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Climate of the Past Discussions

Interactive comment on "Potential imprint of Spörer and Maunder solar minima on coral skeleton carbon isotopes" *by* T. Ourbak et al.

Anonymous Referee #2

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Ourbak et al. discuss a coral d13C record and its potential connection to solar activity variations. By comparing solar forcing records and their d13C data Ourbak et al. argue that metabolical processes in corals are influenced by changes in solar irradiation.

I think the paper by Ourbak et al. is an interesting discussion. However, as a non-expert in this field, I am not sure how reasonable their interpretation of the d13C record really is. To me it seems that it is rather complicated to draw reliable conclusions from these data since there are many mechanisms that can influence the d13C signal in corals. The poor correlation with the solar activity reconstructions and the uncertain mechanism behind the suggested solar-d13C link question the conclusions presented in this study (see below).

Ourbak et al. seem to suggest that d13C in corals is a good proxy to reconstruct solar activity. I think this is very far-fetched. Solar activity variations are supposed to influence total solar irradiance (TSI) only in the per mil range (see e.g. ref. 1). This is not even detectable with ground-based irradiance monitors since cloud, dust etc. have a far more important influence on local irradiance changes. Therefore, I doubt that long-term (per mil) solar effects can reliably be recorded by d13C variations in corals. However, there might be a solar - climate connection that has an influence on the corals and therefore on d13C. To me, Figure 2 in Ourbak et al. does not make a very convincing case for such a connection. A more detailed analysis might help to show this relationship. Figure 3 makes a more convincing case for a solar influence. However, this figure needs more explanation about the details of the analysis (see details below).

Specific comments:

To the dating: For me as a non-expert it would be interesting to know how good the dating really is. Are there well-defined layers and are the layers indeed annual? Potential problems in the chronology are only briefly mentioned at the end of the manuscript. I think it would be important to expand this discussion.

Page 1024 line 23/24: There is no doubt that there is a significant correlation between the different variables shown in figure 1 (table 1 is not necessary to see that). In addition, there is no question that all signals show an annual cycle. However, to write that there is " ...a significant relationship between solar activity and carbon isotope signal in coral skeleton..." indicates that there is a fundamental misunderstanding. Solar activity can be constant but there is still an annual cycle. Figure 1 shows this annual cycle but it does not show a "significant relationship between solar activity and carbon isotope signal in coral skeleton". This would require an analysis of TSI variations and their connection to d13C. I doubt that such an analysis is feasible with the available data since it seems impossible to extract the very small TSI changes (from Figure 1, lower panel) and their influence on d13C. It would be interesting to see if there is a correlation

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between local solar irradiance variations (e.g. due to cloud cover changes) and d13C. However, this seems to be impossible due to the relatively low temporal resolution of the d13C record. I think the annual cycle does not only inflate the correlation. It seems to me that it is solely responsible for the correlation. I do not understand what "computed anomalies" (page 1024 line 26) mean. Is it the signal after removing the annual cycle? How was that done?

page 1025 line 11: The TSI estimate by Lean et al. (1998) is outdated. Presently the estimates for long-term changes in total solar irradiance are rather smaller (see e.g. review by Foukal et al.).

page 1025: The relationship between TSI and d13C is not very convincing to me (figure 2). I agree that there seems to be a trend in the d13C data (especially in the Amedee data). However, to see if there is really a solar influence on d13C (as mentioned, I doubt that this link is directly via TSI changes) one would have to filter the records in the same way and calculate the correlation coefficients. This should be done after removal of the long-term trends to see if solar minima (as e.g. the Maunder minimum) indeed show a correlation with the d13C record. It seems to me that the Suess effect appears dominantly in the long-term d13C changes which could suggest a (coincidental) correlation to solar activity variations.

page 1026 line 2ff: the discussion of the short-term changes is partly based on the TSI reconstruction from the 10Be record from the South Pole (ref. 2). However, especially around 1500 AD this record does not agree well with the tree-ring 14C record (ref. 3). Therefore, it can be argued that the first d13C minimum does not agree with a change towards lower solar activity.

page 1026 line 9 ff: "insufficient light availability..." I doubt that tiny (a few per mil) change in TSI could cause a change in metabolic processes in corals. If there is indeed a solar influence it is much more likely due to indirect effects (e.g. solar influence on climate -> e.g. cloud cover change -> light availability change)

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It is not clear to me how figure 3 was produced. Is it based on the smoothed data? How is the Maunder and the Spörer minimum period defined for this analysis?

page 1026 line 27: "agreement and discrepancies" with what?

page 1027 line 7: Here we are in the fortunate situation that we have a good solar record (the sunspot record). If there is indeed an 11-yr cycle it should be possible to isolate this cycle in the d13C data and compare it with the sunspot record. I think this would be a valuable exercise. The same applies to the Gleissberg cycle. To have 70-100 years cycles in a 500-yr long record does not make a convincing case for a solar influence.

page 1028 line 8: the long-term change in solar irradiation from 1450 AD is based on Bard et al.'s record. As mentioned there are differences to other solar activity reconstructions. I cannot see such a long-term change in the d13C record.

figure 1 & 2: the records should be presented with the same time resolution. Otherwise, the comparison between the records is very difficult (especially in figure 2)

details:

page 1025 line 26: ".. reject this hypothesis"

the English could be improved at several places in the manuscript

References:

1. Foukal, P., Fröhlich, C., Spruit, H. & Wigley, T. M. L. Variations in solar luminosity and their effect on the Earth?s climate. Nature doi:10.1038/nature05072, 161-166 (2006).

2. Bard, E., Raisbeck, G. M., Yiou, F. & Jouzel, J. Solar irradiance during the last 1200 years based on cosmogenic nuclides. Tellus 52B, 985?992 (2000).

3. Muscheler, R. et al. Solar activity during the last 1000 yr inferred from radionuclide records. Quaternary Science Reviews 26, 82-97, doi:10.1016/j.quascirev.2006.07.012

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