Response to Reviewer #2's Comments:

Jiming Li et al. (Author)

We are very grateful for the Review #2's detailed comments and suggestions, which help us improve this paper significantly. In the original manuscript, we are sorry to only use cloud fraction information from lidar so that our results missed too many thick clouds. By combining the information of "LayerBase", "LayerTop" heights and "CloudFraction" parameter, we reconstruct the cloud mask and redo the whole study. Based on two Reviewers' comments, we reorganized the manuscript and paid more attentions to interpret our finding and results. In addition, some superfluous information in each section was deleted and some interpretations in each section were added in order to make the manuscript more clear.

Specific responses

(1) At a few points throughout the paper, there are allusions to the climate changes experienced by the Tibetan Plateau, but little detail on what these changes are, and indeed how misrepresentation of cloud overlap could affect predictions of these changes.

Response: We agreed with reviewer. In the revised paper, we added some information and interpretations of climate changes over TP region (see Line 62-70 in Introduction section).

"**For example**, many studies have showed that significant warming occurs in the TP region during the last decades and will continue to warm in the future (e.g., Duan et al., 2006; Wang et al., 2008). The rapid warming has caused glacier retreat and expansion of glacier-fed lakes (Zhu et al., 2010), permafrost degradation and temperature increasing (Cheng and Wu, 2007), heating source became weakened (Yang et al., 2011) and corresponding variation of summer precipitation downstream (Duan et al., 2013). In addition to increased greenhouse gas emission, Kang et al. (2010) summarized that the changes of cloud cover also is one of dominant factors causing the rapid warming over TP region. Indeed, some studies have linked the rapid warming to variations in the cloud

cover over the TP region (e.g., Chen and Liu, 2005; Duan and Wu, 2006; Li et al., 2006; Yang et al., 2012; You et al., 2014; Wu et al., 2014). Such as, a recent study has indicated that increased nocturnal cloud cover over the northern TP would warm the nighttime temperature via enhanced atmospheric back-radiation, while decreased daytime cloud over the southern TP has contributed to the increasing of surface air temperature during daytime(Duan and Xiao, 2015). Based on the above studies, it is necessary to reasonably simulate the cloud cover in the climate models in order to better predictions these climate changes over TP."

(2) Line 73: overlap parameterizations, rather than overlap states. They are not really states that occur in the atmosphere, but parameterizations that we apply to them in models. You alternate throughout between cloud cover and cloud coverage. Cloud cover is more commonly used.

Response: In the revised paper, we already corrected it. Thanks reviewer.

(3) Lines 75 onwards: you introduce maximum, minimum and random overlap, but do not state exactly how they are calculated. Describing the cloud cover for two layers under each overlap assumption is useful, but a proper physical definition of what the overlap schemes mean will help. (This could also belong in the data/methods section.)

Response: In the revised paper, we added some interpretations to each overlap assumption (see Line 85-90). In addition, the physical definitions were emphasized in the section 2.3 (see Line 220).

"**The maximum assumption** minimizes the total cloud cover, while minimum assumption produces minimally overlap between cloud layers and results in maximum total cloud cover. The total cloud cover predicted by the random assumption will fall somewhere between maximum and minimum assumptions. For example, if the cloud covers in two model layers are given as 50%, then the maximum overlap will result in a total cloud cover of 50%, and a minimum overlap will result in an overcast condition (a complete cloud cover, i.e., 100%)"

(4) Line 88. “Accurate” perhaps isn’t the word you mean – this implies that the radar

always calculates the exact masks of the true clouds.

Response: It was corrected in the revised manuscript.

(5) Line 94: “space-based” is better than “space-borne” (the satellite is not carried along by space!).

Response: It was corrected in the revised manuscript.

(6) Lines 135 onwards. This section was not clear, and I needed to read it multiple times to get an idea of what you meant. For a start, I assume that the CloudSat profiles are columns of zeros and ones for clear and cloudy, which are then combined to give two dimensional scenes? Are CloudSat bins the same as CloudSat profiles (presumably the bins are height layers within the profiles)? And what are the horizontal and vertical resolutions referring to? This all needs to be made clear or the reader will struggle to follow.

Response: Related information was added in the section 2.1 to make the manuscript more clear.

“**In the dataset,** every CloudSat profile includes 125 height layers (e.g., vertical bin), and the “*CloudFraction*” parameter reports the fraction of the lidar volume within each radar vertical bin that contains hydrometeors (Mace et al., 2009; Mace and Zhang, 2014). Several previous studies have identified a cloudy atmospheric bin based on different thresholds of the lidar-identified cloud fraction, including a 99% (Barker, 2008; Di Giuseppe and Tompkins, 2015) or 50% threshold (Haladay and Stephens, 2009; Verlinden et al., 2011). Here, a threshold of 99% is used in our study. However, due to the significant attenuation of lidar signals to the optically thick layers, this parameter fails to provide the “*CloudFraction*” value in those optically thick layers. Thus, we have to use other radar information (that is, cloud “*LayerBase*” and “*LayerTop*” fields) from the aforementioned dataset as supplementary to construct the complete two-dimensional cloud mask (See Fig. 1b)”.

(7) Section 2.3. The first time I read this, again it was not clear here why and how is the domain divided into different domain sizes. You should probably describe this more

explicitly. I assume the data is simply divided up into sections of these different lengths? You also define two terms ("spatial sampling size" and "domain size") for this quantity, but then proceed calling it something else ("spatial sampling scale").
Response: We agreed with reviewer. In the revised paper, we already added some information and interpretations in the section 2.3.

(8) Line 205. Going back to my main points above – I don't understand why this result is in the paper in this much detail. Figure 2 shows that there is little difference in terms of overlap statistics whether the threshold is 99% or 50%, but I don't see how this particularly justifies the use of the 99% threshold. I wonder if this result is even worth a mention – removing it would mean that the definition of the threshold is no longer necessary.
Response: We agreed with reviewer. In the revised paper, this result is already deleted.

(9) Several of your paragraphs are far too long. A reader will be daunted by paragraphs that span multiple pages. I recommend breaking these paragraphs down into manageable sections that describe one element of the study.
Response: We already changed it in the revised paper.

(10) Line 235 to end of paragraph. I am not sure what you mean here – I think it is about the domain size needing to be greater than the cloud scales at each level. But now there is another threshold that is introduced of 50% that is different in definition to the previous threshold. Basically, as far as I can tell, the overview of the latter parts of section 2.3 is to pick a set of values for the two thresholds and the spatial sampling scale. This should probably be partitioned off into a separate section.
Response: We agreed with reviewer. In the revised paper, we already added a section to interpret the selection of thresholds for cloud cover and spatial scale (see the section 2.4).

(11) Sections 3.1 and 3.2. These were very difficult to read and need reworking – the material within them is fine, but the key results need to be emphasized and worked into more of a scientific story.

Response: We agreed with reviewer. In the revised paper, we already reorganized these sections and added some necessary explanations (see section 3.1 and 3.2).

(12) Table 1 and Figure 8: which of the overlap schemes in the table are yours? By the looks of it, it's 5 and 6, but it wasn't immediately obvious. Why not give the schemes names that highlight those that are yours, then when you compare the performance of the schemes over the Tibetan Plateau, it is easier to see that yours perform best.
Response: It was corrected in the revised manuscript. (See Figs.6 and 7, table 1).

(13) Figure 8. This figure would be clearer if the colour bar used white for zero. Then it would be clearer which overlap schemes produce biases.
Response: It was corrected in the revised manuscript. (See Figs.6 and 7).

(14) Section 4. Your conclusion section is just a summary of the results and some future ideas, with little extra insight. You need to place your results here into context. You allude at many points along the way to climate change and modeling over the Tibetan Plateau and how radiation budget is affected by cloud overlap issues here – how could this parameterization help?
Response: We agreed with reviewer. In the revised paper, we tidied up the conclusion section and further added some discussions.