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Climate of the Past Discussions

Interactive comment on "The climate in the Baltic Sea region during the last millennium" *by* S. Schimanke et al.

Anonymous Referee #2

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The manuscript presents a modelling study of the state of the Baltic Sea in two key periods in the past Millennium. The authors use a regional atmosphere-ocean model for the Baltic Sea area which is driven at the boundaries by global climate simulations over the entire past millennium performed with the climate model ECHO-G. The global model itself has been driven by past solar variability, orbital forcing and atmospheric concentrations of greenhouse gases. Additionally to this basic set-up the authors have conducted some simulations artificially increasing the air temperature in the Mediaeval Warm period to test the effects of thermal forcing on the stratification and oxygen concentrations in the Baltic Sea. This simulations cannot be considered realistic but they do provide interesting topic of discussion regarding the evidence provided by proxy data. There exists an on-going discussion about the relative roles of thermal forcing and eutrophication as responsible for diminished oxygen concentrations in the Baltic

waters. The proxy records cited by the authors indicate that in warm periods such as the Medieval Warm Period the conditions at the bottom of the Baltic Sea should have been nearly anoxic. These anoxic conditions are now being approached in the recent decades and it is interesting to estimate what kind of warming, in the absence of anthropogenic eutrophication, would be necessary to attain anoxic conditions in the Baltic bottom waters.

My impression of the manuscript is generally positive, although I have some recommendation regarding particular points.

A general comment about the validity of the simulation is that the global model has been only driven by changes in solar irradiance and greenhouse gases. There is no volcanic forcing in thus run. It is not yet clear which has been the major external driver for the global climate in the past millennium, but it seems that volcanic forcing has indeed had an important contribution. I think this should be clearly pointed out in the paper as a possible shortcoming.

Another general comment is that the introduction should, in my opinion, highlight a little bit more the significance of this study in estimating the relative contributions of temperature and eutrophication for anoxic conditions in the Baltic Sea. This relevance is a bit hidden in the introduction and in the discussion, but I think it is important to underline the conclusion of this model study that temperature alone is unlikely to have caused anoxic conditions during the Medieval Climate Anomaly

Particular points:

'the exact period varies between diïňĂerent studies. DiïňĂerences between periods prior to 1850 reïňĆect internal unforced variability and changes in external forcing as man-made contributions were small before that.'

This sentence is a bit contradictory, since man-made anthropogenic forcing also counts as changes in external forcing

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'Regional temperature variability in Europe is related to changes in the North Atlantic Oscillation (NAO) (Hurrell, 1995). Proxy data (Mann et al., 2009; Trouet et al., 2009)' ′ 'and model studies (Gomez-Navarro et al., 2011) indicate that a positive NAO phase prevailed during the MCA whereas the NAO was negative during the LIA (Spangehl'

When addressing the cause of past temperature changes in Europe, the state of the NAO is indeed important but it is not the whole story. When the external forcing is changing this has also a contribution to temperatures that can be stronger than the effect of the NAO. For instance, in future climates, the NAO will likely tend to become more positive, this lowering air temperatures in Greenland, but the overall evolution of Greenland temperatures will be dominated by the greenhouse gas forcing, independently of the NAO state.

′In the methods section a discussion on the external forcings used in the global simulation is in place see my general comment above). First, the absence of volcanic forcing should be clearly stated. Second, the amplitude of the variations in solar irradiance is also debated. The forcing used in this simulation is one choice, but not the only one that is justified.

'series. Applying a 20-yr running mean to the data increases the correlation coeïňČcients to 0.66 in RCA3 and 0.52 in the proxies (Fig. 4). These results show that the model has a somewhat stronger dependence on the NAO for the winter time temperatures in Stockholm than indicated by the proxies. This holds true both on inter-annual and decadal time scales but on even longer time scales the opposite is the case as the corresponding correlation coeïňČcient reduces to 0.59 in RCA3 while being higher, 0.68, in the proxies when a running 30-yr mean ïňĄlter is applied.'

The differences in the correlations are not very large, and I wonder if they warrant a conclusion about the strength of the relationship between NAO and temperatures. In this case, uncertainties in the estimation of the correlation should be indicated to guarantee that the values are statistically different.

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'Most proxy and model studies agree that the LIA was characterised by prevailing negative NAO conditions (e.g. Luterbacher et al., 2002; Spangehl et al., 2010). For the MCA the conïňĄdence level is not that high since very few proxy data sets reach that far back in'

Here, the work of Shindell et al. Science 294,2149 (2001) should be cited

'the LIA without any strong positive anomalies, the other series include several maxima with positive anomalies. Also, the strong positive NAO anomaly during the MCA in the Trouet et al. (2009) data indicates that colder than average conditions should have been prevailing in Greenland and parts of Northern Canada which is not the case following temperature reconstructions for that area (Ljungqvist et al., 2012). '

This conclusion is not necessarily correct. see my previous comment on the relative role of the NAO and of the external forcing on temperatures

'parameters have an eïňĂect on even longer time scales (Sect. 3.1). Consistently, the SLP diïňĂerence between the full MCA and LIA shows a rather weak negative NAO pattern which is mainly characterised by lower pressure in the North (Fig. 7). '

should it not read ' a rather weak positive NAO pattern '?

'over the Baltic Sea (0.73 K). The remaining energy is consumed at least partly for the melting of sea ice. '

The discussion here is a bit confusing. Temperature is not equal energy. Higher or lower temperatures may be sustained without any change in the energy content. It all depends on the balance of energy fluxes.

'Sec-ond, the long-term variability (50-yr average) within the observational data is larger than the diïňĂerence between the modelled MCA and LIA conditions. This adds further evidence that the simulated temperature diïňĂerence between the MCA and LIA is un- derestimated.'

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This comparison is not totally fair because it related to two different time scales. The annual cycle at a certain location is certainly larger than the temperature difference between MCA and LIA. By the same token the decadal variability in the observational period, specially at regional scales, can be perfectly larger than the centennial time-scale difference between MCA and LIA.

'The mean diffrence in salinity between RCO-MCA and RCO-LIA is 0.69 PSU'

volume-averaged?

Interactive comment on Clim. Past Discuss., 8, 1369, 2012.