Thank you for dedicating your time and expertise to review our paper. Your comments and feedback are invaluable to enhancing the quality and clarity of the work. We are truly grateful for your careful review and comprehensive suggestions. Please see the responses below. Referee's comments (RC) are marked in bold font, authors' responses (AC) are marked in normal font. All line numbers mentioned correspond to the preprint version.

Specific comments:

Line 39-49: I understand that the authors intend to begin with the topic of famine and subsequently introduce drought as one of its primary causes. However, in my view, the second paragraph of the introduction would benefit from a more detailed discussion of drought, especially since the first paragraph focuses solely on climate change. A logical progression from climate change to drought and then to famine would seem to flow more naturally and align more coherently with the subsequent narratives.

Response: We agree with the logical progression suggested by the reviewer, which is indeed more conducive to paragraph articulation. Thus, we will reorganize this paragraph. Text:

Drought, characterized as an extreme climatic event, may intensify the conflicts between humans and the environment at different time scales, influencing the trajectory of civilizational development. Prolonged droughts contributed to the collapse of the Classic Maya civilization (Medina-Elizalde and Rohling, 2012; Douglas et al., 2015), the migration of the Anasazi population (Benson et al., 2007), and the demise of Angkor, the capital of the Khmer Empire (Buckley et al., 2014). In China, drought is the most frequent natural disaster, with 1,074 years of recorded droughts from 1766 BCE to 1937 CE (Li et al., 2003; Deng, 2012). In historical times when agricultural harvests depended heavily on climatic conditions, long-lasting and widespread drought events declined food production and thus were likely to trigger famine (Teng et al., 2014). Defined as a state of extensive hunger resulting from a lack of food, famine denotes a crisis in food security. Famines may further lead to consequences like displacement, plague outbreaks, and social unrest. Historically, the large-scale peasantry uprisings in China in the late Eastern Han (180s), late Sui (610s), late Tang (860-880s), late Ming (1620-1640s), and late Qing dynasties (1840-1860s, 1890-1900s) all erupted in the context of extreme drought and famines (Ge, 2011; Fang et al., 2019), most of which played a critical role in dynasties changing. In sum, famine is a significant manifestation of the adverse effects of climate change reaching the human system. It also serves as a vital link in the chain of transmission of these effects to the economic, political, and military domains, which is particularly evident in agrarian societies.

References:

Benson, L., Petersen, K., Stein, J.: Anasazi (pre-Columbian native-American) migrations during the middle-12th and late-13th centuries -were they drought induced?, Clim. Change, 83(1), 187-213, https://doi.org/10.1007/s10584-006-9065-y, 2007.

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Deng, Y., The History of famine relief in China (in Chinese), Wuhan University Press, Wuhan, China, 2012.

Douglas, P.M., Pagani, M., Canuto, M.A., Brenner, M., Hodell, D.A., Eglinton, T.I., and Curtis, J.H.: Drought, agricultural adaptation, and sociopolitical collapse in the Maya Lowlands. Proc. Natl. Acad. Sci. U.S.A., 112(18), 5607-5612. https://doi.org/10.1073/pnas.1419133112, 2015.

Li, M., Li, S., Li, Y.: Studies on drought in the past 50 years in China (in Chinese with English abstract), Chinese Journal of Agrometeorology, 24(1), 7-10, 2003.

Medina-Elizalde, M., and Rohling, E.J.: Collapse of Classic Maya civilization related to modest reduction in precipitation, Science, 335(6071), 956-959, https://doi.org/10.1126/science.1216629, 2012.

Teng, J., Su, Y., and Fang, X.: The reconstruction and analysis of famine sequence from the Western Han to the Qing Dynasty (206BC~1911AD) (in Chinese with English abstract), Journal of Chinese Historical Geography, 29(4), 26-32, 2014.

Ge, Q.: Climate change in China's past dynasties (in Chinese), Science Press, Beijing, China, 2011.

Fang, X., Su, Y., Zheng, J., Xiao, L., Wei, Z., and Yin, J.: The Impact of Historical Climate Change on China's Social Economy (in Chinese), Science Press, Beijing, China, 2019.

Line 46: It would be beneficial to clearly mark the corresponding periods of the late Eastern Han, Western Jin, late Sui, late Tang, late Ming, and late Qing dynasties in order to assist readers unfamiliar with Chinese history in understanding the context. The same applies to line 51.

Response: We will add the corresponding periods of the peasantry uprisings mentioned in line 46, as well as the duration of the Ming dynasty in line 51. Text:

Historically, the large-scale peasantry uprisings in China in the late Eastern Han (180s), late Sui (610s), late Tang (860-880s), late Ming (1620-1640s), and late Qing dynasties (1840-1860s, 1890-1900s) all erupted in the context of extreme drought and famines (Ge, 2011; Fang et al., 2019), most of which played a critical role in dynasties changing.

1627-1644 CE saw an extraordinary and extreme drought in China, known as the "Chongzhen Megadrought" because it coincided with the last period of the Ming Dynasty (1368-1644 CE), the Chongzhen Emperor's reign.

References:

Ge, Q.: Climate change in China's past dynasties (in Chinese), Science Press, Beijing, China, 2011.

Fang, X., Su, Y., Zheng, J., Xiao, L., Wei, Z., and Yin, J.: The Impact of Historical Climate Change on China's Social Economy (in Chinese), Science Press, Beijing, China, 2019.

Figure 1: The figure contains a mix of historical and modern geographical concepts, potentially leading to confusion. For instance, under contemporary geographical categorizations, Shanxi Province is not typically considered part of the northwest region, nor is Henan part of the North China region, and Hunan is not included in the Southeast region, among others. It might be clarifying to substitute "Northwest China" with "Northwest region" and "North China" with "Northern region." The former terms are commonly employed in the delineation of modern China's geographical divisions: East China, South China, North China, Central China, Southwest China, Northwest China, and Northeast China.

Response: In this manuscript, the division of the study area does not strictly adhere to modern China's geographical categorizations. Instead, we consider two aspects when dividing: firstly, the geographical attributes encompassing topography and climate, as well as the socio-economic distinctions; and secondly, the progression of droughts from 1627 to 1644. Considering the spatial concurrence and temporal synchronicity of droughts, the division aims to minimize intra-regional differences while maximizing inter-regional differences. Nonetheless, our naming of regions might lead to potential confusion with the modern geographical divisions of China, as the reviewer put forward. Therefore, we accept the suggestion to substitute "Northwest China" with "Northwest region" and "North China" with "Northern region", to mitigate ambiguity and ensure a greater degree of nomenclatural consistency across the five regions. Corresponding adjustments will be made in Figure 1, as well as in the text, tables, and other figures.

Table 1: I have the following three types of questions:

(1) The translation of Chinese expression "崇祯十年旱" should be "Drought in the tenth year of Chongzhen period" which is analogous to the expression "Drought in the third year of Chongzhen period (崇祯三年旱)". Given this similarity, both records should be classified at the same level. However, in Table 1, the former is classified as level 3, while the latter is classified as level 2.

(2) The expression of "Drought in the third year of Chongzhen period (崇祯三年旱)" means "There is a drought in a specific year". "Winter drought (冬旱)" is also a situation in which drought occurs in a given year. From this perspective, the two records should be classified at the same level. However, in Table 1, the former is classified as level 2 and the latter is classified as level 1.

(3) How should readers interpret and compare different types of drought expressions? For instance, why is the drought level of 'Drying up of wells' classified as Level 3 in Table 1, which is higher than that of 'The grass and trees are withered and scorched', classified as Level 2?

It is recommended to provide more detailed descriptions on how to classify the original records using the semantic difference method. This would assist readers in achieving similar classification results with the same data. The authors could consider categorizing all descriptions into groups such as drought descriptions, plant descriptions, and descriptions of rivers, wells, and groundwater. Subsequently, they could summarize the text descriptions within each category and classify them into levels 1-4. The same approach could be applied to Table 2.

Response:

(1) There is a clerical mistake in cell Level-3-2) in this table. The original Chinese text for "Great drought in the tenth year of Chongzhen period" should be "崇祯十年大旱". It differs from the record "Drought in the third year of Chongzhen period (崇祯三年旱)" in the intensity of drought. That's why they are classified at different levels. We will correct the mistake.

(2) Climate disaster records in Chinese historical documents exhibit two characteristics: focusing on anomalous rather than normal phenomena and emphasizing events that significantly affect agricultural production and the human-living. Thus, more attention is given to summer and autumn when recording drought. Compared to winter and spring, droughts in these seasons represent greater precipitation anomalies and are more likely to threaten agricultural production. Generally, if a drought occurs only in the winter, it would not be recorded as "drought in year XX."

In our database, some years and locations have records from multiple sources that can serve as evidence. For example, for the year 1639 in Lianshui County, Jiangsu Province, *A compendium of Chinese meteorological records of the last 3000 years* notes the event as "drought," while *Climatic historical materials for the last 500 years in East China* records it as "summer drought," among many similar instances.

Thus, we consider "Drought in a certain year" to represent droughts occurring in the summer or autumn and should be divided as level 2. In contrast, "winter drought" represents less precipitation anomalies and is categorized as level 1.

(3) Drought initially originates in the atmosphere, characterized by prolonged periods without precipitation or reduced rainfall, i.e., meteorological drought; then it begins to impact other Earth system spheres. In formulating the criteria for drought classification in this study, we gave priority to those records directly related to the season of occurrence, duration, and intensity of meteorological drought. Additionally, other relevant records are also considered, such as hydrological conditions including declines in river levels, drying of surface water bodies, and lowering of groundwater levels. Similarly, vegetation conditions such as plant wilting or even widespread plant mortality are referenced. Based on these phenomena, the drought level is determined, as illustrated in the table below.

	Seasons, duration, and intensity of drought	Hydrological conditions	Vegetation Conditions	Comprehensive descriptions of drought conditions
Level-1	Drought in the dry season and no drought in the wet season, or one-month drought.	-	-	-
Level-2	Drought in one wet season.	The river and lake levels have dropped significantly, but have not dried up completely.	Plant wilting	“Drought” occurred in a certain year is recorded
Level-3	Drought in two wet seasons, or severe drought in one wet season.	Complete drying up or ceasing to flow of rivers and lakes, or lowering of groundwater levels.	Extensive plant mortality	“Great drought” occurred in a certain year is recorded
Level-4	Drought throughout the year, or severe drought in two wet seasons.	-	-	-

As for the example the reviewer mentioned, well water originates from underground aquifers, while plants primarily absorb capillary water in the soil through their roots. The burial depth of the former exceeds that of the latter. Moreover, the phenomenon of "drying up of wells" indicates a significant decline in the groundwater level, whereas the withering of plants (not as severe as the widespread death of plants) suggests a reduction in soil moisture. Consequently, the degree of drought represented by the "drying up of wells" should be considered greater than that indicated by "the grass and trees are withered and scorched."

Line 149: Readers unfamiliar with China may not know the locations of the Wei River, Fen River, and Guanzhong Plain. The same applies to Line 189, where the locations of Changsha, Hexi Corridor, Fen and Zhang Rivers in Shanxi, Wen and Si Rivers in Shandong, Baiyangdian, Suzhou Creek, etc., have not been introduced in the article.

Response: Thanks for the suggestion. We decide to add another map to illustrate the geographical overview of the study area as Figure 1(b), shown below. This map will label the rivers and lakes mentioned in the text, such as the Wei River, Fen River, Zhang River, Dawen River, Si River, Suzhou Creek, and Baiyangdian. Additionally, we will remove or replace those terms in the manuscript that may be less understandable to readers, such as "Guanzhong Plain," "Changsha," and "Hexi Corridor." For instance, the phrase in line 149, "the area along the Yellow, Wei, and Fen Rivers in Guanzhong Plain and southwestern Shanxi," will be revised to "the area along the Yellow, Wei, and Fen Rivers in central Shaanxi and southwestern Shanxi."

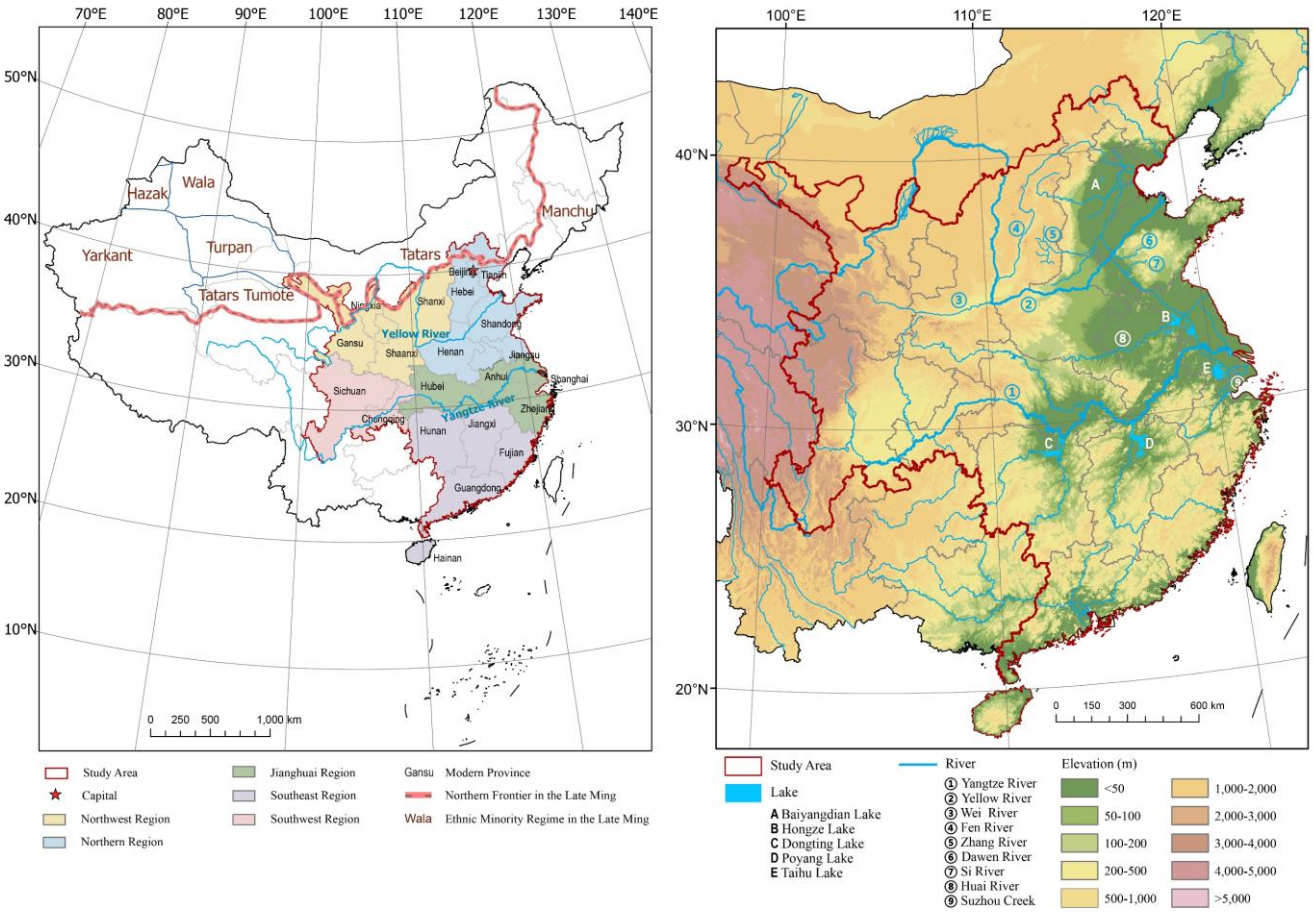

Figure 1: Map of the study area
(a) The location of the study area and subregions; (b)DEM of the study area with main rivers and lakes

Figure 2a: What distinguishes a Drought Zone from a Severe Drought Zone? What criteria are used to classify areas into Drought Zones and Severe Drought Zones? Is it the case that areas experiencing level 1-2 drought events are classified as Drought Zones, while areas experiencing level 3-4 drought events are classified as Severe Drought Zones? The same question applies to the classifications in Figure 4a.

Response: The classification of Drought Zone and Severe Drought Zone was based on the drought kernel density distribution map for the entire study period (1627-1644). We used the natural breaks method to classify kernel densities, with densities from 0.00008 to 0.00392 representing Drought Zone, and densities from 0.00392 to 0.02084 representing Severe Drought Zone. Thus, there is not a direct correspondence between this classification and the levels of drought events. However, the kernel density of a given raster is determined by the number and levels of drought events surrounding it.

To avoid ambiguity, we will mark the ranges of drought kernel densities corresponding to the Drought Zone and Severe Drought Zone in the legend of Figure 2a, shown below. Similar modifications will also be made to Figure 4a.

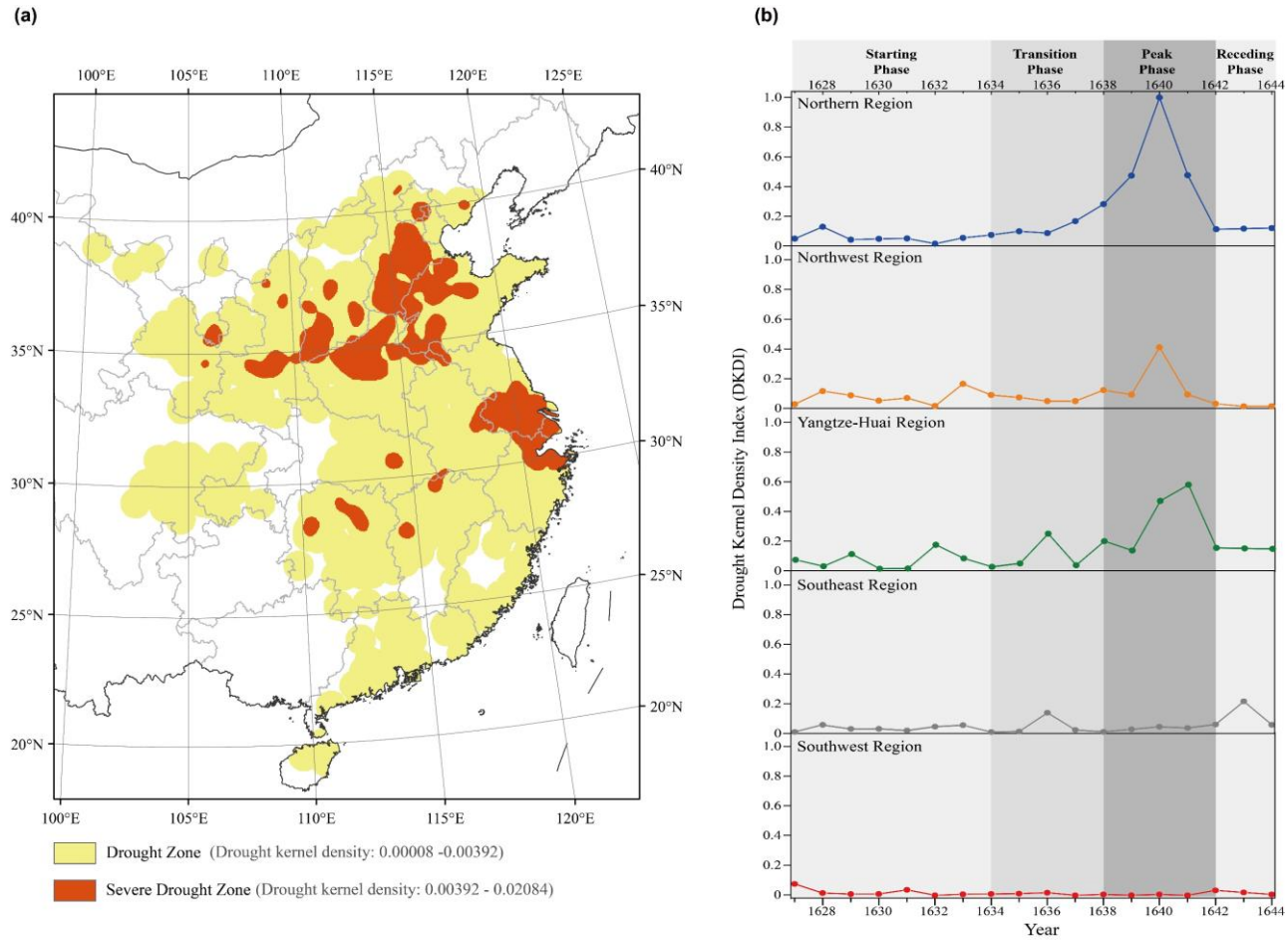

Figure 2: Spatial and Temporal Patterns of Drought, 1627-1644 (a) Overall spatial distribution of drought, 1627-1644. (b) Drought Kernel Density Index (DKDI) series for five regions

Figure 2b: I have the following two suggestions.

(1) By converting the ordinates to the same scale, the changes and differences in the DKDI index across each region can be displayed more intuitively. For example, it can be unified into a range from 0 to 1 with an interval of 0.1.

(2) The expression of the start and end time of each stage in the figure is different from the text content. Taking the "Starting Phase" as an example, the start time seems to be someday before 1627 and the end time seems to be someday after 1633 from the figure.

Response: We accept the suggestion to standardize the vertical axis of Figure 2b to the same scale, ranging from 0 to 1 with an interval of 0.2. We will also adjust the plotting expression for phases to avoid ambiguity, as shown in Figure 2b above.

Line 160-170: The changes of DKDI in the southeast and southwest regions are not mentioned in this paragraph.

Response: Regarding the changes of DKDI in the Southeast and Southwest regions, we have discussed this in the previous paragraph (see lines 157-159 in the preprint). Compared to the other regions, these

two regions have overall low DKDI values, with peaks not exceeding 0.2, indicating that they were not the main drought-affected regions. Therefore, a detailed analysis is not conducted.

Line 171: It is recommended to provide more details on how the four phases of the drought were determined by analyzing the temporal and spatial variations of the drought.

Response: The four phases were determined based on the temporal changes in DKDI and the comparison of DKDI across the three main regions (Northwest, Northern, and Jianghuai regions). We will add a sentence in line 179 to clarify the key events that led to the division into four phases. Text:

The delineation of the four phases is informed by key events: declining DKDI in the Northwest Region while increasing DKDI in the Northern Region in 1634; the beginning of a significant increase in DKDI in all three regions mainly affected in 1638; and a remarkable decline and following stabilization in DKDI in those three regions in 1642.

Line 190: This line implies that the Yellow River once flowed through Jiangsu Province. But as we can see from Figure 1, the Yellow River does not flow through Jiangsu Province. This discrepancy is due to Figure 1 representing the modern course of the Yellow River, which has historically changed its course. This statement could potentially cause confusion among readers and therefore necessitates additional clarification.

Response: We will add a footnote at line 190 to explain. Text:

In the 17th century, the Yellow River flowed through Jiangsu Province into the sea. However, after a breach at Tongwagang, Henan Province, in 1855, its course changed. Currently, it does not flow through Jiangsu Province, as illustrated in Figure 1.

Figure 4b: Can it be divided into distinct phases like drought? If not, the phases of drought are suggested to be re-marked on the chart for easier comparison.

Response: To avoid confusion with the drought phases, we have not segmented the famine evolution into phases. However, we will mark the drought stages above the FKDI series graph in Figure 4b, as shown below, to facilitate the analysis of famine evolution during different phases.

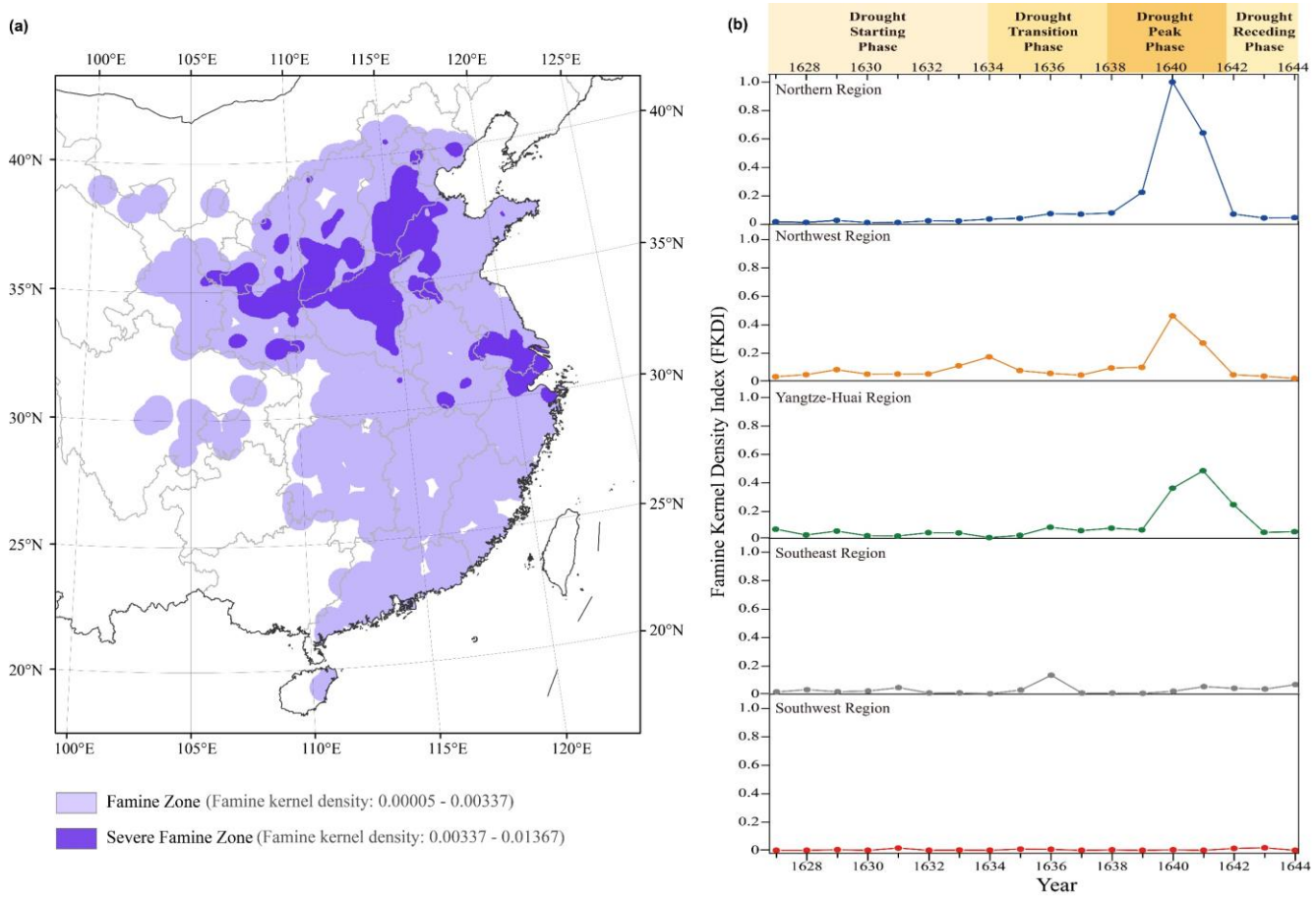

Figure 3: Spatial and Temporal Patterns of Famine, 1627-1644 (a) Overall spatial distribution of famine, 1627-1644. (b) Famine Kernel Density Index (FKDI) series for five regions

Table 4: What is the correlation coefficient in the fourth year? If we want to draw conclusions that affect three years, shouldn't we at least list the correlation coefficient for the fourth year?

Response: Thanks for the referee's suggestion, which prompted us to revisit the correlation analysis in Table 4. We found that these results do not significantly contribute to the paper and do not provide conclusions different from those in Table 3. Therefore, we will remove this table and its related content. Thus, Section 5 will now include: (1) correlation analysis at the regional scale to demonstrate the correlation between DKDI and FKDI, and the continuity of drought's impact on famine; (2) regression analysis at the sub-provincial scale to explore the varying contributions of drought to famine across different regions.

Line 302: Do these 15 response types occur exclusively in the Yangtze-Huai Region, or are similar patterns observed in other regions as well?

Response: Measures in Table 5 were recorded across various regions, but the Jianghuai Region exhibited the greatest frequency of those measures, particularly at the local government level. In the Northern and Northwest Regions, the recorded response measures predominantly involve financial or food relief, also with some instances of giving porridge and selling grain at low prices. However, measures like treatment, corpse management, hosting of orphans, and praying for rain are rare. There are two possible reasons for this: compared to other regions, the Jianghuai Region owned a more

developed economy and more abundant grain storage, providing a solid material basis for disaster response; additionally, the local officials in the Jianghuai Region showed stronger governance capabilities. Many of the measures, such as treatment and corpse management, were initiated by those officials, and the records documenting their names. It illustrates that human response measures can moderate the transmission process of drought impacts and reduce social damage. Due to space limitations, we choose the most typical region, Jianghuai Region, as an example for illustration.

Technical corrections:

Line 139: Formulas need to be numbered.

Response: We will number the formulas in the manuscript.

Figure 3: The graticules appear to be missing from the figure. The same issue is observed in Figure 6.

Response: We will add the graticules in Figure 3 and Figure 6, as shown below.

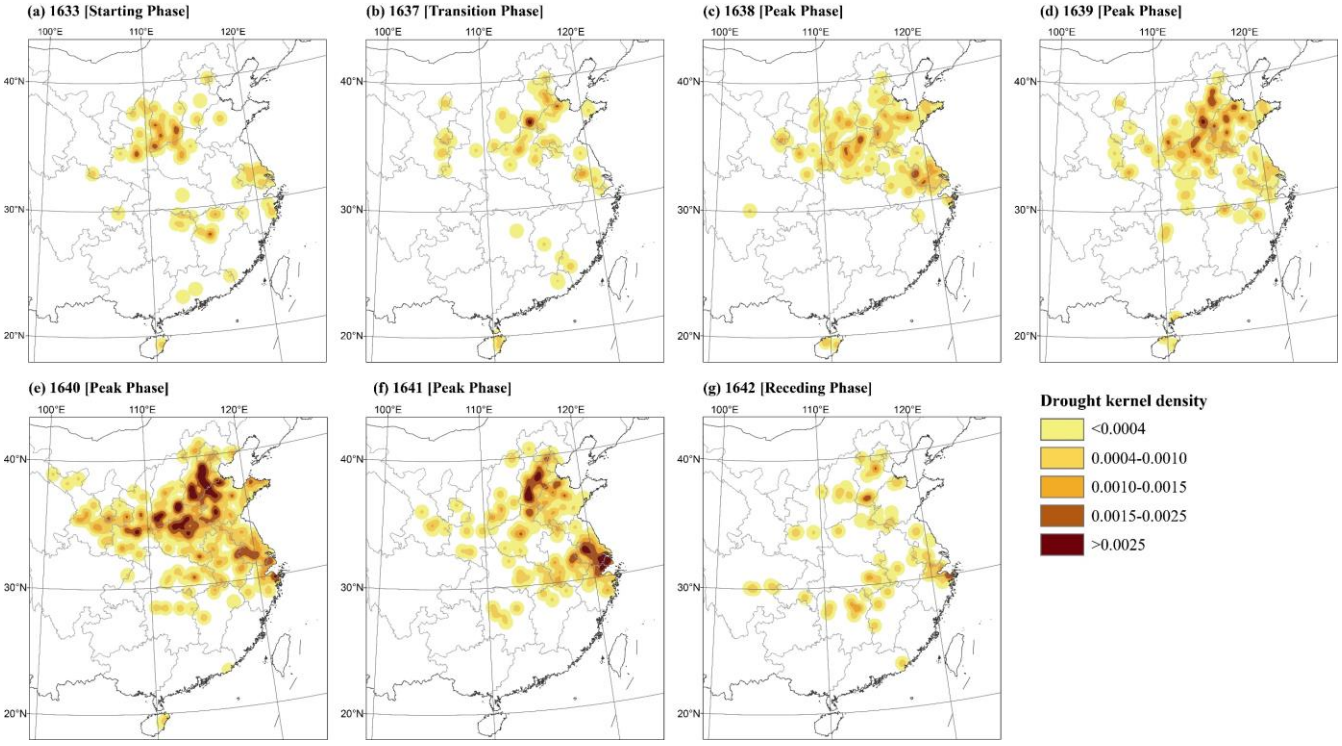

Figure 4: Spatial distribution of drought during representative years of each phase

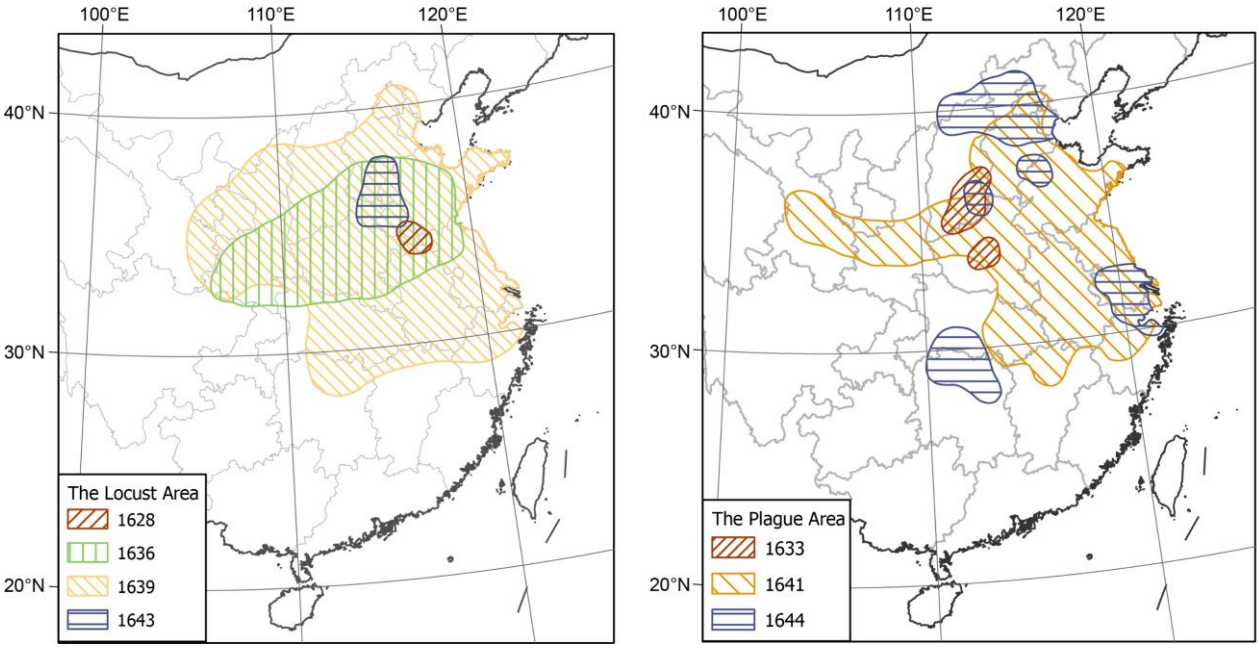

Figure 5: Areas affected by the locust infestation and plague

(a) Locust infestation (b)Plague

Figure 4: Typically, figures are not placed directly beneath the title.

Response: We will move Figure 4 below the first two paragraphs of Sect 4.

Table 6: This table should be reformatted into a three-line table.

Response: We will reformat Table 6 into a three-line table, as shown below.

Table 6: Response measures in the Yangtze-Huai Region from 1627 to 1644

	Response Measure	Main Actor	Meaning
(1)	Reseeding	Farmer	After the crop dies due to drought, re-plant some if rainfall occurs.
(2)	Locust catching	Farmer	Catch locusts to prevent them from destroying crops. Sometimes local government also encouraged people to do so and gave them some grain or money as an award.
(3)	Food substitution	Famine victim	Eat wild herbs, chaff, grass roots, tree bark, soil, and so on to satisfy their hunger. The most extreme case is cannibalism (i.e. some people kill others and eat corpses).
(4)	Selling property	Famine victim	Selling property such as houses, land, cattle, agricultural tools, etc., in exchange for money to buy food. The most extreme case is trafficking women and children.
(5)	Displacement	Famine victim	Leave their hometown and flee to surrounding areas in search of food
(6)	Robbery	Famine victim	Rob on the road, or rob the homes of the wealthy, landlords, and gentries to obtain food or money.
(7)	Giving porridge	Local government, officials, gentries	Open porridge factories to feed famine victims

(8)	Selling grain at low price	Local government	Sell stored grain at low prices to prevent excessive increases in grain prices on the market due to shortages.
(9)	Financial or food relief	Local government, central government	Distribute food or money to the victims directly.
(10)	Tax exemption	Central government	A discretionary exemption from taxes or corvees.
(11)	Tax substitution	Central government	Allow disaster areas to convert the tax grain into money or other items to hand in.
(12)	Treatment	Doctors, local government	Distribute medicine to the population if a plague occurred, or hire doctors to treat the patients.
(13)	Corpse management	Local government, officials, gentries	Distribute coffins to the families of the deceased, or bury the corpses together.
(14)	Hosting of orphans	Local government	Set up shelters to take in abandoned kids.
(15)	Praying for rain	Local officials	Offer sacrifices to gods and pray for rain.

Figure 7: The figure is not cited in the text.

Response: We will add the citation of Figure 7 in line 347.