

Measuring air pollution in Africa

combining high-tech with low-tech

Introduction

In many cities around the world people are exposed to unhealthy levels of air pollution, with populations in low-income cities the most at risk for respiratory diseases and other long-term health problems. Monitoring air pollution is key to a better local understanding of the problem, needed to take appropriate measures. Unfortunately, air pollution is difficult to measure, and reference equipment is expensive in purchase and maintenance. As a result there are hardly any measurements done in developing countries.

TROPOMI

Satellite instruments such as [TROPOMI](#) measure nitrogen dioxide (NO₂, an important air pollutant) around the globe on a daily basis. TROPOMI measures the average NO₂ concentration in the troposphere (see Figure 1), but does not provide information about the height distribution. Without ground truth it is complicated to translate these column measurements to surface concentrations.

Palmes tubes

Palmes tubes offer a low-tech, cost-effective means of measuring NO₂ (see Figure 2). These plastic tubes are open at one end. Based on molecular diffusion, NO₂ reacts with an absorbing agent at the closed end of the tube. The tubes are mounted at a fixed location for a period of 4 weeks, after which they are sent to a laboratory for analysis. Using colorimetry, the average concentration of NO₂ during the measurement period can be determined.

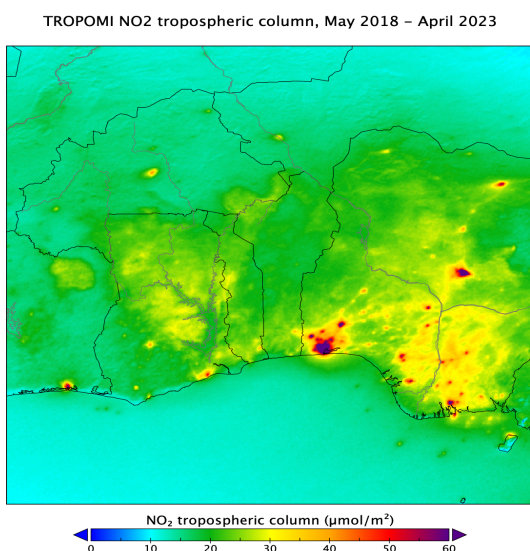


Figure 1 High-tech: NO₂ concentrations over West Africa, measured by the TROPOMI instrument.



Figure 2 Low-tech: Measuring NO₂ with a Palmes tube mounted on a lamppost.

The GLOBE campaign

In spring 2023, KNMI organized with [GLOBE Netherlands](#) a measurement campaign in which 10 secondary schools participated. Students were asked to mount Palmes tubes at different locations in their surroundings. After analysis, the measurements were published on [an open data portal](#). The campaign provided insight into air pollution levels at the surroundings of the school, and how these relate to levels found at other schools. The measurements turned out to correlate well with colocated satellite measurements (Figure 3). This relation could then be used to translate satellite data in a national map of surface concentrations (Figure 4).

The challenge

The GLOBE campaign shows how low-cost measurements help to add value to satellite measurements, and reveals a great potential for measuring NO₂ in African countries. The challenge, however, is how to prepare and analyze Palmes tubes without depending on a remote laboratory. Based on existing [documentation](#) of best practices, we will investigate implementation methods for low-cost operation by local people in Africa, targeting preparation and chemical analysis of the tubes based on the local availability of materials and instrumentation. Collaborating with team members of the Trans African Hydro Meteorological Observatory ([TAHMO](#)) will give access to their experience and measurement infrastructure. Focus will be on introduction in Ghana, where the hydrology network is already well developed. The final goal is to create a sustainable network of Palmes tubes providing monthly measurements of NO₂ in cities across the continent. This will provide crucial information for validating satellite measurements and creating surface concentration maps.

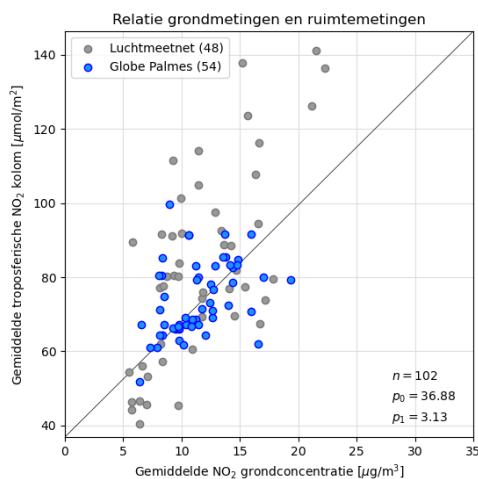


Figure 3 Relation between surface measurements of NO₂ with Palmes tubes and column measurements from space by TROPOMI.

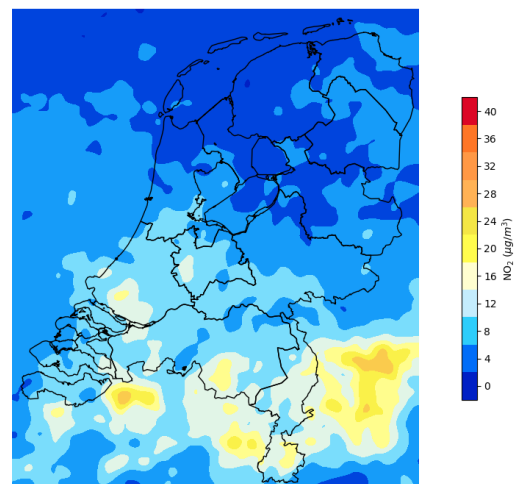


Figure 4 Derived average surface NO₂ concentrations during the measurement campaign (17 March to 14 April 2023).

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