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Subject Revision manuscript

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Dear Dr. Achim A. Beylich and Anonymous reviewers,

We thank you for your time in reviewing this manuscript.

We have addressed all comments below, with reviewers' comments in black, our responses in blue, and revised text in red. In the revised manuscript, we highlight our new text in blue.

With kind regards,

Yustisi Lumban-Gaol, Ramon Hanssen

Reviewer 1

We thank you for your time in reviewing this manuscript. We have addressed all comments below.

Comment 1.1 — The overall purpose of generating this data (justification) could be made much clear and a clear statement of how this improves on previous estimates / methods included.

Reply: We justify this in the introduction, paragraphs 4-5.

Comment 1.2 — Although I have said the structure of the paper of clear, the methodology could be better illustrated by included in a schematic diagram (Figure) of the structure of the method showing the significant stages (steps in generating the data.

Reply: Thank you for your suggestion. We added a schematic diagram in Figure 1 that divides the processes into five general stages: (i) input data, (ii) PS and DS analysis to obtain the observed phases, (iii) contextual grouping and coherent segment identification, (iv) SPAMS model parameter estimation, and (v) the SPAMS10 dataset.

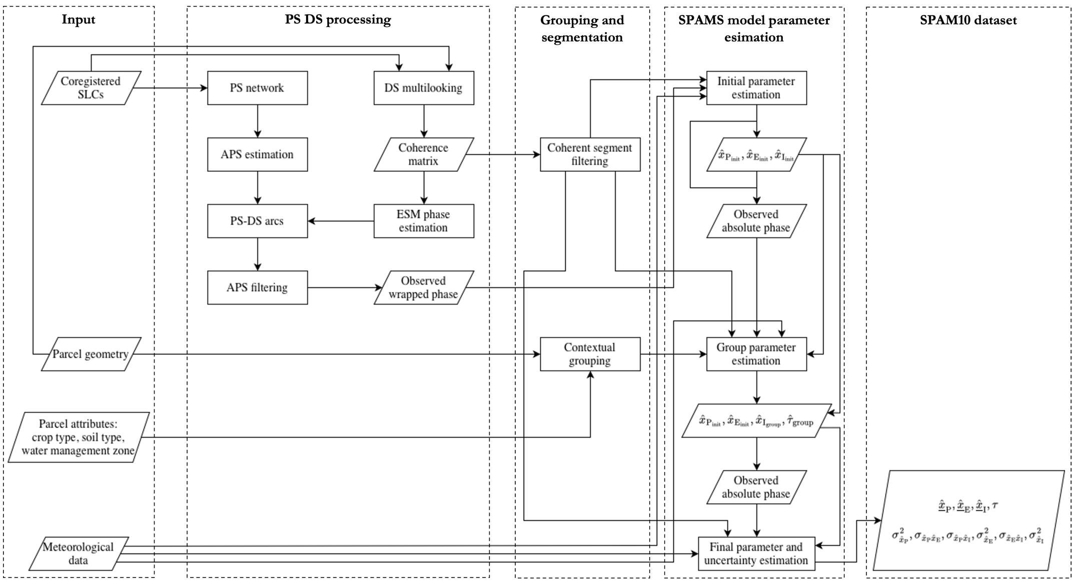

Figure 1: A schematic workflow to create the dataset. We divide the processes into five general stages: (i) input data, (ii) PS and DS analysis to obtain the observed phases, (iii) contextual grouping and coherent segment identification, (iv) SPAMS model parameter estimation, and (v) the SPAMS10 dataset.

Comment 1.3 — The structure of the dataset could be better explained and justified. For example, on L134-135 - You say " We group parcels by soil type and water table zone and include only grassland parcels. The contextual grouping reduces the number of segments, thereby aiming to reduce segment shift noise. The group is formed if there are at least 15 and no more than 50 parcels. " This fundamentally affects the dataset but the background to this is not really explained in detail or justified. By how much are the segments are reduced? Why are only grassland parcels included? How are the group limits (15-50) determined?

Reply:

We removed the "include only grassland parcels" part from this sentence to avoid misinterpretation and mentioned that the dataset includes grassland parcels in Section 3.1.

The contextual grouping mainly aims to improve the irreversible estimates as mentioned in lines 140-141.

Group size is determined through trial and error. We did not make any changes to this part.

Comment 1.4 — The field area is poorly described. Given that the main deliverable of this paper is a 'dataset' it is important that the context of the data are well explained. Some additional information on the following should be included:

- Type of soils, peat types and peat depths
- Basic description of hydrology – annual precipitation, ET rates, water table variability (and how this varies over the 7-year period)
- Type of agricultural practices in areas with landcover types, average field size, etc.
- Basic description of how these properties vary across the field area e.g. any gradients E to W or N to S.

Reply: We added a new subsection 'Description of the study area' (lines 187-209) under the Case Study Section to provide a general overview about the study area and modified Figure 2 to include the soil type map.

Lines 187-209:

The Krimpenerwaard region is an open agricultural area with traditional peaty meadows, cows and windmills, used for dairy farming. It covers an area of $\sim$147 km^2, with elevations ranging from -3.8 to $+4.3$ m NAP (Dutch ordnance datum) (AHN, 2026). Positive elevations are along the main road or dikes surrounding the study area. Grasslands or pastures for dairy farming dominate rural areas, where the average elevation is around -1.9 m NAP. These areas are divided into parcels with ditches in between to channel water. These ditches are interconnected within the same water management zone, where the phreatic groundwater table within a zone is maintained between certain levels according to the groundwater stages described by de Vries et al. (2003). These stages specify the average classes of highest and lowest groundwater level in centimeters below the local ground level (*maaiveld (mv)* in Dutch), thus [cm$-$mv]. In our study area, the average highest ground water level is < 40 [cm−mv] while the lowest groundwater level are in between 50 and 80 [cm−mv].

As mentioned, the dataset covers 3621 parcels with an average size of $\sim$1.6 $\pm$ 0.9 ha. These are grassland parcels. The area is characterized by substantial peat deposits in the inner part, surrounded by marine and river clay soils in the outer part. Figure 1 shows different peat types distributed in circular shapes. These peat rings vary in their classes or subsoil materials. In the center and second inner layer, we have mesotrophic fen peat (hVc) and eutrophic fen peat (hVb), both with a clayey peaty topsoil. Further out, we have peat bogs with a sandy loam or clay cover (pVb), where a humus-rich topsoil has been developed. Similarly, some parts of the outer peat rings are peat bogs (kVb), but with a thinner or absent mineral layer on top.

According to the nearest meteorological stations located in Rotterdam and Cabauw, the annual mean precipitation and evapotranspiration in the study area are roughly 831 mm and 653 mm, respectively (KNMI, 2026). The annual precipitation-to-evapotranspiration ratio from 2015 to 2025 ranges from 0.8 to 1.7, with an average of 1.3. Several dry periods are indicated by ratios less than 1, i.e., when annual precipitation fell below annual evapotranspiration, which occurred in 2018 and 2025. In contrast, 2023 and 2024 are recorded as the wettest years over the 11 years, with precipitation approximately 1.6 times evapotranspiration and annual precipitation approximately 31 $\%$ and 17 $\%$ above the mean, respectively.

Comment 1.5 — Evaluation / illustration of the results could be more thorough to show the utility of the dataset in more detail. I understand the purpose of the paper is the description of the dataset, but the accompanying Figures do not show the value or main characteristics (structure) of the data very well. The spatial maps are very small, and the time series plot is quite simple. Some additional Figures showing the distributions of the data (histograms) and box and whiskers plots of the data by parcel group would be much more helpful.

Reply: Thank you for your suggestions. We added several box plots in Figure 4 to illustrate the distributions of each parameter across different soil types. We also modified the time series plot in Figure 5 to include the uncertainty for the modeled time series.

Figure 4 shows the distribution of the parameters across different soil types. It suggests that $\hat{x}_{\mathrm{P}}$ values are similar across different soil types (Figure 4a), with a narrow spread and a relatively homogeneous distribution. The box heights of $\hat{x}_{\mathrm{E}}$ in Figure 4b indicate a wider spread compared to $\hat{x}_{\mathrm{P}}$, with less dispersion in marine clay than in other soils. It also indicates that $\hat{x}_{\mathrm{E}}$ values are about twice those of $\hat{x}_{\mathrm{P}}$. Given the mean precipitation-to-evapotranspiration ratio of around 1.3, parcels with smaller $\hat{x}_{\mathrm{E}}$ are less susceptible to precipitation deficit. This condition implies fewer dry periods, which translates into lower annual subsidence rates, assuming a similar distribution of the $\hat{x}_{\mathrm{I}}$ parameter shown in Figure 4c. Note that the $\hat{x}_{\mathrm{I}}$ parameter cannot be used directly to estimate the annual subsidence rates. It should be used together with other parameters to determine the number of dry and wet days in the time series. Once we flag the dry periods, we can compute the irreversible component and estimate the annual subsidence rates.

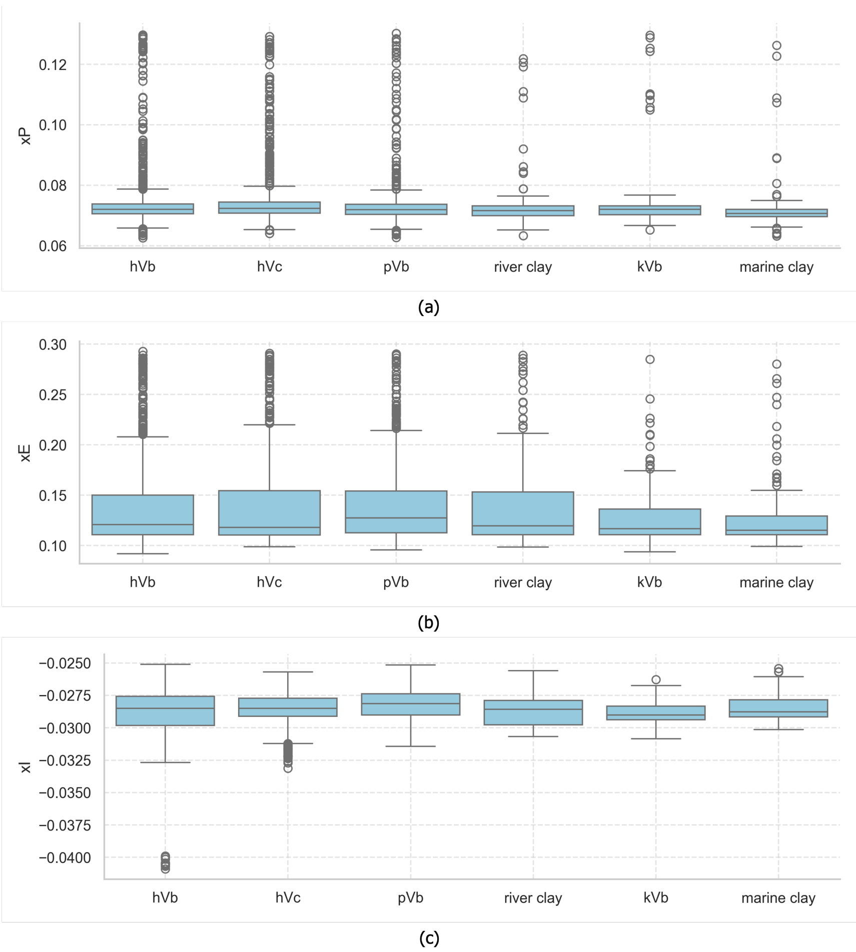

Figure 4: Boxplots of the scaling factor of precipitation $\hat{x}_{\mathrm{P}}$ (a), the scaling factor of evapotranspiration $\hat{x}_{\mathrm{E}}$ (b), and the irreversible scaling factor $\hat{x}_{\mathrm{I}}$ in mm/day (c) for six soil types: hVc, hVb, pVb, kVb, marine clay, and river clay, where the first four represent peat.

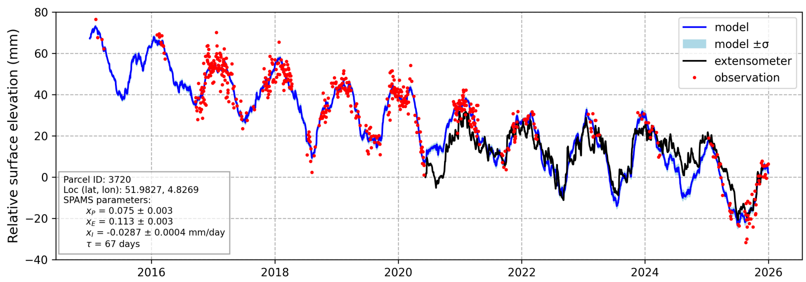

Figure 5: Comparison of relative surface elevation changes from extensometer data (black line), InSAR-based relative elevation estimates (red dots), and the SPAMS model (blue line) showing relatively similar agreement levels. The RMSE values for InSAR and SPAMS, relative to the extensometer, are approximately 8.3 mm and 7.1 mm, respectively. The RMSE between InSAR and SPAMS is around 4.6 mm. The $\hat{\sigma}^2$-statistic is roughly 0.8, indicating model adequacy.

Comment 1.6 — Subsidence is described at one point in the large field area (Figure) some more context is needed here. How does the 7-year record here fit with longer term trends and patterns?

Reply: Thank you for pointing this out. We added more description and explanation in lines 225-227 and lines 232-238:

Note that the extensometer measures only a single point, whereas the model represents the entire parcel. The parcel stretches west to east of about 1000 m long and is approximately 40 m wide. The extensometer is in the middle between the northern and southern ditches, about 20 m from each side.

The model shows some discrepancies relative to the extensometer; for example, in summer 2020, the extensometer records subsidence, whereas the model estimates slight uplift. Also, in 2024, the model subsides more than the extensometer. Several factors can cause these discrepancies: (i) the extensometer and the parcel do not observe the same behavior in which what occurs at one surface point may not be the same at every point within the corresponding parcel; (ii) the lack of observations, especially in summer periods, limit the model parameter estimation process and lead to undetected errors since the quality of the model is statistically propagated based on the available observations; (iii) limitations of the model in capturing surface responses to driving factors beyond meteorological conditions.

Comment 1.7 — The abstract is very descriptive and could usefully be rewritten to include much richer detail (results) that better describe the dataset (see specific comments).

Reply: Noted.

Comment 1.8 — Title – I would recommend including the word 'dataset' alongside SPAMS10, so it is clear this is the data and not the SPAMS model. This is the practice throughout the majority of the paper so I would also do it here. I was initially confused whether this was the data or the model.

Reply: We agree to include 'dataset' in the title.

SPAMS10: An InSAR-derived soil motion parameter dataset to model relative peat surface elevation changes

Comment 1.9 — L1 – What is meant by 'environmental stability' this is a very vague term please say something more specific.

Reply: Land and environmental stability are affected by peat subsidence through increased flood risk and greenhouse gas emissions. We added these examples to make the sentence clearer.

Lines 1-2:

Peat subsidence poses a significant challenge to long-term land and environmental stability by increasing flood risk and producing greenhouse gas emissions.

Comment 1.10 — L5 – Make it clear why it is 'SPAMS10' – 10 parameters.

Reply: Done.

Line 6:

InSAR-derived SPAMS parameters provide displacement models that can describe peat subsidence and dynamics with a set of parameters, namely four parameters for modeling and six variance-covariance terms for model uncertainties. We publish the SPAMS10 dataset, which refers to the descriptive displacement model SPAMS with ten parameters. The dataset also provides additional contextual information, such as soil code, at the parcel level, defined by the administrative boundary of an agricultural field.

Comment 1.11 — L6 – please state clear what you mean by physical and statistical parameters and contextual information. This is too descriptive and does not tell us anything.

Reply: We revised the sentence in lines 6-8: We publish the SPAMS10 dataset, which refers to the descriptive displacement model SPAMS with ten parameters. The dataset also provides additional contextual information, such as soil code, at the parcel level, defined by the administrative boundary of an agricultural field.

Comment 1.12 — L6 – What is meant by 'parcel' – this is not clear at this stage in the paper so should be given context (adda few words in brackets?).

Reply: In this context, a parcel is defined based on the administration boundary of an agricultural field.

Comment 1.13 — L8 – You state 'These parameters enable detailed and reproducible analyses of peat subsidence.' You need to give some statistics of the actual data and some error estimates (reproducibility) to support this statement. Inclusion of quantitative results would better illustrate the utility of the dataset.

Reply: We revised this sentence in line 10: These parameters enable the reconstruction of displacement models for peat subsidence analyses.

Comment 1.14 — L16 – Conclude this sentence with some suitable references.

Reply: Done.

Comment 1.15 — L16-18 - Link the specific references to the particular challenges don't just list at the end of the sentence.

Reply: Done.

Comment 1.16 — L33-35 - Add references to support this statement.

Reply: Done.

Comment 1.17 — L37 – You define SPAMS10 in terms of 10 parameters yet on L5 you say there were “a limited set of parameters”. Ten parameters do not appear to be a limited set – can you word this better. Or do you really mean there are three main parameters and one constant (integration time). I think this could be better explained and worded.

Reply: We removed the limited part in the abstract and revised it by stating the number of parameters used for modeling and estimating the uncertainties.

Comment 1.18 — L41-42 – It is unclear how you arrived at an integration time of 69 days and why it is so ‘constant’. Some physical explanation of this is needed.

Reply: We consider SPAMS as a descriptive model. Therefore, the parameters follow from the estimation but are not necessarily linked to a physical phenomenon. The integration time is considered constant since it does not deviate significantly from the defined initial value.

Comment 1.19 — L47 – 49 - How realistic is the “ assumption that conditions such as soil stratigraphy, groundwater management, and land use remain constant over time”. Do you mean over the 7 years of the data? If you described the field area better (see earlier comments) then you would be in a stronger position to justify this assumption.

Reply: ”... forecasting of past and future subsidence under the assumption that conditions such as soil stratigraphy, groundwater management, and land use remain constant over time.” When users want to use this dataset to model surface motion outside the observation period used to estimate the parameters, they need to make this assumption.

Comment 1.20 — L51 – Define an ‘agricultural parcel’ – do you mean a field or unit of similar land use? Also see earlier comments about the description of the field area.

Reply: An agricultural parcel is defined by the administration boundary of an agricultural unit (line 8). In this area, the boundary is often the ditch in between the parcels (line 65).

Comment 1.21 — Figure 1 - How representative is one extensometer site at the eastern margin of the study area. You should address this point in the text to assure readers it is representative.

Reply: Thank you for pointing this out. The parcel stretches west to east and is approximately 40 m wide. The extensometer is located in the middle between the northern and southern ditches, about 20 m from each side. Since the extensometer measures a single point, whereas the model represents the entire parcel, we expect some discrepancies between them. We added more description about this particular parcel in lines 224-226 and lines 231-237 (also in comment 1.6).

Comment 1.22 — L85 - You state "while the displacement signals are assumed to be correlated in time with limited spatial correlation". Why do you assume limited spatial correlation - this is not always the case with subsidence over wide areas? How can you justify this assumption?

Reply: This assumption is used during the atmospheric phase screen estimation, where we exclude the parcels to build the network, as mentioned in lines 109-114.

Comment 1.23 — L88-89 – See earlier comments - define 'parcel' and provide some statistics on the size distribution of these parcels.

Reply: Done.

Comment 1.24 — L92-93 - It is stated " In peatlands, we assume that surface elevation changes are driven by environmental (meteorological) conditions." – If this is the case then give some context for the seven-year period over which subsidence was measured.

Reply: There is a correlation between the seasonal uplift during winter and subsidence in summer and the seasonal precipitation and evapotranspiration. We added this in lines 98-99:

In peatlands, we assume that surface elevation changes are driven by environmental (meteorological) conditions, where the seasonal uplift during winter and subsidence in summer correlate with the seasonal precipitation and evapotranspiration.

Comment 1.25 — L103-104 - You provide some insights into the agriculture of the area (ploughing events) but because you have not provided a fuller description of the area these events are hard to contextualise.

Reply: Thank you for pointing this out. Since we only include grassland, we modified the sentences accordingly in line 115: Due to irrecoverable temporal decorrelation, e.g., grazing events, we have gaps in the time series data.

Comment 1.26 — L134-135 - You say " We group parcels by soil type and water table zone and include only grassland parcels. The contextual grouping reduces the number of segments, thereby aiming to reduce segment shift noise. The group is formed if there are at least 15 and no more than 50 parcels. " This fundamentally affects the dataset but the background to this is not really explained in detail or justified. By how much are the segments are reduced? Why are only grassland parcels included? How are the group limits (15-50) determined?

Reply: See comment 1.3 above.

Comment 1.27 — L162-167 - The results and data could be much better explained. See suggestions above.

Reply: Noted.

Comment 1.28 — Figure 2 (page 8) – Add additional information to the Figure caption. Plots (a) and (b) explain scaling factor vales. Also state whether the data shown in the Figure is averaged over the 7-year observation period?

Reply: Done. Figures 3a-c (previously Figure 2) show the estimated SPAMS parameters per parcel based on InSAR observations, using precipitation and evapotranspiration data from the closest meteorological station for each parcel centroid.

Spatial distributions of the SPAMS parameters for each parcel: (a) scaling factor of precipitation $\hat{x}_{\mathrm{P}}$, (b) the scaling factor of evapotranspiration $\hat{x}_{\mathrm{E}}$, and (c) the irreversible scaling factor $\hat{x}_{\mathrm{I}}$ in mm/day. Panel (d) shows the $\hat{\sigma}^2$ test statistic values of each parcel. The parameters are estimated from InSAR observations from 2015 to 2025, using precipitation and evapotranspiration data from the closest meteorological station for each parcel centroid. Note that (c) alone should not be used directly to estimate the annual subsidence rates.

Comment 1.29 — Figure 3 (Page 9) – Explain why the length of record differs for the extensometer period compared to the whole data series and why there are no recent observations 2022-2023. It is also stated in the caption " InSAR-based relative elevation estimates (red dots), and the SPAMS model (blue line) showing similar agreement levels" but this should be quantified.

Reply: Originally, we use InSAR observations from 2015 to 2022; the extensometer data is available from 2020 onwards. That is why we have model realization and extensometer data, but no observations in 2022-2023. Since we have extensometer data through early 2026, we updated Figure 5 and also the dataset.

The metrics are provided in the following statements of the caption: The RMSE between InSAR and SPAMS is around 4.6 mm.

We also added an additional analysis in lines 239-245: Figure 5 also shows the uncertainty of modeled displacement per epoch represented by the blue shades. This uncertainty was estimated using a Monte Carlo simulation that reconstructs different realizations from parameter sets distributed according to the covariance of the estimated parameters. The figure shows varying uncertainty, with summer periods showing higher uncertainty than winter, where the standard deviation (2σ) can reach approximately 3.6 mm. Across all parcels in the study area, the standard deviation can reach up to 12 mm. Although these values are relatively small, they remain useful indicators for assessing the effect of parameter uncertainty on the model realization. Further study is required to evaluate the stochastic model of the observations.

Comment 1.30 — L51 – You do not need to say, 'see Figure 1.' You can just bracket it (Figure1).

Reply: Done.

Comment 1.31 — L114 (bottom of page 5) – You provide one footnote. This is the only one in the document and is at odds with the general style. You should remove it and add the relevant text to the main body of the paper.

Reply: Done.

Comment 1.32 — L270 – 'Van Asselen@ should be 'van Asselen'

Reply: Done.

Comment 1.33 — L273 – Subscripts for CO2 and CH4

Reply: Done.

Reviewer 2

Comment 2.1 — In the section Introduction, peatland subsidence is briefly introduced, and a limited number of references are cited to acknowledge recent advances in peatland surface-change research. Although the research gaps are mentioned, the lack of modelling studies on peatland surface dynamics is only implied rather than explicitly identified. The authors should emphasize this gap more clearly and present the main objective and novelty of the study in a more focused manner.

Reply: Thank you for this comment. We revised lines 39-40 to emphasize that the main contribution of this study is the SPAMS10 dataset derived from InSAR observations.

Lines 39-40:

To address this, we propose SPAMS10, a dataset derived from InSAR observations and intended for the study of peatland surface dynamics.

Comment 2.2 — I found it surprising that the manuscript does not include a general description of the study area. Either the Introduction or the Methods sections should provide essential background information on the peatland, including its geomorphological, climatic, and hydrological characteristics, vegetation cover, soil properties, agricultural practices, and the history of human activities that have influenced its morphology. Such information would help readers better understand the environmental context in which the study was conducted.

Reply: We added a new subsection 'Description of the study area' under the Case Study Section to provide a general overview about the study area. Also in comment 1.4.

Comment 2.3 — The InSAR time series data acquisition and interpretation is well presented and the methodological steps are described in a rigorous manner, as well as the results of the modelling validated by the ground-based extensometer measurements. A flow chart that resumes all these methodological steps and results obtained would facilitate the readability of the research results presented in this study.

Reply: We added a schematic diagram in Figure 1 that divides the processes into five general stages: input data, PS and DS analysis to obtain the observed phases, contextual grouping and coherent segment identification, SPAMS model parameter estimation, and the SPAMS10 dataset. Also in comment 1.2.

Comment 2.4 — Figure 2 is missing both a scale bar and a north arrow. These cartographic elements should be added to improve the clarity and completeness of the maps.

Reply: Done.