Review of "Classification of Alpine South Foehn based on five years of km-scale analysis data" by Jansing et al.

The authors present a climatological analysis of the large-scale conditions, thermodynamic history of foehn air parcels, and local conditions in Altdorf for five subjectively defined (often used, not well-defined in literature) foehn types. The analysis is based on station data and COSMO analysis data at a resolution of 1 km for 2016-2021. The results to a large degree justify the subjective categorisation by revealing distinctly different synoptic conditions and meso-/local-scale characteristics. The paper is generally very well written and if the following comments (largely pertaining to the presentation not the contents of the paper) are addressed, I recommend the paper for publication.

Major comments

1. l. 417: Why use 6 h travel time and not a particular distance from crest? Travel time will place the "upstream" location at very different distances from crest for parcels travelling in the PBL compared to those in the free troposphere (and for cases with varying free tropospheric wind speeds).
2. l. 620: Is it possible to explain differences in local meteorological changes in Altdorf, which are due to differences between the pre-foehn valley atmosphere and meteorological properties of the foehn air, solely with the thermodynamic pathway of foehn air parcels? Given the different synoptic conditions, would it also be a possibility that temperature and humidity (structure) of the pre-foehn valley atmosphere varies between the different types?
3. Section 6.2: Consider removing this section from the paper. The paper is already quite long with all the other interesting analysis, this section has methodological issues (everything being pre-conditioned on Foehn occurrence in Altdorf), and overall does not provide a lot of new insight.
4. Conclusions: The bullet points with the key findings are very lengthy and often are a mixture of methods and results. Would it be maybe more useful to have one bullet point per foehn type summarising all the key characteristics of that type (large-scale, meso-/local scale, Lagrangian) and a separate paragraph summing the Lagrangian results (cluster analysis, before tying them to the foehn types)?

Minor comments

1. l. 6: "Mean wind direction and speed around Altdorf" - please provide the spatial scale of averaging as the statement as is can be misleading (local effects?)
2. l. 57: briefly explain the term "foehn wall"
3. l. 180 f: The explanation of "m" is not understandable without consulting Duerr (2008). Please expand or rephrase.
4. l. 221ff: By starting the back trajectories in Altdorf you implicitly assume that the first part of the travel to the Alpine crest is captured correctly. Please comment on this.
5. Figures: In many colourbar labels missing (variable!), e.g. "geopotential height" in Fig. 3.
6. l. 382ff / Fig. 4: The relative humidity values in the "dry foehn" composite seem to be comparable to those in the "shallow foehn" composite, also there seems to be a stable layer over the Po valley during "dry foehn". Please comment.
7. l. 421f: Would be interesting to see how the scatter looks in the original phase-space. Maybe include scatterplots in the SI.
8. l. 421: Explain how variables are standardised.
9. l. 435: Linking the cluster Δlon to a specific geographic location is possible, because trajectories cross the crest at very similar locations? Please comment.

10. l. 459: “their ascent speed increases“ > You infer this from the spacing of points along the T axis? If yes, then this is also the case for cluster 1 and should be mentioned in the discussion there as well.
11. l. 487: “mainly associated with cloud formation and only minor amounts of precipitation“ - Why would that be? Can you speculate on the processes leading to inefficient precipitation formation in these cases?
12. Fig. 9: Why do the largest moisture losses occur so much before the main precipitation region? Also somehow indicate the areas blanked out due to small sample size.
13. l. 578f: “constrain the observed wind speed“ - Is a range of 10-60 km/h not almost the full climatological range to be expected? I do not understand the word “constrain“ in this context.
14. l. 600f: Is this a consequence of “unusually“ high temperatures or “unusually“ low specific humidity and what is considered as “usual“ values (the non-foehn climatology)?
(This question also applies to the humidity signal of the other foehn types discussed in the following)
15. l. 815f: “distinct thermodynamic evolution“ - The clear differences only arise when considering the mean, or? If considering all trajectories (Fig. 6) there seems to be rather a continuum of different properties.

Technical corrections

1. l. 32f: “relative drying of the air“ - specify relative to which airmass.
2. l. 53: “while foehn winds **are** already“
3. l. 60f: “Another example“ - what is the first example?
4. l. 63: “where **a** record-breaking cross-Alpine pressure differen**ce** of 24hPa **was** observed“
5. l. 67: “humid air precipitates“ - You mean precipitation forming in the still (on the Alpine North side) very humid and cloudy foehn airstream falls into the valley atmosphere? Please reformulate.
6. l. 75: “To this point“ > “To this point in time“ or “So far“
7. l. 115: “The other Foehn focus of MAP“ > “Another focus of MAP“
8. l. 135: “these type**s** of upstream airstreams“ (?) - Also not clear what types you are referring to.
9. l. 140: remove “Especially“
10. l. 188: Please cite the more up-to-date reference of Baldauf et al. (2011)

```
@article{Baldauf2011,
author = {Baldauf, M. and Seifert, A. and F\"orstner, J. and Majewski, D. and Raschendorfer, M.},
journal = {Monthly Weather Review},
pages = {3887-3905},
title = {Operational convective-scale numerical weather prediction with the COSMO Model: Description and Sensitivities},
volume = {139},
year = {2011}}
```

11. l. 189: “Aside from NWP at the convective scale“ - not clear what you mean here with NWP (conventional meaning does not make a lot of sense in this context)
12. l. 199f: Sounds like this has already been done at coarser spatial resolution
13. l. 261: “The procedure **is as** follows“
14. l. 283: “**are comparable** to Innsbruck“
15. l. 294: “approach in **our** study“
16. l. 321: “albeit **a** more northerly flow … in **his case** study“ (is there another than this case study from Gueller?)
17. l. 344: “**see Fig.** S5a“
18. l. 356: “**as is** typical for“

19. p. 14, footnote: “the mean potential **temperature** at 3 km altitude“
20. l. 368: “field **at** 2.5 km“
21. l. 368f: “discussing the **correlation of** the Altdorf foehn type **with** the Foehn“
22. l. 370: “to a **weak** orographic lifting with **little** precipitation“
23. l. 371/384: “moistening“ implies an increase in specific humidity, but what you show is an increase in relative humidity.
24. l. 396: “structure (**relative humidity** distribution, precipitation“
25. l. 405: “pathway. **In this section we** will“
26. l. 406: “their occurrence“ - unclear reference of “their“
27. l. 407: The “linkage“ of what?
28. l. 401: “and **to** quantify“
29. l. 421: “**For further** analysis“
30. l. 426: “correlated **with** the“
31. l. 434: “This **is evident** from“ (?)
32. l. 439: “exhibit **a larger** spread“
33. l. 440: “corresponding **variability** in the“
34. l. 463: What do you mean with “a particularly northern position“?
35. l. 492ff: Are these parcel passing close to the cloud top? What about longwave cooling?
36. l. 526: “stable layer that largely inhibits the ascent of air parcels“ - What role does the limit on trajectory travel time of 6h play for this conclusion?
37. l. 537: “(Fig. 11d). **The** majority“
38. Fig. 11: Mention in the caption that these are E-W cross-sections.
39. l. 552: “(Fig. 4c) **indicates** adiabatic ascent“ (?)
40. l. 554: “while the trajectories **originating** from above“
41. l. 617: “spread **ranging from** below-zero“
42. l. 645: “valleys. **This** section“
43. l. 770: “explained by **our** study“
44. l. 783: “distinguishing“ seems not to be the right word here - maybe “formalising“ or “better characterising“?
45. l. 799: “precipitation~~,~~ with spillover“
46. l. 800: “Alps. **A** deep“