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Sensitivity optimisation of seismic observables

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Coupling between structural parameters plays a major role in seismic tomography but limited information usually prohibits the simultaneous inversion for the complete parameter space of inverse problems. We therefore propose a multi-observable approach that optimally decouples structural parameters.

Performing a principle component analysis we find linear combinations of seismic observables that optimise the sensitivity with respect to subspaces of the parameter space. Those optimal observables provide high sensitivity power in terms of the volume integral of their squared Fréchet kernels with respect to selected structural parameters and simultaneously low sensitivity power to unresolved parameters.

Being applicable to arbitrary parameter subspaces and inversion schemes from local to global scales our first synthetic test of the developed method is focused on the resolution of density structures which are still poorly resolved in seismic tomography. We consider cross-correlation time shift measurements of surface waves corresponding to four different frequency bands. Following our optimisation process we combine these four observables to one observable with optimal sensitivity with respect to density. In a synthetic test with a volumetric point perturbation we can demonstrate for example that the new observable shows high sensitivity to density perturbations and simultaneously low sensitivity to the shear modulus which is of course not true for the individual observables.