

Interactive
Comment

Interactive comment on “Airborne observation of mixing across the entrainment zone during PARADE 2011” by F. Berkes et al.

Anonymous Referee #1

Received and published: 1 November 2015

The atmospheric composition of an atmospheric boundary layer formed above a complex terrain is studied using surface and aircraft measurements gathered during the PARADE experiment. The study is carried out with a complete data set of observations and analysis to encompass all the relevant contributions. The study mainly focus on a single day (September 6th 2011). Lagrangian trajectories are calculated to show the influence of the arrival at noon of air mass with different composition and how they contribute with the mixing driven by more local processes like entrainment of clouds. The finding are very interesting identifying the different processes that contributes to the diurnal variability of CO₂ and O₃ with special emphasis on the mixing event. The paper is well written and with supportive figures. I have however comments on the interpretation of the results, in particular the role of clouds and the effect of subsidence

Full Screen / Esc

Printer-friendly Version

Interactive Discussion

Discussion Paper



on the entrainment process.

General comments

1) I miss through the paper a clear separation between the role of synoptic and mesoscale in the presentation of the results (section 3). At section 3.1 they described the synoptic situation, but little is mentioned on the potential arrival of anabatic winds characterize with different meteorological and atmospheric composition. I realize that it is difficult to establish a clear difference between the synoptic and mesoscale contribution, but I believe it is necessary to comment the role of mesoscale for a measurement site that is higher than 800 meters.

2) Key variables like the potential temperature and wind (speed and direction) could be shown and discuss more in depth. The values of the potential temperature inversion are very large (3 and 10 K) for typical boundary layers formed over land. I believe a figure and a more elaborated discussion is needed here.

3) At section 3.2 it is mentioned the existence of the aerosol layer. Is it impacting the transfer of radiation and the subsequent development of the boundary layer? How does it evolve? Can it be characterized (for instance with the aerosol optical depth)? It will be interesting to discuss the role of these observed aerosols on the boundary layer and the entrainment zone (see for instance Yu et al. J. Geophys. Res. 107, D124142 (2002) or Barbaro et al. J. Geophys. Res. 119, doi:10.1002/2013JD021237 (2014)).

4) I have two major comments in the discussion. The first one is related to the role of clouds. In the discussion the ventilation of atmospheric compounds from the PBL into the free troposphere driven by the mass flux is not mentioned neither discussed. In my opinion, boundary layer height and the transport by mass flux is an important contribution to the budget of the atmospheric components in the sub-cloud layer. Mass flux influences boundary layer height according to (see Equation 4 at Ouwersloot et al., 2014, J. Geophysical Research 118, doi: 10.1002/2013D020431, 2013)):

Full Screen / Esc

Printer-friendly Version

Interactive Discussion

Discussion Paper

$$(dh/dt) = w_e + w_s + w_m, [1]$$

where (dh/dt) is the boundary layer growth, w_e the entrainment velocity, w_s the subsidence motion and w_m is the mass flux velocity. This mass flux leads to a reduction of the boundary layer growth and dominates also the vertical transport of atmospheric compounds (see Equation 3 at Ouwensloot et al, 2014). For instance, it leads to drying of the sub-cloud layer. The authors mentioned the descending air between the clouds resulting from the presence of roll vortices, but I believe it is necessary to include in the discussion how the mass flux influence the transport of ozone and CO₂ in the studied case. In other words, it is necessary to show that the descending air between the clouds (1st paragraph at page 29188) is as important as the mass flux vertical mixing contribution. Note that once the air is introduced in the cloud layer, the stability of the environment diminish the capacity of mixing and therefore the downward transport of atmospheric components (see figure 10a at Vreijbergh et al., Atmospheric Chemistry and Physics 9, 1289-1301, 2009)

Connected to this, this section needs to be more quantitative in the description of clouds. At the last paragraph at page 29187 it is mentioned that the clouds are driven by shallow convection (typical cloud covers 20%) whereas at the second paragraph at page 29190, they mentioned that there is a large cloud fraction. The authors need to provide and discuss the evolution of the cloud cover during the analysed day.

5) My second comment is related to the relation between ABL growth and entrainment (last paragraph section 4.2 at page 29188). As equation [1] indicates there are other processes that influence boundary layer growth. I disagree with the statement that subsidence (w_s) limits entrainment. From Equation [1] it can be seen that assuming no clouds ($w_m=0$), (dh/dt) can become 0 (no growth ABL) in the case that the entrainment velocity is equal to the subsidence. In other words, entrainment is still a relevant process (since $w_e>0$) in spite there is not boundary layer growth. Similar to clouds, here large scale subsidence is mentioned, but it is not quantified. I believe this information is useful to complete the case description and it can be extracted from a meteorological

[Full Screen / Esc](#)[Printer-friendly Version](#)[Interactive Discussion](#)[Discussion Paper](#)

model (COSMO, WRF or ECMWF).

Interactive comment on Atmos. Chem. Phys. Discuss., 15, 29171, 2015.

ACPD

15, C8809–C8812, 2015

Interactive
Comment

Full Screen / Esc

Printer-friendly Version

Interactive Discussion

Discussion Paper

C8812

