

**Author's final response:**

**The role of the North Atlantic overturning and deep-ocean for multi-decadal global-mean-temperature variability**

We would like to thank Antonio Speranza and an anonymous referee for their comments on our manuscript. We are delighted that Antonio Speranza considers our manuscript publishable in the present form and like to thank him for his comments. With regard to his question about the graph-theoretical statistical approach followed in this manuscript, we would like to give the following answer: In this analysis we used partial correlations which only capture linear statistical relationships. The same graphical models framework can, however, also be used with nonlinear information-theoretic measures such as conditional mutual information. This has been done in Runge et al., Physical Review Letters 108, 258701 (2012).

We will try to reply to the comments of an anonymous referee and hope that our answers and modifications of our manuscript will suffice.

**Comment 1:**

The authors do not state clearly whether they use annual datasets (I presume they do)– this should be clarified in the abstract and in the description of the data (section 2). The used CMIP5 models are given by acronyms, and I would expect at least a brief description of the models and why these particular ones (among many others) were chosen for analysis.

**Response:**

We'd like to thank the reviewer for his comment and agree that clarification regarding the usage of annual data is needed. We modified the manuscript accordingly. Following the suggestion of the reviewer we included a table providing additional information and references for the models analysed. As the reviewer points out, the CMIP5 model ensemble contains much more models than the seven models analysed here. However, unfortunately only very few models provide output for the global overturning over the pcmdi-portal. Also the paragraph on AMOC stability of the recent IPCC AR5 includes only a sub-group of the full AR5 model ensemble (compare Fig. 12.35 in the AR5). We clarified our choice on page 4, line 24:

*"We analyze the unperturbed control run of seven Atmosphere Ocean General Circulation Models (AOGCMs) from the coupled model intercomparison project CMIP5 (Taylor et al., 2012) that provide all diagnostics required for our analysis and at minimum 300yr of model data."*

**Comment 2:**

In the caption of Figure 2, the authors mention "red noise first order auto-regressive process" but do not give specific details on the scaling exponent of the red noise – this is important to describe. It is not clear whether the AR(1) process is expected to simulate red noise with some high value of the parameter – if this is what the authors mean then it is not exactly power-law red noise.

Carl-Friedrich Schleussn... Today, 4:25 PM Deleted: their
Carl-Friedrich Schleussn... Today, 4:24 PM Replaced: XXX
Carl-Friedrich Schleussn... Today, 4:25 PM Added Text

**Response:**

To test for the significance of the peaks in the power spectra of Fig. 2 we fitted a first order auto-regressive process to the time series of the three quantities analysed. The 95% significance level is determined by ensembles consisting of N=10000 realizations. We agree that we should be more explicit about this and changed the caption of Fig. 2 accordingly.

Carl-Friedrich Schleussn...  
Nov 7, 10:31 AM  
**Added Text**

Carl-Friedrich Schleussn...  
Nov 7, 10:31 AM  
**Deleted:** We then used bootstrapping with N=10000...

**Comment 3:**

In page 976, the authors say that time series have been standardised. Do they mean "normalised", i.e. removed mean values and divided by std?

**Response:**

Indeed we subtracted the mean and divided by the standard deviation. We modified the sentence for clarification:  
*"All time series have been standardized (time series mean subtracted and divided by the standard deviation)."*

Carl-Friedrich Schleussn...  
Nov 7, 10:44 AM  
**Replaced:** We thank the reviewer for pointing this out and of cou...

Carl-Friedrich Schleussn...  
Nov 7, 10:46 AM  
**Added Text**

**Comment 4:**

The caption of Table 1 should be re-arranged, because it is not clear which column is "middle" and why first and second columns are described at the end.

**Response:**

We agree with the reviewer and re-arranged the caption accordingly.

**Comment 5:**

It is not clear why in Fig.2 the light lines for significance levels are of different colours (in Fig.3 they are both grey). Also, the legend of Fig.3 shows these lines, whereas the legend of Fig.2 does not.

**Response:**

This comment points in a similar direction as comment 2 and we changed the caption of Fig. 2 to be more explicit about the method used to determine the significance threshold. We fitted an AR(1) process to the time series of each of the three different quantities (AMOC, GMT and SIE) and the different significance levels are indicated by the three different colours. We change the legend of Fig. 2 accordingly. In Fig. 3, however, we show cross-correlations for which the significance level is the same for all quantities.

Carl-Friedrich Schleussn...  
Nov 7, 10:32 AM  
**Deleted:** as a result of the bootstrapping approach

Carl-Friedrich Schleussn...  
Nov 7, 10:32 AM  
**Added Text**

Carl-Friedrich Schleussn...  
Nov 7, 10:32 AM  
**Deleted:** three

Carl-Friedrich Schleussn...  
Nov 7, 10:32 AM  
**Deleted:** as they

**Comment 6:**

The caption of Table 1 should be re-arranged, because it is not clear which column is "middle" and why first and second columns are described at the end.

**Response:**

We agree with the reviewer and re-arranged the caption accordingly.

**Comment 7:**

The meaning of the numbers on the colour links in Fig.6 should be explained in the caption of the figure.

**Response:**

The caption of Fig. 6 includes the following statement:

*“Direct links are indicated by curved lines (numbers denote different time lags), whereas straight lines represent contemporaneous links at lag zero.”*

Which we changed for clarification to:

*“Direct links are indicated by curved lines with the associated time lags. Straight lines represent contemporaneous links at lag zero.”*