Review by J.E. Saylor

Summary

The authors present a sensitivity study of the effects of diachronous elevation changes in the Alps on regional climate and, specifically, the stable isotopic composition of precipitation. The sensitivity study is conducted using the ECHAM5-wiso isotope-enabled General Circulation Model. They explore a range of end-member models, ranging from no Alpine topography, to double modern elevations in the western and eastern Alps individually or uplift of the full Alps to twice their modern elevation. The authors conclude that there are significant changes in isotopic lapse rates (in addition to changes in isotopic ratios as a result of topographic change but not due to changes in lapse rate). The authors also identify changes in temperature, precipitation amounts, and atmospheric circulation related to uplift. The authors conclude that uplift of the western Als has a greater effect than uplift of the eastern Alps and that diachronous uplift can be assessed from the geologic record, given appropriate archives.

Recommendation

There are significant unexplored limitations to the dataset that need to be addressed before the manuscript can be published. These limitations may undermine, or at least put caveats on, the authors' conclusions that should be incorporated into the Abstract, Discussion, and Conclusions. I recommend that the authors address the considerations below in a major revision prior to publication.

General comments

The authors need to calculate and present uncertainties associated with their lapse rates. It is difficult or impossible to determine if the difference in lapse rates is significant without some estimate of the uncertainty associated with the values.

The authors conclude that changing the topographic configuration changes the d18O values across the region. This goes without saying and is the basis for paleoaltimetry. The question is whether the d18O values change more or less than is expected given a certain amount of topographic rise. The authors have not demonstrated that that is the case based on my evaluation of Figure 5, 6 or 7.

There are places where the authors apparently favor non-uniformitarian interpretations based on data that are equivocal (see comment on Line 519 below). It seems that the most conservative interpretation should be favored where possible and unless the data require alternative interpretations.

Detailed comments

Lines 15, 117: Delete the "e.g.,"

Line 22: What is "significant"? This should be presented in terms of absolute lapse rates and their uncertainties.

Line 25: Obviously the absolute values change and that that change will vary if part or all of the orogen is uplifted, the question is whether the underlying lapse rates in isotopic ratios or temperatures change.

Line 70: Rephrase as "remains an open question."

Line 103: It would be useful to have a succinct statement of the modern elevations and the basis for selecting the elevations selected for the experiments. The latter is disseminated through this section, but it would be useful to have it stated concretely and in one location.

Line 108: What is deemed unlikely about the topographic development? It seems like this sentence needs an additional clarifying phrase.

Line 108: Should this be, "between 200 and 100 km"?

Line 108: What is meant by "post crustal shortening"?

Line 310: What about W0E0?

Line 314: I recommend rephrasing as, "The topographic scenarios predict significant localized cooling or warming where the topography is raised or lowered, respectively.

Line 315: Are these adiabatic or non-adiabatic cooling or warming?

Line 330: Consider annotating the legend with text to guide the reader, such as "Warmer than control," or "Cooler than control." Consider something similar for figure 2 and 4.

Line 370: It is quite difficult to correlate between the legends and the curves. I think this is in part because the topography is semi-transparent and so the colors are washed out. As the colors selected in the legend are somewhat similar, it makes it hard to tell the difference when they are semi-transparent. I recommend making all lines 100% opaque and perhaps labelling individual curves to aid visual correlation.

Line 370: Include these cross-sections or swaths on figure 2.

Line 370: What about W2E2? How do the lapse rates change for that scenario?

Line 380 and figure 6: What are the uncertainties in these lapse rates? I suspect that a lapse rate of -2.08 per mil per km is virtually indistinguishable from -1.83 per mil per km. Ditto for -3.11 per mil per km and -2.96 per mil per km.

Line 390: I'm not sure that linear lapse rates are appropriate here. From Figure 5 it looks like there are very different lapse rates between 0–500 m and >500 m. A back-of-the-envelope calculation of lapse rate for the W2E1 and control scenario yields similar lapse rates above 500 m. CTL: $(-7.5 - -4.5)/(1.25-.5) = -4$ per mil / km; W2W1: $(-14 - -4.5)/(3-.5) = -3.8$ per mil / km

Line 519: This 2 C is well within the range of lapse rates cited above (4.1–5.9 C/km). Without further examination of the data, it seems like an over-interpretation to invoke non-adiabatic processes here. In other words, the non-adiabatic processes must be demonstrated and not simply invoked. No such demonstration is offered here.

Line 520: Yes, plausible and the simplest explanation prima facie.

Line 523: What remainder of the signal? I am not sure what is being referred to here.

Line 525: "All of the signal can be explained via adiabatic processes. Other processes appear to be insignificant." The "small contribution" has not been demonstrated and should not be invoked without caveats.

Line 554: I can see the higher atmospheric origin (maybe…) but the paths are not convincingly longer than the CTL experiment. Also, specify that you are referring to the topography of the western Alps (obviously W2E0 has topography both raised and lowered).

Line 555: An origin at higher atmospheric levels when the topography is lowered seems to be the opposite of what was stated in the previous sentence. Reference the relevant figure.

Line 557: They also lower the elevation of the vapor source if I am interpreting the figures correctly.

Line 617: To what is the 8 per mil additional? Perhaps replace "an additional" with "a"?

Line 617: But are these differences in d18O values unexpected, or are they what would be predicted based on increasing topography without significantly changing the lapse rates? It looks like the latter based on my evaluation of Figure 5, for example.

Line 630: Where is this difference in summer versus annual lapse rates shown? The text needs to refer to specific figures and panels to support statements like this.

Line 640: Again, is the change significant? What are the uncertainties? Are the uncertainties greater than the calculated change in lapse rates?

Line 645: Where is this shown?

Line 682–684: Whether they differ or not depends on the uncertainties associated with these measurements.