



University of Natural Resources
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How standard are standardized drought indices?

Uncertainty contributions for the SPI & SPEI case

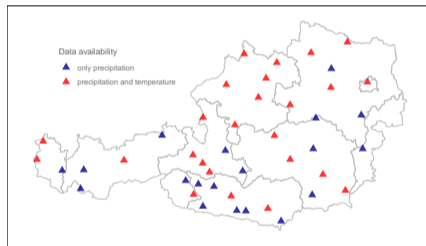
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- SPI and SPEI have **no standard calculation procedure**.
- Uncertainty of calculation procedure is either out of the analysts control - *sample size, observation period*, or can be subjectively decided - *choice of distribution, method of parameter estimation and use of a goodness of fit test*.
- In our study we analyse relative and total uncertainties of the calculation procedure in one, comprehensive, statistical framework
- **43 stations** in Austria of the HISTALP network for SPI, and **25 stations** for the SPEI are used.

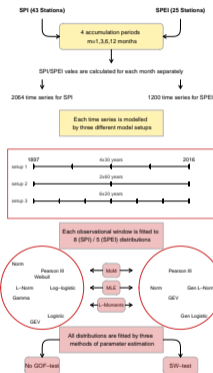


Overview of the used stations in the HISTALP network.

Model design

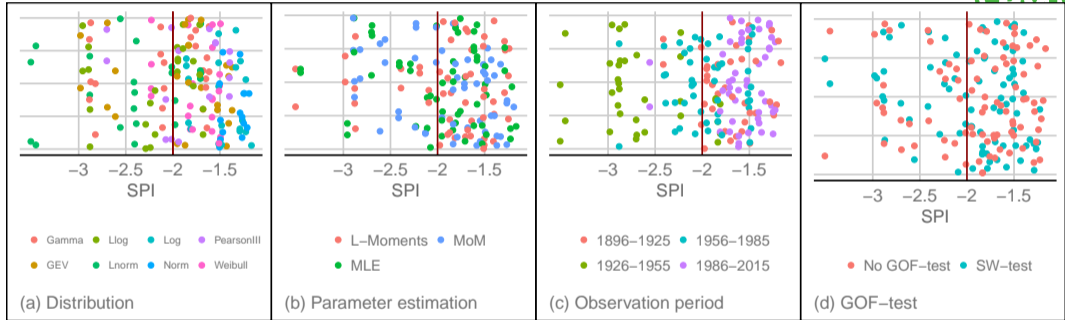


- For each time series a reference precipitation is calculated, with a theoretical drought index value of -2.
- To show the variability in the results we use **8 different distribution** for the SPI and **5** for the SPEI.
- **3** different methods of **parameter estimation** and application of a **GOF-test** or not.
- 3 different sample sizes with non-overlapping **observation periods**.
- All possible outcomes are calculated for each time series and the deviations to a reference value of SPI/SPEI = -2 are used to calculate the expected error by use of the **RMSE**.
- Relative uncertainty contributions of each calculation step are estimated by a **Linear Mixed Model (LMM)**.

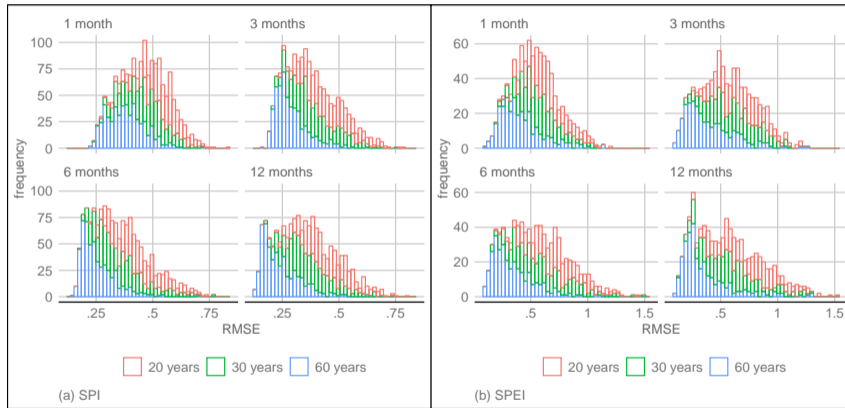


Overview of the different calculation possibilities in our model design. Yellow indicates the uncertainties are calculated outside the LMM - accumulation period and sample size. Red indicates the uncertainty is calculated inside the LMM - observation period, parameter estimation, choice of distribution and use of a GOF-test.

Variability



The four panels show the variations of each uncertainty for January with one month of aggregation in Vienna-Hohe Warte. Panel (a) shows variations for the choice of the distribution. Panel (b) variations for the method of parameter estimation. Panel (c) variations in the observation period. Panel (d) variations of the use of a GOF-test. The points are randomly ordered on the y axis. Red vertical line indicates the "true" SPI value.

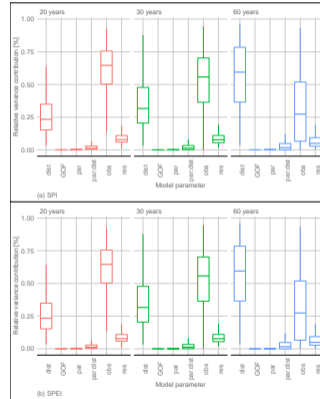


As a first indicator of the error of the calculation procedure we can calculate the RMSE for each obtained time series (6192 for the SPI, 3600 for the SPEI). Each plot shows the histograms of the RMSE, separated by sample size and accumulation periods. Panel (a) shows the SPI, panel (b) shows the SPEI. Clearly the error is reduced by increasing the sample size.

Linear Mixed Model (LMM)



- To get **unbiased estimates**, and to consider the fact, that not all possibilities are included, we used an *LMM* with **random effects** only for estimating the uncertainty contributions.
- Model parameters are estimated by *Restrictive maximum likelihood (REML)*.
- Significance testing is performed by a *Restricted likelihood ratio test (RLRT)* and *the AIC*.
- A *LMM* is estimated for each time series, to avoid high residuals in an overall model.
- Results indicate that the two dominant uncertainties are the choice of the distribution and the observation period for both indices.



Relative uncertainty contributions over all stations, estimated by a LMM. Relative uncertainty contributions are defined by the variance of a single effect divided by the total uncertainty.



- The **expected error** for SPI and SPEI are so large that, e.g., an extreme drought may be wrongly classified as severe or moderate drought.
- We found low significant rates for the method of parameter estimation or the use of a GOF-test.
- Total uncertainty is **higher for the SPEI** than for the SPI.
- The **dominant sources** of uncertainty are the **observation period** and the **choice of distribution**, but these effects vary with accumulation period and the sample size.
- More detailed results can be read in our paper "How standard are standardized drought indices?", which will be submitted to HESS in May!