Response to the comment by Anonymous Referee #2

(1) Introduction part: It is expected that introduction part should shows the purpose of this study, though peers' studies are listed, what is the new science in this study is not clear.

The revised introduction part is as follows:

This study identifies the influences of biomass burning on East Asia during intense burning episodes by employing a regional "one atmosphere" model, the Community Multiscale Air Quality Modeling System (CMAQ) (Byun and Schere, 2006; Byun and Ching, 1999). Two different biomass burning emission inventories were evaluated. Model simulations were compared with satellite observations and in situ ground measurements to validate the model, including $PM_{2.5}$, trace gases and aerosol optical depths. The long-range transport and vertical transport patterns of particles and trace gases were visualized and quantified by conducting scenario simulation of cutting off the biomass burning emission.

(2) Line 171: During converting carbon emission into more detailed pollutant species, only Andreae and Merlet (2001)'s emission factor are applied. This step is quite critical for later results. Have other EF methods been considered?

We chose emission factors from Andreae and Merlet (2001) because this paper is highly cited (around 1200 times) and widely used in research that modeling biomass burning. By using the emission factors from Andreae and Merlet (2001), it is easy to compare with research results by using the same emission factors. We agree with the reviewer that some other EFs should be considered. More sensitivity runs regarding different EFs will be conducted to quantify the ranges of biomass burning impacts.

(3) Line 202: For other researchers to repeat this study, please introduce this interesting part with more detail. Computing plume vertical dispersion, exhaust temperature might be necessary, how to define the exhaust temperature in this study?

In this study, the potential plume height is computed from the buoyant efficiency at different hours and different fire sizes. Usually, larger fire sizes and fire occurrences around noon time caused higher exhaust temperature, hence inducing higher plume height. Five plume classes were defined with increasing potential plume heights to reflect the range of “heat release” as shown in the lookup table below. Plume bottom heights and percent of the plume fumigated to the first layer of the atmosphere were also developed for the five plume classes.

Table 10: Fire-Related Parameters as Function of Fire Size Classes

Class	1	2	3	4	5
Size (virtual acres)	0 – 10	>= 10 – 100	>= 100 – 1,000	>= 1,000 – 5,000	>= 5,000
BE_{size}	0.40	0.60	0.75	0.85	0.90
Ptop max (m)	160	2,400	6,400	7,200	8,000
Pbot max (m)	0	900	2,200	3,000	3,000

A table of hourly buoyant efficiency values was derived in the table below:

Table 11: Buoyant Efficiency as Function of Hour of Day

Hour	1	2	3	4	5	6	7	8	9	10	11	12
BE_{hour}	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.06	0.10	0.2	0.4

Hour	13	14	15	16	17	18	19	20	21	22	23	24
BE_{hour}	0.7	0.8	0.9	0.95	0.99	0.8	0.7	0.4	0.06	0.03	0.03	0.03

Equations were used to calculate Ptop and Pbot as a function of time of day and size of the fire (expressed in terms of virtual acres). Note that the calculations used an hourly value for buoyant efficiency (Table 11) and heat release value based on fire size, also referred to as normalized fire growth.

The hourly top of the plume was calculated as follows:

$Ptop_{hour} = (BE_{hour})^2 * (BE_{size})^2 * Ptop_{max}$

Where: BE is the buoyant efficiency looked up from the hourly or size class tables. The hourly bottom of plume was similarly calculated as:

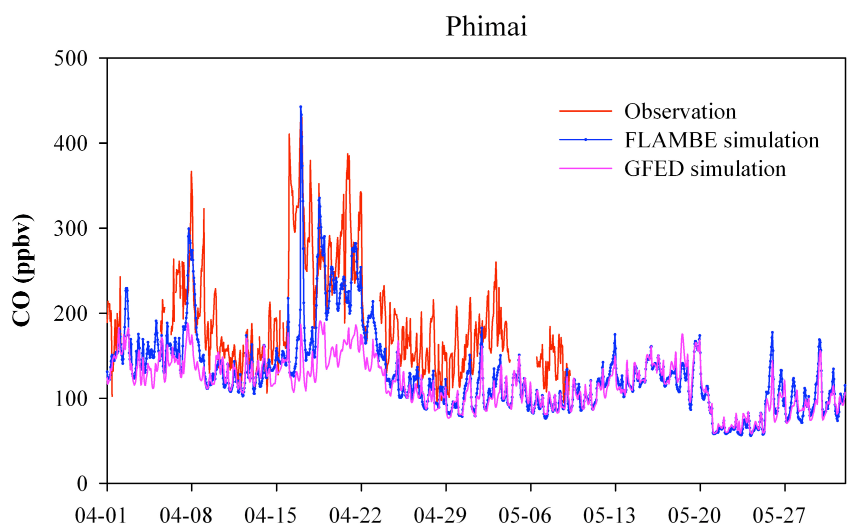
$Pbot_{hour} = (BE_{hour})^2 * (BE_{size})^2 * Pbot_{max}$

All detailed descriptions could be found in the report of “2002 Fire Emission Inventory for the

WRAP Region – Phase II" prepared by Air Sciences, Inc.

(4) Figure 2, font size and font name are so different with others. Also to work better with the caption, please use Gregorian date instead of Julian date. Fractional bias and gross error look better when peaks are better predicted. Some average value comparison should be give? Only then we shall know which emission inventory is better.

Yes, we now have re-plotted the figure to change the font size, font name and dates as shown in the figure below. In the revised manuscript, we have added more statistical analysis in the discussion, e.g, average values. The discussion related to Figure 2 is now re-written as below: "The average CO concentration measured at Phimai was 192.9 ppbv during the study period as shown in Figure 2. By using two different biomass burning inventories, i.e, FLAMBE and GFED, the correspondingly simulated average CO concentrations were 143.9 and 124.1 ppbv, respectively. Although both emission inventories showed underestimation, simulation using FLAMBE was undoubtedly more close to the real atmosphere. As shown in the figure, simulation based on FLAMBE agreed well with the surface measurements and successfully captured the peak values from 27 to 28 March and 13 to 14 April. While the simulation based on GFED emissions obviously underestimated the CO concentrations during the peak periods by as much as 200 to 300 ppbv. This comparison indicated that the FLAMBE emission provided a better representation of biomass burning sources in our model than did the GFED emission."



(5) Figure 4, it is "unit less". Line 325-326, calculating AOD with CMAQ, IMPROVE is used,

since Mie theory also provide light extinction data, why not use it?

Thanks for pointing out the mistake in Figure 4, we have changed the caption in the revised figure. The choose of calculating AOD using the IMPROVE algorithm is based on various research (Daniela et al., 2009; Park et al., 2011; Roy et al., 2007), where they have performed relatively good agreement with various datasets, e.g, satellite, AERONET, Lidar, by using CMAQ. The extinction coefficient based on the Mie theory is function of ambient aerosol characteristics such as index of refraction, volume concentration and size distribution. As the particle size distribution information is often not available, we think it is maybe not very proper to use the light extinction data provided by Mie theory. While the IMPROVE algorithm has been testified by various research (e.g, in references above), thus we tended to calculate the aerosol optical properties by using IMPROVE protocol in this study.

References:

Daniela Viviana Vladutescu, Erika Garofalo, Barry Gross, Fred Moshary, Samir Ahmed, 2009. CMAQ validation of optical parameters and PM2.5 based on lidar and sky radiometers. A sensitivity study of optical parameters to hygroscopic aerosols. Lidar Remote Sensing for Environmental Monitoring X, edited by Upendra N. Singh, Proc. of SPIE Vol. 7460, 74600H. doi: 10.1117/12.826248.

R. S. Park, C. H. Song, K. M. Han, M. E. Park, S.-S. Lee, S.-B. Kim, and A. Shimizu, 2011. A study on the aerosol optical properties over East Asia using a combination of CMAQ-simulated aerosol optical properties and remote-sensing data via a data assimilation technique. Atmos. Chem. Phys., 11, 12275–12296, doi:10.5194/acp-11-12275-2011.

Roy, B., R. Mathur, A. B. Gilliland, and S. C. Howard, 2007. A comparison of CMAQ-based aerosol properties with IMPROVE, MODIS, and AERONET data, J. Geophys. Res., 112, D14301, doi:10.1029/2006JD008085.

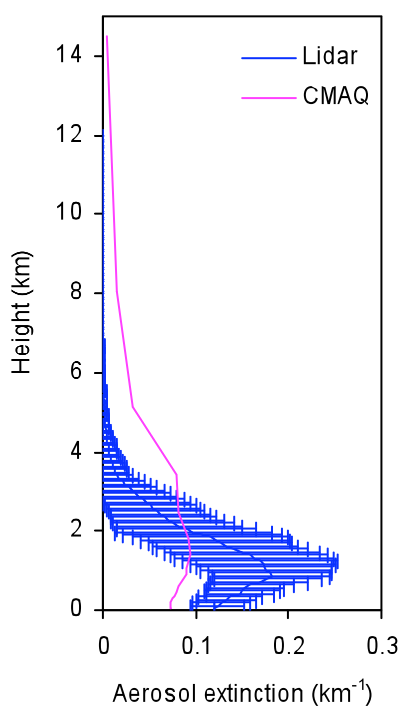
(6) Section 4.3 it is not clear and concise. It is long, and I do not know where Fujian, Jiangxi and Hunan provinces are. One more figure describing pollutant transporting path might be helpful.

We have rephrased this section and divided it into two sub-sections to make it clearer for the readers. And we have added the key locations of provinces (e.g, Fujian, Jiangxi and Hunan) onto

Figure 1 to make the manuscript more readable and visualized.

(7) In Figure 7, it can be seen that pollutant is vertically transported as high as 3 km. This pollutant vertical profile seems very unphysical. Is it possible to compare model result with sounding data.

Now we added the comparison between model result and Lidar. During the BASE-Asia field campaign, NASA operated a Micro-Pulse Lidar (MPL) in Phimai, which provided vertical distribution of aerosol. The figure below shows the comparison between measured and modeled aerosol extinction coefficient (km^{-1}). The modeled aerosol extinctions were converted from the same IMPROVE algorithm as used in the other parts of this study at each layer (total 19 layers). As shown in the figure, the model could generally capture the aerosol vertical distribution. Both lidar and model presented a decreasing trend of aerosol extinction coefficient from the ground to the high altitudes. However, there was underestimation below the PBL (i.e, around 2km), which could be due to underestimation of local anthropogenic emission near the ground. Some overestimation was observed at higher altitudes, which could be due to the problem of the allocation method of biomass burning emission. Generally, the vertical distribution of aerosol was reasonably well simulated, implying that the modeled vertical results could be further utilized.



This study is quite helpful to understand biomass burning characteristic in Asia, and its transport mechanism, but the authors failed to calculate uncertainties of biomass burning.emission factors, biomass burning emission inventory, biomass burning emission spatial and temporal profile. Emission temporal and spatial profile could be compared with MODIS infrared channel. Mont Carlo method might be helpful to evaluate total emission amount.

In this study, we mainly focused on modeling the impact of biomass burning on the Southeast Asia region with the application of a high resolution biomass burning emission inventory. The uncertainties of biomass burning spatial and temporal profile are related with the uncertainties of satellite sensors, which are really not the scope of this study. For the Southeast Asia region, FLAMBE mainly derived from the MODIS temperature anomaly (fire), thus the temporal and spatial profile of FLAMBE emission should be very consistent with the MODIS infrared channel. We agree that Monte Carlo method is needed to evaluate total emission amount. However, hundreds of runs generated from Mont Carlo would definitely consume computation over 1 million hours in a regional air quality model. We hope that the reviewer could understand this.