Authors' replies to the Referee

We thank a lot the Referee for their comments and further suggestions. Below, we provide our replies.

Minor comments

1. *The authors noticed the existence of a significant specific humidity trend in their simulation, and exploited this observation to explain the observed surface temperature increase and associated stability reduction during PCAP events. Even the proposed mechanism is physically plausible, the connection between the humidity and the temperature trend is not shown explicitly. Would it be possible to check whether trends in incoming long-wave radiation match the observed specific humidity trend, in general and/or during PCAP events? Without this type of analysis, the statement at line 12 in the abstract would need to be toned down, for instance by replacing of "is due to" with a more hypothetical formulation (e.g., "might be due") as done in the Conclusions.*

   We agree with the Referee that the sentence in the abstract is too "strong". We rephrased the sentence as follows: "This decay is explained by the fact that air temperature over the century increases more at 2 m above the valley bottom than in the free air at mid-altitudes in the valley; this might be due to the increase of specific humidity near the ground."
   (Unfortunately, the outputs of MAR←MPI for radiation, longwave and shortwave radiation, were not saved.)

2. *Could the authors explain how trends are computed, and in particular how serial correlation is taken into account when assessing trend significance? If trends are computed on all points displayed in Fig. 6 (daily means), there is a risk that positive auto-correlation might lead to spurious trends and detection of significance (e.g., https://doi.org/10.1016/j.earscirev.2018.12.005).*

   The trends are computed as linear regressions based on the daily means of winter (NDJFM) periods (i.e. all the points displayed in Fig. 6). The python function "scipy.stats.linregress" has been used for the computation. We added in the manuscript that the trends are computed as linear regressions in the captions of Fig. 6 and Fig. 8; thanks for noticing this missing information.

   We also thank the Referee for the interesting reference of Mudelsee 2019. We would like to explain that we decided not to compute the linear regression after the application of a running mean (one of the methods suggested in the reference) for the following reason: the temporal series we consider do not evolve on a continuous time axis as summer days are missing, therefore, we would have averaged values of March with values of November in the same window. We rather preferred to compute the trend on the original time series as it contains more than 18000 points which should allow for a robust computation of the trend. Finally, the autocorrelation mentioned in Mudelsee 2019 is interrupted once per year, in our case, due to the selection of winter periods only.

   Nevertheless, we investigated some aspects mentioned by Mudelsee 2019 and we performed the following computations. We computed the correlation between the residuals of two daily temporal series (i.e. $(\Delta T/\Delta z)_{MAR}$, which we will call $X(i)$, with i=days) shifted by Δi. The residuals are computed as $R(i) = X(i) - (at(i) + b)$, where a and b are the coefficients of the linear regression. We obtained that, if Δi is equal to one day ($\Delta i = 1$), the Pearson correlation between $R(i)$ and $R(i + 1)$ is about 0.53; such a (not low) correlation is expected since Δi is equal to one day only (we remind that Mudelsee 2019 considers annual means in the temporal series, instead of days). If we increase the shift by one more day, namely $\Delta i = 2$, the correlation becomes very low: the Pearson correlation between $R(i)$ and $R(i + 2)$ is about 0.27 and the scatter plot is a cloud.

Finally, we also computed the correlation of the residuals of $X(i)$ and $X(i+1)$ where $X(i)$ is the annual (i.e. winter) mean of $(\Delta T/\Delta z)_{MAR}$ (i.e. using annual time series, like in the example of Mudelsee 2019, Figs. 2 and 3). This time, the correlation is really close to zero, showing no autocorrelation between years. We therefore believe that the use of the linear regression method for the trend computation in our paper is justified.

3. *Line 402: "cold air intrusion" would be a clearer terminology in this context, as "subsidence" is usually associated with descent and adiabatic warming. Besides being confusing, no analysis of vertical motion is performed in the paper.*

   We thank the Referee for the suggestion. We used the expression "cold air intrusion" instead of "cold-air subsidence". (The analysis of air vertical motion, especially above the inversion top, was not the focus of this study.)