

Interactive comment on “Anticyclonic atmospheric circulation as an analogue for the warm and dry mid-Holocene summer climate in central Scandinavia” by K. Antonsson et al.

Anonymous Referee #1

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This paper discusses the idea that warm and dry summer conditions in Scandinavia in the mid-Holocene were caused by the relatively frequent occurrence of an anticyclonic atmospheric circulation type. The characteristics of the weather conditions associated with this circulation type are illustrated using modern meteorological measurements. The paper is well-written, includes clear figures and uses an original approach to find an answer to the question why the mid-Holocene climate was warm and dry in Northern Europe. The manuscript should therefore be of interest to all paleoclimatologists working on the Holocene climate in Europe. There are however some issues that need to be resolved before publication (see below). For that reason I propose accepting this paper after moderate revisions

Major comments

A. It is not clear to me what the exact procedure is to produce Figures 4, 5 and 6. The paragraph on page 590 suggests that these figures are based on data from 16 grid points covering the period 1850-2000. But where are the data from Falun used? And why do Figures 4 and 5 only cover 1900-2000?

B. Page 593, line 25. 'A number of experiments have been carried out...' The cited model studies are the ones that performed transient experiments, i.e. with time-varying forcings. These studies were all performed with intermediate complexity models. You should also include in your discussion the numerous experiments performed for the 6 ka climate with state-of the art general circulation models in the framework of the Paleoclimate Modelling Intercomparison project (PMIP). For instance, Masson et al., (1999, *Clim Dyn* 15, 163-182) discuss results from 9 models that reproduce dry climatic conditions in Scandinavia at 6 ka. There are also more recent PMIP2 results published for the mid-Holocene (e.g., Braconnot et al., 2007, *CP* 3, 261-277).

C. Page 594, line 8. 'Hence the simulated summer temperature trend deviates from the observed pattern in central Scandinavia...' This is only partly true. Figure 2 reveals that both the model and reconstructions show a cooling trend from 7 ka onwards. In the model, the summer conditions in Scandinavia at 7 ka are warmer than at 0 ka due to the summer insolation. I would argue that the decreasing insolation provides still a good explanation for the long-term summer cooling trend observed in the data and for the relatively warm summer conditions in the mid-Holocene compared to the present. This should be emphasized in the paper. In my view, the issue is more the lack of relatively cool conditions in models between 9 and 7 ka, and the failure to simulate dry summer conditions in Scandinavia in the mid-Holocene. It is indeed possible that the model underestimates the occurrence of atmospheric blocking, which could explain part of the model-data mismatch. But I think it is an over-simplification to neglect the influence of the high insolation and to explain the entire warm summer anomaly in the mid-Holocene by anticyclonic atmospheric circulation. Please revise.

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Minor comments

1. Page 586, line 9: 'As an alternative explanation...' This is somewhat confusing, as model experiments have not been able to provide an explanation for the timing of the mid-Holocene optimum in Europe.
2. Page 586, line 15: 'The hypothesis is tested ...' I would argue that the hypothesis is not really tested, but rather illustrated using modern meteorological records.
3. Page 587, line 8. '... with major impact on, for example, ground-water level, hydrological conditions, plant phenology, and agricultural productivity'. Could you please be more specific? What kind of impact? Presumably, lower ground water table, lower agricultural productivity etc.
4. Page 589, line 22. Please provide additional information on the Falun site in the table caption: latitude, longitude and altitude.
5. Page 590, line 14. 'SLP data at 16 grid points same as in Chen (2000) during 1850-2003 were used'. Incorrect grammar, please rephrase.
6. Page 591, line 14. Please make the discussion of your results more quantitative. Discuss what the actual 'maximum Holocene level' is.
7. Page 592, line 3. 'Tilia, most likely *Tilia cordata*'. Please clarify for non-experts (like me): why do you think this is 'most likely'. Can pollen of *Tilia cordata* easily be distinguished from other *Tilia* taxa?
8. Page 593, line 18. 'Most the lakes', remove 'the'.
9. Page 594, lines 22-24. 'Therefore, the deviation between the model simulations and the climate reconstructions may be interpreted as deficiency of the model in simulating at least one of these processes'. This is not entirely fair. The extent and elevation of icesheets were prescribed in the model. So the model does not include ice-sheet dynamics, and can therefore not be expected to correctly reproduce the im-

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pact of changes in interactions between ice-sheets and the rest of the climate system. This is not a model deficiency, rather a failure of the model user to prescribe the correct icesheet characteristics.

10. Page 596. In addition to Figs 4 and 5, it would be interesting to have maps of typical conditions of the two main circulation types in Europe, showing typical pressure distribution, and anomalies for precipitation and surface temperature.

11. Page 596, line 21-22: 'combinations of warm and dry summer climate exist'. What do you mean by this? Do you mean the occurrence of warm and dry weather during summer? Please clarify.

12. Page 598, line 2-3: 'The mid-Holocene dominance of the anticyclonic conditions may have been caused by Atlantic surface circulation and sea-surface temperatures and their influence on the ocean-continent temperature and pressure gradients'. Could you explain how this would work? What would be the relation between ocean circulation and atmospheric blocking? In Section 3.3 the authors note that climate models fail to reproduce the correct mid-Holocene summer climate. These models, however, in principle include ocean dynamics and the coupling to the atmosphere. So if the ocean circulation is driving atmospheric conditions over Scandinavia during summer in the mid-Holocene, the models should show this. Or do you mean to suggest that this coupling is incorrectly included in climate models? Please elaborate on this point.

13. Figure 2c. There is an error in this figure. The scale indicates that the summer insolation is increasing over the course of the Holocene, whilst it should be declining.

14. Figures 4 and 5. It appears to me that the evolution of the temperature anomaly of A types shown in Figure 5a correlates in time with the frequency of the A types shown in Figure 4b, i.e. relatively elevated values during 1930s-1940s and 1965-1980, but relatively low values in the periods 1900-1930 and 1950-1965. If I am right, why is there such correlation? Please clarify.

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