Clim. Past Discuss., 10, C1765–C1771, 2014
www.clim-past-discuss.net/10/C1765/2014/

Climate of the Past Discussions

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.

P. Lin et al.

songy@mail.iap.ac.cn

Received and published: 28 October 2014

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 #2 Received and published: 3 September 2014 Review on the manuscript "An abrupt slowdown of Atlantic Meridional Overturning Circulation during 1915-1935 induced by solar forcing in a coupled GCM", by P. Lin, Y. Song, Y. Yu and H. Liu.

General comments: In the study is described and abrupt slowdown of the Atlantic Meridional Overturning Circulation (AMOC) identified in a numerical simulation with a

Global Ocean-Atmosphere-Land System model. It is argued that the AMOC weakening is induced by the solar forcing. A significant rapid change in TSI after 1910 is not clear and the proposed links between the changes in the solar forcing and the AMOC weakening are not convincing (please see below). The text needs significant improvement. Therefore I cannot recommend publication of the manuscript in its present form.

Reply: To examine the effect of solar forcing on the change of AMOC, four experiments were done. . The sensitivity experiments are summary in Fig. 1. As shown in Fig. 2, CTL is forced by ïňĄxed 11-year solar cycle (1860-1870), SOL is forced by observed 11-year solar cycle from 1880-1940. Through these experiments, the roles of solar forcing can be identiïňĄed. As shown in Fig. 3, not only SOL experiment, a signiïňĄcant rapid change of AMOC after 1910 also appears in the experiment only forced by ïňĄxed 11-yr cycle solar radiation (CTL). This implies the change of solar radiation may not the most important reason to cause the abrupt change during 1910-1935 in the model.

Specific comments In Fig. 4a the differences in sea ice concentration are close to zero in the Labrador Sea. Then what is the significance of this composite map?

Reply: Thanks. The differences in sea ice concentration (SIC) are close to zero in the Labrador Sea. The significant change of SIC is located on the interface of Baffin Bay and Davis Strait and at the exit of Hudson Bay (blue color shaded in Fig 4a). Due to the transport by oceanic circulation in this region, the freshwater anomalies from sea ice melting will lead to the weakened AMOC.

In Fig. 2 are shown differences between 1920-1930 and 1910-1920, whereas in Fig. 4 the differences are between 1913-1917 and 1900-1912 averages. Why are used different periods to calculate de composite maps in Figs. 2 and 4?

Reply: In this study, the abrupt AMOC change is caused by weakened deep convection in the Labrador Sea, which mainly results from an increase in freshwater transportations due to the melting of sea ice in Baffin Bay and Davis Strait. As shown in Fig.

CPD
10, C1765–C1771, 2014

3c, the melting first appears in 1913, and via positive ice–albedo feedback additional sea ice melting results in a lasting freshwater input to the ocean during 1913 to 1920. This cumulative effect in turn leads to salinity and density reductions (Fig 3a) and then an abrupt slowdown of AMOC. The different periods used for comparison in different figures are related to the time-lead or time-lag processes.

The TSI changes around 1900 do not indicate and abrupt behavior. For example, the TSI increases after 1954 and after 1975 have much larger amplitude that that after 1914. Why there are no AMOC abrupt weakenings after 1954 and 1975? An increases TSI could initially warm the SST in the tropics, but this would be then attenuated by the associated clouds induced by increased convection (as a negative feedback). The increase of the NAO index around 1915 is associated with increased westerlies over the Labrador sea. This should decrease the SST and result in increased density (through a thermal effect) and convection, and consequently in an AMOC increase, but not a weakening as is shown in Fig. 1. The discussion and conclusions should be separated and clearer.

Reply: Thanks. We admit the TSI change around 1900 do not indicate an abrupt behavior. The TSI change does have different change comparing with that in other periods. Four experiments were done to examine the effect of solar forcing. According to the simulated result from these experiments (appended figure S5), the roles of solar forcing are identified. Actually, a significant rapid change of AMOC after 1910 appears in the experiment only forced by 11-yr solar cycle. In the study, we replaced our previous inferred conclusions by the abrupt change is due to internal variability in this coupled climate model.

Technical corrections Abstract "The weakened AMOC can be explained in the following"- needs reformulation.

Reply: Thanks. We have fixed accordingly. Because we change some conclusions, this sentence is deleted in the abstract.

CPD
10, C1765–C1771, 2014

Introduction, para 1 "The Atlantic meridional overturning circulation (AMOC) is a major thermohaline circulation characterized by :" – needs reformulation.

Reply: Thanks. We have fixed accordingly. The revision sentence now is “As a major thermohaline circulation, the Atlantic meridional overturning circulation (AMOC) is characterized by a northward flow of warm, salty water in the upper Western Atlantic Ocean and a southward flow of colder water in the deep Atlantic”.

Introduction, para 2 "The abrupt slowdown of AMOC had been found in the paleoclimate proxy records : : :" - need reformulation.

Reply: Thanks. We have fixed accordingly. The sentence had been replaced by “The abrupt climate changes had existed in the geological records”.

A wealth of abrupt climate changes were identified in paleoarchives.

Reply: Thanks. We have fixed accordingly. The sentence had been replaced by “The abrupt climate changes had existed in the geological records”.

Introduction, para 2 The questions formulated at the end of the paragraph are not clear. - they need reformulation.

Reply: Thanks. We delete the questions and replaced those by our purposes. “Here we describe the abrupt change of AMOC in a coarse climate model driven by historical forcings and link the abrupt change to that in the simulation forced by preindustrial forcing. The possible reasons of the abrupt change of AMOC in the climate model are discussed.”

Section "Reasons for abrupt slowdown", para 3, last sentence: "reductive DC" - needs reformulation.

Reply: Thanks. We have fixed accordingly. “Reductive” is replaced by “weakened”.

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

Summary of simulations performed during this analysis

	Length or period	Ensemble size	11-year solar cycle	
CTL	90	1	Yes	Fixed 11-year solar cycle
SOL	1880-1940	3	Yes	Observed 11-year solar cycle

Fig. 1. Summary of simulations performed during this analysis

CPD
10, C1765–C1771, 2014

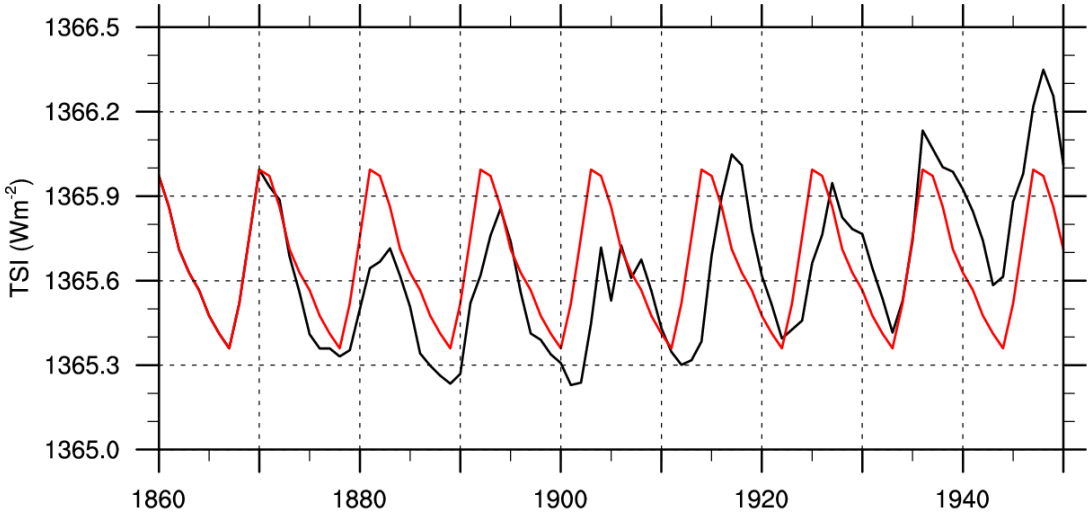

Fig. 2. The time series of annual mean total solar irradiance (TSI) in CTL (red) and SOL (black).

Full Screen / Esc
Printer-friendly Version
Interactive Discussion
Discussion Paper

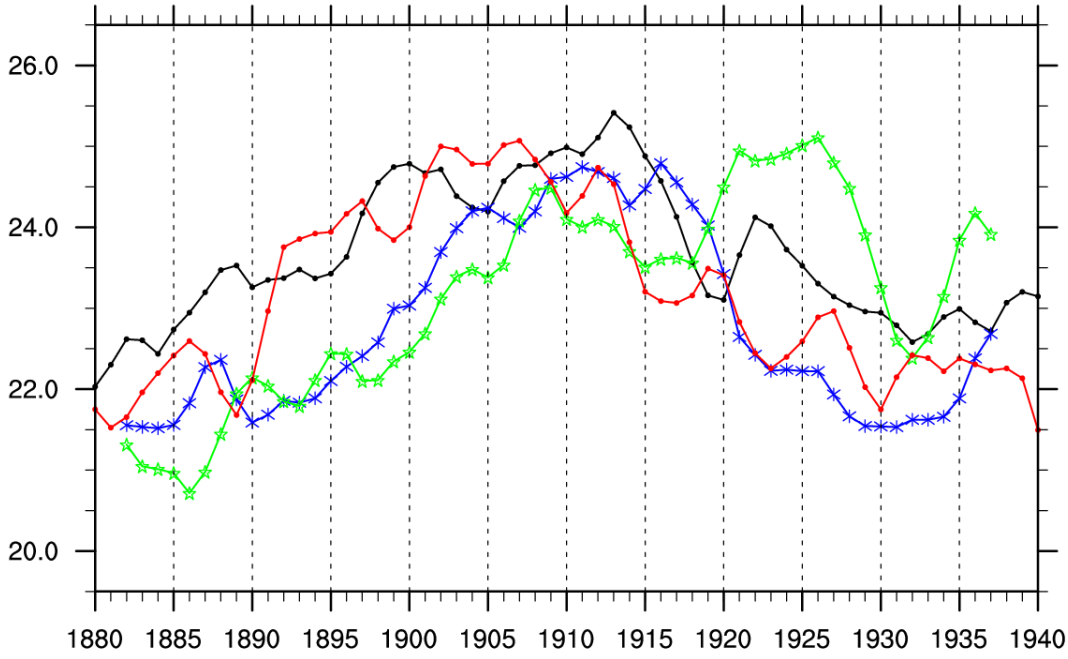

Fig. 3. Time series of maximal Atlantic meridional overturning circulation obtained from 500m to 3000m at 26.5N in CTL (red line) and SOL (black, blue and green lines). The values are for the 5 year run mean.

CPD
10, C1765–C1771, 2014