Reconstruction of Crop Yield Potential for the Past 1000 Years Using Paleoclimate Reconstruction Methods: A Comparative Analysis with Societal Events

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Although paleoclimate reconstructions using observational proxies have advanced considerably, the societal impacts of such climate changes remain largely unexplored, creating a significant gap between the two fields.

This study focuses on crop yield as a fundamental link between climate and society. We attempted to reconstruct rice and wheat yield potentials over the last millennium using an offline data assimilation framework—widely employed in paleoclimatology—combined with MATCRO, a process-based model integrating land surface and crop growth processes. For the yield potentials reconstruction, we used real-world proxy data (DoD2k), and the reconstructed results were compared with independent famine indicators (burial data) and climate variables.

In the millennial reconstruction, we compared the high-reliability wheat reconstructions in Western Europe with historical burial data (famine indicators). We found no clear correlation between the burial data and reconstructed yields, suggesting that the link between crop yield and famine involves numerous complex factors. However, a focused analysis of specific crop failure periods identified within the reconstruction suggested relationships with reconstructed winter temperatures and the NAO index.

We further analyzed late 18th-century France during the Revolution, a period where crop failures and famines overlapped. Our reconstruction indicated a high crop yield in 1788, followed by low yields from 1789 onwards. In contrast, previous historical studies state that while crop production was high in 1787, it was low in 1788. Assuming both results are reliable, we propose the following hypothesis: In 1788, although climatic conditions favored a high crop yield, actual crop production declined due to factors such as social turmoil. Conversely, from 1789 onwards, climatic conditions deteriorated to cause low yields. This, combined with ongoing social disruption, inevitably resulted in low crop production, thereby sustaining public discontent and potentially contributing to the prolongation of the French Revolution.

Despite uncertainties arising from the limited availability of proxies, these results demonstrate that proxy data assimilation has significant potential for reconstructing past crop yields. This study offers a vital perspective on the relationship between past climate and society, bridging the gap to enable more detailed analyses of these historical interactions.

Keywords: History of Climate and Society, paleoclimate reconstruction, offline data assimilation, crop yield

