Resolution of group velocity models obtained by adjoint inversion in the Czech Republic region

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1. Introduction

Data: Traveltimes of Love waves between stations of CRSN network obtained by crosscorelation of ambient noise filtered for selected frequencies are used in the inversion (Ruzek et al, 2012).

Inversion: As the misfit, we use L2 norm of crosscorrelation traveltimes. Misfit minimization is perfomed with conjugate gradients (Polak-Ribiére). Gradients are calculated using adjoint method. Gaussian smoothing is applied on descent directions. Inversion starts from homogenous model.

Forward problem: Membrane wave approximation of surface wave propagation for each period separately enables us to reduce the calculation to only 2D domain. Point sources are located in selected stations with Ricker wavelet as time function centered around given periods. Numerical calculations are performed using program SeisSol (ADER-DG method) (Käser et al, 2006), specifically recently developed adjoint version of SeisSol2D.

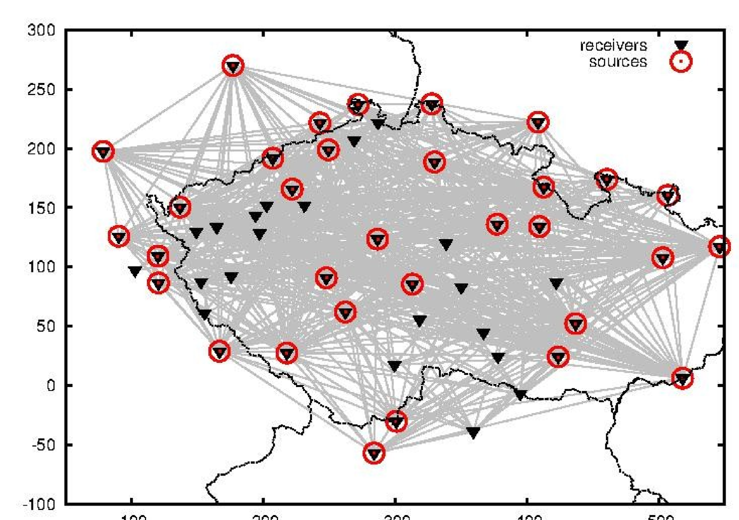

Fig 1.1: Sources and stations configuration. Source-station pairs with traveltimes used in inversion are connected with lines.

2. Results of real data inversion

20s Love waves

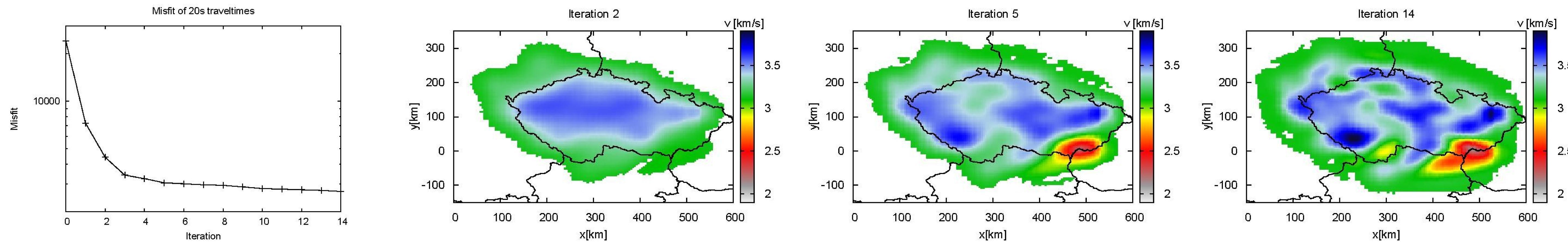

Fig 2.1: Left:misfit decrease with iterations for 20s data. Right: obtained models of group velocities after iteration 2, 5 and the last one.

16s Love waves

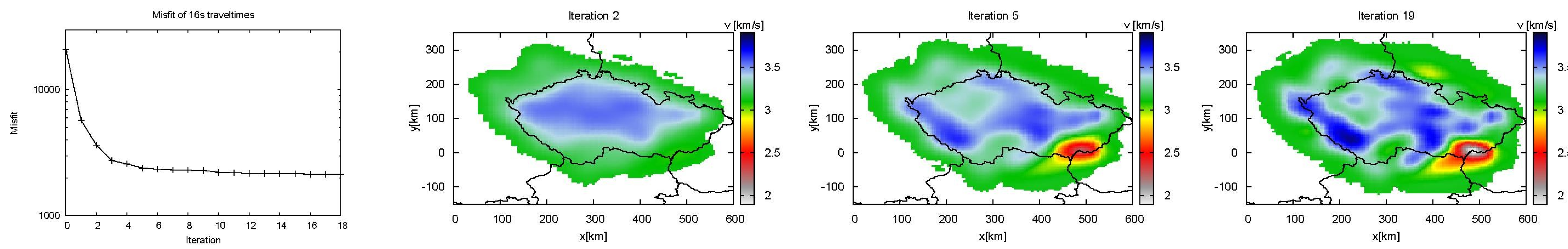

Fig 2.2: Left: misfit decrease with iterations for 16s data. Right: obtained models of group velocities after iteration 2, 5 and the last one.

12s Love waves

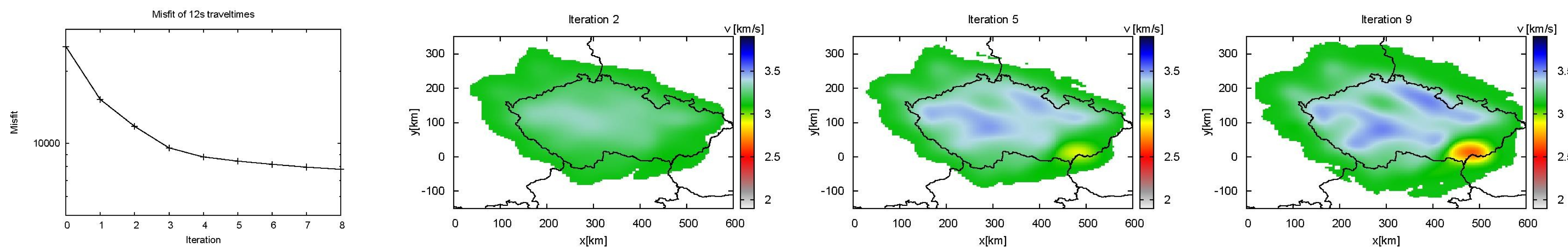

Fig 2.3: Left: misfit decrease with iterations for 12s data. Right: obtained models of group velocities after iteration 2, 5 and the last one.

Summary: 16s and 20s group waves have similar depth sensitivities, therefore the new models are expected to resemble each other. Some differences arise after the first few iterations and mainly on smaller-scale structures.

3. Effect of data noise - synthetic tests with traveltimes perturbed using different level of errors

We examined the effect of traveltime noise on two different target models. Target model 1 was simple very smooth model (Fig 3.2), target model 2 contains checkerboard pattern of size 100km (Fig 3.4). Synthetic waveforms calculated in these models were shifted by a random value generated from Gaussian distribution (Fig 3.1). The results of inversion are more stable for checkerboard test, even with relatively high noiselevel.

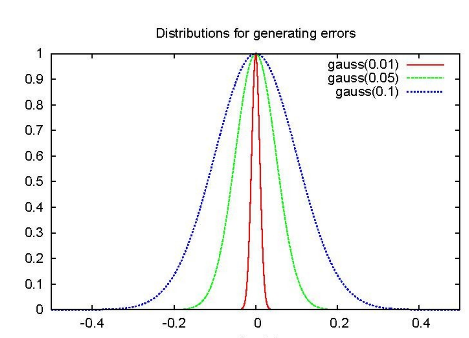

Fig 3.1: Distributions used to generate traveltime errors

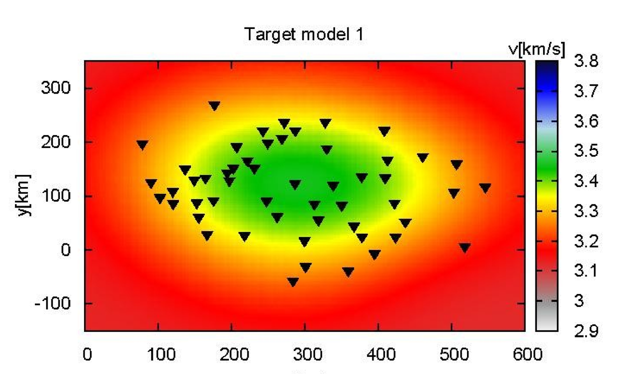

Fig 3.2: Target model and station configuration for synthetic inversion of long-wavelength structure (test 1)

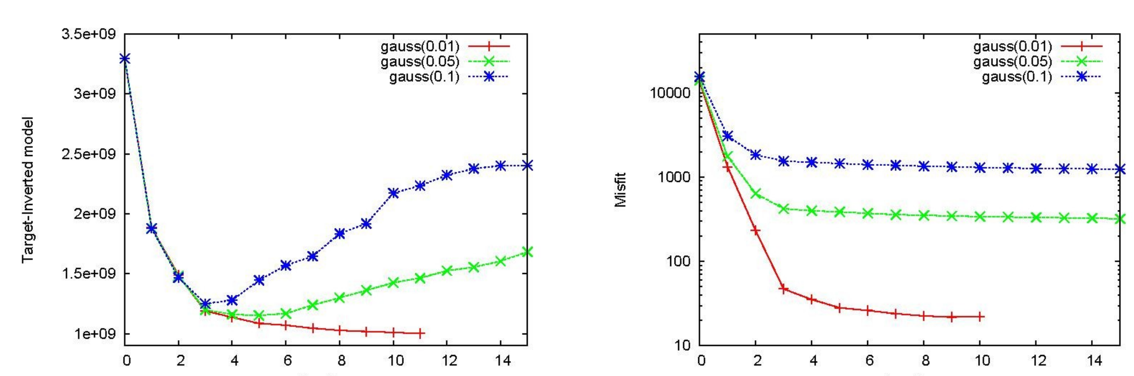

Fig 3.3: Difference between target model and model found (left) and misfits (right) with iterations for every level of noise (test 1)

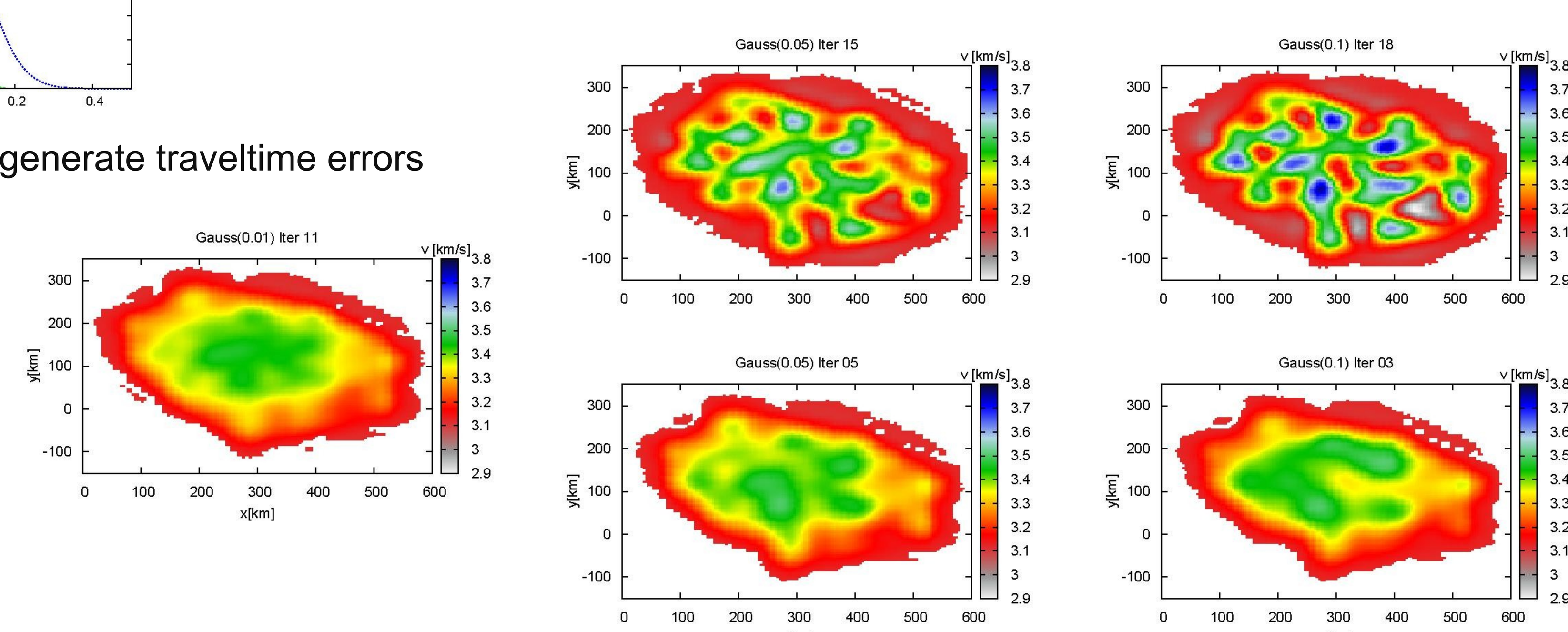

Fig 3.4: Results of test 1: best models from the viewpoint of misfit values (top) and from the viewpoint of similarity to the target model (bottom): left – red line, middle – green line, right – blue line in Fig 3.3.

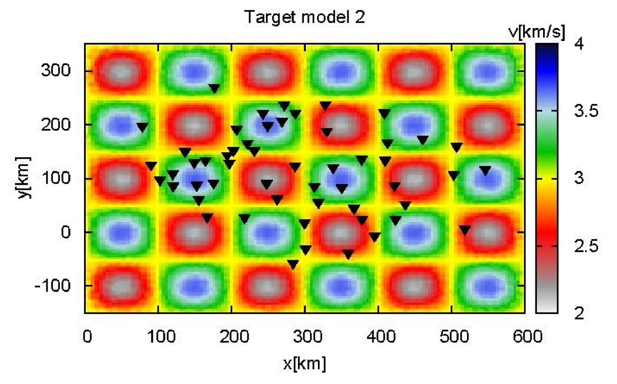

Fig 3.5: Target model and station configuration for checkerboard test (test 2)

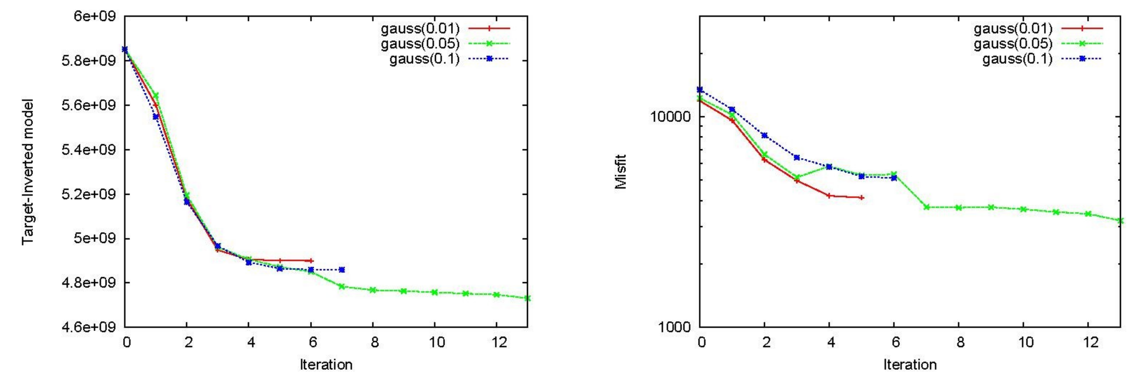

Fig 3.6: Difference between target model and model found (left) and misfits (right) with iterations for every level of noise (test 2)

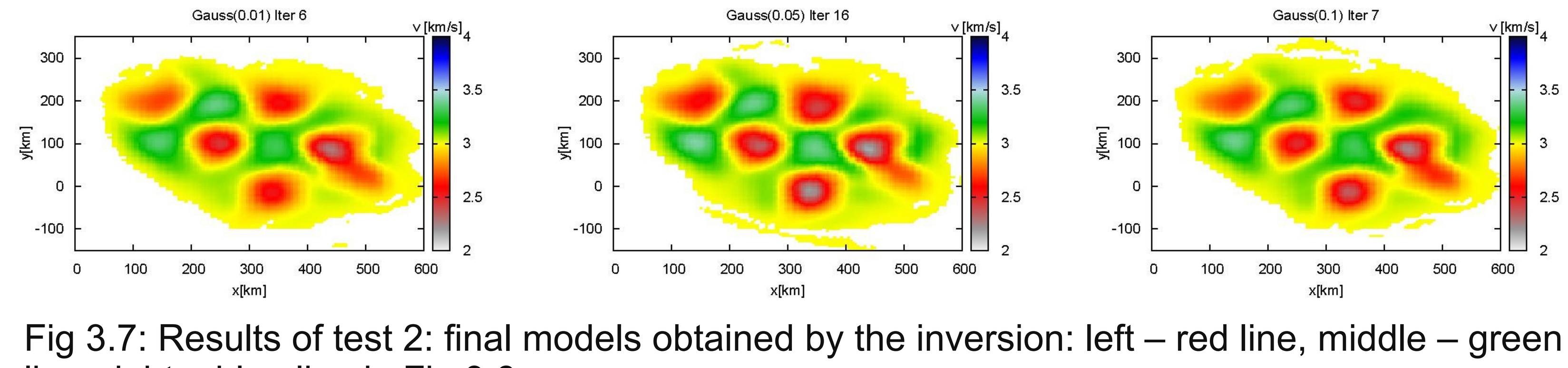

Fig 3.7: Results of test 2: final models obtained by the inversion: left – red line, middle – green line, right – blue line in Fig 3.6.

4. Comparison with classic tomography of real data

Similar results between classical method and adjoint method might be achieved for good setup of inversion parameters, although some differences arise

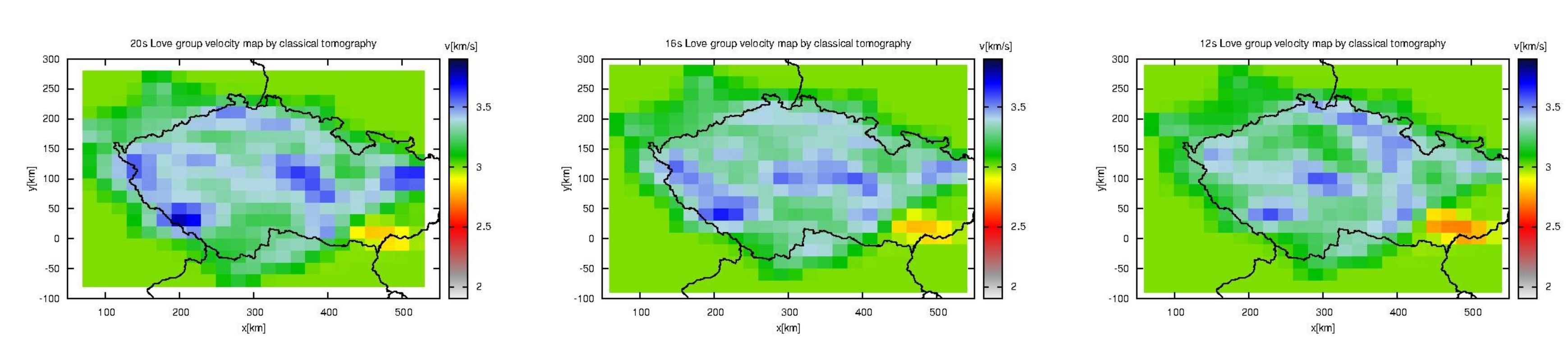

Fig 4.1: Results for classic ray inversion of 20s, 16s and 12s Love wave traveltimes.

References:

Růžek et al, Joint inversion of teleseismic P waveforms and surface-wave group velocities from ambient seismic noise in the Bohemian Massif, *Studia Geophysica et Geodaetica*, **56** (2012).

Käser, M. and M. Dumbser, An arbitrary high-order discontinuous Galerkin method for elastic waves on unstructured meshes – I. The two dimensional isotropic case with external source terms, *Geophys. J. Int.*, **166** (2006).

Acknowledgments:

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MARIE CURIE ACTIONS