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Correction for the effects of small-scale structures on the measurement of wavefield gradients

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Small-scale structures, like geological inhomogeneities, surface topographies and cavities are known to affect gradients of displacement. These effects are in fact measurable with current instruments. For example, the agreement between data and synthetics computed in a tomographic model is often not as good for rotation as it is for displacement. Using the theory of homogenization, we explain why small-scale structures strongly affect the gradients of displacement, but not displacement itself. We show that at any receiver measuring gradient of displacement, small-scale structures couple the gradient of displacement with strain through a coupling tensor χ. Furthermore, we show that this χ is (1) independent of source, (2) independent of time, but (3) only dependent on the receiver location. χ is the solution of the 'cell equation' from the homogenization theory and it can be computed if the geology is known, which is usually not the case. Nevertheless, we can invert for χ based on a tomographic model that fits displacement data reasonably well. Once inverted, χ can be used to correct and predict the effect of small-scale structures at that particular receiver. Results of the correction and prediction are shown for synthetic rotational receivers before moving on to the ring laser located in Wettzell, Germany. We find that χ leads to a better fit between the computed and rotation data. Although results here are derived for rotations, they can be extended to receivers measuring any wavefield gradient.