

The SMART|AtmoSim_LAB at TSU

Activity Report (2017-2021)

July 2021

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Executive Summary

SMART|AtmoSim_LAB (SMART-Science, Medicine, Applied Research, Technology | **AtmoSim_LAB**- Atmospheric research and **Simulations laboratory**) is the second SMART laboratory which was open in frame of the Georgian-German Science Bridge by collaboration between Chair of Physical and Analytical Chemistry (Faculty of Exact and Natural Sciences, Ivane Javakhishvili Tbilisi State University, TSU) and Institute of Energy and Climate-Troposphere (IEK-8, Forschungszentrum Jülich) and with support of Tbilisi City Hall and National Environmental Agency (NEA). SMART|AtmoSim_LAB was opened on September 29, 2017 at TSU Building 2, room 353.

The laboratory received funding for 2018 by Tbilisi City Hall's resolution №48.22.980 to study atmospheric contamination in Tbilisi. Head of the Laboratory is assistant professor Giorgi Jibuti and young researchers (TSU students) are involved in studies. Professor Bezhan Chankvetadze (TSU) and Professor Ramaz Botchorishvili (Kutaisi International University, KIU) are scientific advisors.

Along with routine analysis and evaluation of contaminants, scientific research is conducted for developing contamination model and forecast methods, as well as new methods and platforms for analysis of various toxicants in atmosphere.

Currently the following contaminants can be measured at SMART|AtmoSim_LAB: Nitrogen monoxide (**NO**), nitrogen dioxide (**NO₂**), carbon monoxide (**CO**), carbon dioxide (**CO₂**), methane (**CH₄**), ozone (**O₃**), aerosols (particulate matter, e.g., **PM 10**, **PM 2.5**)

Above mentioned contaminants can be measured on-line (e.g., direct sampling of air into the instruments) or offline – by sampling air with special cylinders and bringing back in the lab for analysis, which is unique possibility of this lab in comparison to similar air monitoring stations (usually these stations measure only on-line and on-site).

Following report summarizes activity of SMART|AtmoSim_LAB for the period from establishment (September 2017) till July 2021.

Short summary of the smartlab project are following:

- Tbilisi City Hall project
- Collaboration with SMART|EDM_LAB
- Sensor project with IEK-8
- Drone Project/ National Environmental Agency collaboration
- Scientific output

SMART|AtmoSim_LAB equipment

SMARTLAB received following equipment from Forschungszentrum Jülich (IEK-8)

- ECO PHYSICS CLD 780 TR- NO and NO₂ measurement based on ozone chemiluminescence
- Ansyco O3 41 M- Ozone measurement by UV photometry
- PICARRO CRDS Analyzer – CO, CO₂, CH₄, H₂O measurement by cavity ringdowns spectroscopy
- Grimm Aerosol Technik 11.09 aerosol monitor bases on light scattering
- EC/PC analyzer – total/organic carbon analyzer
- 10x Silicometal cans – for the air sampling.

Projects at SMART|AtmoSim_LAB

SMART|AtmoSim_LAB serves not only the research, but educational role as well.

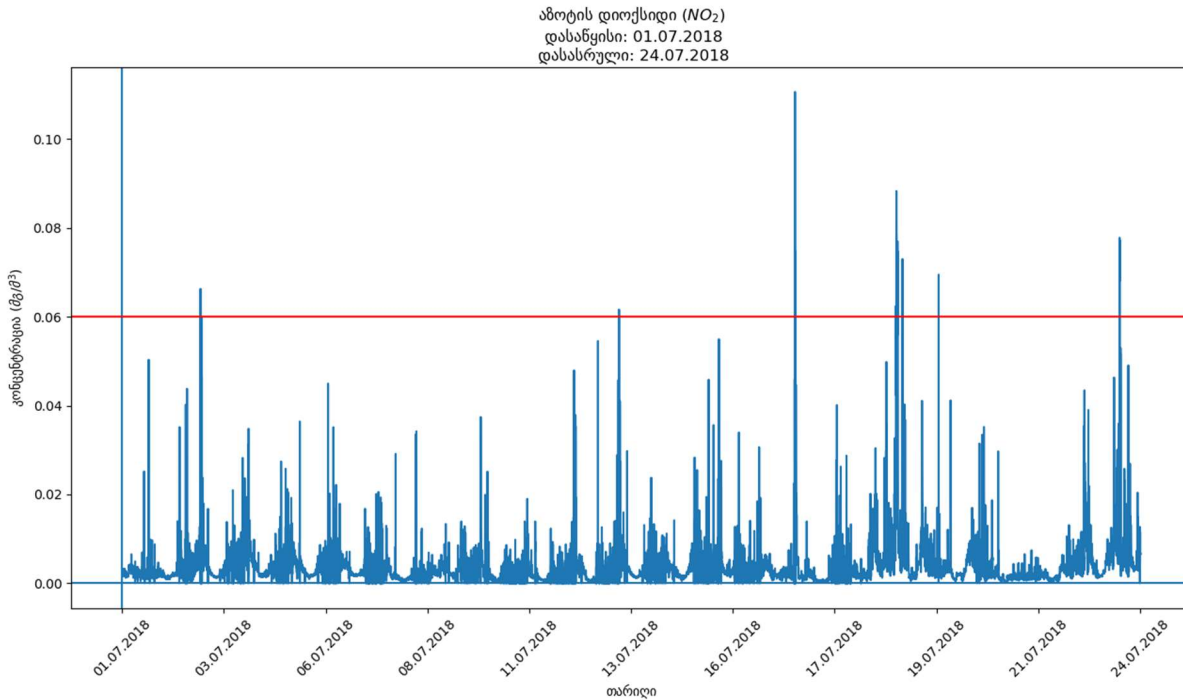
Since its opening in September 2017 11 master theses, as well as several BS degree work and undergraduate studies were completed by students of TSU and San Diego State University-Georgia.

Results of research carried out at SMART|AtmoSim_Lab were presented on various local and international conferences. Please see [table 1](#) for more information

Tbilisi city hall project

During 2018, with financial support of Tbilisi City Hall, SMART|AtmoSim_Lab carried several measurement campaigns in various regions of Tbilisi. Prof. Ramaz Botchorishvili's group helped us with data analysis scripts, which were used in our research. Concurrent research project was to use cheap, readily available material, such as quartz capillaries as restrictors to limit air sampling canister filling rate, to have better average sample instead of costly commercial systems. Based on this work, 2 students completed their bachelor thesis in 2018 and 3 students completed their master's thesis in 2019 ([table 2](#))

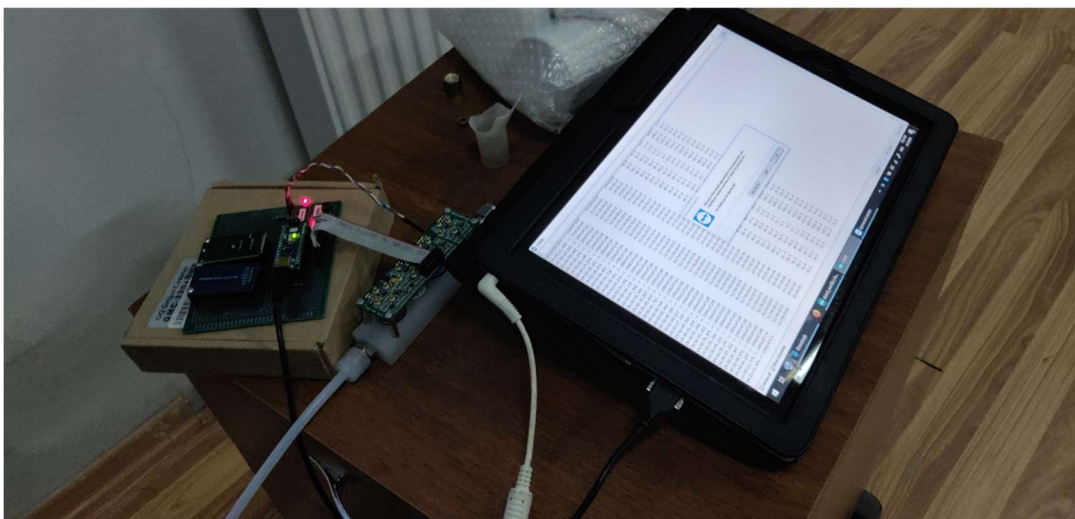
Graph 1 shows NO₂ measurement in July 2018 during this project



Graph 1: NO_2 measurement in SMART/AtmoSim_LAB (July 2018)

Collaboration with SMART|EDM_LAB

In 2019, in collaboration with the head of the SMART|EDM_LAB Dr. David Mchedlishvili, we constructed a measurement platform (including data analysis scripts) based on cost-effective commercial gas sensors and examined their suitability to use for routine atmospheric analysis, 5 students completed their master's thesis based on this research in 2020. ([table 2](#))



Picture 1: sensor platform prototype

Dr. David Mchedlishvili helped us with another project, where goal was to construct sensor set to be attached on unmanned aerial vehicle (UAV, drone), this drone was custom built based SMART|AtmoSim_LAB requirements and was used to take air sampling canisters, but this project is on hold due to COVID restrictions and renovations at TSU 2nd building.

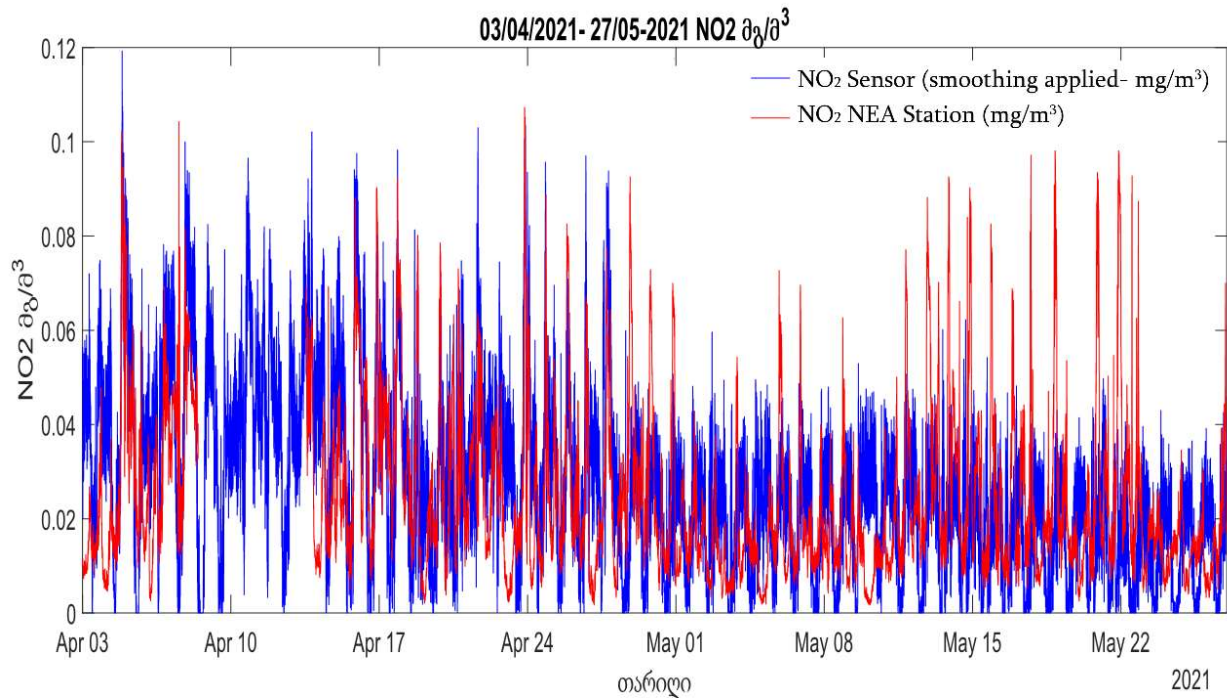
Sensor project with IEK-8

By the end of 2019, we received 5 sets of cost-effective sensors (with boards) from Forschungszentrum Jülich, which we used in collaboration with Professor Ramaz Botchorishvili's group to compare them to each-other and to measurements from reference stationary equipments available in our Smartlab. Collected data were processed and analyzed by four students using different machine learning approaches. These students presented three talks on GGSB 2020 session for machine learning held online. The session was organized in collaboration with Dr. Hanno Scharr from Forschungszentrum Juelich. (See [Table 1](#))

Drone Project/ National Environmental Agency (NEA) collaboration

Due to COVID restrictions in 2020 and renovations ongoing at TSU 2nd building, laboratory is currently disassembled and stored, but meanwhile we received commercial sensor set "USM SOWA" with DJI M600Pro drone in the frame of **Erasmus + project "Educational for Drone (eDrone)" No 574090-EPP-1-2016-1-IT-EPPKA2-CBHE-JP**. We collaborated with National Environmental Agency to compare data gathered from sensors with data collected by air monitoring stations of NEA. Based on this research 2 students from San Diego State University Georgia completed their undergraduate research project and 3 TSU students completed their master's theses ([Table 2](#)).

Graph 2 shows sensor and NEA station comparison of NO₂ concentration during April and May 2021



Graph 2: *NO2 concentration comparison between the sensor and NEA station*

Future projects

In near future, we plan another collaboration with NEA to continue comparison and “training” of sensor sets from Forschungszentrum Jülich with equipment of air monitoring stations. After renovations will be finished, we plan to resume other suspended projects.

Scientific output

Table 1: Conferences and symposia

No.	Author(s)	Event	Title
1	Lia Kirtadze (BS Student, SDSU-G)	The 9 th Annual Student Conference in Exact and Natural Sciences July 6-7, Tbilisi, Georgia	Nitrogen dioxide measurement and data analysis
2	Mari Jananashvili (MS student, TSU)	Heath as a Global Challenge: contributions by GGSB and its SMART Labs	Optical Flow for Clustering CO Measurements from Low-Cost Sensor
3	Marta Melia (MS student, TSU)	Heath as a Global Challenge: contributions by GGSB and its SMART Labs	CO measurements from high precision and low cost sensors: comparison, visualization and clustering
4	Giga Aptsiauri, Salome Shekiladze (MS students, TSU)	Heath as a Global Challenge: contributions by GGSB and its SMART Labs	RNN for Classification of Measurements
5	Ramaz Botchorishvili	10th Annual Symposium on Physical and Analytical Chemistry Tbilisi State University January 03-04, 2020, Tbilisi, Georgia	Deep learning and numerical partial differential equations for smart measurements of Air pollution with low- cost sensors
6	Giorgi Jibuti	10th Annual Symposium on Physical and Analytical Chemistry Tbilisi State University January 03-04, 2020, Tbilisi, Georgia	Air sampling and pollution sensing research at SMART AtmoSim_LAB
7	Ana Chelidze, (BS student, TSU)	10th Annual Symposium on Physical and Analytical Chemistry Tbilisi State University January 03-04, 2020, Tbilisi, Georgia	Comparative evaluation of atmospheric pollution sensors with laboratory equipments

8	Ramaz Botchorishvili	9th Annual Symposium on Physical and Analytical Chemistry Tbilisi State University January 04-05, 2019, Tbilisi, Georgia	Coupling models and measurements for atmospheric simulations
9	Giorgi Jibuti	9th Annual Symposium on Physical and Analytical Chemistry Tbilisi State University January 04-05, 2019, Tbilisi, Georgia	One year of Atmosim SmartLab and future plans
10	Qetevan Kharaishvili (PhD Student, TSU)	9th Annual Symposium on Physical and Analytical Chemistry Tbilisi State University January 04-05, 2019, Tbilisi, Georgia	Atmospheric measurements and monitoring in Tbilisi
11	Salome Pantsulaia (MS Student, TSU) Elene Gvazava (PhD Student, TSU)	9th Annual Symposium on Physical and Analytical Chemistry Tbilisi State University January 04-05, 2019, Tbilisi, Georgia	Overview of the current experiments on air pollution control in Tbilisi
12	Nana Khundadze (MS Student, TSU)	9th Annual Symposium on Physical and Analytical Chemistry Tbilisi State University January 04-05, 2019, Tbilisi, Georgia	Contamination gradient for air pollutants in space
13	Tamar Khatiashvili (MS Student, TSU)	9th Annual Symposium on Physical and Analytical Chemistry Tbilisi State University January 04-05, 2019, Tbilisi, Georgia	Nitrogen oxides pollution in Tbilisi
14	Lina Ugulava (MS Student, TSU)	9th Annual Symposium on Physical and Analytical Chemistry Tbilisi State University January 04-05, 2019, Tbilisi, Georgia	Study of contamination of atmosphere by nitrogen oxides of the central district in Tbilisi

15	Tsira Shalashvili (MS Student, TSU)	9th Annual Symposium on Physical and Analytical Chemistry Tbilisi State University January 04-05, 2019, Tbilisi, Georgia	Study of contamination of atmosphere by carbon oxides and methane of the central district in Tbilisi
16	Mariam Sofromadze (MS Student, TSU)	9th Annual Symposium on Physical and Analytical Chemistry Tbilisi State University January 04-05, 2019, Tbilisi, Georgia	Sampling inaccuracy in atmospheric measurements
17	Giorgi Jibuti, Bezhan Chankvetadze, Ramaz Botchorishvili, David Mchedlishvili, Andreas Wahner, Astrid Kiendler-Scharr, Franz Rohrer	Euroanalysis September 1-5, 2019, Istanbul, Turkey https://euroanalysis2019.com/scientific-programme/ Abstract Book	Application of smart gas sensors for monitoring of atmospheric air quality in urban areas
18	Giorgi Jibuti	8th Georgian – German School and Workshop in Basic Science (GGSWBS' 18) August 20 – 25, 2018 • Tbilisi, Georgia	Project overview: smart platform- sensors and drones
19	Ramaz Botchorishvili	8th Georgian – German School and Workshop in Basic Science (GGSWBS' 18) August 20 – 25, 2018 • Tbilisi, Georgia	Project overview: numerical modelling, measurements and machine learning
20	Ketevan Kharaishvili (PhD student, TSU)	8th Georgian – German School and Workshop in Basic Science (GGSWBS' 18) August 20 – 25, 2018 • Tbilisi, Georgia	Current projects at AtmoSim_lab
21	Giga Aptsiarui Salome Shekiladze (BS students, TSU)	8th Georgian – German School and Workshop in Basic Science (GGSWBS' 18) August 20 – 25, 2018 • Tbilisi, Georgia	Shekiladze, Processing measurements using deep learning

22	Tamar Khatiashvili (MS student, TSU)	8th Georgian – German School and Workshop in Basic Science (GGSWBS' 18) August 20 – 25, 2018 • Tbilisi, Georgia	Nitrous oxides pollution in Tbilisi
23	Lasha Giunashvili (MS student, TSU)	8th Georgian – German School and Workshop in Basic Science (GGSWBS' 18) August 20 – 25, 2018 • Tbilisi, Georgia	Carbon monoxide and dioxide pollution in Tbilisi
24	Salome Pantsulaia (MS student, TSU)	8th Georgian – German School and Workshop in Basic Science (GGSWBS' 18) August 20 – 25, 2018 • Tbilisi, Georgia	Methane pollution in Tbilisi
25	Nana Khundadze (MS student, TSU)	8th Georgian – German School and Workshop in Basic Science (GGSWBS' 18) August 20 – 25, 2018 • Tbilisi, Georgia	Contamination gradients for air pollutants in space
26	Mariam Maisuradze (BS student, TSU)	8th Georgian – German School and Workshop in Basic Science (GGSWBS' 18) August 20 – 25, 2018 • Tbilisi, Georgia	Contamination gradients for air pollutants in time

Table 2 BS and MS theses completed at SART|AtmoSim_LAB

No.	Author	Year, Type	Title
1	Ms. Ana Chokheli	BS Thesis, 2018	Concentration of nitrogen dioxides in Tbilisi
2	Ms. Nino Kirtadze	BS Thesis, 2018	Concentration of carbon oxides in Tbilisi
3	Ms. Natia Badzgaradze	MS Thesis, 2019	Evaluation of air pollution during rush hours in Tbilisi at I. Chavchavadze avenue
4	Ms. Tamuna Lapachi	MS Thesis, 2019	Evaluation of air pollution outside rush hours in Tbilisi at I. Chavchavadze avenue
5	Ms. Megi Choniashvili	MS Thesis, 2019	Optimization of air sampling for pollution analysis

6	Ms. Mariam Lazariashvili	MS thesis, 2020	Evaluation of cost-effective carbon monoxide sensors for atmospheric analysis
7	Ms. Nino Macharashvili	MS thesis, 2020	Evaluation of cost-effective ozone sensors for atmospheric analysis
8	Ms. Maka Popiashvili	MS thesis, 2020	Evaluation of cost-effective nitrogen monoxide sensors for atmospheric analysis
9	Ms. Lina Ugulava	MS thesis, 2020	Evaluation of cost-effective nitrogen dioxide sensors for atmospheric analysis
10	Ms. Tsira Shalashvili	MS thesis, 2020	Comparison of canister air sampling analysis with online measurements
11	Ms. Leone Akmeteli	Undergraduate research project, SDSU-G, 2021	Suitability of Alphasense Sensor for Measuring Concentration of Particulate Matter in the Atmosphere
12	Ms. Lia Kirtadze	Undergraduate research project, SDSU-G, 2021	Nitrous Oxides Contamination in Atmosphere
13	Mr. Ilia Aduashvili	MS thesis, 2021	Carbon monoxide measurement in atmosphere using cost-effective sensors and unmanned aerial vehicle
14	Mr. Levan Turmanidze	MS thesis, 2021	Ozone measurement in atmosphere using cost-effective sensors and unmanned aerial vehicle
15	Ms. Monika Kartvelishvili	MS thesis, 2021	Nitrogen oxides measurement in atmosphere using cost-effective sensors and unmanned aerial vehicle