Reviewer 1:

General answers:

1) Quality of the dataset:

We thank both reviewers for their help in improving our manuscript. We answered thoroughly to all their suggestions and interrogations as detailed below, especially concerning the long lasting debate related to the use and representativity of small magnitude earthquakes and corresponding fault plane solutions.

To answer the main concern of reviewer 1 we would like to emphasize on a few aspects of our work. First, several studies of the past decades, (e.g. Maurer, 1993; Bonjer, 1997; Thouvenot et al., 2003, Diehl et al 2021) already demonstrated that small magnitude focal mechanisms could be well constrained and reliable, even for Ml < 1, if based on local seismic network records, which is the case of the Western-Alps-dedicated Sismalp network, which records are additionally completed by national networks. Second, several studies also demonstrated that these small magnitude earthquakes are as much representative of the regional tectonic regime as higher magnitude ones (e.g. Amelung and King, 1997, Kastrup et al., 2004 for the Alps), which is once again demonstrated here (Figure R1 and supplementary material).

Concerning the polarity readings, we stress that intensity is more important than magnitude in the matter of identifying clear deviation directions in the waveforms. In our case we deal with shallow earthquakes recorded by a dense local network, resulting in distances most of the time ~ 10 km for the closest station, as well as in short ray lengths, providing a good S/N ratio (e.g. Thouvenot and Bouchon, 2008, Thouvenot et al. 2003). Several studies focused on the Western Alps moreover showed that for specifically chosen low noise sites with stations less than 50 km away from hypocenters, reliable focal mechanisms could be derived for low magnitude events (e.g., aftershock sequence of the Vuache earthquake, Thouvenot et al., 1998).

However, we recognize that the unprecedented focal mechanisms dataset computed in the present study is likely noisy and bearing several mistakes both on polarity readings and on derived focal mechanisms. Despite the presence of less-well constrained mechanisms, we choose to use the whole dataset presented here since our study aims at increasing the spatial resolution of seismic stress and strain fields which were previously derived on the Western Alps from moderate magnitude earthquakes (e.g. Delacou et al., 2004, Kastrup et al., 2004, Sue et al., 2007, Bauve et al., 2014). Since very few moderate earthquakes occurred since then, this goal could only be achieved by using lower magnitude events. This initiative results from the increasing number of available seismic records for low deforming areas in the recent years, provided by seismic networks in constant evolution. For our study, we benefit from an unprecedented low magnitude seismic records dataset which we aim to exploit for seismotectonic purposes for the first time. To achieve our goal, we aim at exploring the statistical distribution of this database, since it does not present any systematic bias in polarity readings nor any correlated uncertainty in focal mechanisms. Thus, in addition to classical seismotectonic inversion procedures, we assess which features of the seismic deformation field are robust through a Bayesian inversion scheme in which focal mechanisms are weighted according to their quality.

Last, we stress that the selected focal solutions dataset was already cleared out from possible worse solutions by applying the computation criteria described in the main text section 2.2, resulting in A-D quality events instead of A-F quality solutions. We would also like to emphasize that the "D" quality flag outputted by HASH is rather conservative and represents formal uncertainties depending on several criteria such as the number of polarities and station distribution ratio, but does not necessarily represent an unreliable mechanism. We stress that we used in the main text the word "preferred mechanism" as defined by Hardebeck and Shearer (2002) : "The preferred solution, or the most probable solution, is the average of the acceptable fault plane solutions after outliers have been removed [...] If there are clustered outliers, alternative solutions (or "multiples") are found based on those outliers.". Thus it does not represent an arbitrary choice but a statistical one on which uncertainty estimates and quality flags are based. However, since we are aware that our dataset presents various quality events, we provide the full list of focal mechanisms computed along with their quality flag, so that the reader may choose to rely only on a subset of focal mechanisms to further investigate fault plane solutions for any specific area. In addition to this quality criteria, to additionally help the reader to decipher which events provide more constraints on each inversion result, we now provide in the revised version of the manuscript the magnitudes of earthquakes with Ml >3.5 included in our inversion procedures.

<u>2) Geodynamics:</u>

In our view, the discussion of processes driving crustal deformation and seismicity represents a geodynamical discussion. We improved this discussion with a final interpretative sketch and by further discussing several geodynamical aspects detailed in the answer to reviewer 2, and added the corresponding citations to the reference list.

<u>Minor issues</u>

- *Line 90 "by six local or national networks operated from 1989 to 2014"*

Only five are listed

This is now corrected in the main text.

- *Line 105 "Arrival time uncertainties were harmonized." How ? "Potential picking errors were identified and cleared out." How ?*

Picking weights from 0 to 4 were translated into time uncertainties through a statistical analysis, and outliers were removed through Wadati diagrams analysis. We refer to Potin (2016) for further information on the data compilation procedure.

- *Line 110 "The complete set of earthquakes includes blasts, quarrying or mining events." I do not see the significance of plotting non-natural seismicity. Please discharge these events from the dataset*

Polarities are indeed not read for quarries. We discharged these events from the dataset (Figure 1 and Figure 7) in the revised version as requested.

- *Line 120 "Thanks to the high density of stations provided by the combination of six networks, we were able to apply strict computation criteria. The maximum allowed* *azimuthal gap between polarities was set to 90 ◦ and the maximum azimuthal gap of incidence angles to 60 ◦ ." As already discussed, these criteria are not strict at all.*

These criteria appear more strict than many displayed in the seismotectonic literature : e.g. minimum number of polarities of 6 and max azimuthal gap of 220° (Ammirati et al., 2019), maximum azimuthal gap = 180° (Sue et al., 1999) … We thus provide in our view strict criteria in order to take into account the specifically low deforming context of our study area. However we stress that, as mentioned above, the goal of our study is to provide an increased spatial resolution of the seismic deformation pattern, which can only be obtained by using a new, thus more noisy, focal mechanism dataset. For this exact reason we provide the complete list of the derived focal solutions with their associated quality flag in the case further studies would wish to focus on a specific area while using only higher quality focal mechanisms.

- *Line 175 "Strain rates are computed by averaging moment tensors (i.e., symmetrical 9 components 2nd order tensor, plus seismic moment amplitude), for which the 9 components directly depend on strike, dip and rake parameters of the focal mechanisms." That means that the quality of focal mechanisms is fundamental.*

As explained in the main text we are aware that the direction of the strain axes could be influenced by a few stronger earthquakes only. That is why we also compare the direction derived from strain rate estimates with the directions obtained through stress inversions.

- *Line 315 "we investigated the distribution of stress orientations using focal mechanism inversions. All inverted earthquakes are equally weighted, regardless of their magnitude" If all focal mechanisms are equally weighted their quality is not considered.*

As described section 2.2 (l. 137-141), we use several classical seismotectonic tools, in which focal mechanisms are either not weighted (stress inversions), weighted depending on their magnitude (Kostrov summation), or weighted according to their quality (Bayesian surface reconstruction). We thus compare the different results to assess the quality of our results. Our results suggest that small magnitude events carry as much regional tectonic signal as higher magnitude ones since results are, to the first order, similar between the different approaches.

- *Line 375 "The angle between the direction of extension and the strike of the belt is of the order of 30 ◦ to 40 ◦ ." I disagree, northern of GP is almost perpendicular.*

This result description was indeed only right to the first order. We replaced the corresponding sentence by the following more nuanced one in the revised version : "**The angle between the direction of extension and the strike of the belt is of the order of 30° to 40°, except north of Gran Paradiso massif (GP) where the sigma3- axis of the transtensional stress tensor is almost perpendicular to the strike of the belt. This shows that the extensional direction is almost systematically deflected clockwise with respect to the direction normal to the arc.**"

- *Line 380 "All the western periphery of the belt (corresponding to the zones VSN, DPH, NMT,VAR Figure 5) show strike-slip stress fields, with a rotating state of stress compatible with dextral motions along longitudinal directions (typically along longitudinal faults such as the Belledonne fault, Thouvenot et al., 2003). " Ok for VSN and DPH why for* *the other sectors?*

In the Southern part, the western periphery of the chain includes several longitudinal right-lateral faults, such as the Sérenne, Tinée and Bersézio faults (Bauve et al., 2014), as well as transversal and antithetic NNE-SSW left-lateral faults (e.g. Blausasc fault, Courboulex et al. 2007) .

- *Fig. 9 Named cross-section in the text as in the fgure 9*
  References to Figures 9a) to 9e) were added in the main text as suggested.

- *Line 535 "The seismic events seem grouped in several clusters along these two transverse profiles" Where are seismic events in figure 10a? Do you mean the focal mechanisms? The focal mechanisms cannot have clusters, it depends on which earthquakes you choose to compute focal mechanisms.*

This shortcut was corrected with the following sentence : "**Seismicity appears grouped in several patches of distinct deformation style along these two transverse profiles, especially beneath the Belledonne area and the Briançonnais and Piémontais arcs where the two main extensive patterns described in section 3.3 are lying.**"

- *Line 540 "While the depth distribution of the seismic events follow the structure of the European crust (Figure 10b)," Where are seismic events in figure 10b?*

Same as above, the term "seismic events" was replaced by "focal mechanisms".

- Line 585 "former stress inversions in the Alps have established a first order contrasted stress field. It is characterized by roughly orogen-perpendicular extension all along the backbone of the arc, surrounded by a transcurrent stress state at the periphery of the orogeny, locally modulated by a reverse component." Which authors?

We added the appropriate references : Maurer et al., 1997; Baroux et al., 2001, Sue et al., 2002; Delacou et al., 2004; Kastrup et al., 2004, Bauve et al., 2014.

- *Line 600 "Thirdly, the direction of the principal stress axes in the internal zones (namely 600 the extensional σ3 axes) is systematically deflected of 30 ◦ to 40 ◦ clockwise from the radial extension pointed out up to now." I disagree.*

We nuanced this point of view as done above and rephrased the sentence : "**the direction of the least compressive stress axes in the internal zones (namely the σ3 axes) is almost systematically deflected of 30 ◦ to 40 ◦ clockwise from the orogen-perpendicular extension pointed out up to now.**"

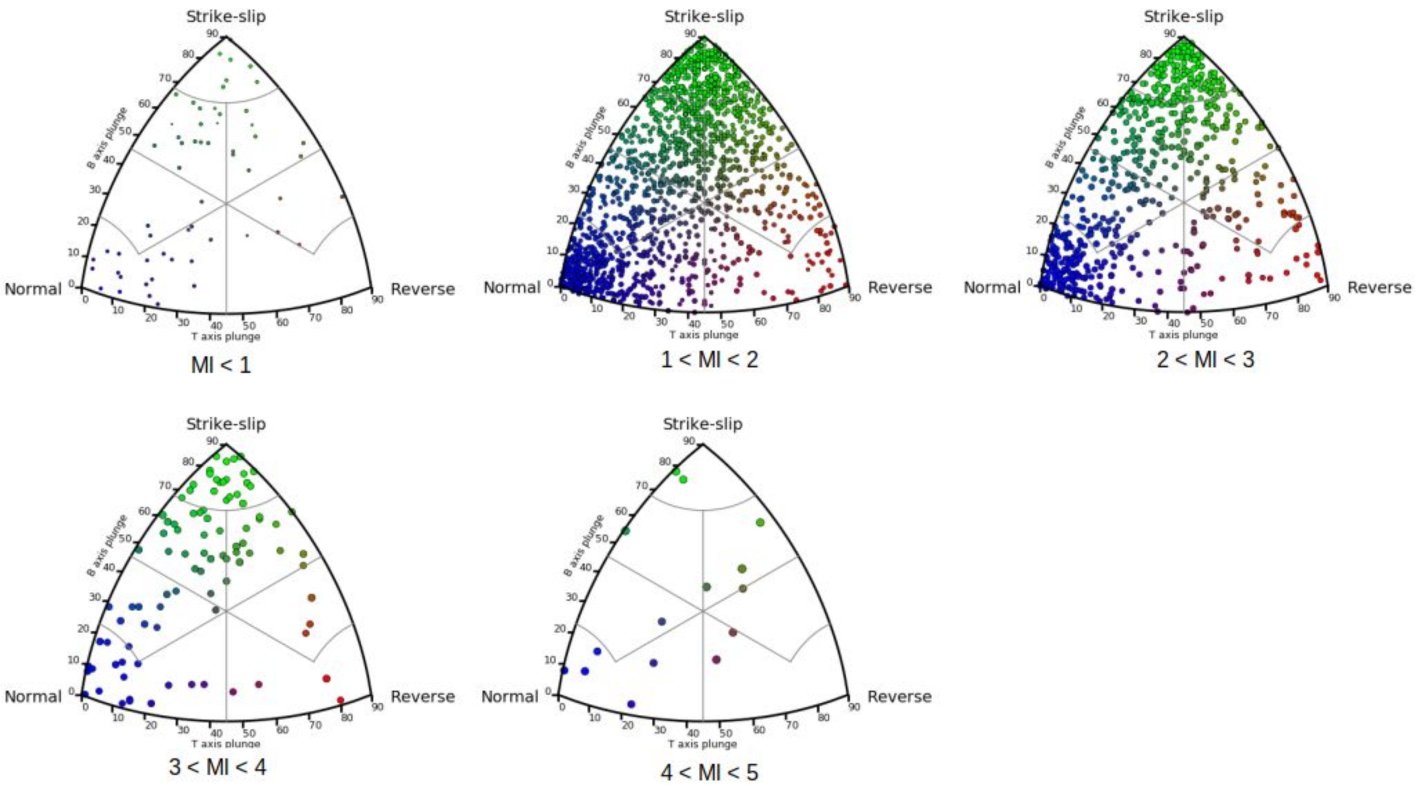

Figure R1. Kaverina diagrams displaying the style of deformation of the computed focal mechanisms for different magnitude ranges.

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