponding RMS-error on c and f. The gray boxes, represent the 95% probability, that the original and the perturbed model are statistically different based on F-test calculations.

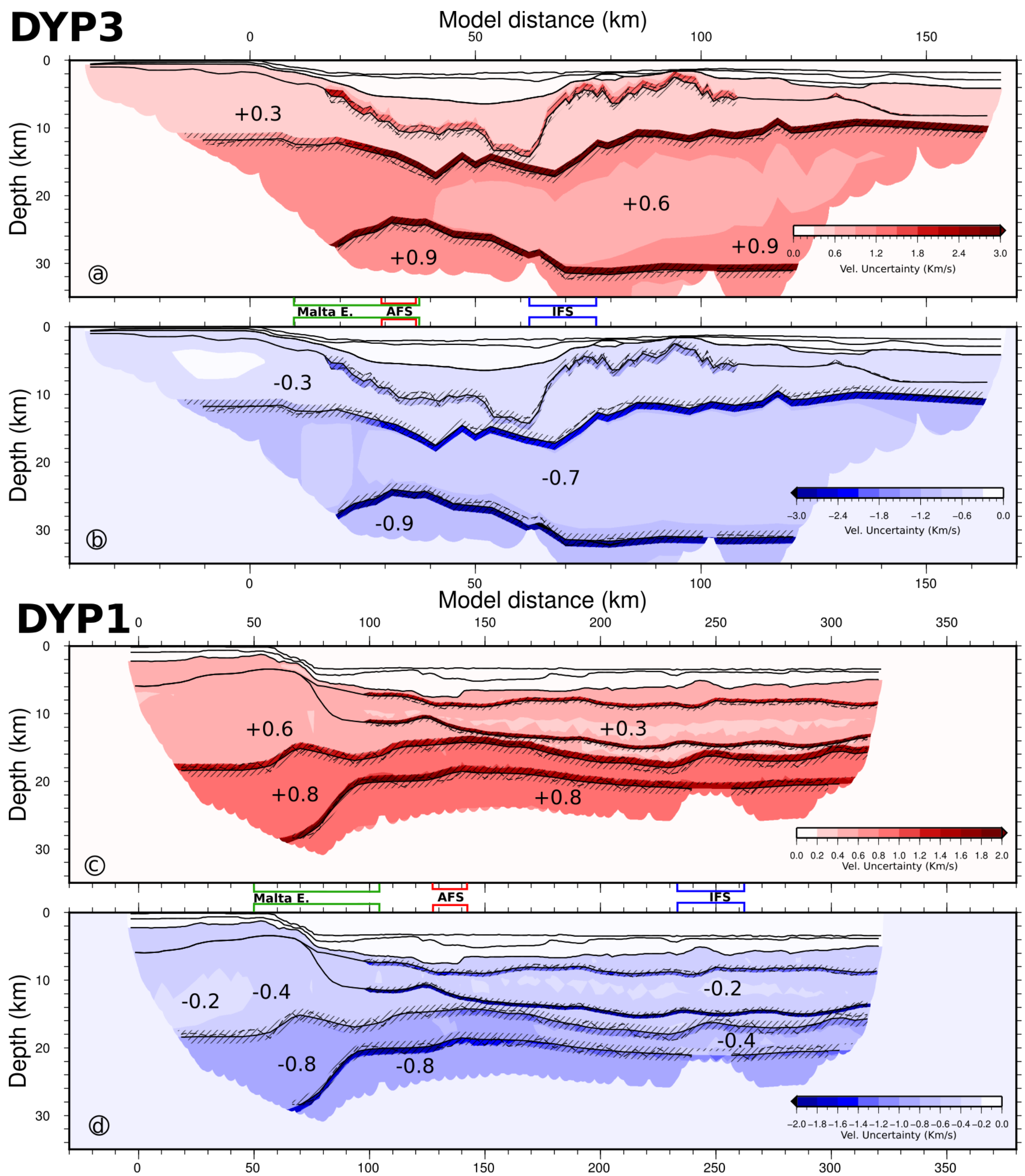
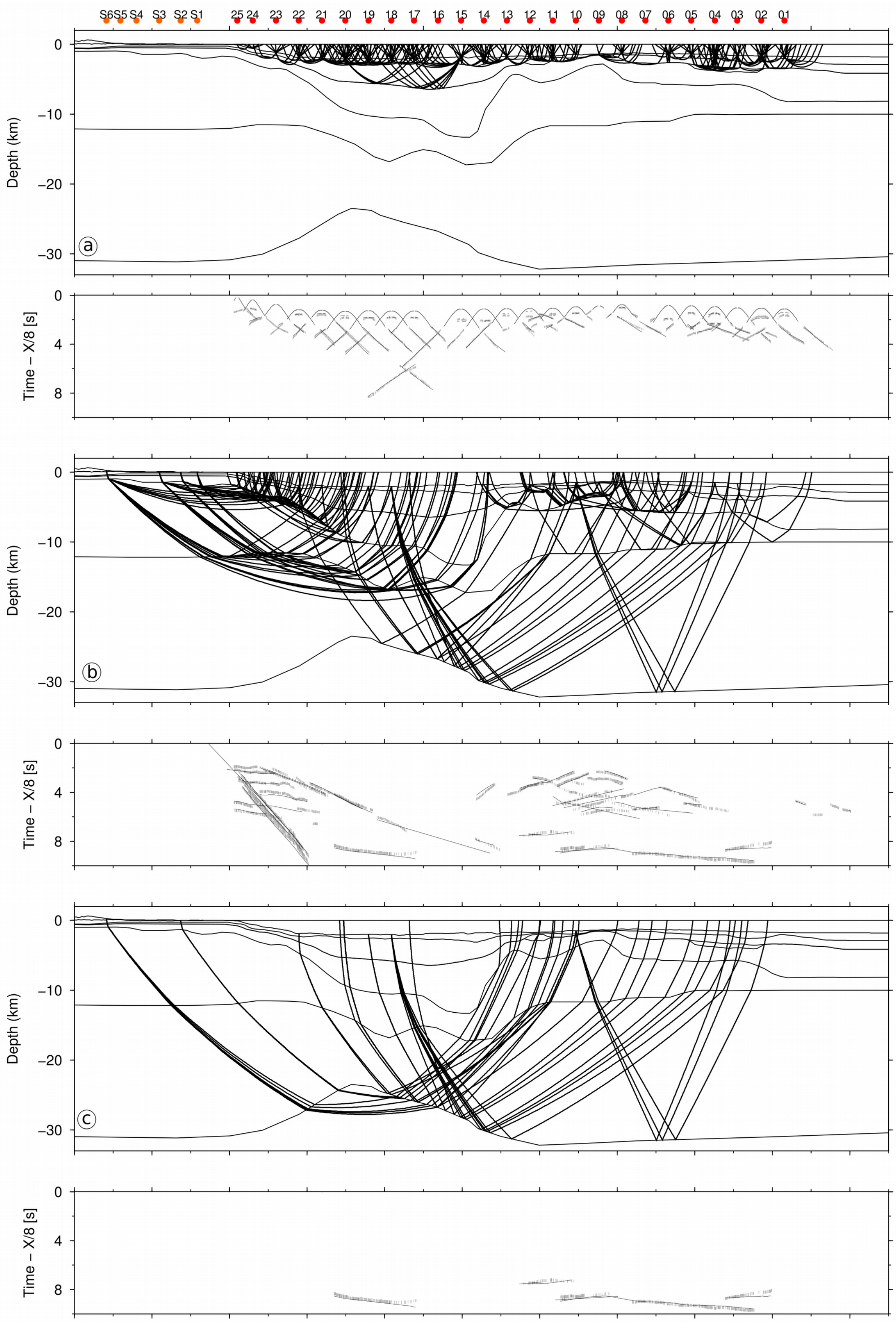

DYP3
Model distance (km)
Depth (km)
+0.3
+0.6
+0.9
+0.9
Vel. Uncertainty (Km/s)
a
Malta E.
AFS
IFS
-0.3
-0.7
-0.9
b
DYP1
+0.6
+0.3
+0.8
+0.8
c
-0.2
-0.4
-0.2
-0.4
-0.8
-0.8
d

Figure S2. Global uncertainty plot of profile DYP3 (top) from Monte Carlo modeling. a) Maximum and b) minimum admissible velocity deviations from the preferred model, built from 9405 models capable of tracing at least 4660 rays (95% of the preferred models), with an RMS value under 195 ms (150% of the preferred models) and a χ^2 not exceeding 2.7 (150% of the preferred models). And of profile DYP1 (bottom) Global uncertainty plot from Monte Carlo modeling. a) Maximum and b) minimum admissible velocity deviations from the preferred model, built from 1872 models capable of tracing at least 18400 rays (95% of the preferred models), with an RMS value under 173 ms (150% of the preferred models) and a χ^2 not exceeding 2.6 (150% of the preferred models). On both figures, Shaded areas indicate ray coverage. Preferred model's interfaces are indicated by black lines. The best random model's interfaces are indicated by dashed lines. Hatched areas correspond to the maximum variation allowed in the Monte Carlo process.



S6 S5 S4 S3 S2 S1 25 24 23 22 21 20 19 18 17 16 15 14 13 12 11 10 09 08 07 06 05 04 03 02 01
Depth (km)
0
−10
−20
−30
a
Time − X/8 [s]
0
4
8
Depth (km)
0
−10
−20
−30
b
Time − X/8 [s]
0
4
8
Depth (km)
0
−10
−20
−30
c
Time − X/8 [s]
0
4
8

Figure S3. Fit between picked arrivals from OBS data (vertical gray lines that include pick uncertainties) and calculated from the velocity model (black lines) along the DYP3 profile. (a) For sedimentary layers (b) for crustal layers (c) and for the Moho interface. For each layer, ray dispersion calculated in the velocity model (top) and fit of the picked data and the calculated arrivals (down) are shown.

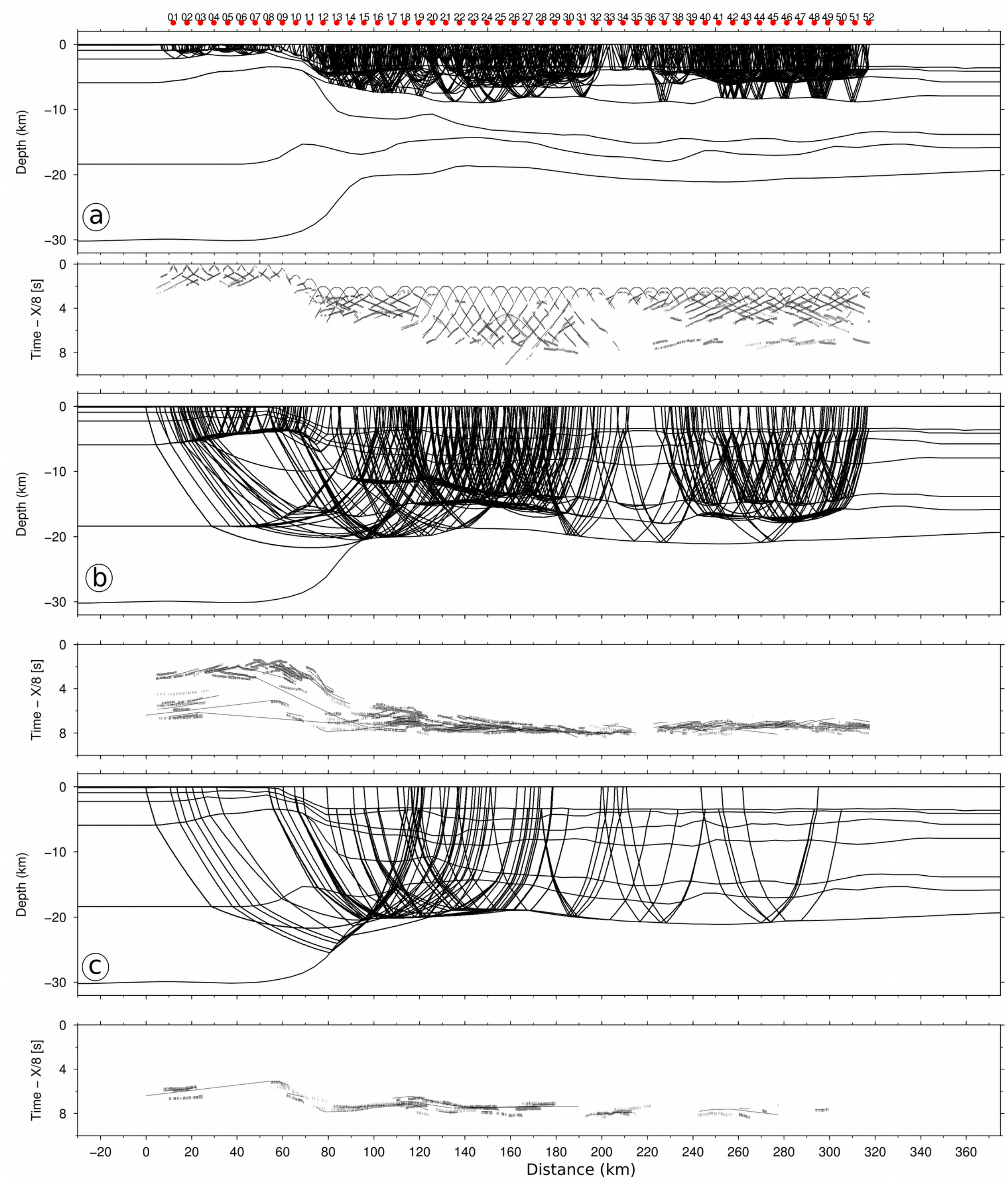


Figure S4. Fit between picked arrivals from OBS data (vertical gray lines that include picks uncertainties) and calculated from the velocity model (black lines) along the DYP1 profile. (a) For sedimentary layers (b) for crustal layers (c) and for the Moho interface. For each layers, ray dispersion calculated in the velocity model (top) and fit of the picked data and the calculated arrivals (down) are shown.