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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Identifying biomass burning impacts on air quality in Southeast Texas 26–29 August 2011 using satellites, models and surface data" *by* David A. Westenbarger and Gary A. Morris

David A. Westenbarger and Gary A. Morris

david.westenbarger@tceq.texas.gov

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Interactive comment on "Identifying biomass burning impacts on air quality in Southeast Texas 26–29 August 2011 using satellites, models and surface data" by David A. Westenbarger and Gary A. Morris

Anonymous Referee #2 Received and published: 13 March 2018

This paper attempts to show the impacts from biomass burning on SE Texas (Houston area) from multiple biomass burning events in August 2011. The stated goals are to

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demonstrate an impact on surface O3 from the bb emissions. The analysis is a hodgepodge of surface observations, models and satellite data that tries to show the link with surface O3. Unfortunately none of these really convincingly link the bb emissions to O3. One can find many bb events, satellite data and even trajectories that purport to show a link, but often the actual concentrations are very low. How can we say that high O3 in Houston (a very high O3 city) was due to bb emissions?

Author response: We have compiled multiple data sources that we believe have made a compelling case, adding ozonesonde data in the revised version. See response to Reviewer #1.

What are the concrete pieces of evidence that support transport of smoke into the city and how much was O3 enhanced by this process?

Author response: Satellite instruments, surface measurements and ozonesonde profiles. In the original manuscript, we provided one estimate of the enhancement by comparing surface O3 concentrations from prior days to one of the days in question (26Aug11) to calculate an approximate O3 enhancement of 63-71 ppb. A second approach, not in the original version but integrated into the revised manuscript, is provided by examining data from an ozonesonde flight from the University of Houston on 29Aug11, the second day of concern during the period. From Figure R-1.1 below, we identify a surface O3 enhancement of about 76 ppb relative to the lower free troposphere (subtract the O3 mixing ratio of 136 ppb in the boundary layer from the O3 mixing ratio of 60 ppb in the lower free troposphere at about 3.5 km altitude). This difference represents a surface enhancement substantially in excess of a typical bad air day in the HGB region, as supported by Figure R-1.2 below which plots these computed gradients between the boundary layer and lower free troposphere for all 600+ soundings in the Houston region from 2004 to 2016. This plot shows that the enhancement observed on 29Aug11 is quite exceptional over a considerable historical record (> 1 decade), as it would not even appear on this chart, which ranges from -40 to +40 ppb enhancements/disenhancements. This second approach strengthens the prior result as the computed value (76 ppb) is substantially similar to the first (63-71 ppb), which appears in the original version of the paper.

So this analysis (and manuscript) needs a major redo before it can demonstrate something useful. To guide this, I suggest the authors consider, at minimum, these questions:

1. What is the proof that PM, O3 or its precursors (CO, VOCs and/or NOx) were transported into Houston at that time?

Author response: The authors believe the evidence from satellite instruments and backward trajectories are well-described in the paper. This evidence includes retrievals of smoke and aerosols from several satellite instruments as well as two independent sources of backward trajectories showing transport from areas with many active fires. We also put surface monitor data in context to show that during the event, the HGB environment appears different than typical.

2. Are there specific tracers that could be used to identify smoke influence at the surface (e.g. enhancement ratios, pattern of VOCs, potassium or other bb tracers, etc). Author response: Unfortunately, many of the best tracers (e.g., PAN, levoglucosan) are not available, since these generally are only measured during targeted studies using special equipment, not retrospective analyses such as this one. However, this paper does present indicators such as the ratio between fine and coarse particulate matter at the AERONET surface station and the aerosol subtype from the CALIOP instrument aboard CALIPSO. These measures support the conclusion that smoke from biomass burning was present. Other measures build upon these to suggest that this smoke contributed to O3 enhancements.

3. Does high PM prove that smoke was transported?

Author response: By itself, the presence of PM does not prove that smoke was transported. However, fine mode fraction data and the wide geographic range of affected monitors are suggestive of biomass burning influences.

4. Were PM and O3 correlated on these days or does this matter?

Author response: Typically, O3 and PM are not correlated. However, on the days in question, they were. In the HGB area, PM generally increases as the boundary layer shrinks while O3 decreases. Figure 3 demonstrates that PM and O3 increased simultaneously during the period in question. This figure also shows that PM decreased at the end of the period, though not as precipitously as O3, and that this was likely due to the change in meteorological regimes and the O3 production rate due to enhanced clouds with arrival of a cold front. Finally, Figure 3(b-1) shows that all 12 PM monitors measured PM2.5 exceeding 20 μg m-3 in the middle period, a substantial enhancement over the "before" period.

5. Why do the observations show a wide range in highest days (eg highest O3 on 8/26 and 8/29, highest PM on 8/30 and 31, highest AOD on 8/26, highest NAAPS on 9/2).

Author response: O3 photochemistry is very complex and involves many factors, including precursors, meteorology, and sunlight. Presence of precursors alone is not sufficient to lead to high O3. Also, 9/2 was strongly influenced by Tropical Storm Lee to the east of Houston.

6. If O3 was enhanced by the bb emissions, by how much and why isn't O3 enhanced on days with highest PM? Are there other factors (e.g. temp, meteorology, etc) that are needed to explain this? A few other comments: Abstract: The abstract states ". . .we examine the influence of transported emissions....on O3 and precursors. . ." But most of the analysis is focused on the satellite data and models. If the goal is to demonstrate surface impacts, the authors need to spend more time analyzing and presenting the surface data. Most of the surface data presentation uses daily means, which is insufficient to understand what is going on.

Author response: Technically, the analyses in the paper use means of daily maxima, not means alone. The authors believe examination of these observations from the high ends of the distributions are more informative. As for the amount of the O3 enhancement, we referenced 63-71 ppb in the Abstract and 70+ ppb from the new ozonesonde data.

While the introduction and background section include a lot of citations, most are 2010 or earlier. The authors need to update these citations to include more recent findings on O3 and biomass burning influence.

Author response: The references have been updated to include more recent research.

Figure 2: These demonstrate that peaks occur on random days throughout the period. It is not clear what is the connection between any of these. And none of this "proves" the presence of smoke. Figure 3: Very hard to decipher. Caption says histograms, but this figure does not show a usual histograms and the legends are hard to read (fonts too small). What are you trying to show here?

Author response: It is important to note that several time series plots in Figure 2 include multiple regions. Peaks do not align temporally because of the nature of transport timing, meteorology and recirculation influences, with LA/MS impacted first, followed by BPA then HGB. These may appear random because of the overlapping regional plots. Figure 3 has been revised to improve legibility and increase its size. Text has been revised to clearly note that each panel contains six histograms (except for Figure 3(c-3) which includes only 3) (See paragraph [9]).

Does this figure show something that is not in figure 2?

Author response: Yes. Both the time series and histograms provide important insights. However, we have revised both for clarity. The histograms demonstrate well the changing pollution regimes from before to during to after the event.

Figure 4: I think a key missing point is that fires are very often present in the Mississippi Valley. The fact that trajectories go by fires in no way proves that these fires had a

significant impact. You need a stronger case to make that claim. Is PM much higher than usual for this trajectory direction on 8/26 and 8/29?

Author response: Wind directions were highly variable on 8/26, less so on 8/29. On 8/26, winds rotated clockwise around the city before arriving at the target surface monitoring station, as backward trajectories show. So, identifying a source direction from available wind direction data is complicated. However, the below Figure R-2.1 shows wind roses for all stations in the metro area, both frequencies (left; grey rings are a frequency of 30) and peak PM2.5 concentrations (right; grey rings are 60 μg/m-3) by wind direction (binned into 16 directional bins) on each of the days during the study period. On both 8/26 and 8/29, winds arrived from many directions so there are more, shorter barbs, than on other days (left). Much higher PM2.5 concentrations are evident on the "during" days (26-30Aug) than the period "before", especially arriving from the direction of the Gulf of Mexico (generally, southeast, south and southwest). However, as noted, wind variability makes even these source directions questionable. This may be more easily detected in the tables presented in Figure R-2.2 which show frequencies (left) and daily peak PM2.5 concentrations (right) in the HGB area by day and 16 wind direction bins. In the "before" period, except for a single northerly signal, most winds arrived from southerly or nearly southerly directions and the PM2.5 contained in those parcels was relatively low. In the "during" period, winds arrived from more directions and PM2.5 concentrations were generally higher from all directions. Finally, in the "after" period, variable winds at the beginning (31Aug) became dominated by Tropical Storm Lee to the east of the HGB area, as winds shifted to almost entirely northerly or near-northerly, and PM2.5 concentrations dropped considerably.

Figure R-2.1a

Figure R-2.1b

Figure R-2.2

Figure R-2.2b

Figure 7: All models seem to have a hard time getting bb transport right and NAAPS is no exception. It's a challenging problem for many reasons. I note from Figure 2, that NAAPS predicts highest PM on 9/2, whereas in reality it occurred on 8/30. So what do we take away from this?

Author response: Models often do not match observations for a variety of reasons. Our intention in this paper was to focus on observations, while using model predictions to supplement these. The authors believe that the observations alone provide a compelling case.

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Please also note the supplement to this comment:
https://www.atmos-chem-phys-discuss.net/acp-2017-1234/acp-2017-1234-AC2-supplement.pdf

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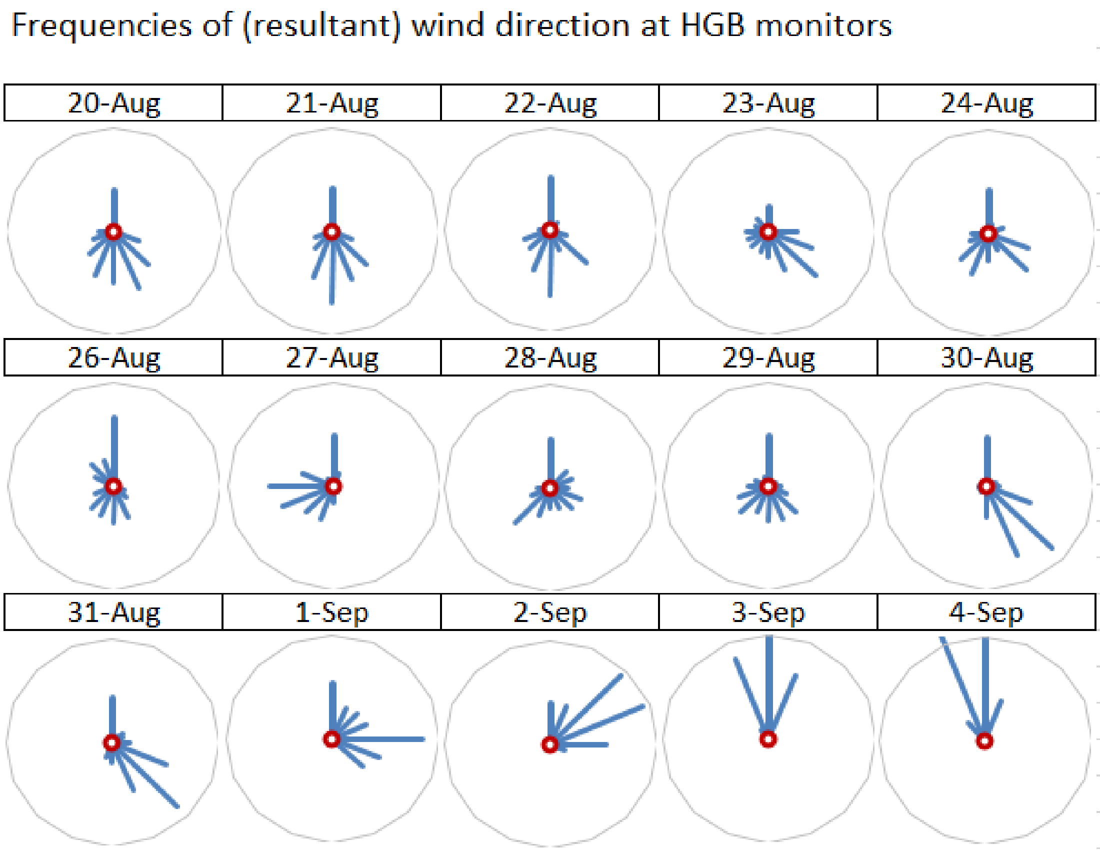

Fig. 1. Figure R-2.1a. Frequencies of (resultant) 16 wind direction bins at HGB monitors, 20Aug-04Sep11

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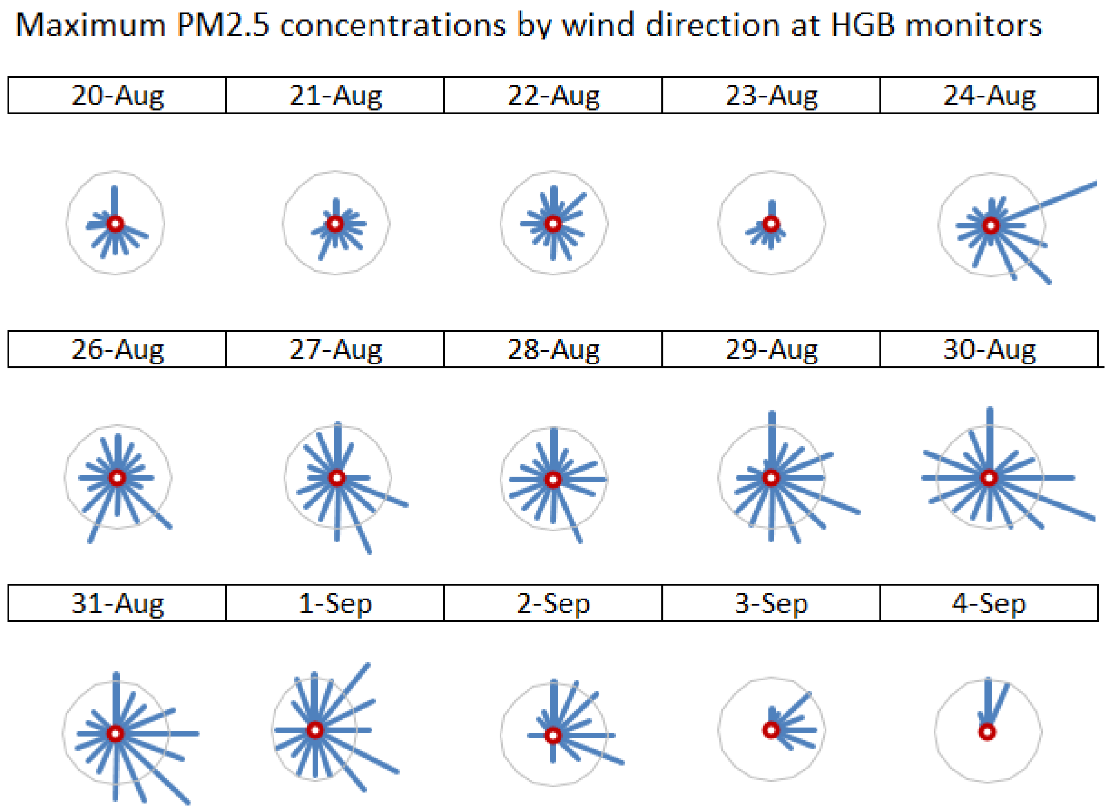

Fig. 2. Figure R-2.1b. Maximum PM2.5 concentrations by 16 wind direction bins at HGB monitors, 20Aug-04Sep11

	Aug 20	21	22	23	24	Aug 26	27	28	29	30	Aug 31	Sep 1	2	3	4
N	12	12	15	12	13	20	15	14	14	14	13	16	12	51	45
NNE			2		3	2	4	2		1	2	10	12	20	12
NE		1	3		1		1	7	1	1	4	10	28	1	
ENE		2	1		4		2	7	2	3	3	10	28		
E		2		0	2	1	1	5	3	3	5	26	16		
ESE	7	6	5	4	12	3	2	9	5	13	16	14	4		
SE	13	14	14	9	15	5		9	11	26	26	12	1		
SSE	18	15	7	10	6	10	2	7	10	22	15				
S	15	21	20	14	8	11	5	6	10	9	6	1			
SSW	14	14	13	11	13	9	10	9	8	1	5				
SW	9	7	8	15	11	9	11	14	11	2	1				
WSW	6	5	8	15	6	6	16	6	9	2	1				
W	4	2	4	7	5	2	18	4	6	2	1	1			
WNW	0		1	1	2	6	10	2	4	1					
NW	1	1	1	0	1	9	3	1	1	1	1	1		3	7
NNW			2		1	8	2	1	3		2	1		25	36

Fig. 3. Figure R-2.2a. Frequencies of (resultant) 16 wind direction bins at HGB monitors, 20Aug-04Sep11

	Aug					Aug					Aug	Sep			
	20	21	22	23	24	26	27	28	29	30	31	1	2	3	4
N	20	13	21	18	13	30	29	37	40	34	32	31	11	29	22
NNE			12		17	20	18	20		24	30	33	10	29	16
NE		11	23		11		14	24	21	22	53	34	30	0	
ENE		13	16		88		25	36	26	35	45	21	19		
E		16		20	18	17	28	28	47	46	38	33	24		
ESE	20	15	17	33	32	42	24	53	65	40	63	41	25		
SE	18	20	17	46	46	28		41	41	57	49	20	15		
SSE	19	15	22	30	34	47	39	40	31	42	28				
S	17	13	20	20	11	36	25	36	32	38	27	15			
SSW	21	22	13	16	26	26	24	31	25	24	28				
SW	18	10	15	17	16	25	24	29	28	23	21				
WSW	18	14	13	16	19	23	26	22	36	24	29				
W	16	6	18	16	19	16	24	19	37	21	27	14			
WNW	13		15	11	13	17	19	13	39	17					
NW	9	8	10	12	14	25	15	5	19	17	22	13		5	8
NNW			18		7	27	22	9	28		31	15		12	13

Fig. 4. Figure R 2.2b. Maximum PM2.5 concentrations by 16 wind direction bins at HGB monitors, 20Aug-04Sep11

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