Reviewer 2:

SUMMARY
The authors present eddy-covariance VOC measurements over an urban footprint in Innsbruck, Austria. They examine the observed terpenoid (isoprene, monoterpenes, sesquiterpenes) fluxes in terms of tree species coverage within the flux footprint and in terms of the T and light dependencies driving emissions. They go on to compare results from two summers to assess interannual variability and the degree to which it can be understood mechanistically. There are not very many urban VOC flux datasets, and fewer still that explore interannual differences. I find the paper makes a useful contribution and is suitable for publication in ACP. Below I include some minor comments for the authors to consider.

GENERAL COMMENTS

Comment: 81-100, A nicely comprehensive summary of prior work, but quite long. Since the current paper doesn't address seasonal variability, it may be helpful to shorten this paragraph to only focus on those prior studies examining interannual changes.

Response: We agree with the reviewer and removed the part about the seasonal variability.
Change: Remove seasonal variability references to shorten the paragraph.

Comment: 119, to avoid confusion please clarify if you mean into the NE/SW or out of the NE/SW

Response: We thank the reviewer for this useful comment and changed the text accordingly.
Change: The text was changed to clarify that the wind is from NE during the day and from WS during the night.

Comment: 121-122, please provide information here on the distribution of building heights within the flux footprint, and the degree to which the inlet is above versus within the roughness sublayer.
Response: We have published this information before (Karl et al., BAMS, 2020, doi: 10.1175/BAMS-D-19-0270.1). Briefly, within 500 m from IAO, the mean building height is 17.3 m whereas the modal building height of about 19 m corresponds to the 5–7 story buildings, which are more important in terms of their form drag. For this reason, the displacement height, z_d, is estimated as 13.3 m (0.7 m × 19 m; e.g., Grimmond and Oke 1999). The roughness length, z_0, is 1.6 m.

Change: We have added the information about building height within the flux footprint.

Comment: 137-146, it would be helpful to show some spectral analysis here to quantify how well the different frequency contributions to the fluxes were captured by the sampling system.
Response: We thank reviewer 2 for this comment. We added a co-spectral analysis of the isopreniods to the Supplemental Information demonstrating very small attenuation loss of the sampling and measurement system.

Change: We inserted at the end of first paragraph of 2.2 Eddy covariance fluxes:
"Figure S1 shows the co-spectral response of the PTR-QiTOF-MS and inlet system. The loss of covariance of isoprenoids signals with vertical windspeed due to lowpass filtering is less than 4% (see Spectral analysis in Supplemental Information).

Comment: 153, "Monoterpene and sesquiterpene eddy covariance fluxes are known to be purely temperature dependent". Not true. Some mono- and sesquiterpene emissions have been shown to also be light-dependent.
Reply: We acknowledge that monoterpene and sesquiterpene emissions can also be light dependent. We agree that the word 'purely' in this context is not correct.

Change: We corrected the wording in section 2.2 on temperature dependent terpene emissions.

Comment: 156-159, please indicate how these timescales were estimated

Response: We thank the reviewer that there is more clarification needed and we added information on how the timescales were estimated in the text. The chemical lifetime was estimated according to measured ozone reaction rates with terpenes. The transport timescale was estimated by turbulence measurements (i.e. H/u*).

Change: We added text describing how these timescales were estimated.

Comment: 183-189, the validity of this ratio approach relies on the assumption that the ISO, MT and SQT emitters don't differ systematically in size (i.e. dry leaf weight). I imagine this is not strictly true. So some language here about this caveat is warranted.

Response: We acknowledge this comment and added text clarifying that this is a caveat of our calculation as well as performed a sensitivity analysis doubling and halving the emission potentials of the highest 20 emitters to get a sense of the uncertainty due to unknown dry leaf weight differences in the trees and found that the average study area emission ratios changed on the order of 5-15%. This gives us a better estimate of the robustness of this analysis.
Change: We added the caveat as well as the robustness analysis in the text.

Comment: 200, Very interesting! I would not have guessed that so much of the flux came from just 12 trees.
Response: Yes, these trees have dominant emission potential and the differences in footprint density are overpowered by the emission strength of these emitters. The same number of trees don't account for 100% or the emissions but for the percentages as mentioned in the manuscript. The exact order of percent influence also varies between the two years due to footprint density differences but overall a large percentage of emissions arrive from the same trees.
Change: No changes

Comment: 226-227, Guenther 2012 lists a light-dependent fraction of 0.5 for all sesquiterpenes. If you have evidence that sesquiterpene emissions are "mostly temperature dependent" it should be cited here. In the case of monoterpenes it is true that the most globally predominant emissions are mainly T-dependent but some individual species have >50% light dependence. So the extent to which "monoterpene emissions are mostly temperature-dependent" would depend on the monoterpene speciation in the flux footprint. Do you see any evidence for light-dependent MT/SQT emissions in your dataset?

Response: It is true that Guenther et al. 2012 suggests a light - dependent fraction of 0.5 for sesquiterpenes. We changed the parameterization to include a possible light dependent fraction of sesquiterpenes. Since the PTR instrument can also not differentiate between

different monoterpene isomers, we can not fully exclude the possibility of light dependent terpene emissions. We estimate a ratio of 50% light dependence for monoterpenes as well using evidence from planted city trees and Guenther et al., 2012.

Change: We changed the parametrization for higher terpenes according to Guenther et al., 2012. The light dependent fraction for monoterpenes varies between 0.2 and 0.8, and for sesquiterpenes it is currently assumed to be 0.5. In addition to the simple temperature dependent formulation, we now use the temperature and light parameterization from Guenther et al., (2012) who prescribed a 50% light dependent fraction for SQT emissions. For Monoterpenes we estimate a light dependent fraction of 50%.

Comment: 241-244, "Measured monoterpene and sesquiterpene measured fluxes at lower temperatures (280K-295K) were higher than the predicted values based on the Guenther et al. (1994) algorithm. This could be an indication that at lower temperatures other, non-biogenic sources contributed to monoterpene and sesquiterpene fluxes at this site." Along similar lines to the above, could this reflect partly a light-dependence?

Response: Yes this is indeed a plausible explanation. We elaborate more on this issue. In particular we plot the residual of predicted vs observed MT fluxes and see a positive correlation with benzene fluxes, an anthropogenic tracer.
Change: We added a new figure and more discussion on the anthropogenic part of terpene emissions.

Comment: 305-319, are any of the isoprene-emitters juvenile trees? I.e. could tree growth within the 3 years be relevant?

Response: Rather unlikely, since just 8 % of the strong isoprene emitters were younger than 5 years in 2015.
Change: A corresponding sentence has been added to the revised manuscript.

Comment: 365-366, "Mild to severe drought conditions would reduce isoprene emissions further and therefore could not explain an increased isoprene emission potential". This is confusing because paragraph (c) above discusses isoprene fluxes increasing under drought. Some more clarity in the arguments is needed.

Response: It is true that drought parameterizations based on wilting points or similar would generally lower the isoprene emission potential. The reason why the isoprene emission potential can increase during the onset of drought is still debated and we have elaborated on this in our response to reviewer 1. Most likely higher emissions during the early phase of drought are attributed to changes in leaf temperature.

Change: We have clarified this paragraph accordingly.

MINOR / TECHNICAL / WORDING SUGGESTIONS
27, suggest deleting "formation", it is redundant here
35, suggest "in predominantly isoprene-emitting forests"
50, "determined by PMF to mainly (60-70%) originate from vegetation"
51, "… isoprene, attributing it therefore"
58, "Whereas all the studies cited above…"
60, comma after "dilution"
60 & 82, period rather than colon

70, “as well as via storm water interception”
72, “are very plant-species dependent”
78-80, this sentence appears out of place
81, “even fewer such studies”
97, “is with 18% in July” is awkward
230, should say “Mean daytime maxima”

Response: We thank the reviewer for these wording suggestions and changed the text.
Change: Changed text accordingly