UAS for Meterological and Atmospheric Studies

Centre National de Recherches Météorologiques
GMEI : Groupe de Météorologie Expérimentale et Instrumentale
MNPCA : Microphysique des Nuages et Physiquo-Chimie de l'Atmosphère

Unmanned Aerial Systems at CNRM

The National Center for Meteorological Research (CNRM-GAME, Toulouse, France) has conducted UAS flights in Southern France on multiple UAS platforms (mini and mid-size UAS) to demonstrate their feasibility for meteorological and atmospheric studies.

UAS are especially adapted to
- observe the atmospheric boundary layer processes at high spatial and temporal resolution,
- access to the vertical dimension and compliment ground-based observatories,
- conduct measurements in hazardous or remote areas unreachable for manned aircraft (i.e., fog events, ocean studies, volcanic plumes).

Unmanned Aerial Vehicle
- R/C airframe equipped with autonomous navigation system.
- Payload : ~ 300 g
- Total weight : < 2 kg
- Endurance : ~40 min, electric
- Ceiling : ~4 km

Autonomous Navigation System
- Paparazzi open-source code
- Developed by ENAC in 2003
- Inertial navigation and real-time radio communication
- URL: http://paparazzi.enac.fr/

UAS Instrumentation

Aerosol sampling (150 g)
Cloud droplets (1.4 kg)
Electrical field (<30 g)
Particle size & number (Dp > 0.3 µm; 580 g)
Smoke aerosol (280 g)
CCN aerosol (1.9 kg)
Total particle number (870 g)
Temperature / humidity / airspeed (<20 g)
Data acquisition system (<20 g)
Broadband flux (190 g)
Sun energy: visible (45 g)
Turbulence (100 g)

- A number of instruments have been miniaturized for UAS payloads to measure aerosols, clouds, solar fluxes and meteorological parameters.
- A central data acquisition systems collects, time stamps, and stores the data for post-processing. A subset of the data is streamed to the ground control station.

First experiments – Avion Jaune Systèmes
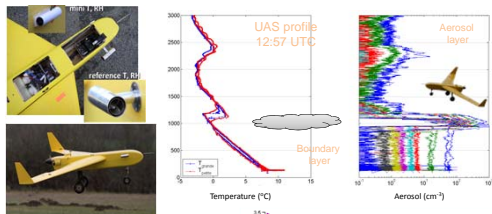
- Mid-size UAS (4 m wingspan; payload < 5 kg; 8+ hours)
- High aerosol concentrations in boundary layer; cloud layer at 900 m.asl; second aerosol layer at 2300 m.asl
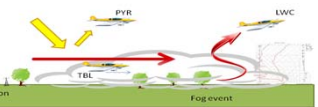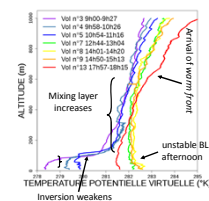- Profiles to 3000 m.asl

VOLTIGE

VOLTIGE objectives :
- Demonstrate the use of multiple lightweight UAS to study the life cycle of fog,
- encourage direct participation of students on the advancement and development of novel observing systems,
- assess the feasibility of deploying UAS in Météo-France's operational network.


http://www.cnrm.meteo.fr/voltige/

- Probe the atmosphere with multiple UAS
- PTU, solar flux, turbulence, cloud, and electric charge sensors
- Observation strategy with modular payloads based on science focus
- Master student, engineer, 8 stagiares, 2 ENM courses, collaboration COST

(Vecteur d'Observation de La Troposphère pour l'Investigation et la Gestion de l'Environnement)

ANR Blanc 2012
Jan '13 – Dec '14

BACCHUS

- UAS observations to evaluate aerosol-cloud closure studies (bottom-up and top-down)
- Compare in-situ measurements to remote sensing observations (lidar and satellite)
- Focus on contrasting environments: polar; tropics; mid-latitude
- CNRM: PhD students, two engineers + stagiaires
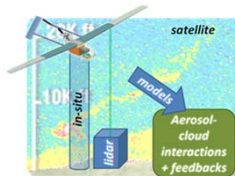

Planned parallel studies:
- ENVI-MED : Cyprus (mCCN UAS, aerosol aging; Apr 2015)
- DACCIWA : Benin, Africa (aerosol-clouds; ATR-42, June 2015)

(Impact of Biogenic versus Anthropogenic emissions on Clouds and Climate: towards a Holistic UnderStanding); Prof. Ulrike Lohmann, ETH Zürich

EU FP7
Dec '13 – Nov. '17
http://www.bacchus-env.eu/

Skyscanner

Concept: Multiple, coordinated intelligent navigation to 'scan' the sky
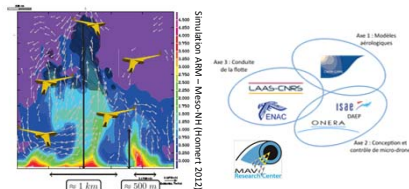
- Follow 4D evolution of cloud with UAS to study entrainment and the formation of precipitation
- Use MesoNH boundary layer Large-Eddy Simulation cases to define flight strategies
- Multi-UAS exploratory development (intelligent swarming)
- Collaboration with laboratories in Toulouse centered around the use of UAS in research

Funded by RTRA STAE
May '14 – April '17

UAS activities at CNRM

Research programs
- Test flights w/ Avion Jaune Systèmes (CNRM): Jan. 2012
- Vecteurs d'Observation de La Troposphère pour l'Investigation et la Gestion de l'Environnement (**VOLTIGE** ; ANR Blanc 2012) :   2013 – 2014
- Basse Couche Campagne (**BACC+** ; Météo France) : regular profiles to study evolution of boundary layer related to fog events (2014 – 2015)
- Impact of Biogenic versus Anthropogenic emissions on Clouds and Climate: towards a Holistic UnderStanding (**BACCHUS**; EU FP7) : aerosol-cloud interactions at climatically contrasting sites (2013 – 2017)
- **SkyScanner** (RTRA-STAE) : 4D evolution of cloud to study entrainment and precipitation (2014 – 2017)
- Synergie Transdisciplinaire pour Répondre aux Aléas liés aux Panaches volcaniques (**STRAP**; ANR Blanc) : Evolution of aerosol and trace gases in volcanic plume (2014 – 2016)

Professional societies
- Unmanned Aerial Systems in Atmospheric Research (**COST Action ES0802**) : centralize UAS activities for Atmospheric Research at the European level (2010 – 2013)
- Micro Air Vehicle Research Center (**MAVRC**; RTRA-STAE) : promote UAS activities among laboratories in Toulouse (2013 – 2015)
- Institut de Recherche sur les Mini-Drones (**GIS IRMID**; RTRA-ISAE) : continuation of MAVRC
- International Society for Atmospheric Research using Remotely-piloted Aircraft (**ISARRA**) : next conference in 2016 at University of Oklahoma (USA).