NOAA Chemical Sciences Laboratory

Instrument Fact Sheet

NOAA CHEMICAL SCIENCES LABORATORY

Photo credit: Patrick Cullis, NOAA/CIRES

OPUS: Ozone Photometer for UAS/balloon-based Studies

Background :

Ozone (O_3) is an air pollutant in the troposphere. In the troposphere, O_3 has a lifetime of days to weeks and its concentrations continuously evolve through photochemistry and dynamic processes such as mixing and deposition. Small uncrewed aircraft systems (UAS) would be ideal to track O_3 evolutions in the boundary layer and lower free troposphere if suitable O_3 sensors could be found.

Description :

The NOAA CSL Ozone Photometer for UAS/balloon-based Studies (OPUS, **Figure 1**) has been invented specifically to address the need of a fast and light-weight O_3 sensor for scientific studies on moving platforms. The instrument is based on the UV absorption technique, which is generally easy to use due to the absolute nature of the technique, overall simplicity, and reliability. Because this instrument is designed for small UAS and weather balloons, the total weight of the instrument must be kept as low as possible. High sensitivity and fast response time are also important. Size, on the other hand, is generally not a significant concern for UAS/balloon platforms. The instrument is completely autonomous.

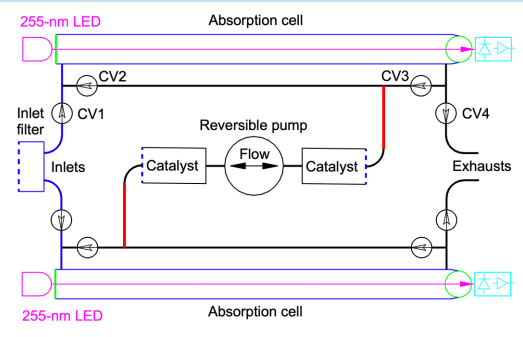

Figure 2. Schematic diagram of the OPUS design. Two 255-nm LEDs are used as the light source. Magenta-colored lines represent VU beams. The PTFE-lined absorption cells are sealed by sapphire windows on the left end and fused silica ball lenses on the right end. Two photodiodes with built-in amplifiers are shown in teal color. The four circled arrows for each channel represent one-direction check valves. Dashed lines on the two catalyst cans are filters that prevent the catalyst material entering absorption cells. Blue color indicates O_3-inert materials.

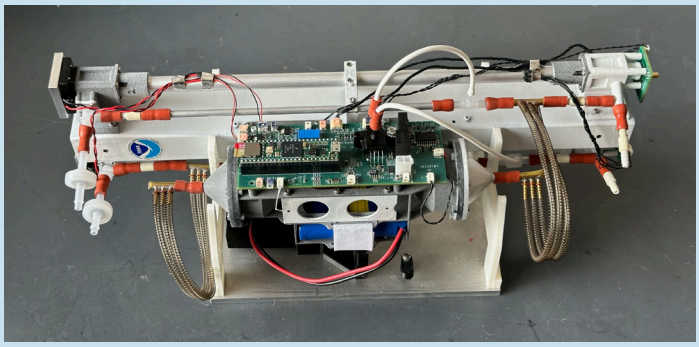

Figure 1. The NOAA CSL OPUS O_3 instrument.

Innovations :

Two important innovations have made this high-performance instrument possible. The first one is the invention of a flow-control system using a reversible pump and check valves as shown in **Figure 2**. The second is the extensive use of 3D-printed and composite parts.

Instrument Specifications :

- Accuracy: 5%
- Precision: 1 ppb
- Time resolution: 1 s
- Preparation time before flight: None
- Weight: 570 g (720 g with a battery pack)
- Battery operation time: 10 hours.

Instrument Status :

- February 2022: Provisional patent filed
- August 2022: Engineering test flights on the DOE tethered balloon
- December 2022: Patent filed*
- Spring 2023: Test flights on the NOAA CSL quadcopter

** The patent application also contains another low-cost O_3 sensor design that is particularly suitable for education and environment monitoring.*

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