Editor comments on egusphere-2024-3249

Influence of atmospheric waves and deep convection on water vapour in the equatorial lower stratosphere seen from long-duration balloon measurements by Carbone et al.

Although this manuscript went already through a round of revisions, there are many things left that need to be corrected before the manuscript can be accepted for publication. Thus, another round of major revisions is necessary.

General comments:
1. Please consider the ACP manuscript preparation guidelines and prepare your manuscript accordingly.
https://www.atmospheric-chemistry-and
physics.net/submission.html#manuscriptcomposition

In the abstract the introductory part and the concluding part is missing, see the specific guidelines for title, abstract and conclusions:
https://www.atmospheric-chemistry-and-physics.net/policies/guidelines_for_authors.html
Please revise the abstract accordingly. See also my comments given below under specific comments.

Authors : We have rewrite most of the abstract, beginning with a more introductive context, and ending with more conclusive sentences.

2. In the text Section and Figure abbreviated as Sect. and Fig. unless they appear at the begin of the sentence. Please correct this throughout the manuscript.

Authors : Done.

3. Paragraphs should have a reasonable length. Please check all paragraphs and combine the ones
which consists only of 1-3 sentences. The text becomes hardly readable to to this from page 10 on there this has excessively been done,

Done, we have merged paragraphs as much as possible.

4. The whole manuscript feels a bit mixed up. Text that belongs to the results is added in the methodology section and text that belongs to methodology is found in the results. Also the data is described in the wrong order. MLS data is used already before the data and instrument are described. Please sort your text and prepare the manuscript according to the manuscript preparation guidelines.

Authors: We have revised the structure of the manuscript so the reading becomes smoother. Therefore, some of the comments below do not apply anymore.

Specific comments:
P1, L15: An introduction to the field is missing. What is the purpose of this study?

Authors : It was added in the third sentence of the abstract.

P1, L22 and L26: Using the names you have given your flights in the abstract is meaningless for the reader. Use the dates instead.

Authors : We erased the flight names and instead, referred them as “first flight” and “last flight”.

P1, L27: The concluding part in the abstract is missing. What are the implications of your study and
results?

A last sentence was added to insist on the significant role played by waves in the water vapour modulation

P2, L60: Has the abbreviation “CPT” been introduced?

Authors : You are right. Cold Point tropopause appears for the first time l49. We’ve added the acronym there.

P2, L65: change to “that not necessarily reaches the stratosphere, see e.g. Rysman et al., 2017)

Authors : Done.

P4, L105: Don’t make paragraphs consisting of one line. Add this sentence to the following paragraph.

Authors : As written before, we have merged several paragraphs belonging to the same subsections.

P4, L111: What do you mean with “the environmental cold temperature”? Do you mean “cold
environmental temperatures”? Please rephrase/correct the sentence.

Authors : To avoid any confusion, we have rephrased “to protect electronics from the lower stratosphere cold temperatures (e.g. Thermodynamic Sensor TSEN)”.

P4, L112: What is “TSEN”? The abbreviation has not been introduced.

Authors : Thermodynamic SENsor. It was defined later in Section 3. Now it is defined at its first appearance.

P4, L117ff: Using the flight names here alone is not helpful for the reader. Please add the dates and also add a table summarizing the names and dates for the flights used in your study.

Authors: Done. We added Table 1 listing the flights characteristics.

P4, L122: Who is meant with “They”? The balloons? Please be more precise.

Authors: Yes, we refer to the flights.

P5, L124: Who or what is meant with “it”?

Authors : In the following of the previous sentence, it refers to the figure.

P5, L126: To which figure are you referring to?

Authors: Figure 2, panels b and c.

P5, L127: What do you mean with “the balloons evolved”? Please rephrase,
Authors: We rephrased such as : “All the balloons were flown during…”.

P5, Figure 2: MLS used here, but neither the data or instrument have been described yet. Doesn’t
this figure rather belong to the result section?
Authors: No, this figure aims to give the context of the flight

P6, L132: What is “SLDA”? The abbreviation has not been introduced.
The SDLA acronym has been added L124.
P6, L138: “regions of strong absorptions within fundamental bands” not clear. Make an own sentence clearly writing what you mean.
Authors: This is about spectroscopy. Fundamental bands being regions of stronger absorption by molecules. We rephrased “These spectral regions depict strong absorptions within fundamental bands.”

P6, Section 2.2. (and also previous section): A large part of what is written here goes beyond the pure data description and rather belongs to the methodology section. Move these parts to the methodology section and rename this one to e.g. “Balloon flights and methodology”.

P6, L193: It is not clear what kind of methodology you have developed. Is this really new? I have the feeling already known methods are used here.
Authors: we do not claim using a methodology based on anomalies of water vapor is strictly new. However, applying this kind of approach to the Stratéole 2 *in situ* measurements, allows to bring to light the impact of wave and sometimes overshooting deep convection on lower stratospheric water vapour from long duration balloons, which is unprecedented.

P6, L197: How do you know that these are caused by overshooting convection and atmospheric waves? Provide an explanation for the impact of overshooting convection and atmospheric waves on the anomalies and also provide some references.
Authors: Do not apply anymore following the revisions. The meaning here was that the selected temporal extent for the averaging of MLS dataset smooth out the impact of large-scale/medium scale equatorial atmospheric waves (±10 days around each of the balloon nights), which is longer than the longest wave periods as seen from ECMWF. Due to the coarse horizontal resolution of MLS, direct injections from overshooting deep convection are surely not resolved in the vertical profiles of MLS.
Subtracting such a smoothed average of MLS from the *in situ* data removes the tape recorder variability, keeping the information on atmospheric waves’ and overshooting convection’s modulation in the *in situ* data.

P7, L161: Description of MLS appears after it the data has been used. See my comment above. The sections should be revised and appear in a different order.
Authors: This has been arranged.

P7, L164-165: The sentence “The vertical grid …..” is not clear and should be revised.

Authors: This is how it is explained in the MLS Quality product document.

P7, L171-172: Remove line break. This sentence should be added to the previous paragraph.
Authors: Done.

P7, L182: "……. and by using cloud-type data deduced from cloud-type and phase product" not clear and needs to be revised.
Authors : We revised such as "This algorithm generates CTH products combining data and models. It uses different AHI observations, a radiative transfer model (RTTOV), temperature and humidity vertical profiles (from Numerical Weather Prediction models (NWP)) and cloud-type data deduced from cloud-type and phase product (Kouki et al., 2016)."

P7, L188: Why do you want to evaluate ERA5? Aren't you just comparing these data sets to see if these can be applied together?
Authors: No, we don't compare the *in situ* water vapour anomalies with temperature anomalies from ERA5. The purpose of this section is to show that the ERA 5 temperature products can be used to highlight perturbations due to large-scale atmospheric waves. To be confident, we first demonstrate that the ERA 5 temperatures compare well with measured *in situ* temperatures if we select ERA 5 following colocalization criteria. Then, being confident, we can use temperature anomalies for our analysis. Though we could remove this section, we believe that it gives a bit more confidence in the approach and we prefer to keep it.

P7, L188: Which products are used? List these here explicitly.
Authors: This section has been revised and the sentence completed : "The methodology we have developed relies on the calculation of local anomalies which are obtained as the difference between nighttime i*n situ* water vapour measurements and unbiased MLS v5 water vapour values averaged in the same area, around the same date."

P8, L199: Combine the sentences and replace "indeed" by "since" or "because".
Authors: We prefer to remove "Indeed" since the other proposition do not fit with our meaning.

P8, L201: trapped in what? Clouds? Not clear. Please rephrase sentence,
Authors: This issue of outgassing is well-known in the community of stratospheric water vapour. During the ascent of the balloon through the wet tropical troposphere, and in some cases where the balloon flies through a mixed phase cloud, water vapour but also supercooled water or crystals stick onto the balloon or gondola surfaces. In subsaturated environment, such as the TTL and the stratosphere, the crystals or supercooled dropplets sublimate or evaporate, releasing additional water vapour. In the case of water vapour trapped on the surface during the ascent, the pressure decrease during the ascent favors the outgassing through breaking of weak Van der Walls bonds. We believe that it is not necessary to provide as much details here: it will add additional information which is not useful for the focus of this study.
We therefore propose the following revision: "Daytime measurements are contaminated by outgassing of the (tropospheric) water vapour molecules, or supercooled droplets found while crossing high altitude clouds, which sticks to the balloon or the Zephyr surfaces during

the ascent of the balloon. As the surrounding pressure decreases, the trapped water is released in the environment, especially during daytime."

P8, L205: delete "first" and replace "followed" by "based on".
Authors: Do not apply anymore.

P8, L205: add the criteria here (again) or refer to the previous paragraph/section where these are stated.
Authors: Done.

P9, L216: Introducing ERA5 and ECMWF comes here long after ERA5 has already been mentioned and used. This introduction should be made at the begin of Sect. 3.
Authors: Do not apply anymore.

P9, Figure 4: The green dots and red line are not that good visible. The bullets for the dots should be larger and the red line plotted somewhat thicker.
Authors : We have thickened the red line and grown the dots and added a black border for all dots

P10, L240: Why evaluation? This is rather just a comparison between the data sets.
Authors : The section has been renamed. See our comment above about this section.

P10, L241-249: This text part belongs to Sect. 2.2 where the balloon instrument should be described.
Authors: Done.

Further make paragraphs with a reasonable length and not one paragraph for just one or two sentences.
P11, L266: Which data is shown here? MLS? Please clearly state which data is shown.
Authors: The *in situ* water vapour anomalies are from Pico-STRAT Bi Gaz, since MLS data are remote sensing. We rephrased such as "Longitude/time "quasi-Lagragian" Hovmöller diagrams in temperature anomalies for each flight with their night-time trajectory color-coded as a function of balloon-borne water vapour anomalies from Pico-STRAT Bi Gaz."

P11, Figure 5 caption: You mean the respective balloon trajectory with the MLS water vapour color coded?
Authors: No. We calculated *in situ* water vapour anomalies: from Pico-STRAT Bi Gaz.
In addition, we make it clear in the main text also (line 292-295): "In this section, we explore the impact of atmospheric waves on the modulation of water vapour by studying the correlation between *in situ* water vapour anomalies (from Pico-STRAT Bi Gaz measurements) and ERA5 temperature anomalies." And in the caption of Figure 5 : "…color-coded as a function of balloon-borne water vapour anomalies from Pico-STRAT Bi Gaz."

P11, Figure 5: Which data sets have been used to derive the Hovmöller diagram is not clear. Maybe it would also be good to mention somewhere what a Hovmöller diagram is and for what it is used.

Authors: In the main text (now lines 293-294), we express that the ERA5 3D temperature fields are used to build the Hovmöller diagrams. The details on how the ERA5 temperature anomalies are calculated are given a bit later in the text (now lines 297 -301).
The caption of figure 5 is then revised: "Figure 5: Longitude/time "quasi Lagragian" Hovmöller diagrams in temperature anomalies, calculated from ERA5 3D temperature fields for each flight of Pico-STRAT Bi Gaz. The balloons night-time trajectories are color-coded as a function of balloon-borne water vapour anomalies from Pico-STRAT Bi Gaz. The temperature anomalies are calculated hourly as the difference between the ERA5 temperatures averaged over ±5° around the mean latitude of the balloon for each night and the zonal mean temperature over the same latitude band. (a) C0_05_TTL2. (b) C1_12_STR4 flight. (c) C1_03_TTL4 flight, (d) C1_07_TTL4 flight, (e) C1_15_TTL4 flight."

In addition, we moved the paragraph "Figure 5 shows longitude/time quasi-Lagrangian Hovmöller diagrams of ERA 5 temperature anomalies for the 5 flights of Strateole 2 carrying the Pico-STRAT Bi Gaz instrument. We superimposed *in situ* water vapour anomalies from Pico-STRAT Bi Gaz, color-coded in anomaly amplitude along the balloon trajectory" at a later position in the text.

P12, L268-270: This sentence belongs to the data description section. Rephrase the sentence and refer to the respective section and only point here out the limited resolution of the ERA5 data.
Authors: Done. We also added a new subsection "3.4. ERA 5 temperature fields" (Lines 180-190) which describes ERA 5 products and includes the paragraph L268-270.

P12, L274ff: The entire remainder of the page belongs to the methodology section. Also revise here the paragraphs so that each has a reasonable length.
Authors: We thought it would be more straightforward and understandable to leave this part along in the Wave influence section. This is not the methodology to calculate the temperature anomalies from ERA5 but to highlight the presence of large scale wave along the trajectory of the balloons.
We prefer to keep this part here.

P13, L306: add the date.
Authors: we revised this section so this comment does not apply anymore.

P14, L314: What is "VGWV"? The introduction has not been introduced.
Authors: the definition of this acronym is given Line 332, right before the first mention of this acronym "The sign of this correlation depends on the local vertical gradient of water vapour (hereafter VGWV) at the balloon flight level:…"

P15, L327: Sentence should be added to the previous paragraph.
Authors: Done.

P15, Table 2: This table appears in the middle of the text (last part of the paragraph appears between table and table caption).
Authors: this has been corrected.

P16, L358-361: These sentences should be added to the previous paragraph.
Authors: Done.

P16, L381-382: Add this paragraph either to the previous or following paragraph.
Authors: Done.

P17, L394-395: Again one paragraph for just one sentence.
Authors: Solved: the sentence moved to the next paragraph.

P17, L396: Which data? MLS? The balloon data?
Authors: The anomalies are balloon-borne *in situ* anomalies. This is now specified in the text.

P17, Figure 8 caption: Add that the dates for the flights are given in the figure legend.
Authors: Done.

P18, L407-408: Again one paragraph for just one sentence. This sentence also rather belongs to the figure caption than in the main text.
Authors: Thank you for pointing this out: we removed it.

P18, L412: Do you mean colored in the figure? Be more clear.
Authors: You are right. In fact, this sentence applies to any cases. Then, we revised this sentence such that: "A linear behaviour of the balloon-borne water vapour anomalies with potential temperature would indicate that water vapour variations are mainly dominated by the displacement of the balloons in the vertical gradient of water vapour even in the vicinity of deep convection."

P18, L412: Sentence "displacement of the balloons in the vertical gradient of water vapour " not clear. What do you mean? Another flight showing a different case? Please rephrase.
Authors: We have rephrased this sentence. It means exactly what was described in section 4.1 about vertical displacement though it was badly written.
We revised such as: "A linear behaviour of the balloon-borne water vapour anomalies with potential temperature would indicate that water vapour variations are mainly dominated by the vertical displacement of the balloons. This is due to the vertical gradient of water vapour, such as detailed in the section 4.1 about atmospheric waves influence."

P18, L422-425: Where is this shown? To which figure are you referring to?
Authors: We can see the cold perturbation of low-amplitude large-scale wave on Fig. 5d (the reference to this figure is now added in the text). We also revised this paragraph such as: "The only exception for the dry cases is the night of November 13, 2021, of C1_07_TTL4: the Hovmöller diagram for this night indicates a very weak wave signature (very weak cold temperature anomalies, see Fig. 5d), for which the calculated vertical displacement is too small to explain amplitude of the dry anomalies. The additional vertical displacement of isentropes due to convection which is overpassed by the balloon could be an explanation since upward vertical motion would bring lower mixing ratios from below. Another possible explanation would be the impact of a small wavelength gravity wave generated by the overpassed deep convective system that is not resolved in ERA5, nor seen in the Hovmöller

diagram. The perturbation produced by the gravity wave can cumulate on the top of the cold perturbation resolved in the Hovmöller diagram."

P18, L426: Sentence "Another case of flight C1_15_TTL4 should be underlined" not clear and should be rephrased.
Authors: this has been revised such as : "Similarly, the case of December 5, 2021, of flight C1_15_TTL4 depicts dry balloon-borne anomalies, originating from the cumulative effect of atmospheric waves of different scale." (L447).

P19, L435: What is HIMAWARI? The abbreviation has not been introduced.
Authors : Himawari is not an abbreviation, it is the name of a satellite meaning "Sunflower" in Japanese. We do not think useful to specify this. Additionally, the Himawari cloud top products which are used in the study are described in a specific section 3.3 (page 6).

P19, L441: The abbreviation CALIOP has not been introduced. Also it should be mentioned what kind of instruments these are.
Authors : You are right. CALIOP (with its acronym) is now introduced in a short new subsection 3.5. So the acronym is not specified anymore p19.

P19, L457: Add some more details on the storm Rai (when did it form, how long did it last, from where to where did it move and what implications had this storm).
Authors: Details on the storm Rai are already given in the beginning of section 4.2. (L400).

P19, L460: The abbreviation ICARE has not been introduced. Also a reference should be added.
Authors: ICARE is one of the 4 poles of the AERIS French e-infrastructure. The meaning of ICARE has been found to be "Cloud-Aerosol-Water-Radiation Interactions".
We revised the sentence such as "The time and date of the cloud top image is chosen to be the closest to the time when the water vapour anomaly is the highest. Cloud top products are made available on the French AERIS/ICARE (Cloud-Aerosol-Water-Radiation Interactions) datacenter."

P19, L463: Which figure? Figure 9?
Authors: Yes, figure 9a. This is corrected.

P19, L463: Abbreviation HYSPLIT has not been introduced.
Authors: Done (L485).

P20, Figure 9: The point and lines are difficult to see. Please try to improve the figure (by e.g. using different colors than the ones currently used).

Figure 9 has been improved using blue color scale for the cloud tops.

P21, L473-474: I don't see any blue dots. Do you mean green crosses?
Authors: No, in fact it was referring to Fig 8 again, panel c. The paragraph has been revised such as:

"It is worth noticing that the signature of December 13, 2021, in Fig. 8c (pink dots) may also be under the influence of Raï, with anomalies above 0.5 ppmv and out of the main scatterplot at 414 K. The balloon position close to Raï's eye on December 12, 2021, induced a depressurization. Though on the edge of the scatter plot, the water anomaly distribution on Fig. 8c (blue dots) is linear and not typical of an overshoot signature."

P21, L481-485: This four line paragraph should be combined with the previous or following one.
Authors: We included the sentence to the following paragraph.

P21, L482: Add reference to the respective figure.
Authors: Done, it was Fig. 5b.

P21, L500: Which figure? Figure 9 or Figure 8?
Authors: This is Fig. 9d. We corrected it.

P22, L505-514: Combine paragraphs.
Authors: Done.

P22-23, Conclusion: Make real paragraphs and not one paragraph each 1 or 2 sentences!
P23, 550: What are the implications of your study? A concluding paragraph stating this is missing.
Authors: We added a sentence at the end of the wave paragraph to insist on the role of waves in the H2Ovap modulation L563-565."These statistics show that atmospheric waves are an important process, or even the main process for some flights, driving the modulation of water vapor during Stratéole 2". Concerning the convection part, we let the conclusion as it is, this we think it summarizes the main results of our study. We end we a more general sentence about our study "More generally, this study uses long duration balloon measurements and an approach based on *in situ* anomalies of water vapour. We demonstrate that they are useful tools to study the impact of large scale waves as well as very intense deep convection on the lower stratospheric water vapour abundance all around the equatorial belt."

"

P23, L585: Add this sentence to the previous paragraph.
Authors: Done.

P24, Figure 10: This figure should be labelled "Fig. A1".
Authors: Done.

P24-25: Make real paragraphs!
Authors: We reorganized the paragraph properly.

P25, Figure 11: This figure should be labelled as Figure A2.
Authors: Done.

P25, Figure 11 caption: Provide the date additional to the name of the flight.
Authors : We have changed night number to the dates.

P26, L625-626: empty line between the references is missing.
Authors : References have been updated.

Technical corrections:
P1, L31: Hydroxyl -> hydroxyl
Done
P1, L33: space between comma and year missing
Done
P2, L34: Add “e. g.” before the references.
Done
P3, L87: Section 2 -> Sect. 2
Done
P3, L97: A last objective -> Another objective
P4, L101: lower the troposphere -> the lower troposphere
done
P4, L103: add comma before “respectively”
done
P4, L103-104: replace “in” by “for” and add “campaign” so that it reads “A third campaign is planned for 2026/2027.”
Done
P4, L113: Figure 1 -> Fig. 1
done
P6, L150-151: Avoid separation of unit and number at the line break.
ok
P6, L133: space between number and unit missing.

P7, L163: add “a” -> a microwave limb sounding system
done
P7, L176 and 178: add “the” before naming the institutions.
Done
P7, L177: including -> rather “consists of”
Done
P7, L178: add a comma and “respectively” after “2 km”.
Done
P10, L232: Change sentence as follows: Once the balloon has passed the convective system, it returns to the initial altitude…..
Done

P16, L335: influences -> influence
Done
P17, L400: Figure -> Fig.
P18, L421: delete “of”
P19, L462: flight -> balloon
P20, L466: flew -> was transported

Done
P20, L469-470: Avoid separation between number and unit.
P20, Figure 9 caption: The dots are rather crosses.
Now, these are dots.
P20, Figure 9 caption: HIMAWARI or Himawari? Use a consistent way of writing.
Done, Himawari is now chosen everywhere.
P21, L467: Dots -> crosses?
No. We are referring to Fig. 8 where nights of depressurization are indicated with colored dots.
P21, L482: add “diagram” after “Hovmöller”
P21, L487: Himawari or HIMAWARI? See my comment on P20, Figure 9 caption.
P21, L488: line break obsolete.
P21, L499: Himawari or HIMAWARI? See my previous comments on this. Use a consistent way of
writing.
P22, L514: necessaries -> necessary