Prediction and predictability of drought events in the Spree region

Clara Hauke, Uwe Ulbrich, Henning Rust

c.hauke@fu-berlin.de

Freie Universität Berlin — Institute of Meteorology

EGU24 Abstract

Sharing is encouraged

SPONSORED BY THE Federal Ministry of Education and Research

FONA Research for Sustainability

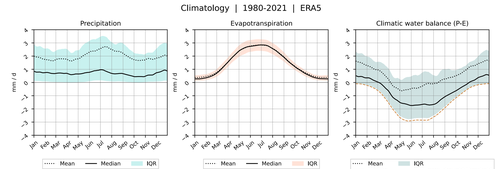
WaX Wasser-Extremereignisse

EGU 2024, Vienna

1. Motivation

- Under climate-change conditions, droughts and other meteorological extremes are likely to increase in frequency and intensity
- **SpreeWasser:N** investigates the impacts of such extremes on the hydrological system in the region of the river Spree
- To estimate regional risks, the probability of future drought events is assessed
- The results are used to develop strategies for adapting regional water use

2. Drought variables

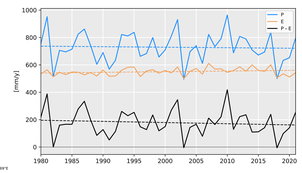


Annual variability of key drought variables

Study area

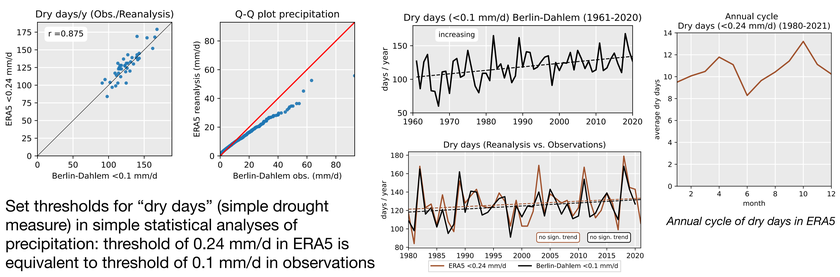
Graphic: P. Schönau, Freie Universität Berlin

- Time span: 1980 - 2021
- Mean over study area of precipitation (P) and evapotranspiration (E) from reanalysis ERA5 (ECMWF)
- Calculate "climatic water balance" (P-E) as drought measure



Yearly precipitation (P), evapotranspiration (E), climatic water balance (P-E)

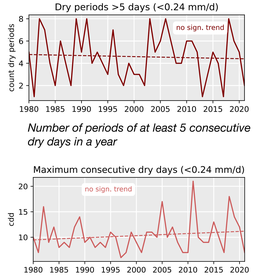
3. Dry days - comparison to observational data



- Set thresholds for "dry days" (simple drought measure) in simple statistical analyses of precipitation: threshold of 0.24 mm/d in ERA5 is equivalent to threshold of 0.1 mm/d in observations

Annual cycle of dry days in ERA5

4. Simple drought measures

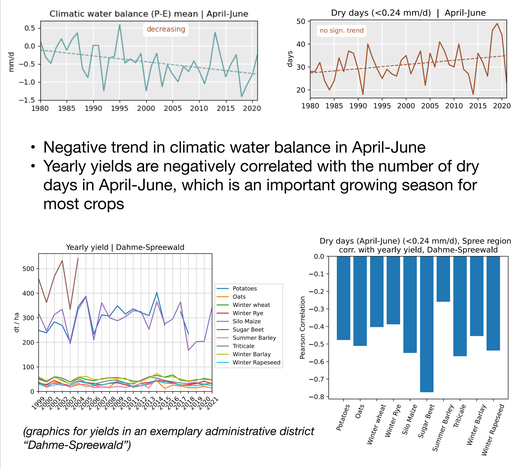


Number of periods of at least 5 consecutive dry days in a year

Maximum number of consecutive dry days in a year

- Simple statistical drought measures can give some insights, but are not specific enough for most use cases

5. Exemplary application: agriculture



(graphics for yields in an exemplary administrative district "Dahme-Spreewald")

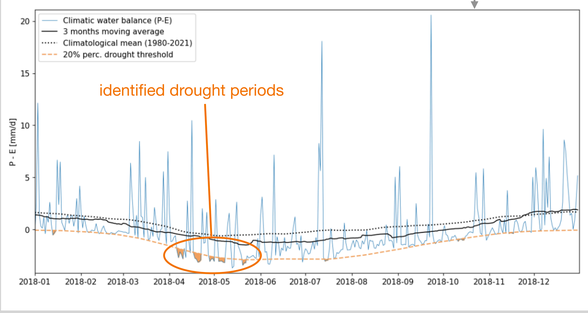
- Negative trend in climatic water balance in April-June
- Yearly yields are negatively correlated with the number of dry days in April-June, which is an important growing season for most crops

6. Drought identification and detection tool

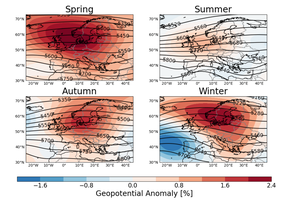
- in development -

- **Input**: Time series of climatic water balance
- Tool identifies drought periods based on drought threshold (a percentile of the smoothed daily climatological mean, in this example 20%), allowing a certain number of days where the threshold is not reached as gaps
- **Output**
  - Detected drought periods
  - Many parameters possible: beginning/end, duration, intensity, mean, minimum, precipitation sum, deviance from climatological mean, …
- Parameters (drought threshold percentile, maximum number of gaps, examined season, …) are set dependent on needs of the user, e.g. for a certain crop it would be beneficial to only examine its growing season and set the other parameters according to the water needs of the crop

…open to suggestions and ideas! *(also for the visualization)*



7. Large-scale weather context



Graphic: P. Schönau, Freie Universität Berlin

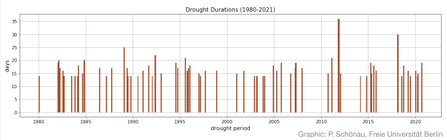
ERA5 500 hPa geopotential relative anomaly of driest (below 5th percentile of monthly precipitation anomalies) months in the study region and isohypses of all months, 1959-2020

Investigation of large-scale weather patterns leading to local drought in the study region

500 hPa geopotential height

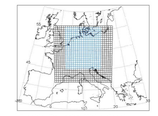
- Anti-cyclonic pattern in "dry months" in all seasons
- High-pressure ridge in "dry months" in all seasons except summer

Objective weather type classification



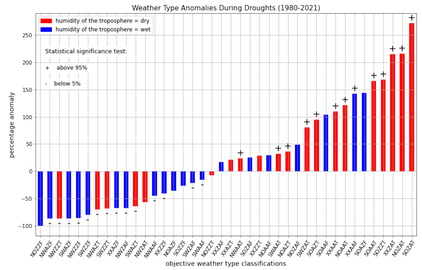
Graphic: P. Schönau, Freie Universität Berlin

Drought periods (<1 mm/d of precipitation for at least 14 consecutive days)



Graphic: Deutscher Wetterdienst

Classification area of the "Objective weather type classification" by Deutscher Wetterdienst



Graphic: P. Schönau, Freie Universität Berlin

Percentage anomalies of the occurrence of each weather type during drought periods

1. Use simple drought period definition to identify drought days (once the drought identification tool is finished the resulting drought periods will be used)
2. Analyze occurrence of weather types ("Objective weather type classification" by Deutscher Wetterdienst) during drought days

8. Identification of drought predictors / drought forecast

- planned -

- Identify meteorological predictors for drought using a machine learning model which automatically selects predictor variables and regions yielding the highest (drought index) forecast skill, taking into account preliminary meteorological conditions and the evolution of meteorological variables (persistence, succession, frequency)
- Forecast drought index, for different forecast lead times

Meteorological variables serve as predictors (input)

Machine learning model based on k-nearest neighbors algorithm

Drought index (output)

Graphics: C. Hauke, 2021, "Prediction of the North Atlantic Oscillation Index […]"

Schematic of drought index prediction with a machine learning model

9. Analysis of drought predictability

- planned -

- Analyze predictability of weather patterns related to drought for forecast lead times from weeks to months
- Assess forecast skill of drought in the Spree region with seasonal forecast system ensemble-hindcasts (GCFS by Deutscher Wetterdienst)
- Examine how lead time affects uncertainty
- Investigate specific situations with above-average predictability w.r.t. weather patterns (persistent weather patterns, successions of weather patterns, …)

10. Estimate future development

- planned -

- Estimate future occurrence probabilities of relevant drought events and the associated uncertainties on the basis of available model calculations of decadal climate predictions and climate projections
- Determine dependence on lead time (for decadal predictions)