Drought Detection Methods in Comparison

M. J. Tran

justin.tran@haw-hamburg.de

Hamburg University of Applied Sciences (HAW) Hamburg, Department Informatik, Berliner Tor 7, 20099 Hamburg, Germany

MOTIVATION & PROBLEM DEFINITION

The summer months in Germany experience persistent dry spells, which become more severe from year to year. **Not only animals but also people are directly affected** by low water levels and crop failures[1]. In order to develop and apply measures against droughts, it is important to know when droughts have occurred in the past and when they will occur in the future.

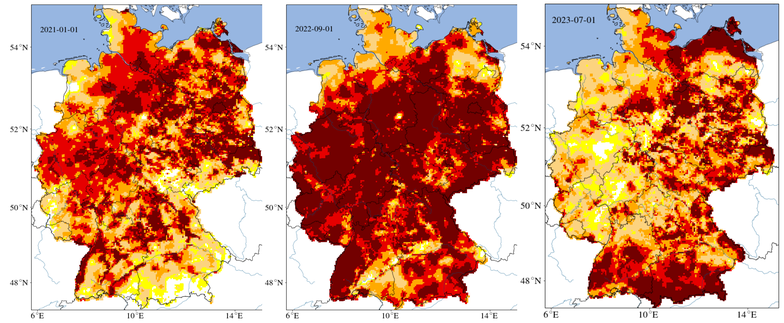

Figure 1. Dry periods in Germany in Jan 2023, Sep 2022 and Jul 2023 (*left to right*)[2]

As can be seen in Fig. 1, droughts can occur at different times with different intensities depending on the location which makes this topic complex. Used methods must reach a high accuracy.

REQUIRED DATA

Satellite imagery plays a crucial role in generating **remote sensing indices**, which are key tools in identifying indicators of droughts, such as dry soil and poor vegetation health. Indices like the 'Normalized Difference Vegetation Index' (NDVI) and 'Soil Moisture Index' (SMI) are used to identify and quantify potential deficits in **rainfall and soil moisture**, helping to detect and evaluate the severity of drought conditions.

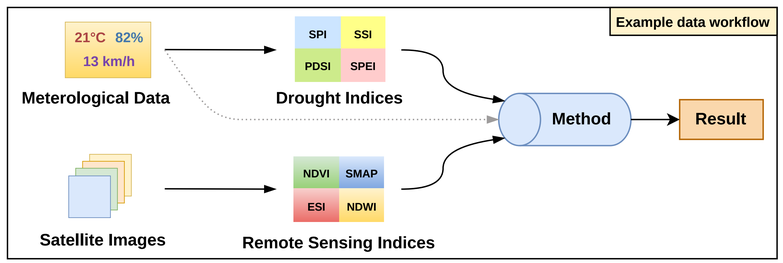

Figure 2. Shows how the data is generated and how it is used.

Using **meteorological data** provides information like precipitation, temperature and evapotranspiration rates. The 'Standardized Precipitation-Evapotranspiration Index' (SPEI) is an example of a **drought index** and on how the just mentioned values can lead to a detection of a drought event. The question is: can you detect drought using only remote sensing indices?

RELATED WORK'S METHODS

Three different methods of related work are being investigated to find out which method provides the most reliable results.

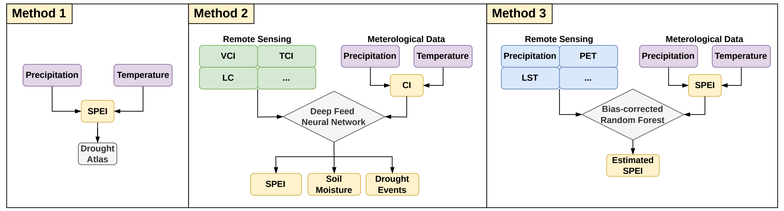

Figure 3. Drought detection methods by Chuphal et al.[3], Shen et al.[4] and Feng et al.[5](*left to right*)

Chuphal et al.'s [3] method (*Method 1 in Fig. 3*) uses meteorological data for drought index calculation. **Shen et al.** [4] (*Method 2 in Fig. 3*) employs remote sensing indices. **Feng et al.** [5] (*Method 3 in Fig. 3*) uses a bias-corrected random forest algorithm for drought index estimation.

OBJECTIVES & CHALLENGES

Enhancing the **Drought Early Warning System (DEWS)** [6] involves comparing drought prediction methods to choose the most accurate for integration. Key aspects include:

- **High Accuracy**: Ensuring reliability by comparing with existing results.
- **Method Comparison**: Conducting experiments in Germany and comparing outcomes using historical data.
- **Ongoing Training**: Updating methods with the latest satellite and meteorological data.

METHOD COMPARISON

To evaluate accuracy, meteorological and remote sensing variables are input into the method, with a focus on the **SPEI used by the German weather service** [7]. Outcomes are compared to high-accuracy SPEI results. This workflow is illustrated in Figure 4.

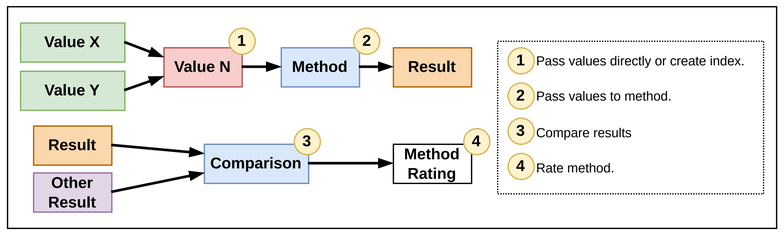

Figure 4. Example workflow from passing of values to the method rating.

Comparing methods is vital for real-world reliability. It will identify the most suitable method for the German climate out of the three methods. E.g. a min. 90% match with the high-accuracy results could indicate the method precision.

EXPECTATION

It is to be expected that the **Deep Feed Neural Network** and the **Bias-corrected Random Forest** will calculate an approximate but not the exact value compared to the meteorological calculation method.

Since the authors achieved satisfactory results in their comparison and in their region it is expected to **achieve similar satisfactory results**. However, there are some drought detection methods that are only applicable in certain regions. It will be interesting to find out whether these methods can be used in Germany.

It is also expected that at least method 2 [4] will be carried out slightly modified, as it is not too efficient to use a drought index such as the CI to calculate the SPEI drought index.

SYSTEM ENHANCEMENT

This project utilizes the DEWS' datahub [6]. The DEWS datahub allows users to **upload satellite data archives** or **retrieve it via an satellite image API**.

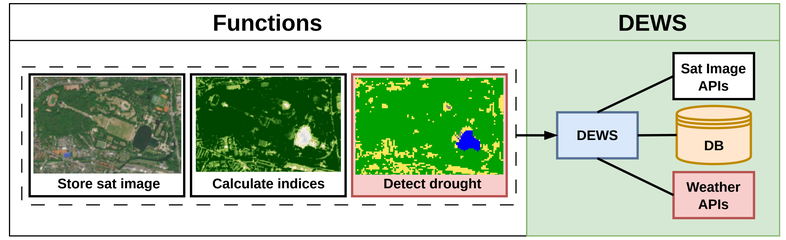

Figure 5. Planned DEWS additions in light red. Existing features in other colors.

For enhanced analysis, **meteorological data** corresponding to each satellite image could be essential. This data will be acquired individually for the specific area covered in each satellite image through a weather data API. If a method detects drought extremely accurately only using remote sensing, the meterological data could also be left out.

REFERENCES

[1] Bundesministerium für Bildung und Forschung. Drought in Germany: research, solutions, adaptation, 2022. https://www.bmbf.de/bmbf/shareddocs/kurzmeldungen/de/2022/08/duerre-und-trockenheit-in-deutschland.html.

[2] UFZ Helmholtz. Droughts since 2014, 2023. https://www.ufz.de/index.php?de=40990.

[3] Chuphal et al. Drought Atlas of India, 1901-2020, 2024. https://doi.org/10.1038/s41597-023-02856-y.

[4] Shen et al. Construction of a drought monitoring model using deep learning based on multi-source remote sensing data, 2019. https://doi.org/10.1016/j.jag.2019.03.006.

[5] Puyu Feng, Bin Wang, De Li Liu, and Qiang Yu. Machine learning-based integration of remotely-sensed drought factors can improve the estimation of agricultural drought in South-Eastern Australia, 2019. https://doi.org/10.1016/j.agsy.2019.03.015.

[6] Minh Justin Tran. DEWS DataHub, 2023. https://github.com/JustinTrvz/drought-ews.

[7] Deutscher Wetterdienst. Wetter und klima - deutscher wetterdienst - Übersicht - standardized precipitation evapotranspiration index (spei), 2024. https://www.dwd.de/DE/fachnutzer/landwirtschaft/dokumentationen/agrowetter/spei.html.

[8] E. Fadaei-Kermani et al. Drought Monitoring and Prediction using K-Nearest Neighbor Algorithm, 2017. https://doi.org/10.22044/jadm.2017.881.

[9] Lotfirad et al. Drought monitoring and prediction using SPI, SPEI, and random forest model in various climates of Iran, 2022. https://doi.org/10.2166/wcc.2021.287.

[10] Mokhtarzad et al. Drought forecasting by ANN, ANFIS, and SVM and comparison of the models, 2017. https://doi.org/10.1007/s12665-017-7064-0.