Aircraft measurements during GoAmazon2014/5 – G1 and HALO inter-comparison

Fan Mei¹, Micael A. Cecchini³, Jian Wang², John Shilling¹, Jason Tomlinson¹, Jennifer Comstock¹, John Hubbe¹, Mikhail Pekour¹, Luiz A. T. Machado³, Mira Polhlker⁵, Manfred Wendisch⁵, Martin Zoeger⁶, Bernadett Weinzierl⁶, Scot Martin⁴, Beat Schmid¹
Introduction

- Large aerosol variability – pristine background and smoky and urban polluted plumes.
- Clouds and precipitation over the Amazon region have very large susceptibility to aerosols: warm cloud base and humid conditions – thermodynamic invigoration
- The GoAmazon2014 IOPs obtained unique datasets in chemistry, aerosols and clouds for studying how the anthropogenic plumes from Manaus impact aerosol formation and properties at the downwind areas and then impact cloud and convection.

Objectives

- Evolution and interaction of Manaus plume and biogenic aerosols
- Remote sensing validation
- Aerosol – Cloud Interactions
- Explore how Manaus plumes impact aerosol properties in the downwind areas and how changed aerosols impact convection, clouds and precipitation in the influenced area
GoAmazon2014/5 (IARA/ACRDICON-CHUVA)

- Location: Manaus, Brazil
  - Manaus Eduardo Gomes, SBEG, Runway 8,858 ft × 148 ft

- **G1** Aircraft Mission Dates
  - IOP1: 40 days. Feb. 15 - March 26, 2014 (16 flights – 42.8 hrs)
  - IOP2: 40 days. Sep. 1 - Oct. 10, 2014 (19 flights – 53.7 hrs)

- **HALO** Aircraft Mission Dates
  - Sep. 1 – Oct. 4, 2014 (14 flights – 96 hrs)
G1 and HALO Coordinated flights

- Sep. 9, 2014
- Sep. 16, 2014
- Sep. 21, 2014
- Oct. 1, 2014
G1 and HALO coordinated flight on Sep. 21, 2014 (AC 14)
Vertical profiles of ambient Temperature, $RH_w$ and Pressure

- G1 and HALO measurements inter-comparison criteria:
  - Sampling at the similar altitude layer (< 5000 m)
  - Sampling time difference less than 30 mins
  - Under STP condition
Vertical profiles of particle number concentration by CPC and UHSAS

CPC (>10 nm)

UHSAS (100-700 nm)

Difference between HALO and G1 is about 20-30%
• G1 UHSAS valid size range is from 70 -700 nm.
• At high concentration, G1 UHSAS seemed to underestimate the number concentration.
Vertical profiles of aerosol number concentration

- G1
- HALO

- UHSAS (>100 nm)
- CPC (>10 nm)

Altitude, m

UHSAS number concentration, #/cc

Aerosol number concentration, #/cc
Vertical profile of CCN activation fraction
(SS= 0.25%)
AMS data inter-comparison between G1 and T3

Good agreement between G1 (dotted line) and T3 ground site (circle marker)

No significant chemical composition change
CCN closure using G1 UHSAS Size Distribution

Assumption:
- Using bulk aerosol chemical properties.
- The $\kappa_{\text{Org}}$ is estimated from O:C ratio. (Mei et al. ACP, 2013)

- Underestimation of CCN number concentration for both experiment SS.
- Underestimation of CCN happened at lower altitude/higher concentration.
- Organic aerosols in Amazon may have different hygroscopicities than those we regularly observed in the US.
- The aerosol hygroscopicity is more uniform in higher altitude.

![CCN closure using G1 FIMS Size Distribution](image)
Vertical profiles of Trace Gas Concentrations

[Graphs showing vertical profiles of Ozone and CO concentrations with data points labeled G1 and HALO.]
Vertical transport sustains aerosol concentration in BL
The coordinated flight on Sep. 9, 2014 (AC 08)
G1 and HALO coordinated flight on Sep. 9, 2014 (AC 08)
Vertical profiles of particle number concentration by CPC and UHSAS

![Graph showing vertical profiles of particle number concentration by CPC and UHSAS]
Vertical profiles of aerosol number concentration

Sep. 21 (AC14) flight

Sep. 9 (AC08) flight
Vertical transport may contribute to BL aerosol concentration near Manaus city

Sep. 21 (AC14) flight

Sep. 9 (AC08) flight

Ozone, ppbv

Altitude, m
Vertical profiles of organic aerosol concentration
Validation of HR-Tof-AMS measurement in G1
Sep. 9, 2014 G1 Flight

CPC concentrations
- **Solid Line**: > 1500 #/cc
- **Circle symbol**: < 1500 #/cc
  around 1.6 km altitude

**FCDP and 2DS combined size distribution at same flight leg around 1.6 km**
UHSAS and PCASP issues

Mean PSDs From the Probes

Date: 20140909a
Time: 164007--164704 (Circle)
Time: 161659--162226 (Line)
Cloud probe inter-comparison
Summary

• Based on the inter-comparison results, G1 and HALO measurements are in a good agreement.
  ➢ Atmospheric state parameters
  ➢ Aerosol properties from CPCs, UHSAS
  ➢ Ozone and CO concentrations
  ➢ Chemical composition between G1 and T3 site

• Need further investigation
  ➢ UHSAS: Size dependent counting efficiency
  ➢ Discrepancy between UHSAS and FIMS at high number concentration
  ➢ Chemical composition from HALO
  ➢ Gas phase concentration for NO and NOx.
  ➢ Cloud probe: CIP
Acknowledgement

• Support from the Atmospheric Radiation Measurement (ARM) Climate Research Facility, a U. S. Department of Energy Office of Science user facility sponsored by the Office of Biological and Environmental Research.

• Support from the Central Office of the Large Scale Biosphere Atmospheric experiment in Amazonia (LBA), the Instituto Nacional de Pesquisas da Amazonia (INPA), and the Instituto Nacional de Pesquisas Espaciais (INPE). The work was conducted under 001262/2012-2 of the Brazilian National Council for Scientific and Technological Development (CNPq).

• Support from the Max Planck Society, the Deutsche Forschungsgesellschaft (DFG), and the German Aerospace Center (DLR)
Sep. 9, 2014, LWC comparison
Sep. 21, 2014, LWC comparison
Vertical profiles of aerosol number concentration

- UHSAS (>100 nm)
- CPC (>10 nm)
March 17, 2014 G1 Flight

CPC concentrations
- Manaus: Leg0, Leg0r, Leg 1 (r: denotes return path).
- T3: Leg 4
- **Phase 1**: mostly clear-sky at 500 m altitude
- **Phase 2**: mostly cloudy around 1 km altitude
**Phase 1 UHSAS clear-sky**

- **Phase 2 UHSAS clear-sky**
  - Plume has 2-3 times higher aerosols than background

**Phase 2 cloud properties**

- Storm clouds were coincident with plume well. Clean cloud samples are only a few and they are not part of storm clouds

![Graphs showing aerosol concentrations and cloud particle number distributions.](image-url)