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Review of egusphere-2023-1961

*'Comparison between ground-based remote sensing
observations and NWP model profiles in complex
topography: the Meiringen campaign"*

by Alexandre Bugnard et al.

Paper in review for Atmospheric Measurement Techniques

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Summary

The manuscript presents a comparison of campaign observations from the Meiringen Campaign in a narrow Swiss Alpine valley with the high-resolution 1-km KENDA analysis. The comparison focuses on temperature and wind profiles measured by a microwave radiometer and Doppler wind lidar for ten months during 2021/2022. It is shown that observed and modeled seasonal climatologies of temperature and wind profiles agree well, although for specific situations, such as for example temperature inversions or foehn events the differences are relatively large. The manuscript also links the complex topography to thermal wind system and presents cross- and along valley flow systems observed during the campaign period.

The manuscript presents valuable observations from an Alpine site and provides new insights in the quality of the high-resolution analysis in complex terrain and shows examples of how specific terrain-induced flow features can influence the differences between observations and the analysis. In general, I support publication of the manuscript, but I have several comments and questions to the authors that should be addressed prior to publication and which are primarily related to the general state of the manuscript, the selection of results and the storyline.

1 General comments

1 General state of the manuscript
Generally, the research results in the manuscript are well presented, however, the overall structure as well as the overall "state" of the manuscript should be improved. For example, (i) citations are frequently not correctly used (e.g., double brackets, missing references, incorrect citation style), (ii) references to Sections and Figures are frequently missing, (iii) the presentation of Figures could be improved, and (iv) the Appendix should be substantially shortened to only include the additional information that is absolutely necessary for the manuscript (see also General Comment 4). Moreover, please check if all abbreviations are correctly introduced when first mentioned (e.g. "T" for temperature is not introduced, l. 31, p. 2). Thus, while I find the content of the manuscript interesting, the manuscript needs further polishing prior to publication.

2 Structure

The overall structure of the manuscript with introduction, methods, results, etc. is good, however, in my opinion the Results Section is missing a coherent storyline. I would suggest to re-structure and streamline this section with a strong focus on relevant synoptic features and important differences/agreements between observations and the analysis. Some specific suggestions for potential improvements are listed below. Generally, the manuscript is (unnecessarily) long (in total more than 50 pages), and focusing on a coherent storyline will likely help to shorten the manuscript and convey the key results in a concise way.

3 Figures

Many figures contain a large number of panels and show the results from the analysis and the observations. In my opinion, the figures should be optimized (i) by minimizing white space between panels and (ii) by showing the result from the analysis or observation and directly the difference between both as sub-panels. This would help to combine the synoptic conditions and associated errors and remove redundancies when analysis and observations are very similar. It also emphasizes differences between observations and analysis. The manuscript includes a relatively large number of figures. I believe that the figure number could be reduced by carefully selecting the relevant ones and combining figures.

4 Appendix

The appendix includes too many figures. I would ask the authors to carefully select only those of primary relevance for the manuscript. Moreover, similarly to General Comment 3, the information content of many figures can probably be condensed to fewer figures. E.g., Figures 1, B1, B2, and G1 all show a map of the measurements sites. I suggest their content can be summarized in 1-2 panels.

5 Consistency

I would ask the authors to double-check the consistency of used abbreviations and naming conventions. E.g., it is explicitly stated that data are presented with instrumentation/site, however, this is often not consistently applied (in particular in Results Section). Moreover, several different data sets and sites are compared with each other. When overestimations / underestimations are mentioned, please check that it is specified which data/site are compared.

2 Specific comments

1. **Introduction**
   The introduction is well written, cites relevant literature, and the goals of the study are clearly presented. As a minor adjustment, I would suggest to remove the sub-sections in the introduction.

2. **Methods**
   In the results, bias and errors of the analysis comparison to MWR are shown. How strongly does this result depend on the quality of trained retrieval algorithm? Is it possible that the MWR measurements itself are biased? I would appreciate if the authors could comment on the error

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magnitude of MWR-retrieved temperature profiles and relate this to the shown bias and error magnitudes compared to the analysis.

3. I appreciate the 3D map (Fig. 1), however, it would suggest to use the "northing". Moreover, it is very similar to Fig. B1, although B1 contains some added useful information. I would suggest to replace Fig. 1 by Fig. B1, and also include some information from Fig. G1 (specifically, I would find it a lot easier if wind arrows would depict the median wind direction instead of coloring the stations accordingly).

4. The different instrumentation and sites are well described. Due to different durations of employment I would appreciate an overview table of instrumentation, available data, sites, and the measurement period.

5. l. 86: COSMO-1E: Please introduce this abbreviation.

6. l. 136 "Five km before the lake": I would suggest to write "Five kilometers".

7. l. 186: "perpendicular to the valley (not used in this study)": To streamline the manuscript I would suggest to only describe the measurement setup that was actually applied during the campaign.

8. l. 197: "These precipitations arrived in form of snow": I'm not sure if precipitation is commonly used in plural.

9. Section 2.4
I appreciate a description of the weather during the campaign, although I do not fully understand why the authors focus on precipitation, snow, and sunshine duration while the focus of the study is on wind and temperature profiles and circulation features. I think this section could more strongly focus on the relevant aspects for the analysis.

10. Section 2.5
I believe that this section is not necessary as a separate section, but the information should be included in the previous paragraphs, e.g., where the sites, instrumentation, KENDA, etc. are described, respectively.

11. l. 590: "Therefore, this study does not allow to make prediction of model performance for forecasting." Can the authors please elaborate on this, I do not fully follow the reasoning and relation to forecasts here.

12. **Results**
I would suggest to streamline the Results Section (see also General Comments above).

13. I would suggest to use more informative titles in the Results Section (e.g. "3.1.1 Climatology" is only based on observations, which cannot be deduced from the title).

14. The overall section structure could be improved. It is not very intuitive to show (i) temperature, (ii) wind, and (iii) Foehn (with wind and temperature), while other atmospheric features were explicitly discussed in (i) and (ii). I would suggest to define a storyline to follow in the Results Section and focus on the key results.

15. Generally I would be careful with the word "climatology" as here only a few months and not several years of data are analysed.

16. Section 3.1.1
I would suggest to streamline this section and focus on relevant features. E.g., the presence of a diurnal cycle and temperature increase after sunset are expected features and their description could be streamlined.

17. l. 230f: Please correct units: temporal gradient of 5C/?.

18. l. 235: I struggle to see the daytime temperature inversions. Could these features be outlined in the figures (e.g., through contours)?

19. Section 3.1.2
Which differences are analysed in this section? Is it hourly values?

20. l. 255 f: "The difference in the effect of the ELR correction" Which difference? At both stations RMSE increases? Please clarify.

21. Section 3.1.3
Would it make sense to place this sub-section before Section 3.1.2 as profiles have already been described Section 3.1.1 (Fig. 6 fits better to Fig. 3)? Is Fig. 3b required? If I'm not mistaken it is not referenced in the text. The comparison of temperature profiles and respective KENDA biases assumes the MWR retrieval does not include a bias. Given some uncertainty in the retrieval algorithm, could the authors comment on this issue (see also comment above)?

22. Section 3.1.4
l. 308 f: "All this leads to both an important overestimation of the T at ground level (Fig. 5) and a slight underestimation of the T just above the T inversion (Fig. 6)." Both figures compare different data sets, i.e. a direct comparison of temperature differences at different heights is difficult. Moreover, I struggle to see temperature overestimations at the lowest level in MWR-KENDA comparisons in Fig. 5. Can the authors please clarify?

23. l. 309-311: Please either elaborate on this or remove.

24. l. 315 - 322 I find this very interesting and would like to see some results, as this observation rejection is linked to some of the surface temperature differences reported in the study.

25. Section 3.1.5
Personally, this very short sub-section interrupts the storyline which strongly focuses on MWR and surface measurements. Did the authors also compare MWR profiles with the RS profile? Please note that Fig. F1 is not referenced. Please also elaborate on the influence of the RS from Payerne. Was the additional RS/MEE not assimilated? Please double-check the spelling of radiosounding.

26. Section 3.2.1
This section appears unfinished and I think it needs some more work. The writing style with bullet points differs substantially from the style used above for temperature. Moreover, I would ask the authors to improve

Fig. 8. It is very difficult to identify relevant features in a 60 panel figure. Would it be an option to, e.g., show differences in panel b)?

27. Section 3.2.2
    This section should be removed.

28. Section 3.2.3
    I appreciate the comparison of allong valley winds during the campaign period to the 10-year climatology, however, this interrupts the storyline. In my opinion, it would be sufficient to mention the good agreement and move the figure to the appendix.

29. Fig. 10a: Typo in axis label: "DWL/MER"

30. Section 3.2.4
    This section provides a very detailed description of the circulation evolution at different sites. I would ask as the authors to streamline this section and highlight the important circulation features. Figure B1 could also be referred to for clarification.

31. Section 3.2.5
    l. 493-495 Could the authors please elaborate on this? How was the vertical velocity estimated?

32. Section 3.3
    General comment: In my opinion, much of the comparison between KENDA and observations has already been described above. I would suggest to restructure to avoid repetion and potentially include foehn events as subsections in 3.1 and 3.2.

33. l. 505: Please define the foehn index and provide a reference.

34. l. 505: Is the subsequent analysis (e.g., Fig. 14) performed for three events only or for "all the period" with foehn? Please clarify.

35. l. 506: Which April episode? Fig. 15 shows again different time periods? Please clarify.

36. l. 516: I would expect a better agreement of KENDA and observations if both data are taken from the same site (compared to different sites). I would appreciate if the authors could explain the reason for comparison of KENDA/MEE with SMS/MER (instead of KENDA/MEE). Such comparison are frequently performed throughout the manuscript, and to some extent it is difficult to follow all different comparisons.

37. l. 521: "mettre reference fig ap 26"?

38. l. 537: Does KENDA/MER really show a delay in foehn onset? To me it rather looks like a too early onset (similar to KENDA/MEE)?

39. l. 541-544: In particular in this section it is very difficult to see where wind speed is over-/unterestimated, i.e., showing differences to DWL might be helpful.

40. l. 545: Based on Fig. 15 (which is the main figure discussed in this paragraph), I find it difficult to follow the conclusion that the representation at MER is better than MEE. Improved visualization may help.

41. l. 554: Please elaborate on the link between wind bias, temperature bias and specific humidity bias.

42. Fig. 14: Please specify what is shown in the figure. What do the numbers on top represent? What is shown in the x-axis in b)?

43. Fig. 15: Are the dates correctly shown in all panels? I cannot find any figures for 19-22 March nor 23-24 April. Are data shown only at 11 am and 11 pm?

44. **Discussion**
    The manuscript includes an extensive discussion of the results, which I appreciate. However, I would suggest to condense the information and streamline the Discussion Section. It may also be helpful to include a short summary and/or discussion after the respective Results Sections, respectively.

45. l. 680: The daily cycle of temperature underestimation/overestimation is not apparent in the MER observations (Fig. 6). Could the authors please elaborate on this?

46. l. 681 f: Comparisons are made to different versions of COSMO. Please either specify the versions /differences or remove.

47. **Conclusions**
    The Conclusions provides a bullet point summary of the key results. I would suggest to formulate continuous text for the conclusions with distinct paragraphs instead of bullet points.

48. l. 772 - 787. The important circulation features are listed here. I would appreciate a figure/sketch similar to Fig. B1 where all the identified flow features are outlined and summarized.