

2nd review on “Late Pliocene Cordilleran Ice Sheet development with warm Northeast Pacific sea surface temperatures” by Sánchez-Montes et al.

General comments

In my first review I stated to major points of criticism, i.e. the presentation of the TAR and CPI indices and the confusing presentation of section 4.4. The authors addressed both points so that the clarity of the entire discussion greatly improved overall. The new section 4.4 is much clearer than before and the authors' inferences are easy to follow, now. So, I don't have further complaints here. However, I still have some concerns regarding parts of their interpretation of the TAR index which partly arise from having the CPI plotted next to the TAR. At the present stage, the inferences made from the TAR during the oNHG (3-2.8 Ma) are questionable and require further clarification by discussing the different potential factors controlling the TAR in more detail (see below). This is crucial to strengthen the key conclusions that the onset of the Cordilleran Ice Sheet glaciation occurred during this time interval. I am convinced, a more comprehensive discussion around the different factors controlling the TAR will unequivocally strengthen the inferences made from this multi-proxy approach. As already mentioned in my first review, presenting a multi-proxy approach the study is a valuable and important contribution to the ongoing discussion about the glaciation chronology in the Cordillera during the Plio-Pleistocene transition. The paper should be accepted for publication as soon as this last issue regarding the TAR has been addressed.

Interpretation of TAR during the oNHG, 3-2.8 Ma (page 10, line 40-page 11, line 5):

As the authors correctly describe in the methods section, the TAR index estimates the relative abundance of long-chain *n*-alkanes versus the short chain homologues and is commonly used to estimate changes in the relative contributions of plant-wax lipids from higher land plants and aquatic production (page 5, lines 4-7). In the discussion of the onset of the Cordilleran Ice Sheet glaciation (3 to 2.8 Ma) the authors infer an increase in the export of plant-derived organic matter based on a decrease in the TAR-values (page 10, line 40 to page 11, line 5). In fact, this interpretation is contradictory to the general way of interpreting the TAR according to which decreasing values would imply the opposite i.e. an increase in aquatic production and/or a decrease in the contributions from higher land plants. Although I don't doubt the possibility that the export of terrigenous material including the long-chain *n*-alkanes may increase despite a decrease in the TAR, this interpretation needs further justification and cannot be based on the TAR alone. Concentrations or mass accumulation rates of the short-chain and long-chain *n*-alkanes are needed to support this statement since they allow to disentangle the individual developments of the input of short chain and long-chain *n*-alkanes. It may help to compare them to concentrations of other marine biomarkers, e.g. alkenones. Moreover, there are several possibilities to explain the decrease in the TAR-index and not all of them support expanding glaciation in the hinterland. Based on the current presentation of data, the authors don't have a means to rule these options out. Firstly, there could be an increase in aquatic production which does not necessarily mean that the controls on the export of leaf-wax biomarkers change. That means it would be possible that the vegetation cover remains as extensive as before (during the early to mid-Pliocene) which would be in conflict with the authors' inference of advancing ice cover in the region. Secondly, assuming that the

source of the long-chain *n*-alkanes remains the same as during the early to mid-Pliocene, the decreasing TAR may report on a decline in the export of terrigenous organic matter attesting to e.g. a reduction of the vegetation cover. Although this view would be in harmony with advancing ice masses in the hinterland it would be in conflict with the authors' idea of enhanced discharge of leaf-wax lipids from vegetation. Thirdly, the overall low CPI-values (around 1.5) point to a high degree of degradation. So, it is plausible that a large fraction of the long-chain *n*-alkanes may be petrogenic instead of dominantly vegetation-derived. As the authors point out, there are coal-bearing bedrocks in the region and these are characterized by low TAR (up to 2) and low CPI-values (<1) (page 10, lines 25-28 and page 12, lines 25/26). As such, the decrease in the TAR may also indicate intensified erosion of bedrock compared to the early and mid-Pliocene. Under these circumstances, decreasing TAR would be compatible with increased export of terrigenous organic matter. This scenario would be in accordance with the idea of reduced vegetation cover and expanding ice masses in the Cordillera.

Since the inferences for the Ice Sheet Glaciation strongly depend on the way of interpreting the TAR, the different potential controls on the index need a more detailed recognition in the discussion in order to strengthen the authors' key conclusions, namely that the onset of the Cordilleran Ice Sheet Glaciation occurred between 3 and 2.8 Ma.

Detailed comments

Page 5, line 9: remove the sentence in line 9. This seems to be out of context here in the method section. The following paragraph encompassing lines 10-16 stands well by itself.

Page 10, line 20: *n*-alkane => *n*-alkane

Page 12, line 12-13: Actually, the CPI cannot attest to the maturity of the short-chain alkanes as the formula used here does not consider the homologues shorter than C₂₄.

The interpretation of the TAR should be justified a little more in detail considering the different interpretation of a similar signal for the period from 3-2.8 Ma. It is not clear why the low TAR values are interpreted as stemming from increased productivity from 2.7 Ma onwards while between 3-2.8 Ma the progressive decrease towards these low values is attributed to an increased export of leaf-wax lipids from land plants. Please, explain.

Page 2, lines 17 and 20: In line 17 it says St. Elias Mountains while in line 20 it is St Elias Mountains. Please, unify the spelling throughout the entire manuscript.