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Hydrology and Earth System Sciences
Discussions

Interactive comment on "The predictability of reported drought events and impacts in the Ebro Basin using six different remote sensing data sets" *by* Clara Linés et al.

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We thank the reviewer for taking the time to review the manuscript thoroughly and for the helpful comments and suggestions. Here we provide answers to the specific comments and indications of how the manuscript has been improved to address the reviewer's concerns.

Specific comment:

1- You have used the newspaper data as benchmark data for drought occurrence. Could you please elaborate on why you decided to choose newspaper

data? How reliable do you think the newspaper data is? What is the false alarm rate?

The focus of our analysis was to identify indicators that could help managers in detecting drought conditions that may lead to impact and therefore we were looking for a benchmark based on drought impact occurrence.

The only available database of drought impact, the European Drought Impact report Inventory, does not provide enough records to allow an analysis at regional scale. And although there are a few reports and scientific articles that describe drought impacts in the area, especially in relation with the drought period 2005-2008, impact data in these studies is aggregated by year or even for the whole drought episode.

We selected newspaper records as a benchmark data source because it allowed us to systematically collect impact occurrence data of all affected sectors with a monthly time step for the whole period of analysis.

As mentioned in section 4.1. (second paragraph), a few reliability issues were noticed when collecting the data. The issues related to the wrong use of the word drought to report different situations such as summer shortages are the ones that may have the most impact on the reliability of the source. With this issue in mind, we classified the records of drought occurrence according to the source of the information about drought occurrence to make a distinction between official sources such as mandated authorities, managers and scientists (labelled in Fig 2 as "drought acknowledged by the authorities", "ongoing mitigation measures", and "periods retrospectively defined as anomalously dry", respectively) and non-official sources such as the journalist or the water users (labelled as "mention of drought occurrence"). This second type of source is the one that is susceptible to accuracy issues. In our case, only the mention of drought recorded in 2003 is not backed-up by mentions from official sources during the same period and may therefore be considered a false alarm. The rate of false records

derived from a misuse of the word drought depends on the rigour of the newspaper.

Bias issues (over or understatement of drought caused by political or public interests) do not have an influence in our analysis since we are only considering binary data of occurrence or non-occurrence. However, we acknowledge that these can have a significant impact on reliability if the records are used to estimate the severity of the event. These clarifications will be added to the second paragraph of the discussion.

2- For the daily remote sensing data, you have used "monthly aggregate". Could you please explain more on how the aggregate was obtained?

Monthly aggregates were generated from precipitation, Land Surface Temperature (LST) and Soil Moisture (SM) daily datasets. Precipitation data in mm/day was aggregated by a sum of the daily values for each pixel to obtain monthly data in mm/month. LST and SM data were aggregated by averaging the daily values for each pixel. A clarification will be added to the remote sensing data section.

3- You have used the cross-correlation function as expressed by (Chatfield, 2004), which assumes the bivariate data is stationary and ergodic (on page 122 of Chatfiled, 2004). How did you test if your data was stationary and ergodic?

We acknowledge that stationarity as well as ergodicity of the data is a point of concern. Part of the input data (LST, SM, NDVI, ET, GPP and PsNet) present a seasonal trend. For these, monthly anomalies were obtained by subtracting the mean for the whole period from each monthly average value, using these anomaly time series as input for the cross-correlation function. We have added a comment to clarify this in the manuscript.

To detect possible issues related to the stationarity or ergodicity of the series, their time autocorrelation and partial autocorrelation plots were considered. Overall, time plots show no trends or discontinuities and the values in the autocorrelation plots show that the autocorrelation diminishes quickly with increasing lag. An exception are the series of the reservoir indices. In that case, for some of the series it is not clear from the plot if the series is stationary. For one of them (management unit 122) it clearly is not. This management unit corresponds to a reservoir (Rialb) that started to be filled in the year 2000 and therefore the levels cannot be considered stationary for the period of study. Most of the autocorrelation plots for the reservoir level series present a small peak of autocorrelation at a lag of 12 months, and one of them (management unit 132) presents autocorrelation values declining more slowly (significant values until lag 20).

Additionally, we have run a stationarity test (Dickey-Fuller test) on the series. The results show that most of the datasets are stationary at the 95% confidence level. There are a few exceptions: for the LST series, two of the management units (120i and 130X) have a p-value of 0.07; while for the SPI-12 series, four of the management units have p-values higher than 0.05, these are management units 132 (p-value=0.07), 140 (0.10), 150 (0.19) and 151 (0.07); for the reservoir index series, again management units 122 and 132 present p-values over the significance level, 0.13 and 0.7 respectively.

We considered the remote sensing datasets to be stationary and ergodic enough to be used as input for the cross-correlation function. As for the reservoir data, a comment on the two reservoirs that do not satisfy the conditions could be included in the article.

We have verified the plots showing the anticipation to drought events. A small error was detected in these plots on careful review, which was corrected (Figure Q3 shows the corrected plots). In these plots we can clearly see that the two management units that do not satisfy the conditions for stationarity are those (at least two out of the three) that do not present anticipation. This last sentence will be included in the results section.

4- You have used the cross-correlation function as a method of drought anticipation. Can the same technique be applied for foreseeing the end of droughts?

This is a very interesting question, given the difficulty in identifying the cessation of drought events. By using records of direct drought impact as a benchmark to assess the different parameters we were aiming to identify the onset of the conditions that cause these impacts. A good knowledge of the conditions that lead to impacts would be useful to identify both the start and end of a drought event, since the end of those conditions (return to normal conditions) would be an indicator of the end of the drought event.

5- As you explained in figure 3 and 4, the values on the left side of (negative side) of the central line, show how early the remote sensing data have anticipated the newspaper headlines on droughts, or anticipated the decline in crop yield. Could you please explain what the values on the right side (positive side) of the central line show?

The positive side of the plots reflects the correlation of the drought occurrence and impact series with the values of the different datasets in later months. For example at lag +1 the correlation between the impact and the value of the dataset the following month is shown. This type of correlation appears if the conditions that define the start of the event or impact occurrence last longer than one month.

For long term SPIs these correlation with positive lags are stronger since previous months are included in the SPI. For example for SPI-9 at lag +1 the drought event or impact occurrence is compared to an SPI built from the following month and the 8 previous months.

6- Following from the previous comment, regarding figures 3 and 4, could you please explain what the values on both extremes of the graphs mean? They mostly seem to be happening around lag -24 and lag 24.

The positive correlations of the timelines of drought occurrence and impacts with the values of the indicator datasets with lags over one year (most notably at -15 and $\pm$24 lags) are casual correlations. For example the figure Q6 shows how the periods of reported drought impacts coincide with positive anomalies when the data is shifted by a lag of -15.

Since we are focusing our evaluation at anticipations within a period of one hydrological year, the correlations should not be affected by this issue. An explanation will be added to the results section.

Technical suggestions:

1- I suggest signposting the paper early in the introduction. The reason is that the introduction although being an interesting read, is rather long.

We agree with the suggestion and we will introduce the aim of the paper at the end of the second paragraph (page 2, line 10) of the introduction instead of in the last paragraph (page 3, lines 25-27).

2- It would be easier for the reader to have the zone numbers on the map in figure 1.

We agree, and on inspection found that the figure seems to have lost the numbers

in the conversion to pdf. We have amended the figure to ensure these numbers are preserved.

3- On page 7 line 19, it would be interesting to state briefly why the 2nd largest news-paper in the Aragon region selected, and not the 1st largest? Is it because unlike all the other newspapers in the region, it had an online record?

Yes, the online record of the main newspaper only goes back to 2008. We also reviewed the available records for that newspaper, but did not include them in the analysis to avoid having the later years better represented than others. This will be clarified in the manuscript.

4- On page 8 line 9, why only “winter" cereal crops are selected?

Winter cereals are the cereal crops that are planted in the autumn and they are the crops that cover the largest surface area (especially barley and wheat). Their importance for the region results in better data availability than other crops and for this reason only this type of crops were selected for the analysis. A clarification will be added to the manuscript.

Technical suggestions 5-8:

We agree with the corrections suggested by the reviewer and will modify the text accordingly.