Response to Referee #1

General Comments:

This manuscript explores how biomass burning impacts surface albedo and regional meteorology using radiosonde, satellite retrievals, reanalysis data and the WRF-Chem model. It is well organized and written. The results demonstrate improvements in modeling meteorology during biomass burning seasons. It is worth to be published in ACP after addressing the following issues.

Response: We would like to thank the referee for providing the insightful suggestions, which indeed help us further improve the manuscript.

Specific Comments:

1. My major concern is on the treatments of changes in surface albedo in the model. Observed changes in albedo for shortwave and near infrared are -0.02～-0.06, and -0.06～-0.1. The largest decrease of -0.1 was used in the ABD run, while changes of about -0.05 occurred more frequently. Will this treatment overestimate the impacts of biomass burning in the model? Could you discuss how this will affect your conclusion.

Response: Thanks for the suggestions. Sensitivity tests for different surface albedo decline have been supplemented in the following part. Related discussion will be added in the revised manuscript.

In this study, we aim to figure out the possible radiative effects of straw burning induced surface albedo decline and its impact on regional meteorology. Many existing studies have indicated that the effect of fire on surface albedo is complex and depends on combustion completeness, fire intensity, pre-fire land cover structure，underlying soil reflectance (Roy and Landmann, 2005). Based on satellite retrievals, the surface albedo declines in June 2012 show obvious spatial heterogeneity (Fig. R1), and have a larger decline margin in Province Anhui (AH) than Jiangsu (JS). It is relatively consistent with the two apexes on the frequency distribution of albedo decline (Fig. 3). And the burning in AH was indeed more severe, which is consistent with the distribution of fire detection by satellite. In the numerical experiments，the fire prone areas were extracted out by setting a threshold number of fire counts in a grid unit.

To further understand the impact of the albedo decline values on the conclusions, three experiments are supplemented: On the one hand, to compare with the ALB-0.1 run (namely the ABD run in manuscript), the decline margin in run ‘ALB-0.05’ and ‘ALB-0.08’ are set to -0.05 and

-0.08, respectively. One the other hand, decline values in run ‘ALB-Δ modisalb’ were set by the difference of MODIS-detect surface albedo (MOD09A1) on 24 May and 17 June directly. The distribution of albedo change is shown in Fig. R2. It is clearly demonstrated that the declines of most areas in northern AH, featuring the highest fire density, are even far more than 0.12. In addition, albedo changes in adjacent areas are less than 0.06, or have not been extracted as fire prone area for higher threshold of fire counts density here.

Results of these runs and site observations were compared. In Fig. R3a, both ‘ALB-0.1’ and ‘ALB-Δ modisalb’ perform well at Bengbu, especially in the evening. In contrast, by comparing ‘ALB-0.1’, ‘ALB-0.08’ and ‘ALB-0.05’, we can find reverse increment in the evening, which can be explained by the longwave radiation balance in the evening. As for the surrounding areas with slight burning (Fig. R3b), warmings at noon have a positive increase among ‘ALB-0.05’, ‘ALB-0.08’ and ‘ALB-0.1’. And the ‘ALB-Δ modisalb’ with the direct albedo difference of pre-fire and post-fire even performs better, owing to the better characterization of surface albedo decline, in aspects of both spatial distribution and scope in severely burned area. Your valuable and thoughtful comment led me to explore more deeply about the heterogeneity of surface albedo change and the albedo change set in sensitivity tests. Related discussion will be modified in the revised manuscript. In addition, more descriptions on the scope and distribution characteristics of surface albedo decline will be added in the revised manuscript.

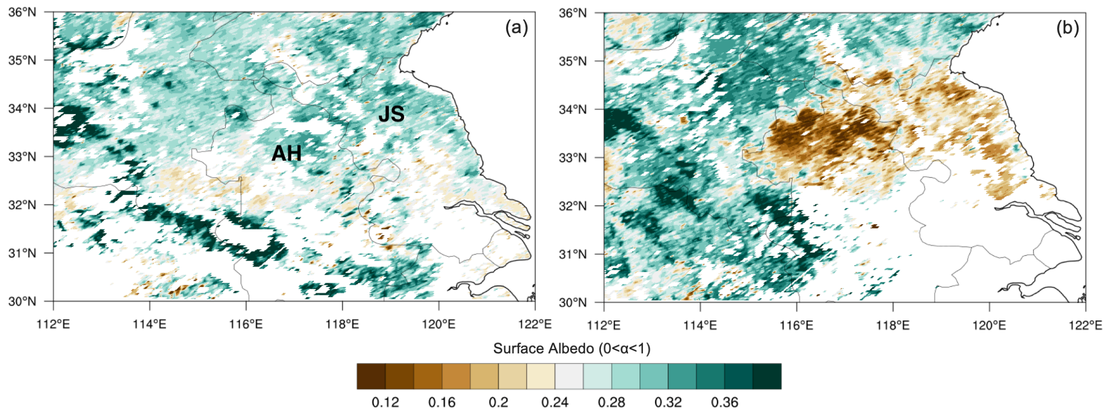

Fig. R1 Distribution of surface albedo by MODIS band2 on **(a)** 24 May, **(b)** 17 June in 2012. Two provinces Jiangsu (JS) and Anhui (AH) are marked respectively.

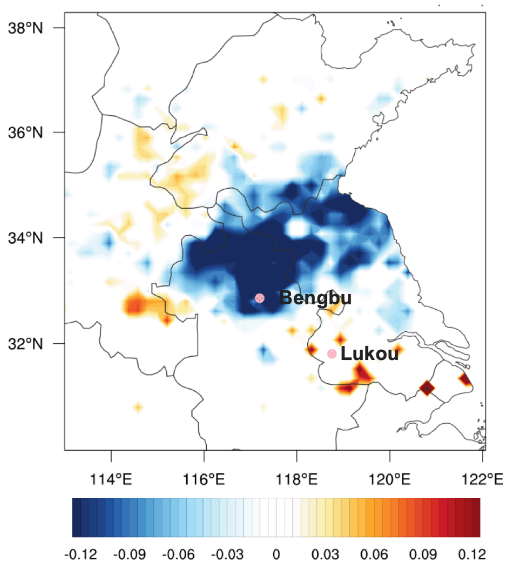

Fig. R2 Distribution of surface albedo change set in experiment 'ALB-Δ modisalb '.

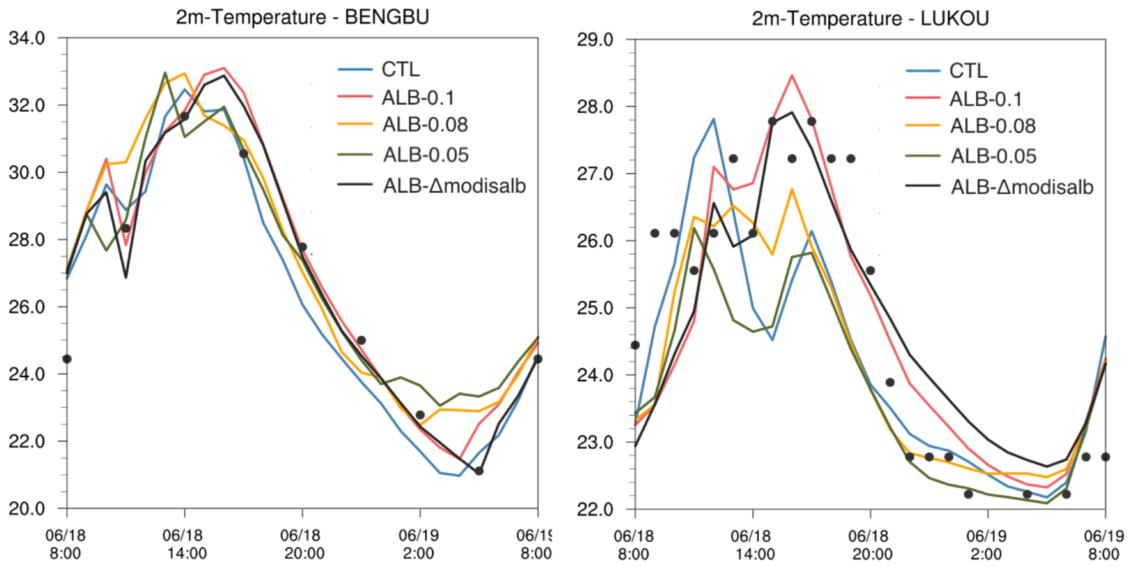

Fig. R3 Simulated and observed 2-m temperature at meteorological stations: **(a)** Bengbu and **(b)** Lukou.

2. Page 6, line 190-191: why abnormal signal of surface warming happens in the down-wind direction? Is fire induced surface warming treated in your model?

Response: Thanks for your suggestions. Observational evidences show that signals of surface warming exists over fire-prone area, and even extend to downwind areas. The decreased surface albedo over fire prone areas can make the surface absorb more solar radiation and then enhance air temperature through vertical mixing (Fig. R4a). Then, the downwind areas are influenced by warm advection transportation. It is consistent with the abnormal warming signals in Fig. R4b.

The heat released by fire was not treated in the model based on some researches related to the burning characteristics and fire radiative power. For this biomass burning case, during which the burned biomass is winter wheat straw (Li et al., 2016; Huang et al., 2012b). In East China, especially in the northern Jiangsu and Anhui province, most fires of wheat straw are characterized by short-lived smoldering (Fig. R5) (Huang et al., 2012a; 2016). When crops are harvested by hand, the residue is often burned in piles that may smolder, together with short-lived burnings of wheat roots over the surface. The combustion process of smolder is not as full as flaming. Correspondingly, the fire radiative power (FRP) between this straw burning is much weaker than the grassland fire in North America (Fig. R6) based on MODIS Thermal Anomalies Product (MOD14A1 and MYD14A1). The relationship between fire radiative power and fire size varies at a global scale (Laurent et al., 2019). As shown in Fig. R6, the average maximum FRP for the most severe area in this burning case is almost less than 0.02 kW/m^2. As for radiative effects, the maximum of solar shortwave radiation reaching the surface in summer can be over 1kW/m^2, and the sunshine duration is about 11~12 hours (Wallace and Hobbs, 2006). Moreover, surface albedo decline in this place can be over -0.12, as aforementioned (Fig. R2). The energy disturbance aroused by surface albedo decline can be much larger than this kind of straw burning. Therefore, the fire induced warming was not treated in the model.

In addition, the observational signals not only exists on the burning days, but also on the following days (Fig. R7). According to the time series of fire counts (Fig. 1a), the burning had already gone to the end during 16th to 18th June, but surface warming signals still exists over both local and downwind area. The decreased surface albedo can maintain for a period of time before char materials are removed by weathering and new-generated vegetation. But the heat from smoldering cannot last as long. The abnormal warming can be explained by direct radiative effect of decreased surface albedo and the influence of warm advection.

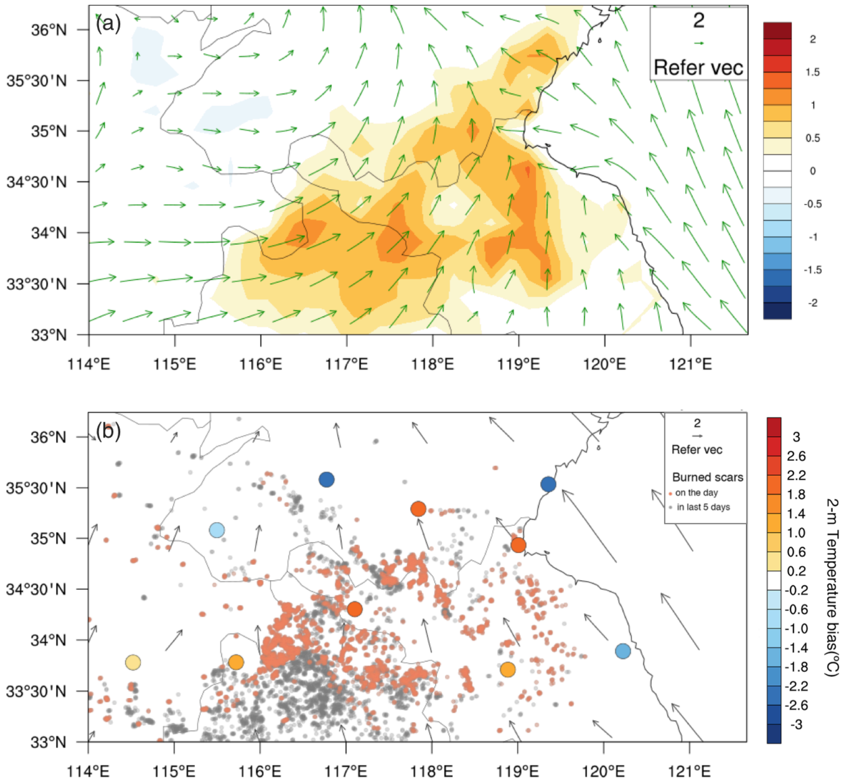

Fig. R4 (a) Temperature bias at 2 m height between FNL data and station observations (OBS), and the 'burned scars' on 13 June 2012 at local time 20:00. Bias is defined as value of OBS minus FNL. Grey arrows mark the 10-m wind field in FNL. Grey dots mark the 'burned scar' (defined as accumulated fire counts in the past 5 days) while orange dots mark fire counts on the day. **(b)** Temperature bias at 2 m height between CTL run and ABD (ALB- ∆ modisalb) run, and the 10-m wind field in ABD run, on 13 June at 12:00.

Fig. R5 A photo showing the field burning of wheat straw in Suixi county (33°54′37″N, 116°45′46″E), northern Anhui province on June 14, 2013.

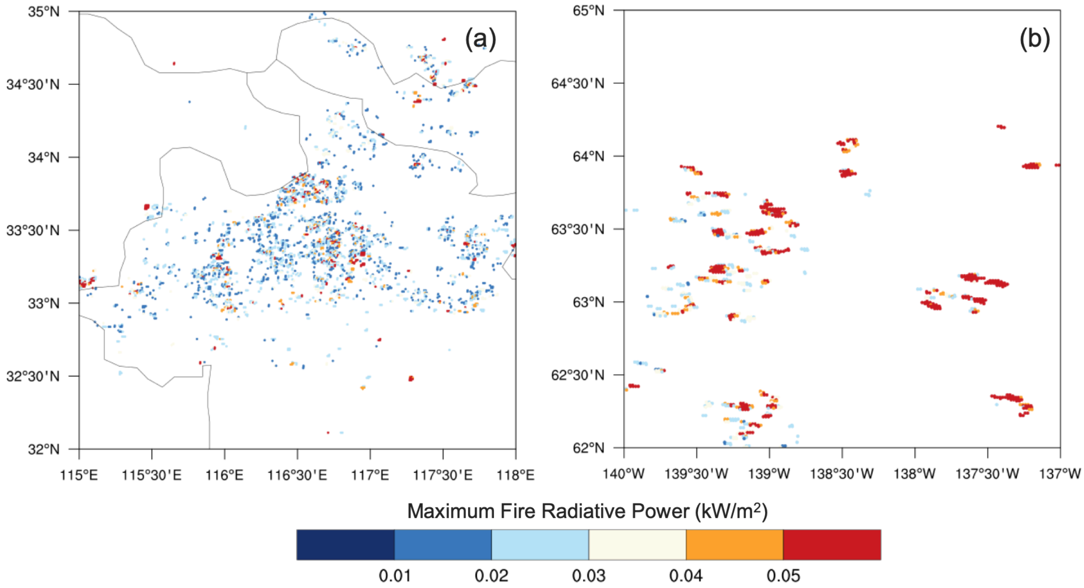

Fig. R6 MODIS-detect maximum fire radiative power (FRP) during crop straw fire in northern Anhui on 9 June 2012 and grassland fire in North America on 3 July 2004.

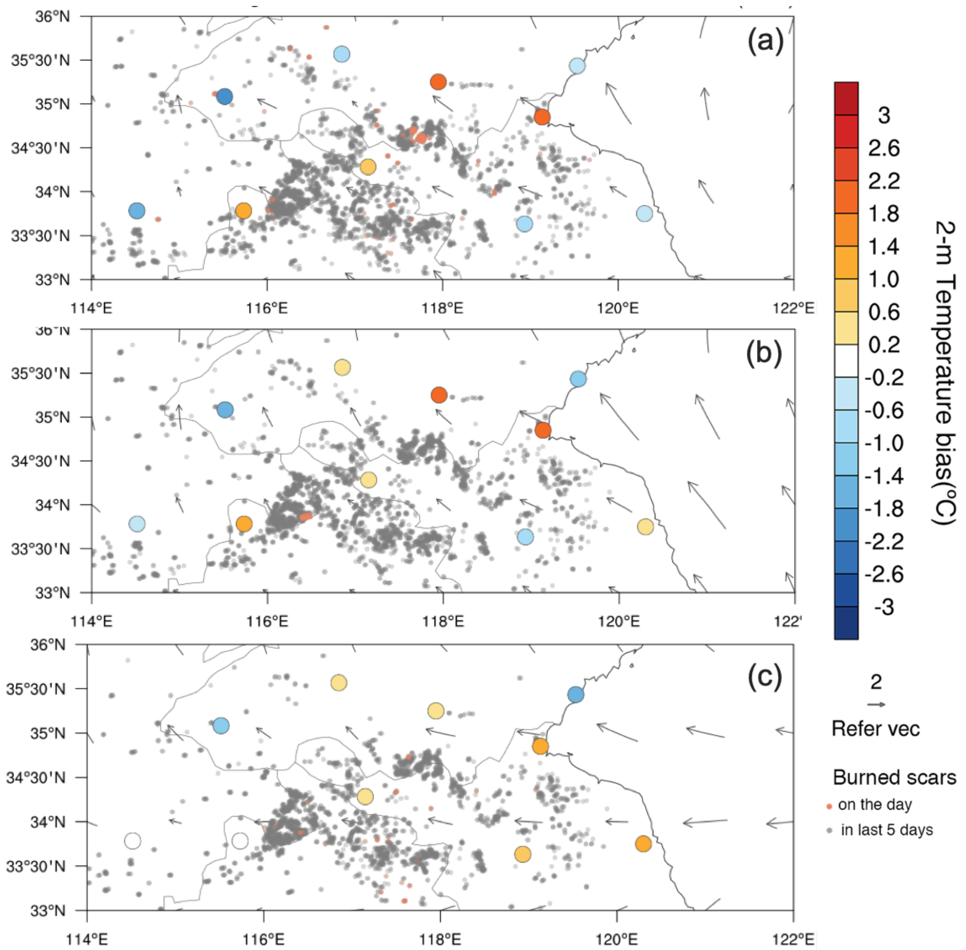

Fig. R7 Temperature bias at 2 m height (fill-coloured circles) between FNL analysis data and station observations (OBS) in zone YHR **(a)** on 16 June 2012, **(b)** on 17 June 2012 and **(c)** on 18 June 2012, at local time 20:00. Bias is defined as value of OBS minus FNL. Grey arrows mark the 10-m wind field in FNL. Grey dots mark the 'burned scar' (defined as accumulated fire counts in the past 5 days) while orange dots mark fire counts on the day.

Minor Suggestions：

Page 1, line 8: impacts air quality

Page 1, line 13: show that surface

Page 1, line 15: show a positive deviation

Response: Accepted. Great thanks for your carefulness.

Page 4, line 102: meteorological observations from

Response: Accepted.

Page 7, line 221: "and the behind physical images has" to "and the underlying physical images have not"

Response: Accepted.

Page 7, line 222-224: please rephrase this sentence to make it easier to read

Response: Accepted. This sentence will be modified in the revised version.

Page 9, line 262: change the sentence to "A typical and severe burning episode in 2012 was chosen as the study case."

Response: Accepted.

Page 9, line 279: naturally induced

Response: Accepted.

References

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