A new method to detect changes in displacement rates of slow-moving landslides using InSAR time series

Alexandra Urgilez Vinueza, Alexander L. Handwerger, Mark Bakker, and Thom Bogaard

Alexandra Urgilez Vinueza PhD (c)

a.r.urgilezvinueza@tudelft.nl

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Introduction – Study area

- InSAR data → Displacement time series per evaluated pixel → identify areas of high displacements

To quantify the times at which the displacement rate of the slow moving landslide changes.

We developed a **new method**

Evaluated method in two study areas:

- Mud Creek landslide in California, United States
- Mazar region, South-east Ecuador (Figure 1)

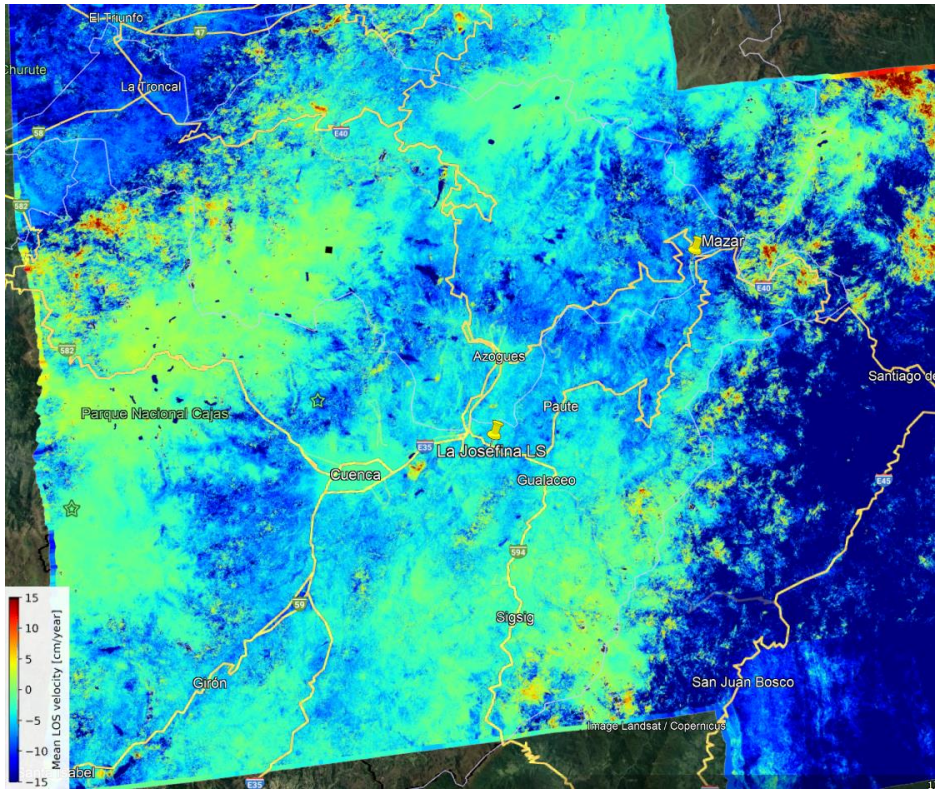

Figure 1. InSAR velocity in south-east Ecuador including the major city of Cuenca and the Mazar hydropower complex.

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Method

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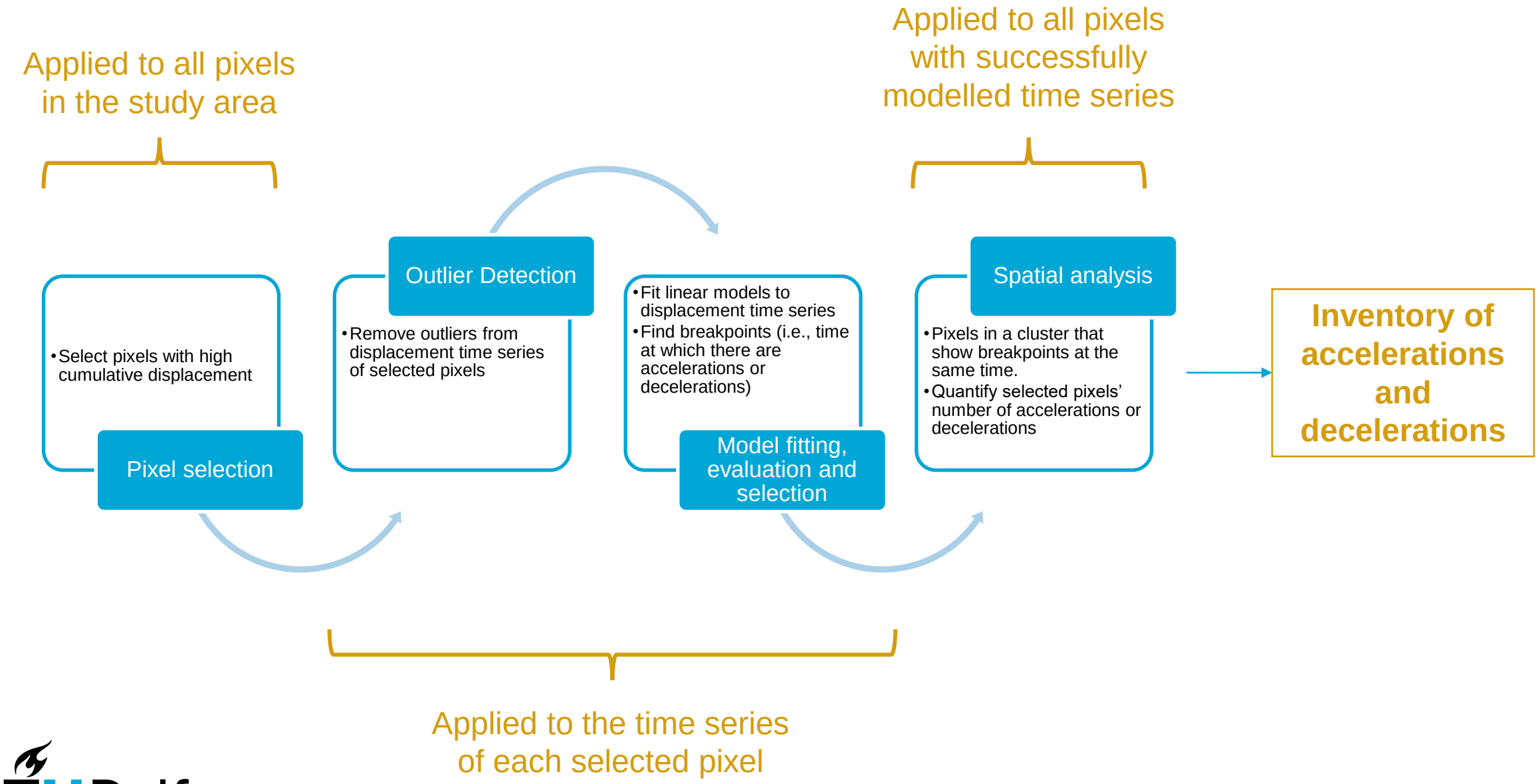
Applied to all pixels in the study area
Applied to all pixels with successfully modelled time series
Pixel selection
•Select pixels with high cumulative displacement
Outlier Detection
•Remove outliers from displacement time series of selected pixels
Model fitting, evaluation and selection
•Fit linear models to displacement time series
•Find breakpoints (i.e., time at which there are accelerations or decelerations)
Spatial analysis
•Pixels in a cluster that show breakpoints at the same time.
•Quantify selected pixels' number of accelerations or decelerations
Inventory of accelerations and decelerations
Applied to the time series of each selected pixel

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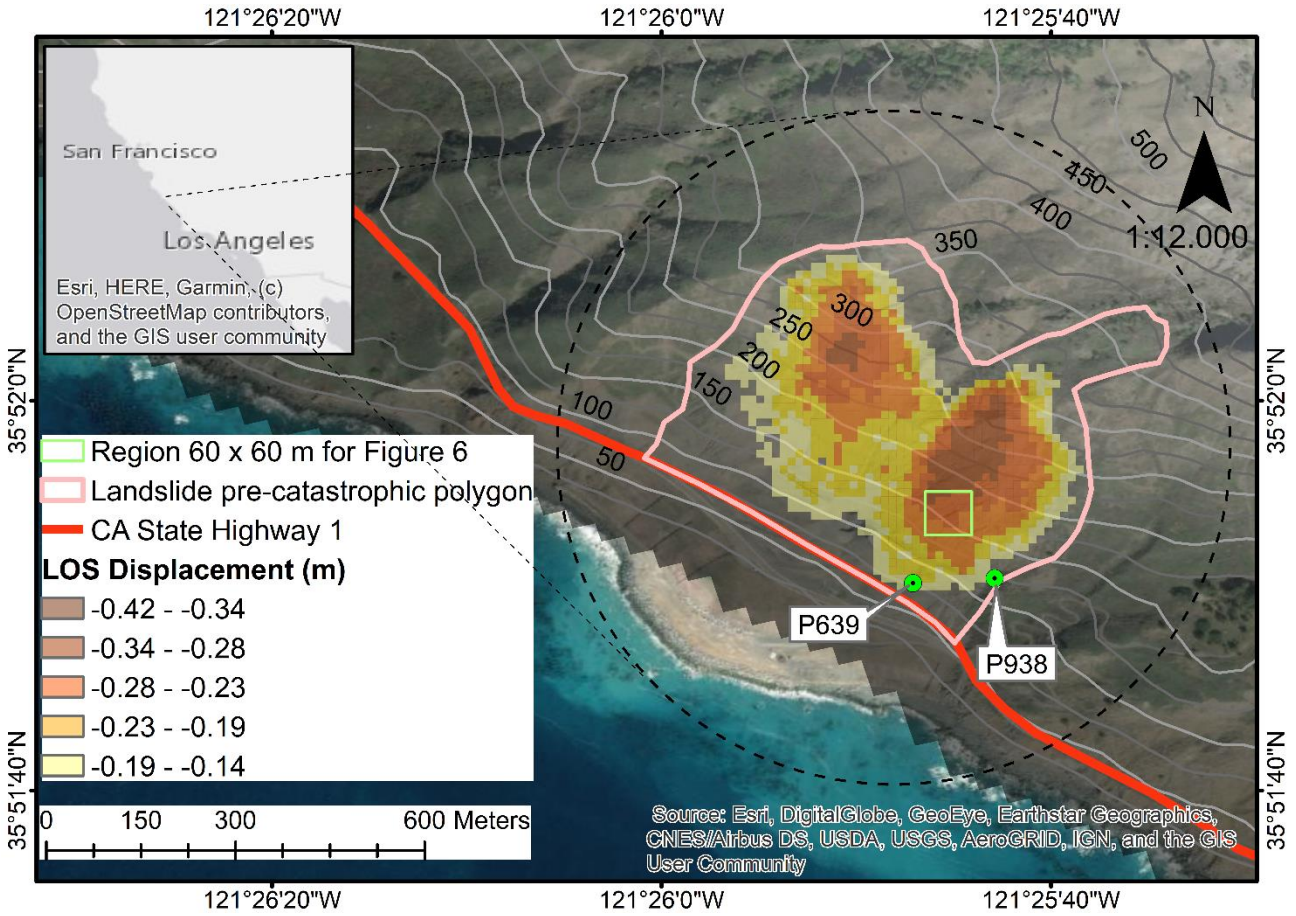
Pixel selection Outliers Fitting Spatial analysis

- In the Mud Creek landslide, 1124 pixels with an absolute displacement value above the 98th percentile were selected.
- All selected pixels are within the boundaries of the pre-catastrophic polygon defined in other studies.



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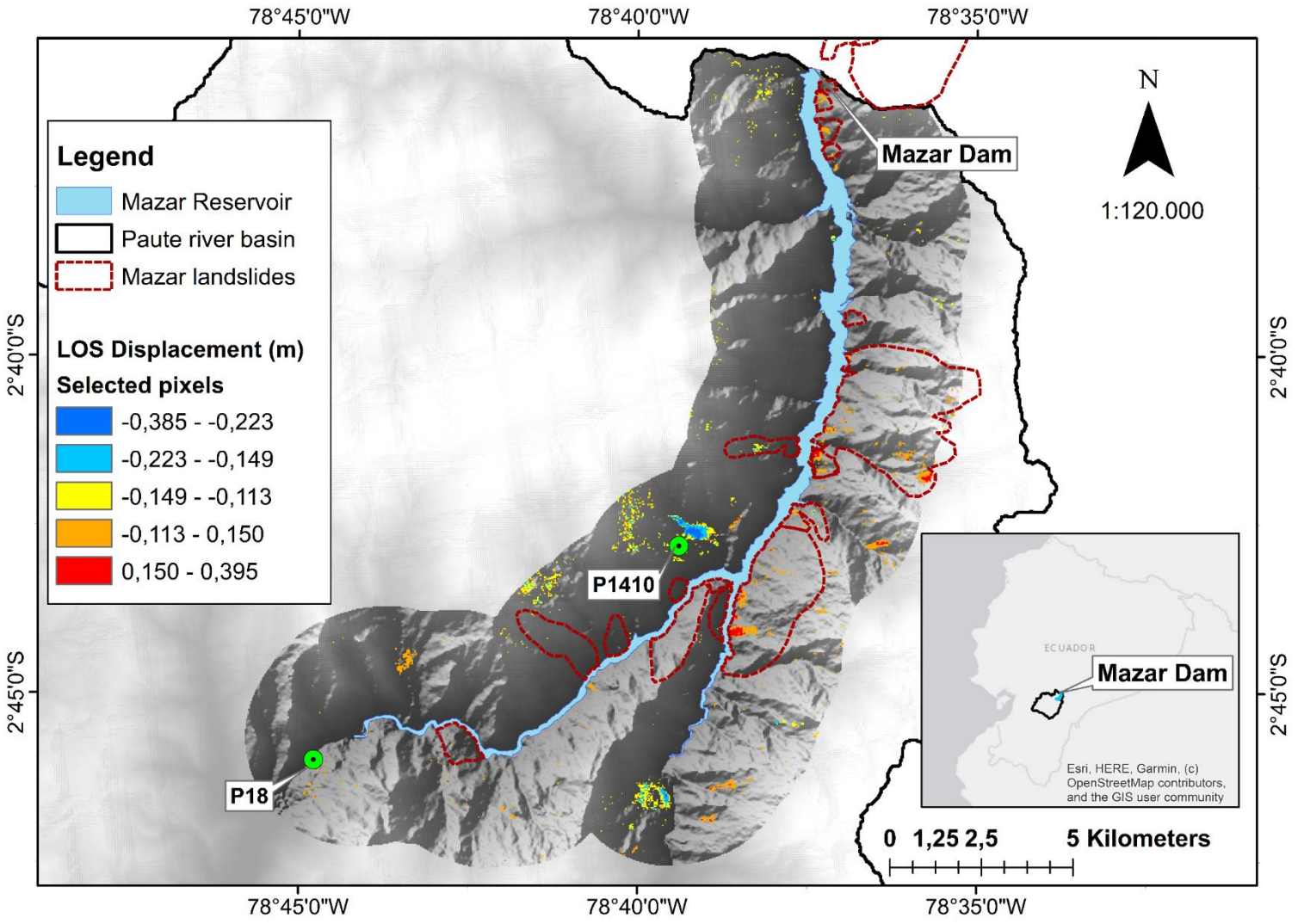
Pixel selection Outliers Fitting Spatial analysis

- In the area of interest in Ecuador, 3230 pixels with an absolute displacement value above the 98th percentile were selected within an area of 211 km^2 around the reservoir.



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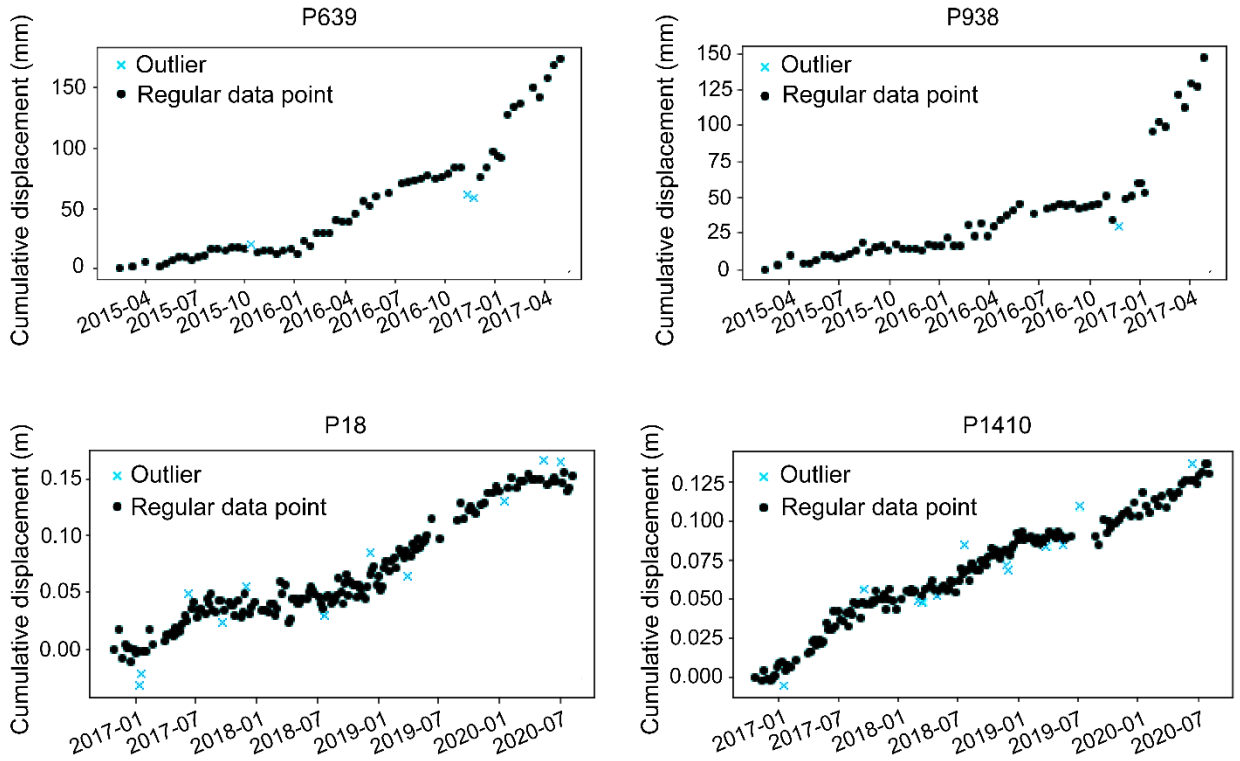
Pixel selection Outliers Fitting Spatial analysis

- Very few outliers were detected and removed from this high quality data set in Mud Creek
- In the case of the Mazar area more outliers were found.



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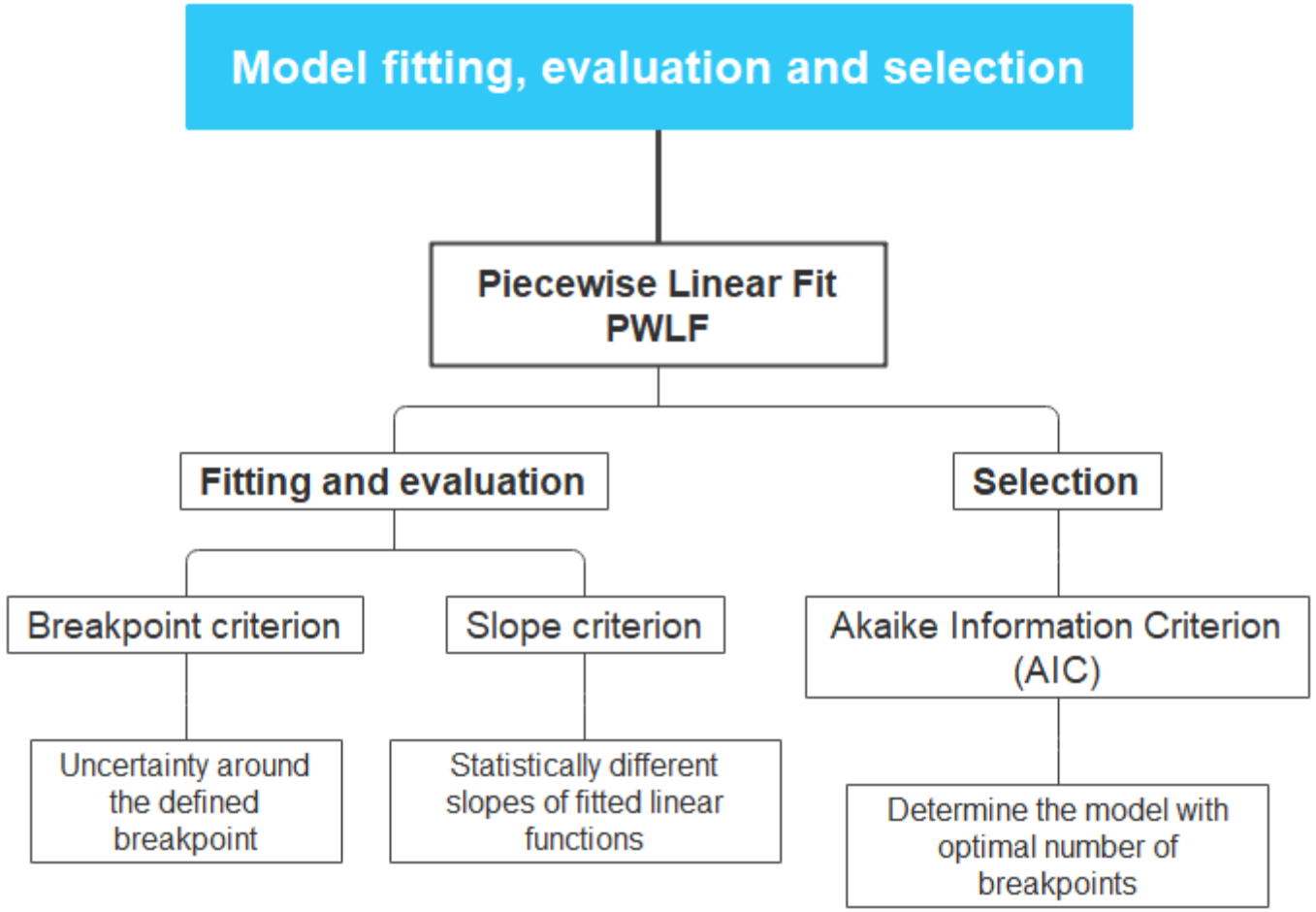
Pixel selection Outliers Fitting Spatial analysis



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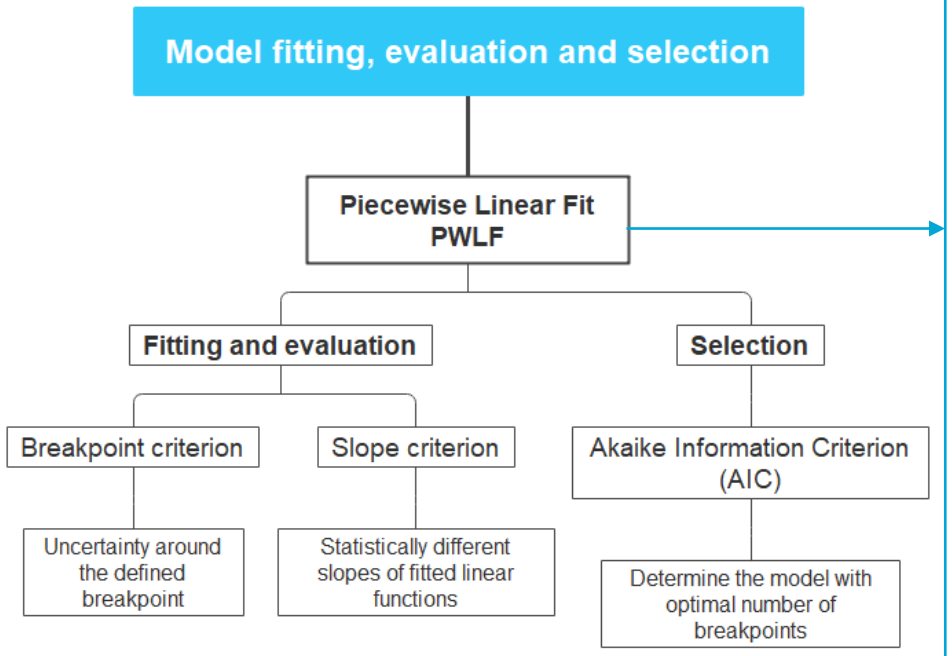

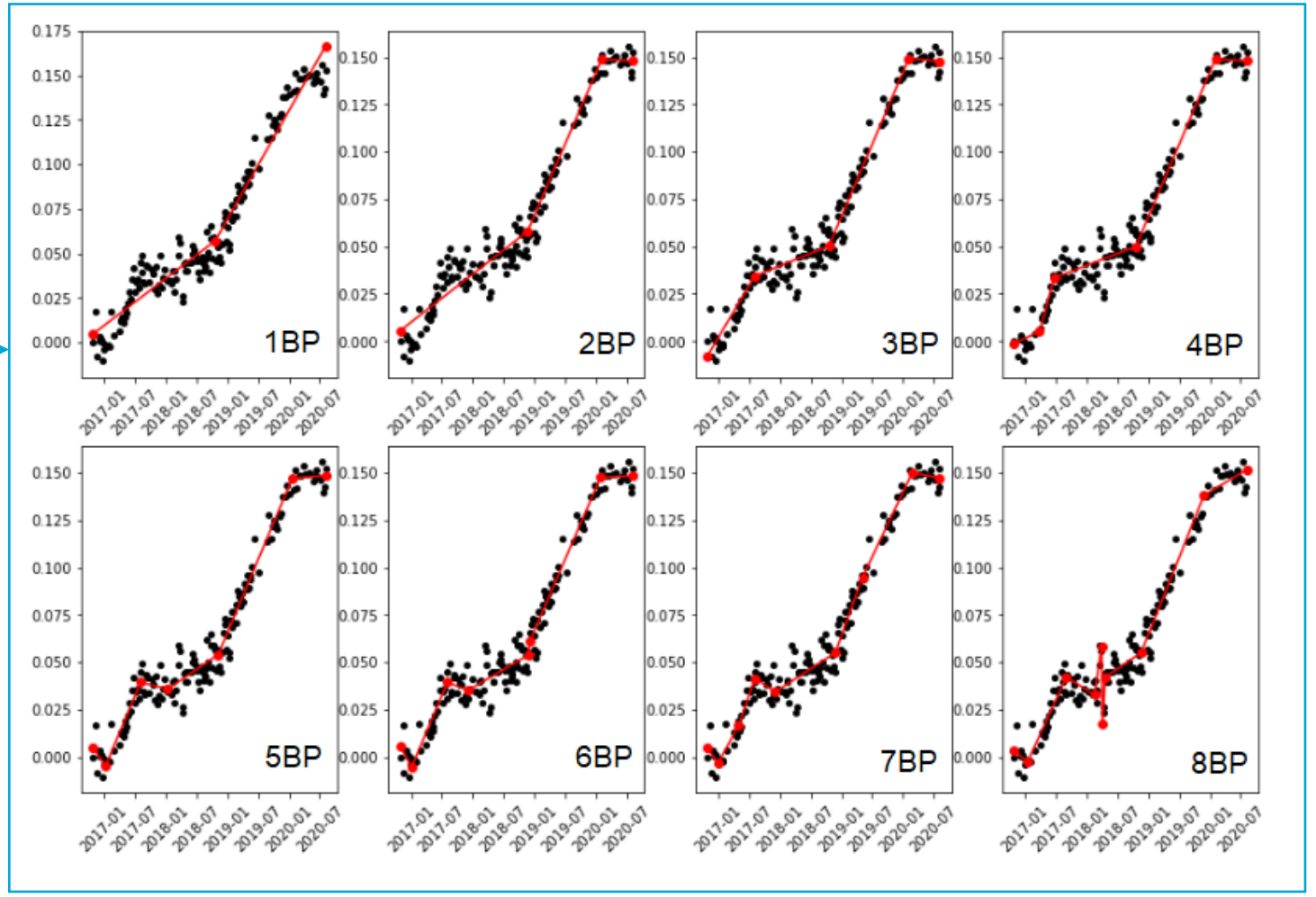

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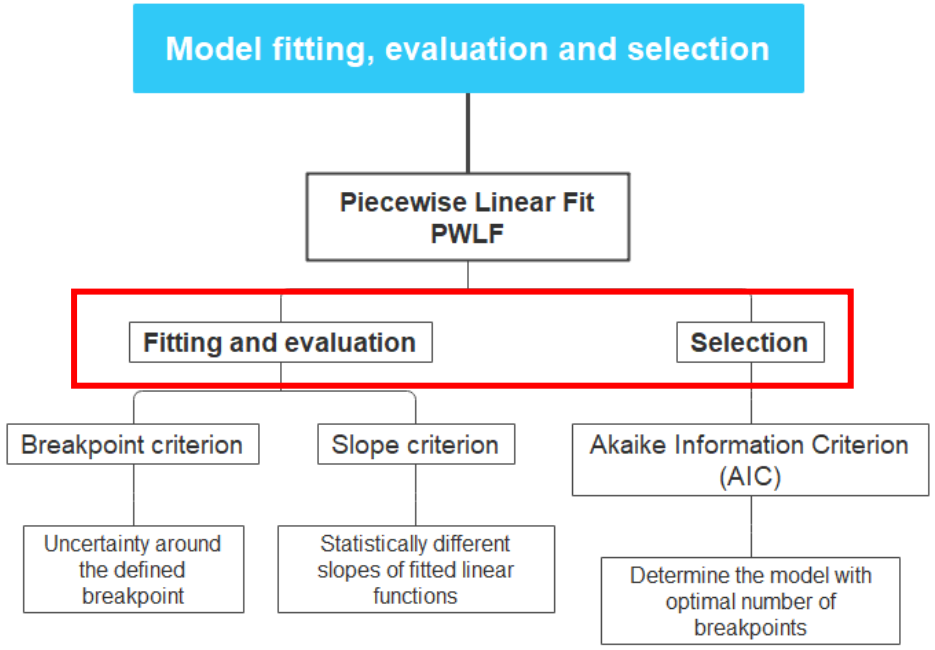

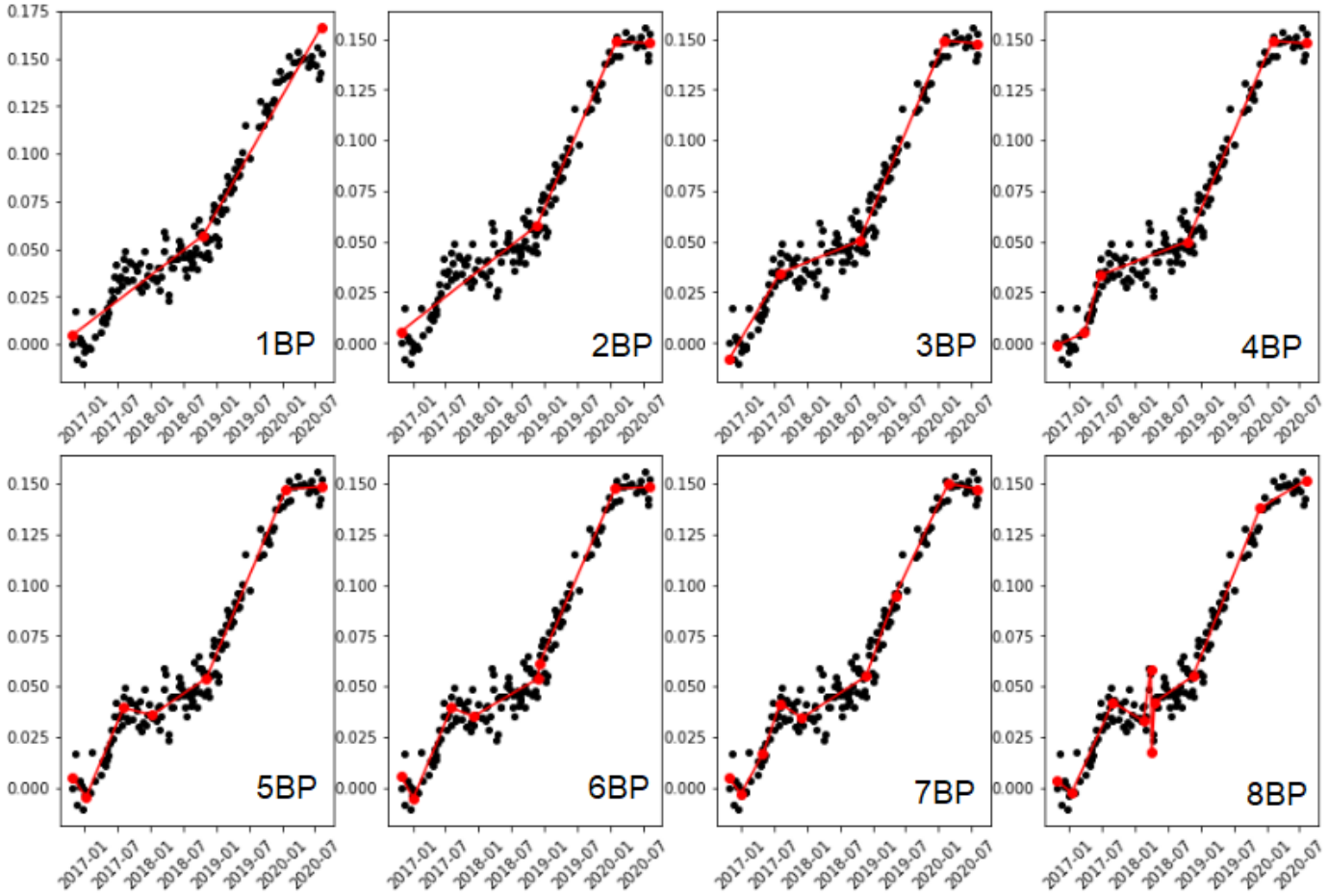

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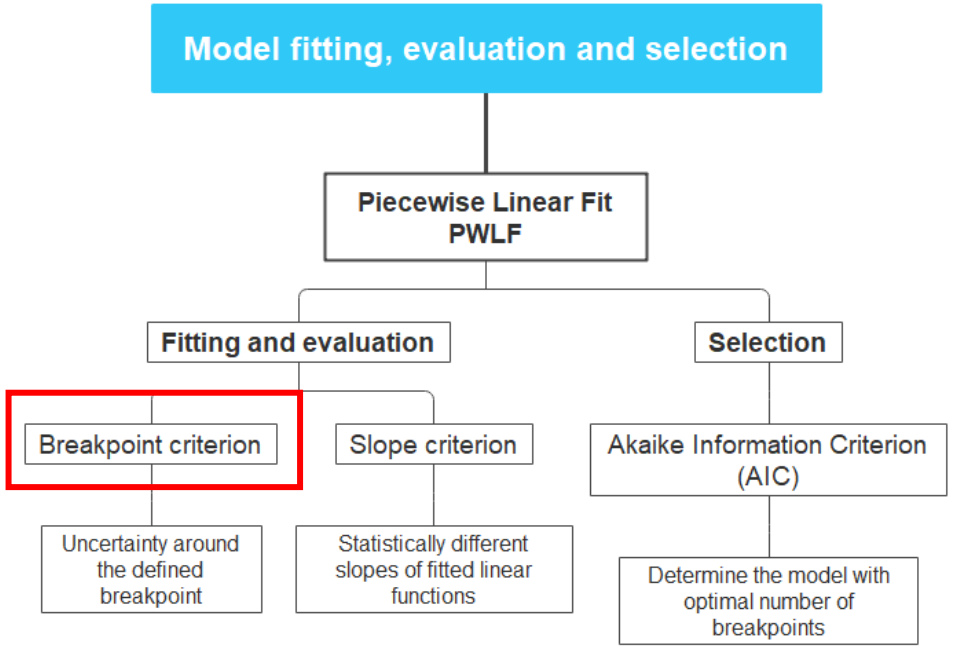

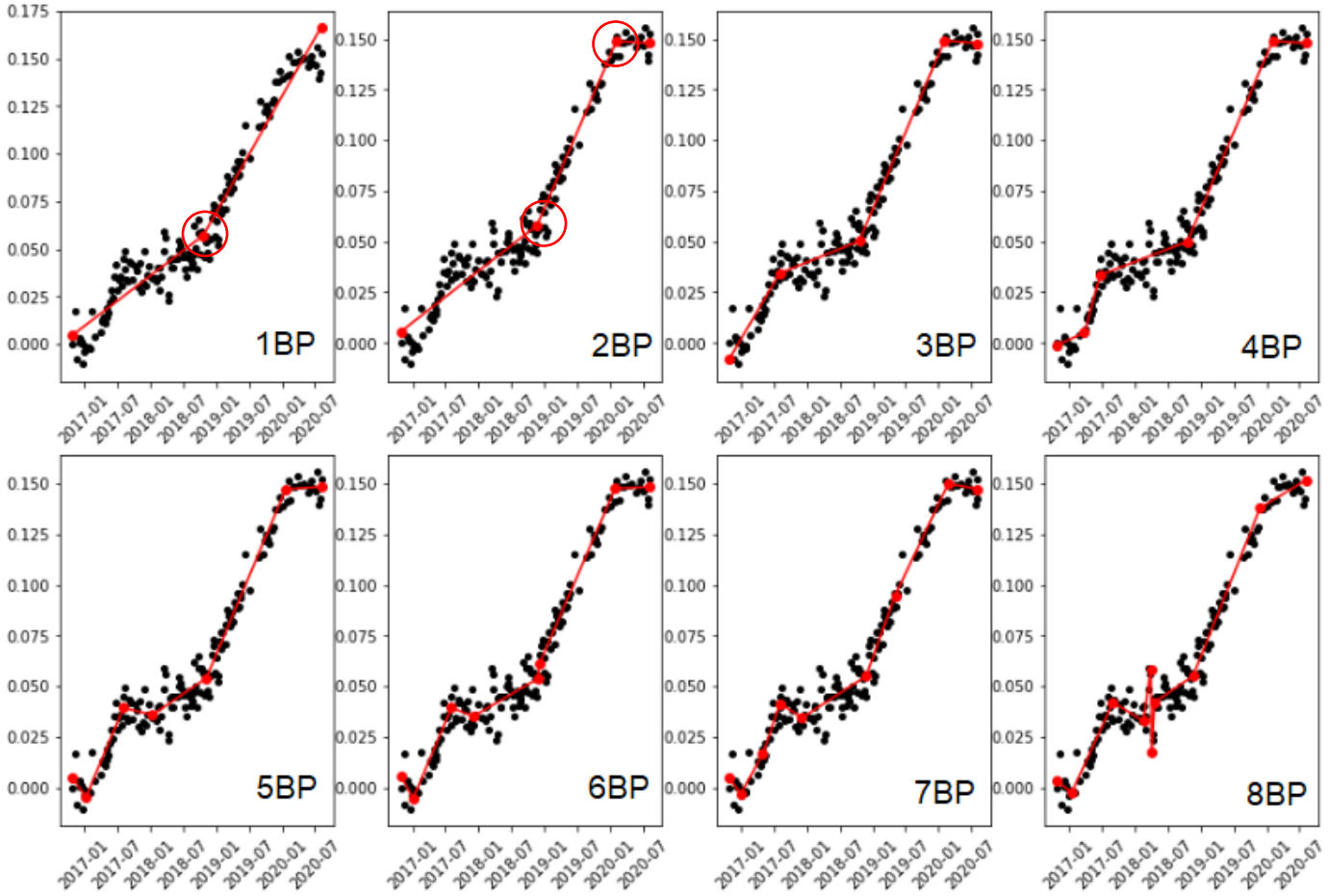

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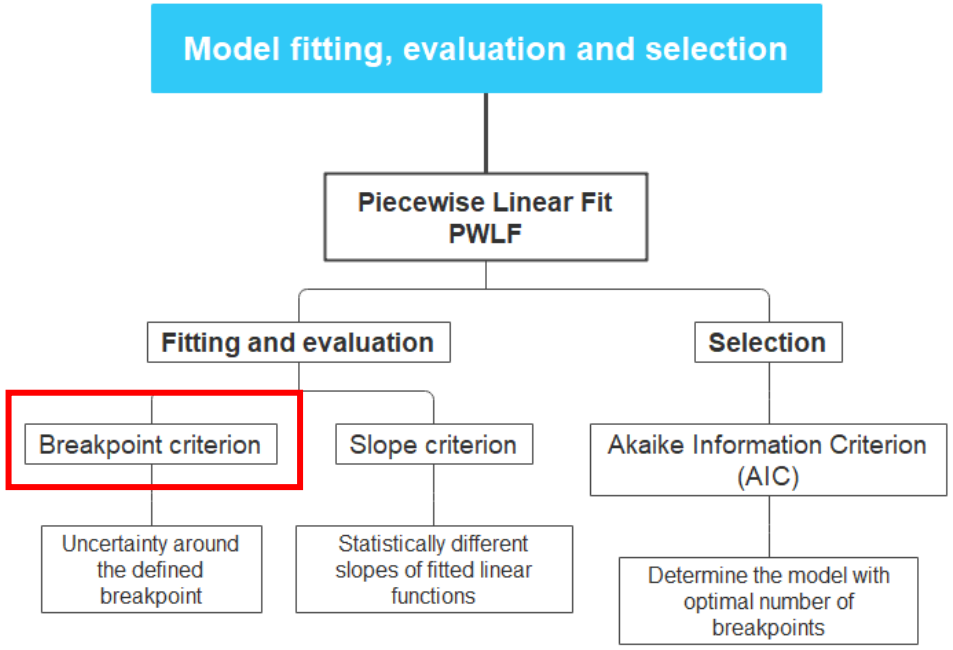

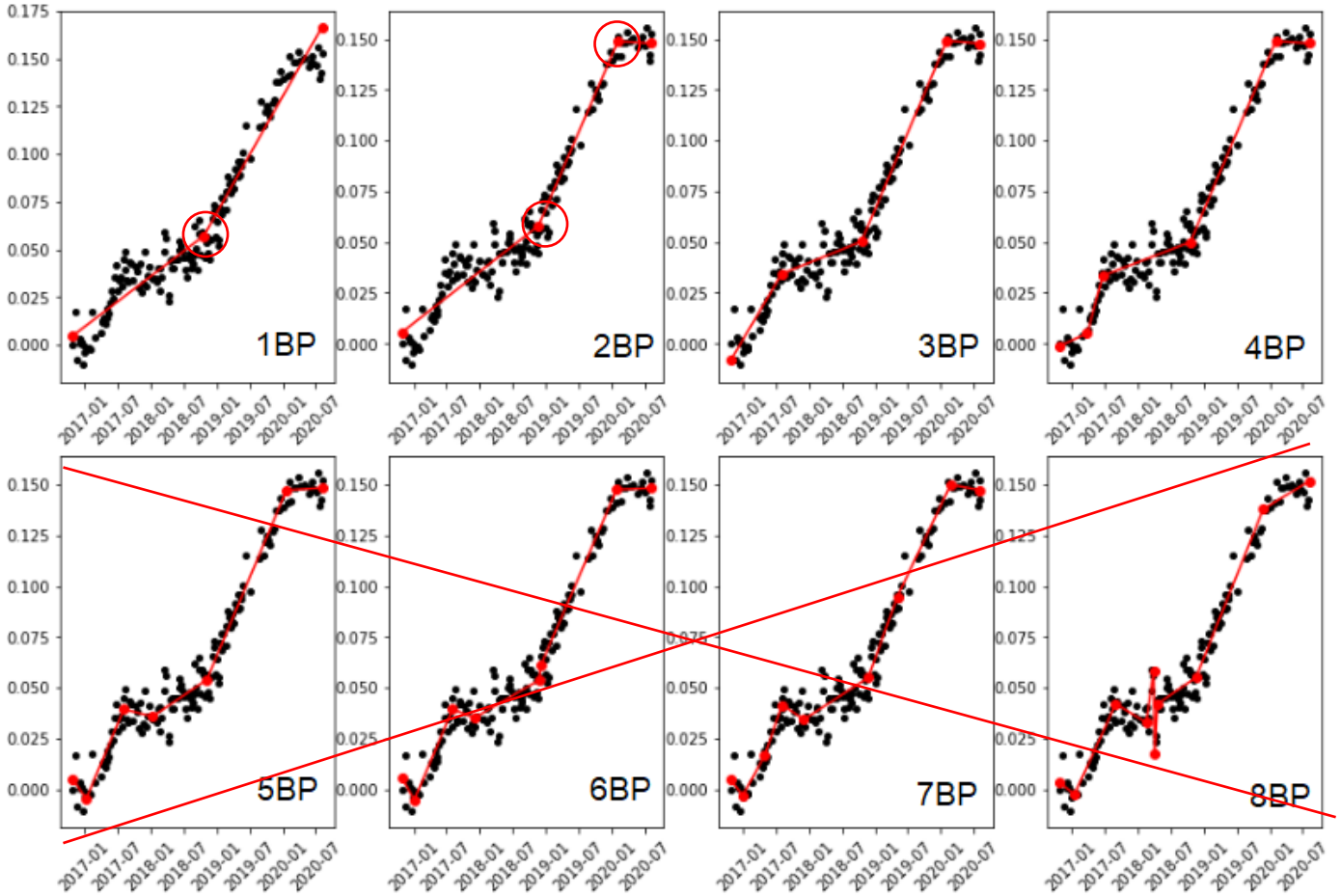

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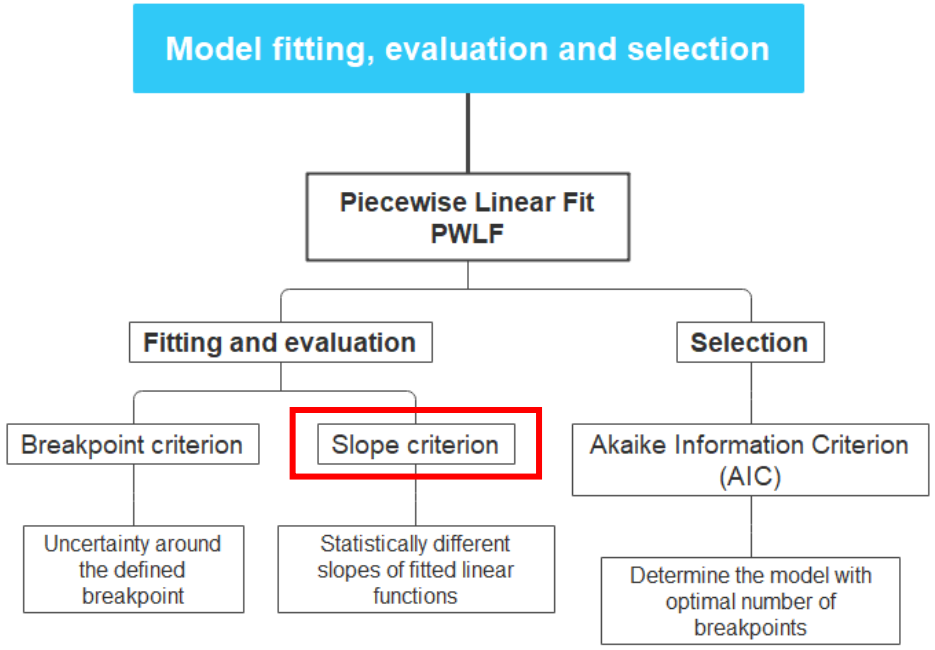

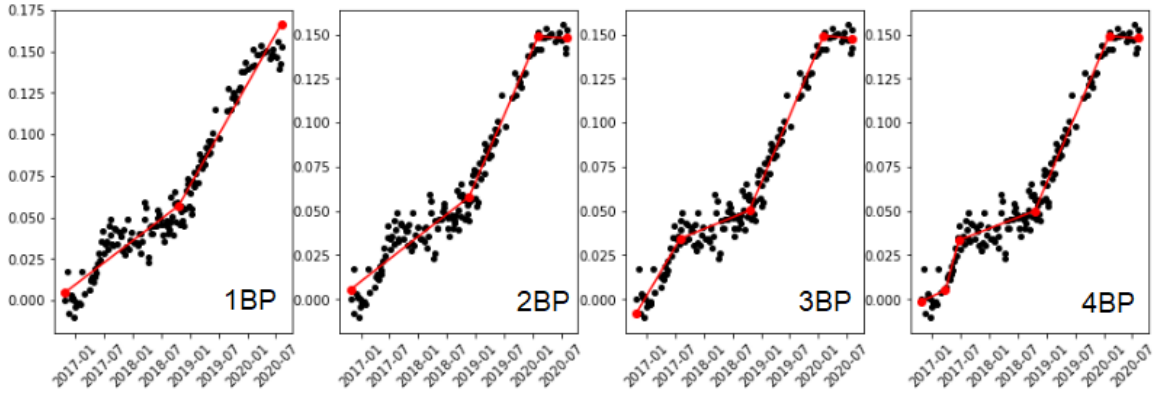

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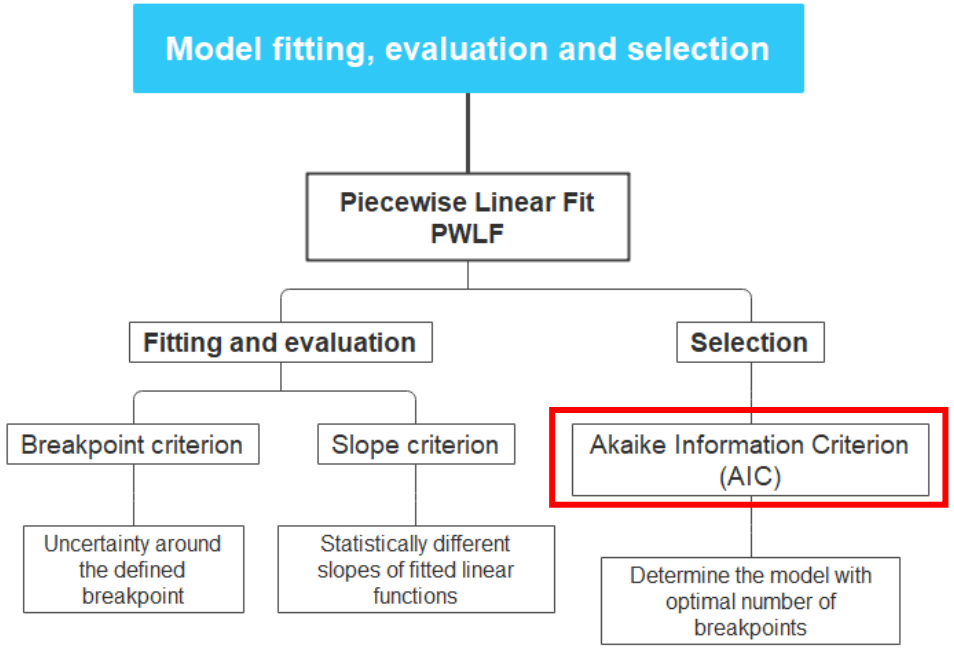

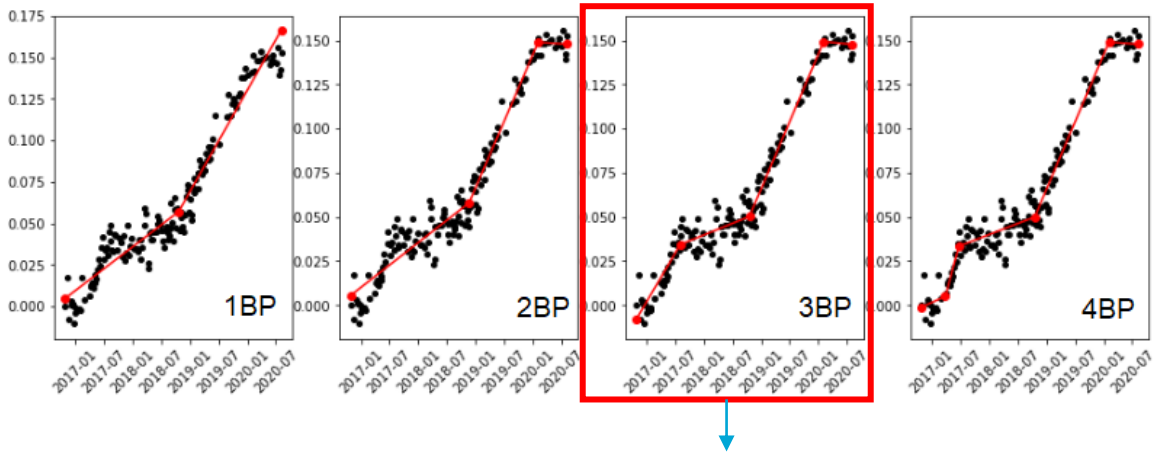

AIC 3BP < AIC 1BP
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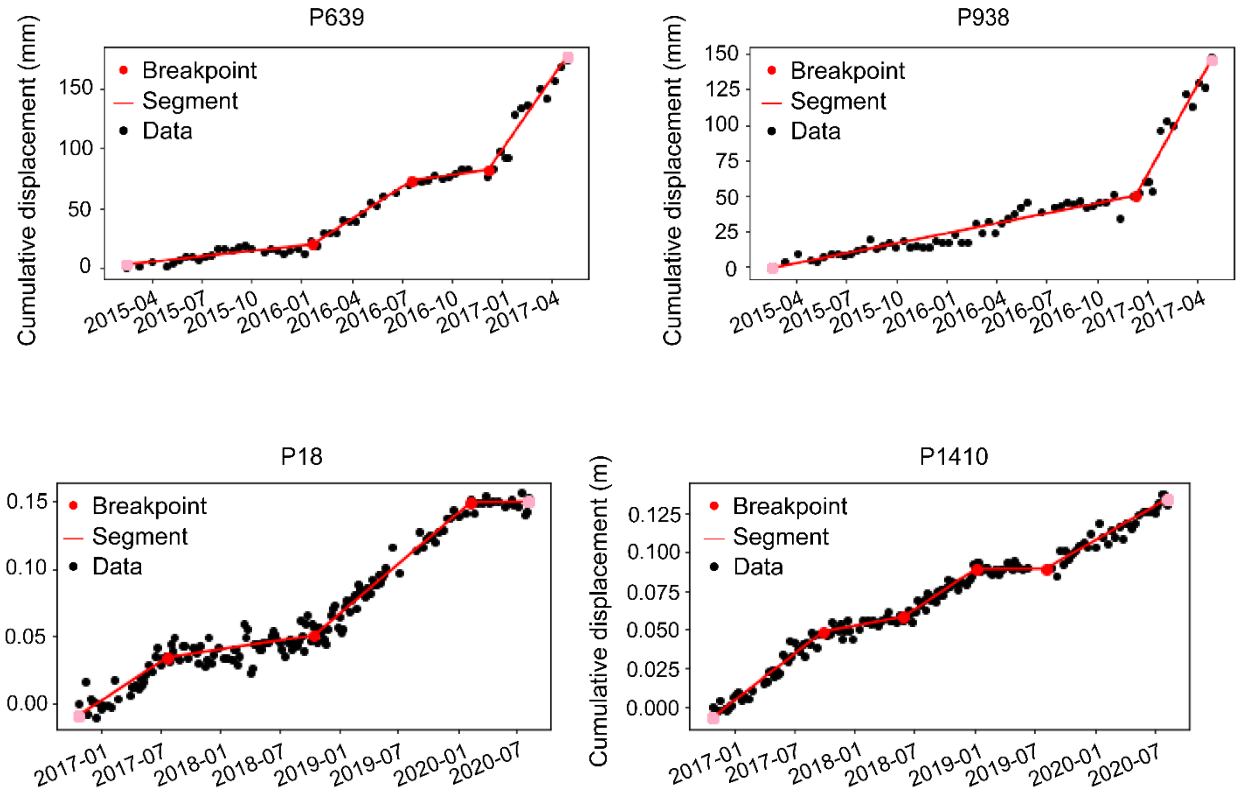
Pixel selection Outliers Fitting Spatial analysis

- Defined number of breakpoints per time series
- Important → the timing of accelerations and/or decelerations is associated with an uncertainty.



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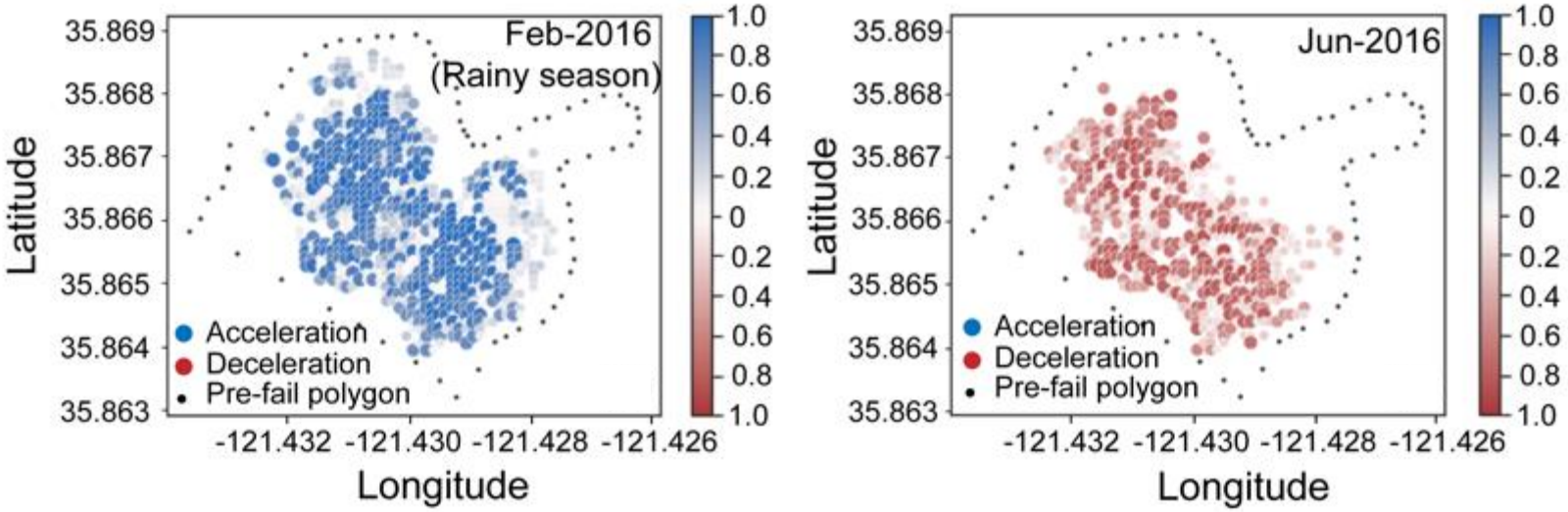
Pixel selection Outliers Fitting Spatial analysis

- We use the **DBSCAN algorithm** to select pixels that are in a cluster and have a change in velocity in the same month



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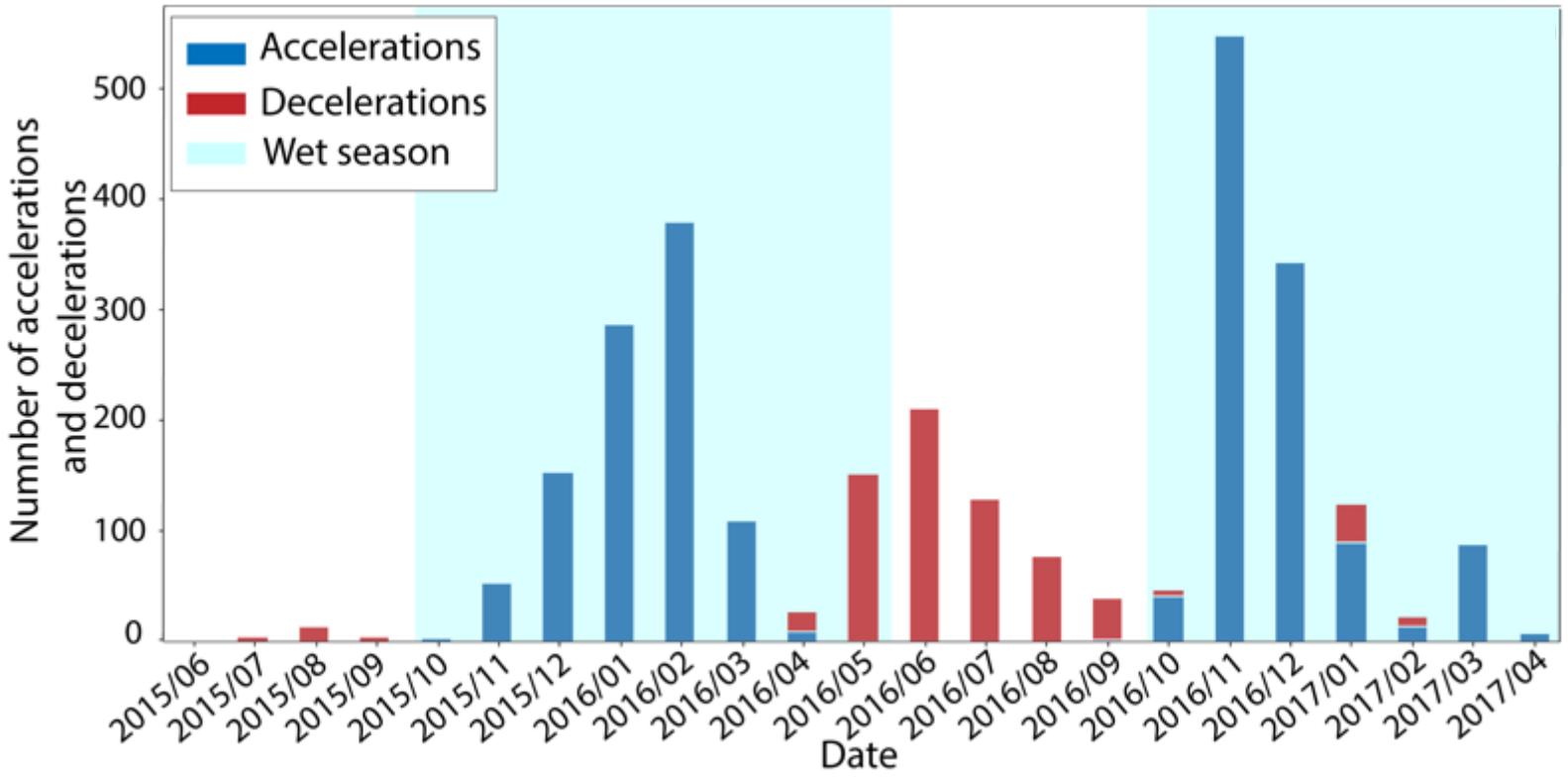
Pixel selection Outliers Fitting Spatial analysis

- We quantify the number of accelerations and decelerations in the entire landslide area per month.



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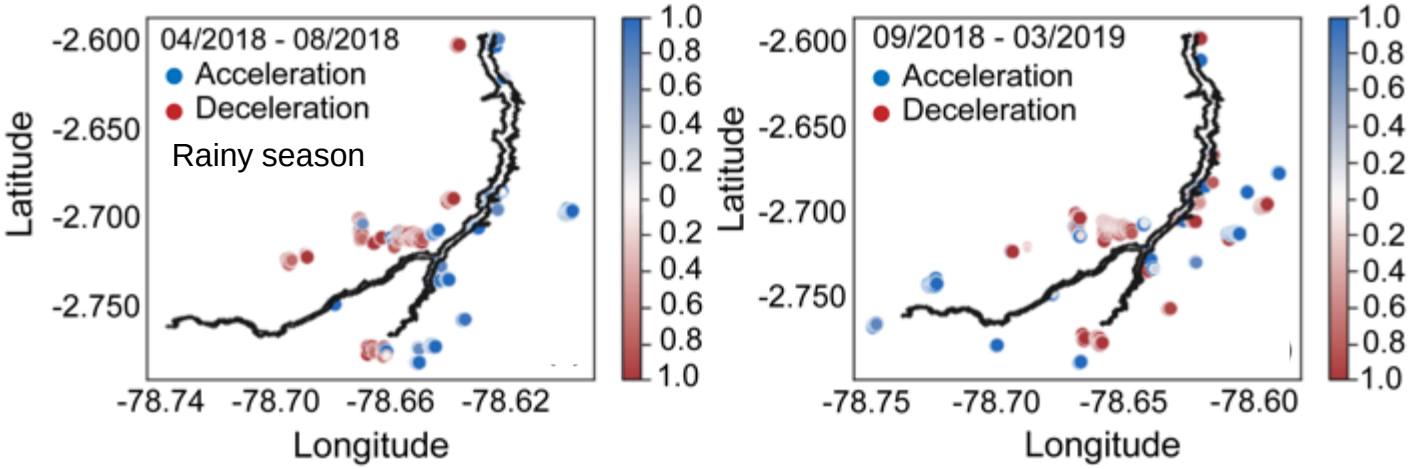
Pixel selection Outliers Fitting Spatial analysis

- We use the **DBSCAN algorithm** to select pixels that are in a cluster and have a change in velocity in the same season



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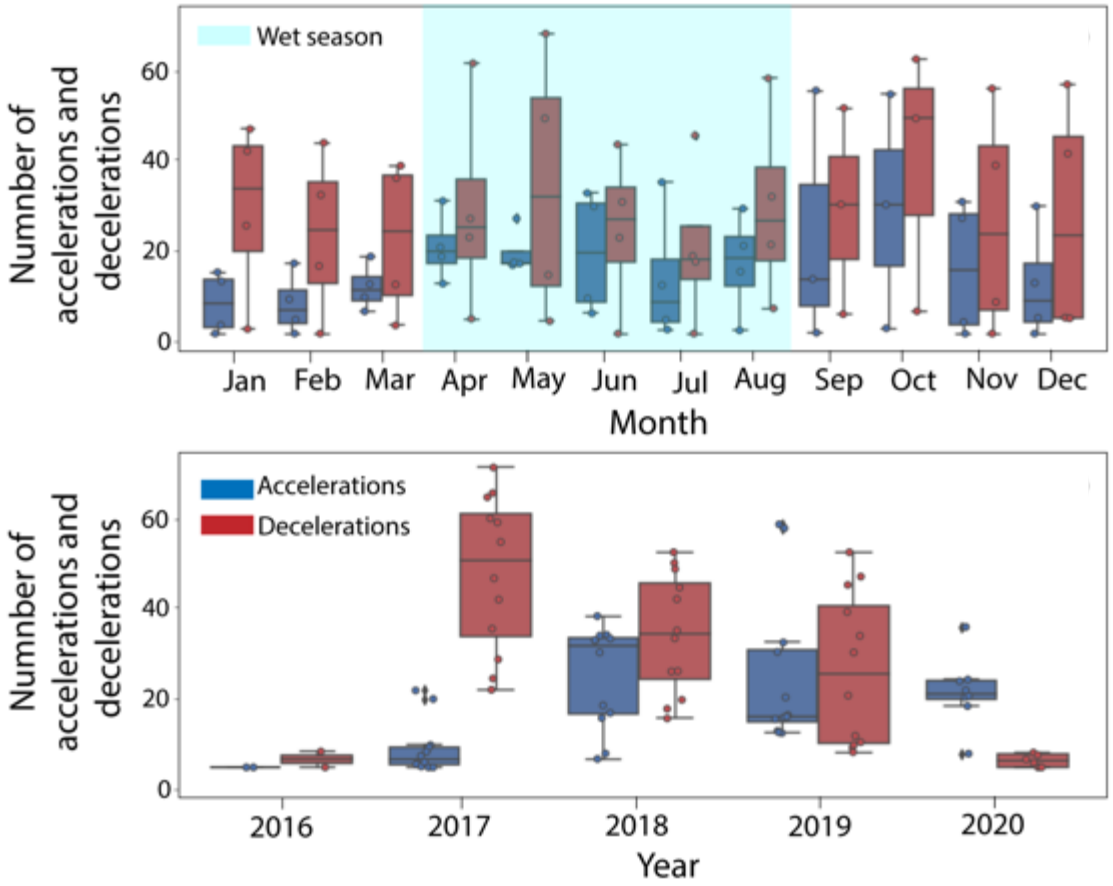
- We quantify the number of accelerations and decelerations in the region.
- We observe accelerations and decelerations occurring throughout the year, with a higher number of accelerations in the first months of the year.
- The number of decelerations diminishes by the end of the period, with more accelerations in 2020 than decelerations.



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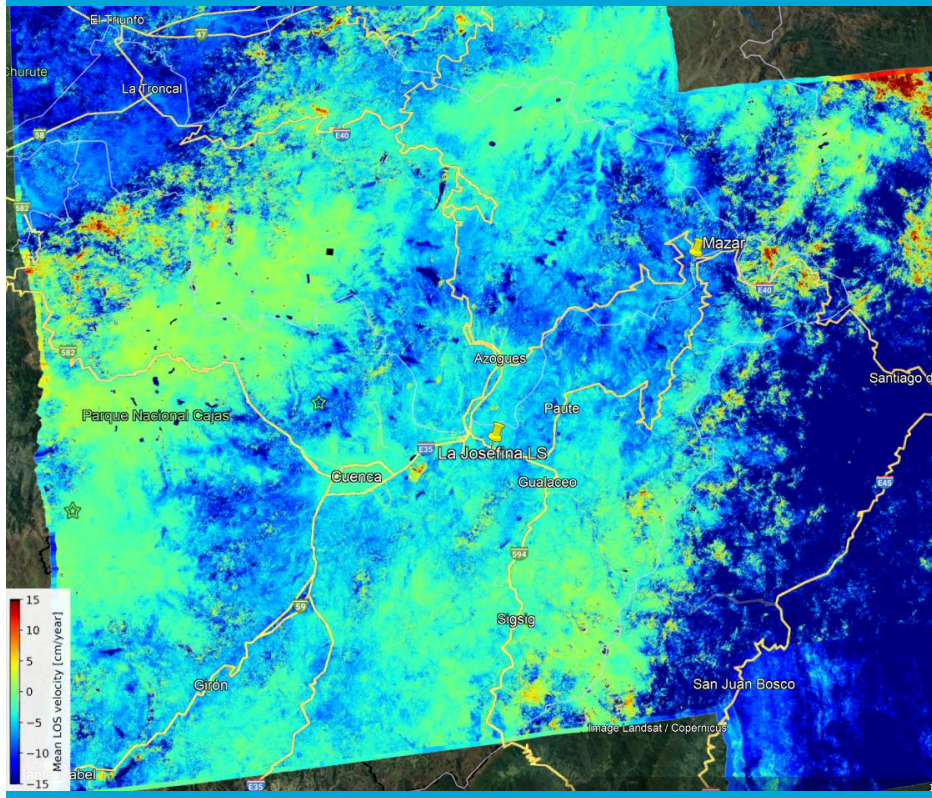
Concluding remarks

- We developed an objective and systematic method for the detection and quantification of accelerations and decelerations of slowly deforming areas from InSAR data.
- The ability to determine the temporal and spatial variation of velocity changes is a step forward in the large-scale interpretation of the physical behavior of slow-moving deforming areas at both sub-landslide and regional scales with high spatial and temporal resolution.



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Thank you for your attention

Alexandra Urgilez Vinueza PhD (c)

a.r.urgilezvinueza@tudelft.nl

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