

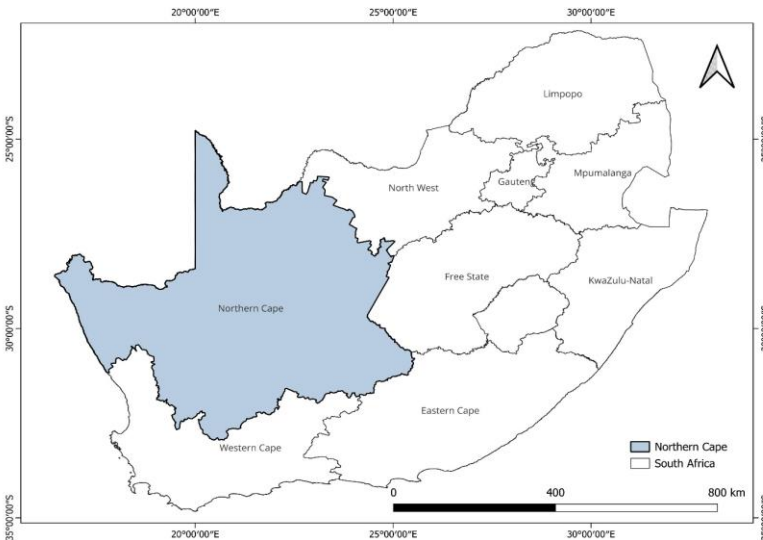
Validation of CHIRPS and ERA-5 Derived SPI and SPEI for Drought Monitoring and Characterization Using Ground-Based Meteorological Station in Arid Landscape

Background

Drought is a recurrent hazard in arid and semi-arid South Africa, threatening water resources, ecosystems and socio-economic activities. The Northern Cape is particularly vulnerable because of low and variable rainfall, high evapotranspiration, and rising temperatures. Ground stations provide accurate point observations but have limited spatial coverage and can be affected by uneven distribution or malfunction.

Aim: Validate Google Earth Engine-derived SPI and SPEI against ground-based observations, compare performance across 3-, 6-, and 12-month timescales, and assess their suitability for drought monitoring.

Study Area Map



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DATA & METHODOLOGY

Study area: Northern Cape Province, South Africa

Period: 2013-2023

REMOTE/CLOUD DATA

- CHIRPS monthly precipitation
- ERA5-Land potential evapotranspiration
- Processing in Google Earth Engine (GEE)

GROUND OBSERVATIONS

Department of Water and Sanitation stations:

Brandvlei, Calvinia, De Aar, Kathu, Kimberly and Pofadder.

DROUGHT INDICES

SPI and SPEI

VALIDATION

- Correlation
- RMSE
- MAE

RESULTS

SPI validation

- Moderate to strong agreement with station observations.
- Performance generally improved from SPI-3 toward SPI-12.
- Brandvlei showed the strongest agreement.
- Calvinia performed poorly at shorter timescales but improved at SPI-12.
- SPI R^2 reached up to 0.88.

SPEI validation

- Outperformed SPI across stations and timescales.
- R^2 ranged from 0.95 to 0.99.
- Strongest performance was particularly evident at SPEI-3 and SPEI-6.
- Errors were generally minimal.

Spatial Patterns

SPI

- **SPI-3:** western and southwestern areas are mostly moderately dry to very dry; central/eastern areas are near-normal to moderately wet.
- **SPI-6:** dry conditions expand across central, northern, and eastern areas.
- **SPI-12:** long-term drought becomes evident in central, northern, and eastern regions.
- Drought severity increases with longer accumulation periods.

SPEI

- Western and southwestern areas remain wetter.
- Central to northeastern areas show stronger dry conditions.
- A consistent west-east gradient is evident.
- Eastern and central regions show greater drought persistence and severity.

Conclusions & Implications

- CHIRPS- and ERA5-Land-derived drought indices captured drought variability and aligned well with ground observations.
- SPEI consistently outperformed SPI, particularly in semi-arid conditions, because it incorporates evapotranspiration.
- Drought severity and persistence were strongest during 2015–2020, followed by wetter conditions after 2021.
- Central and eastern Northern Cape were more vulnerable to prolonged drought than the west.
- GEE-derived indices offer a practical approach for drought monitoring in data-scarce environments.
- Future work should integrate additional drought indicators and climate datasets to strengthen assessment and forecasting.