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Uncertainty in spatio-temporal drought assessment

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Abstract
In the last decade, uncertainty in drought assessment studies has received increasing attention in the hydrometeorology research community. Spatio-temporal characteristics of this phenomenon are affected by uncertainties resulting from the calculation of standardised drought indices (SDI). To our knowledge, to date, there is no analysis of how these uncertainties affect the assessment of the spatial extent of droughts. In the present study, the uncertainty of meteorological drought extent determination in specific classes is investigated from the perspective of a candidate probability distribution, the data record length and the cumulative time scale. E-OBS precipitation daily gridded data were used to calculate the Standardised Precipitation Index (SPI) in the Vistula catchment in Poland using four parametric distribution functions (Birnbaum-Saunders, Weibull, Generalised Extreme Value and Gamma) and nonparametric approach. Preliminary results indicate significant discrepancies in the spatial classification of individual drought categories, indicating greater uncertainty in determining the area affected by severe and extreme droughts.

Introduction

The Standardized Precipitation Index (SPI) is one of the most widely used indicators in drought assessment studies. This is due to its flexibility, spatial-temporal comparability, and quite simple calculation. The World Meteorological Organization recommended SPI for meteorological drought assessment, pointing out that SPI allows confidently comparing historical and currently occurring droughts between different climatic and geographic regions.

Nevertheless, the SPI is a relative measure. Its calculation depends mainly on the probability density function adopted as well as on the method used for parameter estimation and the reference period used in the estimation. There are several related problems concerning the drought research community in the application of SPI in different regions, including the adequate probability distribution to fit the cumulative precipitation, the proper time scale, the record length, and the nonstationarity of the observations.

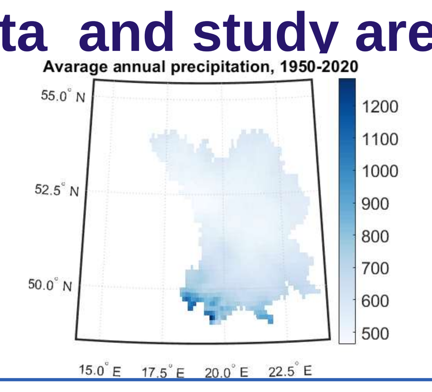
The proper choice of probability distribution for precipitation is the foundation for accurate SPI calculation. The use of different types of distributions would lead to different SPI values.

AIM OF THE STUDY:

- Investigation of the uncertainty effects on drought assesment

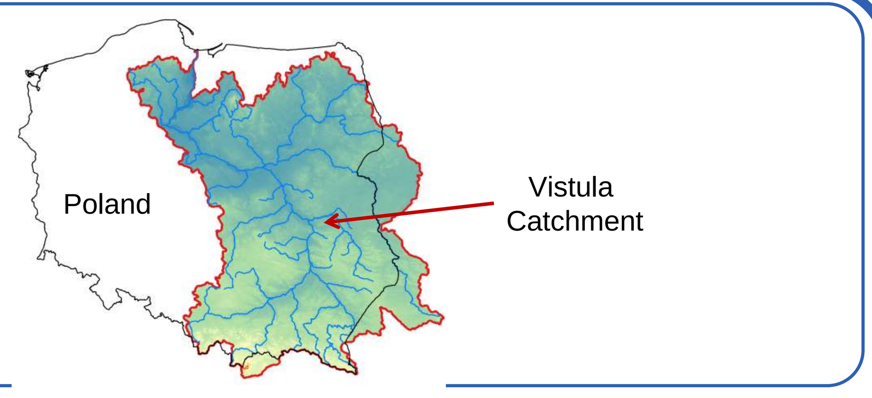
Materials and methods

Data and study area

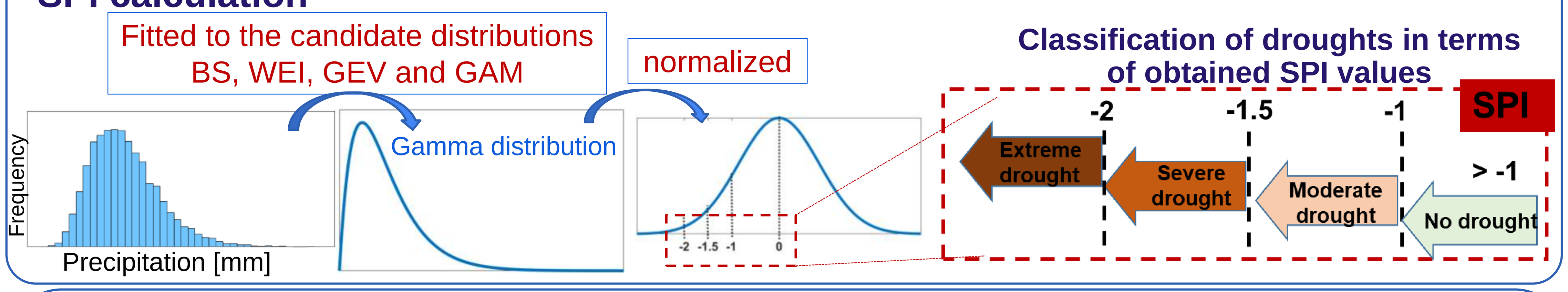


E-OBS gridded dataset version - v23.1e

- precipitation daily gridded data 1950 -2020



SPI calculation -



Distribution name	Probability density function	Parameter
Birnbaum–Saunders (BS)	$f(x)=\frac{1}{\sqrt{2\pi}}\exp\left\{-\frac{\left(\sqrt{x/\beta}-\sqrt{\beta/x}\right)^2}{2\gamma^2}\right\}\left(\frac{\left(\sqrt{x/\beta}+\sqrt{\beta/x}\right)}{2\gamma x}\right)$	γ and β
Weibull (WEI)	$f(x)=\beta/\alpha(x/\alpha)^{\beta-1}\exp[-(x/\alpha)^{\beta}]$	α and β
Generalized extreme value (GEV)	$f(x)=\frac{1}{\alpha}\left[1-k\left(\frac{x-\beta}{\alpha}\right)\right]^{1/k-1}\exp\left\{-\left[1-k\left(\frac{x-\beta}{\alpha}\right)\right]^{1/k}\right\}$	α and β and k
Gamma (GAM)	$f(x)=\frac{1}{\beta^{\alpha}\Gamma(\alpha)}x^{\alpha-1}e^{-x/\beta}$	α and β
Empirical probability (EMP)	*Gringorten plotting position* $p(x_i)=\frac{i-0.44}{n+0.12}$	-------

Evaluation of the goodness-of-fit of probability distributions

- Kolmogorov-Smirnov test

$$D=\max|F(x)-G(x)|$$

- The test statistic D of the KS test measures the largest distance between the empirical cumulative distribution function ***F(x)*** fitted by sample series and the theoretical cumulative distribution function ***G(x)***.The hypothesis regarding the distributional form is rejected if the test statistic D is greater than the critical value at a given significance level.

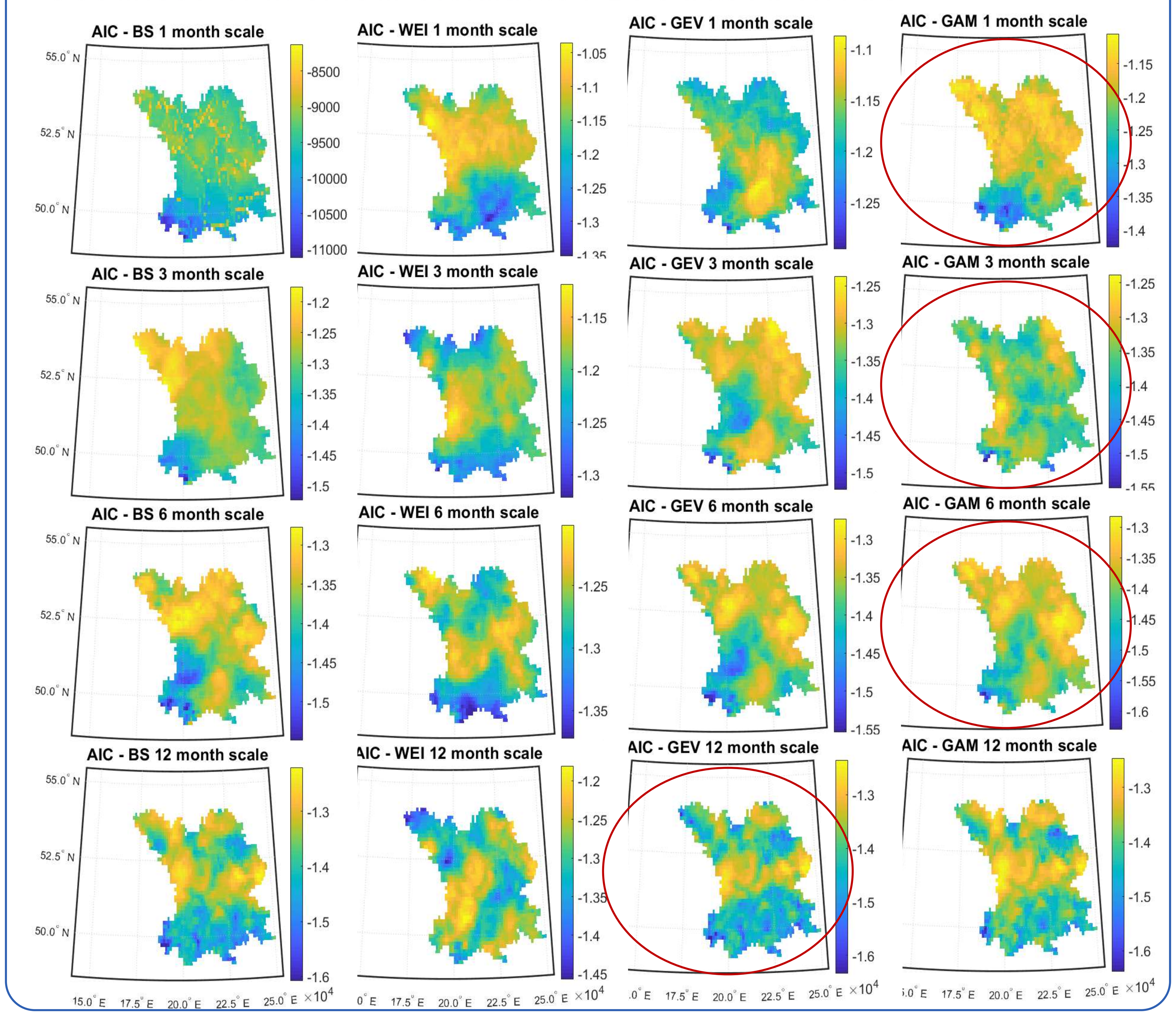
- Akaike Information Criterion (AIC)

$$\mathrm{AIC}=n\log(\mathrm{SSE}/n)+2m$$

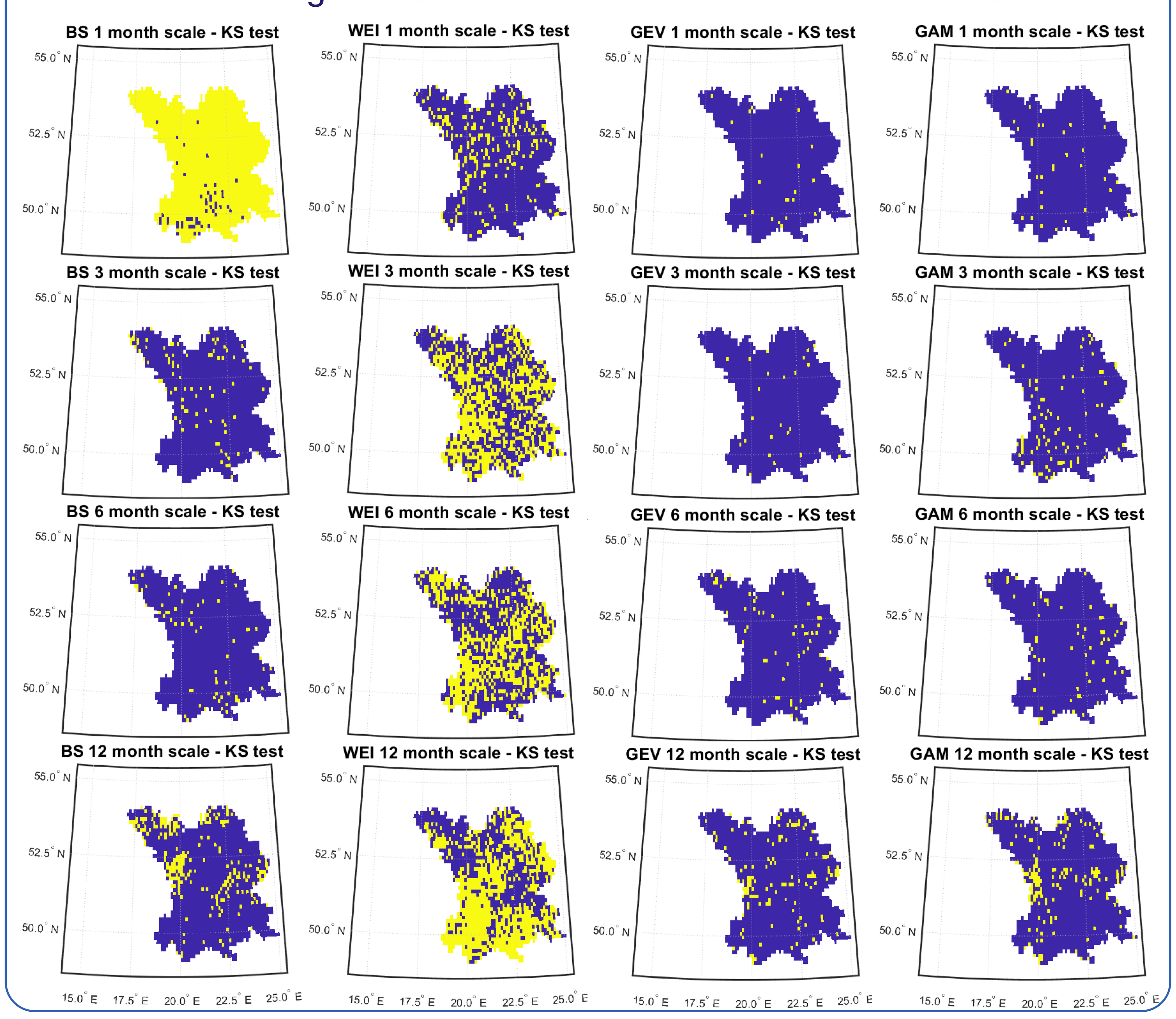
- Where ***n*** is the length of the observation series and ***m*** is the number of parameters. SSE is the sum squared residual of the fitted model.

Results

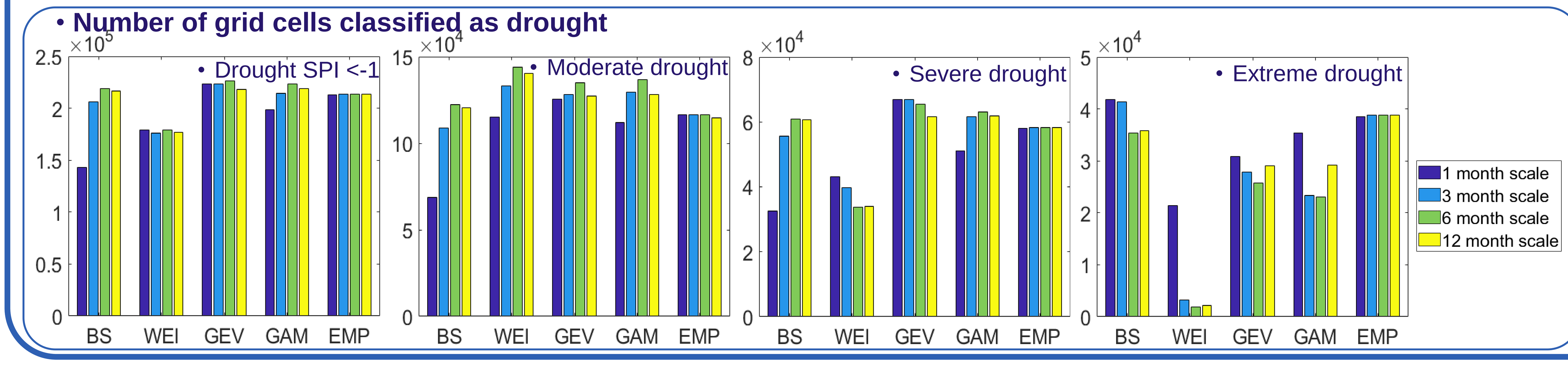
- Goodness-of-fit of four candidate PDFs based on AIC



- Results of Kolmogorov-Smirnov test for four candidate PDFs



- Number of grid cells classified as drought



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