Interactive comment on "The PMIP4 contribution to CMIP6 – Part 4: Scientific objectives and experimental design of the PMIP4-CMIP6 Last Glacial Maximum experiments and PMIP4 sensitivity experiments" *by* Masa Kageyama et al.

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It has been found that the AMOC does not adjust monotonically to glacial forcing (e.g. Stouffer and Manabe, 2003; doi:10.1007/s00382-002-0302-4) and that the integration time in many PMIP simulations is likely insufficient to reach deep-ocean equilibration (e.g. Zhang et al., 2013; doi:10.5194/cp-9-2319-2013). Moreover the criteria for equilibration requested by the PMIP protocols are likely to be insufficient (Zhang et al., 2013). While this issue is addressed in the manuscript (page 15 at lines 25-28), the specific requirements remain somewhat unclear and should be rephrased. Specifi-

cally, we believe that a quantitative criterion for the drifts in the AMOC (see Figure 1 as an example), deep-ocean temperature and salinity should be provided. While it is expected that not all simulations in the archive will be integrated to full equilibrium, the level of deep-ocean equilibration needs to be clarified in order to avoid erroneous interpretations of modeling output that is dependent on transient effects. This is already discussed to some degree on page 15 (lines 29-31), but it should be clarified what exactly is the information requested as part of the documentation. Among other things, we believe that time-series of abyssal temperature, salinity and AMOC need to be provided. Finally, while we understand that the complete time-dependent data for all simulations cannot be stored on ESGF, the modeling groups should be encouraged to provide time-dependent data upon request.

A number of studies have pointed towards the important role of temperature and sea ice changes around Antarctica in controlling deep-ocean circulation and stratification (e.g. Shin et al., 2003 doi:10.1007/s00382-002-0260-x; Ferrari et al., 2014 doi: 10.1073/pnas.1323922111; Jansen and Nadeau, 2016 doi:10.1175/JPO-D-16-0084.1; Klockmann et al., 2016 doi:10.5194/cp-12-1829-2016; Jansen, 2017 doi: 10.1073/pnas.1610438113). The PMIP models show a widely varying sea-ice extent in the LGM, with most models likely underestimating the abundance of sea ice (e.g. Roche et al., 2012 doi.org/10.1016/j.quascirev.2012.09.020; Goosse et al., 2013 doi.org/10.1016/j.quascirev.2013.03.011). It may therefore be worth to point out that the representation of climatic changes around Antarctica – in particular sea ice expansion and export – should receive careful attention when setting up and analyzing the PMIP4 LGM simulations.

The lack of deep-ocean equilibration, and the unrealistic representation of sea ice formation and export, may explain many of the apparent inconsistencies between different PMIP models and with the LGM geological record.

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Figure 1 - The data shown are from the LGM simulation with CCSM4 described by Brady et al. (2013; doi:10.1175/JCLI-D-11-00416.1). The additional data for part of the spin-up and for a continuation of the PMIP3 simulation are available from the Earth System Grid at NCAR archive. Years of integration are calculated from a branching point of the PMIP3 spin-up. The final 100 years of the PMIP3 simulation are stored in the ESGF archive. The trend for the 100 years of simulation available from the PMIP3 archive clearly highlights that AMOC drifts cannot be determined from such short time-scales, due to the high internal variability. The manuscript should therefore specify that longer time series need to be analysed to test the equilibration criterion of a "stable Atlantic Meridional Overturning Circulation" (page 15, line 25).

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(part of) spin up   **PMIP3 run**   **NCAR continuation run**
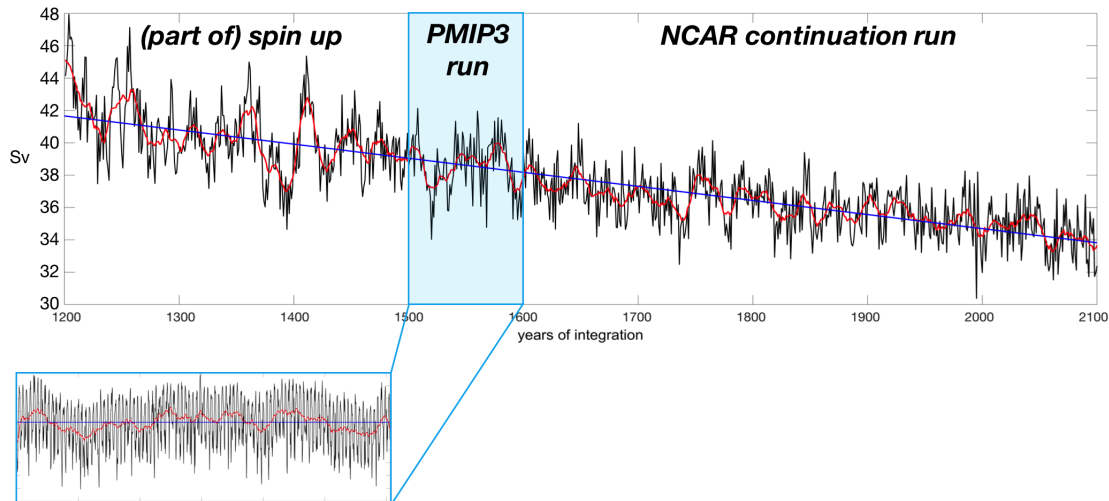
Fig. 1. Evolution of the AMOC strength (defined as the maximum in the overturning stream function) throughout the last 900 years of integration for the CCSM4 LGM simulation