We thank the reviewers for their very helpful and relevant comments. Our respons are below in black.

Major questions and comments

- **Seasonal amplitudes**: For the static area analysis, the authors state that "The seasonal amplitude is computed using a weighted rolling median applied on the image-pair velocities stacked according to their respective day of the year … Then, the amplitude is defined as the difference between the maximum and minimum of this smoothed time series." However, this method seems to yield a general noise level rather than a seasonal amplitude. Do the timing of maximum and minimum values show some seasonality? Unfortunately, I could not find any useful information in the manuscript to answer this on my own. No time-series analysis, such as that shown in Figure 1, is being done for the static area. Figure 8 might have some clues, but it is ambiguous. Peak velocity happens in both spring (Issungata and Kaskawulsh) and fall (Kaskawulsh only). It may be recognized as certain seasonality, but it is not the type with only one peak in spring/summer and one valley in fall/winter, as shown in Figure 1.

  We thank the reviewer for this relevant remark. In our initial approach, we applied a sinusoidal fit to the static areas. However, we noticed that the seasonal pattern observed in the shaded areas did not follow a sine wave; see, for example, Fig. 5 (now Fig. 7). The sinusoidal fit approach often underestimated the seasonal bias. Therefore, we decided to estimate the seasonal amplitude by aggregating the signal per day of the year first. Then, we smoothed this signal using a rolling median filter. This approach shows the same trend as a sinusoidal fit (i.e., the north-facing slopes also show stronger amplitude than the south facing slopes), which gives us confidence that it is not capturing general noise levels. Moreover, we can clearly see a seasonal behavior on the time series over static areas, now represented in Figure D1 in the manuscript, and Figure 1 below. In addition, the seasonal peak timing (the yearly maximum of the smoothed signal) do not follow a random behaviour. We clearly see a correlation between the seasonal peak timing and the slope (see the new Figure 2 below and Figure 5 in the manuscript).

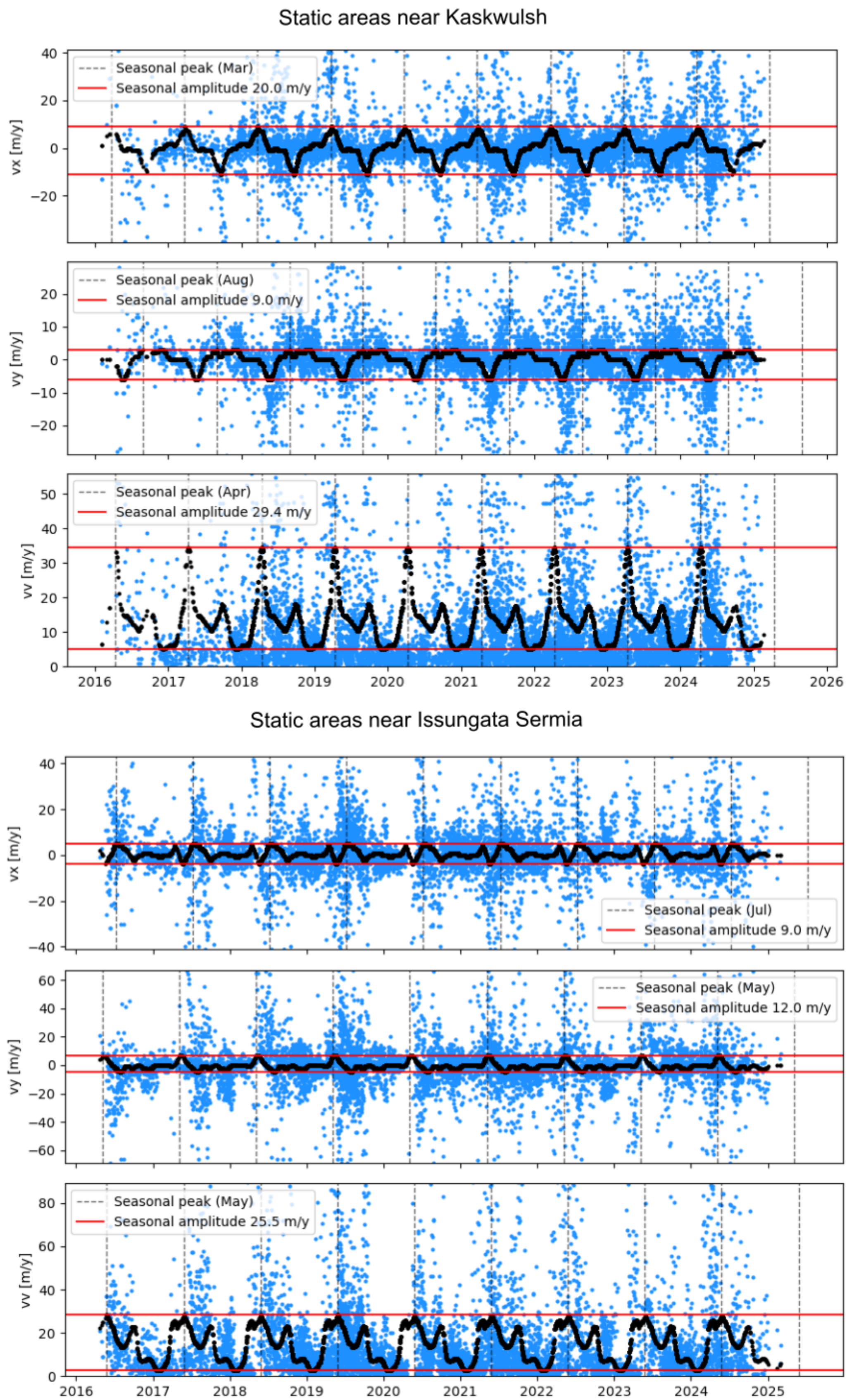

Figure 1 Example of velocity time series over static areas. The coordinates of the point located near Kaskawulsh Glacier and Issungata Sermia are (-138.7238°E, 60.8552°N) and (-50.348547°E,67.339909°N) respectively.

My experience makes me think these peaks might be linked to the spring snowmelt and the first autumn snow, when the surface completely decorrelates within a short period. If true, this causes an issue when this "seasonal amplitude" is compared with the seasonal amplitudes on the ice surface, which is argued to be due to the cast shadow and illumination effects. In addition, Figures 2 and 3 provide clues that shadows and illumination effects control the "seasonal amplitude" with varying strengths depending on the slope aspect. Snowmelt, however, might have similar effects, since snow accumulates and melts differently on different slopes and aspects.

We agree with the reviewer: the dynamic of the snow cover could impact the estimation of the seasonal bias over the Mont-Blanc Massif. However, the same trends are observed over areas not covered by snow, in case of landslides and sand dunes studies:

- Landslide in northwestern Argentina (transition zone between subhumide and aride climate): Mueting, A., Charrier, L., and Bookhagen, B.: Challenges in reconstructing seasonally driven landslide motion from optical satellite data: insights from the Del Medio catchment, NW Argentina, EGUsphere [preprint], https://doi.org/10.5194/egusphere-2025-6445, 2026.
- Sun dunes in northwestern China: Ding, C., Zhang, L., Liao, M., Feng, G., Dong, J., Ao, M., and Yu, Y.: Quantifying the spatio-temporal patterns of dune migration near Minqin Oasis in northwestern China with time series of Landsat-8 and Sentinel-2 observations, Remote Sensing of Environment, 236,111 498, 2020.
- Landslides in Peru (desert of southern Peru): Lacroix, P., Araujo, G., Hollingsworth, J., and Taipe, E.: Self-entrainment motion of a slow-moving landslide inferred from Landsat-8 time series, Journal of Geophysical Research: Earth Surface, 124, 1201–1216, 2019.

In addition, changes in snow cover would likely not results in systematic changes in direction, as observed on Figure 5 in the manuscript (now Figure 7). We added some of these elements in section 4.3.3 of the manuscript: "changes in the surface state between the two images of a pair (e.g. snow on one image and ice on the other, **snow melt occurring between the two images**). However, usually, high surface changes result in completely incoherent velocities, which can be filtered out using the correlation score or spatio-temporal filters. **In addition, seasonal biases caused by changes in illumination and shadow casting have also been observed in areas without any snow cover: in desert or semi-arid climates (Mueting et al., 2026; Ding et al., 2020; Lacroix et al., 2019)**

With the thoughts above, I would suggest adding a time series analysis of a static terrain, like what is done for the tongue of Argentière Glacier (Figure 1), to clearly show that the noise follows the same seasonality as on the ice surface.

We thank the reviewer for this very good suggestion and we have added the Figure D1 in the Supplement, which corresponds to the Figure 1 just above.

Additionally, how is the seasonal amplitude of the LOWESS and TICOI time series determined? I can see that the amplitude is computed directly by the SR model, but I am not certain about the other two.

Correct, the amplitude is determined directly from the SR model. For the LOWESS and TICOI, we took the average amplitude (defined as the difference between the min and max) of all the years.

- **Phase offset as seasonal bias**: I assume the seasonal bias is not limited to the modeled amplitude of the seasonal signal, but also includes the modeled phase. In Figure 1, we can clearly see an offset in the timing of the velocity peak between the GNSS and remote sensing data, and the authors briefly mentioned this in Section 4.1 as well. However, no further discussion is present, and I am particularly interested in whether this phase offset could also result from mistracing the shadow movement on the ice surface. The phase bias might not be the main focus of this paper, but it would be great if the discussion of it is not skipped, so readers are aware of it.

We thank the reviewer for giving us the opportunity to add an analysis of the seasonal peak timing. We have added a new section "4.2.2 Seasonal peak timing", and a new figure (Fig. 2 below) .

Here is the new section:

« Seasonal peak timings (i.e., the date of the maximal value) retrieved over static areas are also significantly different between south and north-facing slopes (Fig. 5).

First, for both the datasets "ITS_LIVE with NDC filter" and "IGE with a spatial filter only", we observe that seasonal peak timings are between the days 260 and 330 of the year, i.e. between August and October, on north-facing slopes, especially for the steepest slopes (Fig. 5 a) and b)). This peak timing is centered on the autumn equinox in the Northern Hemisphere. On the south-facing slopes, the velocity reach a maximum mainly around days 180 and 240 of the year, i.e. between June and August.

Second, for the dataset "IGE with a spatial filter only", we also notice another high density seasonal peak timings on the north-facing slopes around the day 90 of the year, corresponding to the spring equinox (Fig. 5b)). This is especially observed on the north-west facing slopes, for the steepest slopes.

Third, for the dataset "IGE with advanced filters" the seasonal peak timings do not show significant differences between south and north-facing slopes (Fig.5 c)). This highlights again the ability of the filters to reject outliers.

The analysis of both seasonal amplitudes and peaks over static areas reveals a systematic seasonal bias over the Mont-BlancMassif. To better characterize it, we examine potential sources of bias and the characteristic patterns they may produce in the following section. »

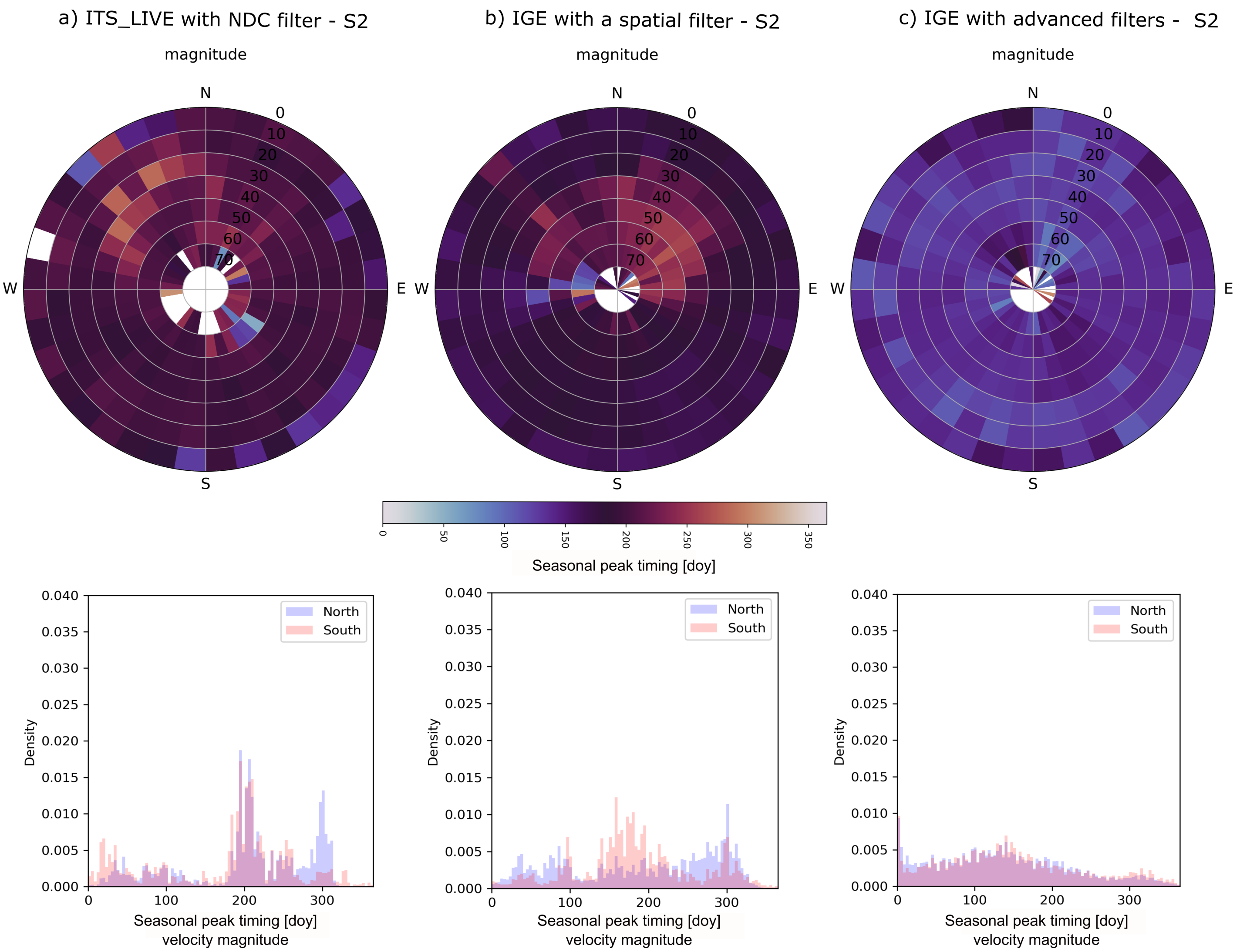

Figure 2 Polar diagram (top) and histogram (bottom) of the median seasonal peaks timings of velocity magnitude over static areas for the dataset: (a) "ITS_LIVE with NDC filter" using Sentinel-2 images (left column), (b) the dataset "IGE with a spatial filter", and (c) "IGE with advanced filters". For the polar diagram, the size of the bin is 10° for both slope and aspect. The slopes are shown along the radial axis, with the highest slopes in the center.

- **Cast shadow effect**: According to the text and Figure B5, the cast shadow effect can be interpreted as unintentionally tracking the shadow movement over time. Does the azimuth variation of glacier velocity match the shadow movement? (e.g., according to Figure 5, does the shadow move to the ~50-degree azimuth direction between the winter solstice and the summer solstice?) Based on Figure B6, we should observe glacier speed-up in the autumn as the shadow stretches and slow-down in the spring as the shadow shortens. However, this does not match what is observed in Figure 5, where the maximum velocity is observed in the winter/spring. Maybe I am thinking about this incorrectly, but could you help clarify this?

We thank the reviewer for this comment, and try to clarify this point. The shadow extends from the winter solstice to the summer solstice and shortens from the summer solstice to the winter solstice. However, the velocity at which the shadow extends or shortens varies: it increases from the summer solstice to the autumn equinox (and from the winter solstice to the spring equinox), and then decreases. Therefore, the velocity of shadow evolution is maximal at the equinox and minimal at the solstice. This is what we observe in Figure 2 above. The movement of the shadow is represented by an analemma in Figure B6 (now Figure C3). The same explanation has been added to the figure caption.

This also consistent with our new figure (Figure 2 above). We added l.286: "This pattern is consistent with our observations over static areas: the seasonal bias induced by shadow casting tends to be maximal at the spring and autumn equinox."

The azimuth variation follows the same trends as the seasonal amplitude. However, in this case, the shadow movement may be mixed with the glacier movement, since we are located in the accumulation zone of the Bossons Glacier. Therefore, it is hard to define what should be the exact angle between the velocity vector in autumn, and the velocity vector in spring. However, we still see that the vectors point toward the west in autumn and toward the east in Spring.

- **Dependence on the satellite missions**: Since the seasonal amplitude of Landsat-based velocities is 1.6-1.8 times higher than the Sentinel-2 based velocities (Section 4.2), the seasonal amplitude may be further reduced if we use high-resolution optical images, such as Planet Lab or Pleiades, to track glacier movement. This might be worth mentioning in the conclusion, as it is often necessary to assess whether high-resolution optical images are needed for glacier velocity maps.

We thank the reviewer for this suggestion. Mitigating seasonal bias is a topic by itself. We discussed different mitigation strategies in a recent paper which have been accepted for publication on July 27:

Mueting, A., **Charrier**, L., and Bookhagen, B.: Challenges in reconstructing seasonally driven landslide motion from optical satellite data: insights from the Del Medio catchment, NW Argentina, EGUsphere [preprint], https://doi.org/10.5194/egusphere-2025-6445, 2026.

The two studies are complementary. Therefore, we added at the end of the manuscript a new section in the Discussion section called “Possible strategies to reduce seasonal biases”:

“In this study, we propose a framework to estimate the location and amplitude of seasonal biases. However, several strategies can also be considered to reduce seasonal biases during the post-processing of image-pair velocities, particularly through a post-processing approach based on temporal closure inversion, as described in (Charrier et al., 2025; Ding et al., 2020; Lacroix et al., 2019; Bontemps et al., 2018). Recently, Mueting et al. (2026) compared different strategies proposed for studying dunes and landslides: (1) removing a seasonal error estimated on static areas through harmonic functions to the displacement time series (Lacroix et al., 2019), (2) restricting the image-pair velocities used as input of the temporal closure inversion to pairs with similar illumination (Ding et al., 2020), (3) weighting the temporal closure inversion using a proxy of illumination changes (Bontemps et al., 2018) and (4) upsampling optical images (Antoine and Liu, 2025). The study site of Mueting et al. (2026) is a slow-moving landslide in northwest Argentina. However, the same strategies could be used for glaciers because the effects of shadows and illumination changes are not object-dependent.”

In Mueting et al., 2026, we compare Sentinel-2, Landsat-8 and PlanetScope derived displacements. We especially recommend the section 4.3 Impact of spatial resolution, and section 5.2 Comparison between the different satellite missions to respond to the reviewer comment. You can read in section 4.3:

“We initially correlated imagery from all three satellite missions at their native resolution, only adjusting the correlation and subpixel refinement kernel size to be as comparable in meters as possible, taking into account the odd-integer constraint. However, we noticed that the lower-resolution Landsat-8 and Sentinel-2 correlation results were more strongly affected by seasonal biases than the 3-m PlanetScope displacement maps. A test with two scene pairs from PlanetScope and Sentinel-2 (similar dates) acquired under different illumination conditions (May and September 2020) resampled to 3, 6, and 9 m confirmed this observation (Figure 5): Over stable terrain (estimated zero displacement), the seasonal bias increased significantly as the spatial resolution of the input imagery decreased. A similar observation was made by Antoine and Liu (2025), who found that correlation noise decreases when the images are upsampled. We attribute this effect to the subpixel refinement step of the correlation process, which refines the integer pixel match obtained from previous block matching. "

Minor questions and comments

- Figure 5: "Shadow casting is illustrated on two Sentinel-2 images in Fig. 5." – I am not sure what this refers to.

Corrected to Figure B7.

- Figure 8 should be cross-referenced somewhere in Section 5.

Corrected

- I can identify typos and minor grammatical errors scattered in the manuscript; perhaps one more round of manual proofreading is required. Here is my incomplete list to get started.
    - L88: ampcor

    Corrected

    - L119: seasonal variations in section 4.1

    Corrected

    - L169: tilted (?)

    Corrected

    - L330-331: careful; biases

    Corrected

    - L339: additional "he"

    Corrected

    - L345: based on

    Corrected