Aircraft Observations of the Lower Atmosphere and Surface Exchange Processes

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Outline

• Results from BAe-146 during AMMA

• Aircraft observations over Canada

• Existing capacity in Canadian atmospheric chemistry academic community
African Monsoon Multidisciplinary Analysis (AMMA)
AMMA-UK Flight Tracks

UK BAe-146 (FAAM) Facility for Atmospheric Airborne Measurements

100 hours between July 15- Aug 18, 2006

CO, O₃, NOₓ
VOC (in situ and canister)
OH, HO₂, RO₂
CH₂O, ROOH
aerosol number, physical properties and composition
dropsondes
Coordinated flight plans

Niamey
• FAAM Bae-146
• SAFIRE Falcon
• ATR42

Ouagadougou
• DLR Falcon
• Geophysica

Special issue in *Atmos Chem Phys*
VOC measurements by PTR-MS

Murphy et al., ACPD, 2010
Coupling of Chemistry and Dynamics – Shallow Convection

Murphy et al., ACPD, 2010
Coupling of Chemistry and Dynamics – Deep Convection

Murphy et al., *ACPD*, 2010
Coupling of Chemistry and Dynamics – Long Range Transport of Biomass Burning

700 mb from the TERRA-tude and time and averaged

Mari et al., ACP, 2008

Murphy et al., ACPD, 2010
Isoprene Flux Modelling using MEGAN

Fereira et al., ACPD, 2010
Top Down Constraints on VOC

Use satellite observations of CH$_2$O

To constrain modelled emission inventories of biogenic VOC

Millet et al., *JGR*, 2008
Vertical Profiles of VOC Oxidation

Figures from Eloise Marais, Harvard University
Top Down Constraints on $\text{NO}_x$

Jaegle et al., *Faraday Discuss.*, 2005
Emissions of NO$_x$ from recently wetted soils

Land Surface Temperature Anomaly

boundary layer NO$_x$ concentration

Purple = colder than usual and therefore recently wet

Stewart et al., ACP, 2008
Localized ozone production

Maximum PBL ozone above storm track
Fine scale features above wet surface

Stewart et al., ACP, 2008
Boundary Layer Ozone: forest is a sink, wet soil is a source of precursors

NO$_x$-limited ozone production over the Sahel

below 700 m
Assessing satellite constraints on boundary layer ozone

Mean August surface $O_3$ (12-18 hr, local time) in GEOS-Chem

![Map of GEOS-Chem $O_3$ with TES $O_3$ assimilation and NOx and isoprene emissions based on SCIAMACHY and OMI data]

Ozone Differences: GEOS-Chem with the satellite information minus the standard model

![Map of Ozone Differences]

Ozone Differences due to NOx emissions: Top-down NOx emissions minus the standard model

![Map of Ozone Differences due to NOx emissions]

Ozone Differences due to isoprene emissions: Top-down isoprene emissions minus the standard model

![Map of Ozone Differences due to isoprene emissions]

In situ observations of $O_3$, NO, NO$_2$, OH, HO$_2$, HCHO, etc... throughout the boundary layer and lower troposphere would be valuable for validating the changes in atmospheric composition associated with incorporating the satellite data into the model.
Other Aircraft Missions over Canada

- TOPSE 2000
- ICARTT 2004
- INTEX 2006
- ARCTAS 2008
- BORTAS 2010
Trans-Pacific Aerosol Transport Observed by Aircraft and Satellite

Intercontinental Chemical Transport Experiment (INTEX-B)

Altitude (km)

Mass Concentration [µg/m³]

SO₄²⁻

Org

Contributed by Randall Martin

van Donkelaar et al., ACP, 2008
ARCTAS 2008

DC-8 FLIGHT STRATEGIES

Lidar remote sensing:
- mapping of pollution plumes
- satellite validation

Process studies:
- photochemistry
- plume evolution
- transport mechanisms

Satellite validation (limb)

Satellite validation (nadir)

Arctic haze characterization

Surface interactions, site overflights

Air mass characterization
- global and regional chemical budgets
- long-range transport
Quantifying the impact of Boreal forest fires on Tropospheric oxidants over the Atlantic using Aircraft and Satellites (BORTAS): Phase I
July 2010 Aircraft Mission

Composition and distribution of biomass burning outflow → $O_3$ production and loss within the outflow → Resulting perturbation to atmospheric chemistry in the troposphere.

International partners:
NASA, CNRS, Environment Canada, Free University of Amsterdam, Dalhousie, Washington State

BORTAS PI: Paul Palmer, University of Edinburgh
## Existing Canadian Interest/Capacity in Atmospheric Chemistry Academic Community

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<th>Institution</th>
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Instrumentation for field trace gas measurements

Chemical Ionization mass spectrometer

Target species:
PAN, PPN, APAN, MPAN, CINO$_2$, Cl$_2$, Br$_2$

Sensitivity (1 sec data):
• PANs: better than 1 pptv
• CINO$_2$: better than 5 pptv

Specifications:
• dimensions: w. 21", h. 52", d. 40"
• weight 250 lbs
• power requirement: 850 watt

Upgrades required for aircraft duty:
• construction of rear-facing inlet
• remount in aircraft-certified 19" rack-mount frame
• aircraft certification

Diode laser cavity ring-down spectrometer
(under construction)

Target species:
N$_2$O$_5$, NO$_3$

Sensitivity (1 sec data):
• better than 5 pptv

Specifications:
• dimensions: w. 21", h. 45", d. 29"
• weight: tbd (<200 lbs expected)
• power requirement: tbd (< 1kW expected)

Upgrades required for aircraft duty:
• construction of rear-facing inlet
• remount in 19" rack-mount frame
• aircraft certification