

Long-term simulation of the boundary layer flow over the double-ridge site during the Perdigão 2017 field campaign

Reply to comments of anonymous referee #2 of manuscript acp-2018-997

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1 Introduction

We thank the anonymous referee for the comments and acknowledge his effort to improve our manuscript.

In the following, comments of the referee are marked with numbers and corresponding replies of the authors are written in bold and labeled with “ \Rightarrow ”. In the manuscript we implemented a few new figures (e.g. Fig.4, Fig.7, Fig. 11, Fig. 15) to demonstrate differences in the model results due to different model resolutions (D1 to D3) and to confirm that the main driving mechanism for LLJs were thermally induced pressure gradients and not the inertial oscillation theory of Blackadar (1957). Changes in the new manuscript are written in bold.

2 Comments

This is a well written paper describing a very high resolution simulation of the Perdigão field experiment. It certainly required a strong computational investment. It is probably relevant for an ACP special issue on the experiment (I say probably because I have not read the other submitted papers), but I feel it does not contain ”a substantial contribution to scientific progress within the scope of this journal“, as required by ACP.

Indeed, while the paper mentions a number of relevant mesoscale processes that could be analyzed in detail by 200 m resolution simulations (internal waves, low level jets, catabatic flows, to mention a few), there is no detailed analysis of any of those processes, which could be of general interest for atmospheric research. The analysis is restricted to mean diurnal cycles

in specific cross sections, which do show interesting and qualitatively nice responses to the topography, and to the coarse time evolution of a few meteorological variables, which are ok but could be also ok at coarser resolutions. The main conclusion is that the WRF model (with ECMWF high-resolution analysed boundary conditions) performs "well", although there is no indication of its error statistics, or a comparison against a benchmark. The descriptions of the low level flow are rather vague and not supported by specific analysis that could be of general interest.

I understand that such a general paper can make sense in this ACP number, but as an individual paper it makes little sense for ACP as it is.

⇒ We appreciate your critical comments. The paper was submitted within the ACP special issue "Flow in complex terrain: the Perdigão campaigns" to provide a uniform and continuous data set of meteorological fields throughout the campaign period. This is very useful to understand and interpret flow structures observed in measurement data. It was not the focus of this study to provide realistic turbulence characteristics, but to describe the general meteorological situation and to analyse frequently observed flow phenomena like LLJs. The precondition of such a simulation was to resolve the double-ridge topography, which required a horizontal grid resolution of at least 200 m. To our knowledge a simulation with such a high grid resolution that is conducted over 49 days is not common and worth to be presented to the scientific community. We agree that we did not show comparisons between the 200 m run and results of coarser model domains. We implemented additional figures, described the differences in the text and added a table for correlation coefficients and RMSE-values. We also tried to improve the LLJ-analysis and attempted to demonstrate that the main driving mechanism were thermally induced pressure gradients and not the inertial oscillation theory of Blackadar (1957).

At least I would like to see:

1. (a) a comparison between 200m, 1km simulations and the ECMWF forcing (at 1h): are the higher resolution ones worth the much higher cost? This is a bit technical but of general interest and should be straightforward to do before the paper is accepted;

⇒ We included comparisons of wind fields for all three WRF domains D1 to D3 (Figs. 4, 7 and 11). We did not include a comparison with ECMWF, as we used the data with a 6 h interval, which would result in wrong interpretations. We showed in the additional table 2 that correlation coefficients cannot be improved by increased model resolutions and that even the coarse domain D1 reproduces the phase of the cross- and along-valley wind signal surprisingly well. RMSE-values are improved by increasing the model resolution, as the

topography becomes more realistic. This becomes clear, e.g. in Fig. 4 and Fig. 7. If only mesoscale flows have to be reproduced, then grid resolutions in the order of 1 km are acceptable. If, however, the interaction of the flow with complex topography should be resolved, 200 m and even finer grids are necessary. This is shown, e.g., for T25 within the valley in Fig. 7.

2. (b) a more thorough analysis of the low level jet. What process leads to it. Is it an inertial oscillation? What is its typical peak time? How often does it occur and why? I feel this is also important and feasible.
- ⇒ We introduced a new section 5, which deals with the LLJ-analysis. We show that LLJs occurred during 30% of all synoptic conditions and during 42% of NE cases during the campaign at T20 (L231-L233). By means of the new Fig. 11 we show that nearly all detected LLJs come from NE directions and are decoupled from very weak synoptic conditions aloft (L217-225). The typical peak time is between 6 and 9 UTC (L247) as can be seen in Fig. 13 (a) and (c). We tried to identify processes, which might indicate that the inertial oscillation theory of Blackadar (1957) plays a role for the LLJs over Perdigão. We show a hodograph of the ageostrophic wind component for three exemplary LLJ-cases in Fig. 15, which is not in agreement with the circular oscillation of Blackadar (1957). Fig. 14 shows that pressure gradients are not constant in time within the LLJ-layer and can be directed opposite to the synoptic pressure gradient. In 26% of the LLJ-cases winds were more than 100% stronger than synoptic winds, which is also in contrast to the Blackadar (1957) theory (L272-L288).
3. (c) some diagnostic of katabatic flows: what is their intensity, location, structure. This is mentioned but not really analysed.
- ⇒ The presented LLJ-index is a measure for the strength of LLJs and in our case also for katabatic flows, as we showed that the jets over Perdigão are thermally driven. Fig. 10 gives an overview of the locations of strongest katabatic flows (L200-L209). In addition, we introduced the new Fig. 11, which demonstrates dominant wind directions of LLJs (katabatic flows) at T20.
4. (d) some diagnostic of internal waves. This may be more difficult, and could be left for future work, but it deserves work.
- ⇒ We think that this is an interesting suggestion, but requires a thorough and in-depth analysis of the physical processes leading to internal waves and is therefore beyond the scope of this study.

References

Blackadar, A. K.: Boundary Layer Wind Maxima and Their Significance for the Growth of Nocturnal Inversions, *Bull. Amer. Meteor. Soc.*, 38, 283–290, 1957.