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A Spatially Dependent Normalization of Kernels in Adjoint Tomography

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An adjoint tomography is an iterative inversion using an adjoint method to compute a spatially dependent gradient of wavefield misfit (kernel) with respect to model parameters. The gradient therefore provides information, how to modify the trial model in order to get a new one leading to a smaller misfit. The method has been recently successfully applied to many inversion problems at global or regional scales.

However, application of the adjoint method is not straightforward. Computed kernels are usually complicated and have some problematic properties. We may mention singularities at point sources and receivers, high values at a free surface, numerical artefacts, and rapidly spatially varying values.

Local surface sedimentary structures can enhance the problematic properties due to their structural complexity that may involve complicated interfaces with large velocity contrasts and large velocity gradients. Singular or rapidly spatially varying values in kernel imply very small values of the step length in gradient direction. This leads to very small and inefficient changes of the model parameters in other parts of model.

The problematic aspects can be further enhanced in case of unfavourable spatial distribution of sources and receivers in the computational domain.

In order to improve kernel properties for an inversion, a process called gradient preconditioning is used. Usually, the gradient preconditioning consists of truncating excessive kernel values and then smoothing truncated kernel.

On the other hand, the truncation and smoothing can remove too much information from the original kernel – especially in case of complex medium.

Therefore, we have developed a method which significantly reduces the need of truncation and smoothing. We normalize the original kernel values using a spatially dependent norm. The norm is determined from values of forward and adjoint field.

We numerically demonstrate efficiency of the developed normalization.