CLIMATE RESEARCH FOUNDATION

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Detection of inhomogeneities in daily data: a test based in the Kolmogorov-Smirnov test

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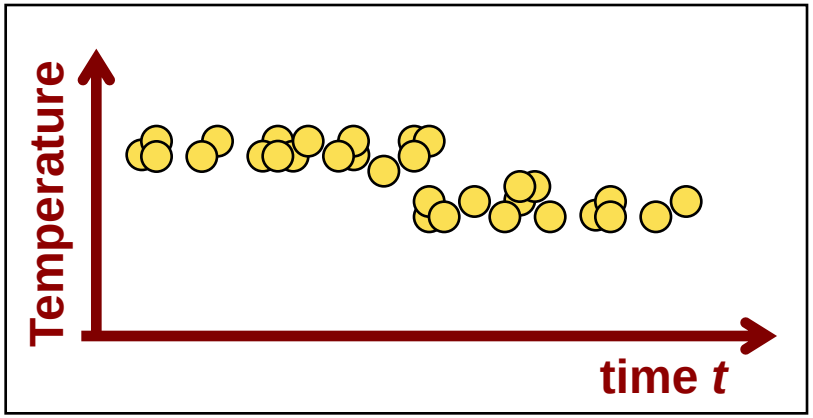

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Problem: Abrupt change in observations

- Changes in the weather shelter (best / worst ventilation, white painting, ...)
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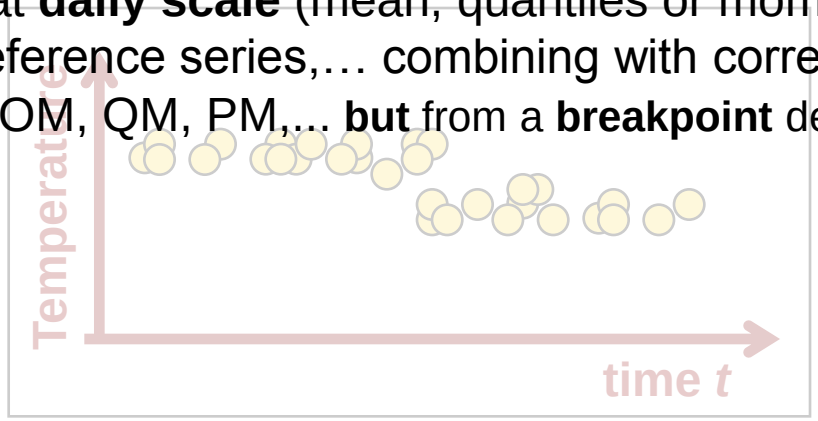
Current solutions

- SNHT: Standard Normal Homogeneity Test (by Alexandersson, 1986)
- Others methods at **monthly scale**: Buishand range test, Pettitt test, von Neumann ratio tests,…
- Some methods at **daily scale** (mean, quantiles or moments): Using parallel measurements, reference series,… combining with corrections as HOM, HOMAD, SPLIDHOM, QM, PM,... **but** from a **breakpoint** detection at **monthly** scale.



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Current limitations

- Detection of inhomogeneities in daily time-series is partially saved.
- Alternatives should be explored

Contents

Methodology

Definitions

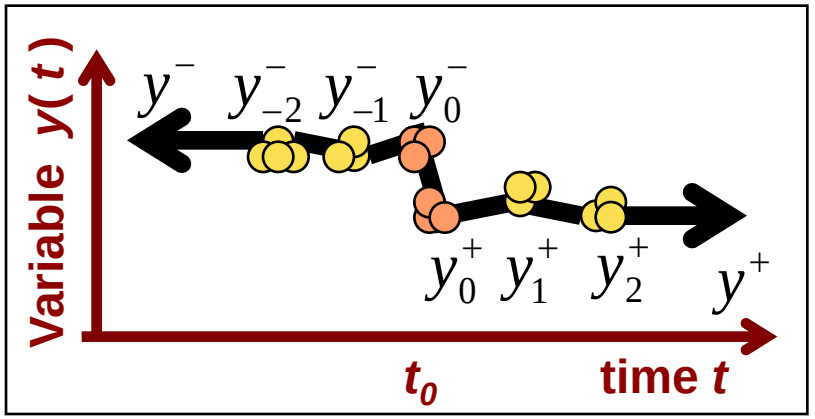
$y_i \equiv$ set of daily data

$t_0 \equiv$ inhomogeneity candidate

$t^- \equiv$ time values to the left

$t^+ \equiv$ time values to the right

PV ≡ p-value of KS test



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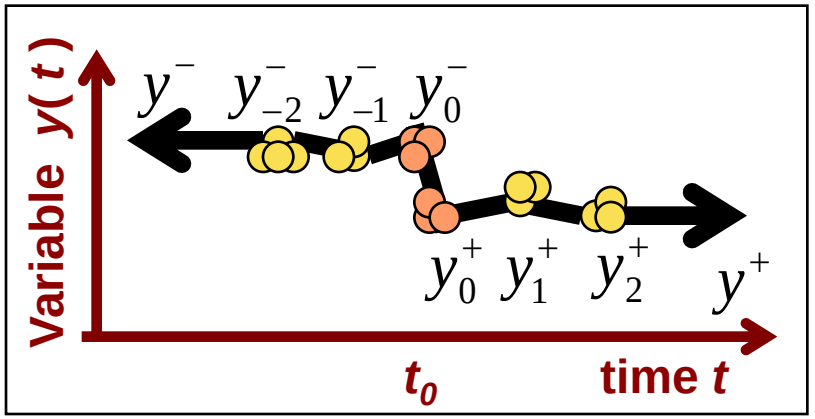

Measure of the dissimilitude between two sets (e.g. 365 days)

$$LPV_j^i \equiv \log_{10}\left(PV(y_i, y_j)\right)$$

$$PV_j^i \in (0,\ 1) \longrightarrow LPV_j^i \in (-\infty,\ 0)$$

High ↔ low dissimilitude

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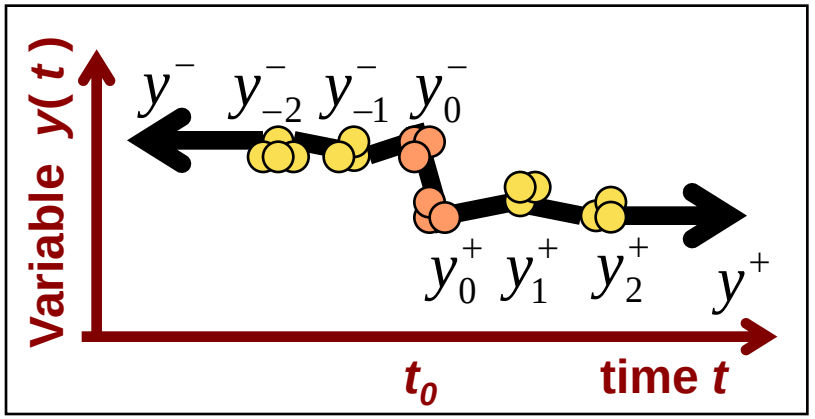

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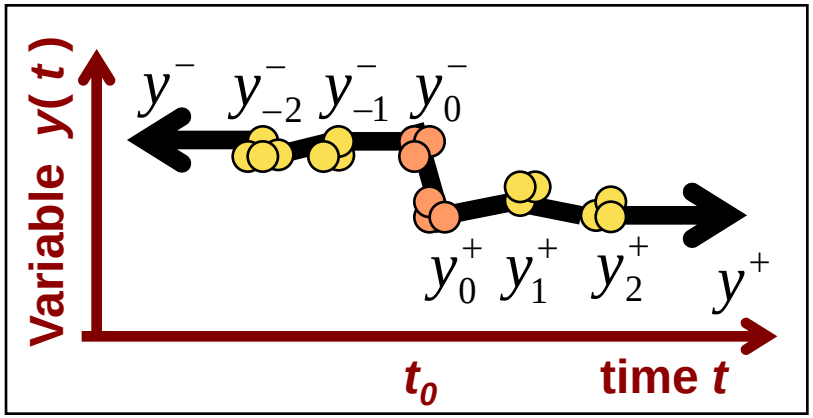
Measure of possible Inhomogeneity jumps: Dissimilitude between 2 contiguous sets

$$LPV_{i+1}^i \equiv \log_{10}\left(PV(y_i, y_{i+1})\right)$$

Control Analysis

Introducing an **artifitial inhomogeneity** to each set of data $y_i \rightarrow \tilde{y}_i$



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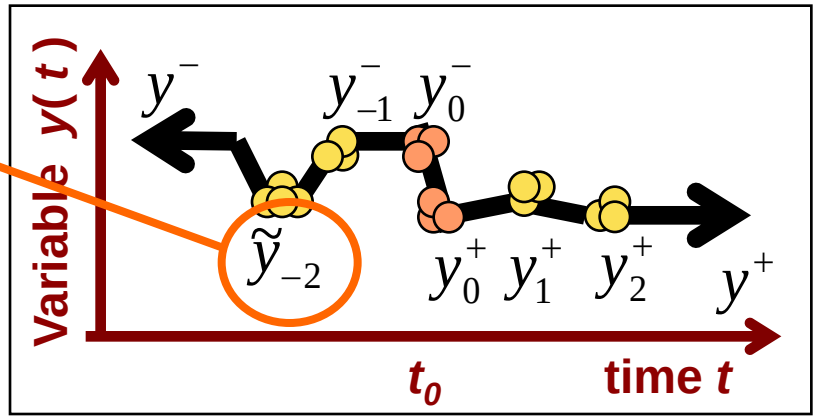

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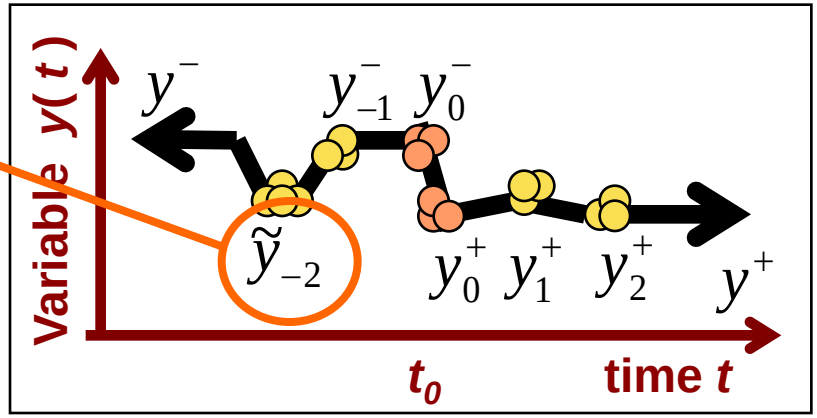
Variable	*a*	*b*
Temperature	1	2
Precipitation	3	0

EXAMPLE

$$\tilde{y}_i \equiv a^{\pm 1} \cdot y_i \pm b$$

Artificial inhomogeneity



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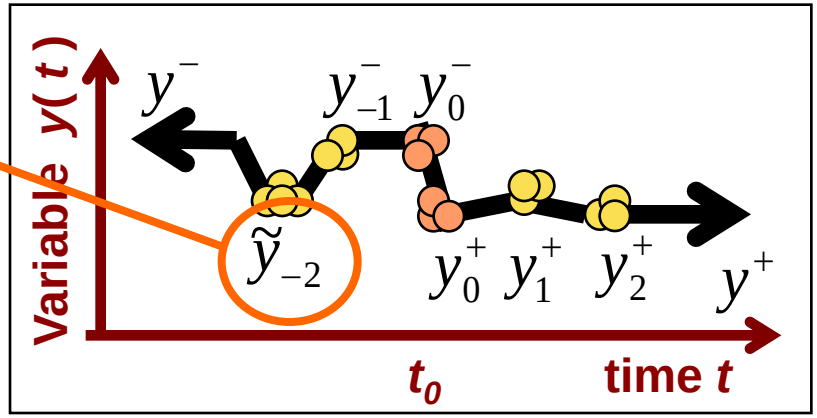

Reference LPV is defined from the **average value**: inhomogeneity of control

$$LPV_{Inh} \equiv \frac{1}{N-1}\sum_{i=1}^{N-1} LPV^{i}_{\{i+1\}}$$

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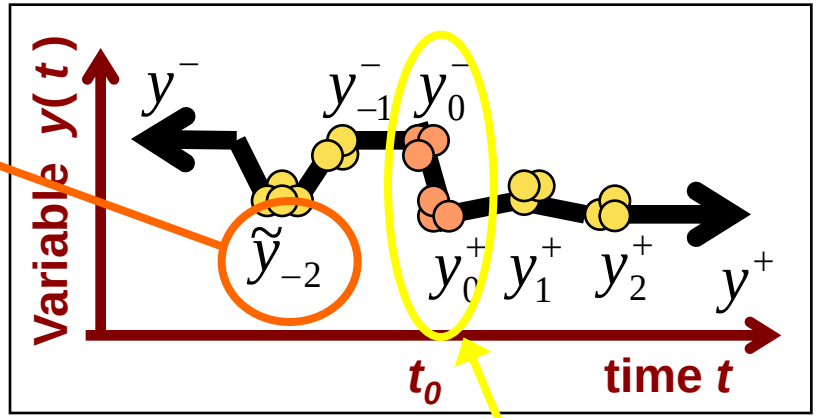

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$$LPV^{i}_{i+1} \leq LPV_{Inh} \rightarrow \begin{cases} y^-_0 = y_i \\ y^+_0 = y_{i+1} \end{cases}$$

Methodology

Inhomogeneity detection

Similarity between the **candidates** y_0 and the other **populations** that are on the left (-) and right (+)

$$LPV_{-}^{-} \equiv \log_{10}\left(PV(y^{-}, y_0^{-})\right)$$ **Similar**

$$LPV_{-}^{+} \equiv \log_{10}\left(PV(y^{+}, y_0^{-})\right)$$ **different**

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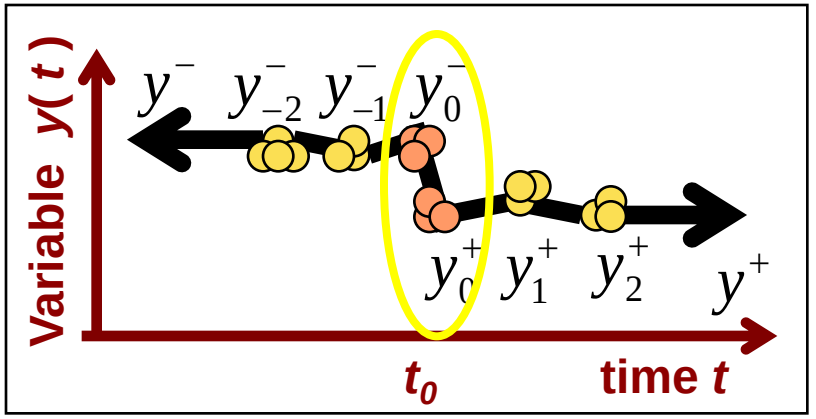

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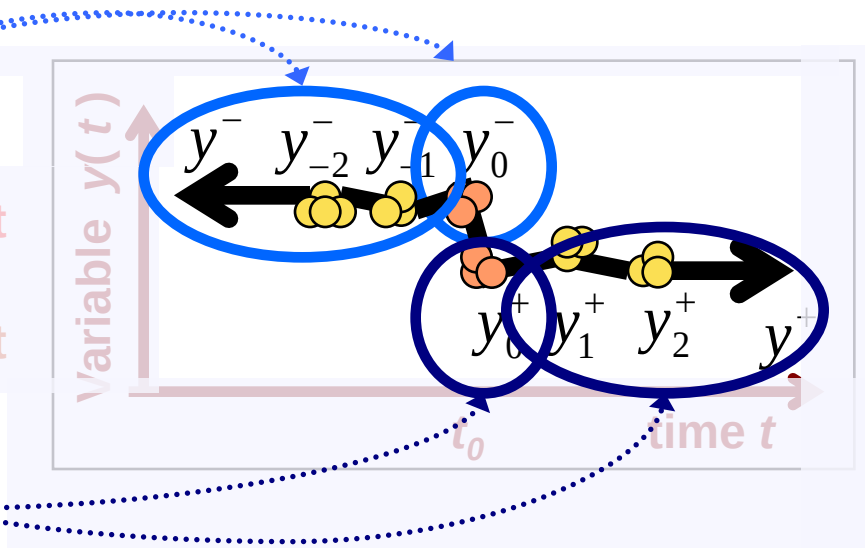

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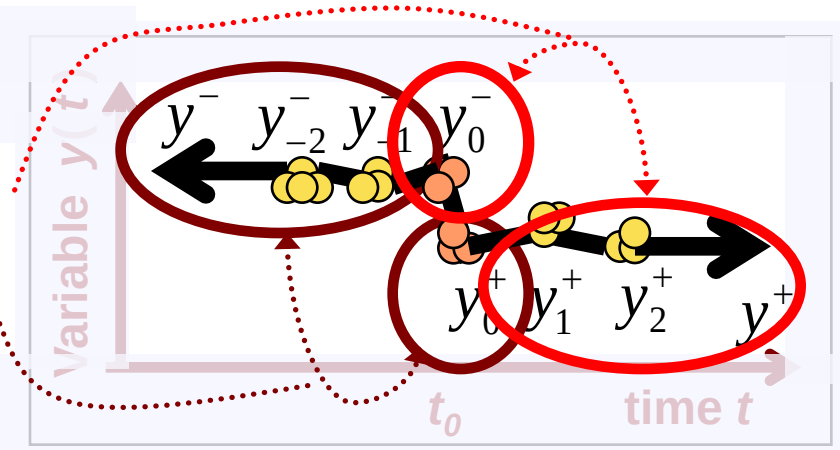
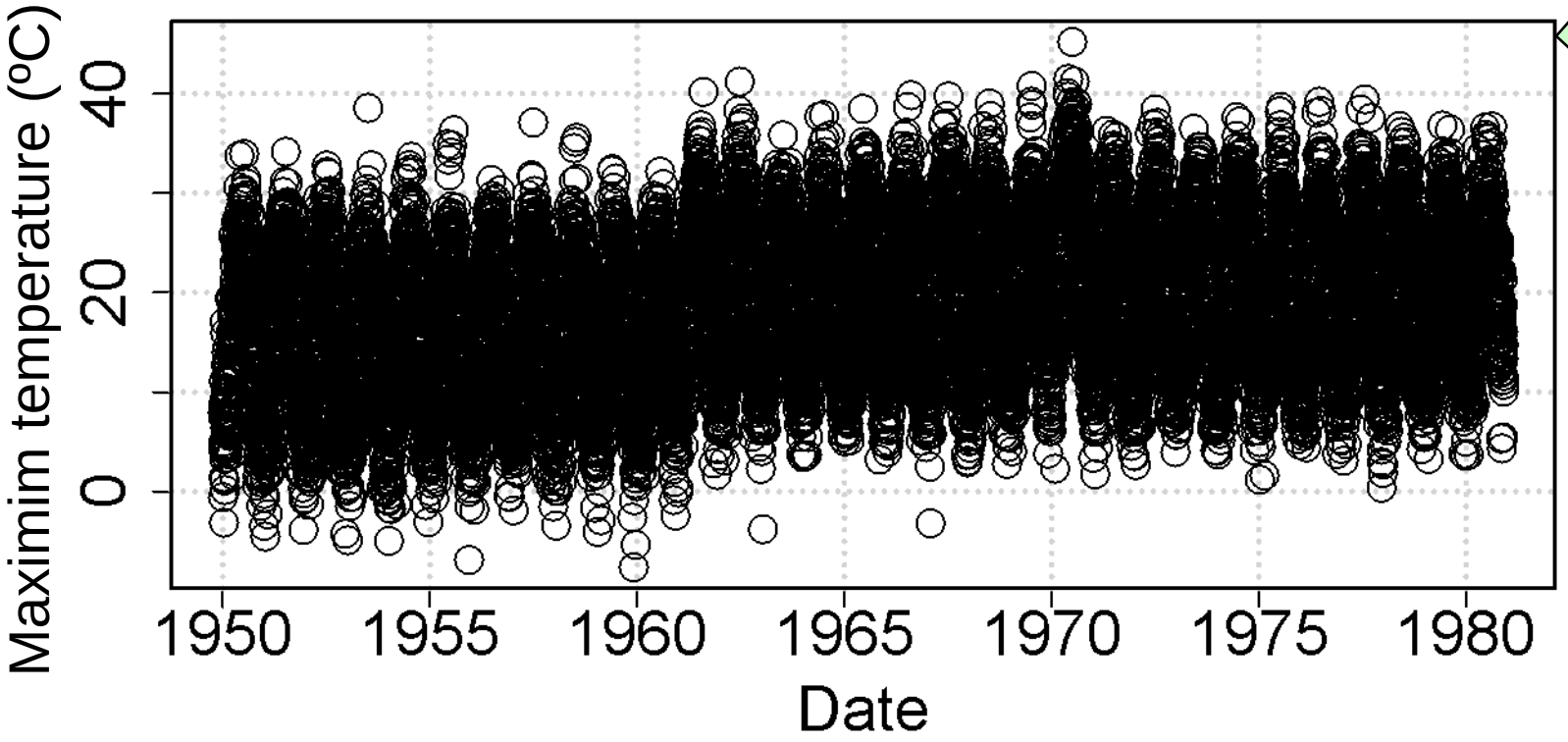


Inhomogeneity detection: EXAMPLE 1

Ideal case with a jump and one unusual year

Theoretical case built from normal distributions



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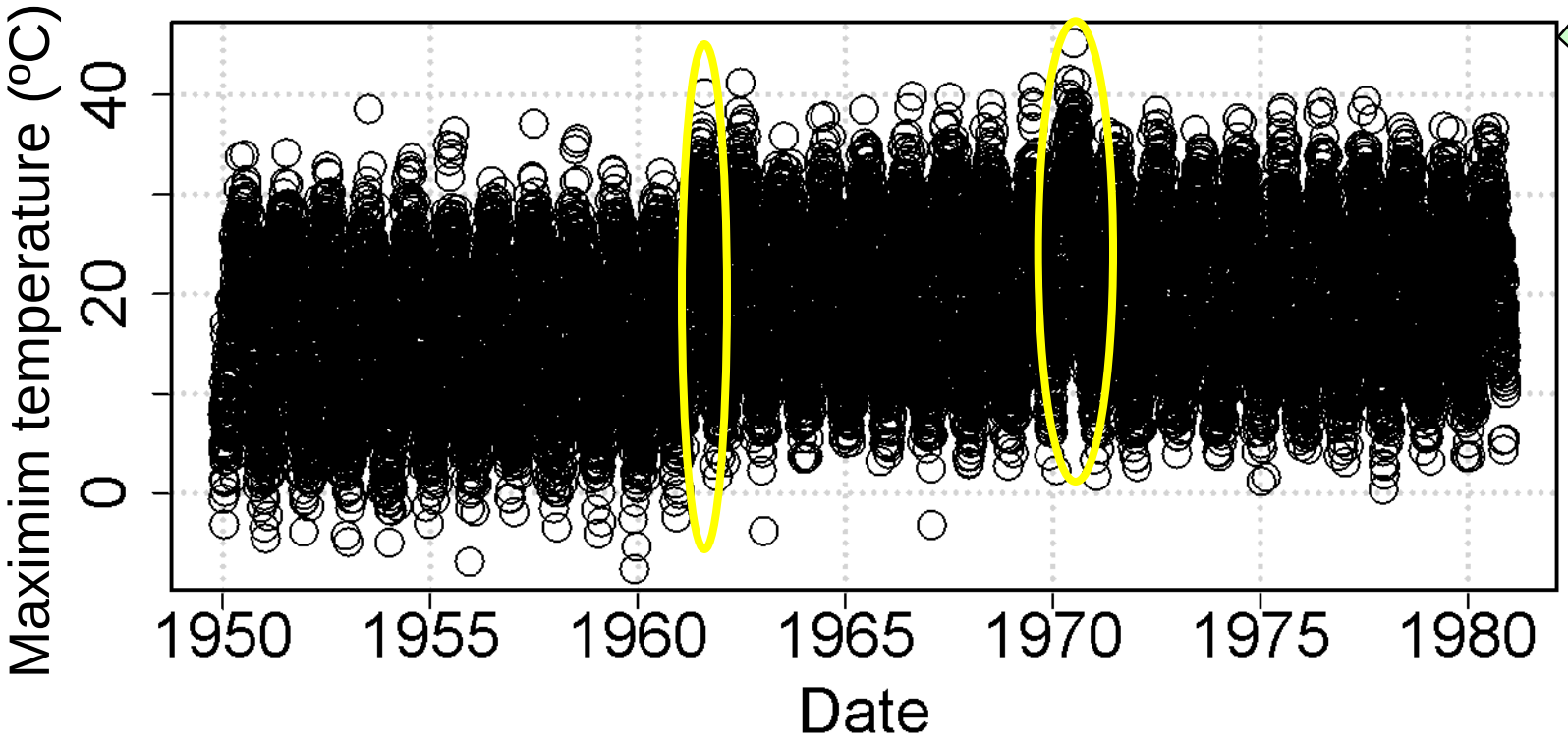

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Inhomogeneity de[illegible]MPLE 1

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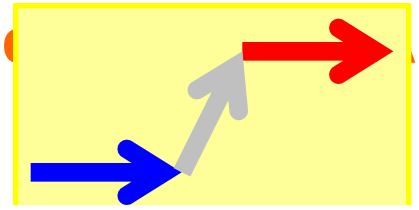

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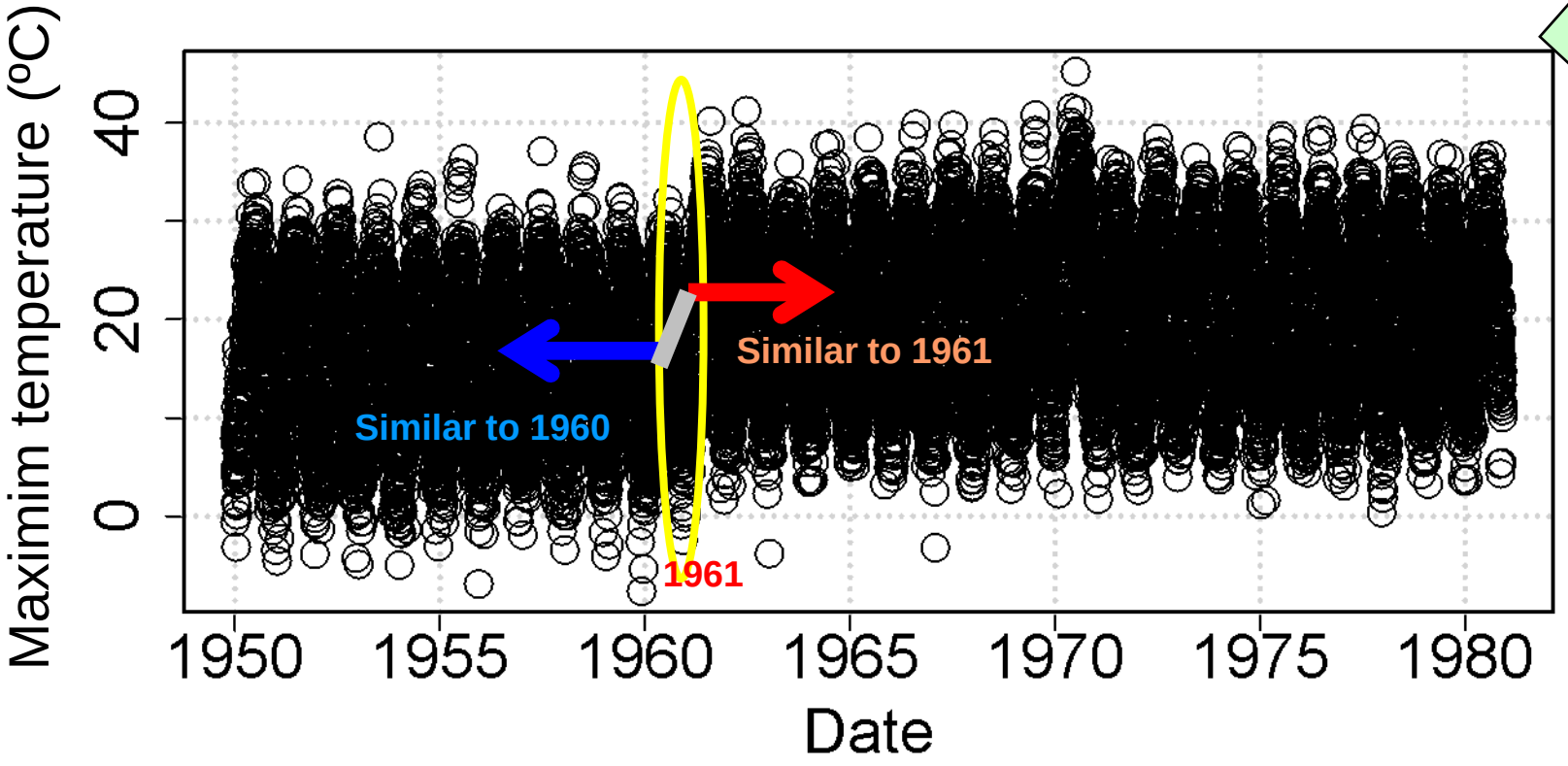

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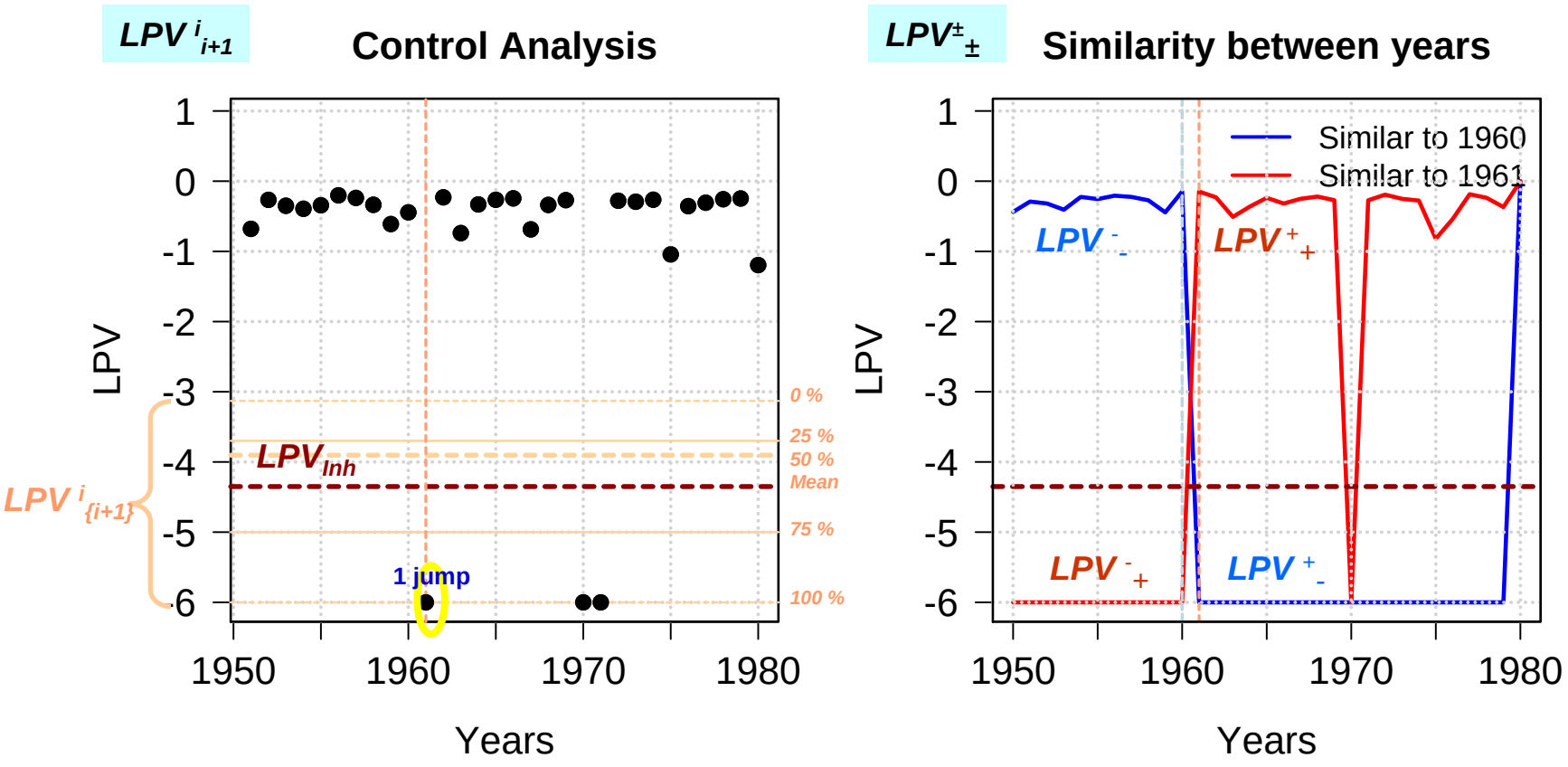

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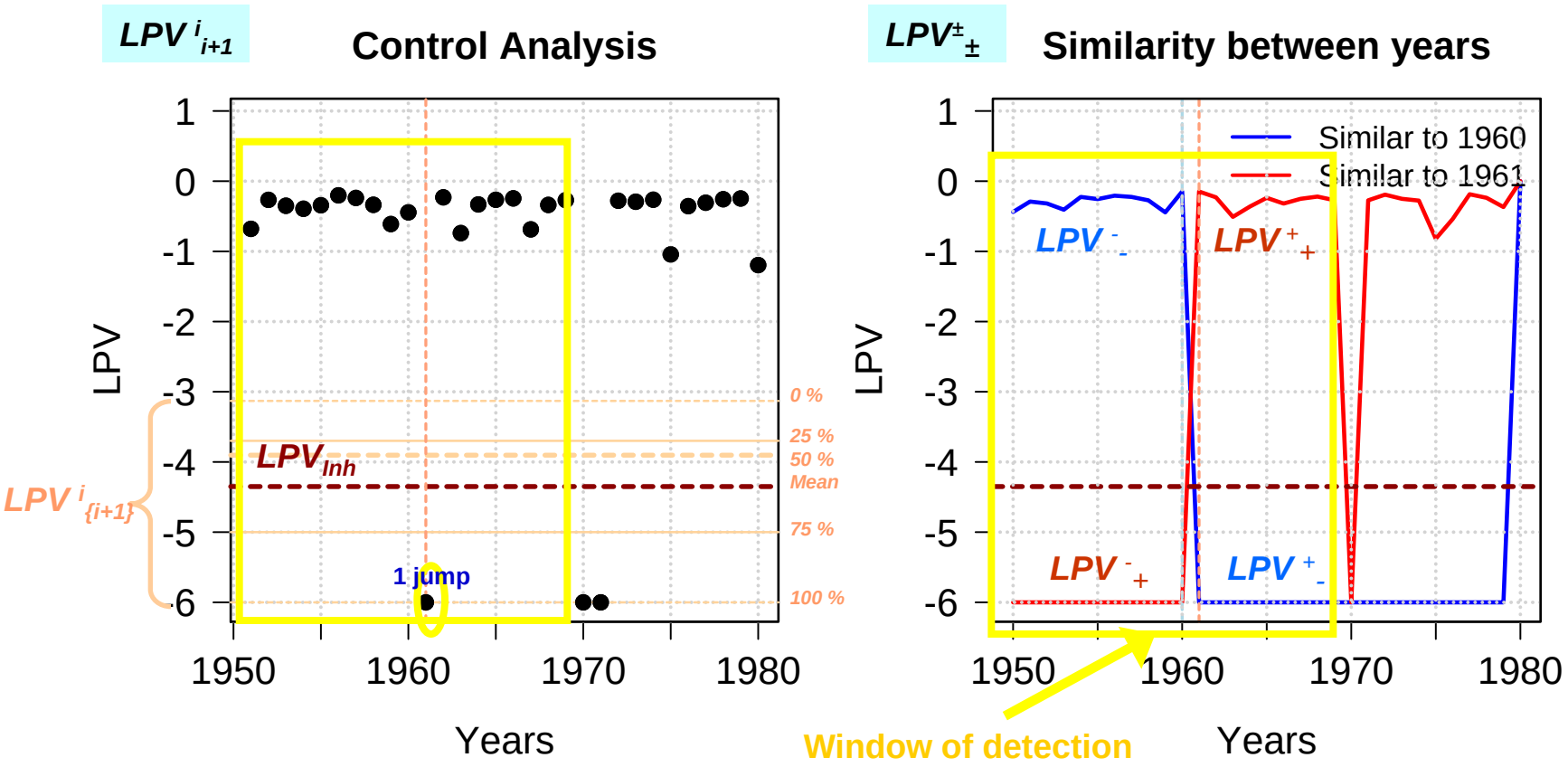

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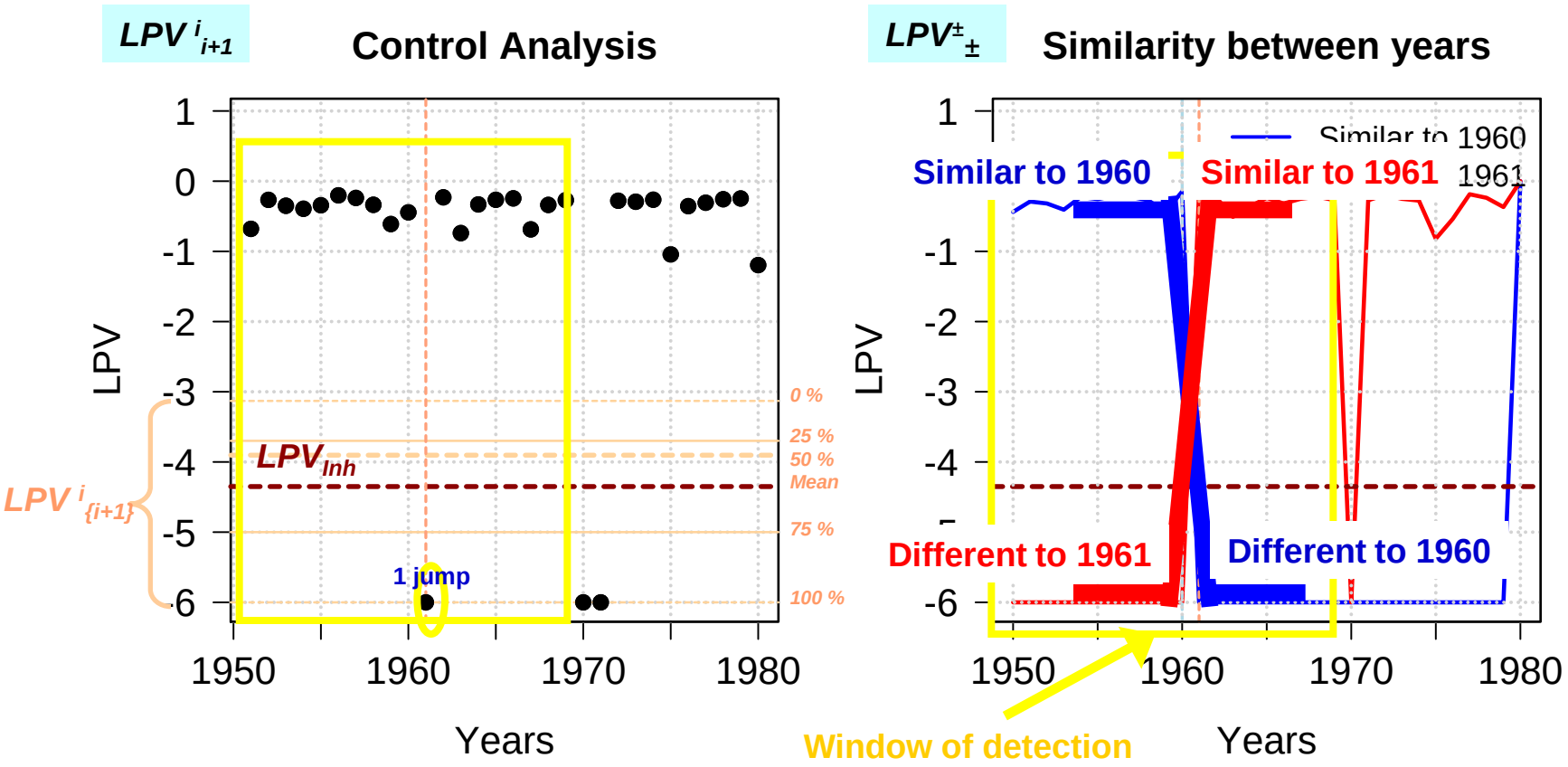

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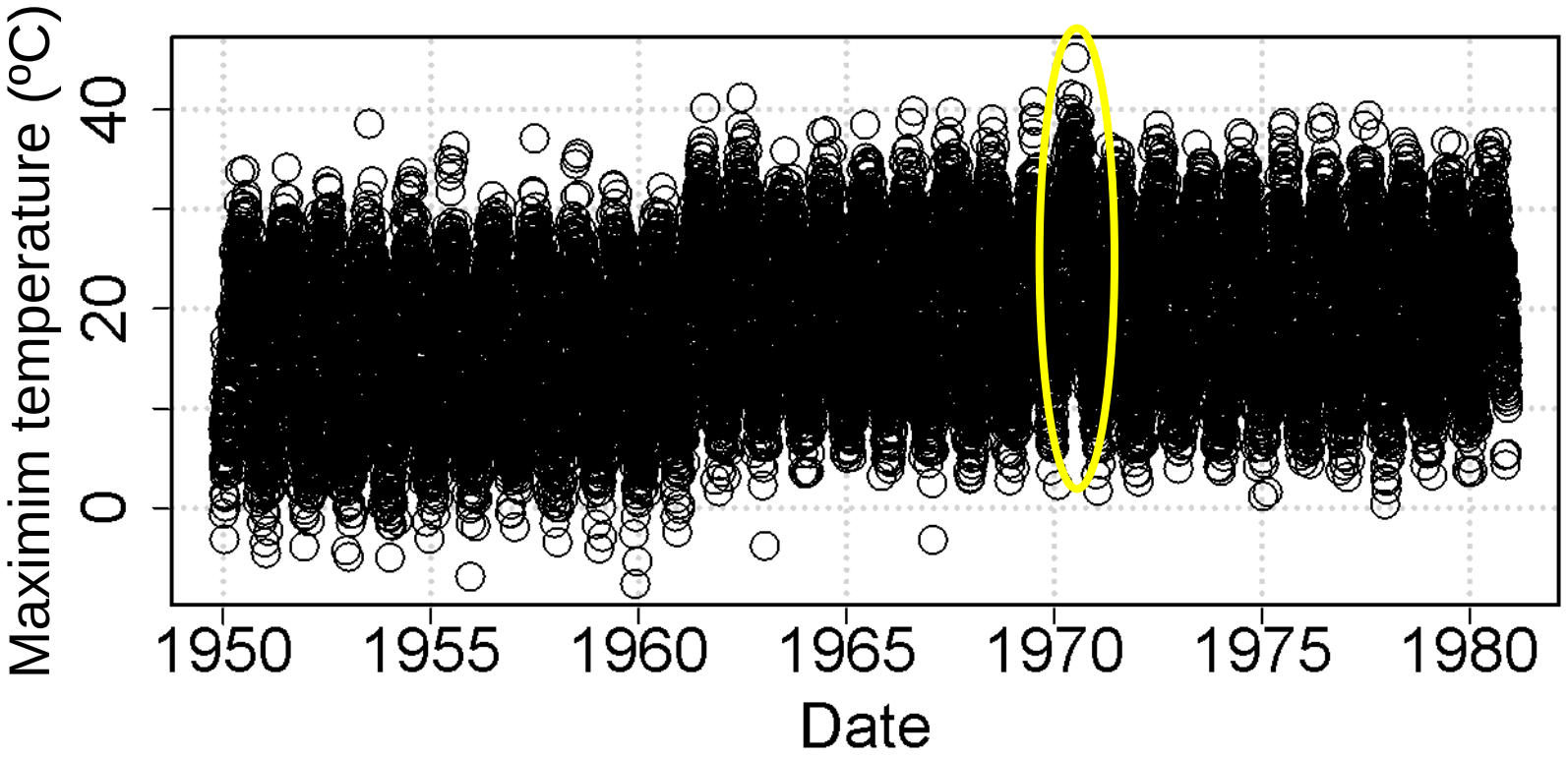

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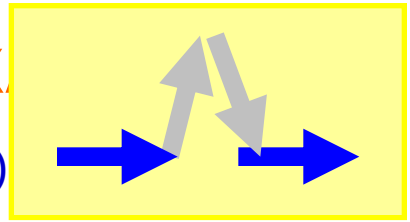

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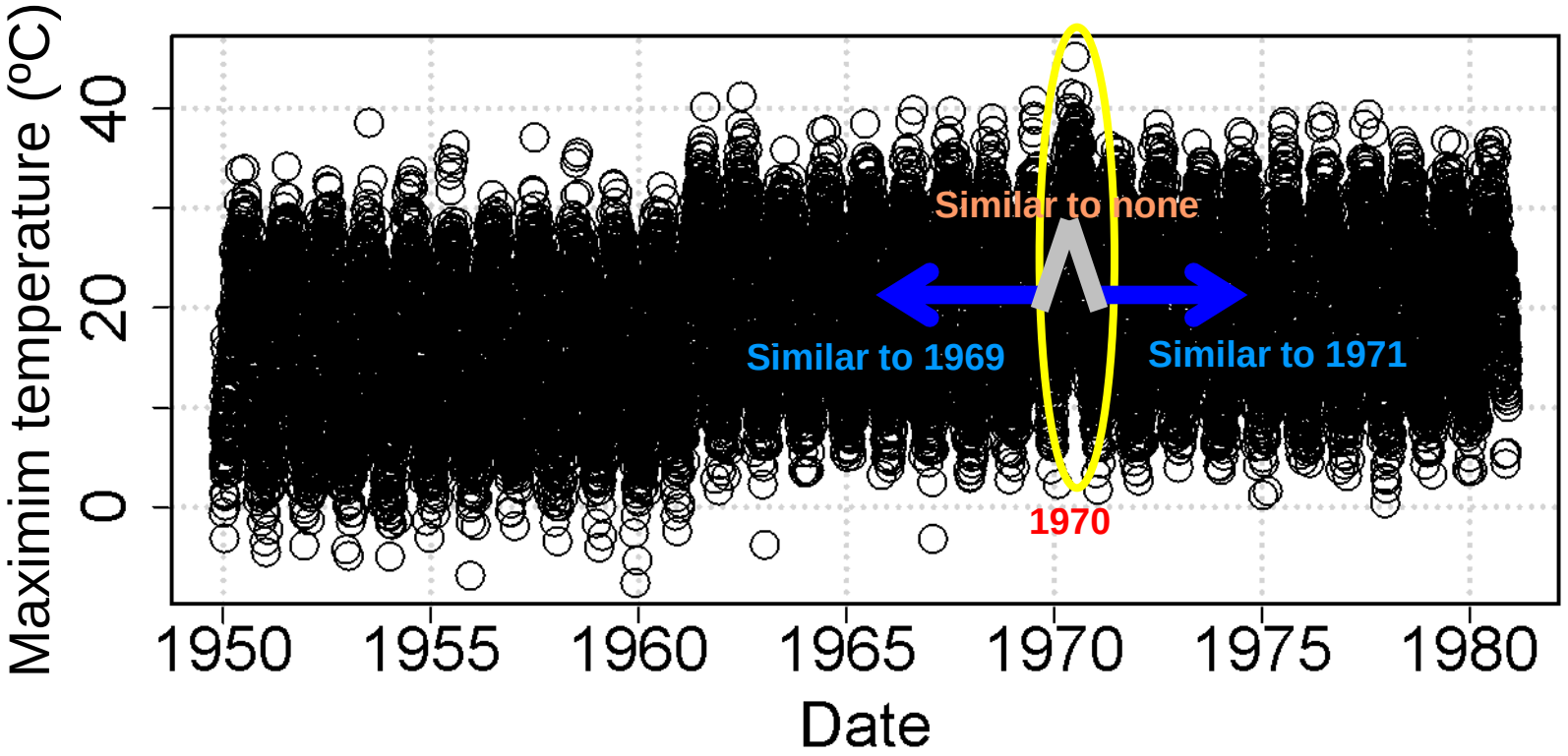

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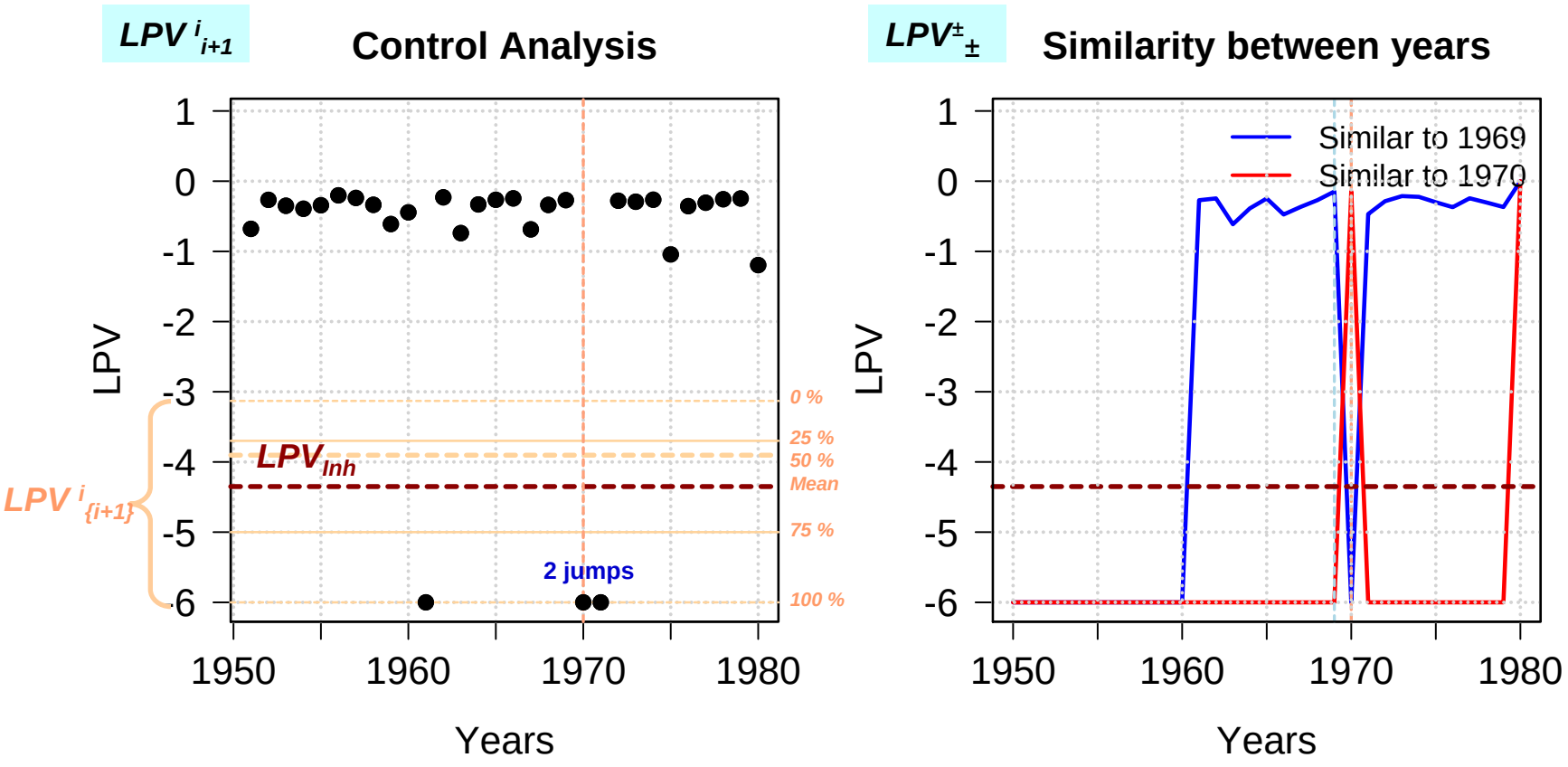

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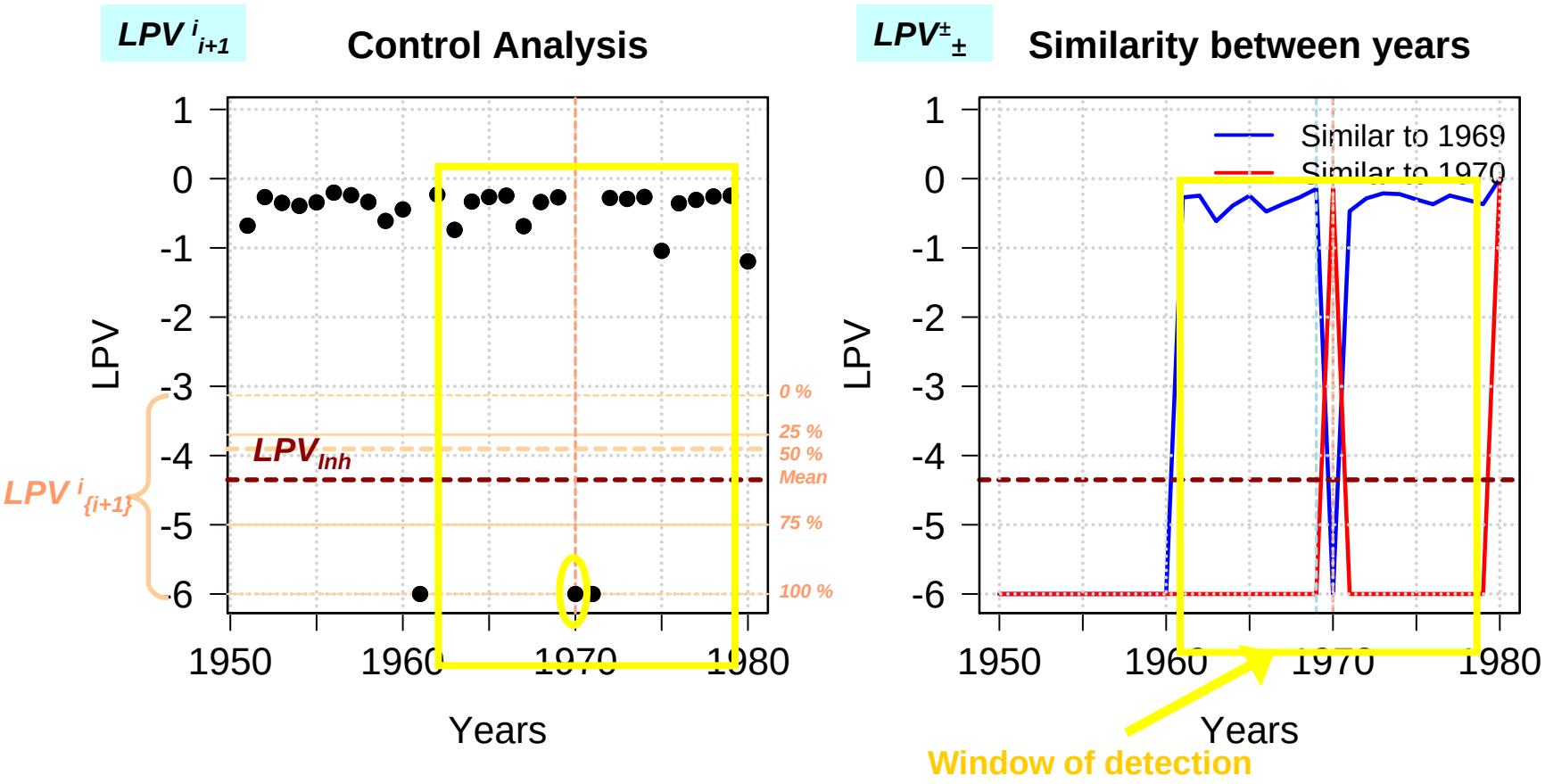

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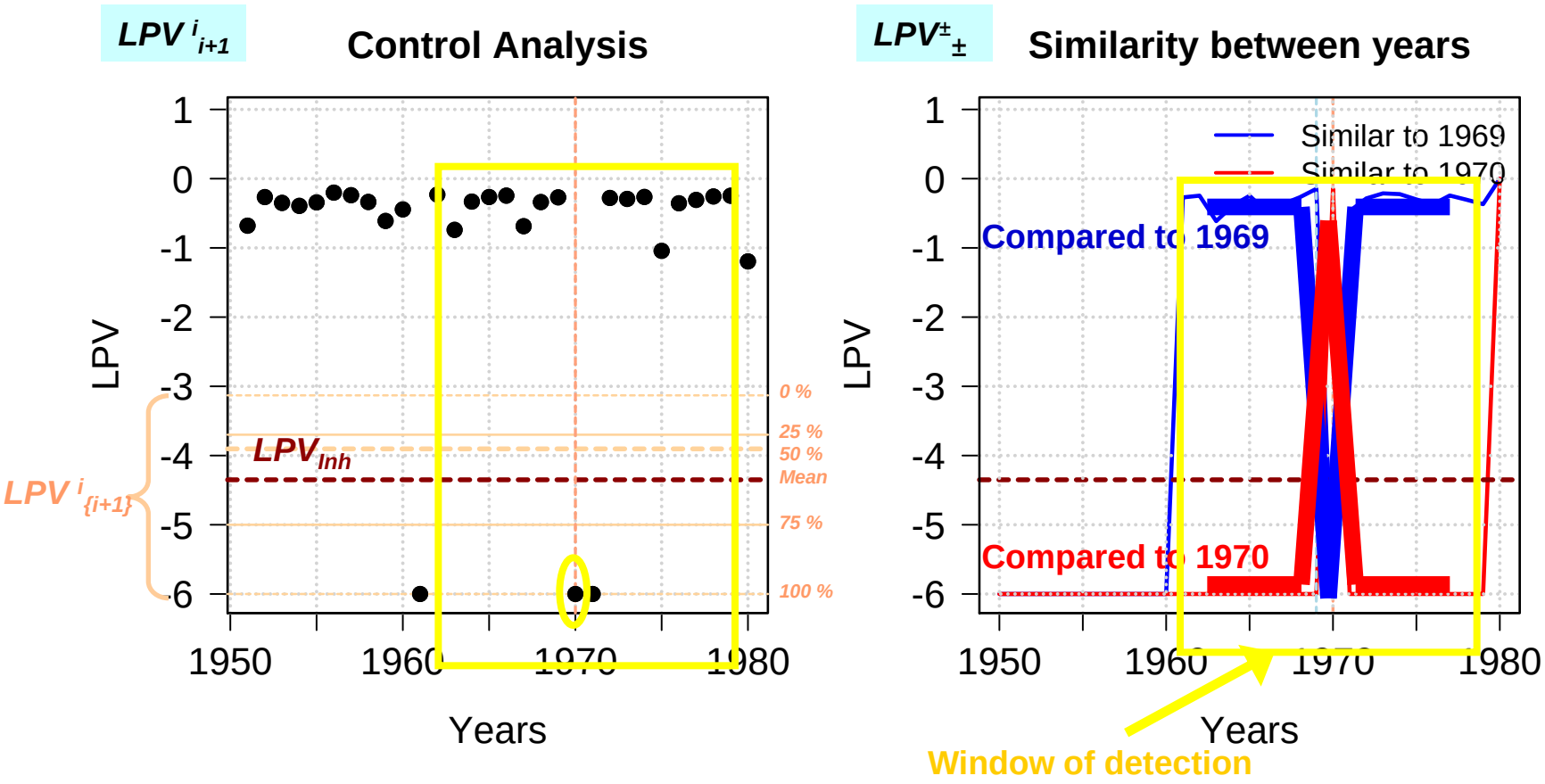

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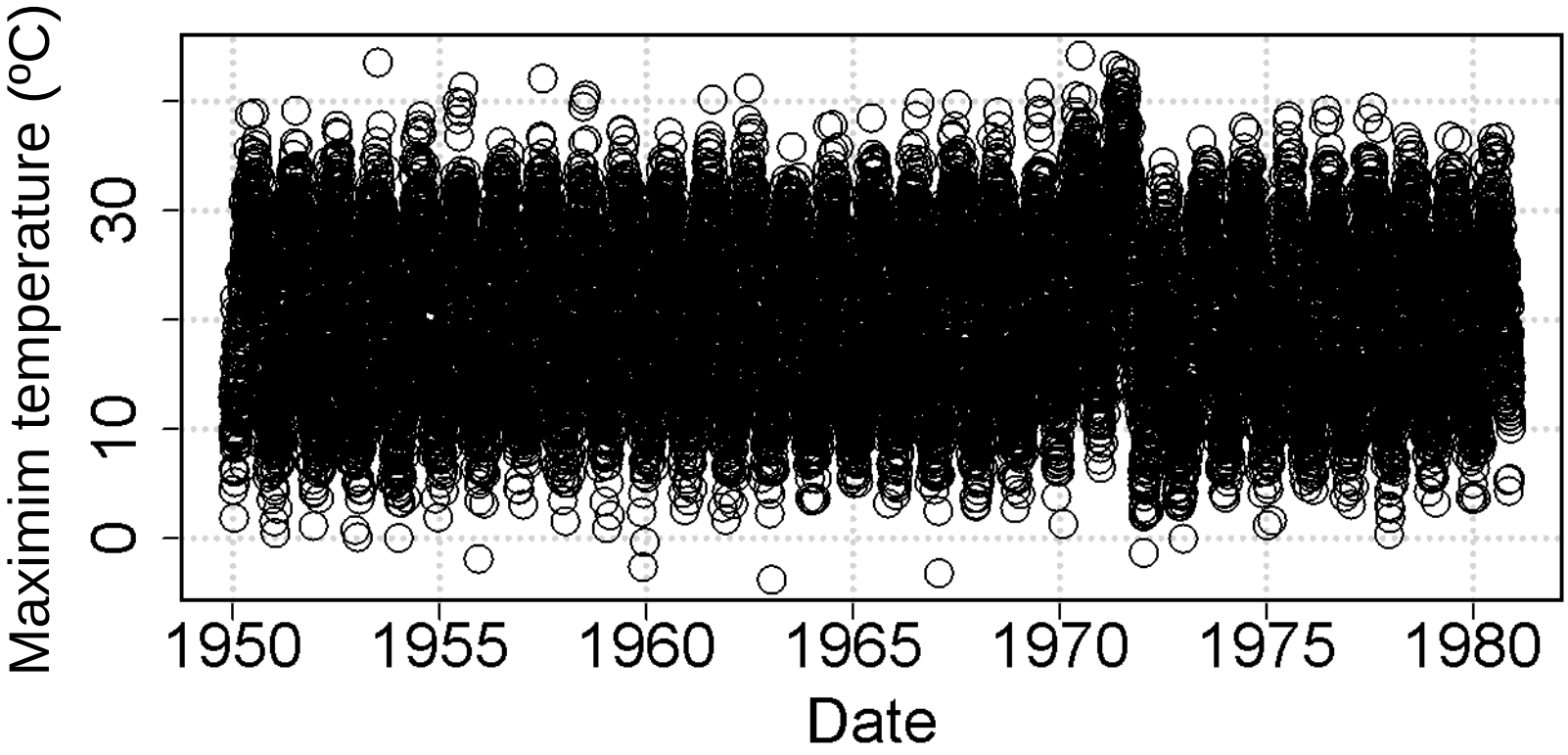
Ideal case of inhomogeneity of **second order** (i.e., more of 2 jumps)



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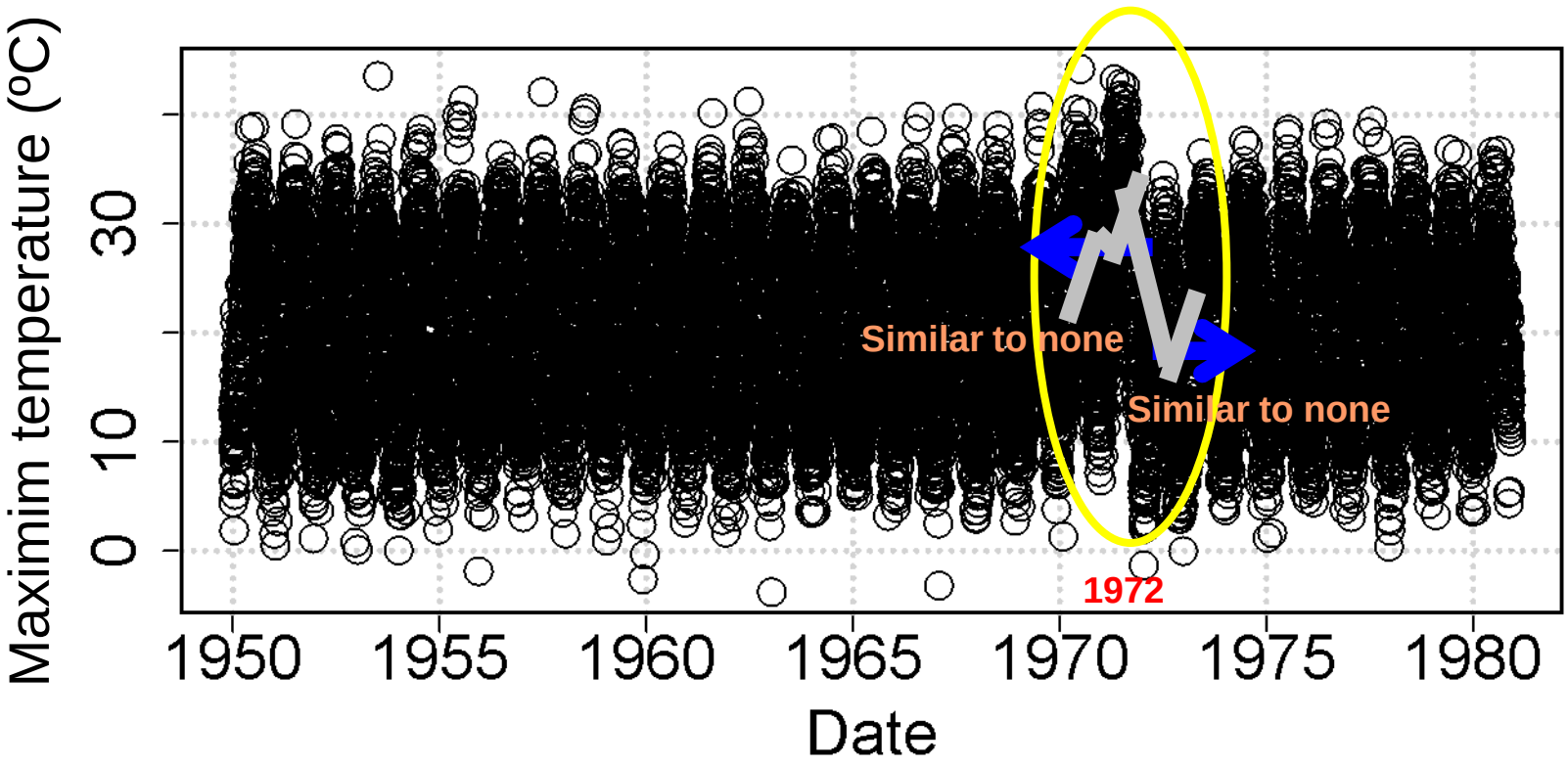

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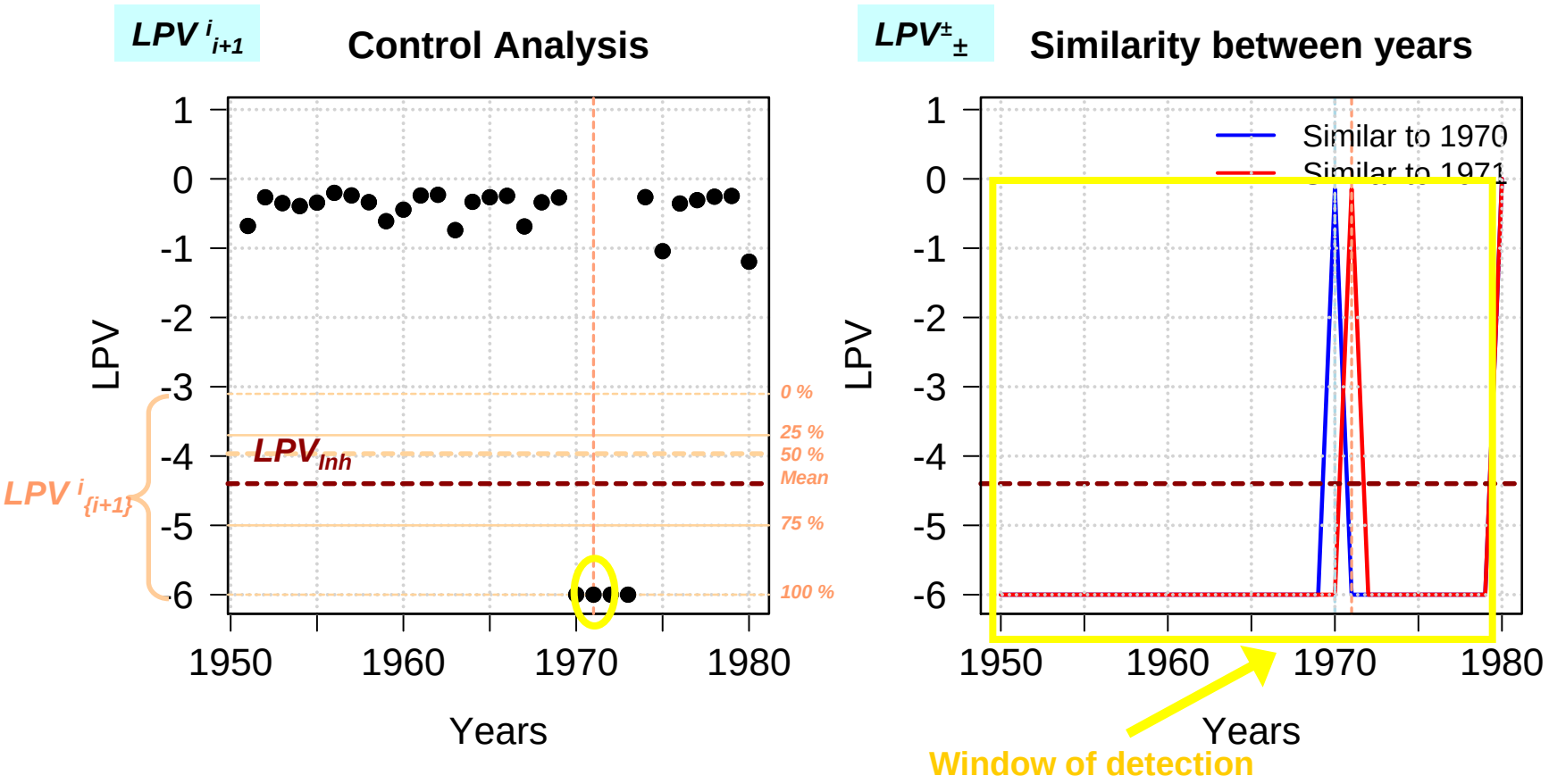

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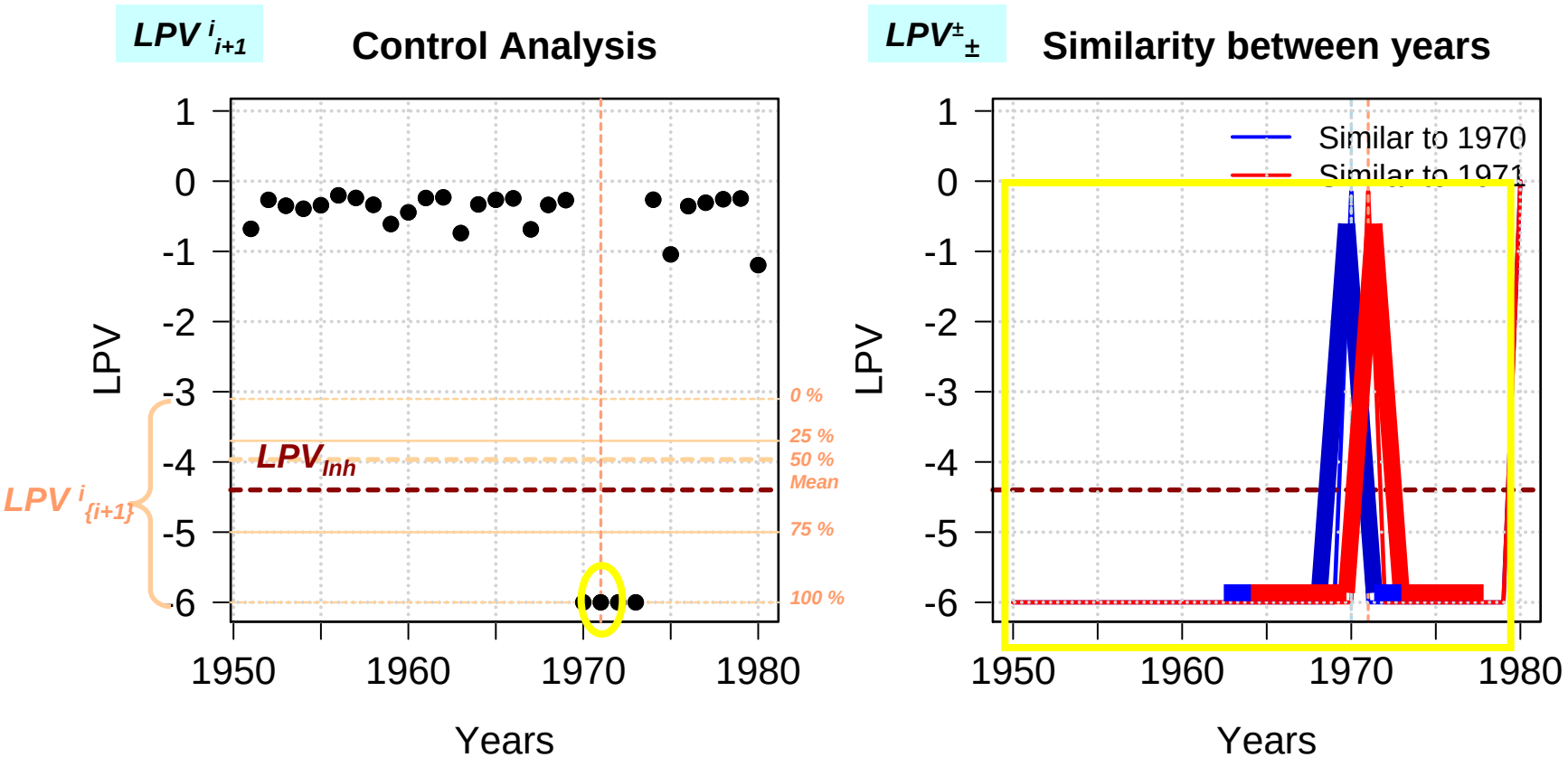

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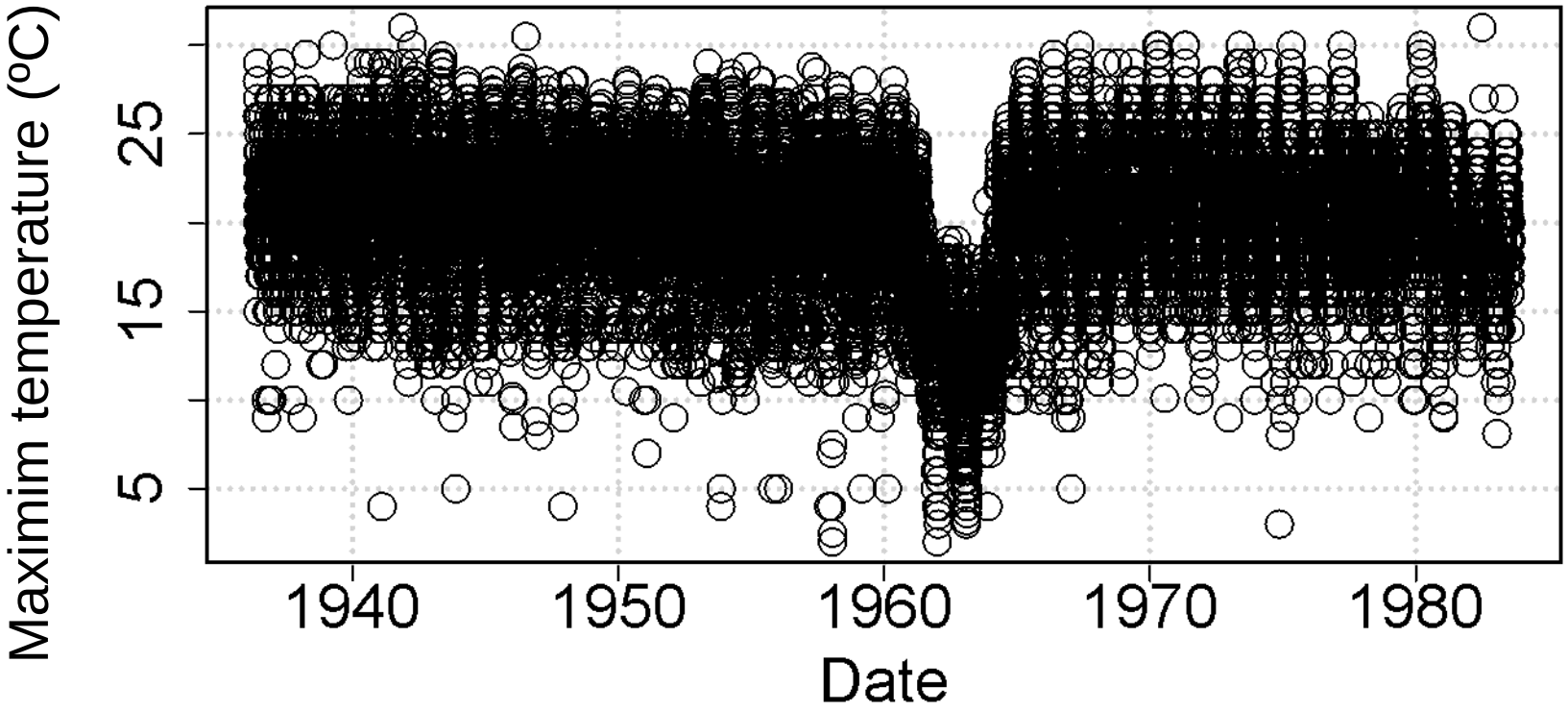
Temperature: CASE 1

Inhomogeneities in **temperature**



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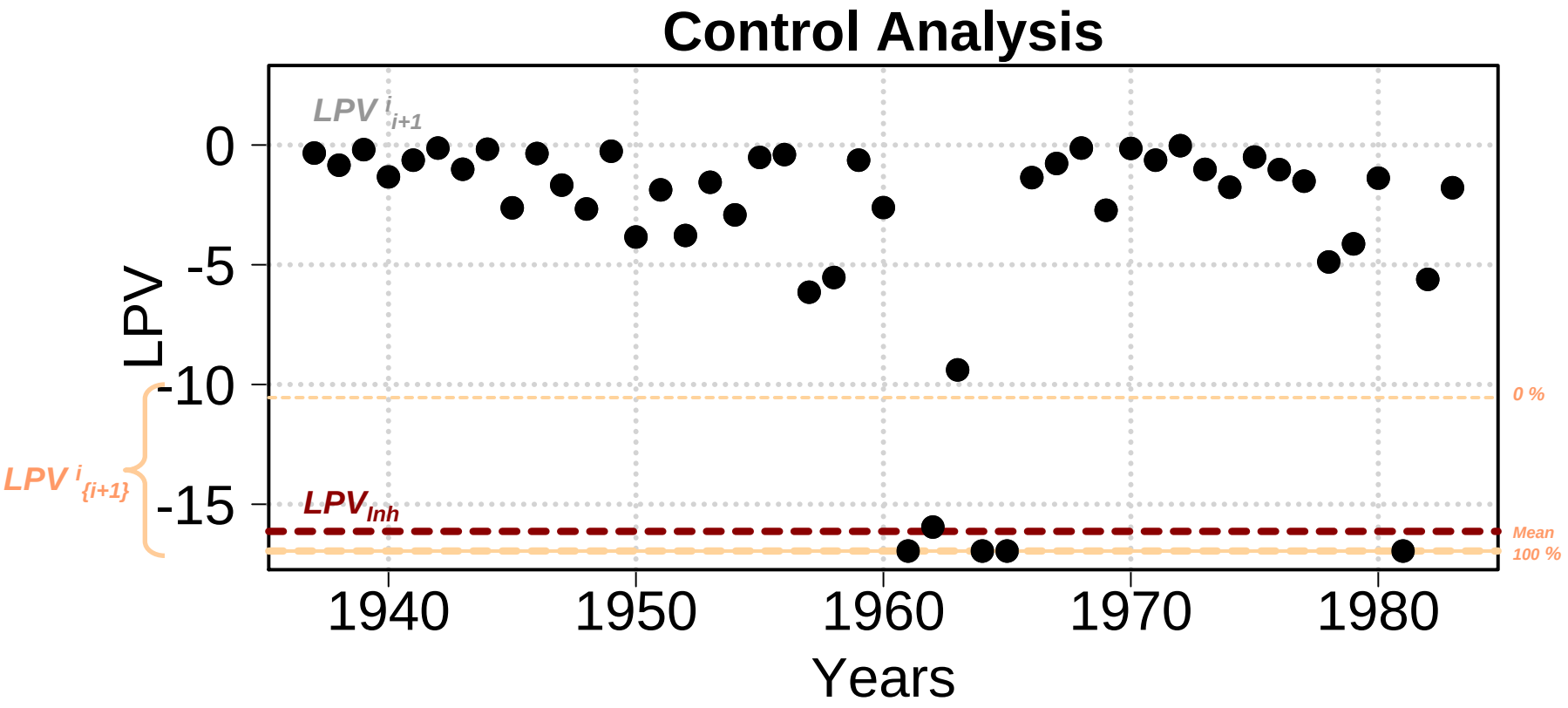

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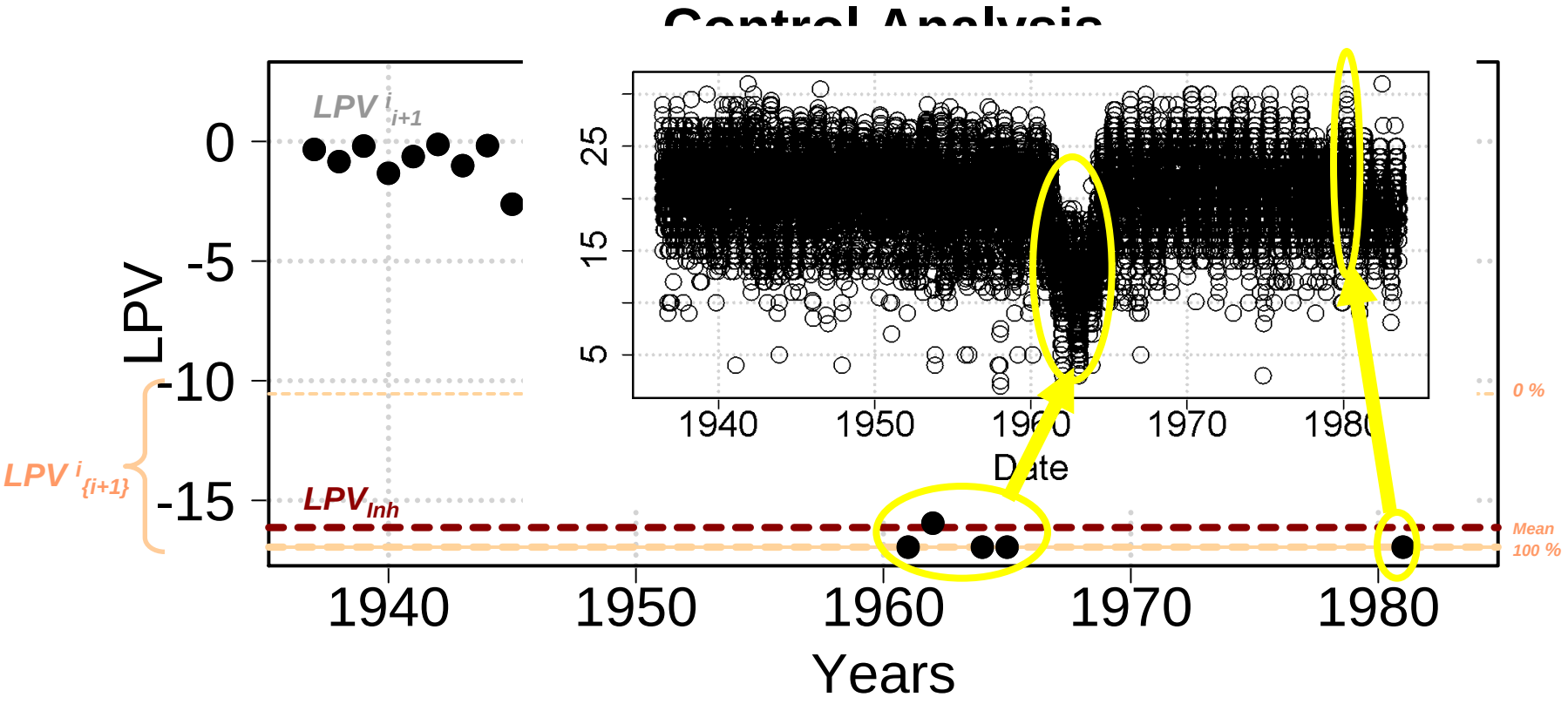

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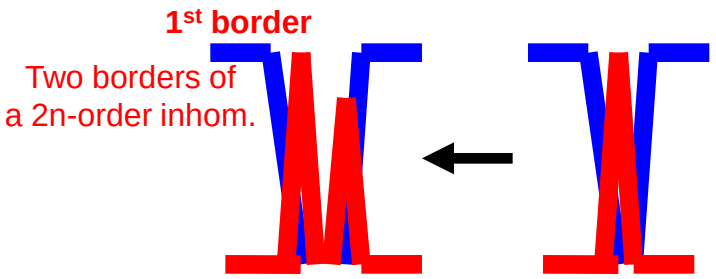

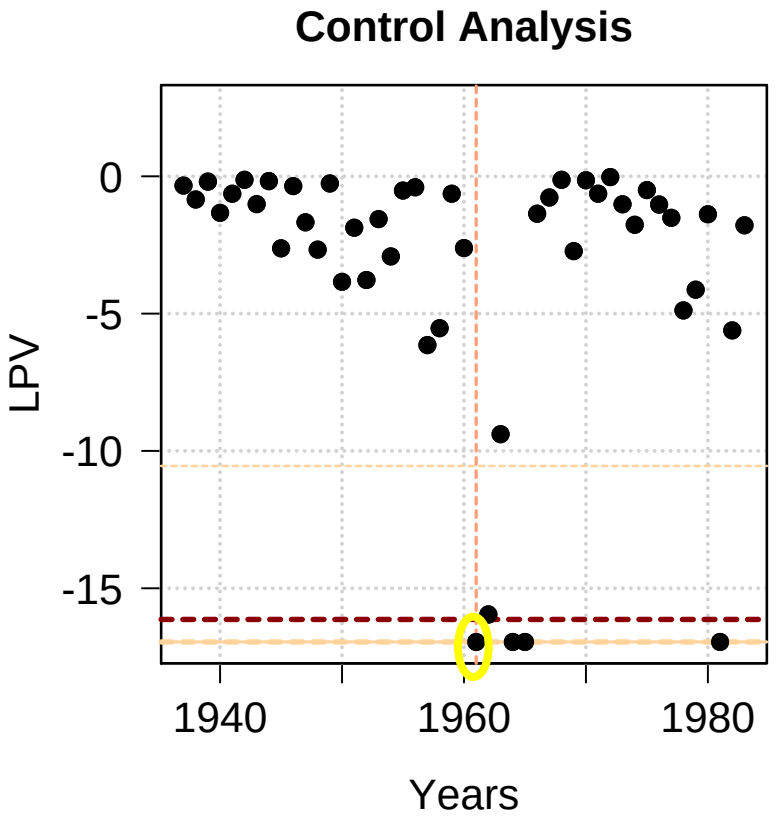

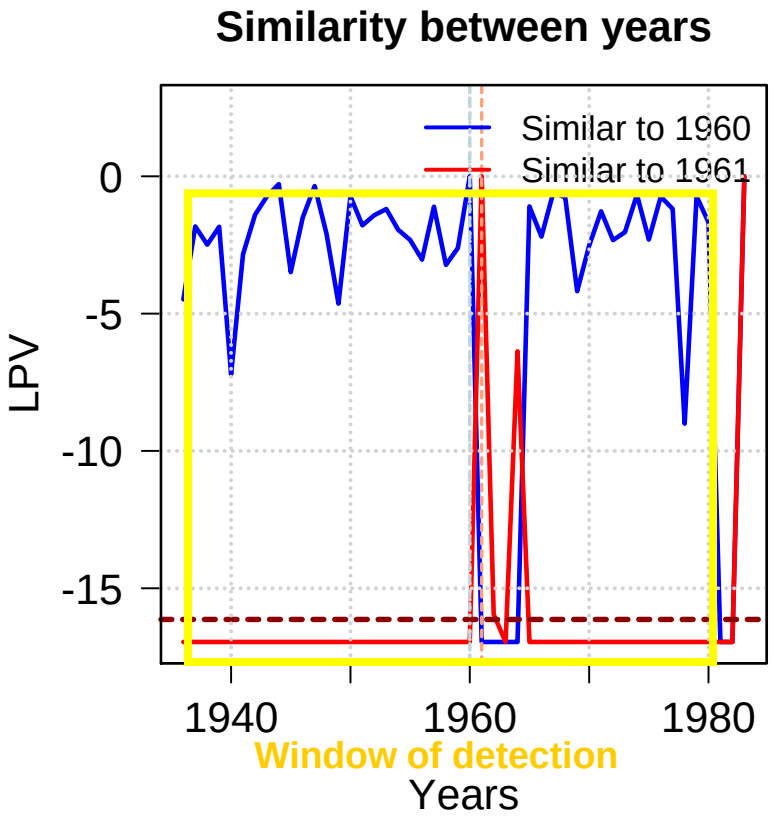

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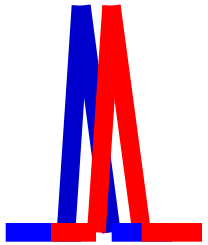

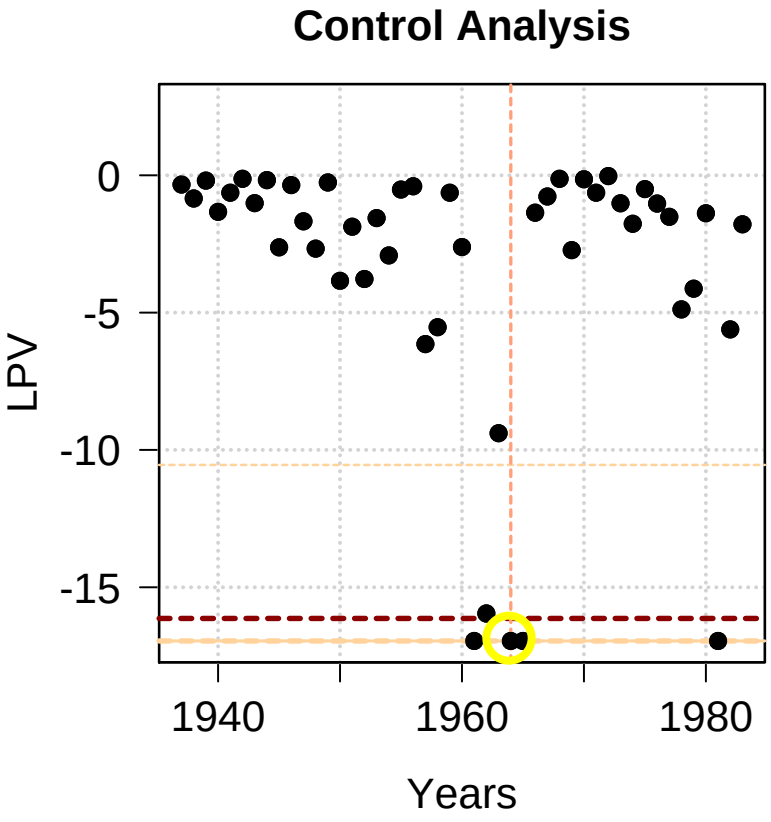

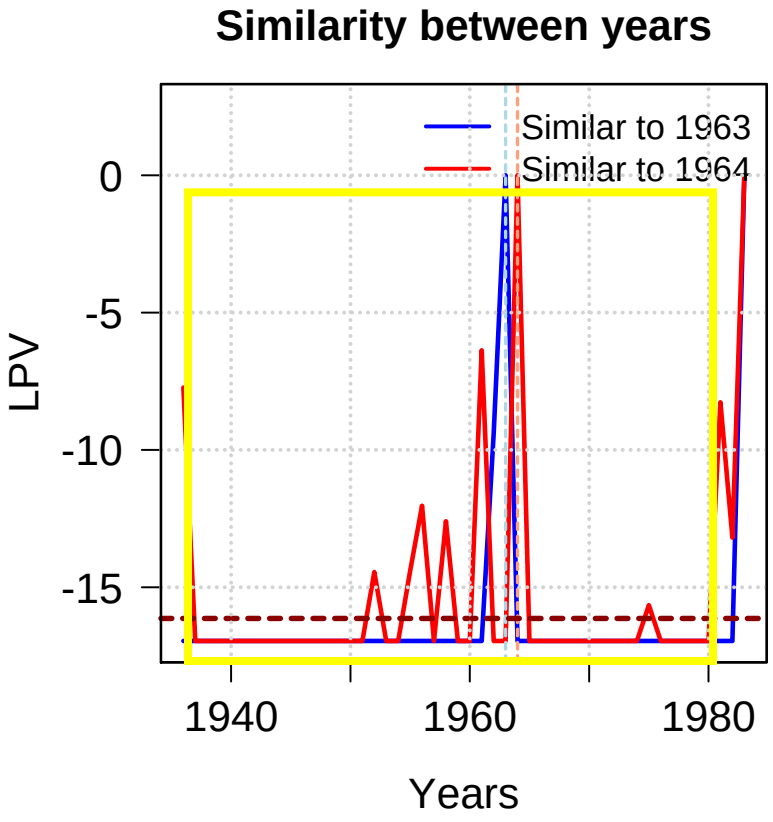

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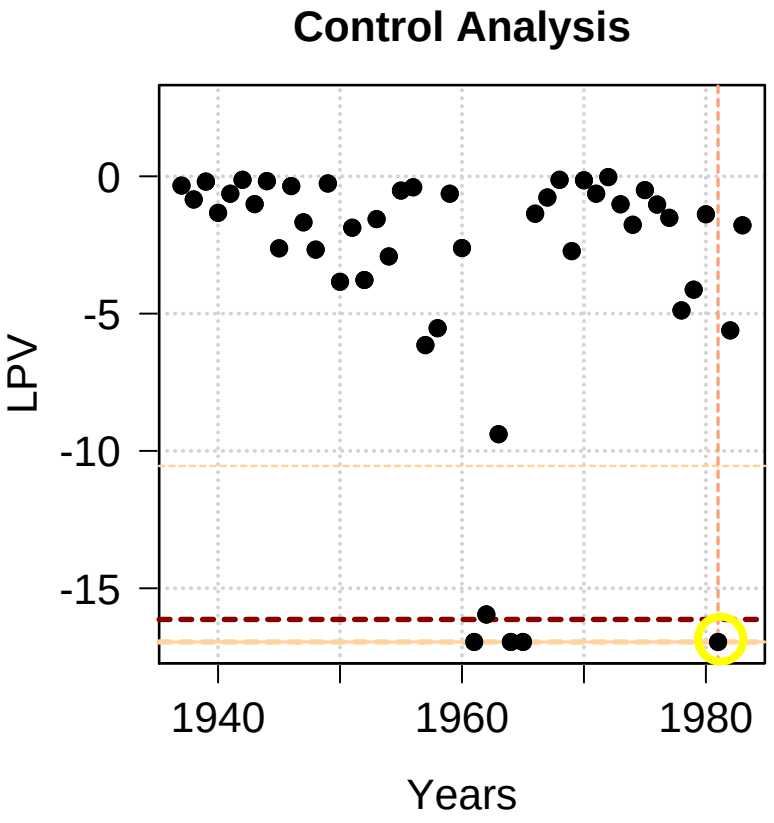

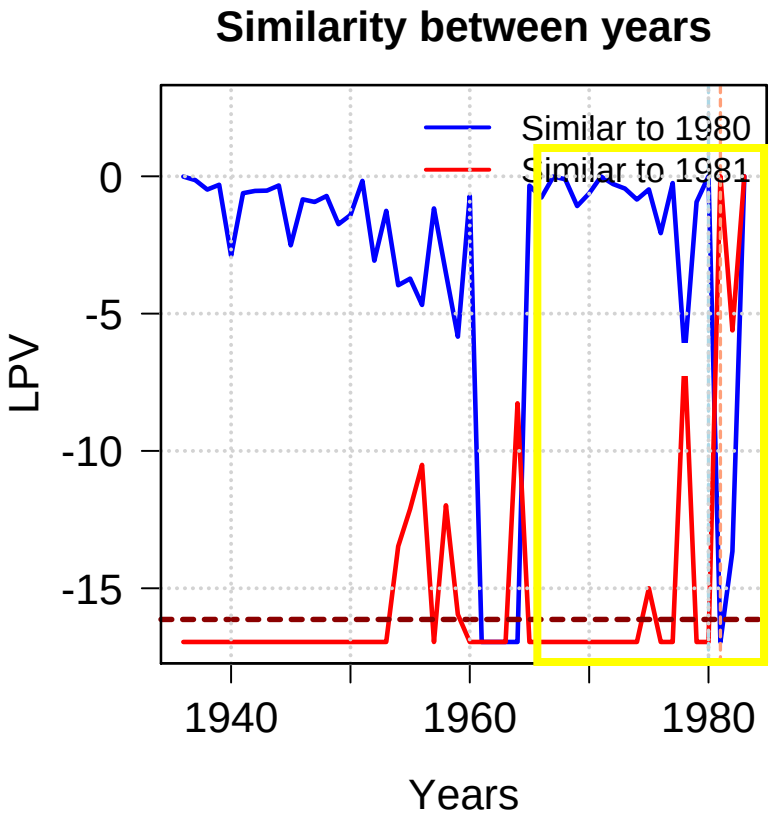

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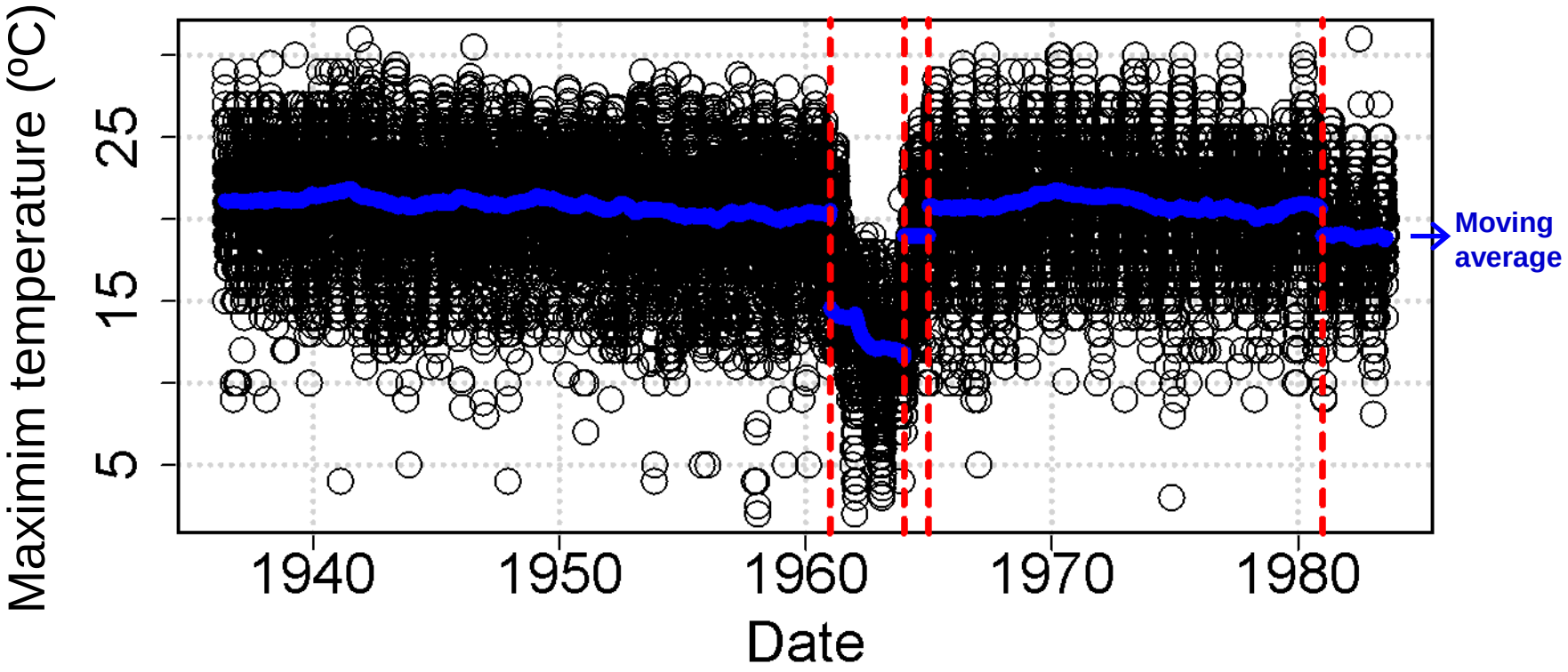
Temperature: CASE 1

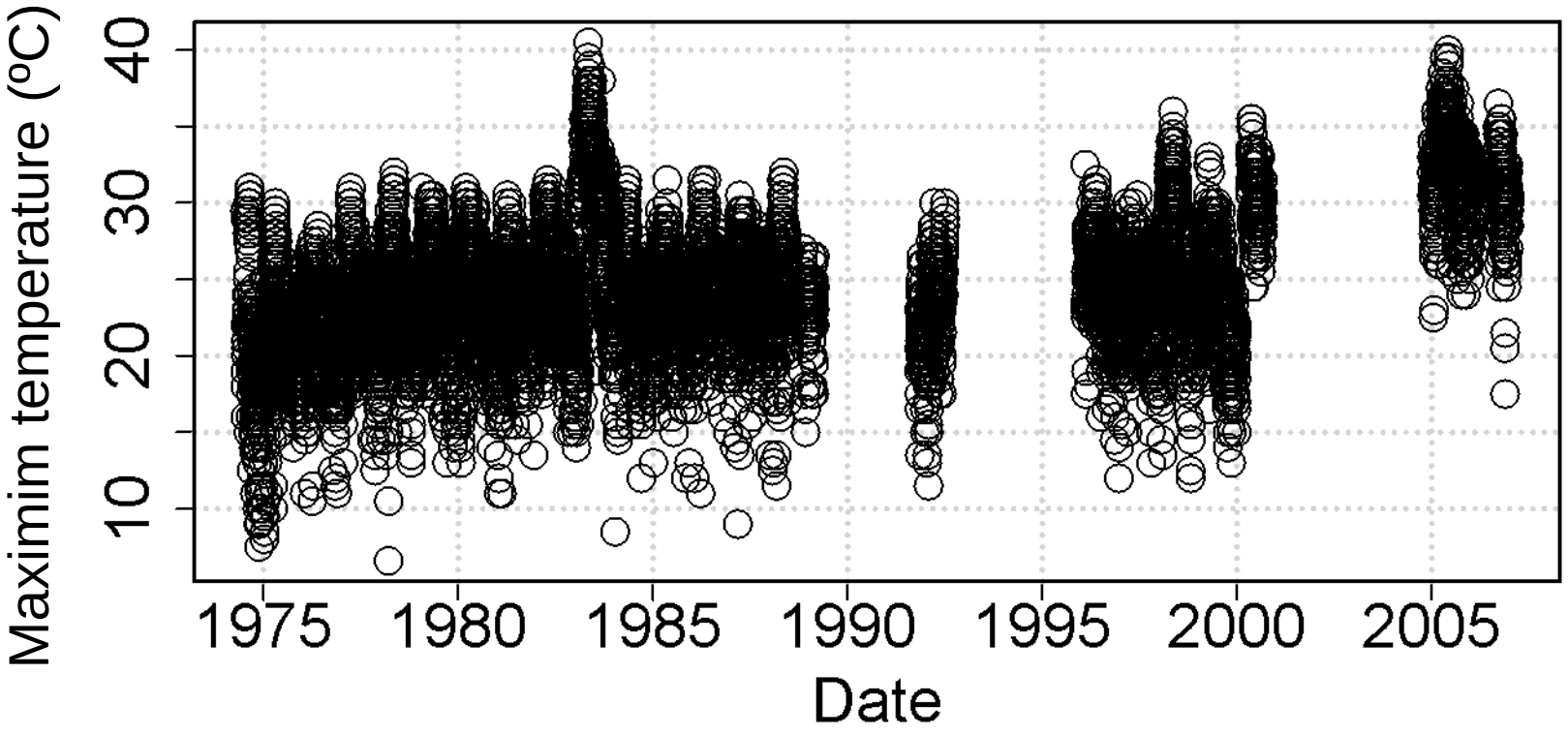
Inhomogeneities in **temperature**: final analysis



Real cases

Temperature: CASE 2

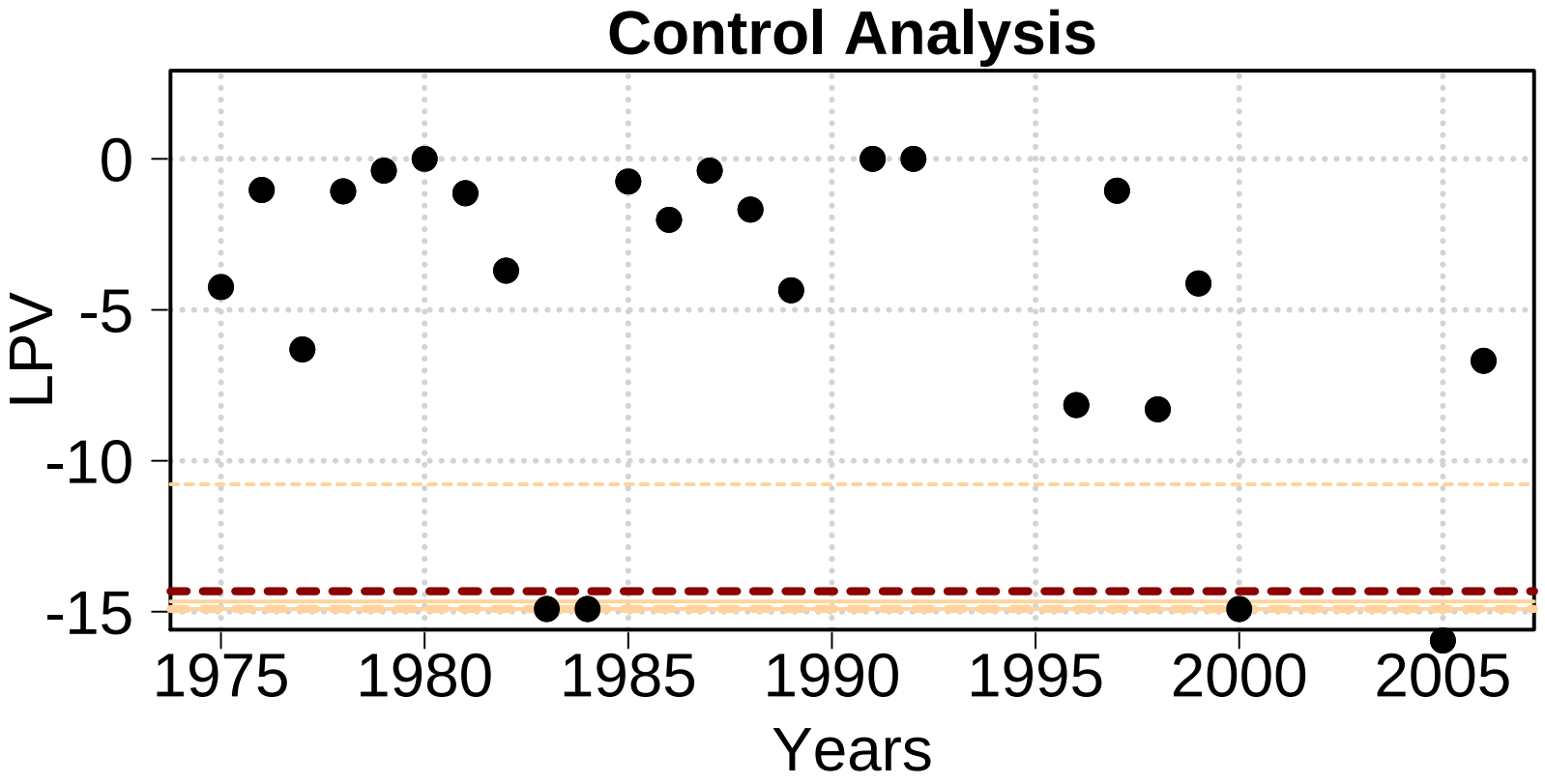
Inhomogeneities in **temperature**



Real cases

Temperature: CASE 2

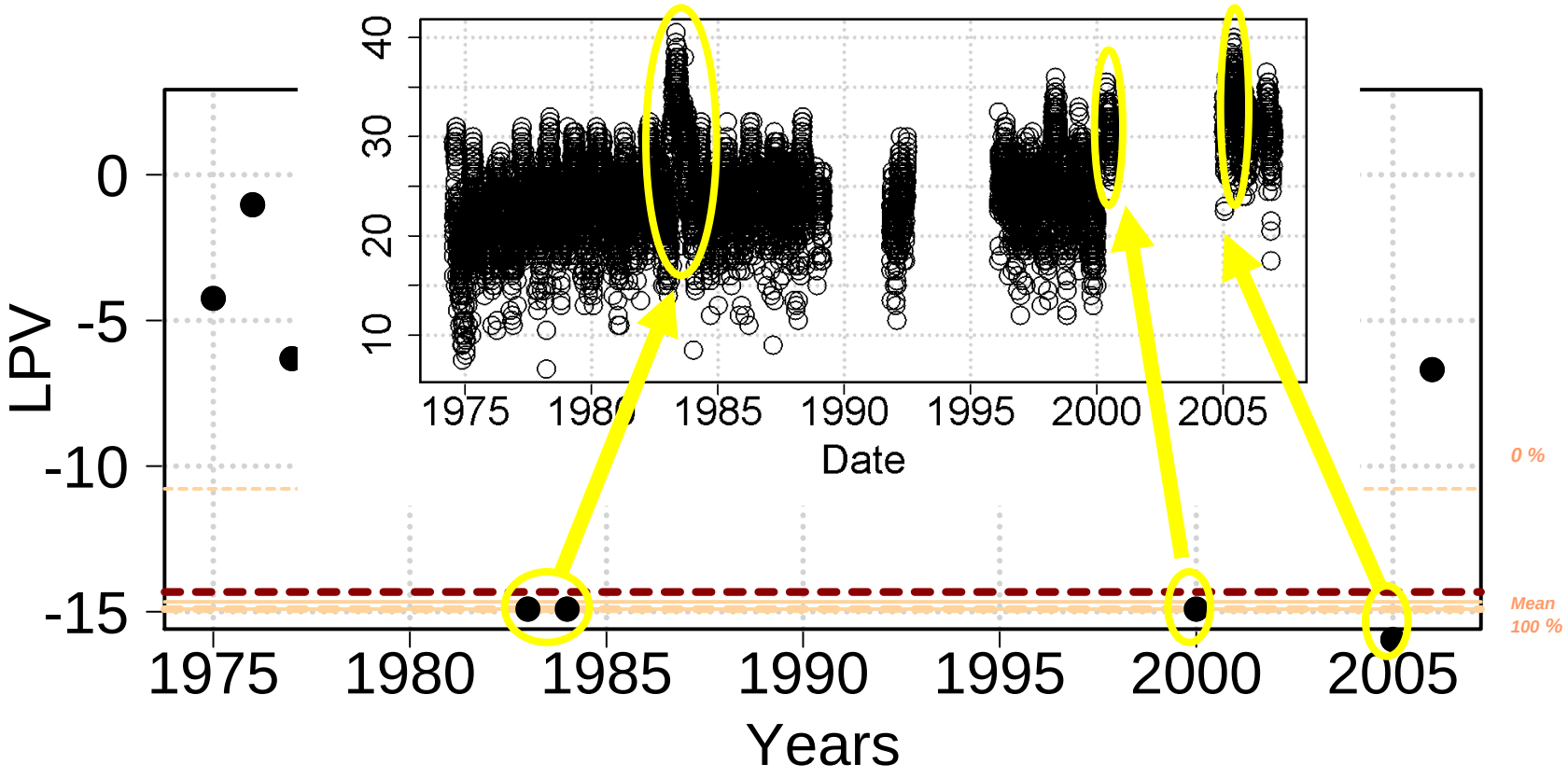
Inhomogeneities in **temperature**: LPV diagrams



Real cases

Temperature: CASE 2

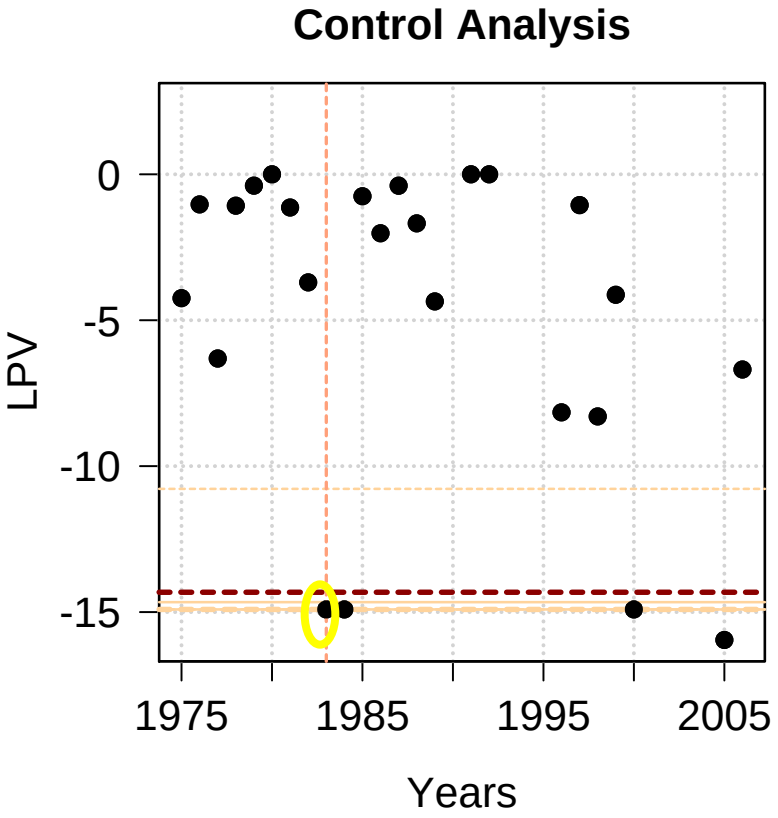
Inhomogeneities in **temperature**: LPV diagrams

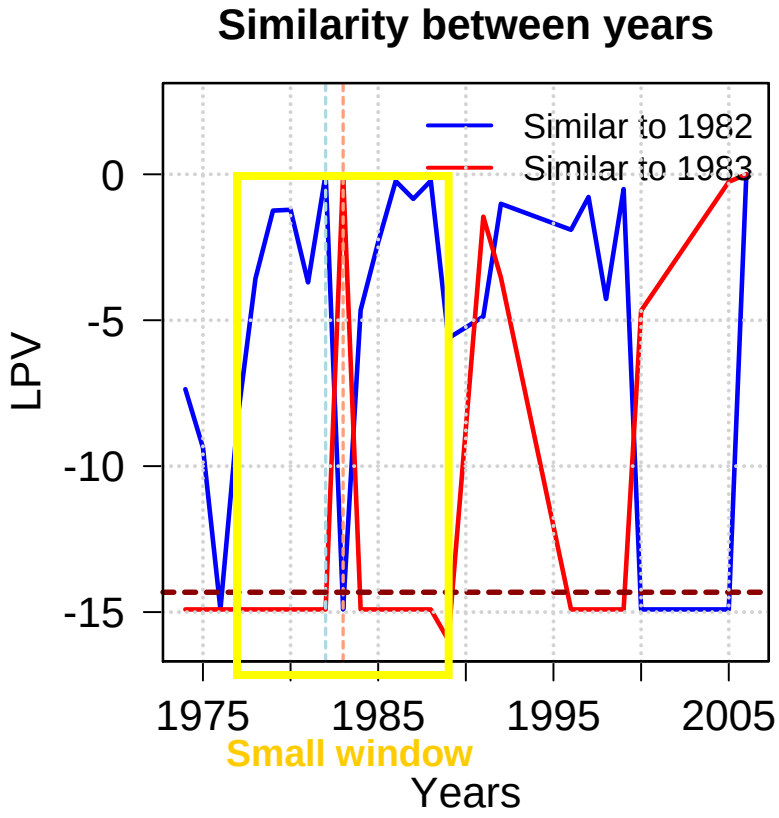


Real cases

Temperature: CASE 2

Inhomogeneities in **temperature**: LPV diagrams

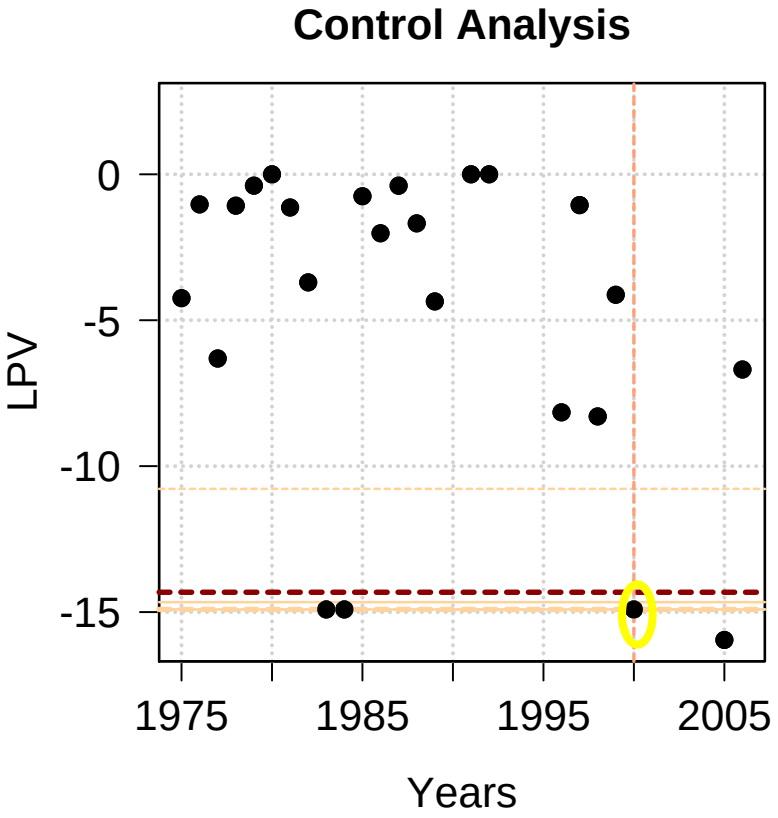


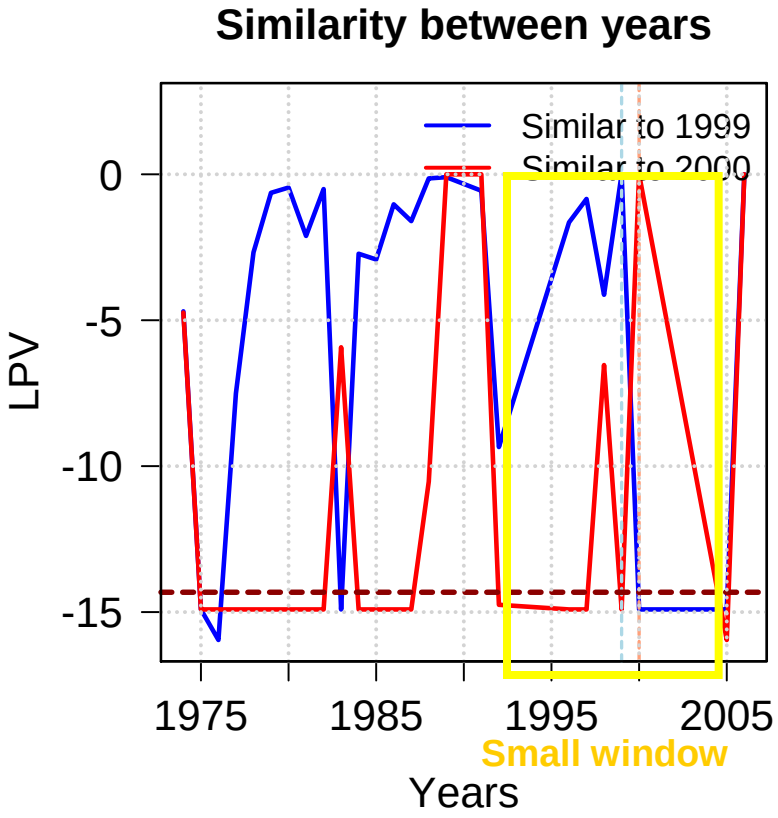


Real cases

Temperature: CASE 2

Inhomogeneities in **temperature**: LPV diagrams

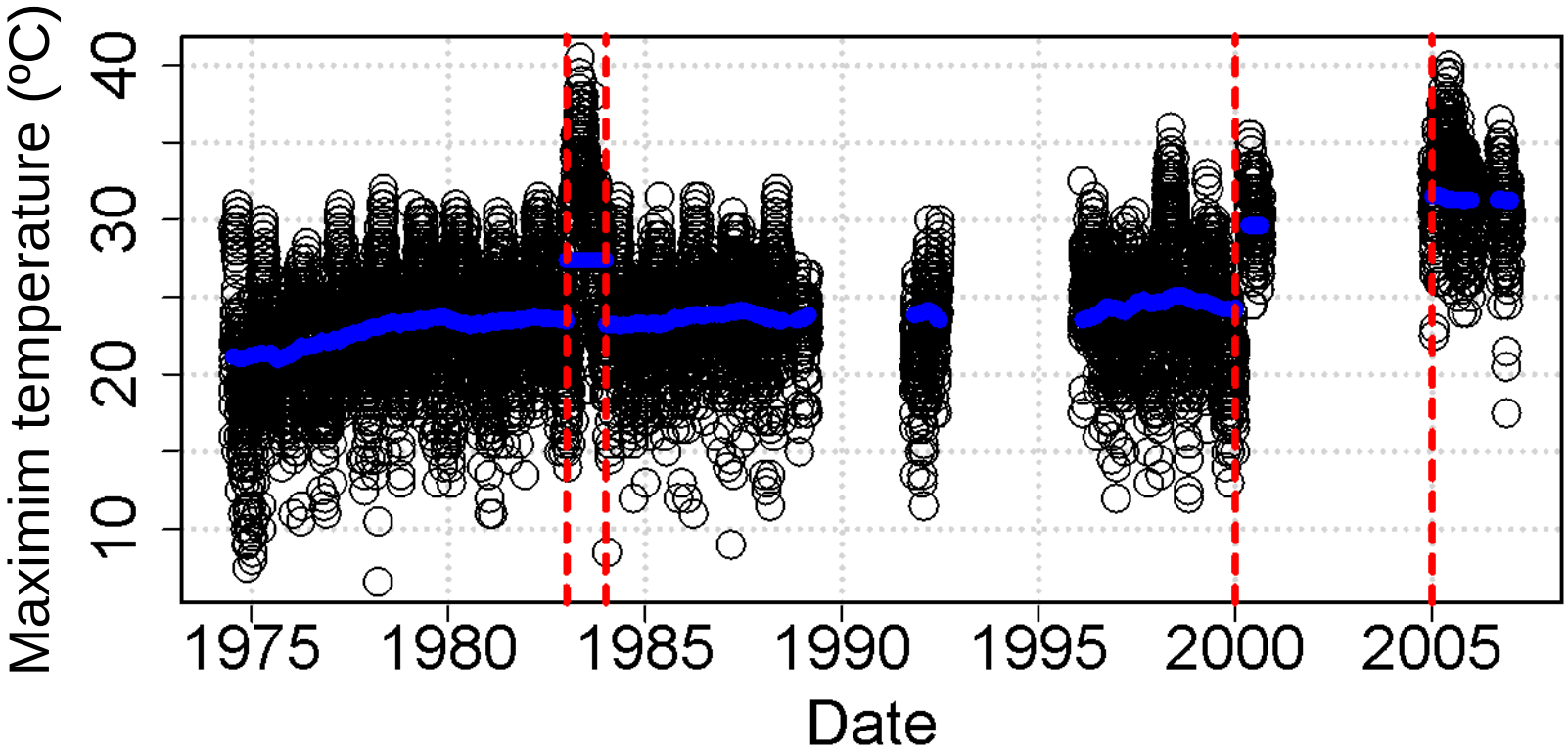




Real cases

Temperature: CASE 2

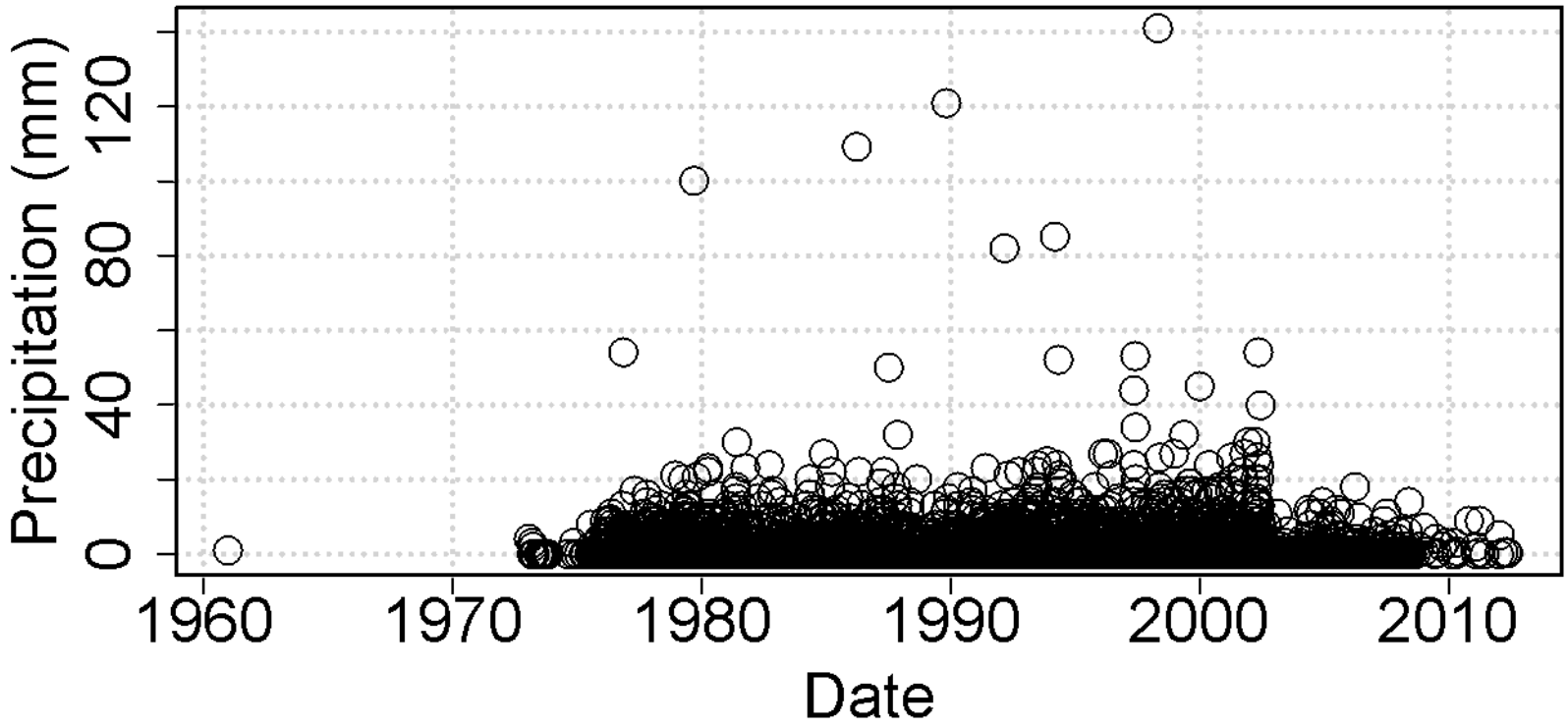
Inhomogeneities in **temperature**: final analysis



Real cases

Precipitation: CASE 1

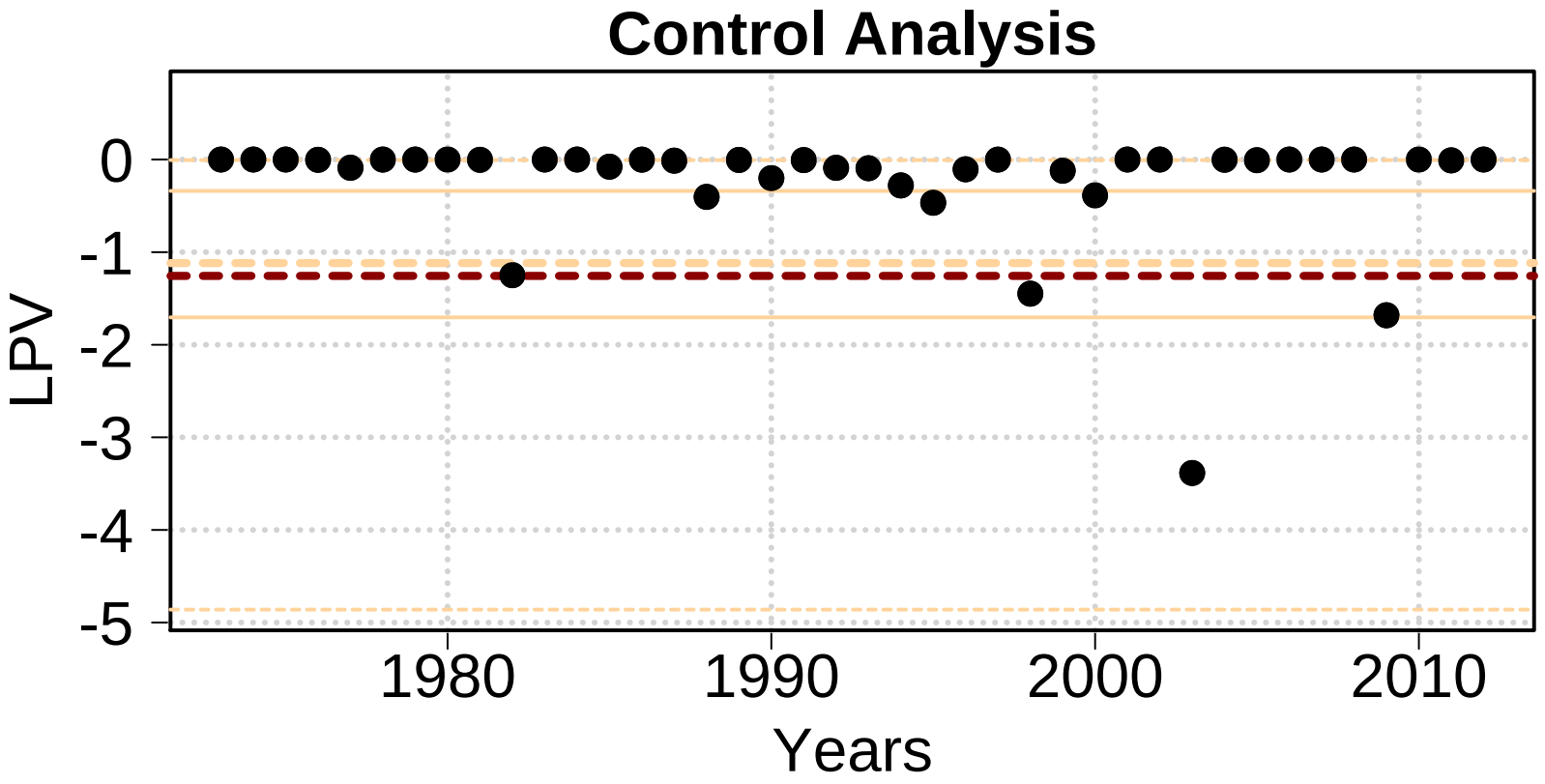
Inhomogeneities in **precipitation**



Real cases

Precipitation: CASE 1

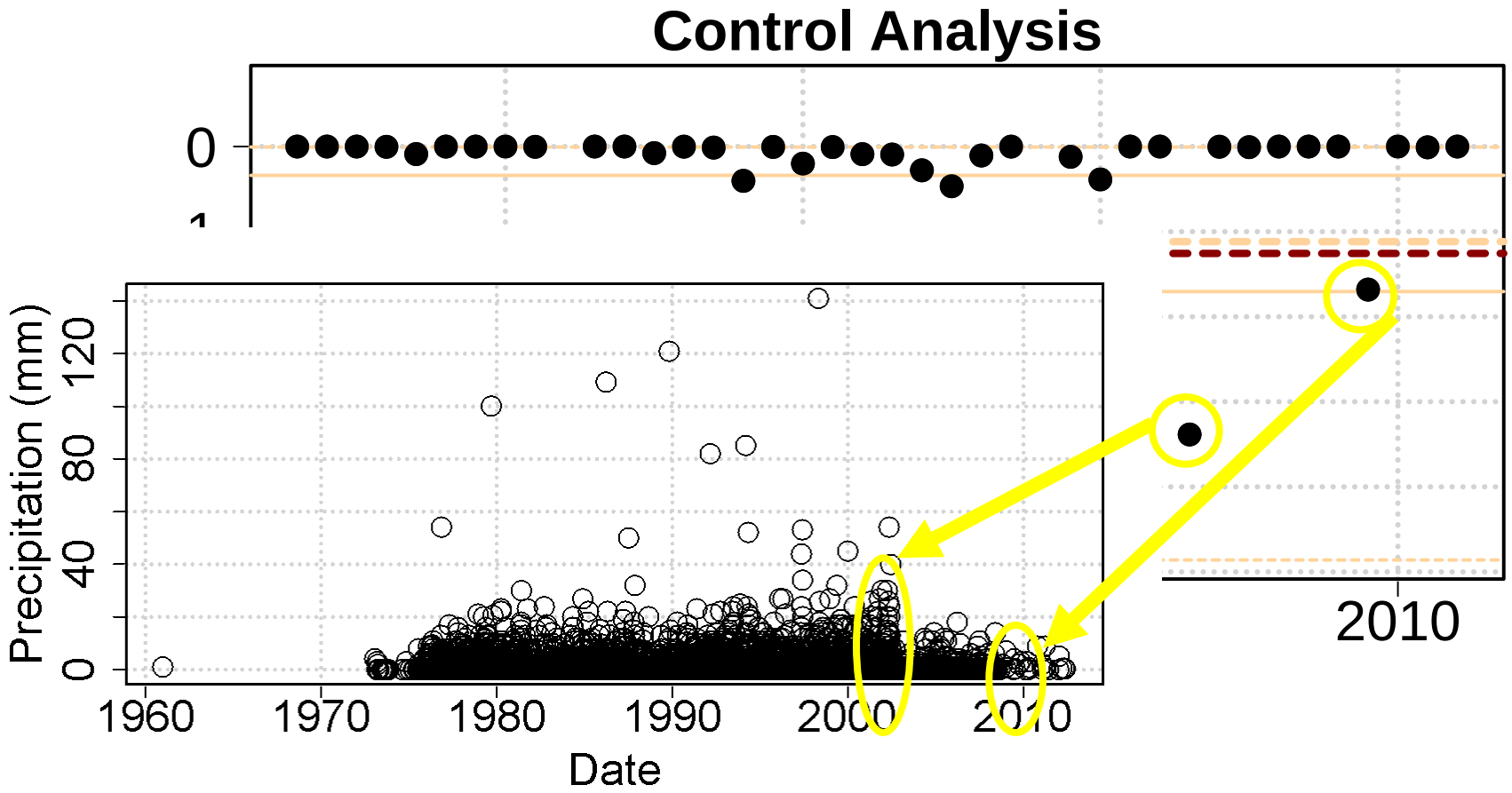
Inhomogeneities in **precipitation**: LPV diagrams



Real cases

Precipitation: CASE 1

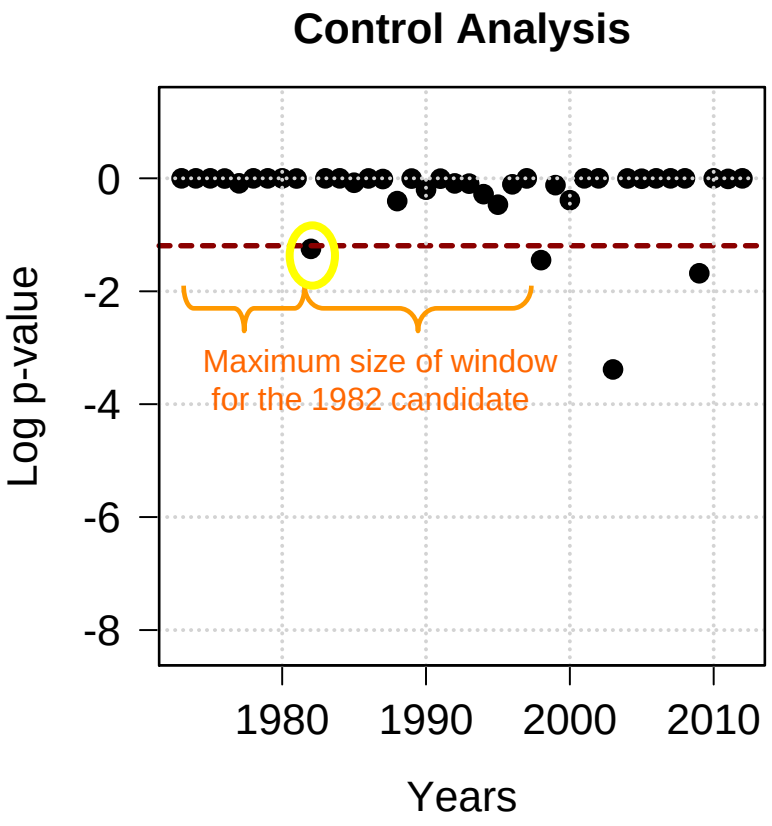
Inhomogeneities in **precipitation**: LPV diagrams

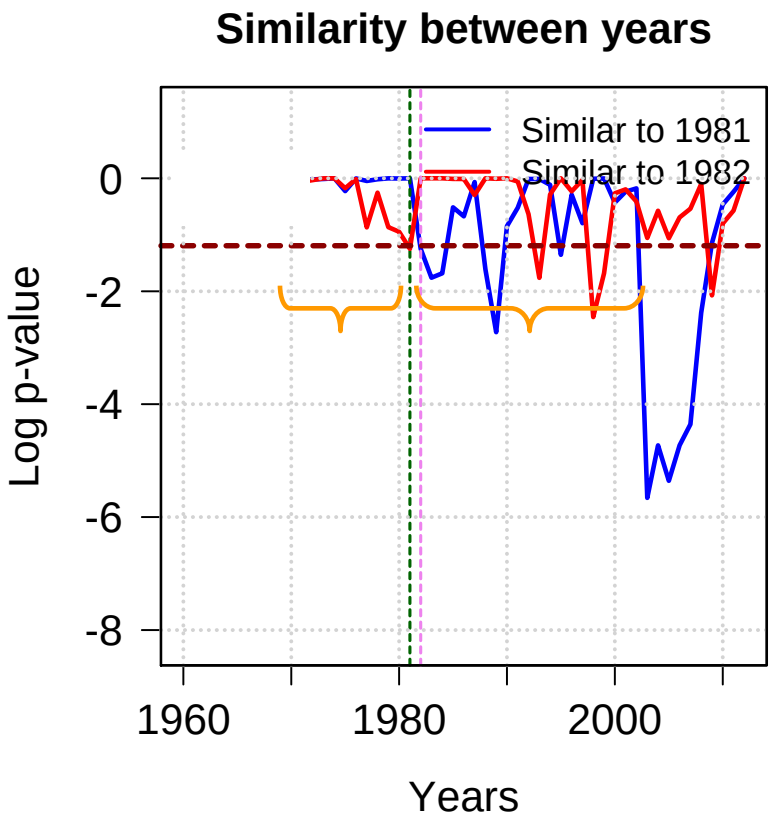


Real cases

Precipitation: CASE 1

Inhomogeneities in **precipitation**: LPV diagrams

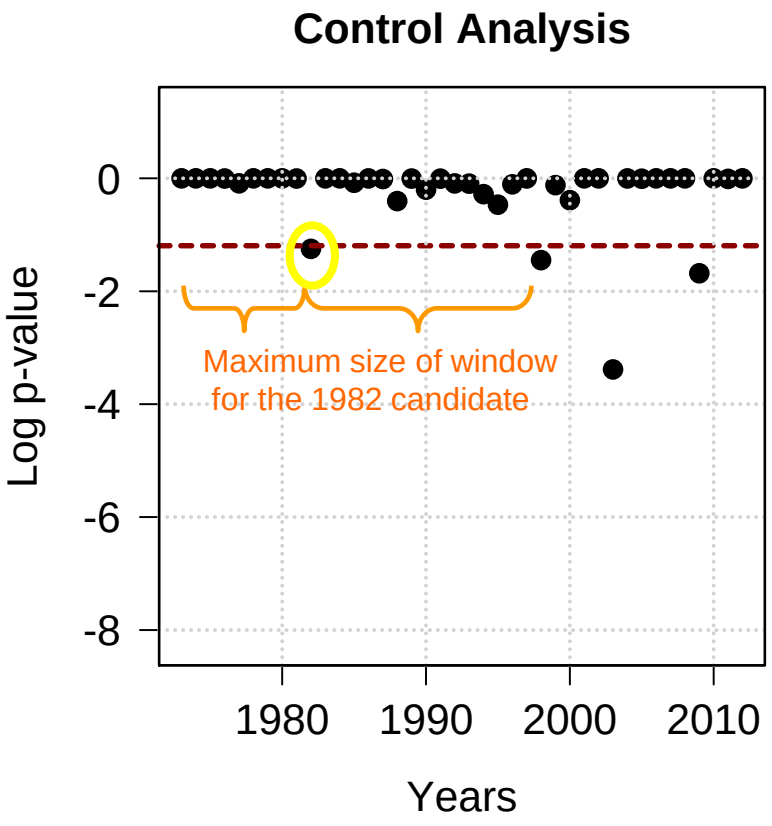


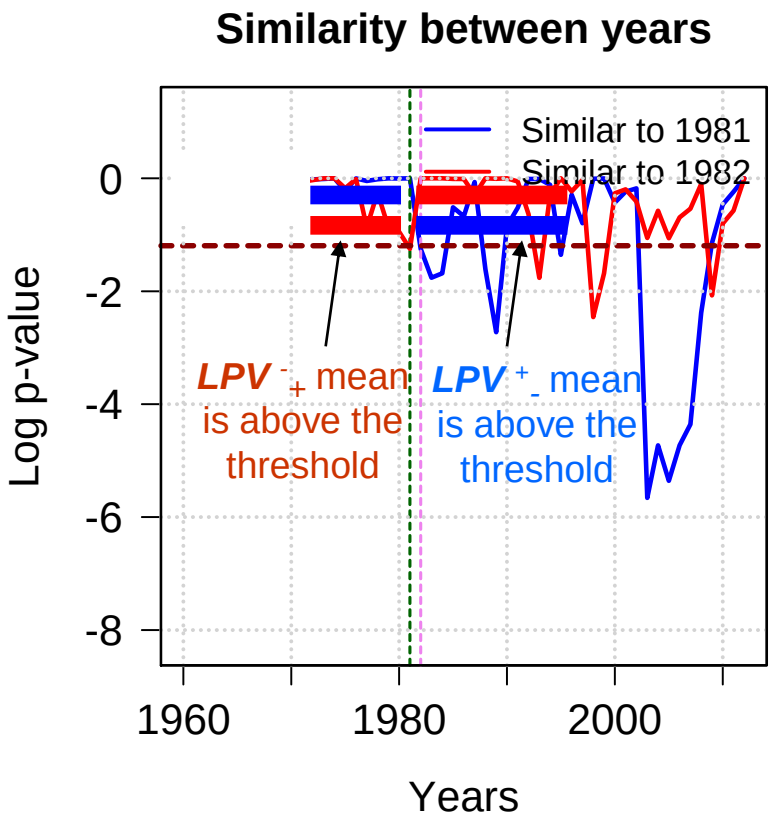


Real cases

Precipitation: CASE 1

Inhomogeneities in **precipitation**: LPV diagrams

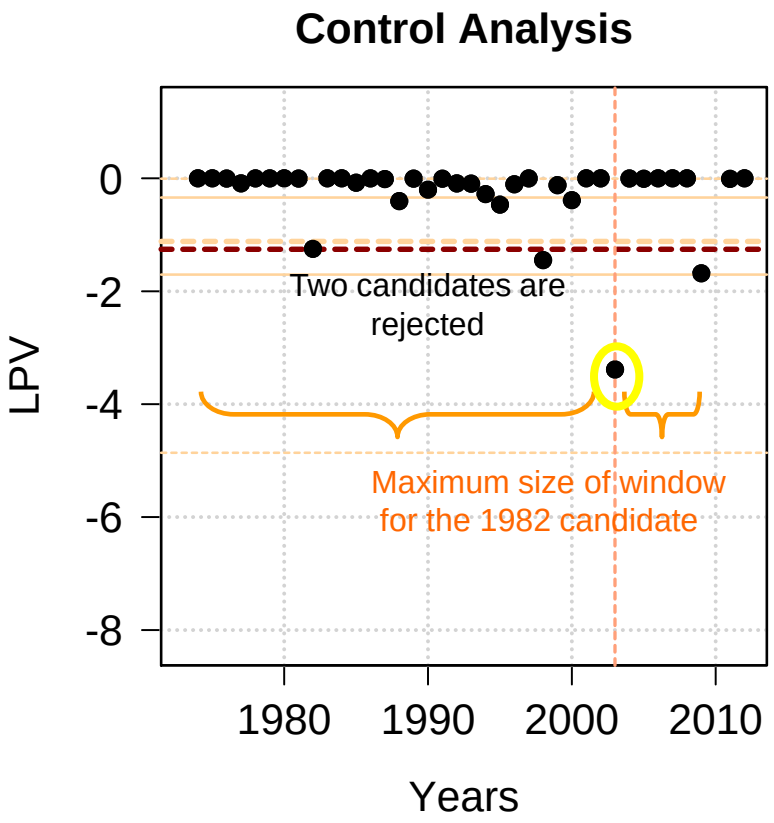


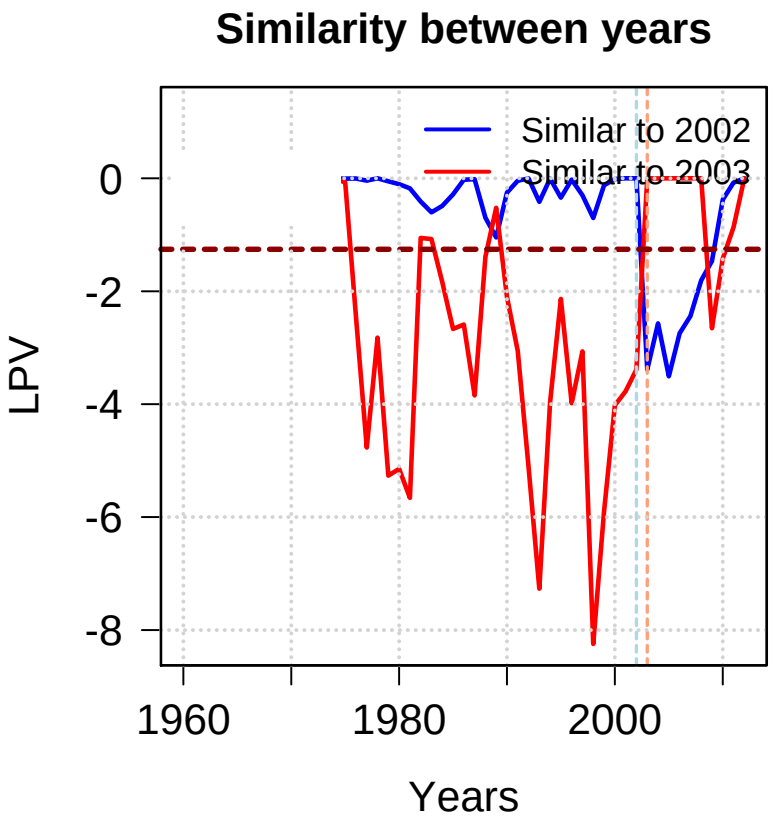


Real cases

Precipitation: CASE 1

Inhomogeneities in **precipitation**: LPV diagrams

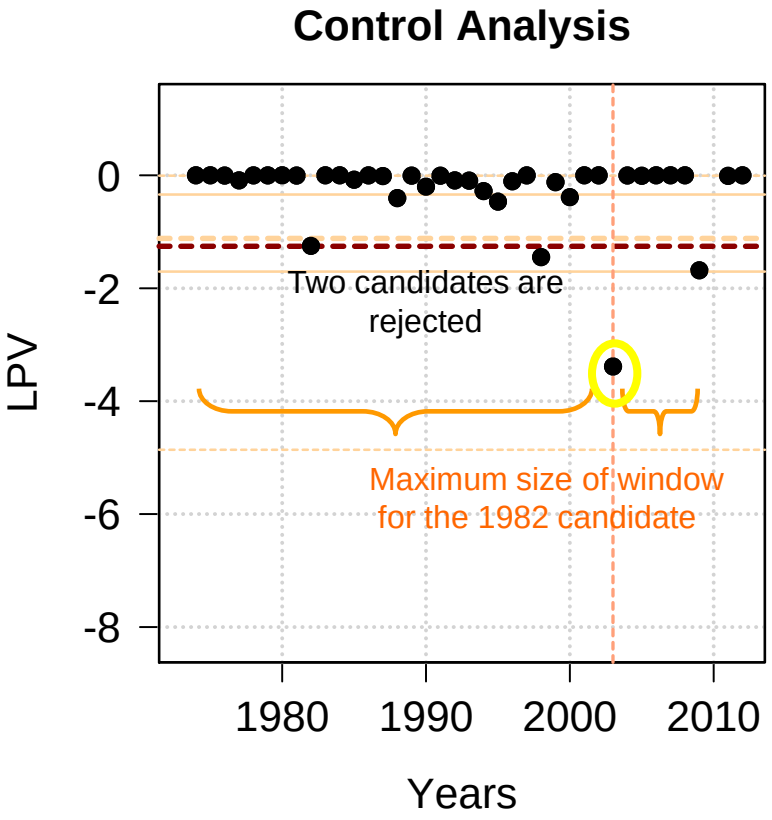


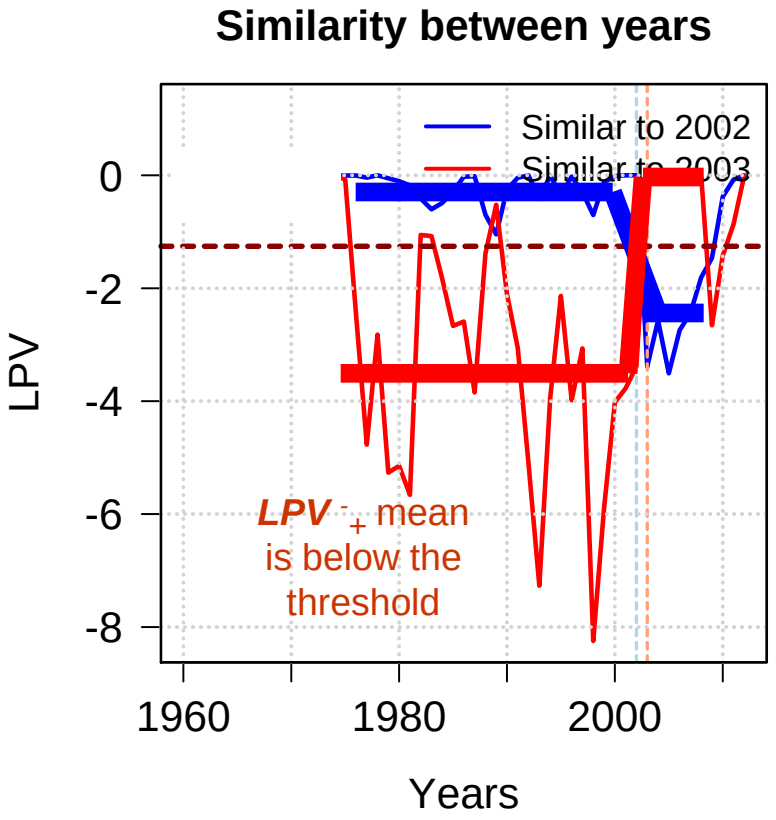


Real cases

Precipitation: CASE 1

Inhomogeneities in **precipitation**: LPV diagrams

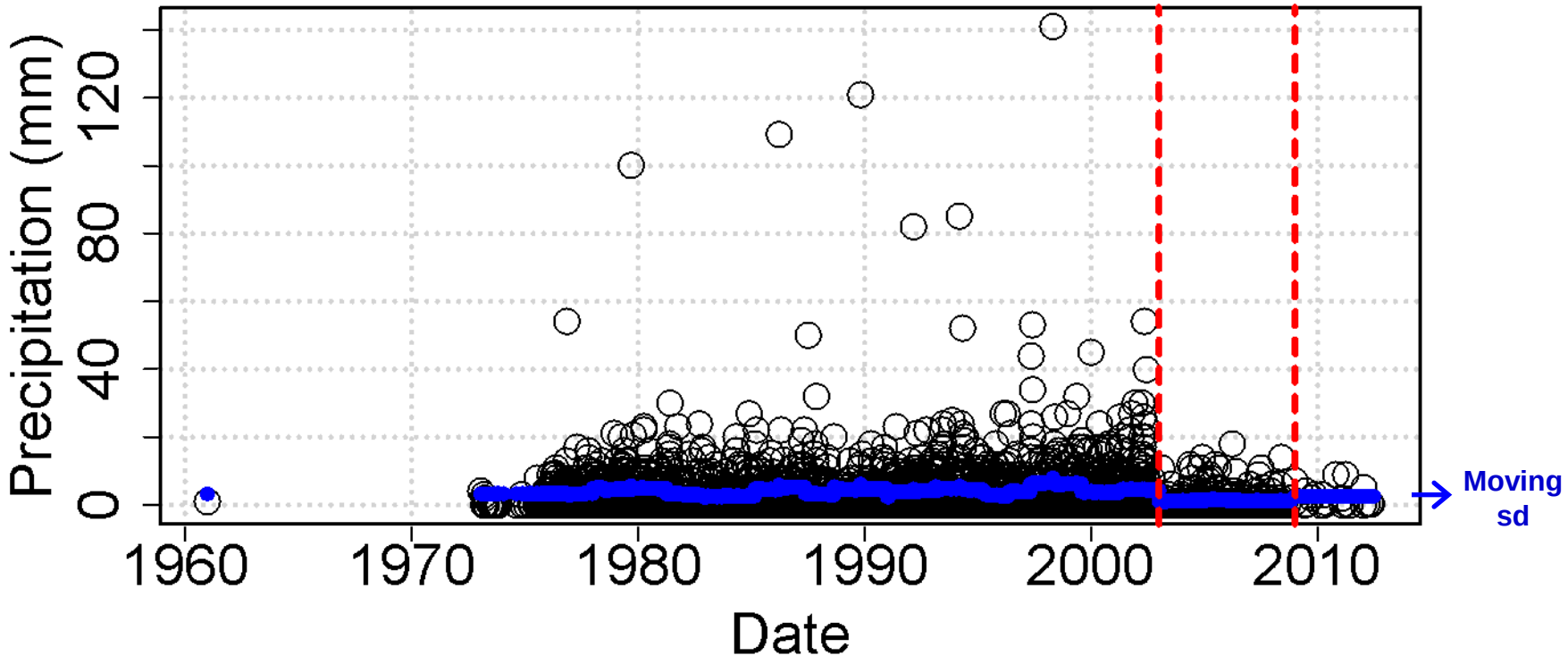




Real cases

Precipitation: CASE 1

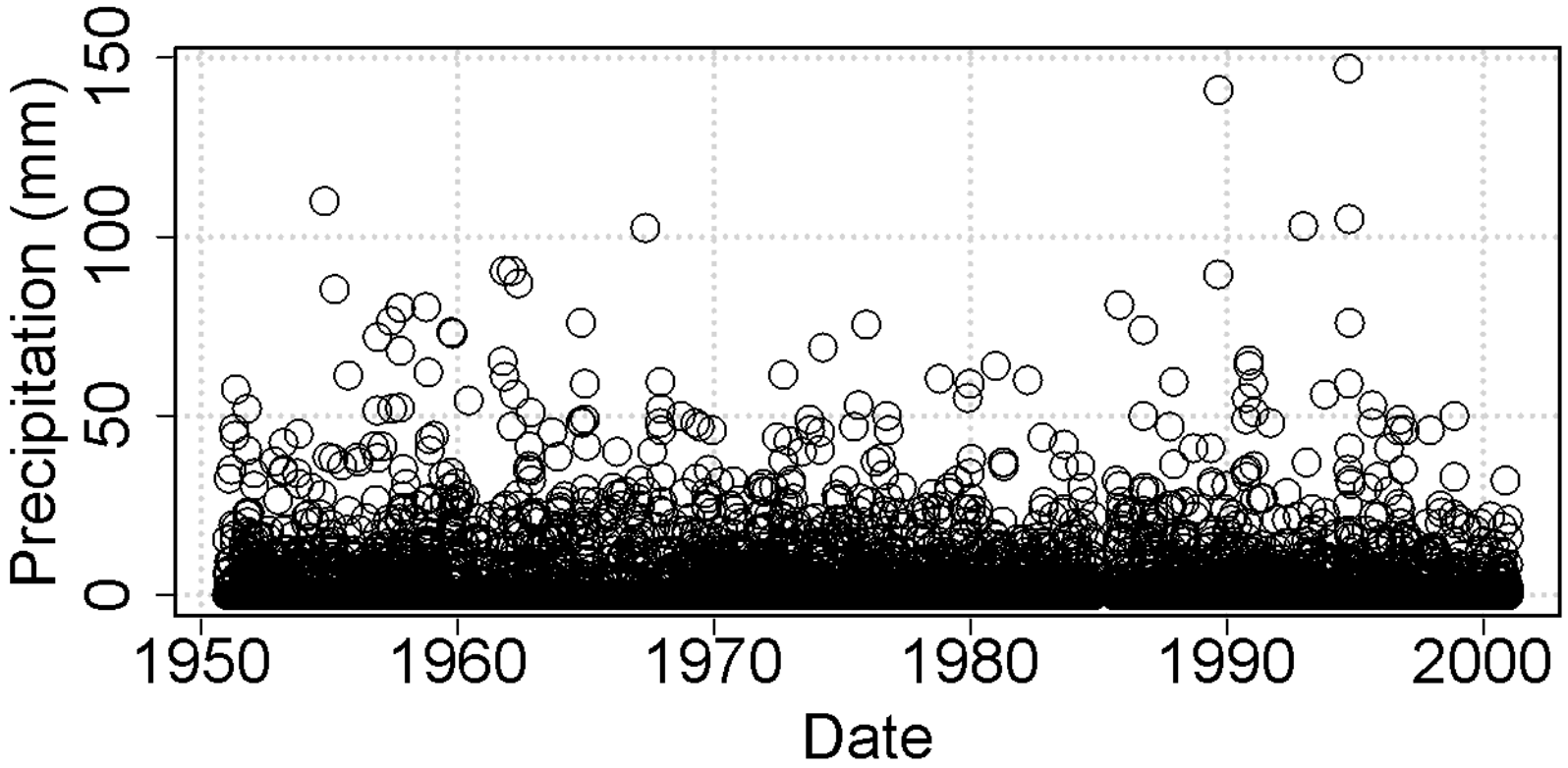
Inhomogeneities in **precipitation**: final analysis



Real cases

Precipitation: CASE 2

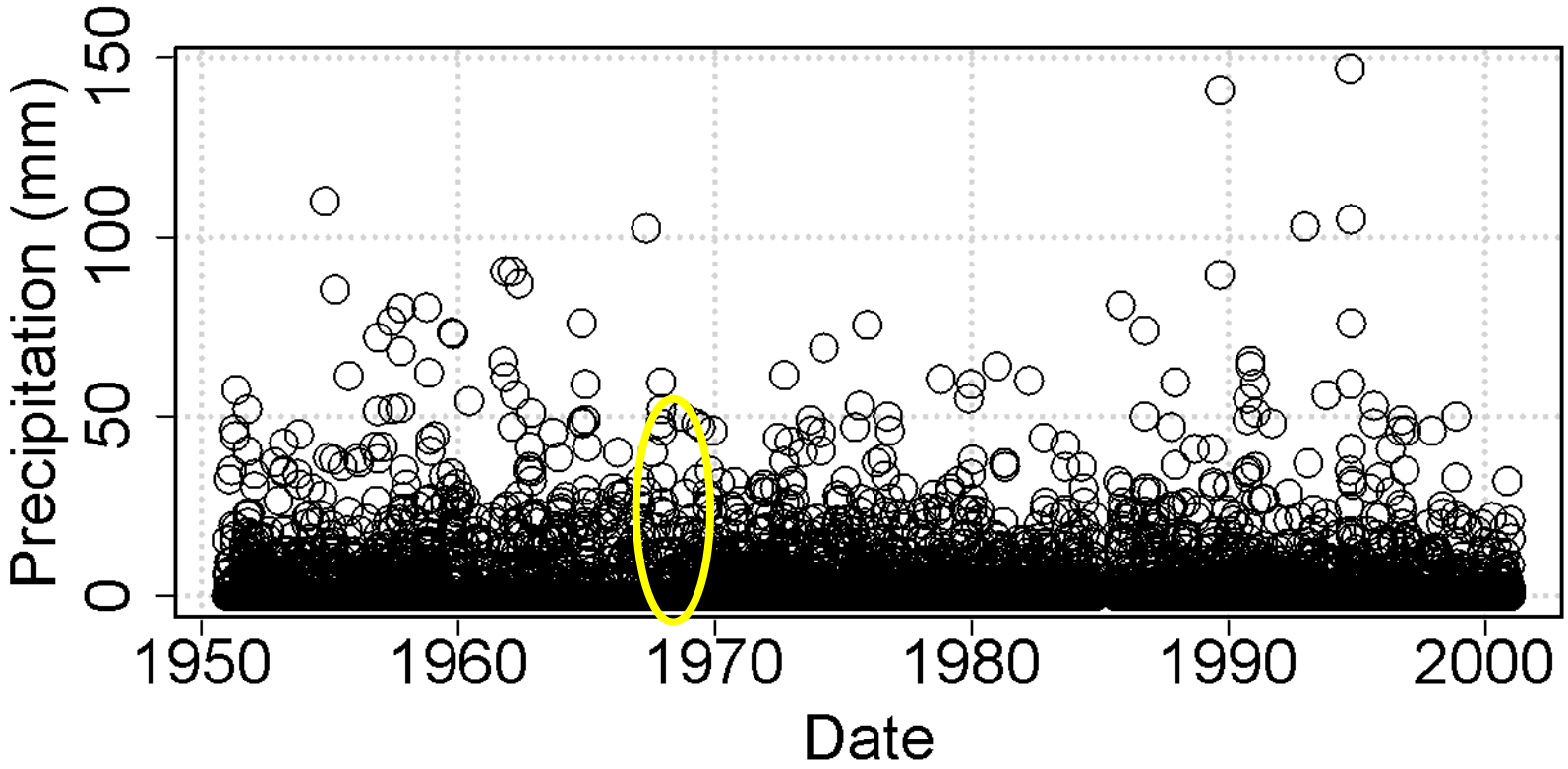
Inhomogeneities in **precipitation**



Real cases

Precipitation: CASE 2

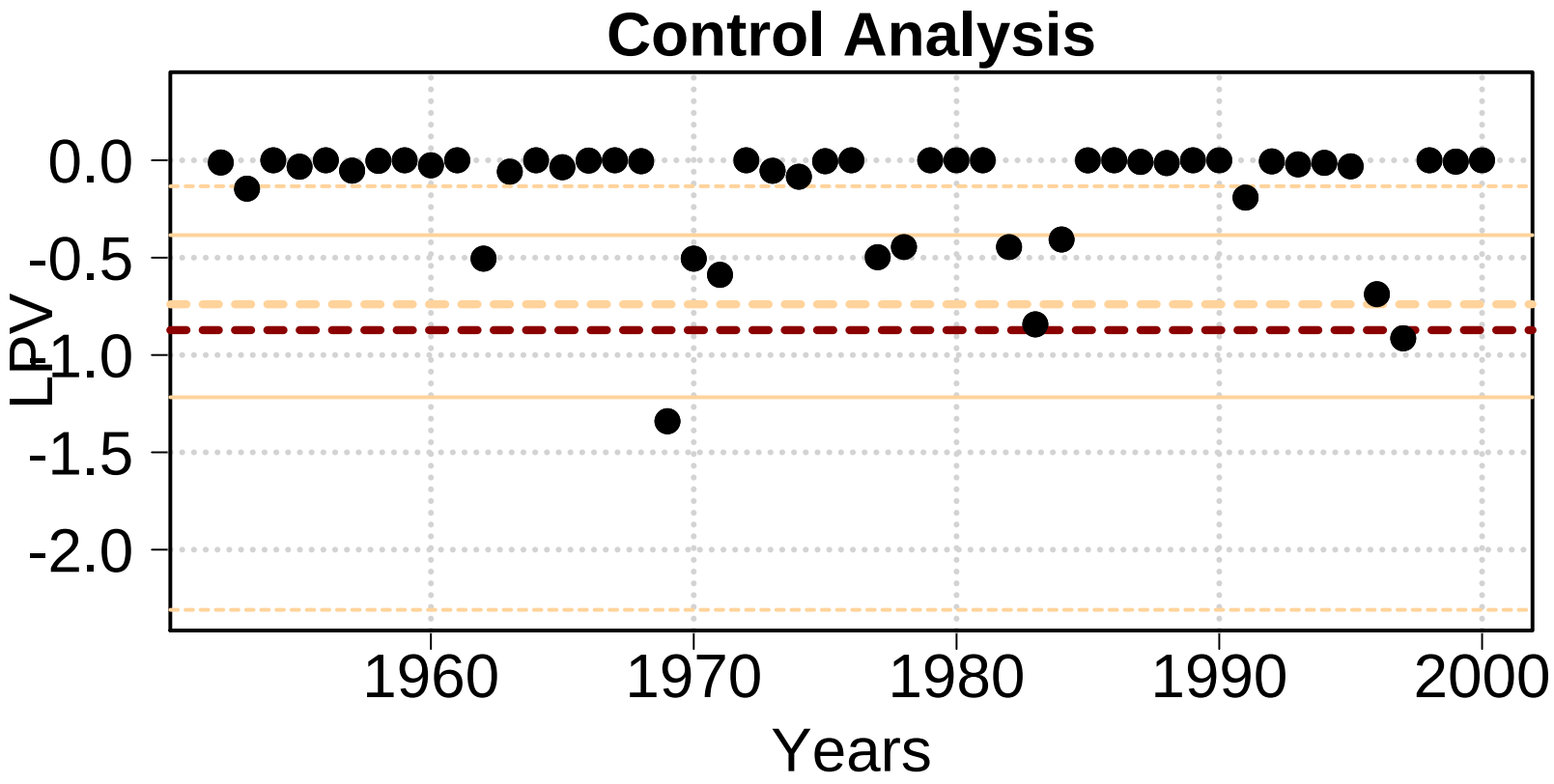
Inhomogeneities in **precipitation**



Real cases

Precipitation: CASE 2

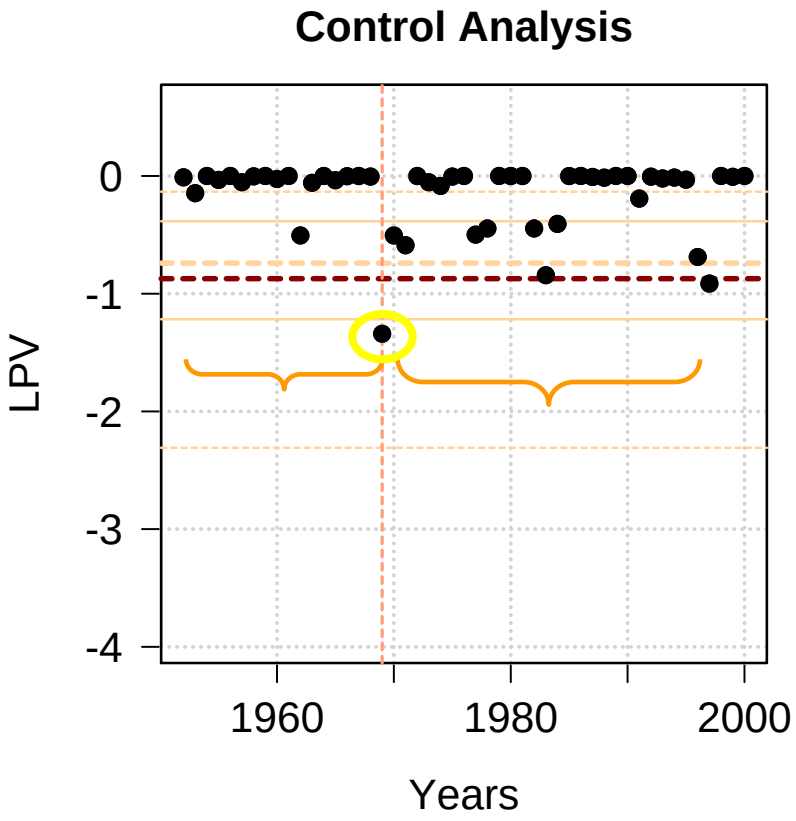
Inhomogeneities in **precipitation**: LPV diagrams

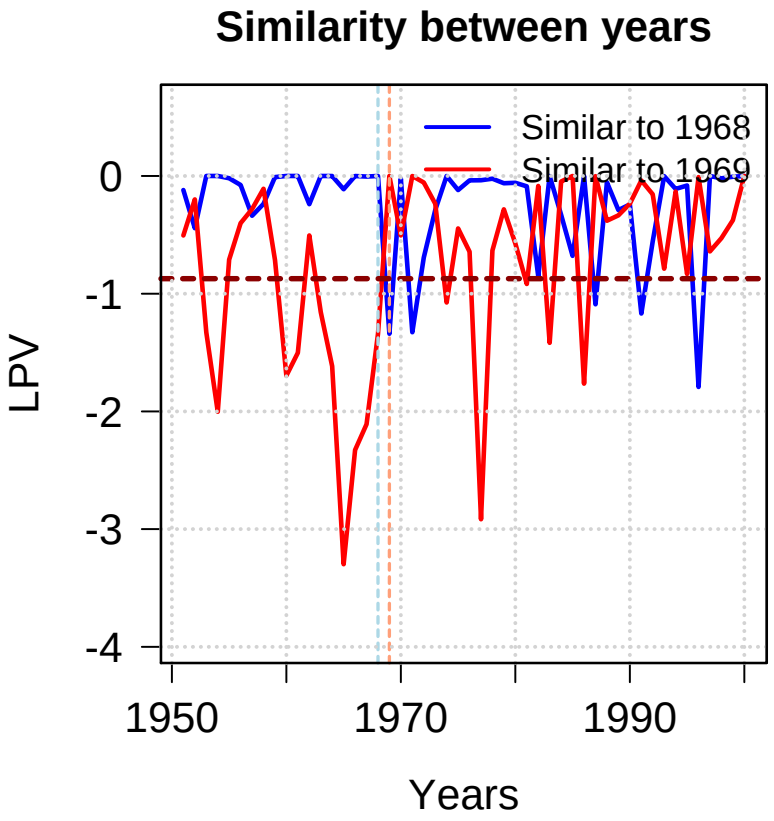


Real cases

Precipitation: CASE 2

Inhomogeneities in **precipitation**: LPV diagrams





Real cases

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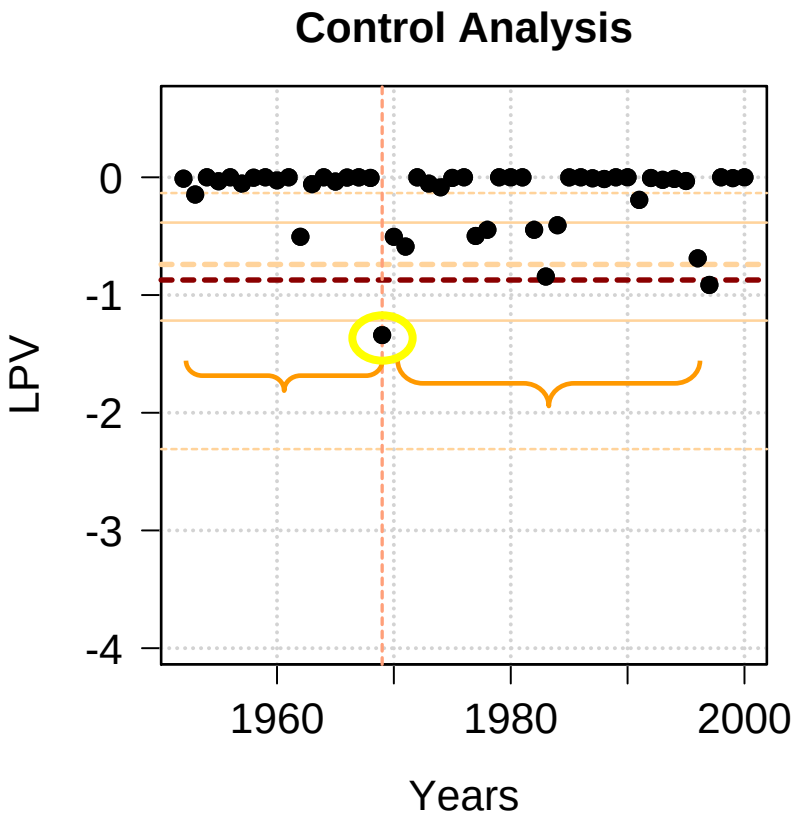

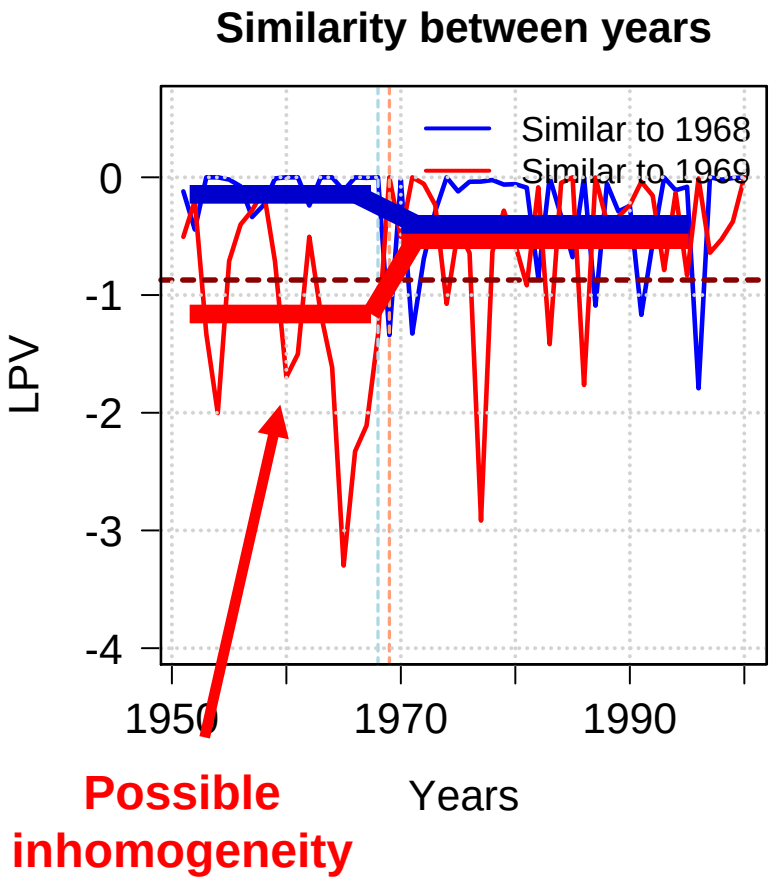

Real cases

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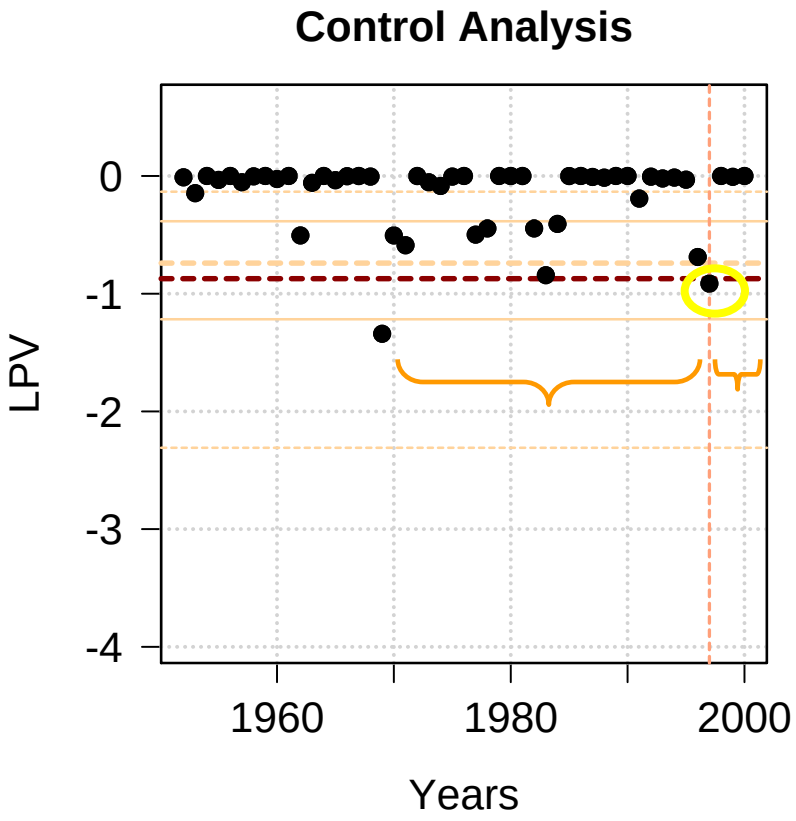
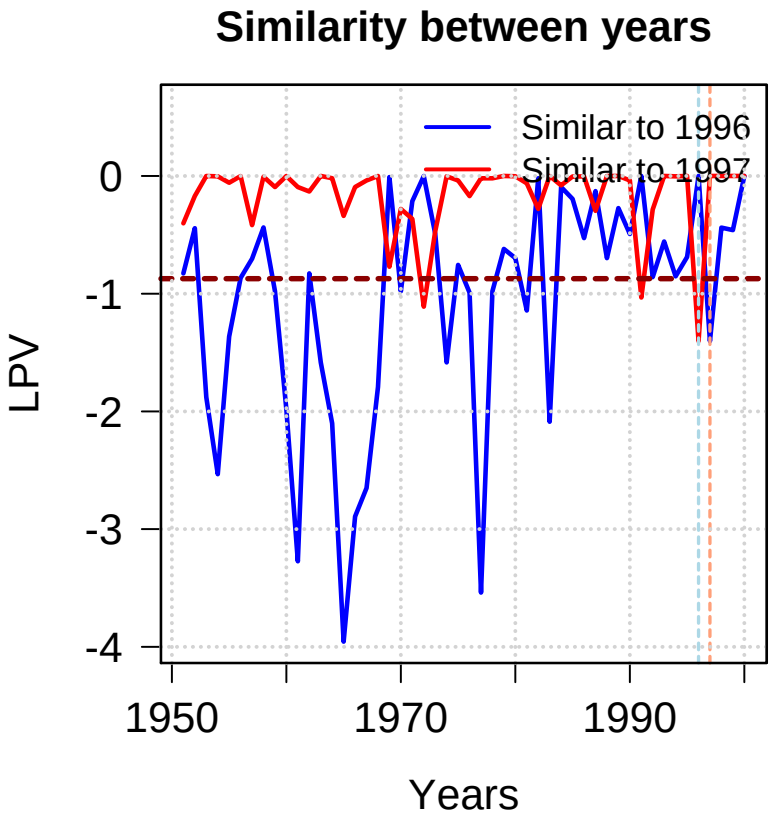
Inhomogeneities in **precipitation**: LPV diagrams





Real cases

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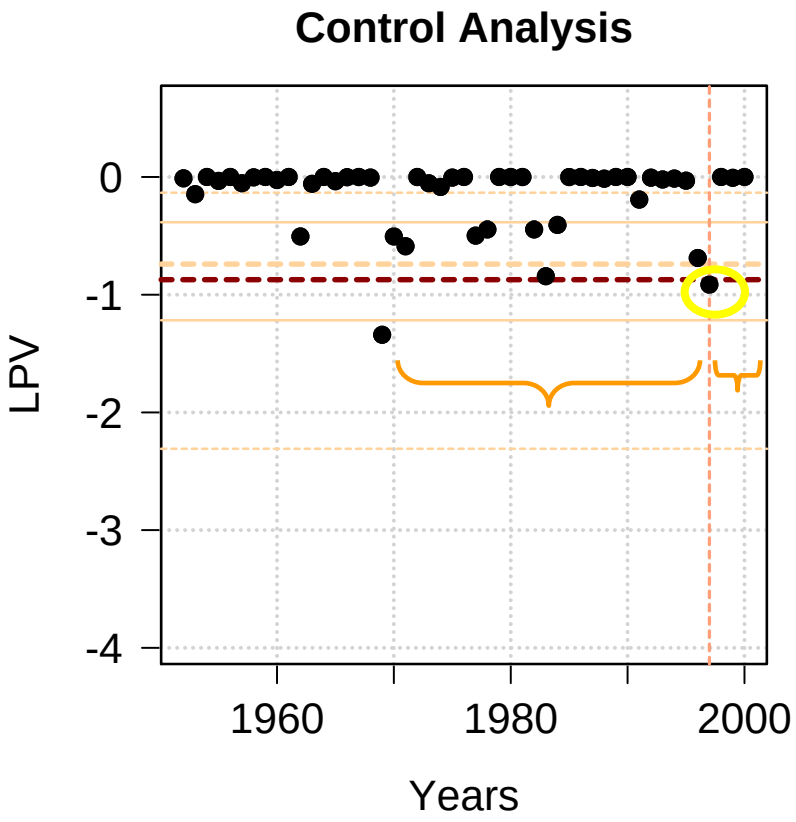
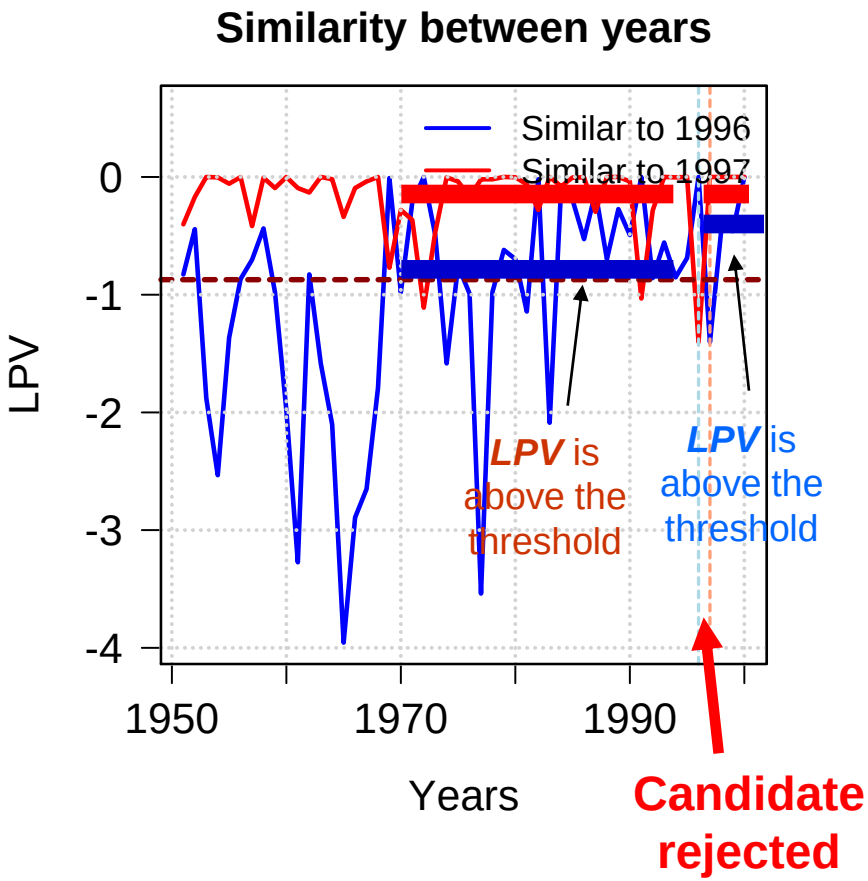
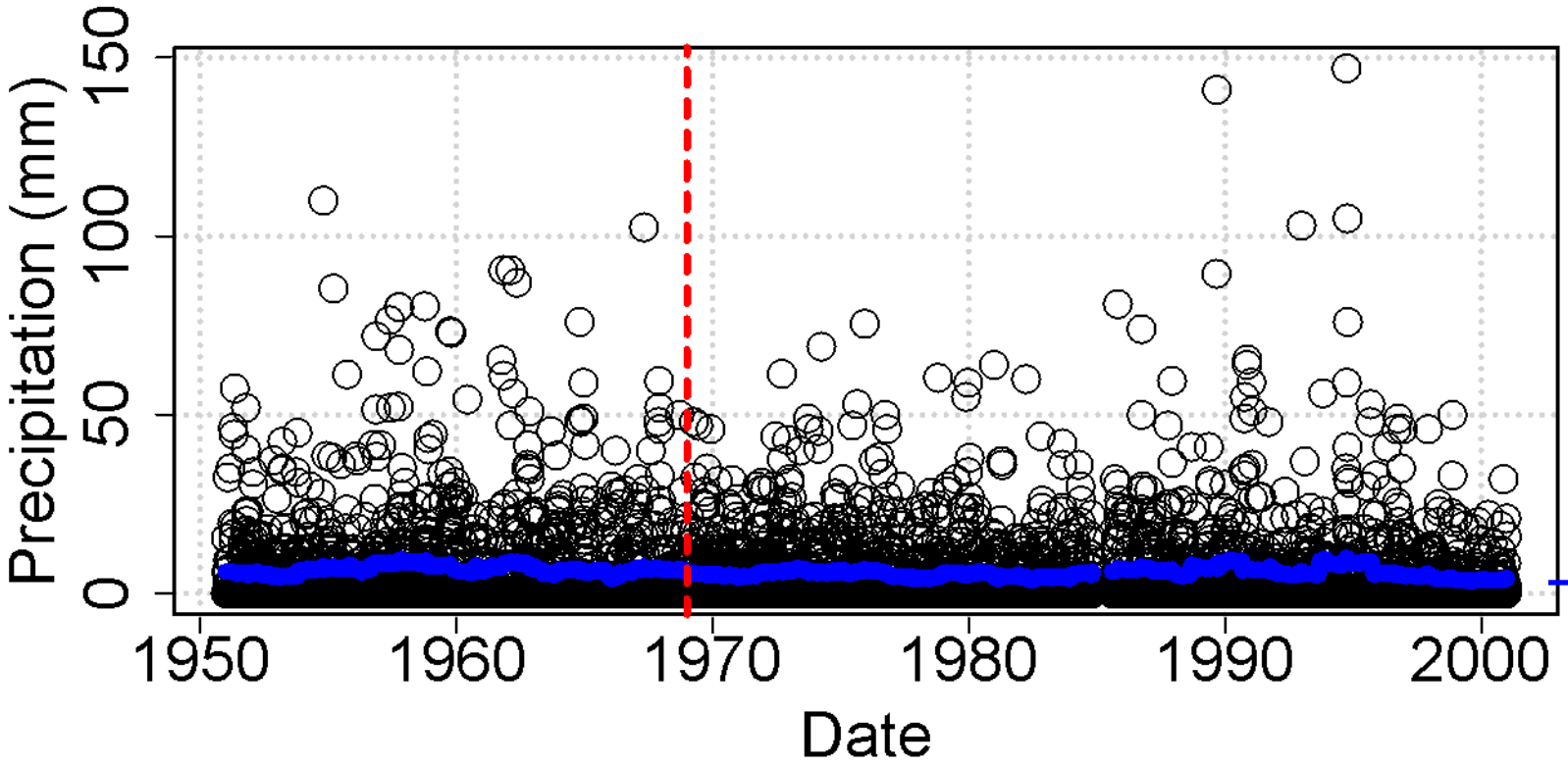




Real cases

Precipitation: CASE 2

Inhomogeneities in **precipitation**: final analysis



Contents

Discussion

- **Selection of non-parametric test**:
  - Kolmogorov-Smirnov: It is adequate for temperature and precipitation.
  - Other? Anderson-Darling: For precipitation is too much sensitive due to the high natural variability (takes a lot of extremes as “unusual year”)

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- **Analysis of control**:
  - Introduction of the artificial inhomogeneity: Choice of parameters of the control (a=?, b =?). Our case, *a* = 3 for precipitation, *b* = 2 for temperature
  - Percentile of the LPV of reference. Level of confidence for a candidate? For precipitation can be important due to the high uncertainty.

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- **Inhomogeneity detection**:
  - Inhomogeneity (on the left/right) must be greater than the reference jump
  - Size of the detection window is limited by the candidate neighbors.
  - Time-series with trends are a priori considered homogenious because increase is soft (no jumps), except if there is a long gap.

Contents

Conclusions

About the methodology

- Non-parametric test of Kolmogorov-Smirnov can be used to detect inhomogeneity for both temperature and precipitation at daily scale.

- A control analysis is required introducing an artificial inhomogeneity ("reference jump") for comparing with the original time-series: LPV diagrams.

- For temperature, the recommended "reference jump" is 2ºC and for precipitation is a multiplication factor of 3.

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About its aplication

- Temperature shows a reference LPV with less uncertainty than precipitation.

- Test can detect (sistematic) changes in ECDF, not only in the averages

- Some candidates of precipitation can be due to natural variability.

- A more extensive study of real cases could refine the methodology.

Thanks

Thank you for your attention

and
for getting up so early…
… as me.