Answer to the first anonymous referee's comments :

The authors thank the referee for their constructive comments that help us to improve the clarity and the quality of the manuscript. In the following, all the comments are answered and the modifications introduced in the revised manuscript are described.

General comment:

- I'm missing a combined PBL time series, resulting of all methods, due to the authors knowledge of advantages and limits of the different methods.

The conclusions of the paper and Table 4 try to synthetize a kind of "best use" of all experimental methods. The MWR with the various PBL detection based on the T profiles has the great advantage of producing a complete diurnal cycle of the CBL, NBL and SBL, but missed all information concerning the RL. The lidar (comprising also the ceilometers, even if not used in this study) seems to the best suited instrument to measure the RL. The radio sounding has a too low time resolution but remains the most reliable measures at midday and midnight.
To implement a real operational algorithm that chose in each case (depending on the time of the day, the season, the meteorological conditions) the best measurement for each PBL layer (CBL, NBL, SBL and RL), a further work on the uncertainty and consequently on a kind of quality flag for each method would be necessary. Then an adjustment to the various and probably numerous special cases related to particular meteorological conditions has also to be developed. This stays however beyond the scope of this paper.

Specific comments:

- I think it's a pity that you have a ceilometer, but used is just for cloud detection. Instead of the temporally "bad" resolved ASR, you could use the pure backscatter signal of the ceilometer with very high temporal resolution for the detection of the CBL height (see Lammert and Boesenberg: Determination of the convective boundary-layer height with laser remote sensing. Boundary-Layer Meteorology 119, 159-170, 2006).

The fact is that the ceilometer used for this study (CBME80 from Eliasson) was not set up in 2012 and 2013 to provide the whole backscatter profile but only the cloud bases (see manuscript p. 15426 line 7). Moreover, the resolution of the backscatter profile is far too low to be applied for PBL detection. It would be otherwise clearly used in this inter-comparison! A new Jenoptic ceilometer was installed at Payerne in 2013, allowing a future comparison (on-going activity).

- You have shown the limits of the bR method due to the sensitivity to the correct surface temperature. In COSMO this method is used for PBL height determination – so doesn't it make sense to choose another method? Have you checked other quantities, like humidity or temperature profiles from the model in combination with one of the other methods?

A study was done (Balazs Szintai, Improving the Turbulence Coupling between High Resolution Numerical Weather Prediction Models and Lagrangian Particle Dispersion Models, Phd Thesis, EPFL, Lausanne, : http://infoscience.epfl.ch/record/150277/files/EPFL_TH4827.pdf, 2010) to choose the best suited method. Not only the reliability but also the applicability were tested and bR method was chosen. The focus of the present paper is to compare the various measurements among each other and with the existing COSMO-2 product , not to improve the latter. A study is however presently conducted to improve the COSMO-2 PBL height estimation.

- The climatology of the CBL and cloudy CBL: in Fig. 9 and 10 you showed a very good agreement of Lidar and MWR for the cloudy CBL, but an underestimation for the CBL. That surprises me, due to the advantage of lidar in cases of cloud free, convective conditions. Where does this underestimation comes from?

The difference between lidar/ASR and MWR/PM PBL height is not really smaller for cloudy-CBL cases than for CBL cases. These difference are plotted on the next figure. It can be seen that:

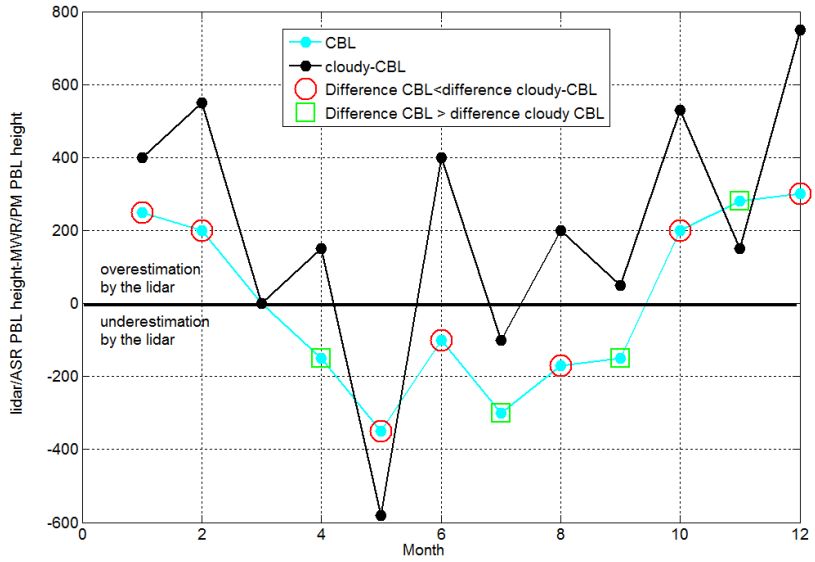
- The difference for CBL cases are more regular, showing an overestimation by the lidar in winter and an underestimation in summer.
- The results for the cloudy-CBL cases are much more scattered, reflecting the great difference in the number of cases for the lidar and the MWR. The lidar cannot measure if there is too much or too low clouds. The comparison between the PBL detected by both method has therefore to be taken with great care for the cloudy-CBL climatology.
- The difference between the lidar/ASR and the MWR/PM PBL height is smaller for CBL cases for 7 months and larger for 4 months.

- Taken into account the uncertainties of both methods, we cannot really conclude that the lidar/ASR underestimate the PBL height (or that the PM overestimates it, which can also be possible due to the MWR uncertainties). The absolute differences are most of the time smaller than 200 m, which is similar to the uncertainty range.

The following atmospheric phenomena could also occur:

- The PM method considers an adiabatic rise of the air masses. In the atmosphere, there is probably a deviation of the adiabatic conditions and a mixing of the air masses during the rising up to the PBL top, leading to a lower altitude for the PBL measured by particle concentration than by theoretical convection conditions.
- The PM was applied to θ and not to θ_v. The PBL estimated from θ_v is higher than the one estimated from θ, since the water vapor is lighter than dry air. The consideration of the air moisture will involve higher PBL height and a greater difference between MWR/PM and lidar/ASR in summer, but a smaller one in winter.
- The particles are heavier that air masses and can perhaps stay at a lower altitude than air due to the gravity force, at least for the greatest particles such as mineral dust and pollens. This could explain the lower PBL height measured by the lidar/ASR.

I do not have however a clear estimation of the impact of these atmospheric phenomena and cannot therefore scientifically estimate their end effect on the PBL height determination.



- Fig. 9 and 10: Why haven't you included the time series for MWR/bR? It would be helpful to better rate the results of COSMO.

The MWR/bR results are now included in the CBL and cloudy-CBL climatology (Fig. 9 and 10) and the text was consequently adapted. Not much modification were added, since MWR/PM and MWR/bR present, as expected, similar results. MWR/bR were already present in the night climatologies (Fig. 11 and 12).

- Fig. 11 and 12: The spread between the lines is very high, so it is hard to know, which lines should be compared together. What's the reason for the low number of cases for MWR compared to the other instruments? MWR PM in CBL cases and MWR/bR for stable ones are both plotted in red, which suggest a bit that both methods are complementary – was what your intention? In the conclusion your suggestion for a good combination is MWR/PM and MWR/SBLpT.

The authors try to adapt the figures describing the climatology in the new version of the manuscript. Now the color code and the symbols are completely similar to Fig. 4, 5 and 8 to allow a better comprehension of all figures. There was no reason for having the MWR/PM and MWR/SBLpT both in red, this was modified.
There is a low number of cases for MWR/bR, but not for MWR/SBI and MWR/SBLpT as can be seen on the lowest panel of Figures 11 and 12. The bR method needs a wind measurement and the first levels of the wind profiler are often invalidated by the automatic quality check of the instrument. All SBL under 300 m could therefore not be calculated due to the absence of wind measurements. This information was added in the description of the bR method:" During night, the Ri_b number is sometimes greater than the threshold already at the ground level due to stable θ profile near ground impeding any PBL detection. Moreover, the invalidation of

the first levels of the windprofiler data caused by environmental perturbations also restrict the detection of low PBL height (< 200-400 m) by the bR method.".

Technical corrections:

- P9, L33: please compare with values in Table 3 (0.47 vs. 0.49 . . .)
  Your comment is right, the values between the text and Table 3 were harmonized.

- P12, L6: Please explain APCADA.

Apcada is explained under § 2.1: "The cloud cover is detected by Automatic Partial Cloud Amount Detection Algorithm (APCADA) that estimates in real-time the sky cloud cover from surface based measurements of long-wave downward radiation, T and humidity (Dürr and Philipona, 2004). APCADA does not take into account the cirrus clouds."

- Fig. 4, 5, and 8: please exclude the legend of the lower plot and plot it to the right hand site.
  The legends are now outside the lower plot.

- Fig. 5: What's the reason for "no data" below 400m in the background?
  The windprofiler is not able to measure the first 110-130 m due to electronic time delay between the emission and reception of the signal (some ns). A quality check then flag all the data and often leads to an invalidation of the measurements under 200-300 m a.g.l. due to contamination by the direct environment of the instrument (such as cars, leaves movement, reflection of building, trees,…). This automatic QC is based on numerous parameters (time and spatial homogeneity, SNR threshold, width of the peaks,…) and leads to the invalidation of the measurement up to an altitude depending mostly on the meteorological conditions. A sentence was added to the revised version: "The first levels of measurements up to 200-400 m a.g.l. are often automatically invalidated because they suffer from internal and environmental perturbations.".

- Fig. 8: The background is SNR or lidar? Both would make sense, but please decide. ;-)
  It is SNR, which is now mentioned in both text and figure caption!

- Fig. 11 and 12: The additional lines in the lower plots are not explained. Why have you separated the number of days in these cases, but not for the CBL cases?
  The additional lines give the number of cases used to calculate the monthly medians for each method as explained now in the figure captions. In case of CBL only the MWR/bR and lidar/ASR have been differentiated since they really have a lower number of bases for each months. The monthly medians of all the other methods were calculated on the same number of cases.
  Concerning the SBL cases, the restriction to clear and cloudy nights greatly restrict the number of available cases. Taking into account only the cases when all methods provided PBL heights would have restricted the analysis to a too low number of cases (<10 or even <5) and therefore limited the pertinence of this SBL climatology analysis.

- Please notice a uniform notation of the methods (MWR PM or MWR/PM,COSMO vs. COSMO-2...)

The various notations were checked in the text, tables and figures.