Responses to Reviewer # 2:

We are very thankful to the reviewer for his/her valuable advice and comments, which helped us improve the manuscript significantly. We have addressed these comments and revised the manuscript accordingly. The detailed responses to the queries are below.

1. *Although, as far as I know, some of the data used here have never been used for this purpose, the manuscript lacks the necessary consideration of related work (although cited) that face the same problem in a rather similar and, possibly, more accurate way. Richardson et al. (2013) suggest a "continuous" relationship (as opposite to the one proposed here, which is based on very broad classes) and Basu et al. (2014) refine the coefficient also using one the experiment considered here. Authors must account for those papers, and discuss their results accordingly.*

Response: We thank the reviewer for his/her constructive suggestions. Richardson et al. (2013) did propose a stability-dependent relationship for Ri_{bc}. However, their "continuous" relationship is only applicable to stable boundary layers. Their equation $\mathrm{Ri}_{bc} = \alpha \frac{h}{L}$ implies that L<0 (unstable) cannot be used since Ri_{bc} should be positive in the bulk Richardson number method. This is also clearly stated in their papers, as follows:

"We only focused on (non-intermittent) stably stratified flows" (Richardson et al., 2013) and

"Data points with L > 500 m (near-neutral condition) and $L < L_{min}$ (very stable conditions) are not included" (Basu et al., 2014).

As a result, our study examines a wider range of atmospheric thermal stratification conditions as compared to Richardson et al. (2013) and Basu et al., (2014).

Following the reviewer's suggestion, we have added the discussion of Richardson et al. (2013) method in section 3.2 and Fig. 1 has been revised:

"**After we estimate the Ri_b vertical profile from Eqs. (3-6), the PBLH can be determined as the height where the Ri_b exceeds Ri_{bc}, the bulk Richardson number for the entire PBL, which needs to be defined as a prior known. Richardson et al. (2013) proposed a stability-dependent Ri_{bc} for SBLs:**

$$Ri_{bc} = \alpha \frac{h}{L} \qquad (7)$$

where h/L is a bulk stability parameter, L is the surface Obukhov length, α is a proportionality constant, which depends on surface characteristics and/or atmospheric conditions. It varies between 0.03 and 0.21 with suggested values of 0.045 and 0.07 (Richardson et al., 2013; Basu et al., 2014). As shown in Fig. 1c1-c2, in the Type I SBL case, a relatively reliable PBLH (133 m) was calculated with α =0.045, but an overestimation (184 m) occurs when α =0.07. While in the Type II SBL case both α values (0.045 and 0.07) yield too small estimates of PBLH, because the two values are determined by idealized stably large-eddy simulation datasets (Richarsdon et al., 2013) and observational datasets under weakly and moderately stable conditions (Basu et al., 2014), respectively. In addition, Eq. (7) is only applicable for SBLs but not UBLs. As such, in this study we used a fixed Ri_{bc} value for each type of boundary layers instead of adopting this equation (see Sect. 4)."

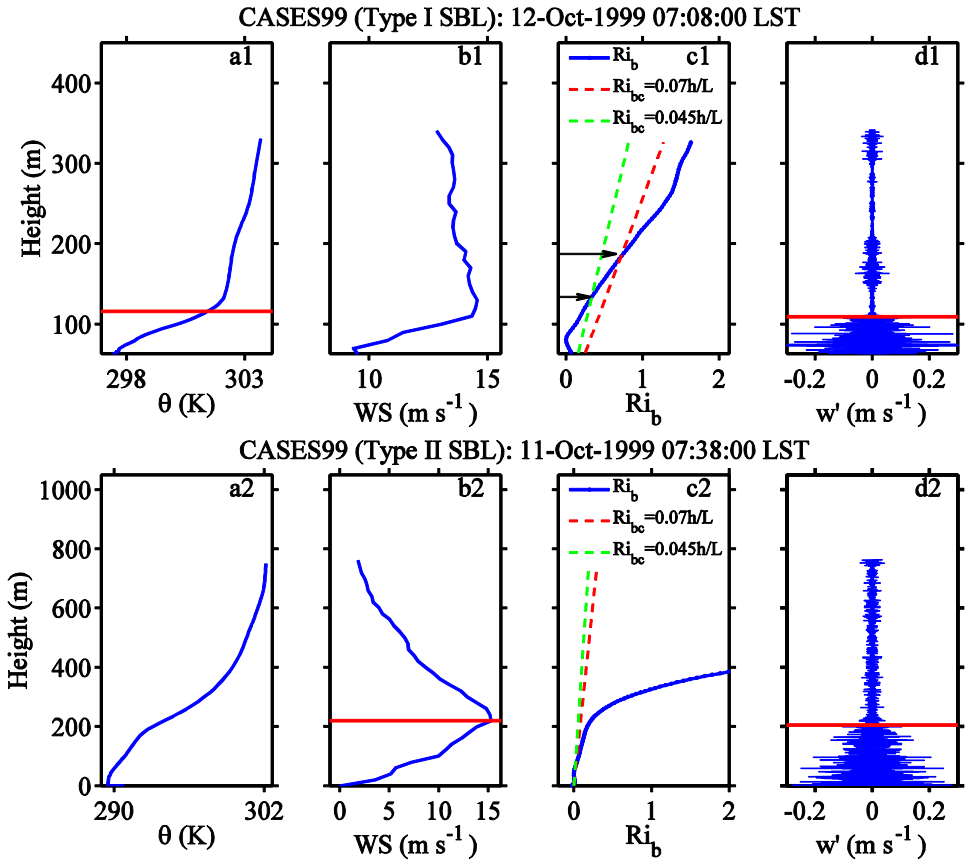

Figure 1. Examples of vertical profiles of the Type I SBL (upper panels) and the Type II SBL (lower panels) from CASES99 aircraft measurements: (a) potential temperature (K); (b) horizontal wind speed (m s^{-1}); (c) bulk Richardson number Ri_b and Ri_{bc}; (d) w perturbation (m s^{-1}). The red solid lines on (a1) and (b2)

denote the PBLH calculated by the PTG and LLJ methods, respectively, and those on (d) denote the PBLH determined by the Tur method. The black arrows on (c1) denote the PBLHs determined by the bulk *Ri* method with Ri_{bc} from Eq (7).

2. *In case the authors are requested to submit a revised version of the manuscript, I strongly suggest revise carefully the language.*

Response: Thanks for the comment. We have revised the language carefully and thoroughly.

3. *It would also be very interesting to go a bit farther and show (or at least discuss) to what extent the proposed parameterization can improve model results in real applications.*

Response: Following the reviewer's suggestion, we also added a few discussion about real applications of the new Ri_{bc} values in the end of section 4.3, as follows:

"**To investigate the improvement of numerical models with the new Ri_{bc} values, we compared the simulated PBLHs of CAM4 with default (= 0.3) and new Ri_{bc} values to the observed PBLH at the ARM site. The results indicate that, the Bias, SEE, NSEE are 270.1 m, 379.3 m, 0.75 for CAM4 with the new Ri_{bc} values, respectively, and 306.2 m, 417.5 m, 0.83 for CAM4 with the default Ri_{bc} value, respectively. Fig. 13 shows a comparison between the observed and simulated PBLHs with the default and new Ri_{bc} values over a six-day period. It can be seen that the simulated PBLHs with the new Ri_{bc} values have a more pronounced diurnal cycle, which are also closer to the observations. As a result, the impacts of thermal stratification on Ri_{bc} should be considered in calculating PBLH with the bulk *Ri* method and the new Ri_{bc} values determined in this study improves model results in real applications.**

The better performance of CAM4 with the new Ri_{bc} values clearly suggests that the impact of thermal stratification on Ri_{bc} should be taken into account when computing PBLH. It is pointed out here that there are still large biases in the CAM4-simulated PBLH even with the new Ri_{bc} values, which are related to the biases in the model physics and parameterizations (e.g., parameterizations of land-atmospheric interactions and boundary layer turbulence). Unraveling how biases in the model physics and parameterizations affect the PBLH is nevertheless out of the scope of this study."

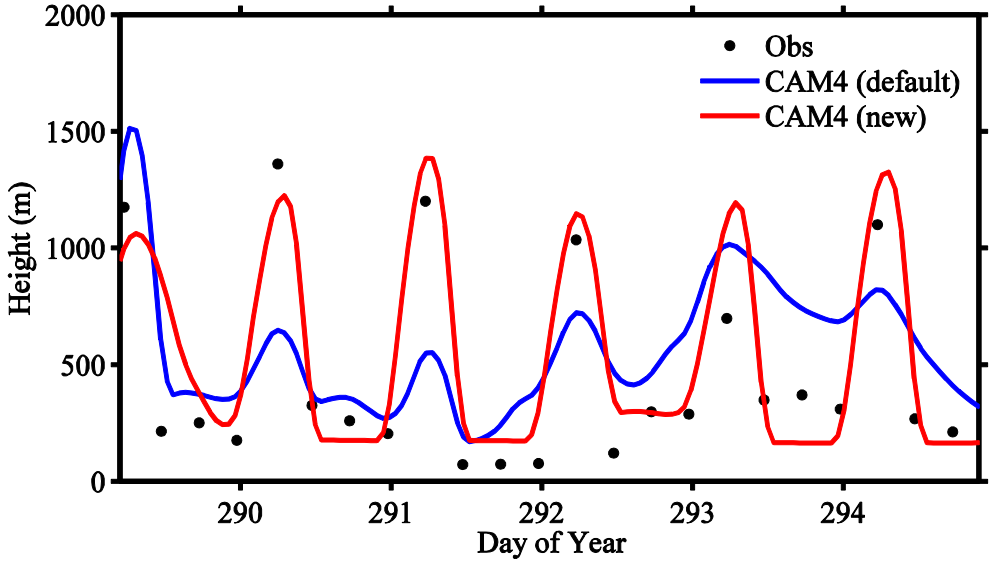

Figure 13. Comparison of observed and simulated PBLHs using CAM4 with the default and new Ri_{bc} values during 16-21 Oct, 2008 at the ARM site.

The related conclusions have also been revised, as following:

"**…Both offline and online evaluation showed the new Ri_{bc} values proposed in this study yield more reliable PBLH estimations, suggesting that the variation of Ri_{bc} should be considered in the PBLH parameterization. Therefore, it is expected that the new Ri_{bc} values, when used in numerical models, will help to improve model results.**"

Minor comments:

1. *- the word "critical" referred to the Bulk Richardson number between the ground and the boundary layer height can be misleading because it does not indicate that the whole boundary layer undergoes a transition to laminar regime);*

Response: Following the reviewer's suggestion, using "the critical bulk Richardson number" is avoided in the revised manuscript since it causes confusion with 'the critical flux Richardson number' at which turbulence dies down and the flow starts to laminarize. We use "the bulk Richardson number of the entire PBL" in the revised manuscript.

2. *- it can be useful to define the range of stability parameters for the different classes (this can also help comparing to Basu et al. (2014);*

Response: Following the reviewer's suggestion, we have added Table 1 and the related discussion in the end of section 3.1, as following:

"**With these procedures, the obtained PBLHs by using these three methods are treated as 'observed' PBLH hereafter. The ranges of the observed PBLHs and stability parameter (*h/L*) for different PBL types are provided in Table 1.**"

Table 1. Ranges of PBLH and stability parameter at four observational sites.

PBL Types	PBLH (m)				*h/L*			
	Litang	CASES99	ARM	SHEBA	Litang	CASES99	ARM	SHEBA
Type I SBL	45~265	25~157	54~593	42~414	0.12~323.0	1.5~94.2	0.22~327.2	0.4~38.3
Type II SBL (H<0)	68~543	151~299	131~670	97~312	0.64~74.8	8.1~56.9	0.36~113.1	0.1~21.3
Type II SBL (H>0)	357~678	\	152~879	138~414	-33.4~-0.32	\	-34.1~-0.2	-55.1~-0.01
UBL	315~2594	\	293~1693	121~981	-866.4~-4.3	\	-350.9~-1.3	-342~-0.03

3. *- numerical models using Richardson bulk method to estimate the PBLH are cited. It would be useful to add some details;*

Response: More discussion has been added in section 3.2 (Page 4055, line 8), as following:

"**In the non-local PBL scheme of the Community Climate Model version 2 (CCM2), Eq. (1) is applied to estimate the PBLH with Ri_{bc} chosen as 0.5. The computation starts by calculating the Ri_b between the surface and subsequent higher levels of the model. Once Ri_b exceeds Ri_{bc}, the PBLH is derived by linear interpolation between the level with $Ri_b > Ri_{bc}$ and the level below.**

To avoid overestimating the shear production in Eq. (1) for relatively high wind speeds (i.e., in Type II SBL) and to account for turbulence generated by surface friction under neutral conditions, Vogelezang and Holtslag (1996) proposed an updated formulation, which is employed in the Community Atmosphere Model version 4 (CAM4), written as…"

4. *- figures presentig vertical profiles could be improved by increasing the line thickness;*

- in all of the figures, axes labels must be increased;

Response: All figures have been revised. The line width is increased and the font size of the axes labels is also increased.

5. *- as "h" is typically used for "fixed" height (e.g. boundary layer height) I suggest replacing it with "z" in equation (1).*

Response: Revised.