Long-Term Monitoring of Aerosols and Cloud Properties using Unmanned Aerial Vehicles (UAVs)


ISARRA 2017
Oban, Scotland
23rd May 2017
Outline

Infrastructure
• Laboratory & Permanent Runway / Airspace
• Fleet of UAVs
• Mobile GCS

Long-Term Monitoring of Aerosols and Cloud Properties
• Routine Monitoring Activities (2017)
• Experimental setup
  • Instrumentation
  • Flight strategy
  • Preliminary results

Future Work
• AQABA Campaign
• Stratosphere UAV release from balloon
Infrastructure

- 100 m² Laboratory
- Equipped for unmanned systems research and development
- Next to the CyI instrumentation laboratory for atmospheric sciences
- Next to the CyI chemistry analytical laboratory
Our fleet of UAVs

Fixed wing

Cruiser
- Medium Size: 35 Kg
- Payload: 12 Kg
- Endurance: 4 hours
- Ceiling: 4 Km

Mini Cruiser
- Small Size: 11 Kg
- Payload: 4.5 Kg
- Endurance: 3 hours
- Ceiling: 4 Km

Skywalker EVE
- Small Size: 5.5 Kg
- Payload: 2.5 Kg
- Endurance: 2 hours
- Ceiling: 3 Km

Skywalker 1680
- Small Size: 4 Kg
- Payload: 1.5 Kg
- Endurance: 1.5 hours
- Ceiling: 3 Km

Rotary Wing

I-Soar
- Small Size: 6 Kg
- Payload: 2 Kg
- Endurance: 1.5 hours
- Ceiling: 3 Km

Logo 800
- Small Size: 12 Kg
- Payload: 5 Kg
- Endurance: ~30 minutes
- Ceiling: 3 Km

Dji S1000+
- Small Size: 11 Kg
- Payload: 4 Kg
- Endurance: ~20 minutes
- Ceiling: 1 Km
Mobile Ground Control station (GCS)

GCS / Mobile Laboratory

Truck with GCS

Monitoring & Control of UAV, Payload, Camera

Portable GCS
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UAV routine monitoring activities

- 1-year routine (January 2017 – December 2017) observation of the vertical composition of the atmosphere with weekly UAV flights (Absorption, Size distribution, AOD, Ice Nuclei, etc.) completing similar 1-year co-located (Cyprus) remote sensing observations (TROPOS).

Scientific motivations:

- Building of a unique atmospheric database in the Mediterranean with boundary layer and free tropospheric in-situ observations
- Investigation of atmospheric processes within and above the atmospheric boundary layer, and in-situ observations of dust layers from different source regions
- In-situ constrain of remote sensing (sunphotometer, lidar) retrieval algorithms of aerosol optical properties and IN parametrization
- Demonstration of the added-value of UAV platforms in long-term routine observations of the atmosphere (ACTRIS ESFRI)
UAV monitoring activities: Experimental setting
(January 2017 – December 2017)

Flight Strategy – Focus on contrasted situations
- Clean (Med.) vs Polluted (Europe/Turkey/Middle East)
- Dust (Africa) vs Dust (Middle East)
- Aerosol layer (boundary layer) vs aerosol layer (Free troposphere)
- Aircraft campaigns (April, July-August, September 2017)
Instrumentation

**OPC, Palas, Fly100**
- Size distr. 0.18-40 μm (64 ch.)
- Time res. 1 s

**Printed Optical Particle Spectrometer, (POPS), NOAA prototype**
- Size distr. 0.14-30 μm (14 ch.)
- 550 g, 5 W, lose-able (2000 $)
- Gao et al., 2016

**Mini Scanning Aerosol Sun Photometer, (miniSASP), NOAA prototype**
- 460, 550, 670, 860 nm
- 0.02 AOD detection limit
- 350g, 2 W, lose-able (1000 $)
- Murphy et al., 2015

**Ice Nuclei sampler (IN), Goethe Uni. Prototype**
- 5-15 min collection time / sample
- Schrod et al., 2017

**Dual Wavelength Prototype (DWP), Aerosol d.o.o.**
- 2-λ absorption photometer
- (370 and 880nm)
- Up to 2 lpm inlet flow rate

**STAP, Brechtel**
- 3-λ absorption photometer
  (467, 528, 652 nm)

**NO₂ / O₃ sensors, CairPol**
- 55g, 1min resolution
- 2 separate sensors

T, RH and video on all flights
Flight planning

• Flights are planned to overlap with satellite overpass and/or with different pollution/dust source region.
• Boundary layer height and possible dust layers are identified from lidar data at Limassol (TROPOS).

Level flight above and within the boundary layer for IN sampler and miniSASP

Flights ascend on a spiral path to desired altitude (within or above boundary layer).

Continue to ascend, or descend back to home with similar path.
Ice Nuclei Particle concentration = f(altitude, time)

Higher concentrations of INP in the free troposphere!!!

Aerosol Number concentrations (A.D. > 0.5 µm)

BACCHUS Field Campaign Cyprus, April 2016

Schrod et al., Atmos. Chem. Phys. 2017
Investigating the atmospheric column: Synergy between remote sensing (Lidar) and in-situ (UAV)

Range-corrected signal@1064nm, Pol

5/4/2016

06:32 – 06:47
1800 m

650 m
07:34 – 07:49

boundary layer

INUIT – BACCHUS - ACTRIS
Cyprus (April 2016)
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Air Quality & Climate in the Arabian Basin (AQABA) Campaign – June-August 2017

- Multiphase chemical interactions of gaseous and particulate air pollutants with desert dust and sea salt aerosols
- Life cycle of natural and anthropogenic aerosols and oxidants: impacts on air quality, clouds, climate and biogeochemical cycles

Ship measurement campaign around the Arabian Peninsula from Malta to Kuwait (Roundtrip)
Experimental Setup

- Ship: Kommandor Iona
- UAS: Skywalker 2015 (USRL-ENAC)
- Aerial Measurements: Optical Particle Counter (OPC), $O_3$, $NO_2$, Temperature, Relative-Humidity, Pressure

Ecole Nationale de l'Aviation Civile
National School of Civil Aviation, Toulouse, France
Air Quality & Climate in the Arabian Basin (AQABA) Campaign – June-August 2017

Ground Control Station (GCS) Desk

Stern View through GCS Window

Landing Net

Hand-Launch

Net Landing Attempts
New Tools for Long-term monitoring of the atmospheric composition of the upper troposphere/lower stratosphere

Motivation:
- Updraft of Pollution into the stratosphere from India during monsoon period
- Long Range Transport of pollution and subsidence over the Easter Mediterranean

Tool:
- Balloon-Assisted UAV with atmospheric sensors

Method:
- Balloon carries the UAV to the lower stratosphere (~12 km)
- UAV is released from balloon and glides back to the launch location bringing down useful data and the instruments!
Thank you!

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