Use of Small Unmanned Aerial Vehicles for Air Quality and Meteorological Measurements

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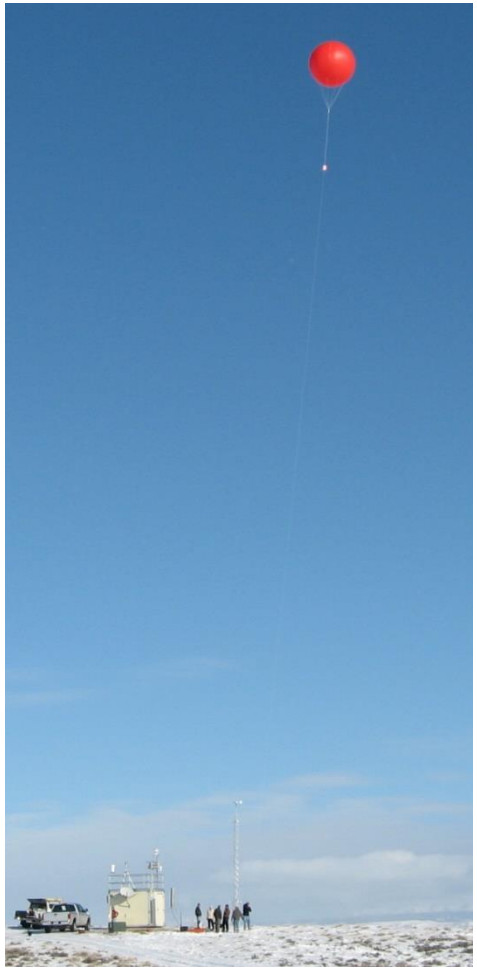
Overview

- Goals for platform development
- UAV types
- Challenges in using UAVs
- Use of new generation lightweight sensors
- Platform development and testing
- Key features as a sampling platform
- Demonstrated uses
- Advanced sampling techniques in development
- Future developments

Goals for platform development

- Replace tethered and/or free-flight sampling techniques
- Provide a stable, high precision X-Y-Z platform, for sample collection
- Provide adequate flight time for various integrated and time series data collection missions
- Provide real-time data links and imaging
- Develop autonomous methods for sample collection



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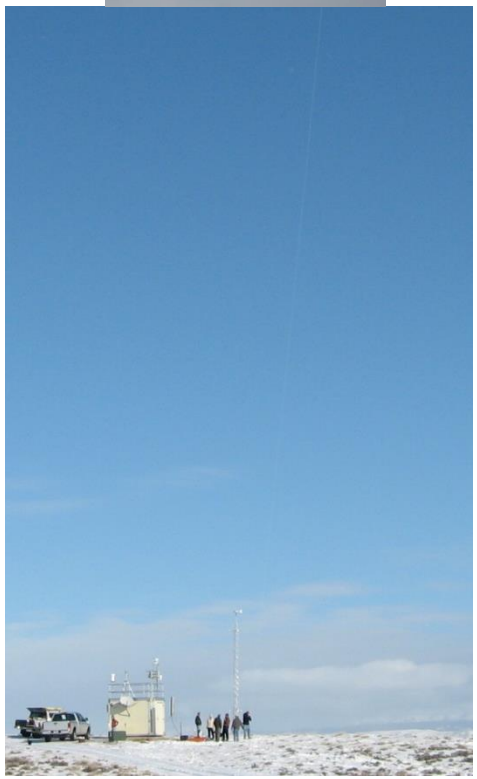


UAV Types

- Fixed wing
  - Larger payload
  - Must remain in X-Y motion
  - No hover sampling mode

Relatively inexpensive

Bad PR and costly

- Multi-rotor
  - Smaller payload
  - Sampling in motion or fixed
  - Extremely stable positioning

Our choice based on development platform

Challenges in using UAVs

- Public Perception
  - Privacy concerns driven by emotions
  - The word "DRONE" has a real negative first impression
  - For acceptance as a research tool, showing the benefits are essential

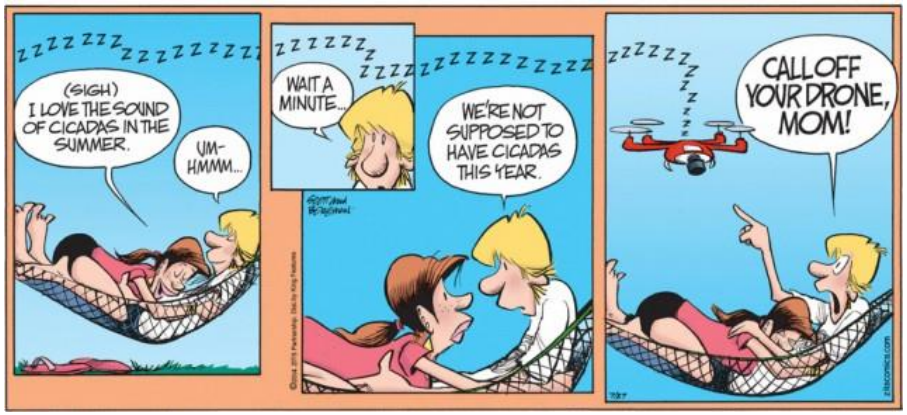
Close encounters on rise as small drones gain in popularity -- *Washington Post*

Video-seeking drone ordered out of fire area -- *USA Today*

Drone wars: The definition dogfight -- *ABC*

Increasing drone use raises privacy concerns -- *CBS News*

Drones, Accidents, and Secrecy -- *ACLU*



- FAA Restrictions
- Technical

Challenges in using UAVs

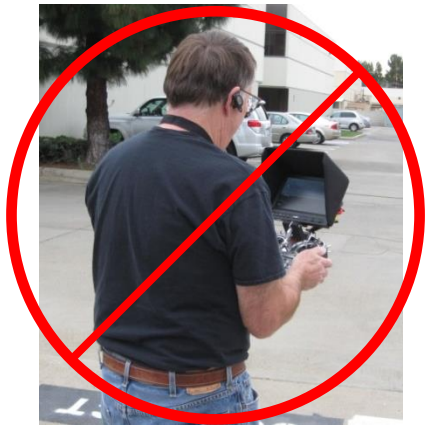
- Public Perception
- FAA Restrictions
  - Aviation interference is a primary concern
  - Safety and protection of property is driving additional concerns
  - Hobbyist flight rules currently govern the use of small UAVs and legally limit the commercial use unless a COA is obtained

<u>Recreational flying</u>

Model aircraft

<u>Commercial flying</u>

Drone



- Technical

Challenges in using UAVs

- Public Perception
- FAA Restrictions
- Technical
  - RF sensitivity of components can create flight issues with shielding needed to minimize the effects
  - UAV electronics and RF may interfere with some instruments that are not well shielded
  - Vibration effects can impact some instruments
  - Technology explosion from overseas provides very capable systems but with very limited and/or incomplete documentation

Use of New Generation Lightweight Sensors

- Meteorological measurements
  - Temperature, relative humidity, pressure, winds (using GPS)
- Continuous gas measurement
  - Ozone and other gases
- Particulate matter measurement
  - Filter based
  - Real-time
- Integrated gaseous sampling
  - Sorbent tube for VOCs and multiple integrations
  - Canister sampling, but limited by canister weights

Platform Development and Testing

- Platform development
  - Commercially available platform as a foundation
  - Carbon fiber, aluminum and stainless steel hardware
  - All electric to minimize emissions and vibration
  - Vibration dampening components for videography and stability of sampling components
- Initial tests
  - Over 700 meters for meteorological soundings
  - High winds > 10 m/s to 300 meters with gas sampling
  - Flight times to 30 minutes

Key Features as a Sampling Platform

- Lightweight design for easy portability
- Quick setup and deployment
- Automated retrieval in the event of flight control failure
- 2-3 pound payload capacity
- Flight time up to 30 minutes depending on payload
- Accurate GPS positioning with pressure-altitude
- Real-time telemetry of key information
- Real-time video broadcast with data overlay
- High definition video documentation
- Relatively large equipment mounting platform

Key Features as a Sampling Platform

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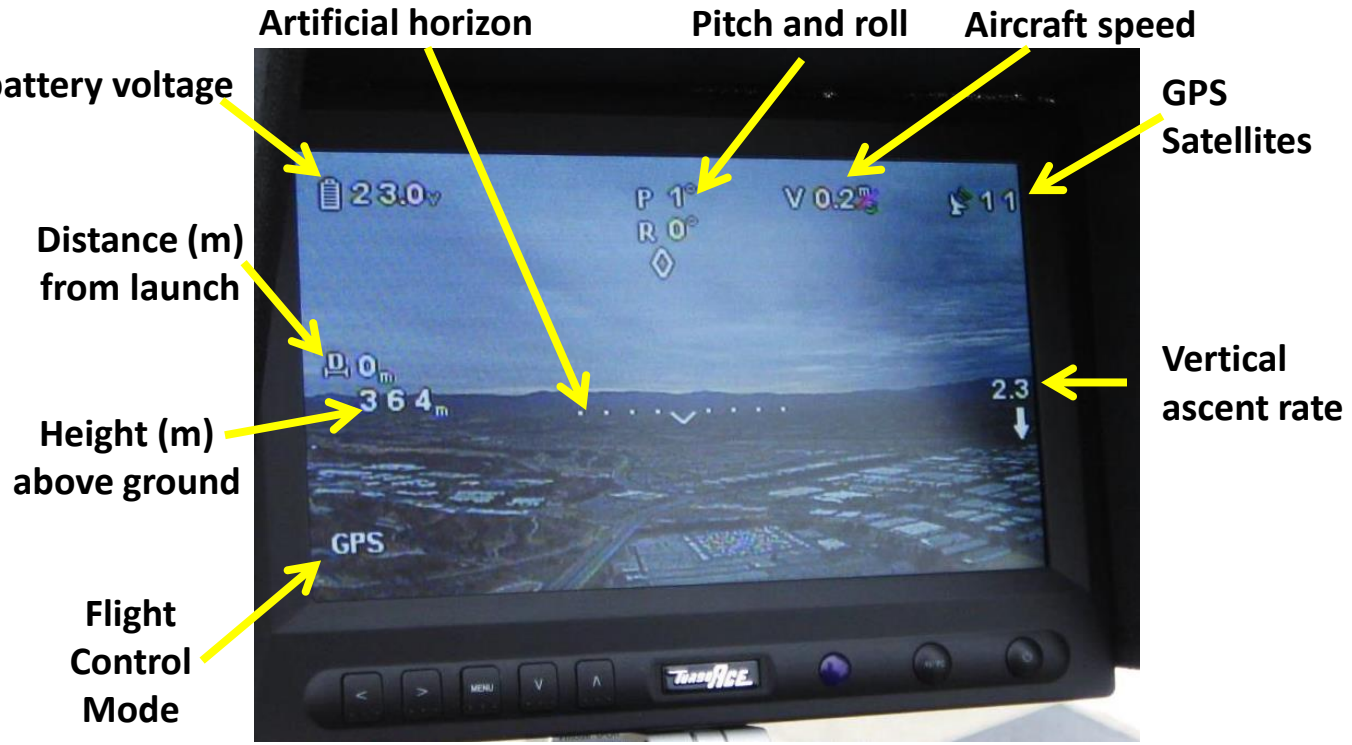
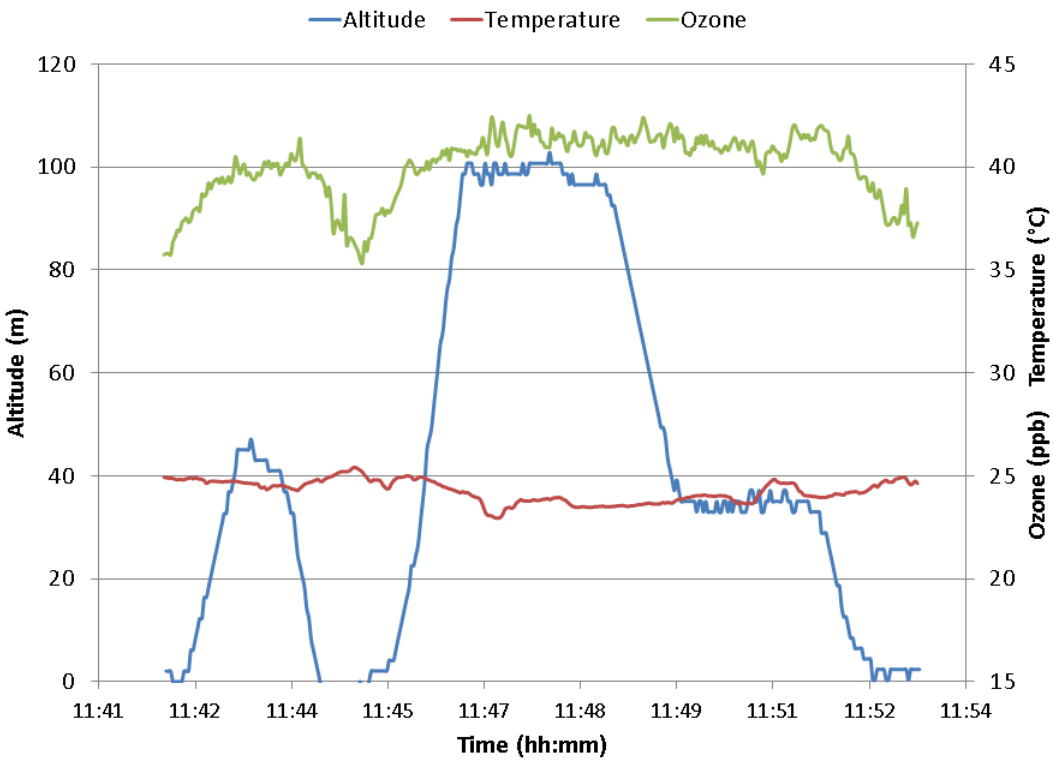


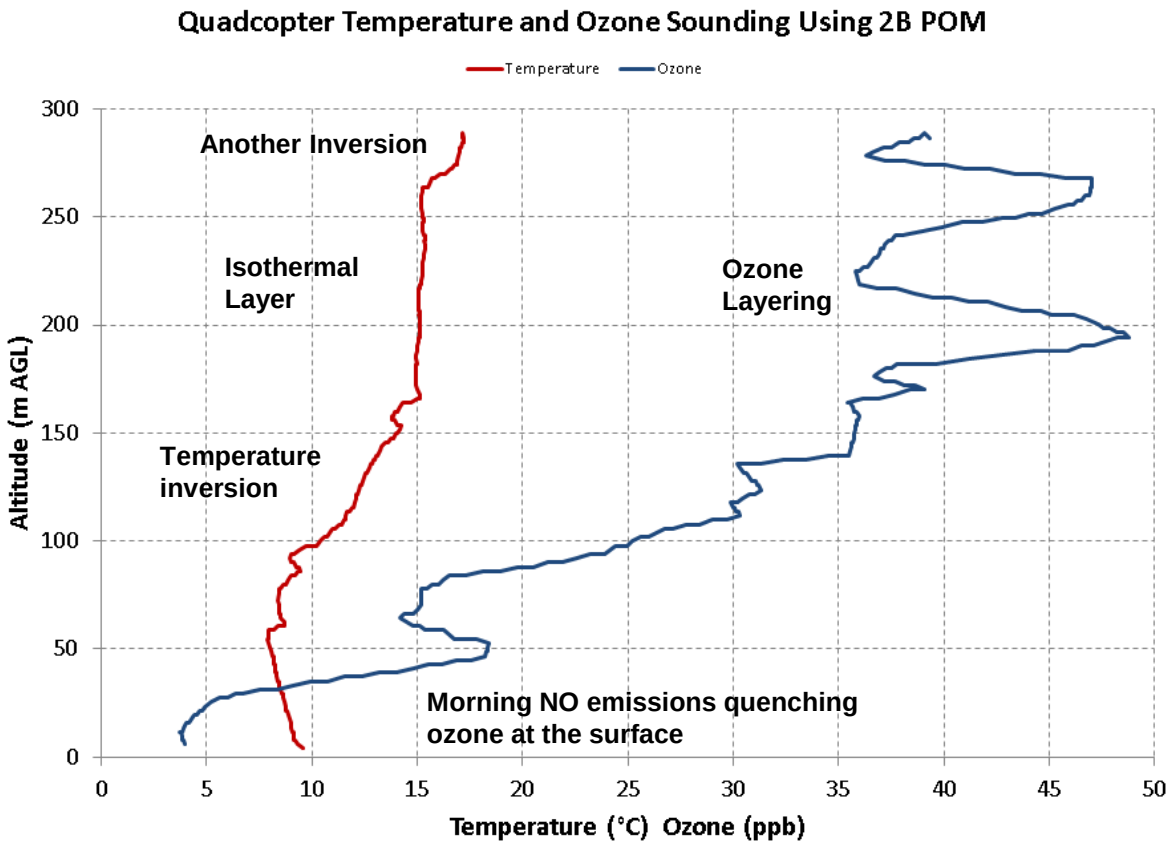
Demonstrated Uses

- Ozone sampling using a KI ozone sampling system
  - Performed during high winds (>10 m/s) – well mixed



Demonstrated Uses

- Ozone sampling using 2B Personal Ozone Monitor



Advanced Sampling Techniques in Development

- Remotely triggered sampling events
- Pre-programmed flight paths and waypoints
- Wind measurements using GPS stability control with measured pitch and roll
- Wind measurements using platform drift (gyro stabilization only)
- Real-time telemetry of measurements for sampling strategy modification
- Plume profiling with real-time displays
- Fence-line monitoring

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DJI Ground Station4.0
Joystick
ToolBox
Sys_set
Language(□□)
Help
Real Mode
Enter goto location
FLY TRACE
PATHEXTRUDE
MAP DETAILS
INSTRUMENT BOARD
EDITOR
CONTINUE
PAUSE
COM1
CONNECT
Aircraft
NORTH LATI: 038.6904849
WEST 120.7020014
ALTI: 0000.0 M
One Key Takeoff
Home Point
NORTH LATI: N/A
WEST N/A
ALTI: 0000.0 M
Current point flight time: 00:00:00
Total flight time: 00:00:00
Total estimated time of one way: 00:01:52
Total distance of one way: 202.015m
To Target(M):0.0
Altitude(M):0.0
H.Speed(M/S):0.0
V.Speed(M/S):0.0
0[15.0m]
3[30.0m]
0.0m
61.87m
69.94m
1[20.0m]
70.21m
2[25.0m]
62 m
EDITOR
Editing Mission
0
1
2
3
1.Way point properties
Latitude 38.6905632019043
Longitude -120.702842712402
Altitude 15
TurnMode StopAndTurn
Forward_Flight_Speed 4
HeadingDegree 360
HoldTime 10
Latitude
Latitude of the selected way point.
+
-
CLEAR
SAVE
OPEN
+1
+10
-1
-10
CANCEL
UPLOAD
GO
Imagery Date: 5/26/2014
1993
38°41'26.59" N 120°42'08.82" W elev 781 m
Eye alt 1.06 km
Terms of Use
GPS:
ATTI:
MODE:
0
Cancel

Future Developments

- Evolving FAA rules defining operational requirements hopefully by 2015
- New ASTM standards for small Unmanned Aircraft Systems
- Telemetry and real-time display development
  - Arduino based systems for data ingest and sampling control
  - Data overlays on the first-person view
- Data logging
  - Evaluation of existing systems for applicability
  - Development of hybrid logging and control systems
- Measurement sensor evaluations
  - RF field generated by UAV electronics
  - Vibration sensitivity and minimization through dampening
  - Motion effects on sensors

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Questions?

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