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To what extent can seismology image the structures and the continuous deformation of the Earth? (Beno Gutenberg Medal Lecture)

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Earthquake records were the main source of information for the study of the deep Earth andto the imaging of the roots of the geological structures. The conjunction of the development of instruments, of computer power and of storage capability renders possible to consider almost the entire continuous recording as a workable piece of observation. This results in diverse discoveries, ranging from exotic sources related to glaciers to non-volcanic tremors. The interpretation of the long-range correlations of the ambient noise produced mostly by the oceans leads to new developments in imaging and monitoring. Noise based imaging is another tool of seismic imaging, shown so far to be particularly adapted for producing reliable S wave velocity models of the crust and lithosphere. Originally mostly used for surface wave imaging, one can envision that the other techniques based on body waves will also benefit from continuous noise recordings. I discuss examples of extraction of different deep body wave phases that can be retrieved from noise.Modern geodesy measures the motion of the surface with a precision that leads to the direct observation of the continuous evolution of the lithosphere. Ambient noise monitoring allows for a continuous measure of seismic velocity changes. I present some examples showing that a deformation at depth can be detected with seismological techniques and that those changes are related to the deformation.In the context of a subduction zone, I discuss the relations between tremors, slow slip events and change of seismic velocity.