An Advected Plume Study of Commercial Aircraft Take-off PM Emissions

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Delta – Atlanta Hartsfield Study

Part 1:
A study to:
• Measure PM emissions close to exhaust nozzle from stationary in-service commercial aircraft using state of the art extractive sampling techniques.
• Evaluate the viability of characterizing PM emissions using remote sensing of the exhaust plumes with a LIDAR source.

Part 2:
A study to:
Explore feasibility of measuring PM emissions and plume geometry in advected exhaust plumes during normal operations at a major commercial airport.
Science Team:

**Extractive Sampling**

UMR

Aerodyne Research, Inc.

**Remote Sensing (LIDAR)**

University of Central Florida

NOAA

NOAA Center for Commercialization
UMR Center of Excellence for Aerospace Particulate Emissions Reduction Research
Measurement Suite

- Cambustion DMS500
- Scanning Mobility Particle Sizer (SMPS)
- Condensation Particle Counter
- Multi-Angle Absorption Photometer (MAAP)
- Aerosol Mass Spectrometer (AMS)
- Tunable Diode Laser Differential Absorption Spectrometer (TILDAS)
- Non-dispersive IR (Licor)
- LIDAR
Data Presentation Plan

- Background
  - Want aircraft (esp. takeoff) emissions.
  - Other PM sources are active.
  - They are time dependent.

- Four specific take-off events
  - Several different airframe and engine types
  - Kinds of information that can be extracted

- Compilation of 289 take-off events
  - Six popular engine types
  - Three different days
Average Total Concentration Vs. Time
(for 1 minute intervals)

Total Number Concentration
(particles per cubic centimeter)

Time (SAM)

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Normalized Standard Deviation of the Total Concentration V. Time
(for 1 minute intervals)
Normalized Standard Deviation of the Total Concentration Slope Vs. Time
(for 1 minute intervals)

Standard Deviation for the Interval divided by Standard Deviation for the Entire Day

Time (SAM)
Background Total Concentration vs. Time

Total Number Concentration
(particles per cubic centimeter)

Time (SAM)

Sum of Individual Background Sizes

Data Points

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Dgeom M (nm) vs. Power

Aircraft: B767-400ER   Engine: CF6-80C2B8F

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B767-300 with GE CF6-80A2
Compilation of 289 take-off events

Six popular engine types

- BR715  B717 (Air Tran)
- CF34  Bombadier, Embraer, ACAC RJ’s
- CFM56  DC8, B737, A319, A320, A340
- CF6-80  B747, B767, MD11, DC10, A300, A310, A330
- JT8D  B727, B737, DC9
- PW2037  B757
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Conclusions

- Demonstrated capabilities and techniques for measuring aircraft specific emissions from in-service aircraft on a non-interference basis with normal airport operations.
- Implemented at a major airport during routine operations without interference with airline activities.
- Acquired take-off data for over 500 departures
- Requires fast instrumentation, ~ 1 Hz.
Conclusions

- Particle emissions evolve as they disperse and show distinct features associated with engine technology.
- Data analysis requires integrating results from multiple PM and gas phase instrumentation.
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