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Reply on RC2

Anna A. Shestakova et al.

Author comment on "The foehn effect during easterly flow over Svalbard" by Anna A. Shestakova et al., Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2021-478-AC2, 2021

We thank the reviewer for his useful comments. Please, find the answer to each of the comments below.

«Although the paper is generally well written, easy to understand and follow, the presentation of the material seems rather lengthy and redundant in some parts. There is a long introduction that focuses on climate impacts and Arctic amplification. Well, that's the framework, but the paper doesn't make a conclusive contribution to the issue.»

The introduction was shortened.

«And then there is the leeward warming, which is looked at in too much detail for my understanding, since it is a known phenomenon. A novel aspect would be for the authors to present a Lagrangian analysis of the temperature and moisture evolution of air parcels starting upstream. This approach could really help to distinguish between the large-scale warming and the mesoscale effect due to the flow past the mountains. Indeed, the mesoscale numerical simulations are available and could easily be used to conduct such an analysis.»

and

«line 170-172: this is one of the too speculative sentences that could be strengthened by a more detailed analysis (the Lagrangian analysis referred to above) and its subsequent incorporation of the results into the content of the paper»

Elvidge et al. (2016) applied Lagrangian analysis to several cases of foehns over the Antarctic Peninsula and it helped them to distinguish the mechanisms of warming. This is the advantage of this approach and, indeed, Lagrangian analysis can be very useful in analyzing various episodes of Svalbard foehns. But for the episode under consideration, isentropic warming seems to be the only mechanism, since the air mass was dry and there was little precipitation (lines 264-266). Turbulent fluxes of heat and moisture could mix warmer and drier air from the upper layers into the Lagrangian volume. At the same time, turbulent exchange with the underlying surface would result in cooling and moistening of a Lagrangian volume. Quantitative estimates of the contribution of these fluxes to the evolution of the temperature and humidity of a Lagrangian volume would undoubtedly be useful, but we assume that there is a rather large uncertainty regarding the turbulent fluxes reproduced by the model in conditions of very complex orography. We consider the

Lagrangian investigation for these reasons as an interesting goal, but it requires a separate future study. In the revised manuscript we explain this difference to the Lagrangian study of Elvidge et a. (2016) and hint to this as a future goal (lines 497-500).

«While browsing the literature on Svalbard, the reviewer came across a paper by Dörnbrack et al. (2010), who also studied a very similar episode of easterly airflow in this journal (Dörnbrack et al., 2010). Although they focused on aerosol distribution from airborne lidar measurements (incidentally using the POLAR 2 aircraft, a predecessor of the current AWI fleet used in the current study), they also discuss most of the phenomena studied in the current paper by Shestakova et al. (especially, the "orographic modification of the flow and of the atmospheric boundary layer during easterly flow over Svalbard." (line 94/95) as e.g. the formation of a "warm" wake in the lee of the mountains, the tipjet that forms on the northern edge of Svalbard, ...) . And there are also similarities in some of the diagrams: cf. current Fig. 7 in this paper and Fig. 9 in Dörnbrack et al. I think the authors should really try to better highlight the novelty of their analysis in a revised version of the paper.»

We thank the reviewer for mentioning the important reference to Dörnbrack et al. (2010) which we overlooked. In the revised version of the paper the study of Dörnbrack et al. (2010) is cited where appropriate, especially, concerning similar conclusions on the flow modification by the orography of Svalbard. Of course, the paper (Dörnbrack et al. 2010) describes all the main features of the wind and temperature fields during foehn, which influence also the aerosol concentration. Also, such features are described in other articles (for example, Sandvik and Furevik, 2002; Skeie and Grønås, 2000; Reeve and Kolstad, 2011). However, in these articles, all these features are considered mainly based on modeling data or not in so much detail as in our study. In contrast, our focus is on studying the foehn effect based on in-situ observations (modeling is used only as an auxiliary tool for interpreting observations) and its impact on the boundary layer and heat balance in the surface layer. To our knowledge, such a large amount of data obtained from various observational platforms during the foehn event is presented for the first time and provides a more solid basis for quantification of the magnitude of the foehn effect, as well as of the orographic modifications of the air flow, such as gap flows and tip jets. Our research based on a completely independent data set confirms many of the features found in previous works (lines 66-68, 288-289, 492-496), and thus highlights these previous findings and shows the high degree of generality of these works.

Minor Comments

«lines 194: the Kvitoya station is missing in Figure 6; generally, the temperature rise increases already before, much earlier than in the time window as shown in Figure 6, see Figure 4; so, the respective discussion should be modified»

Figure 6 and the text (lines 181-188) have been revised. As could be seen from Fig.4 (now removed), the temperature rise began before May 30, and it was not associated with foehn (since the wind was first southerly and then northerly, but not easterly), but with large-scale advection. Since we are interested in foehn warming, we have chosen the period starting from May 30, when foehn began.

«Figure 7: the labels on the left axes are misleading, since there is obviously no reference to the lines in the image»

Fixed.

«Figure 9: dotted -> dashed»

Fixed.

«line 416: Is the snow really melting there at these temperatures or it is mostly drifting away or evaporating?»

Indeed, the snow could sublime or melted water could evaporate, and this process is accounted for in the latent heat flux. But the estimated evaporation rate was one order smaller than the melting rate. The limitations of the estimation of melting rate in Adventdalen on May 31 are listed in lines 431-433.