

## ***Interactive comment on “Extreme droughts/floods and their impacts on harvest derived from historical documents in Eastern China during 801–1910” by Zhixin Hao et al.***

### **Anonymous Referee #1**

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Using databases of Song, Ming, and Qing documents, this paper finds that the frequency of reports of extreme droughts—but not always floods—correlates with reductions in harvests as reported in historical sources. On this basis, the authors conclude that there are clear historical periods when droughts reduced harvests, and therefore that these events had significant societal impacts. The sources and methods used in this manuscript appear to be standard in other publications on Chinese historical climatology. In this instance, however, I am not convinced they are adequate to prove the authors’ conclusion. The problems concern, first, the author’s use of their historical databases; second, the large temporal and spatial scale of the study; and third, the interpretation given to the pattern of correlations found.

Problems in use of databases:

The authors' use of databases of flood and drought events and harvest grades raises numerous questions which must be answered before it is clear whether or not the correlations identified are valid: 1) What kinds of droughts are recorded in the historical sources: meteorological drought? hydrological drought? agricultural drought? or some combination of these? Were observers more likely to report precisely those droughts that affected crops, or did they report all droughts equally? 2) What kinds of floods are recorded in the historical sources: heavy rains? tsunamis? rivers that burst their banks? Does the database control for ongoing problems related to river hydrology? How do major events such as course changes in the Yellow River figure into the measure of flood frequency: as one flood? as many? 3) What is the seasonality of the meteorological events recorded in the historical sources? Does the seasonality of floods or droughts necessarily overlap with the seasonality of critical agricultural activities or phases of crop growth? 4) What is being measured by "harvest"? Yield per seed? Total yield per hectare? Food availability? 5) Are degrees of flood, drought, and harvest based entirely on narrative descriptions, or are there objective phenological or quantitative measures to help define them?

Regarding the temporal and spatial scale of the study, I am concerned that it relies on improbable assumptions of continuity and homogeneity in Chinese population, land use, and record keeping. In order to accept as valid any long-term correlations between reported drought or flood frequency and "Chinese" or even "regional" "harvests" I would need the authors to address the following issues: 1) How do the data control for the changing borders of Chinese empires? A priori, I would expect vastly different vulnerabilities and patterns of reporting between the Northern Song and Southern Song periods, simply based on the major geographical shifts in population and wealth between those two dynasties. 2) How do data on "harvests" control for changes in staple crops, introduction of New World crops including peanuts and sweet potatoes, changing cropping patterns, and the increasing commercial orientation of agriculture?

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3) How do the data deal with the changing vulnerabilities to climate variability based on changing settlement patterns even within regions (e.g., uplands in the south and southwest colonized by Han settlers during the late Ming and Qing periods)? 4) Given the very long time period examined here, wouldn't we expect new adaptations to reduce vulnerabilities to predictable climate variability and disasters? 5) Most importantly, how can we make up for the fact there are simply more records from the Qing period than earlier periods? I don't see that the methods used in this manuscript avoid the problem that more records will create a misimpression of a greater frequency of floods and droughts. The authors propose to ignore reports of "average" conditions in Qing records to make them more comparable to Song and Ming records. However, that would only work if the Song and Ming records still reliably reported all disasters and extremes and only left out "average" conditions. I don't see any reason to make that assumption. Perhaps the authors could experiment with methods of introducing "noise" into the data in order to reflect the events missing from the reports. Or else they could employ a Bayesian method to indicate that the presence or absence of certain descriptions in the records may be used to obtain updated posterior probabilities of actual conditions, without ever assuming that the records provide a complete account of events. In any case, the authors must come up with a way to handle these changes in the documentary record over time if they are to make a convincing case for stable long-term correlations between floods and droughts and harvests.

Third, even if the correlations found in the study are valid, there is a problem with the authors' historical interpretation of them. The correlations discovered here are not between climate and harvests, but rather reports of floods and droughts and reported harvests. The authors assume that the correlations mean that floods and droughts reduced harvests. However, there are a number of potentially confounding variables, which indicate other potential pathways of causality and therefore other historical possibilities: 1. Drought and/or flood might have correlated with other climate variables (such as temperature) that caused harvest failure. 2. Drought and/or flood might have increased the likelihood that officials reported problems such as poor harvests and

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other disasters 3. Harvest failures might have increased the likelihood that officials reported disasters such as droughts and/or floods. 4. Droughts and/or floods might have harmed human and animal health, reducing labor for harvests. 5. Droughts and/or floods might have damaged infrastructure and transportation, leading to food availability decline. 6. Droughts and/or floods might have driven migrations, creating regional shortages both where agricultural labor emigrated and where people arrived seeking food. 7. Periods of drought and/or flood might have reduced public revenue and/or increased public expenses, thus increasing the political and economic instability and decreasing food availability. (For instance, it's not clear how much the figures overall are influenced by the very high frequency of disasters and widespread famine during the political turbulence and violence accompanying the collapse of the Ming dynasty.) I am not arguing that any of these scenarios is necessarily the case. Nevertheless, each of these may be influencing the observed correlations.

In summary, I do not believe that the authors' database and methods currently prove a valid correlation between flood and drought frequency and harvests in imperial China, nor that such a correlation would prove that drought or flood reduced harvest yields. The problem is not that the authors' hypothesis is unreasonable. It is simply that the conditions and data are too heterogeneous over such a large spatial and temporal scale. Any correlations found on such a scale are likely to have arisen from some artefact of the record-keeping or through the influence of some confounding variable, rather than to reflect a real and consistent climatic impact on agriculture.

Nevertheless, I would not like to dismiss this study out of hand. These datasets still have tremendous potential for historical climatology research. Better statistical methods could be devised to deal with changes in the frequency of historical reporting. By bringing trained historians onto such a project, the authors might find ways to handle problems related to historical changes in Chinese population, politics, land use, and economy. I would like to see the authors successfully address such problems in their research

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Technical notes: The paper variously sometimes to geographical parts of the country (e.g., “Northeast China”) and sometimes to regional designations (e.g., “Jiangnan”). The paper would be clearer if it stuck with regional designations and names of provinces only. The paper also needs extensive editing for English language grammar, spelling, and correct syntax. This is not merely a stylistic issue. The meaning of several passages is unclear due to lack of clear and correct English usage.

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