

Dear editor,

Please to find our replies to your comments. The manuscript has been revised accordingly.

Best regards,

Sullivan Carbone and co-authors

P1, L20: flown under not correct, I guess you mean flown “on”. Aren’t this instruments mounted on the balloon?

Authors: No, the instruments are flown hanging down below the balloon. “under” is commonly used in this case.

P1, L24-25: “for a flight which flew” -> this sentence makes no sense. Rephrase it to “for a flight performed” or “for a flight made”.

Authors: The sentence has been rephrased such as “This is the case for one of the flights which flew over the Raï typhoon”.

P1, L26: What do you mean with “variabilities according to the flight”?

Authors: We mean that the rate of nights influenced by atmospheric waves varies depending on the flight. We rephrased such as “with variabilities in this rate according to the flight”.

P1, L20-27: The abstract still needs to be improved, especially the result part and implications of this study. The last sentence of the abstract is really a bit poor. It sounds like that waves are only important for the measurements on balloons although the observations of these waves are important to understand atmospheric processes related to water vapour.

Authors: It has been changed as follows: Most of atmospheric species enter the stratosphere through the tropical tropopause layer, a place of interplay between many processes of different scales. Water vapour ($\text{H}_2\text{O}_{\text{vap}}$) is a key compound in this layer and its entry into the tropical stratosphere is crucial for stratospheric chemistry and climate. In this paper, we present a methodology based on the calculation of *in situ* $\text{H}_2\text{O}_{\text{vap}}$ and temperature anomalies to estimate the modulation of $\text{H}_2\text{O}_{\text{vap}}$ due to atmospheric waves and deep convection. $\text{H}_2\text{O}_{\text{vap}}$ were obtained from *in situ* measurements of five Pico-Strat Bi Gaz spectrometers which were flown under long-duration balloons during the Strateole 2 campaigns. The calculation of Pearson’s correlation coefficients is performed between averaged ERA5 reanalysis temperatures and *in situ* $\text{H}_2\text{O}_{\text{vap}}$ anomalies. In case of a monotonic vertical gradient of $\text{H}_2\text{O}_{\text{vap}}$, the absolute value of the correlation coefficient is high (typically 0.65). For the other flights, we highlight lower correlations, due to changes in time of the vertical gradient of stratospheric $\text{H}_2\text{O}_{\text{vap}}$, and large convective systems overshooting the tropopause. This is the case for one of the flights which flew over the Raï typhoon (correlation coefficient of 0.31 due to both contributions). Depending on the flights, we also show that for 47 % up to 70 % of the probed nights, $\text{H}_2\text{O}_{\text{vap}}$ anomalies can be explained by atmospheric waves, which highlights the major role played by waves on $\text{H}_2\text{O}_{\text{vap}}$ in

the TTL . We also show that long duration balloons measurements are precious to highlight overshooting signature of $\text{H}_2\text{O}_{\text{vap}}$ in the upper TTL.

P3, L86: Acronym MLS has not been introduced.

Authors: Done.

P3, L98: two first -> first two

Authors: Done.

P4, L108: Add “the” -> the stratospheric water vapour budget

Authors: Done.

P4, L109: What do you mean with “five flights have been already released”? Shouldn’t it rather read “five flights have already been performed” although I think that “already” is generally obsolete in the sentence.

Authors: We mean that additional flights of Pico-STRAT Bi Gaz will be carried out in the next (and last) campaign of Strateole 2. We rephrased such as:

“Five Pico-STRAT have been already released during the first two campaigns, allowing to measure *in situ* water vapour, CO_2 and CH_4 mixing ratios. Additional flights of Pico-STRAT Bi Gaz will take place during the last campaign of Strateole 2 in the end of 2026.”

P5, L122: Delete “used” and consider even renaming the section to just “ Instruments and Datasets”.

Authors: Done.

P5, L124 and following subsections: 3.1. -> 3.1, the dot after the second number is obsolete

Authors: Done.

P5, L142: space between number and unit missing.

Authors: Done.

P8, L215 and throughout the manuscript: In many occasions there is a double space between “correlation” and “coefficient” -> one space should be removed.

Authors : The space is due to the paragraph format as “justified”.

P8, L215: to water vapour -> of water vapour

Authors: Done.

P10, L262-263: from 800 m to 1.5 km is an increase and not a drop of the balloon altitude.

Authors: Done.

P10, L270: wave -> waves

Authors: Done.

P11, L274: Remove full stop at the end of the subsection header.

Authors: Done.

P12, Figure 5 caption: “for each flight” misplaced? Doesn’t this hold for both values and thus this should appear at the end of the sentence?

Authors: it has been changed as follows: Longitude/time “quasi-Lagrangian” Hovmöller diagrams in temperature anomalies, calculated from ERA5 3D temperature fields for each Pico-STRAT Bi Gaz flight.

P14, Figure 6 caption, last line: Shouldn’t “respectively” rather appear at the end of the sentence? However, I would rather suggest to omit using “respectively”.

Authors: Done.

P15, L333: Here 0.65 written, but in the table (Table 2) 0.64 listed.

Authors: Done.

P15, L339: fight -> flights

Authors: Done.

P15, L340: In this sentence something is missing. What is the case for the other two flights.

Authors: We rephrased such as:

“All the 2021 flights overflowed the Maritime Continent and two of them (C1_07_TTL4 and C1_15_TTL4) overflowed it during these 8 days.”

P15, L350: stands in -> is in

Authors: Done.

P15, L350: observed in the -> obtained from

Authors: Done.

P15-16: Following your discussion on the results is really difficult. More guidance to which table you are referring to would maybe be helpful and generally improving the structure and better motivate for what you actually do which analysis.

Authors: we revised the discussion about the Pearson's coefficient to improve clarity.

Lines 343-354: "A negative r_{H_2O-T} , such as for the C1_03_TTL4 and C1_12_STR4 flights, does not rule out the signature of atmospheric waves in the water vapour modulation. Since atmospheric waves produce temperature anomalies, another way to verify the effective influence of atmospheric waves is to compute the temperature-temperature Pearson's correlation coefficient (r_{T-T}) between ERA5 temperature anomalies and *in situ* air temperature observed by Pico-STRAT BI Gaz (see Table 3). The r_{T-T} listed in Table 3 are high for all the flights: the mean Pearson's correlation coefficient is 0.77 ± 0.06 . This indicates that even flights which depict near-zero or negative r_{H_2O-T} are strongly influenced by atmospheric waves.

During the period from December 28, 2021, to January 9, 2022, the C1_15_TTL4 balloon flew in a similar structure of the tape recorder as the C0_05_TTL2 balloon (i.e. positive vertical gradient), which has the highest r_{H_2O-T} (0.64). One can thus expect similar Pearson's correlation coefficient for both flights during this period. Indeed, restricting the calculation of the Pearson's correlation coefficient to the period from December 28, 2021, to January 9, 2022, leads to a r_{H_2O-T} of 0.65, very similar to the one obtained for C0_05_TTL2. In both cases, the Pearson's correlation coefficient therefore is in the 0.6-0.7 range, which is the highest value obtained so far for the Strateole 2 flights."

P16, L380: To which table are you referring here to? What about Table 3? This table is only shortly mentioned, but not further discussed.

Authors: The statistics provided here do not refer to any table.

P17, L397: Rai is one -> Rai was one

Authors: Done.

P18, L417: If you cannot derive the anomalies, which anomalies are then plotted in Fig. 8? How have these been derived?

Authors: This figure shows only datapoints obtained out of depressurization events. Depressurizations only occur on a portion of a given night (2-3 hours) and occur whenever the balloon overpass a deep convective system. Whenever a balloon experience depressurization during one given night, it means the measurements during this given night (before or after the depressurization) can potentially be influenced by the deep convective system beneath. Those nights are highlighted in color on Figure 8. One exception is found for the night of November 25, 2021 (Fig. 8b) for which no depressurization occurred.

To clarify, we revised the text such as:

Lines 417-424: “Often, before and after a depressurization, the water vapour anomalies, whether dry or wet, are large. We thus use here depressurization cases as a proxy of deep convection flyover. Whenever a balloon experience depressurization during one given night, the water vapour measurements during this given night can potentially be influenced by the deep convective system beneath. Figure 8 shows scatter plots of balloon-borne *in situ* water vapour anomalies as a function of the potential temperature for the three flights that have experienced depressurizations. Please note that the measurements during the balloon depressurizations are not used to compute water vapour anomalies because it would not be possible to compute anomalies associated with a fast variation of altitude. Only datapoints obtained out of the depressurization for a given day are plotted.”

P18, Figure 8: Hard to see here a quasi-linear relationship. What may help is if you would adjust the y-axis of panel a and b to the y-axis of panel c. Since the black dots overlay over all other coloured dots it is quite hard to follow your discussion later on. It would help if you would use a different colour than black for the data of this date. Further, what date is plotted with the black dots is missing in the legend of panel a and c.

Authors: We have changed the black dots to grey dots, we have enlarged the color dots adding black contours and we have added the linear trends (cyan straight line) of some dot clouds .

P19, L425: Shorten section title? Thus, skip “Isentropic level”?

Authors: the influence of deep convection is here divided into 2 mechanisms: the vertical displacement of isentropes and direct injections. Therefore, the subsection titles are then revised to be “5.2.1 Vertical displacement of isentropes” and “5.2.2 Direct injection”.

P19, L432: Add “the” before “balloon”.

Authors: Done.

P19, L438: Add “the” before “amplitude”.

Authors: Done.

P20, L485: was fed -> was run or was driven

Authors: We selected “run”.

P21, L490: What is meant with signature? Do you mean the structure in the anomalies? Do you mean “positive anomalies”?

Authors: Here we mean the local water vapour enhancement. We corrected this in the text (L497).

P22, L493: The blue dots are hardly visible in the figure.

Authors: We have enlarged the color dots and we have added black contours.

P22, L497: Strateole is written in at least three different ways throughout the manuscript. Decide for one way of writing and do this consistently throughout the manuscript.

Authors: This has been corrected.

P22, L508: are limit cases to the -> are limiting cases of the

Authors: Done.

P23, L533: I suggest to rename “Conclusion” to “Summary and Conclusion” since you also provide a summary of your results.

Authors: Done.

P23, L535: under -> on

Authors: Pico-STRAT Bi Gaz is located under the balloon on the flight chain. Balloon scientists often use “under” for this case. We kept it like that.

P23, L545: flight -> flights

Authors: Done.

P24, L569: Change “More generally” to “To summarize” or “To conclude”.

Authors: Done.

P24, L578: bias -> biases

Authors: Done.

P24, L579: If -> Although

Authors: Done.

P25, L606: robuftstness -> robustness

Authors: Done.

P26, L607: There is no next section!

Authors: it has been removed.

P26, L608: Change TTL2 to the full flight name.

Authors: Done.

P25 and P26, Figure A1 and A2 caption: Blue text should be black text.

Authors: Done.