Towards the Next Generation Model for Plate Coupling in Northern Chile

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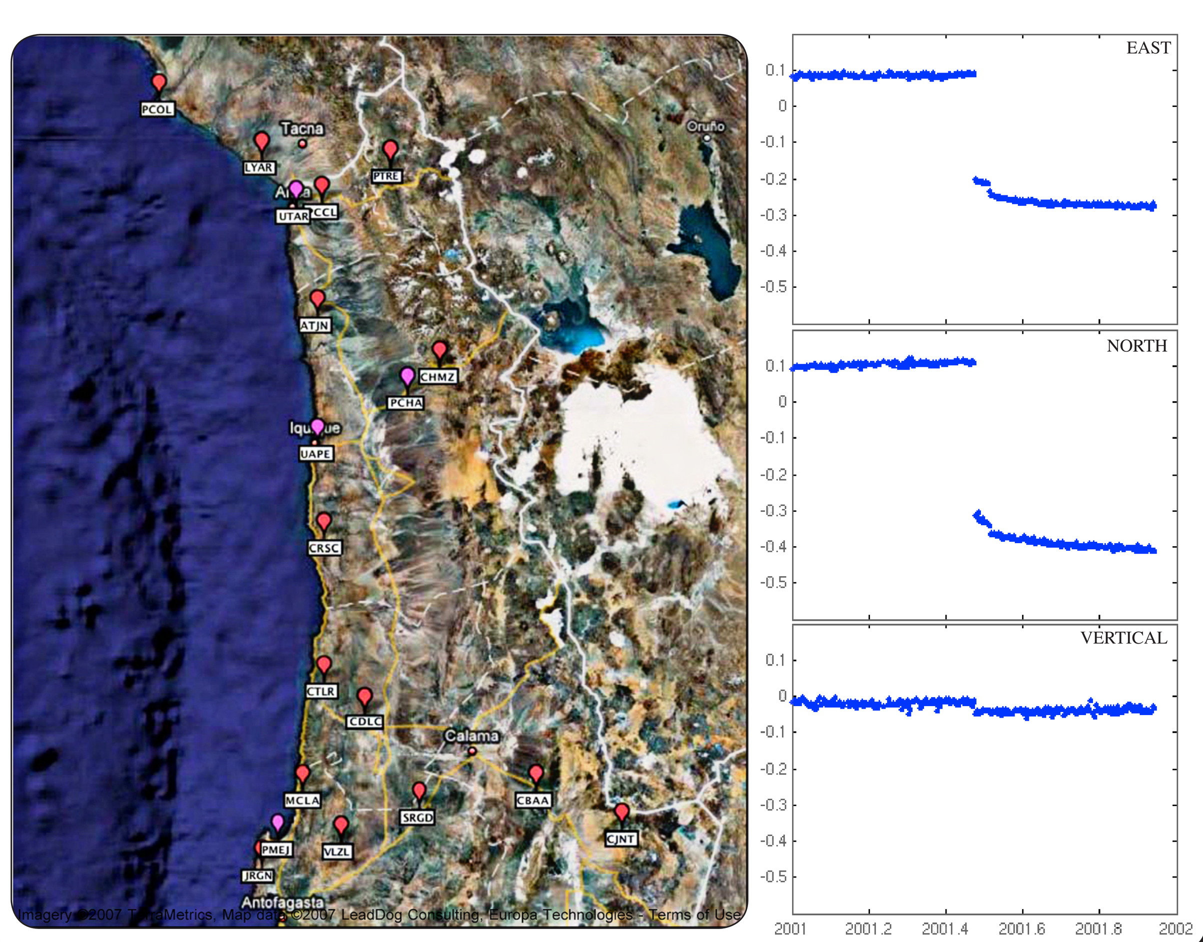
1. Introduction

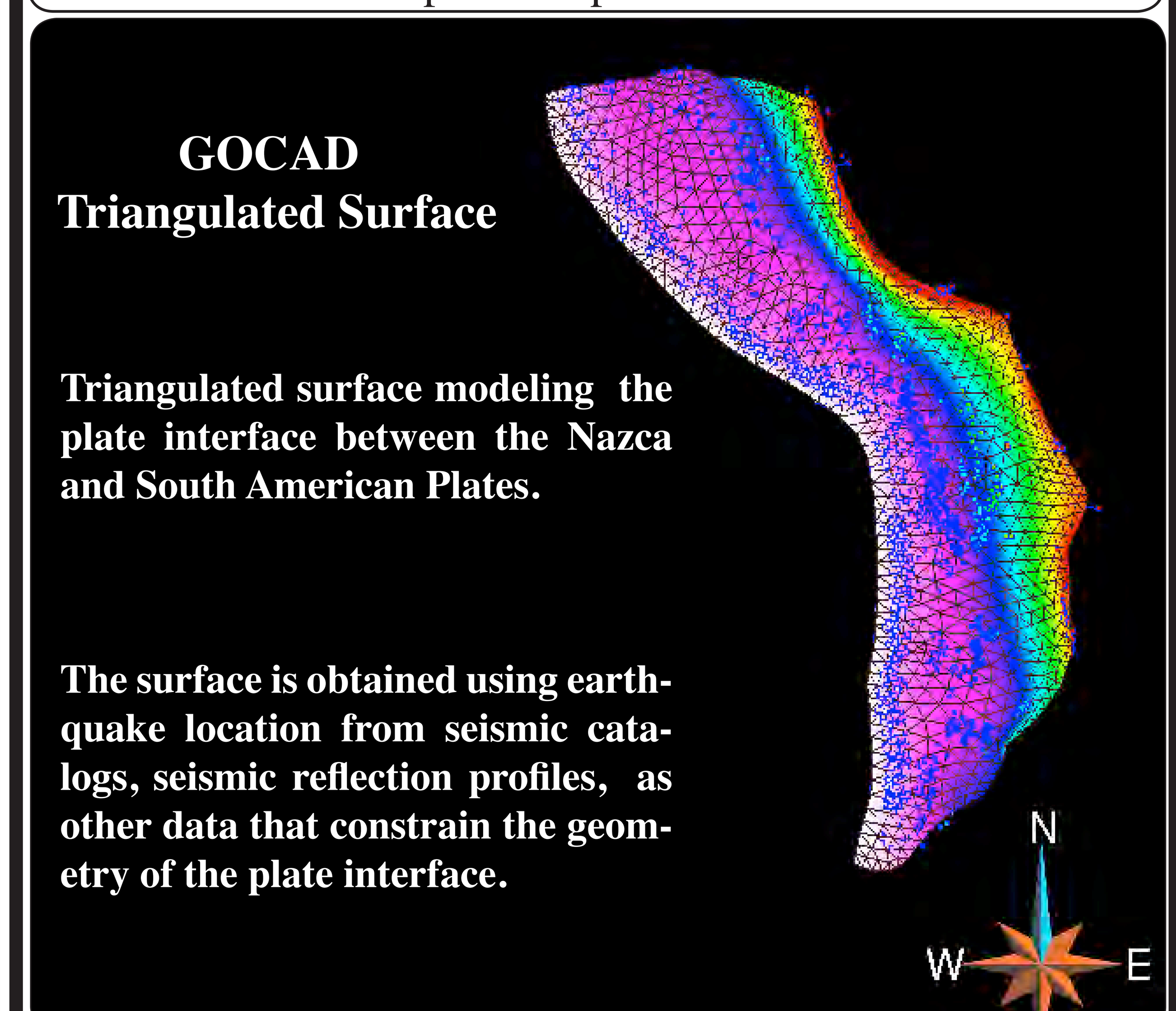
As a part of the Andean Subduction Project, carried out by the Tectonics Observatory[1] together with Chilean geophysicists, this project aims to better understand the rheological characteristics that control temporal and spatial variations of slip on faults. Using a linear elastic rheology to describe the medium of our fault slip models, we implement an inverse method based on a Bayesian approach. A main advantage of this approach is that we can use any model that is physically plausible for the a priori information, data uncertainties and model parameters instead of the Gaussian model that is implicitly assumed when the Least Squares approach is used. With the increasing capacity of computing facilities we are now able to compute several millions of randomly selected fault-slip forward models and hence a sampling of the model parameters and data spaces. Using this samples and the available constraints, we present a set of solutions for the inverse problem in the form of a Probability Density Function (PDF), achieving a complete characterization of the solution space of the inverse problem. We apply this methodology to invert for the interseismic interplate coupled zone in the Chilean-Peruvian subduction margin between 16 S and 24 S.

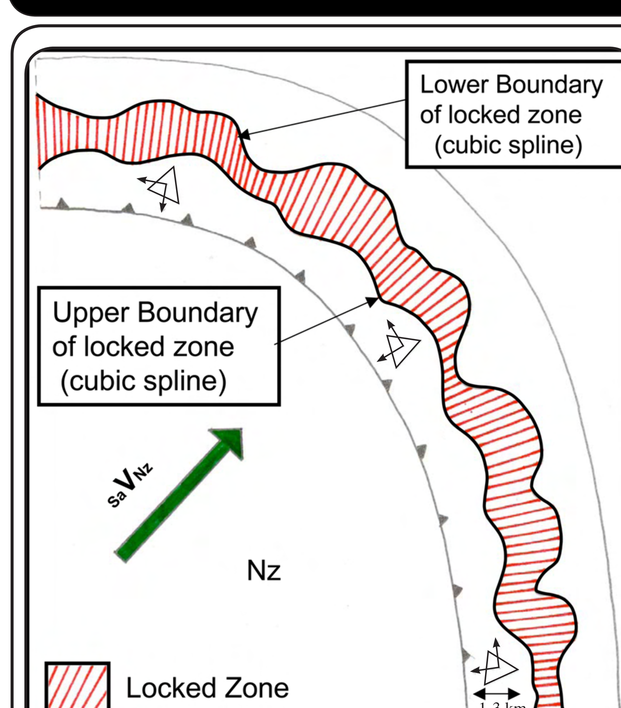
2. cGPS

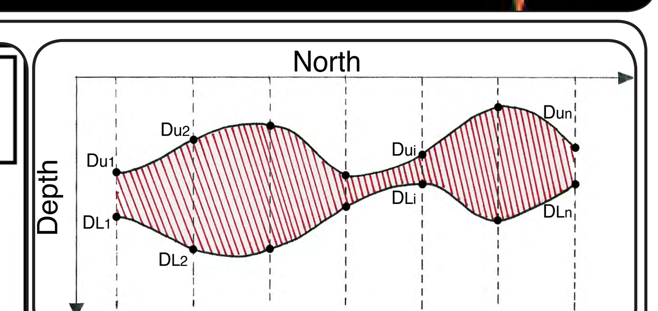


2. cGPS (cont)

Continuous GPS network (left) in the area of study and North, East and Vertical GPS measurements (right) for one station during the year 2001 showing interseismic, coseismic and post seismic signals. GPS data provides constraints for the interseismic velocity field which is used in our inversions for the interseismic interplate coupled zone.







3. Forward Model

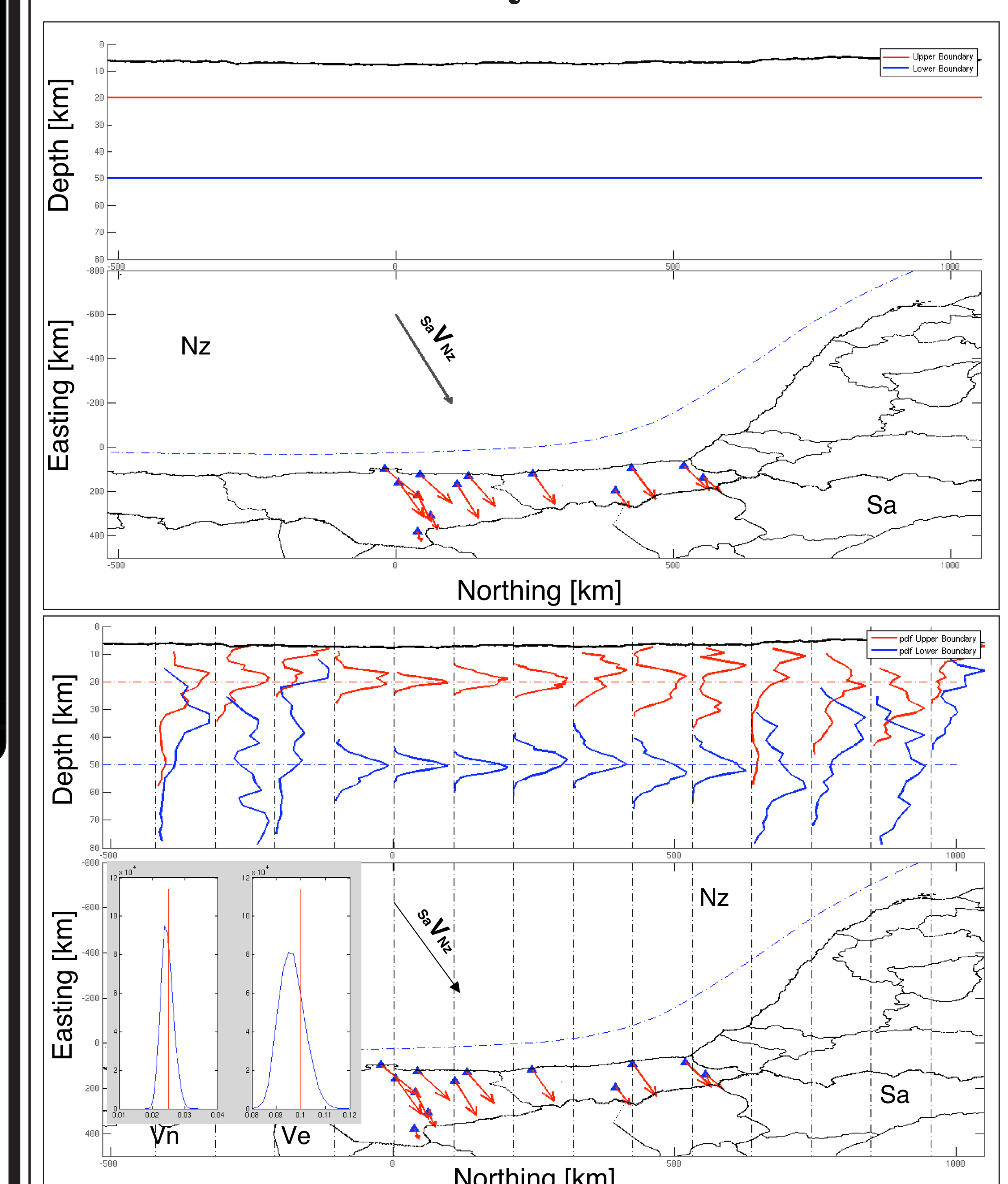
The media is modeled using and elastic half space (Okada, 1982) in order to calculate Green functions.

We use a BackSlip model (Savage, 1983) to represent the interseismic strain accumulation at the plate interface. The geometry of the plate interface is a triangulated surface obtained in GOCAD and we impose a constant backslip rate in the coupled zone. The coupled zone is defined by two curves, its upper and lower boundaries, and this curves are parametrized using cubic splines.

4. Inverse Method

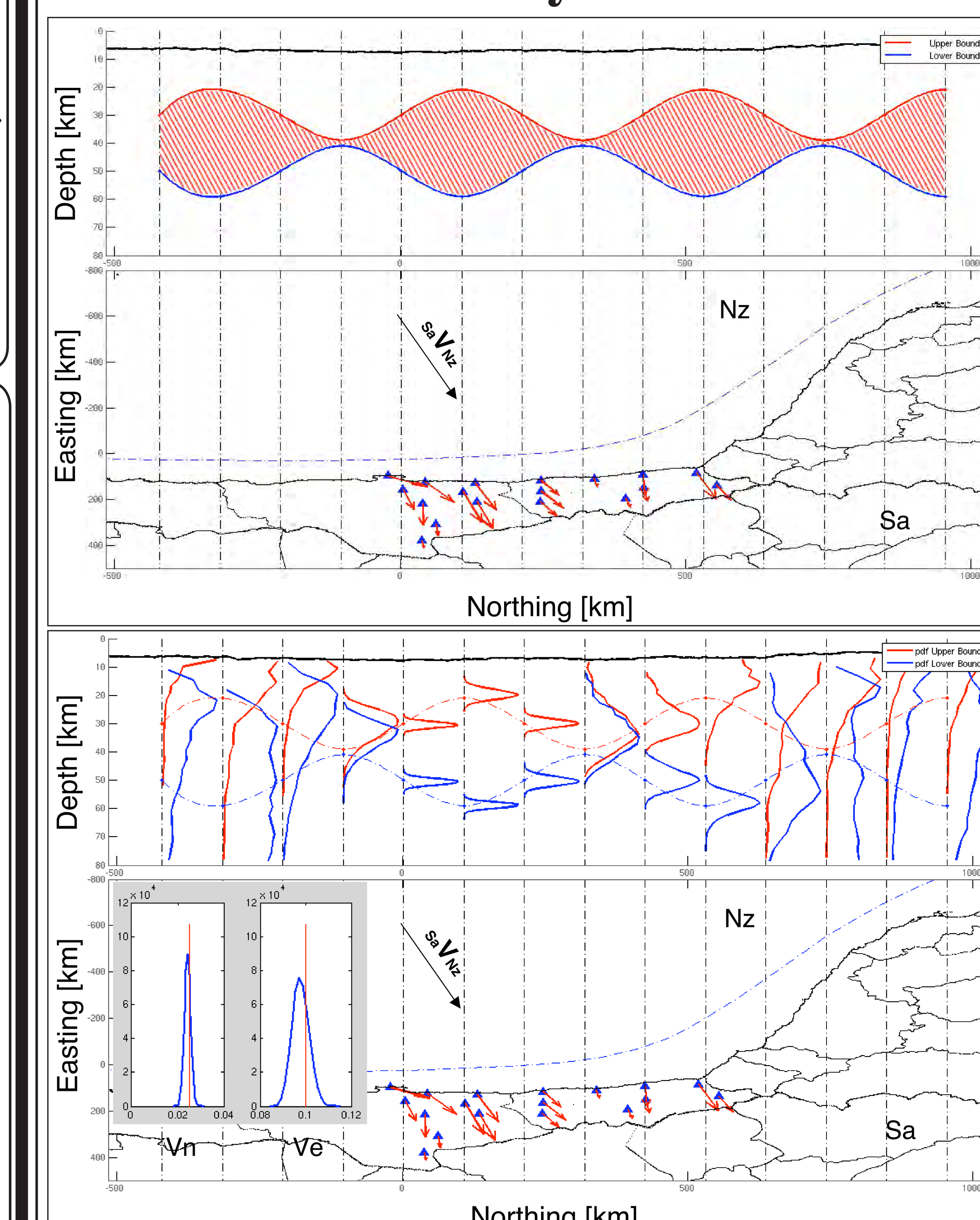
We implement a Monte Carlo Markov Chain or Metropolis algorithm for the inversion. The Metropolis algorithm samples the posterior probability distribution of the parameters of the model: $saVNz_N$, $saVNz_E$ (components of the plate velocity vector), DL_i and DU_i (i-th control point of the splines defining the lower and upper boundary of the interseismic interplate coupled zone respectively).

5a. Inversion with synthetic data



We generate synthetic data (with noise) using the model in the upper figure, where the upper and lower boundaries of the interseismic interplate coupled zone are located at 20 and 50 km respectively. We perform an inversion using this synthetic data. The results of the inversion are shown in the bottom panel of figure 5a where the posterior PDFs of the model parameters (solid blue and red lines) are compared to the target model. We are able to recover the model parameters in the region where the model is sensitive to the data.

5b. Inversion with synthetic data



We perform a synthetic test to our inversion method using the model in the upper panel of figure 5b. The results of the inversion are shown in the bottom panel of figure 5b. Note that the target model is being recovered by the inversion process and the precision is highly dependent on the spatial distribution of the GPS stations.

6. What is next

We developed an inversion environment that ables us to estimate the interseismic interplate coupling region in subduction zones using a 3D geometry for the subduction interface and geodetic data to constrain our models. However, this method has still to be tested with real data. The inversion procedure take several hours to days on a single processor computer depending of the number of model parameters and the number of forward models tested, hence a parallel implementation is a next step in order to do the procedure with a short response time.