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Climate of the Past Discussions

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

F. Domínguez-Castro et al.

f.dominguez@fis.ucm.es

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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.

1) My main concern is the key conclusion of the paper, namely that the droughts 1600–1652 had a more local character than those 1653–1749. I would like a longer and deeper discussion, ruling out that this is merely an artifact of changes in the historical source material or a consequence of changing rogation customs. Such a discussion would significantly improve to vigor of the conclusions.

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 rela-

tionship 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: âĂć 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). âĂć The agriculture in Spain did not experience significant advances neither in the applied techniques 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 quite different climatic conditions c. 1720–1749 compared with those during the

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Maunder Minimum should be discussed in the light of the results. Is it not somewhat surprising that we see the same drought conditions during a cold and a relatively warm period but other conditions during the first half of the likewise cold 17th century?

This is a really interesting aspect that we will investigate in further work. One of the main problems to discuss on detail this issue is the lack of adequate temperature proxies in Iberian Peninsula and we think that a comparison in these terms at present would be too much speculative.

3) The paper would be improved by a little longer general discussion of the field of historical climatology in the beginning of the paper, preferably with references to some recent key papers in the field, for example: Brázdil R., Pfister C., Wanner H., von Storch H., Luterbacher J. 2005. Historical climatology in Europe – the state of the art. Climatic Change 70: 363–430. Brázdil R., Kundzewicz Z.W., Benito G. 2006. Historical hydrology for studying floodrisk in Europe. Hydrol Sci J 51: 739–764. Many excellent articles are also published in the very latest issues of the journal ClimaticChange, which should be discussed in the paper, not at least from a methodological point of view.

A wider discursion of this topic is out of the scope of this paper, especially due to the recently published reviewers paper. However, we have included a short paragraph and some references on this topic.

"The use of documentary sources for climate purposes is largely developed in Europe (Brázdil et al. 2005 and 2010 for a review) due to the development of some research projects as IMPROVE (Camuffo and Jones 20002), CLIWOC (http://www.ucm.es/info/cliwoc/), MILLENNIUM (http://millenniumproject.net). Other regions of the world are studing their own documentary sources as well; in Asia (Ge et al. 2005, 2010; Aono and Kazui 2008; Hirano and Mikami 2008); or in South America (Prieto et al. 2000; García Herrera et al., 2003, 2008; Prieto and García Herrera 2009)."

Aono, Y. and Kazui, K.: Phenological data series of cherry tree flowering in Kyoto,

Japan, and its application to reconstruction of springtime temperatures since the 9th century. Int. J. Climatol., 28, 905–914, 2008.

Brázdil, R., Pfister, C., Wanner, H., von Storch, H., Luterbacher, J.: Historical climatology in Europe – the state of the art. Climatic Change, 70, 363–430, 2005.

Brázdil, R., DobrovolnÃ¡, P., Luterbacher, J., Moberg, A., Pfister, C., Wheeler, D., Zorita, E.: European climate of the past 500 years: new challenges for historical climatology. Climatic Change, 101 (1-2), 7-40, 2010.

Camuffo, D. and Jones, P. (Ed.): Improved Understanding of Past Climatic Variability from Early Daily European Instrumental Sources. Kluwer Academic Publishers, Dordrecht, Boston, London, 2002.

Ge, Q., Zheng, J.Y., Hao, Z.X., Shao, X.M., Wang, W.C., Luterbacher, J.: Temperature variation through 2000 years in China: an uncertainty analysis of reconstruction and regional differences. Geophys. Res. Lett., 37. L03703, 2010.

Ge, Q., Zheng, J.Y., Hao, Z.X., Zhang, P.Y., Wang, W.C.: Reconstruction of historical climate in China. High-resolution precipitation data from Qing Dynasty archives. Bull. Am. Meteorol. Soc., 86, 671–679, 2005.

García Herrera, R., García, R.R., Prieto M.R., Hernández, E., Gimeno, L., Díaz, H.F.: The use of Spanish historical archives to reconstruct climate variability. Bull. Am. Meteorol. Soc., 84, 1025–1035, 2003

García Herrera, R., Barriopedro, D., Hernández, E., Diaz, H.F., Garcia, R.R., Prieto, M.R., Moyano, R.: A chronology of El Niño events from primary documentary sources in Northern Peru. J. Clim., 21, 1948–1962, 2008.

Hirano, J. and Mikami, T.: Reconstruction of winter climate variations during the 19th century in Japan. Int. J. Climatol., 28, 1423–1434, 2008.

Prieto, M.R., García Herrera, R., Dussel, P.: Archival evidence for some aspects of his-

torical climate variability in Argentina and Bolivia during the 17th and 18th centuries. In: Southern Hemisphere Paleo- and Neoclimates. Key sites, methods, data and models. Springer, Berlin, 2000. Prieto, M.R. and García-Herrera, R.: Documentary sources from South America: Potencial for climate reconstruction. Palaeogeography, Palaeoclimatology, Palaeoecology, 281 (3-4), 196-209, 2009. 4) Under the Discussion and conclusion section, it would be preferable if the results of the paper (that are drawn from historical data) are compared with the results of studies of drought based on natural archives such as sediments. The following studies, among many others, could be considered for this purpose: G. Benito, M. Rico, Y. Sánchez-Moya, A. Sopeña, V.R. Thorndycraft, M. Barriendos. The impact of late Holocene climatic variability and land use change on the flood hydrology of the Guadalentín River, southeast Spain. Global and Planetary Change, 70:53–63. G. Benito, V.R. Thorndycraft, M. Rico, Y. Sánchez-Moya, A. Sopeña. Palaeoflood and floodplain records from Spain: Evidence for long-term climate variability and environmental changes. Geomorphology. 10, 2008: 68–77. V. López-Días, Á.G. Borrego, C.G. Blanco, M. Arboleya, J.A. López-Sáez, L. López-Merino. Biomarkers in a peat deposit in Northern Spain (Huelga de Bayas, Asturias) as proxy for climate variation. Journal of Chromatography A, 1217. 2010: 3538–3546.

Our opinion is that in the Iberian Peninsula do not exist natural proxies with enough temporal resolution as to compare with the rogation series. In Dominguez-Castro et al. (2006) an attempt to compare the sedimentary record of a temperate wetland with the rogations in Toledo (both in central Spain) can be found, but the differences in temporal resolution made the task almost impossible. Dendrocronology could be the most useful proxy to produce this comparison, but few dendroclimatic reconstructions can be found in Spain and, mostly, they are done on high altitude sites and they are related with the temperature and not with droughts as rogation ceremonies do.

On the other hand, Benito et al. (2008 and 2009), are chronologies of paleofloods, the comparison with these records is very tricky because droughts and floods are really different meteorological phenomena. But also they are not opposite; therefore a period

without floods is not indicative of a drought period. In the Mediterranean climate is frequent that floods and droughts occur during the same year. For example, the Maunder Minimun in Iberian Peninsula is characterized by a high frequent of hydrological extremes, both of them droughts and floods (Barriendos, 1997).

We do not find the paper of Lopez-Dias et al., (2010) suitable for a comparison with our chronology. It studies a peatland core sampled every 3 cm, taking into account the age model, each sample represents 90 years. With this temporal resolution it is impossible to compare with the seasonal resolution of the rogation ceremonies.

Domínguez-Castro, F., Santisteban, J.I., Mediavilla, R., Dean, W.E., López-Pamo, E., Gil-García, M.J., Ruiz-Zapata, M.B.: Environmental and geochemical record of human-induced changes in C storage during the last millennium in a temperate wetland (Las Tablas de Daimiel National Park, central Spain). Tellus B, 58 (5), 573-585, 2006.

Barriendos M.: Climatic variations in the Iberian peninsula during the late Maunder minimum (AD 1675-1715): an analysis of data from rogation ceremonies. The Holocene 7, 105-111, 1997.

5) It would also be preferable to write something in the Discussion and conclusion section about what long time-series of proxy data (up to several 1000 years long) relate about the relationship between temperature and droughts in Spain. In this way, the observed high-frequency drought patterns of the paper could be placed in millennium-scale low frequency drought patterns.

As explained in question 2 and 4, Spain has no enough high resolution proxy series of drought and temperature to produce this kind of study meticulously.

Minor remarks Page 1113, line 5–10: I would like to see a reference to Spanish rogations as a historical phenomenon.

We think that Martín-Vide and Barriendos 1995 is the best work in this aspect and it has been cited on text.

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Page 1113, line 25 forward: I would like to see a reference to the precipitation requirements for corn and other crops.

A new paragraph has been included in the text:

"In Spain, during the studied period, the cereal production was dominated by wheat followed by barley and rye, and only in some few atlantic areas, corn was cultivated. The annual precipitation needed to grow these cereals is very similar for all of them and it is quite wide, ranging from 400 to 800 mm. But it has to be stressed that total annual precipitation is not a good index to evaluate the hydrological requirements of these cereals, since it is much more important the distributions of the precipitations along the plant cycle, particularly in the Mediterranean area, where the precipitation is concentrated in few months. The length of the moisture-sensitive period has been shown to vary with different cereal crops (Skazkin, 1961) i.e. barley presents a shorter cycle than the other cereals. Consequently, it resists better the drought and can grow with less than 300 mm per year. On the other hand, corn has a long growth phase and needs at least, 150 mm during the summer months (Martin et al., 2006). The wheat and the rye have a similar grow cycles and the main difference is that rye can grow with lower temperatures than wheat." Skazkin, F.D.: The critical period in plants as regards insufficient water supply. Timiryazevskie Chteniya Akad. Nauk SSSR 21, 1-51, 1961. Martin, J.H, Warren L.H., Stamp D.L., Waldren, R.P.: Principles of field crop production. Prentice Hall, Upper Saddle River, N.J, 2006.

Page 1114, line 20: I would like to see a reference to historical research concerning the increasing anticlericalism in Spain after the Napoleonic Wars.

Some new references have been included.

Jiménez de Gregorio (1984), Lorente-Toledo (1993).

Jiménez de Gregorio, F.: El ayuntamiento de Toledo en la guerra por la independencia y su entorno, de 1809 a 1814, Instituto Provincial de Investigaciones y Estudios

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Toledanos, Toledo, 1983 (in Spanish)

Lorente-Toledo, L.: Agitación urbana y crisis económica durante la guerra de la independencia y su entorno de 1809 a 1814, Publicaciones de la Universidad de Castilla-La Mancha, 1993 (in Spanish)

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