



IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 11 Issue: VIII Month of publication: Aug 2023 DOI: https://doi.org/10.22214/ijraset.2023.40715

www.ijraset.com

Call: 🕥 08813907089 🔰 E-mail ID: ijraset@gmail.com



Measurement and Evaluation of Greenhouse Gases with Cloud Based Logging

Aiyeola S.Y¹, Mohammed I.N², Alapa F³, Adewumi O.D⁴, Oluyombo W⁵, Ibrahim Aminu⁶, Udeh B. N⁷, Egan M⁸, Isah S.⁹, Ogbe S.S.¹⁰

1, 2, 3, 4, 5, 6, 7, 8,9,10 Centre for Satellite Technology Development Abuja, Nigeria

Abstract: Robust measurements of natural Greenhouse Gases emissions are vital for evaluating regional to global carbon budgets and for assessing climate feedbacks on natural emissions to improve climate models. To capture and analyze the high temporal variability of these fluxes in a well-defined footprint, we designed and developed an inexpensive device. In addition to automatically collect gas samples from footprint for subsequent various analyses in the laboratory, this device also utilizes a low cost carbon dioxide sensor, Temperature and Humidity Sensor, GPS sensor to measure Greenhouse Gases (GHG). Each of the devices modules were equipped with an ESP32 Wi-Fi, NodeMCU and Transceiver module to enable a local radio communication with the ground receiving Station for onward processing to cloud. This study shows the potential of a low cost and low instrument, open source software for devices development as automatic sensor network system to study GHG fluxes. Results obtained from research is shown as follows: CO2 (360 to 455 ppm), Temperature (26.9 °C to 30.9°C) and Humidity (35.5% to 36.5%) which is good for human health. However, this research proves human capacity building and promotion of open data access for research.

Keywords: Greenhouse Gases; MQ 135, BMP280; DHT11; ESP 32 WiFi Modules; NodeMCU; Cloud.

I. INTRODUCTION

Atmospheric Greenhouse Gas (GHG) concentrations increases by human activities which result in global warming and climate change (IPCC, 2014). Measuring Greenhouse Gas (GHG) emissions is of paramount importance to understanding the emissions trends of companies, vehicular movement, facilities and human activities so that targeted and effective mitigation strategies can be developed. However, this prompt research on GHG emissions which is critical to understanding of the consequences of rapidly increasing atmospheric GHG concentrations. This research should be carried out globally, in both developed and developing countries, since both have different sources and sinks of GHGs, different climate-change vulnerabilities, and different capacities for mitigation and adaptation (López-Ballesteros et al., 2018; Ogle et al., 2014), GHG research has not been widely conducted globally especially developing countries. Recently, GHG research adopting appropriate technology and approach (Murphy et al., 2009) has been proposed and carried out. This uses low-cost and low-technology instruments, open source software and data, and participatory approaches, and in many cases has resulted in valuable research results accepted by International Scientific Communities (Choi, 2019; Shames et al., 2016; DeVries et al., 2016; Bastviken et al., 2015). High frequency measurements over long periods with broad spatial coverage of studied areas could reduce this uncertainty and result in more representative gas emission estimates. Some recent studies using low cost CH₄ (Eugster and Kling, 2012) and CO₂ sensors (Bastviken et al., 2015) could however be coupled to simultaneously study CH₄ and CO₂ flux across the air-water interface. It is a high sensitivity CH₄ gas sensor made for air contaminants and gas leak detection. Eugster and Kling (2012) showed that this sensor has potential to measure CH₄ at ambient air concentrations. The sensor has a high sensitivity to relative humidity and temperature, but these responses can be corrected for to yield a realistic CH₄ signal. To increase the quality and quantity of observations of GHG emission, we developed a low-cost, simple, robust and portable device with a well-defined footprint for investigating gas flux at with a defined location as reference point. Here, we tested three commercial sensors including: MQ135, DHT 11 and BMP 280. The CO₂ sensor used here is MQ135, which is low power modules that measures CO₂; DHT 11 modules is a temperature and humidity sensor features a temperature sensor complex with a calibrated digital signal output and BMP280 modules measures humidity and pressure.

A. Observation of GHG Fluxes

It was reported in 2000, soil CO_2 flux measurements had been conducted at 1815 sites in only 42 countries; this had increased to 6625 sites in 75 countries by 2016 (Jian et al., 2021 and Dung-Gill et al., 2021) (Fig. 1 and 2). The exponential increases in



measurements could be attributed to increased interest in the research area, and quickly-developing, highly advanced instruments using relevant technologies.

In terms of continental scale, measurements in Europe, North America and Asia cover around 90% of the global observations, while Africa and South America remain critically underrepresented (Dung-Gill et al.2021; Jian et al., 2021; Épule, 2015; Kim et al., 2013) compared to their importance in global GHG budgets (Fig. 3).



Figure 1: Global distribution of observed soil carbon dioxide fluxes by 2000 (above) and 2016 (below). Data Source: (Dung-Gill et al. 2021., Jian et al. 2021). Created by Giacomo Nicolini.





Figure 2: Cumulative observations of annual soil-to-atmosphere flux of greenhouse gases (CO2, N2O, and CH4) over time. An observation indicates a set of measurements that resulted in an annual flux estimate. Data source: CO2 – Jian et al. (2021); Dung-Gill et al. (2021); N2O – Global N2O Database (<u>https://ecoapps.nrel.colostate.edu/global_n2o/</u>) and CH4 – Al-Haj et al. (2020),



Figure 3: Number of published soil carbon dioxide flux observations in each region. An observation indicates a set of measurements conducted in a site during a certain period. Data source: Dung-Gill et al. (2021) and Jian et al. (2021)

B. Greenhouse Gas Flux

Low-cost technology has also been adopted in GHG research. Studies have utilized low-cost sensors to monitor atmospheric concentrations of CO_2 (Shusterman et al., 2018). Some studies have also demonstrated how to build low-cost gas sampling and analysis instruments (Carbone et al., 2019; Martinsen et al., 2018; Bastviken et al., 2015). For instance, Bastviken et al. (2015) utilized a low-cost CO_2 logger to measure CO_2 fluxes in terrestrial and aquatic environments. They replaced an expensive and high precision CO_2 analyzer and data logging system with a low-cost CO_2 logger which was originally produced for industrial uses, and with careful practices, bias and accuracy remain good enough for many carbon-cycle applications.

Antero Ollila (2017) reported the Warming Impacts of Greenhouse Gases in the Clear Sky using Average Global Atmosphere Model, AGA15 atmospheric profile, the absorption values of GHG can be calculated changing the concentration of each GHG starting from zero level in clear sky condition. The warming effects can be then calculated by using equation (1).

 $T = -274.3249 + 50.7558 * \ln(E)$ (1)



where T is the temperature impact (°C) and CO2 is the concentration of CO2 (ppm). The coefficient of determination R^2 is 0.999, the standard error is 0.02°C. This formula is valid in the concentration range from 200 ppm to 800 ppm. This formula gives the temperature change 0.6°C for the CO₂ concentration from 280 ppm to 560 ppm.



Fig. 4. The warming impacts of GH gases in the clear sky conditions. The red dots represent the concentrations and warming impacts of the year 2015





Data Source: Antero Ollila (2017)

II. METHOD

This section, describe the technical details of our device that simultaneously measures CO_2 flux, temperature, altitude and equipped with a radio transmitter module as shown in figure 6 for wireless data transfer and monitor. The concept of the Cloud Based System for Greenhouse measurement is to demonstrate proof of concept of a satellite mission by measuring Greenhouses Gases (GHG) at selected altitude from the earth by utilizing greenhouse sensors as stated above and delivering data from such sensors to cloud at real



time. This project will use the "ThingSpeak" server platform to output the data to the cloud, and the "ThingShow" mobile App as users' access terminal. Interested users of the data can download the app, and, with granted access, view the data as shown in figure 7.



Fig 6: Remote Transmitter Unit



Fig. 7 Remote Receiver Unit





Fig. 8 Block Diagram for System Level Requirement

Figure 8 above show high level requirements specifications at stage level.

- Data Capture Unit: Its main components are MQ-135, BMP280, and DHT11. Also, other components such as ESP32 Wi-Fi, NodeMCU, breadboard, and jumper wires will be integrated together to enable the sensors to detect any kind of gases along with dust, temperature and humidity.
- 2) Database Unit: The sensed data will be stored to be used by the XAMPP website and display the results immediately through using different display modules. Captured data will be sent through using IoT gateway to record collected data in a database using web services developed in Hypertext Pre-processor (PHP).
- *3)* Cloud Computing Unit: ESP32 Wi-Fi module will send the sensed data from the sensors into the ThingSpeak cloud computing platform which will process faster and make it ready for use in our web application.
- 4) Mobile App Unit: ThingSpeak's web application needs a database to save and make the visualization of data easier, faster, and more accessible. The database will record information like for example user's personal information, sensing data, and user request information. The basic structure of this database is made of a set of graphs where information about a particular entity is graphically represented. Displayed information has many features and acts as interface for the user and administrator.

III. RESULT

Result of this research were calculated from the measured data of the cloud computing unit and information about a particular entity is graphically represented.

IV. DISCUSSION

Figure 9 presents the relationship of Carbon dioxide (CO_2) parts per million with Time, as it can be clearly seen from graphical representation Carbon dioxide (PPM) is within the recommended and accepted level for good health and human activities and in agreement with standard (<u>https://www.CO2.earth</u> >daily – CO_2). Carbon dioxide emission largely come from human activities such as burning fossils fuels and deforestation and are primary driver of climate change. Figure 10. Presents the relationship of Temperature (^OC) with Time at define footprint and result from graphical representation shown normal Temperature for human. Figure 11 presents the relationship between Humidity and Time, from the graph it shows a level between 35.5% to 36.5% humidity which is typically ideal for keeping home warm and comfortable for human existence.



Carbondioxide



Fig. 10: Relationship between Temperature and Time





Fig. 11: Relationship between Humidity and Time

V. CONCLUSION

Measurement and Evaluation of Greenhouse Gases with Cloud Based Logging research has adopted a highly advanced technological with low-cost and low instrument, open source software for development. Results obtained as follows: CO₂ (360 to 455 ppm), Temperature (26.9 °C to 230.9°C) and Humidity (35.5% to 36.5%) which is good for human health. However, this research proves human capacity building and promotion of open data access which is crucial for scientific information dissemination and training model for future generation of science community in the developing countries.

REFERENCES

- Al-Haj, A. N., and Fulweiler, R. W (2020). A synthesis of methane emissions from shallow vegetated coastal ecosystems, Global 530 Change Biol., Vol (26): 2988-3005, https://doi.org/10.1111/gcb.15046.
- [2] Antero Ollila (2017). Warming Effect Reanalysis of Greenhouse Gases and Clouds. Physical Science International Journal 13(2): 1-13.
- [3] Bastviken, D., Sundgren, I., Natchimuthu, S., Reyier, H., and Gålfalk, M (2015). Technical Note: Cost-efficient approaches to measure carbon dioxide (CO2) fluxes and concentrations in terrestrial and aquatic environments using mini loggers, Biogeosci., Vol (12) 3849-3859.
- Carbone, M. S., Seyednasrollah, B., Rademacher, T. T., Basler, D., Le Moine, J. M., Beals, S., Beasley, J., Greene, A., Kelroy, J., and Richardson, A. D (2019). Flux Puppy–An open-source software application and portable system design for low-cost manual measurements of CO2 and H2O fluxes, Agric. For. Met., Vol (274): 1-6.
- [5] Choi, C. Q (2019). Seven ways scientists handle technology challenges in resource-poor settings, Nature, Vol (569): 147-149.
- [6] Collier-Oxandale, A., Casey, J. G., Piedrahita, R., Ortega, J., Halliday, H., Johnston, J., and Hannigan, M. P (2018). Assessing a lowcost methane sensor quantification system for use in complex rural and urban environments, Atmos. Meas. Tech., Vol (11).3569-3594.
- [7] DeVries, B., Pratihast, A. K., Verbesselt, J., Kooistra, L., and Herold, M (2016). Characterizing forest change using community based monitoring data and Landsat time series, PLOS One, 11, e0147121.
- [8] Duc, N. T., Silverstein, S., Lundmark, L., Reyier, H., Crill, P., and Bastviken, D (2013). Automated Flux Chamber for Investigating Gas Flux at Water-Air Interfaces, Environ. Sci. Technol., Vol (47): 968-975, 10.1021/es303848x, https://doi.org./10.5194/hess-2019-83
- [9] Dung-Gill, K., Ben, B., Youngreyel, R., Bumsuk, S., Dario, P (2021). Reviews and Synthesis: Enhancing Research and monitoring of land to atmosphere gases exchange in developing Countries. Biogeoscience Discussion, pp 1-30.https://doi.org/10.5194/bg-2021-85
- [10] Epule, T. E (2015). A new compendium of soil respiration data for Africa, Chall., Vol (6): 88-97.
- [11] Eugster, W., and Kling, G (2012). Performance of a low-cost methane sensor for ambient concentration measurements in preliminary studies, Atmos. Meas. Tech., Vol (5): 1925-1934.
- [12] IPCC: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Barros, V.R., C.B. Field, D.J Dokken, M.D. Mastrandrea, K.J. Mach, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L. White (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 688, 2014
- [13] Jian, J., Vargas, R., Anderson-Teixeira, K., Stell, E., Herrmann, V., Horn, M., Kholod, N., Manzon, J., Marchesi, R., Paredes, D., and Bond-Lamberty, B (2021). restructured and updated global soil respiration database (SRDB-V5), Earth Syst. Sci. Data, Vol (13): 255-267, https://doi.org/10.5194/essd-13-255-2021.



- [14] Kim, D.-G., Giltrap, D. J., and Hernandez-Ramirez, G (2013). Background nitrous oxide emissions in agricultural and natural lands: a meta-analysis, Plant Soil, Vol (373): 17-30.
- [15] López-Ballesteros, A., Beck, J., Bombelli, A., Grieco, E., Lorencová, E. K., Merbold, L., Brümmer, C., Hugo, W., Scholes, R., Vačkář, D., Vermeulen, A., Acosta, M., Butterbach-Bahl, K., Helmschrot, J., Kim, D.-G., Jones, M., Jorch, V., Pavelka, M., Skjelvan, I., and Saunders, M (2018). Towards a feasible and representative pan-African research infrastructure network for GHG observations, Environ. Res. Lett., 13, 085003.
- [16] Martinsen, K. T., Kragh, T., and Sand-Jensen, K (2018). A simple and cost-efficient automated floating chamber for continuous measurements of carbon dioxide gas flux on lakes, Biogeosci., 15.
- [17] Murphy, H. M., McBean, E. A., and Farahbakhsh, K (2009). Appropriate technology A comprehensive approach for water and sanitation in the developing world, Technol. Soc. Vol (31): 158-167.
- [18] Nguyen, T.D., Samuel, S., Martin, W., Patrick, C., David, B. and Ruth, K.V (2019). Greenhouse Gas Flux Studies: An Automated online System for Gas Emission Measurements. Journal of Hydrology and Earth System Sciences Discussion. Pp 1-18
- [19] Ogle, S. M., Olander, L., Wollenberg, L., Rosenstock, T., Tubiello, F., Paustian, K., Buendia, L., Nihart, A., and Smith, P (2014). Reducing greenhouse gas emissions and adapting agricultural management for climate change in developing countries: providing the basis for action, Global Change Biol., Vol (20): 1-6.
- [20] Riddick, S. N., Mauzerall, D. L., Celia, M., Allen, G., Pitt, J., Kang, M., and Riddick, J. C (2020). The calibration and deployment of a low-cost methane sensor, Atmosph. Env., 117440.
- [21] Shusterman, A. A., Kim, J., Lieschke, K. J., Newman, C., Wooldridge, P. J., and Cohen, R. C (2018). Observing local CO2 sources using low-cost, near-surface urban monitors, Atmos. Chem. Phys, Vol (18): 13773-13785.











45.98



IMPACT FACTOR: 7.129







INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Call : 08813907089 🕓 (24*7 Support on Whatsapp)