Geophysical Inversion: Methods, applications and software

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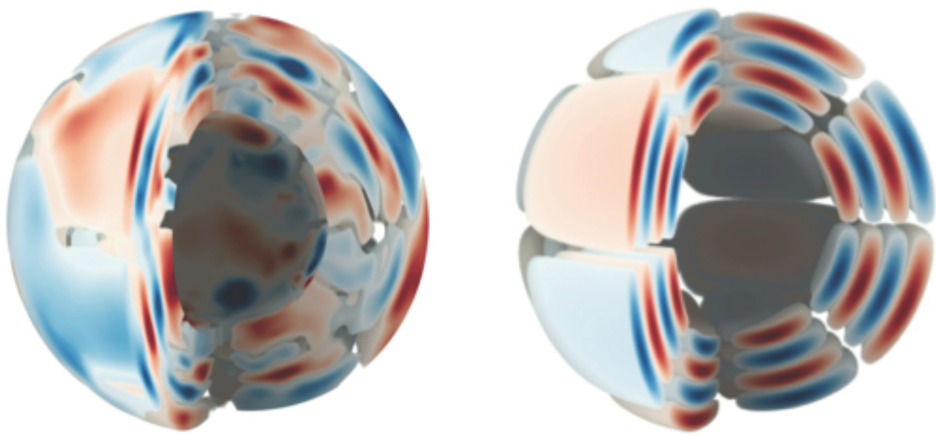
This year a primary thrust of the research has been the continued development and application of trans-dimensional inversion methodologies to geophysical inference problems. Trans-dimensional approaches involve treating the number of unknowns as an unknown in a parameter estimation or inversion problem. This year we have applied these techniques in a variety of geophysical settings including the seismic imaging of the Earth from crust to core; finite fault inversion for earthquake sources; estimation of sea-level rise from global ice volumes; data noise reduction in kinematic reconstructions of tectonic plate motion estimation; detection of paleomagnetic intensity; and also remote sensing of sea floor bathymetry and environmental properties.

Other applications of statistical inference this year have been to resolve questions of significance in the apparent correlation between eruption sites of large igneous provinces at Earth's surface with deep mantle large low shear-wave velocity provinces, and yet another has occurred in Palaeogeography and in particular to U-series analysis of fossilized bones and teeth.

During the year the Inversion Laboratory software portal was launched to provide access to the groups locally developed software packages arising out of research projects. This has seen rapid take up with 178 registrations to date from scientists globally and more than 230 downloads.

This year also saw the development of a new framework of trans-dimensional inversion which involves replacing the Voronoi parametrization structure used successfully to date in 1-D and 2-D imaging with a new wavelet based tree algorithm which promises to be more efficient and allow extensions of trans-D inversion approach to larger 3-D geophysical imaging problems. An earlier example is seen in the figure showing an application to regression in a spherical shell. An important feature of the new approach in addition to efficiency is its versatility in that physical problems in one, two or three dimensions are handled within a single Bayesian sampling algorithm. The spherical 3-D regression example in the figure was completed with a single random sampling Markov chain on a laptop taking just 6.6 hrs. This project will continue to develop over coming years.



Reconstructing a 3-D field using from 2000 random measurements using a 1.6 degree lateral resolution and 24 radial layers. Here the true model is on the right and the ensemble mean obtained by the Trans-D sampling algorithm is shown on the left.