

Interactive comment on “A shift in the spatial pattern of Iberian droughts during the 17th century” by F. Domínguez-Castro et al.

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Thanks by the comments, we have tried to answer all of them, for that, we have typed your comments followed by our replies.

MAIOR POINT

1) The paper relies on the assumption that there is a strong relationship between rogation and drought, and that this relationship is consistent in time at all of the sites studied. To be confident that the effects found are changes in drought it is necessary that all the rogation records are complete for the whole period (or at least homogeneous); and that there are no changes in ecclesiastical policy, agricultural techniques, local political or economic conditions, or other effects that might change the relationship. How confi-

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dent can we be that the amount of drought required to trigger a rogation is the same in 1620 and 1720? In particular, how confident can we be that the observed multidecadal rogation variability is actually drought variability?

We agree with the reviewers (both Ljungqvist and Brohan) that this is a very important point, indeed we have made some changes in the text in order to clarify the relationship between rogations and droughts and its consistency through time. First, the relationship between rogations and droughts is widely proved by previous papers as: Martín-Vide and Barriendos, (1995); Barriendos, (1997); Vicente Serrano and Cuadrat, (2007); Rodrigo and Barriendos, (2008); Domínguez-Castro et al., (2008), Piervitali and Colacino (2001), all these cites have been introduced in the text.

Second, this relationship is consistent during all the analyzed period, so we are quite confident about the multidecadal variability observed on droughts. The documentary source used is homogeneous, furthermore we have studied the agricultural and socio-political factors, concluding that they not affect to the frequency of rogation celebrations during the studied period. This was the most important point to select this time period for the study. The following paragraphs have been included in the main text to clarify these points:

“The documentary homogeneity of the rogation series is guaranteed by the quality and reliability of the documents consulted. These rogations are extracted from documentation of public institutions, and its contents are certified by a public notary. The documentation consulted is continuous over the whole studied period. Several arguments have been used in previous papers to confirm the homogeneity of rogations as a proxy of droughts (Martin-Vide and Barriendos, 1995; Barriendos, 1997) being the most important: “The rigidity of the institutions of the ancient regime prevented any disorder in any subject, especially in liturgical matters. Any substantial change was clearly reflected in the documents (i.e. there are no discontinuities in the collection and no changes in the rogation procedures nor the recording processes). “The agriculture in Spain did not experience significant advances neither in the applied tech-

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niques nor in the introduction of new tools or practices that increased significantly the production during the studied period. Therefore Spain continued suffering subsistence crises in large areas until the early twentieth century. The pro-pluvia rogations were for centuries the unique “remedy” to droughts for the agriculture on dry lands.”

2) The methodology used only analyses seasons where there is a rogation in Toledo (84 of the 600 seasons in 1500-1750?). This is effectively discarding most of the data - why is this a good idea? It would be simple (for example) to make a version of fig.4 with all the years included (whether or not there was a rogation in Toledo), and each year coloured by the total count; and fig. 5 could be re-made similarly. It's possible that only using the Toledo times does not introduce a bias and is a more powerful analysis, but this needs to be explicitly justified.

About the figure 4, the Iberian Peninsula has a high spatial variability in precipitation, and the frequency of agricultural droughts shows a gradient from east to west and from North to South. The high frequency of rogation in the Mediterranean area (252 and 225 in Catalonia and Murcia respectively) should produce a very noisy figure if all the rogations from all locations were represented. Thus, as a compromise we used a location with an average rate of rogation as Toledo (84) and whose series had been very closely scrutinised previously. On the other hand, figure 5 is constructed using all the cities independently, 0 are years without rogations, 1 are years with a rogation in any location (Toledo or any other), 2 are used when two locations have rogations. . . ., that figure shows that the differences between the periods are supported by all locations. We have tried to clarify better this aspect in the text.

3) The division of the series into two periods (1600-1652 and 1653-1749) is arbitrary and shows spurious precision. Looking at figure 4, I would agree that the second half of the seventeenth century showed notably more widespread spring droughts than either before or afterwards; and also that the number of widespread autumn droughts rose in the early eighteenth century. But I don't think the idea of two distinct periods is a defensible conclusion from the data.

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We agree with the reviewer that result of the analysis does not give us enough resolution to divide the periods with annual precision, for that we have changed the years for expressions as “second half of seventeenth century”, “during the 1650s” . . .

MINOR POINTS

1) Bilbao should be added to figure 4 (leaving out data that doesn't fit a pattern gives misleading results).

Data of Bilbao fits perfectly, but it has few pro-pluvia rogations because it is a really humid place. As we have written in the text, page 1118, 14-16 “Figure 4 does not included the Bilbao series, since only one case is coincident with the Toledo series. That case is spring of 1664. . .” 1664 is included in the period when the drought affects to a broader area. We think that including Bilbao in figure 4 only for one point would introduce more confusion than information. Obviously figure 5 takes into account rogations in Bilbao.

2) Figure 5 panel 2 suggests that there were MORE widespread spring droughts in 1600-1652 than afterwards. This is because points where the frequency is zero have been omitted from the graph.

Ok, plot the zero is a good idea, the figure is clearer, we do it.

3) Page 1115 lines 11-25 - this paragraph needs rewriting. It leads to the conclusion ‘the period 1600-1750 was the longest with homogeneous data for all the series’, but the justification for this is inadequate: no references and vague explanations.

We have rewritten the paragraph and added some references of previous work in these locations (Martín-Vide and Barriendos, 1995; Barriendos, 1997; Vicente Serrano and Cuadrat, 2007; Rodrigo and Barriendos, 2008; Domínguez-Castro et al., 2008) that justify the sentence.

4) Page 1118 lines 4-12 - this paragraph is also vague and unconvincing (no references).

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The diverse intensity of drought from different seasons are discussed in Dominguez-Castro et al. (2008), we insert this cite in the text. And the extrapolation of this discussion to the effect of study different locations we think is not very risky.

5) The extra documentary data in section 4 is interesting, but doesn't support the conclusions of the paper. It does demonstrate that on two occasions when the rogations indicate a widespread drought then a widespread drought did occur. But this isn't enough to support the conclusions - that would require separate documentary evidence either validating the relationship between rogations and droughts, or directly supporting the change in drought frequency.

The relationship between rogations and droughts is largely described in the previous papers now cited in the introduction, as we mention in the answer to the first question. We can not extract extra documentary data for all the drought occurred in Spain from 1650 to1750 to support the changes in drought frequency because it will take us 5 or 6 years of works... For that reason we selected only two representative cases. Both cases show very good concordance with the rogations. This fact does not prove the change in drought frequency, it just reinforces the evidence. So, we have changed the text to avoid this interpretation.

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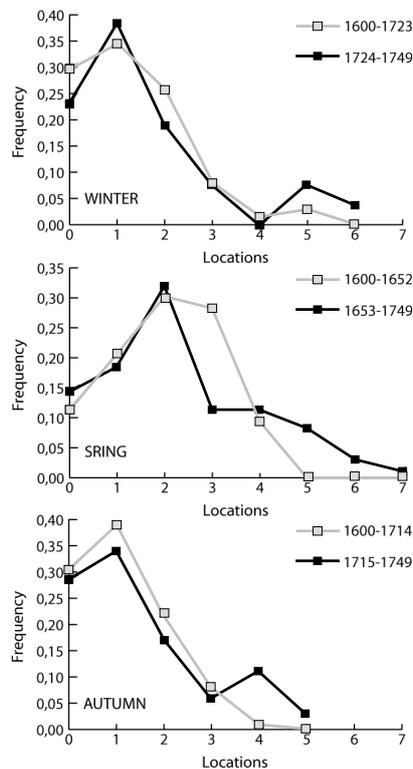


Fig. 1. new figure 5

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