Khordakova et al., 2021, describe two instances of water vapor enhancements observed in the lower stratosphere over Europe. The study is motivated by measurements obtained with balloon-borne instrumentation. Satellite observations of atmospheric trace species as well as convective activity, and air parcel trajectory calculations combined with output from global reanalyses are utilized to understand the source of these individual hydration events within the broader dynamical and chemical context. In both cases, the hydration events are tied to recent convection near the measurement site.

Main comments/concerns/questions:

- Regarding the relative levels of the water vapor and ozone peaks: Are sampling time constants for each instrument accounted for? If the response time for water/CFH is slower than that for the ECC cell, I can imagine a case where their peak locations might be offset?

- The structure of the temperature profiles, and the mixing ratio profiles when converted to potential temperature are peculiar (square-shaped and peaked in Cases 1 & 2, respectively), is it possible there is a measurement issue - either vertical resolution, or something else?

- I am not convinced by the argument given in Lines 237+ regarding the profile of Case 1 being within the “usual range of observations.” This may be true, but with only 8 profiles in total, it’s difficult to define a “usual range.” It might be possible to obtain better statistics on the distribution of ozone mixing ratios at this level using MLS?

- How narrow (vertically) are the modeled ozone enhancements in CLaMS and the ERA5 output? Is it consistent with the exceptionally narrow (~0.6 km) enhancement in ozone observed on the ascent profile?

- Lines 244-247: The brief mention of a model run with CLaMS “using different ECMWF data sets as input” is hard to evaluate and understand, particularly as the results are not shown.
  What is shown is a plot of output from ERA5, which, as the authors state, shows evidence for convective influence in multiple variables.
  More regarding the ERA5 ozone:
  - Why does the map of ERA5 ozone (Fig. 6) with peak values at 145 hPa of ~640 ppbv to 560 ppbv, differ so much from the ERA5 trajectory values in Fig. 9, which are >800 ppbv for the time period of interest?
  - Is it reasonable to assume the assimilated ozone is impacted by convection?
  - Though ozone declines over the trajectory (Fig. 9), the declines do not appear to be closely associated with the locations/timing of convection. This is also noted by the authors in Lines 320-321.

- While I think this paper does a good job of utilizing and even showcasing the value of the new ERA5 product, it’s somewhat concerning that the ERA5 ozone values are so elevated relative to measurements – they’re consistently ~80% higher!

Additional comments:

- I find the practice of referring to reanalysis output as “data” misleading, as it is not a primary observation/measurement.
- Statements such as those in Lines 507-508 and in Lines 498-499 about instruments not requiring calibration are misleading. It is best to leave such statements out of a paper like this where there is not room to fully understand their meaning and context. A reference to papers describing the development, operation, calibration and validation of the ECC ozonesondes and CFH and other chilled mirror hygrometers is sufficient.
    - Ozonesondes do not need a calibration with ozone standards before they are launched, however, they do need to go through careful preparation one to two weeks prior to launch. These steps include high ozone conditioning the pump/tubing, measuring the background cell current, accurately measuring the teflon pump flow rate, using the correct solution and understanding the pump's efficiency over the vertical profile, among many other things.
    - Similarly, while CFH does not need a calibration with water vapor standards prior to launch, it does require a thermistor calibration among other operational assessments to ensure measurement accuracy.
- Similarly, I believe what is meant in Lines 508-509 is that there are few *balloon-borne in situ instruments* capable of measuring stratospheric water vapor. There are balloon-borne remote sensing instruments, as well as satellite instrumentations, e.g., MLS. Furthermore, there are multiple in situ instruments employing different techniques for measuring stratospheric water vapor aboard aircraft.

Minor comments/edits:

Abstract

- Line 14: …values *measured* by MLS in the LS are lower than the in situ observations… (MLS observations are measurements not estimations)
- Line 14: …ERA5 overestimates water vapor mixing ratios… (fine to say that reanalysis overestimates a value, given that it is not a primary measurement/observation)
- Line 16+: This is in good agreement with the reanalysis which shows a strong change in the structure of isotherms and a sudden and short-lived increase in potential vorticity at the altitude of the trajectory. Similarly, satellite data show low cloud top brightness temperatures during the overshooting event. (clearer delineation between the satellite observations and the reanalysis derived output)

Introduction

- Line 27: …entry mixing *ratio*…
- Lines 30-34: It may be worth mentioning that there is some debate about the net magnitude of SWV feedback, with some studies suggesting that the impact on climate sensitivity may be significantly lower if changes in SWV are evaluated within a coupled system, e.g., Huang et al., 2020.
- Lines 43-44: The observational analysis of Smith et al., 2017, focused on a significant *localized* effect. The model analyses of Dessler et al., are looking at global impacts. (By the way, Dessler et al., 2013a is the same as Dessler et al., 2013b.)
- Line 56: …North American and Asian Monsoon *regions*.
- Line 61: …the data *is/are* compared to output of the ECMWF ERA5 reanalysis, while…

Section 2 Data and Methods

- Line 76: (Consistency in tenses.) …before the convective cell *reached* the…
- Line 81 & later, Lines 98-99: The actual uncertainty of the Vaisala humidity sensor is found to be far greater than 3% through comparison with CFH in the altitude range of interest. This is evident both in Figure 2, where differences can be ~100% at altitudes <20 km (log/log plot), and in Figure 3, where differences in the quiescent stratosphere are on the order of 30-50%. That said, for the purposes of this analysis, the absolute accuracy of the Vaisala sensor is less important than its sensitivity to detecting abrupt changes with a magnitude far greater than its measurement uncertainty.
- Line 84: …ozone mixing ratios *with* an uncertainty…
- Line 87: …uncertainty of the CFH instrument *is* given as…
- Line 103: …stratosphere *reaching* altitudes of up to…
- Line 106: …but all other sounding data *are* complete.
- Line 108: What does “a local instrument” mean? MLS is a remote sensing instrument.
- Line 111: *Temperature and pressure are retrieved*…

Section 3.2 Water Vapor Injection – Balloon

- Line 182: (Awkward.) *A background value of ≈5 ppmv agrees well with*…
- Line 185-186: (Given the ~±1 ppmv differences between the Vaisala and CFH in the quiescent stratosphere, i.e., above the hydration layer, I am not convinced the response time is the sole cause of the difference in the plume.) You might say: *The lagging response time of the RS41 may explain most of the difference between the CFH and the radiosonde observations.*
- Line 191: (I think you could start a new paragraph for the discussion of the ozonesonde and temperature profile results.) Consider: *A striking peak in the ozone profile is evident at a similar level as the peak in water vapor.*
- Line 204: (I think you could start a new paragraph for the discussion of Case 2.) Also: …different background atmosphere *than* Case 1.
- Line 205: …as *is depicted* in Figure 4a…

Section 3.3 Source of Ozone Peak

- Line 227: (Delete “that”) …*shows a steep* decrease…
- Line 240: (Delete “but”) …profile at this *altitude, it* remains…
- Lines 241+: (The term “measurement data” is vague.) Consider: *Here, the data from Case 1 (red dots) with the high ozone and water vapor diverge…*

Section 3.4 Comparison with ER5

- Line 290: Consider: …diabatic heating, *which cause* an increase…
- Line 301: Consider: *Similar to* rather than *Similarly to*

Section 3.5 Origin & Evolution Along CLaMS

- Lines 304+: For simplicity, I think it would be best to refer to the trajectory output as ERA5 consistently rather than switching back and forth between ECMWF, ECMWF ERA5, etc.
- I found this confusing and am wondering how to reconcile the “multiple MLS data points” from Line 311 with “Only 7 measurement points” from Line 323? I’m also unclear how

the dots in Fig. 9 panel C correspond to the overpasses in panel A? It looks like there are 9 distinct overpasses that cross the ERA5 trajectory, but only 7 points in panel C?

Section 3.6 Overshooting in Satellite Data

- Line 365: (No comma needed after “Multiple areas”)
- Line 367: Consider: “…*however, at a greater* distance…”

Section 4 Discussion

- Line 375: Consider: “...*on* two consecutive days…”
- Line 376: Consider: “…overshooting *that injected water vapor into the lower stratosphere* several hours…”
- Line 386: Consider: “*The local injection of water vapor was detected within a larger scale peak in ozone for Case 1.*”
- Line 388: Consider: “*A map of ERA5 ozone at 145 hPa in Figure 6 shows that the balloon measurement was at the edge of a front with higher ozone mixing ratios. This explains the lower ozone values at the same pressure/potential temperature level in the descending profile, which was located further north. This is also supported by the sparse data from MLS, which show higher ozone…*”
- Line 393: “…ozone-rich *air mass*…”
- Line 409: Consider: “…further south-west*, but otherwise both the reanalysis and the observational data show a* convective storm moving northwards…”
- Line 434: “…before the suggested *convective* event…”
- Lines 447+: (“it” is vague, I wasn’t sure if “it” referred to ERA5 or the satellite data, and whether you meant to write satellite data at the end of the sentence?) Consider: “*While ERA5 shows a likely overshooting event for Case 1 four hours before and slightly north-west of the event observed by satellites, the convective event in ERA5 for Case 2 is four hours later than the satellite observations.*”
- Line 461: Delete “for example” or consider: “…and is not caused by another mechanism, for example, the horizontal transport and…”

Conclusions:

- Line 468: Consider: “…water vapor enhancements *in excess of* the background…”
- Line 478: (“measured” is used twice.) Consider: “…measured water vapor *enhancement shows*…”

A2:

- Line 518: (“uncertainty” is misspelled.)

Figures

- Figure 1: …after a deep convective event has passed the *measurement* site. On the right hand *side* the…
- Figure 5: Why do the lines corresponding to the ascent/descent profile exceed the gray area, which “marks the measured range of ozone mixing ratios?” Were these two profiles excluded from the definition of the mean and the range?