

Commentary

The Rwanda Climate Observatory: Developing Climate Science in East Africa

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Kigali, Rwanda will forever be associated with climate change with the Kigali Amendment to the Montreal Protocol. This hilly East African capital city, with a population of approximately one million, was where plans to reduce and phase out hydrofluorocarbons (HFCs) emissions were negotiated. As a class of compounds, long-lived HFCs are used as refrigerants and as foam-blowing agents, among other industrial uses, and are the fourth-highest anthropogenic greenhouse gas in terms of radiative forcing (scaled by atmospheric concentration) according to the 2013 Intergovernmental Panel on Climate Change (IPCC) report.

Rwanda itself is a small country not known for its climate forcing emissions. The majority of citizens are subsistence farmers and, while economic development and industry is increasing, greenhouse gas emissions are still minimal compared to other countries in North America, Europe, and Asia. However, Rwanda is a country ripe for the impacts of climate change. IPCC reports find that Rwanda's rain and rainfall intensity will increase, and Rwanda's hilly countryside, often deforested for agriculture, is prone to landslides. Changing rain patterns will impact local farmers and crop yields, and the Rwandan government is concerned about food security, as Rwanda is the second most densely populated country in Africa.

In countries like Rwanda, adaptation to a changing climate and mitigation of climatic effects, rather than reducing greenhouse gas emissions, is the main focus of policy. To really understand local climate change and thus develop adaptation policies, however, local understanding of the changing climate and greenhouse gas concentrations is essential. While many initiatives are starting to emerge in Africa to monitor the atmosphere (e.g., Mt Kenya's Global Atmospheric Watch Station, South Africa's network of air quality monitors), time-resolved and continuous measurements are much sparser than in Europe, North America, and much of Asia. There is a gap in knowledge in this area of the world that needs to be filled.

Rwanda's government is concerned with environmental policies. They have enacted several Green Growth initiatives (<http://www.greengrowthknowledge.org/country/rwanda>), have banned the import of plastic bags (<https://plasticoceans.org/rwanda-plastic-bag-ban/>), and have a thriving conservation

effort in their mountain gorilla tourism. Rwanda is also seeking to move its population from subsistence agriculture to new, higher-income generating industries, particularly the STEM sector. To do this, STEM entities need to be brought into the country. In 2009, Rwanda's president, President Paul Kagame, sought partnership with the Massachusetts Institute of Technology (MIT) for the development of STEM in Rwanda. With thoughts of both STEM and green growth, the government of Rwanda partnered with MIT to establish the Rwanda Climate Observatory (RCO).

Since 1978, MIT, under the supervision of Professor Ron Prinn, has run a global network of greenhouse gas measurements, currently known as the AGAGE (Advanced Global Atmospheric Gases Experiment) network. One of the key components of this network is the measurement of trace greenhouse gas species, such as HFCs, with a GC/MS using a customized sample collection and inlet system (known as the Medusa). This instrument delivers hourly concentration information of HFCs and other trace greenhouse gases. These data can be analyzed and ingested into models to increase understanding of sources, sinks, and long-range transport of these species. Before the establishment of the RCO, no AGAGE site existed in Africa and few HFC measurements were made.

It would be fitting for Rwanda, as the site of the ratification of the Kigali Amendment, to host the first continuous and hourly time-resolved measurements of HFCs in sub-Saharan Africa. And that day is close: a custom-built instrument has been delivered to Kigali for testing in 2018. While waiting the construction of this instrument, much other work has been done to establish the RCO. Potential sites were evaluated for their ability to capture long-range transport (through atmospheric modeling) and for their ease of access for technician visits, remoteness from urban centers, and access to infrastructure (through site visits by MIT scientists). MIT raised funds from donors to make instrument purchases, with the understanding that these would be donated to the government of Rwanda. By 2013, the initial installation of instrumentation at the RCO began on the summit of Mt Mugogo, a 2540 m peak in western Rwanda. Currently, the RCO hosts regular measurements of black carbon particles (an instrument paid for by a grant from COMESA), carbon dioxide, carbon monoxide, nitrous oxide, ozone, meteorological

parameters (such as temperature, wind speed, wind direction), and solar intensity. Nitrous oxide has been measured since 2017 and the other measurements have been ongoing since 2015. In 2017, in a partnership with Carnegie Mellon University (which has a campus in Kigali), a Real-Time Multi Pollutant (RAMP) sensor measuring typical air quality criteria pollutants was also deployed at the RCO. Carbon monoxide and black carbon data have been used to understand the impact of seasonal large-scale biomass burning versus more local pollution on Rwanda, and the carbon dioxide measurements have been used in models to understand emissions and sinks in this understudied region of the world.

Most of the AGAGE network sites are run by MIT or its AGAGE partners, the Scripps Institute of Oceanography and the University of Bristol (with other participating universities). The RCO is a different model: while MIT donors paid for initial instrument purchases, the government of Rwanda owns and manages the Observatory and the station is run by an MIT-trained PhD scientist from Rwanda, Dr. Jimmy Gasore. The day-to-day operation of the station is maintained by four station technicians, trained by MIT scientists, and a technical coordinator and financial coordinator who sit in the Rwandan Ministry of Education. A new University of Rwanda Master's Program in Climate Science, which just graduated its first class in 2018, uses the data generated from the RCO for their research projects. While still able to tap into the scientific expertise of the AGAGE community, embedding the RCO within the Rwandan government ensures the longevity of the project. Local technicians are able to answer any routine maintenance issues, local scientists are able to direct new research, and local students are able to drive the research forward. Government officials like the Director General of Science and Technology, Dr. Marie-Christine Gasingriwa, were involved in the RCO construction process and are able to advocate for the RCO within the government.

The model of providing instrumentation and training, but leaving the infrastructure and project continuation to the observatory country location, has worked well in Rwanda. From this project other associated projects have sprung up, including the establishment of a countrywide air quality monitoring network. In early 2018, the RCO was accepted as a World Meteorological Organization atmospheric watch station. This will connect the RCO, already part of the global AGAGE network, to another global network and help ensure data quality control and data decimation.

Climate change is a global problem, and one likely to impact those who have contributed least to it. These areas of the world are also rapidly developing, but often lack data to understand how their development could affect their emissions of climate forcers. Local scientists who may wish to work in their home country on climate and air quality issues may leave to find better opportunities in countries with established research centers. Beginning to establish more measurements in data poor regions of the world will increase these regions' abilities

to enact and enforce emissions policy and increase accuracy and local applicability of climatic impact models by inserting real, spatially resolved data into climate models. The RCO will hopefully provide (along with Mt. Kenya) long-term data and analysis on climate change in equatorial East Africa.

References

About the Rwanda Climate Observatory Project:
<http://atmoschem.mit.edu/rwanda-climate-change-observatory/>
<http://mineduc.gov.rw/projects/climate/>
<http://www.fonerwa.org/portfolio/rwanda-air-quality-and-climate-change-monitoring-project>
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About Climate Change and the GAW Network:
<http://www.ipcc.ch/>
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