Atmospheric Boundary Layer Studies with the Duke University Helicopter Observation Platform (HOP)

M Adam Bolch and Roni Avissar
Department of Civil and Environmental Engineering
Duke University

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Why a helicopter?

1. Various environmental observations require low altitude, very-high frequency of sampling, and/or slow speed of sampling (e.g., aerosols, which have a key impact on climate and health; fluxes – water, carbon, others)
2. Maneuverability (complex terrain, urban areas, quick turns for flight tracks)
3. Time at station (with a fuel truck on the ground, no need to commute to an airport)
4. Remote location (e.g., operation from a ship)

Why a helicopter?

Federal Aviation Regulation (FAR)

§ 91.119 Minimum safe altitudes: General.

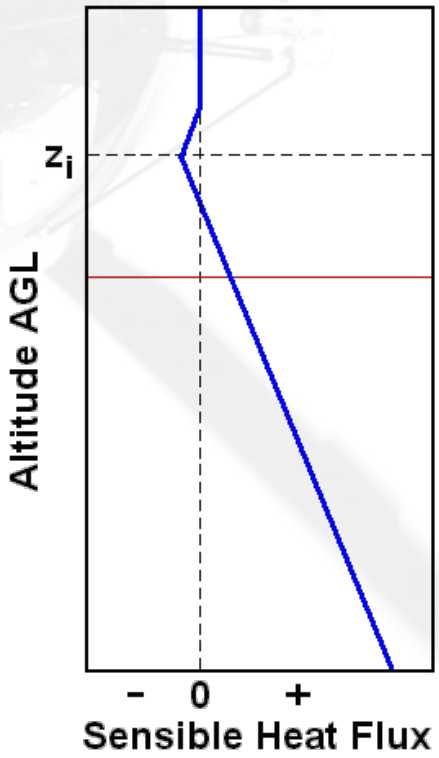
Except when necessary for takeoff or landing, no person may operate an aircraft below the following altitudes:

(a) *Anywhere.* An altitude allowing, if a power unit fails, an emergency landing without undue hazard to persons or property on the surface.

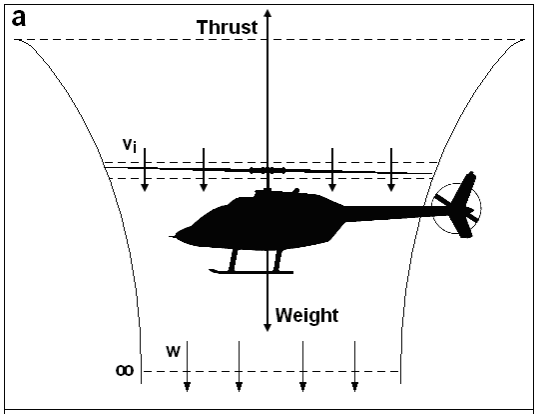
(b) *Over congested areas.* Over any congested area of a city, town, or settlement, or over any open air assembly of persons, an altitude of 1,000 feet above the highest obstacle within a horizontal radius of 2,000 feet of the aircraft.

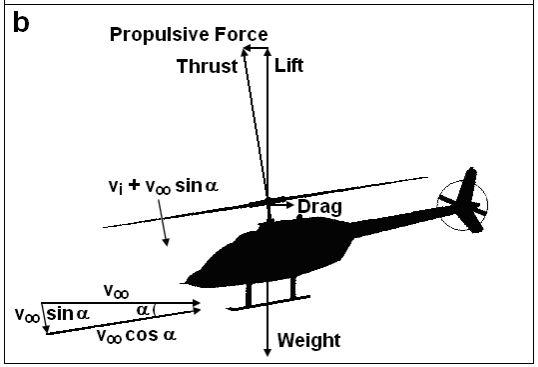
(c) *Over other than congested areas.* An altitude of 500 feet above the surface, except over open water or sparsely populated areas. In those cases, the aircraft may not be operated closer than 500 feet to any person, vessel, vehicle, or structure.

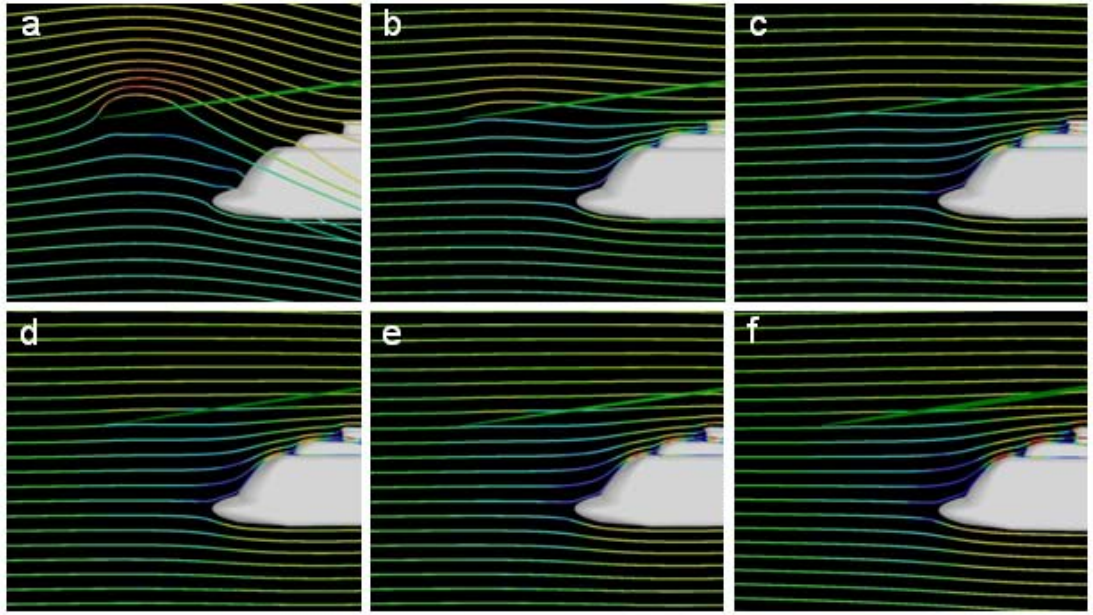
(d) *Helicopters.* Helicopters may be operated at less than the minimums prescribed in paragraph (b) or (c) of this section if the operation is conducted without hazard to persons or property on the surface. In addition, each person operating a helicopter shall comply with any routes or altitudes specifically prescribed for helicopters by the Administrator.

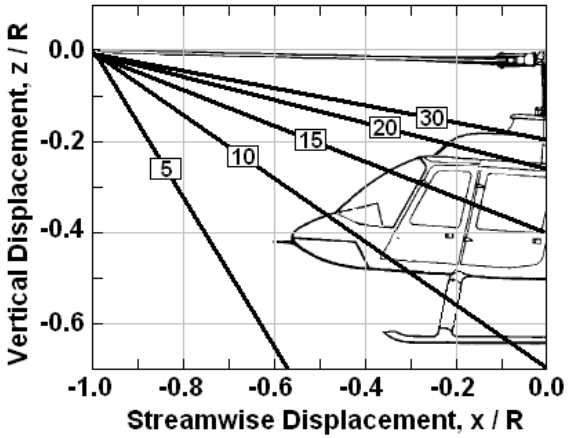


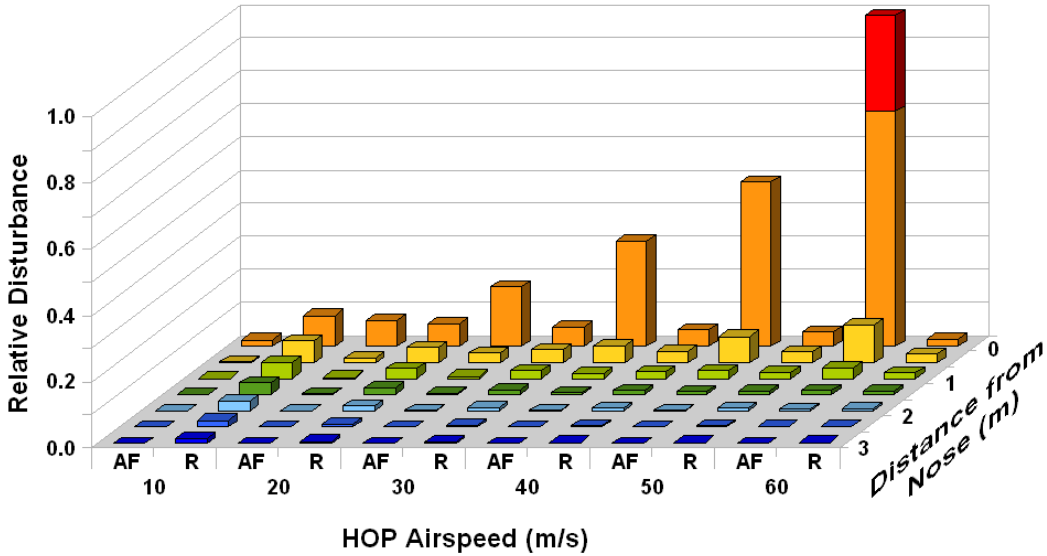
Characteristics	Duke HOP
Maximum Gross Weight (MGW)	3350 lbs
Base Operating Weight (BOW)	2900 lbs
Additional Payload Capability (APC)	450 lbs
Aft Cabin and Baggage Cargo Volume	56 ft^3
Maximum Altitude for Research Mission	12,000 ft
Maximum Endurance for Research Mission	3.67 hrs



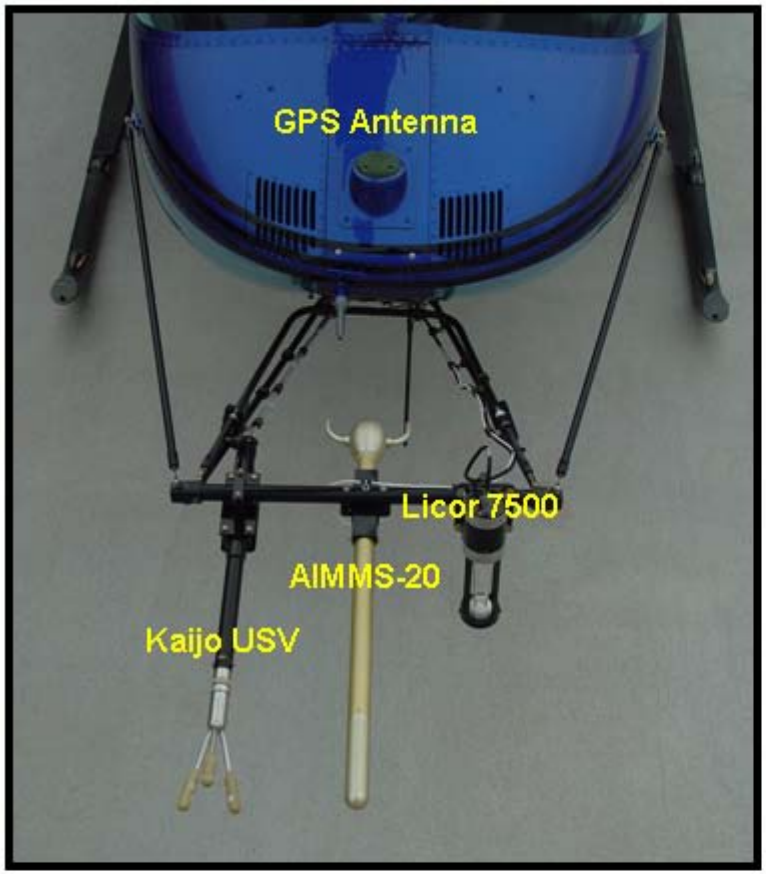


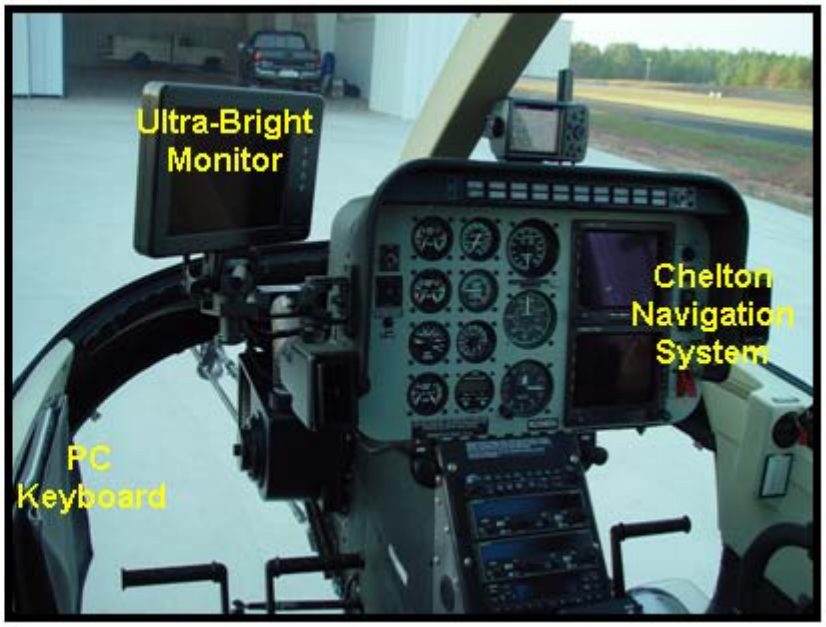




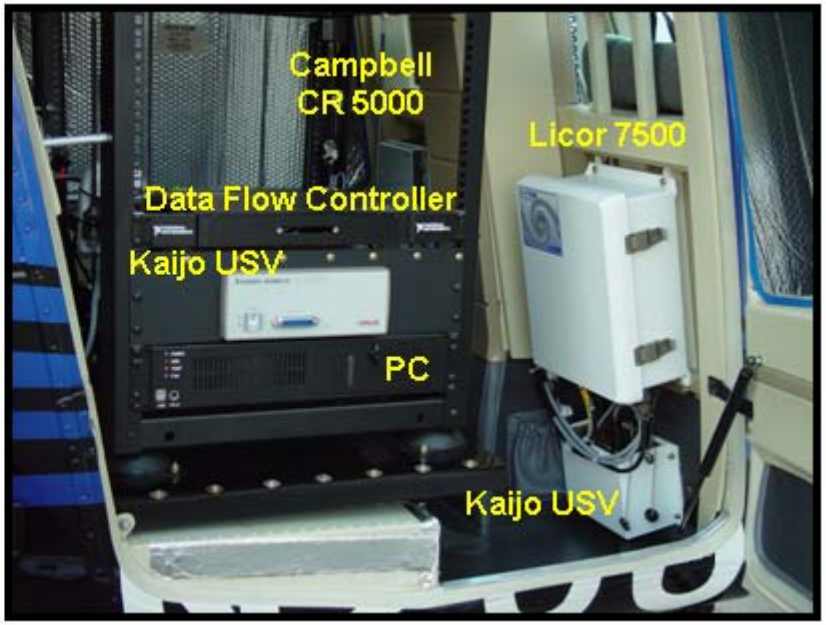


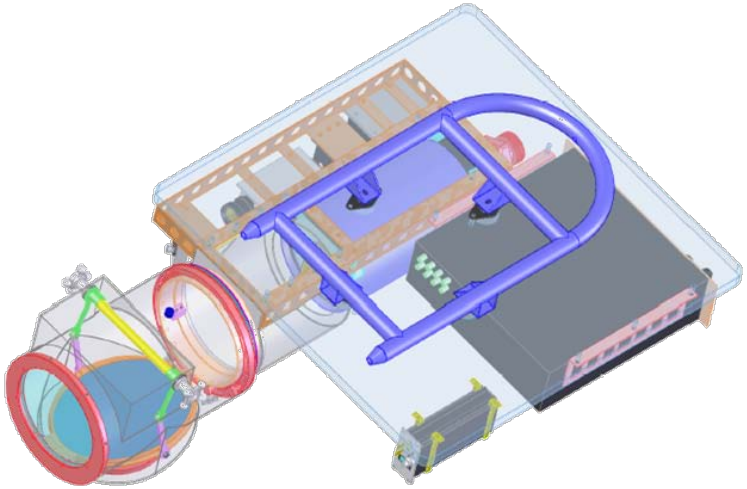
Glauert's (1935) rotor-wake model: $U = \sqrt{(v_\infty \cos\alpha)^2 + (v_\infty \sin\alpha + v_i)^2}$

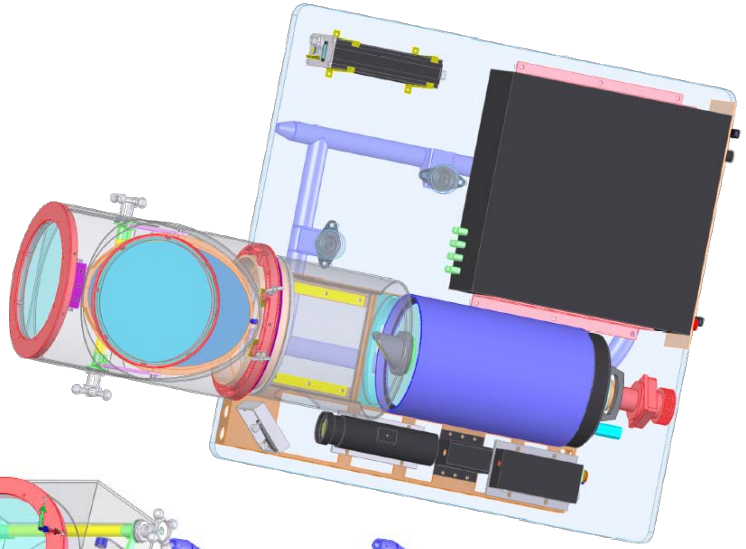

GPS Antenna
Licor 7500
AIMMS-20
Kaijo USV

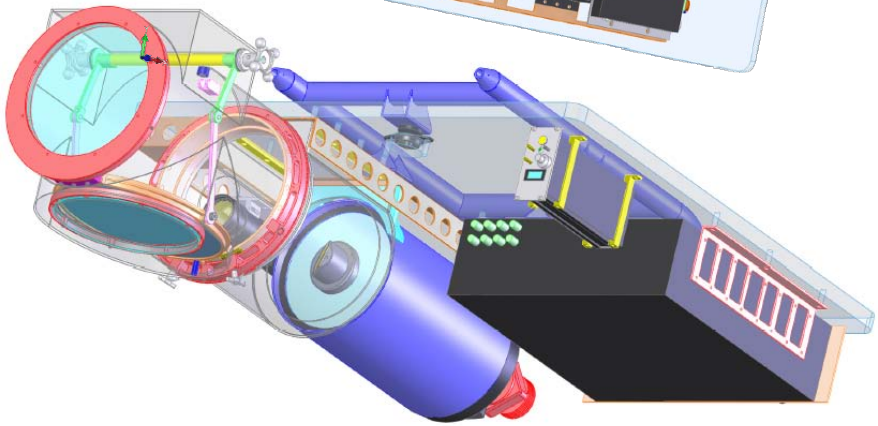

Ultra-Bright Monitor
Chelton Navigation System
PC Keyboard


GPS Antennas
N206DU

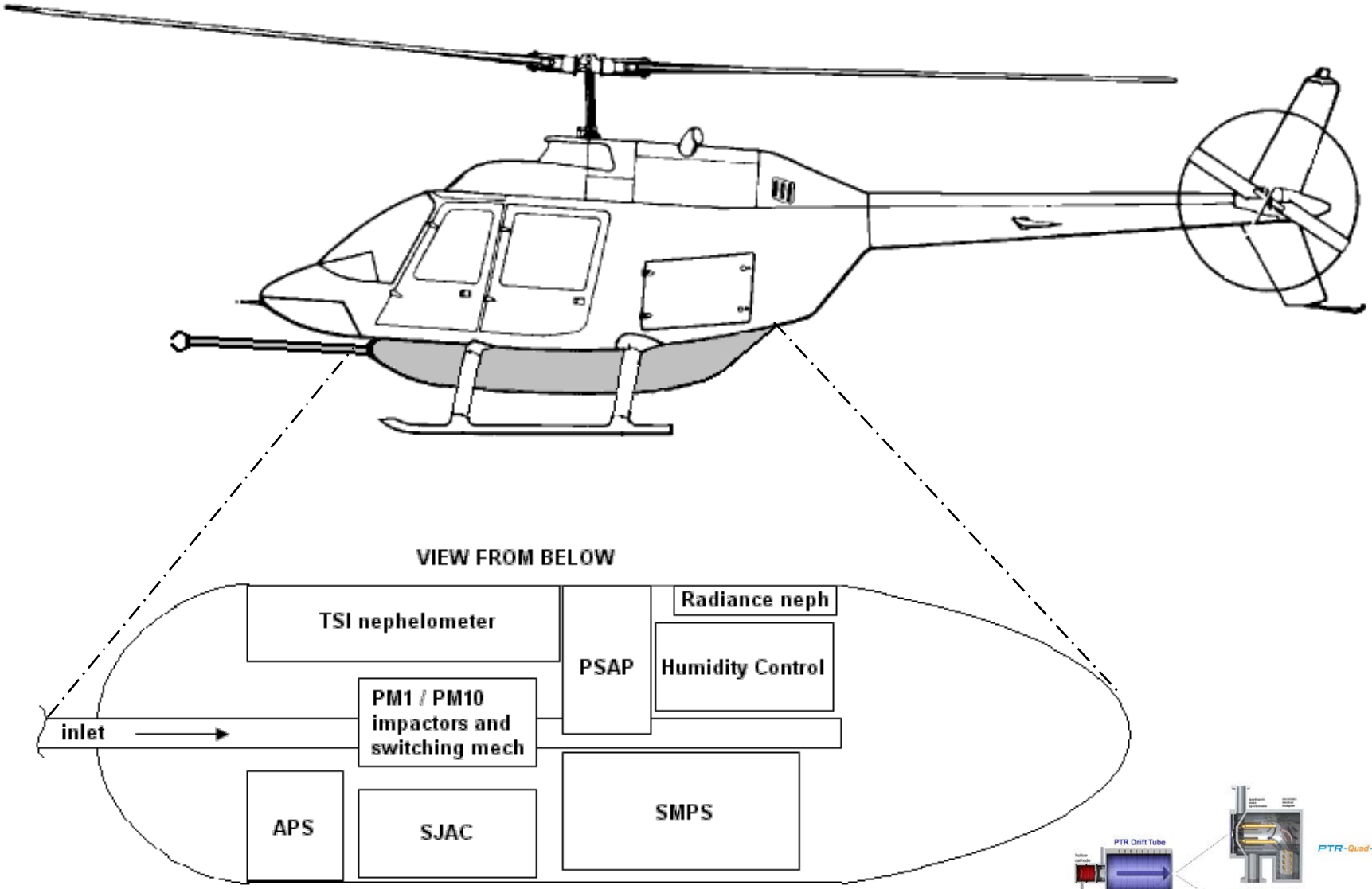

Campbell CR 5000
Licor 7500
Data Flow Controller
Kaijo USV
PC
Kaijo USV



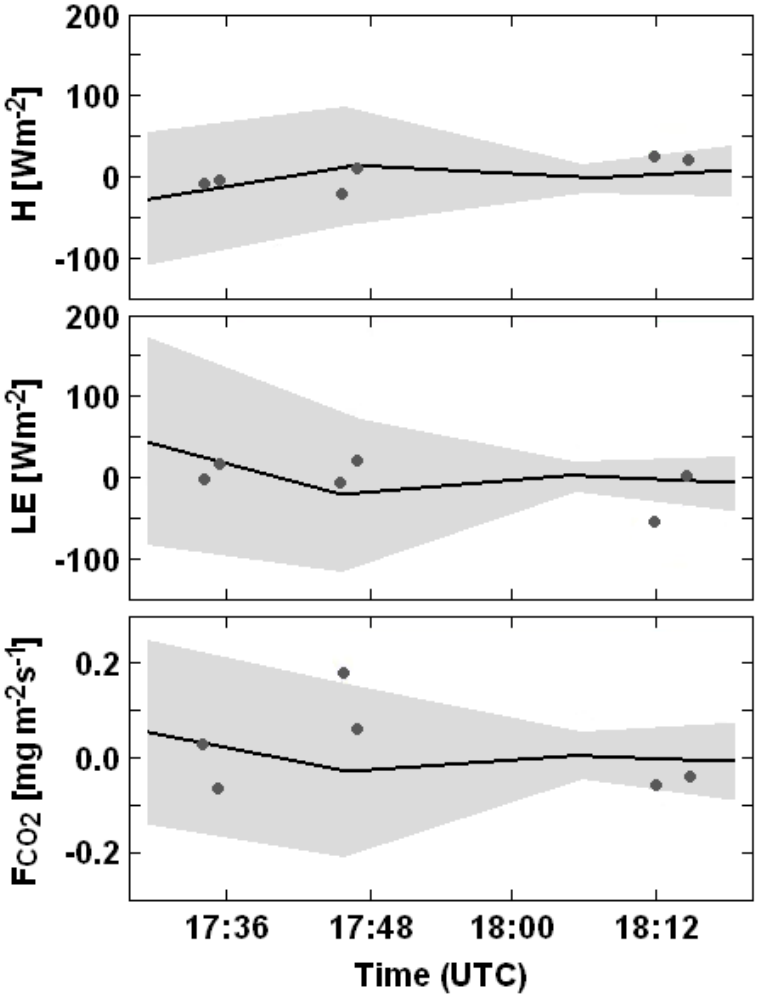


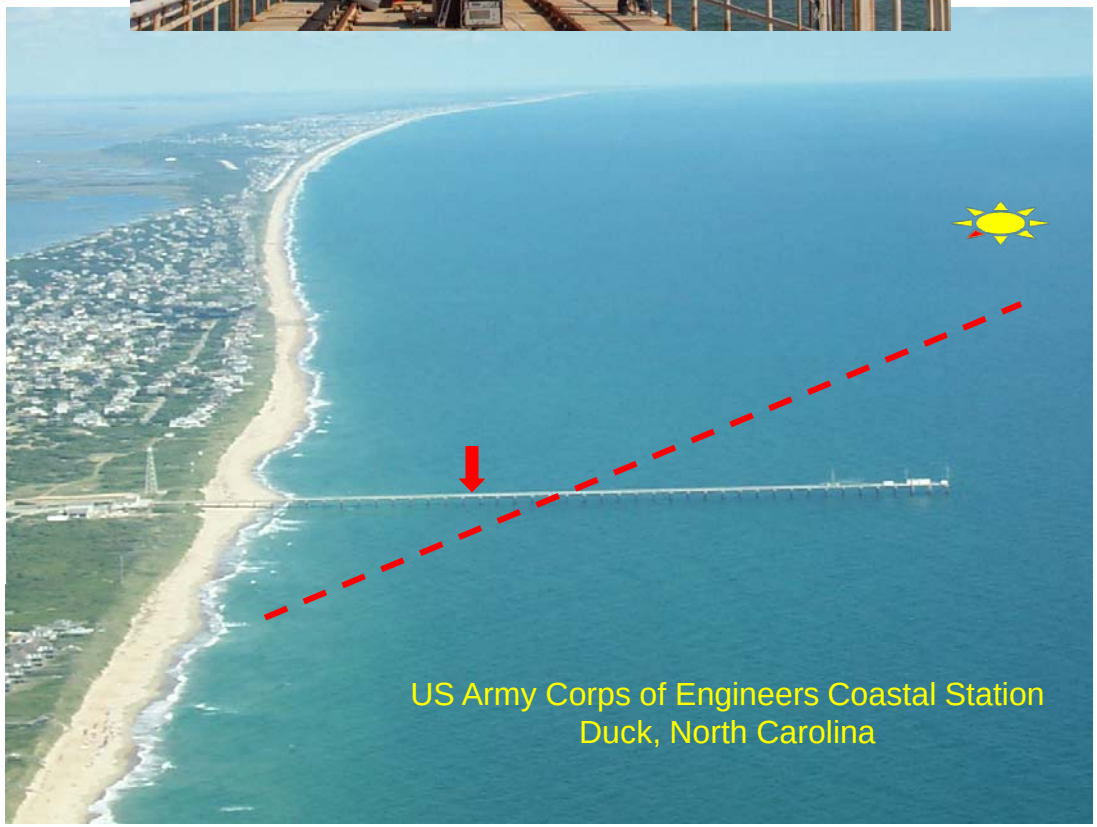


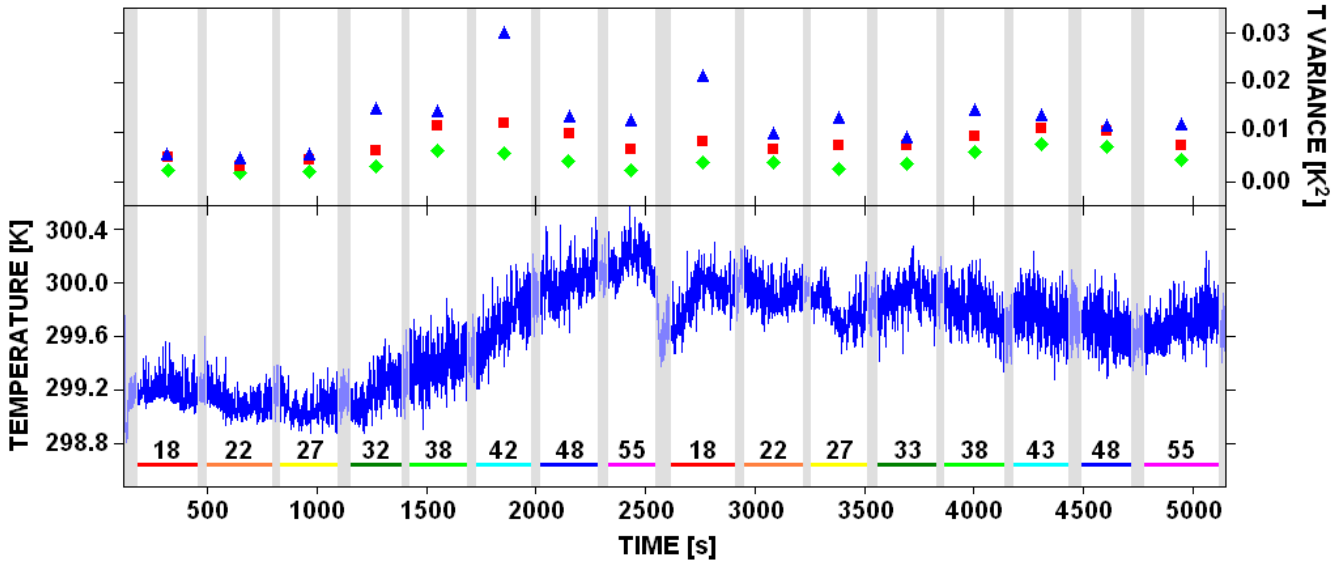

N206DU

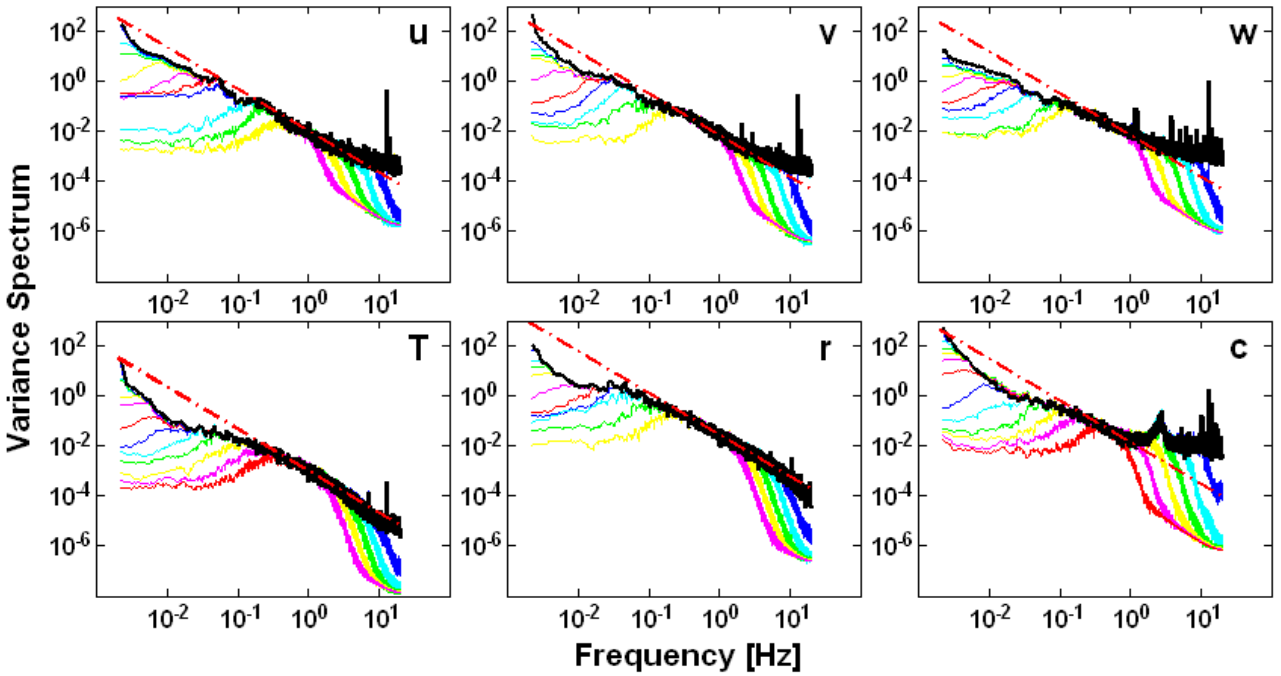


Proton Transfer Reaction -
Mass Spectrometry (PTR-MS)

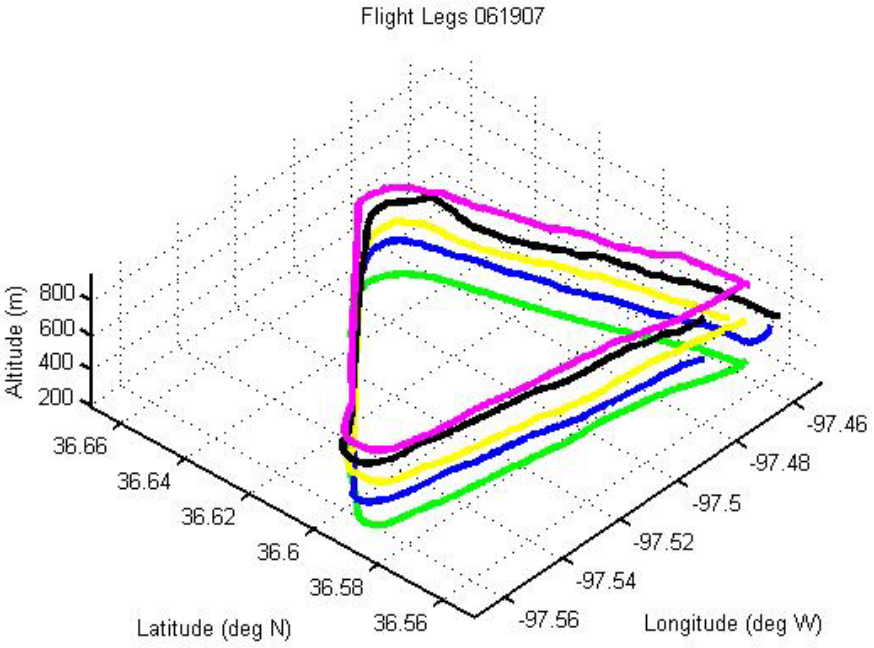

200
100
0
-100
H [Wm-2]
200
100
0
-100
LE [Wm-2]
0.2
0.0
-0.2
FCO2 [mg m-2s-1]
17:36
17:48
18:00
18:12
Time (UTC)


US Army Corps of Engineers Coastal Station
Duck, North Carolina


T VARIANCE [K²]
0.03
0.02
0.01
0.00
TEMPERATURE [K]
300.4
300.0
299.6
299.2
298.8
18 22 27 32 38 42 48 55 18 22 27 33 38 43 48 55
500 1000 1500 2000 2500 3000 3500 4000 4500 5000
TIME [s]


Variance Spectrum
u
v
w
T
r
c
Frequency [Hz]

Date	Flight 1	Flight 2	Flight 3
6/10/07	LW-1	LW-2	LW-3
6/11/07	CF-1	CF-2	
6/12/07	FS-1	Overpass	
6/13/07	LW-1		
6/17/07	FC-1	FC-2	
6/19/07	CF-1	CF-2	Overpass
6/20/07	LW-1		
6/21/07	CF-1	CF-2	CF-3
6/23/07	CF-1	CF-2	CF-3
6/24/07	FC-1	FC-2	
8/10/07	CF-1		
8/11/07	Lagrangian	CF-1	
8/12/07	Lagrangian	CF-1	
8/13/07	FC-1		
8/14/07	FS-1	FS-2	
8/15/07	CF-1	CF-2	Radon
8/16/07	FS-1	FS-2	



22 flights in June
13 flights in August
Total: 35 flights; ~100 hrs data

CF – Central Facility
LW – Little Washita
FC – Fort Cobb
FS – Okmulgee (Forest Site)

Overpass – A-Train Satellites overpass
Lagrangian – CO_2 Lagrangian Experiment
Radon – Atmospheric profiling of Radon

Cost of Operation…

Current rate is $1,595/hr for research flight and $495 for commuting to research site. A typical intensive field campaign lasts about 10 days. Flying 5 hr/day on average results in 25-50 hours of data collection and costs $50-$100K (including all expenses, Duke does not charge indirect cost for use of the facility).

Dr. Roni Avissar
Duke University
avissar@duke.edu
http://hop.pratt.duke.edu