Aircraft Atmospheric Research and Planetary Exploration

Jim Whiteway

Centre for Research in Earth and Space Science
York University, Toronto
York University Aircraft Projects

2009: Twin Otter, Forest Fire Smoke Transport
2009: DC-3, Arctic Surface Air Chemistry
2007: Dimona, Australian Desert Dust
2007: Twin Otter, Forest Fire Smoke Transport
2006: Egrett and Twin Otter
    Tropical Convection, Clouds, Water Vapour
2002: Egrett and King Air
    Tropical Convection, Clouds, Water Vapour
2001: Egrett and King Air, Cirrus Clouds
2000: Egrett, Gravity Wave Breaking
The Egrett
Airborne Research Australia
15 km; 70-100 m/sec; 750 Kg

- CPI
- Turbulence and temperature probes
- TDL
- FSSP
- TAFTS, FPH & the Ozone probe
**Twin Otter**

- Kenn Borek Air, Calgary (2009)

**Figure 3.** Photograph of the Twin Otter aircraft (left) and the new Phoenix Field Lidar (right) during installation on the Twin Otter at Grand Junction Colorado (base of Twin Otter Airborne Research).
The Dimona
Airborne Research Australia
Muloorina 2007
Polar-5 (DC-3) Alfred Wegener Institute
Arctic Flights
April 2009, 2011
Pulsed Laser
Telescope
Receiver
optics, PMT’s and electronics
Detection
Backscatter from molecular constituents and aerosol particulates
Lidar
Pulsed Laser
Transmitter
Phoenix Lidar for Aircraft

Telescope

PMT Detector

APD Detector

Laser

Photon counting and analog acquisition electronics
LIDAR on Phoenix Mars Mission

Landed 25 May 2008
Phoenix Lidar Testing
January 2007

Twin Otter, Forest Fire Smoke
July 2009
Twin Otter Lidar Measurements (July 2009)
Cirrus Clouds Above Northern Alberta

ECHO 2009: BackScatter Coefficient Contour Plot for July 30, 2009

Fall Streaks
Cirrus Clouds on Earth

Fall Streaks

http://australiasevereweather.com/
Lidar Backscatter Coefficient ($m^{-1}sr^{-1}$)

Sol 99, Ls = 122°

Fall Streaks

Local Time

R = 35 um
LIDAR on Phoenix Mars Mission

Landed 25 May 2008
Egrett and Twin Otter
Remote Sensing and In Situ Measurements

- **Egrett**
  - particle measurements
  - water vapour, ozone, temperature, turbulence
  - IR spectra

- **King Air or Twin Otter**

- **Lidar**
Cloud Top

Distance (km)

Height (km)

In situ Cloud crystal Sampling

Egrett Path

Lidar signal

200 μm
Ice Water Content: Lidar and in situ measurements

- Aircraft In situ IWC
- Sol 99: 2 mg/m³

Graph showing the relationship between Ice Water Content [mg/m³] and Extinction Coefficient [km⁻¹]. The line represents the equation $IWC = 10 \times \sigma$. 
Ice Water Content: Lidar and in situ measurements

Aircraft In situ IWC

Sol 99
2 mg/m³

Mars PBL clouds

\[ \text{IWC} = 10 \times \sigma \]
Lidar Backscatter Coefficient \( (m^{-1}sr^{-1}) \)

Sol 99, \( L_s = 122^\circ \)

- 1 mg/m\(^3\)
- 1 g/m\(^2\)
- 1 micron

Altitude [km]

Local Time

04:23  04:37  04:52  05:07  05:21

\( \geq 14.0 \)

\( 11.3 \)

\( 8.5 \)

\( 5.8 \)

\( 3.0 \)

\( \leq 3.0 \)

\( 10^{-6} \)
Cloud Ice Water Content

ICE OD

Column IWC micron

Height (km)

IWC (mg/m³)

Local True Solar Time
Lidar and Aircraft In Situ Desert Campaign
Australia, November 2007
Lidar Measurements of Dust Above Muloorina
Lidar and Aircraft In Situ Comparison
Aircraft …
Vital for Results of the Phoenix Mars Mission
Climate Processes
Humidity in the Tropical Upper Troposphere
Outflow from Tropical Convection

(Hector)

15 km: Outflow cirrus

10-15 km: Moisture
Moving Forward with the Egrett

- Water in the upper troposphere, lower stratosphere
- Testing and characterization of instruments for space missions
Polar-5 (DC-3) Arctic Flights
April 2009, 2011
Polar-5 Lidar Ozone Measurements Over Sea Ice
23 November 2002, Early afternoon

Convection

Tiwi Islands
23 November 2002, Late afternoon

Convection

Cirrus Outflow
Flight leg along the outflow

Flight track
Lidar-Radar Analysis / Jan 27, 2006 / 7:08 - 7:12 UTC

- Radar Reflectivity [dBZ]
- Lidar Extinction [1/m]
- Ice Water Content [g/m³]

Graphs showing vertical profiles of various meteorological parameters.

CAS, CIP, CPI markers indicating specific locations or data points.

Lidar-Radar Method
Parameterization (Hill, 2007)
Egrett Open Path Tunable Diode Laser
York University Ozone Lidar on Polar-5
J. Seabrook, L. Gray, L. Komguem, J. Whiteway
Phoenix Lidar
Testing at CSA David Florida Laboratory, Ottawa