Long series of Swiss seasonal precipitation: Homogenisation, regionalisation and trends

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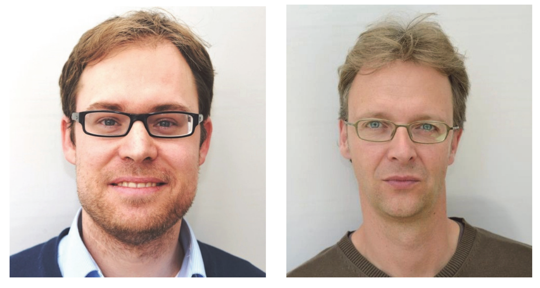

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Introduction

The knowledge of precipitation trends and variability is vital for many aspects of life and socio-economic sectors. However, confidence in precipitation trends is still limited and merits regular reassessment. Here, **seasonal and annual homogenised precipitation series** in **Switzerland** are investigated for the period 1901-2013 in terms of **trends, interannual variability and the influence of large-scale European flow patterns**.

Data homogenisation

Homogenisation methodology

- Homogenised using the MeteoSwiss homogenisation software THOMAS
- Combination of methods using reference series (with large effort put into selection of homogeneous stations) and meta data analysis
- Correction done on monthly basis as several inhomogeneities (e.g. site relocations) show correction factors with strong seasonal dependencies

Causes for inhomogeneities

cause	frequency
site relocation	41%
unknown	17%
automation	12%
change of instrumentation	12%
inspection/calibration/maintenance	10%
observer change	6%
change of environment	2%

Tab. 1: Causes for inhomogeneities in the 32 precipitation series used for regional trend analysis

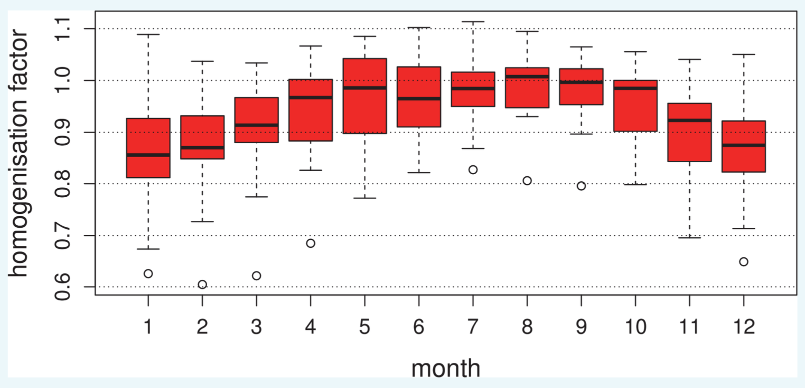

Fig. 1: Monthly homogenisation factors used to correct for automation (transition from Hellmann to tipping bucket)

In total, 87 breaks (e.g. on average 2.7 breaks per series) have been corrected. 90% of the homogenisation factors applied to monthly precipitation sums were between 0.8 and 1.2, in a few cases (especially for mountain stations), factors between 0.6 and 1.6 had to be applied.

Regionalisation

Clustering methodology

- agglomerative hierarchical clustering with complete linkage (DeGaetano 2001)
- dissimilarity measure: Spearman rank correlation
- applied to monthly precipitation anomalies (305 stations, 1961-2006)

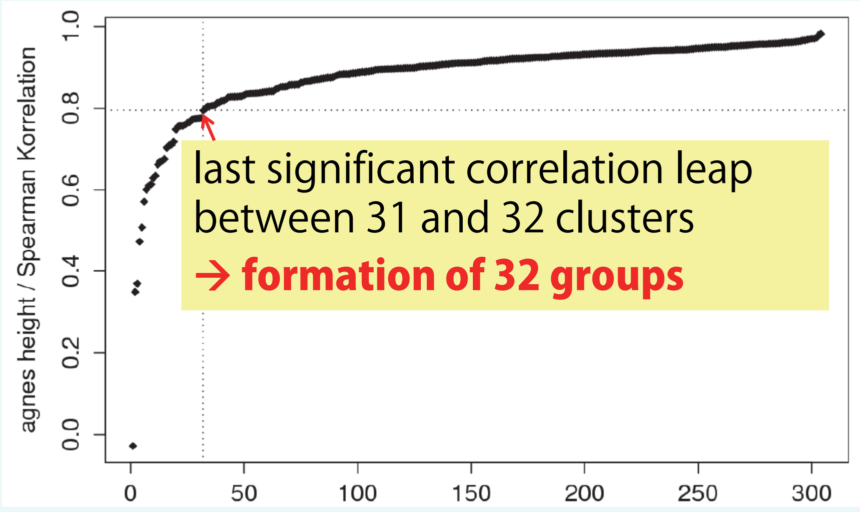

Fig. 2: Dendrogram heights and lowest correlation within the groups, respectively, against the number of clusters in the hierarchical clustering of temperature series. Dashed lines indicate the „optimal" number of clusters and the according correlation.

Map of 32 precipitation clusters

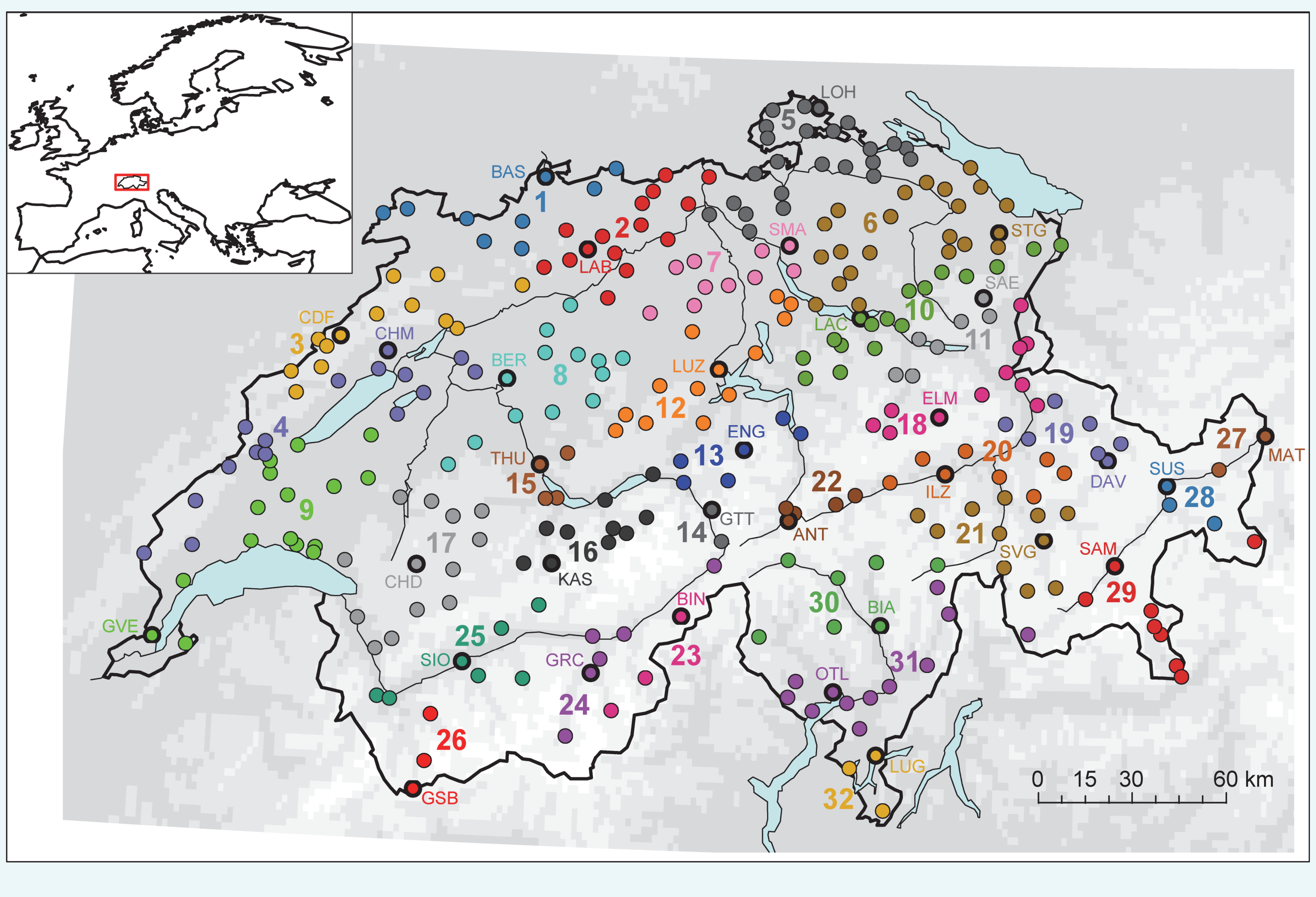

Fig. 3: Map of with location of 305 MeteoSwiss precipitation stations in the colour of the 32 numbered regions as determined with an agglomerative hierarchical clustering algorithm). The 32 stations analysed (one for each region) are marked with bold circles and labelled with a three character code. The grey shading shows basic features of topography. The inset on the top left corner shows the location of Switzerland in Europe.

Trend analysis

Annual trends

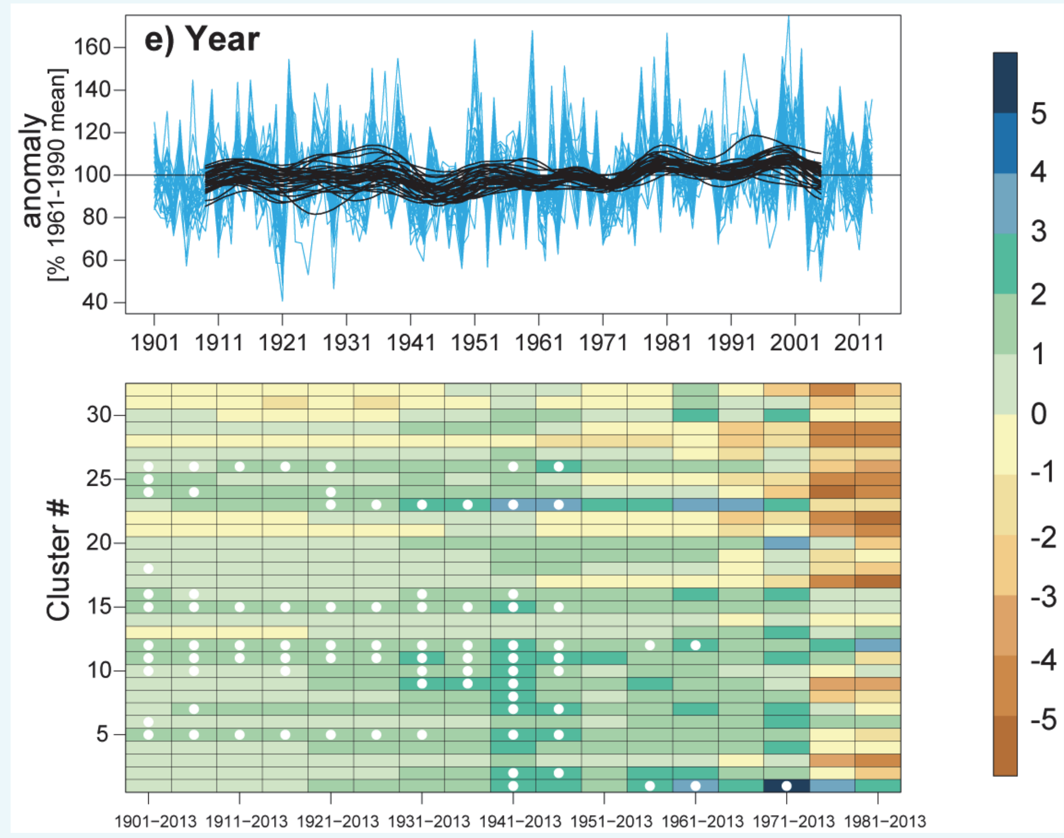

Fig. 4: Time series and time-moving trends for all 32 regions and annual precipitation. Upper panel: precipitation anomalies in % from the 1961-1990 mean (blue lines) and the low pass smoothed anomalies (black lines). Lower panel: linear trends for different time periods. Negative trends: brownish colours, positive trends: green/blue. Significant trends (p<0.05) marked with a white dot.

Winter- and summer trends

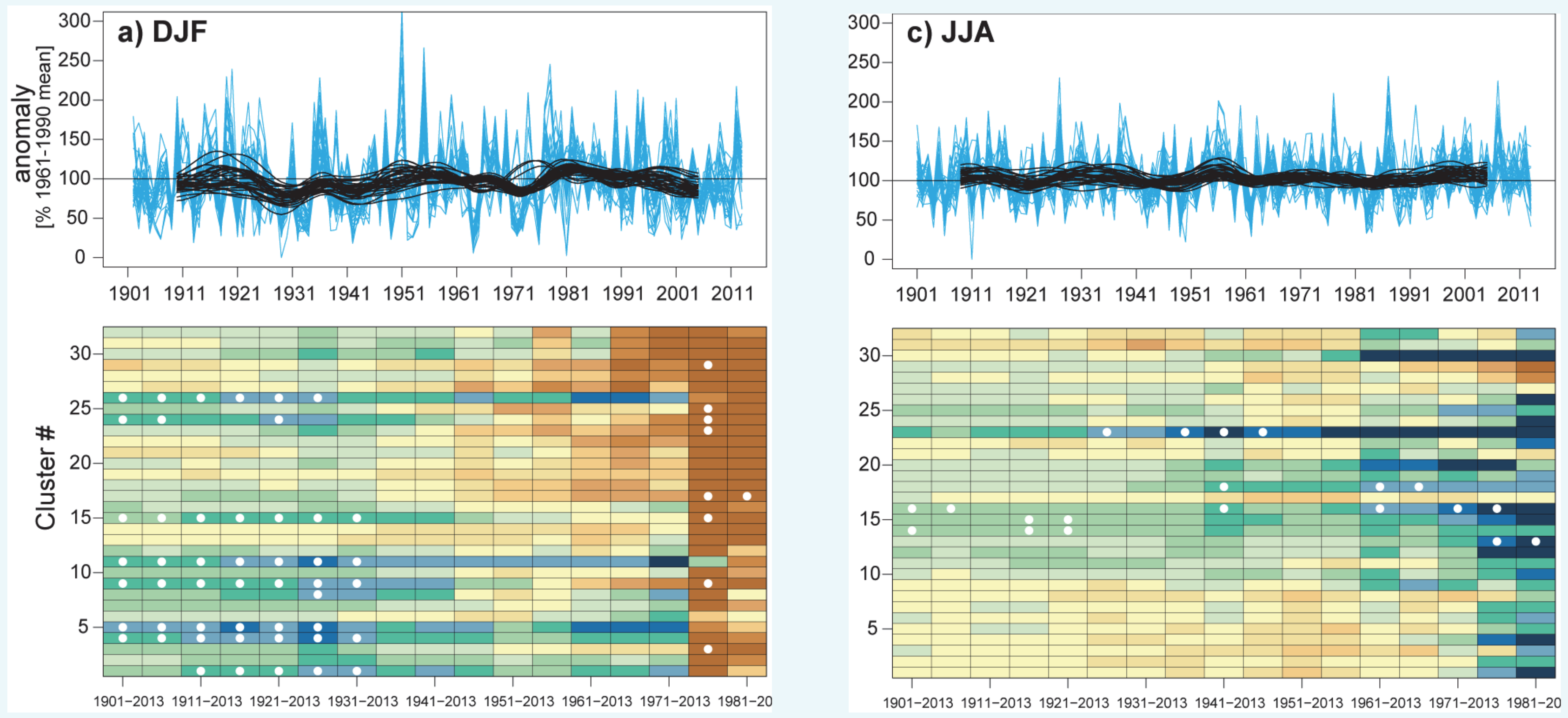

Fig. 5: As Fig. 3 but for winter (DJF, left panel) and summer (JJA, right panel).

Interaction with large scale flow

Climate patterns and Swiss precipitation variability

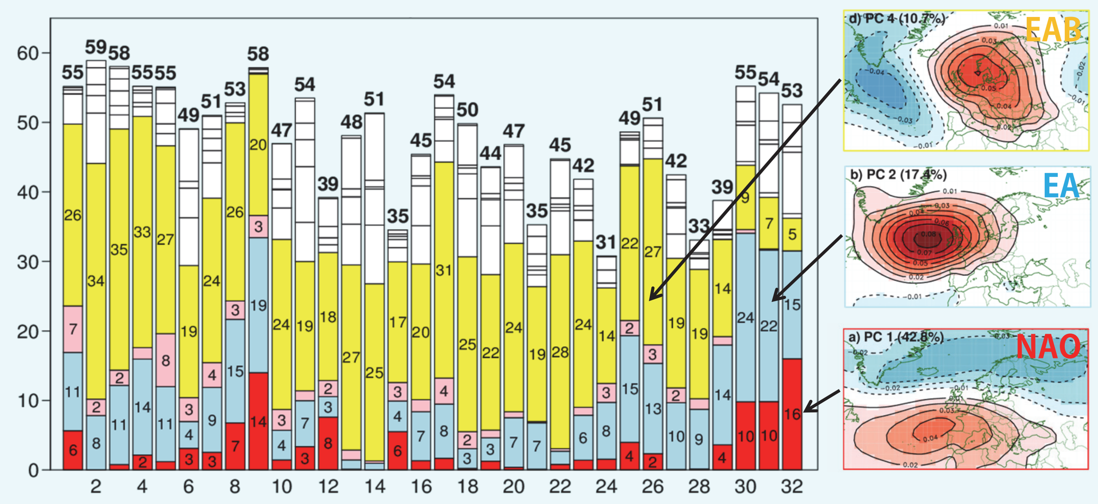

Fig. 6: The variance of the 32 precipitation regions explained by the first 10 sea level pressure patterns for DJF in the 1901-2012 period. Contributions from PC1 (NAO) are shown in red, PC2 (EA) in blue and PC4 (EAB) in yellow. The SLP patterns are shown on the right.

Dry and wet season composites of sea level pressure / wind

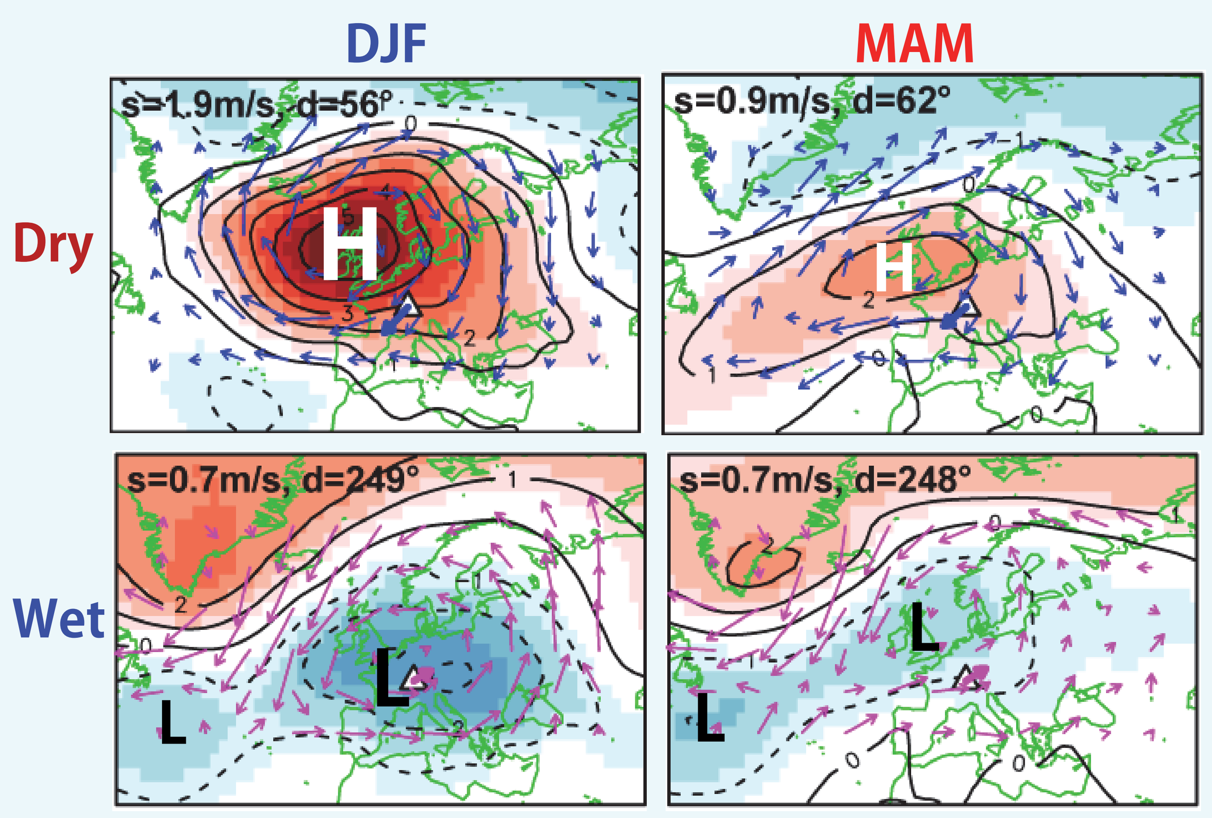

Fig. 7: Composites of sea level pressure and 850 hPa wind anomalies for seasonal "dry" ("wet") composites, (top (bottom) row) defined as the 18 driest (wettest) seasons in the 1901-2012 period for DJF (left) and MAM (right). The arrows show the direction and speed of the anomalous 850 hPa wind. Region considered is the eastern Jura.

Conclusions

- **91% of the series showed inhomogeneities (on average 2.7 per series).**
- **32 distinct Swiss precip regions were defined by objective clustering.**
- **Pos. precip trends for 50+ year series in winter, autumn & year. Pos. trends in 81 (72%) of annual (winter) series in 1901-2013.**
- **Euro-Atlantic blocking (Eastern Atlantic pattern) most important patterns in explaining northern (southern) Swiss precipitation variability in winter. Some different patterns for other seasons.**

Literature

→ DeGaetano AT, 2001. Int. J. Climatol. 21: 791-807. doi:10.1002/joc.645.
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→ Begert M, Schlegel T, Kirchhofer, W. 2005. Int J Climatol, 25, 65–80. doi:10.1002/joc.1118