Hydroclimatic instability during the late Roman Warm Period–early Dark Ages Cold Period transition in the eastern Mediterranean

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General Comments

This manuscript presents a high resolution hydroclimate record from western Tuurkiye. The stalagmite-based record provides a key insight into reconstructed conditions spanning 154–529 CE, a period that coincides with the latter part of the RWP and the transition into the early Dark Ages Cold Period. I commend the authors for a very thorough investigation of the proxy at hand which is reported clearly and with excellent comparison to other available hydroclimate records.

My issue lies with the fact that the historical framing appears insufficiently thought through and overly simplistic. The paper introduced the links between climate and societal change, and the Roman decline and fall in the introduction, but then seemingly forgot about it until an after thought in the conclusion. Moreover, the authors use a hydroclimatic record from the eastern Mediterranean to make broad claims about the decline of the Roman Empire as a whole, without accounting for the distinct historical trajectories of its eastern and western halves. I think if the authors want to use RWP to dark period transition in the title, then they need to discuss this more in the paper. See comments below.

I believe the paper would benefit by improving the structure of the results and discussion, and rethinking the figures. In both cases, a lot of information is squeezed in, and the clutter takes away from the importance of the findings. So far only 3 figures, and limited subsection headings are used, don't be afraid to use more. See detailed comments below.

1 Major Comments

1.1 Vague links to historical context

In its current form, the manuscript appears to invoke the Roman Empire more as a rhetorical device than as a historical framework that is meaningfully integrated into the analysis. The Roman Empire is touched upon briefly in the introduction and even more briefly in the conclusion, but its relevance to the study is never adequately developed. While it may have been intended to provide a broader historical motivation for the investigation, this connection does not appear to have been sufficiently thought through.

The historical framing here is overly simplistic, particularly given that the climate record presented originates from the eastern Mediterranean. The Eastern Roman Empire followed a markedly different historical trajectory from its western counterpart. What was Byzantium, allied with Rome around 73 BCE, became "Roman" around 196 CE, and transformed into Constantinople, the new Roman imperial capital around 330 CE. It did not experience a comparable collapse in the fifth century, but continued for nearly another millennium, until the Ottoman conquest of Constantinople in 1453. Therefore, the discussion on L362–365, where the authors state that "multi-decadal hydroclimatic variability across the transition to the early DACP could have been largely driven by changes in the NAO and associated with the shifts in westerly circulation," and that this climatic instability "coincides with the decline of the

Western Roman Empire, culminating in its collapse in 476 CE" is particularly problematic, the relationship between hydroclimatic variability in this region and the decline of the Western Roman Empire cannot simply be assumed.

Previous studies linking climate and Roman imperial history highlight the importance of distinguishing between regional climatic conditions and the distinct historical trajectories of different parts of the Roman Empire. E.g. Norman et al., 2025 (DOI: 10.1007/s10584-025-03925-4) which examines Roman Britain, or the overarching paper by McCormick et al., 2012 which explicitly acknowledges that "regional differences in climate conditions parallel the diverging fates of the eastern and western Empires in subsequent centuries."

If the authors intend to use the Roman Empire as a motivation for this investigation, they need to establish a more convincing and historically nuanced connection between the hydroclimatic variability recorded in Turkey and the specific historical developments under discussion. In particular, they should clarify which part of the Empire, which period, and what historical process their climatic findings are intended to illuminate. As currently presented, the manuscript draws an overly broad association between climatic instability and the decline of the Western Roman Empire without adequately explaining how an eastern Mediterranean record supports this interpretation. This framing needs to be reconsidered and substantiated, rather than relying on a vague association between climate variability and imperial decline.

1.1.1 Specific comments

Introduction The paper opens with a rather obvious sentence about climate and civilisation, stating that it affects it, referencing three papers that cover very different elements of this subject. It then gives examples related to agriculture and the Romans. I think this sets the paper up to be vague already. Delve into this more, climate variability can both aide and be detrimental to societies - and the Romans exemplify this perfectly. Use the references that are stated - e.g. the Cullen et al and the Akkadian Empire, Shi et al and the Roman, and set up the subject properly.

L30-33 "help to improve future projections" is extremely vague, and to be hones isn't the motivation behind this research. Studying the past is vital to understand climate dynamics - as you mention, but also how these dynamics interact with societal vulnerabilities. This your research actually helps with so discuss that instead.

L49 "1-250 CE in NH" and "150 BCE -270 CE in Spain" (and Italy). Spain and Italy are in the Northern Hemisphere? So do you mean Northern Europe ? Or do you mean it was overall 1-250 CE but Spain and Italy are outliers? The same confusion occurs in L51. But, your study is in the East, so perhaps some timing related to this region rather than the west of Europe is more appropriate.

1.2 Structure

Section 4.2 This section is far too long and hard to follow, especially after the clarity of section 4.1. It would heavily benefit from being broken up:

- Present a summary of the results first concisely, so the reader has a clear idea of the entire chronology in simple terms (wet/dry).

- Subsection explaining volcanic influence, concluding with issues, mainly L186-212 but also 284-295 should be here.
- Subsection explaining NAO (L213-230), but also L304-310?
- Subsection explaining SST (L231-241)
- Subsection explaining Variability (L242-283)

2 Figure Comments

Figure 1 This figure is trying to do too much. I think it would be greatly improved by splitting it up, and removing what is actually not essential:

- Panel A: Chronologically it makes no sense to have this at the bottom right - perhaps it is here because it was squeezed in, but it doesn't read well.
- Panel A: SS1220 is marked but this is not in the legend, nor could i find any discussion of it in the text, nor any reference. Why is it here?
- Panel A: It seems the main role here is to show the ITCZ seasonal position, yet the ITCZ is mentioned only one time in the manuscript on L71, so is this truly needed?
- Panel B: What is the red and what is the blue? I can't find in the legend.
- Panel C: This is interesting, but again it looks like it has been squished on. It's a complicated map, and its position makes it more complicated.

Figure 2 Having the panels labeled with red letters when the plot already features alot of red lines, means it is hard to read. Use black letters and set them away from the plotting (this goes for the other figures too).

Figure 3 Again alot of interesting things, but why is it all crammed in? I would suggest rethinking this, what is essential to show? If section 4.2 is divided up, as i suggest above, then this figure can also be divided up:

- One figure to compare hydroclimate, so panels a,b,c,h,i,j,k,l. The data in A also needs to undergo more smoothing or soften the thresholds as picking out any trends are tricky.
- One figure to show the drivers, so panels d,e,f,g,n, alongside a map showing their locations - taking away some of the clutter from Figure 1b.
- Panel K and L: Your study is lost even with a label, this should go first in the new figures.