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Climate of the Past Discussions

Interactive comment on "Evolution of the seasonal temperature cycle in a transient Holocene simulation: orbital forcing and sea-ice" *by* N. Fischer and J. H. Jungclaus

Anonymous Referee #1

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1 Summary:

The manuscript presents a transient paleoclimate simulation from the mid-Holocene to present (preindustrial times). In this simulation the boundary conditions are kept at pre-industrial conditions for greenhouse gases and ice-sheets. Orbital forcing is the only driving external force. The authors focus their climatic analyses on changes in the seasonal cycle and feedbacks from sea-ice in the high polar latitudes. Compared to their previous publication, the analysis of the seasonal cycle provides interesting new insight into the climatic response to a seasonally and latitudinally varying insolation forcing. The authors also provide a brief qualitative comparison with recent pollen-based tem-

perature reconstructions with emphasis on the seasonal and meridional differences.

Although the paper contains new results regarding seasonally operating climate sensitivities and feedbacks, certain shortcomings need to be removed in the structure, in order to better support the most important ideas.

2 Major critics:

2.1 Introduction:

It should be made clear in the introduction: What is the central question, maybe already what will be the central conclusion of this study. Further, the reader may wonder why transient simulations are needed (e.g. with sea-ice feedbacks we can have non-linear 'threshold' behavior, similar to what has been discussed for the North African Monsoon (Claussen et al., Geophys. Res. Lett., 1999); or lead-lags between forcing and response can be studied). It is further recommended to add one paragraph about the proxy-based studies of Holocene trends in seasonality. All these additions could help to lead the interested reader to a more 'motivated' statement regarding the central aspects of this study.

2.2 Results and discussion:

The authors should avoid the fragmented presentation of the results. For example, in Section 3.1, sea ice effects are described, but one finds inclusions of text describing the mid- to low-latitude response. Furthermore, it switches from the Arctic to the Southern Ocean. It would be much easier to follow the different mechanisms leading to local (Arctic/ SO) changes if they were described in one paragraph, separately for both regions.

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Furthermore, I don't think that in the current version it becomes clear, why the Arctic sea ice and the Southern Ocean sea ice provide opposing feedback mechanisms. As far as I was able to interpret the text and figures, sea ice concentration responds in the same way when insolation changes are imposed (i.e. more spring/summer insolation gives less sea ice in summer, see page 4, lines 97-106 and l.110-118). Hence, I assume that heat flux responses, ocean stratification or other factors must be responsible for the different surface temperature responses. This needs to be described in more detail and should be supported with additional figures, since it is one of the central points in this study!

2.3 Conclusion:

Having discussed the sea-ice effect on the seasonal cycle in surface temperatures, the conclusion should distinguish carefully what they mean by sea-ice-effect. At least two separate effects are important: a) the sea-ice albedo feedback (which is from my understanding a positive feedback, and amplifies the externally induced shortwave insolation anomalies) and (b) the 'insulating' effect for air-sea fluxes.

3 Specific comments:

p.1, l. 9 : remove 'however' from sentence?

p.2, l.23: citation (Milankovitch 1941; Berger (1978) or any work following)

p.2 l. 26: orbital forcing is traditionally not termed 'millennial time-scale' in paleoclimate literature. Most of the readers will immediately think of Dansgaard-Oeschger cycles, or oceanic meridional overturning circulation changes.

p.2, l.32-37: maybe worth mentioning that annual mean changes in insolation (irradi-

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ance) are caused by obliquity not by precession. Furthermore, the point here is that it needs non-linear feedback mechanisms to amplify the annual mean response. Please try to rewrite this part of the introduction. Especially emphasize the importance of sea-albedo or the 'insulating' feedback as one of the feedbacks that has the power to make the climate system more responsive to one season. (as you will show later)

p.2 l. 45 here you could add some more background information for the interested reader. In particular, please review the past simulations (PMIP2-type, and transient with EMIC as well as GCMs). People have studied this part of the climate history extensively. Renssen et al. (2005), also discuss feedbacks from vegetation (albedo feedback) for the NH Holocene climate evolution. Sea-ice albedo feedbacks have also been discussed for the glacial termination phase in the Southern ocean (Stott et al., Science, 2007, DOI: 10.1126/science.1143791)

p.2-p.3 section model description:

Please mention whether the vegetation can change land surface properties (is there an albedo-feedback for example)

p.3 l. 67: what is the acronym's meaning. This might be a standard term in GCM modeling community? I'm not familiar with the paper cited here, can you please explain whether the orbital parameter (eccentricity, obliquity and precession) are comparable to the more often cited computational code of Berger or Laskar?

p.3. l 72: quick notice of the calendar definition is advised –even though the calendar-effect should be less important here for the summer winter season analysis, I suppose. (See "Calendar effect on phase study in paleoclimate transient simulation with orbital forcing" by G.S. Chen et al., Climate Dyn., 2011 doi 10.1007/s00382-010-0944-6 and references therein to earlier discussions of this modeling issue.)

Results:

Section 3.1: Seasonal insolation and sea ice effects

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p.3.l.82-90: Consider moving the low and mid latitude results into separate section /paragraph. From the section title I expected results that focus on the polar latitudes.

p.3l.89 add “[not shown]” after “. . . Bracconnot, 2007b)”

p.3 l.90-p.4 l.92: Recommended: Add a sentence where you give a possible explanation for the observed trends and follow it with a paragraph supporting this ‘hypothesis’.

p.3.l.100-102: I find this regulating effect form the sea ice on the heat flux and its potential memory effect of one or two seasons very interesting and crucial for the understanding of the opposing seasonality trends in insolation and surface temperature. Please provide more information how this mechanism works and how effective it is (relative to the sea-ice-albedo feedback and net SW irradiance anomalies). (For example a seasonal cycle plot for sea ice concentration, surface temperature, heat flux, SW net radiation for pre-industrial and 6000 BP simulations)

p.3. l.103-105: How do these numbers compare with the direct top of atmosphere and net surface shortwave insolation anomalies?

p.3.l.115-117: please add one sentence (or more) to describe what is exactly responsible for the different sea-ice effects in the SO compared with the Arctic Ocean (l.100-104).

p.3 l. 110-118: Note of caution: How much do the numbers depend on the definition of seasons (e.g. Joussaume, S., and P. Braconnot (1997), J. Geophys. Res., 102(D2), 1943–1956, doi:10.1029/96JD01989; or Timm et al, Paleoceanography doi:10.1029/2007PA001461, 2008; or Chen, G. et al. Clim. Dyn. Doi: 10.1007/s00382-010-0944-6, 2010/2011?) Please make sure to describe in Figure caption 4 how the seasonal anomalies were calculated. Three-month averages using present-day definition of months or from daily calculated insolations?

p.3 l.119-124 and p.3 last paragraph to p.4 l.135:

It is suggested to move this mid and low latitude result into separate paragraph or

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section.

p.4. l.1146-149: Will the vegetation response and feedback be described in an upcoming study? Otherwise, how important is changing vegetation for the changes in seasonality? (Please check also Renssen et al, Climate Dynamics (2005) 24: 23–43 DOI 10.1007/s00382-004-0485-y.)

p.6 l. 170-172: summer meridional temperature gradient trends are reproduced well. Winter would require a formal test, since the proxies show more high-frequency variability. (regression analysis)

p.6 l. 176: write "... approaches to reconstruct ..."

p.6,l.177 + 186: "summer cooling" that is: "negative trend in the meridional temperature gradient" ?

p.7, l.202-206: The NAO teleconnection pattern (regression pattern) with temperatures shows a large effect in the Northern European regions, with positive temperature anomalies during the positive NAO years (http://www.cpc.ncep.noaa.gov/data/teledoc/nao_tmap.shtml). Over North Africa a negative temperature is found. Hence, one has to be more precise here, what region is affected. From the modern observations I would have imagined a more positive NAO during the mid-Holocene resulted in a reduced temperature difference (South minus North). Please clarify. Please refer also to the work of Gladstone et al. Geophys. Res. Lett.,32., 2005, doi:10.1029/2005GL023596!

p.7 l.223: Write: "Nevertheless, within a limited region such as Europe, the low latitude summer cooling inferred from pollen reconstructions is not captured by the model."

Interactive comment on Clim. Past Discuss., 7, 463, 2011.