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Low-cost sensor network in remote alpine environments

Federico Dallo[1,2,3], Daniele Zannoni[4], Jacopo Gabrieli[1], Paolo Cristofanelli[5], Francescopiero Calzolari[5], Fabrizio de Blasi[1], Andrea Spolaor[1], Dario Battistel[2], Rachele Lodi[1], Warren R. L. Cairns[1], Ann Mari Fjæraa[6], Paolo Bonasoni[5], Fred Bauman[3], and Carlo Barbante[1,2]

[1]Institute of Polar Sciences (CNR-ISP), Via Torino, 155, 30172, Venice, ITALY
[2]University Ca' Foscari of Venice, Dorsoduro 3246, 30123, Venice, ITALY
[3]Center for the Built Environment, University of California, Berkeley, CA, USA
[4]Geophysical Institute, University of Bergen and Bjerknes Centre for Climate Research, Bergen, NORWAY
[5]Institute of Atmospheric Sciences and Climate (CNR-ISAC), Via P. Gobetti 101, 40129 Bologna, ITALY
[6]Norwegian Institute for Air Research (NILU), Instituttveien 18, 2007 Kjeller, NORWAY

We present the results obtained using an original open-source low-cost sensor (LCS) system developed to measure tropospheric O_3 in a remote high altitude alpine site. We conducted our study at the Col Margherita Observatory (2543 m a.s.l.), a World Meteorological Organization Global Atmosphere Watch Regional Station (WIGOS Id: 0-380-0-MRG), located in the Italian Eastern Alps. The sensing system mounts three equivalent commercial low-cost sensors that have been calibrated using a laboratory standard (Thermo 49iPS), referenced to the Standard Reference Photometer #15 calibration scale by the WMO, before field deployment. Intra and inter-comparison between sensors and reference (Thermo 49c) have been conducted for six months from May to December 2018. The sensor's dependence on the environmental meteorological variables has been considered and discussed. The evaluation of the analytical performances of this sensing system provides a limit of detection < 5 ppb, limit of quantitation < 17 ppb, linear dynamic range up to 250 ppb, intra-Pearson correlation coefficient (PCC) up to 0.96, inter-PCC > 0.8, bias > 3.5 ppb and ±8.5 at 95% of confidence. Thanks to the first implementation of an LCS System in an alpine site, we demonstrated how it is possible to obtain valuable data from a low-cost instrument in a remote harsh environment. This opens new perspectives for the adoption of a low-cost sensor network in atmospheric sciences. We further present our recent experience using LoRa to integrate the sensing system into a low-power wide-area network (LPWAN). We developed an end-node and a gateway, designing PCBs derived from the Arduino Mega, optimizing their power consumption and equipping them with batteries, a proper solar panel or wind turbine to ensure their autonomy while collecting environmental ozone and meteorological (T, RH, WS, WD) data. We drafted the communication software to send compressed data from end-nodes to gateways. The gateways are part of an openVPN with the main server located in Venice. The server also provides a postgreSQL database and a R-shiny web application for data visualization and manipulation. To enhance redundancy, the local data are also synchronized to a cloud database. In the next years, thanks to the Marie Skłodowska-Curie grant PIONEER, we will exploit our experiences to provide a comprehensive low-cost wireless sensor network to

characterize transport of polluted air masses and provide long term climate data collection in support of the state-of-the-art instrumentation and established networks in remote alpine areas.

Bibliography

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