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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Quantification of topographic venting of boundary layer air to the free troposphere" *by* S. Henne et al.

S. Henne et al.

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MASS BUDGET

Firstly, it is criticized that surface measurements are not necessarily representative of the temporal evolution of the valley flow aloft. We agree in this point. But in addition to the surface stations also valley wind measurements during the VOTALP campaign by scintillometers (Poggio et al. 2000) were analyzed. They used 5 different optical paths across the valley with a length from 0.9 to 2.7 km, the heights of the optical paths above the valley ground were between 60 and 600 m. They observed an increasing valley wind from about 8 to 11 CET and rather stable wind speeds afterwards (see their figures 13, 15, 16). In that valley, one was able to observe that in the case of stable wind measurements by the scintillometers, the wind speed measurements at surface stations were stationary too.

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Secondly, the description of the increase of the horizontal mass flux over 2 hours might be confusing in the present version of the paper. If we agree in the first point, that surface stations aren't very representative for the flow aloft, we think it is much better to directly look at the aircraft measurements. The change in flow structure and wind speeds observed by the aircraft within a 2 hour time interval is obvious. That is why we account for this change in our budget calculation. It might not be clear from our text and we will change that for the final paper, but we estimated the temporal change of the horizontal mass flux through a cross section between two different flights. An individual cross sectional measurement takes about 15 minutes. We assume that during this short time period the change in the flow structure and wind speeds is not essential for an individual horizontal flux measurement. The time difference between two horizontal flux measurements at two different cross sections is about 20 minutes. We consider this time difference in the budget analysis by assuming a linear increase/decrease of the horizontal flux within 20 minutes as it is determined by two subsequent measurements in time with a time difference of about 2 hours.

EXTRAPOLATION

We are aware that our assumptions are very crude. But an analysis of the Alpine topography showed that about 25% of the terrain above 1500 m above sea level show similar characteristics like the valleys investigated in our paper (slope length of at least 3 km and slope angle similar to slopes in the Leventina and Mesolcina valley). This criterion includes basically tributary valleys of the large Alpine valleys, meaning narrow sloping valleys. The main reason for our extrapolation was to get a crude estimate of the mountain venting potential in terms of NO_x. NO_x is emitted mainly in the big Alpine valleys and in its tributaries containing cross Alpine highways. From the main valleys pollutants should be quickly advected to the tributaries where we assume strong vertical transport. We are aware that the flow structure in big Alpine valleys like the Inn valley might be different. But it is also much more uncertain to derive budgets for

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these valleys. In the study by Freytag (1987) they had to use very crude assumptions for the flow into tributary valleys and their data coverage was much more coarse than ours. In addition, one always subtracts two very large numbers for the horizontal flux from each other, meaning that the error on the vertical flux is also getting much larger.

For the Kali Gandaki valley the situation is much different. In their first study (Egger et al. 2000) the data coverage is even worse than for the Freytag observations. They did not measure at two different locations at the same time, not even the same day. So, the differences in the flow strength can reflect day-to-day variations in the thermal wind system. In the second part of their paper (Zangl et al. 2001) they use numerical simulations to further investigate the flow structure in the valley. They suggested a hydraulic jump could be the reason for the acceleration of the wind speed in the central part of the valley but could not verify this by measurements of temperature and moisture in a second field campaign (Egger et al. 2002). So it remains unsure if the valley winds in the Kali Gandaki Valley are purely thermal or mechanically driven. In addition, the Kali Gandaki is again much different from the valleys investigated in our study.

Finally, the investigation within the Wipp valley (Rucker 2003) took place in October. At this time of the year the thermal wind system might develop in a different manner as during the summer season, when a much larger amount of sensible heat is available. Our extrapolation is only assumed for days with very strong solar irradiation and therefore large sensible heat flux, resulting in strong thermal flow systems. The criterion to select strong radiation days based on total daily sunshine duration and used for the trajectory study did only select days within the period April to beginning of September. Rucker (2003) suggests that due to different heating rates of different valley sections the along valley pressure gradient varies along the valley, leading to sections with flow acceleration. Vertical subsidence is necessary to adjust the mass balance. On a rather local scale this concept seems reasonable and we agree that not every valley section showing similar slope characteristics like in our study will show positive vertical mass flux. But regarding the whole valley domain, the up-valley flow has to leave the

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valley atmosphere at some point at latest at the end of the valley, therefore a positive vertical mass flux would result in total. Strong and dominating subsidence of clean free tropospheric air into Alpine valleys during strong solar irradiation days, such as those investigated in our study would also contradict the findings of large aerosol mixing heights on a regional domain above the Alps as observed by Nyeki et al. (2000) and simulated by deWekker et al. (2004) and the general concept of an Alpine daytime heat-low. In the future, climatological studies are needed in order to support or change the crude estimation made at this point.

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