Natural Hazards and Earth System Sciences Discussions

Nat. Hazards Earth Syst. Sci. Discuss., author comment AC3
https://doi.org/10.5194/nhess-2021-223-AC3, 2022

Reply on RC2

Edward E. Salakpi et al.

Author comment on "Forecasting vegetation condition with a Bayesian auto-regressive distributed lags (BARDL) model" by Edward E. Salakpi et al., Nat. Hazards Earth Syst. Sci. Discuss., https://doi.org/10.5194/nhess-2021-223-AC3, 2022

Reviewer 2

This paper proposes a new model for forecasting the vegetation condition index (VCI) based on a Bayesian autoregressive distributed lag (BARDL) model. The new model can provide the probability distribution of VCI instead of a deterministic value. In a forecasting framework, it is clear that the BARDL model can improve the current methods, as supplying a probability distribution is crucial for decision making. The BARDL model is applied to a set of counties in Kenya with arid and semi-arid conditions. VCI is forecasted from the available information about precipitation and soil moisture content, considering the current information about drought conditions. The new BARDL model is compared with the results obtained by using a deterministic AR model. The comparison is based on a set of measures that quantify both accuracy and precision. The paper offers a new method that can overcome some limitations of the current models to forecast droughts. However, the paper needs to address the comments included below before accepting it for publication.

General comments

The paper uses the vegetation condition index (VCI) to forecast droughts in Kenya. However, other indices are available like SPI, SPEI, PDSI, multi-variate standardised dry index (MSDI), the temperature condition index (TCI), the vegetation temperature condition index (VTCI), and the temperature vegetation dryness index (TVDI), among others. A discussion could be included in the paper to support the selection of VCI in the paper.

Response: The work done in this paper was in partnership with the national drought monitoring authority (NDMA) in Kenya who are currently using VCI for monitoring drought. They have used the indicator extensively for their monthly drought reports and bulletins. In our attempt to introduce a forecast model as an additional information for bulletins, we did not want to propose a new index to them.

The Introduction Section focuses on three existing techniques to forecast VCI: Auto-

Regression, Gaussian Processes and Artificial Neural Networks. A longer revision of the techniques used in last years to develop EWS for droughts could be included in this section, as well as other papers that develop similar tools. For example, stochastic algorithms based on different types of Markov Chains, autoregressive moving-average (ARMA), autoregressive integrated moving average (ARIMA) techniques, support vector machines, Kalman filters, multiple regression tree techniques, among others, have been used in last years to forecast droughts.

Response: Comment well noted, the section on existing works that use similar tools will be updated with cited papers.

While the BARDL algorithm supplies a probability distribution, the AR model supplies a deterministic value. Therefore, the comparison between the two models is not straightforward. In the paper, a confidence interval for the AR model is estimated from RMSE and z-score. However, this is a simplified way to estimate the prediction uncertainty, supplying a constant confidence interval regardless the magnitude of both VCI and the explanatory variables. This step is very important to compare BARDL results with AR results in a proper way. In addition, the methodology to compare both models should be clarified in the paper, as it is not clear how most of measures used to quantify accuracy and precision have been applied to the probabilistic forecast supplied by BARDL.

Response: Thanks for this comment, the results from the AR model was compared to the means (average) of the forecast distribution obtained from the Bayesian model. We realise this explanation is missing in the paper and will be addressed accordingly together with additional comments.

The Discussion Section should be rewritten, as in its current form it is mostly a mixture of conclusions with some additional results considering seasonality.

The Conclusions Section could be extended to summarise the main findings of the study.

Response: Comment accepted and well noted, the discussion will be restructured so it does not come across as being incoherent. The conclusion will also be rewritten.

Specific comments:

Abstract: Some sentences could be included in the abstract about the case study used in the paper.

Response: Comment accepted and will be fixed

14: The acronym AR has not been introduced in the paper at this point yet.

Response: Comment noted and will be fixed

30: The acronym USAID is not introduced in the paper and could be explained at this point.

Response: Comments noted and will be fixed

46: The ARDA model has been applied to assess droughts previously, such as Zhu et al. (2018). References to previous studies in which the ARDA technique is applied to droughts should be included in the paper.

Response: Well noted will be considered, however, the paper focused on Hydrological Droughts in river basins and not vegetation conditions.

51: The paper proposes the use of a Bayesian framework in the ARDA model to incorporate the prior knowledge about model parameters in the analysis, obtaining a probability distribution for VCI results. Bayesian networks have been also applied to develop a long-term drought forecast (Shin et al., 2019), supplying probabilistic results that can assess forecast uncertainties. A discussion could be included in the paper, stating the benefits of a BARDL model compared to Bayesian networks.

Response: Comment noted and will be considered however, the results in this paper are also for Hydrological drought and not comparable to agricultural drought indicators.

Section 2.1: Some information about the number of counties considered in the study could be included in this section, as well as the number of counties that are arid and semi-arid. In addition, some information about the area in km2 that is considered in the study could be useful for the reader.

Response: Comment accepted and well noted, more details on this will be included

70: 'estimates' should be changed to 'estimate.

Response: Comment well noted and will be fixed

98-99: The description of NVIi and NDVIi variables should be included in this paragraph too.

Response: Comment well noted and will be fixed

103-104: 'long term' should be changed to 'long-term'.

Response: Comment well noted and will be fixed

111: The acronym AR has been introduced in the paper above.

Response: Comment well noted and will be fixed

118: A discussion could be included about the selection of the OLS method for estimating parameters of ARDL. Some other methods are also available.

Response: Comment not too clear because OLS was not used for the ARDL in this paper.

131 – Eq. 3: The variable subscripts should be revised in Eq. 3. Dt-q seems to be the drought indicator in a constant time step t-q, which seems to be constant in the first summation regardless the value of i. Similarly, Pt-p and St-p seem to be constant values in the summations. In addition, the regression coefficients are also constant values in the summation, though they could change in terms of i. A discussion should be included about the use of constant values in summations.

Response: Comment well noted and will be fixed

137 – Eq. 4: How does Xt-i represent several variables? How can i vary from 0 to i?

Response: Comment noted, these subscripts represent lagged order of the input variables, but it will be amended to make it clearer in the paper

143-146: The variable theta should be explained to readers in this paragraph.

Response: Comment well noted and will be fixed

145-146: The term P(Xt) is ignored because it is difficult to compute. This is not a proper statement for ignoring a variable in a research paper.

Response: Comment noted this statement will be better explained

152-154: An analysis should be done to fix the distribution function that best characterises the regression parameters. Why mu is set to 0 and sigma to 0.5?

Response: This parameter was selected after the model optimisation (grid search) process was done. Thes 'mu' and 'sigma' were selected because these parameters gave the best forecast results and with minimum error. This will be better explained in the paper

153-154: Something is missing in this sentence.

Response: Comment noted and will be fixed

164: This is not the standard form of AIC.

Response: Comment noted and has been fixed

161-163: Some figures could be included in the paper to show how a time lag of 6 weeks obtains the best AIC and R2 results.

Response: Comment noted, the figures will be added

168: What is i? What is y hat?

Response: Comment noted these will be explained

176: The R2 measure of Eq. 9 is not a good measure to quantify accuracy of forecasts.

Response: We considered the R2 score for the work because in addition to the knowing deviation of the forested values from observed values (RMSE) we also needed to test the goodness of fit or the variation in dependent variables captured or explained by the model.

188-189: What is m?

Response: Comment noted and will be fixed

196: 'inputs' should be changed to 'input'.

Response: Comment noted and will be fixed

213: How r, R2 and RMSE are calculated for the BARDL model? The BARDL model supplies a probability distribution, but observations are deterministic.

Response: To determine these metrics the mean of the forecast probability distributions were used. This will be made clear in the paper.

214: R2 is not a good measure of forecast accuracy. RMSE is more adequate than R2. Therefore, the gain in performance metrics could be assessed with RMSE. However, the BARDL model supplies a probability distribution of VCI. How do you obtain a RMSE value from the comparison between probability distributions and deterministic values of observations?

Response: We used the R2 because we needed to test the goodness of fit and the variation in dependent variables captured or explained by our model. The R2 and RMSE values were determined with the means (Average) of the forecast probability distribution.

Figure 3: What do the coloured lines mean?

Response: The contour lines represent the density and bins of the joint distribution plot. A detailed explanation of this will be added to the paper to make it clear to the readers.

222-224: The R2 values do not correspond with the values shown in Table 2.

Response: The R2 values do not correspond because table 2 is showing R2 values for the separate Arid and Semi-Arid zones and not the overall as seen in the figure.

Table 2: This table could be summarised in a figure.

Response: Comment noted, and will be considered.

229-231: The table in Appendix A could be summarised in a figure and included in the main text of the paper, in order to analyse the comparison between the two models. The results included in Table 1 show that PICP values are smaller for AR than for BARDL, meaning that a greater number of observations are out of the confidence intervals for BARDL. This result should be discussed in the paper. In addition, most of PCIP values for the BARDL model are smaller than 94-96 %, in contrast to the statement of line 229.

Response: Comment noted, the details will be discussed

Figure 5: Please use the same y-axis scale in each row to compare the AR and BARDL results. The dashed line of the left column differs from the dashed line of the right column, though observations do not change. The green line represents the forecast. What is such a forecast for the BARDL model given that it supplies a probability distribution?

Response: Comment well noted, the y-axis will be set to the same scale. The difference in the dashed line is due to the shift in time-series data when creating observed led time datasets.

235: A drought is forecasted when VCI3M values are smaller than 35. This is straightforward for the AR model, as it is deterministic. However, how do you apply this criterion to the BARDA outputs considering probability distributions?

Response: Comment noted, the criterion was applied to the mean of the forecast distribution from the bayesian model.

We have noted that details on the use of the mean forecast distribution model evaluation are missing the narrative and will be addressed.

251-253: The BARDL lines lie above the main diagonal of the reliability diagram. This means that the probabilities supplied by the BARDL model tend to underestimate droughts. A comment about this point should be included in the paper.

Response: Comment noted, this was an omission in the paper and the details on this have now been outlined in the paper.

253-256: The sharpness diagrams are mostly flat for 10 and 12 weeks. The low values close to 1 means that the BARDL model is not able to forecast droughts. Therefore, the BARDL model is useful to forecast droughts with 6 weeks ahead but it is not for 10 and 12 weeks. A comment about this point should be included in the paper.

Response: Comment well noted, the details on this point will be outlined.

Figure 7: The sharpness diagram should plot percentages in the y axis.

Response: Comment well noted, will be fixed

266-276: These two paragraphs could be moved to the Conclusions Section.

Response: Comment well noted, will be fixed

273-274: The Authors state that the BARDL model gains 2 weeks based on the results of R2. However, more measures should be taken into account to conclude such a statement.

Response: Comment well noted, additional factors informing this gain will be further discussed in the paper.

275-276: This statement is not clear from the results included in Section 4.

Response: Comment will note and will be addressed

280: The number of the figure is missing.

Response: Comment noted and fixed

284-295: This paragraph with figures of Appendixes C to F could be extended to form a new section 4.6 devoted to the seasonality analysis.

Response: Thanks to this comment it's been noted and will be done as suggested.