EGUSPHERE-2023-2774-R4

Reply to Editor

Dear Editor,
We present here a response to your comment (your comments in black, our responses in italic red).
Jacopo Boaga (on behalf of all authors)

Dear authors,

thank you very much for submitting a revised version of your manuscript. As you can see from the reviewer's comments, they suggest to add some more detail, particularly on the data and modelling components of your paper. I do agree with the reviewer in that providing more detail will help to better judge the results and modelling steps, but will also make your research more accessible and reproducible. I do understand that a short communication is restricted in space, and one suggestion would be to create a data repository, that not only holds the data, but also the modelling code, and some additional details on the modelling parameters.
Thank you very much again for addressing the reviewers comments.

All the best,
Sebastian Uhlemann

Dear Dr Uhlemann,
we have carefully considered all the suggestions from you and Rev2. We have added details of the SRT and ERT inversions (more specs have been explained in the published references), and we have added information on modelling. As for the source, we have specified that the commonly used Ricker wavelet centred at 50 Hz fits our experimental shot (as you can verify in Figure R1 here below). Unfortunately, brief communications do not admit supplementary materials, but as you suggest a repository (github) with the data and detailed specifications will be created to help results reproducibility. We believe that going into further processing details (which can be found in the reference) goes over the intentions of the TC short communications, also considering that TC policy asks brief comm. to be 'timely' and we are under revision for more than 6 months. We would appreciate your decision on this, whatever it may be. Thank you for your time.

Reply to Rewier2

Dear Reviewer 2,
Thank you for your time. We present here a response to your comments (your comments in black, our responses in italic red).
Jacopo Boaga (on behalf of all authors)

The authors have partially modified their figures as requested. I thank them for these efforts. However, it seems important to find more information on the assumption of LVL existence in such a structure and its geometry (anticipated thickness and ranges of mechanical properties, their correspondence in terms of resistivity). In addition, the authors should give a minimum of details on the inversion parameters and criteria used for their ERT and SRT models. The length of the paper is indeed strict, but I think part of it can be shortened to give space to essential parameters (information on parameterization, regularization and convergence criteria). As far as modeling is concerned, the authors provide some information on the source, but several questions remain unanswered: "It is also important to provide readers with every modelling parameters, thus making it possible to reproduce the numerical experiment (source parameters, spatial and temporal discretization, boundary conditions etc.). As for the source, does it align well with the experimental one? Did the authors compare their frequency spectra ?". I think the authors have the experimental data and tools perfectly suited to make a very interesting contribution to this special issue. I hope these few comments and the minor revisions requested will help them. I look forward to reading a revised version of their manuscript.

We thank Reviewer 2 for her/his constructive comments, which considerably improved our manuscript. In particular, your very interesting suggestion to show lateral and central shots highlights as in the right part of the Fluelapass site, that miss the LVL, doesn't present the phase reversal. This strengthened our hypothesis. The communication was amended in line with your comments and from the Editor (see highlighted version), and we thank you both for your valuable suggestions. Some sentences were deleted to fit the pages limit, and we now introduced general information about common LVL in RGs thickness, electrical and mechanical properties (ln 43-48). We then added information about SRT and ERT inversion (ln 75-85 related to the cited published reference), whith data errors (previously in the figures captions). Unfortunately, no supporting files are allowed by TC, but following the suggestion of the Editor we will add all the info attached here (see appendix 1) in an available repository with the data (and this appendix too will be also public as the paper discussion). Modelling parameters are now provided in lines 116-120, specifying we adopted adaptive mesh with 10 elements per wavelength and external absorbing boundary. The forward solution time sampling is not a chosen parameter in Salvus, since it is automatically fixed by the code for the algorithm stability (in our case was 198.01 KHz, for the details we refer to Salvus documentation as in Afanasiev et al., 2019). Source parameters of the modelling are now explained in par.3. We adopted a commonly used Ricker wavelet centred at 50 Hz, since it fits our experimental field *shot. The sources have in fact a power range of 10-90 Hz with average central peak around 40-50 Hz (see an example in the figure R1 here below).*

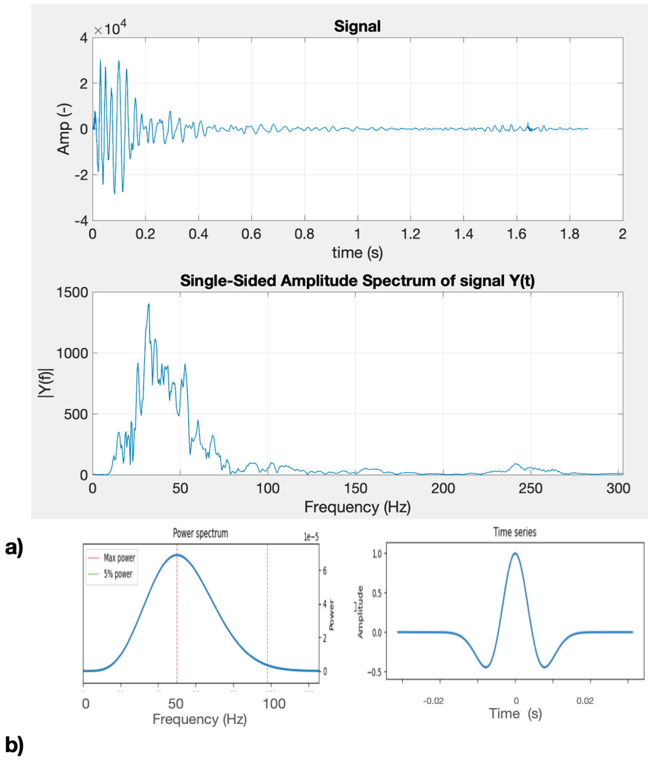

Fig. R1 a) experimental recordings of 1 shot at Schafberg site with 20kg sledgehammer, time and frequency domain; b) Ricker wavelet adopted for synthetic modelling centred at 50 Hz.

We thank Rev2 and we believe her/his suggestions considerably improved our work. We continue to believe that this short contribution is an important message to convey to the cryosphere community to avoid a simplistic interpretation of the subsurface in the common use of reflection seismic tomography in rock glaciers.

Appendix 1 Technical info for SRT / ERT processing

Flüelapass site

- *ERT Acquisition*

Syscal Pro- device, 48 channels, 2 m spacing, Dipole-Dipole skip 0-3, stacking range 3-6 (5% standard deviation threshold), and direct and reciprocal measurements.

- *ERT inversion modelling ResIPy*

Filtering

- $\rho_a < 0$
- $stacking\ error < 5\%$
- $reciprocal\ error < 10\%$ *(1050/1901)*

Inversion modelling

- *Inversion type: regularized inversion with linear filtering;*
- *Regularization mode: normal regularization;*
- *Data type: logarithmic;*
- *Expected data error: 10% (a_wgt = 0.01, b_wgt = 0.10);*
- *Flux type: 3D;*
- *Weights update: routine based on Morelli and LaBrecque (1996);*
- *smoothing factor: normal isotropic regularisation (= 1);*
- *Iteration: 2;*
- *Final RMS misfit: 1;*

Expected data error evaluated with the reciprocal check. We defined a boundary threshold for the reciprocal error that allowed for a reliable quality of the measured apparent resistivities but at the same time a homogeneous distribution of measured points in the pseudo-section.
We applied an isotropic smoothing since we were interested in highlighting both lateral and vertical variations of resistivity.

- *SRT acquisition*

Geode seismographs, 48 channels, 100 Hz geophones, 2 m geophones spacing, 4 meters shots spacing, 2 shots in each position, 20 kg hammer as seismic source.

- *SRT inversion modelling Pygimli*

Inversion modelling:

- *Picking error: 2 ms*
- *smoothing factor: normal isotropic regularisation (= 1);*
- *Regularization factor λ: 150;*
- *Starting model: gradient model 300-3000 m/s;*
- *Iteration: 4;*
- *Abort criteria reached: dPhi = 1.26 (< 2.0%);*
- *rms/rrms(data, Response) = = 0.00489155/14.2038%;*
- *chi^2(data, Response, error, log) = 5.48181;*

Picking error: we evaluated the data uncertainty by performing a repeated picking of P-wave first arrivals for several shot gathered, calculating this way a representative standard deviation of 2 ms.
Regularization factor: we chose λ values using the L-curve analysis.
We applied an isotropic smoothing since we were interested in highlighting both lateral and vertical variations of Vp.

Schafberg site

- *ERT Acquisition*

Syscal Pro- device, 48 channels, 3 m spacing, Dipole-Dipole skip 0-3, stacking range 3-6 (5% standard deviation threshold), and direct and reciprocal measurements.

- *ERT inversion modelling ResIPy*

Filtering

- $\rho_a < 0$
- $stacking\ error < 5\%$
- $reciprocal\ error < 20\%$ *(saved 1029/1901)*

Inversion modelling

- *Inversion type: regularized inversion with linear filtering;*
- *Regularization mode: normal regularization;*
- *Data type: logarithmic;*
- *Expected data error: 20% (a_wgt = 0.01, b_wgt = 0.20);*
- *Flux type: 3D;*
- *Weights update: routine based on Morelli and LaBrecque (1996);*
- *smoothing factor: normal isotropic regularisation (= 1);*
- *Iteration: 2;*
- *Final RMS misfit: 1.17*

Expected data error evaluated with the reciprocal check. We defined a boundary threshold for the reciprocal error that allowed for a reliable quality of the measured apparent resistivities but at the same time a homogeneous distribution of measured points in the pseudo-section.
We applied an isotropic smoothing since we were interested in highlighting both lateral and vertical variations of resistivity.

- *SRT acquisition*

Geode seismographs, 48 channels, 100 Hz geophones, 3 m geophones spacing, 4 meters shots spacing, 2 shots in each position, 20 kg hammer as seismic source.

- *SRT inversion modelling Pygimli*

Inversion modelling:

- *Picking error: 2 ms*
- *smoothing factor: normal isotropic regularisation (= 1);*
- *Regularization factor λ: 200;*
- *Starting model: gradient model 500-5000 m/s;*
- *Iteration: 4;*
- *Abort criteria reached: dPhi = 0.42 (< 2.0%)*
- *rms/rrms(data, Response) = 0.00309603/17.893%*
- *chi^2(data, Response, error, log) = 2.39635;*

Picking error: we evaluated the data uncertainty by performing a repeated picking of P-wave first arrivals for several shot gathered, calculating this way a representative standard deviation of 2 ms.
Regularization factor: we chose λ values using the L-curve analysis.
We applied an isotropic smoothing since we were interested in highlighting both lateral and vertical variations of Vp.