

Interactive comment on “Hydrological drought forecasting and skill assessment for the Limpopo river basin, Southern Africa” by P. Trambauer et al.

Anonymous Referee #1

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Overview

The paper describes the potential for seasonal ensemble hydrological and drought forecasting over the Limpopo River basin in southern Africa. Three methods were applied to provide the seasonal meteorological forecasts that were used to force the PCR-GLOBWB hydrological model at a 0.05×0.05 degree spatial resolution and a daily time step. A historical simulation was carried out (1979–2010) using meteorological forcings from ERA-Interim that has a horizontal resolution of 0.7 degrees that were biased corrected using GPCP v2.1 monthly climatological data provided at a 2.5×2.5 degree resolution. This reference run was used to provide the hydrological initial conditions at each forecast time. Ensembles of seasonal forecast were made based on the ECMWF S4 system (15 ensemble based hindcasts), the Ensemble Streamflow Prediction (ESP)

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method and ESP conditioned on the ENSO index. Forecast skill is measured using standard skill metrics (ROC, BS).

Overall the underlying work is solidly carried out and the results informative as they show for the Limpopo basin that dynamical seasonal forecasting offers the most skill in predicting seasonal drought metrics (SPI, SRI), followed by ESP conditioned on ENSO. As expected, shorter lead times and smaller regions show less skill.

The biggest shortcomings in the paper is that important, but practical, details are omitted, and, in general, the written English is sufficiently weak to make the paper difficult to read – incorrect verb tenses, conditional phrases in the middle of sentences (and not off-set by commas), split infinitives, etc.

As for missing details, most are identified in the specific comments below but the following seems fundamental in helping readers understand the study. 1. There is a scale difference between the meteorological forcings (and forecasts) and the hydrological model. Were the forcings downscaled in time or space? If so, how was this done? If not, what are the consequences of this for both the study and for practical implementation? 2. The description of the weightings for the ESP_cond ensemble generation is poorly described. 3. The number of ensembles for the ECMWF_S4 hindcasts is 15 – is that how many were used in the FS_S4 runs (never well stated)? For ESP 30 ensembles were “created”. Can the authors comment on the effect of the reduced S4 ensemble size on the study results? I think that if the paper is augmented with additional information that can help the reader understand the details of the study, and be properly edited for English to make is more readable, then it is very appropriate for HESS and can be a valuable contribution to the seasonal forecasting literature.

Specific Comments

P9963: There are statements in the introduction that require (or should be supported) by more references. As an example: “Climate change studies show evidence of an intensification of the global water cycle (Huntington, 2006), where extreme events in-

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cluding floods and droughts are expected to become more frequent.” Given the recent focus on the issue of historical and projected changes in floods and droughts, only citing the paper of Huntington seems a little brief. Also the statement (P9963/L 8-10) that seasonal forecasting hasn’t been applied widely in drought predictions fails to recognize that NCEP has a drought monitoring (multi-model) system as well as a seasonal hydrological forecasting system running at EMC, and the NMME is widely focused on seasonal prediction of meteorological drought (as a programmatic focus of the NMME experiment). So the introduction needs to be more reflective of what’s really happening, and to cite the papers that are reporting this work.

P9968/L18. Are the dates correct? September 2009 to December 2010? Should this be 1979-2010?

P9966/L10 “It is, however, unreliable, causing frequent droughts and floods also commonly occur in the rainy season.” Awkward sentence. Restructure the English

P9970/L1 Additional information of when/how the ECMWF ensemble forecasts are generated, would help the readers. Are they all generated at the beginning of the month, or are they distributed throughout the month? As used, are they monthly averaged Tmax, Tmin and total precipitation, or daily forecasts out to 6 months? If hindcasts that were used are monthly mean forecasts, how do you downscale to a daily time step for the hydrological modeling? Or spatially downscale to the fine resolution of the hydrological model? If the ESP (ESP_cond) forecasts use 30 ensemble members, how many does the S4 procedure use given that the ECMWF hindcasts have only 15 members?

P9971/L18-19: By “multi-annual mean of precipitation” I assume you are referring to the precipitation climatology in both the base data set and hindcast data set. Using “climatological” distribution is more standard terminology.

P9971/L25-26. Are the problems with the ECMWF hindcasts/forecasts related to “other problems of the forecasts such as inter-annual variability, ensemble spread or daily

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variability” discussed? They need to be.

P9973. Section 2.2.3 is not well written. The procedures for determining the weights must be clarified. For example, the equations for the parameters β and α need to be provided. On what basis were their values determined? Given the values, what are the weight assigned to the sorted years adjacent to the current year’s ONI? Basically as written, readers will find it difficult to fully understand what was done in the study. Also, given a record of 30 years to generate a 30 member ensemble (by sampling with replacement) on average how many duplicate years occurred on average?

Section 2.3.3. The uncertainty in the skill scores are computed by a bootstrap method where the ensembles are resampled (with replacement). This implies that you’d never get an ensemble member different than one already forecast (or in the case of ESP) previously observed meteorology. What is the impact of this on the uncertainty estimates? For ESP this could be assessed by using a longer data set than 30 years but only generating a 30 member ensemble.

P9976/L20. The “root stress” isn’t defined, so readers won’t know how this drought metric has been computed.

P9978/L1-2. Please explain more clearly the difference between “The mean runoff season and high runoff season”.

P9978/L15+ I’m somewhat confused by how the forecast system is being evaluated. Earlier (pg 9977) there is a discussion that the reservoir level provides a decision metric as to curtailing irrigation so that would be the target for the ROCS and BS forecast metrics (P9977/L17-18). On P9978/L15 it appears that river flows (SRI) and not reservoir levels will be the variable to be used in assessing the forecast system.

P9980/L19. It appears (from the wording) that the water level analysis assumes a virtual reservoir in each grid, which makes no sense. But figures 8 and 9 seem to indicate there are a number of reservoirs across the basin (the circles). If these are

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reservoirs, then it would be useful to indicate them on figure 2, where only Tzaneen dam is shown. The description of the reservoir forecast analysis needs to be clarified and written more clearly. The general discussion of reservoirs and some reference to the Tzaneen dam makes the section confusing and rather weak.

P9981/L27, P9982/L1-2 Figure 10 should also show the “verification” data (i.e. the simulated reference discharge that is your surrogate for the observed streamflow) that actually occurred during the forecast period.)

P9981/L12. I think the weak response described here should be attributed to atmospheric noise” and not to “different climate forcings”.

P9984/L26-28. Sentence as written is rather awkward. Perhaps “Maps of spatially distributed ROCS and BSS show, throughout the basin, skill higher than climatology (ROCS > 0.5, BSS > 0) for the FS_S4 forecast that agricultural droughts and water levels will to be lower than the 50 and 37.5 percentiles.”

P9985/L11 Sentence “It is recommended that as a next step the forecast skill of the FS_S4 and FS_ESPcond is assessed in an actual forecasting mode for the following summer season.” Poor English; wrong verb tense. Try “As a next step, it is recommended that the forecast skill of the FS_S4 and FS_ESPcond be assessed in an actual forecasting mode for the following summer season.”

P9985/L14. What kind of data assimilation. What would be the source of the information?

P9984/L13, L15. On line 13 it is suggested that S4 can be obtained in real-time, yet in line 15 it is stated that a limitation to S4 is its access. So is the earlier statement speculation? If so these sentences need to be edited for clarity for what is and is not available.

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