

Interactive comment on “Atmospheric multidecadal variations in the North Atlantic realm: proxy data, observations, and atmospheric circulation model studies” by K. Grosfeld et al.

K. Grosfeld et al.

Received and published: 24 November 2006

Point by point reply to Reviewer 2: cpd-2-S360p.pdf

We thank the reviewer for his careful reading of our manuscript and his suggestions. In the following we respond to each criticism, separately. In the revised version of the manuscript, these argumentation and additions will be included.

Anonymous Referee 2

Received and published: 14 September 2006

The overall aim of this study is to identify the AMO signature in different data archives and to connect this to physical interpretations based on model studies. Although I found the paper potentially interesting, the authors do not achieve these goals. I was

confused by its organisation and ad-hoc presentation of results. The authors seemingly make a random selection of data and present a very superficial analysis of model simulations for the instrumental period. I recommend major revisions, based on the points raised below, before the paper can be considered for publication.

Main points of criticism:

1) Data selection

The use of SLP (Luterbacher et al), starting 1659, is an obvious choice. Why then only use the annual SAT reconstruction (Mann et al) from 1730 onwards?

Answer: Although the Mann et al. (1998) data covers the period of the last 600 years, a gridded global temperature data set with annual resolution exists only for 1730-1980. To our knowledge, this is the only gridded data set of that length which can be used for pattern analyses over the North Atlantic.

Why include just two proxy records (with again different lengths), although Jones and Mann (2004) and others describe many more high-resolution, well dated records for the last few hundred years.

Answer: The Cariaco Basin data set and the Red Sea data set are not included in the analysis of Jones and Mann (2004) and also not in the Mann et al. (1998) temperature reconstruction. For this respect, the data sets are new. We choose these data sets because they flank our region of interest, the North Atlantic, to the west and east, and hence, they do provide insights in North Atlantic climate variability. The temporal high resolution of the time series provide in addition a good data quality for statistical and cross-pattern analyses.

Is the data selection based on a) the presence of a multi-decadal signal or b) other criteria. Please explain, and expand the dataset used.

Answer: As mentioned before, the reason for choosing Cariaco and Red Sea time series is based on the direct proximity to North Atlantic, which guaranties

[Full Screen / Esc](#)[Printer-friendly Version](#)[Interactive Discussion](#)[Discussion Paper](#)

the recording of climate signals and its variability of this region. The occurrence of a clear multidecadal variation in the time series approves that these records are favourable for the investigation of the AMO.

How reliable are the Mann et al data over the ocean?

Answer: The Mann et al. (1998) data are calibrated against the nearly continuous available land air/sea surface temperature grid-point data from 1902 onwards. For this period the Atlantic is fully data covered from about 30°S to 70°N (comp Fig. 1b of Mann et al., 1998). The reconstruction method and data base allows for a backward reconstruction of surface temperature back to 1760 in a largely indistinguishable skill. Earlier periods suffer under sparseness of data and reduced reconstructive skill. Nevertheless, our study does not aim to judge about data quality, we only take the data as a possible source to investigate AMO beyond the observational period. We will clarify this in the revised version.

2) Model simulations

The study uses (new?) PUMA and (existing?) ECHAM4 AGCM runs, forced by the GISST data (1865-2000 period?), to complement the analysis of the instrumental data. It is disappointing that the PUMA runs at least are not extended to cover also the preinstrumental period.

Answer: We chose the period 1903-1994, because for this period AGCM integrations with the complex ECHAM4 model were available for the inter-comparison of the model results. We perform additional new model simulation for the same period with an AGCM of intermediate complexity to demonstrate the persistence of AMO in different model approaches. Aim of this study is not the demonstration if the AMO can generally be simulated. This has already been done by different authors. Our study compares the spatial and temporal characteristics of multidecadal climate variability in the North Atlantic realm from different methodological approaches. Puma simulations covering the whole observational period

(1856-2000) were also performed on the basis of the Kaplan et al. (1998) data set. However, we did not include these results in the recent study to avoid mixing of model results with different forcing fields. The results are discussed by Grosfeld et al. (2006) in detail. In the revised version, we will include some description of these model results for the pre-industrial period, referring to that study. We do not intend to show additional figures from those simulations. The result including the pre-industrial period shows an extension of the AMO for the period 1856-2000. The signature of AMO is not alone dominated by the North Atlantic, it is composed of different forcing regions, namely the Atlantic and Pacific Ocean. In this respect, the recent model results describe the dominating pattern over the north Atlantic realm which can be extended to the past, when forcing the model with longer global SST data.

What are the 'former' and 'recent' versions of PUMA? Is there a better reference for this model than a technical report?

Answer: The 'former' version of PUMA as used by Frisius et al. (1998) and Franzke et al. (2000) considered dry dynamics, where moisture is not explicitly considered. In the so called 'recent' version, which has been also applied in Romanova et al. (2006a,b) this deficit has been improved. The recent version as described in the paper represents also a precursor of the Planet Simulator (Fraedrich 2005b,c), an Earth system model of intermediate complexity to investigate climate and paleo-climate simulations for time scales up to millennia in acceptable computation time.

An additional reference for PUMA is given by Fraedrich et al., 2005a and will be included in the revised version.

Fraedrich, K., E. Kirk, U. Luksch, and F. Lunkeit, 2005a: The Portable University Model of the Atmosphere (PUMA): Storm track dynamics and low frequency variability. *Meteorol. Zeitschrift*, 14, 735-745.

Fraedrich, K., H. Jansen, E. Kirk, U. Luksch, F. Lunkeit, 2005b: The Planet Simulator: Towards a user friendly model. - Meteorol. Zeitschrift, 14, 299-304.

Fraedrich, K., H. Jansen, E. Kirk, F. Lunkeit, 2005c: The Planet Simulator: Green planet and desert world. - Meteorol. Zeitschrift, 14, 305-314.

Some remarks about the results in section 3.3:

How surprising is it to simulate SAT patterns over the ocean that are similar to observations, when the model is forced by SST?

Answer: The reviewer is right that it is now surprise to find similar results in SAT than in observations over the ocean. Nevertheless, SAT is influenced by the atmospheric flow regime and depends to a certain degree from the resolved physics in the model. As the model results show, the representation over the Atlantic is similar but not the same than SST reconstructions (Kaplan et al, 1998), indicating how this quantity it is represented in the model. Over land, where no boundary condition (SST) forces the atmosphere, the temperature field evolves freely, dependent only from the atmospheric flow regime and the representation of land surfaces. We mask out the land because comparison is only given to Kaplan et al. (1998) SST data. In the revised version we can discuss SAT over land, also, and compare these with the CRU-TS2.1 data set developed by Mitchell and Jones (2005), and covering the period 1901-2002.

Mitchell, T.D. and Jones, P.D., 2005: An improved method of constructing a database of monthly climate observations and associated high-resolution grids. International Journal of Climatology, 25, 693-712.

What about the simulated SAT anomalies over land, are they consistent with observed SAT? (Small point: a band of low-amplitude positive anomalies (obs) is definitely not similar to a band of negative anomalies (ECHAM).)

Answer: Concerning SAT over land, our model results fit to observations for

[Full Screen / Esc](#)[Printer-friendly Version](#)[Interactive Discussion](#)[Discussion Paper](#)

the most part. A figure (which will be enclosed in the revised version) will show the same anomalous pattern (warm-cold) for the CRU-TS2.1 data, compared to Figure 4b,c,d of the manuscript.

Comparison with the ECHAM simulations shows good agreement. The negative anomaly over central Europe with extension over West Africa is as well captured in the model results as the positive anomaly over the eastern Mediterranean Sea and northern Arabian Peninsula. Over America, a transition from positive to negative anomalous temperatures from east to west is given in ECHAM and in the observational data. The coarser resolution PUMA model can not capture the small scale features as ECHAM does, but the general pattern is also represented. Negative anomalous temperatures over western America change to positive temperatures at the East coast. The not resolved separation of SLP into two centres over the Atlantic and Europe/Africa, as obvious from observations and in the ECHAM model, yields to an extension of the positive anomaly over Europe. The negative anomaly over Africa is similar to the ECHAM results. We conclude that a comparable SAT pattern to observations can be modelled with given global SST data by AGCMS. The quality of the model result depends on the model resolution and degree of complexity.

Small point: In our analysis of the model results compared to observations we wrote that the band of low amplitudes in the observation is represented in the ECHAM4 model result as a band of negative anomaly. Here, we can say more explicitly that the ECHAM result is exaggerated compared to observations; however the amplitude reduction occurs in the same region.

One could as well argue that simulated SLP patterns are not consistent with observations; the inter-model differences are huge.

Why compare observations with an ensemble-mean? the observed climate is only one realisation of the system, not an ensemble-mean.

[Full Screen / Esc](#)[Printer-friendly Version](#)[Interactive Discussion](#)[Discussion Paper](#)

Answer: It is true; the observed climate is only one realisation of the climate system and not the result of an ensemble-mean. Nevertheless, presuming a small measuring error and hence a good representation of the observed compared to the real climate variation, the modeled climate field represents only one solution of the non-linear dynamic field as calculated by means of numerical methods. Based on certain limitations and parameterisations of the chosen computer model, the spread of an ensemble-integration enables the possibility to discuss a mean model response which should be closer to reality than only one ensemble-member.

In short, I find the model analysis unsatisfactory. One would expect an analysis of mechanisms here, not just a description of results. What is 'the understanding of multidecadal climate modes' (abstract) derived from these model results?

Answer: The aim of this paper is a thorough description of the signature of multidecadal variability over the North Atlantic realm. This is done by comparison of different approaches: observations, proxy data and model results. The reviewer is right that understanding of multidecadal climate modes needs a more in-depth analysis of the physics behind. However, this is done in a second paper (Grosfeld et al., 2006), where we investigate the influence of different ocean basin forcing on the AMO and search for a forcing mechanism. In the recent study we try to improve the knowledge of AMO and its signature which is important when discussing long term climate change. In this respect it is crucial to now, if and how AMO is changing over time and to what extent it could determine/mask North Atlantic climate change (natural and anthropogenic).

3) Analysis of proxy data

Section 3 is an odd combination of results published earlier in the literature (eg the spectra for the two proxy records) and some new results. I find the ordering confusing (first the long records, then the instrumental period, then back to the long records).

[Full Screen / Esc](#)[Printer-friendly Version](#)[Interactive Discussion](#)[Discussion Paper](#)

Answer: The intention of Section 3 is to show indications for multidecadal variability in the Atlantic realm based on different data and model results. In section 3.1 we start with the description of two time series of the region under investigation to demonstrate the long term persistence of multidecadal signal. The different length of the time series is of no importance, both go far beyond the observational period. The connection of these time series with SAT in a correlation analysis yields the expansion of local data to areal patterns over the whole North Atlantic. Associated to the SAT field is the SLP pattern, which indicates the dynamical atmospheric response on the SST forcing field (Section 3.2). Besides the dominating pattern (EOF1) we only show a spectrum (Fig. 3c) for the SLP field to emphasize the significance of the multidecadal signal compared to the decadal band. In Section 3.3 an intercomparison of model results based on simulations of two models (ECHAM and PUMA) indicates the general ability to simulate the general multidecadal pattern as long as the forcing (SST) is known. The time scale of the last 100 years is long enough to cover at least two phases, the warm phase between 1940 and 1969, and the cold phase from 1970 to 1990. The choice is a little bit biased by the existence of the ECHAM results for the GISST period, which enables a broader comparison based on different resolved physics and model resolution. In section 3.4 the connection of SST and SLP, which was found in observational and model results is extended to the past in a synthesis of different proxy data. The combination of Luterbacher et al. (2002) SLP and the Cariaco Basin sediment record (Black et al., 1999) as indicator of SST yields a projection of the AMO over the last 332 years. This sub-section is set at the end of Section 3 because it summarises the finding of single proxy and model results over different periods and draws a long term perspective of the AMO signature.

4) Statistical significance

Good that the authors apply some sort of significance test, but I don't think that for lowpass filtered records the number of degrees of freedom is simply given by the record

length divided by the filter period. At least the autocorrelation of each record should be taken into account. Anyway, it should be noted that the record length of 150/a few hundred yrs allows for 2/5 cycles of the AMO to be resolved - how significant can this be, even if the t-test looks good?

Answer: The statistical significance of climate signals at multidecadal time scales for the instrumental record is a problem. On observational time scale (last 150 years) only 2 cycles could be resolved (if fully contained in that window). To investigate significance, a much longer time series is necessary; e.g., the Cariaco time series, which covers 800 years, contains about 10 cycles which is at the limit to discuss significance. The reduction of the degree of freedom through filtering the data is only one plausible method to consider the reduced frequency content. Nevertheless, as long as we have no long term model integrations over millennia time scales, a statistical robust investigation of multidecadal variability remains unresolved. However, in such a case, the correct phasing of the signal becomes a problem. Here, our attempt can be seen as a step in the right direction. We are aware that our significance test alone provides no additional argument. Only the compilation of different arguments/independent data sources yields in our opinion evidence for a long term persistent multidecadal signal over the North Atlantic.

Interactive comment on Clim. Past Discuss., 2, 633, 2006.