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Climate of the Past
Discussions
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Interactive comment on "An abrupt slowdown of Atlantic Meridional Overturning Circulation during 1915–1935 induced by solar forcing in a coupled GCM" *by* P. Lin et al.

Anonymous Referee #1

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This paper describes variations of the Atlantic Meridional Overturning Circulation (AMOC) in historical and control simulations using the FGOALS-s2 coupled model. The authors find relatively large-amplitude changes in the overturning stream functions in the early 20th century. These anomalies appear first at higher latitudes and then propagate to lower latitudes. The authors claim that the "abrupt slowdown" is caused by variations in solar radiation. In particular, the weak insolation from 1900 to 1914 is made responsible for changes in atmospheric circulation and deep water formation in the ocean. The link between the modified solar-induced atmospheric circulation changes and the AMOC reduction is given by a negative NAO phase lasting for a couple of years.

The relative role of forced and internal variability and of natural vs. anthropogenic forcing is still important and analysis of model simulations have come to quite different conclusions. Therefore, studies looking in detail into selected processes or forcing mechanism are needed. Unfortunately, the present study is not at all convincing and lacks scientific rigor in many aspects (as explained in detail below).

I therefore cannot recommend publication in Climate of the Past. The authors should go back to the model results and find out what is robust and what is just happening by chance. I recommend very much that the authors read carefully the paper by Menary and Scaife (2014, in the present's paper reference list). I am not an author of the Menary & Scaife study and I am not happy with all their conclusions. However, that paper is an example of providing solid evidence for the claims, based on statistical tests and sensitivity experiments.

Major Points:

The arguments are not based on any solid statistics. The author show composits and changes, but no effort is made to relate this to internal variability in the unforced control run. The least thing one would expect is a comparison with the standard deviations found in the PiCtrl run for similar time-scales. In fact, the authors show in their paper, that a very similar slowdown of the AMOC happens in the PiCtrl run. So what would be needed here is to show that TSI changes could somehow kick the system into a transition state.

The proposed mechanism appears not to be very robust through the three historical simulations. The authors claim that the main ingredient is that the low TSI in 1900-1914 leads to changes in the atmosphere that finally produce a lasting negative NAO. At least in the r2 experiment there is no NAO- in the 1910, but already earlier. Expmt r1 and r3 show also strong NAO- situations later without any effect on the AMOC. Also, why does the stong NAO reduction in r2 around 1900 does not lead to an AMOC shutdown, say in 1905? The argumentation is partly very confusing. On the one hand, the weak TSI in

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1900-1914 is made responsible for the NAO(-), convection (-), AMOC (-) mechanism. Then the authors say that the increasing TSI in 1918ff warmed the SSTs in the tropics and led to higher ocean heat transport that would further warm the subpolar North Atlantic and further weaken the AMOC (so why did the WEAK TSI in 1905-1910 NOT reduce the OHT?). It seems therefore that the authors just select whatever they find convient to explain the sun-AMOC connection. What would be needed here is a careful analysis of soler (-) vs. solar (+) states, eg. From composits over the 11-yr cycle, or, more preferable, dedicated sensitivity studies as in Menary and Scaife.

A new submission should also come with improved writing and grammar.

Other comments: General: use the word “significant” only when demonstrated by statistical test

Abstract

Ln 6, better “weakened by”

Ln 9, and other places use standard acronym “TSI” throughout the text

Ln 13: release of heat, not of heat fluxes

§2: The MTT test is not well explained. What is tested against what? How arbitrary is the choice of alpha?.

§3, page 2523, ln 13: Is that lagged correlation?

Page 2526: the authors speak about freshwater contribution from high latitudes, but discuss only contributions from Davis Strait and Baffin Bay; what about the east Greenland Current and contribution from the Arctic via Fram and Denmark Strait? Page 2527, ln 15ff: the OHT at 30N has been shown to reflect the heat transport by the overturning circulation. Thus the time evolution here would just reflect the AMOC and give no further evidence of the mechanism slowing it down. Moreover, the OHT changes at 60N appear to be pretty small.

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Page 2528, ln 15ff. would it be not more appropriate to show composits for weak-strong solar phase for several cycles?

§4, page 2530, ln 5: If the imprint of the solar forcing is so significant, we would expect the negative NAO phase to occur simultaneously in all three realizations? What is so "significant" about the 1918 increase? There is a drop of similar amplitude right after. Why not comparing the weak TSI phase 1900-1920 with the generally stronger one, say 1960-1990?

Page 2531, ln 5ff: In figure S2, I don#t see anything special in the NAO around ear 1980. There are also negative phases in the 160th and later. . .

Page 2532, ln 11. The paper by Schott et al. discusses the SODA reanalysis data from 1992-2008, how can this give us information on the 1920?

Ln 15ff: The Menary& Scaife paper does NOT argue that the 1920s weakening was part of a multidecadal variability. They show a strengthening of the AMOC until 1920 that is caused, in their model, by a WEAK TSI, and then relaxes. Thus the come to the opposite conclusion as the present paper and this needs to be discussed.

Interactive comment on Clim. Past Discuss., 10, 2519, 2014.