Reply to the comments made by Referee #3

I thank Referee #3 for these comments. He/she has given a short point-to-point reply to my brief response to Referee #1, without visually indicating which parts of the text are his/hers and which parts are originally mine. For the sake of clarity, I have indicated my original response to Referee #1 in blue and my response to Referee #3 in blue and italic, while the comments of Referee #3 are in dark red.

Review of the Omtas manuscript (submitted to CP) :
"Differences between the glacial cycles of Antarctic temperature and greenhouse gases"

First, I should mention that I was reviewer of a previous submitted version of this paper to another Journal. I had at this time some major criticisms related with the analysis made of the ice core data used, the approach for decomposing the temperature signal into an eccentricity component related to CO_2 and an obliquity signal, and the way the author invalidated hypothesis that CO_2 is follower and amplifier of temperature. I concluded that the paper, which presented neither new data nor convincing reanalyse and explanations, was in my point of view confusing, not scientifically sound and of no help for better understanding forcings and feedbacks involved in glacial-interglacial cycles. Although the present manuscript has been partly restructured and shows some changes compared to the previous one, I have still more or less the same remarks. Nevertheless, instead to develop in details my comments here and because I already read the comments of the 2 first referees as well as the answers of A.W. Omta (a benefit of a discussion paper!), I feel more useful to comment on the two questions proposed by Omta in his answer to referee #1.

1. **What is the key point in this manuscript?**

According to the author it is:
Subtracting the ice core CO_2 signal from the ice core δD time series (taken as a proxy of Antarctic temperature) after rescaling both signals with their respective standard deviations yields a residual similar to the rescaled obliquity cycle. This directly implies that temperature is approximately a linear combination of CO_2 and obliquity. After A.W. Omta, this has not been pointed out elsewhere.
To my point of view the key point of a paper, based on spectral analyses and decomposition of time series in components characterized with signatures of different frequency domains, should be thoroughly and quantitatively discussed with an evaluation of the uncertainties and by using and comparing several methodological approaches. For instance, why not filter the δD signal around the 41 ka frequency band to isolate the response of Antarctic temperature to obliquity variations? And if applicable, how such filtering will compare with the method used by Omta? In short, I believe that the methodological approach, on which the key point of the paper is based, is not seriously validated.
The purpose of subtracting the CO_2 signal from the temperature signal was not to filter around the obliquity frequency per se, but to establish whether or not

Antarctic temperature is a linear combination of CO_2 and obliquity which is the central point of the paper. Filtering the δD signal around the 41-ka frequency band may be an interesting exercise, but such an exercise would not help in any way to prove or disprove this central point.

2. Why is this an important finding?

According to the Author, it is because a key question regarding the glacial cycles is the causal relationship between CO_2 and Antarctic Temperature (AT). My understanding is that A.W. Omta discusses two types of scenario: (1) CO_2 primarily responds to and amplifies Antarctic temperature and (2) Antarctic temperature and CO_2 independently respond to a 100 ka cycle of another variable (which one?) or there exists a 100kyr biogeochemical oscillation of CO_2 to which Antarctic temperature responds. On top of that, temperature responds to obliquity variations.

These two scenarios have already been discussed in the past and quite recently in different papers, and several mechanisms have been proposed to explain the phase relationship between temperature and CO_2. It is still an important open question, but honestly it is difficult to believe, in the absence of a detailed discussion and modelling approaches, that only because AT would be a linear combination of CO_2 and obliquity, we will be able to solve or even to constrain the causal relationship between CO_2 and AT..

If Antarctic temperature is a linear combination of obliquity and CO_2, then that does put a strong constraint on the relationship between these three variables. In fact, the prevailing view that CO_2 primarily responds to, and amplifies, Antarctic temperature is inconsistent with Antarctic temperature being a linear combination of CO_2 and obliquity. So far, this argument had not been brought into the ongoing scientific discussion.

A much more elaborated approach is needed taking into account, for instance:

– the full dynamics of the CO_2-AT relationship through the glacial-interglacial cycles (Transitions, onset of glaciations,...; for instance by analysing continuous wavelet transforms of the signal)

Wavelet transforms are very useful to detect whether the dominant frequencies in a time series change over time. However, that is not the focus of this paper.

- the regional character of AT evolution

This issue is elaborated upon under point 1. in the Discussion section of the paper. Essentially, one can explain that the obliquity band is weaker in CH_4 than in δD from the fact that Antarctic temperature is a regional signal, whereas CH_4 is a global signal, but one cannot explain that the obliquity band in CO_2 is even much weaker than in CH_4 in the same way.

- the full spectrum of forcings and feedbacks

This paper deals with what the relationship between Antarctic temperature, CO_2 and obliquity is. Through which mechanisms this relationship could come about, is a different issue, for which one has to investigate the forcings and feedbacks in more detail.

Also a detailed analysis of the phase relationship between CO_2 and temperature, based on paleodata is definitely necessary in order to constrain the causal relationship between CO_2 and temperature during the glacial-interglacial cycles

Many studies have already tried to establish the relationship between CO_2 and Antarctic temperature by temporally overlapping the two signals and analysing

small phase differences. However, this approach relies on very precise dating of the signals and there exists an inherent difficulty in overlapping temperature and greenhouse gas concentrations because of the difference in age between the gas in the bubbles and the surrounding ice which could easily lead to systematic errors. Fourier spectra appear to be an appealing diagnostic, because they are largely insensitive to such an uncertain ice-age/gas-age difference. Therefore, I have based my analysis of the relationship between CO_2 and Antarctic temperature on Fourier spectra. As far as I am aware, this is the first time that this problem has been appraoched from this angle.

To summarize, the key point of this work is not adequately validated, and even if it was, the simple exercise presented in the submitted paper doesnt appear to be an important finding in itself to constrain the CO_2-temperature connection during glacial-interglacial cycles. I still feel that that this paper is not scientifically sound and of no real help for better understanding forcings and feedbacks involved in glacial-interglacial cycles. My recommendation is to reject the manuscript for publication in CP.

I respectfully disagree with this assessment. If Referee #3 asserts that the key point is not adequately validated, then he/she ought to either give reasons why the followed approach would be invalid to establish the key point, or propose viable alternative approaches. The Referee has failed to do either of these. In fact, the analyses suggested by the Referee (filtering, wavelets) would not in any way help to resolve the key issue whether or not Antarctic temperature is a linear combination of CO_2 and obliquity. If the Referee asserts that the interpretation that CO_2 does not primarily respond to Antarctic temperature is invalid, then he/she ought to provide an alternative interpretation of the key finding which the Referee has, again, failed to do.