Atmos. Chem. Phys. Discuss.,
doi:10.5194/acp-2017-334-RC1, 2017

Atmospheric Chemistry and Physics Discussions
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Interactive comment

Interactive comment on "Mountain waves modulate the water vapor distribution in the UTLS" *by* Romy Heller et al.

Anonymous Referee #1

Received and published: 24 May 2017

The authors present an interesting case study addressing vertical transport and irreversible mixing of water vapor in the UTLS associated with a mountain wave event. The wave event located above the Southern Alps of New Zealand is analysed involving observations from two aircrafts and radiosondes. A novel combination vertical flux calculations, wavelet analyses and tracer-tracer correlations is used to identify regions of vertical trace gas fluxes, involved horizontal wavelengths, and indications for irreversible mixing. The analysed data set suggests a dominating upward water vapor transport through the thermal tropopause followed by partial mixing, thus enhancing water vapor mixing ratios in the tropopause region. Furthermore, based on simulations by Riese et al. (2012), a rough estimate of a local ≥ 1 W/m^2 radiative forcing due to mountain wave-induced water vapor transport and irreversible mixing is provided.

The paper is clearly of interest, as trace gas and particularly water vapor transport

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Discussion paper

by mountain waves followed by irreversible mixing is little understood and represents a source of uncertainty in simulations. The presented set of observations supports a consistent picture of local upward transport by mountain waves and partial mixing, resulting in a net enhancement of water vapor in the tropopause region. The estimated radiative forcing should be taken with care, since local observations at a certain time of the year are combined with zonally and temporally averaged data. As indicated by the authors, this aspect clearly requires further studies. The paper is clear-written and well structured. The study should be published in ACP after clarification of some minor points:

P 5 line 16 and elsewhere: cloud-free conditions, water as conservative tracer: As potential condensation may influence the analysis, the absence of (thin) clouds should be assured using airborne data (e.g. particle observations or temperature). Later it is said that ice particles were detected at the leewave side. What is the detection limit for condensed water? Could significant amounts of condensed water be missed, or can this be ruled out?

P 5 line 28: To me it was sometimes difficult to connect the flight legs and locations/directions with the map in Fig. 1. As Mt. Aspiring serves as reference point, coordinates should be provided in the text and it would be helpful to mark this point in the maps.

P8 sect. 4.1 and Figure 1: As the vertical domain is in the focus of this study and locations are relevant, it may be helpful to add a vertical cross section of vertical wind from the model along the cross-mountain flight path and indicate the flight legs.

P12 line 4, Figure 6: While the data suggest upward transport through the thermal tropopause, it would be interesting to include comment on the dynamical tropopause. Are thermal and dynamical tropopause approximately coincident here? Furthermore, how is the approximate thermal tropopause location determined in Figure 6 (dropsondes/model)? Could the location be biased by temperature signatures of the strong waves?

P12 line 6, Figure 6b: exact localization of maxima ... not possible: It is clear that it is difficult to have observations at many different levels in a short time window and here the best possible is done. However, could the pattern in Figure 6b change significantly if more/other levels would be available?

P13 line 25: Turbulence is identified in the dropsonde data between 329 and 334 K and suggests mixing. Figure 7b shows that the situation is changing within hours. Is it robust to apply this potential temperature range from a single dropsonde profile to the H2O-O3 correlation from a full flight covering several hours?

P13 line 21: A local $\geq$ 1 W/m^2 radiative forcing is estimated locally above New Zealand in July. However, Figure 6 in Riese et al. (2012) refers to annually and zonally averaged values. How could this affect this estimate?

Technical:

P3 line 3: correlations

P6 Eqns 1 and 2: define x and t

P9 line 18: check number/unit: -176 m ppmv

P9 line 28: strong negative peak

Figure 5: numbers at right y-axes of panels on the right side would be helpful

Interactive comment on Atmos. Chem. Phys. Discuss., doi:10.5194/acp-2017-334, 2017.