Preliminary Results from the Alternative Fuel Effects on Contrails & Cruise Emissions (ACCESS) Flight Experiment

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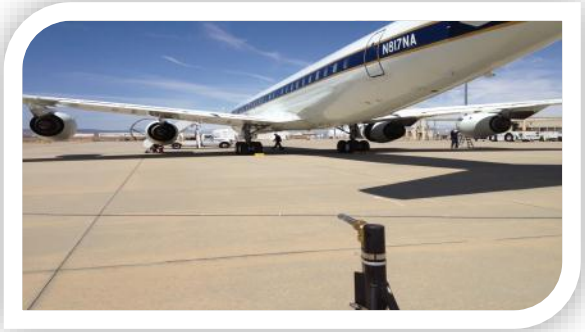
July 18, 2013

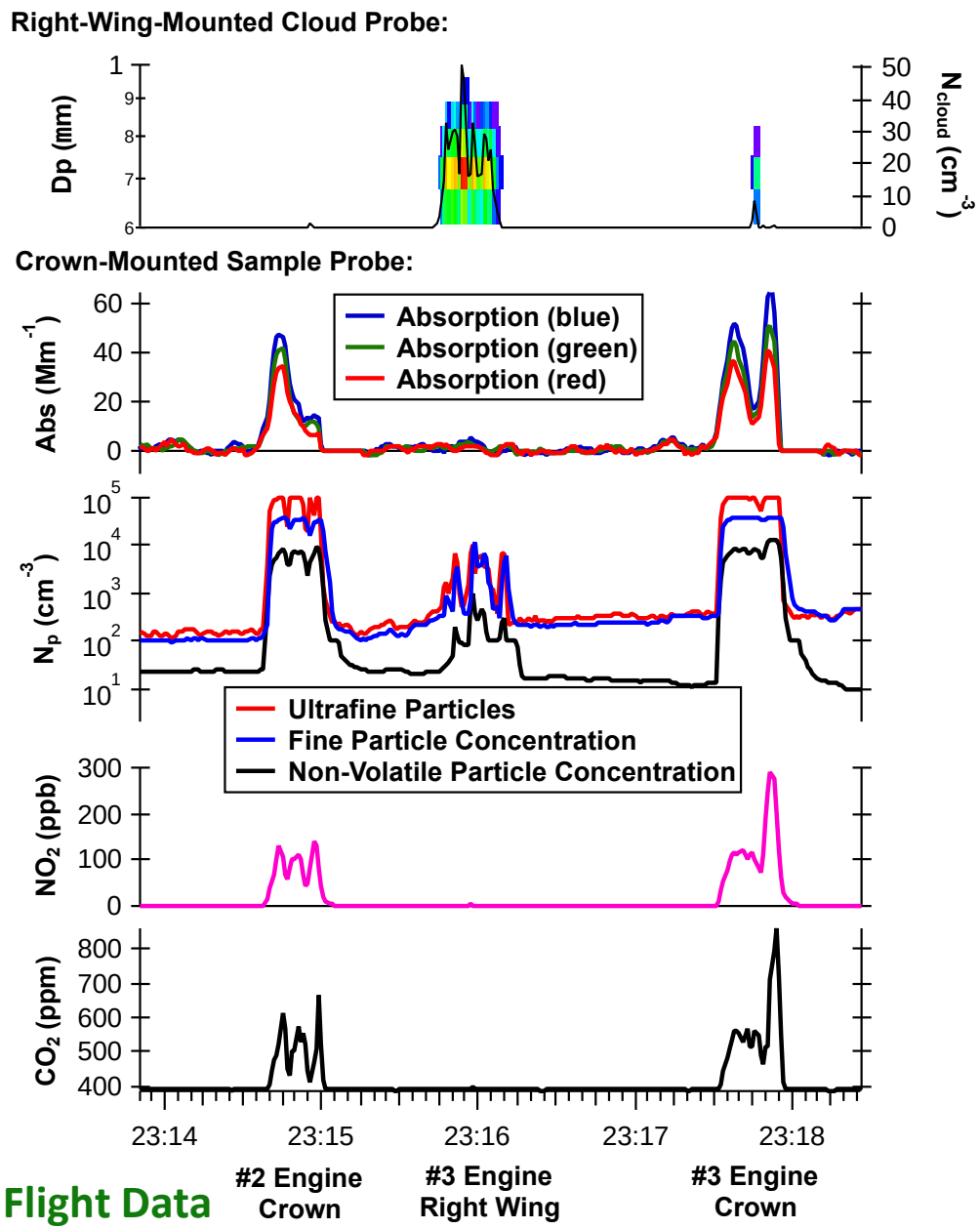
Project Overview

Flight experiment with the LaRC Falcon chasing the Dryden DC-8, which burned both traditional and alternative fuels



Ground test experiment behind the Dryden DC-8, which burned both traditional and alternative fuels at multiple power settings

12 April 2013 Flight Timeseries



Flight Data

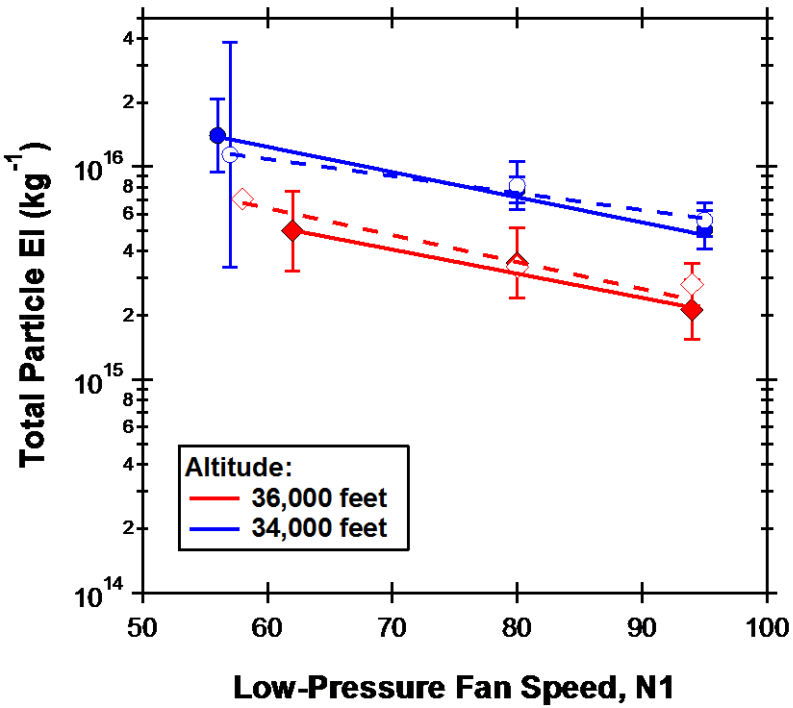
Background

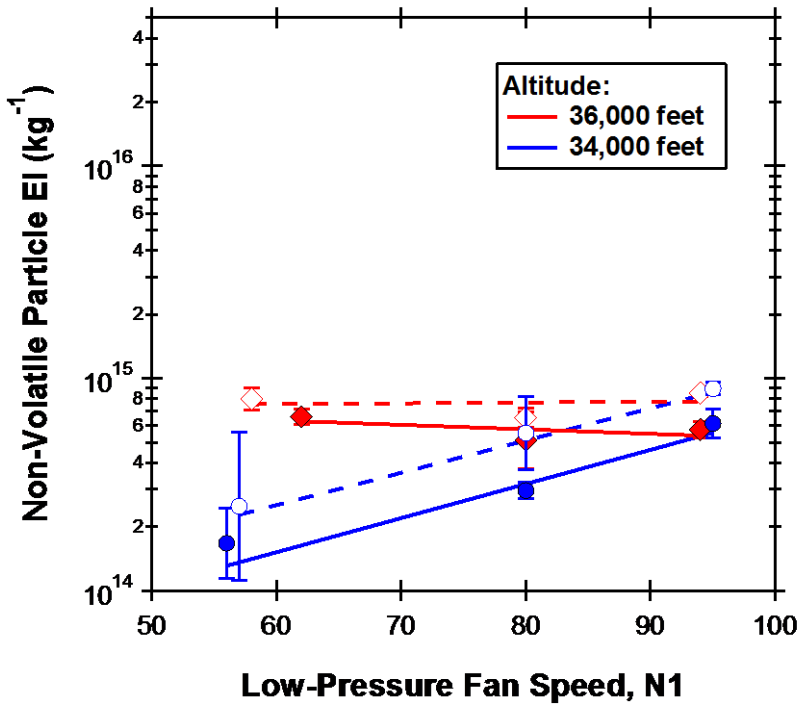
#2 Engine Crown

#3 Engine Right Wing

#3 Engine Crown

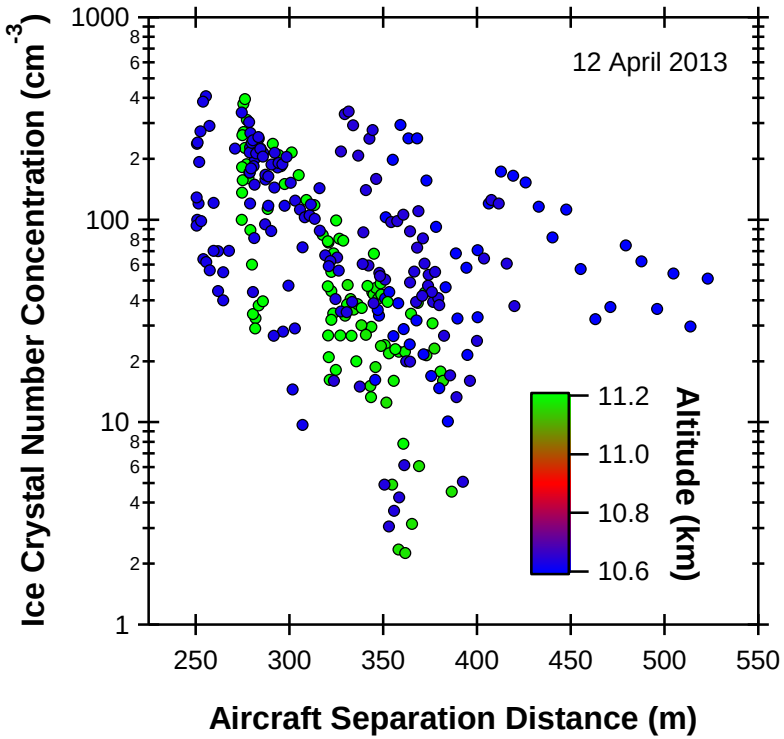
Blending does not change the overall aerosol emissions index, but does reduce non-volatile particles by 30-50%.

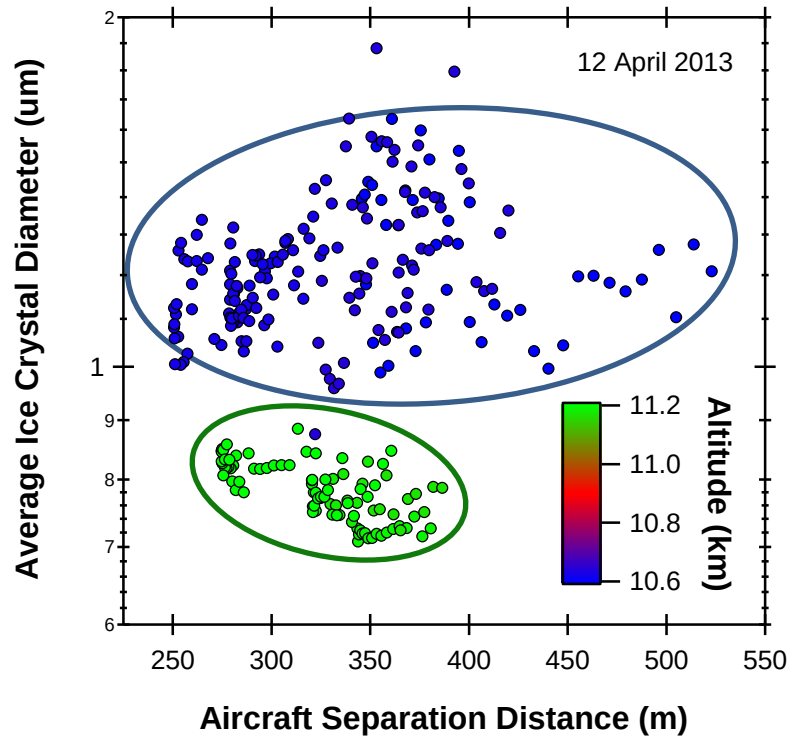


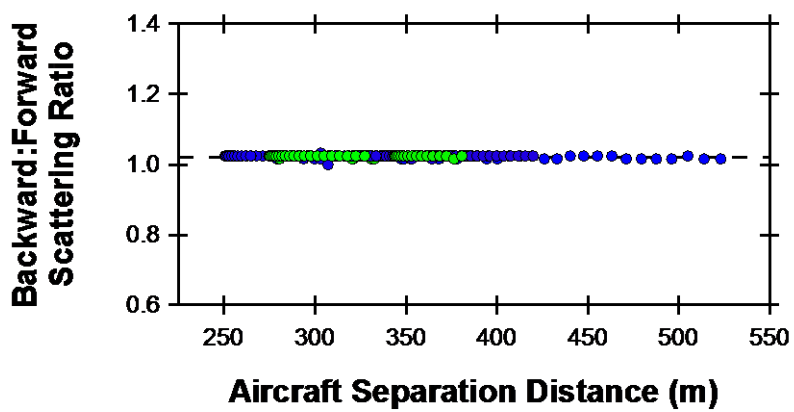


Flight Data

Crystal concentrations dilute with increasing separation, but not clear trend in ice crystal size (which trends with altitude). Crystals appear to be spherical.





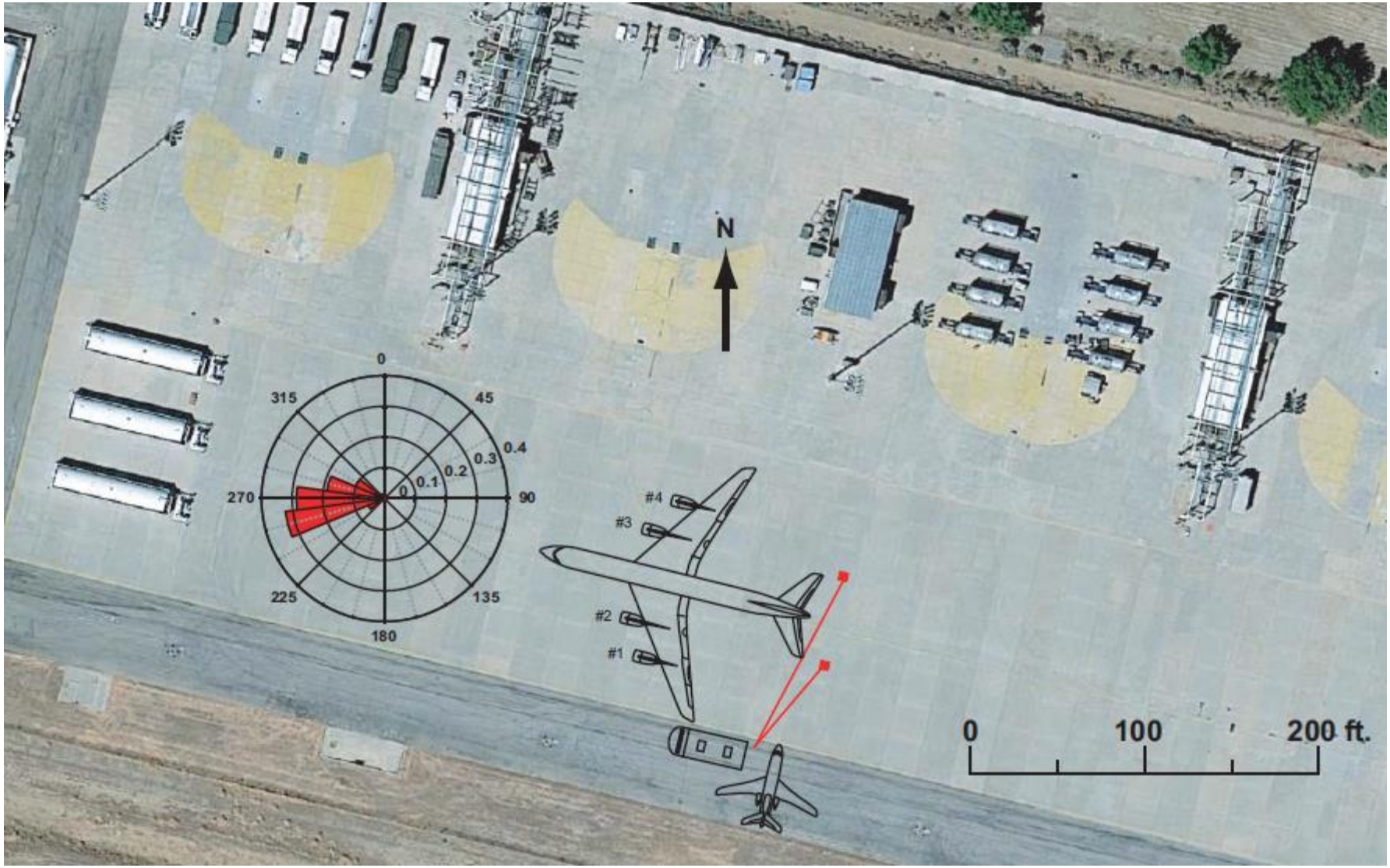


Flight Data

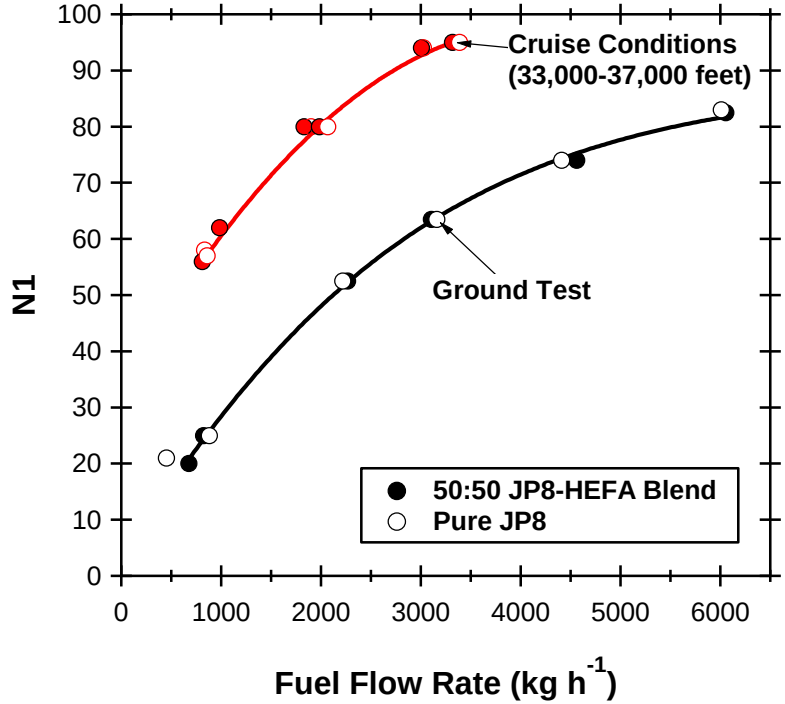
Ground tests enable additional measurements, aircraft power settings, and traceability to past results

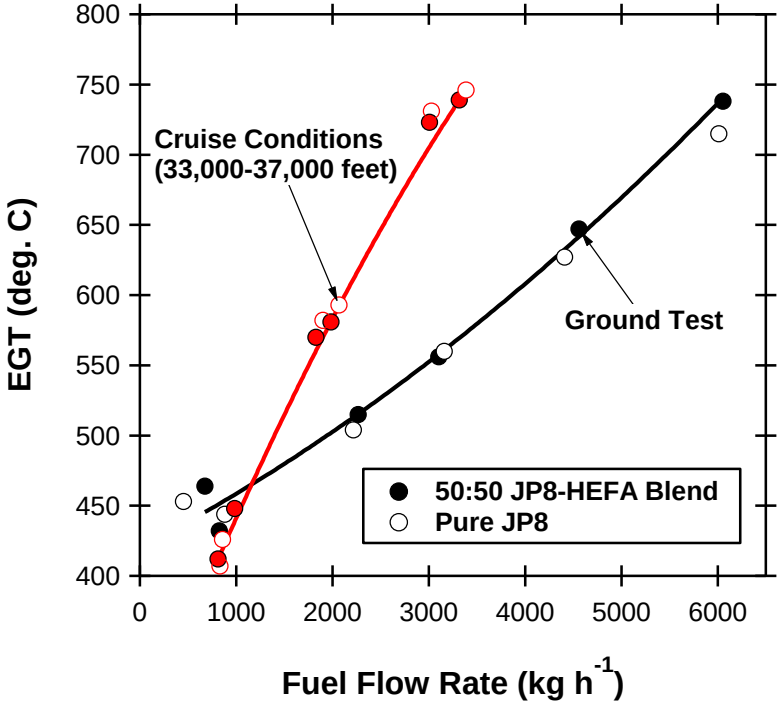
- Probe stands mounted at 30 m behind both inboard engines
- Falcon instrument payload + the LARGE mobile step van with additional instruments (shown at right)
- Cycle through fuels, power settings over an approximately 4-hr. experiment

Top-down view of the ground test pad at NASA Dryden with wind rose plot



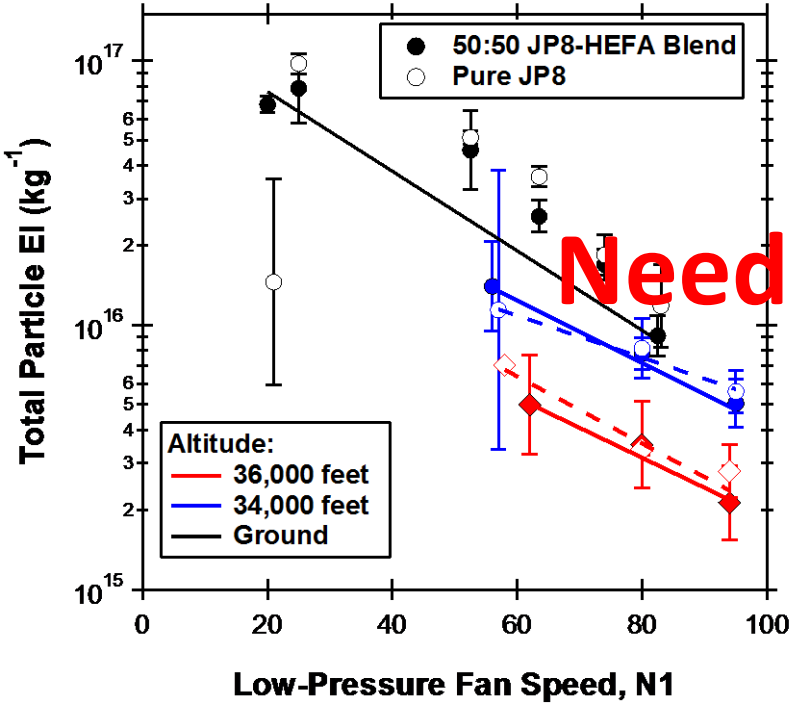
Flight "cruise conditions" are not an apples-to-apples comparison with "ground conditions".

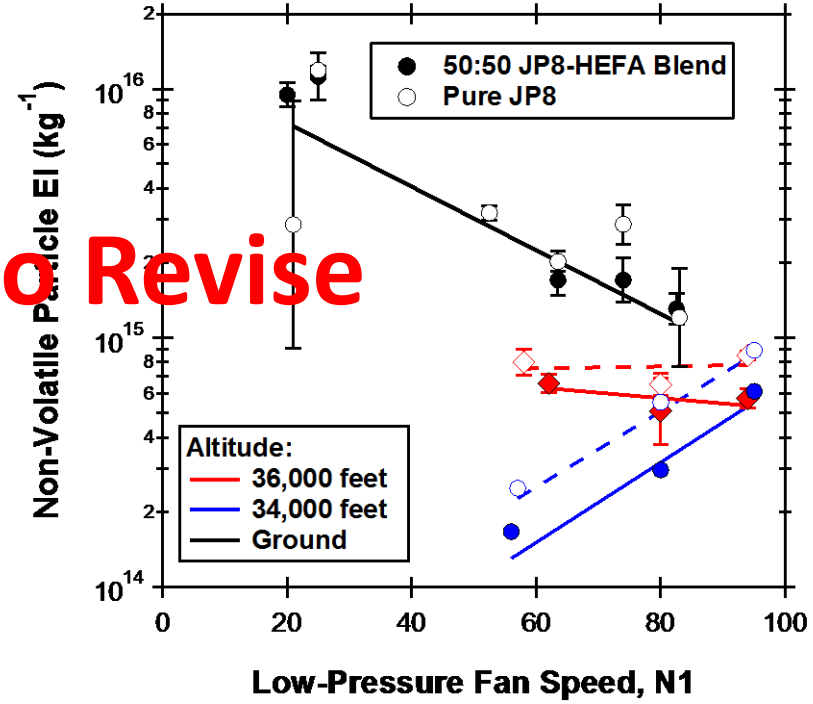




Ground & Flight Data

Lower particle number EIs observed at cruise conditions: Potential ice-particle scavenging?

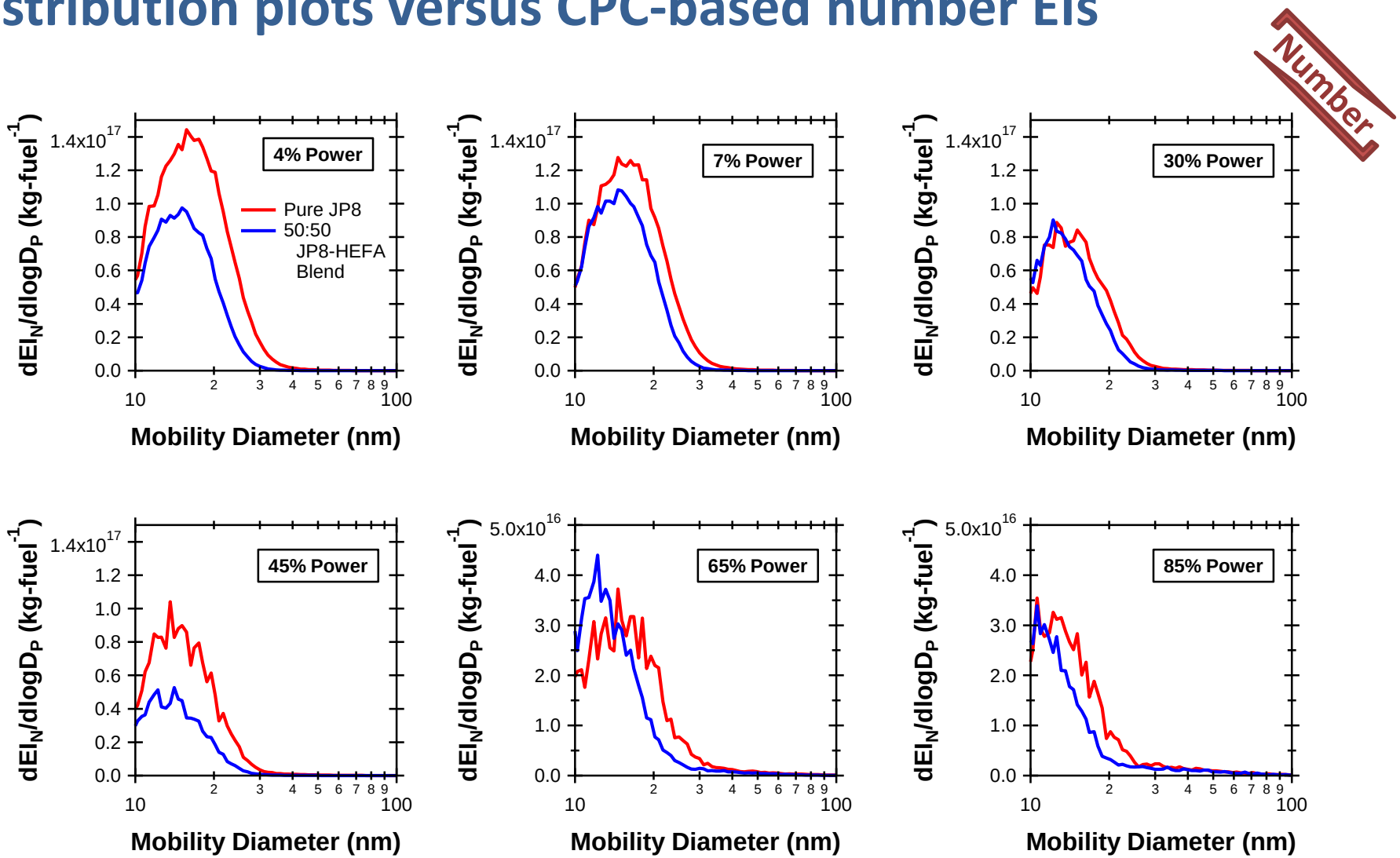




Need to Revise

Ground & Flight Data

Particle number reductions more apparent from size distribution plots versus CPC-based number EIs

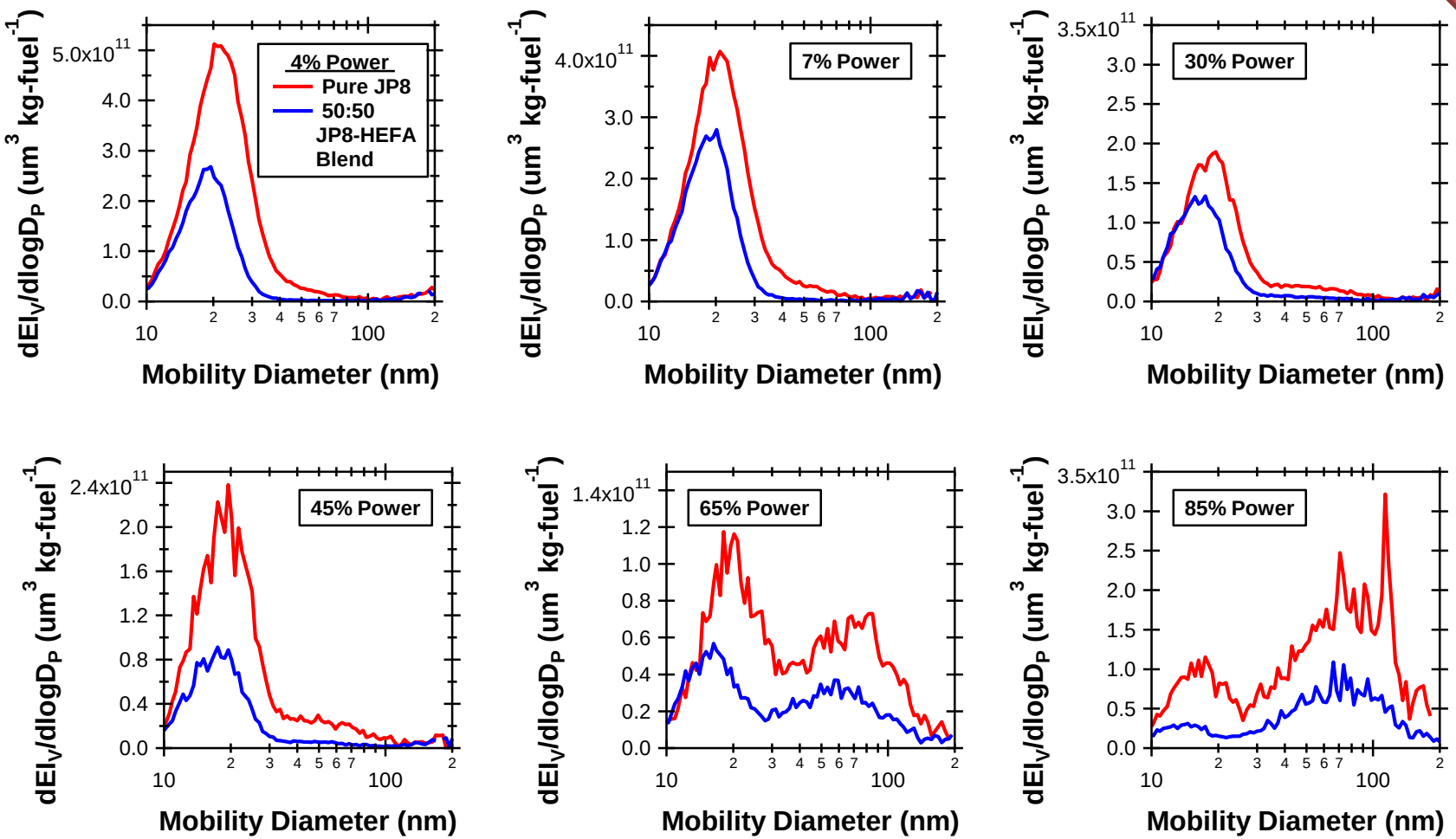


Note the changing y-axis scaling!

Ground Data

Now in aerosol volume space: emergence of a larger, soot mode at higher engine power is apparent

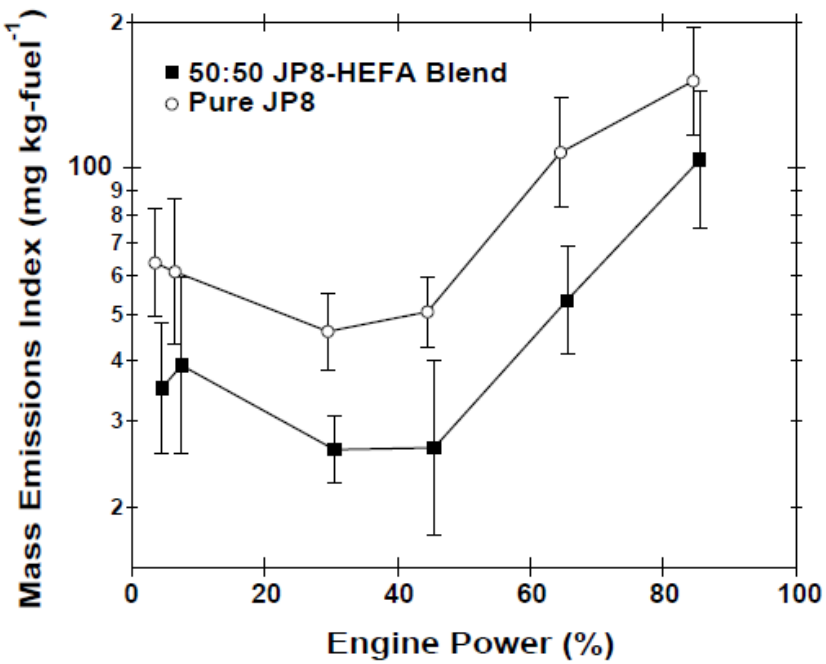
Volume



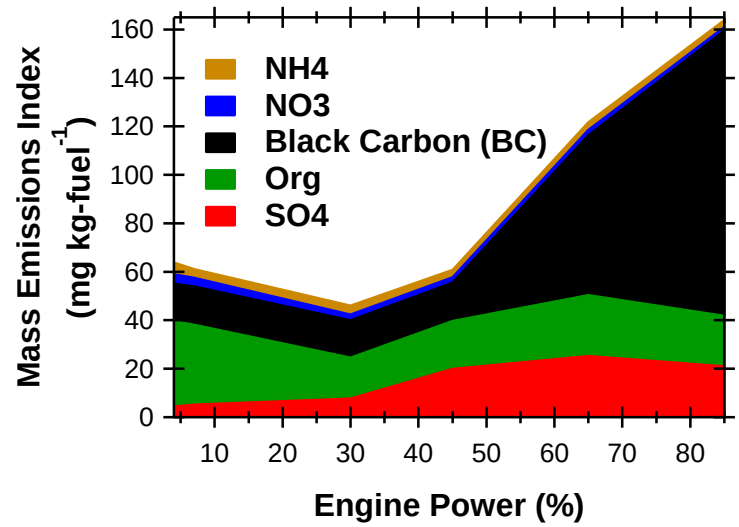
Note the changing y-axis scaling!

Ground Data

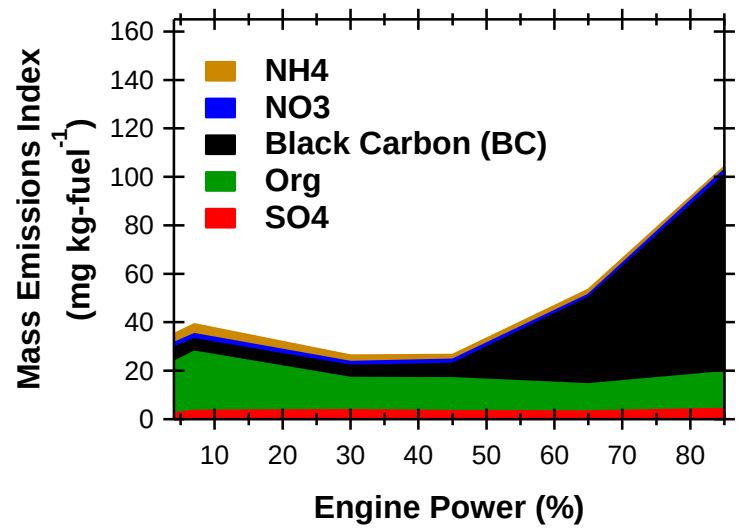
Fuel blending reduces overall particle mass emissions index by 30-50%, both soot and SO4 mass are decreased by two-fold.



Pure JP8:



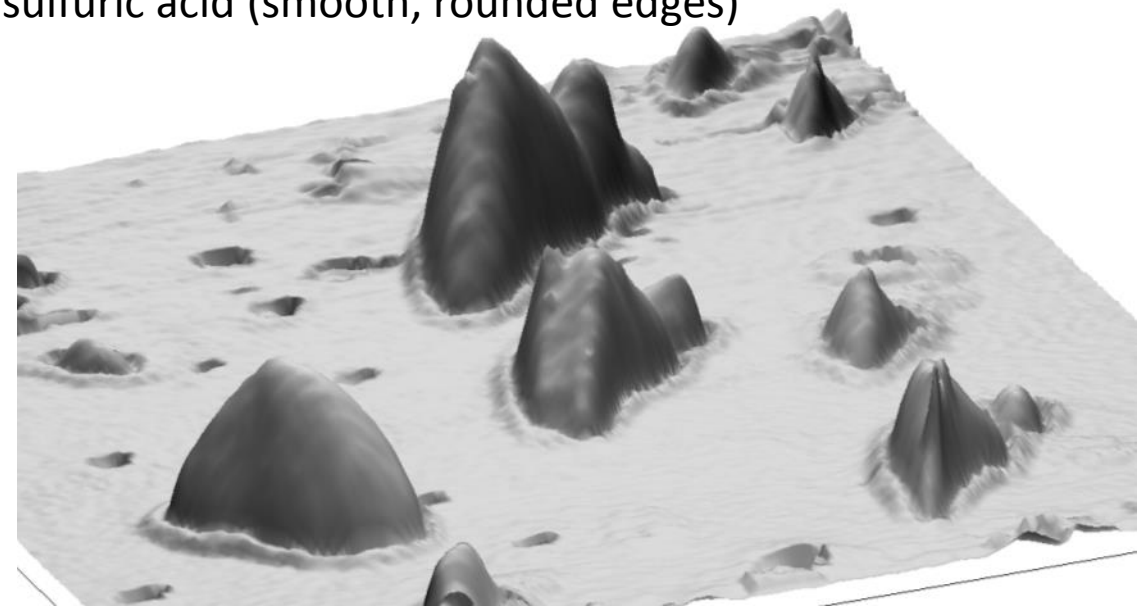
50:50 JP8-HEFA Blend:

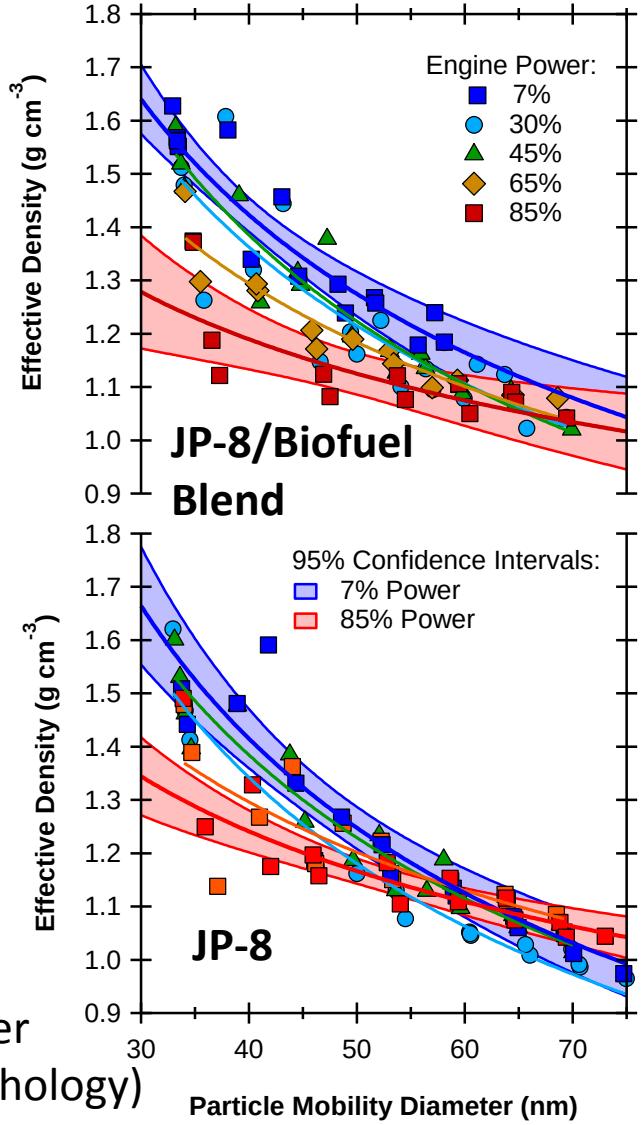


Ground Data

Additional instruments during the ground test can probe soot density and shape, but are not suitable for flight.

Atomic force microscopy image of soot particles, which appear to be coated with liquid organics or sulfuric acid (smooth, rounded edges)

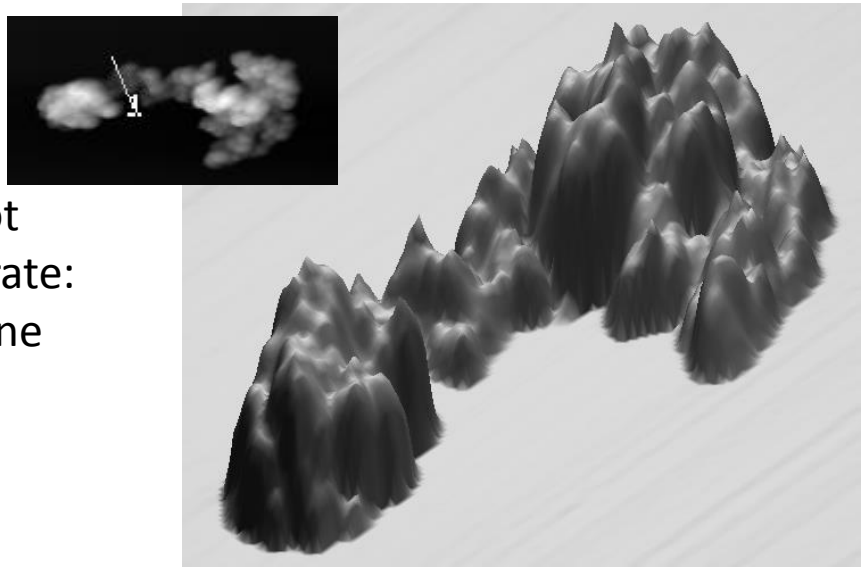




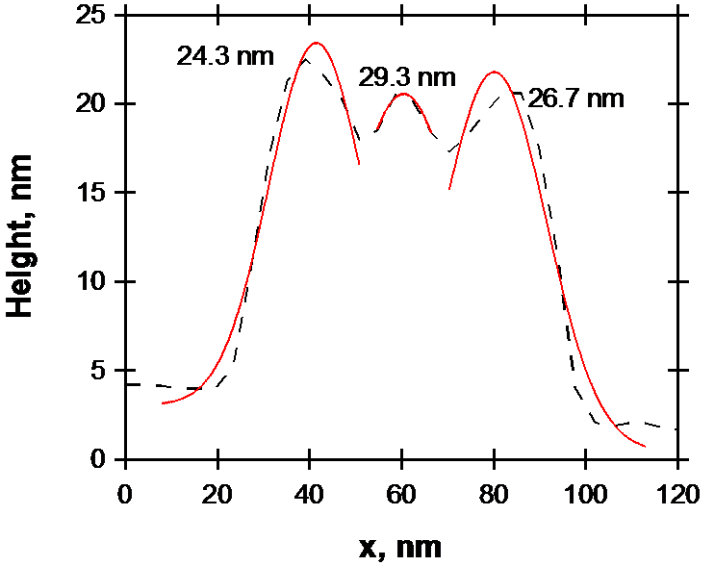
Higher density soot observed at lower power settings (again likely due to liquid-like morphology)

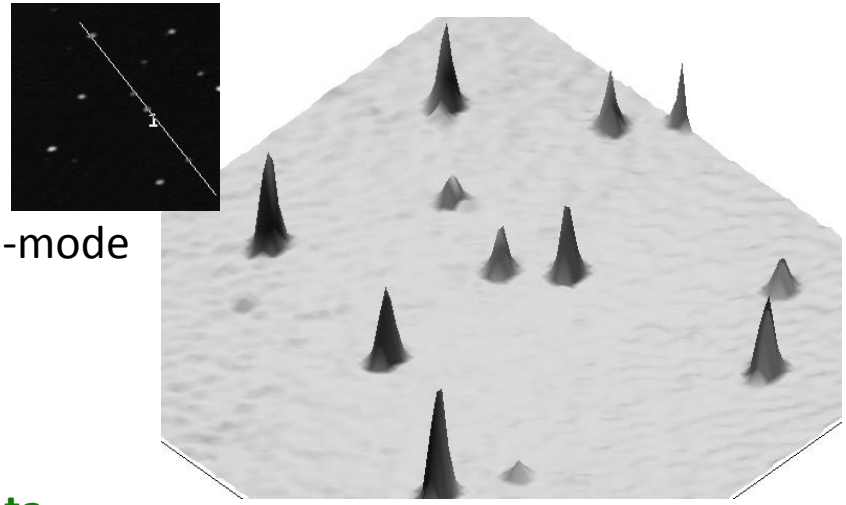
Ground Data

Probe individual particle size/morphology using atomic force microscopy (AFM).

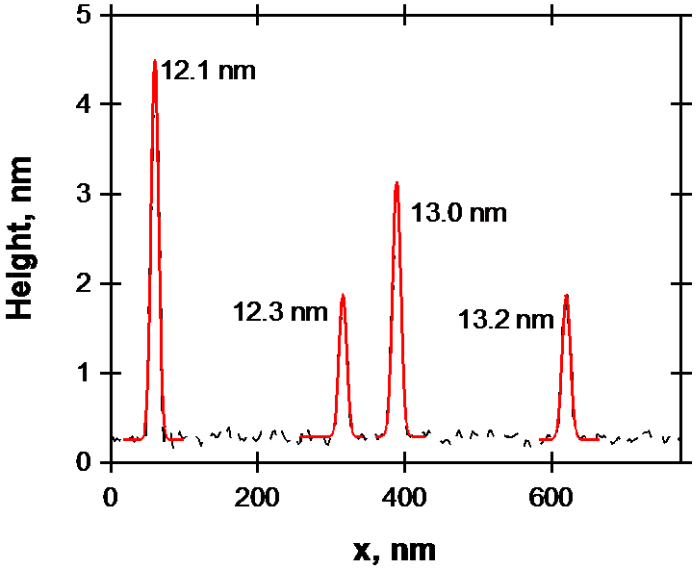


Large soot agglomerate: 45% Engine Power



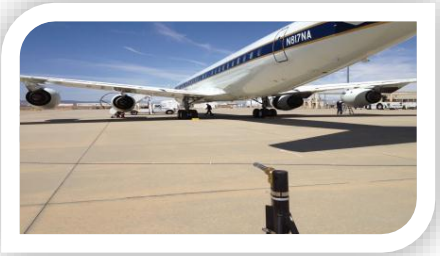


Individual nucleation-mode particles: 4% Engine Power



Ground Data

Summary & Conclusions



- Five joint LaRC Falcon – Dryden DC8 flights completed
- Extensive ground test of DC-8 emissions and survey of in-service aircraft at LAX
- Project completed in mid-April, but data is already yielding valuable insights into
  - Influence of biofuel blending/switching
  - Properties of soot produced under in-flight conditions
  - Ice particle size distributions and contrail properties (relevant for climate!)
  - Ground-based aircraft emissions (relevant for urban air quality!)
- Preliminary results show that blending traditional JP8 fuel with biofuel produces similar overall particle emissions, but <u>reduces non-volatile particle emissions by 30-45%</u>.
- Truly a team effort with excellent support/implementation from LaRC SD, RSD, ARD, and NASA Glenn, Dryden, and HQ.
- Looking forward to future flight testing – ACCESS II in December, 2013!

Questions?