The Impact of Biomass Burning on air Quality and Climate over Northern Sub-Saharan Africa (NSSA)

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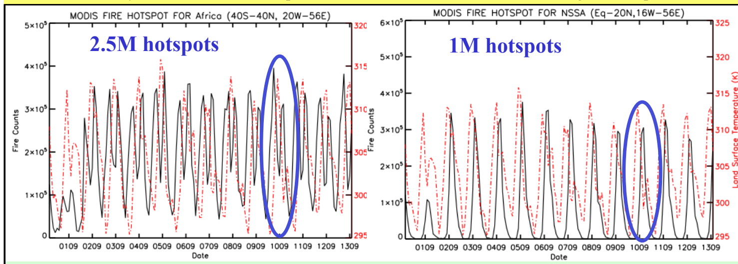
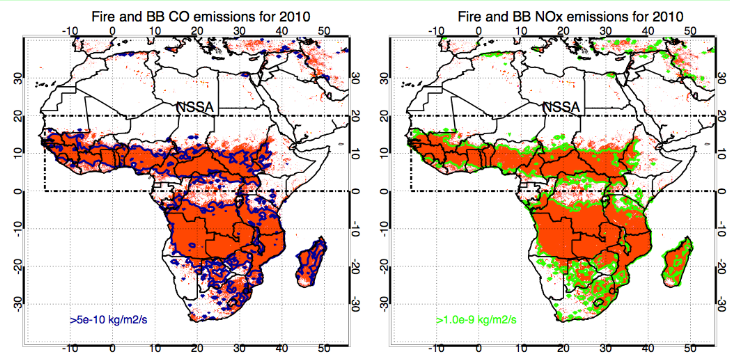
Introduction

Biomass burning (BB) is one of the major sources of troposheric ozone (O_3) precursors such as nitrogen oxides (NO_x), carbon monoxides (CO), and non-methane volatile organics compounds (NMVOCs) as well as primary aerosols such as organic carbon (OC) and black carbon (BC). These emissions do not only affect air quality and climate locally, but also on continental to hemispheric scales through long-range transport. It is estimated that about 350 Million hectares of land burn globally every year of which 54 % are in Africa. The northern sub-Saharan African (NSSA) region (0 – 20N, 20W – 55E) is known to show one of the highest biomass burning rates (in terms of per unit land area) among all regions of the world. This is due to the high concentration and frequency of fires in this region. In 2010 out of 2.5 million fires recorded in Africa more than 40 % were in the NSSA region. We discuss results obtained from NASA's Global Modeling Initiative Chemistry and Transport Model (GMI-CTM), to quantify the impact on air quality and climate triggered by global, African and NSSA biomass burning in 2010. Maximum impact of global BB on surface ozone (excess of > 12 ppbv) was observed in the NSSA region (Chad) and spans northwards to Libya whiles maximum impact of African and NSSA BB was over Angola and spans southwards to Madagascar.



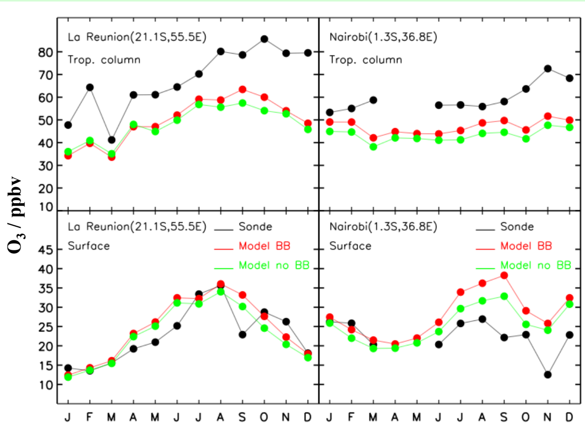
Time series of MODIS total fire counts (black) and land surface temperature from 2001 to 2013. The left panel shows hotpots sampled over the African region and the right is over the NSSA region. 2010 (blue) is among the years with the highest fire counts recorded by MODIS, in fact a total of 2.5 million hotspots were observed in Africa with the NSSA region recording 40 % of the total.



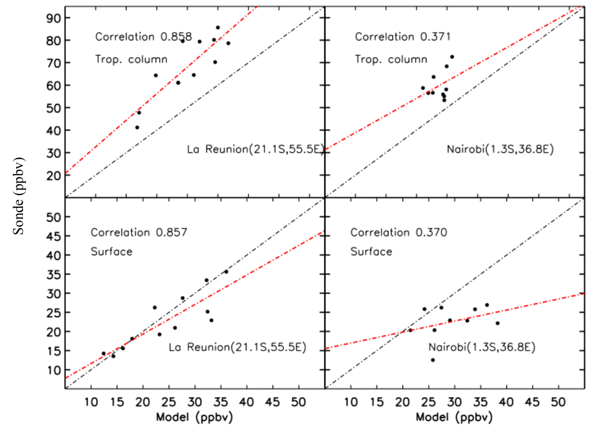
MODIS fire hotspots distribution (red) over Africa in 2010. The blue contours (left panel) and the green contours (right panel) denotes locations where biomass CO and NO_X emissions are greater than $5.0e^{-10}$ kg/m²s and $0.1e^{-10}$ kg/m²s, respectively. Most of the burning accompanied with high emissions of CO and NO_X occurred between 20N – 20S.

	GLOBAL /Tg	AFRICA /Tg	NSSA /Tg
CO	561	250.3	84.3
CH_2O	10.6	4.3	1.45
CH_4	27.6	9.7	3.32
CH_4O	15.6	6.4	2.19
CO_2	12400	6240	2100
NO_x	19.0	9.4	3.18
SO_2	3.5	1.5	0.51
OC	27.3	12.3	4.16
BC	3.6	1.7	0.60
VOC	46.7	21.0	7.13

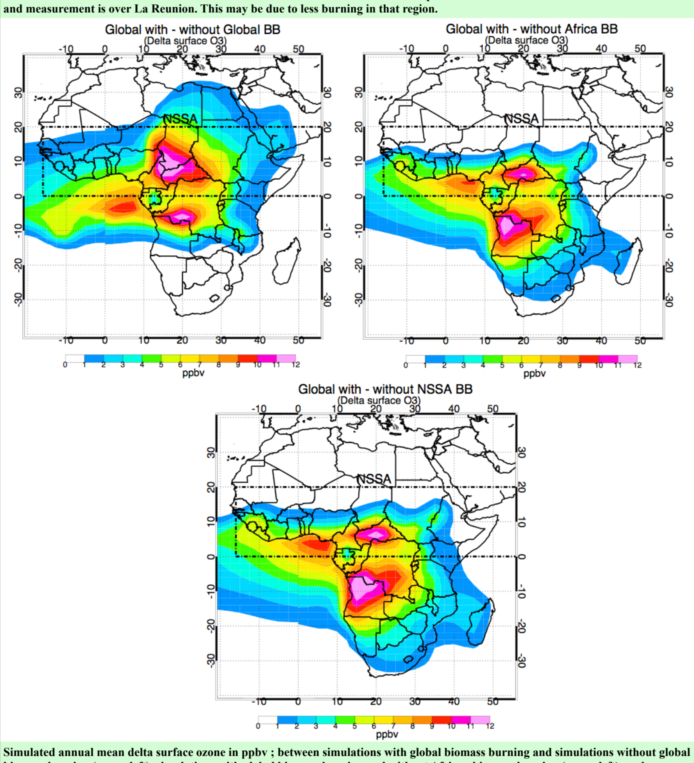
Global annual biomass emissions for selected species in 2010. Also shown are the annuals values for Africa and northern sub-Saharan Africa. In 2010 fires in Africa contributed to 40 % - 50 % of the global BB emissions while fires in NSSA contributed to 30 % - 35 % of the African BB emissions.



Comparison between simulated and radiosonde (black) monthly ozone over La Reunion (left column) and Nairobi (right column). The upper and lower rows show the average tropospheric column ozone (<150 ppbv) and surface ozone, respectively. Red and green are simulations with and without global BB. The model tends to over estimate ozone on the surface but underestimate above the surface especially in the burning season.



Monthly scatter plots of simulated (horizontal) and observed (vertical) ozone similar to the previous figure. The black diagonal broken line shows the one-to-one line whiles the red denotes the best line of fit for the data points. The best correlation between modeled ozone and measurement is over La Reunion. This may be due to less burning in that region.



Simulated annual mean delta surface ozone in ppbv ; between simulations with global biomass burning and simulations without global biomass burning (upper left), simulations with global biomass burning and without African biomass burning (upper left), and simulations with global BB and simulations without NSSA biomass burning (lower panel). Global BB emissions elevated surface ozone more than 12 ppbv over Chad and Congo. Elevated surface ozone resulting from African and NSSA BB emissions peaked over Angola and spread southeastwards to Madagascar compared to the global BB which spread northwards.

Conclusion

We have simulated the impact of global, African and NSSA biomass burning emissions in 2010 on tropospheric ozone over the African region using NASA's Global Modeling Initiative Chemistry and Transport Model (GMI-CTM). The maximum impact of global BB on surface ozone (excess of > 12 ppbv) was observed in the NSSA region (Chad) and spans northwards to Libya. For African and NSSA BB emissions the maximum impact was over Angola and spans southwards to Madagascar. We also compared simulated ozone with radiosonde measurement over Nairobi and La Reunion. The best correlation between modeled ozone and measurement was in La Reunion partly because of less burning there.

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