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Interactive comment on "How can mountaintop CO_2 observations be used to constrain regional carbon fluxes?" *by* John C. Lin et al.

Anonymous Referee #1

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This study examined the ability of different atmospheric transport models (and with different spatial resolutions) to simulate CO2 mixing ratios (specifically the summer time diurnal cycle) at mountaintop locations in western USA. The results showed that regional transport model (Lagrangian Particle Dispersion Model STILT) with higher resolution (WRF at 4 km or less) wind inputs compared better with observations than lower resolution models (WRF at 12 km or CarbonTracker). The comparison and analysis with global model (CarbonTracker) point to some approaches in using mountaintop observations in carbon flux estimates. This type of model evaluation is important to understand the abilities and shortcomings of transport models, and necessary prior to using such models in flux estimation. The results provided more insights on the importance of local scale up slope and down slope winds for mountain top observations. Therefore this paper should be accepted for publication following some minor

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modifications noted below.

General Comments

The WRF-STILT model results at 4 and 1.3 km resolutions compared well with observation. But the differences between WRF-STILT model results and observations became unexpected large at 12 km resolution (Fig. 3), with poorer agreement than the much lower resolution models (GDAS-STILT and CarbonTracker, both at 1 degree resolution). The problem seems to be the modeled PBL. The 12 km WRF-STILT model mean PBL shown in Figs. 7, 8 and 9 are quite different from the WRF-1.3, WRF-4 and GDAS-1 deg results. Similarly the GDAS-STILT results exhibit odd behavior (see below). This raises many questions:

(1) Is there a problem with the modeling of PBL in the WRF-12km model?

(2) Is there a problem with the modeling of PBL in the GDAS-STILT model (Figs. 10, S10, S12)? Figs. S10 and S12 show HDP and NWR PBL much higher (~5000m) compared to PBL from WRF-STILT runs. Fig. 10 appears mislabeled and not consistent with the discussion in the text, therefore very difficult to understand, see specific comment.

(3) How realistic are the PBL results in these models (WRF-1.3km, WRF-4km, WRF-12km, GDAS)? How were the PBL results evaluated (for mountaintop conditions)?

(4) How realistic is PBL model for mountaintop simulations? How does the PBL model account for the difference between flat plain and mountainous conditions (as the model domain contains such surface conditions)?

The authors should provide more technical details on the PBL model (e.g. dependence on atmospheric conditions and topographic variations, daytime and nighttime variations), particularly how it changes for the different (met data) models (to cause the unusual results for WRF-12km and GDAS) in this study. Then present more analysis and discussion on the uncertainties or errors in the PBL and consequently footprints in

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this study.

Specific comments

Lines 413-414: 'Due to the significantly "flattened" mountains in WRF-12km and in GDAS, the PBL height exhibits less spatial variation.' This is not true for WRF-12km in Figure 7.

Lines 469-472: 'Focusing on the three-dimensional plots at the hours of 0800 and 1100 MST (Fig. 10), when the simulated peaks are found at SPL and both NWR/HDP, respectively, the peaks coincide with times when average trajectories are found within a relatively shallow morning PBL.' This statement seems to conflict with Fig. 10, which shows the HDP site with a deep morning average PBL. There seems to be error(s) in Fig. 10. The HDP plot domain is the same as shown for NWR in Fig. 9. The plot domain for NWR is as for HDP in Fig. 7. The plotted curves for the two upper plots with nearby domains seem to show drastic difference for PBL, the PBL for the HDP plot is definitely not 'shallow morning PBL' at ∼6000m.

Lines 734-736: 'Red portions of the trajectory refer to the nighttime (1900∼0700 MST), while pink portions indicate the daytime (0700∼1900 MST).' The red and pink portions are hard to distinguish, use more contrasting colors.

Lines 738-739: 'Fig. 8 Similar to Fig. 7, but for the Storm Peak Laboratory (SPL) site.' The blue PBL line appears to have dark and light portions not explained. Again, the contrast is hard to distinguish, use more contrasting colors. This may apply to Figs. 7, 9, 10 too.

Figure 7 (also 8, 9, 10, and corresponding figures in supplemental material): add color scale to facilitate figure comparisons.

Supplemental material

Figure S3: it is not clear if the flux reversal correction takes into account the longer daytime than nighttime during the summer.

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Figure S5: 'CO.obs...' to 'CO2.obs...'

Figs. S11, S12: PBL for GDAS higher than 6000m seems unusually high.

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