Responses to Reviewer 1

The author would like to thank the reviewer for the constructive and thoughtful comments and suggestions which led to substantial improvements in the revised version of the manuscript.

The reviewer's comments are marked in bold and italic. The responses follow in indented text.

Some specific aspects about your work:

1. In equation 1 and 2, when describing "xi", it would be better if you consider the "i" as a subscript.

> Corrected in the revised manuscript.

2. I think that there is an error in line 205: "that is higher than for precipitation" should be "that is higher for precipitation".

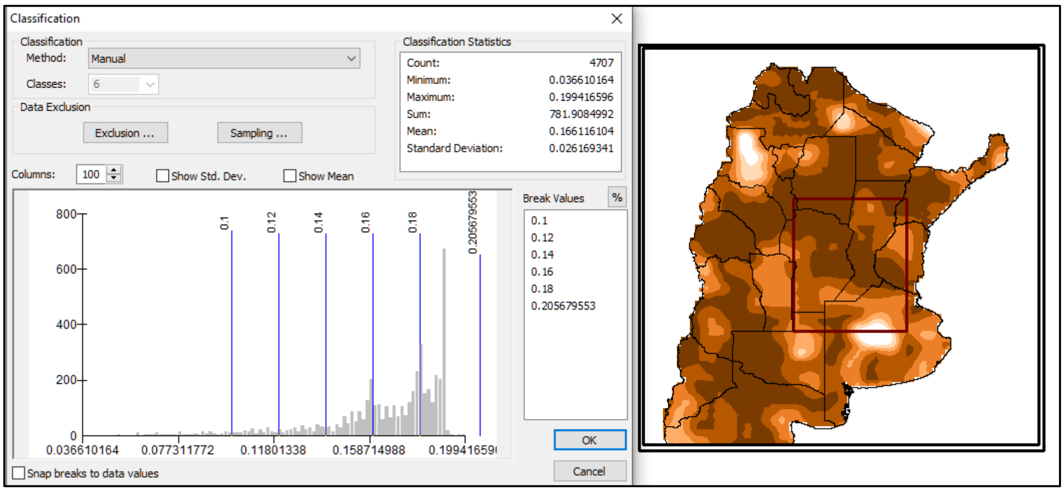
> We realize that the sentence was confusing. In the revised version of the manuscript, the variable "precipitation anomalies" has been replaced by SPI1.
>
> The entire paragraph has been rewritten. It now states:
>
> *"Figure 2 presents the spatial distribution of drought's occurrence percentage for northern Argentina as characterized by SPI1, SPI3, SPI6, and soil moisture anomalies lower than one time their corresponding standard deviations. The occurrence of drought in northeastern Argentina ranges between 12 and 14% for SPI1 (Fig. 2a), while drought percentages seem to increase up to 18% as characterized by SPI3/6 in the same region (Figs. 2b and 2c). Soil moisture anomalies show that droughts are distributed mainly in the north of Argentina, with percentage values ranging between 16% and 18%. Droughts, as characterized by SPI1/3/6 (Figs. 2a-c), reveal a homogeneous spatial distribution and increasing percentages as with the time scale of the indicator. In contrast, the spatial pattern of soil moisture anomalies shows a decrease in drought percentages for arid regions (Fig. 2d). Inside the Core Crop Region, droughts are more frequent towards the north, with percentages from 14% to 16% for SPI1/3 (see Figs. 2a-b). Fig. 2d indicates that the percentage of droughts, as represented by SPI6, is 18% towards the region's north and southwest. Conversely, drought presence declines towards southeastern CCR as all SPI, and SM show percentages descend to 12% (Figs. 2a-d)."*

3. In Figure 3 the color bar is not clear enough. The top value (0.18) is reached in an important fraction of the area, and the impression is that higher values can also be possible. Maybe changing the color bar and allowing a higher limit can improve that figure. Some of your comments are related to the 0.18 probability, but that can change if a different color bar is used.

> Probability was not the proper expression for Figures 2 and 3. Instead, we now use percentages of drought occurrence. Figures 2 and 3 have been redone accordingly (see below).

The drought's occurrence percentage does not exceed 20% in any of the cases. The largest values in Figure 3 are in the range 18 % to 20%. As an example, we present below the class distribution histogram for SPI6 wheat critical months (Fig. 3d). The rest of the maps in Figure 3 present very similar histograms.

To clarify this issue, we have adjusted the color bars in Figs. 2 and 3 by adding the upper maximum limit of 20%.



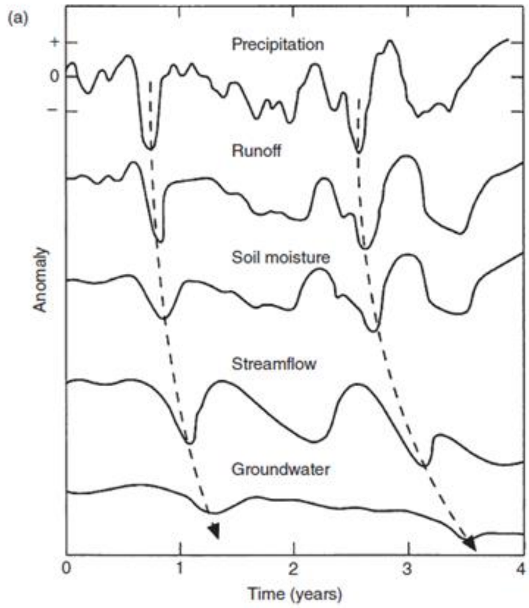
4. When you estimate SPI3 and SPI6 for the critical months and analyze the temporal evolution of drought frequency. Is there any overlapping between these months and the estimation of the SPI-SSI values? How does that overlapping affect your conclusions?

Critical months refer to the specific periods when the crops are most sensitive to ambient conditions. These periods do not necessarily cover the predetermined seasons, e.g., SON or DJF.

Therefore, their analysis is aimed at evaluating the potential of droughts to affect crop yields during those specific periods. Even though there is an overlap with the 3- and 6-months' time scale for indicators, it does not affect any of the conclusions presented in our study.

5. In <u>line 230</u> you mention that SM acts as a physical filter, but there is no mention on the mechanisms. Maybe exploring the physical processes involved should be incorporated and analyzed.

In the framework of the surface water budget, soil moisture is estimated as a difference between incoming precipitation and outgoing runoff and evapotranspiration (these are the main terms). Different mechanisms govern the behavior of each of the components as well as how they interact in a temporal scale. When precipitation enters the system, its signal will propagate in time. The fundamental concept was discussed by Changnon (1987) and McNab (1989) using the schematic shown on the side. The schematic shows a time delay between variables and a smoothing of the curves.



Part of the precipitation that reaches the ground will evaporate from the surface, another part will turn into surface runoff, and the rest will infiltrate into the ground. Some of the infiltrated water may go back to the atmosphere through vegetation transpiration of water extracted by roots. Another portion may percolate to groundwater, and the rest will be stored as soil moisture (Changnon, 1987; Van Loon, 2015).

The time it takes for the precipitated water to infiltrate the soil and through deeper layers has s dampening or smoothing effect that Entekhabi et al. (2006) described as a low-pass filter.

We have added a discussion of this process to the revised manuscript. The analysis if evapotranspiration, runoff, while attractive, would require a different approach (based in land surface models) that is out of the scope of our study.

6. The Cordoba Province is written as Córdoba and Cordoba (with and without accent).

The proper spelling is with an accent. We have corrected it throughout the manuscript.

7. In <u>Figure 8</u>, the inclusion of a legend will facilitate the understanding of the meaning of each line.

Thanks for pointing it out. A new legend has been included in the figure.

8. <u>Figure 9</u> shows the detrended crop yield and the SPI-SSI indexes and your conclusions say that (a) lower SPI-SSI values implies crop yield losses, but that is not the case for every year. Is there any explanation? (b) Why are only some years

shown? (c) Maybe a direct comparison between the SPI-SSI indexes and the crops yields (instead of a time series), considering all the years, can be more descriptive. (d) Your conclusions depend on this figure and should be clearer the relation between SPI-SSi and crop-yields and explain years without reasonable results, like the 2004-2009 period.

(a) Climate conditions (as those given by SPI or SSI) affect crop yields, but they are not the only factors at play. Non-climatic factors like seed quality, different use of fertilizers, sawing or harvesting dates are a few of the possible effects on crop yields. This issue has been clarified in the revised manuscript.

A better way to support our results is by computing correlations between the drought indices and crop yields. The Table 3 below (to be included in the manuscript) shows that indeed there is a relation between indices (SPI3/6 and SSI3/6) and crop yields. Table 3 shows that the shorter-scale indicators (SPI3 and SSI3) achieve a better correlation with crop yields than the larger-scale indicators (SPI6 and SSI6). Then, SPI3 and SSI3 result most appropriate to predict crop yield losses. The relation between detrended crop yields and SPI3 is now presented in the revised Figure 9 (see below).

The results suggest a sensitive relation between summer crops (corn and soybean) and deficits in precipitation and soil moisture during both crops' critical periods. Of the three crops, wheat yields have the lowest correlations with the indices. In the revised version of the manuscript, we will include the new result analysis and conclusions.

(b) In the revised Fig. 9 (see below), SPI3 during each crop critical growing months is contrasted with detrended crop yields. SPI3 is continuous throughout the period of time.

(c) We agree, the table with the correlations is a more straightforward way of discussing the relation. As noted in b), we also include the SPI3 contrasted with detrended crop yields in the revised Fig. 9. SPI3 has been selected because it is the index that presents the highest correlation with crop yields (see Table 3 below).

(d) Figure 9 has been redone with additional details. As noted in the first paragraph, while climate conditions are important factors affecting crop yields, they are not the only ones. The relations between SPI-SSI and crop yields are better analyzed now with the new Table 3 and the revised version of Fig 9.

All these clarifications, together with the revised Fig. 9, will be incorporated in the revised manuscript.

Province	Crop	Indices			
		SPI3	SPI6	SSI3	SSI6
Santa Fe	wheat	0.15	0.05	0.17	0.15
	corn	0.67	0.58	0.58	0.40
	soybean	0.68	0.58	0.62	0.52

Province	Crop	Indices			
		SPI3	SPI6	SSI3	SSI6
Córdoba	wheat	0.49	0.04	0.44	0.38
	corn	0.60	0.55	0.51	0.55
	soybean	0.73	0.70	0.58	0.70

Table 3: Correlation Coefficients of the annual detrended crop yield and the maximum or minimum index value for critical crop months (ON for wheat, DJ for corn and JF for soybean). Maximum or minimum index values are identified according to whether detrended annual crop yields are negative or positive.

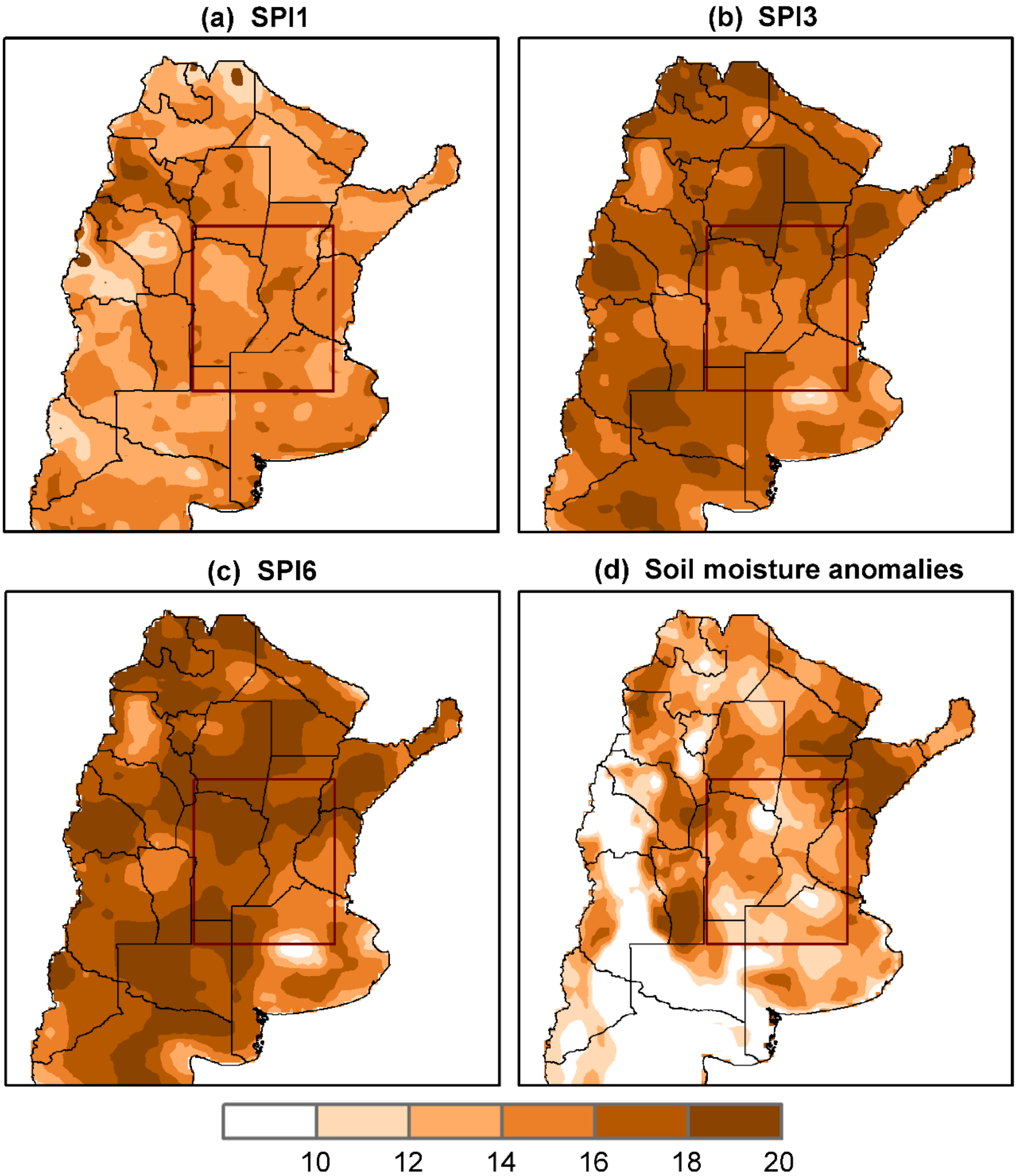


Figure 2: Percentage of months under moderate to extreme drought conditions (months below one standard deviation) of the total months from January 1979 to December 2018, according to: (a) SPI1, (b) SPI3, (c) SPI6 and (d) soil moisture anomalies.

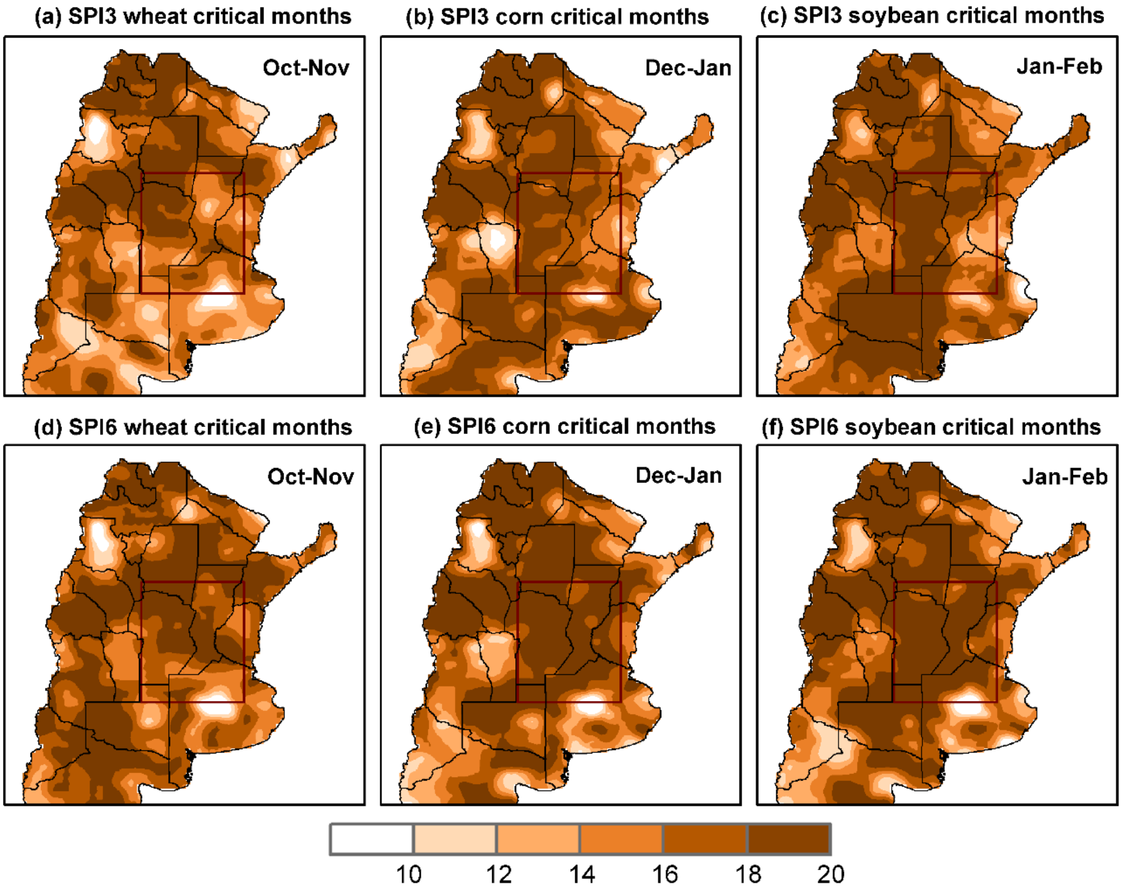


Figure 3: Percentage of months under moderate to extreme drought conditions (months below one standard deviation) accounted during each crop critical growing months from January 1979 to December 2018. For SPI3: (a) wheat during (Oct-Nov), (b) corn during (Dec-Jan), (c) soybean during (Jan-Feb). Panels (d), (e), and (f) showing the same for SPI6.

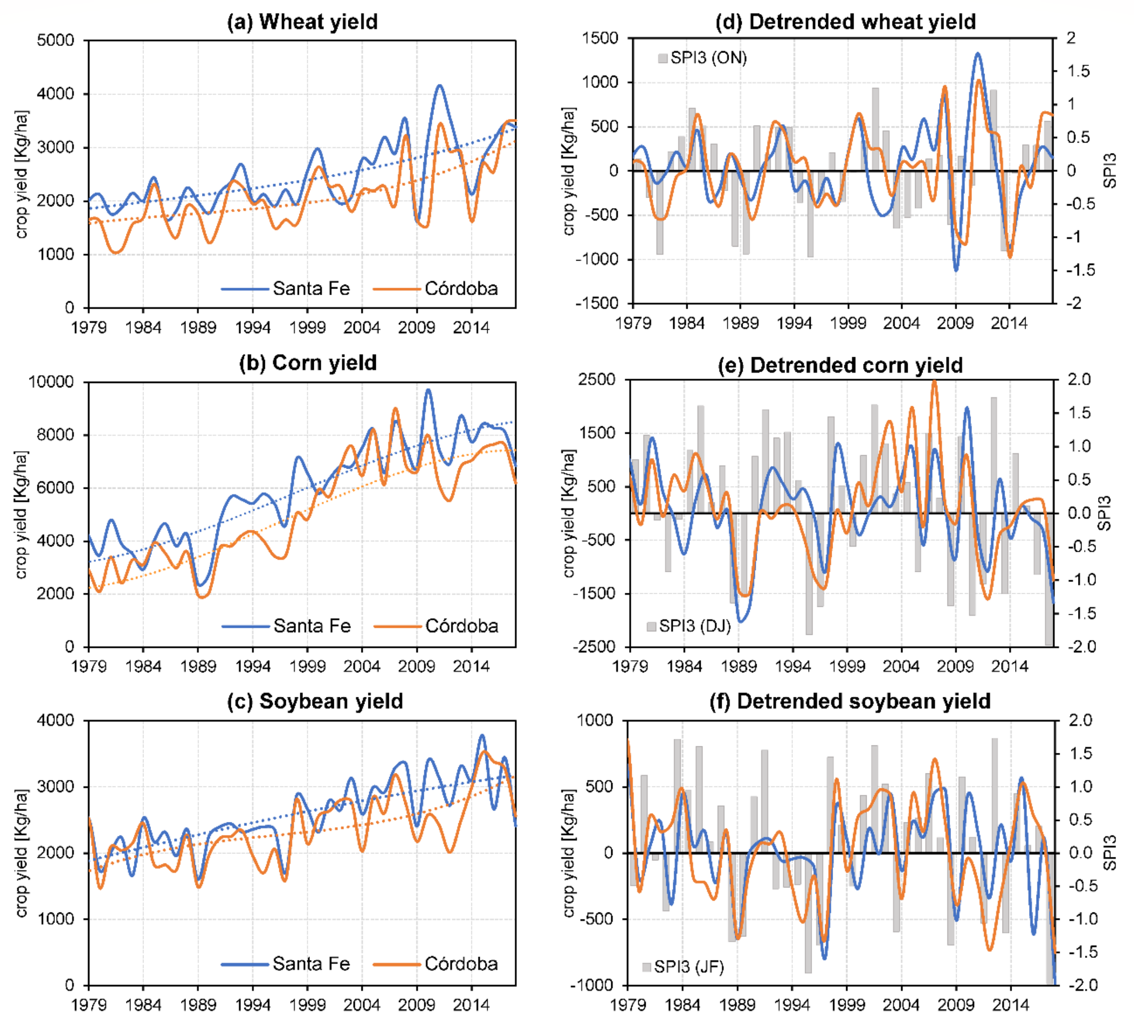


Figure 9: Panels a-c, show the time series of the area-averaged annual crop yield over the provinces of Santa Fe (blue lines) and Córdoba (orange lines) from 1979 to 2018 for: (a) wheat, (b) corn, and (c) soybean. Cubic polynomial trends of each province crop yield time series are in dot line. Panels d-f, presents the detrended time series together with SPI3 index values during each crop critical growing months (ON for wheat, DJ for corn, JF for soybean).

References.

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