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Editorial: Greenhouse gas measurements in underrepresented areas of the world

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Editorial on the Research Topic
Greenhouse gas measurements in underrepresented areas of the world

Background

Major efforts for quantifying greenhouse gas (GHG) production and consumption in agricultural and natural ecosystems and understanding their drivers are currently being developed around the world, as well as on how climate change will influence ecosystem functioning and with that GHG emissions. These efforts include the monitoring of GHG fluxes with both manual and continuous measurements, mainly with closed soil-atmosphere flux chambers and micrometeorological approaches such as the eddy covariance technique, but also with other methods such as animal respiration chambers. These measurements can be used for calibrating models that simulate ecosystem functioning and their responses to climate change and to estimate local, regional or global GHG budgets. Despite these efforts, there is a large spatial concentration of GHG flux measurements in developed countries, while low- and middle-income countries (LMICs) are underrepresented. As a result, the tropics and most Southern Hemisphere biomes are heavily underrepresented in flux networks (1, 2). At the same time, LMICs are regions with fast population growth and land-use change, thereby potentially creating critical uncertainties in national and global GHG budgets.

This situation potentially generates errors in model predictions for these underrepresented areas due to a lack of local data because it is often assumed that ecosystems in these areas behave identical to those sampled elsewhere in similar biomes, ecosystem types or plant functional types, despite differences in climate, ecosystem characteristics, and management. This gap in data availability potentially generates a critical bias for predictions at the global scale.

Furthermore, local data characterizing GHG emissions from management systems in LMICs are urgently needed to develop meaningful interventions to reduce GHG emissions and to help LMICs achieve their climate change mitigation goals. Many LMICs still rely on

Tier 1 GHG emissions reporting, which does not allow for quantifying the mitigation potential of interventions. To achieve this, countries must move to at least Tier 2 reporting, for which local GHG emission factors that represent local production systems and management practices are required.

Research results included in this Research Topic

In this Research Topic of *Frontiers in Soil Science* we report research results from underrepresented areas in Africa (4 studies), South America (2 studies), and Europe (1 study). Sibret et al. described the first eddy covariance system installed at the second largest tropical forest in the world, located at the Congo basin (Figure 1). The measurements of carbon dioxide (CO_2) and water (H_2O) fluxes that started in 2020 will be complemented with methane (CH_4) and nitrous oxide (N_2O) flux measurements using the eddy covariance technique, which will provide key information on the full GHG budget of this relevant area. Farmer et al. measured heterotrophic soil CO_2 emissions in drained peatlands in Uganda used for growing potatoes and found significant effects of microtopography, water table and previous soil disturbance on the fluxes. After reviewing available studies on GHG emissions and soil organic carbon (SOC) storage from livestock systems in Sub-Saharan Africa, Graham et al. found that while some progress has been made in the past decade, large data gaps remain, particularly regarding manure management, small ruminants, agropastoral/pastoralist systems, and in general from West Africa. While in the available studies soil organic carbon stocks show agreement with IPCC estimates, differences were found with IPCC Tier 1 emission factors for different types of animals, highlighting the need for local country-specific emission factors. Kibet et al. measured the three main GHG fluxes (CO_2, CH_4 and N_2O) during one year in five common land use systems within a small farm in western Kenya that are representative for stallholder systems in the area, which will allow filling a gap in the national GHG budget.

By combining 9 years of eddy covariance data with satellite images, Marconato et al. successfully predicted monthly net ecosystem exchange in a crop rotation at the Pampas region in Argentina. The authors estimated net biome productivity after subtracting carbon exported in harvested biomass (between 60% and 80%). Working on a maize-soybean rotation also in Argentina, Vangeli et al. showed that in low-input cropping systems, no-tillage and use of legume cover crops can favour yields but may also increase N_2O emissions during the early stages of the following cash crop.

Finally, Pinto et al. set up a mesocosm study using the ^{15}N isotope pairing technique to study GHG fluxes and nitrogen transformation processes during dry and wet cycles from the interface between aquatic and terrestrial systems. They found that drying enhanced both nitrification and denitrification rates and that N_2O fluxes from nitrification were related to organic matter content, while fluxes from denitrification were controlled by dissolved organic matter quality changes during the drying-rewetting cycles.

FIGURE 1
Tall tower installed at the Congo basin to measure greenhouse gas fluxes. Credit: Thomas Sibret.

Problems faced by researchers in underrepresented areas

Based on a survey among authors and editors of this Research Topic, the dominating problems faced by researchers in underrepresented areas are 1) the lack of local funding for establishing studies on GHG fluxes that often require expensive equipment, which makes these studies dependent on bilateral funding that may or may not allow developing long-term research projects and can take several years until cooperation agreements are reached, 2) lack of qualified personnel, which requires training and therefore additional time and funding, 3) depending on the development status of the country, lack of proper roads and infrastructure at some remote locations may also be a problem, 4) safety of scientific equipment (e.g. risks from wildlife, theft, power fluctuations), and 5) administrative restrictions that hamper the transportation of equipment, samples and personnel across borders and can delay site setup and equipment installation.

After these hurdles have been met and research projects have been successfully established, the lack of continued funding keeps on being the main problem to sustain projects, keep research personnel on board, and maintain equipment functionality, which is further aggravated by high costs related to long distance travel of analysers and other sensors for in-factory calibration, repairs and other services, frequently exacerbated by high customs charges. This situation is often associated with a lack of replacement equipment, affecting data quality and generating long data gaps. Furthermore, security concerns linked to political instability and ethical conflict can restrict site access and make frequent and continuous measurements challenging.

Recommendations

The lack of measurements and estimations in some parts of the world is linked to several factors, including the lack of monetary and human resources, inaccessibility, and political instability. To improve the representation of GHG measurements around the world, our recommendation is to create funding opportunities for international collaboration, specifically aimed at establishing long-term projects in places and ecosystems where there is a known lack of GHG flux measurements. This funding should include resources for training local researchers on the relevance of the measurements, the use of instruments, the postprocessing of data, and the publication of results. Furthermore, decision makers should be included in the development of funding programs to ensure that data gaps and research questions that are of high relevance for the respective countries are addressed. Working on filling these data gaps is critical for improving our knowledge on global GHG emission patterns and controls, reducing model uncertainties, and developing meaningful and targeted interventions for climate change mitigation.

Author contributions

Conceptualisation, writing—review and editing, supervision and funding acquisition: AM, JP-Q, and SL. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors JP-Q and AM declared that they were editorial board members of Frontiers, at the time of submission. This had no impact on the peer review process and the final decision.

The remaining author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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