Follow up Workshop on a Pilot Design for Air Quality in Africa

Jan. 17 to Jan. 19, 2023

CMU-AFRICA CAMPUS, KIGALI, RWANDA

ABSTRACTS

Air quality is a serious issue affecting health, mortality, and human productivity worldwide and in several emerging megacities of Africa. The goal of the Kigali workshop is to build upon the June 2021 workshop outcomes and establish a clear design path for field initiatives in / around an African megacity. With Air quality experts from Africa, Europe and the United States participating in this meeting we will hear from 50 presenters on addressing the following key questions.

- How do African megacity AQ issues differ depending on geographic region?
- Where are the key synergies with ongoing local projects plans over the next 5 years?
- What are the remote sensing capabilities and available ground-based facilities and how can they help accomplish our science goals?
- What existing information data from measurements, and measurement capacities are available?
- Do we have enough information for a field intensive approach, or do we need to start with small projects to gather more information for a large field study in the future?
- What are potential sources of funding and what is the role of local governments in co-funding these efforts?

The meeting is expected define a road map, milestones, and planning for the next 3-5 years, and empowering African scientists to play leadership roles in future campaigns in Africa.

On behalf of the Organizing Committee, I would like to thank leaders of our Host Nation and leaders and staff at CMU-Africa and the UCAR staff who made this possible and all the funding agencies who provided support for participants.

Solomon Bililign,
Chair of the organizing committee

Paper #1

Summary of the 2021 Workshop on Air Quality Pilot Study Design in African Megacities

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This presentation aims to summarize outcomes from the 2021 Workshop: "Air Quality Pilot Study Design in African Megacities - Addis Ababa, Ethiopia". This workshop convened over 50 researchers from all over the world to participate in a virtual review of the state of knowledge and activities associated with air quality observations and modeling in African megacities with particular focus on using that knowledge to inform the design of a pilot study in Addis Ababa. The workshop aimed to identify critical knowledge gaps and develop recommendations for further research from a wide range of perspectives at the nexus of atmospheric chemistry, climate, and health. Recent achievements both within discipline and new inter-disciplinary areas were highlighted. Effective communication between the researchers and high-level users of environmental information, such as international agencies, development programs and concerned organizations operating in the field were emphasized. This talk summarizes the background to the workshop and highlights the key findings and outcomes of the discussions.

Paper #2

Air Quality Research in North America and NOAA's Interest in Air Quality Research in Africa

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The United States has a vigorous research program in air quality spanning more than 50 years. This program encompasses multiple local, state and federal agencies and traces its history to the U.S. Clean Air Act and the establishment of the Environmental Protection Agency (EPA) and the National Oceanic and Atmospheric Administration (NOAA) in the 1960s and 1970s. This research program has underpinned significant improvements in U.S. air quality through scientific understanding to inform the design of air pollution control and mitigation strategies. The Tropospheric Chemistry Program (TCP) at the NOAA Chemical Sciences Laboratory (CSL) has been an integral part of this program through its execution of large-scale U.S. air quality field campaigns utilizing ground sites, mobile laboratories, tall towers, ships and aircraft, as well as the development of modeling tools and incorporation of satellite based remote sensing data.

The last 20 years have witnessed generally declining emissions of major air primary air pollutants such as sulfur dioxide (SO_2), carbon monoxide (CO), volatile organic compounds (VOCs) and nitrogen oxides (NO_x) in the U.S. and Europe. Emissions in China and India have followed different trajectories over this period, resulting in a global shift in major source regions that has had a profound effect on atmospheric composition. Future projections suggest peaking or declining emissions in large economies in Asia, particularly China, but increasing population growth and urbanization in other regions, particularly in Africa. These trends will likely lead to further emissions shifts and changes in the global burden and distribution of primary and secondary pollutants. Africa already has among the highest rates of predicted mortality attributable to poor air quality.

Despite rapid current and future growth and substantial air quality impacts, Africa remains one of the least sampled places in the world. There are a range of potential strategies to address the need for better and more complete observations of atmospheric composition in Africa, from the development of low-cost sensor networks, monitoring sites and networks, an intensive field measurement program, and new remote sensing tools. This presentation will discuss aspects of the NOAA CSL TCP air quality program that may be adapted to address urban centers in East Africa through NOAA engagement and partnership with stakeholders and research institutes in the region.

Paper #3

Low-cost source apportionment of urban air pollution

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Successful air quality management and control not only requires measurement of air pollution levels, but it also requires information on the sources and their relative importance. Without this critical, targeted information on pollution sources, it is difficult to plan and enact control measures with which to reduce air pollution. Source apportionment has historically been carried out with regulatory grade equipment – and hence is expensive and time-consuming data to generate [1]. Over the last 10 years, there has been a revolution in the use of low-cost sensors to measure air pollution concentrations. These sensors are not without problems, but it is now possible to get high quality measurements of air pollutants [2]. In particular, the use of low-cost optical particle counters (OPCs) for the measurement of particulate matter (PM) in regulatory size ranges has been successfully achieved in many urban areas worldwide, with an associated cost that is far less than regulatory instruments [3].

This talk will present new work on using low-cost PM sensors to achieve low-cost source identification and apportionment. Examples will be shown from Africa. The measured PM size distribution obtained from OPCs is used to identify sources. Typically, source apportionment that uses particle size distributions as input relies on particle size information in the sub 300 nm size range to obtain information about sources. However, OPCs typically only provide size information above approximately 300 nm. Initial work used k-means clustering to obtain source information [4]. Subsequent work has used other algorithms including positive matrix factorization (PMF) [5]. Comparison between source information obtained between low cost and regulatory grade instruments is remarkably promising. This presentation will highlight the methodological approaches undertaken. It will then use a series of urban case studies showing how low-cost source apportionment can be used to identify different sources of PM pollution in urban areas, both in the ambient air and indoor air. Finally, the presentation will discuss the prospects for low-cost urban source apportionment and hyperlocal air pollution management within the African context.

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Paper #4

Air pollution monitoring and research in Africa: Gaps, Challenges and Opportunities

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Several previous studies have shown that outdoor and indoor air pollution were estimated to have caused close to 7 million deaths globally. However, recent study based on Global Exposure Mortality Model (GEMM) implied far more deaths of about 8.9 million deaths per year attributed to airborne particulate matter. According to some studies, deaths in Africa from outdoor air pollution have increased from 164,000 in 1990 to 258,000 in 2017-by a factor of nearly 2. Air pollution in Africa has considerable socioeconomic impacts. The economic cost of premature deaths from outdoor air pollution across Africa is estimated to be $215bn. Which is as high as 2.7% of GDP. The World Health Organization (WHO) estimated that the annual median concentration of $PM_{2.5}$ exceeded 26 $\mu g/m^3$ in more than half of the countries in African, exceeding the WHO limit of 10 $\mu g/m^3$. However, there is a lot of uncertainties in these estimates arising from poor air quality and epidemiology data obtained from sparce observational networks and limited health facilities in the continent accessible to the general population. For instance, world bank report shows that among the 47 countries in sub-Saharan Africa, only six can provide long-term data on airborne particulate matter (PM), covering only 16 cities. As a result, the actual spatio-temporal variability of criterion pollutants is largely unknown and the data from the current ground network of observations is not sufficient to constrain the reanalysis models (e.g., MERRA-2) at the continental scale. Satellite observations are common sources, but they suffered from large systematic and random retrieval errors. For instance, recent study shows that there is a significant difference between aerosol optical depth (AOD) from MERRA-2 and MODIS Deep Blue AOD at AERONET sites although AERONET AOD is assimilated into MERRA-2 model. In addition, the emission inventory used in air quality models (e.g., dispersion model) are rarely accurate as they are typically based on surveys instead of actual data. Emission factors for different criterion pollutants and different sources are based on limited laboratory experiments in the West and unlikely to represent the kind of emission sources in Africa. Therefore, accurate and representative information on emission factors related to different types of wood, charcoal, and crop residues that are used for 50% of the cooking and 30% of the residential heating in Africa are needed. Use of proxy variable to monitor air pollution as well as covariate variables has attracted attention in recent times. Extending short time series of air quality data through supervised machine learning (ML) algorithm and predicting air quality from land use regression models are gaining popularity since the reactions between air pollutants and influential factors are highly non- linear resulting in a very complex air pollutant formation mechanism. As a result, more advanced statistical learning (or ML) is necessary. In the past, different ML algorithms related to Support Vector Machines (SVM), Artificial Neural Networks (ANN), and Ensemble Learning (EL) have been used to achieve better prediction accuracy. It has been demonstrated that ML exhibits a higher predictive performance than more complex and physical Chemistry Transport Models (CTMs). In this talk, the scope of the above research in Africa and its limitations (gaps), efforts to improve observational networks and challenges to have consistent and sustainable in-situ observations, as well as the availed opportunities in relation to the use of the huge satellite data, low-cost sensors, and ML algorithms for more insight into air pollution in Africa will be discussed and explored.

Paper #5

Towards the Development of a pan-African System for Air Quality Analysis, Forecast and Attribution

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Air quality remains a largely unexplored societal and environmental issue in many regions of Africa. The major source of pollutants include biomass burning, industrial activities, residential activities (e.g., cooking) and, increasingly, urbanization with related traffic and domestic activities. Although some information is available, more observational data are needed regarding surface emissions and atmospheric concentrations of key chemical species. Exploratory studies through field campaigns will be useful, while the development of a network of sensors combined with space observations will be key to develop a predictive capability. More reliable information on natural and anthropogenic emissions is also crucial to further our understanding.

The paper will propose a strategy required to develop a fully operational system that could analyze and forecast air quality at the regional scale with downscaling capability to the urban scale in selected regions. An approach to use a combination of observations and modeling to attribute the causes of air pollution at selected locations will also be discussed.

Paper #6

Considerations for requesting NSF Aircraft for a field project located in an African Megacity

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This talk will provide an overview over the request process for the NSF aircraft and consider options and requirements for deployment in an African megacity. The planning process of a mission centered on a US urban area will be used as an example to suggest a path to develop a large facility request, considering the added complexity of a foreign deployment in a relatively unexplored area.

Paper #7

Enhanced Integration of Health, Climate, and Air Quality Management Planning at the Urban Scale

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Air pollution levels in Addis Ababa negatively affect residents' health and exceed World Health Organization ambient air quality guidelines. Many sources of air pollution are also sources of climate pollutants, so reducing these sources can have the dual benefits of improving air quality and mitigating climate change. By implementing the actions in the climate action plan, Addis Ababa can contribute to global climate action to mitigate climate change and improve air quality while contributing to the well-being of its citizens. C40 uses Pathways-AQ (a scoping-level air quality tool) and information derived from the Addis Ababa's greenhouse gas (GHG) inventory, to identify the potential reductions in fine particulate air pollution ($PM_{2.5}$) and associated ill-health that can be accomplished by implementing Climate Action Plan (CAP).Currently, the largest contributor to annual average $PM_{2.5}$ concentrations in Addis Ababa is the residential sector, which includes solid fuel burning for cooking and heating. On-road transport is the second largest source, including high-emitting cars and buses. The waste sector is the third largest source of $PM_{2.5}$, including waste incineration and open burning. Manufacturing and construction emissions comprise the fourth largest source. Addis Ababa can improve its air quality by fully implementing its climate action plan by averting hundreds of premature deaths each year through climate actions that benefit air quality as well. By fully implementing the ambitious scenario, Addis Ababa can reduce $PM_{2.5}$ by 94 µg/m^3 in 2050. The sectors that have the highest potential to reduce $PM_{2.5}$ in that year are new residential energy efficiency for cooking and space heating, (because of

decreased solid fuel use), industrial energy efficiency and fuel switching measures, and commercial energy efficiency, followed by conversion of buses from diesel to electric. These actions are expected to prevent just over 1,000 premature deaths per year in 2050, because of reduced exposure to ambient $PM_{2.5}$. Many health benefits are expected to accrue from changes in new residential buildings (cooking and water heating improvements), new commercial buildings (space heating improvements), and as a result of industrial energy efficiency measures. Mainstreaming air quality work across all relevant city departments will encourage better coordination and effective use of resources to accomplish the city's stated air quality management and climate change-related goals.

Paper #8

Selected Air Quality studies in Kenya: Contribution from the Institute of Nuclear Science and Technology, University of Nairobi

Presenter: Michael J Gatari, University of Nairobi,
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The number of air quality studies in Nairobi and by extension Kenya is limited to short duration campaigns or single site monitoring. However, there are two studies of longer duration, Gaita et al. (2014) and unpublished data. Most of the studies are a contribution by the Institute of Nuclear Science and Technology (INST) in the University of Nairobi in collaboration with northern research partners. Majority of the studies assessed size segregated PM10 to fine and coarse particle mass concentrations and very few studied gaseous pollutants. However, the pioneer study (Karue et al., 1992) reported total suspended particles (TSP). Airborne particle sampling was for 24 or 11 h on Teflon filters mounted in standard instruments. Gravimetric method was used to assess aggregated particle mass concentration on the filter while particle source apportionment was achieved by using elements in the PM particles determined by Energy Dispersive X-Ray Florescence (EDXRF) analysis. Introduction of low-cost monitors/counters to INST was in a study carried out in 2017 (Pope et al., 2018) in collaboration with University of Birmingham, UK. The planned presentation will highlight results from some of the studies, published and unpublished, while pointing out the experienced challenges and gaps which have not been resolved.

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Paper #9

Levels and Spatial variations of Atmospheric Depositions-bound Heavy metals in selected Divergent Land-use and Source factor-based sites in Nairobi, Kenya

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Nairobi City is a rapidly growing regional center with divergent land uses with varying pollutants and local pollution sources. This study assessed the atmospheric depositions-bound heavy metals in three sites during the period of January 2022 to June 2022. The study found the overall average deposition rates of Total Solids to be 127±40 mg m^2-day^{-1}. The average dry deposition fluxes (Fd) of cobalt, boron, aluminum, zinc, copper and chromium are; 77, 49, 44, 2, 1.4, 0.01 mg m^{-2} yr^{-1} respectively. Enrichment factors (EFs) were calculated; these reveal that Al, and Cr had low anthropogenic sources since their EFs were less than 10 while other metals had EF factor >10; in the order of B>Co>Zn>Pb>Cu indicating that their presence is greatly because of human activities. Industrial and residential/industrial zones recorded higher amounts of dust fall than commercial zones. The study revealed that heavy metal contamination in the dust fall is dependent on human activities and therefore mitigation measures should be designed to control such activities.

Keywords: Dust-fall, heavy metals, atmospheric, deposition, fluxes, air pollution, enrichment factor

Paper #10

Air pollution and Health in Africa: Perspectives from the State of Global Air Initiative

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Pollution from fine particulate matter, household burning of solid fuels, and ozone imposes a heavy burden on health worldwide. The burden of air pollution on African livelihoods and population health is among the highest in the world and varies widely across countries and regions within the continent. In 2019 alone, air pollution contributed to an estimated 1.1 million deaths in Africa, with 63% of those linked to exposure to household air pollution (HAP), making exposure to air pollution the second leading risk factor for death across Africa after malnutrition.

Countries in Africa continue to experience some of the highest exposures to ambient $PM_{2.5}$ in the world. Furthermore, more than 800 million people across the continent continue to use solid fuels including coal, charcoal, wood, and agricultural residue as well as kerosene for heating or for cooking using open fires or cookstoves with limited ventilation. This results in high exposures to particulate matter in their homes, disproportionately affecting newborns and young children. About 236,000 newborns die within the first month of life from air pollution exposure, with 80% of those coming from HAP.

Drawing on the recently released report on air quality and health in Africa, this talk will provide an overview of trends for air quality and associated health impacts, including impacts on different age groups, and for a variety of health outcomes. The talk will also discuss limitations in current analyses, and opportunities for future research and interventions. Improving air quality requires coordinated action, across sectors and disciplines, on solutions for sustainable transport, proper waste management and efficient energy production. This is of uttermost importance in Africa where energy demand has risen by half since 2000, waste generation is projected to grow to 244 million tones per year by 2025 and the vehicle fleet is old and growing.

Paper #11

Using existing observations of atmospheric composition to characterize urban air quality in Senegal

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Faced with the risks posed by atmospheric pollution, the study of air quality has emerged as one of the major issues in developed countries. However, there are very few initiatives in developing countries, particularly in Sub-Saharan Africa. In this regard, the Senegalese government has established an air quality management center in Dakar since 2010, with six measurement stations representing various types of pollution sources. Gaseous pollutants (SO_2, NO_2, and CO) and particulate pollutants (PM_{10}, $PM_{2.5}$) are measured in real time at each station. Recently, in collaboration with the Penn State University, a network of low-cost sensors (Purple Air and Clarity IO) was deployed in several localities in Senegal in 2019 to measure PM_1, $PM_{2.5}$, PM_{10} and NO_2. In parallel, NO_2 and SO_2 column density are measured using a Pandora spectrometer installed on the rooftop of the Laboratory of Atmospheric and Ocean Physics- Simeon Fongang (LPAO-SF) at Cheikh Anta Diop University of Dakar. The collected data were analyzed to characterize the temporal and spatial variability of atmospheric pollution in Senegal and its sources. The results show that the concentrations of most species vary significantly from year to year, and the observed particulate matter (PM_{10}, $PM_{2.5}$) levels are respectively 65µg/m^3 to 145 µg/m^3 and 26 µg/m^3 to 47 µg/m^3 largely exceeding the WHO annual PM_{10} and $PM_{2.5}$ thresholds. Furthermore, measured concentrations of some species are comparable to those obtained in the most polluted cities in the world. The temporal variations in PM and gas levels vary greatly from one location to another, revealing variety of sources that must be identified. This work clearly highlights high pollution levels in Senegal, with potential important impacts on the health of the local population.

Paper #12

Bridging the gap between policy and science in addressing air pollution in African cities; experiences from Nairobi, Kenya

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Nairobi, which is Kenya's capital, has experienced accelerated growth in both population and economic output in the last two decades driven by its role as an international and regional hub for commerce, transport, regional cooperation, and economic development. Its population has increased from 1.4 million in the 1990s to more than 5 million in 2022 and this is projected to grow to more than 7 million by 2030. The rapid expansion has also worsened the city's environmental footprint, which is evident by the worsening air pollution, where it has increased by more than 180% compared to the 1970s levels. This is an urgent challenge that the city authorities must address however, addressing these challenges, as evidenced in other cities, is complex and it requires a consulted effort between multiple stakeholders including policy makers, researchers, private sector, non-governmental organization, and communities.

Even though several studies have demonstrated the need to develop policy and regulatory instruments to regulate emission of air pollutants in Nairobi, the problem still exists with minimal interventions on the major sources such as vehicles and open burning of waste. The evidence on air pollution levels and its impacts have therefore yielded little to trigger appropriate remedial actions from policy makers and the public. Consequently, actions to limit the emission of air pollutants are still at their infancy. Besides, the city has no adequate and reliable air quality monitoring network further hindering adequate research to influence substantive remedial actions.

In this presentation, we share our experience in supporting the city of Nairobi address air pollution and in particular how decisions are made in a data limited city. In addition, we share our experience on the interaction between science and policy where, by discussing the different driving motivations for these stakeholders and how to bridge the motivations gap.

Paper #13

Improving the characterization of urban pollution and its impacts in South Africa

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Global assessments estimate large impacts from exposure to poor air quality in many countries in Africa. However, these estimates have large uncertainties due to insufficient information, which often stems from the lack of ground-based measurements, as well as the lack of integration of local knowledge. The combined effect of insufficient data and uncertainties impacts not only the understanding and quantification of air pollution levels and impacts, but also affects the understanding of the climate. Many air pollutants have an impact on the climate as short-lived climate forcing pollutants (SCLPs; e.g. particulate matter, ozone). SCLPs and other air pollutants are monitored using multiple platforms and data streams which are useful in understanding and quantifying the spatial and temporal heterogeneity in air quality. This is especially important in African cities, partly due to the large heterogeneity of emissions, ambient concentrations, vulnerabilities, and impacts in urban areas. This presentation will discuss how we used multiple data streams to improve and evolve our understanding of South African urban air pollution. The presentation will also highlight the key role of local knowledge and local data in improving this understanding, and the need for its integration into global studies and products (e.g. emission inventories). Through this discussion, key considerations and lessons learned will be described to assist in the pilot design for an international campaign on urban air quality in Africa.

Paper #14

Satellite based assessment of air pollutants in Africa Megacities

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Advance in satellite technology and computing algorithms with the help of supercomputing facilities leads to a rapid increase in the use and reliability of satellite data for Earth Observation studies. Moreover, the emergence of high-resolution and low repeat cycle satellites provides a great opportunity to monitor the distribution and trends of key air pollutants. Particularly, they have an unprecedented opportunity in inaccessible regions such as Africa, where it is hard to obtain both ground-based measurements and tuned model estimations. In this study, seasonal patterns, and distribution of key pollutants over Africa's megacities and some hotspot areas were examined. A quick overview of Sentinel5or/and Earth Engine with TROPOMI data for key pollutants distribution and identification of hotspot regions will be presented. The work will also present the distribution and trend of NO_2, O_3, CO, and CH_4 over selected African megacities in the years 2010-2019.

Paper #15

Ambient and indoor fine particles concentration in Addis Ababa

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Ambient and indoor $PM_{2.5}$ concentrations in Addis Ababa were measured by air quality monitoring equipment deployed by the Jet Propulsion Laboratory's Multi-Angle Imager for Aerosols (MAIA) project and the University of Surrey's Global Centre for Clean Air Research (GCARE), respectively. The average ambient $PM_{2.5}$ concentration increased from about 30 µg m^{-3} in April 2021 to 60 µg m^{-3} in September, and then steadily declined until it reached a minimum in January of the following year. The diurnal pattern was characterized by a distinct peak in the morning rush hour and a secondary peak in the evening, most likely due to the increased biomass burning emissions from cooking and/or heating activities. Ambient $PM_{2.5}$ levels also showed strong spatial variations, with the highest levels in the central and western parts of the city and the lowest in the northern regions. Ambient daily $PM_{2.5}$ concentrations were 2 to 4 times higher than the WHO guideline (15 µg m^{-3}) throughout the year. Average indoor $PM_{2.5}$ in low-income households that primarily cook with charcoal and employ natural ventilation reached nearly 100 µg m^{-3}, exceeding the WHO guideline by nearly a factor of five. Charcoal and diesel are the primary sources of air pollution in Addis Ababa. Cooking with charcoal increased $PM_{2.5}$ exposure up to 3-fold compared to natural gas and LPG.

Paper #16

High spatial-temporal resolution Land Use Regression models for NO2 concentrations in the West African city Dakar, Senegal

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Nitrogen dioxide (NO_2) is highly variable within cities, with important consequences for secondary pollutant formation and public health. Yet, we have few observations that capture this variability in large cities, as routine monitoring networks are too spatially sparse, especially in West Africa. Here, we describe vehicle-based measurements of the intra-urban variability in NO_2 across Dakar, Senegal in February-March 2020. We show NO_2 mixing ratios are highest downtown, at congested major intersections, and near the Port of Dakar. We use these observations combined with land meteorological variables, providing both spatial and temporal information, to create a land-use regression model, representing the first regression model for NO_2 trained using locally collected measurements for a major West African city. We find predictions based on local measurements yield substantially different NO_2 distributions than global models based largely on datasets collected in cities in the Northern Hemisphere. We use our model to explore the relative importance of various predictors for NO_2 spatial variability and discuss implications for which emissions sources drive variability throughout the city. NDVI (Normalized Difference Vegetation Index), road traffic, major road and distance to coast were the most dominant predictors for NO_2 concentrations. Our final models explained 85% of the variances (R^2) in NO_2.

Paper #17

Dirty Drop Off - Children's Exposure to indoor and outdoor Air Pollutants at School in Rwanda

Presenter: Egide Kalisa, University of Rwanda, Center of Excellence in Biodiversity and Natural Resource Management, College of Science and Technology, Kigali, Rwanda
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Schools around Kigali are located near roads with illegal and dangerous levels of emissions from diesel cars. Consequently, a major part of children's daily exposure to air pollution may occur at their homes or school, inside and outside. In this study, real-time Black Carbon (BC) was measured simultaneously indoors and outdoors at schools over one-year in Rwanda. Outdoor BC levels were found to be significantly higher outdoor than indoor levels during drop-off and pick up times, suggesting dominant contribution of vehicles idling on the school premises. However, when classroom windows were open indoor BC increase than outdoor concentration levels, probably due to infiltration of ambient particles. The study indicates that BC levels in higher at school premises during drop-off/pick-up times and an immediate attention is required. Intervention study shows that air pollution education can influence children's behavior and improve their respiratory health in Rwanda.

Paper #18

Air Quality Status at Selected Congested Road Junctions in Addis Ababa, Ethiopia

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This study aims to investigate the air pollution status and the associated air quality of selected congested road junctions in Addis Ababa. Three of the highest emission sites were selected from the twenty-one most congested road junctions identified by Addis Ababa Transport Authority. $PM_{2.5}$, PM_{10}, CO_2, CO, NO_2, SO_2, and HC were sampled at Megenegna, stadium, and Kality-total for three consecutive days during both the dry and rainy seasons. Climatic variables such as temperature (0C) and relative humidity (%) were also measured. $PM_{2.5}$ concentrations were found to be, 694.67, 533.51, and 500.44µg/m^3 for dry and 506.22, 499.77, 399.11µg/m3 for the rainy season at Kality-total, Megenegna and Stadium, respectively, all were hazardous to health. PM_{10} average concentrations were 269.33, 324.16, and 333.77µg/m^3 during the dry season and 235.55, 215.55, and 239.68µg/m3 for the wet season at Kality-total, Megenegna, and Stadium, respectively. These emission values are unhealthy, especially for sensitive people. The concentrations of particulates were highest during the dry season for both PM2.5 and PM10. Gaseous pollutants such as SO_2 and NO_2 also have higher values. For both particulate and gaseous pollutants, morning and afternoon pick hours had higher concentrations than mid-day values. The study showed that at 5% significant levels, there is a mean significance difference between the level of pollutant concentration for, SO_2, HC, CO, CO_2, PM_{10}, $PM_{2.5}$, and NO2 by location. The relationship between temperature and hydrocarbon showed a moderate positive correlation (0.592 with p-value = 0.000), whereas there was no correlation with humidity. The health status of people who have had long exposure to traffic emissions, should be investigated. We also suggest the Environmental Protection Authority install air pollution monitoring devices at all the congested junctions for continuous air quality monitoring.

Paper #19

A Street-level Assessment of Greenhouse Gas emissions Associated with Traffic Congestion in the City of Nairobi, Kenya

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Traffic congestion significantly contributes to climate change due to the emissions of Greenhouse Gases (GHGs) such as Carbon Dioxide (CO_2), Nitrous Oxide (N_2O) and Ozone (O3). Rapid urbanization and poor planning coupled with increased motorization and fragmented public transport system in cities such as Nairobi has led to increased vehicular emissions especially during heavy traffic along the various roads and within the Central Business District (CBD). To reduce GHG emissions in the urban transport sector, institutional coordination and relevant policy tools must be considered. This study aimed at estimating CO_2 emissions from different vehicle categories during traffic congestion, using Uhuru Highway as a case study. The relationship between traffic congestion and CO_2 emissions was analyzed using qualitative and quantitative methods, through a bottom-up approach. 120 Questionnaires were administered to vehicle owners, passengers, and pedestrians to get individual vehicle characteristics and opinions on the best actions for reduction of CO_2 emissions along Uhuru Highway in Nairobi. The Average Annual Daily Traffic (AADT) for different vehicles from 2014 to 2019 was used to estimate the CO_2 emissions. Results showed that private cars predominate over other vehicle types, contributing 73% of the total CO_2 emissions in Nairobi (CBD). Private cars are the highest contributors of CO_2 emissions with a total of 25.3 million Carbon dioxide equivalent (gCO_2e), between 2014 and2019. In comparison, Public Service Vehicles, commonly referred to as Matatus, emitted 6.89 million gCO_2e, Light Commercial Vehicles (1.82 million gCO_2e), Heavy Goods Vehicles (251,683 gCO_2e) and motorcycles (181,054 gCO_2e). To minimize CO_2 emissions, the study recommended the enforcement of strong mobility policies to control the high motorization rate. One of these policies is the prioritization of the development of mass public transport system to achieve the potential health, economic and environmental gains within the CBD.

Paper #20

Design of an Internet of Things Lab for Air Quality Monitoring

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Atmospheric pollutants, in the form of particulate matter (PM) or gaseous substances, are responsible of several diseases affecting our body in various ways. Poor air quality is now a major concern in most African cities, but local authorities are still unaware and lack human and financial resources to acquire and maintain high graded air quality monitors. As consequence, data related to atmospheric pollutants are scarce and the public is unaware of the consequences of long-term exposure high PM concentrations. Women, children, and workers seem to be the most affected. On the other hand, physics education in Africa suffers from curricula which focus only on fundamental physics and leads to poor performance and unsatisfaction among students. Schools and higher education institutions are usually not well equipped, due to high investment costs of pedagogical instruments and simulators and lack of well-trained teachers. Combining Microelectronics and Programming could help in filling the gap and improve physics education. Low-cost sensors-based monitors which also integrate Internet of Things (IoT) appear as an alternative to expensive conventional air quality monitors and have many advantages. They are cheap, easy to maintain and can be easily deployed. Trough IoT, physical phenomena can be easily demonstrated, what gives more satisfaction to students. Training students on IoT with focus on air quality monitoring (AQM) is therefore a long-term profitable investment. It should be recalled here that air pollution costs close to 1% GDP in some African countries. A plan is being developed at the Alioune Diop University to establish an IoT lab for AQM. It will serve for research and training purposes. The ongoing feasibility study shows that a 300 sqm will be needed for a single-story building for a budget around USD 100k. The facility will host few reference monitors and a meteorological station. The instability observed on the electrical grid and the important solar irradiance of the country push for a solar powered generator.

Abstract #21

Source attribution of PM2.5 in Kinshasa, Democratic Republic of Congo

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Estimates of air pollution mortality in sub-Saharan Africa are limited by a lack of surface observations of fine particulate matter ($PM_{2.5}$). Despite being a large metropolis, Kinshasa, Democratic Republic of the Congo (DRC), population 14.3 million, has had little attention towards air quality monitoring. In 2019, a 5-node PurpleAir network was deployed in the city. Calibrated annual average $PM_{2.5}$ for 2019 in Kinshasa was estimated at 43.5 µg m^{-3}, more than 8 times higher than WHO Interim Target 1 of 5 µg m^{-3}. This initial study motivated additional instrumentation in Kinshasa, the whole Congo and neighboring Brazzaville. New deployments included a small Clarity Node-S network, a QuantAQ Modulair, and a reference method $PM_{2.5}$ MetOne Beta Attenuation Monitor (BAM-1020). In addition, monitoring of gas-phase species, including NO_2, O_3, CO, CO_2 is now underway. Here we present first results from this aggregated, multi-sensor, multi-species network in the Congo. We first conduct a sensor intercomparison, comparing the performance of three different popular sensor brands (PurpleAir, Clarity, and QuantAQ) evaluated against the reference BAM-1020. Initial findings suggest that QuantAQ $PM_{2.5}$ is most correlated and least biased compared to the reference, followed by PurpleAir and by Clarity. We also use our co-location to develop a simple correction factor using both Multiple Linear Regression and Gaussian Mixture Regression, a probabilistic method that has been shown to perform better than commonly used methods in other African cities. We also leverage on-site gaseous pollutant concentrations, particle size distribution data from an optical particle counter, and anemometer data to draw some initial conclusions about sources of $PM_{2.5}$ in Kinshasa. In particular, we link factors resolved from a nonnegative matrix factorization method using the gaseous species and particle bin concentrations to particular source profiles (e.g. combustion). Our results highlight the need for clean air solutions implementation in the Congo.

Paper #22

Engaging local scientists and stakeholders in field mission design and execution: Success Stories from IGAC and the Rwanda Climate Observatory

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In air quality studies, engaging local scientists and stakeholders is essential for both logistical and scientific success, and can help ensure the future of long-term measurements. After an intensive field campaign, long-term monitoring is the next step to track seasonal changes in air quality, provide data for government regulation, and for understanding of existing and emerging sources of emissions in an area. For example, the Rwanda Climate Observatory, hosting continual measurements of greenhouse gases and short-lived climate forcers, was co-developed by the government of Rwanda and MIT. Long-term measurements, made possible by local technicians and facilitated by a Rwanda government project team, allowed the seasonal changes in black carbon, carbon monoxide, and ozone to be observed and major emission sources (primarily large-scale biomass burning) to be found. In a broader example, one of the IGAC (International Global Atmospheric Chemistry) Project's goals is building capacity in atmospheric chemistry. To this end, the IGAC Project sponsors regional working groups and scientific activities with region-specific focuses centered on developing networks of local scientists in understudied regions of the world, both for intra-regional networking and international networking. These local networks have made field missions possible in Asia and other regions of the world through political connections, understanding of shipping logistics, source apportionment knowledge, and other ways. Lessons learned for this work will be presented.

Paper #23

Regional specificities of emissions in Africa: The Dacciwa emissions inventory for air pollutants and greenhouse gases

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There are few emissions data and regional inventories in Africa while Africa is expected to show very large increases in anthropogenic emissions in the next future, if no regulations are implemented. An African regional inventory (version 1 of the so-called DACCIWA inventory) was first developed, which considers the air pollutants emissions from combustion for the 1990-2015 period. A new version of this inventory has been recently developed, which includes greenhouse gases (GHGs) and emissions from all combustion and no-combustion sectors for the 2010-2018 period. This work has been done as part of the Copernicus $CoCO_2$ European project (Prototype System for a Copernicus Service, https://coco2-project.eu/).

For this work, we established a database for Africa on fuel consumption over the period 2010-2018 as well as of emission factors. We included non-combustion sources such as fugitives, agricultural soils and waste dumps that are not considered in version 1 of this regional inventory. The dataset provides annual grid maps by sector at a 0.1°x 0.1° spatial resolution for fossil-fuel CO_2, biogenic CO_2, CH_4, BC, OC, NOx, NMVOCs, SO_2 and CO that can be used for air quality modeling. We will discuss the specificities of the emissions for each region regarding sources and pollutants and the needs to improve the inventories in Africa in terms of uncertainty reduction and spatial resolution to carry out air quality modeling at city scale in African megacities.

Paper #24

The Use of Chemical Reanalyses to Address African Air Pollution Issues

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Rapid urbanization has occurred in several African countries, which has resulted in increased anthropogenic emissions. When combined with emissions from natural sources (desert dust, biogenic hydrocarbons), the resulting air pollution can have serious consequences for humans and the environment. However, there is a severe lack of data as well as appropriate, simple, and accessible tools for monitoring and analyzing the evolution of air quality in African countries. Reanalysis products, produced by combining observational data and simulations obtained through data assimilation techniques, provide gridded and physically consistent data describing the recent history of the atmosphere and land surface. They are becoming popular tools for a wide range of purposes, including monitoring of climate and atmospheric changes, research and education, and commercial applications.

In this work, we will address the specificity of African air pollution issues and present the first version of an atlas of atmospheric pollution that aims at providing a comprehensive coverage of air quality levels in various African countries as well as long-term trends using a 18-year (2003-2020) global reanalysis dataset of atmospheric composition, including particulate matter (PM1, $PM_{2.5}$, PM_{10}) and gases (NO_2, O_3, CO, SO_2) provided by the CAMS (Copernicus Atmosphere Monitoring Service: https://atmosphere.copernicus.eu/). The average air quality index (AQI) calculated for each country will also be presented. The atlas can be used to analyze and understand the air quality situation in each region, as well as how it changes over time, and to compare pollution levels across countries. Furthermore, available in-situ measurements from some African countries are used to evaluate the CAMS reanalysis in the continent. We will show the current version of the atlas, and discuss the development of new features which could be added in support of the activities decided as part of the workshop

Paper #25

Air quality in developing megacities: an experience from campaigns in Beijing, Delhi and West Africa

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The Air Pollution and Human Health in Developing megacities (APHH) programs, funded by UKRI and The Newton Fund, had the aim to study air pollution in Beijing (APHH-China), where it was jointly funded by The National Science Foundation of China (NSFC), and Delhi (APHH-India), with matching funds from the Ministry of Earth Sciences (MOES). The programs aimed to identify the concentrations and sources of urban air pollution in Beijing and Delhi, understand the chemical processes and identify how people are exposed, to understand how it affects their health, and to determine what can be done about it. This program brought together leading Universities and Research Institutes from the UK, China, and India, promoting the bi-lateral exchange of knowledge and data to affect meaningful change in our understanding and management of air quality issues in large urban conurbations. The programs were divided into themes to study emissions, chemical transformation, impact on health and the effect of future interventions of air pollution. Research was underpinned by large measurement campaigns in Beijing and Delhi, along with local and regional modelling and health impact studies.

In addition. The Dynamics-Aerosol-Chemistry-Cloud Interactions in West Africa (DACCIWA) project was funded by the European Union 7th Framework Program to investigate the influence of anthropogenic and natural emissions on the atmospheric composition over South-West Africa and to assess their impact on human and ecosystem health and agricultural productivity. Part of the project involved aircraft measurements of air pollutants from cities across West Africa, including Accra, Ghana; Lomé, Togo; Abidjan, Ivory Coast and Cotonou, Benin. Data collected was used to improve knowledge of emissions of air pollutants from these cities, ultimately enabling improved air quality forecasting.

This presentation will summaries some of the key results from all the projects, as well as the lessons learnt from undertaking large measurement-based projects in China, India, and West Africa.

Paper #26

Air pollution and Health in West Africa: from estimations to mitigation efforts.

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In a context of rapid urbanization, West Africa is confronted with increasing unregulated anthropogenic emissions of pollutants, which leads to a significant deterioration in the air quality of its cities and the health of its populations. However, those issues are poorly studied in this region of the world. First scientific projects focusing on these issues started around 2005 at different spatial scales (from the individual to the regional scale). The main results obtained by these projects, centered on West Africa with local studies in Bamako (Mali), Dakar (Senegal), Abidjan (Ivory Coast), Korhogo (Ivory Coast), and Cotonou (Benin) highlight: (1) Aerosol levels in urban areas are 3 to 15 times higher than the standards recommended by the World Health Organization (WHO); (2) Air pollution is due to a mixture of anthropogenic urban sources (domestic fires, old vehicles, waste burning, etc..) and regional sources (desert dust, savannah fires), with strong seasonal variations; (3) Health effects in terms of inflammation and premature deaths are due to fine particles; (4) Projections in the future show an increasing importance of anthropogenic emissions, air pollution and health impacts if no mitigation is implemented and (5) Air pollution is one of the hazards faced by people on a daily basis, linked to poverty and/or the social hierarchy.

Health risks in the long term are often not a priority, in favor of short-term risks. From all these results, mitigation efforts to limit sanitary risks linked to air pollution and particularly particulate pollution with the most harmful effects are urgently needed. In this context, we have developed a new interdisciplinary program with a participatory approach including scientists, the civil society and local and national policy makers. This 4-year project is called APIMAMA (Air Pollution Mitigation Actions for Megacities in Africa) and will focus on the city of Abidjan as a real-world laboratory study. The main objective of APIMAMA project which will be presented in this session, is to contribute to a reduction of the health risks associated with air particulate pollution through the implementation of emission mitigation strategies and adaptation of the populations in their daily activities but also of public action on urban space organization. The APIMAMA methodology combines research and societal issues, environmental and sociological issues, with a multi-faceted tools and multi-scale approach. Adopting an ecosystemic approach, the project aims : (1) To bring together researchers from various disciplines (physicochemists, doctors, biologists, sociologists and economists) as well as the main actors of the city to jointly define how the project will be implemented from scientific measurements and surveys to the definition and experimentation of mitigation/adaptation measures; (2) To set up an interdisciplinary methodology to test in particular the impact of improved cooking stoves on the reduction of the health risks, with a detailed study on domestic and commercial cooking activities carried out by women. This objective will be based on studies linking the understanding of personal exposure of populations and their health status to that of vulnerability factors versus individual health risk mitigation strategies; (3) To map urban-scale emission sources; (4) To evaluate their impact and those of various emission scenarios identified by all the actors of the project taking into account new infrastructures, technologies and practices (evolution of the car fleet and road developments, residential and commercial activities, waste management ...) on air pollution and health; (5) To identify the leverage and constraints for future implementation of strategies to mitigate the health risks.

Paper #27

Air Pollution, a serious health and economic hazard suffocating Africa – actions towards better air quality

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Air pollution is the dominant global environmental factor of ill health, and annually 8.9 million people die of exposure to airborne particles smaller than 2.5 µm. The quest for cleaner air has expanded from Europe and North America to Asia and South America. The issue has, however, gained little traction in Africa, where it is taking a serious toll on human health and on the economy. Air pollution kills more Africans than any other major risk factor. Efforts to mitigate air pollution might initially require some funding, but they will result in positive impacts on health, human well-being, the economy of the affected countries. Economic growth and viability are linked to clean air and the health benefits of clean air. The long-term economic and health benefits of clean air need to be clearly explained to policy makers so they can make short-term painful decisions to limit pollution. This cannot be done without long-term high-quality measurement data, of both outdoor and indoor air pollution exposure, but without policies to follow, few incentives exist to collect data. Among sub-Saharan Africa's 47 countries, only 6 (a total of 16 cities) can provide long-term data on air pollution. Indoor emission inventories, if existing, are typically based on surveys of e.g. fuel consumption. A first step would be to increase the amount and the quality of indoor and outdoor air pollution measurements, thereby increasing public concern, without which there will be no policy actions. Air pollution monitoring, enabled by capacity building, could break this negative feedback loop and generate a demand for mitigation strategies, as has been seen in Europe, North America, and more recently, China.

Paper #28

Using a mobile lab to go beyond the stationary flux towers to assess Biosphere-atmosphere interactions

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Networks of permanent, stationary flux towers that allow continuous canopy-scale measurements over annual timescales have revolutionized the study of the contemporary Biosphere-atmosphere interactions over the past two decades. However, this approach is limited in addressing questions related to fast and dynamic, and spatially large changes in land use, vegetation types, disturbance, and their interactions with variations in the climate system. Using a mobile laboratory for measuring CO_2, water, energy, COS, SIF, and VOC fluxes, permitted us to extend our stationary FLUXNET tower measurements across a wide range of sites in Israel. At the same time, the mobile system operation is based on short-time campaigns (usually weeks). To overcome this limitation, we adopted an empirical approach (often used in remote sensing) to 'calibrate' measurements to local meteorological data available on a continuous basis to estimate longer terms perspectives of ecosystem functioning. Using this approach, we investigated over the past 10 years the interactions of land use changes (e.g., afforestation) and climate (e.g., humid Mediterranean to semi-arid, precipitation gradients) on the ecosystem-atmosphere exchange fluxes and ecosystem impact on the planetary boundary layer. The results provided a quantitative assessment of shifts in the tradeoffs associated with afforestation in this region, between the hydrological and energy-budget 'costs', vs. the 'benefits' such as from carbon sequestration and other ecosystem services. Following the successful "proof of concept" of using the Mobile Lab in Israel, a 5-year project has been initiated to deploy the mobile system in Africa to provide much-needed measurements and validation of remote sensing data across a wide range of land cover and vegetation types.

Paper #29

Utilizing retrospective analyses to increase the performance of low-cost sensors in Africa.

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Over much of the Global South, air quality monitoring, especially for PM2.5, is lacking. Low-cost PM sensors (LCS) offer one way to help close that data gap. Unfortunately, the various sensitivities of LCS require that local calibrations (usually done with reference or research-grade sensors) are applied before low-cost data quality can be assured. This requirement can be a problem in many parts of the world where expensive reference or research-grade equipment is simply unavailable. One way to potentially alleviate this requirement is to use data assimilation tools that combine the high spatial and temporal resolution of global models with constraining observations to calibrate LCS. The Modern Era Retrospective analysis for Research and Applications (MERRA) tool from NASA is one such toolset that offers aerosol speciation. MERRA aerosol speciation can be used to estimate bulk hygroscopicity which can then be used to calibrate LCS. This work will demonstrate how this process works and how it performs for 3 areas in sub-Saharan Africa: Ghana, Kenya, and South Africa. Results suggest that simple hygroscopicity corrections from these reanalysis datasets do not generally improve the correlation between LCS and reference monitors, but can both reduce the mean-normalized bias by up to 20% and can increase the accuracy by up to 25% (reductions in MAE, CvMAE) for otherwise uncalibrated LCS, depending on area.

Paper #30

Using satellite observations to contextualize present-day air pollution in fast-growing cities in Africa

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By 2100, African cities are expected to be larger than anywhere else in the world due to rapid urbanization and unprecedented population growth rates. We used a recent (2005-2018) long-term, consistent record of satellite observations of nitrogen dioxide (NO_2), ammonia (NH_3), aerosol optical depth (AOD), and formaldehyde (HCHO) to identify large and significant air quality degradation in fast-growing cities across Africa. We attribute this to a mix of emerging city anthropogenic sources, rather than rural open burning of biomass, indicating a shift in pollution sources responsible for air pollution trends. The change in burden of disease in African cities from increased exposure associated with positive trends in air pollution and population growth during the period analyzed is buffered by improvements in healthcare, but this effect may be short-lived. An on-the-ground megacity campaign is vital for discerning city sources dominating the trends we derive and to validate the satellite observations that have addressed severe monitoring gaps in Africa.

Paper #31

Long-range transport of pollution and microorganisms by desert dust

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Desert dust from major the Sahara can affect air quality and the health of people and ecosystems thousands of kilometers away from the emission sources. Dust storms frequently affect air quality in African megacities such as Cairo, Dar es Salaam, Lagos, Nairobi, and others. The effects stem from visibility reduction, health issues, and effects on the atmospheric microbiome. This talk will give examples of transporting anthropogenic pollutants and biological materials by dust storms from Africa and the Arab Peninsula in the Middle East. In addition, we will describe recent work on forecasting dust storms by AI and big-data methods.

Paper #32

NASA's Multi-Angle Imager for Aerosols (MAIA) Investigation in Africa: An Integrated Satellite and Surface Monitoring Approach for Mapping Speciated Particulate Matter Air Pollution

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NASA's Multi-Angle Imager for Aerosols (MAIA) investigation aims to study the health effects of exposure to ambient particulate matter (PM) and its chemical constituents over a set of globally distributed primary target areas (PTAs). The MAIA satellite instrument will measure column-integrated aerosol abundances and microphysical particle properties. Using a geostatistical regression modeling framework, satellite retrievals will be integrated with measurements from a network of ground-based PM monitors and outputs from a chemical transport model to generate 1-km-resolution daily maps of near-surface total PM10, total PM2.5, and speciated $PM_{2.5}$ (sulfate, nitrate, organic carbon, elemental carbon, and dust). Epidemiologists on the MAIA team will use the resulting exposure maps to investigate the association of PM species with a variety of health outcomes. Fabrication of the MAIA instrument was completed in October 2022 and its launch into sun-synchronous Earth orbit is anticipated to occur in 2024. Prelaunch surface PM monitoring has begun to establish baseline pollution levels and test the ground data processing software. Two of the MAIA PTAs are in Africa: Ethiopia (Addis Ababa and vicinity) and South Africa (Johannesburg and vicinity). Each PTA encompasses a region that is approximately 360 by 480 km. Due to the prior lack of $PM_{2.5}$ measurements in Ethiopia, the MAIA project has deployed and is operating a variety of in-situ PM sensors in Addis Ababa and Adama, including an AirPhoton SS5 $PM_{2.5}$ sampling station as part of the international Surface Particulate Matter Network (SPARTAN) for $PM_{2.5}$ speciation, two AethLabs microAeth MA350 monitors for black carbon measurements, and 11 PurpleAir-II-SD sensors for total $PM_{2.5}$ monitoring. For calibration purposes, two PurpleAir sensors are collocated with reference beta attenuation monitors. In addition, two Aerosol Mass and Optical Depth (AMOD) monitors are being deployed to supplement $PM_{2.5}$ speciation measurements. In South Africa, the MAIA project has supplemented an existing SPARTAN station in Pretoria with an additional AirPhoton SS5 sampler in Johannesburg and has also deployed an AMOD monitor about 30 km north of Johannesburg for PM2.5 speciation, while relying on the South African Air Quality Information System's existing monitoring network for total $PM_{2.5}$ and total PM_{10} measurements. This presentation will provide an overview of the MAIA project and its key components, as well as preliminary findings from the in-situ PM monitoring in Ethiopia and South Africa.

Paper # 33

The Power of TROPOMI to Bridge African Science and Policy: insights from the April 2022 workshop and next steps towards interdisciplinary and transdisciplinary collaboration

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In April 2022, African Studies Centre Leiden, NCAR, KNMI, University of Pretoria and AERC organized a workshop entitled "The Power of TROPOMI to Bridge African Science and Policy". It took place in the Lorentz Centre in the Netherlands and virtually. The aim of this meeting was to bring African scientists and policymakers together with other international members of the environmental and socio-economic science communities to illustrate how powerful TROPOMI satellite data can be used in various ways to jointly address pressing air quality issues. This workshop also served as an arena to identify opportunities to develop a community of practice for researchers, policymakers, and practitioners on the use of air quality and satellite data in Africa. Three priority research areas were jointly identified for further exploration: (i) a combination of satellite and mobile reference ground measurements may help to increase coverage of air quality measurements in the absence of a dense air quality ground measurement network, (ii) to generate so-called 'level 4' data to combine quantitative satellite data with existing socio-economic data, including the need to translate the results into the language of policy; (ii) environmental justice in data scarce regions with regard to North-South relations; (iii) promoting source attribution research, including using methane?, NO_2 and ozone measurements as indicators for air quality in addition to aerosol measurements.

Paper #34

Emissions from Mining-related Activities in Africa using TROPOMI Satellite Observations

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We have analyzed TROPOMI NO_2 data over the Copperbelt, a mining region which straddles the Democratic Republic of Congo and Zambia. While the main ore mined there is copper, this region is currently of great strategic interest because it is the world's biggest producer of cobalt. Demand for cobalt, key to clean energy technologies (e.g., electric car batteries), is increasing worldwide and cobalt control is becoming a matter of national and global energy security. The impact of increasing mining-related activities on local air quality (high NO_x is harmful to respiratory systems and vegetation) is unknown.

TROPOMI, onboard ESA's Sentinel-5 Precursor, is an imaging spectrometer in a sun-synchronous orbit at 824 km of altitude which measures concentrations of relevant atmospheric species (trace gases, aerosols, cloud) with quasi-global daily coverage and at high spatial resolution (~ 3.5 x 5.5 km^2 in the case of NO_2).

We show that mining-related activities (such as extraction, smelting, and refining) can be remotely detected based on their TROPOMI NO_2 signature, even in the presence of high background NO_2 from biomass burning. Annual TROPOMI NO_2 means for 2019, 2020, and 2021 show local enrichments consistent with point sources spatially collocated with both mines and large cities where mining-related activities take place. We have identified temporal trends in NO_2 from these point sources and, when possible, we have compared those to production figures from the mining companies involved. We have quantified top-down annual NO_x ($NO+NO_2$) emissions for each of the point sources identified by applying the divergence method to the TROPOMI retrievals, using ancillary ERA5 meteorological data. Because in situ NO_x measurements are not available, we contrast our emission results with emissions from the CAMS-GLOB-ANT v5.1 inventory.

Our results show that NO_x emissions from mining-related activities can be quantified remotely, which is important in the absence of local air quality monitoring. They also demonstrate that NO_2 trend analysis can be a good indicator of mine production. This is particularly relevant for non-publicly traded mining companies, which are not required to publish their production figures. Lack of TROPOMI SO_2 enhancements colocated with our NO_2 point sources is consistent with SO_2 capture and transformation into H_2SO_4, which is then used in mining-related processes or commercialized.

Paper #35

Investigating increasing air pollution and climate change on the African continent using TROPOMI data

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In the coming decades, the current African continental population is expected to double, likely reaching 2.5 billion by 2050. This population increase is expected to coincide with substantial economic growth. As a result, air pollution and greenhouse gas emissions will increase considerably, adding to the existing burden of adverse health impacts for African nations.

In anticipation of these changes, the impact of biomass burning, and wildfires needs to be carefully assessed. Will the frequency of fire episodes increase? And how will these perturbations compare with anthropogenic emissions in urban areas? In the decades ahead, Africa's contribution to climate change and air pollution will become increasingly important. It is, therefore, essential to address future trends in African emissions, for species relevant to both air quality and climate, in order to understand and quantify global environmental change.

With this presentation we specifically aim to explore which insights can be gained by combining TROPOMI satellite data with emerging modelling efforts for regional and urban emissions analysis. Recent developments featuring the NCAR MUSICA model, and the development of inverse modelling techniques will be highlighted to address these questions related to emission trends and sectorization. Additionally, strategies will be discussed to broach the general lack of surface observations of air quality and climate-relevant species across many African regions.

Recent African research results where both TROPOMI observations and modeling approaches are utilized will be presented. Finally, emphasis will be placed on contributions which can be made toward the type of integrated community effort needed to better characterize air quality and climate-related processes in across this continent.

Paper #36

Application of the Multi-Scale Infrastructure for Chemistry and Aerosols (MUSICA) over Africa

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The Multi-Scale Infrastructure for Chemistry and Aerosols (MUSICA) is a new community modeling infrastructure developed by the Atmospheric Chemistry Observations and Modeling (ACOM) Laboratory at NCAR together with the atmospheric chemistry community. MUSICA enables the study of atmospheric composition and chemistry across all relevant scales. Africa is one of the most rapidly changing regions in the world and air pollution is a growing issue at multiple scales over the continent. We have developed a MUSICA grid specifically for atmospheric chemistry research over Africa. The model configuration has a refined resolution over Africa (~28 km) while still containing a global domain (~1-degree resolution). The model configuration also includes carbon monoxide (CO) tracers to indicate the source regions (West Africa, South Africa, North Africa, East Africa, Central Africa, and inflow from outside the continent) and source types (anthropogenic, fire, and waste burning) to the air pollution over Africa. We have run the model for the whole year of 2017 and compared our MUSICA results with a Weather Research and Forecasting (WRF) model coupled with Chemistry (WRF-Chem) simulation over Africa (~20 km resolution). The preliminary results show that the performance of MUSICA is comparable to WRF-Chem when evaluated with in situ observations of CO. In addition, as the in-situ observations over Africa are limited, we also evaluate the MUSICA model results using satellite products. Specifically, we compare the model results to CO from the measurement of pollution in the Troposphere (MOPITT), nitrogen dioxide (NO2) and ozone (O_3) from the Ozone Monitoring Instrument (OMI).

Paper #37

Development of an air quality forecasting system for eastern and southern Africa

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Ambient air pollution leads to 23,310 premature deaths per year, exacerbates respiratory ailments of millions of residents, and causes economic loss in millions of dollars in Eastern and Southern Africa (E&SA). For example, poor air quality is estimated to exacerbate respiratory ailments of about 20 million Kenyans and cause an economic loss of $349 million in Rwanda alone. To reduce such losses, this project aims to co-design and co-develop a regional air quality forecasting system for E&SA together with local scientists that will provide near-real-time and next-two-days information about air quality to the public and decision-makers, as well as past changes in air quality over E&SA from 2003-2022 via a dissemination system. The following tasks are being carried out to achieve this objective. Task 1: Determine the needs of stakeholders in E&SA together with E&SA SERVIR hub and align project activities with the identified needs.
Task 2: Collect and process all available multi-platform observations for assimilation and model validation. Task 3: Develop a Weather Research and Forecasting model coupled with Chemistry (WRF-Chem)-based Air Quality Forecasting system that includes:
● A system for assimilating National Aeronautics and Space Administration (NASA) satellite aerosol optical depth (AOD) and carbon monoxide (CO) retrievals.
● A near-real-time evaluation system based on available multi-platform observations in E&SA.
● A source attribution system to help with the design and implementation of emission control measures.

Task 4: Develop an information dissemination system to disseminate short-term air quality products and a regional air quality atlas from 2003-2022 for E&SA, and its integration into E&SA SERVIR hub's Early Warning Explorer (EWX).
Task 5: Capacity building and transition of the new system to E&SA to ensure sustainability.

This system, providing both the past and short-term future air quality information, will help decision-makers issue timely alerts and warnings about upcoming air pollution events to the public, who then can make informed decisions about protecting their health. The generation of long-term gridded air quality information through a combination of regional atlas and air quality forecasts in unmonitored areas of E&SA can help environment management agencies in this region make informed decisions for designing future air quality monitoring systems in the region.

Paper #38

Comparisons of laboratory and field studies of chemical and optical properties of emissions from African Biomass Fuels

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Biomass burning (BB) is a major source of pollutants that impact local, regional, and global air quality, and public health. Work in our lab is focused on emissions from African biomass fuels - a hotspot source region of carbonaceous aerosols on a global scale. Recently we investigated the relationship between morphology (fractal dimensions) and modified combustion efficiency (MCE); measured emission factors of pollutants from six different sub-Saharan African biomass fuels combusted under a wide range of burning conditions (MCE's). determined the influence of combustion condition and fuel type on the hygroscopicity parameter of BB aerosols measured using the enhancement in light extinction coefficient (f(RH)) using cavity ring-down spectroscopy (CRDS) and a cloud condensation nuclei counter (CCNC). Ongoing studies in our laboratory focus on investigating how the molecular-level composition of smoldering-dominated organic-rich solid African biomass burning aerosols change as a function of aging conditions (i.e., fresh versus dark/photochemical/cloud water aging) and how these aerosol optical properties (mass scattering, absorption, and extinction cross-sections, absorption/scattering Ångström exponents, and the single scattering albedo) change because of any potential molecular-level chemical changes. We analyze filter samples with a platform that consists of ultra-performance liquid chromatography coupled in-line to a diode array detector and a high-resolution quadrupole time-of-flight mass spectrometer, equipped with an electrospray ionization source operated in both positive and negative ion modes. The simultaneous absorption and mass spectral optimized chromatographic analysis of solvent extracts is expected to reveal individual BrC constituents and their key chemical characteristics. The evaluation of the constituents' atmospheric relevance is based on analysis of filter samples collected in the lab and two distinct locations in Africa (Botswana) during the dry-winter fire season in 2022, followed by mass closure of the main chromophores. This study will add to the growing knowledge in African fuel sources and their varied impact on climate and air quality.

Paper #39

Using ground-based measurements and satellite observations to advise policy makers on air pollution mitigation and adaptation in Rwanda

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Rwanda Climate Observatory (RCO) under Rwanda Space Agency is conducting research on air pollutants and greenhouse gases daily and seasonal variability in the region based on both ground-based instruments and satellites data. RCO is currently the only station in Africa among the 15 stations of the Advanced Global Atmospheric Gases Experiment (AGAGE) global network sponsored by Massachusetts Institute of Technology. Several ground-based instruments were used namely: Picarro G2401 and Picarro G5205 instruments were used for CO_2, CH_4, CO, N_2O and H_2O daily measurements respectively from 2016 up to present, the Nephelometer was used for $PM_{2.5}$ measurements from 2018 up to present and Aethalometer was used for Black Carbon measurements from 2017 up to present. The Atmospheric Infrared Sounder (AIRS) was also used to evaluate spatial distributions of CO_2 and CH_4 from 2003 to 2021 while CO from 2002 to 2020. The Ozone Monitoring Instrument (OMI) was used to evaluate spatial distribution of NO2. The Vaisala weather transmitter was used to measure the daily wind direction from 2015 to 2022. The Terra and Aqua Moderate Resolution Imaging Spectrodiameter (MODIS) was used to evaluate diurnal variability of aerosol optical depth (AOD) in all seasons from 2015 to 2021. The Sentinel5P was used to investigate the daily interactions between aerosol-cloud properties based on daily observations of CO, SO_2, NO_2, aerosol index, cloud optical depth, cloud fraction, cloud base height and cloud top height. The Vaisala automatic weather station and ERA-5 model reanalysis were used to indicate the role of winds in transporting air pollutants and GHG while the Hybrid Single Particle Lagrangian Integrated Trajectory (HYSPLIT) model was used to indicate the trajectories of air masses. The findings show that high and low amount of air pollutants and GHG are found in dry and rainfall seasons respectively. The air pollutants and GHG are mostly emitted from anthropogenic activities. The dominated south-easterly winds reveals that the source of GHG, air pollutants and aerosol particles is mainly coming from south-eastern African countries. These new findings will help policy makers on taking better decisions for air pollution mitigation and adaptation.

Paper #40

Assessment of CO pollution sources and fates across the African continent using global simulations and satellite observations

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Atmospheric carbon monoxide (CO) is a tracer of incomplete combustion and therefore a good indicator of air pollution levels from biomass burning and fossil fuel. We first identify the long-term changes in anthropogenic sources in the CO satellite record from the Measurement Of Pollution in The Troposphere (MOPITT). We assess the reliability of the CO trends by comparing with the shorter but more recent time series from Infrared Atmospheric Sounding Interferometer (IASI) and Cross-track Infrared Sounder (CrIS). Second, we perform a global model simulation with the Community Atmosphere Model with chemistry (CAM-chem), driven by the anthropogenic emissions (version 5.1) provided by the Copernicus Atmosphere Monitoring Service. In addition, a couple of simulations are performed with 3 alternative anthropogenic emission inventories for CO only: i) Hemispheric Transport of Air Pollution version 3 (HTAPv3) and ii) Community Emissions Data System version 2 (CEDSGBD-MAPS), iii) DACCIWA version 2. For a case study we also include different biomass burning inputs and evaluate the simulations with NASA ATom aircraft observations and TROPOMI CO. The goal of these simulations and their comparisons with observations is to characterize the spatial and temporal distribution of model uncertainties across the continent and to identify the patterns of anthropogenic pollution. We hope to identify regions where additional observations from a potential field campaign could help guiding future model development.

Paper #41

Use of NASA resources and existing monitor data for air quality monitoring, public communications, and to inform future health data collection efforts in Uganda

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We present ongoing efforts to utilize NASA assets and existing observational data to improve air quality policy and planning and reduce health burdens in cities in low- and middle-income countries. We are currently working in collaboration with the African Center for Clean Air (ACCA), and are initially focusing our efforts on Uganda, though we hope to expand to other African cities and countries. Our work is centered around an integrated approach to air quality management that includes satellite and low-cost sensor observations, air quality forecasts, and communications tools, coupled with tailored technical capacity building activities on the use and implementation of these resources. Remote sensing training to date has covered basic interpretation of satellite traces gas, aerosol, and fire location observations; and the use of webtools for access to these resources. These capacity-building activities are tailored to specific stakeholder communities in Uganda (e.g. decision makers, researchers) through discussions on key user needs and air quality management challenges, and an assessment of existing capacities and knowledge of remote sensing assets. It is expected that these NASA assets will help support air quality monitoring efforts and decisions on future health data collection in Uganda; and facilitate a better understanding of the associations between short-term pollution exposures and local respiratory morbidity outcomes. This project is funded under NASA's Health and Air Quality Applied Sciences Team.

Paper #42

Aerosol Phase State and Impact on Regional Scale Model Predictions of $PM_{2.5}$

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Atmospheric fine particulate matter ($PM_{2.5}$) is known to adversely impact human health and the Earth's climate. The dominant fraction of $PM_{2.5}$ is organic, composing up to 20-60% of $PM_{2.5}$ mass in the continental mid latitudes. These organic aerosols (OA) can be formed in the atmosphere through the oxidative processing leading to secondary OA (SOA) formation. Climate studies of aerosol impacts on clouds and radiation forcing require predictive models with an accurate representation of the formation processes of SOA. Accurate SOA $PM_{2.5}$ predictions are a known challenge for regional and global scale air quality models (AQMs), partly due to reliance on highly parameterized SOA approaches. For example, AQMs currently do not capture the full complexity of interactions of SOA formation and the physicochemical properties of the aerosols. These interactions must be adequately represented in AQM to accurately predict SOA. There is a growing recognition that aerosol phase separation and the formation of aerosol coatings impact aerosol chemistry, and that the lack of consideration of aerosol phase state in AQMs introduces uncertainty in SOA predictions. Recent experiments have shown that SOA coatings can significantly reduce the reactive uptake probability of isoprene-derived SOA. This new data now allows for examination of constraints on critical parameters needed to simulate the coating effects in acid-catalyzed reactive uptake.

This talk highlights a newly integrated gas- and particle-phase chemical mechanism that incorporates the latest knowledge of gas-phase reactions, SOA precursors, and the influence of phase state on acid-catalyzed multiphase chemistry. The work was implemented in both a box model for testing purposes, and in a regional scale (CMAQ) model. Results include data from the box model that utilizes experimental data to evaluate and develop modifications for the CMAQ model. We have also implemented phase state in a CMAQ model that is simulating 2013, for the domain covering the Southeastern US. Results indicate significant impact on SOA. Formation. Chemistry. In phase separated aerosols the amount of anthropogenic versus biogenic organics, and. Atmospheric aging of those organics were critical factors. These results suggest that the prediction of $PM_{2.5}$ from multiphase chemistry could be significantly impacted in African megacities. Updated model runs with improved aerosol phase state could be used to guide future field campaigns in Africa related to $PM_{2.5}$.

Paper #43

Ground-based Remote Sensing for Regional Air Quality & Greenhouse Gases: Pilot Project and Engagement

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We will discuss a project to make observations in the lower atmosphere of several species that are transported to, emitted, or formed near the surface that effect local or regional air quality, are ozone precursors, or are longer lived greenhouse gases.

The instruments to be deployed are broad band moderate spectral resolution solar viewing infrared Fourier transform interferometers (FTIR). They are active from 780-6500 cm^{-1} and consequently sensitive to many atmospheric constituents: O_3, NO_2, N_2O, CO, CO_2, CH_4, NH_3, HCFC-22, CFC-12, H_2CO, C_2H_6, HCN among others. This unique suite of measurements represents emissions from biomass burning, fossil fuel extraction and burning, agricultural activity, ozone and its precursors and greenhouse gas emissions and state.

The project duration will span several seasonal cycles to reasonably characterize the region. Measurements are taken during cloud free daytime periods so maximum output requires locations providing a large fraction of annual time realizing viewing criteria. The instruments are largely autonomous but will require some tending. A pilot project would consist of a minimum of three stations surrounding a region of interest possibly a mixed urban, industrial, agricultural area to measure the atmospheric state over time and provide estimates of regional flux. A modeling component to the program will augment and improve our regional understanding. Satellite data including TROPOMI and MOPITT with their associated footprint and overpass characteristics will also improve information and regional context in conjunction with the local more continuous FTIR data. A further component is that of complementary in situ measurements that can function as calibration stations and a link between lower cost sensors/networks and the remotely sensed data. This will including a mobile cross-calibration facility with both in situ and remote sensing measurements. The project will require local engagement for instrument maintenance, retrieval processing and analysis. We would engage with any/all interested researchers on each aspect of a unique and successful observational program. Data processing tools will be deployed for analysis of the raw data and data products will be shared amongst all interested parties. We would plan a workshop series or course for training on the theory of the experiment, operation, and remote sensing, on FTIR instrumentation design, operations, and maintenance, and on retrieval theory and processing targeting future enthusiasts, operators, and leaders.

Paper #44

Connecting local and regional needs to NSF research goals

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Atmospheric research and air quality management in most African countries is hampered by a lack of essential monitoring and measurement infrastructure that is widely used in the Global North. AfriqAir is dedicated to filling in this infrastructure and the associated training gap. We also firmly believe that local, in-country knowledge and expertise is crucial to improving air quality in Africa. Our goals are to increase our collective understanding of air quality in African cities using ground measurements and to train African scientists and air quality practitioners. This presentation will first discuss research and capacity building needs expressed to us by our African partners. This includes deploying more regulatory-grade and low-cost sensors; training on sensor operation, data analysis, and the use of modeling tools; and quantifying the impacts of transboundary pollution. We will then discuss ways that these basic capacity building needs can be incorporated into the sorts of science questions fundable by agencies like NSF. For example, a study centered on the physicochemical interactions between emissions from solid fuel burning (e.g., charcoal making, home heating) and traditional urban emissions could incorporate training opportunities for local scientists to collect samples and analyze resultant data. Incorporating local capacity building at the proposal stage will create "win-win" scenarios, avoid helicopter science, and meet NSF's requirements for broader impacts.

Paper #45

Assessing air composition over Africa over the last two decades using satellite observations and modelling

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Africa is home to more than a billion inhabitants with about 40% of the population living in large urban centers. Anthropogenic emissions have grown rapidly during the two last decades according to global inventories (Elguindi et al. 2020). However, these estimates bear large uncertainties due to the lack of up-to-date accurate information regarding activity data and emission factor for African countries. Besides the impact of anthropogenic emissions on air pollution, open biomass burning plays an important role, as it accounts for about 50% of fire-related carbon emissions and 70% of the global burnt area (Andela and van der Werf et al., 2014). Further, the African rainforests play a major role as source of biogenic volatile organic compounds (BVOCs), key drivers of tropospheric chemistry through their impacts on ozone, aerosols, and the oxidizing capacity. African ecosystems contribute on average at least one third to global BVOC emissions; long-term trends in those emissions are caused by climate change and forest degradation (Opacka et al., 2021). Despite the importance of the African continent for air quality and climate, this region remains understudied due to a relative scarcity of monitoring capabilities and measurement campaigns. While waiting for the development of long-term ground-based facilities and field studies, satellite chemical observations provide invaluable information which, in combination with models and inversion methods, can deliver useful constraints on the emissions of key pollutants.

Here we present long-term model simulations of the air composition over the African continent at a resolution of 0.5° for almost two decades (2005-2021). We use the regional MAGRITTEv1.1 model (Muller et al., 2019), which includes a fire emission from the QFED database (Koster et al., 2015), anthropogenic emissions from the CAMS-GLOB-ANT inventory (Granier et al., 2019), soil NO emissions from HEMCO (Weng et al., 2020), and an up-to-date representation of BVOC emissions taking into account the impact of land use changes based on satellite land cover data (Opacka et al., 2021). We compare the model output with harmonized satellite observations of HCHO from OMI (2005-2017) and TROPOMI (2018-2021), corrected for biases based on an extensive evaluation against ground based FTIR column observations (Vigouroux et al., 2020). We further compare the model results with satellite observations of NO_2 from OMI and TROPOMI over the same timespan (van Geffen et al. 2022). The model incorporates a state-of-the-art representation of the BVOC chemistry, for low-NOx regimes, which is particularly important over the tropical rainforests. Our aim is to (i) investigate the role of climate and land use changes as drivers of the observed variability in HCHO columns through their impacts on biogenic emissions (ii) assess the consistency between the observed HCHO trends with the predicted biogenic emission trends, and (iii) analyse the NO_2 variability and trends over megacities and over pristine regions to validate the emission trends of bottom-up inventories.

POSTERS

Poster #1

Hygroscopicity Matters – The role of water-uptake for air quality, climate, and health

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In-situ particle hygroscopicity measurements are rarely conducted on the African continent. However, particle hygroscopicity is fundamental to understanding the impact of aerosol for air quality, visibility, climate, and health. Specifically, atmospheric visibility is reduced by regional haze events and has steadily declined in African metropolitan cities over the last 50 years. The formation of haze is directly related to the particulate matter concentrations and the ability of particles to uptake-water and form droplets. How aerosols directly or indirectly modify the radiative balance is also significantly varied by the ability of water to condense on particle surfaces. The ability to uptake water is also directly linked to the biological pathways for which aerosols are incorporated in human pathways. In this talk we will discuss the relationship between hygroscopicity and particle physical and chemical composition. Furthermore, we will discuss the potential of unexplored sources that may contribute to regional haze on the continent and the challenges associated with collecting and analyzing robust hygroscopicity data sets.

Poster #2

Assessment of diurnal and seasonal variation of ambient particulate matter ($PM_{2.5}$) in Juja, Kenya

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Air pollution is a major environmental concern that affects human health worldwide. Despite recent studies indicating ambient air pollution is a growing global concern strongly linked to rapid global urbanization, little has been done to monitor the air quality levels in towns outside Nairobi, Kenya. Juja is one of the largest growing towns subjected to increased population, intense human activities and located along the busy Thika Superhighway. Thus, there is a strong need to monitor ambient Particulate Matter within the town. The purpose of this study was to assess the diurnal and seasonal variations of Ambient Particulate Matter ($PM_{2.5}$) in Juja, Kenya. The data was collected as from November 2019 to April 2021 at JKUAT Institute of Energy and Environmental Technology (IEET) department, a residential house within Kalimoni and an additional site along the busy Thika Superhighway. The PM level was measured using the Purple Air Monitoring Sensor – PA-II-SD in $\mu g/m^3$ on a 24hour cycle. Data analysis was done quantitatively using Excel, SPSS and R programming. The $PM_{2.5}$ level from the low-cost Purple Air Sensors were later calibrated against a reference BAM-1022 to yield corrected PM values. The results revealed that the overall $PM_{2.5}$ concentration was higher during the dry season (June - August 2020) compared to March - May 2020 (wet season) where it dropped by 5-10$\mu g/m^3$ on average. The highest daily $PM_{2.5}$ concentration was recorded at 44$\mu g/m^3$ (JKUAT) and 43$\mu g/m^3$ (Residential) both exceeding the WHO guidelines and the USEPA National Air Quality Standards. JKUAT had an annual mean concentration of 15$\mu g/m^3$, slightly exceeding the WHO guidelines of 5µg/m3. In addition, comparing the month of April 2021 from the previous year, the daily mean dropped by 5-10$\mu g/m^3$ – the period of the new Covid -19 lockdown.

Poster #3

Insights into $PM_{2.5}$ composition and black carbon sources in Nairobi, Kenya

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Air pollution is a major impediment towards resilient and sustainable cities in sub-Saharan. Approximately one million premature deaths are linked to air pollution in the region. However, the pollutant sources and composition are poorly constrained. In this study, we analyzed $PM_{2.5}$ concentration and composition, and used radiocarbon isotopic composition to investigate black carbon sources in Nairobi, Kenya. The $PM_{2.5}$ concentrations exceeded the WHO guidelines, with little seasonal variability in concentration and composition. Organics and water-soluble inorganic ions, dominated by sulfates, constituted the largest contributors to the $PM_{2.5}$ loadings. Unlike large cities on other continents and like other African cities, the fraction of black carbon (BC) in $PM_{2.5}$ aerosols was high (15 ± 4%), suggesting black carbon is a prominent air pollutant in Nairobi and the region. Fossil fuel emissions, likely local traffic, were found to contribute to over 85 of BC aerosols, and thus a prime pollution mitigation target

Poster #4

Relationship between air pollution, meteorological parameters and childhood respiratory diseases in Dakar, Senegal

Presenter: Mame Diarra Toure, Laboratoire de Physique de l'Atmosphère et de l'Océan – Simeon Fongang, Cheikh Anta Diop, Dakar, Senegal
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The role of environmental factors, such as atmospheric pollutants and meteorological parameters, in respiratory diseases is now well established in developed countries, but not in low income-countries in the Sub-Saharan region. Our goal is to investigate the impact of both air pollution and meteorological parameters on childhood respiratory diseases like asthma and acute respiratory infection in Dakar, Senegal.

We used atmospheric pollutants ($PM_{2.5}$, PM_{10}, NO_2, O_3, SO_2 and CO) measured by the CQQA (Centre de Gestion de la Qualité de l'Air) in different stations in Dakar from 2010 to 2020, as well as meteorological parameters such as temperature, relative humidity, wind speed and direction, and water precipitable collected at Dakar-Yoff international airport. In parallel, the number of admissions for asthma and acute respiratory infection is obtained from the CHNEAR (Centre Hospitalier National d'Enfants Albert Royer) at Dakar-Fann for the period 2010-2018 and from the IPS (Institute Pediatrique et Sociale) at Guediawaye, a Dakar suburb, for the period 2017-2020.

For the period 2010 to 2020, annual $PM_{2.5}$ concentrations range from 25.6 to 64.4 $\mu g/m^3$ and PM_{10} concentrations range from 128.3 to 176.0 $\mu g/m^3$, indicating PM levels that are 3 to 6 times and 6 to 9 times higher than the WHO 2005 standard, respectively. Results show a clear seasonal variation, with higher concentrations observed during the dry season in December-January-February, whereas respiratory diseases such as asthma and acute lower/upper respiratory

Poster #5

Aerosol Measurements and Characterization in Botswana During Wet Season

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This presentation reports results from a 5-week in-situ observational study id airborne particulate in Palapye, Botswana during the 2022 wet season. The overall goal of this project was to analyze the chemical components of the aerosol particles collected on size-segregated filters and compare them to local emissions in the region. This project was conducted at a remote weather station on the Botswana International University of Science & Technology (BIUST) campus over a 5-week period during June and July of 2022. The two instruments involved in this study were a single stage cascade impactor (Andersen Cascade Impactor, N6 Single-Stage) and a microanalysis particle sampler (California Measurements, MPS-3). A total of 21 single-stage cascade impactor filter samples and 20 microanalysis samples were collected during the observation period. Both instruments enabled collection of size segregated aerosol particles in the down to .05 micron. The single-stage cascade impactor collected samples on a 47-mm glass fiber filter for a 24-hour period. While the Microanalysis particle sampler collected samples on scanning electron microscope (SEM) stubs for 8 hours.

Analysis of SEM imagery and energy dispersive X-Ray spectroscopy of the daily bulk filters and 8-hour samples reveal the relationships between morphology, distributions, and heavy metal distributions in the airborne particulate during the observation period. These data are combined with wind sector analysis to relate the observed differences to potential source regions and the geographic distribution of local and regional emission sources.