Clim. Past Discuss., 8, C90–C92, 2012
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Climate
of the Past
Discussions

Interactive comment on "Climate bifurcation during the last deglaciation" *by* T. M. Lenton et al.

Anonymous Referee #1

Received and published: 2 March 2012

Review of "Climate bifurcation during the last deglaciation" by T. M. Lenton, V. N. Livina, V. Dakos, and M. Scheffer.

In their publication "Climate bifurcation during the last deglaciation" Lenton et al. examine proxy records of the last deglaciation using time series analysis methods. Their aim is to determine whether major transitions in these records, i.e., the transition into the Bølling-Allerød and the transition into the younger Dryas were preceded by critical slowing down, which could be interpreted as indicating a bifurcation in the climate system. They find that the transitions to the Bølling-Allerød and the Younger Dryas do not show critical slowing down, while they claim that the overall deglaciation does.

It always is a pleasure to read papers written by Tim Lenton, and the present paper is no exception to this. It is exceptionally well written, especially in passages putting their current research into the wider context of Earth System science. The method they

employ to examine the records of the last deglaciation has been well documented in a series of papers by the authors, leaving very little to be desired.

While I quite liked the study in general terms, I have reservations with respect to some details and I strongly disagree with respect to the interpretation of the results.

1. First of all I need to remark that critical slowing down does not prove that a bifurcation exists in the system. While one would expect to see critical slowing down in a system close to a bifurcation point, there are other possible situations that would lead to increases in variance and/or autocorrelation. Therefore the indicators investigated by the authors do not prove that there was a bifurcation in the climate system during the Younger Dryas, they just give supporting evidence to the hypothesis. While the authors do not actually claim that their results prove the existence of a bifurcation, the general tone of the discussion and conclusions gives that impression to the reader.

2. What I am sorely missing from the manuscript is a test of the statistical significance of their results. The Kendall trend statistic the authors use to asses significance tests whether there is a trend in a timeseries, but it does not assess whether the estimate of the indicator itself is statistically significant, which is quite a different problem. I fear that more classical estimates of statistical significance may show that the estimates of the ACF indicator are not statistically significant in some of the cases investigated. It would strongly improve the authors' argument if they could show that indicator estimates also are statistically significant.

3. Figures 2 and 3, as well as 6a and b: Judging from the plots in Figures 2, 3, 6a and 6b, the reader wonders whether the positive trend in the indicators is mainly due to the fact that the transition into and/or out of the Bølling-Allerød is being sampled. That such a transition between states, i.e., a major instationarity in the time series, leads to an increase in autocorrelation, implying positive trends for both indicators, is trivial. It is NOT an indication of slowing down, though, but an artefact of the instationarity in the time series. In addition, the Bølling-Allerød (B/A) likely is a state different from

the ones before and after, implying that stability, i.e., the timescale of recovery from a perturbation, may be quite different. Whether the trend in the indicators shown in the Figures is real or just due to sampling of the two distinct states or even an artefact of the the instationarity in the time series is the crucial point the entire argument in the paper hinges on, and so far the authors do not convince me it's not an artefact. The authors try to address this point in section 3.3, but neglect to address the main problem. Their analysis shows (Fig. 4 and 5) that there is no robust indication of slowing down before the B/A transition, no robust indication of slowing down during the B/A (Fig. 6c) and no robust indication of slowing down before the Younger Dryas (Fig. 6d). The only cases when they detect indications of slowing down are when they include the transitions between states, i.e. in Fig. 2 and 3, as well as 6 a and b. The initial conclusion one would draw from these findings is that the observed signal of slowing down is an artefact of the transitions between states. Other conclusions would need to be justified. In the discussion section, on the other hand, the authors claim that their core result is "a robust overall slowing down", but as indicated above, there actually is no evidence of this "robust" trend.

This major shortcoming needs to be addressed. So far the authors do not convincingly show that the slowing down is not an artefact, implying that the entire discussion and conclusions sections address "evidence" that actually isn't given by the paper.

Interactive comment on Clim. Past Discuss., 8, 321, 2012.