Ozone Depletion in Filaments of the Arctic Polar Vortex, Observed the First Global Hawk Science Mission

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How can we measure polar $O_3$ loss? When it is not obvious as below?

Unmanned Aircraft Systems (UAS), like Global Hawk, bridge the gap between ground based and satellite measurements.

GMD data, courtesy Bryan Johnson
How good are our UAS measurements? Comparisons of Unmanned Global Hawk data vs
1. Manned NCAR HIAPER (Gulfstream-V).
2. MLS instrument on AURA satellite.
Aura-MLS Profile Locations from 2010-04-13,14 (circles) with NASA Global Hawk track during GloPac RF02 (blue), NSF/NCAR Gulfstream V track during HIPPO-3 RF09 (red).

Aura pre-selection criteria: within 600 nmi, 6 hours of aircraft.

Comparison transect highlighted green (MLS), solid (aircraft).
Aircraft data along MLS Comparison Transect
GloPac RF02-20100413 (blue), HIPPO-3 RF09-20100413 (red)

Palt

O3

N2O

CH4

Latitude (deg N)
$\text{N}_2\text{O vs CH}_4$

Aircraft data from GloPac RF02-20100413 and HIPPO-3 RF09-20100413 along MLS comparison transect.

(1 Hz QCLS data presented as 1-minute averages)
Selected Aura-MLS N₂O Profiles from 2010-04-14 (Hour 0) with N₂O measured from nearby NASA Global Hawk during GloPac RF02 and NSF/NCAR Gulfstream V during HIPPO-3 RF09.

![Graph showing N₂O profiles with pressure, concentration, and latitude measurements.]
Selected Aura-MLS O$_3$ Profiles from 2010-04-14 (Hour 0) with O$_3$ measured from nearby NASA Global Hawk during GloPac RF02 and NSF/NCAR Gulfstream V during HIPPO-3 RF09.
N₂O vs O₃

From selected MLS profiles (2010-04-14, hour 0) and Aircraft data from GloPac RF02-20100413 and HIPPO-3 RF09-20100413 along MLS comparison transect.

Global Hawk latitudinal transect at nearly constant altitude

Global Hawk vertical profiles

N₂O (ppb)

O₃ (ppb)

(1 Hz QCLS data presented as 1-minute averages)

Latitude of Measurement
Ozone loss observed on 7 May
Region of stratospheric penetration highlighted solid.
Ozone-depleted stratospheric region highlighted green, red.
Aura-MLS Profile Locations from 2010-04-23,24 (circles) with NASA Global Hawk track during GloPac RF03 (blue)

Aura pre-selection criteria: within 600 nmi, 6 hours of Aircraft
Comparison transect highlighted green (MLS), solid red (aircraft)
50-90°N Minimum Temperature

HNO₃ = 6 ppbv, H₂O = 4.5 ppmv

Type I PSC

Type II PSC

P. Newman (NASA), E. Nash (SSAI), S. Pawson (NASA)
CLaMS Model Simulation for 7 April 2010
(450K ~ 17 km)

CLaMS O₃ / ζ=450K / 07.04. [ppmv]

CLaMS N₂O / ζ=450K / 07.04. [ppbv]

Courtesy of Jens-Uwe Grooss, Forschungszentrum Juelich
CLaMS Accumulated Ozone Loss since 1 Dec 2009

$\Delta O_3$ (accum.) / $\zeta=450K / 07.04.$

[ppmv]

0.30
0.00
-0.30
-0.60
-0.90
-1.20
Conclusions

- Overflight of the Global Hawk over the GV during HIPPO/3 produced similar tracer-tracer relationships with structure.

- There was a good agreement of common tracers from different instruments on two aircraft and one satellite instrument.

- Breakup of the polar vortex with low ozone during HIPPO/3 and GloPac was observed in filaments.

- Agreement of ozone loss between ozone loss and model simulation.
Extras
Aircraft Time Series Data

GloPac RF02-20100413 (blue), HIPPO-3 RF09-20100413 (red)

- Lon
- Lat
- Palt
- O₃
- N₂O
- CH₄

Global Hawk
- northern-most point
- vertical profiles

Midnight UTC 2010-04-14
- Gulfstream V high profile

Comparison transect highlighted solid.