

Dear Dr. Igo Paulino,
Topical Editor
Annales Geophysicae (ANGEAO)

Ref : angeo-2019-97
Title : Historical Aurora Borealis Observations in Anatolia during medieval period: Implications for the past solar activity
Journal : Annales Geophysicae (ANGEAO)

Thank you for your constructive comments. I have just revised the manuscript in view of the reviewer comments as outlined in detail below and the paper is now ready to resubmit the journal of Annales Geophysicae (ANGEAO) titled “Historical Aurora Borealis Observations in Anatolia during medieval period: Implications for the past solar activity”. Please find our response to reviewer’s comments step by step below.

I would like to thank the reviewers for their thoughtful comments. Responses to comments are presented in the following pages along with explanations.

Thanks again and looking forward to hearing from you soon.

Best regards,
Dr. Nafiz MADEN
Corresponding author

Detailed Response to Reviewers

Response to comments from Anonymous Referee #1:

General Comments:

Apparently, the author has slightly improved this manuscript but the revision seems only stopgap and cannot resolve the problems at its root. Therefore, I have addressed my concerns as positively as possible and tried to show how to revise this manuscript more explicitly. The novelty issue should be resolved pushing scientific implications for the medieval grand maximum and the extreme solar particle storm in 774/775, as the author does not have any novelty in the source records. The usage of “Anatolia” is highly problematic, as Constantinople, providing more than half of involved reports, is situated in the European side. The author needs to be more explicit about the obtained implication for the solar activity around the extreme solar particle storm in 774/775. The climatological discussions must be removed as the current evidence does not satisfy scientific threshold and will reduce the value of this manuscript. Overall, these comments are minimal requirements for publication in the *Annales Geophysicae*, which “publishes original articles and short communications (letters) on research of the Sun– Earth system...”. The author is duly requested to address these comments appropriately and improve his scientific discussions and English grammar.

Reply: *I would like to thank the Reviewer #1 for encouraging comments to improve the quality of the manuscript. The manuscript is revised according to Reviewers comments. The title of the manuscript is changed as “Historical Aurora Borealis catalog for Anatolia and Constantinople (hAcAC) in the medieval period (AD 1-1453): Implications for the past solar activity” including observations recorded in the Constantinople. Also, the sentence of “High auroral activity around the extreme solar particle storm in 774/775 and the medieval grand maximum in 1100s in Anatolia and Middle East is quite consistent with the past solar variability reported in other scientific literature” is added to the Abstract section.*

Specific Comments

1. Novelty of the Records

Unfortunately, compiling local auroral reports from existing catalogs does not guarantee novelty. This is especially the case, as the author explicitly admitted that he has not consulted the original historical documents and declined to provide example images of the original historical documents. The readers would have found its novelty, if the author extracted auroral records not from existing catalogs but from original historical documents.

Even more seriously, more than half of the auroral reports in this catalog (9 out of 14) are derived not from Anatolia but from Constantinople. As Constantinople is situated in the European side (“Macedonia” in the Byzantine Epoch or “Rumelia” in the Ottoman

Epoch), they are not classified as “historical Anatolian Aurora”. This is explicitly shown in Figure 1. Therefore, this catalog must drop these 9 records, in order to let this manuscript be a “historical Anatolian Aurora catalog”.

Therefore, the author needs to show its novelty in his scientific discussions, as these data are not new and more than half of them are not from Anatolia.

Reply: *Thank you for your encouraging comments to improve the quality of the manuscript. The novelty of this manuscript is given below:*

The aim of this research is to establish a relationship between historical Aurora observations recorded in Anatolia and Constantinople during the medieval period and the past solar activity of interrelated social and economic climate change impacts. This research may also contribute to the understanding of public perception of the historical auroras. Anatolia and Constantinople have not been studied until now with respect to historical-climatological data and aurora observations. The available catalogs described above present a number of records covering Europe, Japan, China, Russia and Middle East regions.

The title of the manuscript is modified as “Historical Aurora Borealis catalog for Anatolia and Constantinople (hAcAC) in the medieval period (AD 1-1453): Implications for the past solar activity” covering aurora observations recorded in the Constantinople.

High auroral activity around the extreme solar particle storm in 774/775 and the medieval grand maximum in 1100s in Constantinople, Anatolia and Middle East is quite consistent with the past solar variability reported in other scientific literature.

2. “Strength of the Aurora” and their Validity

This has been much improved, removing misleading usage of likeliness evaluations. However, the narrative in L61-70 is then too long. Given the author’s existing discussions, this lengthy phrase (“Neuhäuser and Neuhäuser (2015) are implemented ... cannot be classified as extreme events associated with extreme magnetic storms.”) should be revised and connected more to their scientific discussions as follows:

“Recently, such candidate records of mid-latitude aurorae have been intensively investigated (e.g., Usoskin et al., 2013; Stephenson, 2015), due to the discovery of footprints of an extreme solar particle storm in the cosmogenic isotopes around 774/775 (Miyake et al., 2012; Usoskin et al., 2013; Mekhaldi et al., 2015). While Neuhäuser and Neuhäuser (2015) suggested five likeliness “criteria” and rejected most of the candidate aurorae around this event. However, these criteria actually contradicted auroral behaviour during the extreme space weather events (Kimball, 1960; Kataoka and Iwahashi, 2017; Kataoka et al., 2019; Kataoka and Kazama, 2019). Indeed, Stephenson et al. (2019) rejected these criteria and their analyses on the basis of multiple counter-examples during the extreme space weather events and confirmed an enhanced solar activity around this epoch. Their conclusion is consistent with the isotope evidence for the extreme solar particle storm such as the detected ratio of Be10 and Cl36 (Mekhaldi et al., 2015),

latitudinal concentration of C14 concentration (Uusitalo et al., 2018), and coincidental spikes of the multiple cosmogenic isotopes in both hemispheres (Büntgen et al., 2018)."

Reply: *I would like to thank the Reviewer #1 for encouraging comments to improve this study. The paragraph is revised according to the Reviewer #1 suggestion.*

4. Solar Activity around 774/775

In order to push their scientific novelty, the author needs to expand this section, rather than dropping it. Extending what the author has written, I would suggest writing as follows, on the basis of what the author has claimed.

"The low-latitude aurorae of 772-773 are interesting, as being very close to the extreme solar event of 774/775 (Miyake et al., 2012; Usoskin et al., 2013; Mekhaldi et al., 2015). These low-latitude aurorae are quite close from the extreme solar particle storm in 774/775 and support not the solar minimum (Neuhäuser and Neuhäuser, 2015) but high solar activity back then (Usoskin et al., 2013; Mekhaldi et al., 2015; Stephenson et al., 2019)."

Reply: *I would like to thank the Reviewer #1 for their thoughtful comments. The suggested paragraph is added to the manuscript.*

5. Chronological Coverage

To say "1453 is considered the end of the medieval period by historians", the authors must provide evidence. This is the end of Byzantine Empire, not the medieval epoch. I do not think the Ottoman conquest of the Constantinople is a benchmark of the medieval epoch. After all, it is not "medieval Anatolia" but "Byzantine Anatolia" that the author surveyed.

Reply: *The title of the manuscript is modified as "Historical Aurora Borealis catalog for Anatolia and Constantinople (hAcAC) in the medieval period (AD 1-1453): Implications for the past solar activity" covering aurora observations recorded in the constantinople.*

6. Definition of the Medieval Anatolia

The revision of Figure 1 can be mistaken as concealment, as Constantinople is anyways situated not in the Anatolian side but in the European side. The existing title with "Anatolia" is anyways highly misleading. If the author wishes to keep this title, the author must drop 9 records from Constantinople. The territory of Anatolia and modern Republic of Turkey is not the same.

Reply: *I would like to thank the Reviewer #1 for the encouraging and constructive comments to improve the quality of the manuscript. The title of the manuscript is modified as "Historical Aurora Borealis catalog for Anatolia and Constantinople (hAcAC) in the*

medieval period (AD 1-1453): Implications for the past solar activity" covering aurora observations recorded in the constantinople.

7. Relationship with Past Solar Activity and Climate Change

As I commented before, the author must not mix up the solar activity and the terrestrial climate changes (see Vaquero and Trigo, 2012; Lockwood et al., 2017). As the author does not have a clear tie between the medieval solar maximum and medieval warm period, the author needs to discard almost everything between P12L269 and P14L309: "This study could also be significant constraints for exploration of solar activity on Earth's atmosphere and climate during the historical periods previously proved by Bard and Frank (2006). ... An important increase in agricultural production and population seems to have occurred in Anatolia after the year of 1100". If the author wishes to claim this relationship, he needs more supporting evidence and write another article.

Then, the author needs to rewrite his discussion on the medieval grand maximum focusing not on the periodicity but on the amplitude of solar cycles. I would suggest writing as follows.

"Vaquero and Trigo (2012) stated the period from 1095 to 1204 as an average solar cycle length, whereas this needs to be carefully compared with the reconstructed solar cycles on the basis of cosmogenic isotopes (Miyahara et al., 2008; Kataoka et al., 2017). Nevertheless, this period is characterised with numerous records of sunspots and aurorae shown in Vaquero and Vazquez (2009) and supported by Anatolian reports compiled in this article. This is highly consistent with an appearance of a gigantic sunspot in 1128 that caused a serious geomagnetic storm (Willis and Stephenson, 2001) and contrasts well with the Oort Minimum (Usoskin et al., 2007, 2017; see also Inceoglu et al., 2015). Indeed, Bekli et al. (2017) demonstrated that the naked-eye sun spot observations from 974 to 1278 and aurora records from 965 to 1273 show multiple unusual peaks related to the high solar activity at latitudes below 45° by using Chinese and Korean historical sources."

Reply: I would like to thank the Reviewer #1 for their comments. The paragraph is revised according to the Reviewer comments.

9. Conclusion

I appreciate that the author compiled auroral reports in Anatolia and Balkan Peninsula (Constantinople) from existing catalogs and compared them with other scientific results. However, unfortunately, what the author did in the climatological context does not satisfy scientific threshold and needs much more scientific supports. This can be done only writing another article for that issue. Therefore, the fifth and sixth conclusions must be removed, as well as the discussions on the climate change. Instead, the author should add their finding on the high solar activity around the extreme solar particle storm in 774/775 in the conclusion.

Reply: I would like to thank the Reviewer #1 for the constructive comments. As I stated before the fifth and sixth conclusions are prominent findings achieved from aurora catalogs for Constantinople, Anatolia and Middle East regions.

Minor Comments

P1L14-17: "High Aurora activity during the years around 1100 in Anatolia and Middle East is quite consistent with the past solar variability and planetary climatic changes drastically impacting on the economy and human events." => "High auroral activity around the extreme solar particle storm in 774/775 and the medieval grand maximum in 1100s in Anatolia and Middle East is quite consistent with the past solar variability reported in other scientific literature"

Reply: Revised

P7L145: Neuhäuser and Neuhäuser (2015) did not do anything more than Harrak (1999) for Zuqnin Chronicle. Just cite Harrak (1999). These Zuqnin records have been intensively analysed in Hayakawa et al. (2017). Cite it here and Table 2 #11.

Reply: Revised

P8L187: Cite references for definition of the Armenian years.

Reply: Revised

P14L313: "Medieval grand maximum" should not be mixed up with "Medieval Climate Anomaly".

Reply: Revised

We thank to you and the Reviewer #1 and Reviewer #2 for their constructive and helpful comments.

Sincerely,
Dr. Nafiz MADEN