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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Characterization of a boreal convective boundary layer and its impact on atmospheric chemistry during HUMPPA-COPEC-2010" *by* H. G. Ouwersloot et al.

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We thank Referee #1 for his/her constructive and insightful comments that helped to improve this paper. Below we will respond to them point by point.

More specific comments

While the potential temperature gradient in the conditionally unstable layer of Fig. 1b is only twice the gradient in the boundary layer of Fig. 1a, it is important to note that the gradient in Fig. 1b changes by more than an order of magnitude between two different layers (at 1050 m). This sudden change in the magnitude of the gradient identifies the transition between the mixed layer and the conditionally unstable layer above. This

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Interactive Discussion

Discussion Paper

issue will be clarified in the manuscript. Additionally, we would like to comment that while we show the potential temperature profiles belonging to certain prototypes, the prototype classification is based on the analysis of the virtual potential temperature profiles, which will be clarified in the text. As the derived boundary layer heights and main features are equal between potential temperature and virtual potential temperature profiles, we took the potential temperature profiles for illustration. However, if the virtual potential temperature is used, the gradients in the conditionally unstable layer of Fig. 1b and in the mixed layer of Fig. 1a differs by a slightly larger factor of 2.5.

As the referee suggested, indeed a fourth profile prototype does occur during the transition between a stable layer below a residual layer and a convectively mixed boundary layer. However, even though this stage is important and therefore treated in this paper, it only occurs during short periods of time and is therefore not present in the available radiosonde data.

The conditionally unstable layer is indeed considered to be part of the boundary layer. As such, the atmospheric boundary layer consists of a separate mixed layer and a conditionally unstable (potentially cloud) layer. These types are fundamentally different as only saturated air will mix through the entire boundary layer. Unsaturated air will only mix in the mixed layer.

The entrainment could be described more accurately and complex, but as shown by multiple previous publications (Vilà-Guerau de Arellano et al., 2004; Vilà-Guerau de Arellano et al., 2011; van Stratum et al., 2012), this simple representation is able to accurately reproduce both observations and LES results under convective conditions. This is further corroborated by our results. A sentence about better representations for the entrainment ratio will be included.

Although the authors do not have direct data to confirm that the values for dry deposition are low enough to not significantly alter the average mixed-layer concentrations, we do show that the atmospheric chemistry can be represented well with the chosen surface forcings. However, we want to emphasize that we aim to show the presence and impact of specific dynamical processes and do not claim an exact representation. We acknowledge that additional processes, like deposition, could be of importance. The example of dry deposition will be included in the manuscript.

The authors agree that the MXL model cannot do a single continuous run to describe the ABL evolution including the effects of the residual layer, however the MXL model can give a continuous representation by restarting the model. This difference will be better expressed in the conclusion.

As stated by the referee, horizontal homogeneity is assumed and therefore the mixed layer depth is independent of the horizontal location. With regards to the equal advection effect in both the boundary layer and the free troposphere, an extra sentence will be included to put more emphasis on this strong assumption.

The relative humidity indeed has an accuracy of 2 %. This typo will be corrected. The wind speed is direct output from the GRAW DFM-06 software. Their data sheet states that their accuracy is finer than 0.1 m/s. How this is achieved is not known to the authors, but also irrelevant for the results presented here. Therefore, this value will be removed.

The virtual potential temperature is indeed the relevant parameter for ABL stratification and it is used to determine the ABL types. However, as shown by the figure below, their profiles are qualitatively the same as the potential temperature profiles in Figure 1 of the manuscript. As stated before, we will introduce that the classification is based on the virtual potential temperature profiles.

As the referee noted, the chemical species concentrations in the surface layer can significantly deviate from the bulk (mixed layer) values. Due to absence of data at greater heights, the available observations are used as first order estimates as the general behaviour and order of magnitude are expected to be similar (Vilà-Guerau de Arellano et al., 2011). A note on this will be included.

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Minor comments

The entrainment contribution to the mixed layer NOx is indeed due to the higher NOx mixing ratio in the free troposphere, as is the case in Section 3.4. The initial mixing ratios are only set equal in the boundary layer and free troposphere for the hypothetical case in Section 3.3.

The chemical reactions do have a (quite constant) influence on the O3 mixing ratio evolution, but the effect of entrainment is stronger and drives this evolution. This will be clarified.

Due to Taylor's frozen turbulence hypothesis, averaging in time equals averaging in space. Therefore, all spatial fluctuations, which are an issue when using local observations, can be filtered by averaging in time.

The referee asked for a clarification of the units of q in equations A6 to A8. Although these values could be derived to be dimensionless (and thus kg/kg) by accounting for dimensions, we agree that an extra note could avoid future misunderstandings. Therefore, this point will be clarified.

Figure 9 is updated and now clarifies that A and B denote a chemical transformation.

All other (minor) corrections have been applied as proposed by Referee #1.

References:

Vilà-Guerau de Arellano et al., 2004: Entrainment Process of Carbon Dioxide in the Atmospheric Boundary Layer, J. Geophys. Res., 109, D18110

Vilà-Guerau de Arellano et al., 2011: The role of boundary layer dynamics on the diurnal evolution of isoprene and the hydroxyl radical over tropical forests, J. Geophys. Res., 116, D07304

Van Stratum et al., 2012: Case study of the diurnal variability of chemically active species with respect to boundary layer dynamics during DOMINO, Atmos. Chem.

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Interactive Comment

Phys., 12, 5329–5341

Interactive comment on Atmos. Chem. Phys. Discuss., 12, 13619, 2012.

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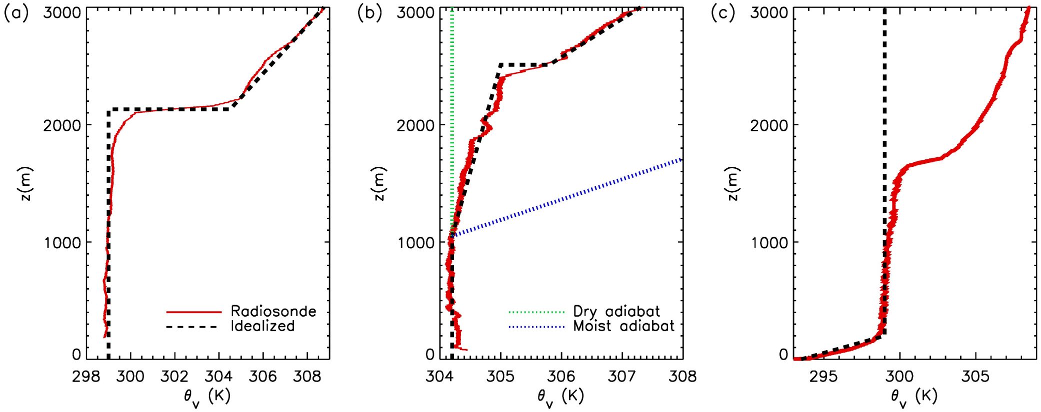

Fig. 1. Characteristic vertical virtual potential temperature profiles for (a) a mixed layer, (b) a mixed layer topped with a conditionally unstable layer and (c) a stable boundary layer.

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