

Impact of wildfires on air quality in Sub-Saharan Africa (SSA)



SUMMARY

Title

Impact of wildfires on air quality in Sub-Saharan Africa (SSA)

Key Points

- The results show that frequent wildfires, especially during prolonged dry conditions such as during El Niño events, may result in the disturbance of forest and savannah ecosystems.
- Drier conditions influenced by low latent heat flux, low precipitation and low relative humidity aid in the intensity of the fire.
- This study necessitate better regional fire management and air quality control strategies and enforcement to combat the devastating effects of wildfires, especially during DJF, JJA and SON, to preserve endangered species and habitats, promote sustainable land management, and reduce greenhouse gases (GHG) emissions.

Service

Protocol monitoring

End users

- Government agencies
- Researchers

Intermediate user(s)

- National meteorological bureaus
- National climate centers

Application(s)

Monitoring of harmful aerosols and gases from wildfires

Essential Climate Variables

—Atmosphere

- Precipitation
- Wind speed and direction
- Temperature
- Aerosols
- Carbon dioxide, methane and other greenhouse gases, precursors for aerosols and ozone

—Land

- Fire
- Land Cover
- Land surface temperature

Climate data records used

- Normalized difference vegetation index (NDVI)
- Snow cover
- Soil moisture
- Land surface temperature

Satellite observation used

- Moderate Resolution Imaging Spectroradiometer (MODIS)
- Tropical Rainfall Measuring Mission (TRMM)
- MEdium Resolution Imaging Spectrometer (MERIS)
- Advanced Very High Resolution Radiometer (AVHRR)
- The Modern-Era Retrospective Analysis for Research and Applications, Version 2 (MERRA-2)
- Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations (CALIPSO)
- Atmospheric Infrared Sounder (AIRS)

Sustainability of service (demonstration or ongoing)

Massive wildfires seem to be the “new normal” since the start of the twenty-first century, as large fires destroying property, vegetation, and infrastructure have been reported every year of this century thus far. These fires release large amounts of carbon dioxide, black carbon, brown carbon, and ozone precursors into the atmosphere. These emissions affect radiation, clouds, and climate on regional and even global scales. These emissions further affect air quality and human health. Improved monitoring of these pollutants to determine their impact on the climate, environment, and human health is important. Even more important is the construction of a long-term emission dataset.

Parameter	Instrument and modelled data	Link to data
Precipitation	Tropical Rainfall Measuring Mission (TRMM) satellite	https://giovanni.gsfc.nasa.gov/giovanni/
Black carbon extinction 550 nm, carbon monoxide concentration and latent heat flux	Modern-Era Retrospective analysis for Research and Applications, Version 2 (MERRA-2)	https://giovanni.gsfc.nasa.gov/giovanni/
Relative humidity	Atmospheric Infrared Sounder (AIRS)	https://giovanni.gsfc.nasa.gov/giovanni/
Smoke AOD	Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations (CALIPSO)	https://urs.earthdata.nasa.gov/

DESCRIPTION

Wildfires are common in many parts of the world, igniting either naturally by lightning or intentionally by anthropogenic activities such as grassland management, deforestation, and “slash and burn” agricultural practices. Although wildfires are an integral part of many terrestrial ecosystems, their frequency, intensity, and extent may be detrimental to endangered and threatened ecosystems and their resilience. Furthermore, the burning and combustion of vegetation biomass can significantly increase the global atmospheric load of trace gases and aerosols such as smoke, which impacts on air quality, the earth’s radiation budget, and visibility [18,19]. Smoke aerosols are known to perturb

regional and global radiation budgets through their light-scattering effects and influences on cloud microphysical processes. But most importantly, smoke aerosols have been linked to illnesses in human populations [21].

Other harmful constituents from wildfires are carbon monoxide (CO) and black carbon (BC). Studies have shown that BC particles can be more harmful to human health than larger particles, because they tend to accumulate in the alveolar region of the lungs. Additionally, BC has been indicated as a greater contributor to climate warming influence. Therefore, studying the sources of BC, its spatial and vertical height distribution has become the key focus in the recent literature due to devastating climate and health implications.

Satellites are great instruments to use in monitoring and characterizing wildfires. The availability of operational satellite-based products, such as land cover, temperature, rainfall, tree cover, etc., provide prospects for assessing and quantifying the impact of wildfires on the ecosystems and biodiversity. Datasets from sensors such as the Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation (CALIPSO) and reanalysis data such as the Modern-Era Retrospective analysis for Research and Applications–Version 2 (MERRA-2) have been instrumental in characterizing the spatio-temporal and vertical patterns of smoke, BC, and CO.

The SSA region covers latitudes between 25°N and 35°S as shown in Figure 1. This area is characterized by several biomes that are habitats to thousands of terrestrial mammals, birds, herpetofauna, and vascular plants. The area around the equator consists of mainly tropical forests, whilst subtropical areas consist of tropical and subtropical Savanna. Most of southern Africa consists of temperate Grasslands, Savanna, and Shrubland, as well as Mediterranean forests. Parts of the SSA region also consists of deserts and Xeric Shrublands.

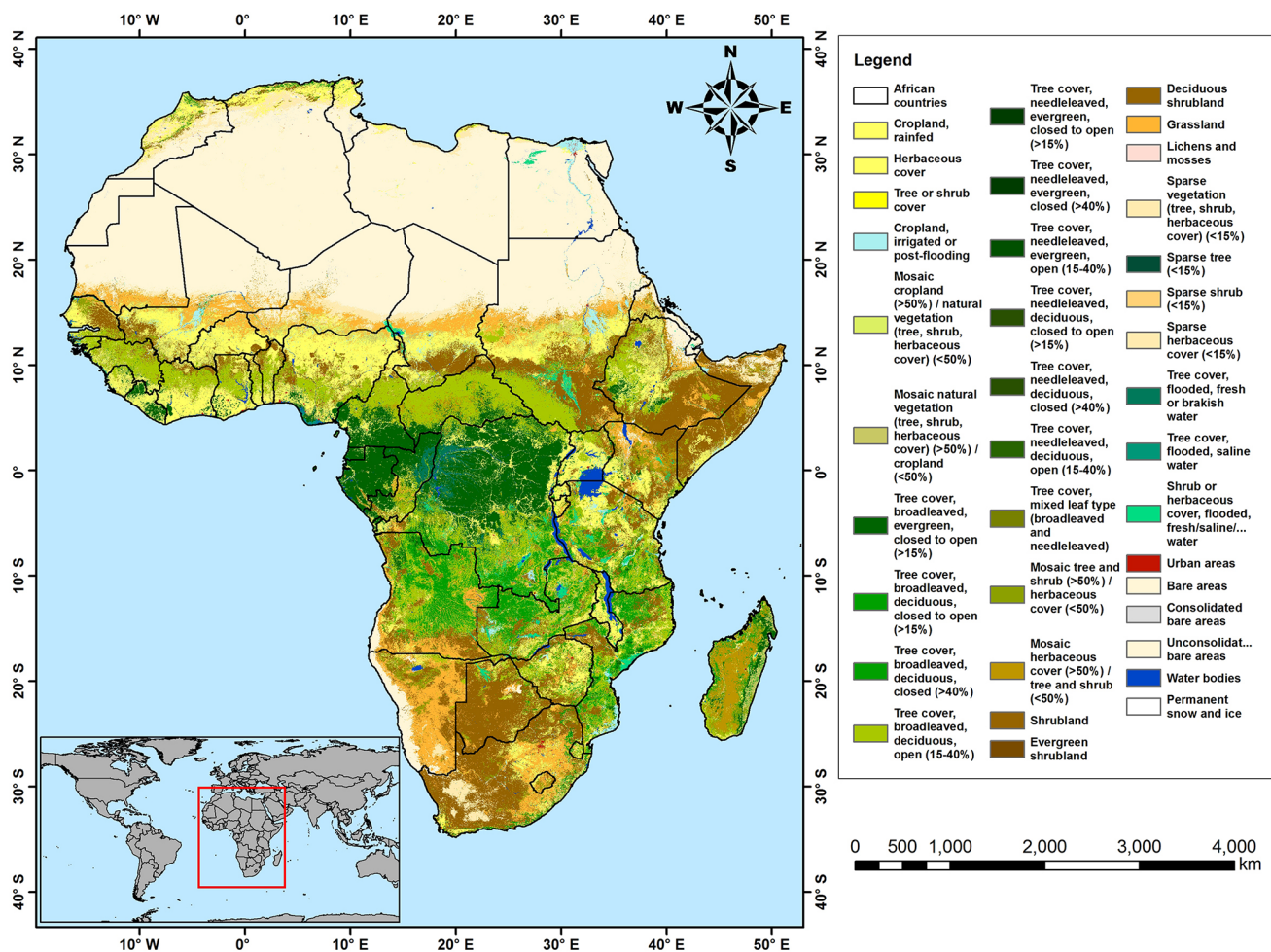


Fig. 1. Land cover map of Africa.

A detailed analysis of BC, CO, and smoke, their sources and variations across seasons in the SSA region is shown in Figure 2. An intense plume of BC, smoke, and CO that extends between the 0° and 18°S region over the Atlantic Ocean during June–July–August (JJA) season is observed. This is as a result of vast quantities of agricultural land, forest, and grass in this region being burned on an annual basis. Other activities present throughout the year that contribute to the emissions of BC, smoke, and CO are domestic fires used for cooking, as well as motor vehicle traffic and industrial activities. JJA is the only season where BC, smoke, and CO have equal dominance in the 0° to 18°S region.

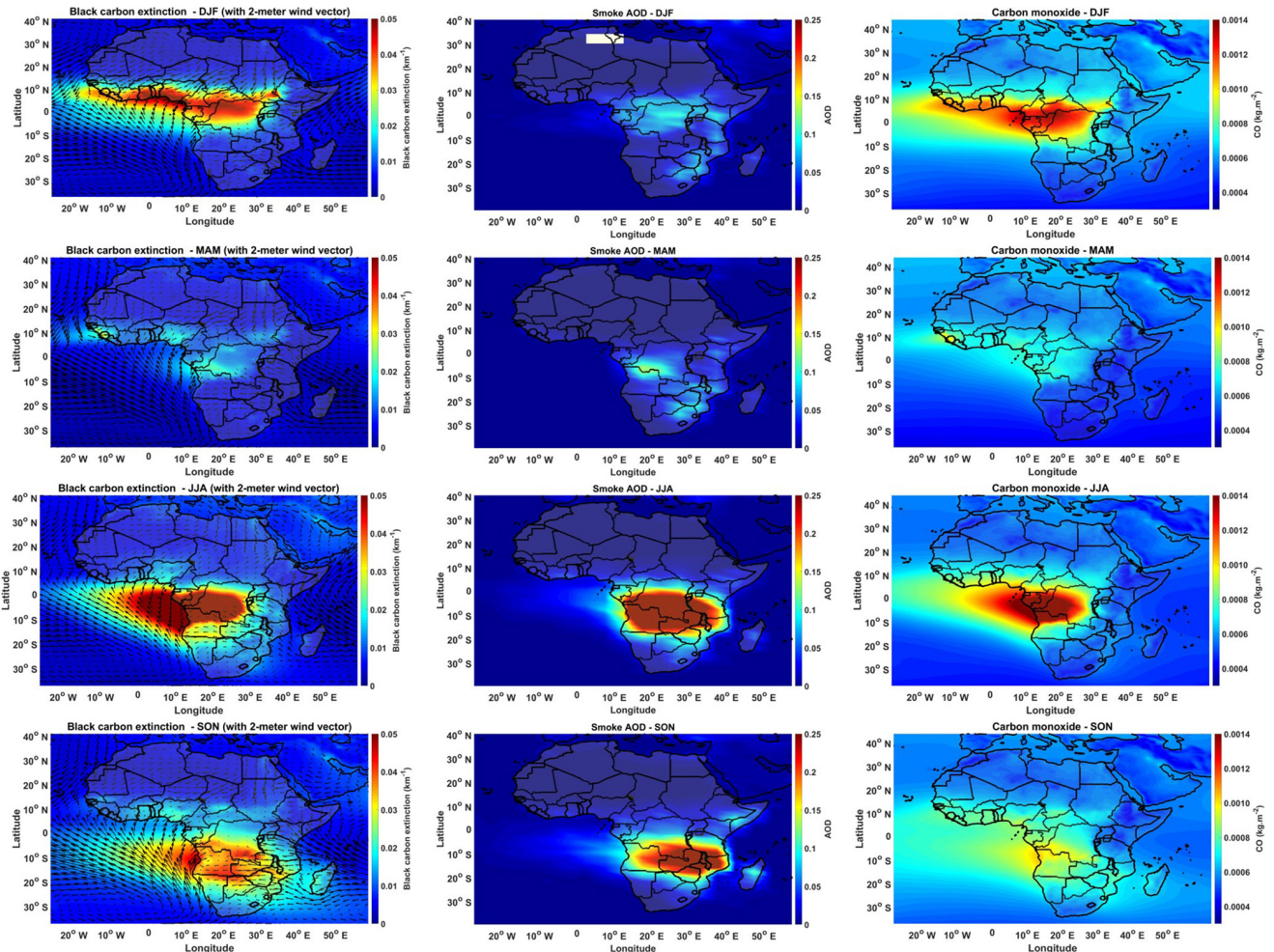


Fig. 2. Seasonal sub-Saharan averaged spatial distribution of black carbon extinction and carbon monoxide AOD for 2007–2016 obtained by MERRA-2, and smoke AOD for 2007–2016 obtained by CALIPSO.

Meteorological conditions such as temperature and humidity show a notable variability throughout the year. The temperature of the fire will affect the humidity in the air and moisture content within combustible materials. During the JJA season in the 0°–18°S region, a low latent heat flux ($\sim 40 \text{ W/m}^2$), a low precipitation ($\sim 50 \text{ mm/month}$), and low relative humidity ($\sim 40\%$) is observed (Figure 3). This is the season with the maximum emissions of BC, smoke, and CO.

This study can be improved by adding CO_2 data from the fires as well as direct health impact data from the regions.

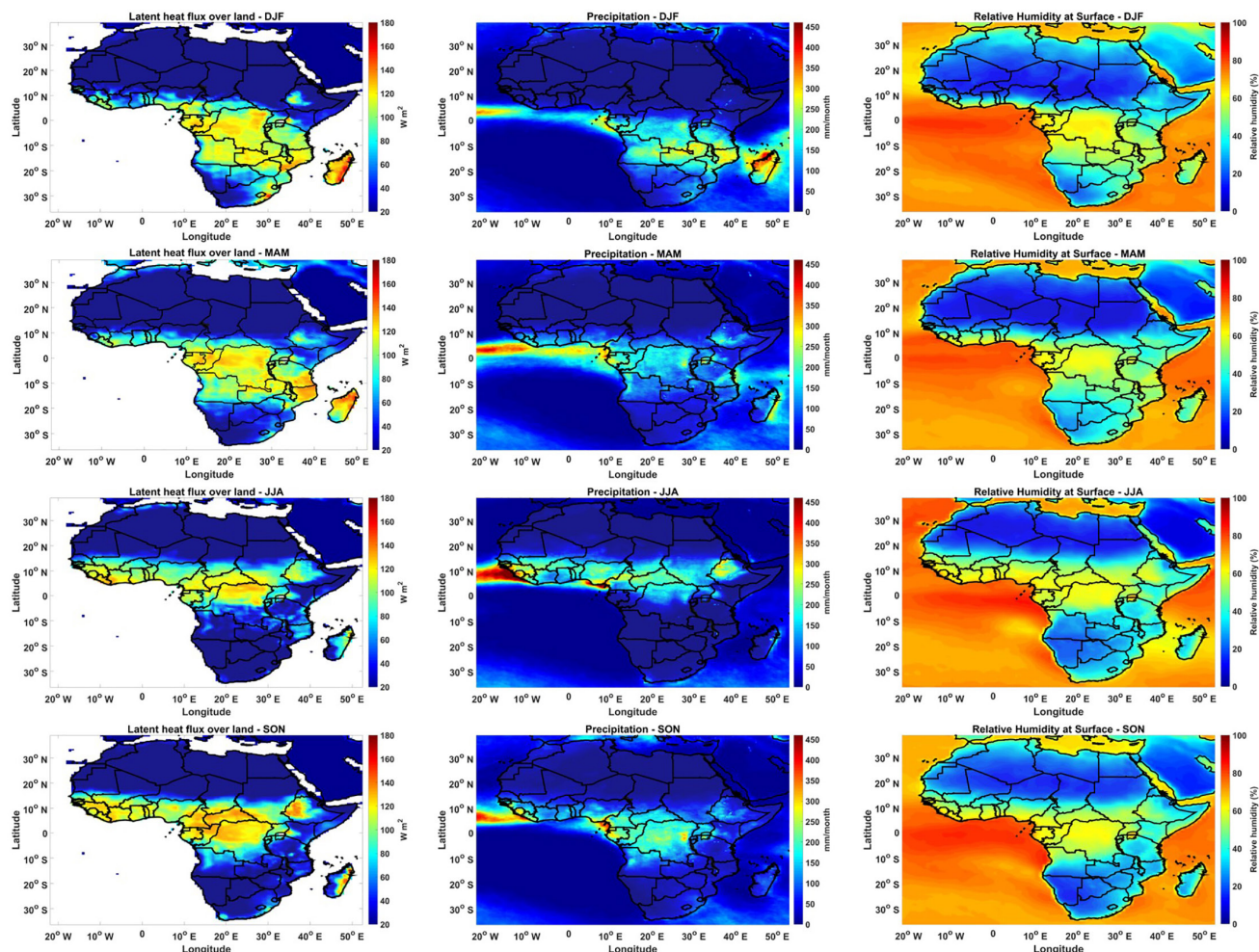
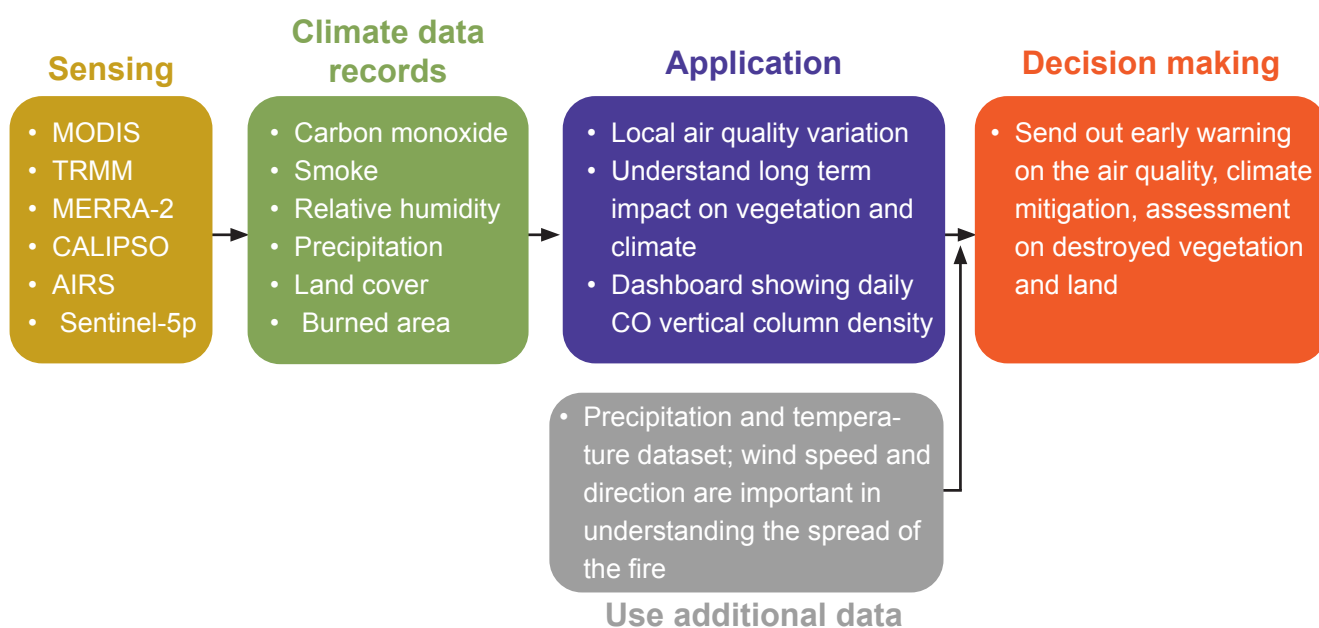


Fig. 3. Seasonal sub-Saharan averaged spatial distribution of latent heat flux over land, precipitation and relative humidity for 2007–2016 obtained by MERRA-2, TRMM and AIRS respectively.

INFORMATION FLOW



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