Effect of Biomass Burning Emissions to Air Quality in Africa

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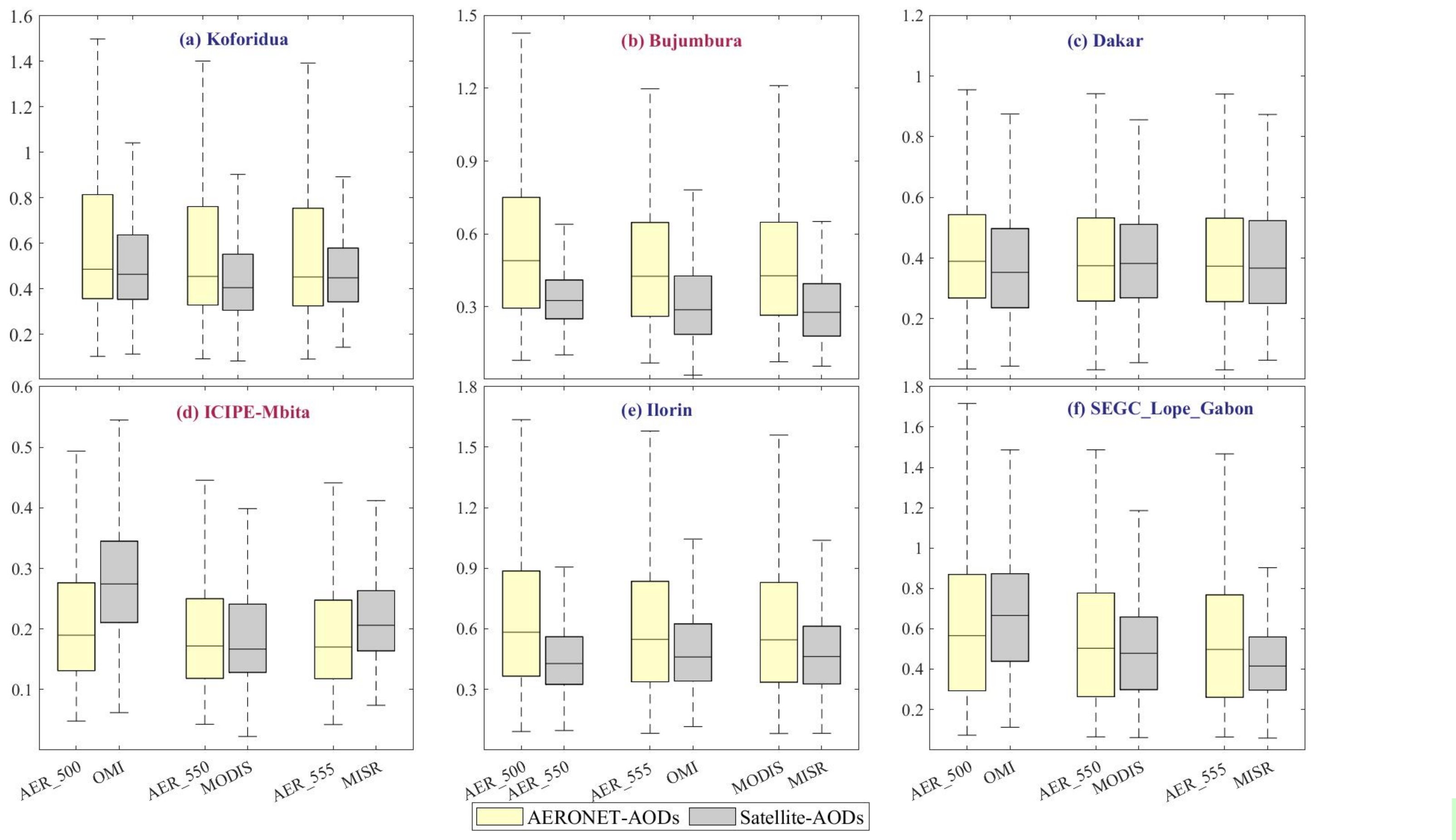
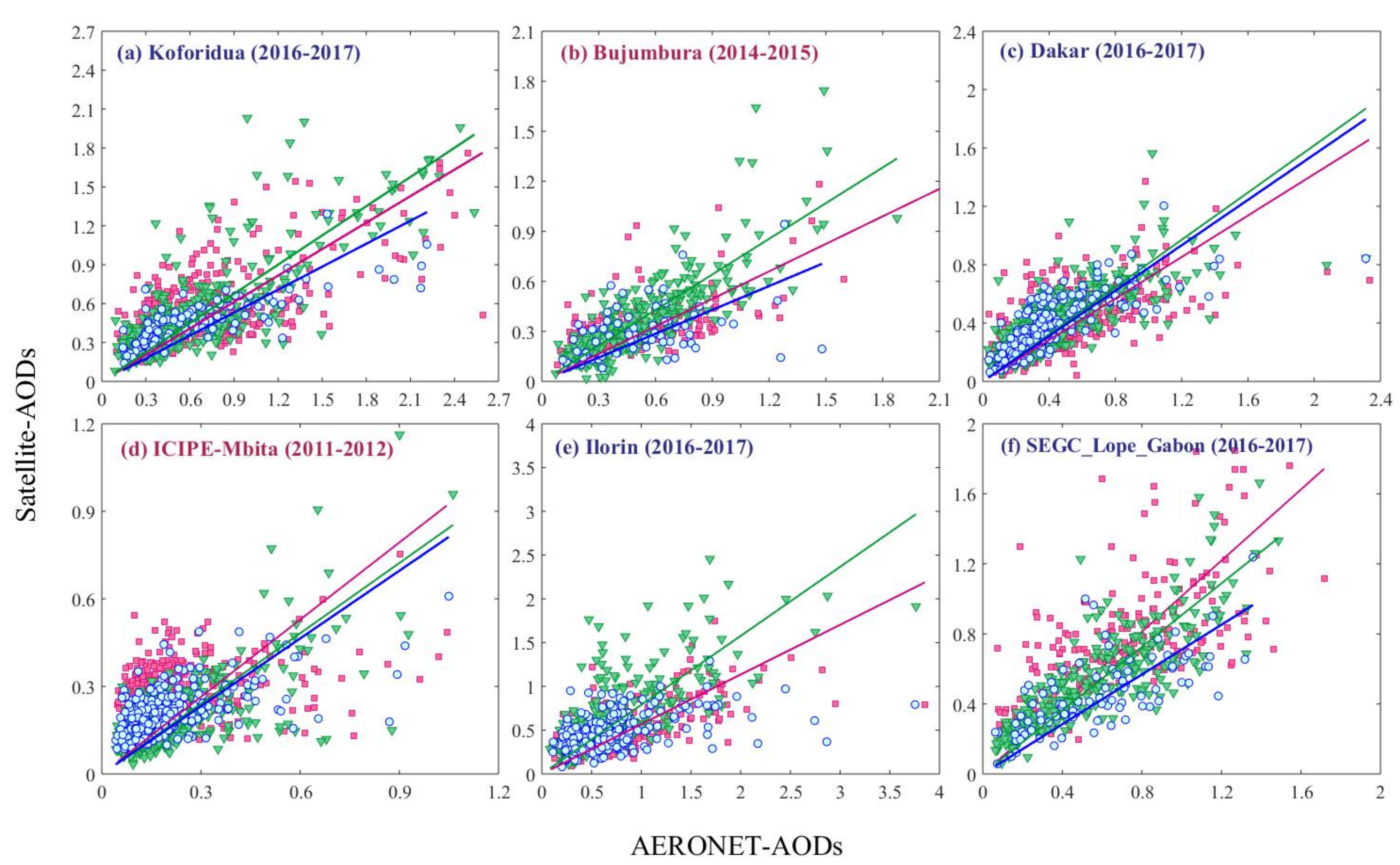
Summary

Aerosols sources from fires do not only affect air quality and human-health but also the climate. It is estimated that 54% of global biomass burning every year occurs in Africa due to high concentration and frequency of fires in this region. We report on an enhanced aerosol optical depth (AOD) captured by NASA AERONET (Aerosol Robotic Network) sun photometer located at All Nations University (ANU) in Ghana presumed to be triggered by fires. We also employ NASA's Global Modelling Initiative Chemistry and Transport Model (GMI-CTM) to quantify the contribution of the fires to air quality. We start by comparing AERONET AOD with AOD derived from three satellite sensors, the Ozone Monitoring Instrument (OMI), the Moderate Resolution Imaging Spectrometer (MODIS), and the Multi-angle Imaging Spectroradiometer (MISR) at six African AERONET stations. We also include comparison between AERONET AOD and PurpleAir PM2.5 at ANU. On average, MODIS shows a better agreement with AERONET than OMI and MISR. AERONET AOD correlation with PM2.5 at ANU is 0.61. According to the GMI-CTM simulations most of the winter biomass burning impact (92 %) is due to local burning while the summer burning impact (96 %) is due to burning from outside.

AERONENT and Satellite Comparison

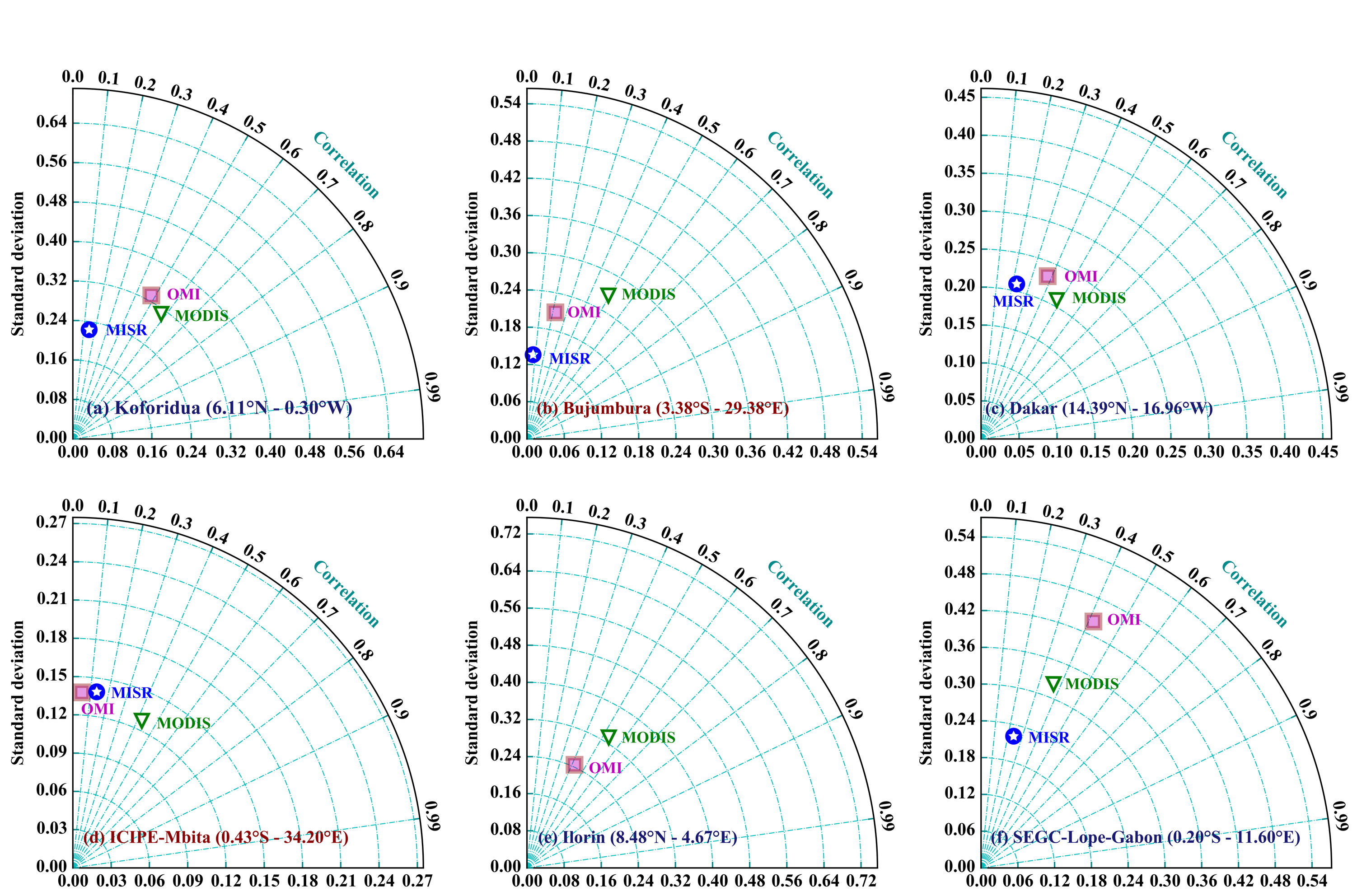


Comparison between AERONET aerosol optical depth distribution (yellow) and three satellites observation (gray) at six AERONENT stations in Africa. The three satellite instruments used are OMI, MODIS and MISR. On average MODIS shows a better comparison with AERONENT at all the stations than OMI and MISR. The Satellite data were sampled to coincide both spatially and temporally with the AERONENT observations.



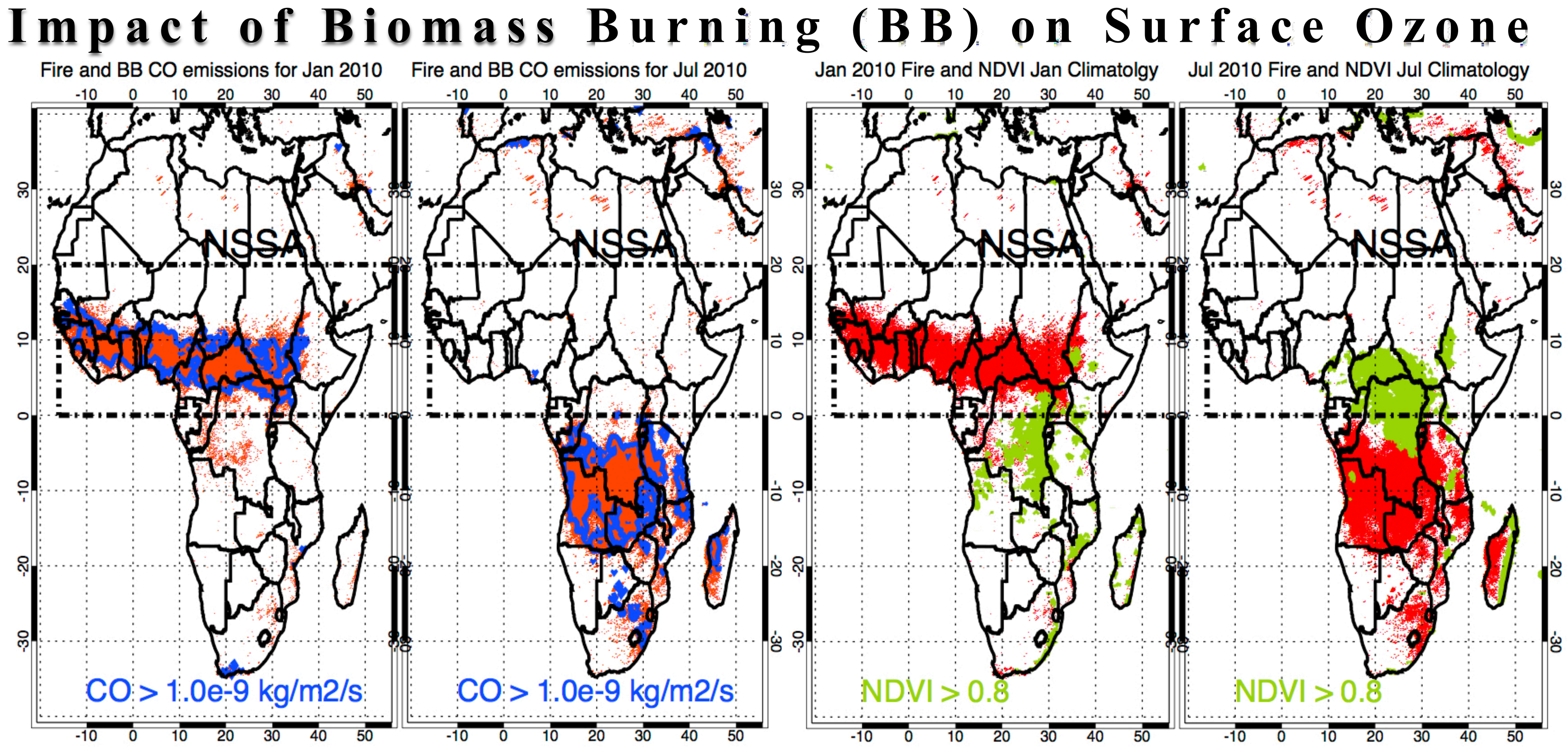
Monthly scatter plot comparison of satellite AOD (vertical) and AERONENT AOD (horizontal). MODIS is represented in green, OMI is represented in red and MISR is in blue. The plots reveal that the satellites underestimate the AOD compared to the AERONENT.

Statistical patterns evaluating satellite data against AERONET observations over six African regions for a two-year period

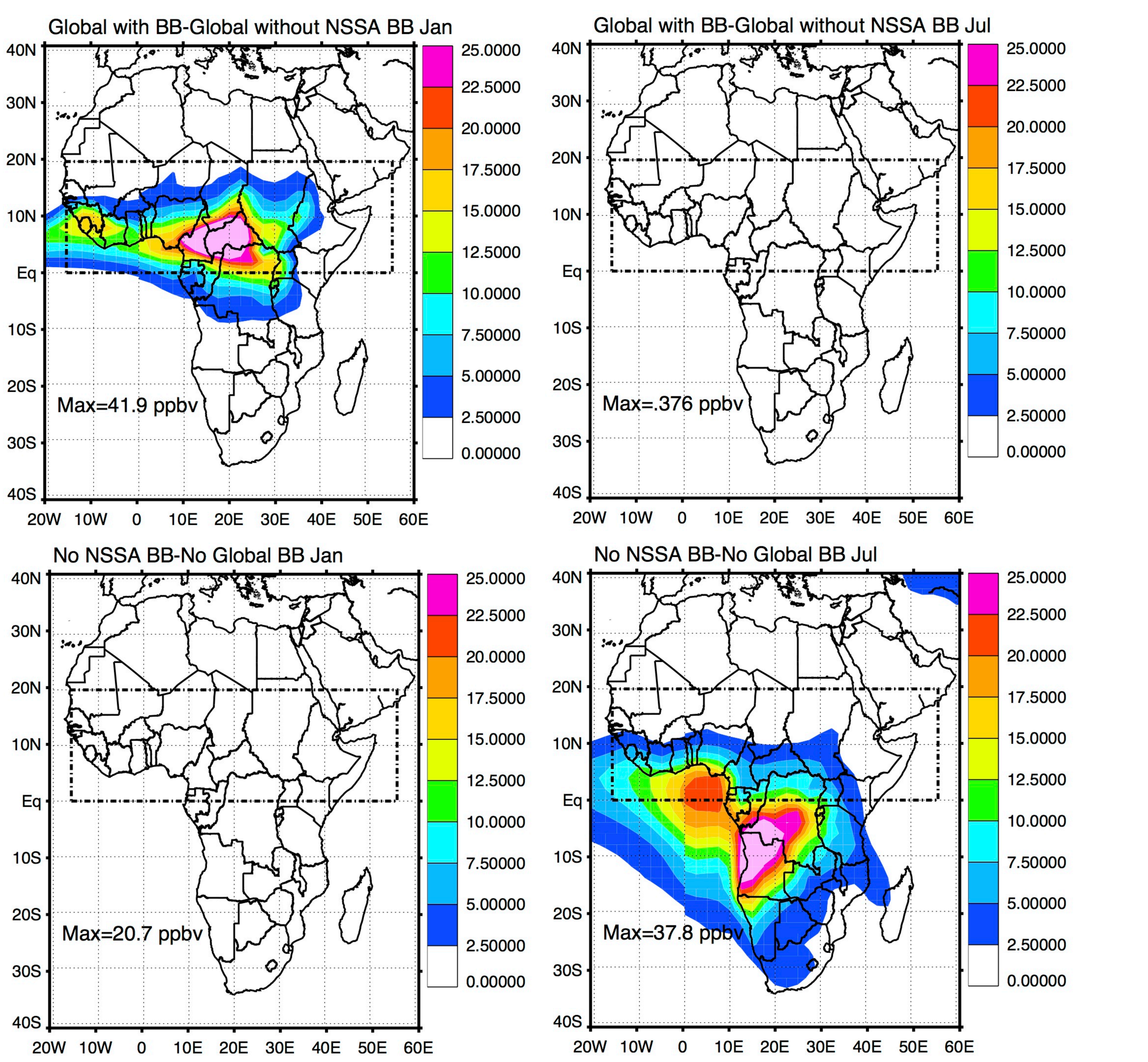


Taylor diagram comparison of satellite AOD and AERONENT AOD. The diagram compares satellite AOD and AERONENT AOD using standard deviation and correlation. The best agreement exits between MODIS and AEROENT at most of the sites.

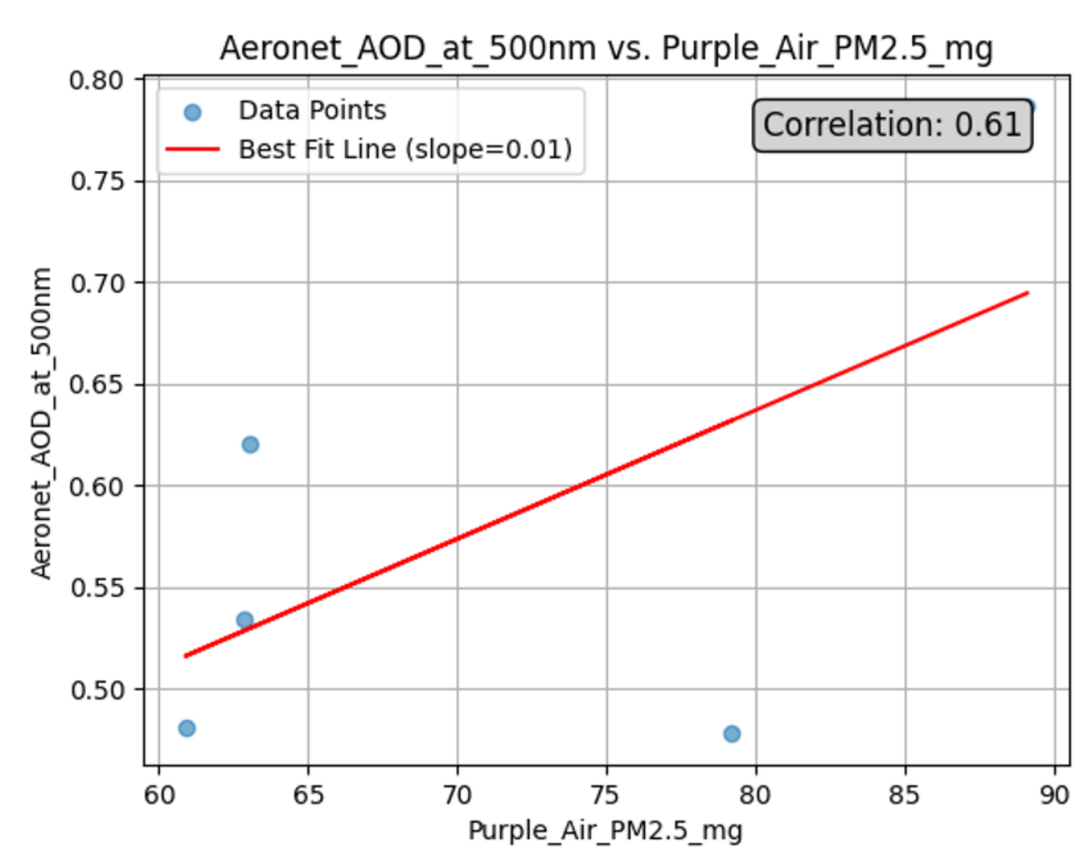
Impact of Biomass Burning (BB) on Surface Ozone



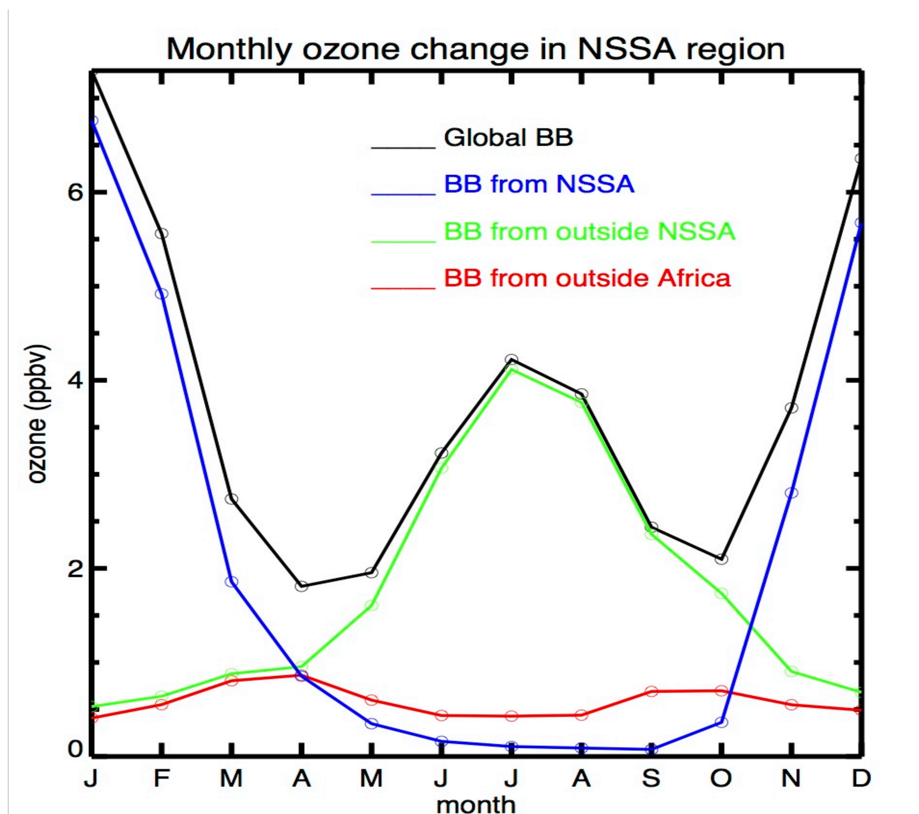
MODIS fire hotspots distribution (red) over Africa in January (first and third column from the left) and July (second and fourth column) 2010. The blue contours denote locations where biomass CO emissions are greater than $1.0e^{-9}$ kg/m^{2}s and green contours are locations with NDVI (Normalized Difference Vegetation Index) greater than 0.8. The burning is associated with high emissions of CO and low NDVI (<0.8).



Simulated January (left column) and July (right column) changes in surface ozone (ppbv) due to BB from Northern Sub-Saharan Africa (NSSA) (top row) and outside NSSA (bottom row) region. Surface ozone due to NSSA BB peaks (>41 ppbv) over Central African Republic in January but the impact of NSSA BB is almost zero in July due to little to no burning in the NSSA region during this period. Impact on surface ozone due to BB from outside NSSA peaks (>37 ppbv) over Angola in July but almost zero impact in the region during January. This is because most of the burning outside of the NSSA region occurs in July.



Monthly scatter plot comparison of AERONET AOD (vertical) and Purple Air PM2.5 (horizontal) at ANU. The comparison shows a good correlation (0.61) between the AERONET AOD and the Purple Air PM2.5



Monthly simulated changes in surface ozone averaged over the NSSA region due to BB emissions from the globe (black), NSSA (blue), outside NSSA (green) and outside Africa (red). In winter months 92 % of the BB induced surface ozone over the NSSA region is due to local burning (black and blue) with the rest mostly coming from outside Africa (green and red). In summer however 96 % BB induced ozone is due to BB from outside the NSSA region (black and green) with only 10 % (red) of that coming from outside Africa. This is because most of the burning during this period occurs outside the NSSA but within Africa.

Conclusion

We have analyzed the impact of biomass burning on air quality in the NSSA region using both model simulations and ground observation. Model simulations of 2010 reveal that most of the January BB impact (92 %) in the NSSA is due to local burning while in July (96 %) is due to burning from outside the NSSA. This is because of severe burning in the NSSA in January with little to no burning outside, and severe burning outside in July with little to no burning in the NSSA. AOD derived from ground instrument (AERONENT) across sites in Africa show a good agreement with MODIS and OMI than with MISR, also there is a good correlation between AEFRONET AOD and Purple Air PM2.5 at ANU. There is Aerosol enhancement in winter months (burning season) than summer months.

Acknowledgement:

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