Interferometric imaging with global phases

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A number of seismic methods exist to image the lithosphere below a collection of receivers, using distant earthquakes. Although both global and teleseismic phases could be used, in the current practice, especially teleseismic phases are utilized. We are working on a method that takes advantage of the availability of global phases.

Nowadays it is known how to extract reflection responses from a collection of phase responses, using seismic interferometry. Reflections can be obtained between any two receivers at the Earth's surface. However, a wide distribution of earthquakes is required to achieve this. This distribution does not always exist or it might take ages to detect. In this abstract we propose a simple, but effective, alternative.

We consider the extraction of zero-offset P-wave responses. A zero-offset response is obtained when a virtual source and a receiver are created at the same station position. We only need illumination with phases which impinge on the lithosphere with angles of incidence close to zero, considering the lithosphere is, grosso modo, horizontally layered. Thus, we use global phases, like PKP. A large advantage of these global phases is that the vertical component is already a good approximation of the P-wave response. Consequently, we can leave out of the equation, the lower signal-to-noise of the horizontal components and inaccuracies introduced by decomposition. Another advantage of global phases is that a large backazimuthal range may be included. For about any station on the globe, there exists a good distribution of earthquakes within the allowed range. From a sampling perspective, only a few global phases would suffice to retrieve a reflection response. However, global phases can be highly triplicated. These triplications lead to spurious cross terms. Therefore, still a large number of phases need to be used to unveil the actual reflectivity.

We test the technique on data from the Hi-CLIMB experiment (2002-2005). This was a large and well-sampled seismic array, passing the Himalayas and a significant part of the Tibetan Plateau. For this array, a few images have been published, which were obtained by applying different techniques. This enables benchmarking of our own results. We select a number of high-quality (M>6) global phase responses from the Andes region. We apply seismic interferometry for each station position individually. After concatenating the obtained zero-offset responses, consistent reflections are shown. The zero-offset response is migrated to obtain a sharp image of the lithosphere. Along with the main crustal reflections, the image shows a double Moho below Southern Tibet, a complicated transition zone below the northern portion of the Lhasa block and again a clear Moho below the Qiangtang block.