# SWING-UAV: Small Whiskbroom Imager for atmospheric compositioN monitorinG (SWING) from an Unmanned Aerial Vehicle (UAV): status and perspectives

A. Merlaud[1*], F. Tack[1], D. Constantin[2], F. Mingireanu[3], I. Mocanu[4], J. Maes[1], C. Fayt[1], L. Georgescu[2], and M. Van Roozendael[1]

*(1) Belgian Institute for Space Aeronomy (BIRA-IASB) (alexism@oma.be), (2) University of Galati, Romania, (3) Romanian Space Agency (ROSA), (4) Reev River Aerospace*

## Scientific rationale and simulations

Several DOAS imagers have already been operated from planes to map the distribution of trace gases (1,2,3). These measurements offer a ground resolution enabling to study the fine structures of the $NO_2$ field close to the sources, which is not possible from satellite. A whiskbroom imager, the ACAM (5), has been operated from a UAV, the NASA Global Hawk. The instrument presented here, SWING, uses a whiskbroom set-up for spatial mapping, similarly to ACAM. However, it is designed for a smaller UAV and is therefore more compact.

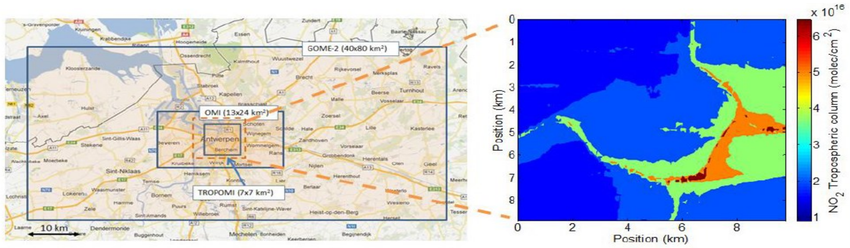


**Figure 1. Simulations of $NO_2$ observations from an UAV flying at 3 km.**

To estimate a realistic ground resolution achievable with a compact spectrometer from 3 km altitude, we performed simulations using a local high resolution air quality model (IFDM, http://promote.vito.be/webtool/). The noise level was scaled according to the different geometry and integration time from a previous airborne experiment (4) with the same spectrometer. Results for different ground resolution (and thus integration times) are shown in Fig. 1.

**References**

(1) Heue et al., ACP, 2008, (2) Schönardt et al., Proc. DOAS workshop, 2011, (3) Popp et al., AMT, 2012

(4) Merlaud et al., AMT, 2012, (5) Kowalewski and Janz., Proc. SPIE 7452, 2009

**References for SWING-UAV:**

-Merlaud A., Development and use of compact instruments for tropospheric investigations based on optical spectroscopy from mobile platforms, Phd Thesis, 2013

-Merlaud et al., Small Whiskbroom Imager for atmospheric compositioN monitorinG (SWING) from an Unmanned Aerial Vehicle (UAV) , Proc. 2013 ESA conference on Rockets and Balloons

## Instrument and platform description

SWING is based on a compact grating spectrometer (AvaSpec 2048 from AVANTES). The scanning mirror is driven by a servomotor around the nadir direction. A zenith channel enables to record reference spectra. The spectra are saved on the PC during the flight.

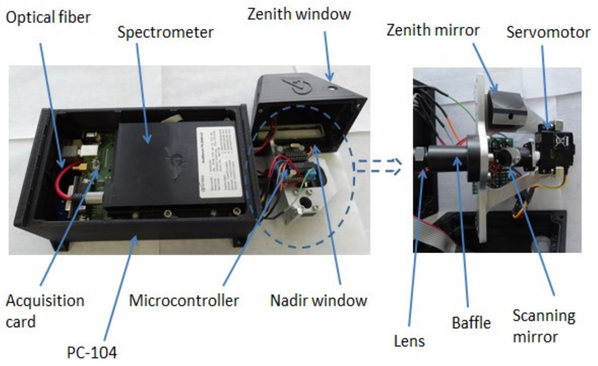


**Figure 2. The SWING instrument.**

The UAV was customly built by ReevRiver Aerospace. It is an electrically propelled 2.5 m flying wing, which can fly in preprogrammed tracks for 2 hours at 3 km altitude.

**Figure 3. The custom built UAV.**

**Table 1. Main characteristics of the SWING-UAV observation system.**

| | | |
|---|---|---|
| SWING | Size | 27x12x12 $cm^3$ |
| | Weight | 920 g |
| | Power consumption | 6 W |
| | Angular FOV | 120° |
| | Instantaneous FOV | 2.5° |
| UAV | Ceiling | 3 km |
| | Wingspan | 2.5 m |
| | Speed | 60-130 km/h |
| | Autonomy | 2 h |
| SWING-UAV | Pixel size | 200 m |
| | Detection limit ($NO_2$) | 2 ppb |

## Results of UAV test flights

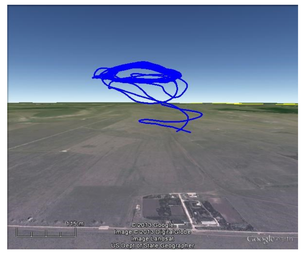

**Figure 4. Flight tracks of the 1st UAV flight.**

On 11 May 2013, we perfomed the first test flight with SWING on the UAV, 15 km NW of Galati, Romania (45.53°N, 27.9°E). The flight pattern consisted of loops at 420 to 450 m altitude around predefined waypoints (Fig. 4).

The area was too clean for $NO_2$ to be detected, but the experiment confirmed the expected detection limit (fig 5).

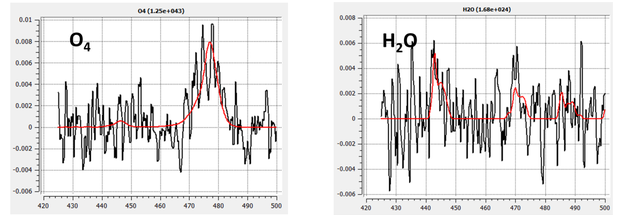


**Figure 5. DOAS analysis of a spectrum recorded during the 1st test flight.**

On 20 Sept 2013, we performed a second flight (Fig.7), also in the vicinity of Galati, but downwind the city. The UAV reached 1200 m altitude. $NO_2$ was clearly detected in the spectra (Fig.6).

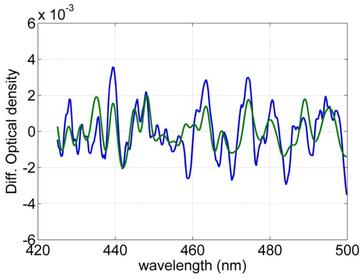


**Figure 6. $NO_2$ DOAS fit (2nd test flight).**

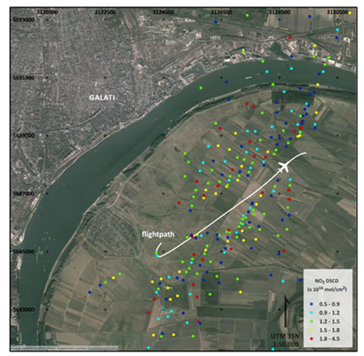


**Figure 7. Preliminary $NO_2$ map from the 2nd flight.**

## Perspectives

The next experiments with the SWING-UAV observation system will be performed during the AROMAT campaign, scheduled between June 23 and July 2014 in Romania. AROMAT will involve several other airborne instruments (KNMI $NO_2$ sondes, AirMAP from Uni. Bremen,...). Geophysical targets are the exhaust plumes of large power plants and of the city of Bucharest.

**This poster as pdf**

**Acknowledgements:** Belgian Science Policy, European Space Agency. We thank Dirk Schuettemeyer from ESA for useful discussions.