Seasonal predictions of agro-meteorological drought indicators for the Limpopo basin

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Abstract

The rainfall in Southern Africa has a large interannual variability, which can cause rain-fed agriculture to fail. The staple crop maize is especially sensitive to dry spells during the early growing season. An early prediction of the probability of dry spells and below normal precipitation can potentially mitigate damages through water management. This study investigates how well ECMWF's seasonal forecasts predict dry spells over the Limpopo basin during the rainy season December-February (DJF) with lead times from 1 to 5 months. Seasonal forecasts were evaluated against ERA-Interim reanalysis data which in turn was corrected with GPCP (EGPCP) to match monthly precipitation totals. The seasonal forecasts were also bias-corrected with the EGPCP using quantile matching as well as post-processed using a precipitation threshold to define a dry day as well as spatial filtering. The results indicate that the forecasts show skill in predicting dry spells in comparison with a "climatological ensemble" based on previous years. Quantile matching in combination with a precipitation threshold improved the skill of the forecast, whereas a spatial filter had no effect. The skill in prediction of dry spell was largest over the most drought-sensitive region. Seasonal forecasts have potential to be used in a probabilistic forecast system for drought-sensitive crops, however these should be used with caution given the large uncertainties.

Study area

The Limpopo basin (22-25°S, 27-32° E) land use is governed by croplands, in particular in the downstream (i.e. eastern) part of the basin (Figure 1). Most of these croplands are rain-fed or rely on the scarce and over-committed surface water resources. The climate is characterized by extremely variable rainfall, resulting in a mixture of very dry years and years with floods. Rainfall concentrates in one rainy season, largely controlled by the Inter-Tropical Convergence Zone which means that most of the rainfall is received in the December–January–February (DJF) months

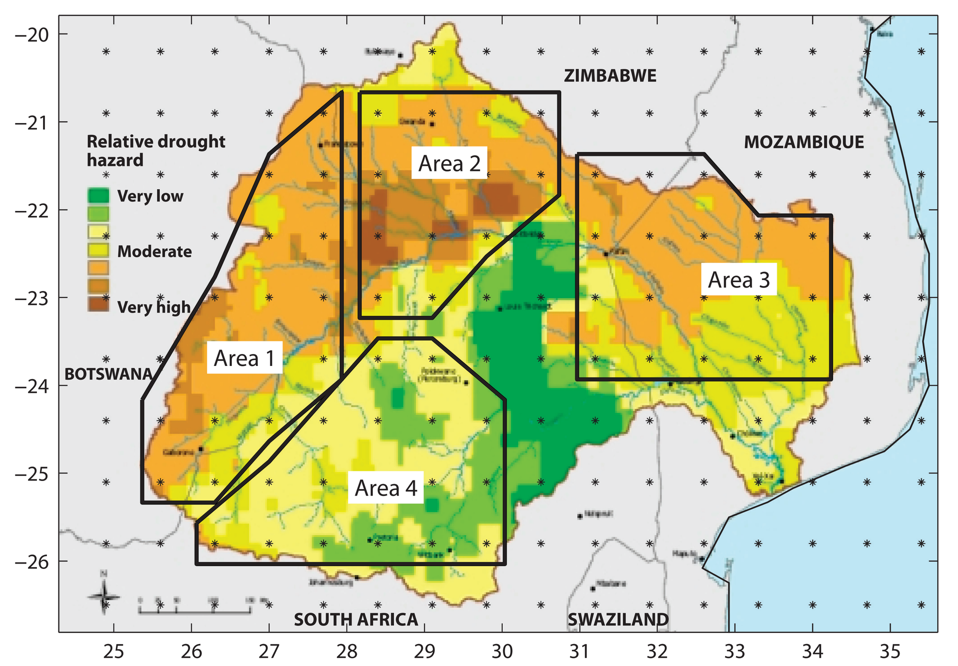

Figure 1 Areas of drought hazard for the limpopo basin. The 4 areas are characterized by their sensitivity to droughts, ranging from low/moderate to Very high/High. The underlying maps are from from *Muñoz Leira et al.* (2003). The grid points denote the grid points of SYS4.

Precipitation bias correction

The data used was:

- ECMWF reanalysis data ERA-Interim (ERAI) from 1979-2010
- ECMWF System 4, 50-member seasonal forecast with a lead time of 7 months (SYS4)
- Global precipitation climatology project v2.1 (GPCP)

ECMWF's reanalysis and seasonal forecasts suffer from biases in precipitation, and through post-processing some of these biases can be removed. Firstly, the mean seasonal bias of the reanalysis (ERAI) was removed by adjusting the monthly means to match the GPCP data. The corrected data set is referred to as EGCP. Secondly, the SYS4 data was corrected though quantile matching with EGCP (Figure 2).

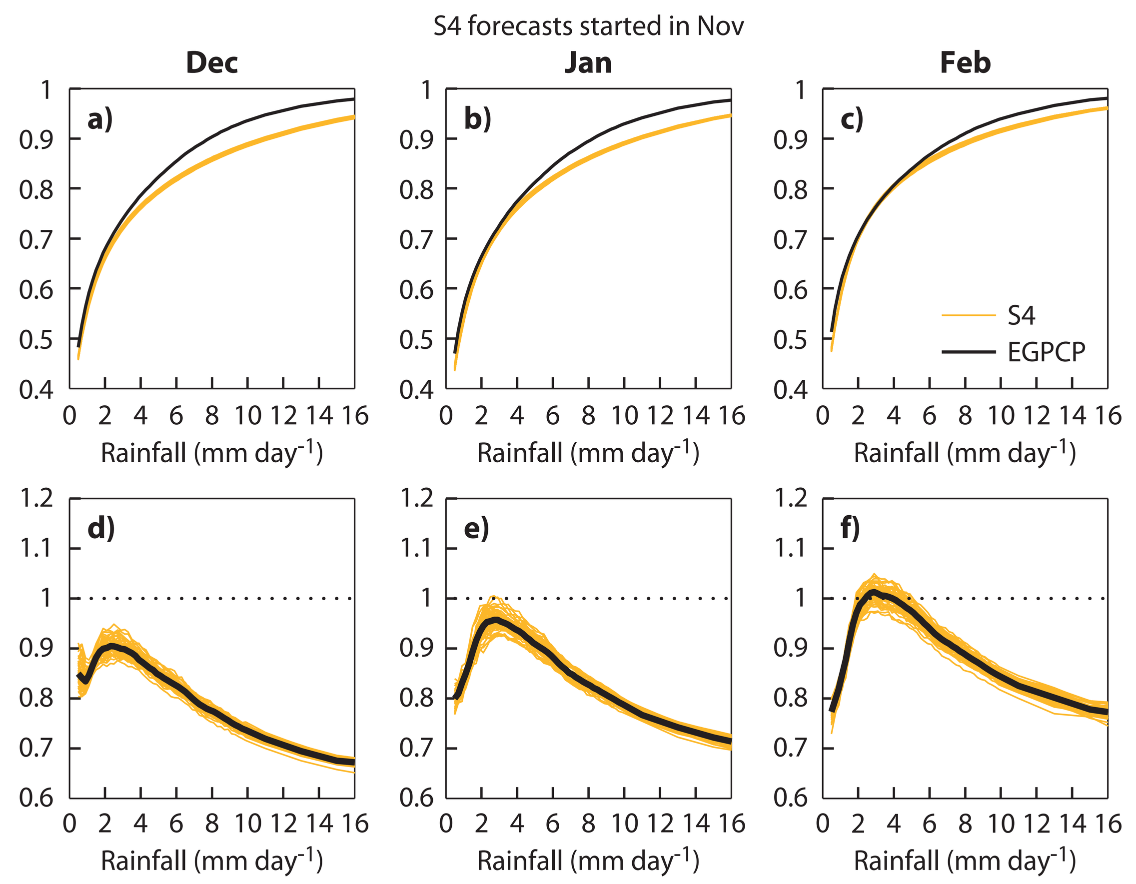

Figure 2 Cumulative density function (CDF) (a-c) of daily precipitation from EGPCP (black) and SYS4 forecasts started in November (yellow lines from the bootstrapping sampling) valid for December (a), January (b) and February (c). Quantile match coefficients applied to correct SYS4 forecasts (black mean, yellow bootstrapping range) started in November and valid in December (d), January (e) and February (f). The represented CDFs and quantile match coefficients were averaged over the region: [27E to 32E; -22N to -25N].

Seasonal forecasting of dry spells

The raw and corrected forecasts were then used to predict dry spells over the Limpopo basin for the rainy season (DJF) with lead times ranging from 1-5 months. Different thresholds to define a dry spell (above a certain rainfall amount in mm) and spatial averaging of the forecast were used to further test the predictability of dry spells. Spatial averaging had little effect, but applying a precipitation threshold had a positive effect on the skill scores (Figure 3). From this figure it is also clear that the bias correction of the forecast improves the skill.

There is also a spatial pattern in the skill of the forecast, where area 2 and 3 (the northernmost) has a higher skill than the southern and western part of the catchment (Figure 4). After bias correction, the difference between the areas is less pronounced (Figure 5). the areas which are most drought sensitive are also the areas where the forecast performs best.

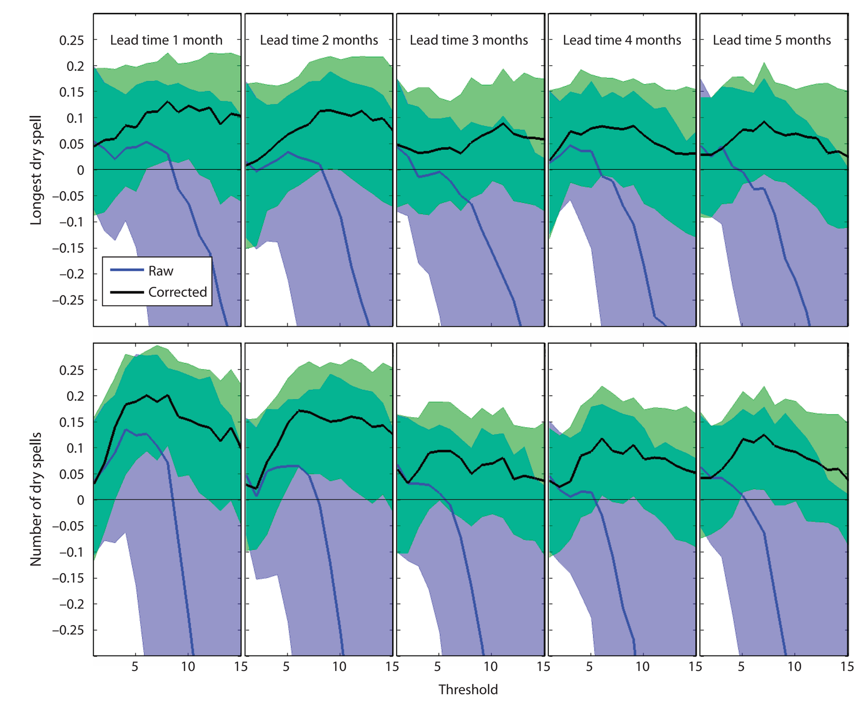

Figure 3 CRPSS as a function of precipitation thresholds for different lead times over the Limpopo catchment. Top panel shows the results for the longest dry spell over the rainy season, and the bottom panel the number of dry spells over the rainy season. The blue line denotes the raw forecast, and the black line the bias-corrected. The blue (green) areas denote the 5 to 95 spread of the raw (corrected) forecasts respectively.

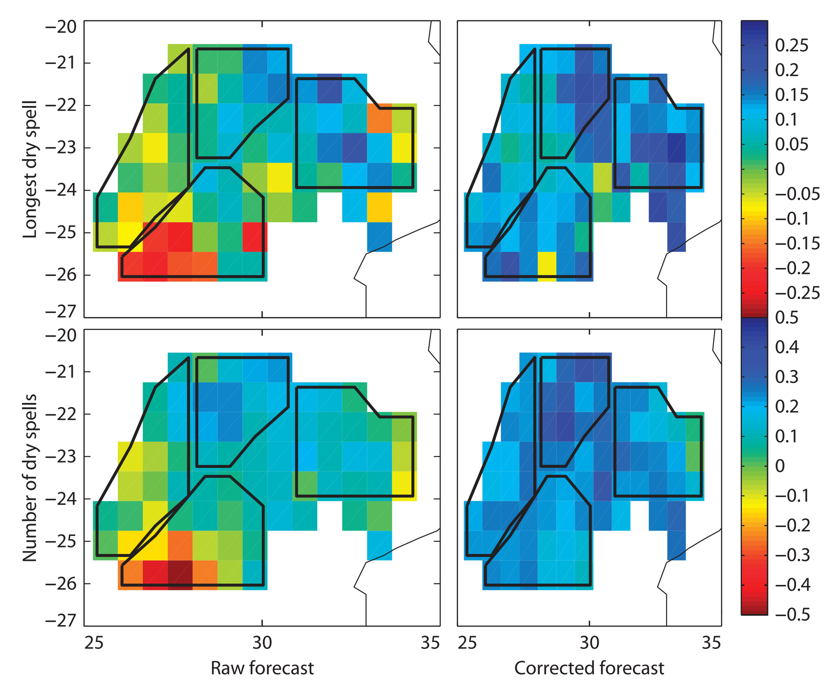

Figure 4 CRPSS for the different areas over the Limpopo basin. Blue colors denote a good forecast. The results are with no area filtering and with a precipitation threshold of 5mm for the lead time of 1 month.

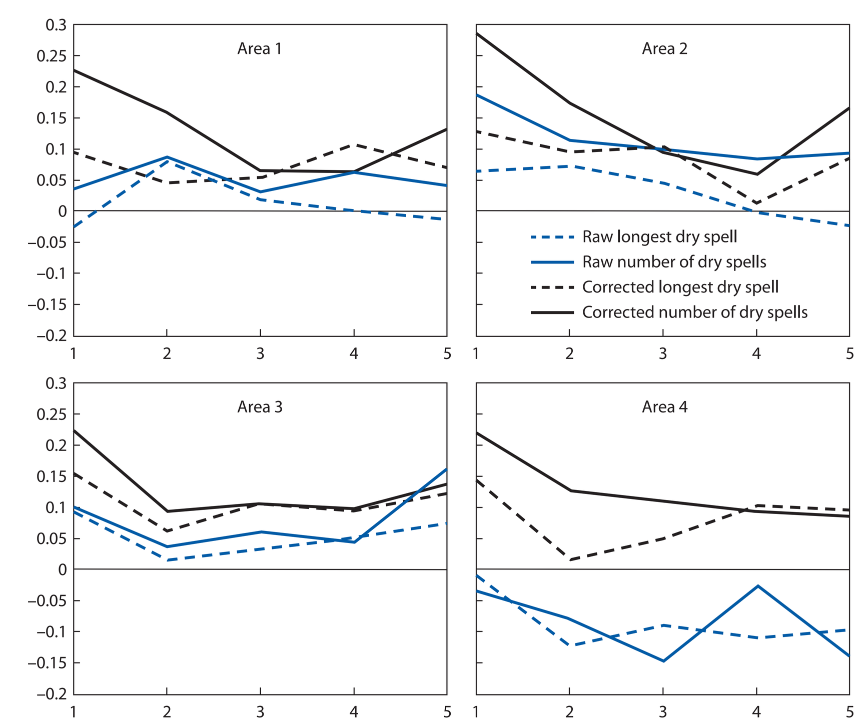

Figure 5 CRPSS as a function of lead time for the 4 areas in the Limpopo basin

Conclusions

The results show that the raw forecasts are improved by using a threshold to define events in combination with quantile matching of the forecast. This shows the potential value of using seasonal forecasting of dry spells for agricultural planning, and that post-processing increases the potential predictability of the forecasts. In order to assess the full added value of a forecasting system it would need to be tested as a decision support tool by local stake holders.

Acknowledgments

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SEVENTH FRAMEWORK PROGRAMME

DEWFORA

Reference

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