LETTER

REPLY TO PARKER:

# Robust response of AMOC interdecadal variability to future intense warming

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Based on 19 experiments using five models of the Coupled Model Intercomparison Project Phase 5, our study (1) finds a shortened and weakened interdecadal variability (IV) of Atlantic Meridional Overturning Circulation (AMOC) over a future intense warming period in the 22nd and 23rd centuries, and proposes that warming-induced changes of oceanic dynamics may be responsible for these changes of AMOC-IV. As the key modulator of long-term climate variation, AMOC-IV and its response to global warming are important for future climate projection.

Parker's letter (2) casts doubts on our results, mainly because there is no evidence in the AMOC's reconstruction consistent with our projection. We believe his comment does not disprove our results. As pointed out in our study (1), the response of AMOC-IV to warming is only significant under intense warming scenarios, such as Representative Concentration Pathway (RCP) 60/85. In the weak warming scenarios of RCP26/45, even for the period of full warming in, say, the 22nd and 23rd centuries, there is no robust cross-model response of AMOC-IV. Therefore, for the early stage of current global warming from the mid-19th century to the present, in the AMOC reconstruction based on scattered tide gauge data, it's not surprising at all that the change of AMOC-IV is not detected, because the warming is too weak.

Another argument of Parker concerns the insignificant weakening of mean AMOC strength in AMOC's reconstructions. First, this change of mean AMOC is not relevant to our study, which deals mainly with the interdecadal variability of AMOC. Second, even for the mean AMOC change, the opposite impact between greenhouse gases (e.g., refs. 3 and 4) and aerosols (e.g., refs. 5 and 6) could lead to the insignificant trend during the early stage of current global warming. With intensified warming in the future, warmer/lighter surface water may lead to a robust reduction of mean AMOC strength (e.g., refs. 7 and 8) and an alteration of AMOC-IV (1).

Furthermore, the long reconstruction of AMOC in Parker's letter (2) has not been seriously validated by other observations, such as Rapid Climate Change (RAPID) array (9). Actually, reliable observations of AMOC are limited for the validation of the simulation ability of AMOC in coupled climate models, especially for its long-term variability (10). In fact, the simulated AMOC-IVs in the five models used in our study (1) are different in their dominant timescales and magnitudes, due to the different model details. However, their responses to global warming are almost consistent, especially for strong warming scenarios. As a sensitivity study of AMOC-IV responding to warming, not as a real prediction, our study is valuable for our understanding and projection of the possible climate change in the future.

Overall, we welcome the interest and comment from Parker very much. However, his comment does not pose any serious challenge to our conclusion. Indeed, we feel that his comment is not very relevant to our work, because it can't be tested with the short time series of present AMOC (even ignoring its great uncertainty in the reconstruction).

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The authors declare no conflict of interest.

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