# A preliminary case study on low-cost sensor systems towards building a dense $CO_2$ monitoring network

*Ryo Fujita[1], Kazuhiro Tsuboi[1], Kentaro Ishijima[1], Yoichi Inai[2], Shigeyuki Ishidoya[3], Takahisa Maeda[3], Kazuki Kamezaki[3], Shohei Murayama[3], Shinji Morimoto[4], Shinya Takatsuji[5], Yuta Fukuda[5], Masashi Yoshida[5], Nobuyasu Ushio[5], Subaru Fujiwara[5], Kentaro Yamada[5], Takanori Ishihara[5], Yuki Matsuoka[5]

1. Meteorological Research Institute, Japan Meteorological Agency, 2. Sapporo Regional Headquarters, Japan Meteorological Agency., 3. National Institute of Advanced Industrial Science and Technology, 4. Graduate School of Science, Tohoku University, 5. Japan Meteorological Agency

The World Meteorological Organization approved a new global greenhouse gas (GHG) monitoring initiative "the Global Greenhouse Gas Watch (G3W)" in May 2023, to monitor the impact of mitigation actions under the implementation of Paris Agreement. However, high financial and human costs for high-precision GHG measurements still pose a hurdle to build a new observational platform for monitoring country/city scale GHG emissions. To address this, we initiated experimental studies to establish a domestic multi-point observation network using compact, affordable nondispersive infrared (NDIR) $CO_2$ sensors (approximately 50,000 yen per sensor). This study evaluates the performance of low-cost $CO_2$ sensors through preliminary observations at four stations: Tsukuba, Sapporo, Sendai, and Ryori. Over two years, parallel observations using multiple $CO_2$ sensors were conducted at a laboratory in Tsukuba, where equipped with an outdoor air intake duct. Sensors captured distinct diurnal variations and multi-day fluctuations in atmospheric $CO_2$ associated with local vegetation activity, changes in atmospheric boundary layer height, and synoptic-scale atmospheric transport. Concurrent measurements with a high-precision laser spectrometer confirmed the general consistency in the observed fluctuations, highlighting the sensor performance in detecting short-term variations. However, the variations in long-term drift among individual sensors emphasized the importance of regular calibration. Observations in Sapporo and Sendai revealed differing diurnal $CO_2$ concentration variations between weekdays and weekends, indicating the potential impact of weekly variations in anthropogenic $CO_2$ emissions. Notably, in Sapporo, differences in diurnal $CO_2$ variations between sunny and cloudy days suggested the potential influence of photosynthesis in nearby mountainous forests, as indicated by wind direction relationships. These findings underscore the significance of establishing a new $CO_2$ observation network in regional cities.
Our presentation will discuss current challenges and future perspective, including sensor calibration, environmental factor correction (e.g. humidity, pressure), and the application of atmospheric transport models. Ultimately, our goal is to contribute to providing useful information for local governments to understand the impact of their mitigation measures, while raising awareness among local residents, through the dense $CO_2$ observation networks.

Keywords: CO2, greenhouse gas, low-cost sensor, G3W

 