Assimilation of lidar planetary boundary layer height observations

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Response to reviewer 2

1. The definition of PBLH. As described on lines 77-82, for PBLH data calculation, the Doppler shift of the backscattered signal is used to calculate wind speed as a function of range, which can then be used to produce a multitude of wind and turbulence variables useful for PBL characterization (e.g. vertical velocity variance and signal-to-noise ratio variance). The PBLH algorithm applied for this study combines several such aerosol and wind variables for PBLH measurement and was described at length in Bonin et al. (2018). The PBLH in the model is estimated using the total kinetic energy (TKE) method. The two definitions are different but seem close enough. Is there a way to show to what extent the two PBLH definitions are comparable?

This Doppler lidar was not making measurements capable of direct TKE retrieval, only TKE proxies (such as vertical velocity variance), so an explicit apples-to-apples comparison is not possible here. To make further inference would be speculative, so instead we only present and discuss this best possible PBLH measurement from the Doppler lidar to assess model performance.

Once a much larger number of PBLH lidar observations are obtained, along with radiosonde observations, it would be worthwhile to generate some statistics on this, on both bias and random differences. We have 6 sonde observations to compare with our forecasts, and with these we can show here is how the lidar observations can impact the thermodynamic profiles within the PBL using assimilation of the lidar observations. With a better understanding of differences between the two PBLH schemes, and a much larger data set to compare with, it's likely that further improvements can be made.

2. The vertical localization factor. How is the parameter alpha in equation (6) chosen? According to the equation, this parameter works the same way for layers both above and below the PBL height, for example, if $k_P BLH = 4$, then $C_l oc$ at layer 3 is the same as $C_l oc$ at layer 5. However, that seems not the case in Fig. 5.

We have redone the assimilation to fix a couple of inconsistancies in the code, including this. The profile plots now show the vertical localization above and below the top of the PBL, though the final form of any localization that would be needed will be more clear once this is implemented with an enKF.

3. Equation (7). Where is number "8" coming from? The top of boundary layer is not a constant during the 22 hours, which can be seen clearly in Figures 3-6.

The maximum extent of the PBL in the late afternoon is at layer 8, and we felt is was more consistent to compare the same levels at each time, rather than comparing a much smaller number of layers during the night and early morning. This is explained further in the text.

4. In the abstract, it states that water vapor is improved by assimilating lidar PBLH. However, Fig. 5 shows that it is degraded.

We have corrected this statement. A more accurate statement is that the assimilation changes the water vapor profile in the right direction, but the increment is too large, so that the RMS difference with the radiosondes increases. This would require additional tuning in an EnKF.