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Layer-specific imaging and monitoring in the Groningen subsurface using seismic interferometry

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Seismic interferometry (SI) is a method that retrieves new seismic traces from the cross-correlation of existing traces, where one of the receivers acts as a virtual seismic source whose response is retrieved at other receivers. When using sources only at the surface, and so-called one-sided illumination of the receivers occurs, not only desired physical reflections are retrieved, but also non-physical (ghost) reflections. These non-physical reflections are caused by internal reflections inside subsurface layers. They are thus particularly interesting to use for monitoring changes in the specific subsurface layer that causes them to appear in the SI result because they could provide valuable information about the physical properties of the subsurface.

We illustrate the potential of SI with active-source data from numerical acoustic modelling using the Groningen subsurface model. This model describes the natural gas field located in the Groningen province in the northeastern part of the Netherlands. The reservoir of the Groningen gas field is located at depths between 2600 m and 3200 m, the total thickness ranges from approximately 100 m to 300 m. The Groningen field is cut by several fault systems, subdividing the field into a large number of fault blocks, and it is a clear example of induced seismicity by gas production.

We investigate the utilization of non-physical reflections retrieved from surface active-source data using SI by cross-correlation and auto-correlation. With multi-offset gathers, besides physical reflections, we retrieve non-physical reflections as well; by muting undesired reflections, we can retrieve better target-related non-physical reflections. To illustrate the potential of the non-physical reflections for monitoring purposes, we apply velocity changes in the Groningen reservoir. With zero-offset gathers, which are retrieved from SI by auto-correlation, we show that in case of velocity changes, the non-physical reflections show a clear change; furthermore, they show a good agreement with the geometry of specific subsurface layers, specifically with the faulted structure. Thus, we can utilize non-physical reflections for imaging and monitoring in the Groningen reservoir.