

Third Referee Report on MS angeo-2019-97 “Historical Aurora Borealis Observations in Anatolia during medieval period: Implications for the past solar activity” by N. Maden

General Comments

With regret, I found that the author has failed to address most of my previous comments or clarify the novelty of this manuscript, while the author’s version is slightly better than the virtually unchanged previous version. The author has almost explicitly admitted that he has not consulted the original historical documents for his survey. He has failed to explain the strength of aurora and has not done anything more than repeating what Neuhäuser and Neuhäuser (2015) have written, while their criteria themselves contradict the actual observational evidence (see *e.g.*, Stephenson et al., 2019). With great respect, I have to comment that applying dubious criteria to non-original records would not guarantee a novelty for an academic article, at least in *Annales Geophysicae*. Overall, I cannot recommend its publication in *Annales Geophysicae*, unless otherwise the author seriously revises this manuscript from its basis.

Specific Comments

1. Novelty of the Records

As I commented before, the largest issue for this manuscript is its novelty. What the author has done in this manuscript is to simply recompile the Anatolian auroral reports from the existing catalogs (not from the original historical documents!). Therefore, these presented results are unfortunately not new. The scientific method is currently no more than a repetition of Neuhäuser and Neuhäuser (2015), while the author’s outcome for the solar activity around 774/775 contradict what Neuhäuser and Neuhäuser (2015) have concluded. In this case, the only potential novelty of this manuscript is – at best – the emphasis of the high solar activity around 774/775. As long as I understand, “ANGEО publishes *original* articles and short communications (letters) on research of the Sun–Earth system...”. Therefore, the originality of this manuscript is crucially important to let this manuscript get subjected to further considerations.

2. “Strength of the Aurora”

The author must read Neuhäuser and Neuhäuser (2015) more carefully. Neuhäuser and Neuhäuser (2015) have explicitly stated “we establish five criteria for the *likeliness* of the event to be an aurora which are selected to distinguish from the other effects” in page 230. As the author has cited “The observation is classified as potential (N=0), possible (N=1), very possible (N=2), N aurora is probable (N=3), very probable (N=4), or certain (N=5) according to the criteria number (N) satisfied”. This is not about strength but about likeliness. As the equatorward extension of auroral oval has good correlation with “strength” of magnetic storm (Yokoyama et al., 1998), the “strength” would be better understood with the equatorward extension of auroral oval. Therefore, repeating an excerpt from Neuhäuser and Neuhäuser (2015) does not make any good sense here.

3. The Validity of Criteria

Even more seriously, the author has entirely failed to address the scientific concern for the validity of Neuhäusers’ criteria, only repeating what Neuhäusers described. As I commented previously, their criteria have been seriously doubted with counter-examples (Stephenson et al., 2019). The fact-based studies show that the equatorward boundaries of the aurora reach 25°, 24°, and 38° magnetic latitudes during the historical magnetic storms in 1770, 1859, and 1958 (Kimball, 1960; Kataoka and Iwahashi, 2017; Kataoka et al., 2019; Kataoka and Kazama, 2019). In the cases of such extreme space weather events, aurorae will be seen even southward from medieval Turkey (45 – 50.1° in magnetic latitude). It is also known that whitish pillar appears equatorward of the red glow during the strong magnetic storms, probably due to field-align currents carried by precipitating electrons (Kataoka et al., 2019). It is also not clear why fire or fiery means dynamics of aurora. The descriptions like “fire” more likely means auroral color and brightness (see Figure 1 of Kataoka and Kazama, 2019). The author needs to address these facts to evaluate validity of these criteria at the very least, if he strongly wishes to use these criteria in his manuscript. Otherwise, the author must not use these “criteria”.

4. Solar Activity around 774/775

While I appreciate scientific contribution by Mekhaldi et al. (2015) on the extreme solar storm in 774/775, Neuhäuser and Neuhäuser (2015) have claimed “they [their auroral

records] cannot support a hypothetical solar super-flare” in page 236, for example. This is almost in an opposite spectrum against Mekhaldi et al. (2015). The author needs to clarify what he can say from Anatolian records for such scientific conflict.

5. Chronological Coverage

Why “Any aurora observations could not be reached up to 1453”? That must be scientifically explained. Moreover, the title of “medieval Anatolian” should be revised to “Byzantine” or “Byzantine Anatolian”, given what the author surveyed.

6. Definition of the Medieval Anatolia

The author needs to see Figure 1 a little more carefully. Edessa (and probably Amida too) is/are situated outside of the Byzantine territory. More seriously, this figure explicitly shows that Constantinople is situated not in Asia Minor but in “Macedonia”, while majority of the records in the author’s catalog are derived from Constantinople. Therefore, Figure 1 shows that they are not in Anatolia either.

7. Relationship with Past Solar Activity

While I commented on this aspect, the author just cited Willis and Stephenson (2001) without enough explanation. I cannot consider the author’s addition as a “detailed explanation”. Therefore, I have to repeat what I have written previously. The second conclusion in this manuscript states “In Anatolia and Middle East, there was a relatively high auroral activity during the years around 1100 is quite consistent with the naked-eye sunspot observations”. However, the naked-eye sunspot observations are mentioned only briefly in the context of Medieval Maximum (p.12) and periodicity between 1095 and 1204 is usual (Vaquero and Trigo, 2012). Therefore, the author should compare these auroral records with the naked-eye sunspot observations. Moreover, the cycle length during the Medieval Maximum is probably shorter (~9 years) on the basis of ^{14}C data (Miyahara et al., 2008) and their cycle reconstructions are shown in Kataoka et al. (2017). Hence the existing statement for solar cycle length needs to be revised, citing Miyahara et al. (2008) and Kataoka et al. (2017). This enhanced solar activity is also better illustrated, citing the earliest datable sunspot drawing and relevant Korean auroral records in 1128 (Willis and Stephenson, 2001; Willis and Davis, 2014), and contrasted with the Oort Minimum (Usoskin et al., 2007, 2017; see also Inceoglu et al.,

2015).

8. Relationship with Climatic Change

As I commented previously, the logic was extremely difficult to follow and the revision of humidity with auroral record has been applied without scientific explanations. The author needs to seriously note that the relationship between solar activity and climatic change in historical time span is not very clear (Vaquero and Trigo, 2012; Lockwood et al., 2017). Lockwood et al. (2017) have especially clarified how misleading to explain the Little Ice Age with the Maunder Minimum. They have casted a caveat “The association of the solar Maunder minimum and the Little Ice Age is also not supported by proper inspection and ignores the role of other factors such as volcanoes” in page 2.23 for example. This made me strongly doubt the validity of the author’s discussion for climatological impact. This manuscript cannot be published, unless otherwise the author removes their speculation about the climatic impact.

9. Conclusion

Accordingly, the fifth and sixth conclusions must be removed, as well as the discussions on the climate change. In the same time, the author needs to clarify which made aurora visible in Anatolia so frequently in the Byzantine period: solar activity or intensity of dipole moment and position of geomagnetic pole.