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Interactive comment on "Orbital forcings of the Earth's climate in wavelet domain" *by* A. V. Glushkov et al.

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We wish to thank the referees for their useful comments and interesting discussion. A number of comments are mostly taken into account in the revised version of the paper. Hopefully, the presentation has improved and is more precise.

In this comment, we dwell on questions that were scanty elucidated in the paper. From our point of view, this causes most of censorious remarks from the referees. These subjects – data, method, and age model – are clarified in more detail in the revised version of the paper.

i) Data

We were in adequately earnest about the choice of original data to be analyzing. Delphi Project Page (http://delphi.esc.cam.ac.uk) contains a quantity of datasets on paleorecords. Realizing fully that any preliminary interpolation is not a good approach for an analysis by a method demanding equidistant data point, as well as surmising that it can be the occasion for the additional criticism of referees, we picked out the composite record that was preliminary interpolated by the distributor (Shackleton, 1995). We not cast doubt at all on the goodness of this dataset.

From our point of view, the 3-ky time step in the data of Shackleton (1995) is adequate fully to reveal the ~100- and ~40-ky periodicities but is not satisfactory for the periodicity of the ~20-ky in accordance with circumstances denoted by Witt (2005). In the paper, the latter periodicity is required to investigate an interaction between the temperature fluctuations caused by the Earth's orbit parameters during the dominant 100-ky cycle. To choice the dataset allowing this investigation, we calculated differences, Δt_i, between the age in the interpolated points, t_i, and the age in the points of original dataset, t_j, by

$$\Delta t_i = \min |t_i - t_j|.$$

Table 1 summarizes some results of our preliminary analysis for several datasets. From all datasets, the Vostok ice core record only allows an interpolation without significant errors affecting the results if the last ~400 ky is considered. Nevertheless in Section (ii) of this comment we shall also consider results by the Dome C record to compare these two datasets.

Thus, to analyze paleoparameters by the non-decimated wavelet transform we used the interpolated datasets of:
1) the Vostok ice core record from 3.4 to 412.6 ky BP with the time step of 0.4 ky (1024 data points);
2) the composite record of Shackleton (1995) from 0.0 to 4101 ky with the time step of 3.0 ky (1368 data points);
Such a choice is validated in Section (ii).

ii) Method

There are currently a few wavelet analyses based either on the discrete wavelet transform (DWT) or on the continuous wavelet transform (CWT). The non-decimated wavelet

Table 1: Some statistics for differences, Δt_i, between the age in the interpolated points and the age in the points of original dataset. For the interpolated time series, the age is from 3.4 to 412.6 ky BP and the time step is 0.4 ky.

Dataset	$\sim \Delta t$ at 400 ky (in yr)	number of $\Delta t > 200$ yr (in percents) $(in percents)$	number of $\Delta t \leq 40$ yr
Vostok	550	5	58
Dome C	1200	43	13
ODP 980	400	59	12
TN 056-7	1300	56	10
ODP 982	1300	81	4
ODP 846	1500	82	4

transform (Nason et al., 2000) used in our paper is a particular version of DWT whereas the weighted wavelet Z-transform (Foster, 1996) or the cross wavelet transform (Torrence and Compo, 1998) are a particular version of CWT. Both the DWT and the CWT have advantages and shortcomings like any other statistical analysis.

One of shortcomings of CWT is that a decomposed signal contains redundant details (Goswami and Chan, 1999). To separate significant and insignificant details, Torrence and Compo (1998) proposed the proper test. A strict binding of detail component (an amplitude is changing) to a given period can be considered as other shortcoming of CWT when the signal is stipulated by a process with different (but almost equal) periodicities. The variations of paleoparameters due to the obliquity fluctuations can be an example of this ambiguity. For this case, Torrence and Compo (1998) proposed the scale-averaged wavelet power.

Detail components obtained by the DWT are strictly bound to the levels of decomposition, the maximum of these levels is defined by dataset length that must be (preferably) dyadic one. (The non-dyadic dataset length can be also used. But in this case whole dataset is separated into two overlapping dyadic ones, which can be 'glued' after the wavelet decomposition. This approach was applied to the composite dataset.) This means that when different time intervals or dataset length are used, the results of DWT are also different. On the other hand, for a separate detail component the DWT not restricts the period, i.e. the period of detail component (an amplitude is changing) varies. Hence one detail component is able to describe a process with different (but almost equal) periodicities. Figure 2c in our paper shows this feature. The significance testing is also applicable to the DWT (Torrence and Compo, 1998). The results of significance testing are described in the revised version of the paper.

Thus the CWT seems to be the perfect tool to discover hidden periodicities and to test their significance (as well as for many other objectives) whereas the DWT, form our point of view, is a more preferable and visual approach to study relations between detail components of time series when periodicities are known. The paleoparameters can be considered as such datasets since their fluctuations are influenced by the well-known variations of the Earth's orbital parameters (or seem to be the same, at least).

Anonymous Referee #2 (2005) noted quite justly in his specific comment #10 that we not found the major Milankovitch scales in the Vostok ice core record. The wavelet decomposition was forced to find these scales due to input parameters of non-decimated wavelet-transform. The same relates to the composite dataset. We suppose however that the aforementioned paragraphs justify our point of view.

iii) Age model

To discuss uncertainties of age models of ice core records as well as the influence of interpolation on the results, we analyze in new version of the paper the detail components for two time series with different age models: the Vostok and the Dome C ice core records. Although apparent differences in time series are registered up to ∼200 ky BP (some reasons are given by Petit et al., 1999 and EPICA, 2004), our outcomes concerning the combined unidirectional influences of three orbital parameters on the abrupt climate warmings with cyclicity of ~100 ky remain valid substantially for the Dome C ice core records also. The plausible reason consists in differences between age models and not in the features of wavelet transform.

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